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Sec. Research Graduate School Committee

NOTA BENE

1. Throughout the text, the spelling of the genus *Biblumena* should be changed to *Bibulmena*.

2. The genus name *Montikola* should be regarded as temporary (see p.219 – Vol. 1) and therefore will be published under an alternative name.

TAXONOMY, DISTRIBUTION PATTERNS AND PHYLOGENY OF AUSTRALIAN LEPTOPHLEBIIDAE (EPHEMEROPTERA).

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A thesis submitted in accordance with the requirements for the
Degree of Doctor of Philosophy at Monash University, Victoria, Australia.

STATEMENT OF ORIGINALITY

Except where reference is made in the text or acknowledgements this thesis contains no material published elsewhere or extracted in whole or in part from a thesis which I have qualified for or been awarded another degree or diploma.

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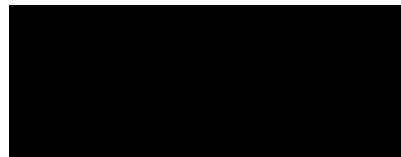
Kyla J. Finlay

DEDICATION

I would like to dedicate the thesis to the late Professor William (Bill) Peters
from the Centre for Studies in Entomology at the
Florida Agricultural and Mechanical University (United States)
for his enthusiasm, encouragement and informative
discussions during the progress of this study.

"I followed the living thing, I went upon the broadest
and narrowest paths that I might know its nature."

Friedrich Nietzsche 1883

"See everything; overlook a great deal: correct a little."

Pope John XXIII

ABSTRACT

The taxonomy of the Leptophlebiidae, the largest family of Ephemeroptera (mayflies) in Australia, is poorly known despite a relative proliferation of work in the last decade or so. Deficiencies in taxonomic knowledge have hindered ecological studies and use of mayflies as bioindicators. The objectives of this project were to revise the taxonomy of a problematical group of species and investigate their ecology by detailing distribution and habitat preferences. Further, examination of the evolutionary relationships (phylogeny) of the Australian Leptophlebiidae was used to confirm the taxonomic findings and elucidate the hitherto unknown evolutionary relationships at the familial level.

Extensive collecting and rearing of mayflies throughout south eastern Australia was undertaken to obtain the associated nymph and adult material required for taxonomic revision. The rearing process was accompanied by the design and evaluation of a new rearing chamber.

The taxonomic revision of two closely related, morphologically similar and possibly congeneric taxa was undertaken on the subgenus *Nousia (Australonousia)* Campbell and Suter and the genus *Koorrnonga* Campbell and Suter. The revision established consistent morphological variations between the two taxa, specifically in regard to the hindwing, penes, egg and labrum, leading to the conclusion that the taxa are not congeneric. As a result of the revision of the subgenus *Nousia (Australonousia)* five species are now included; one of which is new to science. Three morphospecies, apparently endemic to Tasmania, have also been described but remain unnamed due to lack of adult material. In addition to this, three species previously thought to belong in the subgenus have been removed and are considered as belonging to two new genera: *Montikola* containing two new species (one newly described), and the monotypic *Gemmayaluka*. Revision of the genus *Koorrnonga* resulted in synonymization with the genus *Thraulophlebia* Demoulin which was found to have priority. All species were therefore transferred to *Thraulophlebia* which now contains four species. Keys, drawings, scanning electron micrographs and, in some instances colour photographs, are provided for all species.

Habitat preferences for the revised species were examined and, for two species of *Nousia (Australonousia)* for which sufficient data were available, factors determining geographical distributions were explored using rapid bioassessment techniques and logistic regression. Environmental variables apparently affecting distribution differed considerably between the two species with *Nousia (Australonousia) nigeli* showing a preference for high altitude cool streams and *Nousia (Australonousia) fusca* tolerating a wider range of conditions but

being less frequent at the higher altitudes. Evaluation of the technique, however, indicated that the predictive power could probably be improved by measurements of additional environmental variables.

Lastly evolutionary relationships of the Australian Leptophlebiidae, perceived as a large gap in the knowledge of Gondwanan Leptophlebiid phylogeny, were studied using cladistic analysis. Outgroup material was provided primarily by the sister group Ephemeroidea. Thirty-four phylogenetically informative characters were identified and used to produce a strict consensus tree from the three most parsimonious trees initially produced. A high consistency and retention index indicated evidence of true evolutionary relationships within the ingroup. Comparisons of the cladogram with the relationships elucidated for other Gondwanan Leptophlebiid fauna reveal that the Australian fauna does not readily fit into the evolutionary lineages previously proposed and that these may need to be reconsidered. This work should be considered as a contribution to the development of an inclusive Gondwanan Leptophlebiid phylogeny which has never before been attempted.

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LIST OF APPENDICES

All Appendices are included in Volume 1.

No.	Appendix Title	
1	<u>Publication</u>: Finlay, K.J. (2001). Construction and evaluation of a new laboratory system for rearing mayflies. pp. 241-250. Proceedings of the Ninth International Conference on Ephemeroptera and the Thirteenth International Symposium on Plecoptera - Trends in Research in Ephemeroptera and Plecoptera, Tucumán, Argentina, Kluwer Academic Publishers.	refer to page
2	Alphabetically listed locality data for each specimen examined. Presence or absence of each species and genus at each site also noted.	349
3	<u>Publication</u>: Finlay, K.J. (2000). Description and distribution of a new species of *Nousia* Navás (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) from south-eastern Australia. *Australian Journal of Entomology* **39**: 111-117.	
4	Summary data on site characteristics where each species was present for all species found at more than 10 sites.	

1. GENERAL INTRODUCTION

"It has long been an axiom of mine that
the little things are infinitely more important."

Arthur Conan Doyle

1.1 Introduction

Australian streams differ greatly from their Northern Hemisphere counterparts (Williams 1968a; Williams and Wan 1972; Lake et al. 1985) being characterised by low discharge, intermittent and high variability of flow, high allochthonous inputs in summer rather than autumn and high proportions of woody debris. For these reasons Northern Hemisphere studies have been considered to have little relevance to Australia. Further, there are few full time limnologists in Australia due to the country's small population. As a result efforts have been thinly spread across a large country encompassing diverse biogeographic regions which include the tropics, desert and alpine regions. Most investigations, so far, have focussed in the more populated temperate zones such as the south east and south west. Areas such as the Northern Territory, north west Western Australia, the tropical North and Tasmania have been virtually neglected, a result of fewer centres from which to work and often long and arduous travel required for sampling.

As such the Australian freshwater invertebrate fauna has also been relatively little studied in comparison to that of the Northern Hemisphere. Taxonomic knowledge of the North American and European fauna is extensive (Thorp and Covich 1991; Merritt and Cummins 1996; Anonymous 2002) providing keys and major references for the vast majority of taxa. There is no equivalent up-to-date text for the Australian fauna. The first text to comprehensively summarise knowledge of the Australian invertebrate freshwater fauna was "Australian Freshwater Life" (Williams 1968) which was updated in 1980 (Williams 1980). Since the time of the second edition there has been an expanding body of knowledge accumulated about the Australian aquatic fauna, usually based on individual taxa (see Hawking 1996). Unfortunately, a substantial amount of it has been published in the "grey literature" , such as industry and government reports, (eg taxonomic identification guides published jointly by the Murray Darling Freshwater Research Centre and the Co-operative Research Centre for Freshwater Ecology) and remains difficult to obtain for overseas researchers. Despite this research, however, the current view is that the state of knowledge of the taxonomy and distribution of our macroinvertebrate aquatic fauna is merely "moderate" (Cullen and Lake 1993). Lake (1994) notes this lack of knowledge is "severely impeding our understanding of ecological processes".

To add to the difficulty, Australian streams also appear to have relatively high species richness compared with similar streams overseas (Lake et al. 1985) and much of the fauna appears to be distinctive and endemic (Williams 1980; Yen and Butcher 1997; Ponder and Lunney 1999). This gives no basis for comparison with the overseas literature.

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The enormity of the task of identifying all Australian freshwater fauna has led researchers to target certain taxa. Benthic macroinvertebrates in general are considered ideal candidates for water quality monitoring due to their abundance, long aquatic life spans, relative lack of mobility and wide range of responses to environmental stress (Rosenberg and Resh 1996). However, three orders (Ephemeroptera, Plecoptera, Trichoptera) are considered more useful than others due to their perceived pollution sensitivity. The EPT index, sometimes referred to as EPT richness (percentage abundance of each order), has been used as a means to measure water quality without having to examine all the individuals in the community (Lenat 1988; Rosenberg and Resh 1996; Baker and Sharp 1998).

Ephemeropteran nymphs, in particular, are found in a wide variety of lentic and lotic habitats from fast flowing upland streams to meandering lowland rivers, lakes and reservoirs (Williams 1980). Most are commonly associated with highly oxygenated fast flowing water (Merritt and Cummins 1996) and are particularly sensitive to changes in water quality.

Ephemeroptera are also considered an integral part of the recreational freshwater fishing industry in Australia (Tillyard 1933b; Tillyard 1936; Scholes 1961). The success of the industry depends directly on the ability to maintain healthy insect communities as fish food. This requires a knowledge of the species common in each area along with their habits. This knowledge is also of enormous interest to fly fishermen in order that suitable artificial flies can be   chosen.

Due to the restriction of the nymphal stage to water, and the adults' short life span and limited flight capabilities, Ephemeroptera are regarded as poor dispersers (Edmunds 1972). Mackerras (1970) hypothesized that this made the group ideal candidates for phylogenetic and biogeographic studies. Support for this view is seen in the numerous phylogenetic and zoogeographic studies of certain groups over the years; for example: Ephemeroidea (McCafferty and Gillies 1979; Bae 1991; McCafferty 1994); Heptagenioidea (McCafferty 1991a) and Leptophlebioidea (Peters 1971; Peters et al. 1978; Pescador and Peters 1980a; Peters 1980; Towns and Peters 1996).

1.2 Current status and knowledge of Australian Ephemeroptera

Like many of the other Australian aquatic insect orders, Australian Ephemeroptera is relatively understudied compared to North America and Europe although there has been substantial progress made in the last ten years or so (Campbell 2001). Eaton (1871)

discussed Australian fauna in his early monographs but it was Tillyard who produced the first substantial body of work on mayflies for this country (Tillyard 1926). The discipline, however, did not really begin to flourish until the 1980's with a relative proliferation of work from a few authors. Today there remain fewer than a dozen researchers working on mayflies in this country.

A striking feature of the Australian mayfly fauna is its uniqueness. Of the seven major groupings now generally accepted, and usually referred to as superfamilies (McCafferty 1991b; Hubbard *et al.* 2001; McCafferty 2002), Australian species are represented in all but the Ephemeroidea group. The distribution, however, is quite disparate with species of the Leptophlebioidea and Baetoidea dominating the Australian fauna (Table 1). Only three species, *Cloeon virens* Klapálek, *C. fluvatile* Ulmer and *Pseudocloeon kraepelini* Klapalek are not endemic (Campbell 1990).

Table 1. Percentage of Australian genera and species occurring in each Ephemeropteran superfamily.

Superfamily	% of genera	% of species
Baetoidea	29.7	24.7
Baetiscoidea	2.7	2.7
Heptagenioidea	2.7	0.9
Ephemeroidea	0	0
Ephemerelloidea	2.7	0.9
Caenoidea	8.1	10.6
Leptophlebioidea	54.1	60.2
TOTAL	**100.00**	**100.00**

1.2.1 Taxonomy

The earliest taxonomic study of an Australian mayfly is a description of *Baetis costalis* (now *Atalophlebia albiterminata*) by Burmeister (1839). Subsequently, workers such as Pictet (1843-1845) and Walker (1853) described a few species between them but it was not until the substantial monographs of Eaton (1871 and 1883-1888) that a large number of Australian species were first discussed. Eaton's work remains an important reference for taxonomic studies today.

The next influential and prolific worker was Georg Ulmer who described a great number of species now held at the Naturhistoriska Risksmuseet, Stockholm (Swedish Museum of Natural History) collected as part of the Mjöberg expedition to Australia (1910-1913).

Ulmer's numerous publications (Ulmer 1908; Ulmer 1916; Ulmer 1919; Ulmer 1920; Ulmer 1938) refer to at least 15 current Australian species.

Following Ulmer, R.J. Tillyard described a large number of new Australian species in his publication of works outlining the Ephemeropteran fauna of the Mount Kosciusko region (Tillyard 1933a) and Tasmania (Tillyard 1933a; Tillyard 1933b). This work describes a number of species (*Nousia darkara, N. delicatula, Atalophlebia superba, A. pallida, A. hudsoni, A. ida, Tasmanophlebia lacustris, Cloeon tasmaniae* and *Baetis frater*) which he considered endemic to Tasmania. Unfortunately, many of these species have not been revisited in subsequent revisions and little more is known of them other than Tillyard's original descriptions.

It took until the 1950's for the next substantial contribution to the taxonomy of Australian mayfly fauna to be made. Janet Harker outlined many new species (Harker 1950b; Harker 1954; Harker 1957a; Harker 1957b). Unfortunately much of her work includes specimens that are poorly described and inadequately drawn. Added to this her type specimens, all of which are listed as being held in the Natural History Museum in London, are missing. It is believed they were transferred to the Australian Museum in Sydney at some point but their whereabouts is still unknown (I.C. Campbell, *pers. comm*). This is unfortunate as her work needs revision due to a number of current species which appear to correspond to the described fauna in her papers. The ambiguities of her descriptions, however, provide much difficulty in the determination of these possible new species.

There were few authors actively pursuing mayfly taxonomy in the 25 years following Harker. Of note, however, are Demoulin (1955b & c), Riek (1955 & 1963), Soldán (1978) and Pearson and Penridge (1979) who were responsible for descriptions of selected individual taxa.

From the mid 1980's, Ephemeropteran taxonomic study was actively pursued by a few Australian workers and has produced a plethora of new species descriptions. Influential has been P. J. Suter with his substantial revision of the South Australian fauna (Suter 1986) and his subsequent descriptions of new taxa of Caenidae (Suter 1993; Suter 1999), Baetidae (Suter 2000) and Leptophlebiidae (Campbell and Suter 1988). Suter's contributions have also provided working knowledge of the Australian mayfly fauna in the form of keys (Suter 1979; Suter 1992; Dean and Suter 1996). I. C. Campbell has also been responsible for establishing several new genera such as *Kalbaybaria* (Campbell 1993) and *Koormonga, Garinjuga* and *Austrophlebioides* in association with Suter (Campbell and Suter 1988). He has also revised several other genera (Campbell 1983;

Campbell and Peters 1986; Campbell and Peters 1993) and described a new species of *Prosopistoma* (Campbell and Hubbard 1998).

J.C. Dean has made a substantial contribution to the knowledge of mayfly taxonomy in Australia, publishing many new generic and species descriptions (Dean 1987; Dean 1988; Dean 1997; Dean *et al.* 1999; Dean 2000). He has also produced a number of keys (Dean 1989; Dean 1999, Dean and Suter 1996) which have detailed character variation in the nymphal stages. The latest guide, although based on morphospecies identification only, includes a large number of specimens and has provided a solid platform on which to base this present study.

Recently there have been a number of overseas papers describing new Baetidae from Australia (Lugo-Ortiz and McCafferty 1998a; Lugo-Ortiz and McCafferty 1998c; Lugo-Ortiz and McCafferty 1999; Lugo-Ortiz *et al.* 1999). Most of these revisions are based on material collected in the 1960's by J. Illies and G.F. Edmunds Jr. and there is some concern amongst Australian taxonomists that the authors have been hampered by lack of material. Further, it appears that they have produced many synonymies by not referring to the Australian literature. Papers are in press at present to correct some of these errors (P.J. Suter *pers. comm.*).

A totally new family, Siphlaenigmatidae, was also added to the Australian fauna by Lugo-Ortiz and McCafferty 1998b) with the description of *Siplaenigma edmundsi* Lugo-Ortiz and McCafferty. Subsequently, however, this has been proved to be an error due to the mislabelling of the original specimens (I.C. Campbell & P.J. Suter *pers. comm*). The family has been subsequently formally removed from the Australian fauna (McCafferty 1999).

The latest catalogue of Australian mayflies (Hubbard *et al.* 2001) lists 113 extant species described within 37 genera and 9 families although 10 families are recorded (see Table 2). The discrepancy in the family number derives from the erroneously described *Atopopus spadix* (Harker 1950a) which she attributed to Heptageniidae. The species is, in fact, a leptophlebiid awaiting redescription and the family Heptageniidae is considered absent from Australia (Hubbard and Campbell 1996; Hubbard *et al.* 2001).

Despite the discrepancy, the total is a significant improvement on previous tallies of the Australian species: 84 (Peters and Campbell 1991) and 95 (Hubbard and Campbell 1996). However, the total is still considered a significant underestimate of Australian species richness, despite the relative proliferation of work in the last decade or so. Recent publications have alluded to large numbers of undescribed taxa (Dean and Suter

1996; Dean 1999) and many authors believe there may be at least twice the number of species to be described (Campbell 1988; Campbell 1990; Dean and Suter 1996; Hubbard and Campbell 1996).

1.2.2 Biology and ecology

Autecological studies of the Australian mayfly fauna are also few in number especially in comparison to the Northern Hemisphere. Only a small number have detailed work, other than life history analyses, and the most significant of these are listed here. One study has investigated size allometry in various species belonging to the families Siphlonuridae, Ameletopsidae, Oniscigastridae and Coloburiscidae (Campbell 1991). Bailey (1981b) investigated *Atalophlebioides* sp. (now *Austrophlebioides*) in relation to drift. Three studies (Campbell 1979; Bailey 1981a; Pinder *et al.* 1993) have recorded diel activity, often related to drifting behaviour, of various mayfly species. Investigations into the burrowing Ephemeroptera world-wide have included mention of *Jappa* sp. in behavioural studies (Edmunds and McCafferty 1996) and investigations of tusk phylogeny (Bae and McCafferty 1995). Two dietary studies have ascertained most of the fauna thus far studied are predominantly detritivores although certain species of *Baetis* and *Ameletoides* were found to contain large amounts of algae (Campbell 1985; Chessman 1986). There have also been some investigations into egg development (Suter and Bishop 1990; Brittain and Campbell 1991; Brittain 1995) which indicate that the relationships between water temperature and egg development time of the Australian temperate species are similar to those of their Northern Hemisphere relatives.

Table 2. Number of families, genera and species of extant Australian Ephemeroptera.

Family	Genus	No. of species	Key references
Ameletopsidae	Mirawara	3	(Harker 1954; Riek 1955)
Baetidae	Baetis	2	(Harker 1954; Suter 1986)
	Bungona	1	(Harker 1957b)
	Centroptilum	2	(Harker 1957b ; Suter 1986)
	Cloeodes	2	(Lugo-Ortiz and McCafferty 1998a)
	Cloeon	5	(Suter 1986 ; Suter 2000)
	Edmundsiops	2	(Lugo-Ortiz and McCafferty 1999; Suter 2000)
	Offadens	3	(Lugo-Ortiz and McCafferty 1998c; Suter 2000)
	Pseudocloeon	4	(Waltz and McCafferty 1985; Lugo-Ortiz et al. 1999)
Caenidae	Ipracaenis	3	(Suter 1999)
	Tasmanocoenis	6	(Demoulin 1955b; Soldán 1978; Alba-Tercedor and Suter 1990)
	Wundacaenis	3	(Suter 1993)
Coloburiscidae	Coloburiscoides	3	(Tillyard 1933a; Campbell 1986)
Heptageniidae*	Atopopus	1	(Harker 1950a)
Leptophlebiidae	Atalomicria	7	(Campbell and Peters 1993)
	Atalophlebia	18	(Tillyard 1936; Harker 1950a; Harker 1954; Harker 1957a; Suter 1986)
	Atalophlebioides**	3	(Harker 1954; Towns and Peters 1978)
	Austrophlebioides	4	(Campbell and Suter 1988; Parnrong and Campbell 1997)
	Bibulmena	1	(Dean 1987)
	Deleatidium**	4	(Harker 1954; Towns and Peters 1996)
	Garinjuga	1	(Campbell and Suter 1988)
	Jappa	3	(Skedros and Polhemus 1986)
	Kalbaybaria	1	(Campbell 1993)
	Kaninga	1	(Dean 2000)
	Kirrara	3	(Harker 1954; Harker 1957b)

Table 2 cont'd.

Family	Genus	No. of species	Key references
	Koorrnonga	6	(Campbell and Suter 1988)
	Loamaggalangta	1	(Dean et al. 1999)
	Neboissophlebia	2	(Dean 1988)
	Nousia (subgenus Australonousia)	4	(Campbell and Suter 1988)
	Nyungara	2	(Dean 1987)
	Thraulophlebia	1	(Demoulin 1955c)
	Thraulus	1	(Grant 1985)
	Tillyardophlebia	2	(Dean 1997)
	Ulmerophlebia	2	(Demoulin 1955c; Suter 1986)
Oniscigastridae	Tasmanophlebia	3	(Tillyard 1921; Tillyard 1933a)
Prosopistomatidae	Prosopistoma	1	(Campbell and Hubbard 1998)
Siphlonuridae	Ameletoides	1	(Tillyard 1933a)
Teloganodidae (formerly Ephemerellidae)	Austremerella	1	(McCafferty and Wang 1997; Chessman and Boulton 1999)
Total families	Total genera	Total species	
10	37	113	

* Heptageniidae does not occur in Australia, species attributed in error and now considered a Leptophlebiid, awaiting revision.

**genus presently considered endemic to New Zealand, awaiting revision.

As mentioned previously the majority of studies in Australia have focused on life history investigations (Duncan 1972; Suter and Bishop 1980; Marchant 1982a; Campbell 1983; Campbell and Holt 1984; Marchant et al. 1984a; Campbell 1986; Bunn 1988; Campbell et al. 1990; Brittain and Campbell 1991; Campbell 1995; Schreiber 1995; Campbell et al. 1998; Pardo et al. 1998). Generally these have revealed somewhat poorly synchonized life histories with long emergence periods, multiple cohorts present and variation in life cycle patterns over time and space in temperate regions (Campbell 1986; Bunn 1988; Brittain and Campbell 1991). These patterns do not conform to studies undertaken in the Northern Hemisphere and have been attributed to the ecological variations between Australian and Northern Hemisphere streams (Lake et al. 1985; Williams 1988) with temperature being a dominant factor (Brittain and Campbell 1991). It is generally concluded that fauna from higher altitude streams show a relatively higher degree of synchrony (Duncan 1972; Campbell 1986; Campbell et al. 1990; Brittain 1991) than their lower altitude counterparts. The few mayfly studies from the Australian tropics have also shown lifecycles to be multivoltine and asynchronous with emergence and recruitment occurring throughout the year (Marchant 1982a; Campbell 1995). This conforms with studies completed in the Northern Hemisphere which show a trend towards multivoltinism and asynchrony with lower latitudes (Clifford et al. 1973; Clifford 1982; Brittain 1990).

These autecological studies, however, on the Australian freshwater insect fauna have been hampered by the lack of taxonomic knowledge. Thirteen (68%) of the above mentioned Australian papers refer to one or more undescribed species.

Multispecies investigations (including synecological studies) are somewhat more common although they usually refer to freshwater macroinvertebrate communities in general rather than just the Ephemeropteran component. Invariably, however, mayflies tend to be a significant component of the freshwater fauna.

A paucity of information on the Australian invertebrate fauna has led to a number of baseline investigations simply detailing macroinvertebrate communities in particular areas. For example, the Northern Territory Magela Creek (Marchant 1982b; Paltridge et al. 1997) and the George Gill Range (Davies et al. 1993). In Western Australia Bunn et al. (1986) have investigated the spatial and temporal variation in macroinvertebrate communities of Northern Jarrah forest streams. Timms (1978) documented the variety of benthos in Tasmanian lakes and in South Australia the invertebrate assemblages of the floodplains of the Murray were investigated (Boulton and Lloyd 1991). In Victoria invertebrates of the Goulburn River tributaries above Eildon (Doeg 1987), the Lake Mountain plateau (Jelinek et al. 1997), Lake Tali Karng (Timms 1974) and the environs of Mt Buffalo (Hawking 1998) have all been surveyed. Leading on from the above there

have been investigations into changes in macroinvertebrate community structure due to outside influences such as dam construction (Blyth *et al.* 1984; Doeg 1984; Chessman *et al.* 1987; Pardo *et al.* 1998); forestry activities (Davies and Nelson 1994; Growns and Davis 1994); pulp mill waste water (Harris *et al.* 1992) and mine effluent (Norris *et al.* 1982). Studies were also conducted into the effects on macroinvertebrate structure of altering abiotic variables such as substrata size (Doeg *et al.* 1989a; Barmuta 1990; Hearnden and Pearson 1991); velocity (Barmuta 1990); sediment loads (Doeg and Milledge 1991) and by artificial disturbance (kicking and raking) the stream bed (Doeg and Lake 1989). A number of these studies also observed the phenomenon of drift in response to the abiotic variation (Doeg and Lake 1989; Doeg *et al.* 1989a; Doeg and Milledge 1991) and background drift for both temperate (Schreiber 1995) and tropical rainforest streams (Kerby *et al.* 1995).

A major two year study of the La Trobe River in Victoria was undertaken in which the organisation of macroinvertebrate communities was investigated (Marchant *et al.* 1984a; Marchant *et al.* 1984b; Marchant *et al.* 1984c; Metzeling *et al.* 1984; Marchant *et al.* 1985; Marchant 1988). These studies, in particular, led to a preliminary attempt at predictive modelling of lotic macroinvertebrate communities in Victoria (Marchant *et al.* 1994; Marchant *et al.* 1999). They have been useful in the development of Australian Rivers Assessment System (AusRivAS), a computer program that uses environmental data to measure the river health (Davies 1994; Coysh *et al.* 2000) along the same lines as the Riverine InVertebrate Prediction and Classification System (RIVPACS) in the United Kingdom (Wright *et al.* 1984; Moss *et al.* 1987; Wright *et al.* 1993).

1.2.3 Systematics

Inferences regarding the systematic relationships of the Australian fauna have been made within wider discussions regarding the evolution and biogeography of the group Ephemeroptera as a whole (Illies 1968; Edmunds 1972; Riek 1973; Landa and Soldán 1985) with many of the Australian families found to be amphinotically distributed. Indeed the comparative morphology of certain families found indicate that the Australian fauna is more closely related to that of Chile and Argentina rather than New Zealand. Tsui and Peters (1975) examined the comparative morphology of the Leptophlebiid thorax, tentorium and abdomen and hypothesized a transantarctic dispersal route. Pescador and Peters (1980a) included Southern Hemisphere genera in an investigation of the cool-adapted Leptophlebiidae of South America and came to a similar conclusion.

The only cladistic analysis of Australian fauna to date studied the relationships between members of the *Meridialaris* lineage (*sensu* Pescador and Peters 1980a) (Christidis

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*A primary objective of this study is to elucidate the phylogenetic relationships of the Australian Leptophlebiidae. This is because despite being the largest family of Ephemeroptera in Australia, and an important component of water quality assessment, the relationships between the genera are poorly defined. In order to undertake such a study, however, some Australian generic designations required clarification; in particular the *Atalonella* lineage as originally defined by Pescador and Peters (1985). Therefore, a revision of the problematical Australian genera within this lineage was undertaken, including new diagnoses of genera and descriptions or redescriptions of all species. To complete this revision new methods for rearing mayflies in the laboratory were developed in order that associations could be made between nymph and adult specimens. Further, collecting specimens for the taxonomic revision on a large scale produced new distributional data. Rapid assessment techniques were employed during field collection and allowed some preliminary investigation of habitat requirements of certain species.

2001). The aim was to establish the monophyly of the lineage which was supported but relationships between taxa of the larger clade, which included the other Australian Leptophlebiidae, varied considerably.

1.3 The significance of the family Leptophlebiidae

Leptophlebiidae is the largest mayfly family in the world and in Australia (Hubbard 1990; Peters and Campbell 1991). Further, maximum diversity of the genera is apparent in the Southern Hemisphere (Edmunds 1972) accompanied by a high degree of endemism (Tsui and Peters 1975). Indeed, all but two genera of Leptophlebiidae in Australia (*Nousia* and *Thraulus*), and all species within the family, are endemic.

The wide variety of environs inhabited by Ephemeropteran nymphs in Australia is largely due to the high diversity of the Leptophlebiidae. Their preference for highly oxygenated lotic waters makes them ideal for biomonitoring. The large diversity and high biomass of individuals that would be expected in a pristine environment can be readily detected by their absence. Further, as the majority of Leptophlebiid larvae are swimmers, clingers or sprawlers (Edmunds and Waltz 1996) pollution or spates result in immediate downstream drift. As the Leptophlebiidae are commonly encountered in survey work, mayflies are an integral part of the Australia-wide Monitoring River Health Initiative (Lake 1994; Coysh *et al.* 2000) which compares observed communities with those expected in an unpolluted environment.

1.4 Overall scope and objectives
see opposite*
1.4.1 Taxonomy

Members of the endemic subgenus Nousia (*Australonousia*) Campbell and Suter and the closely related *Koorrnonga* (Campbell and Suter) are some of the more commonly encountered mayfly species. Yet both are poorly described and can be confused due to their morphological similarities. An objective of this study was to revise these two, possibly congeneric, genera. This required the collection of new material and rearing of nymphs to establish associations between nymphs and adults, the description of new species and matching of voucher specimens to newly, or previously described, specimens.

1.4.2 Factors affecting distribution

The species of *Nousia (Australonousia)* and *Koormonga* that have previously been described, as with much of the Australian fauna, are also poorly known ecologically. An objective of this study was to use the collection of new material to detail the distribution and habitat preferences of the newly revised taxa.

1.4.3 Phylogeny

Finally, the relationships of Southern Hemisphere Leptophlebiidae have been reasonably well studied through analysis of a restricted number of Gondwanan (Tsui and Peters 1975), eastern Hemisphere (Peters and Edmunds 1970), South American (Pescador and Peters 1980a; Dominguez 1995) and New Zealand (Towns and Peters 1996) taxa. The only place in the Southern Hemisphere where relationships have not been comprehensively investigated is Australia. An objective of this study was to determine the phylogenetic relationships between Australian Leptophlebiidae to provide a baseline from which the Leptophlebiid Gondwanan fauna can continue to be investigated. The relationships found in this study will be compared with the evolutionary lineages of certain Southern Hemisphere fauna already proposed by Pescador and Peters (1980a & 1985); the hypotheses of which have not been tested on Australian fauna.

2. FIELD COLLECTION AND LABORATORY REARING✦

"When the insects take over the world,
we hope they will remember with gratitude how
we took them along on all our picnics."

Bill Vaughan

2.1 Introduction

The extensive collections of Ephemeroptera at various institutions throughout Australia such as the Australian National Insect Collection (ANIC), the Murray Darling Freshwater Research Centre (MDFRC), the State Environment Protection Authorities (EPA's) and the Museum of Victoria (MV), provided a basis for this study. In 1993 an Australia wide National River Health Program was established with an aim to improve the management of Australia's rivers. One of the major subprograms of this is the Monitoring River Health Initiative (MRHI) (Davies 1994) which uses a system of reference and test sites to determine predictive models for the health of each river catchment. Access to these specimens is possible through the various lead agencies contracted to sample reference sites (eg: EPA VIC, Power and Water Authority NT, EPA SA, Department of Primary Industry and Fisheries TAS, Department of Natural Resources QLD, Department of Conservation and Land Management WA, and the Department of Environment Land and Planning ACT).

Unfortunately, many of these collections consist of adult or, more usually, nymphal material only. In many cases no definitive link has been made between the two. Field collection of nymphs and adults in one location is an accepted method of identifying all insect life stages for a species but has the inherent problem of the difficulty of discriminating between different species, especially if one has to rely on immature nymphs for initial identification. A better method is to collect nymphs and rear them to adults individually, keeping the subsequent larval skin case for examination. For most taxa examined in this study the animals had to be collected live and reared to adults to make this definitive association therefore field work constituted an extensive part of the project.

2.2 Field collecting

2.2.1 Timing of fieldwork

As mayflies can only be collected during the emergence season, collecting times were restricted to an extended summer period. The main collection of nymphal material occurred over three seasons: September 96 to April 97 (year 1), October 97 to March 98 (year 2) and October 98 to April 99 (year 3). Supplementary collections were made in the summer of 1999 to 2000 to sites previously visited to collect extra specimens for rearing. In total 368 sampling events were undertaken from locations throughout Victoria, Tasmania and New South Wales during the course of the project (see Appendix 2, collector: KJF).

2.2.2 Choice of locations to be sampled

For taxonomic review it was important that all known species of *Nousia* and *Koormonga* were examined in nymph and adult form. Limited resources dictated that the collection area be restricted. As the majority of possible species were thought to occur in south-east Australia, it was decided to concentrate on Victoria and southern New South Wales as the main source of supply. It was assumed that specimens from other states or territories could be obtained from lead agencies and other sources, although this has not proved to be the case in all instances.

An early visit to Tasmania (December 96) established the difficulty of collecting and rearing in the field and it was hoped that collaboration would provide the specimens needed. Unfortunately, the time involved in collecting and rearing specimens proved difficult on a volunteer basis and very few associated specimens were gained this way. As a consequence, a second trip to Tasmania was planned for later in the study but ultimately time and resources did not permit this.

2.2.3 Methods of collecting

2.2.3.1 Collection of nymphs

Both *Nousia* and *Koormonga* prefer unpolluted environments and are relatively common in upland streams in association with logs, leaf packs and organic matter (Peters and Campbell 1991). Riffles with heterogeneous substrate appear to be favourites of these animals although there are some species of *Koormonga* which are also thought to be common in shallow pools (Peters and Campbell 1991). Cool, upland streams were therefore targeted as potentially good sampling areas for both these genera.

For the most part nymphs were collected live for subsequent rearing in the laboratory, however, some nymphs were preserved in the field using 70% ethanol and subsequently used as reference material.

Collections were primarily made by closely examining the substrata in the field and removing the nymphs individually with a small paintbrush. This reduced the chance of damage to the delicate nymphs which may have prevented them from successfully emerging. In slow flowing or standing waters a rectangular framed 300µm aperture nylon mesh net was swirled through the water close to the substrate to pick up the nymphs.

At each sampling locality all likely habitats (riffle, pool, edge) were sampled. Sampling continued until sufficient nymphs of all visibly different taxa were collected with no apparently new types being found. The method employed was not quantitative as this was considered too time consuming and the fact that the collections were made at different times of the year made the significance questionable. Further, it was considered the main priority was the acquisition of nymphs for rearing rather than abundance estimates.

2.2.3.2 Collection of adults

Adults mayflies are difficult to collect in the field for several reasons. Adults generally live for a short time, usually several hours to a few days only (Peters and Campbell 1991) although some have been recorded living up to 14 days (Brittain 1982). In either case the chance of being present at a site when adults are emerging is quite small. Mayflies are also unique in that they are the only order of insects to moult after becoming fully winged. The first winged stage is called the subimago and is characterised by dull translucent, often patterned wings and a body surface covered with microtrichia. Further the forelegs, caudal filaments, male genitalia and occasionally eyes are not fully formed (Edmunds and McCafferty 1988). A second moult results in the true adult or imago. Only the imago can be used for taxonomic purposes so the subimago must be kept alive whether reared from a nymph or caught in the field.

In the field subimagos and imagos were caught when the opportunity arose. Imagos tend to swarm above the stream or along the stream banks and were collected by using a sweep net. Subimagos tend to be slow flying and passive (Edmunds et al. 1976) and can be captured easily by hand or with a net. They are often found on the underside of rocks in a stream during low flow having recently emerged from the water or close to the waters edge on stream side vegetation. Care is required in handling the subimagos as any damage, especially to the wings, can result in death. Subimagos were transferred to a plastic container to await emergence to the adult form. This container was a modified example of the subimago box used by Edmunds et al. (1976). The container was clear plastic container, about 8cm high, with a white plastic screw on lid. Inside was placed a wetted cloth to create a humid environment and a branch for the subimago to perch on. A small hole was punched in the lid and the container was placed carefully in cool conditions. One to two days were required for the subimago to moult to an imago. Unfortunately this technique was not found to be particularly successful and most subimagos died before emerging.

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An alternative method of collecting adults is to use a light trap. An ultra-violet light powered by a 12V battery was set near the stream bank at dusk at various sampling localities throughout the study period. However, low numbers of emerging adults, and often unfavourable weather conditions, produced poor results.

2.2.3.3 Transporting

One of the main concerns for rearing was keeping the animal alive while it was transported to the laboratory. Live nymphs collected from one site were placed in a 1.25 litre clear plastic bottle filled with stream water. The bottles were sealed and placed in an insulated container filled with ice to cool the animals and slow metabolic rates so that emergence might be delayed (Fig. 1). In order to provide for the high oxygen requirements of the mayflies the bottles had to be constantly aerated. During the day the water was adequately aerated by the motion of the vehicle. Overnight, a battery operated pump was employed to aerate each individual chamber.

A small number of sites were accessible only by foot. Time was required to walk out of these sites during which problems with low oxygen levels in the water might be likely to develop. Further, the container could easily heat up, causing possible stress to the animal. These problems were overcome to some extent by planning the trip so that the shortest possible route was taken. Animals were also collected at the last possible moment so that as little time as possible was spent walking. Further, a small insulated container was used for collecting, rather than a bottle, and this was filled with ice beforehand to ensure conditions were kept as cool as possible.

2.3 Rearing

2.3.1 Background

Many authors have made suggestions for rearing aquatic insects to adults (see review by Merritt et al. (1996)). The two main approaches are field and laboratory rearing. Each method has its advantages and disadvantages which will be briefly reviewed here.

Most field rearing techniques involve a mechanism for containing the nymphs within the existing water body and providing room for the animal to emerge while safe from drowning. Methods used include jars partially immersed in the stream (Speith 1938), specially constructed wire screen cylinders sitting upright on the substrate (Day 1956) or plastic cups suspended in the water column on a foam float (Edmunds et al. 1976). An

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alternative is to enclose a section of the stream bed with a large mesh covered frame to capture the emerging animal (Hynes 1970; Southwood 1978; Merritt *et al.* 1996). In fast flowing or deep water these emergence traps are anchored to the substrate.

The obvious advantage of field rearing is that the nymphs are reared *in situ* where the environmental conditions are ideally suited to the individual. Disadvantages are that field rearing is often very time consuming, requiring the researcher to be in the field until emergence has occurred. It is difficult to rear at several locations simultaneously as the cages or traps require frequent checking. Vandalism is also a potential problem but perhaps the most significant difficulty is that the nymphal exuviae, necessary for nymph-adult association, is more likely to be lost during the process.

Laboratory methods range from simple to extremely complex as authors have tried to address the problem of recreating stream flow conditions. Covered aquariums have been used in conjunction with various methods of inducing a current such as a magnetic stirrer (Mason and Lewis 1970) or directed air (Craig 1966; Bay 1967). Gravity flow systems sustained by running tap water have been used by Hynes (1941). Pumps for recirculating the flow were later introduced by Mason and Lewis (1970). More sophisticated are the large flow tanks powered by propellers (eg. Vogel and LaBarbera 1978) and complicated systems designed more specifically for the purposes of toxicity testing (Buikema and Voshell 1993). Using these designs the rearing process and environmental conditions can be closely monitored. However, these systems are primarily suitable for mass rearing as the cost and logistics of setting up individual tanks becomes prohibitive.

The disadvantages of each method above led to the design of a new laboratory rearing system for mayflies specifically for this study. The aim was to produce a low cost system that would still allow for definitive associations between nymph and adult. Each chamber was therefore designed to house one individual mayfly and allowed the animal to pass through the stages of nymph and subimago without disturbance.

The chambers are made from readily obtainable material and are easy to construct. They are also inexpensive and cost less than AUS$2.00 each assuming an air supply is available. As the chambers are quite small the air supply required for each is minimal and the cost of pumps no longer becomes a limiting factor. Up to ten chambers can be accommodated with a small 240V aquarium pump. The compact chamber size also makes them space-efficient with many chambers able to be housed in a small area. Although similar systems have been described before in the literature (Merritt *et al.* 1996) I have yet to find a published account of their use.

2.3.2 New rearing chamber design

The new rearing chamber (Fig. 2) was constructed from a 1.25 litre transparent plastic bottle. This was cut in two at about two-thirds its length from the bottom, at the point where the sides start to converge towards the lid. The open container was lined with nylon mesh, which can either be glued in place or simply wetted and pressed against the sides. Two hooks were attached facing outwards and opposite each other on the outside of the bottle using electrical tape so that a rubber band could be stretched between them across the open end. A small hole (diameter of 6-7mm) was drilled in the plastic bottle lid. The top third of the bottle with the lid was then inverted to sit in the chamber, lid downwards, and secured by the rubber band. The chamber was then half filled with water. Compressed air was supplied to the chamber by means of PVC aquarium tubing (interior diameter 4mm) attached to a pump or laboratory air supply. Up to ten chambers were aerated from one small air pump linked through aquarium tubing, although each chamber required a two-way controller so flow could be balanced. It was found beneficial to attach a plastic micropipette tip to the end of the tubing to restrict the flow of bubbles to a small stream. Glass pipettes proved too fragile and, being heavier, were prone to blockage by resting on the chamber bottom.

2.3.3 Rearing system

Each rearing chamber was half filled with water from a particular site and one late instar individual from that site was added. Twigs collected from the site were added to each chamber supplying detritus and algae as a food source and providing a platform for emergence. Each chamber was attached to an air supply (air outlet or pump) and placed in a controlled temperature room that was variously set at 16°C, 18°C, 20°C or 22°C. Only one room was available for rearing and as such temperature changes were a result of identifying optimal conditions rather than experimental design. Photoperiods of 12 hours daylight and darkness (12:12) or 14 hours daylight, 10 hours darkness (14:10) were used at different times. Some nymphs were placed in much larger chambers designed by (Campbell 1983, Fig. 3). These were made from a cube-shaped frame of wood to which fly-screen or mesh is stapled on all sides. A 500ml container was placed inside the frame and connected to an air supply by aquarium tubing through a small hole. Surplus nymphs were stored in an aerated container refrigerated to 7°C. Empty chambers were thoroughly washed and nymphs replaced from refrigerated stock. These new nymphs were acclimatised to the controlled temperature environment for a period of 20 to 30 minutes before being placed in the rearing chambers.

2.3.4 Emergence data collection

In the controlled environment the nymphs were checked every second day and the life cycle stage of the individual noted as N (nymph), S (subimago) or I (imago). Once emergence (or death) occurred the animals were removed and genus and sex determined by observation using a stereomicroscope.

Some effort was expended in documenting and analysing rearing success. One reason for this was to identify the suitability of the new chambers and other environmental conditions so rearing could be conducted as efficiently as possible. The results are presented here because it may be of assistance to other workers in the discipline to know: (1) what conditions proved suitable for various taxa, (2) success rates that can be expected in these conditions and (3) which factors the insects responded to, which may be of more general application to mayfly rearing.

2.4 Results

Emergence success data have previously been published (Finlay 2001, Appendix 1). It should be noted, however, that this publication was prepared and submitted in 1998 and therefore analysed prior to the taxonomic changes described in Chapters 3 and 4. The analysis that follows therefore differs slightly from the publication in that it incorporates these taxonomic changes.

The full data set included 1251 individuals of which *Austrophlebioides* and *Nousia* predominated, comprising 36.5% and 33.8% respectively. Next came *Atalophlebia* Eaton at 12%, then *Garinjuga* Campbell and Suter at 6.6%, *Tillyardophlebia* Dean at 4.6%, *Thraulophlebia* Demoulin (previously *Koorrnonga,* see Chapter 3) at 2.6% and *Ulmerophlebia* Demoulin at 0.9%, *Montikola* gen. nov. (previously *Nousia*, see Chapter 4) at 1.6% and *Gemmayaluka* gen. nov. (previously *Nousia*, see Chapter 4) at 0.7%. A few individuals of other genera, such as *Atalomicria, Jappa, Kirrara* and the unnamed Genus 'W' (Dean 1999) were also collected representing the remaining 0.6%. Of the ten named genera in south-east Australia, all were sampled except *Neboissophlebia* Dean despite this genus having been found previously in many of the sites where I collected. Data analysis will focus on the six most prevalent genera: *Austrophlebioides, Nousia, Atalophlebia, Garinjuga, Tillyardophlebia* and *Thraulophlebia.*

2.4.1 Emergence success

Imago emergence success rate for the full data set was 34.1% with 10.0% reaching the subimago stage before dying and 55.9% dying as nymphs. Individual genera, however, differed significantly in emergence success (χ^2=47.09, df=5, p<<0.001, Fig. 4). *Atalophlebia* was reared most successfully with 48.7% becoming imagos. Other highly successful genera were *Tillyardophlebia* (47.4%) and *Thraulophlebia* (45.5%) followed by *Nousia* (39.0%). The genera with the lowest success rates were *Austrophlebioides* (25.0%) and *Garinjuga* (22.0%).

The new rearing chamber was compared with that designed by Campbell (1983). The new chamber produced higher imago emergence rates compared with the 'old' one (Campbell's) for all the genera examined (except *Tillyardophlebia*). However, a small sample size prevented analysis of all but three predominant genera (Table 3). A significant difference was found only for *Austrophlebioides* (χ^2= 5.993, df=1, p=0.014), whose emergence success rate more than doubled in the new chambers (27.1% v. rsus 12.6%).

Emergence success did not differ between the sexes for any genus except *Tillyardophlebia* (Table 3) where a much greater proportion of females (58.8%) than males (30.4%) emerged successfully (χ^2= 4.435, df=1, p=0.035).

The effect of varying the photoperiod could be analysed only for year 1 as there were no individuals reared under 12:12 conditions during year 2. Within the restricted data set a significant difference due to photoperiod was found only for *Austrophlebioides* (χ^2= 17.810 df=1, p<<0.001, Table 3), yet this went against the trend for all other genera where success rates, although not significantly different, were generally higher under a 12:12 cycle. Similarly, the effect of year of collection could only be examined in relation to photoperiod 14:10. Again there was a significant difference between year 1 and 2 only for *Austrophlebioides* (χ^2= 56.936, df=1, p<<0.001, Table 3). There was no apparent trend for the other genera.

For most genera, the proportion successfully emerging was highest at 18°C (Table 3) and the temperature which produced the lowest proportion of successful emergence was 22°C. The effect of temperature was significant for *Austrophlebioides* (χ^2= 47.838, df=3, p<<0.001, Table 3) and *Nousia* (χ^2= 11.102, df=3, p=0.011, Table 3). The effect of temperature was also considered in relation to time spent in the rearing system for a restricted number of genera (Fig. 5). Time taken to emerge successfully was greatest at

18°C followed by 16°C, 20°C then 22°C. Although patterns of response to temperature were similar for each genus, the time taken to reach outcome varied considerably. For example, at 18°C mean time to emerge varied from 7.8 days for *Nousia* to 12.9 days for *Atalophlebia*. Data were log transformed to meet the assumption of normality and an ANOVA run to test for a significant effect of temperature. All genera had significant temperature effects (*Nousia*, F-ratio = 3.032, df=3, p=0.031; *Austrophlebioides*, F-ratio=4.269, df=3, p=0.007; *Atalophlebia*, 20°C degrees removed, F-ratio = 4.354, df=2, p=0.017) although multiple r^2 showed that very little variability (around 10% or less) in rearing time was explained by temperature differences. Tukey's HSD tests showed significant differences for all genera between the temperatures of 18°C and 22°C only (Fig. 5).

The effect of altitude of collection on rearing success by genus was examined by chi-squared for four altitude categories: [(1). <400m, (2). 400-800m, (3). 801-1200m, (4). >1200m]. It was found to be significant only for *Austrophlebioides* (χ^2= 29.826, df=3, p<<0.001, Table 3) where the highest success rates were found at progressively lower altitudes (Fig. 6).

Division of storage time into three categories: [(1). 0-2 days, (2). 3-5 days, (3). > 5 days] and subsequent analysis by chi-squared also showed a significant effect only for the genus *Austrophlebioides* (χ^2=18.297,df=2, p<<0.001, Table 3) with a higher success rate for progressively fewer days in storage. However, altitude of collection and storage time were positively correlated as it took longer to return to the laboratory from high altitude collection sites.

Table 3. Percentages of successful emergences affected by collection and rearing conditions.

	Atalo-phlebia	Austro-phlebioides	Garin-juga	Thraulo-phlebia	Nousia	Tillyard-phlebia
CHAMBER TYPE						
p value	0.628	**0.014**	◆	◆	0.926	◆
n	*150*	*454*	*82*	*33*	*423*	*57*
% success old cage	44.4	12.6	15.4	37.5	38.7	50.0
% success new cage	49.6	27.1	23.2	48.0	39.1	47.0
SEX						
p value	0.795	0.909	0.542	0.435	0.238	**0.035**
n	*150*	*456*	*82*	*33*	*423*	*57*
% success female	47.8	24.8	20.0	40.0	40.9	58.8
% success male	50.0	25.3	25.9	53.8	34.8	30.4
PHOTOPERIOD (year 1) †						
p value	◆	**0.000**	◆	◆	0.248	◆
n	*62*	*164*	*82*	*3*	*152*	*14*
% success 12:12	62.3	24.0	28.2	100.0	50.0	53.8
% success 14:10	33.3	56.5	18.0	100.0	40.4	0.0
COLLECTION YEAR (photoperiod 14:10)						
p value	◆	**0.000**	◆	◆	0.461	◆
n	*97*	*377*	*50*	*31*	*365*	*44*
% success – year 1	33.3	56.5	13.0	100.00	40.4	0.0
% success – year 2	42.0	16.1	22.2	40.00	36.2	46.5
TEMPERATURE						
p value	◆	**0.000**	◆	◆	**0.011**	◆
n	*150*	*456*	*82*	*33*	*423*	*57*
% success 16°C	43.4	23.6	20.0	42.1	46.3	51.4
% success 18°C	59.0	45.4	25.6	100.0	49.2	53.8
% success 20°C	50.0	24.3	42.8	0	39.8	25.0
% success 22°C	38.2	10.8	9.5	40.0	29.4	0
ALTITUDE						
p value	0.126	**0.000**	◆	◆	0.210	◆
n	*150*	*456*	*82*	*33*	*423*	*57*
% success <400m	46.9	33.1	24.5	12.5	39.1	50.0
% success 400-800m	44.4	22.5	-	54.5	38.5	16.7
% success 801-1200m	73.3	9.6	0.0	-	16.7	100.0
% success >1200m	-	6.1	19.0	66.7	56.2	-
STORAGE						
p-value	◆	**0.000**	◆	◆	0.808	◆
n	*150*	*456*	*82*	*33*	*423*	*57*
% success 0-2 days	43.8	32.3	20.9	50.0	39.6	62.5
% success 3-5 days	75.0	19.8	33.3	33.3	35.1	28.6
% success > 5 days	62.5	12.0	16.7	50.0	39.6	27.8

Effect of each factor analysed by χ^2 Significant p values (at < 0.05) shown in bold.
† analysed on restricted data set as there were no mayflies reared under the 12:12 regime in year 2.
◆ one or more categories with small sample size: χ^2 test not reliable.

2.4.2 Sex-ratios

Ratios of $\male:\female$ showed a female bias for all individual genera in the range of 1:1.5 for *Tillyardophlebia* to 1:2.2 for *Nousia* (Fig. 7). Chi-squared analysis was used to determine departure from the expected 1:1 sex ratio and was found to be significant for all genera except *Thraulophlebia* and *Tillyardophlebia*.

2.5 Discussion

2.5.1 General

The overall imago emergence success rate was 34%. Clearly, however, success rates depend on the genus in question. Taxa preferring slow waters would be expected to emerge more successfully in aerated tanks with low flow regimes (Edmunds *et al.* 1976). Therefore, it is not surprising that *Atalophlebia*, predominantly found in standing or slowly flowing waters (Peters and Campbell 1991), had the greatest proportion of imagos that emerged. The relatively low success rates of *Garinjuga* may be due to the presence of a large number of a possibly new high altitude species in the sample for which the emergence success was very low, thereby reducing the average for the whole genus.

Overall, the new rearing system was a success in that imago emergence rates were generally higher in the new chamber compared with the older one for all genera. In particular, the success rate for *Austrophlebioides* was much greater in the new chamber. The considerable advantages of the new chambers in terms of time saved in construction and set-up, space efficiency and low cost indicate that the system could be widely used even if just for routine species identification.

In general, few factors had an effect on overall emergence success for any genera other than *Austrophlebioides*. Sex appeared to affect *Tillyardophlebia* but as this was a relatively small data set it may not prove to be biologically significant. There were also temperature effects for *Atalophlebia* and significantly for *Nousia* which must be considered. (Table 3, Fig. 5).

Most striking, however, were the results for the genus *Austrophlebioides* which appeared to be affected strongly by all factors except sex. This is almost certainly related to habitat requirements. For example, the greater rearing success in smaller chambers with much less water could be indicative of an inherent need for highly oxygenated water in this

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genus. Neither chamber adequately simulates current flow, but the new chamber may provide more oxygen per volume than the 'old' chamber. A high rate of water movement may be necessary for the development of this genus. Similarly, the highly positive response to a 14 hour photoperiod, which is typical of an Australian summer light regime, may be required as a cue for *Austrophlebioides* to emerge. If this is so, this is the first record of an enhanced emergence response to photoperiod for Australian Leptophlebiidae as photoperiod has been shown previously to have little effect on mayfly egg hatching or emergence (Brittain 1982; Suter and Bishop 1990; Newbold *et al.* 1994) despite the suggestion that it is important for aquatic insects in general (Hynes 1970).

Austrophlebioides fared better in year 1 possibly because they were stored for much less time (0.1 mean days in year 1 compared with 4.9 mean days in year 2). Progressively shorter storage times produced significantly higher success rates. Another contributing factor may be that altitude range for each year was considerably skewed, with animals being collected no higher than 500m in year 1 but up to 1560m in year 2, as progressively lower altitudes produced greater emergence success rates. Perhaps there is a greater temperature differential between higher altitude sites and the laboratory, creating more physiological stress on the animals and thus impairing the rearing process.

Temperature not only determines abundance, distribution and diversity of stream insects (Hynes 1970; Ward and Stanford 1982; Zamora-Muñoz *et al.* 1993) but is considered to be one of the most important influencing factors affecting insect development (Corkum 1978; Elliott 1978; Brittain 1982; Wallace and Anderson 1996). Indeed in this study, temperature was the only external factor significantly affecting emergence success of a genus other than *Austrophlebioides*. Success rates were much higher at 18°C than at 22°C, yet summer water temperatures would be within the range 16-22°C for all but the highest altitudes; so it is puzzling to find such a restricted temperature preference for emergence. This restricted preference also applied to the length of time taken to emerge. It is possible that the nymphs have a narrow temperature requirement for development which is in line with the optimal thermal regime theory (Sweeney and Vannote 1978) that exists for a given species. Adult size, fecundity and presumably emergence rates, may diminish outside the bounds of the optimal regime for the species.

Trends in the data are not significant with the clear exception of *Austrophlebioides*. A broader study with species level data within this genus may therefore be especially valuable.

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2.5.2 Sex-ratios

Insect sex-ratios in nature are generally expected to be 1:1 although skewed ratios due to
inbreeding occur and will be biased towards females (Thornhill and Alcock 1983).
Although female biased sex ratios in Ephemeroptera have been recorded in New Zealand
in association with rapid flow (Towns 1983) most relate to parthenogenetic taxa of which
50 species are known worldwide (Brittain 1982) and only in three or four families
(McCafferty and Huff 1974). It appears obligatory in only a few species (Peters and
Campbell 1991). In these species parthenogenetic eggs generally develop more slowly,
causing a delayed female bias in the sex ratio of the nymphs which is perpetuated through
the life cycle. For example, sex ratios of Cloeon similae (Baetidae) increased from 1:1 in
the summer to 2:1 in Spring and early Winter over 13 consecutive years due to a longer
development time for the unfertilised eggs and subsequent late appearance of
parthenogenetic progeny (females) (Harker 1997). Data for the present study were
collected from a wide range of sites over two years, so it is possible that the observed sex
ratio actually reflects what occurs in nature. As far as I am aware there are no previous
records of parthenogenesis occurring in Australian Leptophlebiidae.

3. REVISION OF THE SUBGENUS *NOUSIA (AUSTRALONOUSIA)* CAMPBELL AND SUTER AND THE GENUS *KOORRNONGA* CAMPBELL AND SUTER

"There is no excellent beauty that hath not
some strangeness in the proportion."

Francis Bacon 1561-1626

3.1 Introduction

The subgenus *Nousia (Australonousia)* Campbell and Suter, which comprises all *Nousia* species in Australia, and the endemic genus *Koorrnonga* Campbell and Suter, are poorly known. At present three species are accommodated in the subgenus *Nousia (Australonousia)* while six species reside within the genus *Koorrnonga* although the status of some of these species is questionable and their placement acknowledged as tentative (Campbell and Suter 1988). The two taxa are also considered very closely related (Campbell and Suter 1988) and possibly congeneric, probably because the characters used to distinguish between them are relatively few. This also puts into question the subgeneric status of *Nousia (Australonousia)* with respect to its South American counterpart, the subgenus *Nousia (Nousia)*.

In addition, potential new species of both taxa are recorded in government and industry reports ("grey" literature) (eg Dean 1999). These morphospecies are known only by voucher collection numbers, usually described only as nymphs with no associated adults. Little attempt has been made to match them with any current species already published.

It is clear that a revision of these taxa is sorely needed. This study aims to:
1.   revise the subgenus *Nousia (Australonousia)* redescribing species where necessary.
2.   investigate the characters determining the subgeneric separation of *Nousia (Nousia)* from South America with *Nousia (Australonousia)* from Australia.
3.   revise the genus *Koorrnonga* redescribing species where necessary.
4.   describe and determine the taxonomic status of any potential new species.
5.   investigate whether *Nousia (Australonousia)* and *Koorrnonga* are congeneric.

3.2 Methods and conventions

There has been much discussion on the various kinds of species concepts (for review see (Sluys 1991)). However, for the practising morphological taxonomist, species are delineated on the straightforward practical approach of morphological similarity: " a set of individuals closely resembling each other." (Darwin 1859). This approach has been somewhat refined in that the full range of morphological variation within a species is (or should be) accounted for when determining species status. The determination of what constitutes a mayfly species has been developed and refined by various ephemeropterists. Therefore, I have based the method of species descriptions on: (1) the prominent overseas workers in the field: William L. Peters (eg Peters and Edmunds 1970; Peters,Peters and Edmunds 1978; Peters and Peters 1979; Peters 1980); George

F. Edmunds Jr. (eg Peters and Edmunds 1964; Peters and Edmunds 1972); David R. Towns (eg Towns and Peters 1978; Towns and Peters 1996); Manuel L. Pescador (eg Pescador and Peters 1980a; Pescador and Peters 1980b; Pescador and Peters 1982; Pescador and Peters 1985; Pescador and Peters 1987; Pescador 1997) and (2) the more recent Australian workers Phillip J. Suter (eg (Suter 1979; Suter 1986; Suter 1993; Suter 1999; Suter 2000); Ian C. Campbell (eg Campbell and Peters 1986; Campbell and Suter 1988; Campbell 1993; Campbell and Peters 1993; Campbell and Hubbard 1998) and John C. Dean (eg Dean 1987; Dean 1988; Dean 1989; Dean and Suter 1996; Dean 1997; Dean 1999; Dean *et al.* 1999; Dean 2000).

3.2.1 Material examined

Mayfly specimens for this study were collected between September 1996 and April 2000 (see 2.2.1) from locations throughout Victoria, New South Wales and Tasmania. This was supplemented by material borrowed from the Museum of Victoria (MV), the Australian Museum (AM), the Australian National Insect Collection (ANIC), the Naturhistoriska Riksmuseet in Stockholm (Swedish Museum of Natural History, SMNH), the Natural History Museum in London (formerly British Museum of Natural History, NHM) and the Oxford University Museum (formerly Hope Museum, Oxford, OUM). Other material was examined from various Australian institutions such as the Monitoring River Health Initiative (MRHI), the Murray Darling Freshwater Research Centre (MDFRC), Australian Water Technologies (AWT), the Australian Water Quality Centre, South Australia (AWQC), the Environment Protection Authorities of Victoria and South Australia and various private collections.

All life stages of the insect were preserved in 70% ethanol either in the field or in the laboratory once rearing was accomplished.

All new type material is lodged in the MV. All other material collected by the author is held personally and will subsequently be donated to the MV.

3.2.2 Preparation of specimens

Whole specimens were examined with the aid of an Olympus SZH dissecting microscope and illustrations made using a SZH drawing attachment. Dissection of the mayflies was necessary to examine mouth and body parts which are diagnostic of the species. Material dissected was soaked in ethoxy-ethanol for 5-10 minutes for clearing, then permanently mounted on slides in Canada Balsam for examination under a compound microscope. Wings of imagos and subimagos were dry mounted as suggested by

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(Edmunds *et al.* 1976) as wings mounted in Canada Balsam can become clouded. I have found dry mounts become brittle easily and minimal handling is required to keep the wing intact. Illustrations of mounted specimens were made with the aid of a microprojector.

Body parts and eggs were also examined in finer detail using the scanning electron microscope (SEM). The material was dissected in 70% ethanol taking care not to expose the parts to the air. The 70% ethanol was then removed and replaced with 100% ethanol through a series of two to three washes. On each occasion the material was left in undiluted alcohol for at least 30 minutes; a process designed to further remove moisture. Eggs were subsequently ultrasonicated for two to three minutes as this was found to dislodge the mucous layer, which surrounds the egg within the body cavity, and expose the detail underneath. Material was then critical point dried to further remove moisture, a process which helps minimize distortion. Once dried, the eggs were placed on metal stubs using adhesive. Body parts and genitalia were mounted on small strips of cardboard attached to a metal stub. This arrangement allowed dorsal, ventral and lateral sides of the genitalia to be viewed and photographed. Finally, the material was sputter-coated with gold. Digital imaging was used to record the SEM images.

3.2.3 Presentation of descriptions

For each genus the synonymies are listed first along with the relevant references. This is followed by the type species information, distribution, diagnosis (description), etymology for new species descriptions, remarks and finally locality data.

Each species description then follows a set pattern. The imago, male then female, are described first followed by the egg, the subimago and the nymph. Measurements are given in mm as ranges followed by the mean, standard deviation and n in parentheses. At least ten measurements were taken for each characteristic where possible. If n is less then not enough specimens of that species were available for that particular measurement.

Diagnosis of species status included measurements and examination of the whole animal for general appearance and colour. Important diagnostic characters for adults include measurements such as body, fore and hindwing length and the hindwing size in relation to the forewing. Body and head colour was recorded as was eye size and shape, noting the dimorphism between the sexes. Relative eye size of the male imagos was measured by the formula ES=B/D following Bae (1991) where ES=upper eye size, B=shortest distance between upper lobes and D=longest diameter of upper lobe. (Fig. 8). Relative upper eye sizes are as follows: large (ES=0.0-0.2), medium sized (ES=0.3-0.5), small

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(ES=0.6-0.9), very small (ES=0.9-1.6) and tiny (ES=1.7-3.0). Other characters on the head worth noting are ocelli size and shape and antennal length and colour (Fig. 8). From the thorax, colour and shape is noted with references to the three regions; the prothorax, mesothorax and metathorax as necessary. Although the detailed morphology of the thoracic region has been used previously for taxonomic distinction (Tsui and Peters 1972) it was not used here; the method is cumbersome and time consuming and it was considered that enough diagnostic information was available from other characters. Associated with the thorax are the legs where colour and length were noted along with foreleg length ratios especially between male (Fig. 9) and female (Fig. 10) and tarsal claw morphology (Fig. 11). Leg length ratios were calculated using the method of Suter (1986) where each segment is compared to the length of the fore femur or first segment and expressed as a ratio. The mean length of the femur is then given at the end in parentheses, followed by *n*. The forewing venation nomenclature followed in this study was that of Edmunds and Traver (1954b) and Edmunds *et al.* (1976) with recent variations outlined by (Dean (1989). This venational terminology is summarised in Fig. 12. The colour of the fore and hind wing and veins therein, the relationships between the various veins and the numbers of crossveins in the costal and subcostal spaces were all recorded. For the male imago, the genitalia are species specific (Edmunds *et al.* 1976) with the size, shape and colour of the forceps and penes being diagnostic in dorsal (Fig. 13), ventral (Fig. 14) and lateral (Fig. 15) view. In the female the ventral posterior margin of sternite nine, sometimes called the anal plate, is variable in shape and can be used to distinguish between taxa (Fig. 16) as can the presence or absence of a genital extension or egg guide at sternum seven (Fig. 16). The size, shape and pattern on the egg chorion is also considered diagnostic for a species and was determined using SEM where possible. Lastly, the caudal filament colour and characteristics were noted.

Subimago body lengths were recorded, if available, and their general appearance and colour in comparison to the imago noted.

Important features of the nymphs include body length of males and females separately. The general appearance and shape of the body was noted as were: head orientation, head colour and width; ocelli size and shape; antennal colour and length and eye size and shape of the dimorphically variant males (Fig. 17) and females (Fig. 18). The mouthparts of the nymph, unlike the adults, are fully functional and represent important diagnostic characters at the species level. With regard to the labrum (Fig. 19) the width, length and width length ratios are important features as is the shape of the lateral margins, the presence or absence of an antero-median emargination and denticles thereon. For certain taxa the presence of a secondary hair fringe, its width in relation to the labrum and frontal setae are diagnostic, as are ratios of the denticle width to labrum width. Finally,

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the width of the labrum in relation to the clypeus is noted as is the angle that the lateral margins of the clypeus project anteriorly towards the labrum (Fig 19). Important features of the mandibles (Figs. 20, 21) include general shape, colour and setation as well as the number, size, shape and denticulation of the incisors. Added to this the size and shape of the prostheca, the prosthecal tuft and the arrangement of hairs on such is important. The maxillae (Fig. 22) size and shape is also determinative. The relative expansion of the galea-lacinae is important and the width length ratio of such is calculated by dividing the width apically by the length of the inner lateral margin to the base of the extension. Also recorded are the number of subapical pectinate setae, and the relative lengths and features of the palps. The hypopharynx features (Fig. 23) include the state of development of the lateral processes, the degree of cleavage of the lingua and the setal arrangement on the superlingua. Finally, for the mouthparts, the labium (Fig. 24) also rates as an important character. Recorded are the arrangement of the glossae in comparison to the paraglossae, the presence or absence of spines on the lateral margins and the relative lengths and features of the palps. Illustrations of mouthparts conform to a standard. All parts are drawn dorsally, except for the labia which follows the method of (Peters and Edmunds 1964) where the ventral surface is shown on the right hand side and the dorsal surface on the left. Palpi segment length ratios of maxillae and labia were calculated using Suter's method for measuring leg length ratios (above, Suter 1986) .

From the thorax, general appearance and colour is noted, occasionally referring to the three major parts of the thorax. The width of the pronotum is often measured and compared with head width as a ratio. Leg colour, size, shape and setation are important (Fig. 25). The foreleg width, length and width length ratio are recorded along with the leg length ratios for all three legs (Suter 1986). Number of spines on the fore tibiae and tarsus are noted. For some species the average length of the spines on the foretarsus compared to the mid-length width of the tarsus is important. Presence or absence of tarsal claw teeth and their number is also a useful diagnostic feature. General colour and patterning of the abdomen was recorded along with presence, absence and size of postero-lateral spines (Fig. 26). An important feature is the size, shape, colour and appearance of both the upper and lower lamellae of the gills (Fig. 27). Lastly caudal filament colour, length and characteristics were noted where appropriate.

Locality data (listed alphabetically in Appendix 2) were recorded for each specimen examined are recorded in the following manner in the text: name of creek in bold, specific location (eg Williams Rd Camp Site, Wandiligong), site identifier which consists of the year, month, day and collection number in an eight digit code (eg 98101703), EPH number if available (code used by the MV), altitude, longitude, latitude, date of collection, number of male specimens and life stages for each using N,S or I for nymph, subimago

and imago respectively, then number of female specimens using the same codes. Life stages were recorded with reared specimens and adult stages first. Thus the following order was employed: NSI (indicating nymph reared through to imago stage), I (imago only), SI (nymph reared to imago, subimago exuviae saved but nymphal exuviae not recovered), NI (nymph reared to imago, subimago missing), NS (nymph reared to subimago then died), N (nymph only). If a recorded site location does not follow this sequence the data missing were unavailable.

Collectors names are shown as abbreviations in parentheses at the end of the locality data. The material I collected during the course of this study is identified by the abbreviation KJF. Material collected by others, or used from other collections, is identified by the abbreviations of the collectors names as follows: NA = Nigel Ainsworth, PA = P. Allbrook, SA = S. Arandt, JB = John Blyth, JBa = J. Barton, JEB = JE. Bishop, SB = Stuart Bunn, RB = R. Blackwood, RBu=Rhonda Butcher, AC = A. Calder, DC = David Cartwright, DCo = D. Coleman, IC = Ian Campbell, GD = G. Drecktrah, JD = John Dean, FM=Franz Mahr, MD = M. Dean, TD = Tim Doeg, ME=Mjöberg Expedition, NF = N. Forteath, IG = Ivor Growns, JG = John Gooderham, PG = Peter Goonan, RG = R. Green, BH = B. Herbert, JH=J. Harker, PH = Pierre Horwitz, JJ = Jean Jackson, JL = J Lidston, BM = Brooke Margery, BJM = B. Moulds, CM = Chris Madden, GJM = GJ Morgan, MSM = Max S. Moulds, RM = Richard Marchant, RMo = R. Morley, CMcP = Catriona McPhee, AN = Arturs Nebriss, TN= Tim New, SP = Supatra Parnrong, ESGS =Sabine Schrieber, LS = Le Souef, RStC = Ros St. Clair, ER = Edgar Riek, DS=David Scholes, MS=M. Suter, PS = Phil Suter, SS = S. Sheerlock, ET = Edward Tsyrlin, RJT=R.J. Tillyard, AW = Alice Wells, KW = Ken Walker, PW= P. Waller, WDW = William (Bill) Williams.

3.3 Revision of the subgenus *Nousia (Australonousia)*

3.3.1 History

The genus *Nousia* was erected by L. Navás (Navás 1918) to accommodate the newly described *Nousia delicata* Navás from Chile, South America. He acknowledged that the description was somewhat inadequate, being based on one male subimago, but considered it still warranted species status. He writes "un ejemplar ♂ muy deficinete, sin las Ms de las patas, sin los cercos superiores o urodios. Como el ala anterior está en buen estado y la posterior ofrece suficientes caracteres, me he atrevido a describirlo de algún modo, aplazando para mejor ocasión, si longo ver algún ejemplar más perfecto, una descripción complementaria" ("An incomplete male specimen, without the majority of legs and caudal filaments. As the anterior wing is in good condition and the posterior one is in reasonable condition showing enough features, I have dared to describe it in some way, leaving for a future opportunity a complementary description if a specimens in better condition becomes available.") (Navás 1918, p.142).

Later, Navás (1925) obtained what he considered better specimens and described the species more thoroughly including a basic line drawing of the genitalia (FIG. 37, p. 309, reproduced here as Fig. 28). He also included supplementary characters from the dichotomous key in Needham and Murphy (1924) after concluding that the morphologically similar genus *Atalonella*, which Needham and Murphy established for *Atalonella fusca* (Ulmer) from Australia (Ulmer 1919) and the new species *A. ophis* Needham and Murphy from Chile, were in fact the same. Unfortunately, Navás did not formally designate *Atalonella* as a junior synonym of *Nousia*. He also left no record of where the type material he described was deposited.

This congeneric origin, however, was disputed by Traver (Traver 1946) who considered the hind wing venation of the two taxa to be quite different and proposed that *Atalonella* and *Nousia* be left as separate genera until careful study of the type material can be made.

Some time later, extensive collections were made at the type locality of *Nousia delicata* (Los Perales, Marga-Marga, Valparasio Province, Chile) by George F. Edmunds Jr. (Peters and Edmunds 1972). All the nymphs (and subsequent reared adult material) found similar to *N. delicata* were those identified as *Atalonella*. However, the original genitalia drawing of *N. delicata* (Navás 1925, Fig. 28) was so indistinct they could not be directly compared. (Peters and Edmunds 1972) concluded the two genera should not be synonymised until the type of *Nousia delicata* was located.

Happily, the missing type species of *N. delicata* was located not long after at Museo Municipal de Ciencias Naturales, Barcelona by Dr. J. Alba-Tercedor of the University of Granada in Spain (Pescador and Peters 1985). Upon examination it was established that *N. delicata* and *A. ophis* were identical and subsequently Pescador and Peters (1985) placed *Atalonella* as a junior synonym of *Nousia*. It followed therefore that *A. ophis* became a junior synonym of *N. delicata*. The species *A. ophis* still remains the type species of *Atalonella* and the species *N.delicata* the type species of *Nousia*. The South American species of the genus were comprehensively revised by Pescador and Peters (1985) and at present there are six described species.

By contrast, the taxonomy of *Nousia* in Australia is very poorly known. The *Nousia* of Australia are considered very speciose with perhaps sixteen species including seven endemic species from the island of Tasmania (Dean 1999). Yet only three are formally described in the literature at present. Of these three species *N. darkara* (Harker) and *N. delicatula* (Tillyard) are known only from Tasmania and are little known and poorly described. *N. fuscula* (Tillyard) is somewhat better known and is found on the mainland as well as Tasmania (Peters and Campbell 1991). *N. fuscula* was extensively redescribed in Suter (1986) although it appears no type specimens were re-examined.

Based on the forewing venation, shape of the imago genitalia and mouthparts of the nymph, the Australian *Nousia* was considered to be quite different from those in South America (Campbell and Suter 1988) and a new subgenus, *Nousia (Australonousia)*, was proposed to accommodate them. Subsequently, the South American species were referred to the subgenus *Nousia (Nousia)*.

3.3.2 Descriptions

3.3.2.1 *Nousia (Australonousia)* Campbell and Suter

Nousia (Australonousia) (Campbell and Suter 1988)

Type species. *Atalophlebia fuscula* (Tillyard)

Species included. *Nousia (Australonousia) fusca* (Ulmer) comb. nov., *Nousia (Australonousia) darkara* (Harker) *Incertae sedis*, *Nousia (Australonousia) fuscula* (Tillyard), *Nousia (Australonousia) nigeli* sp. nov., *Nousia (Australonousia)* sp. "AV5", *Nousia (Australonousia)* sp. "AV7", *Nousia (Australonousia)* sp. "AV8".

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Distribution. New South Wales, Queensland, South Australia, Tasmania, Victoria (Fig. 29).

Diagnosis. Male imago. Dimensions: body length 5.8-9.0; forewing length 5.9-9.6; hindwing length 1.01-1.80; forewing hindwing ratio 4.85-6.96. General body colour variable, ranging from golden to tan to dark brown to black, with darker markings. Head: brown to black. Antennae: pedicel, scape light to dark brown, flagellum golden to light or tan brown. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, often contiguous, ES=0.00-0.16; upper lobe colour variable (pink, red, brown-grey, orange, orange-brown, dark brown), lower lobes grey, black or grey-black. Thorax: pronotum colour variable (golden, orange, brown, black), sometimes with darker markings; mesonotum shiny brown to black. Legs: colour variable (golden, tan, brown, black); femora usually darker; banding present or absent; forelegs with seven segments, total foreleg length 5.76-8.90, tibia approximately 1.3-1.5 times length of femur, the five segmented tarsus approximately 1.4-1.6 times length of femur; tarsal claws of a pair similar, each apically hooked with an opposing hook. Wings. Forewing: membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins dark brown, anal veins yellow; costal and subcostal crossveins usually absent (or very faint), costal space with 0-7 crossveins proximally, 7-14 distally (sometimes anastomosed), subcostal space with 0-7 crossveins proximally, 6-14 distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein, ICu_2 joins ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1. Hindwing: mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately three-quarters to four-fifths wing length; no crossveins in proximal halves of costal space, 2-6 in distal space, 3-6 throughout subcostal space. Abdomen: colour and pattern variable ranging from golden to orange brown with dark brown markings to dark brown and black with golden markings, commonly forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly. Genitalia: forceps three segmented, first segment usually darker, progressively lighter apically; middle and terminal segment about the same length. Penes: fused in basal two-thirds, two lobes distinct, separate apically; often with subapical lobes protruding laterally towards midline, each subapical lobe with a small blunt triangular tooth, often partly sheathed by outer covering and generally visible under transmitted light only. Caudal filaments: three; golden to brown; terminal filament longer than cerci.
Female imago. Dimensions: body length 6.1-10.1; forewing length 5.8-10.4; hindwing length 0.99-1.95; forewing hindwing ratio 4.94-7.12. General patterning and colouring

similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: shorter than male; total foreleg length 3.70-6.43; forelegs with six segments, tibia approximately 1.3-1.4 times the length of the femur, the four segmented tarsus approximately 0.6-0.8 times longer than the femur. Wings. Forewing: colour and venation similar to males except crossveins always in proximal halves of wing and generally more crossveins on average than male; costal space with 3-9 crossveins proximally, 10-18 distally (sometimes anastomosed), subcostal space with 3-8 crossveins proximally, 8-16 distally. Hindwing: no crossveins in proximal halves of costal space, 3-6 in distal space and throughout subcostal space. Abdomen: sternum seven with small to large genital extension; sternum nine moderately or deeply cleft. **Egg.** Ovoid; polar cap absent; chorion with large circular shaped protuberances, sometimes interspersed with smaller ones; pattern variable. **Male and female subimago.** General colour and markings dull greyish black, similar to imago. Wings opaque, uniformly grey-brown. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** Body lengths: ♂ 5.8-9.8, ♀ 6.0-11.4. General body colour variable, ranging from golden to brown to black with light and / or dark markings. Head: prognathous; golden brown to dark brown, sometimes with darker markings; width 1.25-2.20. Ocelli: three; black with white to grey inserts; laterals larger than medial. Antennae: pedicel and scape brown, flagellum golden to light or tan brown; one and a half to more than twice length of head. Eyes: upper lobes of male tan to red-brown, lower lobes black; eyes of female grey-black to black. Mouthparts. Labrum and clypeus: lateral margins of clypeus parallel, slightly or moderately diverging towards anterior; lateral margins of labrum subequal, very slightly or slightly wider than clypeus, rounded to angular; anterior margin with straight, slight or distinct antero-median emargination; labrum length 0.25-0.54, labrum width 0.54-1.03, labrum width length ratio 1.68-2.72; four to five flat elongate, rounded or triangular denticles present on anterior margin extending 0.07-0.38 the width of labrum, denticle width as proportion of labrum width 0.10-0.51; frontal setae arranged as a narrow or broad band, secondary hair fringe usually clearly separated from front row; in one case abutting. Mandibles: outer margins slightly curved, sparse long setae at midpoint on outer lateral margins, shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible: two incisors, each with three apical teeth; outer incisor sometimes inconspicuously serrated on inner lateral margin; prostheca robust, moderately or distinctively serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible: sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, sometimes inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth, sometimes inconspicuously serrated on outer lateral margin; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae: galea-lacinae

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generally as wide as long, width length ratio 0.84-1.28; subapical row of 11-23 pectinate setae; with or without subapical process extending towards inner lateral margin; palpi three segmented, first segment length 0.22-0.30, segment two 0.71-0.97 times the length of first segment, terminal segment 0.51-0.71 times the length of first segment, terminal segment usually with single spine apically. Hypopharynx: well developed lateral processes; anterior margin of lingua moderately to deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded to slightly angular lateral margins, sometimes with slight indentations. Labium: glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment length 0.29-0.38, segment two 0.71-0.94 times the length of first segment, terminal segment 0.53-0.78 times the length of first segment, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; submentum with spines on lateral margins. Thorax: colour ranges from golden to orange to tan and dark brown with light and / or dark markings; pronotum width 1.22-2.43, equal or one-fifth wider than head, head pronotum width ratio 0.88-1.25. Legs: golden to tan and dark brown, banding present or absent; total foreleg length 2.28-4.98; fore femora length 0.95-2.20, fore femora width 0.28-0.73; fore femora length width ratio 2.19-4.11; fore tarsi with 3-15 ventral spines; tarsal claws with 9-18 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; foreleg length ratios, tibiae 0.77-0.89 times length of femur, tarsi 0.36-0.55 times length of femur; midleg length ratios, tibiae 0.76-0.88 times length of femur, tarsi 0.31-0.40 times length of femur; hindleg length ratios, tibiae 0.81-0.92 times length of femur, tarsi 0.28-0.40 times length of femur. Abdomen: colour and pattern variable ranging from golden to orange brown with dark brown markings to light and dark brown to black with golden markings commonly forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly; posterolateral spines present, progressively larger posteriorly. Gills: membrane clear to opaque, colour variable (pink, yellow, brownish); present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; slender, tapering to a thin point apically, main and lateral tracheae strongly to weakly developed. Caudal filaments: three; golden; terminal filament longer than cerci.

Remarks. The subgenus *Nousia (Australonousia)* can be distinguished from all other genera in the Leptophlebiidae family by the following combination of characters. In the imago: (i) body length ♂ 5.8-9.0; ♀6.1-10.1; (ii) male upper eye size large, often contiguous; (iii) male and female forewing 4.9-7 times longer than hindwing; (iv) male forewing crossveins faint, or more usually absent, from proximal halves of wing; (v) MA forked at half to just over half the distance from wing base to margin; MP_2 connected to MP_1 and CuA, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein; ICu_2

joins lCu₁; lCu₁ and lCu₂ parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A₁; (vi) hindwing costa joins subcosta at approximately three-quarters to four-fifths wing length; (vii) tarsal claws of a pair similar, each apically hooked with an opposing hook; (viii) penes fused in basal two-thirds, two lobes distinct; often with subapical lobes protruding laterally towards midline, each subapical lobe with a small blunt triangular tooth, often partly sheathed by outer covering and generally visible under transmitted light only; (ix) female eyes separated on meson of head by a distance about four times maximum width of eye; (x) female sternum seven with small genital extension; (xi) female sternum nine moderately or deeply cleft. In the nymph: (i) body length ♂ 5.8-9.8, ♀ 6.0-11.4; (ii) antennal length one and a half to more than twice length of head; (iii) lateral margins of clypeus straight, slightly or moderately diverging towards anterior; (iv) labrum slightly less than to twice or three times as wide as long; labrum subequal, very slightly to slightly wider than clypeus; lateral margins rounded to slightly angular; antero-median emargination straight, slight or distinct bearing four to five elongate, rounded or triangular denticles; denticles extend one-tenth to half the width of labrum; (v) mandibles with outer margins slightly curved; incisors with or without serrations on lateral margins; (vi) maxillae with galea lacinae generally about as wide or slightly wider than length; subapical row of 11-23 pectinate setae; terminal palp elongate, usually with single spine apically; (vii) hypopharynx moderately to deeply cleft, superlingua with rounded to slightly angular lateral margins; (viii) labium glossae not turned under ventrally, terminal segment elongate with row of triangular spines almost circling apex; submentum with lateral spines; (ix) pronotum about as wide as head; (x) legs with fore femora 2-4 times longer than wide; fore tarsi with 3-15 ventral spines; tarsal claws with 9-18 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; (xi) abdomen with posterolateral spines, progressively larger posteriorly; (xii) gills with margins entire, double, upper and lower lamellae equally developed; slender, tapering to a thin point apically; main and lateral tracheae strongly to weakly developed.

3.3.2.2   *Nousia (Australonousia) fusca* (Ulmer) comb. nov.

Thraulus dentatus Ulmer (Ulmer 1916) [partim]

Atalophlebia fusca Ulmer (Ulmer 1919)

Nousia fusca (Ulmer) (Needham and Murphy 1924) [mistakenly reported from Chile]

Atalophlebia fusca (Ulmer) (Lestage 1931)

Atalonella fusca (Ulmer) (Harker 1954)

Atalophlebia fusca (Ulmer) (Demoulin 1955b)

Koorrnonga fusca (Ulmer) (Campbell and Suter 1988)

Nousia (Australonousia) delicatula (Tillyard) (Campbell and Suter 1988)

Koorrnonga brunnea (Tillyard) (Campbell and Suter 1988)

Nousia sp. "AV1" (Dean 1999)

Nousia (Australonousia) fusca (Ulmer) comb. nov.

Types. Lectotype (here designated). *Atalophlebia fusca* Ulmer. Cedar Creek, Queensland, 10040000, III 1910-1913, 1 ♂ imagos, in alcohol, coll. Mjöberg Expedition. Labels: a) "*Atalophlebia fusca* Ulm. (Ulm. 1920) Typen", b) "=*Thraulus dentatus*", c) "Cedar Creek, März." **Paralectotypes** (here designated). (1) *Atalophlebia fusca* Ulmer. 1 ♂ subimago, in vial with lectotype, same collection data and labels. (2) *Thraulus dentatus* Ulmer / *Atalophlebia fusca* Ulmer, Artherton, Queensland,10010000, I 1910-1913, 1 ♂ imago, in alcohol, coll. Mjöberg Expedition. Labels: a) "*Thraulus dentatus* Ulm. (Type)", b) "*Atalophlebia fusca* Ulm. (Ulmer 1920) Co-Typen", c) "Atherton, Jan", (3) "*Thraulus dentatus* Ulmer / *Atalophlebia fusca* Ulmer. 1 ♂ subimago, in vial with paralectotype 2, same collection data." Held at the SMNH.

Nousia (Australonousia) delicatula (Tillyard)

Atalophlebia delicatula Tillyard (Tillyard 1936)

Atalonella delicatula (Tillyard) (Harker 1954)

Nousia (Australonousia) delicatula (Tillyard) (Campbell 1988)

Nousia (Australonousia) delicatula (Tillyard) (Campbell and Suter 1988)

Nousia (Australonousia) fusca (Ulmer) comb. nov.

Types. Holotype. *Atalophlebia delicatula* (Tillyard), North Esk River, 33012100, 21 I 1933, Perth, Tasmania. ♂ imago [examined]. Labels: a) "*Atalophlebia delicatula* Till. Holotype ♂ R.J.T,. N. Esk, Tas. 21.1.33", b) "Holotype". **Paratypes.** *Atalophlebia delicatula* (Tillyard), 2 ♂ imagos, ♀ imago (marked allotype), ♂ and ♀ subimagos, same locality data, 21 I 1933, R.J. Tillyard; 6 XII 1954, B. McMillan. Held at the NHM [not seen].

Koormonga brunnea (Tillyard)

Atalophlebia brunnea Tillyard (Tillyard 1936)

Atalonella brunnea (Tillyard) (Harker 1954)

Nousia brunnea (Tillyard) (Campbell 1988)

Koormonga brunnea (Tillyard) (Campbell and Suter 1988)

Nousia (Australonousia) fusca (Ulmer) comb. nov.

Types. Holotype. *Atalophlebia brunnea* (Tillyard). South Esk River, Clarendon, Tasmania, 33030900, 9 III 1933, ♂ imago, coll by E. Scott, R.J. Tillyard collection. **Paratype.** Same location and collection data, ♂ imago, genitalia

dissected and mounted on slide. Held at the NHM [examined, except for slide material]. Labels: a) "*Atalophlebia brunnea* Till. Holotype and Paratype Male Imagoes (Hol. in tube), Clarendon, Tas., 9.III.1933, Eric Scott.",b) "Ex. coll. R.J. Tillyard".

Distribution. New South Wales, Queensland, Tasmania, Victoria (Fig. 30).

Diagnosis. A redescription was considered desirable due to the accumulation of a large number of new specimens both as a result of collecting during this project and from examination of MRHI material. This has enabled the little known female imago and subimago stages and the previously unknown nymphs to be fully described. The species *Koormonga brunnea* (Tillyard) and *Nousia (Australonousia) delicatula* (Tillyard) and the morphospecies *Nousia* sp. "AV1" have all been synonymised with *Nousia (Australonousia) fusca* which has priority (see below for discussion).

Male imago. (Fig. 31). Dimensions: body length 5.8-9.0 (7.3±0.68, *58*); forewing length 6.0-8.6 (7.2±0.59, *59*); hindwing length 1.01-1.71 (1.29±0.13, *56*); forewing hindwing ratio 4.85-6.80 (5.61±0.42, *56*). General body colour very variable, ranging from tan brown to dark brown to black. Head: brown to black. Antennae: pedicel, scape and flagellum tan to dark brown. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, sometimes contiguous, ES=0.00-0.16 (0.08±0.07, *15*); upper lobes pink to red to tan brown, lower lobes grey to black. Thorax: pronotum brown to black; mesonotum shiny brown to black. Legs: golden through to tan, medium or dark brown, femora with darker apices, no apparent banding, forelegs with seven segments, total foreleg length 5.76-8.90 (7.28±0.94, *37*); leg length ratios 1.00: 1.35: 0.06: 0.53: 0.50: 0.37: 0.16 (1.8±0.19, *37*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 32). Wings. Forewing (Fig. 33): membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins dark brown, anal veins yellow; costal and subcostal crossveins absent, or if present very faint, in proximal halves of wing, costal space with 0-5 (*61*), faint crossveins proximally, 7-14 (*61*) distally (sometimes anastomosed), subcostal space with 0-5 (*61*) faint crossveins proximally, 6-13 (*61*) distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1. ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1. Hindwing (Fig. 34): mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately three-quarters wing length; no crossveins in proximal halves of costal space, 2-5 (*56*) in

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distal space, 3-5 (56) throughout subcostal space. Abdomen: tan to dark brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly (Fig. 35); colour and pattern highly variable. Genitalia (Figs. 36-49): forceps three segmented (Fig. 36, 38, 39, 41); tapering strongly, first segment dark brown, progressively lighter apically; terminal segment rounded, about the same length as middle segment. Penes brown; fused in basal two-thirds, two lobes distinct, dorsal view with two subapical lobes protruding laterally towards midline; each subapical lobe with a small blunt triangular tooth, partly sheathed by outer covering, generally visible under transmitted light only; shape variable between populations; dorsal view (Figs. 36, 39, 40, 46, 48), ventral view (Figs. 37, 41, 42, 44, 47, 49) and lateral view (Figs. 38, 45). Caudal filaments: three; golden to brown; terminal filament and cerci length unknown. **Female imago.** (Fig. 50). Dimensions: body length 6.1-9.0 (7.6±0.74, 62); forewing length 5.8-9.6 (7.7±0.73, 63); hindwing length 0.99-1.72 (1.26±0.14, 62); forewing hindwing ratio 4.94-7.07 (6.14±0.44, 60). General patterning and colouring similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male; forelegs with six segments, total foreleg length 3.70-6.28 (4.80±0.66, 40); leg length ratios 1.00: 1.30: 0.21: 0.19: 0.16: 0.15 (1.60±0.19, 40). Wings. Forewing (Fig. 51): colour and venation similar to males except crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 3-8 (67) crossveins proximally, 10-16 (67) distally (sometimes anastomosed), subcostal space with 3-8 (67) crossveins proximally, 8-14 (67) distally. Hindwing (Fig. 52): no crossveins in proximal halves of costal space, 3-5 (64) in distal space, 3-6 (64) crossveins throughout subcostal space. Abdomen: sternum seven with small genital extension (Fig. 53); segment nine deeply cleft (Figs. 53 - 55). **Egg.** Ovoid; polar cap absent; chorion with large evenly spaced circular shaped protuberances interspersed with smaller ones; pattern variable (Figs. 56-67). **Male and female subimago.** General colour and markings dull greyish black, similar to imago. Wings opaque, uniformly grey-brown. Male (Fig. 66) forelegs of male not elongated. Genitalia not fully developed (Figs. 69, 70). **Mature nymph.** (Fig. 71, 72). Body lengths: ♂ 5.8-9.6 (7.5±0.87, 63), ♀ 6.0-10.0 (7.9±0.87, 81). General colour golden to tan brown with light and dark markings. Head: prognathous; tan brown; width 1.25-1.82 (1.53±0.11, 83). Ocelli: three; black with white to grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden to tan brown; more than twice length of head. Eyes: upper lobes of male reddish-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus, morphology variable (Figs. 73, 74); lateral margins of clypeus slightly diverging towards anterior; lateral margins of labrum subequal to very slightly wider than clypeus, rounded; anterior margin with straight anterior margin (Fig. 73) or slight antero-median emargination (Fig. 74); labrum length 0.30-0.54 (0.37±0.04, 101), labrum width 0.58-1.03

(0.74±0.08, *101*), labrum width length ratio 1.71-2.23 (1.99±0.12, *101*); five flat elongate denticles present on anterior margin extending 0.14-0.32 (0.20±0.03, *101*) across labrum, denticle width as proportion of labrum width 0.20-0.37 (0.27±0.03, *101*); frontal setae arranged as a relatively narrow band, secondary hair fringe clearly separated from narrow band. Mandibles: outer margins slightly curved, sparse long setae at midpoint on outer lateral margins, shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 75): two incisors, each with three apical teeth; outer incisor inconspicuously serrated on inner lateral margin; prostheca robust, moderately serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 76): sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth, inconspicuously serrated on outer lateral margin; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 77): galea-lacinae as wide as long, width length ratio 0.90-1.11 (0.99±0.06, *25*); subapical row of 11-18 *(25)* pectinate setae; palpi three segmented, terminal palp with single spine apically although sometimes not apparent (Fig. 78); palp length ratios 1:00: 0.77: 0.71 (0.24±0.03, *50*). Hypopharynx (Fig. 79): well developed lateral processes; anterior margin of lingua deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 80): glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface (Fig. 81); palp length ratios 1.00: 0.77: 0.63 (0.36±0.04, *50*); submentum with spines on lateral margins. Thorax: golden to tan brown with darker markings; pronotum width 1.22-1.91 (1.51±016, *83*), approximately equal to width of head (see above), head pronotum width ratio 0.88-1.15 (1.02±0.06, *83*). Legs (Fig. 82): golden to tan brown, femora apices usually darker, no apparent banding, fore femora length 1.05-2.20 (1.42±0.20, *87*), fore femora width 0.28-0.73 (0.50±0.07, *87*), fore femora length width ratio 2.51-4.11 (2.86±0.20, *87*); fore tibiae with numerous short ventral spines; fore tarsi with 5-10 (*25*) ventral spines; tarsal claws with 10-16 (*50*) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated (Fig. 83); total foreleg length 2.45-4.98 (3.31±0.49, *87*); leg length ratios, foreleg 1.00: 0.85: 0.44 (1 43±0.21, *87*) mid leg 1.00: 0.86: 0.35 (1.51±0.26, *60*), hind leg 1.00: 0.91: 0.31 (1.74±0.28, *60*). Abdomen: tan to dark brown with golden markings on each segment forming a broken stripe midline, generally with two golden coloured maculae flanking each midline marking anteriorly but pattern highly variable; posterolateral spines present, progressively larger posteriorly. Gills (Figs. 84, 85): membrane clear to pink; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill slender,

tapered to a thin point apically; main tracheal branch apparent; lateral tracheae present, usually strongly developed (Fig. 84), but sometimes poorly developed (Fig. 85). Caudal filaments: three; golden; terminal filament longer than cerci.

Remarks.

Nousia (Australonousia) fusca. *Atalophlebia fusca* was established by Ulmer (1919) as a new species although it was actually partly described by him in an earlier paper as *Thraulus dentatus* (Ulmer 1916). In the later revision, he considered that the light and dark coloured specimens of this genus were actually two different species and that, in fact, they both belonged to the genus *Atalophlebia*. The light examples he renamed *A. lucida* and the dark examples *A. fusca* as they required a new species name because *dentatus* was pre-occupied. Following this Needham and Murphy (1924) established the genus *Atalonella* to accommodate two species: *A. ophis* from Chile and *A. fusca* which they mistakenly believed to be from South America. Lestage (1931) then referred the species back to *Atalophlebia* on the understanding that all *Atalonella* species only came from South America. Probably without consulting the French (Lestage) literature Harker (1954) assumed the Needham and Murphy stance that the species belonged to *Atalonella*, and Demoulin (1955b) agreed. However, a complication ensued when Campbell (1988) apparently referred the species back to *Atalophlebia*. I consider this is because he misunderstood Demoulin (1955b), the last author to refer to the species, to have attributed the species to *Atalophlebia* whereas, in fact, Demoulin accepted Harker's view. Subsequently, a new combination of the species occurred as a result of the establishment of the new genus *Koorrnonga* (Campbell and Suter 1988) although no explanation was proffered. The current view of the species placement is tentative. Dean (1999) considers that it should be removed from *Koorrnonga* and referred back to *Nousia* on the basis of the genitalia and hindwing morphology.

Assessment of species status was not easily checked. A complication arose as a result of no specimen being nominated as the type species. In response to a request for the type specimens of *fusca* I received four vials from the SMNH, which I have named Series, each containing more than one specimen each:

Series 1. *Thraulus dentatus* Ulmer / *Atalophlebia fusca* Ulmer. Atherton, Queensland, 10010000, I 1910-1913, 1 ♂ imago, 1 ♂ subimago, in alcohol, coll. Mjöberg Expedition. Labels: a) "*Thraulus dentatus* Ulm. (Type)", b) "*Atalophlebia fusca* Ulm. (Ulmer 1920) Co-Typen", c) "Atherton, Jan".

Series 2. *Atalophlebia fusca* Ulmer. Cedar Creek, Queensland,10030001, III, 1910-1913, 1 ♂ imago, 1 ♂ subimago, in alcohol, coll. Mjöberg Expedition. Labels: a) "*Atalophlebia fusca* Ulm. (Ulm. 1920) Typen", b) "=*Thraulus dentatus*", c) "Cedar Creek, März".

Series 3. *Thraulus dentatus* Ulmer / *Atalophlebia fusca* Ulmer, Christmas Creek, Queensland,10000000, 1910-1913, 1 ♂ imago, 1 ♀ imago, 2 ♂ subimagos, 2 ♀F subimagos, in alcohol, coll. Mjöberg Expedition. Labels: a) "*Thraulus dentatus* Ulm. (Typen)", b) "*Atalophlebia fusca* Ulmer (Ulm. 1920) Typen", c) "Christmas Creek".

Series 4. *Thraulus dentatus* Ulmer / *Atalophlebia fusca* Ulmer, Malanda, Queensland,10030002, III 1910-1913, 1 ♀ imago, pinned, coll. Mjöberg Expedition. Labels: a) "*Thraulus dentatus* Ulm. (Type)", b) "*Atalophlebia fusca* Ulmer (1920)", c) "Malanda", d) "Queensl. Mjöberg".

In the situation of a collective type series all specimens constitute the name-bearing type and have equal status being referred to as syntypes (Article 72.1.1, ICZN 1999). Unfortunately, however, the *fusca* syntypes do not all represent the same species. The pinned female imago constituting Series 4, for example, definitely represents a species of *Koormonga* by the shape of its angular forewing and deeply cleft sternum nine. The specimens contained with Series 2 are clearly *Nousia*-like with the separated lobes of the male genitalia and the rounded forewing. Indeed, the male genitalia (Fig. 86) clearly represents the morphospecies *Nousia* sp. "AV1". Similarly, although the male imago of Series 1 had the genitalia removed, the characters of both the imago and subimago are sufficiently similar to assign it to the same morphological status as Series 2. Lastly, the six adults constituting Series 3 are morphologically similar to those of Series 1 and 2 in respect of the wing venation and sternum nine of the female but the genitalia of the adult male has a spine protruding apically from the two penes lobes.

Under the rules of the International Code of Zoological Nomenclature (Article 74.1, ICZN 1999) "a lectotype may be designated from the available syntypes to become the unique bearer of the name of a nominal species-group taxon". I propose that the male imago from Series 2 (Fig. 86) becomes the lectotype primarily as the male genitalia is well preserved and intact but also because Ulmer (1919) himself declares of the two male imagos in this series "diese males betrache ich als typisch!" ("these males I consider typical!", p.22). As a consequence, the male subimago from the Series 2 becomes a paralectotype (Article 74.1.3) as do the specimens making up the Series 1. The remaining Series 3 and 4 are removed from the type series.

Nousia (Australonousia) delicatula. Tillyard (1936) first described this species from specimens collected in Northern Tasmania. Later, Harker regarded this species as a new combination of *Atalonella* after defining the differences between *Atalophlebia* and

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Atalonella (Harker 1954). Scholes (1961) collected some more specimens from the same area and the same rivers as Tillyard and his description proved to be very similar. No explanation was given as to why the species is placed in the genus *Nousia* by either Campbell (1988) or Campbell and Suter (1988) although one can assume this was based on the size and shape of the male genitalia with diverging lobes. I agree with their assessment here. The type genitalia of the pinned imago were examined and found to be somewhat distorted, perhaps through the drying out process. However, I was fortunate to be able to examine some of Scholes' specimens collected from Northern Tasmania in the 1960's, and referred to in his subsequent paper (Scholes 1961). Luckily, the male imago genitalia, which was stored in alcohol, was in good condition providing a better representation of the true shape (Fig. 87). Based on the similarity of the male imago genitalia I have synonymized the species *Nousia (Australonousia) fusca* and *Nousia (Australonousia) delicatula*. As *N. fusca* has priority *N. delicatula* becomes the junior synonym.

Koormonga brunnea. *Atalophlebia brunnea* was originally described as such by Tillyard (1936) but was subsequently transferred to *Atalonella* by Harker (1950a) probably on the basis of fore and hind wing venation. It was referred to as *Nousia* by Campbell (1988) in his catalogue and subsequently transferred to *Koormonga* (Campbell and Suter 1988) on the basis of two characters: (1) the absence of crossveins in the proximal halves of the costal and subcostal spaces in the male forewing and (2) the shape of the penes. I disagree with this assessment. Firstly, other species of *Nousia* have missing or faint veins from the proximal costal and subcostal spaces so this is not necessarily a generic characteristic. Secondly, the genitalia shape of the type (Fig. 88) conforms more strongly with that of *Nousia* with the presence of two diverging lobes rather than the closely associated lobes of *Koormonga*. One more characteristic can be used to cement the position of *K. brunnea* within *Nousia (Australonousia)*. The shape of the hindwing is quite rounded and does not have the characteristic angularity of the *Koormonga* hindwing. I believe, therefore, that the species more correctly belongs to *Nousia (Australonousia)* and formally transfer it here. It is also clear that the genitalia shape is remarkably similar to that of the type species of both *fusca* and *delicatula*. Based on this and other imago characteristics I consider them to be the same species and synonymise them here. As *N. fusca* has priority *K. brunnea* becomes the junior synonym.

General. The synonymy of the three species *N. fusca, N. delicatula* and *K. brunnea* is based largely on the morphology of the male genitalia which were remarkably similar on examination as mentioned above.

Confusion arises, I feel, from the various drawings of the genitalia in the literature which do not appear to conform to the above individuals. Ulmer's drawing of *Atalophlebia fusca* is a simple line drawing with little detail (Ulmer 1919, FIG. 14, p.21, reproduced here as Fig. 89). He describes the penes as ('..breit, tief eingeschnitten (FIG. 14); jeder Seitenabschnitt ist vor dem Ende as der Ventralfläche ausgehöhlt und gt in dieser Höhlung einen das Seitenstück überragenden keulenförmigen Anhang, der an der Anßenkante vor dem rundlichen Apex eingekerbt ist; .." (p.22). This translates as "..wide, deeply indented (FIG. 14); each side section is hollowed out before the end of the ventral surface and bears in this hollow a companion-piece overhanging club-shaped attachment, that is notched on the outer edge before the rounded apex;.."

One could argue that this is not dissimilar to Tillyard's description of the penes of *Atalophlebia delicatula:* "..lobes separated by a deep cleft, each lobe stout, irregularly truncated, with three terminal rounded embossments and a larger rounded process projecting slightly inwards not far from apex. " (Tillyard 1936, p.48) although the three terminal embossments are absent from Ulmer's drawing. Tillyard's simple line drawing of the penes (FIG. 16, p. 34, reproduced here as Fig. 90) clearly depicts the features described by Ulmer (1919).

As for *Koormonga brunnea,* the description of the male genitalia is less revealing. Tillyard (1936) describes the penes of *Atalophlebia brunnea* in the following manner: "..slightly diverging lobes separated by a deep semi-circular embayment; each lobe irregularly truncated. " Campbell and Suter (1988) believed that the lobes mahy have been artificially separated upon being mounted on the slide and this, coupled with Tillyard's description of "slightly diverging lobes" (Tillyard 1936, p. 44), led them to conclude the species belonged to *Koormonga.* However, it is clear from the holotype genitalia (Fig. 88) that the lobes are separated in their natural state. Tillyard's drawing of the genitalia (Tillyard 1936, FIG. 14, p. 34, reproduced here as Fig. 91) does not do the shape justice. I believe he has probably drawn the genitalia in the ventral view so it is not possible to see the apical lobes, and makes the drawing look dissimilar to that of *A. fusca* and *A. delicatula.*

In reference to *Nousia* sp. "AV1" a large number of male imago genitalia, which were collected over the course of this study, were examined by slide mounting and SEM. Although there appear to be some variations in length and width of the penes (see species redescription) the overall shape is similar to *N. fusca, N. delicatula* and *K. brunnea.* Further, as far as I can tell, small internal triangular spines are present on the inner margin of each penis lobe. They appear to be partly covered by a sheath and are not visible unless the genitalia is mounted and viewed under transmitted light.

Synonymy was also established on the basis of comparison of the characteristics of the types and the various literature descriptions. These were compared to the newly described *Nousia (Australonousia) fusca* (above) which is largely comprised of specimens formerly known as *Nousia* sp. "AV1". These are compiled in Table 4. Unfortunately only the imago and subimago stages could be compared as there are no nymphal type specimens or literature descriptions.

Table 4. Similarities between the literature descriptions and type measurements of the imago and subimago stages of the species *Nousia (Australonousia) fusca*, *Nousia (Australonousia) delicatula*, *Koorrnonga brunnea*, and *Nousia* sp. "AV1".

	N. (A) fusca	*N. (A) delicatula*	*K. brunnea*	*Nousia* sp. "AV1"
Male Imago				
eye size	contiguous – lectotype, paralectotype	large (Tillyard 1936, Scholes 1961) almost contiguous – holotype	almost contiguous – holotype, paratype	large, almost contiguous
forewing overall colour	pterostigmal area slightly opaque – lectotype	hyaline (Tillyard 1936) glassy clear (Scholes 1961)	hyaline, pterostigmal area slightly darker (Tillyard 1936) glassy clear (Scholes 1961) pterostigmal area slightly opaque – holotype, paratype	membrane hyaline, pterostigmal region slightly opaque
forewing vein colour	wing veins dark brown (Ulmer 1916, Ulmer 1919)	dark brown to blackish venation, anal veins pale (Tillyard 1936) dark brown to blackish venation (Scholes 1961)	with semi –transparent brownish venation, anal veins faint (Tillyard 1936) semi-transparent brownish venation (Scholes 1961)	longitudinal and crossveins brown, anal veins yellow
costal crossveins – distal	10 (2 faint) (Ulmer 1919) 10 (Ulmer 1919) 10 – lectotype 8 – paralectotype	11 (Tillyard 1936) 9 – holotype	8 (Tillyard 1936) 9 – holotype 10- paratype	7-14
subcostal crossveins – distal	7 (Ulmer 1919) 9 – lectotype, paralectotype	7 (Tillyard 1936) 8 – holotype	8 – holotype 9 – paratype	6-13
MA fork	over half (Ulmer 1919) over half – lectotype, paralectotype	slightly more than half (Tillyard 1936) over half – holotype	slightly more than half (Tillyard 1936) around half – holotype	half to just over half
MP$_2$ connected to MP$_1$ and CuA	yes - (Ulmer 1919), lectotype, paralectotype	yes (Tillyard 1936), holotype	yes (Tillyard 1936, holotype, paratype	yes

Table 4 cont'd.

	N. (A) fusca	*N. (A) delicatula*	*K. brunnea*	*Nousia* sp. "AV1"
CuA-CuP crossvein	yes (Ulmer 1919), lectotype, paralectotype	yes (Tillyard 1936), holotype	yes (Tillyard 1936), holotype, paratype	yes
ICu$_1$and ICu$_2$	parallel (Ulmer 1919), lectotype, paralectotype	parallel (Tillyard 1936), holotype	parallel (Tillyard 1936), holotype, paratype	parallel
ICu$_1$ joins CuA	yes (Ulmer 1919), lectotype, paralectotype	yes – (Tillyard 1936)	yes (Tillyard 1936), holotype, paratype	yes
ICu$_1$ linked to CuA-CuP crossvein	no (Ulmer 1919), lectotype, paralectotype	no (Tillyard 1936), holotype	no (Tillyard 1936, holotype, paratype	no
ICu$_2$ recurved to join ICu$_1$	yes (Ulmer 1919), lectotype, paralectotype	yes (Tillyard 1936), holotype	yes (Tillyard 1936)	yes
CuP linked to A$_1$	no (Ulmer 1919) lectotype, paralectotype	yes (Tillyard 1936), holotype	no (Tillyard 1936), holotype, paratype	yes
hindwing – length at which costa joins subcosta		about four-fifths (Tillyard 1936)	three–fifths (Tillyard 1936)	two-thirds
costal crossveins	4 (Ulmer 1919) 2 – lectotype, paralectotype	2 (Tillyard 1936) 4 – holotype	3 (Tillyard 1936) 3 – holotype	2-5
subcostal crossveins	3-5, sometimes faint (Ulmer 1919) 3 – lectotype, paralectotype	3 (Tillyard 1936) 5 – holotype	4 (Tillyard 1936), holotype	3-5
Forceps		3 segmented (Tillyard 1936)	3 segmented (Tillyard 1936)	3 segmented
Female Imago				
head colour	dark chestnut brown (Ulmer 1919)			brown to black
thorax colour	dark chestnut brown (Ulmer 1919)			pronotum brown to black, mesonotum shiny brown to black

Table 4 cont'd.

	N. (A) fusca	N. (A) delicatula	K. brunnea	Nousia sp. "AV1"
abdomen	reddish brown to brown black with darker markings (Ulmer 1919)			same as male imago
body length		larger than male (Tillyard 1936, Scholes 1961)		length 6.1-9.0 (7.6±0.74, 62), larger than male
forewing general colour	shiny and iridescent, colourless or weakly grey (Ulmer 1919)			membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins brown, anal veins yellow
forewing main colour	veins are pitch black against a white background, under transmitted light they appear dark brown (Ulmer 1919)			longitudinal and crossveins brown, anal veins yellow
forewing crossveins		more than male (Tillyard 1936)		more than male
costal space crossveins – prox	3 unclear (Ulmer 1919)			3-8
costal space – crossveins –distal	2 unclear, 9 clear (Ulmer 1919)			10-16
sternum nine	very deeply indented, bisected (Ulmer 1919)	apparently strongly projecting, slightly truncate at tip at hollowed out (Tillyard 1936)		deeply cleft
Subimagos				
body colour		dull greyish black (Tillyard 1936, Scholes 1961)		dull greyish black

Table 5. Discrepancies between the literature descriptions and type measurements of the imago and subimago stages of the species *Nousia (Australonousia) fusca*, *Nousia (Australonousia) delicatula*, *Koorrnonga brunnea*, and *Nousia* sp. "AV1".

	N. (A) fusca	*N. (A) delicatula*	*K. brunnea*	*Nousia* sp. "AV1"
Male Imago				
body length	almost 6 (Ulmer 1919) 6.3 – lectotype	5 (Tillyard 1936, Scholes 1961) 5.5 – holotype	6 (Tillyard 1936, Scholes 1961) 6.8 – holotype 6.5 – paratype	5.8-9.0 (7.3±0.68, *58*)
forewing length	6-6.5 (Ulmer 1919) 6.7 – lectotype 6.2 – paralectotype	6 (Tillyard 1936, Scholes 1961) 6.3 – holotype	6 (Tillyard 1936, (Scholes 1961) 6.6 – holotype 6.8 – paratype	6.0-8.6 (7.2±0.59, *59*)
hindwing length	1.0 – lectotype, paralectotype	1.1 (Tillyard 1936) 1.0 (Scholes 1961) 1.2 – holotype	1.1 (Tillyard 1936) 1.2 (Scholes 1961) 1.3 – holotype, paratype	1.01-1.71 (1.29±0.13, *56*)
general body colour		blackish (Tillyard 1936)	brown (Tillyard 1936)	variable, from tan brown to dark brown to black
head colour	grey-brown (Ulmer 1919)	black (Tillyard 1936, Scholes 1961)	dark brown (Tillyard 1936, Scholes 1961)	brown to black
antennae colour		dark brown (Tillyard 1936, Scholes 1961)	pale (Tillyard 1936) paler than head (Scholes 1961)	tan to dark brown
eye colour – upper	reddish-grey (Ulmer 1919) tan-brown – lectotype orange – paralectotype		pinkish brown (Tillyard 1936) paler than head (Scholes 1961)	pink to red to tan brown
eye colour – lower	blackish (Ulmer 1919) grey-black – lectotype, black - paralectotype		dark grey (Tillyard 1936) paler than head (Scholes 1961)	grey to black

Table 5 cont'd.

	N. (A) fusca	N. (A) delicatula	K. brunnea	Nousia sp. "AV1"
thorax colour	deep dark brown on top and dark brown below (Ulmer 1916, Ulmer 1919)	black (Tillyard 1936) bl~k and shiny (Scholes 1961)	dark brown above, darker markings (Tillyard 1936) dark brown to blackish (Scholes 1961)	pronotum brown to black, mesonotum shiny brown to black
leg colour	middle and hind legs light brownish yellow, thigh (femora) apices darker (Ulmer 1919),	dark brown, femora and tibia apices blackish (Tillyard 1936) dark brown with blackish markings (Scholes 1961)	medium brown, apices darker (Tillyard 1936) medium brown with blackish markings (Scholes 1961)	golden to tan, medium or dark brown, femora apices darker.
foreleg length		5 (Tillyard 1936, Scholes 1961)	5 (Tillyard 1936, Scholes 1961)	5.8-8.9 (7.3±0.94, 37)
costal crossveins – proximal	4 faint (Ulmer 1916) 4-5 very unclear (Ulmer 1919) 0 (Ulmer 1919) faint – lectotype 0 – paralectotype	a few pale semi-transparent crossveins, sometimes incomplete (Tillyard 1936) 3 faint – holotype	absent (Tillyard 1936) 0 – holotype, paratype	0-5 faint
subcostal crossveins proximal	0 (Ulmer 1919), lectotype, paralectotype	2 faint (Tillyard 1936) 3 faint – holotype	absent (Tillyard 1936) 0 - holotype, paratype	0-5 faint
bullae	3 Sc, R_2, R_{4+5}– lectotype	2 on Sc and R_2 (Tillyard 1936)	2 on Sc and R_2 from (Tillyard 1936)	3 on Sc, R2, R4+5
abdomen colour	yellow to grey-brown with grey brown stripe, pattern variable (Ulmer 1916) yellow with grey-brown to dark brown markings (Ulmer 1919)	grey-black with a pattern of greyish markings (Tillyard 1936) grey-black with greyish markings on the middle segments (Scholes 1961)	pale to medium to dark brown with darker markings (Tillyard 1936) dark brown tending blackish towards the last segments (Scholes 1961)	tan to dark brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly, pattern highly variable

Table 5 cont'd.

	N. (A) fusca	N. (A) delicatula	K. brunnea	Nousia sp. "AV1"
tail filament length	approx 12 (Ulmer 1919)	subequal, 9mm (Tillyard 1936) subequal, 8-10 mm (Scholes 1961)	equal length, 10-11mm (Tillyard 1936, Scholes 1961)	terminal filament longer than cerci
tail filament colour	whitish with black bands least at the base (Ulmer 1919)	grey, segments ringed apically with black (Tillyard 1936, Scholes 1961)	pale buff, slightly darker at bases (Tillyard 1936) dark brown (Scholes 1961)	golden to brown

There are many similarities between the four species according to Table 4. They are all, for example, reasonably small darkly coloured species. The measurements of body length, fore and hindwing length, leg length, caudal filament length all conform reasonably well. There are some variations but most of the individual measurements for the type specimens and literature descriptions fall within (or just outside) the range of the measurements taken for *Nousia* sp. "AV1" (the newly described *Nousia (Australonousia) fusca)*, which appears to be a highly variable species by all accounts.

Variations between the four "species" refer to colour descriptions such as those for the body, head, antennae, eyes, thorax, leg, abdomen and caudal filaments (Table 5). However, large numbers of *Nousia* sp. "AV1" examined show the species to be highly variable ranging in colour from yellow through to tan, brown, dark brown and black and possibly refers to their temperature of development. I propose that the apparent colour variation is an artefact of the subjectivity of describing colour but that these individuals represent morphological variants of the same species.

One discrepancy which is quite clear in Table 5 is the number of bullae on the forewing. Tillyard (1936) claims there are only two bullae on the forewing of the male imago of *brunnea* and *delicatula* which are located at Sc and Rs. I have examined both types and have found there are definitely three as mentioned in my description.

Tillyard (1936) and Scholes (1961) also suggest that the "tail filaments" of these species are subequal in length. The caudal filaments are missing from all the types and although many of the filaments on the specimens of *Nousia* sp. "AV1" are damaged there were enough specimens to establish that the caudal filaments were in fact slightly longer than the cerci. It is quite possible that the slight difference in length could have been inaccurately recorded as "subequal" in length.

The question of the number of crossveins in the proximal half of the forewing also appears to be an issue. The drawing of the three forewings are misleading taken at face value. The forewing of *Atalophlebia delicatula* (Tillyard 1936, FIG. 23, p. 47, reproduced here as Fig. 92) clearly shows crossveins in the proximal half of the costal and subcostal spaces while the forewing of *Atalophlebia fusca* (Ulmer 1916; FIG. 7b, p.8, labelled *Thraulus dentatus* n. sp., reproduced here as Fig. 93) and *Atalophlebia brunnea* (Tillyard 1936, FIG. 21, p. 43, reproduced here as Fig. 94) do not. This is a very effective character for discrimination at the genus level and apparently incongruous. However, Ulmer (1919) writes of proximal *A. fusca* crossveins in the costal space "...von der Bulla 4 bis 5 sehr undeutliche Queradern" (p. 21) (".. in front of the bulla 4 or 5 very unclear crossveins..") indicating that they are apparent but very faint. Tillyard, too, comments on

the *A. delicatula* crossveins "..at first sight there are apparently no veinlets in the costal or subcostal spaces until the region of the pterostigma, but, under careful lighting, a few pale, semi-transparent veinlets can be made out" (Tillyard, 1936, p. 48). Ulmer (1916) apparently chooses not to draw in the faint *A. fusca* crossveins while Tillyard (1936) draws the *A. delicatula* crossveins in boldly giving the false impression of solid presence whereas, in fact, they are quite faint. Comparison with the newly described *Nousia (Australonousia) fusca* (*Nousia* sp. "AV1") reveals that the crossveins are often absent (as in *A. brunnea*), or if present very faint, from the proximal halves of the male forewing leading to the conclusion that both authors are correct in their assessment.

Apart from *Nousia* sp. "AV1" (Dean 1999) there have been numerous other descriptions of this species (mostly the nymphs) in various voucher collections. It is also variously known as *Nousia* MDFRC "sp. 1", MMBW "sp. 1" (Melbourne Metropolitan Board of Works), MV "sp. 3", *Atalonella* "sp. 1", *Atalonella* "sp. D" and *Nousia* "sp. 1" (MRHI). The number of names probably reflects confusion surrounding the species status of the large number of morphologically variant individuals.

Finally, I am aware that the validation of the species would be better aided by the presence of a specimen from the type locality. However, the type locality of *Atalophlebia fusca* (Cedar Creek, Ulmer 1916) is somewhat ambiguous. There are 37 Cedar Creeks of Queensland listed in the current gazetteer ranging throughout the state of Queensland. Campbell and Peters (1993) tried to locate this site whilst collecting species of *Atalomicria*. It is reasonable to assume that this is the same site as both taxa were collected on the Mjöberg expedition of 1910-1913. Campbell and Peters (1993) focussed their search on the Atherton Tablelands where Ulmer had collected from before in the same expedition but failed to find an appropriately named stream. Although specimens of *Nousia (Australonousia) fusca* have been collected in south east Queensland (as *Nousia* sp. "AV1") a comprehensive survey of this genus in Queensland would be required to determine if the species range extends to the Atherton tablelands. Such a survey, which would cover 1.7 million square km, was beyond the scope of this project.

Nousia (Australonousia) fusca can be distinguished from all other species in the subgenus by the following combination of characters. In the imago: (i) male upper eye size large, sometimes contiguous; (ii) thorax often shiny brown to black; (iii) total foreleg length comparatively longer on average; (iv) leg banding absent; (v) hindwing costa joins subcosta at three-quarters wing length; (vi) abdomen colour variable but often with light coloured markings on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking; (vii) penes with subapical lobes; (viii) female sternum nine deeply cleft. In the nymph: (i) antennal length more than twice length of

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head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum subequal to very slightly wider than clypeus, about twice as long as wide, lateral margins rounded; antero-median emargination straight or very slight bearing five flat elongate denticles, denticles extend one-third the width of the labrum on average; frontal setae arranged as a narrow band, secondary hair fringe clearly separated from frontal band; (iv) mandibles with no subapical processes on incisors, outer incisors inconspicuously serrated on inner lateral margins, right mandible inner incisor inconspicuously serrated on outer lateral margin; left mandible prostheca robust, moderately serrated; right mandible prostheca simple, slender; (v) maxillae with 11-18 subpectinate setae; (vi) hypopharynx deeply cleft, superlingua with rounded lateral margins; (vii) leg banding absent (viii) fore femora 2.9 times longer than wide; fore tarsi with 5-10 ventral spines; fore tarsal claws with 10-16 ventral teeth; (ix) abdomen colour variable but often with light coloured markings on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking; (x) gills clear, slender, tapering to a thin point apically, tracheae poorly to strongly developed.

Specimens examined.

Atalonella delicatula TASMANIA. **Meander River**, Westwood, 60010900, 09 I 1960, 1 ♂ I, 1 ♀ I, 1 ♀ S. D. Scholes. Held at the ANIC.

Nousia sp. "AV1" collection. NEW SOUTH WALES. **Barrengary Creek,** Upper River Rd to Upper Kangaroo Valley, 84102801, 28 X 1984, 70m, 150°31′ 34°43′, EPH 1683, 3 ♂ N, 16 ♀ N (DC). **Betts Creek,** Summit Rd, 97120202, 02 XII 1997′ 1740m, 148°23′ 36°22′, 2 ♂ N, 2 ♀ N (KJF). **Boonoo Boonoo River,** Lindsay Highway Bridge, 84111000, 10 XI 1984, 960m, 152°05′ 28°53′, EPH 1677, 8 ♀ N (DC). **Brogo River,** Princes Highway Bridge, 81052201, 22 V 1981, 80m, 149°49′ 36°32′, EPH 1668, 3 ♀ N (JD). **Brogo River,** 5km downstream Princes Highway Bridge, 81052201, 22 V 1981, 40m, 149°49′ 36°34′, EPH 1684, 2♂ N, 6 ♀ N (JD). **Eucumbene River,** Kiandra-Adaminaby Rd, 9712 0104, 01 XII 1997, 1340m, 148°31′ 35°53′, 1 ♀ N (KJF). **Georges River,** 5 km S of Cambelltown, 84102802, 28 X 1984, 100m, 150°48′ 34°06′, EPH 1674, 1 ♀ N (DC). **Murray River tributary,** Tom Groggin Picnic Area, 80102400, 24 X 1980, 490m, 148°08′ 36°21′, EPH 1649, 2 ♂ N, 1 ♀ N (DC). **No. 1 Creek,** upstream Alpine Way, 84012301, 23 I 1984, 1400m, 148°23′ 36°26′, EPH 1681, 2 ♂ N, 3 ♀ N (JD). **Perisher Creek,** Smiggin Holes-Guthega Rd, 97120203, 02 XII 1997, 1520m, 148°25′ 36°22′, 1 ♀ NSI (KJF). **Swampy Plains River,** Alpine Way, Kosciusko National Park, 97120206, 2 XII 1997, 420m, 148°12′ 36°23′, 1 ♂ S, 1 ♂ N, 1 ♀ NSI, 1 ♀ NS, 1 ♀ S, 1 ♀ N (KJF). **Thredbo River,** Bullocks Nature Track, 84012302, 23 I 1984, 1140m, 148°35′

36°26′, EPH 1667, 2 ♂ N, 3 ♀ N (JD). **Thredbo River,** Thredbo Golf Course, 84012502, 25 I 1984, 1380m, 148°18′ 36°30′, EPH 1682, 8 ♂ N, 7 ♀ N (JD). **Thredbo River,** Thredbo-Khancoban Rd, 97120204, 02 XII 1997, 1560m, 148°17′ 36°31′, 3 ♀ N (KJF). **Wentworth Falls,** Blue Mountains, 88101900, 19 X 1988, 800m 150°22′ 33°43′, EPH 1669, 4 ♀ N (DC). **Wentworth Falls,** 150m upstream Falls, Blue Mountains, 84111200, 12 XI 1984, 800m 150°22′ 33°43′, EPH 1680,1 ♂ N, 2 ♀ N (DC). **TASMANIA. Break O'Day River,** East of Fingal, 95011000, 10 II 1995, 240m, 148°03′ 41°36′, EPH 0182, 1 ♀ N (PS&PG). **Clyde River,** Hamilton, 96121901, 19 XII 1996, 90m, 146°49′49″ 42°33′30″, 1 ♂ NSI, 1 ♂ NI, 15 ♂ I, 2 ♀ NSI, 2 ♀ I, 3 ♂ S, 5 ♀ S, 1 ♂ N, 8 ♀ N (KJF). **Dee River,** Lyell Highway, 96121903, 19 XII 1996, 200m, 146°38′13″ 42°45′51″, 1 ♂ I, 5 ♂ S, 1♀ S (KJF). **Don River,** B14 crossing, 96123004, 30 XII 1996, 120m, 146°19′00″ 41°17′04″, 1 ♂ I, 1 ♀ N (KJF). **Echo Point,** unnamed stream flowing into Lake St. Clair, Cradle Mountain-Lake St Clair National Park, 96122702, 27 XII 1996, 740m, 146°08′13″ 42°02′37″, 1♀ NSI (KJF). **Elizabeth River,** Campbelltown, 96122202, 22 XII 1996, 190m, 147°29′18″ 41°56′01′, 1 ♂ N (KJF). **Huon River,** locality 27, 82030702, 7 III 1982, EPH 0154, 2 ♂ N, 2 ♀ N (DC). **Lake River,** Bridge on Highway C522, 96121702, 17 XII 1996, 160m, 145°05′44″ 41°47′02′, 1 ♀ I, 1 ♀ N (KJF). **Lake Sorrell,** Interlaken Boat Ramp, 88110402, 4 XI 1988, 900m, 147°10′ 42°11′, EPH 0158, 2 ♂ N (DC). **Liffey Falls,** 82022301, 23 II 1982, 470m, 145°47′ 41°41′, EPH 0143, 1 ♀ N (DC). **Little Forester River,** 94030601, 6 III 1994, 100m, 147°21′ 41°11′, EPH 0217, 1 ♀ N (PS). **Pipers Brook,** 94030602, 6 III 1994, 147°10′ 41°09′, EPH 0241, 1 ♂ N, 1 ♀ N (PS). **Powers Rivulet,** 94030703, 7 III 1994, 100m, 148°05′ 41°19′, EPH 0227, 1 ♂ N (PS&MS). **Ringarooma River,** Pioneer, 95020909, 9 II 1995, 147°57′ 41°05′, EPH 0210, 1 ♀ N (PS&PG). **Scamander River,** Upper Scamander, 82030900, 9 III 1982, 20m, 148°11′ 41°26′, EPH 0146, 5♂ N, 6 ♀ N (DC). **Shannon River,** Waddamana Rd, 96121704, 17 XII 1996, 910m, 146°45′39″ 42°03′04′, 1 ♀ N (KJF). **St Patricks River,** Targa, 82031002, 10 III 1982, 380m, 146°21′ 41°18′, EPH 0120, 1 ♀ N (DC). **Tower Rivulet, Rossarden Rd,** Pepper Hill, 94092700, 27 IX 1994, 260m, 147°52′ 41°37′, EPH 1673, 3 ♀ N (MRHI). **Unnamed Creek,** E of Waratah, 88110100, 1 XI 1988, 600m, 145°32′ 41°26′, EPH 0167, 2 ♂ N, 2 ♀ N (DC). **QUEENSLAND. Blackfellows Falls,** Springbrook, Warrie National Park, 79120601, 6 XII 1979, 770m, 153°16′ 28°13′, EPH 1691, 1 ♂ N (DC). **Branch Creek,** Conondale Ranges, 97061100, 11 VI 1997, 160m, 152°43′ 26°53′, EPH 1688, 1♀ N (JJ). **Stony Creek lower,** Conondale Ranges, 97082600, 26 XIII 1997, 140m, 152°41′ 26°51′, EPH 1685, 3 ♀ N (JD). **Yabba Creek tributary,** Brooloo-Imbil Rd, 84110800, 8 XI 1984, 100m, 152°40′ 26°29′, EPH 1687, 2 ♂ N, 3 ♀ N (DC). **VICTORIA. Acheron River,** Granton Rd, 98020101, 1 II 1998, 390m, 145°41′27″ 36°34′42′, 1 ♂ N, 1 ♀ NSI, 2 ♀ SI (KJF); 98021505, 15 III 1998, same locality

data, 3 ♂ N, 3 ♀ NSI (KJF). **Agnes River,** Agnes Falls, 99021104, 11 II 1999, 150m, 146°22'10" 38°38'37', 1 ♂ N, 1 ♀ N (KJF). **Arkins Creek west branch,** weir at Wyelangta, 99121903, 19 XII 1999, 330m, 143°26'24" 38°39'00", 2 ♂ NSI, 3 ♀ NSI, 1 ♀ NS, 1 ♀ N (KJF). **Aura Vale Lake inlet stream,** Cardinia, 76111200, 12 XI 1976, 175m, 145°23'14" 37°56'25', EPH 1620, 1 ♂ NI, 1 ♀ NI (JD); 980220601, 26 II 1998, same locality data, 5 ♂ NSI, 1 ♂ NI, 1 ♂ NS, 3 ♂ N, 2 ♀ NSI, 1 ♀ NI, 2 ♀ NS, 3 ♀ N (KJF). **Badger Creek,** junction Badger Creek Rd & Bluegum Drive, 97040602, 6 IV 1997, 130m, 145°32'11" 37°41'02", 1 ♀ NSI, 2 ♀ NS (KJF). **Badger Creek,** Dalry Rd, 76032500, 25 III 1976, 90m, 145°31" 37°41', EPH 1626, 2 ♂ NSI (JD); EPH 1557, 1 ♂ NI (JD). **Badger Creek** downstream weir, 80010800, 8 I 1980, 280m, 145°34' 37°41', EPH 1631, 1 ♂ NSI (JD); 80020700, 7 II 1980, same locality data, EPH 1627, 2 ♂ NI (JD); 80022102, 21 II 1980, same locality data, EPH 1630, 1 ♀ NSI (JD); 80032001, 20 III 1980, same locality data, EPH 1628, 1 ♂ NI (JD). **Barneys Creek,** Grampians, 83120200, 2 XII 1983, 300m, 142°32' 37°13' EPH 1635, 1 ♂ N (JD); EPH 1636, 1 ♂ N (JD); EPH 1637, 1 ♀ N (JD); EPH 1638, 4 ♂ N, 4 ♀ N (JD). **Bellbrook Creek,** Midland Highway, Yinnar South, 99030402, 4 III 1999, 100m, 146°18'37" 38°22'03", 2 ♂ N, 7 ♀ N (KJF). **Bemm River,** Club-Terrace-Goolengook Rd, 81032100, 21 III 1981, 100m, 148°54' 37°34', EPH 1654, 1♂ N, 1 ♀ N (JD). **Big River,** Jamieson-Eildon Rd, 98021503, 15 II 1998, 300m, 146°03'12" 37°22'03", 1 ♂ NSI (KJF). **Black Snake Creek,** Dyers Creek Picnic Ground, Gembrook South, 97012902, 29 I 1997, 115m, 145°40'08" 37°56'55", 1 ♀ NSI, 1 ♀ NS (KJF). **Bonang River,** Bonang Rd, N of Bonang, 99021308, 13 II 1999, 640m, 148°43' 37°09', 2 ♂ N (KJF). **Brandy Creek,** Great Alpine Rd, Alpine National Park, 96111802, 18 XI 1996, 1560m, 147°11'22" 37°00'55", 3 ♀ N (KJF); 96111902, 19 XI 1996, same locality data, 4♀ NSI, 1 ♀ SI, 1 ♀ I, 4 ♂ N, 8 ♀ N (KJF); 97011902, 19 I 1997, same locality data, 1 ♂ SI, 1 ♀ NSI (KJF). **Buckland River,** Mt Buffalo Rd,96110701, 07 XI 1996, 280m, 146°53'32" 36°41'52", 1 ♀ N (KJF). **Butchers Creek,** Gelantipy Rd, S of Gelaptipy, 99021407, 14 II 1999, 640m, 148°15' 37°13', 1 ♀ N (KJF). **Cann River east branch,** W.B. Line Track, Coopracambra National Park, 98012503, 25 I 1998, 230m, 149°12'16" 37°20'48", 1 ♀ N (KJF). **Cann River west branch,** Buldah Rd, 98012504, 25 I 1998, 320m, 149°08'43" 37°17'59", 2 ♂ N, 1 ♀ NSI, 2 ♀ N (KJF). **Cardinia Creek,** Crystal Brook Park, 98022602, 26 II 1998, 80m, 145°23'23" 37°58'21", 2 ♀ NSI, 1 ♀ I (KJF). **Carisbrook Creek,** Great Ocean Rd, 97030203, 02 III 1997, 10m, 143°48'27" 38°41'27": 1 ♀ I, 5 ♀ S, 1 ♂ N, 1♀ N (KJF); 99121901, 19 XII 1999, same locality data, 2 ♂ NSI, 10 ♂ S, 2 ♂ I, 1♀ I, 1 ♂ N, 14 ♀ N (KJF). **Cement Creek,** Mount Donna Buang Rd, 76042301, 23 IV 1976, 670m, 145°42'20" 37°42'48", EPH 1619, 1 ♀ NS (JD); 98030503, 5 III 1998, same locality data, 1 ♀ N (KJF). **Charleys Creek,** Charleys Creek Rd, outside Gellibrand, 98010304, 03 I 1998, 80m, 143°31'30" 38°32'30", 4 ♀ NSI, 1 ♂

N, 4 ♀ N (KJF). **Charleys Creek,** Gellibrand Rd, 99121904, 19 XII 1999, 70m, 143°31′
38°31′, 7 ♀ NSI, 1 ♂ NI, 1 ♀ SI, 1 ♀ NS, 4 ♀ N (KJF). **Cobungra River,** 4WD track
across Horsehair Plain, 97110803, 08 XI 1997, 1000m, 147°19′33″ 37°01′32″, 1 ♀ N,
(immature) (KJF). **Cockatoo Creek,** upstream Cockatoo, 94120100, 1 XII 1994, 170m,
145°29′ 37°55′, EPH 1671, 1 ♀ N (MRHI); EPH 1672, 1 ♂ N, 3 ♀ N.(MRHI).
Combienbar River, Budlah Track, 98012506, 25 I 1998, 270m, 149°02′02″ 37°20′58″, 2
♂ NSI, 1 ♂ N, 3 ♀ N (KJF). **Coranderrk Creek,** Badger Weir Rd, 97040606, 6 IV 1997,
240m, 145°34′16″ 37°41′07″, 1 ♀ NS (KJF); 98030502, 5 III 1998, same locality data, 1
♂ NS, 1 ♂ N, 4 ♀ N (KJF). **Crystal Brook,** Mount Buffalo Rd, 96110704, 07 XI 1996,
1330m, 146°48′15″ 36°43′22″, 1 ♂ S, 1 ♂ N, 4 ♀ N (KJF). **Dairy Creek,** Grampians
Tourist Rd, 90122600, 26 XII 1990, 290m, 142°32′30″ 37°11′38″, EPH 1653, 1 ♂ N, 3 ♀
N (DC); 99011601, 16 I 1999, same locality data, 1 ♀ NSI, 2 ♂ N, 10 ♀ N (KJF).
Deddick River, Deddick River Rd, Tubbut, 99021403, 14 II 1999, 440m, 148°36′ 37°04′,
2 ♀ N (KJF). **Deep Creek,** Benambra-Corryong Rd, 11kms N of Uplands, 99021501, 15
II 1999, 620m, 147°42′ 36°49′, 2 ♂ N, 7 ♀ N (KJF). **Deep Spring,** Wombat State Forest,
97122003, 20 XII 1997, 480m, 144°04′20″ 37°21′07″, 1 ♂ NS, 2 ♀ NSI (KJF); 98110103,
1 XI 1998, same locality data, 1 ♂ NSI, 1 ♀ N (KJF). **Delatite River,** 5m upstream
Merrijig, 81052101, 21 IV 1981, 540m, 146°20′ 37°06′, EPH 1661, 1 ♂ N (JD). **Delegate
River,** Monaro Highway, 99021401, 14 II 1999, 800m, 148°48′ 37°03′, 5 ♂ N, 9 ♀ N
(KJF). **Diggers Creek,** Island Bend on Summit Rd, Kosciusko National Park, 97120201,
02 XII 1997, 1200m, 148°29′ 36°19′, 1 ♂ NSI (KJF). **Donnelly Creek,** Donnelly Weir Rd,
97040604, 6 IV 1997, 140m, 145°32′03″ 37°37′40″, 1 ♀ N (KJF). **Erskine River,** Erskine
Falls, 98010401, 04 I 1998, 200m, 143°54′48″ 38°30′30″, 1 ♂ NSI, 6 ♀ NSI, 1 ♂ NS, 1 ♀
N (KJF). **Eurobin River,** Mt Buffalo National Park, 96110702, 7 XI 1996, 440m,
146°50′29″ 36°43′10″, 1 ♂ N (KJF). **Ferny Glade,** Sealers Cove Walk, Wilson's
Promontory National Park, 97021503, 15 II 1997, 340m, 146°23′21″ 39°01′40″, 1 ♂ I, 2 ♀
NSI (KJF). **Four Mile Creek,** Horners Rd, Warburton, 97042501, 25 IV 1997, 185m,
145°41′56″ 37°45′33″, 1 ♂ N, 1 ♀ N (KJF). **Franklin River,** South Gippsland Highway,
99021102, 11 II 1999, 20m, 146°17′54″ 38°39′11″, 2 ♀ I, 1 ♀ S, 3 ♂ N, 10 ♀ N (KJF).
Frosty Creek, Frosty Creek Rd, 96110803, 08 XI 1996, 1380m, 147°08′05″ 37°05′55″, 2
♂ N, 3 ♀ N (KJF). **Fyans Creek,** Grampians Tourist Rd, 99011608, 16 I 1999, 290m,
142°32′30″ 37°12′59″, 1 ♀ NS, 8 ♀ N (KJF). **Geilibrand River,** Barramunga-Upper
Geilibrand Rd, 98010301, 03 I 1998, 180m, 143°31′10″ 38°34′47″, 1 ♂ NSI (KJF).
German Creek, Bright-Tawonga Rd, 96110901, 9 XI 1996, 440m, 147°03′25″ 36°43′58″,
5 ♂ N, 7 ♀ N (KJF). **Gibbo River,** Benambra-Corryong Rd, 99021502, 15 II 1999, 500m,
147°42′ 36°45′, 4 ♂ N, 7 ♀ N (KJF). **Goulburn River,** junction Flourbag Ck, 17km
upstream Jamieson, 81110100, 1 XI 1981, 360m, 146°12′ 37°23′, EPH 1658, 2 ♂ N, 9 ♀

N (JD). **Goulburn River,** Twin Rivers Caravan Park, 99032005, 20 III 1999, 190m, 145°42'33" 37°14'28", 1 ♀ S, 4 ♂ N, 5 ♀ N (KJF). **Grace Burn,** Wallace Pde, Healesville, 97040601, 6 IV 1997, 110m, 145°32'18" 37°39'16", 1 ♀ I (KJF). **Grace Burn,** downstream weir, 75101600, 16 X 1975, 180m, 145°33' 37°39', EPH 1640, 2 ♂ N, 3 ♀ N (JD); 78011900, 19 I 1978, same locality data, EPH 1617, 2 ♂ NS, 2 ♀ NI, 2 ♀ NS (JD); 79101700, 17 X 1979, same locality data, EPH 1561, 1 ♀ I (JD). **Grey River,** Grey River Rd, 97030101, 01 III 1997, 190m, 143°48'50" 38°39'43", 1 ♀ I (KJF). **Growlers Creek,** Williams Rd Camp Site, Wandiligong, 96110801, 8 XI 1996, 380m, 146°59'10" 36°45'54", 7 ♂ N, 10 ♀ N (KJF). **Gulf Stream,** downstream Epacris Falls, Mount Victory Rd, 99011603, 16 I 1999, 440m, 142°29'36" 37°09'00", 1 ♀ NSI, 1 ♀ NS (KJF); 00012201, 22 I 2000, same locality data, 1 ♂ NSI, 3 ♀ NSI, 1 ♀ NS, 1 ♀ N (KJF). **Haunted Stream,** Great Alpine Rd, 99021409, 14 II 1999, 180m, 147°49' 37°28', 1 ♂ N, 2 ♀ N (KJF). **Hensleigh River,** Combienbar Rd Ford, 98012505, 25 I 1998, 240m, 149°01'08" 37°21'36", 1 ♂ NSI, 3 ♂ N, 1 ♀ NSI, 1 ♀ N (KJF). **Hopkins River,** Allansford, 80031000, 10 III 1980, 10m, 142°35' 38°23', EPH 1632, 1 ♀ N (DC); EPH 1633, 1 ♀ N (DC); EPH 1634, 1 ♂ N, 3 ♀ N (DC). **Jacksons Creek,** Gisborne, 97102602, 26 X 1997, 410m, 144°35'17" 37°29'04", 1 ♂ NSI, 1 ♂ I, 6 ♀ NSI (KJF). **Jamieson River,** Gerran's Bridge, 98021502, 15 II 1998, 320m, 146°10'28" 37°17'38", 1 ♀ NS (KJF). **Jimmys Creek,** Grampians Tourist Rd, 96101901, 19 X 1996, 310m, 142°30'18" 37°22'29", 1 ♂ S, 1 ♂ N (KJF); 99011607, 16 I 1999, same locality data, 2 ♀ NS, 1 ♀ N (KJF); 00012203, 22 I 2000, same locality data, 1 ♂ NSI, 5 ♀ NSI, 1 ♂ NS, 4 ♀ N (KJF). **Jingalalla River,** Dellicknora Rd, 2km SW Dellicknora, 99021402, 14 II 1999, 520m, 148°39' 37°07', 4 ♂ N, 1 ♀ I, 6 ♀ N (KJF). **Kangaroo Creek,** Kangaroo Rd, 5km E Daylesford, 97010901, 9 I 1997, 600m, 144°13'45" 37°21'10", 1 ♂ NI, 6 ♂ N, 1 ♀ NSI, 1 ♀ SI, 5 ♀ N (KJF). **Kennett River,** Great Ocean Rd, Kennett River, 98010306, 3 I 1998, 20m, 143°48'03" 38°40'05", 1 ♀ NSI, 1 ♀ N (KJF). **Kiewa River west branch,** Blair's Hut, 97021901, 19 II 1997, 1010m, 147°10'17" 37°55'16", 1 ♀ N (KJF). **King Parrot Creek,** Whittlesea-Yea Rd, 15km SW Flowerdale, 98030501, 5 III 1998, 350m, 145°14'48" 37°25'50", 2 ♂ N, 1 ♀ NSI (KJF). **Langford East Aqueduct tributary,** Bogong High Plains Rd, Langford Gap, 96111001, 10 XI 1996, 1600m, 147°19'05" 36°53'05", 1 ♀ N (KJF). **La Trobe River,** 5km E of Powelltown, 96101002, 10 X 1996, 320m, 145°50'10" 37°52'35", 4 ♂ N, 4 ♀ N (KJF). **Learmonth Creek,** Yarra Junction-Neerim Rd, Powelltown, 96101001, 10 X 1996, 180m, 145°44'33" 37°51'43", 1 ♂ N, 5 ♀ N (KJF). **Lerderderg River,** Lerderderg Gorge State Park, 97122005, 20 XII 1997, 140m, 144°25'06" 37°37'42", 1 ♀ NSI, 1 ♂ N (KJF). **Light Bound Creek headwaters,** Dargo High Plains Rd, 96110804, 08 XI 1996, 1570m, 147°09'30" 37°06'23", 8 ♂ N, 29 ♀ N (KJF). **Lilly Pilly Gully,** Wilson's Promontory National Park, 97021504, 15 II 1997,

60m, 146°20'01" 39°00'55", 2 ♂ NSI, 1 ♂ NS, 2 ♀ NSI (KJF). **Little Ada Creek,** Ada River Rd, La Trobe State Forest, 96101004, 10 X 1996, 500m, 145°52'07" 37°50'45", 5 ♂ N (KJF). **Little Toorongo River,** Toorongo Falls, 98020901, 9 II 1998, 420m, 146°02'55" 37°50'58", 1 ♂ N, 1 ♀ N (KJF). **Little Yarra River,** Warburton Highway, 96092501, 25 IX 1996, 120m, 145°37'41" 37°47'03", 2 ♀ S (KJF). **Love Creek,** Loves Creek Picnic Ground, Colac-Beech Forrest Rd, 98010303, 3 I 1998, 100m, 143°34'52" 38°28'55", 1 ♂ NSI, 1 ♂ NS, 6 ♀ NSI, 3 ♀ NI, 1 ♀ NS, 1 ♂ N (KJF). **Lyrebird Creek,** Olinda Creek Rd, Dandenong Ranges, 97032404, 24 III 1997, 220m, 145°23'45" 37°49'50", 1 ♂ NSI, 1 ♀ NSI, 1 ♀ NI (KJF). **Main Creek,** Baldry's Rd, Green's Bush, Nepean State Park, 97041601, 16 IV 1997, 110m, 144°57'34" 38°25'20", 6 ♀ NSI, 1 ♀ N (KJF). **MacKenzie River,** Wartook Rd, Grampians, 99011605, 16 I 1999, 420m, 142°24'56" 37°06'43", 1 ♂ N, 3 ♀ N (KJF). **Martins Creek No. 2,** Bonang Rd, 0.5km S Malinns, 99021306, 13 II 1999, 260m, 148°36' 37°25', 3 ♂ N, 14 ♀ N (KJF). **Melba Gully,** Anne's Cascades, Melba Gully State Park, 98010305, 03 I 1998, 340m, 143°22'15" 38°41' 44", 2 ♀ NSI, 3 ♀ NS, 4 ♂ N, 2 ♀ N (KJF); 99121902, 19 XII 1999, same locality data, 4 ♂ NSI, 1 ♀ NSI, 1 ♀ NS, 2 ♂ N, 4 ♀ N (KJF). **Menzies Creek,** Emerald-Monbulk Rd, Butterfield Wildlife Reserve, Dandenong Ranges, 97032403, 24 III 1997, 160m, 145°26'22" 37°53'47", 3 ♀ NSI, 3 ♀ I, 1 ♀ NS, 1 ♀ N (KJF). **Middle Creek,** Omeo Highway, 96111004, 10 XI 1996, 700m, 147°27'50" 37°55'19", 1 ♂ N, 5 ♀ N (KJF). **Mitta Mitta River,** Omeo Valley Rd, 99021503, 15 II 1999, 540m, 147°36' 36°56', 5 ♂ N, 1 ♀ N (KJF). **Moroka River,** Moroka River Track, Alpine National Park, 97020603, 6 II 1997, 440m, 146°53'00" 37°23'30", 1 ♀ N (KJF). **Morwell River,** Morwell River Rd, 21km S of Morwell, 99030403, 4 III 1999, 110m, 146°18'17" 38°24'32", 2 ♂ N, 2 ♀ N (KJF). **Mountain Creek,** 7km E Tawonga South, 90110300, 3 XI 1990, 510m, 147°14' 36°42', EPH 1660, 5 ♀ N (DC). **Muddy Creek,** Selby-Aura Rd, 96101303, 13 X 1996, 225m, 145°23'15" 37°55'15", 1 ♂ N, 2 ♀ N (KJF). **Myrtle Gully,** Sylvia Creek Rd, Toolangi State Forest, 96112901, 29 XI 1996, 620m, 145°31'44" 37°31'44", 1 ♀ N (KJF). **Myrtle Creek,** Donna-Buang Rd, 00031901, 19 III 2000, 780m, 145°36'42" 37°42'35", 1 ♂ NS, 3 ♀ N (KJF). **Olinda Creek,** Olinda Creek Rd, Dandenong Ranges, 97032405, 24 III 1997, 260m, 145°22'35" 37°49'47", 3 ♀ NS (KJF). **O'Shannassy River,** (restricted access), 75111400, 14 XI 1975, 580m, 145°49' 37°36', EPH 1554, 1 ♂ N (JD), EPH 1555, 1 ♀ N (JD), EPH 1610, 4 ♂ N, 4 ♀ N (JD); 75102401, 24 X 1975, same locality data, EPH 1611, 4 ♀ N (JD); 76102103, 21 X 1976, same locality data, EPH 1609, 2 ♀ N (JD); 76121501, 15 XII 1976, same locality data, EPH 1608, 1 ♂ N, 1 ♀ N (JD); 80010401, 4 I 1980, same locality data, EPH 1553, 1 ♂ NI (JD), EPH 1556, 1 ♀ NSI (JD), EPH 1607, 2 ♂ NI (JD). **Ovens River,** School Bridge, Harrietville, 97011903, 19 I 1997, 500m, 147°03'48" 36°53'25", 1 ♀ N (KJF). **Perrins Creek,** Warwick Rd, Dandenong Ranges, 97032406, 24 III 1997, 350m, 145°22'

37°52', 1 ♂ NI, 1 ♀ I, 1 ♀ N (KJF). **Poddy Creek,** Princes Highway, S Club Terrace, 99021203, 12 II 1999, 180m, 148°54' 37°35', 6 ♂ N, 19 ♀ N (KJF). **Pyramid Creek,** Combienbar Rd, N Club Terrace, 99021304, 13 II 1999, 100m, 148°54' 37°32', 7 ♂ N, 21 ♀ N (KJF). **Raymond Creek,** Princes Highway, 12km E Orbost, 81052102, 21 V 1981, 20m, 148°34' 37°42', EPH 1657, 1♂ N, 14 ♀ N (JD). **Roadknight Creek,** Roadknight Creek Rd, Otways, 98010302, 3 I 1998, 160m, ,143°41'21" 38°31'06", 1 ♂ NSI, 1 ♂ NS, 2 ♂ N, 3 ♀ NSI (KJF). **Rubicon River,** Rubicon Bridge, Taggerty-Thornton Rd, 98101701, 17 X 1998, 220m, 145°47'56" 37°16'55", 3 ♂ NSI, 1 ♂ I, 1 ♂ S, 1 ♂ NS, 4 ♀ NSI, 5 ♀ N (KJF); 98111701, 17 XI 1998, same locality data, 2 ♂ NSI, 6 ♀ NSI, 4 ♀ NS (KJF). **Running Creek,** downstream Running Creek Reservoir, 85071000, 10 VII 1985, EPH 1639, 1 ♀ N (JD). **Running Creek,** Warburton-Jamieson Rd, 85030700, 7 III 1985, 750m, 145°58' 37°25', EPH 1644, 5 ♀ N (JD). **Russell Creek,** off Gunn Rd, 3km N of Noojee, 96101005, 10 X 1996, 280m, 145°59'26" 37°50'45", 1 ♀ NSI, 1 ♀ N (KJF). **Sassafras Creek,** Sassafras Creek Rd, 96112101, 21 XI 1996, 320m, 145°22'18" 37°52'46"; 2 ♀ S, 1 ♂ N (KJF). **Sassafras Creek,** Kay's Picnic Ground, Monbulk Rd, 96101303, 13 X 1996, 250m, 145°23'21" 37°53'03", 3 ♂ N (KJF); 97032402, 24 III 1997, same locality data, 1 ♂ NSI, 1 ♂ NI, 4 ♀ NSI, 1 ♀ N (KJF). **Sawpit Creek,** Donnelly Weir Rd, 97040605, 6 IV 1997, 100m, 145°32'03" 37°38'15", 1 ♀ NS, 2 ♀ N (KJF). **Shaw Creek,** Kelly's Lane Bridge, Alpine National Park, 97020601, 6 II 1997, 1280m, 146°44'22" 37°27'30", 1 ♀ N (KJF). **Shicer Creek,** West Ovens Track, Bonang National Park, 96110802, 8 XI 1996, 580m, 147°02'30" 37°55'20", 1 ♂ N, 1 ♀ N (KJF). **Snowy Creek,** Wonton Bridge, 74031700, 17 III 1974, EPH 1645, 1 ♂ N (coll. unknown). **Starvation Creek,** Warburton-Woods Point crossing, 75102402, 24 X 1975, 240m, 145°47' 37°42', EPH 1558, 1 ♀ NI (JD); 76031900, 19 III 1976, same locality data, EPH 1559, 1 ♂ NI (JD), EPH 1616, 1 ♀ NS (JD); 76042302, 23 IV 1976, same locality data, EPH 1560, 1 ♂ NS (JD). **Starvation Creek,** upstream weir, 79121900, 19 XII 1979, 340m, 145°50'53" 37°45'39", EPH 1621, 1 ♂ NI (JD), EPH 1622, 1 ♀ NSI (JD). **Steavensons River,** Buxton-Marysville Rd, 98021504, 15 II 1998, 460m, 145°45'02" 37°28'53", 1 ♂ NSI, 2 ♀ NSI, 3 ♀ NS (KJF). **Steavensons River,** Marysville Rd, 98101703, 17 X 1998, 320m, 145°44'01" 37°28'32", 1 ♂ N, 1 ♀ NSI, 1 ♀ NS, 6 ♀ N (KJF). **Stony Creek,** Wonderland Car Park, Grampians, 90112600, 26 XI 1990, EPH 1646, 410m, 142°30'10" 37°09'04", 2 N (DC); 99011602, 16 I 1999, same locality data, 1 ♂ N (KJF). **Swindlers Creek tributary,** 6km from Mt Loch Car Park, off Australian Alps walking track, Mt Hotham, 96111903, 19 III 1996, 1640m, 147°09'40" 36°58'42",1♂ N (KJF). **Taggerty River,** Lady Talbot Drive, outside Marysville, 98101704, 17 X 1998, 400m, 145°46'28" 37°30'20", 1 ♀ NSI (KJF). **Tanjil River,** 5km N Moe, 87100600, 6 X 1987, 60m, 146°16' 38°08', EPH 1652, 1♂ N, 1 ♀ N (KW&AN), EPH 1659, 2 ♀ N

(KW&AN). **Tanjil River East Branch tributary,** Mount Baw Baw Tourist Rd, Tanjil State Park, 96101105, 11 X 1996, 490m, 146°12'11" 37°50'18", 1 ♀ N (KJF). **Taponga River,** Eildon-Jamieson Rd, 99022008, 20 II 1999, 320m, 146°02'50" 37°22'42", 3 ♀ N (KJF). **Tarra River,** Tarra Valley National Park, 84010900, 9 I 1984, 340m, 146°32'13" 38°26'57", EPH 1717, 1 ♂ N (JD). **Tarra River branch 1,** Tarra-Bulga National Park, 98112101, 21 XI 1998, 340m, 146°32'13" 38°26'57", 1 ♂ NSI, 1 ♂ N, 2 ♀ N (KJF). **Tarra River branch 2,** Tarra-Bulga National Park, 98112102, 21 XI 1998, 340m, 146°32'15" 38°27'00", 1 ♀ NSI (KJF); 99021601, 16 II 1999, same locality data, 1 ♂ NI, 2 ♂ NS, 2 ♂ N, 2 ♀ N (KJF). **Tarwin River East,** Mirboo Bridge, Mirboo, 99030404, 4 III 1999, 90m, 146°12'37" 38°28'25", 3 ♂ N, 2 ♀ N (KJF). **Thowgla Creek,** upstream Nariel-Thougla signpost, 80102000, 20 X 1980, 420m, 147°54' 36°18', 7♂ N, EPH 1662, 8 ♀ N (JD). **Thurra River west branch tributary,** Thurra Junction Rd, 97101802, 18 X 1997, 200m, 149°17'41" 37°27'35", 4 ♂ N, 1 ♀ N (KJF). **Toorongo River,** 5km NE Noojee, 96101102, 11 X 1996, 280m, 146°02'29" 37°51'17", 1 ♂ N (KJF); 98020902, 9 II 1998, same locality data, 1 ♂ N (KJF). **Turitable Creek,** Devonshire Lane, Mt Macedon, 81120100, 1 XII 1981, 680m, 144°35' 37°23', EPH 1744, 1 ♀ N (JD), EPH 1745, 1 ♀ N (JD), EPH 1746, 1 ♀ N (JD), EPH 1747, 2 ♀ N (JD). **Tyers River,** Moe-Rawson (Walhalla) Rd, Moondarra State Park, 99021507, 15 II 1999, 180m, 146°19'42" 38°02'15", 2 ♂ N, 4 ♀ N (KJF). **Unnamed Creek,** 2km W of Genoa, 82112100, 21 XI 1982, 100m, 149°34' 37°28', EPH 1563, 1 ♀ N (JD). **Unnamed Creek,** 3km W of Genoa, 81052203, 22 V 1981, 60m, 149°33' 37°28', EPH 1564, 1 ♂ N (JD), EPH 1565, 3 ♂ N, 11 ♀ N (JD). **Victoria River,** Victoria River Track, 96111804, 18 XI 1996, 1010m, 147°21' 37°05', 1 ♂ S (KJF); 96111901, 19 XI 1996, same locality data, 1 ♂ NI, 1 ♂ NS (KJF). **Wangarabell Creek,** Wangarabell Rd, Wangarabell, 99021302, 120m, 149°28' 37°22', 2 ♂ N, 3 ♀ N (KJF). **Watchbed Creek,** 96031800, 18 III 1999, 1680m, 147°19' 36°51', EPH 1693, 1 ♀ N (JD), EPH 1694, 1 ♀ NS (JD). **Watts River,** Fernshaw Rerserve, 74122000, 20 XII 1974, 200m, 145°36' 37°37', EPH 1642, 2 ♂ N, 5 ♀ N (JD). **Wellington River,** Tamboritha Rd, Alpine National Park, 96092204, 22 IX 1996, 340m, 146°38'15" 37°31'02", 1 ♀ N (KJF); 97020702, 7 II 1997, same locality data, 1 ♂ NI, 1 ♂ I, 1 ♀ I, 1 ♀ N (KJF). **Wild Dog Creek,** Wild Dog Creek Rd, 97030201, 2 III 1997, 10m, 143°40'44" 38°44'04", 1 ♂ I (KJF). **William Wallace Creek,** Triangle Link Rd, Gembrook Park, 97012901, 29 I 1997, 150m, 145°35'38" 37°59'03", 1 ♂ NSI, 2 ♀ NSI, 1 ♂ N, 5 ♀ N (KJF). **Wingan River,** Drummer Rd, Coopracambra National Park, 98012501, 25 I 1998, 180m, 149°25'15" 37°28'03", 2 ♂ N, 2 ♀ S, 9 ♀ N (KJF). **Wombat Creek,** Wombat Creek Dam Picnic Area, near Daylesford, 97122004, 20 XII 1997, 635m, 144°10'22" 37°23'25", 2 ♂ NSI, 1 ♂ NS, 1 ♀ NSI (KJF). **Yarra River,** upstream of Warburton, 97042502, 25 IV 1997, 170m, 145°42'43" 37°45'03", 1 ♂ S, 1 ♀ S (KJF).

Yarra River, Hazelwood Rd, 80112000, 20 II 1980, EPH 1614, 1 ♂ I (JD), EPH 1623, 1 ♂ NSI, 1 ♀ NS (JD). **Yarra River,** Peninsula Rd, 78122100, 21 XII 1978, EPH 1612, 1 ♂ NS (JD); 80010402, 4 I 1980, same locality data, EPH 1625, 1 ♀ NI (JD); 80020600, 6 II 1980, same locality data, EPH 1562, 1 ♂ NI (JD), EPH 1613, 1 ♀ NI (JD), EPH 1624, 1 ♂ NI (JD). **Yarra River,** Reefton Rd, 77110300, 3 XI 1977, EPH 1615, 1 ♀ S (JD).

3.3.2.2.1   Investigation of morphological variation within *Nousia (Australonousia) fusca.*

Nousia (Australonousia) fusca appears extremely abundant throughout south-eastern Australia. It was found at 225/678 (33%) of all sites examined (see Appendix 2) and was the most abundant species of the MRHI collections. The large number of collection sites covered many different locations through eastern Australia and groups of these were geographically isolated from others; possibly represented different ecological habitats. Isolated populations included the Otways, Grampians, Tasmania and high altitude sites (above 1000m). As there was some morphological variation in the species from these collections, attempts were made to further examine species variation between these isolated sites through statistical analysis. Differences amongst regions were examined by oneway ANOVA for appropriate individual characters for populations from the Otways, Grampians, Tasmania, high altitude sites (above 1000m) and "the rest" of Victoria which refers to all other sites where this species was found throughout Victoria. Typical habitat in these locations are shown in Figs. 95-106. A subset of the nymphal characters was further examined by discriminant analysis; this was not possible for the adult characters due to the low numbers of individuals available.

Of the eighteen ANOVA's run examining differences amongst regions eight showed significant variability amongst the collection sites (Table 6), which suggests that some genuine differences exist. The significant results pertained to the male and female imago characteristics in all cases but one (nymph female body length) and was generally based on very low number of individuals ($n < 7$). High altitude collections tended to exhibit the highest mean values whilst the Grampians had the lowest mean values.

Discriminant analysis was conducted on three subsets of nymphal data (labrum, leg and head and pronotum measurements including ratios). These subsets had to be examined separately because not all measurements were available for each individual. Tolerances were generally low indicating high correlations between characters. The classification matrices returned overall percent correct figures of 35, 34 and 35% for each subset respectively. This indicated that the differences in characters were not strongly associated with place of collection and confirmed the predominance of non-significance

amongst the one-way ANOVA's of the nymphal characters. Multivariate ANOVA was only significant for the third subset analysis (p=0.083, 0.064, **0.033**).

Whilst there were some indications of differences amongst collections from different regions these were not sufficient to contradict the view based on morphology that the material constitutes a single, albeit very variable, species. It is still possible that this species constitutes a group of cryptic species or a species complex. Molecular taxonomy may elucidate such differences in the future.

Table 6. Analysis of differences in various characters of *Nousia (Australonousia) fusca* according to location of collection. Order of means where differences significant: G=Grampians, H=High Altitude, O=Otways, T=Tasmania and R="The Rest" of Victoria.

	df	p	Order of means
Male imago			
body length	4, 53	**0.024**	H>R>T>O>G
forewing length	4,54	**0.039**	H>O>R>T>G
hindwing length	4,51	0.315	
total foreleg length	4,32	**0.021**	O>H>R>G>T
Female imago			
body length	4,57	**0.003**	H>O>R>T>G
forewing length	4,58	**0.009**	H>R>O>T>G
hindwing length	4,57	**0.024**	H>R>O>T>G
total foreleg length	4,35	**0.005**	H>R>T>O>G
Nymph			
male body length	4,58	0.243	
female body length	4,76	**0.006**	O>H>T>G>R
head width	1,81	0.186	
pronotum width	4,78	0.425	
labrum length	4,96	0.252	
labrum width	4,96	0.565	
labrum denticle width	4,96	0.102	
total fore leg length	4,82	0.260	
fore femora length	4,82	0.488	
fore femora width	4,82	0.920	

3.3.2.3 Nousia (Australonousia) darkara (Harker) Incertae sedis

Atalonella darkara Harker (Harker 1957b)

Atalonella darkara Harker (Scholes 1961)

Nousia darkara (Harker) (Campbell 1988)

Incertae sedis

Types. Holotype. *Atalonella darkara* Harker, Burnie, Tasmania, ♀ subimago, 6 XII 1954, B. McMillan. Held at the NHM. [not seen].

Distribution. Tasmania (no locality data available).

Diagnosis. Due to lack of specimens the following description is derived from Harker (1957b). **Male imago.** unknown. **Female imago.** unknown. **Egg.** unknown. **Male subimago.** unknown. **Female subimago.** Dimensions: body length 12; forewing 6; hindwing 1.5. General body colour yellow with dull brown markings. Head, antennae, ocelli colour and characteristics unknown. Eyes: size and colour unknown. Thorax colour and characteristics unknown. Legs: cream, no markings; tarsal claws "acute". Wings. Forewing: colour uniformly grey; pterostigmal region opaque ("milky"); costal and subcostal crossveins absent, or if present very faint, in proximal halves of wings, 8 crossveins distally, subcostal space with 3 faint crossveins proximally, 6 crossveins distally. Presence of bullae unknown, MA forked at approximately half the distance from wing base to margin, MP_2 apparently not connected to MP_1 and CuA, CuA and CuP not linked by crossvein, ICu_1 recurved to join CuA, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel or very slightly diverging as wing margin approached, CuP strongly recurved and apparently not linked by crossvein to A_1. Hindwing: colour unknown; slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at four-fifths of wing length; no cross veins in costal space, 7 throughout subcostal space. Abdomen: colour unknown, sternum nine shallowly cleft. Caudal filaments: three; terminal filament shorter than cerci. **Nymph.** Body length ♀ 10. General body colour unknown. Head, antennae, ocelli colour and characteristics unknown. Eyes: size and colour unknown. Mouthparts. Labrum and clypeus: lateral margin of labrum much wider than clypeus, angular; anterior margin with slights antero-median emargination; five rounded denticles. Clypeus unknown. Mandibles: outer margins slightly curved; number of incisors unknown, much denticulated, molar regions small. Maxillae: palpi three segmented, basal segment longer than the second, terminal segment "small and pointed". Hypopharynx: unknown. Labium: glossae not turned under ventrally and lying in same plane as paraglossae; palpi three segmented, basal segment longer than the second. Thorax: colour unknown. Legs: yellow, without markings, slightly darker dorsally; tarsal claws

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each segment; posterolateral spines present, apparently progressively larger apically. Gills: colour unknown; present on segments one to seven; double, lanceolate.

Remarks. Very little is known about this species. It was established only on the basis of a female subimago and a nymph by Harker (1957b). There is no explanation as to why *Atalonella* was chosen as the genus to which this species belongs although one can assume that she made the assessment based on a previous paper (Harker 1954) where the distinctions between *Atalophlebia* and *Atalonella* were outlined. Unfortunately, the descriptions and drawings of Harker are very simplified and somewhat enigmatic. The drawing of the forewing (Harker 1957b, FIG. 30, p.70, reproduced here as Fig. 107) shows no (or a few very faint) costal crossveins in the proximal halves of the costal and subcostal spaces, a trait usually associated with male wing venation, not female. Further, the forewing is said to be half the body length which is clearly an error as it is more usual for the wing to be at least as long, if not longer, than the body. Lastly, the labrum appears as though it is much wider than the clypeus and possesses angular lateral margins which are not diagnostic for the genus (Harker 1957b, FIG. 33, p. 70, reproduced here as Fig. 108).

Despite the genus status of the species being unclear it was included in the Australian catalogue of Ephemeroptera as belonging to *Nousia (Australonousia)* (Campbell 1988). Strangely, however, it was not included in the genus revision of Australian *Nousia* published the same year (Campbell and Suter 1988).

A request was forwarded to the Natural History Museum to obtain the holotype *Atalonella darkara* but this could not be found. There is no direct mention that she lodged the specimens with the Natural History Museum in her paper 'Some new Australian Ephemeroptera Part II' (Harker 1957b) although Part I of that series (Harker 1957a) clearly states that the types were to be deposited there. As all her other types were lodged with the NHM there is no reason to assume she would choose another repository. Apparently, no other specimens of *Atalonella darkara* exist apart from the type.

A further complication is that the type location of this species is ill-defined. Burnie is a large town in Tasmania and collection of material in and around Burnie failed to produce a species similar to this description.

Without the type, any other specimens or an adequate description, it is not possible to place this species definitively in any genus. I therefore remove this species from *Nousia (Australonousia)* and propose that the status of *Incertae sedis* be adopted until the type is located and examined.

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3.3.2.4 *Nousia (Australonousia) fuscula* (Tillyard)

Atalophlebia fuscula Tillyard (Tillyard 1936)

Atalonella fuscula (Tillyard) Harker (Harker 1954)

Nousia fuscula (Tillyard) (Suter 1986)

Nousia (Australonousia) fuscula (Tillyard) (Campbell and Suter 1988)

Types. Holotype. *Atalophlebia fuscula* (Tillyard), Tasmania, River Shannon, ♂ imago, 33012700, 27 I 1933, R.J. Tillyard. Labels: a) "Holotype", b) "*Atalophlebia fuscula* Till. Holotype ♂ R.J.T. R. Shannon. Tas., 27.I.33", c) "Brit. Mus. 1937-408". **Paratypes.** *Atalophlebia fuscula* (Tillyard), ♀ imago, subimagos, same collection data. Held at the NHM. [not seen].

Distribution. South Australia, Tasmania (no locality data available).

Diagnosis. Due to relative lack of material the following description and measurements combines information from descriptions by Tillyard (1936), Scholes (1961) and predominantly Suter (1986). I was also able to examine the holotype from the NHM and a very small number of specimens borrowed from the AWQC and the ANIC. **Male imago.** Dimensions: body length 5.8-7.8; forewing length 5.9-8.0; hindwing length 1.1-1.6; forewing hindwing ratio approx. 5. General body colour black. Head black. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper lobes brown-grey. Thorax: black. Legs: brown to black, no apparent banding; forelegs with seven segments, total foreleg length 6.23; leg length ratios 1.00: 1.29: 0.14: 0.49: 0.44: 0.28: 0.16 (1.64); tarsal claws of a pair similar, each apically hooked with an opposing hook. Wings. Forewing: membrane hyaline, pterostigmal area red brown, opaque; longitudinal and crossveins brown, anal veins yellow; costal and subcostal veins absent, or if present very faint, in proximal halves of wing; costal space with 6 proximally, 10 distally, subcostal space with 2-4 proximally, 7-10 distally. Three bullae present on veins Sc, R_2 and R_{4+5}, MA forked at half to just over half the distance from base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 joins CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1. Hindwing: mostly hyaline; costal margin slightly convex at midlength immediately preceding shallow concavity, costa joins subcosta at approximately four-fifths wing length; no cross veins in proximal half of costal space, 4 in distal half, subcostal space with 4-6 cross veins. Abdomen: black with light brown to brown markings forming a broken stripe midline, two maculae flanking each midline marking anteriorly. Genitalia: forceps three segmented;

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terminal segment globular. Penes brown, fused in basal two-thirds, two distinct lobes; in dorsal view two indistinct subapical lobes, each with a small blunt triangular tooth, partly sheathed by outer covering, generally visible under transmitted light only. Caudal filaments: three, dark brown, 10. **Female imago.** Dimensions: body length larger than male; forewing length 8; hindwing length larger than male. General patterning and colouring similar to male. Legs: total leg length shorter than male. Wings. Forewing colour and venation similar to male except crossveins in proximal halves of wings and generally more crossveins on average than male. Hindwing: unknown. Abdomen: sternum seven with small genital extension; sternum nine deeply cleft. **Egg.** Ovoid, polar cap with three rings of tubular processes, chorion with small circular tubules regularly placed over surface. **Male and female subimago.** General colour dull black. Wings opaque, dark-grey. **Mature nymph.** Body lengths: 7-8. General colour black. Head: prognathous; dark brown to black. Ocelli: three; black with white to grey inserts; laterals larger than medial. Antennae: pale greyish. Eyes: upper lobes of male reddish-brown. Mouthparts. Labrum and clypeus: lateral margin of clypeus slightly diverging towards anterior; lateral margins of labrum subequal to very slightly wider than clypeus, rounded; anterior margin with slight antero-median emargination; labrum two times wider than long; four to six triangular denticles extending less than one-third the entire width of labrum, frontal setae arranged as a narrow band, secondary hair fringe clearly separated from narrow band. Mandibles: outer margins slightly curved; sparse long setae at midpoint on inner lateral margins, shorter setae between tuft and base; dark coloured nodule at midpoint on inner mesal surface. Left mandible: two incisors, each with three apical teeth, no apparent serrations on lateral margins; prostheca robust, moderately serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible: sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inner incisor with two apical teeth, no apparent serrations on lateral margins; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae: galea-lacinae as wide as long; subapical row of approximately 15 pectinate setae; palpi three segmented; palp length ratios 1.00: 0.71: 0.78 (0.21). Hypopharynx: well developed lateral processes; anterior margin of lingua deeply cleft; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium: glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with stout spines on dorsal surface; palp length ratios 1.00: 0.71: 0.69 (0.29); submentum with spines on lateral margins. Thorax: dark brown. Legs: medium brown, no apparent banding; fore femora length width ratio approx. 2.74; fore tarsi with approx. 13 ventral spines; tarsal claws with approx. 11 ventral teeth, progressively larger apically; total foreleg length 2.86; leg length ratios, foreleg 1.00: 0.87: 0.55 (1.18), midleg 1.00: 0.84: 0.39 (1.19), hindleg 1.00: 0.91: 0.38 (1.40). Abdomen: black with yellow-brown markings.

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Gills: membrane pale, brownish; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill slender, tapering to a thin point apically; main and lateral tracheae strongly developed. Caudal filaments: three, 10.

Remarks. *Atalophlebia fuscula* was first established by Tillyard in his monograph of the mayflies of Tasmania (Tillyard 1936). Following this it was transferred to *Atalonella* by Harker (1954) on the basis of wing venation and gill shape. Scholes (1961) briefly described the nymph and adult stages in his popular treatise on fly-fishing and an extensive revision of the South Australian fauna was completed by Suter (1986) in which the species was transferred to *Nousia*. I agree with this designation based on Suter's description.

Unfortunately, only a few of Suter's specimens could be located and these comprised a series of nymphs from Tookayerta Creek in South Australia and some specimens marked *Atalonella fuscula* from the ANIC. I also endeavoured to recollect this species from some of the places Suter collected in his revision (Suter 1986) such as Jimmy's Creek, MacKenzie River and Stony Creek in the Grampians and Tanjil River, Tarwin River and Tooroongo Falls in eastern Victoria. However, I was only able to collect a few specimens from Jimmy's Creek on several different occasions (96101901, 99011607, 00012203) and was only able to rear one male to adulthood. The adult conformed more readily to the newly described *N. (A) fusca* in that the subapical lobes were more developed..

It occurs to me that *N. (A). fusca* and *N. (A) fuscula* are very closely related and may be conspecific. This may explain why only specimens of *N. (A) fusca* were found at Suter's collecting sites. I have attempted to examine the similarities (Table 7) and differences (Table 8) between the two species by close examination of the literature, holotype and scant specimens of *N.(A) fuscula* with specimens of the newly described *N. (A) fusca*.

The two species appear to have more similarities than differences (Table 7). They are similarly sized in both the imago and nymph. They are also similarly coloured and patterned although *N. (A) fuscula* tends to be a darker in general. In the imago, wing colouring and venation are practically identical and the female imago possesses a deeply cleft sternum nine in both cases. In the nymph, mouthpart morphology appears very closely aligned between the two with the possible exception of maxillae and labium palp relative lengths. Fore femora length to width ratio and gill colour, shape and size are also compatible.

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Discrepancies in the male imago (Table 8) include measurements of the dissimilar body and forewing lengths. T-tests were performed and a significant difference was found between the two (p<0.001 in both cases) where the lengths *N. (A) fuscula* were smaller than that of *N. (A) fusca*. This appears to be the case with the foreleg lengths (as shown by the ratios) although no statistical test could be applied. The total foreleg length of *N. (A) fuscula,* although quite small, is within or just outside the range of *N. (A) fusca*. Another variation in the male imago pertains to the equality in tail filament length, although this is disputed (Suter 1986).

I admit that these few differences, when compared to the similarities, are not conclusive evidence of species status and felt that if I was able to examine the genitalia closely I would be able to make an assessment. For some time, however, the only male imago specimen I had was the type specimen and as this was pinned it was quite shrivelled. I have found, through trial and error, that air dried specimens (and the parts dissected from them) do not retain their shape. The genitalia of the type specimen was one such example and frustratingly provided little clue as to the true shape, especially as it did not compare with the literature drawings such as Tillyard (1936, FIG. 15, p. 34, reproduced here as Fig. 109) and Suter (1986, FIG. 10j, p. 375, reproduced here as Fig. 110). It was not until some time later that I was fortunate to find a vial containing Scholes' specimens of *N. (A). fuscula* from Tasmania which contained a number of specimens including two intact male imagos. The genitalia of these specimens have a somewhat similar design to *N. (A). fusca* in that the two species both have two lobes which are fused in the basal two-thirds, each lobe has a small triangular process on the inner lateral margins which appear to be partly sheathed (Fig. 111). The obvious difference between this and the literature drawings appears to be lack of prominent subapical lobes in the descriptions and drawings of Tillyard (1936) and Suter (1986). It is unfortunate the genitalia drawings do not conclusively determine species status either way.

In the female imago, a discrepancy between the two descriptions appears to be with regard to the genital extension which is considered to be absent in *N. (A) fuscula* ("no ovipositor" (Suter 1986, p. 349) and small in *N. (A) fusca* (3.3.2.2). However, the drawing of the female abdomen by Suter (1986), FIG. 10f, p. 375, reproduced here as Fig. 112) indicates a small extension which is at least as big as the one present on *N. (A) fusca*. Two female imagos of *N (A) fuscula* collected by Scholes (1961) in Tasmania also possess a small genital extension on sternum seven.

Another concern is the morphology of the egg. The SEM taken by Suter (1986, FIG. 16b, p. 381, reproduced here as Fig. 113), has three rings of tubular processes and looks remarkably like a *Thraulophlebia* egg (see 3.4.3.1). Moreover, it does not conform to the

general morphology of all the other *Nousia* eggs, which have no polar caps or tubular processes. I had many problems with contamination with eggs from other samples and would often have eggs of more than one species in a sample. After many false starts, I resorted to a new set of equipment (glassware, pipettes, critical point drier container etc) for each sample and did not process more than one sample at the same time. Although there were very few viable specimens, I was able to dissect a few eggs from one of the mature female nymphs from Tookayerta Creek, South Australia (Figs. 114, 115). The general shape and patterning appears to conform more closely with the *Nousia* species.

Lastly, variation exists with respect to the head width and leg length of the nymph, as in the imago, and again *N. (A) fuscula* is much smaller. The leg length ratios and mouthpart ratios of the maxillae and labium, as mentioned earlier, are also incongruous. The head width of *N. (A) fuscula* proved to be significantly smaller than that of *N. (A) fusca* as measured by t-test ($p < 0.001$). There also appears to be a body colour variation between the two species where the *N. (A) fuscula* nymph, like the imago, is generally darker.

Table 7. Similarities between the literature descriptions and measurements of *Nousia (Australonousia) fuscula* and the newly described *Nousia (Australonousia) fusca*.

	Nousia (Australonousia) fuscula	newly described *Nousia (Australonousia) fusca*
Male Imago		
hindwing length	1.6 mm (Tillyard 1936) 1.6 (Scholes 1961) 1.12-1.40 (1.29±0.09, 23) (Suter 1986) 1.6 – holotype	1.01-1.71 (1.29±0.13, 56)
general body colour	black (Tillyard 1936, Scholes 1961)	variable, from tan brown to dark brown to black
head colour	black (Tillyard 1936, Scholes 1961, (Suter 1986)	brown to black
thorax colour	black (Tillyard 1936, Suter 1986)	pronotum brown to black, mesonotum shiny brown to black
forewing colour	wings hyaline with dark brown venation, slight fuscous tinting of membrane at pterostigma, anal veins pale (Tillyard 1936) glassy clear with dark brown venation (Scholes 1961) pterostigmal region slightly tinged with brown, (Suter 1986)	membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins brown, anal veins yellow
costal crossveins – proximal	6, faint (Tillyard 1936) 3-7 ,faint (Suter 1986) 5, faint – holotype	0-5 faint
costal crossveins – distal	10 (Tillyard 1936) 14 (Suter 1986), holotype	7-14
subcostal crossveins proximal	5 – holotype 2-4 (Suter 1986)	0-5 faint
subcostal crossveins – distal	more numerous than costal crossveins (Tillyard 1936) 7-10 (Suter 1986) 11- holotype	6-13
bullae	3 on Sc, R_2, R_{4+5}(Tillyard 1936)	3 on Sc, R_2, R_{4+5}
MA fork	about half (Tillyard 1936, Suter 1986), holotype	half to just over half

Table 7 cont'd.

	Nousia (Australonousia) fuscula	newly described *Nousia (Australonousia) fusca*
MP_2 connected to MP_1 and CuA	yes (Tillyard 1936, Suter 1986), holotype	yes
CuA-CuP crossvein	yes (Tillyard 1936, Suter 1986), holotype	yes
ICu_1 and ICu_2	parallel (Tillyard 1936, Suter 1986), holotype	parallel
ICu_1 joins CuA	yes (Tillyard 1936, Suter 1986), holotype	yes
ICu_1 linked to CuA-CuP crossvein	no (Tillyard 1936, Suter 1986)	no
ICu_2 recurved to join ICu_1	yes (Tillyard 1936, Suter 1986)	yes
CuP linked to A_1	yes (Tillyard 1936, Suter 1986, holotype	yes
hindwing – length at which costa joins subcosta	four fifths (Tillyard 1936, Suter 1986)	three-quarters to four-fifths
costal crossveins	4 (Tillyard 1936), holotype 3-4 (Suter 1986)	2-5
subcostal crossveins	4 (Tillyard 1936) 4-6 (Suter 1986) 5 – holotype	3-5
abdomen colour	black, marked with a pattern of dark brown and black (Tillyard 1936) shiny black, marked with dark brown beneath towards the centre, (Scholes 1961) black with brown and light brown markings (Suter 1986)	tan to dark brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly pattern variable
forceps	3 segmented (Tillyard 1936)	3 segmented
Female Imago		
body length	larger than male (Tillyard 1936, Scholes 1961, Suter 1986)	6.1-9.0 (7.6±0.74, 62), larger than male

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Table 7 cont'd.

	Nousia (Australonousia) fuscula	newly described *Nousia (Australonousia) fusca*
forewing length	8 (Tillyard 1936)	5.8-9.6 (7.7±0.73, *63*)
hindwing length	longer than male (Tillyard 1936), (Scholes 1961)	0.99-1.72 (1.26±0.14, *62*)
hindwing crossveins	more than male (Tillyard 1936), (Suter 1986)	C 3-5, Sc 3-6
sternum nine	deep V shaped incision, (Suter 1986)	deeply cleft
Egg		
general shape	ovoid	ovoid
Subimago		
body colour	dull black (Tillyard 1936), (Suter 1986)	dull greyish black
wing colour	almost black (Tillyard 1936) opaque, dark grey (Suter 1986)	grey-brown
Nymph		
body length	7-8 (Tillyard 1936, Scholes 1961)	♂5.8-9.6 (7.5±0.87, *63*) ♀ 6.0-10.0 (7.9±0.87, *81*)
male eye colour	grey black (Tillyard 1936, Scholes 1961) reddish brown (Suter 1986)	upper lobes – russet to dark brown, lower lobes black
antennae colour	pale greyish (Tillyard 1936, Scholes 1961)	golden to tan brown
labrum	slight antero-median emargination (Tillyard 1936, Suter 1986)	no apparent or slight anteromedian emargination
labrum length width ratio	2 times wider than long (Suter 1986)	1.71-2.23 (1.99±0.12, *101*) times wider than long
labrum denticles	4-6 rounded denticles (Suter 1986)	5
left mandible	incisors with 3 apical teeth (Suter 1986)	teeth 3,3
right mandible	outer incisors with 3 apical teeth, inner incisors with 2 teeth (Suter 986)	teeth 3,2
maxillae galea-lacinae length width ratio	short and broad (Tillyard 1936) galea-lacinae appears as wide as long (Suter 1986)	0.90-1.11 (0.99±0.06, *25*)
thorax	dark brown, mesonotum with two yellowish brown marks above apex, apex itself tipped with blackish (Tillyard 1936) chiefly dark brown (Scholes 1961)	golden to tan brown with darker markings

Table 7 cont'd.

	Nousia (Australonousia) fuscula	newly described Nousia (Australonousia) fusca
leg colour	medium brown, semi-transparent, femora with dark line along dorsal ridge, apex fuscous (Tillyard 1936) brown, not banded (Suter 1986)	golden to tan brown, femora apices usually darker, no apparent banding
fore femur length to width ratio	2.74 (Suter 1986)	2.51-4.11 (2.86±0.20, 87)
abdomen	black above with a mid longitudinal row of pale yellowish brown markings (Tillyard 1936) colour pattern irregular (Suter 1986)	tan to dark brown with golden markings on each segment forming a broken stripe midline, generally with two golden coloured maculae flanking each midline marking anteriorly, pattern highly variable
gill shape	double, seven pairs, on segments 1-7, narrowly lanceolate and end in a long slender filament (Tillyard 1936) linear (Suter 1986)	double on segment 1-7 tapering to a thin point apically
gill colour	pale, semi-transparent brownish (Tillyard 1936) pale (Scholes 1961)	clear to pink
gill tracheae	main and lateral branches apparent (Tillyard 1936) main branch apparent, linear branches faint(Suter 1986)	main and lateral tracheae strongly or poorly developed

Table 8. Discrepancies between the literature descriptions and measurements of *Nousia (Australonousia) fuscula* and *Nousia (Australonousia) fusca* showing outcomes of t-tests comparing the two species where measurements were available.

	Nousia (Australonousia) fuscula	newly described *Nousia (Australonousia) fusca*	Sig.
Male Imago			
body length	7.8 (Tillyard 1936) 8 (Scholes 1961) 5.82-7.01 (6.58±0.32, 23) (Suter 1986) 7.3 – holotype	5.8-9.0 (7.3±0.68, *58*)	***
forewing length	7-8mm (Tillyard 1936, Scholes 1961) 5.90-6.97 (6.41±0.28, 22) (Suter 1986) 7.6 – holotype	6.0-8.6 (7.2±0.59, *59*)	***
eye colour – upper	brown-grey (Suter 1986)	pink to red to tan brown	
penes shape	turned upwards; lobes separate, cylindrical; irregularly truncated at apex which is divided into 2 blunt lobes with a third lobe arising on the inner side and not reaching the level of the apex, inner lobe carries a small blunt triangular tooth (Tillyard 1936); lobes widely separated, cylindrical, constricted near apex, apex rounded, lobes apparently sheathed, inner margin with a small spine hidden within sheath visible in mounted preparation using transmitted light but not in the scanning electron micrographs (Suter 1986)	fused in basal two-thirds, two lobes distinct, in dorsal view two subapical lobes protruding laterally towards midline; each lobe with a small blunt triangular tooth apparent, generally visible only under transmitted light;	
leg colour	chiefly black, hind femora mostly dark brown (Tillyard 1936); chiefly black (Scholes 1961); forelegs black, middle and hind legs brown, no banding (Suter 1986)	golden to tan or dark brown, femora apices darker, no apparent banding	

Table 8 cont'd.

	Nousia (Australonousia) fuscula	newly described *Nousia (Australonousia) fusca*	Sig.
foreleg length	6.5mm (Tillyard 1936) 5-6 mm (Scholes 1961) 6.2 mm (Suter 1986)	5.8-8.9 (7.3±0.94, *37*)	
foreleg leg length ratio	1.00: 1.29: 0.14: 0.49: 0.44: 0.28: 0.16 (1.64) (Suter 1986)	1.00: 1.35: 0.06: 0.53: 0.50: 0.37: 0.16 (1.8±0.19, *37*)	
tail filament length	subequal, 10 (Tillyard 1936, Scholes 1961) cerci - 9.23-11.11 (10.32±0.62, *12*) (Suter 1986) terminal filament 10.77-13.00 (11.67±0.76, *8*)) (Suter 1986)	terminal filament longer than cerci	
tail filament colour	dark fuscous (Tillyard 1936) blackish (Scholes 1961)	golden to brown	
Female Imago			
sternum seven	no ovipositor (Suter 1986)	small genital extension	
Egg			
chorion	polar cap with three rings of tubular processes, chorion with small circular tubules regularly placed over surface.	polar cap absent, chorion with large evenly spaced circular shaped protuberances	
Nymph			
head width	1.36-1.50 (1.44±0.06, *6*) (Suter 1986)	1.25-1.82 (1.53±0.11, *83*)	**
general colour	black (Tillyard 1936) blackish (Scholes 1961)	golden to tan brown with darker markings	
head colour	blackish with dark brown (Tillyard 1936, Scholes 1961) dark brown (Suter 1986)	tan brown	
maxillae palp ratios	1.00: 0.71: 0.78 (0.21) (Suter 1986)	1.00: 0.77: 0.71 (0.24±0.03, *50*)	
labium palp length ratios	1.00: 0.71: 0.69 (0.29) (Suter 1986)	1.00: 0.77: 0.63 (0.36±0.04, *50*)	
total foreleg length	2.86 (Suter 1986)	2.45-4.98 (3.31±0.49, *87*)	
foreleg	1.00: 0.87: 0.55 (1.18) (Suter 1986)	1.00: 0.85: 0.44 (1.43±0.21, *87*)	
midleg	1.00: 0.84: 0.39 (1.19) (Suter 1986)	1.00: 0.86: 0.35 (1.51±0.26, *60*),	
hindleg	1.00: 0.91: 0.38 (1.40) (Suter 1986)	1.00: 0.91: 0.31 (1.74±0.28, *60*).	

I do not feel there is enough evidence to conclude that these two taxa are definitely different species. On the other hand, I consider there is insufficient evidence to consider them conspecific. A major concern is the lack of specimens for comparison. As a result, I believe I have not been able to determine the correct morphology of the male genitalia and egg. I consider the best option is to leave the two as separate species until more specimens can be examined.

Nousia (Australonousia) fuscula can be distinguished from all other species in the subgenus by the following combination of characters. In the imago: (i) body colour generally dark, brown to black, abdomen colour black with light markings on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking; (ii) leg banding absent; (iii) hindwing costa joins subcosta at four fifths wing length; (iv) penes with indistinct subapical lobes; (v) female sternum nine deeply cleft. In the nymph: (i) general body colour dark, brown to black, abdomen colour variable but usually black with light markings on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum subequal to very slightly wider than clypeus, lateral margins rounded; antero-median emargination slight bearing four to six triangular denticles extending less than one-third the width of labrum; frontal setae arranged as a narrow band, secondary hair fringe clearly separated from front band; (iv) mandible incisors with no serrations on lateral margins, no subapical processes; left mandible prostheca robust, moderately serrated; right mandible prostheca simple, slender; (v) maxillae with 15 subpectinate setae; (vi) hypopharynx deeply cleft, superlingua with rounded lateral margins; (vii) leg banding absent; (viii) fore tarsi with 13 ventral spines, fore tarsal claws with 11 ventral teeth; (ix) gills pale, slightly opaque; slender, tapering to a thin point apically; tracheae strongly developed.

Other specimens examined. SOUTH AUSTRALIA. Tookayerta Creek: TI AS1, 84120501, 5 XII 1984, 62 ♂ N, 89 ♀ N, (most immature); **N7 AS1,** 84120502, 5 XII 1984, 10 ♂ N, 11 ♀ N, (most immature); **S7 ASI,** 84120503, 5 XII 1984, 7 ♂ N, 10 ♀ N; **S7 AS2,** 84120504, 5 XII 1984, 8 ♂ N, 11 ♀ N, (many immature); **S5,** 85012300, 23 I 1985, 14 ♂ N, 23 ♀ N; **S5 AS3,** 85030600, 6 III 1985, 4 ♂ N, 7 ♀ N, (most immature); **S5, Cleland Gully Rd,** location 3956, 95051200, 12 IV 1995, 2 ♂ N, 1 ♀ N; (PS). Held at the AWQC. **TASMANIA. North Esk River,** near Perth, 60011800, 18 I 1960, 2 ♂ I, 2 ♀ I. (DS), det. E.F. Riek 1960. Held at the ANIC.

3.3.2.5 *Nousia (Australonousia) nigeli* sp. nov.

Nousia sp. "AV2" (Dean 1999)

Nousia (Australonousia) nigeli sp. nov.

Types. *Nousia (Australonousia) nigeli* sp. nov. **Holotype.** Taggerty River, Lady Talbot Drive, outside Marysville, Victoria (Fig. 116) 98101704, 400 m, 145°46'28" 37°30'20 ", 17 X 1988, 1 ♂ NSI (reared) (KJF). **Paratypes.** Taggerty River, 98101704, locality data as above, 17 X 1988, 1 ♂ NSI (reared) (KJF). Donnelly Creek, Donnelly Weir Rd, 97040604, 140m, 145°32'03" 37°37'30", 6 IV 1997, 1 ♀ NSI (reared) (KJF).

Distribution. New South Wales, Victoria, Queensland (Fig. 117).

Diagnosis. Male imago. Dimensions: body length 7.0-8.6 (7.5±0.52, *10*); forewing length 6.9-8.5 (7.6±0.50, *10*); hindwing length 1.13-1.55 (1.27±0.13, *12*); forewing hindwing ratio 5.03-6.89 (5.99±0.60, *10*). General body colour chocolate brown to black. Head black. Antennae: pedicel and scape dark brown; flagellum light brown. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, almost contiguous, ES=0.09-0.15 (0.11±0.02, *10*); upper lobes orange-brown, lower lobes grey-black. Thorax: pronotum black; mesonotum shiny dark brown to black. Legs: femora yellow to tan brown with very dark brown to black markings giving a banded appearance; fore tibia dark brown, middle and hind tibiae yellow; all other segments yellow; forelegs with seven segments, total foreleg length 6.05-7.35 (6.54±0.55, *7*); leg length ratios 1.00: 1.48: 0.07: 0.47: 0.44: 0.33: 0.15 (1.66±0.10, *7*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 118). Wings. Forewing (Fig. 119): membrane hyaline, pterostigmal area slightly opaque, longitudinal and crossveins brown, anal veins yellow; costal and subcostal crossveins absent, or if present very faint, in proximal halves of wing, costal space with 0-5 (*10*) faint crossveins proximally, 7-13 (*10*) distally (often some faint, some anastomosed), subcostal space with 0-4 (*10*) faint crossveins proximally, 9-11 (*10*) distally (some faint). Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join IC u_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing (Fig. 120): mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal halves of costal space, 3-4 (*10*) in distal space, 3-6 (*10*) crossveins throughout subcostal space. Abdomen: dark brown to black with golden markings on each segment forming a broken

stripe midline, two golden coloured maculae flanking each midline marking anteriorly (Fig. 121), pattern variable. Genitalia (Figs 122-126): forceps three segmented; first segment brown, progressively lighter apically; terminal segment rounded, about the same length as middle segment; penes dark brown, fused along at least two-thirds length in dorsal (Fig. 122, 124) and ventral (Fig. 123, 125) view; not extending beyond length of forceps; apical lobes with shallow concavity; two subapical lobes apparent in dorsal view (Fig. 122, 124), protruding laterally towards midline, each lobe with a small blunt triangular tooth apparent, generally visible only under transmitted light. Caudal filaments: three; brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length 6.6-10.1 (8.1±1.2, *10*); forewing length 7.6-10.4 (8.6±0.76, *10*); hindwing length 1.20-1.38 (1.28±0.06); forewing hindwing ratio 6.08-7.54 (6.73±0.44, *10*). General patterning and colouring similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male; forelegs with six segments, total foreleg length 4.62-5.34 (5.07±0.23, *10*); leg length ratios 1.00: 1.37: 0.18: 0.16: 0.15: 0.14 (1.69±0.09, *10*). Wings. Forewing (Fig. 127): colour and venation similar to male except crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 4-6 (*10*) crossveins proximally (some anastomosed), 12-18 (*10*) distally, subcostal space with 3-5 (*10*) crossveins proximally, 10-14 (*10*) distally. Hindwing (Fig. 128): no crossveins in proximal halves of costal space, 3-4 (*10*) in distal space, 4-6 (*10*) crossveins throughout subcostal space. Abdomen: sternum seven with small genital extension, sternum nine moderately cleft (Figs. 129). **Egg.** Ovoid; polar cap absent; egg chorion with similarly shaped, circular protuberances medially, surrounded by interlocking polygons which cover the whole surface (Figs. 130, 131). **Male and female subimago.** Body lengths: ♂ 6.4-7.2 (6.7±0.38, *4*), ♀ 6.6-9.9 (8.1±1.2, *7*). Colour and markings similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Figs. 132, 133). Body lengths: ♂ 7.2-8.2 (7.7±0.39, *12*), ♀ 8.3-10.0 (8.9±0.49, *15*). General colour dark brown with light markings. Head: prognathous; dark brown with darker brown wash between ocelli; width 1.48-1.78 (1.61±0.10, *11*). Ocelli: three; black with white inserts; laterals larger than medial. Antennae: pedicel and scape dark brown, flagellum golden; approximately one and a half times length of head. Eyes: upper lobes of male reddish-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 134): lateral margins of clypeus straight or slightly diverging towards anterior; lateral margins of labrum slightly wider than clypeus, rounded; anterior margin of labrum with straight antero-median emargination; labrum length 0.25-0.39 (0.34±0.04, *20*), labrum width 0.66-0.89 (0.77±0.07, *20*), labrum width length ratio 2.11-2.72 (2.29±0.15, *20*); five flat elongate denticles present extending 0.24-0.34 (0.30±0.05, *11*) across labrum, denticle width as proportion of labrum width 0.33-0.51 (0.39±0.08, *11*); frontal setae arranged as a broad band, secondary hair fringe abuts broad band.

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Mandibles: outer margins slightly curved, sparse long setae at midpoint on outer lateral margins, shorter setae along margin between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 135): two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin; prostheca robust, distinctly serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 136): sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 137): galea-lacinae about as wide as long, width length ratio 0.84-1.00 (0.95±0.05, 10); subapical row of 13-16 (10) pectinate setae; palpi three segmented; terminal palp with single spine apically; palp length ratios 1.00: 0.69: 0.63 (0.22±0.02, 10). Hypopharynx (Fig. 138): well developed lateral processes; anterior margin of lingua deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 139): glossae not turned under ventrally and lying in the same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with ring of triangular spines circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.81: 0.55 (0.35±0.03, 10); submentum with spines on lateral margins. Thorax: tan to dark brown with darker chocolate brown markings; pronotum width 1.38-1.73 (1.53±0.13, 11), approximately equal to width of head (see above), head pronotum width ratio 0.89-1.06 (0.95±0.06, 11). Legs (Fig. 140): tan brown with chocolate brown markings across femora, tibiae and tarsus giving a banded appearance; fore femora length 1.15-1.55 (1.37±0.14, 13), fore femora width 0.44-0.63 (0.56±0.07, 13), fore femora length width ratio 2.19-2.70 (2.45±0.14, 13); fore tarsi with 6-8 (10) ventral spines; tarsal claws with 10-14 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated (Fig. 141); total foreleg length 2.66-3.53 (3.12±0.28, 13); leg length ratios, foreleg 1.00: 0.89: 0.40 (1.37±0.14, 13), midleg 1.00: 0.82: 0.31 (1.51±0.14, 13), hindleg 1.00: 0.83: 0.28 (1.79±0.16, 13). Abdomen: dark chocolate brown to black with yellow to light brown markings medially on each segment forming a broken stripe midline, two light coloured maculae flanking each midline markings anteriorly; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 142): membrane opaque, grey to black; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed, each gill slender, tapered to a thin point apically; main tracheal branch just apparent, lateral tracheae poorly to moderately well developed. Caudal filaments: three; yellow, darkened apically at each segment giving banded appearance; terminal filament longer than cerci.

Etymology. The species epithet is named for Nigel Ainsworth who was of significant help with field work and general support throughout the project.

Remarks. The nymph of this species has been known for some time but has remained undescribed. It has variously been referred to *Atalonella* "sp. 2" or *Atalonella* "sp. E", MMBW "sp. 2", *Nousia* "sp. 2", *Atalophlebioides* " sp. B", *Atalophlebioides* "sp. D" and Dartmouth "sp. 8A" in voucher collections held at various institutions throughout the state. It is listed as *Nousia* sp. "AV2" in the most recent publication (Dean 1999).

Nousia (Australonousia) nigeli can be distinguished from all other species in the subgenus by the following combination of characters. In the imago: (i) general body colour chocolate brown to black, (ii) male upper eye size large, never contiguous; (iii) thorax often shiny brow n to black; (iv) leg banding present; (v) hindwing costa joins subcosta at three-quarters wing length; (vi) abdomen colour chocolate brown to black with golden coloured markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking; (vii) penes with subapical lobes; (viii) female sternum nine moderately cleft: (ix) egg chorion with similarly shaped, circular protuberances medially, surrounded by interlocking polygons which cover the whole surface . In the nymph: (i) antennal length one and a half times length of head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum slightly wider than clypeus; more than twice as long as wide; lateral margins rounded; antero-median emargination straight bearing five rounded denticles, denticles extend two-fifths the width of the labrum on average; frontal setae arranged as a broad band secondary hair fringe abutts front band; (iv) mandibles with no subapical processes on incisors, outer incisors inconspicuously serrated on inner margin; (v) maxillae with 13-16 subpectinate setae; (vi) hypopharynx deeply cleft, superlingua with rounded lateral margins; (vii) leg banding present; (viii) fore femora 2.5 times longer than wide; fore tarsi with 6-8 ventral spines; fore tarsal claws with 10-14 ventral teeth; (ix) abdomen dark chocolate brown to black with yellow to light brown markings medially on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking anteriorly; (x) gills grey-black, opaque, slender, tapering to a thin point apically, tracheae poorly to moderately well developed.

Specimens examined. NEW SOUTH WALES. Boonoo Boonoo River tributary, 83052000, 20 V 1983, EPH 1670, 3♂ N, (DC). **Diggers Creek,** Summit Rd near Stonehenge, Kosciusko National Park, 97120201, 02 XII 1997, 1500m, 148°29' 36°22', 1 ♀ N (KJF). **Friday Flat Creek tributary,** near Thredbo, 84011900, 19 I 1984, 1380m, 148°19'29" 36°30'02", EPH 1675, 1 ♂ N, 1 ♀ N (JD). **Leather Barrell Creek,** Alpine Way, Kosciusko National Park, 97120205, 02 XII 1997, 1000m, 148°11' 36°31', 2 ♂ N, 2 ♀ N (KJF). **Murray River tributary,** Tom Groggin Picnic Area, Kosciusko National Park, 80102400, 24 X 1980, EPH 1650, 1 ♂ N, 3 ♀ N (DC). **No 1 Creek,** 6kms downstream Thredbo, 78121401, 14 XII 1978, 1260m, 148°23' 36°28', EPH 1679, 6 ♂ N, 4 ♀ N (JD). **Swampy Plains River,** Alpine Way, Kosciusko National Park, 97120206, 2 XII 1997, 420m, 148°10' 36°23', 2 ♀ N (KJF). **Thredbo River,** Thredbo Golf Course, 84012501, 25 I 1984, 1380m, 148°18' 36°30', EPH 1656, 5 ♂ N, 4 ♀ N (JD). **QUEENSLAND. Blackfellows Falls,** Springbrook, Warrie National Park, 79120601, 6 XII 1979, 770m, 153°16' 28°13', EPH 1692, 1 ♂ N, 3 ♀ N (DC). **Branch Creek,** Conondale Ranges, 88070900, 9 VII 1988, 160m, 152°43' 26°53', EPH 1689, 1 ♀ N (SB). **Upstream Falls,** Natural Bridge National Park, 79120602, 6 XII 1979, 800m, 153°14' 28°15', EPH 1791, 1 ♀ N (DC). **VICTORIA. Acheron River,** Granton Rd, 98021505, 15 II 1998, 390m, 145°41'27" 37°34'42", 1♂ NS (reared, sub em 2 III 1999), 1 ♀ N (KJF). **Badger Creek,** junction of Badger Creek Rd and Bluegum Drive, 97040602, 6 IV 1997, 130m, 145°32'11" 37°41'02", 1 ♀ N (KJF). **Badger Creek** downstream weir, 80011801, 18 I 1980, 280m, 145°34' 37°41', EPH 1582, 1 ♂ NSI (reared), (JD). **Bluff Creek,** 11.7 km up Mt Stirling Rd, 81110201, 2 XI 1981, 1310m, 146°28' 37°07', EPH 1742, 1 ♂ N, 1 ♀ N (JD). **Bogong Jack Creek,** West Kiewa Logging Rd, 97110602, 6 XI 1997, 1070m, 147°10'12" 36°49'59", 1 ♀ N, 1 ♀ NS (reared, sub em 10 XI 1997) (KJF). **Bonang River,** Bonang Rd, N of Bonang, 99021308, 13 II 1999, 640m, 148°43' 37°09', 1 ♀ N (KJF). **Brandy Creek,** Great Alpine Rd, 96111902, 19 XI 1996, 1560m, 147°11'22" 37°00'55", 1♂N (KJF); 97011902, 19 I 1997, same locality data, 2 ♀ N (KJF). **Brodribb River,** Bonang Rd, 16kms N of Malinns, 99021305, 13 II 1999, 100m, 148°32' 37°30', 1 ♀ N (KJF). **Bull Creek,** Bull Creek Rd, 96113003, 30 XI 1996, 360m, 145°35'39" 37°28'31", 1 ♂ N, 1 ♀ N (KJF). **Bull Creek tributary,** W of Yea Rock, 450m, 96113004, 30 XI 1996, 145°35'14" 37°27'07", 1 ♂ NS , 1 ♂ N (KJF). **Cement Creek,** Mount Donna Buang Rd, 76102101, 21 X 1976, 670m, 145°42'20" 37°42'48", EPH 1583, 1 ♀ NI (reared), (JD); 98030503, 5 III 1998, same locality data, 1 ♂ NSI (reared), (KJF); 00022601, 26 II 2000, same locality data, 1 ♀ N (KJF). **Charity Creek tributary,** Mt Baw Baw Tourist Rd, 99021602, 16 II 1999, 1180m, 146°15'15" 37°50'47", 1 ♀ N, 1 ♂ N (KJF). **Clearwater Creek,** Bogong High Plains Rd, 96111003, 10 XI 1996, 1410m, 147°21'10" 36°57'10", 2 ♀ N (KJF). **Coranderrk Creek,** Badger Weir Rd, 98030502, 5 III 1998, 240m,

145°34'16" 37°41'07", 1 ♀ NSI, 2 ♀ N, 1 ♂ N, 2 ♀ N (KJF). **Deep Creek,** Benambra-Corryong Rd, 11kms N of Uplands, 99021501, 15 II 1999, 620m, 147°42' 36°49', 2 ♂ N, 4 ♀ N (KJF). **Eurobin Creek,** Mt Buffalo Rd, Mt Buffalo National Park, 96110702, 7 XI 1996, 440m, 146°50'29" 36°43'10", 1 ♂ N, 2 ♀ N (KJF). **Faith Creek,** Tanjil Bren Rd, 96101205, 12 X 1996, 540m, 146°14' 37°52'20", 1 ♀ N, 1 ♂ N (KJF). **Falls Creek,** Telephone Box Junction, Mt Stirling Rd, 81110203, 2 X! 1981, 1220m, 146°27' 37°06', EPH 1572, 1 ♀N, (JD); EPH 1574, 2♂ N, (JD). **First Creek,** Warburton-Jamieson Rd, 85120700, 7 XII 1985, 750m, 145°58'10" 37°25'25", EPH 1733, 1 ♀N, (JD). **German Creek,** Bright-Tawonga Rd, 96110901, 9 XI 1996, 440m, 147°03'25" 36°43'58", 5 ♂ N, 4 ♀ N (KJF). **Gibbo River,** Benambra-Corryong Rd, 99021502, 15 II 1999, 500m, 147°42' 36°45', 2 ♀ N (KJF). **Growlers Creek,** Williams Rd Camp Site, Wandiligong, 96110801, 8 XI 1996, 380m, 146°59'10" 36°45'54", 1 ♂ N, 7 ♀ N (KJF); 97110801, 8 XI 1997, same locality data, 1 ♀ N, 1 ♀ NS (reared), (KJF). **Haunted Stream,** Great Alpine Rd, 99021409, 14 II 1999, 180m, 147°49' 37°28', 4 ♂ N, 5 ♀ N (KJF). **Hensleigh Creek,** Combienbar Rd Ford, 98012505, 25 I 1998, 240m, 149°01'08" 37°21'36", 1 ♀ NSI (reared), 1 ♂ NSI (reared, sub em 29 I 1998, im em 30 I 1998), 1 ♂ N, 2 ♀ N (KJF). **Hope Creek,** Tanjil Bren Rd, 96101204, 12 X 1996, 550m, 146°14'03" 37°51'55", 1 ♂ N (KJF). **Kiewa River west branch,** Blairs Hut, 97021901, 19 II 1997, 120m, 147°10'36°55'16", 1 ♂ N (KJF). **King Parrot Creek,** Whittlesea Yea Rd, 15km SW of Flowerdale, 98030501, 05 III 1998, 350m, 147°14'48" 37°25'00", 1 ♀ NSI (reared, sub em 12 III 1998, im em 13 III 1998), 1 ♀ NI (reared, im em ; 13 III 1997), 2 ♀ N; 1 ♀ NSI (reared, imago em 16 III 1998) (KJF). **La Trobe River,** Big Creek Basin Rd, 5km E of Powelltown, 96101002, 10 X 1996, 320m, 145°50'10" 37°52'35", 2 ♂ N (KJF). **Lawler Springs,** Bright-Tawonga Rd, 96110902, 09 XI 1996, 760m, 147°07'47" 36°43'30", 2 ♂ I, 2 ♂ N, 3♀N (KJF). **Learmonth Creek,** Yarra Junction-Neerim Rd, Powelltown, 96101001, 10 X 1996, 180m, 145°44'33" 37°51'43", 3 ♂ N (KJF). **Little River,** Maroondah Highway, outside Taggerty, 77122200, 22 XI 1977, 210m, 145°42'40" 37°19'25", EPH 1651, 2 ♂ N, 7 ♀N, (JD); 98101702, 17 X 1998, same locality data, 1 ♀ NS (reared, sub em 21 X 1998) (KJF). **Little Toorongo Falls,** Toorongo Falls, Toorongo Falls Rd, 98020901, 09 II 1998, 420m, 146°02'55" 37°50'58", 2 ♂ NI (reared), 1 ♀ N (KJF). **Loch River,** Loch River Rd, 1st bridge from Noojee, 98020903, 9 II 1998, 290m, 145°59'40" 37°50'53", 1 ♂ NSI (reared, im em 16 II 1998), 1 ♂ NSI (reared, sub em 17 II 1998, im em 18 II 1998), 1 ♀ N (KJF). **Menzies Creek,** Butterfield Wildlife Reserve, Emerald-Mcnbulk Rd, 97032403, 24 III 1997, 160m, 145°26'22" 37°53'47", 1 ♀ N (KJF). **Middle Creek,** Omeo Highway, 96111004, 10 XI 1996, 700m, 147°27'50" 37°55'19", 700m, 7 ♂ N, 9 ♀ N (KJF). **Mitta Mitta River,** Omeo Valley Rd, 99021503, 15 II 1999, 540m, 147°36' 36°56', 1 ♂ N, 2 ♀ N (KJF). **Mountain Creek,** 7km E of Tawonga South,

90110300, 3 XI 1990, 510m, 147°14' 36°42', EPH 1584, 7 ♂ N, 12 ♀ N, (DC). **Myrtle Gully**, Sylvia Creek Rd, Toolangi State Forest, 96112901, 29 XI 1996, 620m, 145°31'44" 37°31'44", 1 ♂ N (KJF). **Myrtle Creek**, Donna-Buang Rd, 00031901, 19 III 2000, 780m, 145°36'42" 37°42'35", 2 ♀ N (KJF). **O'Shannassy River**, (access restricted), 75111400, 14 XI 1975, 580m, 145°49' 37°36', EPH 1570, 1 ♀ N, (JD); 76121502, 15 XII 1976, same locality data, EPH 1567, 1 ♂ N (JD), EPH 1581, 3 ♀N, (JD); 80010401, 4 I 1980, same locality data, EPH 1568, 1 ♂ NI (reared), (JD), EPH 1569, 1 ♂ NI, reared (JD), EPH 1577, 1 ♀NI (reared), (JD). **Ovens River tributary**, upstream Harrietville, 82091000, 10 IX 1982: 540m, 147°00'0" 36°54'15", EPH 1571, 1 ♀ N (JD), EPH 1579, 1 ♂ N, 2 ♀ N, (JD). **Pioneer Creek**, Bennetts Track, Tarago-La Trobe State Forest, 96101003, 10 X 1996, 330m, 145°49'47" 37°53'01", 1 ♀ N (KJF). **Pretty Valley Creek**, Bogong High Plains Rd, 1.5km S of Bogong, 96110904, 9 XI 1996, 740 m, 147°13'20" 36°49'10", 2 ♀ N (KJF). **Running Creek**, Warburton- Jamieson Rd, 81103102, 31 X 1981, 750m, 145°58'10" 37°21'42", EPH 1580, 2 ♀ N, (JD). **Rubicon River**, Rubicon Bridge, Taggerty-Thornton Rd, 98101701, 17 X 1998, 220m, 145°47'56" 37°16'56", 1 ♀ NS (reared, sub em 28 X 1998), 1 ♀ N (KJF). **Rubicon River**, Rubicon Falls, 80112001, 20 XI 1980, 560m, 145°51'02", 37°20'29", EPH 1648, 2 ♀ N, (JD). **Russell Creek**, off Gunn Rd, 3km N of Noojee, 96101005, 10 X 1996, 280m, 145°59'26" 37°50'45", 1 ♀ N (KJF). **Sandy Creek**, Murrindindi Falls, 96112903, 29 XI 1996, 390 m, 145°34'27" 37°26'27", 1 ♂ N (KJF). **Sassafras Creek**, Monbulk-Olinda Rd, 96101302, 13 X 1996, 320m, 145°22'18" 37°52'46"; 2 ♂ N, 1 ♀ N, 96112101, 21 XI 1996, same locality data, 1 ♀ NS (reared), 1 ♀ NSI (reared), (KJF). **Sassafras Creek**, Kay's Picnic Ground, Monbulk Rd, 96101303, 13 X 1996, 250m, 145°23'21" 37°53'03", 3 ♀ N (KJF); 97032402, 24 III 1997, same locality data, 1 ♀ N, 1 ♀ NS (reared), (KJF). **Sassafras Creek**, Perrins Creek Rd, 97101502, 15 X 1997, 370m, 145°22' 37°52'46", 2 ♂ N (KJF). **Shicer Creek**, West Ovens Track, Bonang National Park, 96110802, 8 XI 1996, 580m, 147°02'30" 37°55'20", 2 ♀ N (KJF). **Snobs Creek**, Snobs Rd crossing, 81103103, 31 X 1981, 760m, 145°54'38" 37°21'00", EPH 1573, 1 ♀ N (JD); EPH 1585, 4 ♂ N, 10 ♀ N (JD). **Starvation Creek**, upstream weir, 77120901, 9 XII 1977, 340m, 145°50'53" 37°45'39", EPH 1566, 1 ♂ N (JD); EPH 1578, 4 ♂ N, 3 ♀ N (JD). **Steavensons River**, Marysville Rd, 98101703, 17 X 1998, 320m, 145°44'01" 37°28'32", 1 ♂ N (KJF). **Steavensons River**, Buxton-Marysville Rd, 98021504, 15 II 1998, 460m, 145°45'02" 37°28'53", 1 ♂ NSI (reared), 1 ♀ NSI (reared, sub em 17 II 1998, im em 18 II 1998), 1 ♀ NSI (reared, sub em 19 II 1998, im em 20 II 1998), 1 ♀ NS (reared, sub em 19 II 1998), 4 ♂ N, 1 ♀ N (KJF). **Suggan Buggan River**, Snowy River Rd, Suggan Buggan, 99021406, 14 II 1999, 390m, 148°19' 36°57', 1 ♀ N (KJF). **Swindlers Creek**, 6km from Mt Loch Car Park, off Australian Alps walking track, Mt Hotham, 96111903, 19 XI 1996, 1640m, 147°09'40"

36°58'42", 8 ♀ N (KJF). **Taggerty River**, 98101704, 17 X 1998, locality data as per
types, 1 ♂ NSI (reared, sub em 21 X 1998, im em 22 X 1998), 1 ♂ NI, 12 ♂ N, 4 ♀ N
(KJF). **Taggerty River headwaters**, Royston Gap Rd, Lake Mountain, 96102501, 25 X
1996, 1320m, 145°52'35" 37°29'39", 1 ♀ N (immature) (KJF). **Talbot Creek**,
downstream Thomson River Reservoir, 86040900, 9 IV 1986, 700m, 147°22'20"
37°50'52", EPH 1753, 1 ♀ N, (DC). **Tanjil River east branch tributary**, Mt Baw Baw
Tourist Rd, 96101104, 11 X 1996, 500m, 146°11'29" 37°49'58", 5 ♀ N (KJF). **Taponga
River**, Eildon-Jamieson Rd, 99022008, 20 II 1999, 320m, 146°02'50" 37°22'42", 2 ♂ N, 2
♀ N (KJF). **Tarra River**, Tarra Bulga National Park, 84010900, 9 I 1984, 340m,
146°32'13" 38°26'57", EPH 1716, 1♂ N, (JD); 98112101, 21 XI 1998, same locality data,
1 ♀ NSI (reared, sub em 30 II 1998, im em 1 XII 1998), 1 ♀ NS (reared, 23 II 1998), 1 ♀
N (KJF); **Tarra River**, Tarra Bulga National Park, 99021601, 16 II 1999, 340m,
146°32'15" 38°27'00", 3 ♀ N (KJF). **Toorongo River**, 5km NE of Noojee, 96101102, 11
X 1996, 280m, 146°02'29" 37°51'17", 1 ♀ N (KJF). **Unnamed tributary of Tanjil River
east branch – 'Rubbish Tip'**, Mt Baw Baw Tourist Rd, 96101206, 12 X 1996, 620m,
146°13'00" 37°50'38", 1 ♀ N (KJF). **William Wallace Creek,** Triangle Link Rd,
Gembrook Park, 97012901, 29 I 1997, 150m, 145°35'38" 37°59'03", 2 ♀ NSI (reared),
1♀ NI (reared), 1♀NS (reared), 2 ♀ N (KJF).

3.3.2.6 *Nousia (Australonousia) wiltkorringae* Finlay

see Chapter 4

3.3.2.7 *Nousia (Australonousia)* sp. "AV5"

Nousia sp. "AV5" (Dean 1999)

Distribution. Tasmania (Fig. 143).

Diagnosis. Male imago. Unknown. **Female Imago.** Unknown. **Egg.** Unknown. **Male and female subimago.** Unknown. **Mature nymph.** (Fig. 144). Body lengths: body length ♂ 7.3-9.3 (8.3±0.70, *10*); ♀ 8.3-9.0 (8.4±0.36, *7*). General colour golden to tan brown with light and dark markings. Head: prognathous; golden brown, darker anteriorly and between ocelli; width 1.43-1.65 (1.57±0.07, *11*). Ocelli: three, black with grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; approximately one and a half times the length of the head. Eyes: upper lobes of male reddish-brown, lower lobes black; eyes of female grey-black. Mouthparts. Labrum and clypeus (Fig. 145): lateral margins of clypeus moderately diverging towards anterior; lateral margins of labrum wider than clypeus, rounded to angular; labrum length 0.31-0.39 (0.35±0.02, *10*); labrum width 0.73-0.91 (0.83±0.05, *10*); labrum width length ratio 2.21-2.48 (2.36±0.10, *10*); anterior margin of labrum with slight antero-median emargination; five flat elongate denticles present on anterior margin extending 0.15-0.38 (0.26±0.06, *10*) across labrum; denticle width as proportion of labrum width 0.21-0.42 (0.30±0.061, *10*); frontal setae arranged as a narrow band; secondary hair fringe clearly separated from narrow band. Mandibles: outer margins slightly curved; sparse long setae at midpoint on outer lateral margins; shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 146): two incisors, each with three apical teeth, both inconspicuously serrated on inner margin; outer incisor occasionally with subapical process; prostheca distinctly robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 147): sparse long spine-like setae on inner lateral margin; two incisors; outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth, serrated on outer lateral margin; prostheca simple, slender, divided apically; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 148): galea-lacinae wider than long, width length ratio 1.06-1.28 (1.20±0.07, *10*); subapical row of 20-23 (*10*) pectinate setae; subapical process extending laterally towards inner margin; palpi three segmented, terminal segments often with single spine apically, palp length

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ratios 1.00: 0.95: 0.51 (0.30±0.02, 10). Hypopharynx (Fig. 149): well developed lateral processes; anterior margin of lingua moderately cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, angular lateral margins with slight indentation. Labium (Fig. 150): glossae not turned under ventrally and lying in the same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.90: 0.53 (0.38±0.01, 10); submentum with sparse spines on lateral margins. Thorax: golden to tan brown with darker brown markings; pronotum width 1.33-1.60 (1.47±0.08, 10), slightly narrower than width of head (see above), head pronotum width ratio 0.88-0.98 (0.93±0.03, 10). Legs (Fig. 151): golden to tan brown, no apparent markings; femora slightly darker than tibia or tarsus; fore femora length 1.38-1.70 (1.56±0.09, 11); fore femora width 0.43-0.53 (0.48±0.03, 11); fore femora length width ratio 3.00-3.50 (3.24±0.15, 11); fore tarsi with 3-6 (10) ventral spines; tarsal claws with 9-12 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated (Fig. 152); total foreleg length 3.03-3.81 (3.54±0.21, 11); leg length ratios, foreleg 1.00: 0.88: 0.39 (1.56±0.09, 11), midleg 1.00: 0.88: 0.35 (1.57±0.12, 10), hindleg 1.00: 0.87: 0.31 (1.84±0.15, 10). Abdomen: predominantly tan brown with underlying yellow colour; yellow patches of colour on segments six to nine, progressively larger posteriorly; segment ten almost entirely yellow; small posterolateral spines present, progressively larger posteriorly. Gills (Fig. 153): membrane somewhat opaque, greyish; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill slender, tapering to a thin point apically; main tracheae strongly developed, lateral tracheae absent or weakly developed. Caudal filaments: three; golden; terminal filament longer than cerci.

Remarks. This morphospecies appears to be endemic to Tasmania and is known only from the nymph. It has been known as *Nousia* sp. 5 (Dean and Cartwright 1992) and is now referred to in the literature as *Nousia* sp. "AV5" (Dean 1999) but cannot be given species status due to the absence of the adult stages. As its species status remains uncertain, I suggest it remains informally within *Nousia (Australonousia)* until associations between the nymphs and the adults can be made.

It appears many individuals were found by David Cartwright and John Dean on a collecting trip to the Pelion Valley World Heritage Area (Dean and Cartwright 1992). Much of this area is inaccessible except by foot and is more than a day's walk from civilisation. I did not visit this area for the purpose of rearing species due to the logistic difficultly of transporting live specimens long distances. Further, I was unsuccessful in my attempts to collect this species from relatively accessible sites in and around Cradle Mountain-Lake St. Clair National Park despite visiting numerous streams eg: Watersmeet

(96122701) near Lake St Clair; Little Navarre River (96122801), Collingwood River (96122803) near Lyell Highway and Pencil Pine Creek (96123002) and Iris River (96123003) near Cradle Mountain. Other collecting sites in Tasmania did not yield any of this species either.

According to Dean and Cartwright (1992) the animal prefers larger streams in the Pelion Valley. Collection trips to similar habitat around Tasmania failed to produce any specimens, despite the fact that it has been found in a few areas outside the Park. A comprehensive survey of the state, concentrating on larger streams, would be of value in attempting to collect some specimens for rearing. Failing that, rearing *in situ* in the Pelion Valley may be the only way to obtain an associated adult. Such a process is logistically difficult, time-consuming and expensive.

The morphospecies *Nousia (Australonousia)* sp. "AV5" can be distinguished from all other species in the subgenus by the following combination of characters. In the nymph: (i) antennal length approximately twice length of head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum slightly wider than clypeus, more than twice as long as wide, lateral margins rounded to angular; antero-median emargination slight bearing five flat elongate denticles; denticles extend one-third width of the labrum on average; frontal setae arranged as a narrow broad, secondary hair fringe separate from front band; (iv) mandibles with incisors inconspicuously to conspicuously serrated on lateral margins; left mandible outer incisor with small subapical process; left mandible prostheca robust, distinctly serrated; right mandible prosthecal simple, slender, divided apically; (v) maxillae galea-lacinae slightly wider than long, 20-23 subpectinate setae, subapical process extending laterally towards inner lateral margin; (vi) hypopharynx moderately cleft, superlingua with slight angular lateral margins; (vii) leg banding absent; (viii) fore femora 3.2 times longer than wide; fore tarsi with 3-6 ventral spines; fore tarsal claws with 9-12 ventral teeth; (ix) abdomen tan brown, yellow patches of colour on segments six to nine, progressively larger apically, segment ten almost entirely yellow; (x) gills greyish, opaque; slender, tapering to a thin point apically; main tracheae strongly developed, lateral tracheae absent or very weakly developed.

Specimens examined. TASMANIA. Boyd River, locality 25, 82030400, 4 III 1982, EPH 0113, 2♂ N, 2 ♀ N (DC). **Dans Rivulet** near Mathina, 95021002, 10 II 1995, 310m, 147°52' 41°26', EPH 0189, 1 ♂ N, 1 ♀ N (PS & PG). **Douglas Creek,** High Bridge near old Pelion Hut, Cradle Mountain-Lake St Clair National Park, 90011801, 18 I 1990, 840m, 146°03' 41°49', EPH 1532, 3 ♂ N (JD&DC). **Douglas Creek,** Pelion Rangers Hut, Cradle Mountain-Lake St Clair National Park, 90011601, 16 I 1990, 820m, 146°04' 41°50', EPH

1533, 1 ♂ N, 1 ♀N (JD & DC). **Douglas Creek,** upstream of confluence with Lake Ayr outlet stream, Cradle Mountain-Lake St Clair National Park, 90011602, 16 I 1990, 840m, 146°04′ 41°49′, EPH 1527 1 N, (JD&DC), EPH 1528, 1 ♀ N (JD&DC); EPH 1534, 2 ♂ N, 1 ♀ N (JD&DC). **Huon River,** locality 27, 82030702, 7 III 1982, EPH 0155, 4 ♂ N, 2 ♀ N (DC). **River Forth headwaters,** 0.25km E of Frog Flats, Cradle Mountain-Lake St Clair National Park, 90011802, 18 I 1990, 760m, 146°01′ 41°50′, EPH 1530, 1 ♀ N (JD & DC). **River Forth headwaters,** Frogs Flat Overland Track, Cradle Mountain-Lake St Clair National Park, 90011803, 18 I 1990, EPH 1529, 1 ♀ N, (JD&DC). **Tom Creek,** locality 16, south of Zeehan, 82022801, 28 II 1982, 190m, 145°25′ 41°55′, EPH 0125, 1 ♂ N (DC). **Wedge River,** locality 23, 82030301, 3 III 1982, EPH 0128, 1 ♀ N, (immature) (DC).

3.3.2.8   *Nousia (Australonousia)* sp. "AV7"

Nousia sp. "AV7" (Dean 1999)

Distribution. Tasmania (Fig. 154).

Diagnosis. Male imago. Dimensions: body length 8.3 (*1*); forewing length 9.0 (*1*); hindwing length 1.8 (*1*); forewing hindwing ratio 5 (*1*). General body colour golden to tan and chocolate brown with light and dark markings. Head tan brown. Antennae: pedicel, scape and flagellum tan brown. Ocelli: three: black with white inserts; laterals larger than medial. Eyes: upper eye size large, contiguous, ES=0.00 (*1*); upper lobes tan orange, lower lobes grey-black. Thorax: pronotum and mesonotum tan brown with darker markings. Legs: femora tan brown; tibiae and tarsi golden; forelegs with seven segments, tarsal claw morphology unknown. Wings. Forewing: membrane hyaline, pterostigmatal region slightly opaque, longitudinal and crossveins brown, anal veins yellow, costal and subcostal crossveins absent from proximal halves of wings, costal space with 12 crossveins distally (*1*), subcostal space with 10 crossveins distally (*1*). Three bullae present on veins Sc, R_2 and R_{4+5}, MA forked at approximately half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing: mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal halves of costal space, 6 in distal space, 5 crossveins throughout subcostal space (*1*). Abdomen: golden with the occasional darker margins, darker stripe apical on each segment. Genitalia: forceps three segmented; first

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segment tan brown, progressively lighter apically; terminal segment rounded, slightly shorter than middle segment; penes (Fig. 155): golden brown with darker markings, fused along at least two-thirds length; two apical lobes, conspicuously separate, three embossments on each lobe apically; dorsal view with two subapical lobes extending laterally, one internal spine visible on right hand lobe (may be present on left lobe but detached in this specimen). Caudal filaments: unknown. **Female Imago.** Unknown. **Egg.** Unknown. **Male subimago.** unknown. **Female subimago.** unknown. **Mature nymph.** (Fig. 156). Body lengths: ♂ 6.0-8.3 (7.2±0.85, *12*); ♀ 7.5-9.7 (8.8±0.65, *17*). General colour yellow with tan brown to dark chocolate brown markings, colour variable. Head: prognathous; yellow, tan brown surrounding ocelli; width 1.43-1.80 (1.64±0.10, *20*). Ocelli: three; black with grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; approximately twice length of head. Eyes: upper lobes of male reddish-brown, lower lobes black; eyes of female grey-black. Mouthparts. Labrum and clypeus (Fig. 157): lateral margins of clypeus slightly diverging towards anterior, lateral margins of labrum slightly wider than clypeus, rounded; anterior margin of labrum with slight antero-median emargination; labrum length 0.37-0.44 (0.40±0.02, *13*); labrum width 0.66-0.98 (0.80±0.08, *13*); labrum width length ratio 1.74-2.29 (1.99±0.16, *13*); five denticles present on anterior margin; denticles rounded to triangular, median denticle moderately enlarged; denticles extending 0.19-0.31 (0.25±0.03, *13*) across labrum, denticle width as proportion of labrum width 0.24-0.37 (0.32±0.04, *13*); frontal setae arranged as a narrow band; secondary hair fringe clearly separated from narrow band. Mandibles: outer margins slightly curved; sparse long setae at midpoint on outer lateral margins; shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 158): two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin, occasionally with small subapical process; prostheca robust, distinctly serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 159): sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth; prosthecal simple, slender, divided apically; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 160): galea-lacinae as wide as long, width length ratio 0.98-1.13 (1.04±0.05, *10*); subapical row of 16-18 (*10*) pectinate setae; palpi three segmented; terminal segment with single spine apically, palp length ratios 1.00: 0.97: 0.65 (0.23±0.02, *10*). Hypopharynx (Fig. 161): well developed lateral processes; anterior margin of lingua moderately cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, angular lateral margins with slight indentation. Labium (Fig. 162): glossae not turned under ventrally and lying in the same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal

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segment with a row of triangular process almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.96: 0.67 (0.36±0.05, 12); submentum with sparse robust spines on lateral margins. Thorax: golden brown with darker brown markings; pronotum width 1.30-1.85 (1.64±0.17, 20), approximately equal to width of head (see above), head pronotum width ratio 0.91-1.09 (1.00±0.06, 20). Legs (Fig. 163): yellow with no apparent markings; fore femora length 1.25-1.83 (1.56±0.15, 12); fore femora width 0.43-0.60 (0.52±0.05, 12); fore femora length width ratio 2.83-3.29 (3.03±0.17, 12); fore tarsi with 6-9 (10) ventral spines; tarsal claws with 12-15 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated (Fig. 164); total foreleg length 3.03-4.24 (3.69±0.32, 11); leg length ratios, foreleg 1.00: 0.83: 0.42 (1.56±0.15, 12), midleg 1.00: 0.87: 0.37 (1.58±0.11, 12), hindleg 1.00: 0.91: 0.33 (1.89±0.13, 12). Abdomen: predominantly tan brown with yellow and dark brown markings, yellow markings form a broken stripe midline, two yellow coloured maculae flanking each midline marking, segment ten predominantly yellow, pattern variable; postero-lateral spines present, progressively larger posteriorly. Gills (Fig. 165): membrane clear, present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; linear, tapered to a thin point apically, upper lamellae with slightly longer tail; main and lateral tracheae present, main and lateral tracheae strongly developed. Caudal filaments: three; golden, terminal filament longer than cerci.

Remarks. This unnamed morphospecies also appears endemic to Tasmania. It was first recorded as *Nousia* sp. 7 (Dean and Cartwright 1992) and is now referred to as *Nousia* sp. "AV7" (Dean 1999). It is known from its nymphal stages and one associated male imago located in the MV. There appears much variation in the nymph, particularly in the colour patterns of the abdomen and it is unclear whether this constitutes variation or a separate taxon. For example, Dean (*pers. comm.*) considers there is a coloured variation of sp. "AV7" which is distinguished by a dark tergal segment eight. The male genitalia (Fig. 155) is clearly *Nousia*-like but is drawn from a slide mount enabling only the dorsal view to be detailed and the possibility that the shape may be distorted by flattening. Further, only one internal spine is apparent and it is not known if this is a species characteristic or if the "twin" spine has been accidentally detached. Certainly, there is some indication that a process may have been present on the left hand penis lobe as well.

Despite the similarity with *Nousia,* the description of one imago does not allow for the full variation of the taxa to be detailed. I feel it would be presumptuous to erect a new species on the basis of one associated individual when so little is known about the fauna.

Like *Nousia* sp. "AV5" many of the specimens collected were from the Pelion Valley World Heritage Area (Dean and Cartwright 1992). However, this morphospecies seems to have a more widespread distribution than *N. (A)* sp. "AV5" and has been recorded from many other areas throughout Tasmania. Despite this, I was only able to collect one male nymph of this morphospecies at Watersmeet (96122701) which unfortunately did not rear through to an adult.

The morphospecies *Nousia (Australonousia)* sp. "AV7" can be distinguished from all other species in the subgenus by the following combination of characters. In the imago: (i) general body colour golden to tan brown with darker markings; (ii) male upper eye size large, contiguous; (iii) leg banding absent; (iv) hindwing costa joins subcosta at three-quarters wing length; (v) penes with subapical lobes. In the nymph: (i) antennal length approximately twice length of head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum slightly wider than clypeus, about twice as wide as long, lateral margins rounded; antero-median emargination slight bearing five rounded to triangular denticles extending one-third width of the labrum on average, median denticle moderately enlarged; frontal setae arranged as a narrow broad, secondary hair fringe separate from front band; (iv) mandibles with outer incisors inconspicuously serrated on inner lateral margins; left mandible outer incisor with small subapical process; left mandible prostheca robust, distinctly serrated; right mandible prostheca simple, slender, divided apically; (v) maxilla with 16-18 subpectinate setae; (vi) hypopharynx moderately cleft, superlingua with slight angular lateral margins; (vii) leg banding absent; (viii) fore femora 3 times longer than wide; fore tarsi with 6-9 ventral spines; fore tarsal claws with 12-15 ventral teeth; (ix) abdomen tan brown with yellow and dark brown markings, yellow markings form a broken stripe midline, two yellow coloured maculae flanking each midline marking, segment ten predominantly yellow; (x) gills with membrane clear, slender, tapering to a thin point apically; main and lateral tracheae strongly developed.

Specimens examined. TASMANIA. Ansons River, Rd to Pioneer, 95020902, 9 II 1995, 80m, 148°09' 41°11', EPH 0204, 4 ♂ N, 1 ♀ N (PS&PG). **Boyd River,** locality 25, 82030400, 4 III 1982, EPH 0114, 1 ♂ N, 3 ♀ N (DC). **Coquet Creek,** Tasman Highway, NE of Nunamara, 95020803, 8 II 1995, 380m, 147°20' 41°21', EPH 0246, 2 ♀ N (PS&PG), EPH 0247, 3 ♂ N, 1 ♀ N (PS& PG). **Douglas Creek,** Pelion Rangers Hut, Cradle Mt-Lake St Clair National Park, 90011601, 16 I 1990, 820m, 146°04' 41°50', EPH 1547, 7 ♂ N, 11 ♀ N (JD&DC). **Douglas Creek,** upstream Lake Ayr outlet stream, Cradle Mt-Lake St Clair National Park, 90011602, 16 I 1990 840m, 146°04' 41°49', EPH 1536, 1 ♂ N (JD&DC), EPH 1544, 1 ♂ N, 1 ♀ N (JD&DC), EPH 1545, 1 ♂ N, 14 ♀ N (JD&DC). **Douglas Creek,** High Bridge near old Pelion Hut, Cradle Mt-Lake St Clair National Park,

90011801, 18 I 1990, 840m, 146°03' 41°49', EPH 1546, 5 ♂ N, 5 ♀ N (JD&DC). **Douglas Creek headwaters**, 100m N of Pelion Gap, Cradle Mt- Lake St Clair National Park, 90011702, 17 I 1990, 800m, 146°02' 41°48', EPH 1537, 1 ♀ N (JD&DC), EPH 1548, 1 ♂ N, 1 ♀ N (JD&DC). **Douglas Creek tributary**, 1.5km NW of Pelion Gap, Cradle Mt-Lake St Clair National Park, 90011703, 17 I 1990, 146°02' 41°48', EPH 1550, 5 ♂ N, 17 ♀ N (JD&DC). **Douglas Creek tributary**, 2.5km N of Pelion Gap, Cradle Mt-Lake St Clair National Park, 90011704, 17 I 1990, 800m, 146°02' 41°49', EPH 1551, 2 ♂ N, 3 ♀ N (JD&DC). **Franklin River**, 82030201, 2 III 1982, EPH 0136, 1 ♀ N (DC). **George River,** Intake Bridge, St Columba Falls Reserve, 95020905, 9 II 1995, 150m, 147°59' 41°17', EPH 0232, 3 ♂ N, 5 ♀ N (PS&PG). **Hellyer River Gorge**, 82022800, 28 II 1982, 220m, 145°3ː' 41°16', EPH 0151, 2 ♂ N, 2 ♀ N (DC). **Huon River**, locality 27, 82030702, 7 III 1982, EPH 0156, 5 ♂ N, 2 ♀ N (DC). **Iris River tributary**, 82022600, 26 II 1982, EPH 0165, 1 ♀ N (DC). **Lake Ayr inlet stream**, Cradle Mt-Lake St Clair National Park, 90011603, 16 I 1990, 880m, 146°05' 41°49', EPH 1542, 1 ♂ N, 4 ♀ N (JD&DC), EPH 1543, 1 ♂ NSI (JD&DC). **Liffey Falls**, 82022301, 23 II 1982, 470m, 146°47' 41°41', EPH 0142, 1 ♂ N, 4 ♀ N (DC). **Mother Logans Creek**, Terrys Hill Rd, 95020907, 9 II 1995, 130m, 148°06' 41°13', EPH 0201, 1 ♂ N (PS&PG). **Nelson River**, 18km E of Queenstown, 88110200, 2 XI 1988, 500m, 145°42' 42°06', EPH 0159, 1 ♂ N (DC). **New River**, upstream Ralph Falls, 95021003, 10 II 1995, 810m, 147°50' 41°19', EPH 0207, 4 ♂ N, 7 ♀ N (PS&PG). **North Eldon River,** Lake Burbury, 94110100, 1 XI 1994, EPH 1460, 1 ♀ N (MRHI), EPH 1461, 1 ♂ N, 1 ♀ N (MRHI). **Ransom Creek**, Terrys Hill Rd, 95020908, 9 II 1995, 90m, 148°04' 41°15', EPH 0175, 2 ♀ N (PS&PG). **River Forth headwaters**, 0.75km NE of Frog Flats, Cradle Mt-Lake St Clair National Park, 90011705, 17 I 1990, 1000m, 146°01' 41°51', EPH 1540, 2 ♂ N (JD&DC). **River Forth headwaters,** 0.25km E of Frog Flats, Cradle Mt-Lake St Clair National Park, 90011802, 18 I 1990,760m, 146°01' 41°50', EPH 1541, 9 ♂ N, 8 ♀ N (JD&DC). **River Forth headwaters,** Frog Flats Overland Track, Cradle Mt-Lake St Clair National Park, 90011803, 18 I 1990, 740m, 146°00' 41°50', EPH 1538, 1 ♀ N (JD&DC), EPH 1539 14 ♂ N, 17 ♀ N (JD&DC). **River Forth tributary**, 2.75km NW of Pelion Gap, Cradle Mt-Lake St Clair National Park, 90011701, 17 I 1990, 760m, 146°01' 41°49', EPH 1552, 2 ♂ N, 2 ♀ N (DC&JD). **Russell Falls**, near Lonnavale, 82030202, 2 III 1982, 130m, 146°47' 42°56', EPH 0124, 1 ♂ N (DC). **Second River**, upstream Lilydale Falls, 82031100, 11 III 1982, 150m, 147°12' 41°13', EPH 0155, 1 ♀ N (DC). **Second River,** upstream Lilydale Falls, 82031100, 11 III 1982, 150m, 147°12' 41°13', EPH 0155, 1 ♀ N (DC). **St Columbia Falls,** Pyengana, 82031001, 10 III 1982, 150m, 148°00' 41°17', EPH 0162, 1 ♂ S (DC). **St Patricks River**, Targa, 82031002, 10 III 1982, 380m, 147°21' 41°18', EPH 0121, 1 ♂ N, 1 ♀ N (DC). **Stoney Creek,** 82022302, 23 II 1982, 350m, 146°51' 42°51',

EPH 0110, 1 ♂ N, 1 ♀ N (DC). **Tom Creek,** locality 16, S of Zeehan, 82022801, 28 II 1982, 190m, 145°25' 41°55', EPH 0122, 1 ♀ N (DC). **Unnamed Creek,** 3 miles E of Waratah, 82022800, 28 II 1982, 650m, 145°33' 41°26', EPH 0161, 2 ♀ N (DC). **Unnamed Creek,** Strickland Ave, Hobart, 82030800, 8 III 1982, 110m, 147°17' 42°53', EPH 0123, 1 ♂ N, 1 ♀ N (DC). **Unnamed Creek,** E of Waratah, 88110100, 1 XI 1988, 600m, 145°32' 41°26', EPH 0166, 1 ♀ N (DC). **Unnamed Creek,** Strickland Ave, Hobart, 88110300, 3 XI 1988, 110m, 147°17' 42°53', EPH 0131, 1 ♂ N, 2 ♀ N (DC). **Walkers Creek,** Mt Saddleback, 95021005, 10 II 1995, 750m, 147°46' 41°22', EPH 0186, 4 ♂ N, 6 ♀ N. (JD&DC). **Watersmeet,** conjunction of Cuvier and Hugel Rivers, Cradle Mountain-Lake St Clair National Park, 96122701, 27 XII 1996, 740m, 146°09'37" 42°06'41", 1 ♂ N (KJF). **Wedge River,** locality 23, 82030301, 3 III 1982, EPH 0130, 2 ♂ N, 5 ♀ N (DC). **Weld River,** E of Weldborough, 94030603, 6 III 1994, 360m, 147°56' 41°12', EPH 0221, 1 ♂ N (PS).

3.3.2.9 *Nousia (Australonousia)* sp. "AV8"

Nousia sp. "AV8" (Dean 1999)

Distribution. Tasmania (Fig. 166).

Diagnosis. Male imago. Unknown. **Female Imago.** Unknown. **Egg.** Unknown. **Male and female subimago.** Unknown. **Mature nymph.** (Fig. 167). Body lengths: ♂ 5.8-9.0 (7.1±0.91, *10*); ♀ 6.0-9.1 (7.4±1.10, *13*). General colour golden to tan to dark brown with light to dark markings. Head: prognathous; golden brown with tan brown surrounding ocelli; width 1.32-1.68 (1.51±0.12, *11*). Ocelli: three; black with grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; approximately one and half times length of head. Eyes: upper lobes of male purplish-brown, lower lobes black; eyes of female grey-black. Mouthparts. Labrum and clypeus (Fig. 168): lateral margins of clypeus slightly diverging towards anterior; lateral margins of labrum subequal to clypeus, rounded; labrum antero-median emargination abrupt (Figs. 168, 169); labrum length 0.30-0.40 (0.35±0.03, *10*); labrum width 0.54-0.72 (0.63±0.05, *10*); labrum width length ratio 1.68-1.94 (1.80±0.08, *10*); five triangular denticles present on anterior magrin; median denticle greatly enlarged, triangular; denticles extending 0.07-0.09 (0.08±0.01, *10*) across labrum; denticle width as proportion of labrum width 0.11-0.15 (0.13±0.01, *10*); one large prominent median denticle (Fig. 169); frontal setae arranged as a narrow band; secondary hair fringe clearly separated from narrow band. Mandibles: outer margins slightly curved; sparse long setae at midpoint on outer lateral margins; shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; row of

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setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 170): two incisors, each with three apical teeth; outer incisor inconspicuously serrated on inner lateral margin, occasionally with subapical process; inner incisor stout, broad at base, inconspicuously serrated on outer lateral margin; prostheca robust, distinctly serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 171): sparse spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth; prostheca more simple, inconspicuously serrated, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 172): galea-lacinae as wide as long, width length ratio 0.88-1.08 (0.96±0.07, *10*); subapical row of 11-13 (*10*) pectinate setae; palpi three segmented; terminal segments often with single spine apically, palp length ratios 1.00: 0.92: 0.64 (0.22±0.01, *10*). Hypopharynx (Fig. 173): well developed lateral processes; anterior margin of lingua moderately cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 174): glossae not turned under ventrally and lying in the same plane as paraglossae, series of stout spines apically; palpi three segmented, terminal segment with a row of triangular process almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.92: 0.78 (0.29±0.02, *10*); submentum with sparse robust spines on lateral margins. Thorax: golden brown with darker brown markings; pronotum width 1.30-1.75 (1.49±0.18, *11*), approximately equal to width as head (see above), head pronotum width ratio 0.88-1.07 (0.99±0.07, *11*). Legs (Fig. 175): golden brown with no apparent markings; fore femora length 0.95-1.40 (1.15±0.11, *13*); fore femora width 0.40-0.53 (0.45±0.04, *13*); fore femora length width ratio 2.38-2.86 (2.58±0.16, *13*); fore tarsi with 10-15 (*10*) ventral spines; tarsal claws with 16-18 (*10*) ventral teeth, progressively larger apically, subapical tooth greatly enlarged, apical tooth inconspicuously serrated (Fig. 176); total foreleg length 2.28-3.31 (2.71±0.25, *13*); leg length ratios, foreleg 1.00: 0.87: 0.49 (1.15±0.11, *13*), midleg 1.00: 0.84: 0.41 (1.19±0.11, *10*), hindleg 1.00: 0.92: 0.40 (1.33±0.14, *10*). Abdomen: predominantly golden to tan brown with distinctive dark brown markings, segment ten predominantly yellow; postero-lateral spines present, progressively larger posteriorly. Gills (Fig. 177): membrane clear, present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; linear, tapered to a thin point apically; main tracheae strongly developed, lateral tracheae present, weakly developed. Caudal filaments: three, golden, terminal filament longer than cerci.

Remarks. *Nousia* sp. "AV8" (Dean 1999), also known as *Nousia* sp. 8 (Dean and Cartwright 1992), is also considered endemic to Tasmania. Like *N. (A).* sp. "AV5" and "AV7" it came to the attention of the authors on a collecting trip to the Pelion Valley (Dean

and Cartwright 1992). However, further inspection showed it had previously been collected from a wide range of sites throughout Tasmania (see specimens examined).

Nousia (Australonousia) sp. "AV8", although similar in many respects to the other species and morphospecies of *Nousia*, has some profound differences. The unusual shape of the labrum, with the abrupt antero-median emargination, represents a morphology seen in other apparently endemic Tasmanian morphospecies such as *N. (A)* sp. "AV10" and *N. (A)* sp. "AV9" (Dean and Cartwright 1992). (Unfortunately I had very few specimens of each of these and therefore did not attempt to describe them). It may be that these three represent a different taxon from *Nousia (Australonousia)* although one would not be in a position to judge this without the availability of adult specimens. Again, I propose this morphospecies remains informally described as part of *Nousia (Australonousia)* until nymph and adult associations can be made.

The morphospecies *Nousia (Australonousia)* sp. "AV8" can be distinguished from all other species in the subgenus by the following combination of characters. In the nymph: (i) antennal length approximately one and a half times length of head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum subequal to clypeus, less than twice as wide as long, lateral margins rounded; labrum antero-median emargination abrupt bearing five rounded to triangular denticles, median denticle greatly enlarged; denticles extend one-seventh the width of the labrum on average; frontal setae arranged as a narrow broad, secondary hair fringe separate from front band; (iv) mandibles with incisors inconspicuously serrated on lateral margins; left mandible outer incisor with small subapical process; left mandible inner incisor stout, broad at base; prostheca robust, distinctly serrated; right mandible prostheca simple, slender, divided apically; (v) maxillae with 11-13 subpectinate setae; (vi) hypopharynx moderately cleft, superlingua with rounded lateral margins; (vii) leg banding absent; (viii) fore femora 2.5 times longer than wide; fore tarsi with 10-15 ventral spines; fore tarsal claws with 16-18 ventral teeth; (ix) abdomen golden to tan brown with distinctive dark brown markings, segment ten predominantly yellow; (x) gills with membrane clear, slender, tapering to a thin point apically; main and lateral tracheae present, main tracheae strongly developed, lateral tracheae present, weakly developed.

Specimens examined. TASMANIA. Ansons River, Rd to Pioneer, 95020902, 9 II 1995, 80m, 1487°09', 41°11', EPH 0205, 2 ♂ N, 2 ♀ N (PS&PG). **Arthur River**, Tayatea Bridge, 94102500, 25 X 1994, EPH 1475, 1 ♀N (MRHI). **Barrow Creek**, Tasman Highway, 95020801, 8 II 1995, 390m, 147°21', 41°20', EPH 0215, 1 ♂ N, (immature), (PS&PG). **Brid River**, Tasman Highway, W of Scottsdale, 95020802, 8 II 1995, 180m, 147°27', 41°13', EPH 0239, 4 ♂ N, 5 ♀ N (PS&PG). **Coquet Creek**, Tasman Highway,

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NE of Nunamara, 95020803, 8 II 1995, 380m, 147°20' 41°21', EPH 0244, 1 ♂ N, (PS&PG). **Creekton Rivulet,** near Dover, 82030701, 7 III 1982, 60m, 146°57', 43°21', EPH 0150, 1 ♂ N (DC). **Dee River,** Lyell Highway, 96121903, 19 XII 1996, 200m, 146°38'13" 42°45'51", 1 ♂ N (KJF). **Douglas Creek,** High Bridge near old Pelion Hut, Cradle Mountain - Lake St Clair National Park, 90011801, 18 I 1990, 840m, 146°03' 41°49', EPH 1466, 1 ♀ N (JD&DC), EPH 1472, 1 ♂ N (JD&DC). **George River,** Goshen, 95020904, 9 II 1995, 60m, 148°05', 41°16', EPH 0178, 1 ♂ N, 2 ♀ N (PS&PG). **George River,** Intake Bridge, St Columba Falls Reserve, 95020905, 9 II 1995, 150m, 147°59' 41°17', EPH 0239, 2 ♂ N, 3♀ N (PS&PG). **Great Musselroe River** Rd to Pioneer from St Helens, 95020906, 9 II 1995, 60m, 148°03', 41°05', EPH 0206, 2 ♂ N, 8 ♀ N (PS&PG). **Groom River,** Tasman Highway, 94030701, 7 III 1994, 90m, 148°05',41°15', EPH 0228, 2 ♀ N (PS&MS). **Lake Ayr inlet stream,** Cradle Mt-Lake St Clair National Park, 90011603, 16 I 1990, 880m, 146°05' 41°49', EPH 1464, 1 ♀ N, (JD&DC), EPH 1471, 2 ♂ N, 4 ♀ N, (JD&JDC). **Lake Ayr outlet stream,** 100m downstream Lake, Cradle Mountain-Lake St Clair National Park, 90011605, 16 I 1990, 800m, 146°03', 41°49', EPH 1467, 1 ♂ N (immature) (JD&DC). **Lake Ayr outlet stream,** upstream Douglas Creek, Cradle Mountain-Lake St Clair National Park, 90011604, 16 I 1990, 640m, 146°02', 41°48', EPH 1465, 1 ♀ N (JD&DC), EPH 1470, 3 ♂ N, 4 ♀ N, (JD&DC). **Lake Crescent,** outlet stream, 88110401, 4 XI 1988, 900m, 147°10', 41°07', EPH 0133, 1 ♂ N, 3 ♀ N (DC). **Margisons Creek,** St Mary's, 95021001, 10 II 1995, 280m, 148°11', 41°34', EPH 0192, 1 ♂ N, 1 ♀ N (PS&PG). **Mother Logans Creek,** Terrys Hill Rd, 95020907, 9 II 1995, 130m, 148°06', 41°13', EPH 0200, 2 ♂ N, 2 ♀ N (PS&PG). **North George River,** 94030702, 7 III 1994, EPH 0197, 2 ♂ N (PS&MS). **Pipers Brook,** 94030602, 6 III 1994, 147°10', 41°09', EPH 0242, 1 ♂ N, 3 ♀ N (PS). **Powers Rivulet,** 95020901, 9 II 1995, 100m, 148°05', 41°19', EPH 0228, 2 ♀ N (PS&MS). **Ransom Creek,** Terrys Hill Rd, 95020908, 9 II 1995, 90m, 148°04' 41°15', EPH 0174, 3 ♂ N, 4 ♀ N (PS&PG). **Ringarooma River,** Pioneer, 95020909, 9 II 1995, 147°57', 41°05', EPH 0213, 1 ♀ N (PS&PG). **River Forth headwaters,** Frog Flats Overland Track, Cradle Mt-Lake St Clair National Park, 90011803, 18 I 1990, 740m, 146°00' 41°50', EPH 1479, 1 ♂ N (JD&DC). **South George River,** St Columba Falls Reserve, 94100500, 5 X 1994, 150m, 147°58', 41°18', EPH 1473, 1 ♀ N (MRHI), EPH 1474, 2 ♂ N, 2 ♀ N (MRHI). **St Patricks River,** Nunamara, 95020805, 8 II 1995, 350m, 147°17', 41°23', EPH 0236, 1 ♂ N, 1 ♀ N (PS&PG). **St Patricks River,** Targa, 82031002, 10 III 1982, 380m, 147°21' 41°18', EPH 0177, 2 ♀ N (DC). **Township Creek,** near Fingal, 95021004, 10 II 1995, EPH 0184, 1 ♀ N (PS&PG). **Tyenna River,** Westerway, 94031100, 11 III 1994, 100m, 146°47', 42°40', EPH 0191, 1 ♀ N (PS).

3.3.3 Key to the species (and morphospecies) of *Nousia (Australonousia)*

This key is accompanied by a matrix of main characters for separating the species as an alternate means of identification (Table 9).

Male imagos

1. Penes without distinct subapical lobes dorsally; abdomen darkly coloured brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking; hindwing costa joins subcosta at four-fifths wing length..*fuscula*

    Penes with distinct subapical lobes dorsally; body colour variable, light to darkly coloured; hindwing costa joins subcosta at three-quarters wing length................2

2(1) Upper eye lobes large but never contiguous; darkly coloured chocolate brown to black species; legs yellow to tan brown with darker coloured banding; mesonotum often shiny dark brown to black...*nigeli*

    Upper eye lobes large, often contiguous but not always; body colour variable, light to darkly coloured; no leg banding..3

3(2) Body colour light, golden to tan brown with darker markings; mesonotum tan brown; legs, femora tan brown, tibiae and tarsi golden; penes straight sided..sp."AV7"

    Body colour very variable, ranging from tan brown to dark brown to black; pronotum shiny brown to black; abdomen colour variable but usually with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking; penes with prominent subapical lobes dorsally...*fusca*

Mature nymphs

    Darkly coloured chocolate brown colour with light coloured markings; labrum slightly wider than clypeus, more than twice as wide as long; secondary hair fringe arranged as a broad band, abutting front row; gills dark, grey to black, tracheae poorly to moderately well developed...*nigeli*

    Not as above..2

2(1)   Light coloured with distinctive dark brown markings on abdomen segments; labrum subequal to clypeus, less than twice as wide as long; abrupt antero-median emargination; triangular denticles, median denticle greatly enlarged; tarsal claws with 16-18 ventral teeth, subapical tooth greatly enlarged; Tasmania only..sp."AV8"

Not as above..3

3(2)   Labrum slightly more than twice as long as wide, slightly wider than clypeus, slight antero-median emargination, denticles extend one-third the width of entire labrum; left mandible outer incisor with small subapical process, prostheca robust, distinctly serrated; right mandible prostheca simple, slender, divided apically; hypopharynx moderately cleft, somewhat angular lateral margins with slight indentations; fore femora about 3 times as long as wide, Tasmania only...4

Labrum about twice as long as wide, subequal to very slightly wider than clypeus, slightly diverging towards anterior, rounded lateral margins; left mandible outer incisor without subapical process; prostheca moderately serrated; right mandible prostheca simple, slender, not divided apically; maxillae galea-lacinae about as wide as long; hypopharynx deeply cleft, rounded lateral margins..5

4(3)   Labrum moderately diverging towards anterior, rounded to angular lateral margins, denticles flat, elongate; mandible with all incisors serrated, right mandible inner incisor conspicuously serrated; maxillae galea-lacinae slightly wider than long, 20-23 subapical setae, subapical process extending laterally towards inner lateral margin; fore tarsi with 3-6 ventral spines; tarsal claws with 9-12 ventral teeth; gills greyish, opaque; main tracheae strongly developed, lateral tracheae absent or very weakly developed, Tasmania only...sp."AV5"

Labrum slightly diverging towards anterior, rounded lateral margins, denticles rounded to triangular, median denticle moderately enlarged; maxillae galea-lacinae as wide as long, 16-18 subapical setae; fore tarsi with 6-9 ventral spines; tarsal claws with 12-15 ventral teeth; gills clear, main and lateral tracheae strongly developed, Tasmania only...sp."AV7"

5(3)   Dark coloured, dark brown to black, with lighter markings; labrum with four-six triangular denticles extending less than one-third the width of entire labrum; incisors without serrations on lateral margins; fore tarsi with more than 10 ventral spines; gills pale, brownish; main and lateral tracheae strongly developed; total leg length shorter than other species..*fuscula*

Variously coloured, usually tan to dark brown with light markings; labrum with five flat elongate rounded denticles extending one-third the width of entire labrum; incisors inconspicuously serrated on lateral margins; fore tarsi with 5-10 ventral spines; gills clear to pink; tracheation variable, main tracheae strongly developed, lateral tracheae weakly to strongly developed............................*fusca*

Table 9. Matrix of main characters useful for separating taxa of *Nousia (Austalonousia)*.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
Imago – male				unknown		unknown
general body colour	very variable, ranging from tan brown to dark brown to black.	body colour black	chocolate brown to black		golden to tan brown with darker markings	
eyes contiguous	sometimes		no		yes	
eye size (ES)	0.00-0.16 (0.08)		0.09-0.15 (0.11)		0.00	
thorax colour	pronotum brown to black; mesonotum shiny brown to black	black	pronotum black; mesonotum shiny dark brown to black.		pronotum and mesonotum tan brown with darker markings.	
total foreleg length	5.76-8.90 (7.28)	6.23	6.05-7.35 (6.54)			
leg colour	golden through to tan, medium or dark brown,	brown to black	femora yellow to tan brown with very dark brown to black markings fore tibia dark brown, middle and hind tibiae yellow; all other segments yellow;		femora tan brown; tibiae and tarsi golden;	
leg banding	no	no	yes		no	
hindwing – length where costa joins subcosta	three-quarters	four-fifths	three-quarters		three-quarters	

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
abdomen colour	tan to dark brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly colour and pattern highly variable	black with light brown to brown markings forming a broken stripe midline, two maculae flanking each midline marking anteriorly.	dark brown to black with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly		golden with the occasional darker margins, darker stripe apical on each segment.	
penes with subapical lobes	yes	not distinct	yes		yes	
Imago – female					unknown	
sternum nine	deeply cleft	deeply cleft	moderately cleft			
Egg		unknown				
egg shape	ovoid		ovoid			
egg polar cap	absent		absent			
egg pattern	large evenly spaced circular shaped protuberances, pattern variable		chorion with similarly shaped, circular protuberances medially, surrounded by interlocking polygons which cover the whole surface			

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
Mature nymph						
general body colour	golden to tan brown with light and dark markings.	black, light markings	dark brown with light markings.	golden to tan brown with light and dark markings.	golden to tan to chocolate brown with light and dark markings, colour variable	golden to tan to dark brown with dark markings .
antennal length	more than twice length of head		approximately one and an half times length of head	approximately one and a half times the length of the head.	approximately twice length of head.	approximately one and half times length of head.
lateral margins of clypeus	slightly diverging towards anterior	slightly diverging towards anterior	straight or slightly diverging towards anterior	moderately diverging to anterior;	slightly diverging towards anterior,	slightly diverging towards anterior;
labrum compared to clypeus	subequal to very slightly wider than clypeus	subequal to very slightly wider than clypeus,	slightly wider	slightly wider	slightly wider	subequal
lateral margins of labrum	rounded	rounded	rounded	rounded to angular	rounded	rounded
anterio-median emargination	straight or very slight,	anterior margin with slight antero-median emargination	straight	slight antero-median emargination;	slight antero-median emargination,	abrupt anteromedian emargination
labrum width length ratio	about twice as wide as long	about twice as long as wide	more than twice as wide as long	more than twice as wide as long	more than twice as wide as long	less than twice as wide as long
denticle number	5	4-6	5	5	5	5
denticle shape	flat, elongate	triangular	flat, elongate	flat, elongate	rounded to triangular, median denticle moderately enlarged	triangular, median denticle greatly enlarged

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
denticle width / labrum width ratio	denticles extend one-third the width of entire labrum	denticles extend less than one-third the width of entire labrum	denticles extend two-fifths the width of entire labrum	denticles extend one-third the width of entire labrum	denticles extend one-third the width of entire labrum	denticles extend one-seventh the width of entire labrum
frontal setae arrangement	narrow band	narrow band	broad band	narrow band	narrow band	narrow band
secondary hair fringe separate or abutting front row	separate	separate	abutting	separate	separate	separate
left mandible incisors – serration	outer incisor inconspicuously serrated on inner lateral margin	incisors with no apparent serrations on lateral margins	outer incisor inconspicuously serrated on inner lateral margin	incisors inconspicuously to conspicuously serrated on inner margin,	outer incisor inconspicuously serrated on inner lateral margin,	outer incisor inconspicuously serrated on inner lateral margins, inner incisor stout, broad at base
left mandible incisors - subapical process	no	no	no	outer incisor with small subapical process;	outer incisor with small subapical process;	outer incisor with small subapical process;
left mandible – prostheca shape	robust, moderately serrated	robust, moderately serrated	robust, distinctly serrated	robust, distinctly serrated	robust, distinctly serrated	robust, distinctly serrated

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
right mandible incisors – serration	outer incisor inconspicuously serrated on inner lateral margin; inner incisor inconspicuously serrated on outer lateral margin;		outer incisor inconspicuously serrated on inner lateral margin	incisors inconspicuously to conspicuously serrated on inner lateral margins, inner incisor conspicuously serrated on outer lateral margin	Outer incisor inconspicuously serrated on inner lateral margin;	Outer incisor inconspicuously serrated on inner lateral margin;
right mandible – prosthecal shape	simple, slender	simple, slender	simple, slender	simple, slender, divided apically	simple, slender, divided apically	simple, slender, divided apically
Maxillae – galea-lacinae width length ratio	about as wide as long	about as wide as long	about as wide as long	slightly wider than long	about as wide as long	about as wide as long
maxillae - number of subapical pectinate setae	11-18	approx. 15	13-16	20-23	16-18	11-13 (*10*)
maxillae – subapical process	no	no	no	yes	no	no
hypopharynx – superlingua shape	rounded lateral margins	rounded lateral margins	rounded lateral margins	slightly angular lateral margins with slight indentation.	slightly angular lateral margins with slight indentation.	rounded lateral margins
hypopharynx – cleftness	deeply cleft	deeply cleft	deeply cleft	moderately cleft	moderately cleft	moderately cleft

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
leg colour	golden to tan brown	medium brown	tan brown with chocolate brown markings	golden to tan brown,	yellow	Golden brown
leg banding	no	no	yes	no	no	no
total leg length	2.45-4.98 (3.31)	2.86	2.66-3.53 (3.12)	3.03-3.81 (3.54)	3.03-4.24 (3.69)	2.28-3.31 (2.71)
foreleg length ratios	1.00: 0.85: 0.44 (1.43)	1.00: 0.87: 0.55 (1.18)	1.00: 0.89: 0.40 (1.37)	1.00: 0.88: 0.39 (1.56)	1.00: 0.83: 0.42 (1.56)	1.00: 0.87: 0.49 (1.15)
midleg length ratios	1.00: 0.86: 0.35 (1.51)	1.00: 0.84: 0.39 (1.19)	1.00: 0.82: 0.31 (1.51)	1.00: 0.88: 0.35 (1.57)	1.00: 0.87: 0.37 (1.58)	1.00: 0.84: 0.41 (1.19)
hindleg length ratios	1.00: 0.91: 0.31 (1.74).	1.00: 0.91: 0.38 (1.40)	1.00: 0.83: 0.28 (1.79)	1.00: 0.87: 0.31 (1.84)	1.00: 0.91: 0.33 (1.89)	1.00: 0.92: 0.40 (1.33)
fore femora length width ratio	fore femora 2.9 times longer than wide		fore femora 2.5 times longer than wide	fore femora 3.2 times longer than wide	fore femora 3.0 times longer than wide	fore femora 2.6 times longer than wide
fore tarsi – number of spines	5-10	approx. 13	6-8	3-6	6-9	10-15
tarsal claws – number of ventral teeth	10-16	approx. 11	10-14	9-12	12-15	16-18, subapical tooth greatly enlarged

Table 9 cont'd.

	fusca	*fuscula*	*nigeli*	"AV5"	"AV7"	"AV8"
abdomen colour	tan to dark brown with golden markings on each segment forming a broken stripe midline, generally with two golden coloured maculae flanking each midline marking anteriorly but pattern highly variable	often black with yellow-brown markings, pattern variable.	dark brown to black with yellow to light brown markings medially on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline markings anteriorly	tan brown with underlying yellow colour; yellow patches of colour on segments six to nine, progressively larger posteriorly; segment ten almost entirely yellow;	tan brown with yellow and dark chocolate brown markings, segment ten almost entirely yellow; pattern variable;	golden to tan brown with distinctive dark brown markings; segment ten almost entirely yellow
gill colour	clear to pink	pale, brownish	grey to black	opaque, greyish;	clear	clear
gill shape	slender, tapering to a thin point apically	slender, tapering to a thin point apically	slender, tapered to a thin point apically	linear, apically tapered;	linear, tapering to a thin point apically, upper lamellae with slightly longer tail;	linear, tapering to a thin point apically;
gill tracheation	variable – main tracheae strongly developed, lateral tracheae strongly to weakly developed	main and lateral tracheae strongly developed.	weakly to moderately well developed.	main tracheae strongly developed, lateral tracheae absent or weakly developed.	main tracheae strongly developed, lateral tracheae strongly developed.	main tracheae strongly developed, lateral tracheae weakly developed.

3.3.4 Subgeneric separation

As mentioned in 3.3.1 Campbell and Suter (1988) created the new subgenus *Nousia* (*Australonousia*) to accommodate the Australian species of *Nousia*. However, they based this subgeneric separation on five characters which have subsequently been questioned (Dean 1999). The five characters included: from the male imago, distance of the MA fork in the imago forewing and the penes shape; the shape and surface characteristics of the egg and from the nymph, the cleftness of the hypopharynx anterior margin and shape of the left mandible prostheca.

As a result of the revision of *Nousia* (*Australonousia*) and the subsequent redefinition of the subgenus (3.3.2.1) I have been able to assess the validity of these characters and identify some others. In the male imago, I found that the MA vein of the forewing was forked at half to just over half the distance from wing base to margin in *Nousia* (*Australonousia*) not slightly less than half as espoused by Campbell and Suter (1988). As Pescador and Peters (1985) state that at the genus level the MA of *Nousia* (*Nousia*) forks at more than half the distance from wing base to margin this character cannot̬ be̬ used as a subgeneric separator. The penes of both taxa are fused in basal two-thirds as Campbell and Suter (1988) claim but the maxim that the remainder is divided and tubular in *Nousia* (*Nousia*) and divided and divergent in *Nousia* (*Australonousia*) does not always apply (eg *N. (A)* sp. "AV7"). The only other imago character I can determine as a variation between the two taxa is the frequent absence of crossveins in the proximal halves of the costal and subcostal spaces of the male forewing in *Nousia* (*Australonousia*) and the presence of such veins, albeit sometimes weakly developed, in *Nousia* (*Nousia*). However, this is not a consistent difference as *Nousia* (*Australonousia*) also has weakly developed crossveins in this area in some species (eg *N. (A) fuscula*).

As stated in 3.3.2.4 I believe the egg morphology of *N. (A) fuscula*, with the three rings of tubular processes, as represented in Suter (1986) and Campbell and Suter (1988) is false. The true morphology of *Nousia* (*Australonousia*) eggs appears to be a chorion with large circular shaped protuberances, sometimes interspersed with smaller ones. The tubular processes, I believe, are representative of the genus *Koorrnonga*.

The nymphal characters identified by Campbell and Suter (1988) to separate the subgenus are consistent. The lingua of the hypopharynx is shallowly cleft in *Nousia* (*Nousia*) and moderately to deeply cleft in *Nousia* (*Australonousia*). Also, the left mandible prostheca is relatively slender in *Nousia* (*Nousia*) compared with the robust serrated prostheca in *Nousia* (*Australonousia*). Other characters identified as variations between the taxa as a result of this study are as follows: denticle width always narrow in

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Nousia (Nousia) usually wider in *Nousia (Australonousia)* (exception *N. (A)* sp. "AV8");
maxillae with an average 9-12 subpectinate setae in *Nousia (Nousia)*, 11-23 in *Nousia*
(Australonousia); galea-lacinae slightly wider than long in *Nousia (Nousia)*, usually as
wide as long in *Nousia (Australonousia)*; hypopharynx superlingua always with rounded
lateral margins in *Nousia (Nousia)*, variable in *Nousia (Australonousia)* from rounded to
slightly angular, sometimes with indentations; segment two and three of maxillary palps
subequal in length in *Nousia (Nousia)* segment three usually shorter than segment two in
Nousia (Australonousia); subapical denticles of tarsal claws greatly enlarged in *Nousia*
(Nousia), not usually greatly enlarged in *Nousia (Australonousia)* (exception *N. (A)* sp.
"AV8").

It appears that the male and female imago characters used for subgeneric separation do
not hold. The nymphal characters are somewhat more robust, but apart from the original
differences proposed by Campbell and Suter (1988) the other differences I elucidated are
not distinct, either having exceptions or overlapping with each other.

I consider my revision of Australian *Nousia (Nousia)* is incomplete, largely due to lack of
material. I believe *Nousia (Australonousia)* is not as morphologically diverse as stated
(Dean 1999) but has become a "dumping ground" for undescribed species. Certainly,
some of the morphospecies included in this revision do not conform to the definition of the
genus *sensu* Pescador and Peters (1985). After careful consideration I transferred three
of these morphospecies into two new genera (See Chapter 4). However, I have still not
accounted for seven morphospecies in this revision (not including sp. "AV5", "AV7" and
"AV8"). Many of these morphospecies were searched for extensively from the locations
of the few specimens that were available to me, with no success. Ultimately, these
species will have to caught, reared and identified and included (or not) in *Nousia*
(Australonousia).

I must conclude that although I feel the subgeneric classification is superfluous at this
stage, further material must be collected to complete the revision and make a more
informed decision. In the interests of stability it would be prudent to retain the subgeneric
classification until these possible new species are found and described.

3.4 Revision of the genus *Koorrnonga*

3.4.1 History

This genus *Koorrnonga* was established by Campbell and Suter (1988) primarily to accommodate the species *Nousia inconspicua* and *Nousia pilosa*. These species were described thoroughly as *Nousia* by Suter (1986) during his revision of the South Australian mayflies. The two species were subsequently considered sufficiently different to warrant the establishment of a new genus. The other four species placed in the new genus at the time; *fusca, simillima, brunnea* and *parva* all became new combinations. They had been previously assigned to *Atalonella*, then automatically transferred to *Nousia* when the two genera were synonymized (Pescador and Peters 1985). Very little was known about these species at the time; the descriptions and drawings being scarce and somewhat inadequate. It also appears the types were not examined. Campbell and Suter (1988) admit that some of the placements were considered tentative at the time but generally the characters described in the literature appeared to fit more closely to the nominated type species, *Leptophlebia inconspicua* Eaton. It was reasonable to assume therefore that they belonged in the new genus but their status remained questionable.

3.4.2 Generic designation

I believe that establishment of the genus *Koorrnonga* was premature. The species *Thraulus dentatus* (Ulmer 1916) (subsequently renamed *Atalophlebia lucida* (Ulmer 1919; Ulmer 1920)) and automatically transferred to *Atalonella* by Harker (1954) is remarkably similar to other species belonging to *Koorrnonga*. Demoulin (1955c) recognised this fact. He considered that the angular shape of the hindwing, and the wing venation in general, prevented its placement in *Atalophlebia* or *Atalonella*. No other genus described at the time seemed to fit the characters of the specimen and he therefore created a new genus *Thraulophlebia*, nominating *Atalophlebia lucida* Ulmer as the type specimen.

I have examined the type specimens of *Atalophlebia lucida* (two male imagos) from the SMNH and they conform to the genus description of *Koorrnonga* in that the forewings have no crossveins in subcostal and costal spaces, the hind wing has a strong projection on the costa and the penes lobes are not distinctly separated facing inwards towards the midline. As a result of this, and my understanding of the features of the genus as a result of this study, I believe *Koorrnonga* should be synonymized with *Thraulophlebia*. As *Thraulophlebia* has priority, all species now belonging to *Koorrnonga* are now transferred to this genus. *Atalophlebia lucida* becomes the type species for the genus.

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3.4.3 Descriptions

3.4.3.1 *Thraulophlebia* Demoulin

Thraulophlebia Demoulin (Demoulin 1955c)

Koormonga Campbell & Suter (Campbell and Suter 1988)

Type species. *Atalophlebia lucida* Ulmer (Ulmer 1919)

Species included. *Thraulophlebia lucida* (Ulmer) comb. nov., *Thraulophlebia inconspicua* (Eaton) comb. nov., *Thraulophlebia parva* (Harker) comb. nov., *Thraulophlebia simillima* (Ulmer) *Incertae sedis*.

Distribution. New South Wales, South Australia, Queensland, Victoria (Fig. 178).

Diagnosis. Male imago. Dimensions: body length 5.6-7.4; forewing length 5.7-8.1; hindwing length 0.83-1.58; forewing hindwing ratio 4.37-7.56. General body colour variable, ranging from light to tan to chocolate brown to black. Head: tan brown to dark brown to black. Antennae: pedicel, scape medium to dark brown, flagellum golden to tan brown. Ocelli: three; black with white to white-grey inserts; laterals larger than medial. Eyes: upper eye size large, often contiguous, ES=0.00-0.15; upper lobe colour variable (orange-brown, tan brown, pink brown), lower lobes grey-black. Thorax: pronotum and mesonotum tan to dark brown, mesonotum sometimes shiny brown. Legs: colour variable (golden, light brown, tan brown); femora usually darker; banding present or absent; forelegs with seven segments, total foreleg length 4.45-7.46, tibia approximately 1.4 times length of femur, the five segmented tarsus approximately 1.3-1.6 times length of femur; tarsal claws of a pair similar, each apically hooked with an opposing hook. Wings. Forewing: membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins dark brown, anal veins yellow; costal and subcostal crossveins usually absent proximally, costal space with 6-11 crossveins distally, subcostal space with 4-10 crossveins distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at around half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein, ICu_2 joins ICu_1, ICu_1 and ICu_2 parallel or very slightly diverging as wing margin approached, CuP strongly recurved and linked by cross vein to A_1. Hindwing mostly hyaline, costal space washed with yellow and very slightly opaque; strong projection of the costa which joins subcosta at approximately two-thirds to four-fifths wing length; no crossveins in proximal halves of costal space, 2-4 in distal space, 3-5 throughout subcostal space. Abdomen: colour and pattern variable ranging from tan to dark brown to black with golden to light tan markings on each segment forming a broken stripe midline,

two golden coloured maculae flanking each midline marking anteriorly. Genitalia: forceps three segmented; first segment usually darker, progressively lighter apically; middle and terminal segment about the same length. Penes: two lobes distinct, lobes joined apically (or very nearly so), fused in basal third to half ventrally, separated at base or fused in basal third dorsally; lobes sometimes indented apically; rounded to angular expanded lateral margin in apical third; ventral view with or without subapical lobes protruding laterally outwards; with or without small blunt triangular tooth on inner lateral margin, generally visible under transmitted light only. Caudal filaments: three; golden to brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length 5.6-8.8; forewing length 5.9-8.5; hindwing length 0.69-1.70; forewing hindwing ratio 4.93-8.55. General patterning and colouring similar to male. Eyes: brown-black to grey-black; separated on meson of head by a distance four to five times maximum width of eye. Legs: shorter than male; total foreleg length 3.81-5.13; forelegs with six segments, tibia approximately 1.2-1.4 times longer than the femur, the four segmented tarsus approximately 0.6-0.7 times longer than the femur. Wings. Forewing: colour and venation similar to males except usually with weakly developed crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 2-6 weakly developed crossveins proximally, 7-15 distally, subcostal space with 0-5 weakly developed crossveins proximally, 6-11 distally. Hindwing: no crossveins in proximal halves of costal space, 2-4 in distal space, 3-6 throughout subcostal space. Abdomen: sternum seven with small genital extension; sternum nine deeply cleft. **Egg.** Ovoid to cylindrical with rounded ends, polar cap with two or three rings of tubular processes; chorion with small evenly spaced circular proturbences. **Male and female subimago.** General colour and markings dull greyish black, similar to imago. Wings opaque, uniformly grey-brown. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** Body lengths: ♂ 5.0-7.5, ♀ 5.8-10.0. General body colour variable, ranging from tan or middle to chocolate brown to black with light and / or dark markings. Head: prognathous; tan to middle to dark brown; width 1.28-1.65. Ocelli: three; black with white to grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; one and a half to more than twice length of head. Eyes: upper lobes of male orange to reddish-brown, lower lobes grey-black to black; eyes of female black. Mouthparts. Labrum and clypeus: lateral margins of clypeus very slightly diverging towards anterior; lateral margins of labrum subequal to slightly wider than clypeus, rounded to slightly angular; anterior margin of labrum with slight or distinct antero-median emargination; labrum length 0.27-0.41, labrum width 0.51-0.86, labrum width length ratio 1.69-2.56; four to five elongate denticles present on anterior margin extending 0.08-0.38 times the width of the labrum, denticle width as proportion of labrum width 0.14-0.38; frontal setae arranged as a single row or narrow band; secondary hair fringe clearly separated from front row, reaching well beyond frontal setae, extending 0.04-0.25 times

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the width of the labrum, containing 12-55 setae; secondary hair fringe width to labrum width ratio 0.06-0.35; thick socketed setae present lateral to secondary hair fringe. Mandibles: outer margins slightly curved, long spine-like setae at midpoint on outer lateral margins, occasionally shorter setae between tuft and base; dark coloured nodule at midpoint on inner lateral margins; sparse tuft of setae on lower mandible body. Left mandible: two incisors, each with three apical teeth; outer incisor often inconspicuously serrated on inner lateral margin; prostheca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible: sparse long setae on inner lateral margin; two incisors, outer incisor with three apical teeth, often inconspicuously serrated on inner lateral margin; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae: galea-lacinae generally as wide as long, width length ratio 0.88-1.12; subapical row of 16-22 pectinate setae; palpi three segmented, first segment length 0.22-0.23, segment two 0.75-0.85 times the length of first segment, terminal segment 0.64-0.75 times the length of first segment, usually with single spine apically. Hypopharynx: well developed lateral processes; anterior margin of lingua shallowly cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded to slightly angular lateral margins. Labium: glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment length 0.32-0.34, segment two 0.84-0.88 times the length of first segment, terminal segment 0.57-0.65 times the length of first segment, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; submentum with spines on lateral margins. Thorax: colour ranges from tan to middle brown often with dark brown markings; pronotum width 1.10-1.72, approximately equal to width of head; head pronotum width ratio 0.92-1.00. Legs: golden to tan to dark brown, banding present or absent; total foreleg length 2.53-3.73; fore femora length 1.05-1.60, fore femora width 0.28-0.53; fore femora length width ratio 2.74-3.75; fore tarsi with 8-14 ventral spines, tarsal claws with 11-15 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; foreleg length ratios, tibiae 0.92-0.93 times length of femur, tarsi 0.40-0.47 times length of femur; midleg length ratios, tibiae 0.90-0.93 times length of femur, tarsi 0.35-0.39 times length of femur; hindleg length ratios, tibiae 0.93-1.00 times length of femur, tarsi 0.34-0.36 times length of femur. Abdomen: colour dark brown to black with golden markings commonly forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly; posterolateral spines present, progressively larger posteriorly. Gills: membrane clear to light-grey or pink; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae dissimilar in size; upper lamellae narrows at three-quarters length with long apical filament or broadened apical third; lower lamellae narrows at four-fifths length,

tapering to a thin point apically; main and lateral tracheae strongly developed. Caudal filaments: three; golden; terminal filament longer than cerci.

Remarks. The genus *Thraulophlebia* can be distinguished from all other genera in the Leptophlebiidae family by the following combination of characters: In the imago: (i) body length ♂ 5.6-7.4; ♀5.6-8.8; (ii) forewing hindwing ratio, ♂ 4.4-7.6; ♀ 4.9-8.6; (iii) male upper eye size large, often contiguous; (iv) male and female forewing 4.4-8.6 times longer than hindwing; (v) male forewing crossveins faint, or more usually absent, from proximal halves of wing, MA forked at around half to the distance from wing base to margin, MP_2 connected to MP_1 and CuA, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein; ICu_2 joins ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1; (vi) hindwing with strong projection of the costa, joins subcosta at approximately two-thirds to four-fifths wing length; (vii) tarsal claws of a pair similar, each apically hooked with an opposing hook; (viii) penes fused in basal third to half ventrally, expanded lateral margins in apical third; (ix) female eyes separated on meson of head by a distance about four to five times maximum width of eye; (x) female sternum seven with small genital extension; (xi) female sternum nine deeply cleft. In the nymph: (i) body length ♂ 5.0-7.5, ♀ 5.8-10.0; (ii) antennal length one and a half to more than twice length of head; (iii) lateral margins of clypeus very slightly diverging towards anterior; (iv) labrum slightly less than to slightly more than twice as wide as long; labrum subequal to slightly wider than clypeus, lateral margins rounded to slightly angular; labrum antero-median emargination slight or distinct bearing four to five elongate denticles; denticles extend 0.10 to 0.38 the width of labrum; labrum frontal setae arranged as a single row or narrow band; labrum secondary hair fringe clearly separated, reaching well beyond front band, containing 12-55 setae, extends 0.06 to one-third the width of labrum; thick socketed setae present lateral to secondary hair fringe; (v) mandibles with outer margins slightly curved; incisors often with inconspicuous serrations of lateral margins; (vi) maxillae with galea lacinae generally about as wide as long; subapical row of 16-22 pectinate setae; terminal palp with single spine apically; (vii) hypopharynx shallowly cleft, superlingua with rounded to slightly angular lateral margins; (viii) labium glossae not turned under ventrally; terminal segment elongate with row of triangular spines almost circling apex; submentum with lateral spines; (ix) pronotum about as wide as head; (x) legs with fore femora 2.7-3.8 times longer than wide; fore tarsi with 8-14 ventral spines, tarsal claws with 11-15 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; (xi) abdomen with posterolateral spines, progressively larger posteriorly; (xii) gills with margins entire, double, upper and lower lamellae dissimilar in size, upper lamellae narrows at three-quarters length with long apical filament or broadened apical third, lower lamellae narrows at four-fifths length tapering to a thin point apically; main and lateral tracheae strongly developed.

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3.4.3.2 *Thraulophlebia lucida* (Ulmer) comb. nov.

Thraulus dentatus Ulmer (Ulmer 1916) [partim]

Atalophlebia lucida Ulmer (Ulmer 1919)

Atalonella lucida (Ulmer) (Harker 1954)

Thraulophlebia lucida (Ulmer) (Demoulin 1955c)

Koormonga sp. "AV1" (Dean 1999)

Koormonga pilosa (Suter) (Campbell and Suter 1988)

Thraulophlebia lucida (Ulmer) (Demoulin 1955c)

Types. Holotype (here designated). *Atalophlebia lucida* Ulmer. Cedar Creek, Queensland. 10030001, III 1910-1913, coll. Mjöberg's expedition, 1 ♂ imago, head and genitalia attached, hindwings missing. **Paratype.** (here designated). *Atalophlebia lucida* Ulmer. Same collection data, stored in the same vial, 1 ♂ imago, head and genitalia detached. Labels: a) "*Thraulus dentatus* Ul. (Type)", b) "*Atalophlebia lucida* Ulm. (Ulm. 1920) Typus", c) "Queensl. Mjöberg ", d) "Cedar Creek", e) "mars". Held at the SMNH.

Koormonga pilosa (Suter)

Nousia pilosa Suter (Suter 1986)

Koormonga pilosa (Suter) (Campbell and Suter 1988)

Types. Holotype. *Nousia pilosa.* Second Wannon River, Grampians, Victoria. 77112502, 25 XI 1997, grid reference 547396, ♂ imago, alcohol and slide material, coll. D.N and P.J. Suter. Labels: a) "Holotype M T-8941", b) "*Nousia pilosa* N.sp. P. SUTER 1986. Second Wannon River South of Halls Gap, Vic. G.R. 547396. 25-11-1977. D.N. and P.J. SUTER Body and Genitalia +2 slides". **Paratypes.** Same location and collection data, 3 ♂ imagos, 3 ♂ nymphs, 3 ♀ nymphs. Hitchcock Drain, South Australia. 77112501, 25 XI 1997, 1 ♂ imago, 1 ♂ nymph, alcohol and slide material. Labels: Vial 1 - a) "Paratypes M T-8942-8945", b) "*Nousia pilosa* N. sp. P. SUTER 1986. Second Wannon R. S of Halls Gap. Vic. G.R. 547396. 25-11-1977. D.N. + P.J. SUTER Imagos"; Vial 2 - a) "Paratypes M T-8946-8947, F T-8948-8950", b) "*Nousia pilosa* N. sp. P. SUTER 1986. Second Wannon R. S of Halls Gap. Vic. G.R. 547396. 25-11-1977. D.N. + P.J. SUTER M + F nymphs"; Vial 3 - a) "Paratype M T-8951 b) *Nousia pilosa* N. sp. P. SUTER 1986. MALE IMAGO. HITCHCOCK DRAIN S.E. South Australia 23-11-1977 D.N. + P.J. SUTER Body + slides (2)". [examined]. Held at the MV.

Distribution. New South Wales, South Australia, Queensland, Victoria (Fig. 179).

Diagnosis. A redescription was considered desirable due to the accumulation of a large number of new specimens. It has also enabled the previously unknown female imago, subimago and nymph stages to be described. **Male image** Dimensions: body lengths 5.7-7.4 (6.6±0.45, *20*); forewing length 5.7-7.4 (6.6±0.51, *21*); hindwing length 0.83-1.26 (0.98±0.10, *17*); forewing hindwing ratio 5.87-7.56 (6.80±0.59, *17*). General body colour ranging from light to tan to chocolate brown, usually quite dark. Head: dark brown. Antennae: pedicel and scape medium brown, flagellum golden. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, often contiguous, ES=0.00-0.04 (0.01±0.01, *10*); upper lobes orange-brown, lower lobes grey-black. Thorax: pronotum and mesonotum tan to dark brown. Legs: golden brown, femora apices darker, banding inconspicuous or absent; forelegs with seven segments, total foreleg length 5.64-6.61 (6.08±0.33, *10*); leg length ratios 1.00: 1.45: 0.06: 0.50: 0.48: 0.37: 0.17 (1.52±0.14, *10*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 180). Wings. Forewing (Fig. 181): membrane hyaline, pterostigmatal area slightly opaque, longitudinal and crossveins light brown, anal veins yellow; costal and subcostal crossveins absent from proximal halves of wing, costal space with 7-11 (*19*) crossveins distally, subcostal space with 5-10 (*19*) crossveins distally. Three bullae present on veins Sc, R_2, and R_{4+5}. MA forked at around half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel or very slightly diverging as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing (Fig. 182): mostly hyaline, costal space washed with yellow and very slightly opaque; strong projection of the costa which joins subcosta at approximately two-thirds wing length; no crossveins in proximal half of costal space, 2-3 (*17*)in distal space, 3-5 (*17*) throughout subcostal space. Abdomen (Fig. 183): tan to chocolate brown with golden markings forming a broken stripe midline, two coloured maculae flanking each midline marking anteriorly. Genitalia (Figs 184-189): forceps (Figs. 184, 186) three segmented; tan brown basally, becoming lighter apically; terminal segment rounded, about the same length as middle segment; penes light brown; two lobes distinct, with expanded lateral margin in apical third, each lobe indented apically; separated almost at base dorsally (Figs. 184, 186, 187); inner margin of subapical lobes corrugated representing small teeth (Fig. 188); fused in basal half ventrally (Figs. 185, 189), with subapical lobes protruding laterally outwards; no internal spines or processes apparent. Caudal filaments: three; light brown; terminal filament longer than cerci. **Female imago.** Dimensions: body lengths 5.6-7.6 (6.6±0.56, *25*); forewing length 5.9-8.3 (7.2±0.58, *21*); hindwing length 0.69-1.28 (1.04±0.14, *20*); forewing hindwing ratio 5.47-8.55 (6.93±0.77, *20*). General patterning and colour similar

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to male. Eyes: grey-black; separated on meson of head by a distance of about four times maximum width of eye. Legs: total leg length shorter than male; forelegs with six segments, total foreleg length 3.81-4.80 (4.25±0.38, 10); leg length ratios 1.00: 1.37: 0.22: 0.19: 0.15: 0.15 (1.38±0.14, 10). Wings. Forewing (Fig. 190): colour and venation similar to males except with weakly developed crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 2-6 (22) faint crossveins proximally, 8-15 (22) distally, subcostal space with 0-5 (22) faint crossveins proximally, 8-11 (22) distally. Hindwing (Fig. 191): no crossveins in proximal half of costal space, 2-3 (20) in distal space, 3-4 (20) crossveins throughout subcostal space. Abdomen (Fig. 192, 193): sternum seven with small genital extension; sternum nine deeply cleft. **Egg.** Ovoid, polar cap with two rings of tubular projections on each apex; chorion with small evenly spaced circular protuberances (Figs. 194-196). **Male and female subimago.** Dimensions: body lengths ♂ 5.5-7.2 (6.2 ± 0.52, 12); ♀ 6.0-7.3 (6.6 ± 0.46, 9). General colour and markings similar to imago. Wings uniformly opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 197). Body lengths ♂ 5.0-7.5 (6.6 ± 0.82, 20), ♀ 5.8-7.9 (7.1± 0.62, 20). General colour ranging from tan to middle to chocolate brown, usually dark, colour variable. Head: prognathous; tan to middle brown, width 1.28–1.53 (1.41± 0.08, 15). Ocelli: three; black with grey inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; approximately one and a half times length of head. Eyes: upper lobes of male orange-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 198): lateral margins of clypeus very slightly diverging to anterior; lateral margins of labrum subequal to clypeus, rounded; labrum anterior margin with slight antero-median emargination; labrum length 0.29–0.40 (0.33±0.04, 25), labrum width 0.51–0.75 (0.61±0.06, 25), labrum width length ratio 1.69–2.18 (1.86±0.13, 25); five elongated denticles present on anterior margin extending 0.14-0.21 (0.18± 0.02, 24) across labrum; denticle width labrum width ratio 0.23–0.38 (0.29±0.05, 24); frontal setae arranged as a single row; secondary hair fringe clearly separated from front row, reaching well beyond the frontal setae, containing between 12-25 (20) setae, extends 0.04-0.14 (0.08± 0.02, 25) across labrum; secondary hair fringe to labrum width ratio 0.06–0.20 (0.14±0.03, 25); thick socketed setae present lateral to secondary hair fringe. Mandibles: outer margins slightly curved; long setae at midpoint on outer lateral margins; shorter setae between long setae and base; dark coloured nodule at midpoint on inner lateral margins; sparse tuft of setae on lower mandible body. Left mandible (Fig. 199): two incisors, each with three apical teeth, outer incisor often inconspicuously serrated on inner lateral margin; prothesca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 200): spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, often inconspicuously serrated on inner

lateral margin; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 201): galea-lacinae as wide as long, width length ratio 0.91-1.12 (1.00±0.07, 12); subapical row of 16-21 (16) pectinate setae; palpi three segmented, terminal palp with single spine on apex (Fig. 202); palp length ratios 1.00: 0.79: 0.64 (0.22±0.02, 19). Hypopharynx (Fig. 203): well developed lateral processes; anterior margin of lingua shallowly cleft; superlingua with thick tufts of setae on anterior margins; lateral margins slightly angular. Labium (Fig. 204): glossae not turned under ventrally and lying in the same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface (Fig. 205); palp length ratios 1.00: 0.86: 0.65 (0.32±0.02, 12); submentum with spines on lateral margins. Thorax: tan to middle brown with darker brown markings; pronotum width 1.10-1.63 (1.36±0.14, 15); approximately equal to width of head (see above); head pronotum width ratio 0.84-1.07 (0.96±0.08, 15). Legs (Fig. 206): golden to tan brown, banding ranges from conspicuous to inconspicuous; total foreleg length 2.53-3.29 (2.89±0.21, 20); fore femora length 1.05–1.38 (1.21± 0.10, 20); fore femora width 0.28-0.43 (0.37±0.04, 20); fore femora length width ratio 2.83-3.75 (3.31±0.26, 20); fore tibiae with numerous short ventral spines, sometimes serrated (Fig. 207); fore tarsi with 8-14 (22) ventral spines, length 0.20-0.34 (0.27±0.04, 10) width of tarsus; tarsal claws (Fig. 208) with 12-15 (12) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated on inner margin; leg length ratios, foreleg 1.00: 0.92: 0.47 (1.21±0.10, 20), mid leg 1.00: 0.93: 0.35 (1.20±0.10, 15), hind leg 1.00: 1.00: 0.34 (1.26±0.12, 14). Abdomen : dark brown with golden markings medially on each segment forming a broken stripe midline, two light coloured maculae flanking midline marking, pattern variable; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 209): membrane clear to light grey; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae similarly shaped; upper lamellae narrows at three-quarters length with long apical filament, lower lamellae narrows at four-fifths length with shorter apical filament; main and lateral tracheae present, strongly developed. Caudal filaments: three; golden; terminal filament longer than cerci..

Remarks. Admittedly there is much confusion surrounding the types species of *Thraulophlebia*. A large number of specimens referred to as *Thraulus dentatus* (Ulmer 1916) were described from specimens taken during Dr Mjöberg's Swedish Expedition to Australia 1910-1913. Upon review some time later Ulmer (1919) considered that the light and dark examples he had described were in fact two different species belonging to the genus *Atalophlebia*. The dark examples were renamed *A. fusca* and the light examples *A. lucida* (a new species name was necessary as *dentatus* was pre-occupied). It was

difficult to tell whether the species *lucida* or *fusca* were being discussed in Ulmer (1916) and this was only clarified by careful examination of the type specimens in conjunction with the literature.

The type specimens were also compared closely with specimens from the MRHI and the MV. Those referred to by Dean (1999) as *Koorrnonga* sp. "AV1" also proved to be the same species. These specimens, and a large number of new specimens collected as a result of this project, enabled a complete redescription of the species including the hitherto unknown female imago, male and female subimago and nymph stages (above). The described species was then compared with the original descriptions of the new species *T. lucida*.

The size and shape of the holotype genitalia match exactly with the redescribed species giving a strong case for synonymy. Unfortunately, the genitalia drawing of the holotype (Ulmer 1919, FIG. 11, p.18, reproduced here as Fig. 210) is somewhat enigmatic with what looks like a covering surrounding the two lobes ventrally for at least two-thirds of the length. Ulmer (1919, p.19) describes the ventral surface of the penis in his paper as "..sehr breit; aus einer flach röhrenförmigen Umhüllung, deren Apikalrand etwas wulstig nach außen gebogen ist.." ("..very wide; arising from a flat tubular formed covering, of which the apical margin is somewhat swollen and bowed out.."). I am willing to concede that the rounded ends of the penes lobes could flatten and "bow out" when mounted for viewing under a compound microscope but do not understand the origin of tubular covering on the specimens I examined. Perhaps Ulmer is referring to the rounded lateral ventral margins of each penis lobe which appears to curl inwards and cover some of the inner surface of the lobes although these do not cover the entire ventral surface. Indeed, Ulmer's drawing is so different from the type specimens, I wonder that he has not confused his specimens and drawn from the wrong specimen. Incongruously, in the same paper he refers to the penes lobes being "..ragen zwei nebeneinander liegende, durch einen Spalt getrennte Loben hervor mit unregelmäßig schief abgestutstem Apex;.." ("..two lobes side by side, separated by a crack with an irregular crooked stumpy apex;..") (Ulmer 1919, p.19). This is not shown in the drawing but more clearly describes the type specimens and the redescribed *T. lucida*.

Two other important characters are the forewing venation and hindwing shape, although these characters are generic, rather than species, specific. The type specimens are consistent with the descriptions and drawings of Ulmer (1919) and the description of Demoulin (1955c). As mentioned previously (3.4.2) these features, especially the sharp curve of vein C of the hindwing ("..La C se corbe brusquement à mid-longueur..")

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(Demoulin 1955c, p.228), led the author to create a new genus for this species as it was so distinct.

In most other respects the type specimens and literature descriptions of *T. lucida* match closely with the redescription (Table 10). However, there are a number of relatively minor discrepancies between the descriptions of Ulmer (1916) and Ulmer (1919) and the redescription of *T. lucida* which should be mentioned (Table 11). These differences relate solely to colour variations amongst the adults. Colour is quite a subjective character and can be strongly influenced by environmental factors such as development temperature. The differences are minimal and I am inclined to disregard this as a major issue. The type specimens do not help to clarify the matter as the colour has faded dramatically to creamy-white and cannot be compared to the darker coloured "fresh" specimens.

Table 10. Similarities between the redescription of *Thraulophlebia lucida* and the literature descriptions and type measurements of *Thraulophlebia lucida* (incorporating *Thraulophlebia dentatus*, *Atalophlebia lucida* and *Koorrnonga* sp. "AV1").

	Thraulophlebia lucida	type measurements and literature descriptions
Male Imago		
body length	5.7-7.4 (6.6±0.45, *20*)	5.8 – holotype, 6.0 – paratype, 6 (Ulmer 1919)
forewing length	forewing length 5.7-7.4 (6.6±0.51, *21*)	6.2 – holotype, 5.6 – paratype, 6-6.5 (Ulmer 1919)
hindwing length	0.83-1.26 (0.98±0.10, *17*)	1.0 - paratype
costal crossveins – distally	absent	absent – holotype, paratype
costal crossveins – proximally	7-11 (*19*)	10 – holotype , 11 – paratype, 8–9 (Ulmer 1919)
subcostal crossveins – distally	absent	absent – holotype, paratype
subcostal crossveins – proximally	5-10 (*19*)	10 – holotype,8 – paratype, 7 (Ulmer 1919) drawing
bullae	Sc, R_2, R_{4+5}	Sc, R_2, R_{4+5} – holotype, paratype
MA fork	about half	slightly less than half – holotype, paratype approximately half (Ulmer 1919)
MP_2 connected to MP_1 and CuA	yes	yes – holotype, paratype
CuA, CuP linked by crossvein	yes	yes – holotype, paratype
ICu_1 joins CuA	yes	yes – holotype, paratype
ICu_2 joins ICu_1	yes	yes – holotype, paratype
ICu_1 and ICu_2 parallel or diverging as wing margin approached.	parallel	parallel – holotype, paratype
hindwing – costal crossveins	2-3 (*17*)	2 – paratype 2 (Ulmer 1919)
hindwing – subcostal crossveins	3-5 (*17*)	3 – paratype 3 (Ulmer 1919)
Nymph		
leg banding	*conspicuous to inconspicuous*	conspicuous (Dean 1999)
length of spines on foretarsus	0.20-0.34 (0.27±0.04, *10*)	one-third or less the diameter of tarsus (Dean 1999)

Table 11. Discrepancies between the redescription of *Thraulophlebia lucida* and the literature descriptions of *Thraulophlebia lucida* (incorporating *Thraulus dentatus, Atalophlebia lucida,* and *Koorrnonga* sp. "AV1").

	Thraulophlebia lucida	literature descriptions
Male imago		
head colour	dark brown	grey-yellow to grey-brown (Ulmer 1919)
eye colour	upper: orange-brown, lower: grey-black	upper: brick-brown to darkly cream coloured, lower: blackish (Ulmer 1919)
thorax colour	tan to dark brown	grey-brown with blackish margins (Ulmer 1919)
abdomen colour	tan to chocolate brown with golden markings	grey-yellow with dark grey-brown (Ulmer 1916,1919).

In addition to the museum and new material used for the redescription, I checked other species for possible matches to *T. lucida*. *Koorrnonga pilosa* was extensively and adequately initially described as *Nousia pilosa* (Suter 1986) in the revision of the South Australian mayfly fauna and subsequently placed in the genus *Koorrnonga* following revision of the Australian *Nousia* (Campbell and Suter 1988). Indeed, it was this same paper that established the genus *Koorrnonga* based on the morphological differences these species showed compared to *Nousia*. I wholeheartedly agree with his assessment which was based on such characters as the width of the secondary hair fringe in the nymph and the shape of the male hindwing and genitalia in the male imago. It was unfortunate then that the genus *Thraulophlebia* was not considered when the genus *Koorrnonga* was established.

The *N. pilosa* holotype has been examined and the male genitalia conforms very closely to that of the *T. lucida* types and the redescribed *T. lucida* material (Fig. 211). In addition, as the redescription of *T. lucida* encompassed a large amount of material this enabled the full range of variation within the species to be examined. In doing so, I was able to establish that *K. pilosa* fitted largely within these boundaries (Table 12).

There are a few discrepancies between the two descriptions that must be accounted for (Table 13). A most significant one, is the genitalia drawings of *N. pilosa* (Suter 1986, FIG. 12d, p377, reproduced here as Fig. 212) and the accompanying SEM photo (Suter 1986, FIG. 15f, p.380, reproduced here as Fig. 213). Although the dorsal view is not shown and the lateral margins of the penes are obscured by the forceps, the shape does not appear similar to the *T. lucida* types or newly redescribed species. I am at a loss to explain this

as the holotype genitalia of *K. pilosa* is more similar to *T. lucida* rather than Suter's drawings and micrographs.

Also in the male imago there is an apparent absence of a crossvein attaching CuP to A_1 in *K. pilosa*. I believe this was an oversight on the part of Suter as both the holotype and paratype show the crossvein present. The issue of the leg colour varying between golden and dark brown between the two "speies" can be dismissed, I believe, as natural variation.

A large number of discrepancies refer to measurements and ratios in both the imago and nymph. For many of the measurements and ratios *K pilosa* is larger and within, or just outside, the range of measurements for *T. lucida* specimens both in the imago (body length, forewing length, hindwing length) and the nymph (head width, pronotum width, head/pronotum width ratio, labrum length width ratio). The total fore leg lengths of both the imago and nymph and the palp length ratios of the labium and maxillae, however, are very much larger in *K. pilosa* than *T. lucida*. As there is no indication of the number of specimens measured for *K. pilosa* (Suter 1986) it is possible that they refer to a few large individuals. In most cases the ratios of the various measurements are similar.

Table 12. Similarities between the redescription of *Thraulophlebia lucida* and the literature descriptions of *Koorrnonga pilosa*.

	Thraulophlebia lucida redescription	*Koorrnonga pilosa* literature descriptions (Suter 1986)
Male imago		
head colour	dark brown	black-brown
eye colour	upper lobes orange brown	upper lobes pink brown
costal crossveins – proximal /.distal	absent / 7-11 (*19*)	absent / 9 (drawing)
subcostal crossveins – proximal / distal	absent / 5-10 (*19*)	absent / 7
bullae	Sc, R_2, and R_{4+5}	Sc, R_2, and R_{4+5}
MA fork	around half	around half (drawing)
MP_2 connected to MP_1 and CuA	yes	yes (drawing)
CuA and CuP linked by crossvein	yes	yes (drawing)
ICu_1 joins CuA	yes	yes (drawing)
ICu_2 joins ICu_1	yes	yes (drawing)
ICu_1 and ICu_2 parallel or diverging	parallel	parallel (drawing)
hindwing costa joins subcosta	two-thirds	two-thirds (drawing)
hindwing crossveins – costal/subcostal	2-3 (*17*) / 3-5 (*17*)	2 / 3
abdomen colour	chocolate brown with golden markings	dark brown, mid dorsal light brown
caudal filaments	terminal filament longer than cerci	cerci length 9.05, terminal filament length 12.00
Nymph		
head colour	tan to middle brown	light brown
male eye colour	upper lobes orange brown	upper lobes red-brown
denticle number	5	6
left mandible incisors	3,3	3,3
right mandible incisors	3,2	3,2
hypopharynx	shallowly cleft	shallowly cleft (drawing)
legs	golden to tan brown	light brown
forefemur length to width ratio	2.83-3.75 (3.31±0.26, *20*)	3.13
leg banding	ranges from conspicuous to inconspicuous	absent
tarsal claws – teeth no.	12-15 (*12*)	12
abdomen colour	dark brown with light central golden markings	dark brown with light central marking
gills	double, upper lamellae longer than lower	double, upper lamellae longer than lower

Table 13. Discrepancies between the redescription of *Thraulophlebia lucida* and the literature descriptions of *Koorrnonga pilosa*.

	Thraulophlebia lucida redescription	*Koorrnonga pilosa* literature descriptions (Suter 1986)
Male Imago		
body length	5.7-7.4 (6.6±0.45, *20*)	7.5
forewing length	5.7-7.4 (6.6±0.51, *21*)	7.67
hindwing length	0.83-1.26 (0.98±0.10, *17*)	1.23
legs	golden brown, femora apices darker	femur dark brown, tibia and tarsi light brown
total foreleg length	5.64-6.61 (6.08±0.33, *10*)	7.07
CuP attached to A1	yes	no (drawing)
penes shape	fused in basal half ventrally, separated almost at base dorsally; two lobes distinct, separating then coming together apically, each lobe indented apically; ventral view with subapical lobes protruding laterally outwards; dorsal view with expanded lateral margin in apical third.	penes fused, apex with two lobes, ventral surface lacking lobes.
Nymph		
head width	1.28-1.53 (1.41±0.08, *15*)	1.20
pronotum width	1.10-1.63 (1.36±0.14, *15*)	1.09
head pronotum width ratio	0.84-1.07 (0.96±0.08, *15*)	pronotum width 0.91 x head width
labrum length width ratio	1.69-? 18 (1.86±0.13, *25*)	1.5 times wider than long
maxillae palp length ratios	1.00: 0.79: 0.64 (0.22±0.02, *19*)	1.00: 0.68: 0.68 (0.27)
labium palp length ratios	1.00: 0.86: 0.65 (0.32±0.02, *12*)	1.00: 0.77: 0.49 (0.44)
total foreleg length	2.53-3.29 (2.89±0.21, *20*)	4.01
foreleg	1.00: 0.92: 0.47 (1.21±0.10, *20*)	1.00: 0.96: 0.40 (1.70)
midleg	1.00: 0.93: 0.35 (1.20±0.10, *15*)	1.00: 0.95: 0.31 (1.77)
hindleg	1.00: 1.00: 0.34 (1.26±0.12, *14*)	1.00: 1.01: 0.29 (1.93)

I am confident in the synonymy of *T. lucida*, *Koormonga* sp. "AV1" and *K. pilosa* based on morphological similarity, especially with regard to the the size and shape of the male genitalia. I therefore formally synonymise *T. lucida* with *K. pilosa*. The types of *K.pilosa* now become part of the type series for *T. lucida*.

I was unable to collect a specimen from the type locality of Cedar Creek in Queensland to confirm my diagnosis (see 3.3.2.2). A small number of specimens of *Koormonga* sp. "AV1" have been found in South East Queensland. Whether this encompasses the Cedar Creek mentioned in Ulmer (1916 and 1919) is unknown. A comprehensive survey of Queensland would be required to determine the extent of the distribution of this species.

Thraulophlebia lucida can be distinguished from all other species in the genus by the following combination of characters. In the imago: (i) forewing hindwing ratio comparatively large; (ii) upper eye size large, often contiguous; (iii) leg banding conspicuous to inconspicuous; (iv) penes with expanded lateral margin in apical third; fused in basal half ventrally; separated at base dorsally; lobes indented apically; subapical lobes ventrally protruding laterally outwards; (v) female body length comparatively shorter on average; (vi) egg ovoid with two rings of tubular processes. In the nymph: (i) labrum subequal to clypeus, lateral margins rounded, antero-median emargination slight, length width ratio less then two on average; single row of frontal setae; secondary hair fringe containing 12-25 setae with width approximately one-sixth across labrum; (ii) hypopharynx superlingua with slightly angular lateral margins; (iii) leg banding inconspicuous to absent; (iv) gill shape with upper lamellae narrowing at three quarters length with long apical filament, lower lamellae narrows at four-fifths length with long apical filament.

Specimens examined. NEW SOUTH WALES. Allyn River, 12km N of Eccleston, 80022101, 21 II 1980, 300m, 151°29′ 32°09′,1 ♀ I (AC). **Jindabyne,** 76022100, 21 II 1976, 1000m, 148°37′ 36°24′,1 ♂ N, 1 ♂ S (AN). **Wentworth Falls,** Blue Mountains, 82111600, 16 XI 1982, 800m, 150°22′ 33°43′, EPH 1130, 1 ♂ N, 2 ♀ N (DC). **QUEENSLAND. Branch Creek,** Conondale Ranges, 97082601, 26 VIII 1997, 160m, 152°43′ 26°53′,EPH 1264, 3 ♂ N, 1 ♀ N (JD). **Stony Creek,** Conondale Ranges, 97082602, 26 VIII 1997, 140m, 152°41′ 26°51′, EPH 1259, 3 ♂ N (JD). **TASMANIA. Aspley River,** Bicheno, 72110900, 9 XI 1972, 20m, 148°18′ 41°52′,1 ♀ I (AN). **Chung River,** Rd to Pioneer from St Helens, 95020903, 9 II 1995, 130m, 147°59′ 41°05′, EPH 0203, 4 ♂ N (PS&PG). **North George River,** 94030702, 7 III 1994, EPH 0198, 2 ♀ N (PS&MS). **Powers Rivulet,** 94030703, 7 III 1994, 100m, 148°05′ 41°19′, EPH 0225, 3 ♀ N (PS& MS). **Seven Time Creek,** Tasman Highway near Targa, 95020804, 8 II 1995, 400m, 147°22′ 41°18′, EPH 0216, 1 ♂ N, 4 ♀ N (PS&PG). **St Patricks River,**

Nunamara, 95020805, 8 II 1995, 350m, 147°17′ 41°23′, EPH 0233, 3 ♂ N, 2 ♀ N (PS& PG). **VICTORIA. Badger Creek,** Dalry Rd, 76032500, 25 III 1976, 90m, 145°31′ 37°41′, EPH 1503, 1 ♀ NI (JD), EPH 1504, 3 ♀ I (JD). **Badger Creek,** downstream weir, 78033000, 30 III 1978, 280m, 145°34′ 37°41′, EPH 1506, 1 ♂ S (JD); 80010800, 8 I 1980, same locality data, 1 ♀ I (JD). **Barkly River,** Lyndon Flat, 9km NW of Liccla, (Mc14), 76120300, 3 XII 1976, 260m, 146°34′ 37°33′, 1 ♂ I (AC). **Bellbrook Creek,** Midland Highway, Yinnar South, 99030402, 4 III 1999, 100m, 146°18′37″ 38°22′03″, 1 ♂ N, 5 ♀ N (KJF). **Bonang River,** Dellicknora, 97031401, 14 III 1997, 600m, 148°40′ 37°06′, 1 ♀ N (KJF). **Branch Creek,** Victoria Range, Grampians, 66121600, 16 XII 1966, 142°15′ 37 °23′,1 ♂ I, 1 ♀ I (AN). **Dairy Creek,** Grampians Tourist Rd, 99011601, 16 I 1999, 290m, 142°32′30″ 37°11′38″, 1 ♂ NSI, 1 ♀ NSI, 2 ♂ N, 2 ♀ N (KJF). **Charleys Creek,** 5km S of Gellibrand, 82012900, 29 I 1982, 90m, 143°41′ 38°33′, 2 ♀ I (AN). **Chinaman's Creek,** Wilsons Promitory National Park, 99030400, 4 III 1999, 60m, 146°23′ 38°55′, 1 ♂ I, MV light, (TN& KW). **Diamond Creek,** Hurstbridge, 28 XI 1986, EPH 1507, 2 ♂ N, 12 ♀ N (JD). **Diamond Creek,** 7km SE of Gembrook, 79013100, 31 I 1979, 130m, 145°37′ 37°58′ 1 ♂ I (AN&AW). **Dinner Creek,** Wangarabell Rd, 99021301, 13 II 1999, 130m, 149°31′20″ 37°24′39″, 5 ♂ N, 7 ♀ N (KJF). **Deep Spring,** Wombat State Forest, 97122003, 20 XII 1997, 480m, 144°04′20″ 37°21′07″, 1 ♀ NSI, 1 ♂ N, 4 ♀ N (KJF); 98110103, 1 XI 1998, same locality data, 1 ♂ NSI, 2 ♀ NSI, 1 ♂ N, 3 ♀ N (KJF). **Donnelly Creek,** upstream Watts River, 78022300, 23 II 1978, 140m, 145°32′ 37°37′,EPH 1495, 1 ♂ I (genitalia missing), 2 ♀ I, 2 ♂ S, 1 ♀ S (JD). **Eurobin River,** Mount Buffalo Rd, Mt Buffalo National Park, 96110702, 7 XI 1996, 440m, 146°50′29″ 36°43′10″, 1 ♂ N, 1 ♀ N (KJF); 99021101, 11 II 1999, same locality data, 2 ♀ I, 1 ♀ S, 3 ♂ N, 10 ♀ N (KJF). **Erinundra Creek,** 15km N of Club Terrace, 75111100, 11 XI 1975, 120m, 148°55′ 37°22′, 1 ♀ I, (JB). **Fitzroy River,** T&W Rd, off Princes Highway, 99022801, 28 II 1999, 80m, 141°25′38″ 38°04′38″, 1 ♀ N (KJF). **Fyans Creek,** Grampians Tourist Rd, 00012202, 22 I 2000, 290m, 142°32′30″ 37°12′59″, 1 ♂ N, 1 ♀ N (KJF). **Gellibrand River,** Pumping Station at Carlisle River junction, 82012500, 25 I 1982, 40m, 143°23′ 38°33′ (AN). **Gellibrand River,** 3km E Gellibrand, 82012600, 26 I 1982, 80m, 143°33′ 38°31′ 1 ♂ I (RStC& AN). **German Creek,** Bright-Tawonga Rd, near Bright, 96110901, 9 XI 1996, 440m, 147°03′25″ 36°43′58″, 1 ♂ N, 2 ♀ N (KJF). **Gulf Stream,** downstream Epacris Falls, Mount Victory Rd, Grampians, 99011603, 16 I 1999, 440m, 142°29′36″ 37°09′00″, 1 ♂ NSI, 2 ♀ NSI, 1 ♂ N, 3 ♀ N (KJF); 00012201, 22 I 2000, same locality data, 2 ♂ NSI, 1 ♀ NSI, 2 ♂ N, 2 ♀ N (KJF). **Hensleigh River,** Combienbar Rd Ford, 98012505, 25 I 1998, 240m, 149°01′08″ 37°21′36″, 1 ♂ N (KJF). **Holland Creek,** Fords Bridge, Tatong-Tolmie Rd, 99022003, 20 II 1999, 360m, 146°08′13″ 36°49′37″, 1 ♂ N (KJF). **Howqua River,** 12km SE of Merrijig, 71113000, 30

XI 1971, 420m, 146°19' 37°11' 1 ♂ 1 (AN). **Jackson's Creek tributary,** Waterloo Flat
Rd, 97102601,26 X 1997, 470m, 144°31'27" 37°28'30", 1 ♂ NSI, 1 ♀ NSI, 2 ♀ NI, 2 ♂ N,
2 ♀ N (KJF). **Jimmys Creek,** Glenelg, 94111000, 10 XI 1994, 1 ♂ I (MRHI). **Johnstone
Creek,** Portland-Nelson Rd, 97030401, 4 III 1997, 110m, 141°19'16" 38°11'33", 1 ♂ NSI,
1 ♀ N (KJF); 97102501, 25 X 1997, same locality data, 2 ♀ NSI, 1 ♀ N (KJF).
Kangaroo Creek, Kangaroo Rd, 5km E of Daylesford, 97010901,9 I 1997, 600m,
144°13'45" 37°21'10", 1 ♂ NSI, 1 ♀ NSI, 1 ♀ NI, 1 ♀ SI, 3 ♂ N, 2 ♀ N (KJF). **King
Parrot Creek,** Whittlesea-Yea Rd, 15km SW of Flowerdale, 98030501, 5 III 1998, 350m,
145°14'48" 37°25'50", 1 ♂ N (KJF). **Lardner Creek,** Lardners Rd, 96040504, 5 IV 1996,
80m, 143°32'33" 38°32'11", 1 ♂ S (KJF). **Love Creek,** Loves Creek Picnic Ground,
Colac-Beech Forrest Rd, 98010303, 3 I 1998, 100m, 143°34'52" 38°28'55", 1 ♂ N, 1 ♀ N
(KJF). **Main Creek,** Baldry's Rd, Green's Bush National Park, 97041601, 16 IV 1997,
110m, 144°57'34" 38°25'20", 1 ♀ N (KJF). **Martins Creek No. 2,** Bonang Rd, 0.5km S of
Malinns, 99021306, 13 II 1999, 260m, 148°36' 37°25', 2 ♀ N (KJF). **Perisher Creek,**
Smiggin Holes-Guthega Rd, 97120203, 2 XII 1997, 1520m, 148'25" 36°22', 1 ♂ NSI, 1 ♀
NSI, 1 ♂ NS, 1 ♂ N (KJF). **Sassafras Creek,** 1km N of Kallista, 74103000, 30 X 1974,
320m, 145°22' 37°52', 1 ♂ I (AN). **Scrubby Valley Creek,** Flat Rock Crossing, Glenelg
River Rd, 16 I 1999, 290m, 142°26'36" 37°09'46", 1 ♂ NS (KJF). **Spring Creek,** 4.5km
upstream Alexandra-Yarck Rd, 81110400, 4 XI 1981, 220m, 145°38' 37°08', EPH 1509, 1
♂ NS (JD). **Starvation Creek,** 76031900, 19 III 1976, 240m, 145°47' 37°42', EPH 1490,
1 ♂ NSI, (genitalia missing) (JD), EPH 1491, 1 ♂ I, (genitalia missing) (JD), EPH 1492, 1
♀ ! (JD), EPH 1493, 1 ♂ I, (genitalia missing), 1 ♀ I (JD); 76042302, 23 IV 1976, same
locality data, EPH 1495, 1 ♂ N (JD), EPH 1501, 3 ♂ S (JD), EPH 1502, 4 ♀ NSI, 9 ♀ S
(JD). **Stevensons Falls,** Upper Gellibrand River, 82012000, 20 I 1982, 3 ♂ I, 2 ♀ I (AN&
AW). **Stony Creek,** Wonderland Car Park, Grampians, 99011602, 16 I 1999, 410m,
142°30'10" 37°09'04", 1 ♀ NS, 1 ♀ NS, 3 ♂ N, 7 ♀ N (KJF). **Tarra River,** Yarram,
91031200, 12 III 1991, 320m, 146°32'20" 38°27'17", 1 ♂ N (MRHI). **Tarwin River East,**
Mirboo Bridge, Mirboo, 99030404, 4 III 1999, 90m, 146°12'37" 38°28'25", 1 ♀ N (KJF).
Thurra River, Princes Highway, 74033000, 30 III 1974, 140m, 149°15' 37°34', 1 ♂ I, 1 ♀ I
(AN). **Thurra River west branch tributary,** Thurra Junction Rd, 97101801,18 X 1997,
200m, 149°17'41" 37°27'35", 6 ♂ N, 5 ♀ N (KJF). **Wannon River,** Serra Rd Bridge,
25km S of Halls Gap, 83120400, 4 XII 1983, 320m, 142°30' 37°21', 1 ♀ I (AN).
Wellington River, Tamboritha Rd, Alpine National Park, 96092204, 22 IX 1996, 340m,
146°38'15" 37°31'02", 1 ♂ N (KJF). **Werribee River,** Blakeville-Bunding Rd, 99032601,
26 III 1999, 550m, 144°10'12" 37°30'04", 1 ♂ NSI, 1 ♂ NS, 11 ♂ N, 12 ♀ N (KJF).
Wingan River, Drummer Rd, Coopracambra National Park, 98012501, 25 I 1998, 180m,
149°25'15" 37°28'03", 2 ♀ N (KJF). **Yarra Flats,** Healesville, 65091400, 14 IX 1965, 1 ♂

N (AN). **Yarra River,** near McMahons Creek, 76021900, 19 II 1976, 250m, 145°50′ 37°42′ ,1 ♀ I (AN). **Yarra River,** O'Shannassy Rd, 79022100, 21 II 1979, EPH 1498, 1 ♂ I, (genitalia missing), (JD). **Yarra River,** Reefton Rd, 78020900, 9 II 1978, 260m, 145°50′ 37°42′, EPH 1500, 1 ♂ NS (JD); 79102400, 24 X 1979, same locality data, EPH 1496, 1 ♂ I (JD), EPH 1497, 1 ♀ NS (JD), EPH 1499, 6 ♀ I (JD). **Yarra River,** Willgrove, 76022400, 24 II 1976, 1 ♀ I (AN). **Yea River,** 7km S of Glenburn, 72120100, 1 XII 1972, 330m, 145°25′ 37°29′, 1♂ I (AN).

3.4.3.3 *Thraulophlebia inconspicua* (Eaton) comb. nov.

Leptophlebia inconspicua Eaton (Eaton 1871)

Atalophlebia inconspicua (Eaton) (Eaton 1883-1888)

Atalophlebia inconspicua (Eaton) (Ulmer 1908)

Atalonella inconspicua (Eaton) (Suter and Bishop 1980)

Atalophlebia inconspicua (Eaton) (Campbell 1986)

Nousia inconspicua (Eaton) (Suter 1986)

Nousia inconspicua (Eaton) (Campbell 1988)

Koorrnonga inconspicua (Eaton) (Campbell and Suter 1988)

Nousia inconspicua (Eaton) (Suter and Bishop 1990)

Koorrnonga inconspicua (Eaton) (Peters and Campbell 1991)

Thraulophlebia inconspicua (Eaton) comb. nov.

Types. Holotype. None designated. **Syntypes.** *Leptophlebia inconspicua* Eaton, Adelaide, South Australia, date unknown, 5 ♂ imago/subimagos, A.E. Eaton, Held at the OUM. (Eaton 1883-1888; Kimmins 1960). [not seen].

Distribution. South Australia (Fig. 214).

Diagnosis. This species has been previously thoroughly described by Suter (1986) and Campbell and Suter (1988). However, access to limited slide material and MRHI specimens from South Australia have enabled a redescription for comparison. **Male imago.** Dimensions: body length 6.7-7.2 (6.8±0.21, *5*); forewing length 6.5-8.1 (7.6±0.42, *11*); hindwing length 1.16-1.58 (1.47±0.11, *16*); forewing hindwing ratio 4.94-5.31 (5.08±0.12, *9*). General body colour brown to black. Head: brown to black. Antennae: pedicel and scape dark brown, flagellum golden. Ocelli: three; black with white-grey inserts; laterals larger than medial. Eyes: upper eye size large, almost contiguous, ES = 0.10-0.15 (0.13±0.02, *5*); upper lobes tan brown, lower lobes grey-black. Thorax: pronotum and mesonotum brown. Legs: femora light brown, tibiae and tarsi golden,

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banding inconspicuous or absent; forelegs with seven segments, total foreleg lengths 6.29-7.46 (6.89±0.32, *10*); leg length ratios 1.00: 1.44: 0.08: 0.45: 0.43: 0.32: 0.16 (1.78±0.08, *10*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 215). Wings. Forewing (Fig. 216): membrane hyaline, pterostigmal region slightly opaque, longitudinal and crossveins brown, anal veins yellow; costal and subcostal crossveins absent in proximal halves of wings, costal space with 7-9 (*11*) crossveins distally, subcostal space with 4-7 (*11*) crossveins distally. Three bullae present on veins Sc, R_2 and R_{4+5}, MA forked at around half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel or very slightly diverging as wing margin approached, CuP strongly recurved and linked by cross vein to A_1. Hindwing (Fig. 217): mostly hyaline; costal space washed with yellow and very slightly opaque; strong projection of the costa, joins subcosta at approximately two-thirds to three-quarters wing length; no cross veins in proximal half of costal space, 3-4 (*11*) in distal space, 3-5 (*11*) throughout subcostal space. Abdomen (Fig. 218): dark brown with golden markings on each segment forming a broken stripe midline, a golden coloured maculae anteriorly and medially on segments two to nine incorporating midline stripe; pattern variable. Genitalia (Figs 219-222): forceps three segmented; first segment brown basally, progressively lighter apically; terminal segment globular, about the same length as the middle segment; penes brown; two lobes distinct, with expanded lateral margin in apical third, each lobe not indented apically; separated almost at base dorsally (Figs. 219, 221); fused in basal third ventrally (Figs. 220, 222); ventral subapical lobes protruding laterally outwards; no internal spines or processes apparent. Caudal filaments: three; brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length 7.0-8.8 (7.6±0.80, *6*); forewing length 7.0-8.5 (7.6±0.70, *6*); hindwing length 1.10-1.70 (1.47±0.22, *6*); forewing hindwing ratio 4.93-6.45 (5.30±0.65, *5*). General patterning and colouring similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male; forelegs with six segments, total foreleg length 3.95-5.13 (4.54±0.83, *2*); leg length ratios 1.00: 1.35: 0.18: 0.17: 0.15: 0.15 (1.52±0.33, *2*). Wings. Forewing (Fig. 223): colour and venation similar to male except with crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 3-5 (*6*) weakly developed crossveins proximally, 10-13 (*6*) distally, subcostal space with 4-5 (*6*) weakly developed crossveins proximally, 6-10 (*6*) distally. Hindwing (Fig. 224): no crossveins in proximal halves of costal space, 3-4 in distal space (*2*), 4-5 throughout costal space (*2*). Abdomen (Fig. 225): sternum seven with small genital extension, sternum nine deeply cleft. **Egg.** Ovoid, polar cap with three rings of tubular processes on each apex; chorion with small evenly shaped circular protuberances (Figs. 226, 227). **Male and female**

subimago. General colour and markings similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 228). Body lengths ♂ 6.3 – 7.5 (6.9±0.60, 3), ♀ 6.7-10 (8.0±0.93, 9). General colour light to middle brown with darker brown markings. Head: prognathous; brown; width 1.50-1.65 (1.58±0.06, 11). Ocelli: three; black with white inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; more than one and half times length of head. Eyes: upper lobes of male reddish-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 229): lateral margins of clypeus very slightly diverging towards anterior; lateral margins of labrum subequal to slightly wider than clypeus, rounded; labrum anterior margin with slight antero-median emargination; labrum length 0.32-0.41 (0.37±0.02, 23); labrum width 0.64-0.83 (0.73±0.05, 23); width length ratio 1.82-2.11 (1.96±0.07, 23); five elongated denticles present on anterior margin extending 0.10-0.20 (0.14±0.02, 23) across labrum; denticle width labrum width ratio 0.14-0.25 (0.19±0.03, 23); frontal setae arranged as a narrow band; secondary hair fringe clearly separated from narrow band, reaching well beyond the frontal setae, extends 0.15-0.21 (0.18±0.02, 22) the width of labrum, containing between 20-40 (18) setae; secondary hair fringe width to labrum width ratio 0.19-0.30 (0.25±0.03, 22); thick socketed setae present lateral to secondary hair fringe. Mandibles: outer margins slightly curved, long setae at midpoint on outer lateral margins, shorter setae between long setae and base; dark coloured nodule at midpoint on inner lateral margins; sparse tuft of setae on lower mandible body. Left mandible (Fig. 230): two incisors, each with three apical teeth, outer incisor often inconspicuously serrated on inner lateral margin; prostheca robust, serrated; prosthecal tuft slender, tapering to a thin point apically, hairs on lateral margins only. Right mandible (Fig. 231): spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth; often inconspicuously serrated on inner lateral margin, inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 232): galea-lacinae as wide as long, width length ratio 0.89-1.11 (0.98±0.07, 19); subapical row of 17-21 (18) pectinate setae; palpi three segmented, terminal palp with single spine on apex; palp length ratios 1.00: 0.83: 0.75 (0.23±0.02, 18). Hypopharynx (Fig. 233): well developed lateral processes; anterior margin of lingua shallowly cleft; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 234): glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.88: 0.62 (0.34±0.03, 17); submentum with spines on lateral margins. Thorax: brown; pronotum width 1.36-1.72 (1.57±0.09, 11), equal to width of head (see above); head pronotum width ratio 0.91-1.05 (1.00±0.05, 11). Legs (Fig. 235): golden to tan brown with

banding inconspicuous or absent; total foreleg length 3.13-3.48 (3.31±0.12, 10); fore femora length 1.30-1.45 (1.38±0.05, 10); fore femora width 0.45-0.53 (0.48±0.03, 10); fore femora length width ratio 2.74-3.11 (2.89±0.12, 10); fore tibiae with numerous short ventral spines, sometimes serrated; fore tarsi with 8-13 (10) ventral spines, length 0.25-0.38 (0.30±0.04, 10) width of tarsus; tarsal claws (Fig. 236) with 12-15 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated on inner margin; leg length ratios, foreleg 1.00: 0.93: 0.46 (1.38±0.05, 10), midleg 1.00: 0.91: 0.39 (1.40±0.06, 10), hindleg 1.00: 0.96: 0.36 (1.49±0.06, 10). Abdomen: dark brown with golden markings medially on each segment forming a broken stripe midline, golden patches also laterally on each segment, pattern variable; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 237): membrane clear to pink; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae similarly shaped; upper lamellae narrows at three-quarters length with long apical filament, lower lamellae narrows at four-fifths length with shorter apical filament; main and lateral tracheae present, strongly developed. Caudal filaments three; golden; terminal filament longer than cerci.

Remarks. There has been much confusion as to the generic designation of *inconspicua* with numerous changes occurring since it was described. Eaton (1871) originally placed the species in *Leptophlebia* along with numerous other species. He admitted, however, that some of these species were placed there for lack of anywhere else to put them, although he did not identify which ones. Once he had established the new genus *Atalophlebia* (Eaton 1881), and examined the distinction between this genus and *Leptophlebia*, he created the new combination *Atalophlebia inconspicua* (Eaton 1883-1888). Eaton drew the penes fused along most of their length, while Ulmer (1908) describes them as divided while noting they are held tightly together in the alcohol preserved specimens and widely separated in dried specimens. Suter (1986) later claimed the separation of the two lobes readily occurs with air dried specimens and slide mounted material, however, he questions whether it is indeed the same species due to variation in forewing venation. Following Ulmer, Tillyard (1936) included *Atalophlebia inconspicua* in his key to the Tasmanian species of the genus *Atalophlebia* but by this stage the description was based on the imago and subimago only, the nymph was yet to be identified. Suter and Bishop (1980) collected the nymph in an intermittent stream in South Australia referring to it as *Atalonella inconspicua*. The new combination of *Nousia inconspicua* was introduced by Suter (1986) some years later and introduced the first full description of all life cycle stages. Around the same time a paper was published referring to *Atalophlebia inconspicua* (Campbell 1986). In the Zoological Catalogue of Ephemeroptera it is referred to as *Nousia inconspicua* (Campbell 1988), and in the same

year a taxonomic review paper was published in which it was considered there were sufficient differences between this species and *Nousia* to warrant the establishment of the genus *Koormonga* into which this species was placed (Campbell and Suter 1988). Suter reverted to using the old name *Nousia inconspicua* in a subsequent paper (Suter and Bishop 1990), probably in error. The correct name *Koormonga inconspicua* was used in the Ephemeroptera chapter of the second edition of "The Insects of Australia" (Peters and Campbell 1991).

Examination of a small number of Suter's specimens and some of those collected for the MRHI has led me to conclude that *Koormonga inconspicua* in fact belongs in the genus *Thraulophlebia* to which it is hereby transferred. This is confirmed in the main by the shape of the genitalia and hindwing, the venation of the forewing and the labrum characteristics of the nymph. Although a redescription was not considered entirely necessary due to the comprehensive description of Suter (1986) it was undertaken to confirm the diagnosis.

A comparison was also made between the redescription of *T. inconspicua* and the literature descriptions and was found to conform in many respects (Table 14). However, there are a number of discrepancies that should also be taken account of (Table 15).

Some of the body lengths of the imago as measured by Eaton (1871) and Suter (1986) are well outside the range of my measurements 6.7-7.2 (6.8±0.21, 5), especially the relatively short body length of Eaton (1871) at 5-6mm. It occurs to me that perhaps Eaton's measurements were not precise as he was unable to distinguish between 5 and 6mm for the one individual. If the animal actually measured closer to 6mm than 5 it almost fits within the range measured by Suter (1986) (6.07-7.95 (7.27±05, 26)). I am reassured by the fact that the mean body length measured by Suter (1986, 7.2) is similar to my mean length (6.8). It must be remembered that Suter's measurements ($n=26$) are likely to be more accurate than mine ($n=5$) as he had access to more specimens. Similarly, the range of some of the male imago forewing lengths in the literature are outside my measurements. Tillyard (1936) measured the forewing length as 5mm but I am sceptical of this for, as far as I am aware, *T. inconspicua* does not occur in Tasmania.

Examination of the forewing in the slide mounted specimens borrowed from Suter clearly showed that CuP is connected to A_1 by a crossvein yet this feature is not apparent in the drawings of Ulmer (1908), Suter (1986) or Campbell and Suter (1988). (Admittedly, though the forewing drawings of Campbell and Suter (1988) are reproduced from Suter (1986). There is no accounting for this except to say that perhaps the anal veins, which tend to a faint yellow colour, are more difficult to see than the brown longitudinal

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crossveins and the feature could easily have been missed and therefore not represented in the drawing.

Although the leg length ratios of the male imago are similar, the total leg length varies significantly between my measurements (6.29-7.46 (6.89±0.32, 10)) and those calculated from the ratios by Suter (1986, 8.6). I cannot account for this large difference although Suter (1986) does not state how many individuals he measured and may have been referring to one aberrant individual.

Despite the fact that the SEM micrographs of the genitalia shown here (Figs. 221, 222) are taken from Suter's specimens they do vary a little from those depicted in Suter (1986, FIG. 15b, p. 380, reproduced here as Fig. 238). Suter's drawing and SEM show the lobes to be quite separate apically, bowing strongly outwards, and curving back in to meet apically whereas Figs. 221 & 222 show a less dramatic separation. Both of these vary from Ulmer's drawing (Ulmer 1908, FIG. 29a & b, p. 43, reproduced here as Fig. 239), which I am inclined to discount as over-simplified. He does, however, state that "Der Penis ist tief gespalten, so daß zwei Flügel eentstehen; die Form derselben variiert nach dem höheren oder geringeren Grade der Austricknung." ("The penis is deeply divided so that two wings arise; the shape of it varies according to the degree of drying") (Ulmer 1908, p.43). Perhaps the variation seen in the micrograph taken by Suter and myself are as a result of shrinkage from drying during the process of SEM preparation. In other respects the penes morphology between the two is similar with the distinctive subapical ventral lobes and no internal spines or processes.

The egg morphology, and the question of whether the species has two rings or three rings of tubular processes, has been hampered somewhat by the lack of specimens. The SEM micrographs of *T. inconspicua* from Suter (1986, FIG. 16a, p 281) and Campbell and Suter (1988, FIG. 85, p. 272, the same photo in fact, reproduced here as Fig. 240), clearly shows a polar cap with two rings of tubular processes on each apex. However, I have extracted eggs from a female imago from the Sturt River, Coramandel Valley (Suter's collection) which has three rings of tubular processes. I also have access to a slide mount of a female imago abdomen which is labelled "Leptophlebiidae A *Atalonella* ①
♀ abdomen & eggs Sturt R Coramandel Valley SA 29/4/76 P.S." The eggs contained within the abdomen show much less detail than an SEM but three rings can clearly be seen under transmitted light. The only other egg with the three ring morphology is *Nousia (Australonousia) fuscula* according to Suter (1986) and Campbell and Suter (1988) but this has been questioned due to problems of contamination (see discussion under 3.3.2.4). Both *N. (A) fuscula* and *T.inconspicua* have been found in Tookayerta Creek so it may be that this *N. (A) fuscula* egg actually belongs to *T. inconspicua!* I am extremely

confident that the three ringed eggs I extracted from the Sturt River female imago belong to that individual and believe that it is a species characteristic.

The few discrepancies between the descriptions and redescription in the nymphs relate to the length of the maxillary and labium palp. It appears that the length of the second maxillary palp measured by me (1.00: 0.83: 0.75 (0.23±0.02, *18*) is consistently shorter than those measured by Suter (1986, 1.00: 0.92: 0.80 (0.22). Similarly, the length of the second labial palp measured by me (1.00: 0.88: 0.62 (0.34±0.02, *18*) is consistently longer than those of Suter (1.00: 0.79: 0.64 (0.35). This is despite the fact that some of my measurements included slide material obtained from Suter! However, it is not clear how many individuals were measured in Suter's paper as no *n* or standard deviation is given, so comparisons may be spurious.

Further, I considered other nymphs described by Dean (1999) as *Koorrnonga* sp. "AV3" and *Koorrnonga* sp. "AV5" were morphologically very similar to *T. inconspicua*. As far as I am aware only one specimen of *Koorrnonga* sp. "AV3" exists; a male nymph from the Wannon River near Dunkeld. *Koorrnonga* sp. "AV5" has also been found in the Wannon River but also apparently occurs in south-east Queensland and New South Wales. Attempts were made to collect more specimens of *Koorrnonga* sp. "AV3" and sp. "AV5" to confirm "synonymy" with *T. inconspicua* but despite two visits to Dunkeld where the Wannon River (99022804), a Wannon river tributary (99022805) and the nearby Wannon River Falls (00122004) were sampled, no such specimens were found.

I am aware that it is dangerous to make these comparisons without seeing the type specimens but it appears that the type specimens have been lost. Several requests were forwarded to the OUM to obtain the type but they cannot find any trace of this specimen. Further to this there is some confusion as to the whereabouts of the type specimen, for although Eaton clearly states he placed the new combination *Atalophlebia inconspicua* in the "Hope Museum Oxford" (Eaton 1883-1888) in a previous paper where the species was actually described for the first time Eaton (1871) states "My own types of new species are placed in the British Museum." Subsequent requests made to the NHM for this specimens have also proved fruitless.

Table 14. Similarities between the redescription of *Thraulophlebia inconspicua* and the literature descriptions of *Atalophlebia inconspicua*, *Nousia inconspicua* and *Koorrnonga inconspicua*.

	Thraulophlebia inconspicua	literature descriptions of *inconspicua*
Male Imago		
hindwing length	1.16-1.58 (1.47±0.11, *16*)	1.2-1.8 (Suter 1986)
head colour	brown to black	black (Suter 1986)
eye colour	upper: tan brown, lower: grey-black	upper: light brown, lower: grey (Suter 1986)
leg length ratios	1.00: 1.44: 0.08: 0.45: 0.43: 0.32: 0.16 (1.78±0.08, *10*)	1.00: 1.46: 0.14: 0.48: 0.45: 0.33: 0.17 (2.13) (Suter 1986)
leg banding	absent	absent (Suter 1986)
tarsal claws	similar	similar (Suter 1986)
thorax colour	brown	dark brown-black (Suter 1986)
costal crossveins – proximal	absent	absent (Suter 1986, Campbell and Suter 1988)
subcostal crossveins – proximal	absent	absent (Suter 1986, Campbell and Suter 1988)
bullae	Sc, R_2, R_{4+5}	Sc, R_2, R_{4+5}
MA fork	about half	about half (Suter 1986, Campbell and Suter 1988)
MP_2 connected to MP_1 and CuA	yes	yes (Suter 1986, Campbell and Suter 1988)
CuA, CuP linked by crossvein	yes	yes (Suter 1986, Campbell and Suter 1988)
ICu_1 joins CuA	yes	yes(Suter 1986, Campbell and Suter 1988)
ICu_2 joins ICu_1	yes	yes (Suter 1986, Campbell and Suter 1988)
ICu_1 and ICu_2 parallel or diverging	parallel	parallel (Suter 1986, Campbell and Suter 1988)
hindwing – length at which costa joins subcosta	two thirds to three quarters wing length	three-quarters wing length (Suter 1986, Campbell and Suter 1988)
hindwing – costal crossveins	3-4	4-5 (Suter 1986, Campbell and Suter 1988)
hindwing – subcostal crossveins	3-5	3-5 (Suter 1986) 4 (Campbell and Suter 1988)
abdomen colour	dark brown with golden markings, variable	piceous (Eaton 1871) black with light central marking dorsally (Suter 1986)
penes – processes	no internal spines or processes	no internal spines or processes (Suter 1986, Campbell and Suter 1988).
Female Imago		
sternum nine	deeply cleft	deep V shaped incision (Suter 1986, Campbell and Suter 1988)

Table 14 cont'd.

	Thraulophlebia inconspicua	literature descriptions of *inconspicua*
Nymph		
head colour	brown	dark brown (Suter 1986)
head width	1.50-1.65 (1.58±0.06, *11*)	1.54-1.70 (1.59) (Suter 1986)
eye colour – male	upper: reddish-brown, lower: black	upper: dark reddish brown (Suter 1986)
labrum antero-median emargination	yes, slight	yes, slight (Suter 1986)
labrum length width ratio	1.82-2.11 (1.96±0.07, *24*)	2 times wider than long (Suter 1986)
left mandible incisors	3,3	3,3 (Suter 1986, Campbell and Suter 1988)
left mandible prostheca	robust serrated,	robust serrated, (Suter 1986, Campbell and Suter 1988)
left mandible prosthecal tuft	slender, hairs on lateral margins only	slender, hairs on lateral margins only (Suter 1986; Campbell and Suter 1988)
right mandible incisors	3, 2	3, 2 (Suter 1986, Campbell and Suter 1988)
right mandible prostheca	robust slender	robust slender (Suter 1986)
right mandible prosthecal tuft	slender, hairs on lateral margins only	slender, hairs on lateral margins only (Suter 1986, Campbell and Suter 1988)
hypopharynx	shallowly cleft	shallowly cleft (Suter 1986, Campbell and Suter 1988)
pronotum width	1.36-1.72 (1.57±0.09, *11*)	1.38-1.56 (1.50±0.08, 8) (Suter 1986)
leg colour	golden to tan brown	brown (Suter 1986)
leg banding	inconspicuous or absent	inconspicuous or absent (Dean 1999)
foreleg	1.00: 0.93: 0.46 (1.38±0.05, *10*)	1.00: 0.92: 0.52 (1.39) (Suter 1986)
midleg	1.00: 0.91: 0.39 (1.40±0.06, *10*)	1.00: 0.92: 0.44 (1.39) (Suter 1986)
hindleg	1.00: 0.96: 0.36 (1.49±0.06, *10*)	1.00: 0.98: 0.36 (1.49) (Suter 1986)
abdomen colour	dark brown with lighter markings, pattern variable	brown dorsally, light stripe mid-line (Suter 1986)
gills	double, upper lamellae slightly longer than lower	double, upper lamellae slightly longer than lower (Suter 1986)
caudal filaments	terminal filament longer than cerci	terminal filament length 10.8, cerci 9.9 length (Suter 1986)

Table 15. Discrepancies between the redescription of *Thraulophlebia inconspicua* and the literature descriptions of *Atalophlebia inconspicua*, *Nousia inconspicua* and *Koorronga inconspicua*.

	Thraulophlebia. inconspicua	literature descriptions of *inconspicua*
Male Imago		
body length	6.7-7.2 (6.8±0.21, *5*)	5.6 (Eaton 1871) 7 (Ulmer 1908) 6.07-7.95 (7.27) (Suter 1986)
forewing length	6.5-8.1 (7.6±0.42, *11*)	6.7 (Eaton 1871) 7 (Ulmer 1908) 5 (Tillyard 1936) 5.74-8.36 (7.25) (Suter 1986)
forewing CuP attached to A_1	yes	no (Ulmer 1908, Suter 1986, Campbell and Suter 1988)
total leg length	6.9	8.6
hindwing C joins Sc	at two thirds wing length	at three-quarters wing length (Suter 1986, Campbell and Suter 1988)
penes shape	lateral expansion more apical	lateral expansion appears more distal (Suter 1986, Campbell and Suter 1988)
penes internal spines	yes	no (Suter 1986)
Egg		
	three rings of tubular processes	two rings of tubular processes (Suter 1986, Campbell and Suter 1988)
Nymph		
maxillae palp length ratios	1.00: 0.83: 0.75 (0.23±0.02, *18*)	1.00: 0.92: 0.80 (0.22) (Suter 1986)
labium palp length ratios	1.00: 0.88: 0.62 (0.34±0.03, *17*)	1.00: 0.79: 0.64 (0.35) (Suter 1986)
fore tarsi number of ventral spines	8-13 (*10*)	15-20 (Dean 1999)

T. lucida also appears morphologically very similar to *T. inconspicua*, particularly in the nymph, and it was extremely difficult to separate the two species by eye. However, on further examination differences between the genitalia of the two species proved to be consistent. Subsequent measurements taken revealed consistent morphological variations between the two taxa (Table 16). Differences in the means of all the measurements were tested using a two tailed t-test assuming unequal variances.

At first glance, the male imagos of the two species are also remarkably similar. Body length, colour and wing venation are all consistent. The most pronounced difference is in the shape of the genitalia. T-tests revealed that the forewing, hindwing, upper eye size and length of foreleg in *T. inconspicua* are significantly larger than those of *T. lucida*. Similarly, there is a significant difference in the forewing hindwing ratio with the hindwing of *T. inconspicua* being one-fifth the length of forewing on average, compared with the hindwing of *T. lucida* which is only one-sixth or less the length of the forewing on average.

In the female imago, body and hindwing length vary significantly with *T. inconspicua* being larger. The forewing hindwing ratio also varies significantly in the same direction and with similar dimensions as the male. The foreleg measurements, however, are not significantly different.

The nymph is superficially similar in many respects, however, the t-tests reveal many significant differences in size and shape of body parts. Very highly significant to highly significant differences were found in most of the measurements compared including: head width, pronotum width, labrum length, labrum width, labrum length width ratio, denticle width, denticle width labrum width ratio, secondary hair fringe width, secondary hair fringe to labrum width ratio, maxillae galea-lacinae width and length, maxillary palp lengths, labial palp lengths, foreleg lengths, femora length width and length width ratios with *T. inconspicua* always being larger. The labrum ratio measurements in particular reveal that the labrum of *T. inconspicua* is slightly wider than long, has a narrower denticle width and a larger secondary hair fringe relative to that of *T. lucida*. The labrum, I believe, is one of the few characters of the nymph that can be used to reliably separate the two species morphologically. Other ratios (maxillae galea-lacinae width length ratio, head pronotum width ratio) showed no significant differences indicating that they were proportionately the same shape.

I have enough confidence in the dissimilarity of the two to retain them as separate species. One should be aware that apart from the male genitalia the two look superficially similar and the differences are difficult to distinguish without detailed measurements.

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Thraulophlebia inconspicua can be distinguished from all other species in the genus by the following combination of characters: In the imago: (i) forewing hindwing ratio comparatively small; (ii) upper eye size large, but never contiguous; (iii) leg banding inconspicuous or absent; (iv) penes expanded lateral margin in apical third, fused in basal third ventrally, separated almost at base dorsally; lobes not indented apically; subapical lobes ventrally protruding laterally outwards; (v) female body length comparatively longer on average; (vi) egg ovoid with three rings of tubular processes. In the nymph: (i) labrum subequal to slightly wider than clypeus, lateral margins rounded, antero-median emargination slight, length width ratio around two on average, narrow band of frontal setae, secondary hair fringe contains 20-40 setae with width approximately one-quarter across labrum; (ii) hypopharynx superlingua with rounded lateral margins; (iii) leg banding inconspicuous to absent; (iv) gill shape with upper lamellae narrowing at three quaters length with long apical filament, lower lamellae narrows at four-fifths length with long apical filament.

Table 16. Comparison of the characteristics of *Thraulophlebia lucida* and *Thraulophlebia inconspicua* showing outcomes of t-tests comparing the two species where measurements were available.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
Male Imago			
body length	5.7-7.4 (6.6± 0.45, *20*)	6.7-7.2 (6.8± 0.21, *5*)	ns
forewing length	5.7-7.4 (6.6± 0.51, *21*)	6.5-8.1 (7.6± 0.42, *11*)	***
hindwing length	0.83-1.26 (0.98± 0.10, *17*)	1.16-1.58 (1.47± 0.11, *16*)	***
forewing hindwing ratio	5.87 – 7.56 (6.80± 0.59, *17*)	4.94-5.31 (5.08± 0.12, *9*)	***
head colour	dark brown	brown to black	
eye colour	upper: orange-brown, lower: grey-black	upper: tan brown, lower: grey-black	
eye size (ES)	0.00-0.04 (0.01± 0.01, *10*)	0.10-0.15 (0.13± 0.02, *5*)	***
total length of foreleg	5.64-6.61 (6.08± 0.33, *10*);	6.29-7.46 (6.89± 0.32, *10*)	***
leg length ratios	1.00:1.45: 0.06: 0.50: 0.48: 0.37: 0.17 (1.52±0.14, *10*)	1.00: 1.44: 0.08: 0.45: 0.43: 0.32: 0.16 (1.78±0.08, *10*)	
foreleg length of segment one	1.25-1.65 (1.52± 0.14, *10*)	1.60-1.88 (1.78± 0.08, *10*)	***
leg colour	golden brown, darker markings	light brown to golden	
leg banding	absent	absent	
tarsal claws	similar	similar	
thorax colour	tan to dark brown	brown	
forewing costal crossveins – distally	absent	absent	
forewing costal crossveins – proximally	7-11 (*19*)	7-9 (*11*)	
forewing subcostal crossveins – distally	absent	absent	
forewing subcostal crossveins – proximally	5-10 (*19*)	4-7 (*11*)	
bullae	Sc, R_2, R_{4+5}	Sc, R_2, R_{4+5}	

Table 16 cont'd.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
MA fork	about half	about half	
MP_2 connected to MP_1 and CuA	yes	yes	
CuA, CuP linked by crossvein	yes	yes	
ICu_1 joins CuA	yes	yes	
ICu_2 joins ICu_1	yes	yes	
ICu_1 and ICu_2 parallel or diverging	parallel	parallel	
CuP attached to A_1	yes	yes	
hindwing – costal crossveins	2-3 (*17*)	3-4 (*11*)	
hindwing - subcostal crossveins	3-5 (*17*)	3-5 (*11*)	
abdomen colour	tan to chocolate brown with golden markings	dark brown with golden markings, variable	
penes shape	lateral expansion more distal than inconspicua (two-thirds length)	lateral expansion more apical (four-fifths length)	
Female Imago			
body length	5.6-7.6 (6.6±0.56, *25*)	7.0-8.8 (7.6±0.80, *6*)	
forewing length	5.9-8.3 (7.2±0.58, *21*)	7.0-8.5 (7.6±0.70, *6*)	ns
hindwing length	0.69-1.28 (1.04±0.14, *20*)	1.10-1.70 (1.47±0.22, *6*)	**
forewing hindwing ratio	5.47-8.55 (6.93±0.77, *20*)	4.93-6.45 (5.30±0.65, *5*)	**
eye colour	grey-black	grey-black	
eye separation	4 times max width of eye	4 times max width of eye	
total foreleg length	3.81-4.80 (4.25±0.38, *10*)	3.95-5.13 (4.54±0.83, *2*)	ns

Table 16 cont'd.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
leg length ratios	1.00: 1.37: 0.22: 0.19: 0.15: 0.15 (1.38±0.14, 10)	1.00: 1.35: 0.18: 0.17: 0.15: 0.15 (1.52±0.33, 2)	
foreleg length of segment one	1.24-1.58 (1.38±0.14, 10)	1.25-1.75 (1.52±0.33, 2)	**ns**
costal crossveins – distal	2-6 (22)	3-5 (6)	
costal crossveins – prox	8-15 (22)	10-13 (6)	
subcostal crossveins – distal	0-5 (22)	4-5 (6)	
subcostal crossveins – prox	8-11 (22)	6-10 (6)	
hindwing – costal crossveins	2-3 (20)	3-4 (2)	
hindwing subcostal crossveins	3-4 (20)	4-5 (2)	
sternum seven	small genital extension	small genital extension	
sternum nine	deeply cleft	deeply cleft	
Egg			
egg shape	two rings of tubular processes	three rings of tubular processes	
Nymph			
body length – male	5.5-7.2 (6.2 ± 0.52, 12)	6.3 – 7.5 (6.9±0.60, 3)	**ns**
body length – female	6.0-7.3 (6.6 ± 0.46, 9)	6.7-10 (8.0±0.93, 9)	*****
head colour	tan to middle brown	brown	
head width	1.28–1.53 (1.41± 0.08, 15)	1.50-1.65 (1.58±0.06, 11)	*****
antennae colour	golden	golden	
eye colour – male	upper: orange-brown, lower: black	upper: reddish-brown, lower: black	
eye colour female	black	black	
clypeus lateral margins	slightly diverging towards anterior	slightly diverging towards anterior	

Table 16 cont'd.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
labrum lateral margins	subequal to slightly wider than clypeus, rounded	subequal to slightly wider than clypeus, rounded	
labrum antero-median emargination	yes, slight	yes, slight	
labrum length	0.29–0.40 (0.33±0.04, 25)	0.32-0.41 (0.37±0.02, 23)	***
labrum width	0.51–0.75 (0.61±0.06, 25)	0.64-0.83 (0.73±0.05, 23)	***
labrum length width ratio	1.69–2.18 (1.86±0.13, 25)	1.82-2.11 (1.96±0.07, 23)	**
denticles	5	5	
denticle width	0.14-0.21 (0.18± 0.02, 24)	0.10-0.20 (0.14±0.02, 23)	***
denticle width labrum width ratio	0.23–0.38 (0.29±0.05, 24)	0.14-0.25 (0.19±0.03, 23)	***
Secondary hair fringe width	0.04-0.14 (0.08± 0.02, 25)	0.15-0.21 (0.18±0.02, 22)	***
secondary hair fringe / labrum width ratio	0.06–0.20 (0.14±0.03, 25)	0.19-0.30 (0.25±0.03, 22)	***
number of hairs in secondary hair fringe	12-25 (18.5, 20)	20-40 (32.7, 18)	
left mandible incisors	3,3	3,3	
left mandible prostheca	robust serrated,	robust serrated,	
left mandible prosthecal tuft	slender, hairs on lateral margins only	slender, hairs on lateral margins only	
right mandible incisors	3, 2	3, 2	
right mandible prostheca	robust slender	robust slender	
right mandible prosthecal tuft	slender, hairs on lateral margins only	slender, hairs on lateral margins only	
maxillae galea-lacinae width	0.36-0.45 (0.40±0.03, 12)	0.40-0.55 (0.48±0.04, 19)	***

Table 16 cont'd.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
maxillae galea-lacinae length	0.34-0.49 (0.40±0.04, *12*)	0.43-0.58 (0.50±0.04, *19*)	***
maxillae galea lacinae width length ratio	0.91-1.12 (1.00±0.07, *12*)	0.89-1.11 (0.98±0.07, *19*)	ns
maxillae – number of pectinate setae in subapical row	16-21 (*16*)	17-21 (*18*)	
maxillae palp length ratios	1.00: 0.79: 0.64 (0.22±0.02, *19*)	1.00: 0.83: 0.75 (0.23±0.02, *18*)	
total maxillae palp lengths	0.40-0.58 (0.53±0.04, *19*)	(0.50-0.68 (0.59±0.05, *18*)	***
hypopharynx	shallowly cleft	shallowly cleft	
labium palp length ratios	1.00: 0.86: 0.65 (0.32±0.02, *12*)	1.00: 0.88: 0.62 (0.34±0.03, *17*)	
total labium palp length	0.74-0.88 (0.79±0.04, *12*)	0.75-0.94 (0.85±0.05, *17*)	**
thorax colour	tan to middle brown	brown	
pronotum width	1.10-1.63 (1.36±0.14, *15*)	1.36-1.72 (1.57±0.09, *11*)	***
head pronotum width ratio	0.84-1.07 (0.96±0.08, *15*)	0.91-1.05 (1.00±0.05, *11*)	ns
leg colour	golden to tan brown	golden to tan brown	
leg banding	inconspicuous or absent	inconspicuous or absent	
total foreleg length	2.53-3.29 (2.89±0.21, *20*)	3.13-3.18 (3.31±0.12, *10*)	***
foreleg femora length	1.05-1.38 (1.21± 0.10, *20*)	1.30-1.45 (1.38±0.05, *10*)	***
foreleg femora width	0.28-0.43 (0.37±0.04, *20*)	0.45-0.53 (0.48±0.03, *10*)	***
foreleg femora length width ratio	2.83-3.75 (3.31±0.26, *20*)	2.74-3.11 (2.89±0.12, *10*)	***
fore tarsi spines	8-14 (*22*)	8-13 (*10*)	
length of fore tarsi spines	0.20-0.34 (0.27±0.04, *10*)	0.25-0.38 (0.30±0.04, *10*)	ns

Table 16 cont'd.

	Thraulophlebia lucida	*Thraulophlebia inconspicua*	Sig.
tarsal claw teeth	8-14 (22)	12-15 (10)	
foreleg	1.00: 0.92: 0.47 (1.21±0.10, 20)	1.00: 0.93: 0.46 (1.38±0.05, 10)	
midleg	1.00: 0.93: 0.35 (1.20±0.10, 15)	1.00: 0.91: 0.39 (1.40±0.06, 10)	
hindleg	1.00: 1.00: 0.34 (1.26±0.12, 14)	1.00: 0.96: 0.36 (1.49±0.06, 10)	
abdomen colour	dark brown with golden markings, pattern variable	dark brown with lighter markings, pattern variable	
gills	double, upper lamella longer than lower, longer apical filament	double, upper lamella longer than lower, longer apical filament	

Specimens examined. SOUTH AUSTRALIA. Brownhill Creek, 76030300, 3 III 1976, 150m, 138°38′ 34°59′, 3 ♂ I, ♀ I (coll. unknown). **Bull Creek,** "The Cliff", Finniss River Survey, location 3929, 89103101, 31 X 1989, 2 ♂ N, 6 ♀N (PS&SS). **Deep Creek Tributary,** Castambul, 77030400, 04 III 1977, 200m, 138°45′ 34°52′, 1 ♂ N, 1 ♀ N (JEB & AW). **Finniss River,** "Riverdale", Finniss River Survey, location 3930, 89103102, 31 X 1989, 1 ♂ N, 2 ♀N (PS&SS). **Meadows Creek,** Fingerboard corner, Finniss River Survey, location 3173, 89103103, 31 X 1989, 2 ♂ N, 7 ♀ N (PS& SS). **North East River,** near Carnarvan, Kangaroo Island, 77111900, 19 XI 1977, 40m, 136°59′ 35°56′, 1 ♂ I, 1 ♀I (JEB). **North Pava River,** downstream Orlando Ford, winery discharge, 83081900, 19 VIII 1983, 1 ♂ N, 1 ♀N (immature), (PS). **North Pava River,** Tanunda, 91102100, 21 X 1991, 40m, 136°59′ 35°56′, 3 ♀ N (PW). **Rocky River,** Flinders Chase National Park, Kangaroo Island: 76121300, 13 XII 1976, 60m, 136°44′ 35°56′, 5 ♂ N, 9 ♀N (WDW); 76121800, 18 XII 1976, same locality data, 8 ♂ N, 10 ♀N (WDW). **Scott Creek,** 94110900, 9 XI 1994, 2 ♂ N, 4 ♀N (PG & CM). **South West River,** Brigadoon, Kangaroo Island, 77101900, 19 XI 1977, 180m, 136°50′ 35°52′, 1 ♂ I (JEB). **Spring Creek,** 95101100, 11 X 1995, 11 ♂ N, 18 ♀N (MRHI). **Stunsail Broom River,** Kangaroo Island, 76121200, 12 XII 1976, 8m, 137°00′ 35°59′, 2 ♀ N (immature), (WDW). **Sturt River,** Bedford Park, 76112700, 27 XI 1976, 60m, 138°33′ 35°02′, 2 ♂ N (immature), (JEB). **Sturt River,** upstream Minno Creek, 94102600, 26 X 1994, 200m, 138°38′ 35°02′, 11 ♂ N, 16 ♀ N (immature), (MRHI). **Sturt River,** Coramandel Valley: 76042900, 29 IV 1976, 200m, 138°57′ 35°03′, 2 ♂ I, 1 ♀ I (PS). **Tookayerta Creek,** location 3956, 84102200, 22 X 1984, 190m, 1 ♂ N, 6 ♀ N (immature), (PS). **Unnamed Creek,** Parawa Rd, near Yankalilla, 78110200, 2 XI 1978, 80m, 138°21′ 35°28′, (JEB & AW).

3.4.3.4   *Thraulophlebia parva* (Harker) comb. nov.

Atalophlebia parva Harker (Harker 1950a)

Atalonella parva (Harker) (Harker 1954)

Nousia parva (Harker) (Campbell 1988)

Koorrnonga parva (Harker) (Campbell and Suter 1988)

Koorrnonga sp. "AV2" (Dean 1999)

Thraulophlebia parva (Harker) comb. nov.

Types. Holotype. *Atalophlebia parva.* Serpentine River, Point Lookout, 4000 feet, 48100000, X 1948, ♂ imago, coll. by J. Harker. Labels: "Holotype Serpentine River Point Lookout 4000′ NSW ♂ imago, 10: 1948 J. Harker ". **Paratypes.** Same location and collection data, ♀ imago; ♀subimago, ♀ nymph, coll by J. Harker. Labels: ♀ imago, a)

"*Atalophlebia parva* Allotype Serpentine River. Point Lookout, 4,000' N.S.W. 10: 1948 J. Harker"; b) ♀subimago, "*Atalophlebia parva* Morphotype (Subimago) Serpentine River. Point Lookout, 4,000' N.S.W. 10: 1948 J. Harker"; c) ♀ nymph, "*Atalophlebia parva* Morphotype Nymph Serpentine River. Point Lookout, 4,000' N.S.W. 10: 1948 J. Harker"; Held at the AM.

Distribution. New South Wales, Queensland, Victoria (Fig. 241).

Diagnosis. Male imago. Dimensions: body length 5.6-7.3 (6.7±0.65, *8*); forewing length 5.8-7.1 (6.4±0.49, *8*); hindwing length 1.05-1.45 (1.23±0.15, *7*); forewing hindwing ratio 4.37-5.90 (5.16±0.55, *7*). General body colour dark brown to black. Head: tan to dark brown. Antennae, pedicel and scape dark brown, flagellum tan brown. Ocelli: three; black with white inserts, laterals larger than medial. Eyes: upper eye size large, contiguous; upper lobes pink-brown, lower lobes grey-black. Thorax: pronotum dark brown; mesonotum darker brown, shiny. Legs: brown, femora tan brown with dark brown middle third and dark brown apices; tibiae golden brown, dark brown markings apically; tarsi golden brown; banding conspicuous; forelegs with seven segments, total foreleg length 4.45-5.58 (5.08±0.58, *4*); leg length ratios 1.00: 1.44: 0.06: 0.40: 0.38: 0.26: 0.17 (1.37±0.09, *4*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 242). Wings. Forewing (Fig. 243): membrane hyaline, pterostigmatal area slightly opaque, longitudinal and crossveins light brown, anal veins yellow; costal and subcostal crossveins absent from proximal halves of wing, costal space with 6-9 (*9*) crossveins distally, subcostal space with 5-9 (*9*) crossveins distally. Three bullae present on veins Sc, R_2, and R_{4+5}. MA forked at around half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 joins CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1. ICu_1 and ICu_2 parallel or very slightly diverging as wing margin approached, CuP strongly recurved and linked by crossveins to A_1. Hindwing (Fig. 244): mostly hyaline, costal space washed with yellow and very slightly opaque; strong projection of the costa, joins subcosta at approximately two-thirds wing length; no crossveins in proximal half of costal space, 3-4 (*7*) in distal space, 3-5 (*7*) crossveins throughout subcostal space. Abdomen (Fig. 245): dark brown to black with light to tan brown patterning on each segment forming a broken stripe midline, two light coloured maculae flanking each midline marking anteriorly. Genitalia (Figs 246-251): forceps three segmented (Figs. 246, 248, 250), tan brown, progressively lighter apically; penes brown, darker apically; each lobe not indented apically, fused in basal third dorsally (Figs. 246, 248, 249) and ventrally (247, 250, 251), no subapical lobes ventrally; small internal spines apparent under transmitted light (Figs. 246, 247). Caudal filaments: three; terminal filament longer than cerci. **Female imago.** Dimensions: body length 5.7-8.7 (7.1±0.80, *13*); forewing length 7.0-7.9 (7.4±0.28, *11*); hindwing length

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1.18-1.40 (1.29±0.09, *10*); forewing hindwing ratio 5.07-6.64 (5.74±0.49, *10*). General patterning and colour similar to male. Body generally larger than male, abdomen wider. Eyes: brown-black; separated on meson of head by a distance of about five times maximum width of eye. Legs: total leg length shorter than male, forelegs with six segments, total foreleg length 4.19-4.94 (4.52±0.24, *10*); leg length ratios 1.00: 1.24: 0.15 : 0.15: 0.13: 0.15 (1.61±0.09, *10*). Wings. Forewing (Fig. 252): colour and venation similar to males except weakly developed crossveins in proximal halves of wing and generally more crossveins on average than male; costal space with 0-6 (*14*) weakly developed crossveins proximally, subcostal space with 7-13 (*14*) crossveins distally; subcostal space with 0-4 (*14*) weakly developed crossveins proximally, 5-10 (*14*) crossveins distally. Hindwing (Fig. 253): no crossveins in proximal half of costal space, 3-4 (*10*) in distal space, 4-6 (*10*) throughout subcostal space. Abdomen (Fig. 254, 255): sternum seven with small genital extension; sternum nine deeply cleft. **Egg.** Cylindrical with rounded ends, polar cap with two rings of tubular projections on each apex; chorion with small evenly spaced circular protuberances (Figs. 256-259). **Male and female subimago.** Dimensions: body lengths ♂ 5.8-7.3 (6.6 ± 0.57, *5*); ♀ 6.3-8.1 (7.3 ± 0.58, *9*). General colour and markings similar to imago. Wings uniformly brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 260). Body lengths ♂ 6.2-7.6 (6.7 ± 0.56, *12*), ♀ 6.7-8.4 (7.3 ± 0.53, *12*). General colour dark brown to black with lighter tan markings. Head: prognathous; dark brown, tan colour surrounding ocelli, two distinct white circular patches on each mandible; width 1.28-1.63 (1.48 ± 0.11, *12*). Ocelli: three; black with grey base surrounding white inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden; more than twice length of head. Eyes: upper lobes of male reddish-brown, lower lobes grey-black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 261): lateral margin of clypeus very slightly diverging to anterior; lateral margins of labrum wider than clypeus, rounded to slightly angular; distinct antero-median emargination; labrum length 0.27-0.38 (0.34±0.04, *15*), labrum width 0.59-0.86 (0.72 ± 0.06, *15*), labrum width length ratio 1.92-2.56 (2.14 ± 0.15, *15*); four to five elongated denticles extending 0.08-0.18 (0.15 ± 0.03, *15*) across labrum; denticle width as proportion of labrum width 0.14-0.29 (0.20±0.04, *15*); frontal setae arranged as a single row; secondary hair fringe clearly separated from front row, reaching well beyond the frontal setae, extends 0.16-0.25 (0.20±0.04, *15*) times the width of labrum, contains 41-55 (*10*) setae; secondary hair fringe width to labrum width ratio 0.23-0.35 (0.28±0.04, *15*); thick socketed setae present lateral to secondary hair fringe. Mandibles: outer margins slightly curved, long setae at midpoint on outer lateral margins, shorter setae between long setae and base, dark coloured nodule at midpoint on inner lateral margins; dark brown basally becoming lighter anteriorly, basal section with golden coloured circular maculae, small tuft of setae flanking the base of each maculae. Left

mandible (Fig. 262): two incisors, each with three apical teeth; outer incisor often inconspicuously serrated on inner lateral margin, prothesca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 263): spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, often inconspicuously serrated on inner lateral margin, inner incisor with two apical teeth; prothesca simple, slender; prothecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 264): galea lacinae as wide as long; width length ratio 0.88-1.06 (0.99±0.06, 10); subapical row of 18-22 (10) pectinate setae; palpi three segmented, terminal palp with single spine on apex; palp length ratios 1.00: 0.85: 0.64 (0.22±0.01, 10). Hypopharynx (Fig. 265): well developed lateral processes; anterior margin of lingua shallowly cleft; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 266): glossae not turned under ventrally and lying in the same plane as paraglossae, series of spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.84: 0.57 (0.33±0.02, 10); submentum with spines on lateral margins. Thorax: light tan to medium brown with darker brown markings; pronotum width 1.20-1.53 (1.36±0.11, 12); slightly narrower than head width (see above), head pronotum width ratio 0.85-0.97 (0.92±0.03, 12). Legs (Fig. 267): colour light tan with dark brown markings giving a banded appearance; femora with middle third dark brown and dark brown at apices; tibiae with proximal sixth and middle third dark brown; tarsi with middle four-fifths dark brown; total foreleg length 2.68-3.73 (3.07±0.27, 12); fore femora length 1.15-1.60 (1.32 ± 0.12, 12), fore femora width 0.40-0.48 (0.44±0.02, 12); fore femora length width ratio 2.78-3.33 (3.01±0.18, 12); fore tibiae with numerous short ventral spines, sometimes serrated; fore tarsi with 8-12 (12) ventral spines; tarsal claws (Fig. 268) with 11-14 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated on inner margin; leg length ratios, foreleg 1.00: 0.93: 0.40 (1.32±0.12, 12), middle leg 1.00: 0.90: 0.35 (1.36±0.15, 12), hind leg 1.00: 0.93: 0.34 (1.48±0.16, 12). Abdomen: dark brown to black, golden markings on each segment forming a broken stripe midline, two light coloured maculae flank the marks anteriorly on each segment; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 269): membrane clear to light grey; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae dissimilar in size; upper lamellae narrow at approximately two-thirds length and broadens again in apical third, inner margin with small emargination near base of broadened apical third; lower lamellae narrow at two-thirds length tapering to a point; main and lateral tracheae present, strongly developed. Caudal filaments three, golden brown, terminal filament longer than cerci.

Remarks. This species was first described by Harker (1950a) as *Atalophlebia parva* from specimens collected in Armidale, New South Wales (type specimens). It was then transferred to *Atalonella* (Harker 1954) after she established the differences between the two genera in that paper. A subsequent transfer was made from *Atalonella* to *Nousia* following Campbell (1988) although no explanation was given for this change. Finally, in revision of the genus *Nousia* (Campbell and Suter 1988) the species was placed in the new genus *Koormonga* based on the egg morphology and genitalia shape. Subsequently this species has been referred to as *Koormonga* sp. "AV2" by Dean (1999).

I have examined all four types of *parva* from the Australian Museum. Unfortunately, they are all quite damaged and give very little useful information regarding the status of this species. The holotype has no forelegs or hindwings and the forewings are so badly damaged it is difficult to distinguish the all important absence of crossvein venation in the costal and subcostal spaces. I was able to examine the penes, which had been dissected from the body, but they definitely do not conform to the original drawings (Harker 1950a). This may be because the specimens lodged in the museum are from the Serpentine River, while those she nominated as the types in her paper (Harker 1950a) are from the Gara and Dumaresque Rivers. It could be inferred, therefore, that the specimens from the three locations may not be the same species. The paratypes are equally frustrating. The female imago has half of the abdomen missing and the hindwings in both the female imago and subimago are damaged or missing. There are, however, no crossveins in proximal halves of the costal and subcostal spaces of the imago and subimago forewing which conforms to the genus diagnosis. Finally the nymph has an indistinct body pattern, all but one hindleg missing and no gills. Despite this, however, the descriptions and drawings of these characters (Harker 1950a) do conform to the species description above. The species has several other quite distinguishing features such as the egg morphology, genitalia and shape of the nymphal gill with the broadened apical third of the upper lamellae, which make it unlikely to be any other species in the genus.

Thraulophlebia parva can be distinguished from all other species in the genus by the following combination of characters: In the imago: (i) forewing hindwing ratio comparatively small; (ii) upper eye size large, always contiguous; (iii) leg banding conspicuous; (iv) penes expanded lateral margin in apical third less distinct, fused in basal third dorsally and ventrally, lobes not indented apically; subapical lobes absent; small internal spines apparent under transmitted light; (v) egg cylindrical with rounded ends, two rings of tubular processes. In the nymph: (i) labrum subequal to wider than clypeus, lateral margins rounded to slightly angular, antero-median emargination distinct, length width ratio higher than two on average, single row of frontal setae, secondary hair fringe contains 41-55 setae and extends approximately one-third the width across labrum;

(ii) hypopharynx superlingua with rounded lateral margins; (iii) leg banding conspicuous; (iv) gill shape with upper lamellae narrowing at two-thirds length and broadens again in apical third, inner margin with small emargination near base of broadened apical third, lower lamellae narrows at two-thirds length with long apical filament tapering to a point.

Other specimens examined. QUEENSLAND. Careys Creek, S of Calen, N of Mackay, 79112001, 20 XI 1979, 140m, 148°43' 20°52',2 ♂ N (DC). **Mother Mountain,** 12km SE of Gympie, 80102900, 29 X 1980, 100m, 152°47' 26°15', EPH 1127, 1 ♂ N (AN). **Priors Creek,** Atherton, 96040600, 6 IV 1995, 760m, 145°28'79" 17°15'32", EPH 1439, 1 ♂ N, 1 ♀ N (BH). **Stony Creek,** Conondale Ranges, 97082602, 26 VIII 1977, 140m, 152°41' 26°51', EPH 1251, 1 ♂ N, 1 ♀ N (JD). **VICTORIA: Acheron River,** 87030500, 5 III 1987, 320m, 145°41' 37°30', nymphs (TD & RM). **Aura Vale Lake,** Hentys Picnic Area, 97112401, 24 XI 1997, 97112401, 140m, 145°23'17" 37°56'19", 1 ♀ N (KJF). **Coliban River,** Lyells Bridge, Redesdale-Bendigo Rd, 97040800, 8 IV 1997, 210m, 144°29'22" 36°57'46", N (JD). **East Errinundra River,** junction with west branch, 82031200, 12 III 1982, 300m, 148°54' 37°20', nymphs, (JB); 84010600, 6 I 1984, same locality data, nymphs (JB). **McIvor Creek,** 6km downstream Heathcote, 81091300, 13 IX 1981, 250m, 144°44' 36°57', EPH 1523, 1 ♀ N (JD). **Plenty River,** Mernda, 77110900, 9 XI 1977, 160m, 145°06' 37°36', EPH 1512, 1 ♀ NI (reared), (JD), EPH 1513, 1 ♂ I (JD), EPH 1515, 2 ♀ NI (reared), (JD), EPH 1516, 3 ♂ N (JD); 77120700, 7 XII 1977, EPH 1514, 1 ♂ N (JD), EPH 1517, 1 ♂ NS, 1 ♀ NS, (reared), (JD), EPH 1518, 1 ♂ NS, 1 ♀ NS (reared), (JD), EPH 1519, 1 ♀ NS (reared), (JD), EPH 1520, 3 ♂ NS, 2 ♀ NS (reared), (JD). **Upper Broken River,** Mansfield-Whitfield Rd, 9km N of Mansfield, 99022005, 20 II 1999, 340m, 146°06'20" 36°58'38", 4 ♂ N, 4 ♀ N (KJF). **West Errinundra River,** Hammond Rd, 82031500, 15 III 1982, 960m, 148°51' 37°18', nymphs (JB). **Wild Duck Creek,** Heathcote-Redesdale Rd, 1km SW Heathcote, 99022304, 23 II 1999, 210m, 144°39'35" 36°52'44", 2 ♂ NSI, 2 ♀ NS, 6 ♂ N, 7 ♀ N; 99040701, 7 IV 1999, same locality data, 1 ♂ NSI, 3 ♀ NSI, 1 ♀ NI, 2 ♀N; 00022001, 20 II 2000, same locality data, 3 ♂ NSI, 3 ♀ NSI, 1 ♀ NI, 2 ♀ NS, 2 ♂ N, 2 ♀ N (KJF). **Wombat Creek,** Wombat Creek Dam Picnic Area, near Daylesford, 97122004, 20 XII 1997, 635m, 144°10'22" 37°23'25", 1 ♀ NSI (KJF). **Yan Yean Reservoir,** 76021800, 18 II 1976, 180m, 145°08' 37°33', EPH 1522, 1 ♀ NI (reared), 1 ♂ N (JD); 76032900, 29 III 1976, same locality data, EPH 1511, 1 ♂ I (JD); 77102600, 26 X 1977, same locality data, EPH 1521, 2 ♂ I, 2 ♀ I (JD).

3.4.3.5   *Thraulophlebia simillima* (Ulmer) *Incertae sedis*

Atalophlebia australasica Ulmer (Ulmer 1916)

Atalophlebia simillima Ulmer (Ulmer 1919)

Atalonella simillima (Ulmer) (Harker 1954)

Nousia simillima (Ulmer) (Campbell 1988)

Koormonga simillima (Ulmer) (Campbell and Suter 1988)

Thraulophlebia simillima (Ulmer) comb. nov.

Incertae sedis

Types. Holotype. *Atalophlebia simillima* Ulmer. Cedar Creek, Queensland, 10040000, IV 1910-1913, ♂ imago. coll. Mjöberg Expedition [examined]. Labels: a) "*Atalophlebia simillima* Ulm (1920) Type", b) "Cedar Creek, April, Mjöberg". Held at SMNH.

Distribution. Queensland (no locality data available).

Diagnosis. The following description encompasses the only available description of the species (Ulmer 1919) and examination of the type specimen. **Male Imago.** Dimensions: body length 9, forewing length 9.5. Head: yellow-brown with black markings. Eyes: upper eye size large; upper lobes reddish-grey, lower lobes black. Thorax: pronotum light yellow brown with black markings; mesonotum light brownish yellow on dark brown background; metanotum dark brown. Legs: forelegs missing; middle and hind legs yellowish-grey, femora with dark brown band medially and at apex, tarsal apices also dark. Wings. Forewing: membrane hyaline, pterostigmatal area opaque, brownish-brick coloured; longitudinal and crossveins brown or reddish-brown; costal and subcostal crossveins present in the proximal halves of wing, costal space with 5 crossveins proximally, 17 distally. Hindwing: hyaline, venation similar to *Atalophlebia australasica*. Abdomen: colour dark brown from tergal segments two to seven with two dark longitudinal light stripes, tergal segments nine and ten darker; sternites brown. Genitalia: forceps three segmented, yellow-brown, progressively lighter apically; penes grey brown, divided into two square-shaped very wide lobes, distal edge weakly bent into an S-shape, between the lobes a blunt heart shaped lobe is apparent, each penis lobe is narrowed from a wider base to a triangle. Caudal filaments: two, umber brown, banding apparent. **Female imago.** unknown. **Egg.** unknown. **Male and female subimago.** unknown. **Mature nymph.** unknown.

Remarks. Very little is known of this species as the account by Ulmer (1919) was incomplete, largely consisting of descriptions of colour patterns on the body of the male imago. Further, no females, subimagos or nymphs were described and remain unknown today. By the definition of Harker (1954) it was considered to be part of the *Atalonella*

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group. It was subsequently placed in *Nousia* by Campbell (1988), then *Koorrnonga* following revision of Australian *Nousia* by Campbell and Suter (1988). The placement in the genus *Koorrnonga* was probably based on the broad based genitalia with the narrow apex although Campbell and Suter (1988) considered the placement tentative.

There is a also a complication regarding the type description created by Ulmer himself. He writes of the specimen he called *Atalophlebia simillima* that: "..Dies Stück fand sich noch nachträglich im Material der *A. costalis*, das Mjöberg auf seinen Expeditionen 1910-1913 gesammelt hatte und von mir als *A. australasica* Pict. in Ark f. Zoologi, 10 No. 4 1916 p 2. f. I.2, beschrieben wurde;.." ("..This specimen was later found in the material of *A.costalis* that Mjöberg collected on the expedition of 1910-1913 and was described by myself as *A. australasica* Pict. in Ark. f. Zoologi 10(4) 1916 p.2. f. 1.2..") (Ulmer 1916, p.17). Unfortunately, it is not clear which specimen was confused with the numerous specimens of *A. australasica* described therein, and which descriptions, if any, actually relate to *T. simillima*. I have decided to consider the description of *Atalophlebia simillima* (Ulmer 1919) as the valid one. Any references to the previous paper (Ulmer 1916) will only be made if directly referred to by Ulmer (1919).

The single type specimen from the Stockholm Museum is very damaged. It is somewhat shrivelled as if it has been dried out and dehydrated making it difficult to see the characters especially the wing venation. Even so, the genitalia shape does reasonably approximate the drawing by Ulmer (1919) with the two wide lobes converging medially. This is a generic characteristic of *Thraulophlebia* and I can see why it would be considered to relate to this genus. However, other genera, such as *Atalophlebia* have penes lobes which are similar.

In other respects the type specimen does not conform to *Thraulophlebia*. Although difficult to see, the type definitely has crossveins proximally in the costal and subcostal space of the forewing; a fact that Ulmer mentions in the text: "..im Costalraume von der Bulla fünf starke, dunkel umschattete Queradern.." ("..in the costal space in front of the bulla five strong, darker shaded cross-veins") (Ulmer 1919, p.16). I would also say the forewing size of the type at 9.5mm is significantly larger than *Thraulophlebia* forewings which I have found to range in size from 5.7-8.1mm.

The *simillima* hindwings appear to be missing from the type but a clue to their shape is provided by Ulmer (1919) when he writes "..Costalraum und seine Adern, ebenso die übrige Nervatur wie bei *A. costalis* Burm. (*A. australasica* Pict.) " ("..the costal space, its veins and the remaining venation are the same as A. costalis Burm. (*A. australascia* Pict..)" (Ulmer 1919, p. 16). If we take Ulmer's drawing of the hindwing of *A. australasica*

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to represent *simillima* as mentioned previously (Ulmer 1916; FIG. 1, p. 2 reproduced here as Fig. 270) it is clear that the wing does not have the characteristics of *Thraulophlebia* with the absence of the strong projection of the costal margin which gives the wing a somewhat triangular shape.

Another characteristic of the type which is incommensurate with *Thraulophlebia* is the large body size (9mm). I found the *Thraulophlebia* species range in size from 5.6-7.4mm.

The option of trying to recollect this species has been ruled out by the ambiguousness of the type locality - Cedar Creek in Queensland (see. 3.3.2.2) and, of course, a full survey of the mayflies of that state was beyond the scope of this project.

As a result of the genus revision, all species belonging to *Koorrnonga* are formally transferred to *Thraulophlebia*. I believe, however, that *simillima* clearly does not belong to this genus. I feel it would perhaps would be better placed in *Atalophlebia* due to the similarities it appears to have to other members of this genus. As it is not possible to determine this without a revision of the genus *Atalophlebia*, I feel there is no choice but to declare this species *Incertae sedis*.

3.4.4 Key to current species of *Thraulophlebia*

This key is accompanied by a matrix of main characters for separating the species as an alternate means of identification (Table 17).

Male imagos

1   Penes fused in basal third dorsally and ventrally, with narrowly expanded outer lateral margins in apical third, without distinct subapical lobes dorsally, small internal spines apparent under transmitted light; upper eye size large, always contiguous; forelegs with conspicuous banding..*parva*

        Penes almost separated at base dorsally, with widely expanded outer lateral margins in apically third, with distinct subapical lobes dorsally, small internal spines absent; leg banding inconspicuous or absent...2

2(1)   Penes fused in basal half ventrally, lobes indented apically; upper eye size large, often contiguous; forewing hinging ratio comparatively large with forewing 5.9-7.6 times larger than hindwing..*lucida*

        Penes fused in basal third ventrally, lobes not indented apically; upper eye size large, never contiguous; forewing hindwing ratio comparatively small with forewing 4.9-5.3 times larger than hindwing......................................*inconspicua*

Female imagos

1   Egg cylindrical with rounded ends, two rings of tubular processes...............*parva*

        Egg ovoid with two to three rings of tubular processes.......................................2

2(1)   Egg ovoid with two rings of tubular processes; body length comparatively smaller; forewing hindwing ratio comparatively larger with forewing 5.5-8.6 times larger than hindwing...*lucida*

        Egg ovoid with three rings of tubular processes, body length comparatively larger; forewing hindwing ratio comparatively smaller with forewing 4.9-6.5 times larger than hindwing ....*inconspicua*

Mature nymphs

1   Labrum wider than clypeus with distinct antero-median emargination, length width ratio generally larger than two, secondary hair fringe contains 41-55 setae and extends approximately one-third the width across labrum; gills with upper lamellae narrowing at two-thirds length and broadens again in apical third, inner margin with small emargination near base of broadened apical third, lower lamellae narrow at two-thirds length with long apical filament tapering to a point...*parva*

        Labrum subequal to slightly wider than clypeus with slight antero-median emargination, length width ratio two or less, secondary hair fringe with 40 or less setae extending one-quarter or less the width across labrum; gills with upper lamellae narrowing at three-quarters length with long apical filament, lower lamellae narrows at four-fifths length with shorter apical filament 2

2(1)   Labrum subequal to clypeus, length width ratio usually less than two, frontal setae arranged as a single row, secondary hair fringe with 12-25 setae extending one sixth the width across labrum; hypopharynx superlingua with slightly angular lateral margins ....*lucida*

        Labrum subequal to slightly wider than clypeus, length width ratio usually around two, frontal setae arranged as a narrow band, secondary hair fringe with 20-40 setae extending one quarter the width across labrum; hypopharynx superlingua with rounded lateral margins...*inconspicua*

Table 17. Matrix of main characters useful for separating the species of Thraulophlebia.

	Thraulophlebia lucida	Thraulophlebia inconspicua	Thraulophlebia parva
Male Imago			
forewing /hindwing ratio	5.87 – 7.56 (6.80±0.59, 17)	4.94-5.31 (5.08±0.12, 9)	4.37-5.90 (5.16±0.55, 7)
eyes contiguous	often	no	always
eye size (ES)	0.00-0.04 (0.01±0.01, 10)	0.10-0.15 (0.13±0.02, 10)	
leg banding	inconspicuous or absent,	inconspicuous or absent	conspicuous
total leg length	5.64-6.61 (6.08±0.33, 10)	6.29-7.46 (6.89±0.32, 10)	4.45-5.58 (5.08±0.58, 4)
leg length ratios	1.00: 1.45: 0.06: 0.50: 0.48: 0.37: 0.17 (1.52±0.14, 10)	1.00: 1.44: 0.08: 0.45: 0.43: 0.32: 0.16 (1.78±0.08, 10)	1.00: 1.44: 0.06: 0.40: 0.38: 0.26: 0.17 (1.37±0.09, 4)
penes shape	widely expanded lateral margin in apical third	widely expanded lateral margin in apical third	more narrowly expanded lateral margin in apical third
penes fusion	fused in basal half ventrally, separated almost at base dorsally	fused in basal third ventrally, separated almost at base dorsally	fused in basal third dorsally and ventrally
penes lobes apically	each lobe indented apically	lobes not indented apically	lobes not indented apically, less distinct
penes –ventral	yes ventral view with subapical lobes protruding laterally outwards	ventral view with subapical lobes protruding laterally outwards	ventral view without subapical lobes
penes with processes inner margins	no	no	yes
Female Imago			
body length	5.6-7.6 (6.6±0.56, 25)	7.0-8.8 (7.6±0.80, 6)	5.7-8.7 (7.1±0.80, 13)
forewing hindwing ratio	5.47-8.55 (6.93±0.77, 20)	4.93-6.45 (5.30±0.65, 5)	5.07-6.64 (5.74±0.49, 10)
Egg			
egg shape	ovoid	ovoid	cylindrical with rounded ends
egg polar cap	two rings of tubular processes	three rings of tubular processes	two rings of tubular processes

Table 17 cont'd.

Mature nymph			
labrum wider than clypeus	subequal to clypeus	subequal to slightly wider than clypeus	lateral margins of labrum wider than clypeus
lateral margins of labrum	rounded	rounded	rounded to slightly angular
antero-median emargination	slight	slight	distinct antero-median emargination
labrum length /width ratio	1.69–2.18 (1.86±0.13, 25)	1.82-2.11 (1.96±0.07, 23)	1.92-2.56 (2.14 ± 0.15, 15)
frontal setae arrangement	single row	narrow band	single row
Secondary hair fringe width to labrum width ratio	0.06–0.20 (0.14±0.03, 25)	0.19-0.30 (0.25±0.03, 22)	0.23-0.35 (0.28±0.04, 15)
secondary hair fringe – number of setae	12-25 (20)	20-40 (18)	41-55 (10)
hypopharynx – superlingua lateral margins	slightly angular	rounded lateral margins	rounded lateral margins
leg banding	conspicuous to inconspicuous	inconspicuous or absent	yes
gill shape	upper lamellae narrow at three-quarters length with long apical filament, lower lamellae narrow at four-fifths length with shorter apical filament	upper lamellae narrow at three-quarters length with long apical filament, lower lamellae narrow at four-fifths length with shorter apical filament	upper lamellae narrow at approximately two-thirds length and broadens again in apical third, inner margin with small emargination near base of broadened apical third; lower lamellae narrow at two-thirds length tapering to a point

3.4.5 Investigation of the congenerity of *Nousia (Australonousia)* and *Thraulophlebia*

It is clearly acknowledged that the two taxa are very closely related as intimated by Campbell and Suter 1988). However, due to the current revision, some of the characters used to separate them no longer apply. For example, Campbell and Suter (1988) state that in *Koormonga* (now *Thraulophlebia*) the crossvein MA is forked slightly less than half the distance from wing base to margin and the penes lack a sclerotised process on the inner margin. I have found that in *Thraulophlebia* MA is forked at around half the distance from wing base to margin. Campbell and Suter (1988) also state that the male forewing is without crossveins proximally in *Thraulophlebia* which I have also found to be true, but I have noted it in the subgenus *Nousia (Australonousia)* as well. Finally, although the question of the egg morphology has not been put to rest because of the lack of *Nousia (Australonousia) fuscula* specimens, the presence of polar caps and rings of tubular processes appears to be characteristic of *Thraulophlebia*. If this is the case, the difference in the number of tubular rings to distinguish between the two genera as outlined in Campbell and Suter (1988) is no longer valid. As for the nymph, *Koormonga* is considered to be distinguished from the Australian *Nousia* by the presence of 4-6 smooth regular denticles and segment one of the labial palpi is 1.3 times longer than segment two (Campbell and Suter 1988). I have found that the revised subgenus *Nousia (Australonousia)* contains some species with 4-6 elongate regular denticles and that there are no apparent differences in the labial palp length of the labium of the two taxa.

Despite this anomalies, there are consistent variations between the two taxa which I believe warrant their separate status. The most significant are the shape of the hindwing, penes and egg and the arrangement and type of setae on the labrum (see Table 18).

Table 18. Main characters separating the subgenus *Nousia (Australonousia)* from the genus *Thraulophlebia.*

	Nousia (Australonousia)	*Thraulophlebia*
Male Imago		
hindwing shape	costal margin slightly convex at midlength immediately preceding shallow concavity – rounded shape	strong projection of the costa – triangular shape
penes fusion	fused in basal two-thirds, lobes separate apically	fused in basal third to half ventrally, separated at base or fused in basal third dorsally, lobes joined or nearly so apically
Female Imago		
forewing – proximal crossveins in costal and subcostal space	present	weakly developed
Egg		
egg polar cap	absent	with two or three tubular processes
egg pattern	large and small circular shaped protuberances, pattern variable	small evenly spaced circular protuberances
Mature nymph		
labrum frontal setae	arranged as a narrow or broad band	arranged as a single row or narrow band
labrum secondary hair fringe	extends more than one half the width of labrum	extends no more than two-fifths the width of labrum
labrum thick socketed setae	absent	present
mandible – setae on lower body	row of setae in an inverted L-shape	small tuft of setae
hypopharynx	moderately to deeply cleft	shallowly cleft
pronotum width	equal to slightly greater than width of head	always equal to width of head

3.5 General discussion

According to Dean (1999) there are eight morphospecies of *Nousia (Australonousia)* not accounted for in these revisions, all of which have been determined by the nymph stages only. At least four appear to be Tasmanian endemics. One is from Western Australia and previously considered to belong to an unnamed genus ("genus R") (Dean and Suter 1996) but subsequently transferred to *Nousia* in a later revision (Dean 1999). The other taxa apparently occur in Victoria but are represented by only one or two specimens. Despite repeated efforts to collect them from Mt Baw Baw, Mt McKay at Falls Creek and the Tarra River in Tarra-Bulga National Park, I was unable to collect or rear specimens that proved different from the other species of *Nousia (Australonousia)*.

With regard to *Thraulophlebia* it is considered there are four morphospecies not accounted for in these revisions (Dean 1999). Two are supposedly found in Victoria. *Koormonga* sp. "AV3" and sp. "AV5". Superficially they appear very similar to *T. inconspicua* but their species status was unable to be verified due to an inability to collect more specimens (see 3.4.3.3). The other two morphospecies of this genus apparently occur only in northern Queensland. Examination of the one or two specimens available in each case revealed *Thraulophlebia*-like characteristics, such as the secondary hair fringe and unequal length of the gills, but there were too few specimens to assess differences that would confer species status.

In summary in the subgenus *Nousia (Australonousia)* two species have been redescribed, one new species described and three morphospecies described. Of the two species redescribed one has been synonymised with two other species, *N. (A) delicatula* and *K. brunnea*. One species, *N. (A) wiltkorringae* has been removed and placed in a monotypic genus (See Chapter 4) and one species *N. (A) darkara* has been declared *Incertae sedis*. The subgenus *Nousia (Australonousia)* now consists of three species: *N. (A) fusca*, *N. (A) fuscula* and *N. (A) nigeli* sp. nov. The subgeneric status of *Nousia (Australonousia)* has been investigated and considered somewhat unnecessary but in the interests of stability should stay until the remaining species of Australian *Nousia* are described.

With regards to *Koormonga*, it was established that is not congeneric with *Nousia (Australonousia)* but should be synonymised with *Thraulophlebia*. *T. pilosa* was synonymised with *T. lucida* and *T. simillima* has been declared *Incertae sedis*. The genus *Thraulophlebia* now contains three redescribed species: *T. lucida* comb.nov., *T. inconspicua* comb.nov., and *T. parva* comb.nov.

These revisions must be considered incomplete as they clearly do not contain all the species. However, the revision of these two taxa has been hampered by the deficiencies of some of the early descriptions and drawings. Further, many type specimens were either unavailable or too damaged to be of sufficient use. A number of the type localities were ill-defined and there was also limited time and too few resources to conduct sufficient field collecting and rearing over the large geographical areas involved. In particular, collecting trips to Tasmania and Queensland are necessary to fill in the gaps and ultimately complete the revisions. Although the geographical restraint became more apparent as the project progressed, the research focus on Victoria allowed a concentration of work in the species-rich south-east. Despite these limitations, substantial progress has been made towards a comprehensive revision, providing a sound platform from which subsequent work can proceed.

4. DESCRIPTIONS OF TWO NEW GENERA FROM SOUTH-EASTERN AUSTRALIA (LEPTOPHELBIIDAE: ATALOPHLEBIINAE).

"The stimulating delight of the systematist is that
he never knows what remarkable unknown organism
or structure of form or function or habit may come
to his attention tomorrow, or the next day or
the next; the tragedy of the systematist is that he
knows that his work can never be completed."

Elwood C. Zimmerman, Entomologist 1991

4.1 Introduction

In revising the subgenus *Australonousia* (Chapter 3) it was recognised that two species, currently considered as *Nousia (Australonousia)* (Dean 1999), were morphologically distinct and did not belong as part of that taxon. Two new genera have been erected here to accommodate them. The first, *Montikola,* encompasses two species and the second, *Gemmayaluka* is monotypic. *Gemmayaluka wiltkorringae* has already been published as a species of *Nousia (Australonousia)* (Finlay 2000, Appendix 3). This paper was written in 1999 and I then believed this taxon correctly belonged in the subgenus *Nousia (Australonousia)* based on the available evidence. Following a further two years intensive study on the subject I have come to the conclusion that the species does not readily fit within the revised generic and subgenus diagnosis.

4.2 Methods and conventions

See 3.2

4.3 Description of *Montikola* gen. nov.

4.3.1 *Montikola* gen. nov.

Type species. *Atalophlebia kala* (Harker)

Distribution. Southern New South Wales, Eastern Victoria (Fig. 271).

Diagnosis. Male imago. Dimensions: body length 8.6-13.5; forewing length 8.8-13.2; hindwing length 1.9-3.3; forewing hindwing ratio 3.81-5.79. General body colour brown, head dark brown, antennae tan to dark brown. Ocelli: three; black with white-grey inserts; laterals larger than medial. Eyes: upper eye size large, sometimes contiguous, ES=0.00-0.11; upper lobes orange brown; lower lobes grey-black. Thorax: brown to shiny brown with darker markings. Legs: femora tan brown with darker apices, tibiae and tarsal golden; total leg length 7.4-11.4; forelegs with seven segments, tibia approximately 1.4-1.5 times length of femur, the five segmented tarsus approximately 1.2-1.5 times length of femur; tarsal claws of a pair similar, each apically hooked with an opposing hook. Wings. Forewing: membrane hyaline, pterostigmal area slightly opaque, longitudinal and crossveins brown, anal veins yellow, costal and subcostal veins present in proximal and distal halves of wing; costal space with 5-11 crossveins proximally, 12-20 distally (sometimes anastomosed), subcostal space with 5-10 crossveins proximally, 11-16 distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and

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CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, CuA and CuP linked by crossvein, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing: mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex and midlength immediately preceding shallow concavity, costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal halves of costal space, 5-9 in distal space, 5-9 throughout subcostal space. Abdomen: light to tan brown with golden and darker brown markings, colour and patterning variable. Genitalia: forceps three segmented; tan brown, progressively lighter apically, terminal segment angular, about the same length as middle segment. Penes golden to tan brown, fused in basal half dorsally, fused almost along entire length ventrally, two lobes distinct, outer lateral margins relatively straight to bulbous; each lobe pointing outwards, small triangular process present apically (although sometimes missing), two pairs of internal spines. Caudal filaments: three, tan brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length forewing length 8.4-15.6; hindwing length 1.4-3.5; forewing hindwing ratio 3.94-6.00. General patterning and colour similar to male. Eyes: grey-black, separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male, 5.8-9.3; forelegs with six segments; tibia approximately 1.4 times length of femur, the four segmented tarsus approximately 0.7 times length of femur. Wings. Forewing: colour and venation similar to male except wings with generally more crossveins on average; costal space with 6-11 crossveins proximally, 13-20 distally (sometimes anastomosed), subcostal space with 5-10 crossveins proximally, 12-17 distally. Hindwing: no crossveins in proximal half of costal space, 5-8 in distal space, 5-10 throughout subcostal space. Abdomen: sternum seven with small genital extension, sternum nine moderately cleft. **Egg.** Ovoid; polar cap absent, chorion with large and small circular shaped protuberances over surface, pattern variable. **Male and female subimago.** General pattern and colouring similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** Body lengths ♂ 10.0-13.3, ♀ 8.0-14.9. General colour tan brown with darker markings. Head: prognathous; tan to dark brown, width 1.9-2.8. Ocelli: three; black with white inserts: laterals larger than medial. Antennae: golden to tan brown; more than twice length of head. Eyes: upper lobes of male orange to reddish-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus: lateral margins of clypeus very slightly diverging towards anterior; lateral margins of labrum slightly wider than clypeus, rounded: anterior margin of labrum straight with no apparent antero-median emargination; labrum length 0.40-0.63, labrum width 0.95-1.33, labrum width length ratio 2.00-2.45; five elongated denticles present on anterior margin extending 0.24-0.58 times the total width of the labrum; denticle width as proportion of labrum width 0.21-0.53; frontal setae arranged as a broad band; secondary hair fringe clearly separated from

broad band. Mandibles: outer margins slightly curved; small indentation and sparse long setae at midpoint on outer lateral margins; shorter setae along margin between midpoint and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in inverted L-shape on lower mandible body. Left mandible: two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin, with or without subapical process; prostheca robust, serrated; prosthecal tuft slender, tapering to a thin point apically, hairs on lateral margins only. Right mandible: spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin, short spines on inner mesal surface; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae: galea-lacinae slightly wider to as wide as long, width length ratio 0.85-1.17; subapical row of 16-23 pectinate setae; palpi three segmented, first segment length 0.37, segments two and three of approximately equal length, 0.69-0.71 times the length of first segment, segment three with single spine apically. Hypopharynx: well developed lateral processes; anterior margin of lingua deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, lateral margins slightly angular. Labium: glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment length 0.51-0.53, segment two 0.81-0.83 times length of first segment, segment three approximately half the length of the first segment, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; submentum with spines on lateral margins. Thorax: tan brown with darker brown markings; pronotum width 1.98-2.90, slightly wider than width of head (see above), head pronotum width ratio 1.00-1.17. Legs: golden to tan brown, femora usually darker at apices; fore femora occasionally with white patch on proximally but this is not always apparent; total foreleg length 3.80-7.33, fore femora length 1.75-3.13; fore femora width 0.63-0.90; fore femora length width ratio 2.69-4.05; fore tibiae with numerous short ventral spines, fore tarsi with 6-11 ventral spines; tarsal claws with 11-15 ventral teeth, progressively larger apically; average leg length ratios, tibiae 0.87-0.93 times length of femur, tarsi 0.29-0.37 times length of femur. Abdomen: golden to tan brown with golden and darker brown markings, colour and patterning variable; posterolateral spines present, progressively larger posteriorly. Gills: membrane clear or opaque, light grey to grey-black colour; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill tapered to a thin point apically; main and lateral tracheae present, strongly developed. Caudal filaments: three; golden; terminal filament longer than cerci.

*Following examination of this thesis an external examiner has pointed out that the generic name *Montikola* has potential to cause confusion and should be changed. The genus name should therefore be regarded as a temporary tag and the genus will be published under an alternative name.

*The new genus is erected according to the criteria outlined by Peters and Edmunds (1970) for separating genera: ie 'if two or more groups of species are separated by a distinct gap of characters evident in both adults and nymphs.' These characters are outlined in the table below.

Main characters separating the genus *Nousia* from the newly erected genus *Montikola*

GENUS	Nousia		Montikola
SUBGENUS	Nousia (Nousia)	Nousia (Australonousia)	
Male imago			
body length	less than 9mm	less than 9mm	generally more than 10mm
forewing length	less than 10mm	less than 10mm	generally more than 10mm
forewing costal and subcostal crossveins	reduced or absent	reduced or absent	present
forewing - number of crossveins in costal space	usually 10-15	usually 10-15	usually 20 or more
penes	fused in basal two-thirds, remainder divided	fused in basal two-thirds, remainder divided	fused in basal half dorsally, fused almost along entire length ventrally
Female imago			
body length	less than 10mm	less than 10mm	generally more than 10mm
Mature nymph			
body length – male	less than 10mm	less than 10mm	more than 10mm
maxillae no. subapical setae	less than or equal to 15	less than or equal to 15	equal to or more than 17
maxillae first segment length	unknown	0.22-0.30mm	0.37mm
hypopharynx – superlingua lateral margins	rounded	rounded to slightly angular, sometimes with slight indentations.	angular
labium first segment length	unknown	0.29-0.38mm	0.51-0.53mm

Etymology. The genus name is derived from the Latin *Monticola* meaning mountaineer and refers to the species preference for high altitude mountainous habitats. The distinct spelling of *Montikola* was adopted as *Monticola* was pre-occupied. see opposite*

Remarks. The genus *Montikola* can be distinguished from all other genera in the Leptophlebiidae family by the following combination of characters: In the imago: (i) body length ♂ 8.6-13.5; ♀ 8.0-13.6; (ii) male upper eye size large, sometimes contiguous (iii) male and female forewing 3.8-6.0 times longer than hindwing; (iv) forewing crossveins present in proximal halves of wing, male with 17-31 crossveins in costal space (sometimes anastomosed distally), 16-26 in subcostal space, female with 19-31 in costal space (sometimes anastomosed distally), 17-27 subcostally; (v) MA forked at half to just over half the distance from wing base to margin; MP_2 connected to MP_1 and CuA, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein; ICu_2 joins ICu_1; ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1; (vi) hindwing costa joins subcosta at four-fifths wing length; (vii) tarsal claws of a pair similar, each apically hooked with an opposing hook; (viii) fused in basal half dorsally, fused almost along entire length ventrally, two lobes distinct, small triangular process present apically (although sometimes missing); each lobe pointing outwards, two pairs of internal spines; (ix) female eyes separated on meson of head by a distance about four times maximum width of eye; (x) female sternum seven with small gential extension (xi) female sternum nine moderately cleft; (xi) egg ovoid, polar cap absent, chorion with small to large circular shaped protuberances. In the nymph: (i) body length ♂ 10.0-13.3, ♀ 8.0-14.9. (ii) antennal length more than twice length of head; (iii) lateral margins of clypeus very slightly diverging towards anterior; (iv) labrum slightly wider than clypeus, 2-2.5 times wider than long; lateral margins rounded; no antero-median emargination; five elongate denticles extend one-fifth to one-half the width of labrum; frontal setae arranged as a broad band, secondary hair fringe clearly separated from broad band; (v) mandibles with outer margins slightly curved; incisors with inconspicuous serrations on inner lateral margins, sometimes with subapical lobe; (vi) maxillae with galea lacinae generally about as wide as long; subapical row of 16-23 pectinate setae; terminal palp elongate, usually with single spine apically; (vii) hypopharynx deeply cleft; (viii) labium glossae not turned under ventrally: terminal segment elongate with row of triangular spines almost circulating apex; submentum with spines on lateral margins; (ix) pronotum generally slightly wider than head; (x) legs with fore femora 2.7-4.0 times longer than wide; fore tarsi with 6-11 ventral spines; tarsal claws with 11-15 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; (xi) abdomen with posterolateral spines, progressively larger posteriorly; (xii) gills with margins entire, double, upper and lower lamellae equally developed; slender, tapering to a thin point apically, main and lateral tracheae strongly to weakly developed. see opposite*

4.3.2 *Montikola kala* (Harker) comb. nov.

Atalophlebia kala Harker (Harker 1954)

Nousia sp. "AV3" (Dean 1999)

Montikola kala (Harker) comb. nov.

Types. Holotype. *Atalophlebia kala* (Harker), Lake Albina, Mount Kosciusko, New South Wales, 29020200, 2 II 1929, ♂ imago pinned, R.J. Tillyard. Labels: a) "Atalophlebia kala", b) "Abdomen in slide cabinet", c) Mt. Kosciusko, Lake Albina 2.2.29, R.J. Tillyard", d) "Type", e) Brit. Mus. 1937-408". **Paratypes.** Lake Cootapatamba, Mount Kosciusko, New South Wales, 30012700, 27 I 1930, R. J.Tillyard, ♀ imago, subimagos [not seen]. Held at the NHM.

Distribution. Southern New South Wales, Eastern Victoria (Fig. 272).

Diagnosis. Male Imago. Dimensions: body length 9.3-13.1 (11.1±1.25, *15*); forewing length 10.3-12.8 (11.8±0.80, *14*); hindwing length 1.9-2.9 (2.52±0.36, *13*); forewing hindwing ratio 4.07-5.79 (4.74±0.52,*13*). General body colour tan to dark brown. Head dark brown. Antennae: pedicel and scape dark brown, flagellum tan brown. Ocelli: three; black with white-grey inserts; laterals larger than medial. Eyes: upper eye size large, sometimes contiguous; ES=0.00 - 0.11 (0.06±0.04, *10*); upper lobes orange-tan brown, lower lobes grey- black. Thorax: pronotum dark brown; mesonotum tan brown with darker brown markings. Legs: femora tan brown, apices darker; tibiae and tarsi yellow; total leg length 9.8-11.4 (10.9±0.57, *10*); forelegs with seven segments; length ratios 1.00: 1.51: 0.05: 0.45: 0.45: 0.37: 0.15 (2.76±0.21, *10*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 273). Wings. Forewing (Fig. 274): membrane hyaline, pterostigmal region opaque, longitudinal and crossveins brown, anal veins yellow; costal and subcostal crossveins present in proximal and distal halves of wing; costal space with 5-9 (*12*) cross veins proximally, 12-20 (*12*) distally (some anastomosed), subcostal space with 5-8 (*12*) cross veins proximally, 11–16 (*12*) distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, CuA and CuP linked by crossvein, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing (Fig. 275): mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity, costa joins subcosta at approximately four-fifths wing length; no cross veins in proximal half of costal space, 5-8 (*11*) in distal space, 6-8 (*11*) throughout subcostal space. Abdomen (Fig.

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276): tan brown, darker posteriorly, usually with golden markings on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking anteriorly, segments eight and nine usually darker, segment ten usually light, colour and pattern variable. Genitalia (Figs 277-283): forceps three segmented (Figs. 277); tan brown; terminal segment angular, sometimes indented, about the same length as middle segment; penes tan brown; fused in basal half dorsally (Fig. 277), fused almost along entire length ventrally (Figs. 278, 282); outer lateral margins bulbous; two lobes distinct, each lobe pointing outwards, small triangular processes present apically (Figs. 277, 278, 282, 283), although sometimes missing (Figs. 279, 280); two pairs of internal spines (Figs. 277-281), although sometimes not apparent. Caudal filaments: three; tan brown; apex of each segment washed dark brown giving a banded appearance; terminal filament longer than cerci. **Female imago.** Dimensions: body length 9.6-12.6 (11.2±1.00, *15*); forewing length 11.3-15.6 (12.8±1.02, *14*); hindwing length 2.2-3.0 (2.62± 0.25, *13*); forewing hindwing ratio 4.27-5.61 (4.93±0.44, *13*). General patterning and colouring similar to male. Eyes: grey-black, separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male, total foreleg length 7.6-9.4 (8.3±0.59, *10*); forelegs with six segments, leg length ratios 1.00: 1.43: 0.21: 0.18: 0.15: 0.13 (2.69±0.23, *10*). Wings. Forewing (Fig. 284): colour and venation similar to male except wings with generally more crossveins on average; costal space with 7-8 (*11*) cross veins proximally, 16-20 (*11*) distally (some anastomosed), subcostal space with 7-9 (*11*) crossveins proximally, 14-16 (*11*) distally. Hindwing (Fig. 285): no crossveins in proximal halves of costal space, 6-8 (*10*) in distal space, 7-10 (*10*) throughout subcostal space. Abdomen: sternum seven with small genital extension; sternum nine moderately cleft (Fig. 286). **Egg.** Ovoid; polar cap absent, chorion with large and small circular shaped protuberances over surface, pattern variable (Fig. 287, 288). **Male and female subimago.** Body lengths: ♂ 9.3-10.6 (9.7 ±0.61, *10*); ♀ 10.0-13.7 (11.5±1.05, *15*). General colour and markings similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 289). Body lengths: ♂ 10.0-12.5 (11.1±0.86, *10*); ♀ 11.5-14.9 (13.0±1.00, *16*). General colour tan to darker brown markings. Head: prognathous; tan to dark brown, golden patches surrounding ocelli; width 1.91-2.75 (2.28±0.21, *18*). Ocelli: three; black with white inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden brown; more than twice length of head. Eyes: upper lobes of male orange-brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 290): lateral margins of clypeus very slightly diverging towards anterior; lateral margins of labrum slightly wider than clypeus, rounded; anterior margin of labrum straight with no apparent antero-median emargination; labrum length 0.40-0.63 (0.51±0.07, *20*); labrum width 0.95-1.33 (1.11±0.12, *20*); width length ratio 2.00-2.45 (2.20±0.15, *20*); five elongated denticles

present on anterior margin extending 0.28-0.58 (0.40±0.07, 20) times the total width of the labrum; denticle width as proportion of labrum width 0.25-0.53 (0.37±0.08, 20); frontal setae arranged as a broad band; secondary hair fringe clearly separated from broad band. Mandibles: outer margins slightly curved; small indentation and sparse long spine-like setae at midpoint on outer lateral margins, shorter setae along margin between midpoint and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 291): two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin; prostheca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 292): spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin, short spines on inner mesal surface; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 293): galea-lacinae as wide as long, width length ratio 0.85-1.17 (1.03±0.10, 10); subapical row of 16-23 (12) pectinate setae; palpi three segmented, terminal palp with single spine apically (Fig. 294); palp length ratios 1.00: 0.69: 0.67 (0.37±0.04, 10). Hypopharynx (Fig. 295): well developed lateral processes; anterior margin of lingua deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, lateral margins slightly angular. Labium (Fig. 296): glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment with sharp spines, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface (Fig. 297); palp length ratios 1.00: 0.83: 0.50 (0.53±0.05, 10); submentum with spines on lateral margins. Thorax: tan brown with darker brown markings; pronotum width 1.98-2.85 (2.43±0.23, 18), slightly wider than width of head (see above), head pronotum width ratio 1.00-1.12 (1.07±0.04, 18). Legs (Fig. 298): yellow to tan brown, femora usually darker at apices; fore femora occasionally with white patch on proximally but this is not always apparent; total foreleg length 4.96-7.33 (5.93±0.73, 15); fore femora length 2.25-3.13 (2.56±0.28, 15); fore femora width 0.63-0.90 (0.77±0.08, 15); fore femora length width ratio 2.88-4.05 (3.32±0.30, 15); fore tibiae with numerous short ventral spines, fore tarsi with 6-10 (10) ventral spines; tarsal claws (Fig. 299) with 11-15 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; leg length ratios, foreleg 1.00: 0.93: 0.36 (2.56±0.28, 15), mid leg 1.00: 0.87: 0.31 (2.52±0.29, 15), hind leg 1.00: 0.89: 0.27 (2.96±0.32,15). Abdomen: tan brown with darker brown markings, golden markings medially on each segment, pattern variable; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 300): membrane clear, light grey colour; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill tapered to a

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thin point apically; main and lateral tracheae present, strongly developed. Caudal filaments: three; golden brown; terminal filament longer than cerci.

Remarks. The larval stage of this species has been recognised previously and referred to as "Genus Y sp. 2" or *Atalophlebioides* "sp. 2" in various unpublished keys from the Museum of Victoria. Recently, it carried the name *Nousia* sp. "AV3" (Dean 1999).

This species, however, appears to have been described previously as *Atalophlebia kala* by Harker(1954) from specimens collected by T:"vard twenty years earlier. Her description only included the adult stages and her basis for including this species in *Atalophlebia* is not clear, although I presume the large size of the animal influenced her decision. I have examined the holotype and type slide of genitalia from the NHM and it clearly represents *Atalophlebia kala* Harker (Harker 1954, FIG. 36, p. 251, reproduced here as Fig. 301).

Dean (1999) considers the nymph to belong to *Nousia (Australonousia)* and it is clear that there are many similarities in mouthpart, leg and gill morphology. However, only the nymph was documented and no association made with the clearly distinct adults. I have also examined a large number of nymphs from the type localities of Lake Albina and Lake Cootapatamba, collected by John Dean in the mid 1980's, which I am satisfied represent *Nousia* sp. "AV3" *sensu* Dean. Specimens collected by me from a small unnamed tributary of Charity Creek underneath a chairlift (Fig. 302) near the summit of Mt Baw Baw were reared in the laboratory and proved to be this species. These specimens and a wide range of other reared material (see below) has confirmed the association between nymph and adult of this species.

Montikola kala can be distinguished from other species in the genus by the following combination of characters. In the imago: (i) male forewing length longer; (ii) male forewing hindwing ratio larger, ie hindwing smaller in proportion to forewing; (iii) male foreleg lengths longer; (iv) abdomen with golden markings medially on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking; (v) outer lateral margins of penis more bulbous. In the nymph: (i) denticles on labrum extend approximately two-fifths the width of the labrum; (ii) total foreleg length longer, particularly femora; (iii) abdomen with golden markings medially on each segment forming a broken stripe midline, two golden coloured maculae flanking each midline marking; (iv) gills with membrane clear.

Other specimens examined. NEW SOUTH WALES. Lake Albina outlet stream (Lady Northcotes Creek), 85020903, 9 II 1985,1920m, 147°16′ 36°26′, EPH 1776, 1 ♀ S (DC),

EPH 1777, 3 ♂ N, 2 ♀ N (DC). **Lake Albina inflowing stream,** Mt Kosciusko, 85020901, 9 II 1985, 1920m, 148°16′30″ 36°26′59″, EPH 1778, 1 ♀ N. (JD). **Lake Albina,** 79042000, 20 IV 1979, 1950m, 147°16′ 36°26′, 1 ♀ N (IC). **Lake Cootapatomba inflowing stream,** Mt Kosciusko, 84012400, 24 I 1984, 2160m, 148°15′59″ 36°28′01″, EPH 1774, 1 ♂ N, 13 ♀ N (JD). **Ramshead Creek,** upstream Kosciusko Walking Track, 84012703, 27 I 1984, 1940m, 148°16′ 36°29′, EPH 1780, 1 ♀ N, (JD). **South Ramshead,** 82032500, 25 III 1982, 1950m, 148°14′ 36°31′, 1 ♂ I (RG). **Unnamed tributary,** small creek crossing track, Upper Snowy Valley, Ramshead, 85020902, 9 II 1985, 1940m, 148°16′ 36°28′, EPH 1785, 1 ♂ N (JD). **Unnamed creek,** south slope of North Ramshead, 84012702, 27 I 1984, 1940m, 148°16′ 36°28′, EPH 1787, 3 ♂ N, 2 ♀ N (JD). **VICTORIA. Albert River,** Albert River Rd, 84053100, 31 V 1984, 330m, 146°23′26″ 38°30′22″, EPH 1768, 3 ♂ N, 4 ♀ N. (DC). **Badger Creek,** downstream weir, 80011801, 18 I 1980, 280m, 145°34′ 37°41′, EPH 1726, 1 ♂ I, (reared), (JD); 80032001, 20 III 1980, same locality data, EPH 1725, 1 ♀ NS (reared), (JD). **Badger Creek,** upstream weir, Badger Weir Park, 5km SE of Healesville, 80011802, 18 I 1980, 300m, 145°34′04″ 37°41′17″, EPH 1714, 5 ♀ N (JD). **Buckland River,** Mt Buffalo Rd, 96110701, 7 XI 1996, 96110701, 280m, 146°53′32″ 36°41′52″, 1 ♀ N (KJF). **Bull Creek,** Bull Creek Rd, 96113003, 30 XI 1996, 360m, 145°35′39″ 37°28′31″, 1 ♀ NS (reared), 1 ♀ N (KJF). **Bull Creek tributary,** W of Yea Rock, 96113004, 30 XI 1996, 450m, 145°35′14″ 37°27′07″, 1 ♀ N (KJF). **Buller Ck,** Mirimbah, 81110202, 2 XI 1981, 670m, 146°24′ 37°06′, EPH 1760, 4 ♂ N, 7 ♀ N (JD). **Cement Creek,** Mount Donna Buang Rd, 670m, 76040800, 8 IV 1976, 145°42′20″ 37°42′48″, EPH 1696, 1 ♀ N, (JD), EPH 1704, 1 ♀ NSI (reared) (JD), EPH 1706, 1 ♀ NS (reared) (JD); 76042301, 23 IV 1976, same locality data, EPH 1705, 1 ♀ NSI (reared) (JD); 76120100, 1 XII 1976, same locality data, EPH 1698, 1 ♂ I (JD); 77041400, 14 IV 1977, same locality data, EPH 1695, 1 ♂ N (JD), EPH 1701, 1 ♂ S (JD), EPH 1702, 1 ♀ I, 1 ♀ S (JD); 78011200, 12 I 1978, same locality data, EPH 1699, 4 ♀ N (JD), EPH 1700, 1 ♂ I (JD); 78100600, 6 X 1978, same locality data, 1 ♂ NI (reared) (JD); 79120700, 7 XII 1979, same locality data, EPH 1697, 1 ♂ NI (JD); 80030300, 3 III 1980, same locality data, EPH 1703, 3 ♂ I, 3 ♀ I, 3 ♀ S (JD), 96092501, 25 IX 1996, same locality data, 1 ♀ NS (KJF); 98030503, 5 III 1998, same locality data, 1 ♀ N (KJF); 99012301, 23 I 1999, same locality data, 1 ♀ NSI (reared), 1 ♀ NS (KJF); 00022601, 26 II 2000, same locality data, 1 ♂ NSI (reared), 1 ♂ N (KJF). **Charity Creek tributary,** Mt Baw Baw Tourist Rd, 99021602, 16 II 1999, 1180m, 146°15′15″ 37°50′47″; 1 ♂ NSI, 1 ♀ NSI, 1 ♀ NI, 1 ♂ NS, 1 ♂ N (KJF). **Clearwater Creek,** Bogong High Plains Rd, 96111003, 10 XI 1996, 1410m, 147°21′14″ 37°57′10″, 1 ♀ N (KJF). **Clematis Creek,** Monbulk Rd, 97101501, 15 X 1997, 290m, 145°21′22″ 37°53′57″, 2 ♀ NSI (reared), 1 ♂ NS (reared) (KJF). **Coranderrk Creek,** Badger Weir Park,

97040606, 06 IV 1997, 240m, 145°34'16" 37°41'07", 2 ♂ N, 1 ♀ N (KJF). **Donnelly Creek,** Donnelly Weir Rd, 97040604, 6 IV 1997, 140m, 145°32'03" 37°37'40", 1 ♀ NS (reared), 1 ♂ N (KJF). **Errinundra River,** 1.5km upstream Combienbar Rd, 81052101, 21 V 1981, 120m, 148°55' 37°27', EPH 1750, 2 ♂ N (JD). **Falls Creek,** Telephone Box Junction, Mt Stirling Rd, 81110203, 2 XI 1981, 1220m, 146°27'43" 37°06'52", EPH 1740, 1 ♀ N (JD). **Four Mile Creek,** Horners Rd, Warburton, 97042501, 25 IV 1997, 185m, 145°41'56" 37°45'33", 1 ♀NS (reared) (KJF). **German Creek,** Bright-Tawonga Rd, 96110901, 9 XI 1996, 440m, 147°03'25" 36°43'58", 1 ♂ N (KJF). **Grace Burn** upstream weir, 78042700, 27 IV 1978, 250m, 145°35'02" 37°39'26", EPH 1721, 1 ♀ NS (reared) (JD). **Grace Burn,** Wallace Parade, Healesville, 97040601, 6 IV 1997, 110m, 145°32'18" 37°39'16", 1♂ N (KJF). **Hope Creek,** Tanjil Bren Rd, 96101204, 12 X 1996, 550m, 146°14'03" 37°51'55", 1 ♀ NS (reared), 2 ♀ N (KJF). **Icy Creek,** Tooronga Rd, 96101103, 11 X 1996, 530m, 146°00'50" 37°48'09", 2 ♀ N (KJF). **Keppel Creek,** upper site, 94091700, 17 IX 1994, 800m, 145°46' 37°27', 8 ♀ N (SP); 94101000, 10 X 1994, same locality data, 1 ♀ NS (reared) (SP); 94111900, 19 XI 1994, same locality data, 1 ♂ NS (reared) (SP); 94120501, 05 XII 1994, same locality data, 1 ♀ NS (reared) (SP); 95031300, 13 III 1995, same locality data, 1 ♂ S (SP); 95031400, 14 III 1995, same locality data, 1♂ NSI (reared), 2 ♀ NSI (reared), 1 ♂ NS (reared), 1 ♀ NS (reared) (SP); 95031500, 15 III 1995, same locality data, 1♂ NS (reared), 1♀ NS (reared), (SP); 95032100, 21 III 1995, same locality data, 1 ♀ I (SP); 95032700, 27 III 1995, same locality data, 1 ♂ NS (reared) (SP); 95033100, 31 III 1995, same locality data, 1 ♂ NSI (reared) (SP); 95041000, 10 IV 1995, same locality data, 1 ♀ NSI (reared) (SP). **King Parrot Creek,** Wallaby Creek Rd, 76081600, 16 VIII 1976: 350m, 145°14'56" 37°25'50", EPH 1710, 1 ♀ S (JD), EPH 1711, 1 ♂ I, 1 ♀ S (JD). **King Parrot Creek,** 4WD track off Whittlesea-Yea Rd, Kinglake West, 96100701, 7 X 1996, 96100701, 340m, 145°15'44" 37°25'20", 1 ♂ N (KJF). **Lake Elizabeth,** inlet stream, Otways, 88052200, 22 V 1988, 210m, 143°45'36" 38°33'13", EPH 1751, 2 ♂ N (DC). **Loch River,** Noojee, 93050200, 2 V 1993, 240m, 145°59' 37°53', 1 ♂ NSI (SP). **Martins Creek No. 2,** Bonang Rd, 0.5km S of Malinns, 99031306, 13 II 1999, 260m, 148°36' 37°25', 1 ♀ N (KJF). **Mt Baw Baw,** 75111900, 19 XI 1975, 1460m, 146°16' 37°50', 11 ♂ I (IC); 75112900, 29 XI 1975, same locality data, 2 ♂ I, 3 ♂ S, 1 ♀ S (IC). **Mt Buller,** 95032800, III 1995, 1680m, 146°25' 37°08', 3 ♂ I, 2 ♀ I, 1 ♀ S, 3 ♀ N (IC). **Myrtle Gully,** Sylvia Creek Rd, Toolangi State Forest, 96112901, 29 XI 1996, 620m, 145°31'44" 37°31'44", 1♂ N, 3 ♀ N (KJF). **North Cascade Creek,** Thomson Valley Rd, 91011300, 13 I 1991, 920m, 146°20'19" 37°48'22", EPH 1722, 1 ♀ N (JD). **O'Shannassy River,** 75111400, 14 XI 1975, 580m, 145°49' 37°36', EPH 1713, 1 ♂ N (JD); 80010401, 4 I 1980, same locality data, EPH 1759, 1 ♂ N, 1 ♀ N (JD). **Perrins Creek,** Warwick Rd, 97032406, 24 III 1997, 350m, 145°22'

37°52', 1 ♂ NSI (reared), 1 ♂ I, 1 ♀ NS (KJF). **Pretty Valley Creek,** Bogong High Plains Rd, 1.5km S of Bogong, 96110904, 9 XI 1996, 740m, 147°13'20", 36°49'10", 2 ♀ N (KJF). **Razor Creek,** Mt Stirling Rd, 89030300, 30 III 1989, 1160m, 146°27'19" 37°06'52", EPH 1754, 1 ♀ N (AN) **Rum Creek,** Thomson Valley, 85041700, 17 IV 1985, 640m, 146°22'49" 37°52'45", EPH 1758, 1 ♂ N, 5 ♀ N, (JD). **Running Creek,** Warburton- Jamieson Rd, 81103102, 31 X 1981, 750m, 145°58' 37°25', EPH 1724, 1 ♂ N, 2 ♀ N (JD). **Running Jump Creek tributary,** Mt Buffalo Rd, 96110705, 7 XI 1996, 1500m, 146°46'26" 36°46'15", 1 ♀ N (KJF). **Sassafras Creek,** Perrins Creek Rd, 97101502, 15 X 1997, 370m, 145°22'18" 37°52'46", 1 ♀ NSI (reared) (KJF). **Snobs Creek tributary,** Snobs Creek Rd, 81103103, 31 X 1981, 760m, 145°54'38" 37°21'15", EPH 1708, 1 ♀ N (JD), EPH 1709, 1 ♀ N (JD), EPH 1763, 4 ♂ N, 8 ♀ N, (JD). **Starvation Creek,** upstream weir, 77102800, 28 X 1977, 340m, 145°50'53" 37°45'39", EPH 1712, 1 ♂ S (JD). **Talbot Creek,** downstream Thomson River Reservoir, 10 VIII 1983, 700m, 147°22'20" 37°50'52", EPH 1757, 1 ♂ N, 7 ♀ N (DC); 86040900, 9 IV 1986, same locality data, EPH 1752, 3 ♂ N, 1 ♀ N (DC). **Tanjil River east branch tributary,** Mt Baw Baw Tourist Rd, 96101104, 11 X 1996, 500m, 146°11'29" 37°49'58", 1 ♂ NS (reared) (KJF). **Tarra River,** Tarra-Bulga National Park, 84010900, 9 I 1984, 340m, 146°32'13" 38°26'57", EPH 1715, 1 ♀ N (JD). **Tarra River,** 20m upstream Tarra Falls, 84120900, 9 XII 1984, 320m, 146°32'20" 38°27'17", EPH 1769, 4 ♂ N, 6 ♀ N (JD). **Tarra River,** Tarra-Bulga National Park, 99021601, 16 II 1999, 340m, 146°32'15" 38°27'00", 1 ♀ NSI (reared), 4♂ N, 2 ♀ N (KJF). **Traralgon Creek,** Guntzler Bridge, 84052900, 29 V 1984, 110m, 146°31' 38°20', 3 ♂ N, 2 ♀ N (DC).

4.3.3 *Montikola adamus* sp. nov.

Nousia sp. "AV11" (Dean 1999)

Types. Here designated. *Montikola adamus* sp. nov. **Holotype.** Frying Pan Raceline tributary, Telmark St, Falls Creek, 99020505, 5 II 1999, 1560m, 147°16'50" 36°52'00", 1 ♂ NSI (KJF). (Figs. 303-304). **Paratypes.** Frying Pan Raceline tributary, same collection data, 2 ♀ NSI, 4 ♀ N (KJF). McKay Creek tributary - waterfall, Mt McKay, Alpine National Park, 99020504, 5 II 1999, 1700m, 147°15'20" 36°52'19", 1 ♂ NSI (KJF). Tanjil River east branch headwaters, Mt Baw Baw Alpine Village, 99021603, 16 II 1999, 1440m, 146°15'45" 36°50'25", 1 ♀ NSI (KJF).

Distribution. Southern New South Wales, Eastern Victoria (Fig. 305).

Diagnosis. Male imago. Dimensions: body length 8.6-13.5 (10.8±1.96, *10*); forewing length 8.8-13.2 (10.5±1.66, *10*); hindwing length 2.05-3.30 (2.50±0.46, *10*); forewing

hindwing ratio 3.81- 4.78 (4.24±0.31, *10*). General body colour tan to brown with dark brown markings. Head dark brown. Antennae: pedicel, scape and flagellum dark brown. Ocelli: three, black with white-grey inserts, laterals larger than medial. Eyes: upper eye size large, sometimes contiguous, ES=0.00-0.09 (0.03±0.03, *10*); upper lobes orange-brown, lower lobes grey-black. Thorax: pronotum and mesonotum shiny tan brown with darker markings. Legs: femora tan brown, apices darker, tibiae and tarsi golden; total foreleg length 7.4-11.4 (9.0±1.32, *10*); forelegs with seven segments; leg length ratios 1.00: 1.39: 0.06: 0.37: 0.35: 0.28: 0.16 (2.50±0.35, *9*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 306). Wings. Forewing (Fig. 307): membrane hyaline, pterostigmal slightly opaque, longitudinal and crossveins brown, anal veins yellow; costal and subcostal crossveins present in proximal and distal halves of wing; costal space with 7-11 (*10*) crossveins proximally, 14-17 (*10*) distally (some anastomosed), subcostal space with 7-10 (*10*) crossveins proximally, 11-14 (*10*) distally. Three bullae present on veins Sc, R_2 and R_{4+5}, MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, CuA and CuP linked by crossvein, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing (Fig. 308): mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal half of costal space, 5-8 (*10*) in distal space, 5-9 (*10*) crossveins throughout subcostal space. Abdomen (Fig. 309): light to tan brown with darker brown markings, dark brown diamond shaped maculae forming central stripe on segments two to nine, flanked by golden markings anteriorly and posteriorly on each segment, segments one and ten predominantly brown. Genitalia (Figs 310-315): forceps three segmented (Figs. 310, 312, 314); tan brown, progressively lighter apically, terminal segment angular, about the same length as middle segment; penes golden brown, fused in basal half dorsally (Figs. 310, 312, 313), fused almost along entire length ventrally (Figs. 311, 314, 315), two lobes distinct, outer lateral margins relatively straight; each lobe pointing outwards: two pairs of internal spines. Caudal filaments: three, tan brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length 8.0-13.6 (11.5±1.86, *13*); forewing length 8.4-13.8 (11.8±1.91, *12*); hindwing length 1.4-3.5 (2.5±0.59, *12*); forewing hindwing ratio 3.94-6.00 (4.69±0.54, *12*). General patterning and colouring similar to male. Eyes: grey black, separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male, total leg length 5.8-9.5 (7.5±1.29, *10*); forelegs with six segments, leg length ratios 1.00: 1.36: 0.21: 0.19: 0.16: 0.14 (2.44±0.42, *11*). Wings. Forewing (Fig 316): colour and venation similar to male except wings generally

with more crossveins on average; costal space with 6-11 (*12*) crossveins proximally, 13-18 (*12*) distally, subcostal space with 5-10 (*12*) crossveins proximally, 12-17 (*12*) distally. Hindwing (Fig. 317): no crossveins proximal halves of costal space, 5-8 (*12*) in distal space, 5-9 (*12*) crossveins throughout subcostal space. Abdomen: sternum seven with genital extension, segment nine moderately cleft (Fig. 318). **Egg.** Ovoid; polar cap absent, chorion with large and small circular shaped protuberances over surface, pattern variable (Figs 319, 320). **Male and female subimago.** General colour and markings similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 321). Body lengths: ♂ 10.0-13.3 (11.7±1.25, *10*), ♀ 8.0-13.7 (11.8± 1.75, *14*). General colour tan brown with darker markings. Head: prognathous; tan brown, slightly darker posteriorly; width 1.98-2.48 (2.20±0.16, *11*). Ocelli: three; black with white inserts; laterals larger than medial. Antennae: pedicel and scape tan brown, flagellum golden; more than twice length of head. Eyes: upper lobes of male reddish brown, lower lobes black; eyes of female black. Mouthparts. Labrum and clypeus (Fig. 322): lateral margins of clypeus very slightly diverging towards anterior; lateral margins of labrum slightly wider than clypeus, rounded; anterior margin of labrum straight with no apparent antero-meɑian emargination; labrum length 0.45-0.60 (0.50±0.04, *14*), labrum width 1.00-1.25 (1.08±0.08, *14*), width length ratio 2.00-2.33 (2.16±0.09, *14*); five denticles present on anterior margin extending 0.24-0.34 (0.28±0.03, *14*) times the total width of the labrum; denticle width as proportion of labrum width 0.21-0.31 (0.26±0.03, *14*); frontal setae arranged as a broad band; secondary hair fringe clearly separated from broad band. Mandibles: outer margins slightly curved; small indentation and sparse long spine-like setae at midpoint on outer lateral margins, shorter setae along margin between midpoint and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 323): two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin, often with subapical process; prostheca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 324): spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, inconspicuously serrated on inner lateral margin, short spines on inner mesal surface; inner incisor with two apical teeth; prostheca simple, slender; prostheca tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 325): galea-lacinae slightly wider than long, width length ratio 1.00-1.22 (1.10±0.06, *10*); subapical row of 16-19 (*10*) pectinate setae; palpi three segmented, terminal palp with single spine apically; palp length ratios 1.00: 0.71: 0.67 (0.37±0.03, *11*). Hypopharynx (Fig. 326): well developed lateral processes; anterior margin of lingua deeply cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, lateral margins slightly angular. Labium (Fig. 327): glossae not

turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment with sharp spines, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface; palp length ratios 1.00: 0.81: 0.51 (0.51±0.05, 10); submentum with spines on lateral margins. Thorax: tan brown with darker brown markings; pronotum width 2.15-2.90 (2.42±0.22, 11), slightly wider than width of head (see above), head pronotum width ratio 1.03-1.17 (1.10±0.05, 11). Legs (Fig. 328): golden to tan brown, femora usually darker at apices; fore femora occasionally with white patch proximally but this is not always apparent; total foreleg length 3.80-6.03 (4.84±0.62, 12); fore femora length 1.75-2.38 (2.14±0.23, 12), fore femora width 0.63-0.90 (0.74±0.07, 12), fore femora length width ratio 2.69-3.14 (2.91±0.15, 12); fore tibiae with numerous short ventral spines, fore tarsi with 7-11 (10) ventral spines; tarsal claws (Fig. 329) with 11-14 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; leg length ratios, foreleg 1.00: 0.89: 0.37 (2.14±0.23, 12), mid leg 1.00: 0.87: 0.35 (2.23±0.27, 10), hind leg 1.00: 0.88: 0.29 (2.58±0.36, 10). Abdomen: golden brown with darker brown markings, dark brown diamond shaped maculae forming central stripe on segments two to nine flanked by tan and golden markings anteriorly and posteriorly on each segment, segment ten predominantly golden; posterolateral spines present, progressively larger apically. Gills (Fig. 330): membrane opaque, grey-black, present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill tapered to a thin point apically; main tracheal branch apparent, lateral tracheae poorly developed and visible under transmitted light only. Caudal filaments: three; golden, terminal filament longer than cerci.

Etymology. The species epithet is derived from the Latin word *adamus* (masc.) meaning diamond and refers to the diamond-shaped marks on the dorsum of both the imago and nymph abdomen.

Remarks. The nymph of this species has previously been identified as a morphospecies and referred to as *Nousia* sp. "AV11" (Dean 1999).

The genitalia of *M. adamus* is remarkably similar to that of *M. kala* with two lobes pointing outwards and two internal spines. They do appear, however, to be somewhat slimmer and with straighter lateral margins than *M. kala* although this difference is slight and not always apparent. One obvious difference from the SEM photographs is that *M. kala* has a process apically on the penes lobes which is apparently missing from *M. adamus*. However, this lobe is sometimes missing from *M. kala* specimens as well. As the indentation for the process is obvious on the *M. kala* photographs I have concluded that

the process itself may be very fragile and easily removed especially during the rigorous process of critical point drying required for electron microscopy. The indentation for the process is not apparent on the *M. adamus* genitalia and I have been unable to determine whether this is a standard feature.

Montikola adamus can be distinguished from other species in the genus by the following combinations of characters. In the imago: (i) male forewing length shorter; (ii) male forewing hindwing ratio smaller, ie hindwing larger in proportion to forewing; (iii) male foreleg lengths shorter; (iv) abdomen with dark brown diamond shaped maculae forming central stripe; (v) outer lateral margins of penis more straight. In the nymph: (i) denticles on labrum extend approximately one-third width of the labrum; (ii) total foreleg length shorter, particularly femora; (iii) fore femora 2.9 times longer than wide; (iv) abdomen with dark brown diamond shaped maculae forming central stripe; (v) gills with membrane opaque, grey-black.

Other specimens examined. NEW SOUTH WALES. Ramshead Creek, "the Cascades", Merritts Track, 84012701, 27 I 1984, EPH 1783, 1 ♂ N, 1 ♀ N (JD). **Ramshead Creek,** upstream Kosciusko Walking Track, 84012703, 27 I 1984, 1940m, 148°16' 36°29', EPH 1781, 2 ♂ N, 1 ♀ N (JD). **Unnamed tributary,** south slope of North Ramshead, 84012702, 27 I 1984, EPH 1788, 1 ♀ I (JD). **Unnamed trickle,** small trickle on Cascade Trail, 1km upstream Deadhorse Gap, 84012100, 21 I 1984, EPH 1782, 1 ♂ N, 7 ♀ N (JD). **VICTORIA. Baldy Creek,** Mt Stirling Rd, 75011700, 17 IV 1975, 1220m, 146°27' 37°06', EPH 1727, 1 ♂ N (RM). **Bluff Creek,** 11.7km up Mt Stirling Rd, 81110201, 2 XI 1981, 1310m, 146°28'38" 37°07'49", EPH 1741, 4♂ N, 10 ♀N (JD). **Bogong Jack Creek,** West Kiewa Logging Rd, 97110602, 6 XI 1997, 1070m, 147°10'12" 36°49'59", 1 ♂ N (KJF). **Brandy Creek,** Great Alpine Rd, Alpine National Park, 87010500, 5 I 1987,1560m, 147°11'22" 37°00'55", PH 1764, 1 ♂ N, 2 ♀ N (JD); 96111802, 18 XI 1996, same locality data, 1 ♂ N (KJF); 96111902, 19 XI 1996, same locality data, 1 ♀ N (KJF); 97011902, 19 I 1997, same locality data, 1 ♂ N (KJF). **Breakfast Creek,** Tamboritha Rd, Alpine National Park, 97020701, 7 II 1997, 320m, 146°36'58" 37°31'09", 1 ♂ I (KJF). **Caledonia River,** Howitts Hut, 96051400, 14 V 1996, 1480m, 147°41' 37°14', EPH 1793, 2 ♀ N (coll. unknown), EPH 1794, 2 ♀ N (coll. unknown). **Cement Creek,** Mount Donna Buang Rd, 78112300, 23 XI 1978, 670m, 145°42'20" 37 °42'48", EPH 1734, 1 ♀N (JD), EPH 1736, 1♂ N, 1♀N (JD). **Charity Creek tributary,** Mt Baw Baw Tourist Rd, 99021602, 16 II 1999, 1180m, 146°15'15" 37°50'47", 1 ♀ NSI, 1 ♀ N (KJF). **Falls Creek,** Telephone Box Junction, Mt Stirling Rd, 81110203, 2 XI 1981,1220m, 146°27'43" 37 °06'52", EPH 1737, 1 ♀N (JD), EPH 1738, 1 ♂ N (JD), EPH 1739, 8 ♂ N, 3 ♀ N (JD). **First Creek,** Warburton-Jamieson Rd,

85120700, 7 XII 1985, 750m, 145°58'10" 37°25'25", EPH 1731, 1 ♀N, (JD), EPH 1732, 2 ♂ N, 2 ♀ N (JD). **Frosty Creek,** Frosty Creek Rd, 96110803, 8 XI 1996, 1380m, 147°08'05" 37°05'55", 1 ♂ NS, 1 ♀ S, 6 ♂ N, 3 ♀ N (KJF). **Frying Pan Raceline tributary,** Telmark St, Falls Creek, 99020505, 5 II 1999, 1560m, 147°16'50" 36°52'00", 4 ♂ NSI, 3 ♀ NSI, 2 ♂ NS, 1 ♀ NS, 1 ♂ N, 6 ♀ N (KJF). **Kiewa River west branch tributary,** track between Blairs Hut and Westons Hut, Mt Hotham, 91110301, 3 XI 1991, 1320m, 147°10' 37°55', EPH 1755, 1 ♂ N, 1 ♀ N (JD). **McKay Creek,** Mt McKay-Howmans Gap Rd, 80011100, 11 I 1980, 1580m, 147°14' 36°52', EPH 1770, 3 ♂ N, 3 ♀ N (JD). **McKay Creek tributary - waterfall,** Mt McKay, Alpine National Park, 96110905, 9 XI 1996, 1700m, 147°15'20" 36°52'19", 3 ♂ N, 10 ♀ N (KJF). **Merritts Creek,** Charlottes Pass, Mt Kosciusko National Park, 96120802, 8 XII 1996, 1920m, 148°19' 36°25', 1 ♀ SI, 1 ♀ N (KJF). **Middle Creek tributary,** Alpine National Park, 96111002, 10 XI 1996, 1620m, 147°18'05" 36°54'55", 1 ♀ N (KJF). **Mt Baw Baw,** 75011400, 14 I 1975, 1460m, 146°16' 37°50', 32 ♂ I, 2 ♀ I, 1 ♂ S (IC). **Mt Buller,** 58011700, 17 I 1958, 1680m, 146°25' 37°08', EPH 1756, 1 ♂ N, 1 ♀ N (AN). **Myrtle Creek,** Mt Donna-Buang Rd, 97040603, 6 IV 1997, 780m, 145°36'42" 37°42'35", 1 ♂ N, 3 ♀ N (KJF); 00022602, 26 II 2000, same locality data, 1 ♀ NSI, 3 ♂ NS, 1 ♀ S, 4 ♀ N (KJF); 00031901, 19 III 2000, same locality data, 1 ♀ NSI, 3 ♀ NS, 1 ♂ N, 2 ♀ N (KJF). **Sawpit Creek,** Donnelly Weir Rd, 97040605, 6 IV 1997, 100m, 145°32'03" 37°38'15", 1 ♂ N (KJF). **South Buller Creek headwaters,** Mt Buller Summit, 97021501,15 II 1997, 1680m, 146°25' 36°08', 1 ♀ NS (KJF). **Tanjil River headwaters,** Mt Baw Baw Alpine Village, 96101201, 12 X 1996, 1440m, 146°15'45" 37°50'25", 2 ♂ N (KJF); 99021603, 16 II 1999, 99021603, same locality data, 1 ♂ NS, 1 ♀ NSI (KJF). **Target Creek tributary,** Heyfield-Jamieson Rd, 97020502, 5 II 1997, 20m, 146°33'57" 37°35'04", 1 ♂ S, 1 ♂ N, 4 ♀ N (KJF). **Tarra River** Tarra-Bulga National Park, 98112101, 21 XI 1998, 340m, 146°32'13" 38°26'57", 1 ♀ N (KJF). **Tarra River,** Tarra-Bulga National Park, 98112102, 21 XI 1998, 340m, 146°32'15" 38°27'00", 1 ♀ NS, 1 ♂ N (KJF). **Unnamed Creek,** NE slope of Mt Buller, 81110300, 3 XI 1981, EPH 1728, 1 ♀ N (JD). **Unnamed Icemelt,** Mt Buffalo Rd, 96110703, 7 XI 1996, 1060m, 146°48'06" 36°42'39", 1 ♂ N (KJF). **Upper Perkins Creek,** 94112100, 21 XI 1994, EPH 1748, 1 ♀N (JBa), EPH 1749, 3 ♀ N (JBa).

4.3.4 Differentiation of the species

I have considered the possibility that the these two species are conspecific due to the similarity of the genitalia. However, there are number of differences between the two species that are consistent (Table 19). In particular there are some significant differences in the length of the forewing and foreleg of the two species with *M. kala* being larger. The

forewing hindwing ratio of the *M. kala* is also larger which presents a smaller hindwing in relation to the forewing. In the nymph there are highly significant differences in the denticle width of the labrum and the denticle width in relation to the labrum width. The total foreleg length and fore femora length are also significant, again with *M. kala* possessing the longer lengths. In addition to these measurements, there are definite differences in the abdomen pattern of the imago and nymph, and in the colour of the nymphal gills. All factors combined I feel warrant the establishment of separate species.

Table 19. Comparison of the characteristics of the two species of *Montikola* showing outcomes of t-tests.

	Montikola kala	*Montikola adamus*	Sig.
Male imago			
body length	9.3-13.1 (11.1±1.25, *15*)	8.6-13.5 (10.8±1.96, *10*)	ns
forewing length	10.3-12.8 (11.8±0.80, *14*)	8.8-13.2 (10.5±1.66, *10*)	*
hindwing length	1.9-2.9 (2.52±0.36, *13*)	2.05-3.30 (2.50±0.46, *10*)	ns
forewing hindwing ratio	4.07-5.79 (4.74±0.52, *13*)	3.81- 4.78 (4.24±0.31, *10*)	*
eye size (ES)	0.00 - 0.11 (0.06±0.04, *10*)	0.00-0.09 (0.03±0.03, *10*)	ns
total length of foreleg	9.8-11.4 (10.9±0.57, *10*)	7.4-11.4 (9.0±1.32, *10*)	**
Female imago			
body length	9.6-12.6 (11.2±1.00, *15*)	8.0-13.6 (11.5±1.86, *13*)	ns
forewing length	11.3-15.6 (12.8±1.02, *14*)	8.4-13.8 (11.8±1.91, *12*)	ns
hindwing length	2.2-3.0 (2.62± 0.25, *13*)	1.4-3.5 (2.5±0.59, *12*)	ns
forewing hindwing ratio	4.27-5.61 (4.93±0.44, *13*)	3.94-6.00 (4.69±0.54, *12*)	ns
total foreleg length	7.6-9.4 (8.3±0.59, *10*)	5.8-9.5 (7.5±1.29, *10*)	ns
Nymph			
body length – male	10.0-12.5 (11.1±0.86, *10*)	10.0-13.3 (11.7±1.25, *10*)	ns
body length – female	11.5-14.9 (13.0±1.00, *16*)	8.0-13.7 (11.8± 1.75, *14*)	ns
head width	1.91-2.75 (2.28±0.21, *18*)	1.98-2.48 (2.20±0.16, *11*)	ns
labrum length	0.40-0.63 (0.51±0.07, *20*)	0.45-0.60 (0.50±0.04, *14*)	ns
labrum width	0.95-1.33 (1.11±0.12, *20*)	1.00-1.25 (1.08±0.08, *14*)	ns
labrum length width ratio	2.00-2.45 (2.20±0.15, *20*)	2.00-2.33 (2.16±0.09, *14*)	ns
denticle width	0.28-0.58 (0.40±0.07, *20*)	0.24-0.34 (0.28±0.03, *14*)	***
denticle width labrum width ratio	0.25-0.53 (0.37±0.08, *20*)	0.21-0.31 (0.26±0.03, *14*)	***
Maxillae galea lacinae width length ratio	0.85-1.17 (1.03±0.10, *10*)	1.00-1.22 (1.10±0.06, *10*)	ns
pronotum width	1.98-2.85 (2.43±0.23, *18*),	2.15-2.90 (2.42±0.22, *11*)	ns
head pronotum width ratio	1.00-1.12 (1.07±0.04, *18*)	1.03-1.17 (1.10±0.05, *11*)	ns
total foreleg length	4.96-7.33 (5.93±0.73, *15*)	3.80-6.03 (4.84±0.62, *12*)	**
foreleg femora length	2.25-3.13 (2.56±0.28, *15*)	1.75-2.38 (2.14±0.23, *12*)	***
foreleg femora width	0.63-0.90 (0.77±0.08, *15*)	0.63-0.90 (0.74±0.07, *12*)	ns
foreleg femora length width ratio	2.88-4.05 (3.32±0.30, *15*)	2.69-3.14 (2.91±0.15, *12*)	ns

4.3.5 Key to the species

Male Imagos

Abdomen with golden markings midline, lateral margins of penes more bulbous...*kala*

Abdomen with dark brown diamond shaped maculae midline, lateral margins of penes straight...*adamus*

Nymphs

Abdomen with golden markings midline, denticles extending two-fifths the total width of the labrum, gills with membrane clear...*kala*

Abdomen with dark brown diamond shaped maculae midline, denticles extending one third the total width of labrum, gills with membrane opaque, grey-black..*adamus*

4.4 Description of *Gemmayaluka* gen. nov.

4.4.1 *Gemmayaluka* gen. nov.

Type species. *Nousia (Australonousia) wiltkorringae* (Finlay)

Distribution. Southern New South Wales, Eastern Victoria (Fig. 331).

Diagnosis. Male imago. Dimensions: body length 7.0-8.9 ; forewing length 8.6-9.6; hindwing length 1.39-1.64 ; forewing hindwing ratio 5.34-6.96. General body colour golden-brown to orange-brown with darker brown markings. Head brown. Antennae: pedicel and scape light brown, flagellum golden. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, often contiguous, ES=0.00-0.09; upper lobes orange, lower lobes grey-black. Thorax: pronotum and mesonotum golden to orange or tan brown with darker brown markings. Legs: golden brown, femora apices darker; forelegs with seven segments, total foreleg length 6.90-7.77; forelegs with seven segments, tibia approximately 1.4 times the length of femur, the five segmented tarsus 1.4 times the length of femur; tarsal claws of a pair similar, each apically hooked with an opposing hook. Wings. Forewing: membrane hyaline, pterostigmal area slightly opaque, longitudinal and crossveins brown, anal veins yellow, costal and subcostal veins present

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in proximal and distal halves of wing; costal space with 6-7 crossveins proximally, 10-14 distally; subcostal space with 5-7 crossveins proximally, 9-14 distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at half to just over half the distance from wing base to margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1. CuA and CuP linked by crossvein, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by crossvein to A_1. Hindwing: mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex and midlength immediately preceding shallow concavity, costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal halves of costal space, 4-5 in distal space,4-5 throughout subcostal space. Abdomen: golden to orange brown, distinct dark brown markings forming distinctive W-shaped pattern which is more apparent on the posterior segments. forceps three segmented; yellow; terminal segment angular, slightly indented at apex; penes yellow, laterally broad with penes extending to approximately half the length of the forceps; ventral surface fused in basal third, remainder divided, divergent; dorsal surface separate, two laterally expanded lobes meeting at two-thirds length; two small triangular processes projecting from inner margin. Caudal filaments: three, tan brown; terminal filament longer than cerci. **Female imago.** Dimensions: body length 7.8-9.7; forewing length 9.8-10.9; hindwing length 1.46-1.95; forewing hindwing ratio 5.75-7.12. General patterning and colouring similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male, 5.1-6.4; forelegs with six segments; tibia approximately 1.4 times the length of femur, the four segmented tarsus approximately 0.8 times the length of femur. Wings. Forewing: colour and venation similar to male except wings with generally more crossveins on average; costal space with 6-9 crossveins proximally, 13-16 distally, subcostal space with 5-8 crossveins proximally, 11-16 distally. Hindwing: no crossveins in proximal half of costal space, 5-6 in distal space, 5-6 crossveins throughout subcostal space. Abdomen: sternum seven with relatively prominent genital extension, sternum nine shallowly cleft. **Egg.** Ovoid, polar cap absent, chorion with similarly sized evenly spaced flower shaped protuberances. **Male and female subimago.** General pattern and colouring similar to imago. Wings uniformly grey-brown, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** Body lengths ♂ 6.2-9.8, ♀ 7.9-11.4. General colour golden to orange or tan brown with light and dark markings. Head: prognathous; golden or orange brown with darker brown wash between ocelli and anterior margins of eyes; width 1.58-2.20. Ocelli: three; black with white inserts: laterals larger than medial. Antennae: pedicel, scape and flagellum golden brown; slightly longer than length of head. Eyes: upper lobes of male tan, lower lobes grey-black; eyes of female grey-black. Mouthparts. Labrum and clypeus: lateral margins of clypeus slightly diverging towards anterior; lateral margins of labrum

subequal to slightly wider than clypeus, rounded: anterior margin of labrum with slight antero-median emargination bearing small medial convex 'hump'; labrum length 0.30-0.45, labrum width 0.72-1.02, labrum width length ratio 2.05-2.46; four to five prominent triangularly shaped denticles extending 0.08-0.15 across labrum, denticle width as proportion of labrum width 0.10-0.19; frontal setae arranged as a broad band; secondary hair fringe clearly separated from broad band. Mandibles: outer margins slightly curved; sparse long setae at midpoint on outer lateral margins; shorter setae along margin between midpoint and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in inverted L-shape on lower mandible body. Left mandible: two incisors, each with three apical teeth, outer incisor inconspicuously serrated on inner lateral margin, inner incisor stout at base; prostheca robust, serrated; prosthecal tuft slender, tapering to a thin point apically, hairs on lateral margins only. Right mandible: sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, conspicuously serrated on inner lateral margin; inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae: galea-lacinae as wide as long, width length ratio 0.90-1.10; subapical row of 15-20 pectinate setae; palpi three segmented, terminal palp with single spine apically , first segment length 0.23, segments two 0.74 times length of first segment, segment three 0.65 times length of first segment, terminal segment with single spine apically. Hypopharynx: well developed lateral processes; anterior margin of lingua moderately cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium: glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, first segment length 0.36, segment two 0.81 times the length of first segment, segment three 0.61 times the length of the first segment, terminal segment with row of triangular spines almost circulating apex and stout spines on lateral margins; submentum with spines on lateral margins. Thorax: golden to orange or tan brown with darker brown markings; pronotum width 1.75-2.43 wider than head, head pronotum width ratio 1.06-1.25. Legs: golden to orange or tan brown, femora tend to be darker than tibiae or tarsi, distinct white patches present, blunt spines on inner lateral margin for about half the total length; fore femora length 1.13-1.65, fore femora width 0.50-0.73, fore femora short and squat, length width ratio 1.95-2.69; fore tarsi with 5-9 stout ventral spines; tarsal claws with 9-11 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; total foreleg length 2.51-3.50 average leg length ratios, tibiae 0.76-0.81 times length of femur, tarsi 0.32-0.36 times length of femur. Abdomen: golden to orange or tan brown with distinct dark brown markings; posterolateral spines present, progressively larger posteriorly. Gills: membrane pale, clear, sometimes slightly tinged pink or yellowish; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill large, wide and ovate, apically tapered; main and

lateral tracheae present, strongly developed. Caudal filaments: three; golden with darker colouration at segment join giving a slightly banded appearance; terminal filament longer than cerci.

Etymology. The genus name is derived from the amalgamation of the Latin *gemma* (fem.) meaning gem and the aboriginal word *yaluk* referring to a creek or a river, that is: gem of the river. The aboriginal word is derived from the language of the Wurundjeri Woiwurung; the people whose land occupies the area of the type locality.

Remarks. The genus *Gemmayaluka* can be distinguished from all other genera in the Leptophlebiidae family by the following combination of characters: In the imago: (i) male upper eye size large, often contiguous (ii) male and female forewing 5.3-7.1 times longer than hindwing; (iii) forewing crossveins present in proximal halves of wing, male with 16-21 crossveins in costal space, 14-21 in distal space, female with 19-25 in costal space, 16-24 distally; (iv) MA forked at half to just over half the distance from wing base to margin; MP_2 connected to MP_1 and CuA, ICu_1 recurved or joined to CuA and not linked to CuA-CuP crossvein; ICu_2 joins ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly recurved and linked by cross vein to A_1; (v) hindwing costa joins subcosta at four-fifths wing length; (vi) tarsal claws of a pair similar, each apically hooked with an opposing hook; (vii) abdomen golden to orange brown, (viii) laterally broad with penes extending to approximately half the length of the forceps; ventral surface fused in basal third, remainder divided, divergent; dorsal surface separate, two laterally expanded lobes meeting at two-thirds length; two small triangular processes projecting from inner margin. (ix) female eyes separated on meson of head by a distance about four times maximum width of eye; (x) female sternum seven with relatively prominent gential extension (xi) female sternum nine shallowly cleft; (xii) egg ovoid, polar cap absent, chorion with similarly sized evenly spaced flower shaped protuberances. In the nymph: (i) antennae slightly longer than length of head; (ii) lateral margins of clypeus slightly diverging towards anterior; (iii) labrum subequal to slightly wider than clypeus, 2-2.5 times wider than long; lateral margins rounded; slight antero-median emargination bearing small medial convex "hump"; five triangular denticles extending approximately one-tenth across labrum; frontal setae arranged as a broad band, secondary hair fringe clearly separated from broad band; (iv) mandibles with outer margins slightly curved; incisors with inconspicuous to conspicuous serrations on lateral margins; (v) maxillae with galea lacinae as wide as long; subapical row of 15-20 pectinate setae; terminal palp with single spine apically; (vi) hypopharynx moderately cleft; (vii) labium glossae not turned under ventrally: terminal segment elongate with row of triangular spines almost circulating apex; submentum with spines on lateral margins; (viii) pronotum moderately wider than head; (ix) legs with fore femora 2.0-2.7 times longer than wide; fore tarsi with 5-9 ventral spines; tarsal claws with

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*The new genus is erected according to the criteria outlined by Peters and Edmunds (1970) for separating genera: ie 'if two or more groups of species are separated by a distinct gap of characters evident in both adults and nymphs.' These characters are outlined in the table below.

Main characters separating the genus *Nousia* from the newly erected genus *Gemmayaluka*.

GENUS	Nousia		Gemmayaluka
SUBGENUS	Nousia (Nousia)	Nousia (Australonousia)	
Male imago			
forewing costal and subcostal crossveins	reduced or absent	reduced or absent	present
penes	fused in basal two-thirds, remainder divided	fused in basal two-thirds, remainder divided	fused in basal third ventrally, not fused dorsally
forewing – number of crossveins in costal space	usually 10-15	usually 10-15	usually 20 or more
Female imago			
sternum nine	moderately or deeply cleft	moderately or deeply cleft	shallowly cleft
egg	ovoid, polar cap absent, chorion granulate with scattered circular ridges enclosing a short cylindrical process,	ovoid, polar cap absent, chorion with large circular shaped protuberances, sometimes interspersed with smaller ones, pattern variable	ovoid, polar cap absent, chorion with similarly spaced evenly shaped flower-shaped protuberances
Mature nymph			
antennae cf length of head	1and ½ times length of head	1and ½ to more than 2	only slightly longer than length of head
anterior margin of labrum	broad, U-shaped with 5 irregular denticles	straight, slight or distinct antero-median emargination	slight antero-median emargination bearing hump
denticle width as proportion of labrum width	approx 0.50	0.10-0.51	0.10-0.19
left mandible inner incisor shape	narrow	narrow	stout
maxillae no. subapical setae	less than or equal to 15	less than or equal to 15	equal to or more than 17
gill shape	slender	slender	wide, ovate

9-11 ventral teeth, progressively larger apically, apical tooth inconspicuously serrated; (x) Abdomen colour golden to orange or tan brown with distinct dark brown markings; (xi) double, upper and lower lamellae equally developed; each gill large, wide and ovate, apically tapered; main and lateral tracheae present, strongly developed.   see opposite*

4.4.2 *Gemmayaluka wiltkorringae* (Finlay) comb. nov.

Nousia sp. "AV4" (Dean 1999)

Nousia (Australonousia) wiltkorringae Finlay (Finlay 2000)

Gemmayaluka wiltkorringae (Finlay) comb. nov.

Distribution. Southern New South Wales, Eastern Victoria (see Fig. 331).

Types. *Nousia (Australonousia) wiltkorringae* Finlay. **Holotype.** Cement Creek (Fig. 332), Mt Donna Buang Rd, outside Warburton, Victoria, 98030503, 05 III 1998, 670m, 145°42'20" 37°42'48", 1 ♂ NI (reared) (KJF). **Paratypes. Victoria. Cement Creek,** same collection data: 76120100, 1 XII 1976, EPH 1587, 1 ♂ I (JD); EPH 1588, 1♂NI (JD); EPH 1602, 1♀SI (JD), 78112300, 23 XI *978, EPH 1589, 1♀NI (reared) (JD), EPH 1590, 1 ♂ NSI (reared) (JD), EPH 1591, 1 ♂ NS (reared) (JD), EPH 1592, 1 ♀ NS (reared) (JD), EPH 1594, 1 ♀ NI (reared) (JD), EPH 1596, 1 ♀ NI (reared) (JD), EPH 1597, 1 ♀ NSI (reared) (JD), EPH 1598, 1 ♀ NS (JD), EPH 1599, 1 ♂ NS (reared), 1♀NS (reared) (JD); 80030300, 3 III 1980, EPH 1593, 1 ♀ NS (JD); 98030503, 05 III 1998, 1 ♀ SI (reared), 1 ♂ N (KJF); 98112901, 29 XI 1998, 1 ♂ NSI (KJF); 99012301, 23 I 1999, 2 ♂ N, 1 ♀ N (KJF); 99032004, 20 III 1999, 1 ♀ N (KJF). Held at the MV.

Diagnosis. Male imago. Dimensions: body length 7.0-8.9 (8.1±0.65, *10*); forewing length 8.6-9.6 (9.0±0.40, *10*); hindwing length 1.39-1.64 (1.48±0.11, *10*); forewing hindwing ratio 5.34 - 6.96 (6.23±0.61, *8*). General body colour ranging from golden-brown to orange-brown with darker-brown markings. Head brown. Antennae: pedicel and scape light brown, flagellum golden. Ocelli: three; black with white inserts; laterals larger than medial. Eyes: upper eye size large, often contiguous, ES=0.00-0.09 (0.02±0.04, *5*); upper lobes orange, lower lobes grey-black. Thorax: pronotum and mesonotum golden to orange or tan brown with darker brown markings. Legs: golden brown, femora apices darker; forelegs with seven segments, total foreleg length 6.90-7.77 (7.39±0.36, *5*); leg length ratios 1.00: 1.37: 0.10: 0.43: 0.36: 0.30: 0.16 (1.99±0.07, *5*); tarsal claws of a pair similar, each apically hooked with an opposing hook (Fig. 333). Wings. Forewing (Fig. 334): membrane hyaline, pterostigmatal region slightly opaque, longitudinal and crossveins brown, anal veins yellow; costal and subcostal crossveins present in proximal halves of wing; costal space with 6-7 (*10*) crossveins proximally, 10-

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14 (*10*) distally; subcostal space with 5-7 (*10*) crossveins proximally, 9-14 (*10*) distally. Three bullae present on veins Sc, R_2 and R_{4+5}. MA forked at just over half the distance from wing base to wing margin, MP_2 connected to MP_1 and CuA, CuA and CuP linked by crossvein, ICu_1 recurved to join CuA and not linked to CuA-CuP crossvein, ICu_2 recurved to join ICu_1, ICu_1 and ICu_2 parallel as wing margin approached, CuP strongly curved and linked by crossvein to A_1. Hindwing (Fig. 335): mostly hyaline, costal space washed with yellow and very slightly opaque; costal margin slightly convex at midlength immediately preceding shallow concavity; costa joins subcosta at approximately four-fifths wing length; no crossveins in proximal halves of costal space, 4-5 (*10*) in distal space, 4-5 (*10*) crossveins throughout subcostal space. Abdomen: golden to orange brown, distinct dark brown markings forming distinctive W-shaped pattern which is more apparent on the posterior segments (Fig. 336). Genitalia (Figs. 337-341): forceps three segmented (Figs. 340), yellow; terminal segment angular, slightly indented at apex; penes yellow, laterally broad with penes extending to approximately half the length of the forceps; dorsal surface separated at base, two laterally expanded lobes meeting at two-thirds length; two small triangular processes projecting from inner margin (Fig. 337, 339), ventral surface fused in basal third, remainder divided, divergent (Figs. 338, 340, 341). Caudal filaments: three; generally yellow; dark brown at proximal edge of each segment giving banded appearance; terminal filament longer than cerci. **Female imago**: Dimensions: body length 7.8-9.7 (8.9±0.60, *10*); forewing length 9.8-10.9 (10.3±0.30, *10*); hindwing length 1.46-1.95 (1.64±0.13, *13*); forewing hindwing ratio 5.75-7.12 (6.35±0.42, *10*). General patterning and colouring similar to male. Eyes: grey-black; separated on meson of head by a distance about four times maximum width of eye. Legs: total leg length shorter than male; forelegs with six segments, total foreleg length 5.07-6.43 (5.78±0.51, *10*); leg length ratios 1.00: 1.35: 0.24: 0.21: 0.17: 0.17 (1.85±0.11, *10*). Wings. Forewing (Fig. 342): colour and venation similar to male except with generally more crossveins on average than male; costal space with 6-9 crossveins proximally, 13-16 (*10*) distally, subcostal space with 5-8 crossveins proximally, 11-16 (*10*) distally. Hindwing (Fig. 343): no crossveins in proximal halves of costal space, 5-6 (*10*) in distal space, 5-6 (*10*) crossveins throughout subcostal space. Abdomen: sternum seven with relatively prominent genital extension, sternum nine shallowly cleft (Fig. 344). **Egg.** Ovoid; polar cap absent; chorion with similarly sized evenly spaced flower shaped protuberances (Figs. 345, 346). **Male and female subimago.** Colour and markings similar to imago. Wings uniformly greyish-yellow, opaque. Forelegs of male not elongated. Genitalia not fully developed. **Mature nymph.** (Fig. 347). Body lengths: ♂ 6.2-9.8 (8.3±0.84, *18*), ♀ 7.9-11.4 (9.5±1.21, *16*). General colour golden to orange or tan brown with light and dark markings. Head: prognathous; golden or orange brown with darker brown wash between ocelli and anterior margins of eyes; width 1.58-2.20 (1.74±0.17, *15*). Ocelli: three; black with white inserts; laterals larger than medial. Antennae: pedicel, scape and flagellum golden brown; slightly

longer than length of head. Eyes: upper lobes of male tan, lower lobes grey-black; eyes of female grey-black. Mouthparts. Labrum and clypeus (Fig. 348): lateral margins of clypeus slightly diverging to anterior; lateral margins of labrum subequal to slightly wider than clypeus, rounded; anterior margin with slight antero-median emargination bearing small medial convex 'hump'; labrum length 0.30-0.45 (0.37±0.04, 10), labrum width 0.72-1.02 (0.84±0.10, 10), labrum width length ratio 2.05-2.46 (2.29±0.15, 10); four to five prominent triangularly shaped denticles (Fig. 349) extending 0.08-0.15 (0.12±0.02, 10) across labrum, denticle width as proportion of labrum width 0.10-0.19 (0.14±0.03, 10); frontal setae arranged as a broad band; secondary hair fringe clearly separated from broad band. Mandibles: outer margins slightly curved, sparse long setae at midpoint on outer lateral margins, shorter setae along margin between midpoint and base; dark coloured nodule at midpoint on inner lateral margins; row of setae in an inverted L-shape on lower mandible body. Left mandible (Fig. 350): two incisors, each with three apical teeth; outer incisor inconspicuously serrated on inner lateral margin; inner incisor stout at base; prostheca robust, serrated; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Right mandible (Fig. 351): sparse long spine-like setae on inner lateral margin; two incisors, outer incisor with three apical teeth, conspicuously serrated on inner lateral margin, inner incisor with two apical teeth; prostheca simple, slender; prosthecal tuft slender, tapering to a point apically, hairs on lateral margins only. Maxillae (Fig. 352): galea-lacinae as wide as long, width length ratio 0.90-1.10 (1.00±0.06, 10); subapical row of 15-20 (10) pectinate setae; palpi three segmented, terminal palp with single spine apically (Fig. 353); palp length ratios 1.00: 0.74: 0.65 (0.23±0.02, 10). Hypopharynx (Fig. 354): well developed lateral processes; anterior margin of lingua moderately cleft, lined with short setae; superlingua with thick tufts of setae on anterior margins, rounded lateral margins. Labium (Fig. 355): glossae not turned under ventrally and lying in same plane as paraglossae, series of blunted spines apically; palpi three segmented, terminal segment with row of triangular spines almost circling apex and stout spines on dorsal surface (Fig. 356); palp length ratios 1.00: 0.81: 0.61 (0.36±0.05, 10); submentum with spines on lateral margins. Thorax: golden to orange or tan brown with darker brown markings; pronotum width 1.75-2.43 (2.08±0.20, 15), wider than head (see above), head pronotum width ratio 1.06-1.25 (1.20±0.06, 15). Legs (Fig. 357): golden to orange or tan brown, femora tend to be darker than tibiae or tarsi, distinct white patches present, blunt spines on inner lateral margin for about half the total length; fore femora length 1.13-1.65 (1.38±0.20, 11), fore femora width 0.50-0.73 (0.59±0.07, 11), fore femora short and squat, length width ratio 1.95-2.69 (2.34±0.21, 11); fore tarsi with 5-9 (10) stout ventral spines; tarsal claws with 9-11 (10) ventral teeth, progressively larger apically, apical tooth inconspicuously serrated (Fig. 358); total foreleg length 2.51-3.50 (2.94±0.40, 11); leg length ratios, foreleg 1.00: 0.77: 0.36 (1.38±0.20, 11) middle leg 1.00: 0.76: 0.36 (1.35±0.19, 10), hindleg 1.00: 0.81: 0.32

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(1.58±0.20, *10*). Abdomen: golden to orange or tan brown with distinct dark brown markings forming a distinctive W-shaped pattern which is which is more apparent on the posterior segments; posterolateral spines present, progressively larger posteriorly. Gills (Fig. 359): membrane pale, clear, sometimes slightly tinged pink or yellowish; present on segments one to seven, progressively smaller posteriorly; double, upper and lower lamellae equally developed; each gill large, wide and ovate, apically tapered; main and lateral tracheae present, strongly developed. Caudal filaments: three; golden with darker colouration at segment join giving a slightly banded appearance; terminal filament longer than cerci.

Etymology. The species epithet is derived from the aboriginal language of the Wurundjeri Woiwurung. The word *wilt-korring* translates as wide and refers to the shape of the gills.

Remarks. In unpublished keys it has also been referred to as "*Atalophlebioides* sp. E" (MDRFC), "*Atalonella* sp 5" (MV) and *Nousia* "sp. 4" (MRHI). More recently it has been referred in the literature as "*Nousia* AV4" (Dean 1999) based on the nymphal morphology. Following this it was published as *Nousia (Australonousia) wiltkorringae* (Finlay 2000) but has herewith been moved to its own genus.

Specimens examined. NEW SOUTH WALES. No. 1 Creek, 6km downstream Thredbo, 78121401, 14 XII 1978, 1260m, 148°23′ 36°28′, EPH 1678, 2 ♀ N (JD). **Thredbo River**, Thredbo Golf Course, 78121401, 14 XII 1978, 1380m, 148°18′ 36°30′, EPH 1655, 1 ♂ N, 2 ♀ N (JD). **VICTORIA. Acheron River,** Marysville Rd, 97120500, 5 XII 1997, 560m, 145°43′26″ 37°38′55″, 3 N, (MRHI). **Badger Creek**, upstream weir, Badger Weir Park, 5km SE of Healesville, 80011802, 18 I 1980, 300m, 145°34′04″ 37°41′17″, EPH 1605, 1 ♂ N, 1 ♀ N (JD); 80032002, 20 III 1980, same locality data, EPH 1606, 1 ♂ N, 1 ♀ N (JD). **Buller Creek,** Mirimbah, 81110202, 2 XI 1981, 670m, 146°24′ 37°06′, EPH 1761, 1 ♀ N (JD). **Charity Creek,** Mt Baw Baw Tourist Rd, 97111200, 12 XI 1997, 700m, 146°13′49″ 37°50′57″ 3 N (MRHI). **Charity Creek tributary,** Mt Baw Baw Tourist Rd, 99021602, 16 II 1999, 1180m, 146°15′15″ 37°50′47″, 3 ♂ N, 7 ♀ N (KJF). **Deep Creek,** Benambra-Corryong Rd, 11km N of Uplands, 99021501, 15 II 1999, 620m, 147°42′ 36°49′, 1 ♀ N (KJF). **Erinundra River,** Erinundra, 94111500, 15 XI 1994, 320m, 148°51′42″ 37°37′19″, 1 N (MRHI). **Eurobin Creek,** Mount Buffalo Rd, Mount Buffalo National Park, 96110702, 07 XI 1996, 440m, 146°50′29″ 36°43′10″, 1 ♂ N (KJF). **Growlers Creek,** Williams Rd camp site, Wandiligong, 96110801, 8 XI 1996, 380m, 146°59′10″ 36°45′54″, 1 ♂ N (KJF). **Kiewa River,** West Kiewa Logging Rd, 5km NE of Mt Hotham, 1180m, 147°10′44″ 36°55′46″, 1 ♀ N (KJF). **King Parrot Creek,** Whittlesea-

Yea Rd, 15km SW of Flowerdale, 98030501, 3 V 1998, 350m, 147°14'48" 37°25'50", 1 ♂ NSI (reared), 1 ♀ NI (reared), 1 ♀ N (KJF). **La Trobe River,** Big Creek Basin Rd, 5km E of Powelltown, 96101002, 10 X 1996, 320m, 145°50'10" 37°52'35", 1 ♀ NSI (reared) (KJF). **Learmonth Creek,** Yarra Junction-Neerim Rd, Powelltown, 96101001, 10 X 1996, 180m, 145°44'33" 37°51'43", 3 ♀ N (KJF). **Mountain Creek,** 7km E of Tawonga South, 90110300, 3 XI 1990, 510m, 147°14' 36°42', EPH 1723, 1 ♂ N, 2 ♀ N (DC). **Myrtle Gully,** Sylvia Creek Rd, Toolangi State Forest, 96112901, 29 XI 1996, 620m, 145°31'04" 37°31'44", 1 ♀ N (KJF). **Myrtle Creek,** Donna-Buang Rd, 00022602, 26 II 2000, 780m, 145°36'42" 37°42'35", 2 ♀ N (KJF). **O'Shannassy River,** 75111400, 14 XI 1975, 580m, 145°49' 37°36', EPH 1603, 1 ♂ N, 2 ♀ N (JD); 80010401, 4 I 1980, same locality data, EPH 1604, 1 ♂ NSI (reared) (JD); 94121502, 5 XII 94, same locality data, 2 N, (MRHI). **Rodger River,** Deddick, 90112300, 23 XI 1990, 560m, 148°46' 37°29' 1 ♀ N (MRHI). **Snowy River,** Wanton Bridge, 74031700, 17 III 1974, EPH 1647, 1♀N (coll. unknown). **Steavensons River,** Buxton-Marysville Rd, 98021504, 15 II 1998, 460m, 145°45'02" 37°28'53", 1 ♂ NSI (reared) (KJF). **Taggerty River,** Lady Talbot Drive, outside Marysville, 98101704, 17 X 1998, 400m, 145°46'28" 37°30'20", 1 ♂ N (KJF). **Thomson River,** 12km NNW of Walhalla, 77111200, 12 XI 1977, 290m, 146°24' 37°52', 1 N, (MDFRC). **West Ovens River,** Harrietville, 90111200, 12 XI 1990, 540m, 147°05' 36°51' 2 ♀ N (MRHI). **Whitelaw Creek,** Whitelaw Portal upstream weir, 77021100, 2 XI 1977, 470m, 146°16' 37°43', 1 N, (MDFRC).

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5. FACTORS CONTROLLING THE DISTRIBUTION OF *NOUSIA (AUSTRALONOUSIA) FUSCA* COMB. NOV. AND *NOUSIA (AUSTRALONOUSIA) NIGELI* SP. NOV. IN VICTORIA WITH NOTES ON *THRAULOPHLEBIA, MONTIKOLA* GEN. NOV. AND *GEMMAYALUKA* GEN. NOV.

" With ho! such bugs and goblins in my life"

William Shakespeare - Hamlet V,ii

5.1 Introduction

Mayflies have a short adult life span, are easily subject to desiccation (Edmunds 1962) and are regarded as poor fliers. As a result they have a poor dispersal ability. For example, there are few representatives on oceanic islands such as Micronesia and Polynesia (Edmunds 1962) and no native species on the Hawaiian islands (Edmunds 1972). Distribution patterns, therefore, are likely to be highly influenced by evolutionary and vicariance events in addition to current availability of suitable habitat.

There is little published information on the distribution of the species described in Chapters 3 and 4. Nor has anything been published on their habitat requirements other than an occasional note accompanying the taxonomic descriptions. Admittedly this deficiency is largely due to the poor state of taxonomic knowledge of the Australian insect fauna. This chapter attempts to address these deficiencies.

Large numbers of specimens were collected for taxonomic purposes (see Chapter 2). This, along with information from previous surveys, enabled the creation of the first broad scale distribution maps for the taxon descriptions in Chapters 3 and 4. These distribution maps accompany the species descriptions and diagnoses.

Fundamental to the study of ecology is understanding the factors affecting the distribution of organisms (Lawton 1996; Gaston and Blackburn 1999). Presence-absence prediction is one such method which has been valuable to the discipline of applied ecology (Manel et al. 2001). It has wide reaching applications to conservation biology, invasion ecology, pest species management and biogeography (Manel et al. 2001). In stream ecology, presence-absence data have been primarily and successfully used to evaluate water quality and assess stream degradation (Parsons and Norris 1996; Wright et al. 1997; Manel et al. 2001).

In general positive prediction becomes more robust with inclusion of detailed environmental data in the model (Manel et al. 1999). At medium to large spatial scales, which can include multiple sites, there is an increasing need for survey methods that can be easily employed by non-specialists, be cost effective and reduce time and effort in the field (Cullen 1990; Chessman 1995). To this end, rapid biological assessment techniques were developed and have been widely employed in stream ecology in the Northern Hemisphere (Wright et al. 1993; Plafkin et al. 1998). This has been the case more recently in Australia, with the development of the Monitoring River Health Initiative (Anonymous 1994; Davies 1994; Marchant et al. 1994; Chessman 1995). As the primary focus of this project was to collect specimens for taxonomic revision (and to try and

assess the full range of the distribution for those species), collecting from a large number of sites enabled the construction of representative distribution maps and offered the best chance of locating new species. This priority prevented very detailed habitat assessments which would have added to the biogeographical analysis. Ultimately the bioassessment variables collected were restricted to those easily and rapidly collected. Therefore the variables collected in the field were divided into three categories: (1) local land use and riparian characteristics, (2) stream abiotic conditions and (3) stream biotic conditions. In addition, topographic, spatial and climate data were added post-field.

Large scale disturbances such as land clearance, urbanisation, forestry or mining activities are often reflective of general catchment degradation. For streams and rivers this can incorporate decreases in bank stability and subsequent increases in sedimentation, decreases of bankside native vegetation (often accompanied by an increase in exotic vegetation), increases in pollution and exotic species and alterations in stream flow, all of which can affect the stream community structure (Boulton and Brock 1999). Such disturbances can be assessed by surrounding land use, including an assessment of the riparian vegetation, both on a local (Marchant et al. 1997) and catchment (Hunter and Zampatti 1994) scale.

Abiotic variables such as velocity, substrate composition and temperature have long been known to affect macroinvertebrate community structure in streams (Minshall 1988; Lampert and Sommer 1997). The components of flow regime (volume, depth and current velocity) interact to produce continual alteration to stream characteristics, such as a restructuring of the stream bed and changing the aquatic plant composition, for example (Lampert and Sommer 1997). In turn such changes lead to macroinvertebrate community restructuring due to changes in habitat requirements and increases (or decreases) in invertebrate drift (see review by Brittain and Eikeland 1988)). Depending on their intensity, high water flow events (floods) can result in small scale disturbances to the substrate or may scour the entire stream bed and alter channel morphology (Lake 1995). Macroinvertebrate recolonisation following these events has been shown to vary greatly between small and large scale disturbances (Brooks and Boulton 1991). A reduction in flow (and subsequently stream depth and width) may decrease oxygen concentrations, causing organsims to die or actively drift in search of more favourable habitat.

Substratum characteristics have been the one of the most extensively studied types of abiotic variables (Minshall 1984) and greatly affect the micro-environmental conditions experienced by the benthos. Preferences for particular substrate types may involve protection from disturbance and predation and oxygen availability. High substrate

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complexity (number and variety of crevices) and particle diversity (varying grain sizes) have been shown to sustain a higher species richness than uniform substrate (Brooks and Boulton 1991; Jowett *et al.* 1991). Further, individuals have consistently preferred to colonise pebble size particles (16 to 64mm) (Brooks and Boulton 1991), which tend to collect more fine organic matter which is the principal food source for many aquatic invertebrates including mayflies (Minshall 1984).

Water temperature cannot be discounted as one of the more important abiotic variables affecting metabolic rate, activity, feeding, growth, emergence and reproduction of freshwater fauna (Lampert and Sommer 1997; Boulton and Brock 1999) leading to changes in the abundance, distribution and diversity of such fauna (see Chapter 2) (Hynes 1970; Ward and Stanford 1982; Merritt and Cummins 1996). Temperature in lotic environments can vary depending on the volume of water present. For example small headwater streams (with small depths and widths) can be rapidly warmed by sunlight whereas larger watercourses further downstream are subject to smaller daily temperature fluctuations (Lampert and Sommer 1997).

Macroinvertebrate distribution is also dependent on the instream biological conditions. Coarse particulate organic matter (CPOM) provides useful habitat for small stream macroinvertebrates such as mayflies (Boulton and Brock 1999). Australian Leptophlebiids are predominantly collector-gatherers or scrapers using the functional-feeding terminology of Cummins and Klug (1979) feeding predominantly on detritus, periphyton and other biofilms (Edmunds and Waltz 1996) and are therefore likely to be greatly influenced by the amount of CPOM.

An assessment of the periphytic and filamentous algae in the field can help determine the amount of photosynthetic production in a stream. Low light levels in heavily shaded upland streams can limit the abundance of plants. Further, the coarse rocky substrate of these environments provides few holdfasts for emergent vegetation (Boulton and Brock 1999). High plant biomass can provide habitat for benthos and emerging invertebrates and can also reduce velocity. However, high productivity can lead to eutrophication and can cause bacterial or algal blooms (Boulton and Brock 1999).

Topographical and spatial data, derived from maps, were used to supplement the information already gathered from each site. It is recognised that altitude, distance from stream source and slope (or steepness) can be considered surrogate terms for other variables such as temperature, substrate, flow regime and oxygen availability that directly affect the fauna (Hynes 1970).

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Finally, climate data were obtained from BIOCLIM, a bioclimatic predictive computer program (Houlder *et al.* 2000). BIOCLIM approximates energy and water balances for a given location derived from bioclimatic parameters such as mean, minimum and maximum monthly values for temperature, precipitation, solar radiation and evaporation. The monthly mean estimates summarise annual and seasonal mean conditions which ultimately may prove to have biological significance (Nix 1986).

5.2 Aims

1. To document the habitat preferences of the Victorian species of *Nousia (Australonousia), Thraulophlebia, Montikola* and *Gemmayaluka*.
2. To identify some of the factors that may determine the geographical distributions of these species
3. To discover the extent to which distribution is predictable from site characteristics.

5.3 Methods

5.3.1 Study sites

For biogeographic purposes it was decided to limit the study area to Victoria and southern New South Wales as collections made in other places did not constitute large enough sample sizes for analysis. Three seasons of data only were used from the summer field work collecting periods: 96-97 (season 1), 97-98 (season 2) and 98-99 (season 3). The fourth season (summer 99-00) was not included in the analysis because this comprised very few sites. Within the main study area (Victoria) the aim was to attempt to sample the majority of the Australian Water Resources Council (AWRC) drainage divisions (Fig. 360) (Anonymous 1989) in order to obtain a good coverage of the state. Within each division multiple sites were searched where conditions for the target mayflies might be suitable. A smaller number of sites which did not immediately appear highly suitable (because of high turbidity, slow flow, uniform muddy or silty substrate) were also searched in order to better define the habitat requirements. However, these sites were limited in number because they were unlikely to contribute to the taxonomic work and time in the field was limited.

Some potentially interesting areas, such as the Wongungarra River, in the north of the Mitchell Basin (24), were deliberately excluded due to difficulty of access. The effort required to reach such places was considered to be excessive for the extra information that would have been obtained. Drainage divisions such as the Mallee (14) and the Millicent Coast (39) were excluded due to the lack of water in these areas. These are areas of low elevation (height above sea level less than 130m) and low rainfall (average

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annual rainfall less than 400mm, mean annual runoff 25mm or less) with very few, if any, permanent streams (Anonymous 1989). Yet other sites such as the Avoca (8) and the Wimmera-Avon (15) were investigated but were predominantly dry at the time of sampling. Accessible, although still poorly studied, sites were considered preferable to maximise the geographic range of taxa able to be collected in the time available.

The total number of sites where environmental data were collected was 267 (Fig. 361). A small proportion of these sites (34) were collected from more than once. The environmental data for these sites were combined so that the site was only represented once in the final analysis. The large number of sites visited ensured a good coverage of the study area, increased the chance of discovering any new species and allowed for documenting distributions in relation to environmental conditions. For each of the 267 sites mayfly nymphs from the family Leptophlebiidae were collected with an emphasis on the taxa of interest. The collection process was an attempt to find all relevant taxa, not to estimate relative abundance of different taxa. Therefore the data obtained are presence/absence at species level.

5.3.2 Site characteristics

At each of the site locations rapid biological assessment techniques were employed to determine site characteristics.

Initially the area surrounding the stream was assessed and the following characteristics determined. As there is evidence that benthic invertebrate communities are more influenced by local conditions rather than regional ones (Corkum 1990; Richards et al. 1993) local land use was considered more biologically appropriate to the presence of a particular species presence rather than the larger scale catchment land use categories of Hunter and Zampatti (1994) where only a determination of the major activity of the catchment (eg: 'agriculture', 'forestry' or 'redevelopment') is recorded. Therefore local land use was determined using a method previously employed by Marchant et al. (1997) where the riparian zone and adjacent land use was placed in one of the four following categories with category one representing the most disturbance and category four representing the least disturbance:
1.   Agriculture, urban development, grass, no native vegetation
2.   Agriculture, native vegetation, introduced plant species, no urban development
3.   Native vegetation, introduced plant species, no agriculture or urban development
4.   Native vegetation, no introduced plant species, no agriculture or urban development.

Riparian vegetation was assessed by two factors. Shade caused by riparian vegetation over the river was assessed as a percentage to the nearest 10% taken at midday, although these estimates were later placed in the following five categories due to concern over the accuracy of field data:

1. $\leq 5\%$
2. 6-25%
3. 26-50%
4. 51-75%
5. 76%

Dominant vegetation type of the riparian zone was recorded using the following categories:

1. grasses, ferns, sedges, rushes etc.
2. shrubs, vines
3. trees (< 10m)
4. trees (>10m)

No attempt was made to distinguish between native and exotic vegetation as this was, in part, assessed by the local land use categories.

Instream physical condition of the stream (ie: abiotic variables) were also assessed. Water temperature was taken as a spot measurement at the time of sampling using a celsius thermometer. It is recognised that a spot temperature is not considered a sufficient record of the temperature regime of the stream, however it did give some information on summer daytime temperature and may be associated with the presence or absence of a particular species. Stream width was estimated in metres at the sampling point from water's edge to water's edge. Stream depth was measured in the field using a metre ruler and recording the mean of five points. Stream velocity was assessed subjectively by characterising the flow into one of the categories below:

1. no flow or very small flow
2. slow flow
3. moderate flow
4. high flow

Sediments in the area immediately surrounding the sample site and 10m upstream and downstream were classified by eye in the field. The substratum composition was estimated in the field using apparent abundance of particle sizes. Traditionally, substratum particles are grouped in millimetre size classes according to the Wentworth scale (Cummins 1962) each class being given a descriptive term such as boulder, cobble or gravel, sand, silt or clay. Grade scales for particle size can be extremely

comprehensive (Brakensiek *et al.* 1979; Gordon *et al.* 1992; Boulton and Brock 1999) yet for the purposes of this study that level of accuracy was not feasible and a reduced scale was considered sufficient. Each size class is assigned a phi (ϕ) value which equates to the negative logarithm (base 2) of the mean particle diameter in mm, resulting in a whole number. This tactic is used as a method of eliminating cumbersome numbers when dealing with the smaller size classes. The following size classes used in this analysis with the accompanying ϕ scale were:

1. Bedrock: $\phi = -9.5$
2. Boulder: 256 – 2048mm, $\phi = -9.0$
3. Cobble: 64-256mm, $\phi = -6.5$
4. Pebble: 16-64mm, $\phi = -4.5$
5. Gravel: 2-16mm, $\phi = -2.0$
6. Sand: 0.06-2mm , $\phi = 2.0$
7. Silt: 0.004-0.06mm, $\phi = 6.5$
8. Clay < 0.004mm, $\phi = 9.5$

The percentage of the total area estimated as covered by each of the particle size categories was recorded and multiplied by the ϕ value for each particle size category. The sum of these values was then divided by 100 to give a mean ϕ value for each site. A higher value of mean ϕ corresponds to an increased representation of fine substrata. Using the same data as above, substrate heterogeneity was measured as the number of particle size categories that covered $\geq$ 10% of the sample area. The possible values for this variable therefore ranged between one and eight.

Coarse particulate organic matter (CPOM), defined as woody and non-woody material larger than 1mm in size (Cummins 1974), was estimated by eye at the time of sampling. The percentage of CPOM in a 20m stretch of stream was categorised into three levels:

1. < 5%
2. between 5–20%
3. 20%

Fine particulate organic matter or FPOM (ie: particle size between 50µm and 1mm) (Cummins and Klug 1979) is considered the dominant food source for Leptophlebiids in the Northern Hemisphere (Edmunds and Waltz 1996; Merritt and Cummins 1996). However, there are indications that this classification does not readily apply to Australian aquatic invertebrates, many of which appear to be generalist and opportunistic feeders (Lake 1995). Therefore CPOM may also provide a valid food source for mayflies as well as a valuable habitat.

Algal (periphytic and filamentous) and macrophyte cover in the same 20m stretch were determined by eye and percentage of area covered noted according to the following categories.

1. < 10%
2. 10-35%
3. 36-65%
4. 66-90%
5. > 90%

The remaining site attributes were determined from maps. Altitude was determined in metres to the nearest 10 to 20m depending on the map scale used (1: 25,000 maps or 1:50,000 respectively). Stream gradient or slope was determined from 1:25,000 maps. The horizontal distance in metres between one contour interval upstream and downstream of the site was determined, then the gradient was calculated as a percentage. For very steep slopes several contour intervals had to be used. Distance from source was measured on 1:100,000 maps to the nearest half km with the use of an opisometer. The source was considered as the highest branch from the original sampling point. Streams marked as intermittent or semi-permanent were considered to be flowing. The highest point of an inlet stream of a regulated waterbody was considered to be the source of the outlet stream. Table 20 summarises the characteristics recorded for each site.

Table 20. Summary table of site characteristics. For var. (variable) type CAT=categorical, CONT= continuous.

Variable name	Var. type	Unit of measurement and precision	Method of determination
1. local land use	CAT	descriptions of surrounding land use and vegetation type in four categories	determined by eye in field
2. shade	CAT	percentage ranges in five categories	determined by eye in field
3. dominant vegetation type	CAT	percentage ranges for four vegetation classes	determined by eye in field
4. water temperature	CONT	°C to nearest 0.5°C	spot temperature, liquid thermometer
5. stream width	CONT	metres to nearest half metre	estimated by eye in field
6. stream depth	CONT	centimetres to nearest 15cm	mean of five metre ruler depths taken around sampling site.
7. flow	CAT	flow estimate in four categories	estimated in field
8. substrate phi	CONT	estimates of each substrate class as a percentage of 20m stretch of stream bed; each size class converted to ϕ	mean ϕ of all substrate classes.
9. substrate heterogeneity	CAT	whole numbers, eight possible categories	number of particle size categories accounting for $\geq$ 10% of the total sample area.
10. coarse particulate organic matter	CAT	percentage in three classes	percentage cover of 20m stretch determined by eye in field.
11. algae	CAT	percentage cover in five classes	percentage cover of 20m stretch determined by eye in field.
12. macrophytes	CAT	percentage cover in five classes	percentage cover of 20 m stretch determined by eye in field.
13. altitude	CONT	nearest 10 or 20m	1: 25,000 / 1: 50,000 maps
14. slope	CONT	percentage to 2 decimal places	1: 25,000 maps, horizontal distance in metres of one or more contour interval(s) upstream and downstream of site; expressed as a percentage
15. distance from source	CONT	km	1: 100,000 maps, measured using opisometer

For each collection site, determined by longitude and latitude, nineteen climate variables were obtained from the BIOCLIM program. These were:

1. annual mean temperature (°C)
2. mean diurnal range (monthly maxmin)
3. isothermality (mean diurnal range / mean seasonal range)
4. temperature seasonality (co-efficient of variation)
5. maximum temperature of warmest period
6. minimum temperature of coldest period
7. temperature annual range
8. mean temperature of wettest quarter
9. mean temperature of driest quarter
10. mean temperature of warmest quarter
11. mean temperature of coldest quarter
12. annual mean precipitation
13. precipitation of wettest period
14. precipitation of driest period
15. precipitation seasonality (co-efficient of variation)
16. precipitation of wettest quarter
17. precipitation of driest quarter
18. precipitation of warmest quarter
19. precipitation of coldest quarter

5.3.3 Statistical analysis

5.3.3.1 Logistic regression

Logistic regression was used to identify the factors or combination of factors most strongly associated with the presence or absence of each taxon. However, this strategy could only be used for *Nousia (Australonousia) fusca* and *Nousia (Australonousia) nigeli* as the other species occurred at too few sites (19/267 or less). Summaries of the characteristics of sites where each species was present are provided in Appendix 4, with the exception of species that were found at fewer than 10 sites. This allows some assessment of the type of sites at which each of the less common species were found.

Logistic regression is useful when describing a relationship between a number of factors (independent variables) and a dichotomous dependent variable with the values of 0 or 1. The logit (or log of the odds) function calculates the probability of being present or absent in one group divided by the probability of being present or absent in another and can determine the combined effect of several variables on the outcome (Hosmer and

Lemeshow 1989; Kleinbaum 1994; Tabachnick and Fidell 1996). The technique is very flexible as it can analyse a group of independent variables which can include continuous, discrete, dichotomous or a mix. It does not require that the independent variables be normally distributed, linearly related or of equal variance. Further, there is no requirement for assumptions relating to the distribution of the independent variables to be tested, although transformation may improve the power of the analysis and is recommended (Tabachnick and Fidell 1996). Although this technique has rarely been used in the field of freshwater ecology (Peeters and Gardeniers 1998) recent comparisons of presence-absence data analyses using discriminant analysis, artificial neural networks and logistic regression on aquatic invertebrates in Himalayan streams concluded that logistic regression was best suited for this sort of work (Manel *et al.* 2001).

Using Systat version 7.0 (Systat 1997) simple logistic regression was used to determine which individual variables, considered singly, best predicted the presence of each species. Multiple logistic regression was then used to determine which site characteristics were significant predictors for the presence of the species.

5.3.3.2 Preliminary screening methods

5.3.3.2.1 Normality of distributions for continuous variables

Box plots were used for all continuous variables to identify distribution patterns. Following this, all pairs of continuous variables were plotted against each other to check for complex non-linear relationships. All continuous variables were transformed as required to approximate a normal distribution. Box-plots of these independent variables revealed that no transformation was necessary for the following BIOCLIM variables: mean diurnal range (monthly maxmin) (MDR), temperature seasonality (TS) , temperature annual range (TAR), maximum temperature of the warmest period (MAXTWARM) and mean temperature of the wettest quarter (MTWET). The following transformations were used to normalise the distribution of the remaining continuous variables, abbreviated names of transformed variables in parentheses:

- Log_e transformation for altitude (LGALT), water temperature (LGTEMP), stream width (LGWIDTH), stream depth (LGDEPTH), precipitation of the wettest period (LGPWETP), precipitation of the driest period (LGPDRYP), precipitation seasonality (LGPSEAS) and precipitation of the wettest quarter (LGPWETQ), precipitation of the driest quarter (LGPDRYQ), precipitation of the warmest quarter (LGPWARMQ), precipitation of the coldest quarter (LGPCOLDQ). For slope (LGSLOPE) and

distance from source (LGDFS) a constant of 1 was added before transformation to cope with zero values.

- Square root transformations for substrate phi (PHISQR), isothermality (ISOSQR) and minimum temperature of the coldest period (MTCOLDSQR). A constant of 8 was added to substrate phi and 2 to the minimum temperature of the coldest period to eliminate negative values before transforming.

- The remaining variables were reflected, a strategy applied for correcting negative skewness. Reflection involves creating a constant by adding one to the largest score and subtracting each score from the constant to produce a new variable. Normal transformation procedure is then applied. All the reflected variables (above) were then subject to a $\log_e$ transformation: annual mean temperature (LREFAMT), mean temperature of the driest quarter (LREFMTDRY), mean temperature of the warmest quarter (LREFMTWARM) and mean temperature of the coldest quarter (LREFMTCOLD)

5.3.3.2.2   Review of discrete variables

Each of the discrete variables were analysed to assess the number of cases in each category. If less than 10% of the cases were present in any category this category was merged with the closest one. Four out of the eight categorical variables had such problems. Too few cases in a category can lead to large parameter estimates and standard errors in the analysis. Tabachnick and Fidell (1996) recommend that categories be collapsed to accommodate larger values at each level or, if this is not possible, the variable be removed from the analysis. Each of the offending variables (shade, substrate heterogeneity, algae and macrophytes) were able to have categories merged so each of the remaining level contained at least 10% of the total values. New categories of each variable are listed below.

The percentage of shade covering the river was reduced from the original five categories to four as there were too few individuals in the ≤ 5% categories. The new categories were as follows:
1.   0-25%
2.   26-50%
3.   51-75%
4.   76-100%

With substrate heterogeneity, the total number of categories possible was eight. In the current data set the maximum number of categories recorded was six, and this had to be

subsequently reduced to four in order that each category was adequately represented. Categories for this variable were then as follows:

1. ≤ 2
2. 3
3. 4
4. ≥ 5

The percentage of algae and macrophytes in a 20m length of stream was originally divided into five categories. However, there were so few levels containing very high percentages of either algal or macrophyte cover at the collecting locations that both categories were reduced to three:

1. 10%
2. 11-35%
3. 36%

To maintain the power of goodness-of-fit tests that compare observed with expected frequencies in cells formed by combinations of discrete variables Tabachnick and Fidell (1996) suggest that all expected frequencies should be greater than one and no more than 20% should be less than five. This was assessed for every pair-wise combination of discrete variables including the two dependent variables; presence of *N.(A) fusca* and *N. (A) nigeli.*

For the 28 combinations of discrete independent variables only two pairs had more than 20% of cells with predicted frequencies less than five (4/16 in both cases). No predicted frequencies less than one were observed in any combination of variables. Over the total 367 individual predicted frequencies only 25 (6.8%) were less than five. In view of these results, no further collapsing of categories was considered necessary. For the two pairs where more than 20% of expected frequencies were less than five (landuse*substrate heterogeneity and landuse*flow) it was decided to accept possibly reduced power of goodness-of-fit tests without making any further adjustment.

For combinations of independent discrete variables with the presence-absence data for each species, only one predicted frequency less than five was found and none less than one was found. Expected frequencies were now considered adequate for all subsequent analyses.

Names for discrete variables shown in statistical output are as follows: landuse (LANDUSE), dominant riparian vegetation (DOMRIP), shade (SHADE), substrate

heterogeneity (SUBHET), flow (FLOW), CPOM (CPOM), algae (ALGAE) and macrophytes (MACROP).

5.3.3.2.3   Collinearities

Once transformed, all continuous variables were checked for multicollinearities using the Pearson's product-moment correlation co-efficient. At this stage, some variables which were found to be highly correlated with each other were dropped from the analysis. Collinearity between the discrete variables was assessed using chi-squared analysis.

Multicollinearity between the eight discrete variables against the continuous ones was assessed by analysis of variance testing the null hypothesis that the continuous variables are consistent across each level of the discrete variables.

5.4 Results

5.4.1 Collinearities

5.4.1.1   Continuous variables

High correlations amongst these variables may result in errors in estimation of the output and can introduce high standard errors for each estimate. Statistical problems created by multicollinearity only occur at very high correlation of ± 0.9 or more (Tabachnick and Fidell 1996) although correlations above ± 0.7 may introduce redundancy in the variables.

Scatter plots of the continuous variables indicated relationships between slope and distance from source, slope and width and slope and water temperature. Temperature plotted against width and depth also revealed reasonably strong relationships. None of the correlations between the above variables exceeded 0.7, although a Pearson correlation co-efficient was calculated at –0.699 for slope versus distance from source indicating that these two variables must be carefully considered.

The remaining correlations occurred only between the BIOCLIM climatic variables. In many ways this is not unexpected as many of the climatic variables record similar information. Outputs from the Pearson correlation co-efficient revealed many correlations at or above ±0.7 (Table 21), all involving the BIOCLIM variables. A strategy for dealing with high correlations, especially those between ± 0.7 to ± 0 .9, is to omit one of the variables (Tabachnick and Fidell 1996). Annual mean temperature, for example, may be considered less biologically significant than the variables with which it correlated (mean

temperature of the warmest and coldest quarter) as conditions in a particular season are more likely to affect a mayfly than an overall average figure. Accordingly, the following variables were excluded: mean diurnal temperature range, temperature annual range, maximum temperature of the warmest period, minimum temperature of the coldest period, annual mean precipitation and precipitation of the driest quarter.

Continuous variables retained for analysis, therefore, were all the instream characteristics (water temperature, stream width and depth and substrate phi), all the topographic and spatial data (altitude, slope, distance from source) and the remaining nine BIOCLIM variables.

Table 21. Pearson product-moment correlation co-efficients for highly correlated (≥ ± 0.7) pairs of transformed continuous variables.

Transformed variables	Pearson correlation co-efficient
Annual mean temperature vs mean temperature of the warmest quarter	0.769
Annual mean temperature vs mean temperature of the coldest quarter	0.736
Mean diurnal range vs temperature seasonality	0.850
Mean diurnal range vs maximum temperature of the warmest quarter	0.880
Mean diurnal range vs temperature annual range	0.968
Temperature seasonality vs maximum temperature of the warmest period	0.811
Temperature seasonality vs minimum temperature of the coldest quarter	0.698
Temperature seasonality vs temperature annual range	0.953
Maximum temperature of the warmest period vs temperature annual range	0.885
Maximum temperature of the warmest period vs mean temperature of the warmest quarter	-0.874
Minimum temperature of the coldest period vs mean temperature of the coldest quarter	-0.846
Mean temperature of the driest quarter vs mean temperature of the warmest quarter	0.728
Annual mean precipitation vs precipitation of the wettest period	0.958
Annual mean precipitation vs precipitation of the driest quarter	0.811
Annual mean precipitation vs precipitation of the wettest quarter	0.955
Annual mean precipitation vs precipitation of the driest quarter	0.838
Annual mean precipitation vs precipitation of the warmest quarter	0.799
Precipitation of the wettest period vs precipitation of the wettest quarter	0.995
Precipitation of the wettest period vs precipitation of the coldest quarter	0.975
Precipitation of the driest period vs precipitation of the warmest quarter	0.985
Precipitation of the driest period quarter vs precipitation of the driest quarter	0.988
Precipitation of the wettest quarter vs precipitation of the coldest quarter	0.980
Precipitation of the driest quarter vs precipitation of the warmest quarter	0.989

5.4.1.2 Discrete variables

Chi-square analysis between each discrete variable against each other discrete variable revealed a high degree of collinearity (Table 22). Despite the high incidence of multicollinearity in these variables, decisions of whether to exclude some from the analysis were postponed until the predictive power of each variable had been separately assessed.

Table 22. Chi-squared p-values determining collinearities between discrete variables.

	DOMRIP	SHADE	SUBHET	FLOW	CPOM	ALGAE	MACROP
LANDUSE	0.000	0.000	0.403†	0.000†	0.123	0.000	0.000
DOMRIP		0.000	0.035	0.007	0.000	0.001	0.162
SHADE			0.077	0.837	0.000	0.012	0.627
SUBHET				0.738	0.630	0.865	0.383
FLOW					0.309	0.000	0.000
CPOM						0.003	0.000
ALGAE							0.000

† suspect due to low predicted frequencies in some category combinations.

5.4.1.3 Continuous and discrete variables combined

Analysis of variance (ANOVA) showed some strong relationships between the continuous and discrete variables (Table 23). There were a number of significant relationships between the categorical variables and the continuous ones especially altitude, temperature, slope, distance from source and stream width and depth. However, the R^2 values were all very low (< 0.150) and on that basis it was considered unnecessary to delete any correlated variables at this stage.

Table 23. ANOVA output testing multicollinearity between continuous and discrete variables.

	LANDUSE			DOMRIP			SHADE			SUBHET		
	F	P	R_2	F	P	R_2	F	P	R_2	F	P	R_2
LGALT	13.957	0.000	0.134	5.960	0.001	0.062	0.463	0.708	0.005	0.815	0.487	0.009
LGTEMP	10.564	0.000	0.105	2.349	0.073	0.026	4.703	0.003	0.050	1.169	0.322	0.013
LGSLOPE	12.215	0.000	0.120	2.092	0.102	0.023	13.015	0.000	0.126	5.286	0.001	0.055
LGDFS	6.634	0.000	0.069	3.140	0.026	0.034	9.968	0.000	0.100	3.272	0.022	0.035
LGWIDTH	0.785	0.503	0.009	6.597	0.000	0.069	4.623	0.004	0.050	1.512	0.212	0.017
LGDEPTH	4.816	0.003	0.051	0.695	0.556	0.008	3.498	0.016	0.037	0.763	0.515	0.008
LREFMTWARM	2.453	0.064	0.027	2.157	0.093	0.023	1.751	0.157	0.019	0.567	0.637	0.006
LREFMTCOLD	1.810	0.146	0.020	2.785	0.041	0.030	0.131	0.942	0.001	0.498	0.684	0.006
LREFMTDRY	3.564	0.015	0.038	1.372	0.252	0.015	0.914	0.435	0.010	1.787	0.150	0.019
MTWET	0.360	0.782	0.004	2.247	0.083	0.024	0.252	0.860	0.003	0.177	0.912	0.002
TS	0.454	0.715	0.005	0.998	0.394	0.011	0.566	0.638	0.006	0.335	0.800	0.004
ISOSQR	1.518	0.210	0.017	1.098	0.350	0.012	0.339	0.797	0.004	0.396	0.756	0.004
LGPDRYP	2.794	0.041	0.030	2.767	0.042	0.030	0.415	0.742	0.005	0.756	0.520	0.008
LGPWETP	1.584	0.194	0.017	2.721	0.045	0.029	0.395	0.756	0.004	0.136	0.938	0.002
LGPSEAS	2.472	0.062	0.027	0.347	0.792	0.004	1.323	0.267	0.014	0.554	0.646	0.006

Table 23 cont'd.

	FLOW			CPOM			ALGAE			MACROP		
	F	P	R_2	F	P	R_2	F	P	R_2	F	P	R_2
LGALT	1.560	0.199	0.017	0.278	0.758	0.002	17.947	**0.000**	0.117	22.018	**0.000**	0.140
LGTEMP	11.980	**0.000**	0.118	3.156	**0.044**	0.023	9.795	**0.000**	0.068	5.950	**0.003**	0.042
LGSLOPE	1.600	0.190	0.017	7.863	**0.000**	0.055	8.037	**0.000**	0.056	3.389	**0.035**	0.024
LGDFS	1.352	0.258	0.015	11.990	**0.000**	0.081	0.082	0.921	0.001	0.200	0.819	0.001
LGWIDTH	8.550	**0.000**	0.088	4.381	**0.013**	0.032	7.231	**0.001**	0.051	1.784	0.170	0.013
LGDEPTH	5.026	**0.002**	0.053	7.801	**0.001**	0.054	1.114	0.330	0.008	2.131	0.121	0.015
LREFMTWARM	0.689	0.560	0.008	0.112	0.895	0.001	0.530	0.589	0.004	0.024	0.976	0.000
LREFMTCOLD	0.155	0.926	0.002	0.835	0.435	0.006	0.564	0.570	0.004	0.290	0.748	0.002
LREFMTDRY	0.161	0.923	0.002	0.615	0.541	0.005	1.787	0.150	0.019	0.054	0.947	0.000
MTWET	1.389	0.246	0.015	3.524	**0.031**	0.025	0.177	0.912	0.002	0.244	0.784	0.002
TS	0.096	0.962	0.001	1.198	0.303	0.009	0.200	0.819	0.001	0.212	0.809	0.002
ISOSQR	1.115	0.343	0.012	1.180	0.309	0.009	0.396	0.756	0.004	0.355	0.701	0.003
LGPDRYP	0.702	0.552	0.008	0.627	0.535	0.005	0.756	0.520	0.008	0.517	0.597	0.004
LGPWETP	0.788	0.501	0.009	1.259	0.286	0.009	0.136	0.938	0.002	0.185	0.832	0.001
LGPSEAS	1.105	0.348	0.012	2.263	0.106	0.016	0.554	0.646	0.006	0.327	0.722	0.002

5.4.2 Simple logistic regression

5.4.2.1 *Nousia (Australonousia) fusca*

All the variables retained following screening were tested in simple logistic regression models to assess whether they were related to the presence or absence of the species without taking into account the other independent variables (Table 24). For *N. (A) fusca*, only two of the sixteen continuous variables (temperature seasonality and mean temperature of the coldest quarter) proved to be significant. For both the direction of the effect is negative. Therefore, for temperature seasonality the higher the co-efficient of variation the less chance of finding the species (Fig. 362). This reflects the variation between the warmest and coldest portions of the year and shows that the presence of the animal is associated with a small difference between the summer and winter temperatures. For the mean temperature of the coldest quarter, the direction of the effect is positive so that the greater the mean temperature of the coldest quarter the more chance of finding the species (Fig. 363) suggesting the animal's propensity for winter temperatures that are not too cold. However, there must be caution in interpreting these results as air temperatures do not always correlate closely with water temperatures.

With regard to the eight discrete variables landuse, dominant riparian vegetation, substrate heterogeneity and CPOM all proved significant (Table 24). Significances of individual comparisons of each category with the reference (highest) category are shown in Table 25. For landuse (Fig. 364), the proportion of sites where the species was found was greatest in category three (second least disturbance). There were significant effects between landuse categories one relative to four and three relative to four. Landuse category one (most disturbance) is significantly negative relative to category four so that the probability of finding the species decreases with more disturbance. However, landuse category three relative to category four is slightly positive so there is a slightly greater chance of finding the species with a small degree of disturbance compared to none. Similarly, dominant riparian vegetation (Fig. 365) is significant when comparing category three (trees < 10m) to category four (trees > 10m) which translates to a greater chance of finding the animal when the tree size is relatively small. For substrate heterogeneity (Fig. 366) categories one ($\leq$ 2 substrate size classes) and three (4 substrata size classes) were also significant relative to category four ($\geq$ 5 substrate size classes). The probability of finding the species when the number of classes is $\leq$ 2 is reduced compared to $\geq$ 5 while the probability of species presence when the number of classes is 4 is greater compared to $\geq$ 5.

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CPOM (Fig.367) was significant overall (Table 24) showing that the species was more likely to be found at the highest percentage category (> 20%). However, none of the individual comparisons between the highest category and the others were significant (Table 25).

The final discrete variable to show significance was flow (Fig. 368). In this case the variable was not significant overall, however category one (no or very small flow) shows a significant negative effect relative to flow category four (high flow) so that the chance of finding the species decreases as the flow decreases (Table 25). However, the proportion of sites where the species was found when the flow was category one (no or very small flow) was still approximately 30%; evidently the species occurs in a wide range of flows as assessed by this technique.

Also of note is the extremely high odds ratio (195.185) for isothermality for this species (Table 24). This occurs because isothermality varies only between 0.3 and 0.5 (ie: when transformed 0.55-0.71) and thus a theoretical change of 1 unit in this variable has an extreme influence on the probability.

5.4.2.2   *Nousia (Australonousia) nigeli*

For this species the continuous variables altitude, water temperature, slope and distance from source are significant (Table 24). The higher the altitude, the lower the water temperature, the steeper the slope and the greater the distance from source the greater the probability of finding the species (Figs. 369-372).

Among the discrete variables shade, flow, CPOM, algae and macrophytes also proved to be significant (Table 24) although few individual comparisons were significant (Table 25). Exceptions include flow category one (no or very small flow) relative to flow category four (high flow) where low flow indicates a reduced probability of finding the species (Fig. 373). Algae and macrophytes also proved to be highly significant for category one (≤ 10% cover) relative to category three (≥ 36% cover). In both cases the direction of the effect was positive indicating a greater success rate for finding the species if the algal and macrophyte percentage cover was low (Figs. 374, 375).

Shade and CPOM were significant overall (Table 24) although none of the individual comparisons between the highest and other categories were significant (Table 25). For shade, the proportion of sites with *N.(A) nigeli* present was greatest in categories with high percentages of shade (ie: category three 51-75% and category four 76-100%, Fig.

376) indicating a preference for shady streams. Similarly, the animal was found in a higher proportion of sites with the highest percentage of CPOM (category three, >20%, Fig. 377).

As with *N. (A) fusca*, an extremely high odds ratio for isothermality (475.681) was calculated for this species in the simple regression model (Table 24).

Table 24. Simple logistic regression analysis for the presence of *Nousia (Australonousia) fusca* and *Nousia (Australonousia) nigeli*. The odds ratio indicates the probability of the species being present at a site relative to it being absent.

Variables	Nousia (Australonousia) fusca			Nousia (Australonousia) nigeli		
	Estimate	Odds ratio	p-value	Estimate	Odds ratio	p-value
LGALT	-0.062	0.940	0.595	0.398	1.489	0.013
LGTEMP	0.036	1.037	0.927	-1.528	0.217	0.002
LGSLOPE	0.062	1.064	0.643	0.396	1.486	0.014
LGDFS	-0.133	0.876	0.241	-0.293	0.746	0.041
LGWIDTH	-0.044	0.957	0.746	0.085	1.088	0.620
LGDEPTH	-0.101	0.904	0.511	-0.222	0.801	0.246
PHISQR	-0.128	0.879	0.558	0.021	1.022	0.938
TS	-1.253	0.286	0.043	-0.171	0.843	0.824
LREFMTWARM	-0.237	0.789	0.435	-0.001	0.999	0.998
LREFMTCOLD	-0.480	0.619	0.042	0.067	1.069	0.819
LREFMTDRY	0.125	1.133	0.635	-0.182	0.834	0.582
MTWET	0.073	1.076	0.056	0.030	1.031	0.524
LGPWETP	-0.646	0.524	0.065	0.272	1.313	0.529
LGPDRYP	-0.574	0.563	0.163	0.407	1.502	0.435
ISOSQR	5.274	195.185	0.204	6.165	475.681	0.259
LGPSEAS	-0.320	0.726	0.338	0.006	1.006	0.989
LANDUSE			0.005			0.187
DOMRIP			0.039			0.056
SHADE			0.820			0.043
SUBHET		see Table 25	0.009		see Table 25	0.868
FLOW			0.081			0.000
CPOM			0.042			0.031
ALGAE			0.245			0.000
MACROP			0.159			0.002

Table 25. Simple logistic regression analysis for the presence of *Nousia (Australonousia) fusca* and *Nousia (Australonousia) nigeli* showing discrete variables category by category.

Variables	Nousia (Australonousia) fusca			Nousia (Australonousia) nigeli		
	Estimate	Odds ratio	p-value	Estimate	Odds ratio	p-value
landuse category 1 relative to category 4	-1.304	0.271	**0.006**	-1.273	0.280	0.103
landuse category 2 relative to category 4	0.317	1.371	0.255	0.278	1.321	0.478
landuse category 3 relative to category 4	0.865	2.375	**0.004**	0.531	1.700	0.193
dominant riparian category 1 relative to category 4	-0.409	0.664	0.086	-0.431	0.650	0.172
dominant riparian category 2 relative to category 4	0.088	1.092	0.696	-0.431	0.650	0.172
dominant riparian category 3 relative to category 4	0.507	1.660	**0.010**	0.161	1.175	0.510
shade category 1 relative to category 4	-0.169	0.845	0.416	-0.496	0.609	0.077
shade category 2 relative to category 4	-0.071	0.931	0.733	-0.426	0.653	0.130
shade category 3 relative to category 4	0.090	1.094	0.680	0.388	1.474	0.126
substrate heterogeneity category 1 relative to category 4	-0.926	0.396	**0.017**	-0.015	0.985	0.970
substrate heterogeneity category 2 relative to category 4	0.113	1.120	0.605	0.101	1.106	0.700
substrate heterogeneity category 3 relative to category 4	0.664	1.942	**0.003**	0.194	1.214	0.476
flow category 1 relative to category 4	-0.545	0.580	**0.044**	-1.431	0.239	**0.011**
flow category 2 relative to category 4	0.465	1.591	0.053	-0.555	0.574	0.174
flow category 3 relative to category 4	0.186	1.204	0.335	0.475	1.607	0.092
CPOM category 1 relative to category 3	-0.166	0.847	0.332	-0.296	0.744	0.182
CPOM category 2 relative to category 3	-0.306	0.736	0.103	-0.293	0.746	0.226
algae category 1 relative to category 3	0.094	1.099	0.586	1.021	2.776	**0.000**
algae category 2 relative to category 3	0.280	1.323	0.164	-0.343	0.709	0.330
macrophyte category 1 relative to category 3	0.353	1.423	0.060	0.908	2.479	**0.003**
macrophyte category 2 relative to category 3	-0.012	0.988	0.956	-0.206	0.813	0.572

5.4.3 Multiple logistic regression

All discrete variables were retained because many of them had significant individual predictive power for one or other of the species (Table 24) and it was considered preferable to retain all eight at the risk of introducing redundancy into the final model, rather than exclude such potentially important predictors.

Further screening of continuous variables was necessary due to the large number of variables and the need to obtain an acceptable ratio of cases to variables for the final analysis. This was accomplished by complete, stepwise forward and stepwise backward regression runs. These were run with the following settings: convergence (the largest relative change in any coordinate before iterations terminate) =1 x 10^{-6}; tolerance (entry of a variable that is highly correlated with the independent variables already included in the model) = 1 x 10^{-12}, probability to enter (enters a variable into the model if its alpha value is less than the specified value) =0.15; probability to remove (removes a variable from the model if its alpha value is greater than the specified value) = 0.15. The entry and removal values are those suggested by (Hosmer and Lemeshow 1989) to ensure entry of variables with coefficients greater than zero. Maximum number of steps was set at 20 although this was never reached.

As a result of the regression runs, it was concluded that the variables to be retained for the final stepwise logistic regression analysis for *N. (A) fusca* were: distance from source, subphi, temperature seasonality, mean temperatures of the warmest, driest and wettest quarters. For *N. (A) nigeli* the variables retained were altitude, water temperature, slope, distance from source, width, subphi, temperature seasonality, mean temperature of the coldest quarter and isothermality.

While distance from source remained a potentially good predictor the other non-BIOCLIM variables (water temperature, width, depth, slope, altitude) showed questionable predictive power. However, these were considered such fundamental variables that interactions between them were tested before deciding whether to remove them from the final analysis. The test was assessed by running multiple logistic regressions for both species for each of the fifteen possible interactions, each of which included two continuous variables plus the interaction term (Table 26).

For both species there was a high number of significant interaction terms. In order to avoid excluding potentially useful interaction terms by applying a strict p=0.05 cut-off, it was decided arbitrarily that all interaction terms with a p-value < 0.075 would be included. For *N. (A) fusca* these interactions were identified as altitude*water temperature,

Table 26. Multiple logistic regression analysis for *Nousia (Australonousia) fusca* and *Nousia (Australonousia) nigeli*; interactions between non-BIOCLIM continuous variables. McF Rho^2 (McFaddens Rho^2) is a measure of strength of association between the outcome and predictors.

interaction	Nousia (Australonousia) fusca				Nousia (Australonousia) nigeli			
	p-value	Odds ratio	Chi^2 p-value	McF Rho^2	p-value	Odds ratio	Chi^2 p-value	McFRho^2
altitude	0.001	0.020	0.007	0.034	0.070	0.068	0.002	0.059
water temperature.	0.001	0.000			0.025	0.000		
altitude*water temperature.	0.001	4.480			0.051	3.256		
altitude	0.009	1.888	0.001	0.047	0.108	1.662	0.023	0.037
slope	0.000	46.83			0.262	3.676		
altitude*slope	0.000	0.542			0.376	0.850		
altitude	0.000	0.164	0.000	0.077	0.325	0.651	0.012	0.043
distance from source	0.000	0.010			0.051	0.093		
altitude*DFS	0.000	2.102			0.066	1.435		
altitude	0.073	0.714	0.252	0.011	0.140	1.441	0.059	0.029
stream width	0.061	0.209			0.799	0.750		
altitude*stream width	0.068	1.290			0.672	1.080		
altitude	0.082	1.654	0.083	0.019	0.271	1.059	0.089	0.025
stream depth	0.019	0.081			0.836	0.760		
altitude*stream depth	0.024	1.515			0.909	1.026		
water temperature	0.022	0.194	0.012	0.031	0.490	0.438	0.007	0.047
slope	0.004	0.032			0.039	0.148		
water temp.*slope	0.003	4.253			0.368	1.573		
water temperature	0.001	26.88	0.002	0.043	0.754	1.406	0.004	0.052
distance from source	0.002	25.60			0.091	7.417		
water temp*DFS	0.001	0.253			0.073	0.415		
water temperature	0.845	1.096	0.986	0.000	0.005	0.162	0.014	0.041
stream width	0.919	1.097			0.719	0.675		
water temp.*stream width	0.877	0.946			0.602	1.271		

Table 26 cont'd.

interaction	Nousia (Australonousia) fusca				Nousia (Australonousia) nigeli			
	p-value	Odds ratio	Chi^2 p-value	McF Rho^2	p-value	Odds ratio	Chi^2 p-value	McFRho^2
water temperature	0.132	0.240	0.301	0.010	0.250	0.249	**0.019**	0.039
stream depth	0.096	10.72			0.877	0.766		
water temperature*stream depth	0.081	0.378			0.943	1.050		
slope	**0.003**	0.397	**0.000**	0.051	0.491	0.790	**0.007**	0.048
distance from source	**0.002**	0.500			0.081	0.605		
slope*DFS	**0.000**	1.765			**0.018**	1.490		
slope	0.652	0.928	0.323	0.010	0.088	1.446	**0.013**	0.042
stream width	0.169	0.746			0.986	1.005		
slope*stream width	0.083	1.263			0.179	1.257		
slope	**0.046**	1.887	0.149	0.015	**0.039**	2.155	0.055	0.029
stream depth	0.051	0.598			0.265	0.680		
slope*stream depth	**0.038**	1.424			0.241	1.254		
distance from source	0.935	0.987	0.287	0.011	0.047	0.626	0.057	0.029
stream width	0.168	1.474			0.258	1.424		
DFS*stream width	0.138	0.861			0.935	1.011		
distance from source	**0.047**	0.614	0.191	0.013	0.232	0.691	0.219	0.017
stream depth	0.140	1.719			0.864	1.075		
DFS*stream depth	0.078	0.782			0.710	0.938		
stream width	0.759	1.070	0.515	0.006	0.672	0.736	0.407	0.011
stream depth	0.271	0.736			0.265	1.162		
stream width*stream depth	0.189	0.825			0.771	0.950		

altitude*slope, altitude*distance from source, altitude*width, altitude*depth, water temperature*slope, water temperature*distance from source, slope*distance from source and slope*depth. For *N. (A) nigeli*, the important interactions were determined as altitude*water temperature, altitude*distance from source, water temperature*distance from source and slope*distance from source. These results indicate that the interactions might have high predictive power and should remain in the final analysis. The Systat manual (Systat 1997) recommends that individual variables constituting such interactions should also remain in the final analysis.

As a result of this screening, 29 variables were retained for the final stepwise logistic regression analysis for *N. (A) fusca*, 21 continuous and eight discrete: substrate phi, distance from source, temperature seasonality, mean temperatures of the warmest, driest and wettest quarters, altitude*water temperature, altitude*slope, altitude*distance from source, altitude*width, altitude*depth, water temperature*slope, water temperature*distance from source, slope*distance from source, slope*depth, water temperature, altitude, distance from source, stream width, stream depth, slope, landuse, dominant riparian vegetation, shade, substrate heterogeneity, flow, CPOM, algae and macrophytes.

For *N. (A) nigeli*, 21 variables were selected for inclusion in the final stepwise logistic regression, 13 continuous and eight discrete: substrate phi, mean temperature of the coldest quarter, isothermality, altitude*water temperature, altitude*distance from source, water temperature*distance from source, slope*distance from source, altitude, water temperature, slope, distance from source, stream width, temperature seasonality, landuse, dominant riparian vegetation, shade, substrate heterogeneity, flow, CPOM, algae and macrophytes.

These variables were included in final stepwise forward and backward logistic regressions using the settings listed earlier. These were run using the Systat command editor to force the individual variables involved in interaction terms into the model. Although the screening process had already substantially reduced the number of variables it was considered that with 29 and 21 variables retained the ratios of cases to variables were still excessively low. Therefore, stepwise analyses to refine the models further were considered appropriate. For *N. (A) fusca*, both the forward and backward processes produced the same model (Table 27). For *N. (A) nigeli*, the stepwise backward model aborted after six steps, so the forward regression was considered the final model (Table 28).

Table 27. Multiple logistic regression model for *Nousia (Australonousia) fusca.*

Log Likelihood: -146.761

	Parameter	Estimate	S.E.	t-ratio	p-value
1	CONSTANT	28.741	9.268	3.101	0.002
2	LGALT	-4.116	1.475	-2.790	0.005
3	LGDFS	-4.628	1.255	-3.688	0.000
4	LGSLOPE	-0.340	0.242	-1.40⁵	0.160
5	LGTEMP	-5.551	3.621	-1.533	0.125
6	LGWIDTH	0.074	0.204	0.364	0.716
7	LGDEPTH	-0.219	0.217	-1.007	0.314
8	MACROP_1	0.843	0.261	3.226	0.001
9	MACROP_2	-0.225	0.256	-0.881	0.379
10	LANDUSE_1	-0.981	0.557	-1.762	0.078
11	LANDUSE_2	0.439	0.319	1.377	0.168
12	LANDUSE_3	0.571	0.354	1.612	0.107
13	SUBHET_1	-1.069	0.449	-2.378	0.017
14	SUBHET_2	0.150	0.249	0.601	0.548
15	SUBHET_3	0.755	0.261	2.890	0.004
16	TS	-1.340	0.734	-1.826	0.068
17	LREFMTWARM	-0.723	0.371	-1.950	0.051
18	LGTEMP*LGALT	0.877	0.596	1.470	0.142
19	LGDFS*LGALT	0.700	0.208	3.359	0.001

			95.0 % bounds	
	Parameter	Odds Ratio	Upper	Lower
2	LGALT	0.016	0.294	0.001
3	LGDFS	0.010	0.114	0.001
4	LGSLOPE	0.712	1.144	0.443
5	LGTEMP	0.004	4.695	0.000
6	LGWIDTH	1.077	1.608	0.722
7	LGDEPTH	0.804	1.230	0.525
8	MACROP_1	2.323	3.878	1.392
9	MACROP_2	0.798	1.318	0.483
10	LANDUSE_1	0.375	1.116	0.126
11	LANDUSE_2	1.552	2.899	0.830
12	LANDUSE_3	1.769	3.541	0.884
13	SUBHET_1	0.344	0.829	0.142
14	SUBHET_2	1.161	1.893	0.713
15	SUBHET_3	2.127	3.550	1.275
16	TS	0.262	1.104	0.062
17	LREFMTWARM	0.485	1.004	0.235
18	LGTEMP*LGALT	2.403	7.736	0.747
19	LGDFS*LGALT	2.013	3.027	1.338

Log Likelihood of constants only model = LL(0) =   -179.365
2*[LL(N)-LL(0)] =   65.207 with 18 df Chi-sq p-value = 0.000
McFadden's Rho-Squared =   0.182

Table 28. Multiple logistic regression model for *Nousia (Australonousia) nigeli.*

Log Likelihood: -96.295

	Parameter	Estimate	S.E.	t-ratio	p-value
1	CONSTANT	-3.566	3.052	-1.168	0.243
2	LGALT	0.131	0.243	0.539	0.590
3	LGSLOPE	-0.379	0.420	-0.901	0.368
4	LGDFS	-0.434	0.383	-1.132	0.257
5	LGTEMP	-0.755	0.774	-0.976	0.329
6	FLOW_1	-1.244	0.660	-1.887	0.059
7	FLOW_2	-0.707	0.461	-1.535	0.125
8	FLOW_3	0.365	0.318	1.151	0.250
9	PHISQR	1.339	0.463	2.893	**0.004**
10	LGDFS*LGSLOPE	0.319	0.215	1.480	0.139
11	ALGAE_1	1.126	0.390	2.886	**0.004**
12	ALGAE_2	-0.503	0.407	-1.236	0.216
13	SHADE_1	0.006	0.387	0.015	0.988
14	SHADE_2	-0.805	0.342	-2.350	**0.019**
15	SHADE_3	0.335	0.307	1.090	0.276
16	CPOM_1	-0.456	0.311	-1.466	0.143
17	CPOM_2	-0.191	0.290	-0.659	0.510

			95.0 % bounds	
	Parameter	Odds Ratio	Upper	Lower
2	LGALT	1.140	1.837	0.708
3	LGSLOPE	0.685	1.561	0.300
4	LGDFS	0.648	1.373	0.306
5	LGTEMP	0.470	2.142	0.103
6	FLOW_1	0.288	1.049	0.079
7	FLOW_2	0.493	1.216	0.200
8	FLOW_3	1.441	2.686	0.773
9	PHISQR	3.814	9.445	1.540
10	LGDFS*LGSLOPE	1.375	2.098	0.902
11	ALGAE_1	3.082	6.620	1.435
12	ALGAE_2	0.604	1.343	0.272
13	SHADE_1	1.006	2.149	0.471
14	SHADE_2	0.447	0.875	0.229
15	SHADE_3	1.398	2.552	0.765
16	CPOM_1	0.634	1.166	0.344
17	CPOM_2	0.826	1.457	0.468

Log Likelihood of constants only model = LL(0) =   -128.757
2*[LL(N)-LL(0)] =   64.923 with 16 df Chi-sq p-value = **0.000**
McFadden's Rho-Squared =   **0.252**

5.4.3.1 *Nousia (Australonousia) fusca*

For *N. (A) fusca*, significant continuous variables from the final multiple logistic regression (Table 27) model included altitude and distance from source. The lower the altitude the greater the chance of finding the species, and as distance from source increases the probability of finding *N. (A) fusca* decreases. This appears contradictory and is evidently related to the significant interaction between these two variables . From examination of the 3D plot of calculated probabilities from a model containing both terms and their interaction (Fig. 378), it is clear that the predicted probability of presence of the species increases with altitude to approximately 500m then decreases as the altitude increases further. In conjunction with this, the predicted probability of finding the species also increases with distance from source up to approximately 9km and then decreases with greater distance from the source.

The only other continuous variable of note is the mean temperature of the warmest quarter which is almost significant (p-value = 0.051). The higher the temperature of the warmest quarter the higher the probability of finding the species.

Of the discrete variables only macrophytes and substrate heterogeneity were significant. Macrophyte category one relative to category three reveals that the lower the percentage of macrophyte cover the greater the chance of finding the species. Both substrate heterogeneity categories one and three are significant relative to four but in different directions. If substrate heterogeneity is ≤ 2 the chances of finding the species are reduced relative to ≥ 5. However, if substrate heterogeneity is 4 the probability of finding the species is increased compared to ≥ 5.

5.4.3.2 *Nousia (Australonousia) nigeli*

The multiple logistic regression model for *N. (A) nigeli* (Table 28) shows far fewer significant variables than for *N. (A) fusca*. Subphi is the only significant continuous variable, showing that a high ϕ value (ie: greater number of smaller sized particles) corresponds to a greater chance of finding the species. Of the categorical variables, only two showed significant comparisons. Shade category two (26-50%) is negative relative to category four (76-100%) so that the probability of finding the species increases as the percentage of shade slightly increases. Algae category one (≤ 10%) is positive relative to category three (11-35%) indicating that the lower the percentage of algae the greater the chance of finding the species.

5.4.4 Model performance evaluation

For the simple logistic regression each of the variables in the final model can be considered to predict preferred habitat for each species when considered individually. However, McFadden's Rho^2 (a measure of strength of association between the outcome and the predictors) is quite low for *all* the predictor variables (< 0.07, see Table 24). According to Tabachnick and Fidell (1996) McFadden's Rho^2 is only considered "very satisfactory" between the values of 0.20 and 0.40. The low values for both *N. (A) fusca* and *N. (A) nigeli* indicate that the predictive power of the significant variables is relatively low when considered individually.

Multiple logistic regression model performance was assessed by alternative measures recommended by Fielding and Bell (1997 and Systat (1997) and Manel *et al.* (2001) for comparison. Values were obtained or calculated from the model prediction success output and the deciles of risk output from Systat. Measures used, with an explanation of how they were derived, and an overall percentage or ratio figure are shown in Table 29.

Model performance appears to vary greatly depending on which measure is used. Overall prediction success is often used by ecologists and shows that the models obtained very successfully place sites into presence or absence categories (70.4% for *N. (A) fusca* and 83.9% for *N. (A) nigeli*). A criticism of this measure, however, is that it does not take into account chance success in correctly predicting cases (Manel *et al.* (2001).

The sensitivity calculation (percent of true positive correctly predicted) shows a 55% success in correctly predicting the presence of *N. (A) fusca* and a 32% success in predicting the presence of *N. (A) nigeli*. The Systat default method of calculating sensitivity, assigning outcomes partially to each class according to predicted probability, produces very similar figures (53% and 39% respectively). Specificity (percent of true negatives correctly predicted) shows a extremely high success for both species (*N. (A) fusca* 81%, *N. (A) nigeli* 96%); somewhat higher than the Systat specificity of 69% and 86% respectively. Sensitivity tends to be more correctly predicted when there is a high prevalence and specificity more correctly predicted when a prevalence is low (Manel *et al.* (2001). This explains why the predictions for specificity for both species are better than sensitivity as there is a higher proportion of negative cases for each species (eg 161/267 for *N. (A) fusca* and 217/267 for *N. (A) nigeli*). For *N. (A) nigeli*, in particular, as the prevalence is so low the prediction success for absence is extremely high (96%).

Table 29. Assessment of multiple logistic regression model performance for *Nousia (Australonousia) fusca* and *Nousia (Australonousia) nigeli* using alternative measures.

Model performance measure	Definition	Formulae†	N. (A) fusca %	N. (A) fusca value	N. (A) nigeli %	N. (A) nigeli value
Overall prediction success	% of all cases correctly predicted	a+d/n	70.41		83.90	
Sensitivity	% of true positives correctly predicted	a/(a+c)	54.72		32.00	
Systat sensitivity	% of true positives correctly predicted, but outcomes assigned partially to each class according to predicted probability	a/(a+c)	52.80		38.70	
Specificity	% of true negatives correctly predicted	d/(b+d)	80.75		95.85	
Systat specificity	% of true positives correctly predicted but outcomes assigned partially to each class according to predicted probability	d(b+d)	68.90		85.90	
Odds ratio	ratio of correctly assigned cases to incorrectly assigned cases	(a*d)/(c*b)		5.07		10.87
McFadden's Rho^2	strength of association between outcome and predictors	-		0.182		0.252
Cohen's kappa (κ)	proportion of specific agreement	[(a+d)-(((a+c)(a+b)+(b+d)(c+d))/n] / [n-(((a+c)(a+b)+(b+d)(c+d)/n]		0.365		0.345

† (a) correctly predicted positive occurrences, (b) falsely predicted positive occurrences, (c) falsely predicted negative occurrences and (d) correctly predicted negative occurrences, (*n*) overall number of cases

An alternative assessment of model success is the odds ratio which is the ratio of correctly assigned cases to incorrectly assigned cases. However, Manel et al. (2001) also found the effects of prevalence to be highly significant, evident here in the high odds ratio for N. (A) nigeli.

Multiple logistic regression output also gives an overall McFadden's Rho^2. McFadden's Rho^2 for N. (A) nigeli is 0.252 (Table 28) which is considered "very satisfactory" (ie: between 0.20 and 0.40, Tabachnick and Fidell 1996). The prediction success for N. (A) fusca is somewhat less than satisfactory at 0.182 (Table 27).

Manel et al. (2001) suggest as an alternative measure of model performance Cohen's kappa (κ), or proportion of specific agreement, which is easily calculable and provides a more accurate measurement of prediction success by accounting for falsely predicted positive and negative occurrences. Further, Cohen's kappa is considered largely insensitive to prevalence. Alternative interpretations of the value of kappa have been made by various authors. Landis and Koch (1977) suggested < 0.4 indicates poor agreement, while > 0.4 indicates good agreement but expanded this to encompass more categories where values of 0.0-0.4 were considered as slight to fair model performance, 0.4-0.6 moderate, 0.6-0.8 substantial and 0.8-1.0 almost perfect (Landis and Koch 1977; Manel et al. 2001). Comparison of simulated vegetation maps with field derived maps led Monserud and Leemans (1992) to propose the following comprehensive scale for kappa values: 0.00-0.05 = no agreement, 0.05-0.20 very poor, 0.20-0.40 poor, 0.40-0.55 moderate, 0.55-0.70 good, 0.70-0.85 very good, 0.85-0.99 excellent, 0.99-1.00 perfect. Accordingly, the final multiple model for N.(A) fusca has 'slight to fair' prediction success according to Landis and Koch (1977) and 'very poor' according to Monserud and Leemans (1992). N.(A) nigeli prediction success is also 'slight to fair' Landis and Koch (1977) or simply 'poor' Monserud and Leemans (1992).

If we accept kappa as the more accurate assessment of model performance, it is clear that the predictive power of both models could be substantially improved. One obvious possible reason for poor model performance is that the species were overlooked at sites where they were actually present. In this respect it is unfortunate that collecting was done over three relatively dry summers in Victoria (Beaureau of Meterology 2002) so a number of potentially interesting sites were dry or running at very low flow. A greater number of visits to each individual site would obviously have been an advantage.

Other possible improvements that may be considered are the inclusion of more environmental variables such as pH, oxygen, conductivity, flow variability, turbidity, nutrient concentrations. For example (Marchant et al. 1994) found changes in

macroinvertebrate communities in Victorian streams were closely associated with altitude (and correlated variables such as water temperature and dissolved oxygen), substratum and conductivity.

Spot water temperature measurements spread over several long collecting seasons probably failed to adequately represent the thermal regime of the streams. Continuous temperature recording at such a large number of sites was impractical. The relatively strong response of *N. (A) nigeli* to the spot water temperature measurements suggests that better temperature data may well have had high predictive value.

5.5 Discussion

5.5.1 *Nousia (Australonousia) fusca*

The simple logistic regression model reveals a number of variables which individually help predict the distribution of the species. The temperature preferences for small differences between warmest and coldest portions of the year and winter temperatures that are not too cold may relate to the optimal thermal regime hypothesis (Sweeney and Vannote 1978). Although the species may still be present outside the optimal thermal regime, it may have reduced abundance at such sites, diminishing the likelihood of it being found.

Several other instream variables (CPOM, flow and substrate heterogeneity) were shown to have an effect on the distribution of the species. *N. (A) fusca* prefers high CPOM, relatively high flows and a high diversity of substrate classes, which is typical of an upland stream environment.

It is easy to interpret a reduced number of substrate size classes as unfavourable habitat since this would reduce the complexity of the environment that the majority of benthos prefer (Jowett and Richardson 1990; Brooks and Boulton 1991; Marchant *et al.* 1994). However, a preference for four substrate size classes as opposed to five or more than five is more difficult to interpret. Perhaps a high number of size classes introduces the extremes of the ϕ scale into the equation (bedrock, silt or clay) which might indicate either a headwater stream or lowland reach. In either case, food availability may be reduced along with the fine organic matter that accumulates between the abundant crevices of pebble-sized particles (Minshall 1984; Brooks and Boulton 1991). Predator avoidance may also be more difficult for mayflies in an environment with a reduced number of crevices.

Undisturbed surrounding landuse and the height of dominant bankside vegetation does not directly affect the species. They can however have an effect on the stream through processes such as erosion, which in turn can alter the hydrological regime of the stream and also substrate composition and dissolved oxygen concentration. Surprisingly, the species prefers the bankside vegetation to be dominated by small (< 10m) rather than larger > 10m) trees. It is conceivable that introduced plant species may indeed make up a large part of the small trees (< 10m) of the riparian zone as native eucalypts tend to be the dominant riparian trees over 10 metres in height for a large part of Victoria at least (Conn 1993). However, this pattern may also reflect the sampling strategy where easy access to the stream was preferable to more isolated areas. Vehicle access and the accompanying disturbance is likely to promote the introduction of weeds and exotic plants.

Each of the variables in the final model can be considered to have predictive power for the probability of finding the species when considered individually. In the multiple logistic regression model, however, the predictive power may increase or decrease depending on the influence of the other variables. In fact, only one variable (substrate heterogeneity) was significant both singly and in the multiple regression model for *N. (A) fusca*.

It appears that altitude, distance from source and the interaction term are some of the more useful variables for predicting the presence of the species. Conditions at altitudes above 500m and closer than 9km from the source appear to be progressively less suitable. This may be related to changes in instream conditions from high altitude streams with high proportions of bedrock/boulders and little CPOM to a more mixed substrate with higher CPOM. For example, substrate heterogeneity increases with distance from source within the first 9km (Fig. 379) then generally decreases with distance from source from this point (Fig. 380). Also, CPOM increases with decreasing altitude until 500m (Fig. 381) then, if anything, the trend is reversed (Fig.382).

In fact, the interpretation that the animal prefers to be at high altitudes and close to the source only until a certain point also appears consistent with the effects of temperature variables in the simple logistic regression models, probably due to the close relationship between altitude and temperature (Minshall 1988; Power *et al.* 1988). Preference for little variation between the winter and summer temperatures and for winter temperatures that are not extremely cold indicates that the very highest altitudes would be unsuitable for the species. Unsuitability of lower altitudes may relate to excessive summer water temperature and perhaps associated deoxygenation.

5.5.2 Nousia (Australonousia) nigeli

The simple logistic regression models for *N. (A) nigeli* reveal a greater number of significant variables than for *N. (A) fusca*. Each significant variable, whether directly impacting on the stream biota (low water temperature, high flow, low percentages of algae and macrophytes and high percentages of shade and CPOM) or indirectly impacting (high altitude, small distance from source and steeper slopes) taken together are all indicative of an upland stream, notwithstanding the limitations of the RCC in Australia (Vannote *et al.* 1980). However, high levels of CPOM in the stream are predominantly the result of litter drop from bankside vegetation and can be directly associated with high levels of shade. The species preference for high CPOM probably precludes arid and alpine zones where riparian shading is sparse (Boulton and Brock 1999) therefore a wooded upland stream is indicated. In fact Fig. 367 does show that CPOM is reduced at higher altitude sites.

The importance of all the above variables is not reflected in highly significant effects in the multiple logistic regression model for *N. (A) nigeli*. Only three variables in the final model are significant with only shade and algae common between the simple and multiple models. The high percentages of shade and low percentages of algae shown to predict the probability of finding the species strengthen the findings of the simple regression model.

The only other variable that was significant was substrate phi, where the presence of smaller sized particles increased the probability that the species was present. The mean ϕ value for sites where the species was present was –2.1 which corresponds to gravel sized particles (2-16mm). This is somewhat finer than the suggested preferred particle size class for Australian macroinvertebrates of 16-64mm (Brooks and Boulton 1991), however it must be borne in mind that the substrate phi figures here are an average for the whole stream bed; therefore presence of very fine particles, such as silt, may reduce the average and the species could, in fact, be inhabiting coarser parts of the substrate. However, this species was certainly recovered, on a number of occasions, from pools dominated by finer particles and is clearly able to tolerate such conditions.

Altitude, slope, distance from source, water temperature and the interaction of distance from source*slope were not significant in the final model, despite their low p-values when considered in isolation. This could be because the discrete variables present in the final model rendered these continuous variables redundant.

5.5.3 Conclusions

For each species there are numerous differences between the variables significantly associated with presence. CPOM is the only variable which was significant for both species in simple logistic regression analysis (Table 24) although this variable was only included in the final multivariate model for *N. (A) nigeli* (Table 28). Of the remaining discrete variables landuse, dominant riparian vegetation and substrate heterogeneity were significant only for *N. fusca* and shade, flow, algae and macrophytes only for *N. nigeli* (Table 24).

For *N. (A) nigeli,* altitude, water temperature, slope and distance from source were all individually significant compared to *N. (A) fusca* where none of these variables were significant (Table 24) unless included in a model which contained interactions between them (Table 26). For example, for *N. (A) fusca* there is a clear peak probability of occurrence at intermediate altitude and water temperature (interaction term p=0.001, Table 26) whereas with *N. (A) nigeli* the peak probability is located at high altitudes and cooler water temperatures (interaction term p=0.051, Table 26). *N. (A) nigeli* is associated with steeper slopes, shorter distance from source, higher altitudes and colder temperatures than *N. (A) fusca*. In particular maximum water temperature recorded at sites where *N. (A) nigeli* was found was only 17°C compared to a maximum of 26°C at sites where *N. (A) fusca* was present. Clearly, *N. (A) nigeli* is more restricted to high altitude cool streams. This is entirely consistent with *N. (A) fusca* preferring low temperature seasonality and higher mean temperature of the coldest quarter, whereas *N. nigeli* shows no significant response to either variable (Table 24).

Another difference between the species is that the final model for *N. nigeli* includes a highly significant effect of substrate phi (Table 28) whereas this variable has no importance for *N. (A) fusca* (Table 27). This may indicate tolerance of a broader range of substrate conditions, consistent with the wider range of average substrate phi values encountered at sites where *N. (A) fusca* was found (-7.6 to 6.8) compared with *N. (A) nigeli* (-6.5 to 3.6). Alternatively, *N. (A) nigeli* may prefer finer substrates.

It is clear that the two species differ substantially in which environmental variables have most influence on them, and illustrates the desirability of recording a wide range of bioassessment variables in order to capture the information relevant to different species.

6. THE PHYLOGENETIC RELATIONSHIPS OF THE AUSTRALIAN LEPTOPHLEBIIDAE.

"I am beginning to push *Species Plantarum*
completely out of my thoughts....
Shall I work myself to death?
Shall I never get to see a taste of the world?
What do I gain by all this?"

Linnaeus 1749

6.1 Introduction

The family Leptophlebiidae is considered to be one of the oldest and most diversified mayfly families (Peters 1988). The Leptophlebiidae are distributed worldwide with over 100 genera; predominantly in the southern Hemisphere (Hubbard 1990).

Leptophlebiid species occur in a wide variety of habitats including fast flowing upland streams, lowland standing or slow flowing waters and lakes. Nymphs are predominantly categorised as swimmers, clingers or sprawlers (Edmunds and Waltz 1996) which are adapted to clinging to submerged objects and swimming short distances. Morphological adaptations include dorso-ventral flattening, long curved tarsal claws and mouthparts sometimes arranged as a suction disc. This is in stark contrast to the robust burrowing mayflies (superfamily Ephemeroidea) which have developed anteriorly directed mandibular tusks to accommodate their burrowing behaviour.

Although the monophyly of the family Leptophlebiidae within the superfamily Leptophlebioidea was in question for some time (Edmunds 1972; McCafferty and Edmunds 1979), it is now well established (Landa and Soldán 1985; McCafferty 1991b). However, phylogenetic relationships within the family have not been considered in total (due to the large number of species involved) but rather studied in smaller groups within geographic regions such as the Southern Hemisphere (Tsui and Peters 1975), the Eastern Hemisphere (Peters and Edmunds 1970), South America (Pescador and Peters 1980a) and New Zealand (Towns and Peters 1979; Towns and Peters 1996) or within certain genera, eg: *Meridialaris* and *Massartellopsis* (Pescador and Peters 1987), *Miroculis* (Savage and Peters 1983), *Nousia* (Pescador and Peters 1985), *Penaphlebia* (Pescador and Peters 1991), *Thraulus* (Grant 1985) and *Ulmeritus* (Domínguez 1995).

Relationships amongst the Australian genera are virtually unknown. Apart from the inclusion of some Australian genera in an investigation of the cool-adapted Leptophlebiidae of South America (Pescador and Peters 1980a), and more recently a cladistic analysis of the *Meridialaris* lineage (*sensu* Pescador and Peters 1980a) in Australia (Christidis 2001) no cladistic analysis of the Australian Leptophlebiidae has been performed.

6.2 Origins of the Leptophlebiidae

The earliest recognition of a leptophlebiid taxon was a discussion of the newly established genus *Leptophlebia* proposed by Westwood (1840). He identified a number of characters in both the larvae and adult form that distinguished it from the genus

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Ephemera (Ephemeridae) to which it formerly belonged; namely the lack of horns and pairs of thin tapering gills in the nymph, the "delicacy of the veins of the wings" (p.32) and the absence of numerous crossveins in the anal region of the forewing in the adult. Despite these differences, however, the genus was still considered part of the family Ephemeridae.

Pictet (1843-1845) identified seven genera based on the number of crossveins in the hindwings, the condition of the male oculi, the number and proportions of caudal setae in the imago and the nymph habitat. Unfortunately, he included all *Leptophlebia* in *Potamanthus* perhaps not realising the existence of the name *Leptophlebia*. He did admit that he assumed some of these species did not belong in *Potamanthus* but was prevented from reaching a definitive decision by lack of available material.

The designation of *Potamanthus* remained unchanged until 1868 when Eaton published a catalogue of genera together with named types and notes on geographical distribution in the Entomologists' Monthly Magazine (Eaton 1868-69). Here he retained *Potamanthus* but named a new genus *Leptophlebia* based on differences in the wings and genitalia. Later, Eaton attempted another revision (Eaton 1871) and although *Leptophlebia* was retained he had significant doubts as to the placement of the taxon, frustrated primarily by the lack of nymphal material.

Following this "A Revisional Monograph of the Recent Ephemeridæ" (Eaton 1883-1888) was published but this resulted only in minor changes to the family despite the inclusion of the examination of nymphs. Eaton recognised a group (which he called a section) of nine genera which he referred to as "the *Leptophlebia* type" (*Atalophlebia*, *Leptophlebia*, *Blasturus*, *Adenophlebia*, *Hagenulus*, *Thraulus*, *Calliarcys*, *Habrophlebia* and *Choroterpes*). This was essentially the beginning of the family Leptophlebiidae which was characterised by the following: in the adult (1) the pronotum of the male with a lengthwise ridge and excised posterior border; (2) hind tibia longer than femur and tarsus shorter than tibia; (3) anal veins (A_1 and A_2) convergent and in the nymph (1) first maxillary palp longer than lacinia; (2) labium palps small; (3) pairs of tracheal abdominal gills on segments one to seven and (4) posterolateral projections on posterior abdominal segments.

Banks (1900) subsequently established authorship for the family Leptophlebiidae by the recognition of seven tribes (Bætiscini, Polymitarcini, Leptophlebini, Siphlurini, Ephemerini, Bætini and Cænini) which are essentially analogous to modern families (Peters and Edmunds 1964). Characteristics of the Leptophlebini include: (1) three

caudal filaments; (2) male eyes contiguous; (3) hind tarsi four jointed; (4) hindwings not angulated on costa near base and (5) numerous costal crossveins.

Subsequent revisions and taxonomic descriptions (eg. Klapálek 1909; Ulmer 1920; Phillips 1930; Barnard 1932; Ulmer 1932-33; Needham *et al.* 1935; Burks 1953; Grandi 1960) have enabled a more complete definition of the family to emerge. The most comprehensive diagnosis of the family was outlined by Peters and Edmunds (1964) and updated in Towns and Peters (1996). It is summarised in Table 30.

6.3 Inter-familial phylogenetic relationships of the Leptophlebiidae

Perhaps the earliest phylogenetic classification of Ephemeroptera was attempted by Spieth (1933) using North American fauna. The extensive study was based on the gills and mouthparts of the nymp.s and the wings and genitalia of the adults. The resulting classification puts the families Leptophlebiidae and Ephemeridae within the superfamily Ephemeroidea, showing the two families to be closely related. However, the classification was limited by the phenetic, rather than cladistic, nature of the data. Edmunds and Traver 1954a) placed the family Leptophlebiidae with Ephemerellidae and Tricorythidae in new superfamily Leptophlebioidea with no explanation, although it was presented as a preliminary revision. Demoulin (1958) however disagreed, placing Leptophlebiidae with Heptageniidae and Ametropodidae within the new superfamily Heptagenioidea. A new superfamily Ephemerelloidea was created for Ephemerellidae and Tricorythidae based on new fossil evidence. However, he believed Leptophlebiidae to be somewhat intermediary between Heptageniidae and Ephemerelloidea and that given more evidence Leptophlebiidae might ultimately require a superfamily of its own.

A revision of the phylogeny of the order Ephemeroptera placed Leptophlebiidae back with the superfamily Leptophlebioidea along with Ephemerellidae and Tricorythidae (Edmunds 1962). The superfamily Leptophlebioidea was presented as most closely related to Ephemeroidea. This revision was based on the cumulative knowledge gained from various investigations (Edmunds and Traver 1954b; Edmunds 1957; Edmunds 1959; Edmunds and Traver 1959). Paleontological data was not included as it was considered too inadequate to determine homologies of extant forms. Edmunds *et al.* (1963) followed up on this work with the production of a key designed to distinguish between nymphs of the families. He stated Leptophlebiidae were distinguished by: (1) the presence of morphologically variable double lamellate gills; (2) mandibular tusks rarely present and (3) the absence of an enlarged thoracic notum forming a shield which partly covers the abdomen. He noted that the inclusion of some highly modified southern hemisphere Leptophlebiidae has resulted in a somewhat altered diagnosis of the family.

Table 30. Diagnosis of the family Leptophlebiidae based on the work of Peters and Edmunds (1964) and Towns and Peters (1996)..

Imago	
eyes	male eyes divided – upper portion with medium to large facets, lower portion with small facets; on a stalk or sessile; female eyes not divided, with small facets
ocelli	median and lateral ocelli well developed
forewings	veins C and Sc well developed; vein MA_2 attached at base to MA_1, one intercalary present between the two; vein MP_2 free at base or attached at base to MP_1 or attached at base to CuA; one intercalary between MP_2 and MP_1; no intercalaries between MP_2 and CuA; vein ICu_1 parallel or strongly divergent distally to CuA; several varied intercalaries between veins CuA and CuP; vein CuP strongly recurved; anal veins present, all strongly recurved; cross veins few to numerous
hindwings	present or absent, if present reduced to moderately large; costal projection well developed to absent; venation varied; crossveins few to numerous
legs	male foreleg tarsi 5 segmented with segment 1 shortest, middle and hind legs 4 segmented; female leg tarsi 3 segmented; tarsal claws similar or dissimilar
female genitalia & associations	ovipositor present or absent; egg guide present or absent; 9th abdominal sternum entire to deeply cleft
male genitalia	forceps 2-4 segmented; segments 2 and 3, when present, shorter than segment 1; penis lobes divided to fused, with or without spines or appendages.
caudal filaments	3, well developed, terminal filament shorter or longer than cerci.
Nymph	
body shape	depressed
head	prognathous, semi-prognathous or hypognathous
clypeus	fused entirely or partly to frons
labrum	with or without anteromedian emargination, emargination with or without denticles
mandibles	outer margin straight to angular, naked or with hair
maxillae	galea-lacinia bearing an apical row of sparse to dense long narrow setae, a subapical row of pectinate spine-like setae and a row of long hair like setae on the inner margin; with or without antero-lateral tooth like projection; cardo with or without a row of marginal setae; palpi 3 segmented
hypopharynx	well developed, with or without lateral processes.
labium	glossae and paraglossae well developed; glossae straight to strongly curved ventrally; submentum with or without setae on lateral margins palpi 3 segmented
pronotum	with or without spine-like setae on antero-lateral margins
tarsal claws	with or without denticles
gills	on abdominal segments 1-7, 2-7 or 1-6; slender to plate like; ventral lamellae present or absent
caudal filaments	3; well developed; with whorls of setae, without lateral (swimming) setae

Criticisms of Edmunds' work were put forward by Tshernova (1970) who disagreed with the exclusion of the paleontological evidence. Her classification took into account evidence from the newly discovered Mesozoic and Recent fauna. She includes Leptophlebiidae within the Siphlonuroidea, a relatively new superfamily first proposed by Demoulin (1958), along with the Metropodidae, Ametropodidae, Isonychiidae, Siphlonuridae, Baetidae and Siphlaenigmatidae, based on the unspecialised venation of the forewing, small or absent hindwings, and the free swimming mode of locomotion of the nymph.

Around the same time, examination of the comparative external anatomy of nymph and adult mayflies and new paleontological evidence led to the placement of Leptophlebiidae as a primitive clade of what Edmunds (1962) recognised as Ephemeroidea (Landa 1969; Landa 1973). Edmunds (1972) then produced a classification based on data from biogeographical, morphological and the palaeontologic sources representing Leptophlebiidae as a highly diverse distinct lineage primitive to the closely allied Ephemeroidea. This classification was updated in Edmunds et al. (1976). An alternative classification was presented by Riek (1973), based largely on nymphal characters, that once again closely allied the Leptophlebiid, Ephemerellid and Trichorythid families.

The classification proposed by McCafferty and Edmunds (1979) was little modified from Edmunds et al. (1976) with the establishment of six superfamilies within two suborders: the Schistonata, (Baetoidea, Leptophlebioidea and Ephemeroidea) and the Pannota (Ephemerelloidea, Caenoidea and Prosoptomatoidea). The classification indicates the ephemerellid-tricorythid lineage as derived from a common ancestor with the superfamilies Caenoidea and Prosopistomatoidea. Leptophlebioidea had a common ancestor with Ephemeroidea both of which stemmed from a pre-leptophlebioid or leptophlebioid-like ancestor. Suborder classification was based on thoracic structure of the nymph and, to a lesser extent, imago morphologies.

The next major phylogenetic classification involved a comprehensive study of the comparative anatomy of the larvae (Landa and Soldán 1985) which included the ventral nerve chord, tracheal system, alimentary canal, malpighian tubules and internal reproductive organs. The resultant classification varied from McCafferty and Edmunds (1979) by altering the composition of the two suborders. Schistonota contained four superfamilies (Baetoidea, Leptophlebioidea, Ephemeroidea and Heptagenioidea) and Pannota contained only two (Ephemerellidae and Caenoidea [encompassing Prosopistomatidae]). The placement of the major stem group Leptophlebioidea (containing only the family Leptophlebiidae) was unchanged showing a close association and common ancestor with Ephemeroidea.

The higher phylogenetic classification was again revisited by McCafferty (1991b) where the suborder Schistonota was identified as a paraphyletic grouping and became no longer valid. Pannota became an infraorder within three new suborders: Rectracheata, Setisura and Pisciforma. The Rectracheata, which now contained the three infraorders Vetulata, Lanceolata and Pannota, was established based on synapomorphies elucidated by the internal anatomy studies (Landa and Soldán 1985). Lanceolata contained the superfamilies Leptophlebioidea, Ephemeroidea, and the new Behningioidea, upgraded to superfamily status because it is highly specialised and contains many autapomorphies. Within the Lanceolata, Leptophlebiidae is shown as more closely related to Behningiidae than Ephemeroidea.

The latest revision of the higher classification of mayflies has been completed for the North American fauna (McCafferty 2002). Rectracheata lost its suborder status and the new suborder Furcatergalia now contained three infraorders: Lanceolata (leptophlebiids), Palpatarsa (primitive burrowing mayflies, Behningiidae) and the Scapphodonta (burrowing mayflies, Ephemeroidea). Essentially, these three infraorders replaced the superfamilies of the former infraorder Lanceolata. The relationships between the infraorders within the new suborder have remained the same.

6.4 Intra-familial phylogenetic relationships of Leptophlebiidae

The first phylogenetic analysis of any group of Leptophlebiidae was attempted by Peters and Edmunds (1970). They proposed a phylogeny for the Eastern Hemisphere genera of Leptophlebiidae including all Palearctic, Ethiopian and Oriental regions but excluding Australia and New Zealand as they considered these taxa to have closer affinities with the Neotropical fauna. This hypothesis had been previously inferred from a revision of the Ethiopian Leptophlebiidae (Peters and Edmunds 1964) and examination of the morphology of certain Gondwana genera (Tsui and Peters 1975).

Peters and Edmunds (1970) proposed an ancestral leptophlebiid type in line with (McCafferty and Edmunds 1979). The most primitive lineage, representing an early dispersal to the Northern Hemisphere, was based on a deeply cleft ninth sternum of the male imago and the brush on the anterior margin of the maxillae of the nymph being completely composed of fine hair. The lineage included eight genera: *Paraleptophlebia, Leptophlebia, Habroleptoides, Habrophlebia, Calliarcys, Habrophlebioides, Dipterophlebioides* and *Gilliesia*. Of these, it was considered *Paraleptophlebia* and *Leptophlebia* were the most primitive of the Leptophlebiidae based on wing shape, venation, penis shape and body shape.

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Subsequent phylogenetic analysis determined the eight genera to be sufficiently different to warrant the establishment of the subfamily Leptophlebiinae (Peters 1980). All other genera in the Leptophlebiidae were placed in a new subfamily designated as Atalophlebiinae.

The question of close affinities between the amphinotic fauna was revisited in an examination of the relationships among the South American taxa (Pescador and Peters 1980a). This small but significant paper provided a basis for further phylogenetic work on the Leptophlebiidae. Five phyletic lineages were established based on cladistic analysis of the cool-adapted Leptophlebiidae of southern South America and were considered to apply to other Southern Hemisphere fauna including Australia. The lineages are shown in Fig. 383 which has been adapted from Pescador and Peters (1980a) and includes the genus designation for 'New genus A' which was subsequently described as *Dactylophlebia* (Pescador and Peters 1980b). The phylogenetic characters defining the members of the five lineages, which may be analogous to tribes, are summarised in Table 31. Although Australian and New Zealand fauna were not included in the analysis, cursory examination of such fauna inferred close relationships between the cool-adapted fauna (referring to cool mountain waters and regular freezing episodes) of the three areas and affinities of the Australian taxa with each of the lineages have been identified (Fig. 383, Table 32). As a result of the analysis, it was hypothesized that the fauna of South America were more closely related to that of Australia rather than New Zealand. This is exemplified, in part, by the genus *Nousia* which the two continents share (Hubbard 1990) and the fact that neither Australia nor South America share any taxa in common with New Zealand. Among insect groups this hypothesis was first intimated by Brundin (1966) studying the biogeography of chironomid midges and coincides with the generally accepted view of the sequential break up of Gondwana (Norton and Sclater 1979). Examination of the phylogenetic relationships of the Ephemeropteran Gondwanan fauna may lend further support.

Subsequent to the study by Pescador and Peters (1980a), authors of new taxa have suggested placement within the lineages based on morphological similarities. Table 32 is a compilation of the current genera thought be included in each lineage. References are given for those genera added since the publication of the original paper. Any genera without references were included in the original study. On the most part, however, these assumptions have not been cladistically tested due to the enormity of the task. The approach has been to analyse each country's or continents fauna separately in the hope that these analyses can be combined into a full scale phylogenetic analysis of all the Gondwanan fauna combined. Relationships between various Gondwanan taxa have

been postulated for the Eastern Hemisphere (Peters and Edmunds 1970), New Caledonia (Peters et al. 1978; Peters and Peters 1979; Peters and Peters 1981a; Peters and Peters 1981b; Peters et al. 1990; Peters et al. 1994), Africa (Peters and Edmunds 1964) and Madagascar (Peters and Edmunds 1984). However, cladistic analysis has only been completed for the New Zealand (Towns and Peters 1979; Towns and Peters 1996) and South American fauna (Pescador and Peters 1980a; Domínguez 1995). The one Australian cladistic study (Christidis 2001) focussed on an examination of the Meridialaris lineage at the species level, although other Australian genera were included for comparison. It is clear that a major gap in our understanding of the Southern Hemisphere Leptophlebiidae is the lack of knowledge regarding the Australian fauna.

6.5 Aims of the phylogenetic analysis

This study aims to:

1. establish the relationships between the Australian Leptophlebiid genera in order to provide a basis for the inclusion of Australian taxa into a future phylogenetic analysis of the Gondwanan fauna.
2. compare and contrast the relationships of the Australian Leptophlebiid genera with the lineages defined by Pescador and Peters (1980a) and those established for other Southern Hemisphere fauna.

6.6 Methods

Representatives of the majority of the species of each of the 17 known Australian genera and one subgenus Nousia (Australonousia), along with the South American subgenus Nousia (Nousia), were examined for the phylogenetic analysis (see 6.6.1). Type species material was borrowed where possible and examined in preference to other species in the genus. The various sources of the type material included the Museum of Victoria (MV), the Australian National Insect Collection (ANIC), the Queensland Department of Primary Industry (DPIQ), the Swedish Museum of Natural History (SMNH) and the Florida Agricultural and Mechanical University collection (FAMU). Other material examined was borrowed from the private collections of I.C. Campbell (Campbell collection), P.J. Suter (Suter collection), Y.J. Bae collection (Bae collection) or was collected by myself during the course of this study (Finlay collection).

Table 31. Phylogenetic characters defining the five lineages of Pescador and Peters (1980a) from the most primitive (*Hapisphlebia*) to the most derived (*Meridialaris*). Bold text refers to apomorphic conditions. Blank spaces are due to the methodology of Pescador and Peters (1980a) where each furcation includes only characters relevant to the present branch and the branches above ie the *Penaphlebia* furcation includes characters relevant to *Atalonella*, *Dactyophlebia* and *Meridialaris* but excludes those of *Hapsiphlebia*.

Character	Hapsiphlebia	Penaphlebia	Atalonella	Dactyophlebia	Meridialaris
Clypeus width compared with labrum width	wider	subequal to slightly narrower	**narrower**	**narrower**	**narrower**
Labrum lateral margins	subparallel	**rounded to angular**	**rounded to angular, smoothly curved**	**rounded to angular, abruptly to angularly curved**	**rounded to angular, abruptly to angularly curved**
Mandible outer margin	almost straight	**rounded to angular**	**rounded to angular - smoothly curved**	**rounded to angular – slightly angular**	**rounded to angular – distinctly angular**
Mandible right outer incisor	**with broad subapical denticles**	smooth or spinose	smooth or spinose	smooth or spinose	smooth or spinose
Abdominal terga lateral margin setae	**prominent**	bare or minute	bare or minute	bare or minute	bare or minute
Maxillae inner margin of palp 2		**pectinate setae**	non-pectinate setae	non-pectinate setae	non-pectinate setae
Abdominal terga posterior margin		**prominent spines and long tassel-like setae**	spines and scattered fine hairs	spines and scattered fine hairs	spines and scattered fine hairs
Forewings MP₂		strongly recurved	**moderately recurved**	**moderately recurved**	**moderately recurved**
Costal crossveins		more than 25	**less than 25**	**less than 25**	**less than 25**

Table 31 cont'd.

Character	Hapsiphlebia	Penaphlebia	Atalonella	Dactyophlebia	Meridialaris
Clypeus lateral margins			parallel	divergent	divergent
Clypeus width / labrum width			less than 4/5	more than 4/5	more than 4/5
Labrum – anteromedial emargination			broad with prominent denticles	narrow (may be cleft or hooded), denticles reduced; if cleft, V-shaped dorsally and ventrally	narrow (may be cleft or hooded), denticles reduced; if cleft shallow U-shaped or deep V-shaped ventrally
Sternum nine of female			deeply cleft	entire or shallow	entire or shallow
Labrum length / width				2/3 – 3/4	1/3 – 1/2
Maxillae galea-lacinia				narrow at apex	broad at apex
Maxillae – subapical pectinate setae				≤ 15	> 15
Labium submentum				thick lateral setae	lateral margins bare
Body of nymph				robust	flattened

Table 32. Genera currently thought to belong to the five lineages outlined by
Pescador and Peters (1980a).

Lineage	Genus	Country / Continent	Reference
1. *Hapsiphlebia*	*Aprionyx*	Africa	
	Atalophlebia	Australia	
	Atalomicria	Australia	
	Jappa	Australia	
	Kalbaybaria	Australia	(Campbell 1993)
	Ulmerophlebia	Australia	
	Papposa	New Caledonia	(Peters and Peters 1981b)
	Acanthophlebia	New Zealand	(Towns and Peters 1996)
	Hapsiphlebia	South America	
2. *Penaphlebia*	*Garinjuga*	Australia	(Campbell and Suter 1988)
	Nesophlebia	Madagascar	(Peters and Edmunds 1984)
	Massartella	South America	
	Penaphlebia	South America	
3. *Atalonella*	*Atalonella =* *Nousia*	Australia/South America	(Pescador and Peters 1985)
	Neozephlebia	New Zealand	(Towns and Peters 1996)
	Nyungara	Australia	(Dean 1987)
	Rhigotopus	South America	
	Archethraulodes	South America	
4. *Dactylophlebia*	*Austroclima*	New Zealand	(Towns and Peters 1996)
	Mauiulus	New Zealand	(Towns and Peters 1996)
	Dactylophlebia	South America	(Pescador and Peters 1980b)
	Magallanella	South America	(Pescador and Peters 1980b)
5. *Meridialaris*	*Austrophlebioides* *(Atalophlebioides)*	Australia	(Campbell and Suter 1988)
	Kirrara	Australia	(Campbell and Peters 1986)
	Tillyardophlebia	Australia	(Dean 1997)
	Petersophlebia	Madagascar	
	Atalophlebioides	New Zealand	(Towns and Peters 1996)
	Deleatidium	New Zealand	(Towns and Peters 1996)
	Massaretellopsis	South America	
	Meridialaris	South America	
	Secochela	South America	(Pescador and Peters 1982)
	Sulawesia	Sulawesi	(Peters and Edmunds 1990)

*Although the method of polarising characters *a priori* has been used extensively it is considered by some to be outdated and preferably should be discarded in favour of analysing ingroup and external, closely related outgroup taxa simultaneously and determining character polarity from the cladogram produced (Nixon and Carpenter 1993). For completeness, then, an alternative analysis was performed using the same morphological characters (Table 33) with closely related taxa as outgroups and assuming no polarity of characters. The three outgroups chosen were *Paraleptoplebia* and *Leptophebia* belonging to the primitive subfamily Leptophlebiinae (Peters 1980) and *Ephemera* from the sister group Ephemeroidea (McCafferty 1991b, McCafferty 2002).

Morphological characters (Table 33) were determined from careful examination of the species and from the species descriptions in the literature. Key sources of information for each of the genera include: *Atalophlebia* (Tillyard 1933b; Suter 1986); *Atalomicria* (Campbell and Peters 1993), *Austrophlebioides* (Campbell and Suter 1988), *Bibulmena* (Dean 1987), *Garinjuga* (Campbell and Suter 1988), *Jappa* (Skedros and Polhemus 1986), *Kalbaybaria* (Campbell 1993), *Kaninga* (Dean 2000), *Kirrara* (Campbell and Peters 1986), *Loamaggalangta* (Dean et al. 1999), *Neboissophlebia* (Dean 1988), *Nousia* (Pescador and Peters 1980a; Campbell and Suter 1988), *Nyungara* (Dean 1987), *Thraulophlebia* (Demoulin 1955b; Campbell and Suter 1988), *Thraulus* (Grant 1985; Suter 1992), *Tillyardophlebia* (Dean 1997), *Ulmerophlebia* (Suter 1986). In the case of the newly revised taxa, *Nousia (Australonousia)* and *Thraulophlebia* (Chapter 3), and the newly established genera *Montikola* and *Gemmayaluka* (Chapter 4), extensive revision was required to determine generic status and as a result these chapters subsequently became the primary sources of information.

In line with Edmunds and Allen (1966), Riek (1973) and Pescador and Peters (1980a) nymph characters were found to be more taxonomically informative than those of the imago, hence the disproportionately low number of adult characters in Table 33. Further, one of the major characteristics of the adult, wing venation, can be subject to significant parallel evolution (Edmunds 1972).

Plesiomorphic and apomorphic characters states were assessed by comparison with all available outgroups following the traditional methods of Hennig (1966) and Ross (1974) where the polarity of characters was determined prior to analysis. The nearest outgroup was the subfamily Leptophlebiinae, considered a primitive furcation in the evolution of the Eastern Hemisphere Leptophlebiidae (Peters and Edmunds 1970, see 6.4). Within this subfamily the plesiotypic *Paraleptophlebia* and *Leptophlebia* provided particularly valuable cladistic information. see opposite*

The latest revisions of the higher classification of mayflies (McCafferty 1991b; McCafferty 2002), encompassing the work of Landa and Soldán (1985), provide the next nearest outgroups within Infraorder Lanceolata: that of the sister group Ephemeroidea (Polymitarcyidae, Euthyplociidae, Potamanthidae, Ephemeridae, Palingeniidae) followed by the superfamily Caenoidea (Ephemerellidae, Tricorythidae and Caenidae). Although the superfamily Behningoidea (containing the single family Behningiidae) is considered more closely related to Leptophlebioidea (McCafferty 1991b) its use as an outgroup is limited due to its highly distinctive and specialised nature in both adult and nymphal forms.

Table 33. Morphological characters used in phylogenetic analysis.

No.	Character	State (0) - plesiomorphy	State (1) - apomorphy	State (2) – apomorphy
Nymphal characters				
0	Mouthparts.	hypognathous	prognathous	
1	Body and gills fringed with fine setae (Figs. 384-387).	no	yes	
2	Setation or spination on lateral margins of abdominal terga.	bare, minute or fine setae	prominent spines	
3	Spines on posterior margins of abdominal terga.	none or small	prominent	
4	Posterolateral spines on abdomen.	on segments 4, 5, 6, 7, 8 to 9	on segments 2 to 9	
5	Labrum width in relation to clypeus (Figs. 388-407).	narrower	subequal to slightly wider	significantly wider
6	Labrum lateral margins (Figs. 388-407).	parallel	rounded	angular
7	Labrum cross section (Fig. 408).	oval	triangular	
8	Labrum 'hood' (Figs. 390, 406).	absent	present	
9	Labrum secondary hair fringe (Figs. 388-407).	absent	present	
10	Labrum denticles on anteromedian emargination (Figs. 388-407).	absent	present	present with one prominent denticle
11	Frontal horns (Figs. 409, 410).	absent	present	
12	Clypeus lateral margins (Figs. 388-407).	converging towards anterior	parallel	diverging towards anterior
13	Mandible outer margins (Figs. 411-430).	relatively straight	smoothly curved	angular
14	Mandible with enlarged process (Fig. 418).	absent	present	
15	Mandible prosthecal tuft (Figs. 431-450).	wide, flap-like; setae on apical and lateral margins	spine-like; hairs on lateral margins only	
16	Right mandible outer incisor inner margin (Figs. 451-470).	smooth or spinose	denticulate	
17	Maxillae galea-lacinae (Figs. 471-490).	narrow at apex; width-length ratio < 1	relatively broad at apex; width-length ratio ≈ 1 (as wide as long)	very broad at apex; width-length ratio > 1

Table 33 cont'd.

No.	Character	State (0) - plesiomorphy	State (1) – apomorphy	State (2) – apomorphy
18	Average number of pectinate setae on maxillae (Figs. 471-490).	≤15	> 17	
19	Maxillary palp morphology (Figs. 471-490).	extending just beyond galea-lacinae	greatly elongate	
20	Labium glossae (Figs. 491-510).	turned over ventrally	straight, upright	
21	Spines on inner margins of labial terminal palp (Fig. 511-530).	prominent	minor or absent	
22	Labium submentum lateral setae.	present	absent	
23	Hypopharynx lateral processes (Figs. 531-550).	absent	present	
24	Tarsal claws (Figs. 551-570).	smooth or with minor processes	denticulate	
Imago characters				
25	Size of male imago dorsal eye lobes. ES=B/D (*sensu* [Bae, 1991 #906], see chapter 3.	eye size large (≤ 0.2 or contiguous)	eye size medium (≥ 0.3)	
26	Male dorsal eye facets.	hexagonal	square	
27	Position of forewing veins ICu_1 and ICu_2 (Figs. 571-590).	strongly diverging as wing margin approached	parallel to very slightly diverging as wing margin approached	
28	Average number of crossveins in the costal space of forewings (Figs. 571-590).	≈ 20 or more	≈ 10-15	
29	costal crossveins in proximal half of male forewings (Figs. 571-590).	present	reduced or absent	
30	Hindwing length relative to forewing (Figs. 571-590).	hindwing large (≈ 1/3th the length of forewing)	hindwing smaller (≈ 1/4 to 1/5th length of forewing)	hindwing very small (≈ 1/10th length of forewing)
31	Length of hindwing subcostal vein (Figs. 591-610).	≥ 0.9 x length of hindwing	≤ 0.85 x length of hindwing	
32	Hindwing midlength costal projection (Figs. 591-610).	absent	present	
33	Sternum nine of female (Figs. 611-630).	cleft	entire	

Outgroup material was borrowed from various sources including the ANIC, FAMU and various private collections. However, insufficient material was an issue and literature was relied upon for some of the taxa. Sources of information for the various taxa included are as follows. Leptophlebiinae - *Paraleptophlebia, Leptophlebia* (Burks 1953; Peters and Edmunds 1970), *Habroleptoides, Habrophlebia, Calliarcys, Habrophlebioides, Dipterphlebioides* (Peters and Edmunds 1970), *Gillesia* (Gillies 1951; Peters and Edmunds 1970). Ephemeroidea - Ephemeridae: *Aethephemera* (McCafferty 1971b; McCafferty 1973), *Afromera* (Demoulin 1955a; McCafferty and Gillies 1979; Elouard 1986a); *Eatonica* (McCafferty 1971a; Elouard 1986b; Elouard *et al.* 1998), *Ephemera* (McCafferty 1973; McCafferty 1975; Hubbard 1982; Hubbard 1983; Balasubramanian *et al.* 1991; Kang and Yang 1994; Bae 1995; Ishiwata 1996), *Hexagenia* (Spieth 1941; McCafferty 1975; Keltner and McCafferty 1986), *Ichthybotus* (Eaton 1899), *Litobrancha* (Lestage 1939; McCafferty 1975). Euthyplociidae: *Afroplocia* (Demoulin 1952a), *Campylocia* (Demoulin 1952a; Pereira and Da Silva 1990), *Euthyplocia* (Lestage 1918; Lestage 1939; Demoulin 1952a), *Exeuthyplocia* (Lestage 1918; Lestage 1939; Gillies 1980), *Proboscidoplocia* (Demoulin 1966), *Polyplocia* (Demoulin 1952a), *Mesoplocia* (Demoulin 1952a). Palingeniidae: *Cheirogenesia* (McCafferty and Edmunds 1976; Sartori and Elouard 1999), *Chankagenesia* (Demoulin 1952b), *Palingenia* (Sartori 1992), *Pentagenia* (Lestage 1918; McCafferty 1972; McCafferty 1975; Keltner and McCafferty 1986). Polymitarcyidae: *Campsurus* (Eaton 1868-69; McCafferty 1975), *Ephoron* (Lestage 1918; Spieth 1933; Demoulin 1952a; McCafferty 1975; Ishiwata 1996), *Tortopus* (Needham and Murphy 1924; McCafferty 1975; McCafferty and Bloodgood 1989; Lugo-Ortiz and McCafferty 1996), *Povilla* (Lestage 1918; Lestage 1939; Hubbard 1984). Potamanthidae (Bae 1991): *Anthopotamus* (McCafferty and Bae 1990), *Neopotamanthus* (Wu and You 1986), *Potamanthodes* (You 1984; You and Su 1987), *Potamanthus* (Uéno 1928; McCafferty 1975; Elpers and Tomka 1994; Kang and Yang 1994; Vuori 1999); *Rhoenanthus* (Soldán and Putz 2000), *Stygifloris* (Bae *et al.* 1990).

Taxa (n=21) and characters (n=34) were compiled into a data matrix (Table 34). NONA version 2.0 (Goloboff 1993) was used to construct a cladogram using the tree bisection-reconnection command (mult*). A strict consensus tree (nelsen command) was constructed from the most parsimonious trees. Winclada version 0.9.99i (beta) (Nixon 1999) was used to redraw the tree with the characters and character states mapped.

For the alternative analysis using multiple outgroups and making no *a priori* assumptions of character polarity, three outgroup taxa plus the same ingroup taxa (n=23) and the same characters (n=34) were compiled into a data matrix (Alternative Table 34 [see adjacent to page 298]). The methodology described above was used to construct a new strict consensus tree.

Alternative Table 34. Data matrix of phylogenetic character states for the Australian genera of Leptophlebiidae."

| | | | 11111 | 11111 | 22222 | 22222 | 3333 |
	01234	56789	01234	56789	01234	56789	0123
Paraleptophlebia	00000	00000	00000	00000	00000	00000	0000
Letophlebia	00000	00000	00000	00000	00000	00000	0000
Ephemera	0000-	00000	00001	-0001	00000	10-00	0000
Atalomicria	10000	00001	10000	01001	00010	11000	1100
Atalophlebia	10001	00001	10000	01000	00010	11000	0100
Austrophlebioides	10011	22011	10220	10210	11111	01100	0001
Bibulmena	10000	11001	10110	10110	01010	01000	1000
Garinjuga	10010	11001	10110	10110	11011	01000	1000
Gemmayaluka	10000	11001	10110	10110	11011	01100	1100
Jappa	11100	00001	21000	01000	00010	01000	1100
Kalbaybaria	10000	00000	00001	011-0	00010	01100	1000
Kaninga	10010	11001	10110	10110	01010	01100	1000
Kirrara	10001	22100	00220	-0210	11111	01000	1001
Loamaggalangta	10000	11001	10110	10110	01010	01100	1000
Montikola	10000	11001	10110	10110	11011	01100	1100
Neboissophlebia	10000	11001	10110	10010	01010	01111	1100
Nousia(Nousia)	10000	11001	10110	10100	11011	01111	1100
Nousia (Australonousia)	10000	11001	10110	10100	11011	01111	1100
Nyungara	10000	11000	10110	10100	11011	01110	2110
Thraulophlebia	10000	11001	10110	10110	11011	01111	1100
Thraulus	10000	11001	10110	10110	11011	0111-	1111
Tillyardophlebia	10011	22011	10220	10210	11111	01100	1001
Ulmerophlebia	11100	00001	20000	01000	00010	01000	1100

Table 34. Data matrix of phylogenetic character states for the Australian genera of Leptophlebiidae.

| | | | 11111 | 11111 | 22222 | 22222 | 3333 |
	01234	56789	01234	56789	01234	56789	0123
Outgroup	00000	00000	00000	00000	00000	00000	0000
Atalomicria	10000	00001	10000	01001	00010	11000	1100
Atalophlebia	10001	00001	10000	01000	00010	11000	0100
Austrophlebioides	10011	22011	10220	10210	11111	01100	0001
Bibulmena	10000	11001	10110	10110	01010	01000	1000
Garinjuga	10010	11001	10110	10110	11011	01000	1000
Gemmayaluka	10000	11001	10110	10110	11011	01100	1100
Jappa	11100	00001	21000	01000	00010	01000	1100
Kalbaybaria	10000	00000	00001	011-0	00010	01100	1000
Kaninga	10010	11001	10110	10110	01010	01100	1000
Kirrara	10001	22100	00220	-0210	11111	01000	1001
Loamaggalangta	10000	11001	10110	10110	01010	01100	1000
Montikola	10000	11001	10110	10110	11011	01100	1100
Neboissophlebia	10000	11001	10110	10010	01010	01111	1100
Nousia(Nousia)	10000	11001	10110	10100	11011	01111	1100
Nousia (Australonousia)	10000	11001	10110	10100	11011	01111	1100
Nyungara	10000	11000	10110	10100	11011	01110	2110
Thraulophlebia	10000	11001	10110	10110	11011	01111	1100
Thraulus	10000	11001	10110	10110	11011	0111-	1111
Tillyardophlebia	10011	22011	10220	10210	11111	01100	1001
Ulmerophlebia	11100	00001	20000	01000	00010	01000	1100

6.6.1 Specimens examined

Leptophlebiidae

Atalophlebiinae

Atalomicria Harker

Atalomicria banjdjalama Campbell and Peters
- holotype, male imago; paratypes, female imago, male and female nymphs; slide material; Booloumba Creek, Connondale Ranges, QLD, 29 xi 89, coll. I.C. Campbell (MV)

Atalomicria bifasciata Campbell and Peters
- holotype, male imago; paratypes, female imago, subimagos, nymphs; slide material; Booloumba Creek, Connondale Ranges, QLD, 5 xii 89, coll. I.C. Campbell (MV)

Atalomicria dalgara Campbell and Peters
- holotype, male imago; paratypes, nymphs; slide material; Booloumba Creek, Connondale Ranges, QLD, 29 xi 89, coll. I.C. Campbell (MV)

Atalomicria chessmani Campbell and Peters
- holotype, male imago; paratypes, male and female imagos, nymphs; slide material; Ferntree Creek, 10km S of Goongerah, VIC, 18 i 1990, coll. I.C.Campbell (MV)

Atalomicria sexfasciata (Ulmer)
- holotype, male imago; paratype, female imago; Cedar Creek, QLD, Dr Mjöbergs Swedish Expedition to Australia 1910-1913 (SMNH).
- slide material, Yuccabine Creek, Kirrama Rd, QLD, 27 ix 87, coll. I.C. Campbell (MV).

Atalomicria uncinata (Ulmer)
- holotype, male imago; Cedar Creek, QLD, Dr Mjöbergs Swedish Expedition to Australia 1910-1913 (SMNH).

Atalomicria sp. "AV1" (Dean 1999)
- nymphs and imagos, NSW, QLD, VIC (MV)
- nymphs, NSW, VIC (Finlay collection)
- slide material, QLD (Campbell collection)

Atalophlebia Eaton

Atalophlebia albiterminata Tillyard
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia australis (Walker)
- nymphs and imagos, reared, VIC, NSW, NT, TAS (NMV, Finlay collection, Campbell collection)
- slide material, VIC (MV)

Atalophlebia sp. "AV2" (Dean 1999)
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia sp. "AV4" (Dean 1999)
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia sp. "AV5" (Dean 1999)
- nymphs and imagos, reared, VIC, TAS (Finlay collection)

Atalophlebia sp. "AV7" (Dean 1999)
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia sp. "AV9" (Dean 1999)
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia sp. "AV13" (Dean 1999)
- nymphs and imagos, reared, VIC (Finlay collection)

Atalophlebia sp. "AV15" (Dean 1999)
- nymphs, VIC (Finlay collection)

Atalophlebia sp. "AV21" (Dean 1999)
- nymphs, VIC (Finlay collection)

Atalophlebia spp.
- nymphs and imagos, reared, VIC, NSW, TAS (Finlay collection)

Austrophlebioides Campbell and Suter

Austrophlebioides booloumbi Parnrong and Campbell
- holotype, male imago & paratypes, male and female nymphs; Booloumba Creek, Connondale Ranges, QLD, 5 xii 89, coll. I.C. Campbell (MV).

Austrophlebioides marchanti Parnrong and Campbell
- holotype, male imago & paratypes, female imago, female and male nymphs; Loch River, Noojee, i 1995, coll. S. Parnrong (MV)
- nymphs, imagos, slide material, NSW, VIC (Finlay collection)

Austrophlebioides pusillus (Harker)
- nymphs, imagos, NSW, VIC (MV)
- nymphs, imagos, slide material, NSW, VIC (Finlay collection)
- slide material (Campbell collection)

Austrophlebioides sp. "AV2" (Dean 1999)
- nymphs, imagos, NSW, VIC (Finlay collection)

Austrophlebioides spp.
- nymphs, imagos, VIC (Finlay collection)

Bibulmena Dean

Bibulmena kadjina Dean
- holotype, male imago, reared, North Dandalup River, North Dandalup, WA, 01 vi 1984, coll. S. Bunn (MV)
- paratypes, male and female imago, slide material, Foster Brook, North Dandalup, 1983, coll. S. Bunn (MV)
- paratype, nymph, slide material, Wungong Brook, Jarrahdale, 2 xii 1981, coll. S. Bunn (MV)
- nymphs, imagos, WA (MV)

Garinjuga Campbell and Suter

Garinjuga maryannae Campbell and Suter
- holotype, male imago & paratypes, subimagos, female and male nymphs; Thredbo River, Summit Rd at entrance to Kosciusko National Park, 19 x 1995, coll. I.C. Campbell (ANIC)
- nymphs, imagos, slide material, NSW, VIC (Finlay collection)
- nymphs, imagos, slide material, NSW (Campbell collection)

Garinjuga sp. "AV1" (Dean 1999)
- nymphs, imagos, NSW, TAS, VIC (MV)
- nymphs, imagos, slide material, NSW, VIC (Finlay collection)

Garinjuga spp.
- nymphs, imagos, slide material, NSW, VIC (Finlay collection)

Gemmayaluka gen.nov.

see Chapter 4

Jappa Harker

Jappa edmundsi Skedros and Polhemus
- holotype and paratypes, nymphs, Hutchinson Creek, Cape Tribulation Rd, N of Daintree Landing, 17 viii 1983, coll. D.A. & T.J. Polhemus (ANIC)
- slide material, QLD (Campbell collection)

Jappa kutera Harker
- nymphs, imagos, slide material, NSW, NT, QLD,
- nymphs, NSW, VIC (Finlay collection)
- slide material, VIC (Suter collection)

Jappa serrata Skedros and Polhemus
- holotype, nymph, Hutchinson Creek, Cape Tribulation Rd, N of Daintree Landing, 17 viii 1983, coll. D.A. & T.J. Polhemus (ANIC)
- nymphs, imagos, slide material, QLD (Campbell collection)

Jappa sp. "AV3" (Dean 1999)
- nymphs, imagos, VIC (Finlay collection)

Jappa sp. "AV4" (Dean 1999)
- nymphs, imagos, VIC (Finlay collection)

Jappa spp.
- nymphs, imagos, VIC (Campbell collection)
- slide material, QLD (Campbell collection)

Kalbaybaria Campbell

Kalbaybaria doantrangae Campbell
- holotype, male imago; paratypes, male and female imago, nymphs; slide material, Romeo Creek, near Helenvale, QLD, 5 v 1988, coll. I.C. Campbell (ANIC)
- slide material, Palmer River, QLD, 20 vi 1971, coll. E.F. Riek (ANIC)
- slide material, Millstream Falls, W of Ravenshoe, QLD, 25 vi 1971, coll. E.F. Riek (ANIC)

Kaninga Dean

Kaninga gwabbalitcha Dean
- nymphs, slide material, WA (MV)

Genus Q sp. "AV1" (Dean 1999)
- holotype, male imago; paratypes, male imagos, Carey Brook, Staircase Road, WA, 15 vii 1989 coll. I. Growns (MV)
- nymphs, subimagos, WA (MV)

Kirrara Harker

Kirrara procera Harker
- nymphs, imagos, slide material, VIC, NSW (MV)
- nymphs, imagos, slide material, VIC (Finlay collection)

Kirrara sp. "AV1" (Dean 1999)
- nymphs, slide material, QLD (Campbell collection)

Loamaggalangta Dean, Forteath & Osborn

Loamaggalangta pedderensis Dean, Forteath & Osborn
- holotype, male imago; paratypes, male imagos, subimagos; Lake Pedder, Trappes Bay, TAS, ii 1997, coll. N. Forteath (ANIC)
- nymphs, slide material, TAS (MV)

Genus K sp. "AV1" (Dean 1999)
- nymphs, NSW, VIC (MV)
- nymphs, TAS (Finlay collection)

Genus K sp. "AV2" (Dean 1999)
- nymphs, QLD (MV)

Montikola gen. nov.

see Chapter 4

Neboissophlebia Dean

Neboissophlebia hamulata Dean
- holotype, male imago; paratypes, male imago, female imagos, subimagos; slide material, Tarago River, 7km W Neerim, VIC, 1 iii 1972, coll. A. Neboiss (MV)
- nymphs, imagos, NSW, VIC (MV)
- nymphs, imagos, NSW, VIC (Finlay collection)

Neboissophlebia occidentalis Dean
- paratypes, male imagos, female imagos, slide material, Harvey River, 15km E Harvey, WA, 21 xi 1978, coll. A. Neboiss (MV)

Nousia Navás

subgenus *Nousia (Nousia)* Navás

Nousia delicata Navás
- male imagos, Santiago Province, CHILE, xi 1972, coll. M.L. Pescador & G. Barria
- nymphs, Rio Caren, Hacienda Illapel, Coquimbo Province, CHILE, 17 xi 1972, coll. M.L. Pescador (FAMU)

- nymphs, Río Caren, Hacienda Illapel, Coquimbo Province, CHILE, 18 xi 1972, coll. M.L. Pescador & G. Barria (FAMU)

Nousia grandis (Demoulin)
- nymphs; female imago reared, male subimago reared; El Coigual, Curico Province, CHILE, i 1964, coll. L. Peña (FAMU)

Nousia minor (Demoulin)
- male imago, Valdivia, CHILE, 19 x 1957, coll. J. Illies.
- nymphs, Río Piquiquen, El Manzano, 35km W Angol, Malleco Province, CHILE, xii 1972, coll. M.L. Pescador (FAMU)

Nousia Navás

subgenus *Nousia (Australonousia)* Campbell and Suter

See Chapter 3

Nyungara Dean

Nyungara bunni Dean
- holotype, male imago reared; paratype, nymph; slide material, Foster Brook, North Dandalup, WA, 22 ix 1983, coll. S. Bunn (MV)
- paratypes, male imago, female imago, nymphs, slide material, Waterfall Gully, Jarrahdale, WA, 1981-1982, coll. S. Bunn (MV)
- imagos, nymphs, slide material, WA (MV)

Thraulophlebia Demoulin

See Chapter 3

Thraulus Eaton

Thraulus sp. "A" sp. nov.(informal description, Grant 1985)
- "holotype", male imago, Drysdale River, WA, viii 1975, coll. I.F. Common and M.D. Upton (ANIC)
- "paratypes", male imagos, Nourlangie Creek, 6km W Cahill, NT, 18 xi 1972, coll. J.C. Cardale (ANIC)
- "paratypes", male subimagos, Cooper Creek, 19km SE of Mt Borrdaile, NT, vi 1973, coll. J.C. Cardale (ANIC)

Thraulus sp. "AV1" (Dean 1999)
- imagos, nymphs, NT (MV)

Thraulus sp. "AV2" (Dean 1999)
- nymphs, QLD (MV)

Thraulus sp. "AV3" (Dean 1999)
- nymphs, QLD (MV)

Thraulus spp.
- nymphs, QLD (DPIQ)

Tillyardophlebia Dean

Tillyardophlebia alpina Dean
- imagos, nymphs, NSW (MV)

Tillyardophlebia rufosa Dean
- holotype, male imago; paratypes, male and female imagos, nymphs; slide material, Badger Creek downstream weir, VIC, 23 ii 1984, coll. J. Dean (MV)
- imagos, nymphs, NSW, VIC (MV)
- imagos, nymphs, NSW, VIC (Finlay collection)

Tillyardophlebia spp.
- imagos, nymphs, NSW, VIC (Finlay collection)

Ulmerophlebia Demoulin

Ulmerophlebia pippina Suter
- nymphs, subimago, VIC (Finlay collection)

Ulmerophlebia sp. "AV2" (Dean 1999)
- nymphs, imagos, NSW, VIC (Finlay collection)
- nymphs, imagos, NSW, VIC (Finlay collection)

Ulmerophlebia sp. "AV6" -*mjöbergi*? (Dean 1999)
- nymphs, imagos, QLD, (MV)

Ulmerophlebia spp.
- nymphs, imagos, VIC (Finlay collection)

Leptophlebiinae

Gillesia hindustanica (Gillies)
- imagos, Assam, INDIA (FAMU)

Leptophlebia cupida (Say)
- nymphs, Indiana, USA (Bae collection)

Leptophlebia sp.
- nymphs, Missouri, USA (Bae collection)

Paraleptophlebia bicornuta (McDonnough)
- nymphs, Idaho, USA (Bae collection)

Paraleptophlebia chocc'ata Imanishi
- nymphs, imago, reared, Kyonggi-do, KOREA (Bae collection)

Paraleptophlebia packi (Needham)
- nymph, imago, reared, Utah, USA (Bae collection)

Paraleptophlebia sp.
- nymphs, Wyoming, USA (ANIC)

Ephemeroidea

Ephemera danica Müller
- nymphs, near Silkeborg, DENMARK (Campbell collection)

Ephemera simulans Walker
- nymphs, Wyoming, USA (ANIC)

Euthyplocia spp.
- nymphs, San Martin Province, PERU (ANIC)

Ichthybotus hudsoni McLachlan
- nymphs, Taupo, NEW ZEALAND (ANIC)

Povilla adusta Navás
- nymphs, Lake Kivu, BELGIAN CONGO (ANIC)

Rhoenanthopsis spp.
- nymphs, Chiangmai Province, THAILAND (ANIC)

6.7 Results and Discussion

The relationships of the Australian Leptophlebiidae are shown in the strict consensus tree (Fig. 631) constructed from the three most parsimonious trees initially produced. This resulted in a relatively short tree length (total number of character changes required to support relationship of the taxa) of 62. The relative amount of homoplasy was shown to be reasonably low as shown by the high consistency index ($ci = 0.66$). Finally a high retention index ($ri=0.82$), or the proportion of apparent synapomorphy which can expected as true synapomorphy in the cladogram, indicates true evolutionary trends within the family.

A number of synapomorphies were found to define the ingroup taxa (clade A): prognathous nymphal mouthparts (character 0), presence of hypopharynx lateral processes (character 23, Figs. 531-550) and the presence of square dorsal eye facets in the male imago (character 26). As each of these characters is present amongst the Atalophlebiinae world-wide an analysis including other Gondwana taxa would be required to investigate the potential monophyly of Australian groups. Square facets have been noted before as a characteristic of all but one of the Atalophlebiinae taxa (Peters and Peters 1995), a condition thought to have evolved to catch a greater proportion of the ultraviolet light available (Horridge *et al.* 1982). All Leptophlebiinae and Ephemeroidea were found to have hexagonal dorsal eye facets (Peters and Peters 1995). The presence of lateral processes on the hypopharynx applies to Atalophlebiinae world-wide, although may be secondarily lost in some species, (Peters and Edmunds 1970) but they are lacking in all Leptophlebiinae and Ephemeroidea. Their evolutionary function is unknown but one may presume it is related to feeding behaviour. The head position in the nymph in Leptophlebiidae can be either hypognathous, semi-hypognathous or prognathous (Peters and Edmunds 1964). I have found the mouthpart position to be more or less stable, even if the head position can be somewhat ambiguous. For example, the position of the head of *Jappa* and *Ulmerophlebia* can sometimes be orientated partly downwards (possibly representing the semi-hypognathous position of Peters and Edmunds (1964) but the mouthparts are most

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commonly directed forward. The habit of the Atalophlebiinae as sprawlers, swimmers and clingers (Edmunds and Waltz 1996) translates into a streamlined body capable of maintaining a position of least resistance on the stream bed. The Leptophlebiinae tend to be more laterally rather than dorso-ventrally flattened, often with prognathous heads (Peters and Edmunds 1970). The Ephemeroidea are very robust and laterally flattened to accommodate their burrowing behaviour and their mouthparts are generally hypognathous for filtering and gathering detritus.

The other synapomorphies defining clade A are all homoplasic. For example, the right mandible outer incisor (character 16, Figs. 451-470) is apomorphic ie: denticulate and triangularly shaped for all taxa below clade F where it reverts to the primitive condition. The width length ratio of the maxilla galea-lacinae (character 17, Figs. 471-490) approximates 1 for most of the ingroup taxa, except for those at clade C where the taxa possess the primitive condition of a narrow apex and those of clade H where the taxa possess the highly derived apomorphy of a very broad apex. All but three of the ingroup taxa possess the derived condition of a small hindwing in comparison to the forewing (character 30, Figs. 571-590). *Atalophlebia* and *Austrophlebioides* possess the plesiomorphic larger hindwings while *Nyungara* has the highly derived condition of a very small hindwing in relation to the forewing. Finally, members of clade A also possess the derived condition of the parallel to slightly diverging veins ICu_1 and ICu_2 of the male forewing (character 27, Fig. Figs. 571-590). This character state appears to have reverted back to the primitive condition in taxa comprising clade C as well as *Bibulmena*, *Garinjuga* and *Kirrara*. The primitive condition tends to be associated with more triangular shaped wings of the outgroup, where the junction of the hind and outer margin form an approximate 90 degree angle. This tends to expand the length of the hind margin and therefore separates ICu_1 and ICu_2 as the wing margin is approached. The relatively larger size of *Jappa*, *Ulmerophlebia*, *Atalomicria*, *Atalophlebia*, *Kirrara* and *Garinjuga* may lead to the possession of this character state from the possession of larger more robust forewings. The explanation for *Bibulmena* is less clear. It does not clearly fit into the lineages outlined by Pescador and Peters (1980a) (Fig. 383, Table 32) and has variously been attributed to the *Hapsiphlebia*, *Atalonella* and *Penaphlebia* groups (Dean 1987).

Clade B is defined by two synapomorphies. The presence of a secondary hair fringe on the labrum (character 9, Figs. 388-407) is shared by all ingroup taxa except *Kalbaybaria*, *Kirrara* and *Nyungara*. Secondary hair fringes are distinctive to Atalophlebiinae and it appears that this feature has been secondarily lost in the three genera. Similarly the ingroup all share the apomorphy of the presence of denticles on the labrum (character 10, Figs. 388-407) except *Kalbaybaria* and *Kirrara* and this may also represent a secondary convergent loss. These hypotheses, however, will only be supported by the examination

of Gondwanan genera from other countries. The monotypic genus *Kalbaybaria* is separated from the rest of the ingroup by the autapomorphy of the mandible extending anteriorly into an enlarged flattened process (character 14, Fig. 418); a feature not homologous with the horns of *Jappa* which are derived from the head capsule. Certain Leptophlebiinae (eg *Paraleptophlebia*) also possess tusks derived from the outer incisor of the mandible (Needham *et al.* 1935) but more work is required to establish the possible homology of *Kalbaybaria* and Ephemeroidea mandibular tusks (Bae and McCafferty 1995). There are some indications that the tusk robustness and setation of the Ephemeroidea is more related to burrowing and filter feeding (Bae and McCafferty 1995) as opposed to the spatulate *Kalbaybaria* tusks which, it is suggested, are used to navigate through leaf packs (Campbell 1993).

Clade C is not supported by any synapomorphies. As discussed, character 17 and character 27 are reversions to the primitive condition and are shared by various other taxa within the ingroup. The length of the hindwing subcostal vein relative to the hindwing length (character 31, Figs. 591-610) is equal to or less than 0.85 of the total wing length in the derived condition and is possessed by all members of clade C and clade J.

The monophyly of the *Hapsiphlebia* lineage (Pescador and Peters 1980a) which is considered to include five genera in Australia (*Kalbaybaria, Jappa, Ulmerophlebia, Atalomicria, Atalophlebia*) (Pescador and Peters 1980a; Campbell 1993) has not been supported in this cladogram. Pescador and Peters (1980a) found only two synapomorphies to support this lineage (see Table 32): abdominal terga with lateral margins possessing prominent setae (character 2) and the right outer incisor with broad subapical denticles (character 16). All five *'Hapsiphlebia'* genera possess the apomorphic condition of an outer incisor of the right mandible being triangularly shaped and denticulate which is considered to form a phenocline from parallel sided and smooth to becoming more triangularly-shaped and denticulate (Towns and Peters 1979; Pescador and Peters 1980a). However, only *Jappa* and *Ulmerophlebia* possess thick prominent spines on the lateral margins. Campbell (1993) assumed *Kalbaybaria* to belong to the *Hapsiphlebia* lineage as it shares several other character states with the other members of the lineage, such as labrum narrower than clypeus (character 5, Fig. 395), labrum lateral margins parallel (character 6, Fig. 395) and mandibles with straight outer margin (character 13, Fig. 418). However, all these characters represent symplesiomorphies which do not provide phylogenetic information. The distinct morphology and habitat of this tropical species, found only in Far North Queensland, may indicate a highly evolved condition although the adaptive or historical origins of its morphology remain obscure.

Clade D shows *Jappa* and *Ulmerophlebia* are closely related by the possession of three synapomorphies: body and gills fringed with fine setae (character 1, Figs. 384-397); abdominal terga with prominent setae on lateral margins (character 2) and one prominent median denticle on the labrum (character 10, Figs. 394, 408). *Jappa* is clearly separated by the autapomorphy of the presence of frontal horns (character 11, Figs. 384, 409, 410). Suggestions have been made that the two taxa are congeneric (Riek 1970; Suter 1986) due to the significant similarities other than the frontal horn. This proposal is currently being disputed (Bae, Finlay and Campbell, unpublished data).

A synapomorphy at clade E reveals a close relationship between the genera *Atalomicria* and *Atalophlebia*. These are the only genera to possess the apomorphic character of medium sized male imago upper eye lobes although this character can be subject to convergence (Bae 1991). However, the two genera are separated by *Atalomicria* possessing the autapomorphy of greatly elongate maxillary palps (character 19, Fig. 471). *Atalophlebia* possesses the convergent state of posterolateral spines on abdominal segments 2-9 (character 4), a homoplasic condition shared with clade H, and also the plesiomorphic larger hindwings.

There are a large number of synapomorphies at Clade F which separate the 'Hapsiphlebia' taxa from the rest of the ingroup. There are four multi-state characters for which all members possess the derived condition except for the *Kirrara*, *Austrophlebioides*, *Tillyardophlebia* trichotomy (clade H) which possess a more highly derived state. Thus, for clade F the labrum is subequal to slightly wider than the clypeus (character 5), the labrum has rounded lateral margins (character 6) the clypeus possesses parallel sided lateral margins (character 12), and the outer margin of the mandible is smoothly curved (character 13) (see Figs. 391-393, 396, 398-405, 414-416, 419, 421-428), while for clade H taxa the labrum is wider than the clypeus (character 5) and has angular lateral margins (character 6), the clypeus has diverging lateral margins (character 12) and the outer margin of the mandible is angular (character 13) (see Figs. 390, 397, 406, 413, 420, 430). These patterns have also been observed in the South American (Pescador and Peters 1980a) and New Zealand fauna (Towns and Peters 1979) with the primitive condition belonging to the *Hapsiphlebia*, the derived belonging to *Penaphlebia* and *Atalonella* and the highly derived belonging to the *Meridialaris*.

There are also several other synapomorphies possessed by all the members of clade F. For example, the mandible with spine-like prosthecal tuft (character 15, Figs 433-436, 439, 441-449). This character is regarded as a phenocline (Towns and Peters 1979) ranging from the primitive flap-like prosthecal tuft with hairs on apical and lateral margins gradually becoming more spine-like with hairs on the lateral margins only, until the highly

derived state is reached where the prosthecal tuft is reduced to a few hairs (eg. *Deleatidium* of New Zealand) although no such maximum reduction occurs within the Australian genera. The average number of pectinate setae on the maxillae (character 18, Figs 473-476, 479-484, 487-489) increases in the apomorphic condition. This character state is related to the width-length ratio of the galea-lacinae (character 17) where a large ratio (>1) is associated with more pectinate setae. However, the number of setae varies greatly between genera and is somewhat subjective. Therefore the number of setae was chosen as a mean rather than raw numbers but this was only able to delineate two groups rather than the three as with character 17. The condition of fewer pectinate setae reverts to the plesiomorphic condition for members of clade C, *Nyungara* and clade N (the South American subgenus *Nousia (Nousia)* and the Australian subgenera *Nousia (Australonousia)*). Finally, minor or absent spines on the terminal palp of the labium (character 21) are considered apomorphic for the all members of clade F (Figs. 513-516, 519-529) The stout equilateral triangular shaped third labial palp considered primitive by Towns and Peters (1979) is apparently associated with the stout spines on the inner margin. In Australia, these plesiomorphic states are retained only by *Atalomicria, Atalophlebia* and *Jappa*. Although *Ulmerophlebia* and *Kalbaybaria* possess spines along the inner margin of the third palp the palp is more elongated in shape. *Kalbaybaria,* in particular, has a rather elongate hirsute third labial palp which appears to be a highly derived condition.

Clade G is well supported by two synapomorphies: labium with straight upright glossae (character 20, Figs 493, 495, 496, 500, 502, 504-509) and denticulate nymphal tarsal claws (character 24, Figs 553, 555, 556, 560, 562, 564-569). The clade contains taxa belonging to the *Penaphlebia, Atalonella* and *Meridialaris* lineages of Pescador and Peters (1980a).

The position of *Bibulmena, Kaninga* and *Loamaggalangta* is unresolved within the cladogram. All possess the pleisiomorphic conditions of the labium glossae turned over ventrally (character 20. Figs. 494, 499, 501) and tarsal claws which are smooth or have minor processes (character 24, Figs. 554, 559, 561). *Loamaggalangta* is considered close to *Bibulmena* (Dean *et al.* 1999). In turn, *Bibulmena* is considered to be intermediate between the *Hapsiphlebia* and *Atalonella* lineages sharing many characters of both. The possibility has been put forward that *Bibulmena* may belong to the *Penaphlebia* lineage (Dean 1987) although it does not share the derived character states of the *Penaphlebia* lineage such as the absence of pectinate setae on the inner margin of palp 2 and prominent spines or pectinate, long setae on the posterior margins of the abdominal terga (Pescador and Peters 1980a). *Kaninga* has only recently been established as a genus (Dean 2000) and its single species is confined to south-west

Western Australia. It has been considered similar to Biblumena (Dean 2000) and Loamaggalangta (Dean et al. 1999) but the symplesiomorphic characters, such as the smooth tarsal claws and the turned over labial glossae, do not demonstrate a close relationship. Biblumena and Kaninga are found only in south west Western Australia, an indication that the origins of these species may vary from their eastern Australian counterparts. Loamaggalangta has been found solely in Tasmania where it occurs only at water depths of greater than five metres clinging to submerged objects (Dean et al. 1999) which may account for some of its more unusual features such as extremely elongated leg lengths of the nymph including a long curved smooth tarsal claw which might help it grip tightly to the substrate.

Garinjuga is the only Australian taxon considered a member of the Penaphlebia lineage (Campbell and Suter 1988). It possesses all the 'Penaphlebia' characteristics of the clypeus width subequal to labrum (character 5, Fig. 392), rounded labrum lateral margins (character 6, Fig. 392), smoothly curved outer margin of mandibles (character 13, Fig. 415) the relatively smooth right mandible inner margin of the outer incisor (character 16, Fig. 455) and the strongly recurved forewing vein MP_2 (Fig. 575). However, all of these character states, apart from the latter, are also shared by the Atalonella, Dactylophlebia and Meridialaris lineages (Pescador and Peters 1980a, see Table 31). The forewing MP_2 character state is ambiguous as 'strongly recurved' (terminology used by Pescador and Peters 1980a) is somewhat subjective. I assessed this character amongst the Australian taxa using the proviso that 'strongly recurved' as referred to more than 90 degrees but was still not able to separate the taxa, therefore this character was not considered in the phylogenetic analysis. Of the other 'Penaphlebia' characteristics there is no evidence of pectinate setae on the inner margin of maxillary palp 2 as suggested by Campbell and Suter (1988) or the long tassel-like setae on the abdominal terga posterior margins, although it does possess prominent spines in this area (character 3). Further, Garinjuga does not possess more than 25 costal crossveins in the forewing. Therefore, in the present phylogeny Garinjuga is distinguished by the prominent spines on the posterior margin of the abdominal terga (character 3) and the strongly diverging ICu_1 and ICu_2 (character 27, Fig. 575); both convergent apomorphic states. Thus the placement of Garinjuga within the lineages defined by Pescador and Peters (1980a) is unclear and will depend upon a phylogenetic analysis including all the Gondwanan fauna.

The monophyly of the three genera constituting Clade H is extremely well supported with many apomorphies. The genera all share the following apomorphies with the Meridialaris lineage (Pescador and Peters 1980a) where they are considered to belong: labrum much wider than clypeus (character 5), lateral margins of labrum angular (character 6), lateral margins of clypeus slightly diverging towards anterior (character 12) (see Figs. 390, 397,

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406), mandible with outer margin angular (character 13, Figs. 413, 420, 429), maxillae galea-lacinae broad at apex (character 17, Figs. 473, 480, 489), labium submentum with no lateral setae (character 22) and ninth sternum of female entire, not cleft (character 33, Figs. 613, 620, 629). This final character is homoplasic, being convergent with the genus *Thraulus* (Fig. 628). One more character was found for this clade that was not considered by Pescador and Peters (1980a) which is the presence of posterolateral spines on abdominal segments 2-9 (character 4), although this character state is convergent within the genus *Atalophlebia* as well.

Within clade H *Austrophlebioides* and *Tillyardophlebia* are shown to be closely related and form a clade possessing two apomorphies (clade I). Pescador and Peters (1980a) refer to a narrow anteromedian emargination of the labrum with reduced denticles and a U and/or V-shaped cleft as a derived condition possessed by the *Meridialaris* lineage (Table 31). *Austrophlebioides* and *Tillyardophlebia* have a U-shaped labrum cleft with reduced denticles which is often referred to as a labrum 'hood' (character 8, Figs. 390, 406). This character is absent from all other members of the ingroup including the other purported *Meridialaris* taxon in Australia (*Kirrara*). The unnamed Genus 'Z' from south-eastern Australia (Dean 1999) is not well known but has a wide labrum and distinct V-shaped cleft. It is considered to be related to *Austrophlebioides* and may well prove to be part of the *Meridialaris* lineage. *Austrophlebioides* and *Tillyardophlebia* are also distinguished by the apomorphic possession of prominent spination on the abdominal posterior margins (character 3); a character state shared by *Kaninga* and *Garinjuga*. Finally *Austrophlebioides* is distinguished from *Tillyardophlebia* by a relatively large hindwing (character 30, Fig. 573), also possessed by *Atalophlebia*. (Fig. 572).

Kirrara is distinguished from clade I by the possession of an autapomorphic labrum which is triangular in cross section with quite a wide anterior margin in apical view (Fig. 408). The previously named 'Genus T' (Dean and Suter 1996), which has recently been referred to *Kirrara* as an unnamed species (Christidis 2001), also possesses an apically expanded labrum where the frontal setae have been modified to form a suction disc. *Kirrara* is very similar to the highly derived *Deleatidium* of New Zealand (Towns and Peters 1996) and *Lepegenia* of New Calendonia (Peters *et al.* 1978) which have laterally and apically expanded labrum and gills forming a suction disc on the venter of the abdomen (not present in all *Deleatidium*). These are considered adaptations to extremely rapid flow which enable the species to cling tightly to the substrate. 'Genus T', *Lepegenia* and several species of *Deleatidium*, for example, have all been found in association with vertical rock faces of waterfalls. Other distinguishing characteristics of *Kirrara* include an absence of a secondary hair fringe in the labrum (character 9, Fig. 397) and an absence of labrum denticles (Fig. 397) which appears to have evolved separately for *Kirrara*,

Kalbaybaria and *Nyungara*. The genus also has the strongly diverging lCu_1 and lCu_2 veins (character 27, Fig. 580), which are probably associated with large forewings as discussed earlier.

The remaining taxa (Clade J) are united only by the homoplasic character state of hindwing subcostal vein being equal to or less than 0.85 times the length of hindwing (character 31, Figs. 591, 592, 596, 597, 602-608, 610) (convergent with all members of Clade C). For clade J this may be related to a reduced number of crossveins in the hindwing costal space (6 or less). For the independently evolved clade C however, the number of costal crossveins is always more than six in line with the rest of the ingroup and probably reflects the larger imago size. *Montikola* and *Gemmayaluka* are unresolved within clade J but do not appear closely related to *Nousia (Australonousia)*, the genus to which they were previously assigned (Dean 1999), lending strength to the establishment of the new genera.

All members of clade K possess the synapomorphy of a reduction in the average number of crossveins in the costal space of the male forewing (character 28, Figs. 583-588) which may be related to the relatively smaller size of the imagos where the cross support between the costal and subcostal veins is not needed. This clade appears to possess a strong affinity with the *Atalonella* lineage (Pescador and Peters 1980a) (with the exception of *Thraulus*). *Nyungara*, *Thraulophlebia*, *Nousia (Nousia)*, *Nousia (Australonousia)* and *Neboissophlebia* share the only derived condition of the *Atalonella* lineage (Pescador and Peters 1980a, Table 31), that of a labrum with a broad anteromedian emargination with prominent denticles. This character, however, proved to be somewhat ambiguous, especially with respect to the definition of 'broad', and as it could not be objectively defined, was not included in the phylogenetic analysis.

Nyungara and *Thraulus* (clade L) both possess the apomorphic well developed midlength costal projection of the hind wing (character 32, Figs 606, 608). Although this character is also possessed by the Leptophlebiinae in some cases (eg *Habrophlebiodes*, *Gillesia*) it is not present in the Ephemeroidea which usually possess an apical costal projection and is therefore considered a derived condition. *Thraulus* was included in the analysis as it is part of the Australian fauna, although its Gondwanan status is unclear, being primarily distributed throughout the Oriental and Ethiopian regions and Europe (Grant 1985). Evidence suggests there are two centres of origin for Leptophlebiidae: one with Holarctic-Oriental distribution and the other Gondwanan (Peters and Edmunds 1970; Edmunds 1972). *Thraulus* is known in Australia from the Northern Territory, north Queensland and north Western Australia, a distribution that superficially suggests Holarctic-Oriental affinities. However, only a more taxonomically inclusive analysis could address the question of its geographic origins.

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Further, our knowledge of *Thraulus* in Australia is rudimentary. Two morphospecies were described from the Alligator River Region of Northern Territory (Suter 1992) but were subsequently considered conspecific being referred to as *Thraulus* sp. 'AV1' (Dean 1999). From the label data attached it is clear that specimens of *Thraulus* sp. 'AV1' were are the same as *Thraulus* sp. A. named in an assessment of the macroinvertebrate fauna of Magela Creek of the Northern Territory (Marchant 1982b). Only two other unnamed species from Queensland are recognised (Dean 1999) but are based only on nymphs. Adult material is essential to further elucidate the total contingent of species in Australia.

Because of the questionable biogeographic affinities of *Thraulus* and the possibility that it does not belong with the rest of the Gondwanan fauna, it could be argued that *Thraulus* should be removed from the phylogenetic analysis. To examine this, a second strict consensus tree was produced from the 20 remaining taxa (tree length = 63, consistency index = 0.65, retention index = 0.81). The resultant clade at K (Fig. 632) collapses all subsequent nodes and introduces a second synapomorphy (character 29) indicating a stronger relationship between the terminals. Other than this very little in the cladogram has changed indicating support for the position of *Thraulus* among the Australian Atalophlebiinae.

Members of clade M all possess the derived condition of an absence of crossveins in the male forewing costal space (character 29, Fig. 583-585, 587). The evolutionary significance of this character state is unknown (W.L. Peters *pers. comm.*) but as with a reduction in the number of costal crossveins in the male forewing (character 28) it could also be related to the relatively smaller size of the male imagos. Ecological investigation will be required to determine the significance of this character state which may or may not relate to the very small size of the adults, although the state is not possessed by the females of the same species. Interestingly, despite the morphological variation between *Thraulophlebia* and *Nousia* which warrants their separate generic status (see 3.4.5, Table 18) there appear to be no phylogenetic informative characters separating the two taxa in this clade. The inclusion of the full complement of Gondwanan fauna in an analysis may elucidate some evolutionary information in the future. There has also been some question of the relationship of *Neboissophlebia* in this clade. It has been indicated that it belongs to the more primitive *Hapsiphlebia* lineage (Dean 1988) sharing characters states such as the plesiomorphic narrow maxilla galea-lacinae (character 17, Fig. 483), hypopharynx glossae turned over ventrally (character 20, Fig. 503) and smooth tarsal claws (character 24, Fig. 563). However, the cladogram indicates a closer relationship with members of the *Atalonella* lineage.

Finally, the relationship between the two subgenera of *Nousia* (clade N) is held together only by the plesiomorphic character of a reduction in the average number of subapical

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*The alternative analysis, assuming no a priori polarity of characters, also produced three most parsimonious trees which were then used to construct a strict consensus tree (Alternative Fig. 631 [see adjacent to page 288, Vol. 2]). Compared to the initial analysis this resulted in a longer tree length of 65, a marginally lower consistency index (0.63) and slightly higher retention index (0.84). No changes were apparent within the ingroup. Indeed the only variation between the cladograms relate to homoplasy connected with the outgroup *Ephemera*. Character convergence shared by *Ephemera* includes: a mandible with an enlarged process along with *Kalbaybaria* (character 14, Fig. 418); greatly elongate maxillary palps along with *Atalomicria* (character 19, Fig. 471) and a medium eye size for the male imago (character 25) along with the other members of clade E (character 25). As mentioned previously (p. 307) the differing morphologies of the enlarged mandibular process in *Kalbaybaria* and ephemerid mayflies may be related to specialised behavioural and feeding habits. The function of elongate maxillary palps is also unknown but, again, the palp morphologies of two genera are quite distinct. In *Atalomicria* it is segments one and two which make up most of the length whereas in *Ephemera* all segments are equally elongate. Reduced or absent maxillary palps are common in the Ephemerellidae (Merritt and Cummins 1996), a family within the superfamily Caenoidea which is considered a more primitive lineage (McCafferty 1991b, McCafferty 2002). Finally, large or contiguous imago eye size is possessed by all terminals of the cladogram except for *Ephemera, Atalomicria* and *Atalophlebia*. Although smaller eye size has been noted as an apomorphy the character is also considered liable to parallelism (Bae 1991).

pectinate setae on the maxillae (character 18, Figs. 484-485). This character is also possessed by various other taxa, for example, members of clade C which also have the companion character of a very narrow galea-lacinae apex but also, less explicably, *Nyungara* which has a width-length ratio of the galea-lacinae approximately equal to 1. No characters separate the two subgenera of *Nousia* which, based on morphological evidence, does not appear entirely warranted (see 3.3.4). However, a more complete revision of *Nousia (Australonousia)* may reveal some consistent phylogenetic evidence that may justify the subgeneric separation. see opposite*

6.8 Conclusions

The relationships of the Australian Leptophlebiidae, as represented in the cladogram (Fig. 631), do not fit readily into the lineages proposed by for the Southern Hemisphere fauna (Pescador and Peters 1980a, Fig. 383). There is no support for the *Hapsiphlebia* lineage, which in Australia is considered to comprise the genera *Atalomicria, Atalophlebia, Jappa, Ulmerophlebia* and *Kalbaybaria* (Pescador and Peters 1980a; Campbell 1993). All five genera share only one plesiomorphic condition (broad subapical denticles on the right outer incisor) which is insufficient to establish monophyly in this case. *Kalbaybaria*, as discussed, is highly distinct and its relationships to the rest of the Australia genera unresolved. *Jappa* and *Ulmerophlebia*, however, form a well supported monophyly.

The *Penaphlebia* lineage is only represented in Australia by the genus *Garinjuga* but this taxon does not possess any of the synapomorphies considered to define the lineage. It appears to have been placed in this lineage predominantly by plesiomorphic characters (Campbell and Suter 1988) which do not constitute an evolutionary relationship and its position amongst the Australian Leptophlebiid fauna is unclear. This also applies to the unresolved relationships of *Bibulmena, Kaninga* and *Loamaggalangta* which are considered to variously belong to the *Penaphlebia* lineages or somewhere between the *Hapsiphlebia* and *Atalonella* lineages (Dean 1987; Dean et al. 1999; Dean 2000). It is likely that their particular characteristics have evolved in response to the varying origins (Western Australia, Tasmania) or habitats (eg: extremely deep pools) of these taxa.

The *Atalonella* lineage is supported only by one character (the reduction in the number of costal crossveins in the male forewing). This character, however, was not included in the original characters considered by Pescador and Peters (1980a) to define the lineage. In fact, the only apomorphy that defines the lineage according to Pescador and Peters (1980a) is the antero-median emargination of the labrum with broad sub-apical denticles, which was considered too ambiguous amongst the Australian taxa and was subsequently not included in the analysis. It is clear that the relationships of the *Atalonella* fauna need

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more examination, especially the placement of the new genera *Montikola* and *Gemmayaluka* which, by virtue of their previous status within *Nousia* (*Australonousia*), are considered closely related to them.

The only lineage of Pescador and Peters (1980a) which is well supported in this cladogram is that of the *Meridialaris*, the Australian members of which include *Kirrara*, *Austrophlebioides* and *Tillyardophlebia* (clade H). This monophyletic clade includes a number of synapomorphies, many of which are multi-state and show highly derived conditions. This finding is supported by the cladogram of Australian fauna Christidis (2001) which also shows a monophyletic *Meridialaris* lineage at the species level, including many unnamed species which she discovered in Queensland. Similarly, the phylogenetic tree of Towns and Peters (1996) shows a close relationship between *Deleatidium* and *Atalophlebioides* which are considered to be the New Zealand representatives of the *Meridialaris* lineage.

The Australian phylogeny by Christidis (2001) also grouped together *Nyungara*, *Nousia* (*Australonousia*) and *Thraulophlebia* (as *Koorrnonga*) in a monophyletic clade, but notably this did not include *Neboissophlebia* whose relationship was unresolved. In line with the phylogeny presented here the relationships of *Biblumena*, *Garinjuga* and *Loamaggalangta* (as 'Genus K') and the '*Hapsiphlebia*' genera (*Jappa*, *Ulmerophlebia*, *Kalbaybaria*, *Atalophlebia*, *Atalomicria*) were also unresolved (Christidis 2001).

In general terms the phylogeny of the New Zealand fauna (Towns and Peters 1996) is also unrepresentative of the lineages outlined by Pescador and Peters (1980a). Apart from the monophyletic *Dactylophlebia* lineage, and the close relationship of the two '*Meridialaris*' genera (see above), the relationships of the rest of the fauna are unresolved. More work is needed, for example, to elucidate the placement of *Neozephlebia*, the only New Zealand representative of the *Atalonella* lineage.

At the beginning of the analysis an assumption was made that the ingroup taxa were monophyletic. In fact, the ingroup taxa are clearly paraphyletic due to the exclusion of the remaining worldwide Leptophlebiid taxa. The inordinately large number of Leptophlebiid taxa worldwide (Hubbard 1990) has so far prevented an analysis of the phylogenetic relationships of the family as a whole. Despite this much progress has been made on the relationships of other Gondwanan fauna, such as those in South America and New Zealand, as we have seen. The value of this analysis is, not only in a preliminary elucidation of the relationships of the Australian fauna, but also the information it contributes to the investigation of a possibly monophyletic Gondwanan lineage. Such a study would require co-operation from ephemeropterologists around the world, each

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conversant with their own country's fauna. Now that the preliminary relationships among the Australian taxa have been more thoroughly elucidated, these findings can be used as a basis for development of a Gondwanan phylogeny and ultimately a phylogeny of the Leptophlebiidae worldwide.

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APPENDICES

APPENDIX 1

CONSTRUCTION AND EVALUATION OF A NEW LABORATORY SYSTEM FOR REARING MAYFLIES

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ABSTRACT

A new laboratory system was developed for rearing adults of Australian Leptophlebiidae (Ephemeroptera). The space-efficient chambers, made from readily available materials, are an inexpensive alternative to conventional rearing systems and worked just as well, and in many cases better, than a comparable larger system. Genera differed significantly in rearing success. No genera were significantly affected by the rearing conditions except *Austrophlebioides* Campbell and Suter (1988), which responded strongly to all external factors. This suggests that a more restricted environmental regime may be required to maximise emergence success for this genus. Sex ratios were biased towards females for all genera, indicating the possible occurrence of parthenogenesis in Australian Leptophlebiidae.

INTRODUCTION

Positive identification of species requires examination of all life stages for most aquatic insects. However, in most cases, identification of species has been based on the nymphs or adults only with no association being made between the two (Hynes, 1970; Smock, 1996; Merritt *et al.*, 1996). Field collecting of nymphs and adults in one location is an accepted method of identifying all insect life stages but has the inherent problem with discriminating between different species, especially if one has to rely on immature nymphs for initial identification. An insect reared from an immature stage to an adult, with the subsequent larval skin moult kept for comparison, provides the definitive association.

Many authors have made suggestions for rearing aquatic insects to adults (see review by Merritt *et al.*, 1996). The two main approaches are field and laboratory rearing. Most field rearing techniques involve a mechanism for containing the nymphs within the existing water body and providing room for the animal to emerge while safe from drowning (Speith, 1938; Fremling,1967; Day, 1968; Schnieder, 1967; Edmunds *et al.*,1976). An alternative is the use of emergence traps (Hynes, 1941; Southwood, 1978; Merritt *et al.*, 1996). Despite the relative
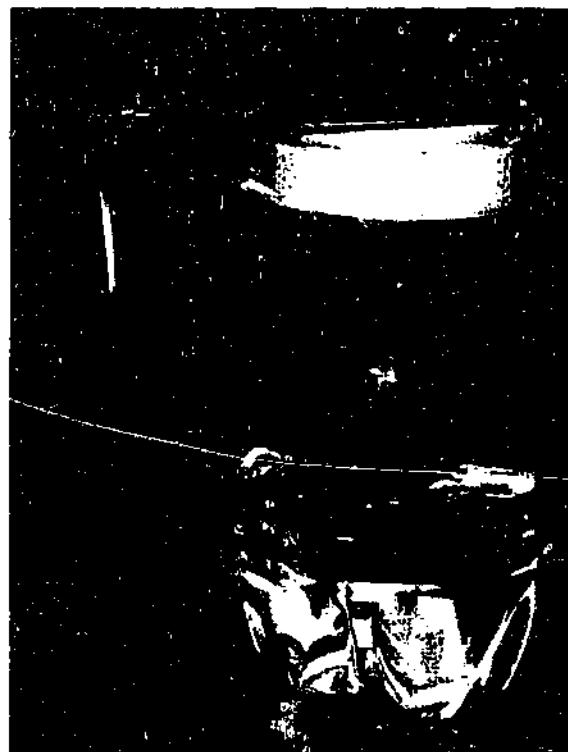
Fig. 1. The new rearing chamber. The aquarium tubing is connected to an air supply.

simplicity of design, the disadvantage of field rearing is that it may require the researcher to be away from the workplace for extended periods. Laboratory methods range from simple to extremely complex as authors have tried to address the problem of recreating stream flow conditions. Covered aquariums are used in conjunction with various methods of inducing a current such as a magnetic stirrer (Mason and Lewis, 1970) or directed air (Craig, 1966). Gravity flow systems were first used by Hynes (1941) and improved upon by Mason and Lewis (1970). Later came the development of large flow tanks powered by propellers (Vogel and La-Barbera, 1978) and complicated systems designed more specifically for the purposes of toxicity testing (Buikema and Voshell, 1993). All have the disadvantage of being suitable only for mass rearing and often requiring large inputs of electrical power. None address the issues of cost-effectiveness and simplicity in a field where rearing is likely to be of secondary concern.

The rearing of mayflies can be especially difficult because of the presence of a fragile subimago stage which has characteristics different to those of the adult. With all these factors in mind I have designed and tested a new laboratory rearing system for mayflies. Each chamber houses one individual and allows the animal to pass through the stages of nymph and subimago without disturbance. The chambers are made from readily obtainable material and are easy to construct. They are space-efficient and inexpensive, costing less than US$2.00 each when an air supply is available. Such systems have been described before in the literature (Merritt et al., 1996) but I have yet to find a published account of their use.

An analysis of the success of the new rearing system by imago emergence success rates in relation to genus, sex, photoperiod, year of collection, temperature, and for an alternative chamber type has been conducted. The influences of altitude of collection and refrigerated storage of nymphs, which was often necessary after a prolonged collecting trip, were also investigated. These data were collected as a consequence of rearing mayfly adults for taxonomic review rather than experimental purposes. The data collected provides indications of how these genera may respond to factors influencing emergence in the field, however, the laboratory outcomes are, at present, analysed at genus level only. Within each genus there may well be species with very different responses to these environmental factors. Further, only one controlled temperature room was used for this work, therefore all individuals from each
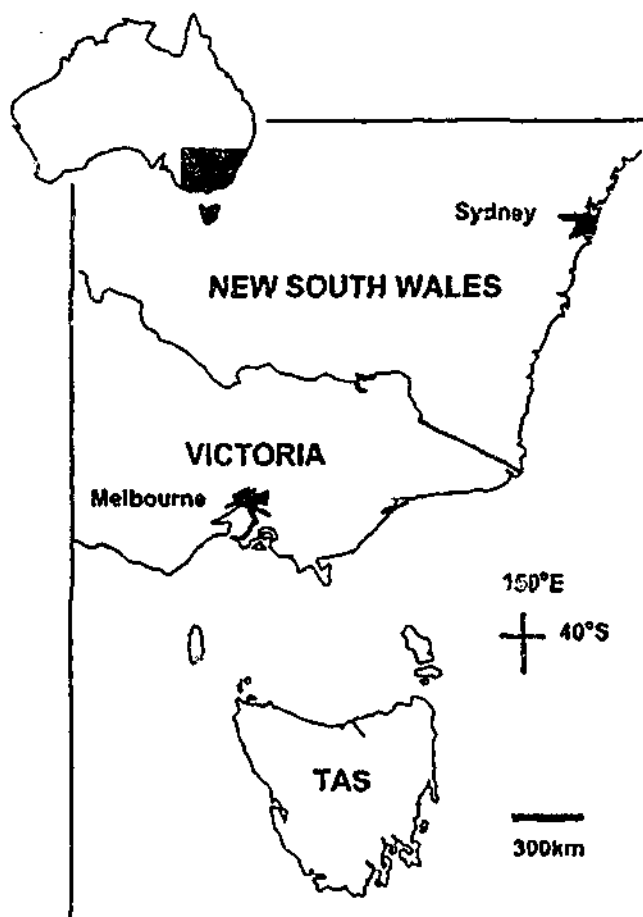
Fig. 2. South-east Australia: area from which mayflies were collected.

separate field collection were placed in the same temperature and photoperiod regimes. As a result the species compositions of the groups receiving each set of conditions may well have been different. In these circumstances it is difficult to be confident that the results obtained mirror responses in the field. Nevertheless, these observations may be of interest to workers concerned with field responses of mayfly nymphs to environmental conditions.

METHODS

Chamber Design

The new rearing chamber (Figure 1) was constructed from a 1.25 litre plastic soft drink bottle. This was cut in two at about two-thirds its length, at the point where the sides start to converge towards the lid. The open container was lined with nylon mesh, which can either be glued in place or simply wetted. Two hooks were attached facing outwards and opposite each other on the outside of the bottle using electrical tape, so that a rubber band could be stretched between them across the open end. A small hole (diameter of 6 -7 mm) was drilled in the plastic bottle lid. The top third of the bottle with the lid was then inverted to sit in the chamber, lid downwards, and secured by the rubber band. The chamber was then half filled with water. Compressed air was supplied to the chamber by means of PVC aquarium tubing (interior diameter 4 mm) attached to a pump or laboratory air supply. Up to ten chambers can be aerated from one s all 240V air pump linked through aquarium tubing, although each chamber requires a two-way controller so flow can be balanced. It is also advisable to attach a plastic micropipette tip to the end of the tubing to restrict the flow of bubbles to a small stream. Glass pipettes proved too fragile and, being heavier, were prone to blockage by resting on the chamber bottom.
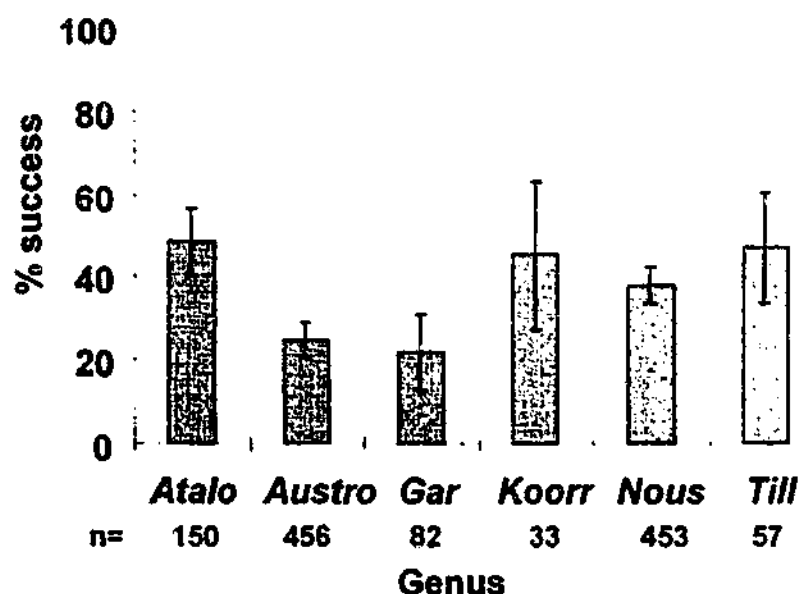
Fig. 3. Imago emergence success by genus.
Abbreviations for genera are as follows: Atalo=*Atalophlebia*, Austro=*Austrophlebioides*, Gar=*Garinjuga*, Koorr=*Koorrnonga*, Nous=*Nousia*, Till=*Tillyardophlebia*. Bars represent 95% confidence intervals.

Data Collection

Mayfly nymphs from the family Leptophlebiidae were collected over two extended summer periods; October 1996 to April 1997 (year 1) and October 1997 to April 1998 (year 2) from 123 sites throughout Victoria, Tasmania and New South Wales (Figure 2). Animals were collected from altitudes on the shoreline (<10 m) to near the summit of Australia's highest point, Mt Kosciusko (1650m), and therefore represent species from a wide range of climatically diverse regions. Two closely related Leptophlebiids, *Nousia* Navás (1918) and *Koorrnonga* Campbell and Suter (1988), were targeted for collection as part of a larger taxonomic study being undertaken, although all Leptophlebiidae were collected if found. *Nousia* and *Koorrnonga* are relatively common in stream riffles in association with logs and organic matter (Peters and Campbell, 1991), so the sampling regime favoured these areas.

Late instar nymphs were carefully removed from the substrate with a paintbrush and placed in a bottle of the stream's water. The bottle was sealed and placed on ice for transportation to the laboratory. During the day the water was adequately aerated through the motion of the vehicle but at night a battery-operated pump was employed to aerate each chamber.

Laboratory Rearing

Each rearing chamber was half filled with water from a particular site; and one late instar individual from that site added. Twigs collected from the site were added to each chamber for the insect to use as a food source and as a platform for emergence. Each chamber was attached to an air supply and placed in controlled temperature room environments at 16°C, 18°C, 20°C or 22°C. Photoperiods of 12 hours daylight and darkness (12:12) or 14 hours daylight, 10 hours darkness (14:10) were used. Some nymphs were placed in much larger chambers designed by Campbell (1983). These were made from a cube-shaped frame of wood to which fly-screen or mesh is stapled on all sides. A container, which can hold volumes up to 500 ml, was placed inside the frame and connected to an air supply by aquarium tubing through a small hole. Surplus nymphs were stored in an aerated container refrigerated to 7°C. In the controlled environment the nymphs were checked every second day and the life cycle stage of the individual noted. Once emergence (or death)

occurred the animals were removed and genus and sex determined by observation using a stereomicroscope. Empty chambers were thoroughly washed and nymphs replaced from refrigerated stock. These new nymphs were acclimatised to the controlled temperatures for a period of 20 to 30 minutes.

RESULTS

The full data set included 1251 individuals of which *Austrophlebioides* and *Nousia* predominated, comprising 36.5% and 36.2% respectively. Next came *Atalohplebia* Eaton (1881) at 12%, then *Garinjuga* (Campbell and Suter (1988)) at 6.6%, *Tillyardophlebia* Dean (1997) at 4.6%, *Koorrnonga* (Campbell and Suter (1988)) (2.6%) and *Ulmerophlebia* Demoulin (1955) at 0.9%. A few individuals of other genera, such as *Atalomicra, Jappa, Kirrara* and an undescribed one, were also collected and represented the remaining 0.6%. Of the ten named genera in south-east Australia, all were sampled except *Neboissophlebia* Dean (1988), despite this genus having been found previously in many of the sites where I collected (Dean, 1988). Data analysis will focus on the six most prevalent genera.

Emergence Success

Imago emergence success rate for the full data set was 34.1% with 10.0% reaching the subimago stage before dying and 55.9% dying as nymphs. Individual genera, however, differed significantly in emergence success (χ^2=46.071, df=5, p<<0.001, Figure 3). *Atalophlebia* was reared most successfully with 48.7% becoming imagos. Other highly successful genera were *Tillyardophlebia* (47.4%) and *Koorrnonga* (45.5%). The genus with the lowest success rate was *Garinjuga* (22.0%) followed by *Austrophlebioides* (25.0%).

The new rearing chamber was compared with that designed by Campbell (1983). The new chamber produced higher imago emergence rates compared with the 'old' one for all the genera examined (except *Nousia*) (Table 1). A significant difference was found only for *Austrophlebioides* (χ^2= 5.993, df=1, p=0.014), where the emergence success rate more than doubled in the new chambers (27.1% versus 12.7%).

Emergence success did not differ between the sexes for any genus excep *Tillyardophlebia* (Table 1) where a much greater proportion of females (58.8%) than male (30.4%) emerged successfully (χ^2= 4.435, df=1, p=0.035). The effect of varying the photoperiod could be analysed only for year 1 as there were no individuals reared under 12:12 conditions during year 2. Within the restricted data set a significant difference due to photoperiod was found only for *Austrophlebioides* (χ^2= 17.810, df=1, p<<0.001, Table 1) yet this went against the trend for all other genera where success rates, although not significantly different, were higher under a 12:12 cycle. Similarly, the effect of year of collection could only be examined in relation to photoperiod 14:10. Again there was a significant difference between year 1 and 2 only for *Austrophlebioides* (χ^2= 56.936, df=1, p<<0.001, Table 1). There was no apparent trend for the other genera.

For most genera the proportion successfully emerging was highest at 18°C (for *Nousia* this occurred at 16°C but the difference in success rate from 18°C was very slight; 0.1%). The temperature which produced the lowest proportion of successful emergence was 22°C. The effect of temperature was significant for both *Austrophlebioides* (χ^2= 47.838, df=3, p<<0.001) and *Nousia* (χ^2= 10.517, df=3, p=0.015, Table 1). The effect of temperature was also considered in relation to time spent in the rearing system for a restricted number of genera (Figure 4). Time taken to emerge successfully was greatest at 18°C followed by 16°C, 20°C then 22°C. Although patterns of response to temperature were similar for each genus, the time taken to reach outcome varied considerably. For example, at 18°C mean time to emerge varied from 7.7 days for *Nousia* to 12.9 days for *Atalophlebia*. Data were log transformed to meet the assumption of normality and an ANOVA run to test for a significant effect of temperature. All genera had significant temperature effects (*Nousia,* F-ratio = 0.635,

Table 1. Percentages of successful emergences as affected by collection and rearing conditions

	Atalo-phlebia	Austro-phlebioides	Garinjuga	Koorrnonga	Nousia	Tillyard-phlebia
Chamber Type						
p value	0.628	0.014	**	**	0.926	**
n	150	454	82	33	453	57
% success old cage	44.4	12.6	15.4	37.5	38.7	50.0
% success new cage	49.6	27.1	23.2	48.0	38.1	47.0
Sex						
p value	0.795	0.909	0.542	0.435	0.234	0.035
n	150	456	82	33	453	57
% success female	47.8	24.8	20.0	40.0	40.0	58.8
% success male	50.0	25.3	25.9	53.8	34.2	30.4
Photoperiod (year 1) *						
p value	**	0.000	**	**	0.293	**
n	62	164	82	3	166	14
% success 12:12	62.3	24.0	28.2	100.0	46.8	53.8
% success 14:10	33.3	56.5	18.0	100.0	38.4	0.0
Year of Coll (photoperiod 14:10)						
p value	**	0.000	**	**	0.687	**
n	97	377	50	31	391	44
% success – year 1	33.3	56.5	13.0	100.00	38.5	0.0
% success – year 2	42.0	16.1	22.2	40.00	36.2	46.5
Temperature						
p value	**	0.000	**	**	0.015	**
n	150	456	82	33	452	57
% success 16°C	43.4	23.6	20.0	42.1	46.4	51.4
% success 18°C	59.0	45.4	25.6	100.0	46.3	53.8
% success 20°C	50.0	24.3	42.8	0	38.9	25.0
% success 22°C	38.2	10.8	9.5	40.0	29.3	0
Altitude						
p value	0.126	0.000	**	**	0.118	**
n	150	456	82	33	453	57
% success <400m	46.9	33.1	24.5	12.5	39.4	50.0
% success 400-800m	44.4	22.5	-	54.5	34.5	16.7
% success 801-1200m	73.3	9.6	0.0	-	15.4	100.0
% success >1200m	-	6.1	19.0	66.7	56.3	-
Storage						
p-value	**	0.000	**	**	0.856	**
n	150	456	82	33	453	57
% success 0-2 days	43.8	32.3	20.9	50.0	38.5	62.5
% success 3-5 days	75.0	19.8	33.3	33.3	35.0	28.6
% success > 5 days	62.5	12.0	16.7	50.0	39.1	27.8

Effect of each factor analysed by χ^2 Significant p values (at < 0.05) shown in bold.
* analysed on restricted data set as there were no mayflies reared under the 12:12 regime in year 2.
** one or more categories with small sample size: χ^2 test not reliable.
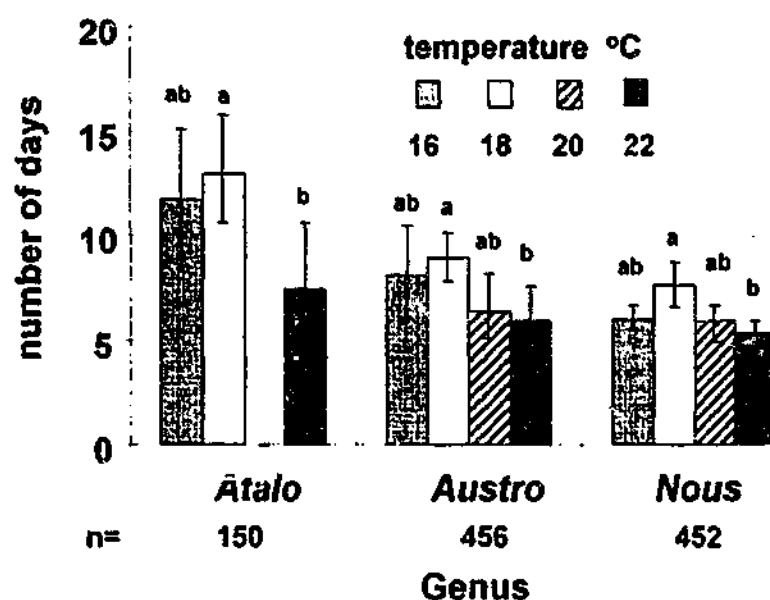
Fig. 4. Effect of temperature on time taken to successful emergence by genus.
Abbreviations for genera as in Figure 3. Data back transformed from logged values. Bars represent back transformed standard error. Within each genus temperatures without a letter in common are significantly different (p-value less than 0.05) by Tukeys HSD tests.

df=3, p=0.010; *Austrophlebioides*, F-ratio=4.269, df=3, p=0.007; *Atalophlebia*, 20°C degrees removed, F-ratio = 4.354, df=2, p=0.017) although multiple r^2 showed that very little variability (around 10% or less) in rearing time was explained by temperature differences. Tukey's HSD tests showed significant differences between the temperatures 18°C and 22°C only for all genera (Figure 4).

The effect of altitude of collection on rearing success by genus was examined by chi-squared for 4 altitude categories. (1. <400 m, 2. 400-800 m, 3. 801-1200 m, 4. > 1200 m) and was found to be significant only for *Austrophlebioides* (χ^2= 29.826, df=3, p<<0.001, Table 1) where the highest success rates were found at progressively lower altitudes.

Division of storage time into three categories (1. 0-2 days, 2. 3-5 days, 3. >5 days) and subsequent analysis by chi-squared also showed a significant effect only for the genus *Austrophlebioides* (χ^2=18.297,df=2, p<<0.001, Table 1) with a higher success rate for progressively less days in storage. However, altitude of collection and storage time were positively correlated as it took longer to return to the laboratory from high altitude collection sites. A logistic regression of both factors against emergence success showed altitude probably was more influential than storage.

Sex-Ratios

Ratios of males to females showed a female bias for all individual genera in the range of 1: 1.5 for *Tillyardophlebia* to 1: 2.1 for *Nousia* (Figure 5). Chi-squared analysis was used to determine departure from the expected 1:1 sex ratio and was found to be significant for all genera except *Koormorga* and *Tillyardophlebia*.

DISCUSSION

The overall imago emergence success rate was 34%. Clearly, however, success rates depend on the genus in question. Taxa preferring slow waters would be expected to emerge more successfully in aerated tanks with low flow regimes (Edmunds *et al.*,1976). Therefore,
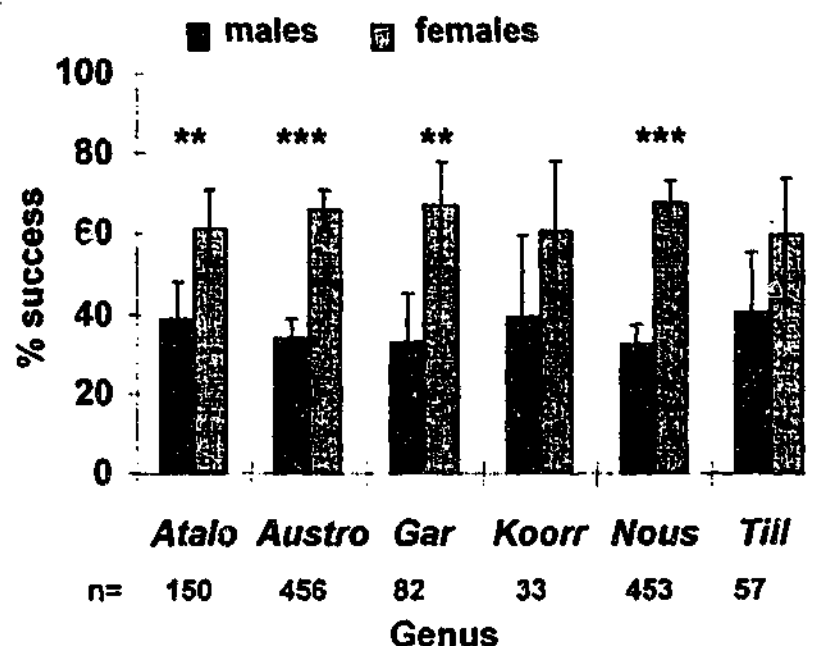
Fig. 5. Mayfly sex-ratios of six genera captured over 2 extended summer periods.
Abbreviations for genera as in Figure 3. Bars represent 95% confidence intervals.
Asterisks indicate significant departures (at less than 5% significance level) from 1:1 ratio by chi-squared.

it is not surprising that *Atalophlebia*, predominantly found in standing or slowly flowing waters (Peters and Campbell, 1991), had the greatest proportion of imagos that emerged. The relatively low success rates of *Garinjuga* may be due to the presence of a possibly new high altitude species for which the emergence success was very low, thereby reducing the average for the whole genus.

Overall, the new rearing system was a success in that imago emergence rates were generally higher in the new chamber compared with the older one for all genera. In particular, the success rate for *Austrophlebioides* was much greater in the new chamber. The considerable advantages of the new chambers in terms of time saved in construction and set-up, space efficiency and low cost indicate that the system could be widely used even if just for routine species identification.

In general, few factors had an effect on overall emergence success for any genera other than *Austrophlebioides*. Sex appeared to affect *Tillyardophlebia* but, because this was a relatively small data set, may not prove to be biologically significant. There are also some temperature effects for *Nousia* and *Atalophlebia* which must be considered. (Table 1, Figure 4). Most striking, however, were the results for the genus *Austrophlebioides* which appeared to be affected strongly by all factors except sex. This is almost certainly related to habitat requirements. For example, the greater rearing success in smaller chambers with much less water could be indicative of an inherent need for highly oxygenated water in this genus. Neither chamber adequately simulates current flow, but the new chamber may provide more oxygen per volume than the 'old' chamber. A high rate of water movement may be necessary for the development of this genus. Similarly, the highly positive response to a 14 hour photoperiod, which is typical of an Australian summer light regime, may be required as a cue for *Austrophlebioides* to emerge. If this is so, this is the first record of an enhanced emergence response to photoperiod for Australian Leptophlebiidae as photoperiod has been shown previously to have no effect on mayfly egg hatching or emergence (Brittain, 1982; Suter and Bishop, 1990; Newbold *et al.*, 1994) despite the suggestion that it is important for aquatic insects in general by Hynes (1970).

Austrophlebioides fared better in year 1 possibly because they were stored for much less time (0.1 mean days in year 1 compared with 4.9 mean days in year 2). Progressively shorter storage times produced significantly higher success rates. Another contributing factor

may be that altitude range for each year was considerably skewed, with animals being collected no higher than 500 m in year 1, yet up to 1560 m in year 2; progressively lower altitudes produced greater emergence success rates.

It is acknowledged that animals do not respond to altitude *per se* but rather environmental variables associated with altitude (see reviews by Minshall, 1988; Power *et al.*, 1988) such as temperature, substrate, dissolved oxygen and hydraulic variation. One can speculate that there is greater temperature differential between higher altitude sites and the laboratory compared with lower altitude sites, possibly making the physiological stress on the animals greater.

Temperature not only determines abundance, distribution and diversity of stream insects (Hynes, 1970; Ward and Stanford, 1982; Zamora-Muñoz *et al.*, 1993) but is considered to be one of the most important influencing factors affecting insect development (Corkum, 1978; Elliott, 1978; Brittain, 1982; Wallace and Anderson, 1996). Indeed, in this study, temperature was the only external factor significantly affecting emergence success of a genus other than *Austrophlebioides*. Success rates were much higher at 18°C than at 22°C, yet summer water temperatures would be within the range 16-22°C for all but the highest altitudes; so it is puzzling to find such a restricted temperature preference for emergence. This restricted preference also applied to the length of time taken to emerge. It is possible that the nymphs have a narrow temperature requirement for development which is in line with the theory of Sweeney and Vannote (1978) that an optimal thermal regime exists for a given species. Adult size and fecundity and, presumably emergence rates, may diminish outside the bounds of the optimal regime for the species.

Trends in the data are not significant with the clear exception of *Austrophlebioides*. Species level data within this genus would therefore be especially valuable.

Sex-Ratios

Insect sex-ratios in nature are generally expected to be 1:1 although skewed ratios due to inbreeding occur and will be biased towards females (Thornhill and Alcock, 1983). Female biased sex ratios in Ephemeroptera have been recorded only for parthenogenetic taxa of which 50 species are known worldwide (Brittain, 1982) and only in 3 or 4 families (McCafferty and Huff, 1974). It appears obligatory in only a few species (Peters and Campbell, 1991). In general, parthenogenetic eggs develop more slowly, causing·a delayed female bias in the sex ratio of the nymphs which is perpetuated through the life cycle. For example Harker (1997) found sex ratios of *Cloeon similae* (Baetidae) increased from 1:1 in the summer to 2:1 in Spring and early Winter over 13 consecutive years due to a longer development time for the unfertilised eggs and subsequent late appearance of parthenogenetic progeny (females). Data for the present study were collected from a wide range of sites over two years, so it is possible that the observed sex ratio actually reflects what occurs in nature. As far as I am aware there are no previous records of parthenogenesis occurring in Australian Leptophlebiidae.

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APPENDIX 2

Alphabetically listed locality data for each specimen examined.
Presence or absence of each species and genus at each site also noted.

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
1	VIC	Aberfeldy River	Walhalla Rd, Aberfeldy Picnic Ground	99021506	320	146.2545	-37.5117	KJF collection	15 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	VIC	Acheron River		87030500	320	145.4100	-37.3000	AWT	05 III 1987	TD&RM	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
3	VIC	Acheron River	Marysville	97120500	560	145.4326	-37.3855	MV	05 XII 1997	MRHI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4	VIC	Acheron River	Granton Rd	98020101	390	145.4127	-37.3442	KJF collection	01 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5	VIC	Acheron River	Granton Rd	98021505	390	145.4127	-37.3442	KJF collection	15 II 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
6	VIC	Agnes River	Agnes Falls	99021104	150	146.2210	-38.3837	KJF collection	11 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7	VIC	Aire River	Hall Rd Track	96033101	170	143.2855	-38.4218	KJF collection	31 III 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	VIC	Aire River	Hopetoun Falls	98100902	260	143.3405	-38.4005	KJF collection	09 X 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	VIC	Albert River	Albert River Rd	97013001	70	146.2830	-38.3205	KJF collection	30 I 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	VIC	Albert River	Albert River Rd	84053100	330	146.2326	-38.3022	MV-EPH1768	31 V 1984	DC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
11	NSW	Allyn River	12km N of Eccelston	80022101	300	151.2900	-32.0900	MV	21 II 1980	AC	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
12	TAS	Ansons River	Rd to Pioneer	95020902	80	148.0900	-41.1100	MV-EPH0204, 0205	09 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
13	VIC	Arkins Creek west branch	weir at Wyelangta	99121903	330	143.2624	-38.3900	KJF collection	19 XII 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14	TAS	Arthur River	Tayatea Bridge	94102500	x	x	x	MV-EPH1475	25 X 1994	MRHI	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
15	TAS	Arthurs Lake	Pumping Station	96121703	960	146.5140	-41.5925		17 XII 1996		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	TAS	Aspley River	Bicheno	72110900	20	148.1800	-41.5200	MV	09 XI 1972	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
17	QLD	Atherton		10010000	800	145.2800	-17.1600	SMNH	I 1910-1913	ME	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
18	VIC	Aura Vale inlet stream	Cardinia	76111200	175	145.2314	-37.5625	MV-EPH1620	12 XI 1976	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similllima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
19	VIC	Aura Vale inlet stream	Cardinia	98022601	175	145.2314	-37.5625	KJF collection	26 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
20	VIC	Aura Vale Lake	Hentys Picnic Area	97112401	140	145.2317	-37.5619	KJF collection	24 XI 1997	KJF	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
21	VIC	Avon River	Princes Highway, Stratford	99021201	10	147.0431	-37.5824	KJF collection	12 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	VIC	Axe Creek	McIvor Highway	99022308	170	144.2541	-36.4629	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	VIC	Badger Creek	Dairy Rd	76032500	90	145.3100	-37.4100	MV-EPH1503, 1504, 1557, 1626	25 III 1976	JD	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
24	VIC	Badger Creek	downstream weir	78033000	280	145.3400	-37.4100	MV-EPH1506	30 III 1978	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
25	VIC	Badger Creek	downstream weir	80010800	280	145.3400	-37.4100	MV-EPH1505, 1671	08 I 1980	JD	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
26	VIC	Badger Creek	downstream weir	80011801	280	145.3400	-37.4100	MV-EPH1582, 1726	18 I 1980	JD	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
27	VIC	Badger Creek	downstream weir	80020700	280	145.3400	-37.4100	MV-EPH1627	07 II 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
28	VIC	Badger Creek	downstream weir	80022102	280	145.3400	-37.4100	MV-EPH1630, 1726	21 II 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
29	VIC	Badger Creek	downstream weir	80032001	280	145.3400	-37.4100	MV-EPH1628, 1725	20 III 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
30	VIC	Badger Creek	junction of Badger Creek Rd and Bluegum Drive	97040602	130	145.3211	-37.4102	KJF collection	06 IV 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
31	VIC	Badger Creek, upstream weir	upstream weir, Badger Weir Park, 5km SE of Healesville	80011802	300	145.3404	-37.4117	MV-EPH1605, 1714	18 I 1980	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
32	VIC	Badger Creek, upstream weir	upstream weir, Badger Weir Park, 5km SE of Healesville	80032002	300	145.3404	-37.4117	MV-EPH1606	20 III 1980	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
33	VIC	Baldy Creek	Mt Stirling Rd	75041700	1220	146.2700	-37.0600	MV-EPH1727	17 IV 1975	RM	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
34	VIC	Barkly River	Lyndon Flat, 9km NW of Licola (Mc14)	76120300	260	146.3400	-37.3300	MV	03 XII 1976	AC	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
35	VIC	Barkly River	Glen Cairn-Licola Rd, Alpine NP	97020501	280	146.3404	-37.3339	KJF collection	05 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	VIC	Barneys Creek	Grampians	83120200	300	142.3200	-37.1300	MV-EPH1635, 1636, 1637, 1638	02 XII 1983	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
37	NSW	Barrengary Creek	Upper River Rd to Upper Kangaroo Valley	84102801	70	150.3100	-34.4300	MV-EPH1683	28 X 1984	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
38	TAS	Barrow Creek	Tasman Highway	95020801	390	147.2100	-41.2000	MV-EPH0215	08 II 1995	PS&PG	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
39	VIC	Barwon River	Princes Highway	96032801	80	143.5922	-38.1435	KJF collection	28 III 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	VIC	Bellbrook Creek	Midland Highway, Yinnar South	99030402	100	146.1837	-38.2203	KJF collection	04 III 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
41	VIC	Bemm River	Club Terrace-Goolengook Rd	81032100	100	148.5400	-37.3400	MV-EPH1654	21 III 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
42	NSW	Betts Creek	Summit Rd	97120202	1740	148.2300	-36.2600	KJF collection	02 XII 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
43	VIC	Big Pats Creek	Riverside Drive	97042503	160	145.4345	-37.4510	KJF collection	25 IV 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	VIC	Big River	Jamieson-Eildon Rd	98021503	300	146.0312	-37.2203	KJF collection	15 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
45	VIC	Black Snake Creek	Dyers Creek Picnic Ground, Gembrook South	97012902	115	145.4006	-37.5655	KJF collection	29 I 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
46	QLD	Blackfellows Falls	Springbrook, Warrie NP	79120601	770	153.1600	-28.1300	MV-EPH1691, 1692	06 XII 1979	DC	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
47	VIC	Bluff Creek	11.7 km up Stirling Rd	81110201	1310	146.2838	-37.0749	MV-EPH1741, 1742	02 XI 1981	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
48	VIC	Bodmans Creek	Hyland Highway	99030401	50	146.4234	-38.3015	KJF collection	04 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	VIC	Boggy Creek	Great Alpine Rd, Alpine National Park	96111803	1300	147.1843	-37.0255	KJF collection	18 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	VIC	Boggy River	Princes Highway, Nowa Nowa	99021202	10	148.0534	-37.4356	KJF collection	12 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	VIC	Bogong Jack Creek	West Kiewa Logging Rd	97110602	1070	147.1012	-36.4959	KJF collection	06 XI 1997	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
52	VIC	Bonang River	Dellicknora	97031401	600	148.4000	-37.0600	KJF collection	14 III 1997	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
53	VIC	Bonang River	Bonang Rd, N of Bonang	99021308	640	148.4300	-37.0900	KJF collection	13 II 1999	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
54	NSW	Boonoo Boonoo River	Lindsay Highway Bridge	84111000	960	152.0500	-28.5300	MV-EPH1677	10 XI 1984	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
55	NSW	Boonoo Boonoo River tributary		83052000	x	x	x	MV-EPH1670	20 V 1983	DC	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
56	T/.	Boyd River	locality 25	82030400	x	x	x	MV-EPH0113, 0114	04 III 1982	DC	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
57	VIC	Branch Creek	Victoria Range, Grampians	66121600	x	142.1500	-37.2300	MV	16 XII 1966	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
58	QLD	Branch Creek	Conondale Ranges	88070900	160	152.4300	-26.5300	MV-EPH1689	09 VII 1988	SB	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
59	QLD	Branch Creek	Conondale Ranges	97061100	160	152.4300	-26.5300	MV-EPH1688	11 VI 1997	JJ	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
60	QLD	Branch Creek	Conondale Ranges	97082601	160	152.4300	-26.5300	MV-EPH1264	26 VIII 1997	JD	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
61	VIC	Brandy Creek	Great Alpine Rd, Alpine NP	87010500	1560	147.1122	-37.0055	MV-EPH1764	05 I 1987	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
62	VIC	Brandy Creek	Great Alpine Rd, Alpine NP	96111802	1560	147.1122	-37.0055	KJF collection	18 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
63	VIC	Brandy Creek	Great Alpine Rd, Alpine NP	96111902	1560	147.1122	-37.0055	KJF collection	19 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
64	VIC	Brandy Creek	Great Alpine Rd, Alpine NP	97011902	1560	147.1122	-37.0055	KJF collection	19 I 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
65	TAS	Break O'Day River	E of Fingal	95011000	240	148.0300	-41.3600	MV-EPH0182	10 I 1995	PS&PG	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
66	VIC	Breakfast Creek	Tamboritha Rd, Alpine NP	97020402	320	146.3658	-37.3109	KJF collection	04 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	VIC	Breakfast Creek	Tamboritha Rd, Alpine NP	97020701	320	146.3658	-37.3109	KJF collection	07 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
68	VIC	Breakfast Creek	Tamboritha Rd, Alpine NP	97103010	320	146.3658	-37.3109	KJF collection	30 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	i. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
69	TAS	Brid River	Tasman Highway, W of Scotsdale	95020802	180	147.2700	-41.1300	MV-EPH 0239	08 II 1995	PS&PG	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
70	VIC	Brodribb River	Bonang Rd, 16kms N of Malinns	99021305	100	148.3200	-37.3000	KJF collection	13 II 1999	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
71	NSW	Brogo River	Princes Highway Bridge	81052201	80	149.4900	-36.3200	MV-EPH1668	22 V 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
72	NSW	Brogo River	5km downstream of Princes Highway Bridge	81052202	40	149.4900	-36.3400	MV-EPH1684	22 V 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
73	VIC	Broken River	Evans Bridge, Swanpool	99022001	200	146.0132	-36.4448	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	SA	Brownhill Creek		76030300	150	138.3800	-34.5900	PS collection	03 III 1976	unknown	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
75	TAS	Brumbys Creek	B51 crossing	96121701	150	147.0452	-41.4253	KJF collection	17 XII 1996	unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	VIC	Buchan River	Buchan	99021408	100	148.1000	-37.2900	KJF collection	14 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	VIC	Buckland River	Mt Buffalo Rd	96110701	280	146.5332	-36.4152	KJF collection	07 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
78	SA	Bull Creek	"The Cliff" Finniss River Survey, location 3929	89103101	x	x	x	AWQC	31 X 1989	PS&SS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
79	VIC	Bull Creek	Bull Creek Rd	96113003	360	145.3539	-37.2831	KJF collection	30 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
80	VIC	Bull Creek tributary	W of Yea Rock	96113004	450	145.3514	-37.2707	KJF collection	30 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
81	VIC	Buller Creek	Mirimbah	81110202	670	146.2400	-37.0600	MV-EPH1760, 1761	02 XI 1981	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
82	NSW	Bulloc's Head Creek	Snowy Mountain Highway		1000	148.2900	-35.5200	KJF collection	04 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
83	VIC	Butchers Creek	Gelantipy Rd, S of Gelantipy	99021407	640	148.1500	-37.1300	KJF collection	14 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
84	VIC	Caledonia River	Howitts Hut	96051400	1480	146.4100	-37.1400	MV-EPH1793, 1794	14 V 1996	unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
85	TAS	Camerons Lagoon	near Great Lake	96122002	1040	146.3813	-41.5913	KJF collection	20 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
86	VIC	Campaspe River	Heathcote-Kyneton Rd	99022305	220	144.3226	-37.0102	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	VIC	Cann River	Cann Valley Highway	96112401	160	149.1144	-37.2411	KJF collection	24 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	VIC	Cann River	Princes Highway, Cann River	99021204	100	149.0600	-37.3400	KJF collection	12 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	VIC	Cann River east branch	WB Line Track, Coopracambra NP	98012503	230	149.1216	-37.2048	KJF collection	25 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
90	VIC	Cann River main branch	Cann Valley Highway, Noorinbee North	98012502	140	149.1152	-37.2611	KJF collection	25 I 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	VIC	Cann River west branch	Buldah Rd	98012504	320	149.0843	-37.1759	KJF collection	25 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
92	VIC	Cardinia Creek	Crystal Brook Park	97112402	80	145.2323	-37.5821	KJF collection	24 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	VIC	Cardinia Creek	Crystal Brook Park	98022602	80	145.2323	-37.5821	KJF collection	26 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
94	QLD	Careys Creek	S Calen, N of Mackay	79112001	140	148.4300	-20.5200	MV-EPH1524	20 XI 1979	DC	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
95	VIC	Carisbrook Creek	Great Ocean Rd	97030203	10	143.4827	-38.4127	KJF collection	02 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
96	VIC	Carisbrook Creek	Great Ocean Rd	99121901	10	143.4827	-38.4127	KJF collection	19 XII 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
97	VIC	Castleburn Creek	Dargo Rd (Private Property)	96041702	180	147.1300	-37.3100	KJF collection	17 IV 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigell	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	No.	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
98	QLD	Cedar Creek	unknown	10030001	x	x	x	SMNH	III 1910-1913	ME	1	0	0	0	0	0	1	1	0	0	0	1	98	0	0	0	0
99	QLD	Cedar Creek	unknown	10040000	x	x	x	SMNH	IV 1910-1913	ME	1	0	0	0	0	0	1	1	0	0	0	1	99	0	0	0	0
100	VIC	Cement Creek	Mt Donna-Buang Rd	76042301	670	145.4220	-37.4248	MV-EPH1619, 1705	23 IV 1976	JD	1	0	0	0	0	0	1	0	0	0	0	0	100	1	0	1	0
101	VIC	Cement Creek	Mt Donna-Buang Rd	96041701	670	145.4220	-37.4248	KJF collection	17 IV 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	101	0	0	0	0
102	VIC	Cement Creek	Mt Donna-Buang Rd	96092501	670	145.4220	-37.4248	KJF collection	25 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	102	1	0	1	0
103	VIC	Cement Creek	Mt Donna-Buang Rd	96113002	670	145.4220	-37.4248	KJF collection	30 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	103	0	0	0	0
104	VIC	Cement Creek	Mt Donna-Buang Rd	98030503	670	145.4220	-37.4248	KJF collection	05 III 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	104	1	0	1	1
105	VIC	Cement Creek	Mt Donna-Buang Rd	98112901	670	145.4220	-37.4248	KJF collection	29 XI 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	105	0	0	0	1
106	VIC	Cement Creek	Mt Donna-Buang Rd	99012301	670	145.4220	-37.4248	KJF collection	23 I 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	106	1	0	1	1
107	VIC	Cement Creek	Mt Donna-Buang Rd	99032004	670	145.4220	-37.4248	KJF collection	20 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	107	0	0	0	1
108	VIC	Cement Creek	Mt Donna-Buang Rd	200022601	670	145.4220	-37.4248	KJF collection	26 II 2000	KJF	0	0	1	0	0	0	1	0	0	0	0	0	108	1	0	1	0
109	VIC	Cement Creek	Mt Donna-Buang Rd	76040800	670	145.4220	-37.4248	MV-EPH1696, 1704, 1706	08 IV 1976	JD	1	0	0	0	0	0	1	0	0	0	0	0	109	1	0	1	0
110	VIC	Cement Creek	Mt Donna-Buang Rd	76102101	670	145.4220	-37.4248	MV-EPH1583	21 X 1976	JD	0	0	1	0	0	0	1	0	0	0	0	0	110	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
111	VIC	Cement Creek	Mt Donna-Buang Rd	76120100	670	145.4220	-37.4248	MV-EPH1587, 1588, 1602, 1698	01 XII 1976	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
112	VIC	Cement Creek	Mt Donna-Buang Rd	77041400	670	145.4220	-37.4248	MV-EPH1695, 1701, 1702	14 IV 1977	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
113	VIC	Cement Creek	Mt Donna-Buang Rd	78011200	670	145.4220	-37.4248	MV-EPH1699, 1700	12 I 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
114	VIC	Cement Creek	Mt Donna-Buang Rd	78100600	670	145.4220	-37.4248	MV-EPH1707	06 X 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
115	VIC	Cement Creek	Mt Donna-Buang Rd	78112300	670	145.4220	-37.4248	MV-EPH1589, 1590, 1591, 1592, 1594, 1596, 1597, 1598, 1599, 1734, 1736	23 XI 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
116	VIC	Cement Creek	Mt Donna-Buang Rd	79120700	670	145.4220	-37.4248	MV-EPH1697	07 XII 1979	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
117	VIC	Cement Creek	Mt Donna-Buang Rd	80030300	670	145.4220	-37.4248	MV-EPH1593, 1703	03 III 1980	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
118	VIC	Charity Creek	Mt Baw Baw Tourist Rd	97111200	700	146.1349	-37.5057	MV	12 XI 1997	MRHI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
119	VIC	Charity Creek - "The Gantry"	Mt Baw Baw Tourist Rd	96101203	700	146.1349	-37.5057	KJF collection	12 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigell	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
120	VIC	Charity Creek tributary	Mt Baw Baw Tourist Rd	99021602	1180	146.1515	-37.5047	KJF collection	16 II 1999	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	1
121	VIC	Charleys Creek	5km S of Gellibrand	82012900	90	143.4100	-38.3300	MV	29 I 1982	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
122	VIC	Charleys Creek	Charleys Creek Rd, outside Gellibrand	98010304	80	143.3130	-38.3230	KJF collection	03 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
123	VIC	Charleys Creek	Gellibrand Rd	99121904	70	143.3100	-38.3100	KJF collection	19 XII 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
124	VIC	Charleys Creek	Gellibrand Rd	99121904	70	143.3100	-38.3100	KJF collection	19 XII 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
125	VIC	Chinaman's Creek	Wilsons Promontory NP	99030400	60	146.2300	-38.5500	MV	04 III 1999	TN&KW	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
126	QLD	Christmas Creek	unknown	10000000	x	x	x	SMNH	1910-1913	ME	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
127	TAS	Chung River	Rd to Pioneer from St Helens	95020903	130	147.5900	-41.0500	MV-EPH0203	09 II 1995	PS&PG	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
128	VIC	Ciancio Creek	Young Creek Rd	96033102	225	143.2840	-38.4131	KJF collection	31 III 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129	VIC	Clearwater Creek	Bogong High Plains Rd	96111003	1410	147.2114	-36.5710	KJF collection	10 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
130	VIC	Clematis Creek	Monbulk Rd	97032401	290	145.2122	-37.5357	KJF collection	24 III 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	VIC	Clematis Creek	Monbulk Rd	97101501	290	145.2122	-37.5357	KJF collection	15 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
132	VIC	Clematis Creek	Monbulk Rd	99032001	290	145.2122	-37.5357	KJF collection	20 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	TAS	Clyde River	Hamilton	96121901	90	146.4949	-42.3330	KJF collection	19 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
134	VIC	Cobungra River	Cobungra Gap, near Dibbin Hut, Alpine Walking Track	97110702	1340	147.1102	-36.5656	KJF collection	07 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
135	VIC	Cobungra River	4WD track across Horseshair Plain	97110803	1000	147.1933	-37.0132	KJF collection	08 XI 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
136	VIC	Cobungra River tributary	4WD track across Horseshair Plain	97110802	1020	147.1943	-37.0140	KJF collection	08 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137	VIC	Cockatoo Creek	upstream Cockatoo	94120100	170	145.2900	-37.5500	MV-EPH1671, 1672	01 XII 1994	MRhI	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
138	VIC	Coliban River	Lyells Bridge, Redesdale-Bendigo Rd	97040800	210	144.2922	-36.5746	MV	08 IV 1997	JD	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
139	VIC	Coliban River	Lyells Bridge, Redesdale-Bendigo Rd	99022306	210	144.2922	-36.5746	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	TAS	Collingwood River	A10 crossing	96122803	340	145.5533	-42.0957	KJF collection	28 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	VIC	Combienbar River	Budlah Track	98012506	270	149.0202	-37.2058	KJF collection	25 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
142	TAS	Coquet Creek	Tasman Highway, NE of Nunamara	95020803	380	147.2000	-41.2100	MV-EPH0244, 0246, 0247	08 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	1	0
143	VIC	Coranderrk Creek	Badger Weir Rd	97040606	240	145.3416	-37.4107	KJF collection	06 IV 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
144	VIC	Coranderrk Creek	Badger Weir Rd	98030502	240	145.3416	-37.4107	KJF collection	05 III 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
145	VIC	Crawford River	Dartmoor-Hamilton Rd	97030502	45	141.1713	-37.5343	KJF collection	05 III 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	VIC	Crawford River	Condah-Hotspur Upper Rd	99022802	80	141.3917	-37.5510	KJF collection	28 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
147	TAS	Creekton Rivulet	near Dover	82030701	60	146.5700	-43.2100	MV-EPH0150	07 III 1982	DC	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
148	VIC	Crystal Brook	Mt Buffalo Rd	96110704	1330	146.4815	-36.4322	KJF collection	07 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
149	NSW	Cudgewa Creek	Tallangatta-Corryong Rd	97113001	380	147.4022	-36.1300	KJF collection	30 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	VIC	Dairy Creek	Grampians Tourist Rd	90122600	290	142.3230	-37.1138	MV-EPH1653	26 XII 1990	DC	1	0	0	0	0	0	1	0	0	0	0	0	VIC	0	0	0
151	VIC	Dairy Creek	Grampians Tourist Rd	99011601	290	142.3230	-37.1138	KJF collection	16 I 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	VIC	0	0	0
152	TAS	Dan's Rivulet	near Mathinna	95021002	310	147.5200	-41.2600	MV-EPH0189	10 II 1995	PS&PG	0	0	0	1	0	0	1	0	0	0	0	0	TAS	0	0	0
153	VIC	Deddick River	Dellicknora Rd	97031402	520	148.3900	-37.0700	KJF collection	14 III 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	VIC	0	0	0
154	VIC	Deddick River	Deddick River Rd, Tubbut	99021403	440	148.3600	-37.0400	KJF collection	14 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	VIC	0	0	0
155	TAS	Dee River	Lyell Highway	96121903	200	146.3813	-42.4551	KJF collection	19 XII 1996	KJF	1	0	0	0	0	1	1	0	0	0	0	0	TAS	0	0	0
156	VIC	Deep Creek	Sheehans Rd Bridge	97102604	420	144.4657	-37.1959	KJF collection	26 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	VIC	0	0	0
157	VIC	Deep Creek	Benambra-Corryong Rd, 11kms N of Uplands	99021501	620	147.4200	-36.4900	KJF collection	15 II 1999	KJF	1	0	1	0	0	0	1	0	0	0	0	0	VIC	0	0	1
158	SA	Deep Creek tributary	Castambul	77030400	200	138.4500	-34.5200	PS collection	04 III 1977	JEB&AW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
159	VIC	Deep Spring	Wombat State Forest	97122003	480	144.0420	-37.2107	KJF collection	20 XII 1997	KJF	1	0	0	0	0	0	1	1	0	0	0	1	VIC	0	0	0
160	VIC	Deep Spring	Wombat State Forest	98110103	480	144.0420	-37.2107	KJF collection	01 XI 1998	KJF	1	0	0	0	0	0	1	1	0	0	0	1	VIC	0	0	0
161	VIC	Delatite River	5 miles upstream Merrijig	81052101	540	146.2000	-37.0600	MV-EPH1661	21 IV 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	VIC	0	0	0
162	VIC	Delatite River	Delatite Rd, Delatite	99022006	350	146.1004	-37.0822	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	VIC	0	0	0

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	MOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
163	VIC	Delegate River	Monaro Highway	99021401	800	148.4800	-37.0300	KJF collection	14 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
164	VIC	Diamantina River	Bridge on Logging Rd before Blairs Hut	97110704	1080	147.1010	-37.5438	KJF collection	07 XI 1997	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
165	VIC	Diamond Creek	7km SE of Gembrook	79013100	130	145.3700	-37.5800	MV	31 I 1979	AN&KW	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
166	VIC	Diamond Creek	Hurstbridge	86112800	70	145.1100	-37.3800	MV-EPH1507	28 XI 1986	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
167	NSW	Diggers Creek	near Stonehenge, Summit Rd, Kosciusko NP	97120201	1500	148.2900	-36.2200	KJF collection	02 XII 1997	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
168	NSW	Diggers Creek	Island Bend on Summit Rd, Kosciusko NP	96120701	1200	148.2900	-36.1900	KJF collection	07 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
169	VIC	Dinner Creek	Wangarabell Rd	99021301	130	149.3120	-37.2439	KJF collection	13 II 1999	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
170	TAS	Don River	B14 crossing	96123004	120	146.1900	-41.1704	KJF collection	30 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
171	VIC	Donnelly Creek	upstream Watts River	78022300	140	145.3200	-37.3800	MV-EPH1495	23 II 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
172	VIC	Donnelly Creek	Donnelly Weir Rd	97040604	140	145.3203	-37.3740	KJF collection	06 IV 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
173	TAS	Douglas Creek	Pelion Rangers Hut, Cradle Mountain-Lake St Clair NP	90011601	820	146.0400	-41.5000	MV-EPH1533, 1547	16 I 1990	JD&DC	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
174	TAS	Douglas Creek	upstream of confluence with Lake Ayr outlet stream, Cradle Mountain-Lake St Clair NP	90011602	840	146.0400	-41.4900	MV-EPH1527, 1528, 1534, 1536, 1544, 1545	16 I 1990	JD&DC	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
175	TAS	Douglas Creek	High Bridge near old Pelion Hut, Cradle Mountain-Lake St Clair NP	90011801	840	146.0300	-41.4900	MV-EPH1466, 1472, 1532, 1546	18 I 1990	JD&DC	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
176	TAS	Douglas Creek headwaters	100m N of Pelion Gap, Cradle Mountain-Lake St Clair NP	90011702	880	146.0200	-41.4800	MV-EPH1537, 1548	17 I 1990	JD&DC	0	0	c	0	1	0	1	0	0	0	0	0	0	0	0	0
177	TAS	Douglas Creek tributary	1.5km NW of Pelion Gap, Cradle Mountain-Lake St Clair NP	90011703	600	146.0200	-41.4800	MV-EPH1550	17 I 1990	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
178	TAS	Douglas Creek tributary	2.5km N of Pelion Gap, Cradle Mountain-Lake St Clair NP	90011704	800	146.0200	-41.4900	MV-EPH1551	17 I 1990	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
179	TAS	Dove River	below confluence with Lilla Creek, Cradle Mountain-Lake St Clair NP	96123001	940	145.5640	-41.3824	KJF collection	30 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	VIC	East Erinundra River	junction with west branch	82031200	300	148.5400	-37.2000	AWT	12 III 1982	JB	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
181	VIC	East Erinundra River	junction with west branch	84010600	300	148.5400	-37.2000	AWT	06 I 1984	JB	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
182	TAS	Echo Point	unnamed stream flowing into Cradle Mountain-Lake St Clair NP	96122702	740	146.0813	-42.0237	KJF collection	27 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
183	TAS	Elizabeth River	Campbelltown	96122202	190	147.2918	-41.5601	KJF collection	22 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
184	VIC	Erinundra Creek	15km N of Club Terrace	75111100	120	148.5500	-37.2200	MV	11 XI 1975	JB	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
185	VIC	Erinundra River	1.5 km upstream Combienbar Rd	81052101	120	148.5500	-37.2700	MV-EPH1750	21 V 1981	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
186	VIC	Erinundra River	Erinundra	94111500	320	148.5142	-37.3719	MV	15 XI 1994	MRHI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
187	VIC	Erinundra River	Erinundra	96110500	320	148.5142	-37.3719	KJF collection	05 XI 1996	MRHI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
188	VIC	Erskine River	Erskine Falls	98010401	200	143.5448	-38.3030	KJF collection	04 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
189	NSW	Eucumbene River	Kiandra-Adaminaby Rd	97120104	1340	148.3100	-35.5300	KJF collection	01 XII 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
190	VIC	Eurobin Creek	Mt Buffalo Rd, Mt Buffalo NP	96110702	440	146.5029	-36.4310	KJF collection	07 XI 1996	KJF	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	1

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTKOLA	GEMMAYALUKA
191	VIC	Eurobin Creek	Mt Buffalo Rd, Mt Buffalo NP	99021101	440	146.5029	-36.4310	KJF collection	11 II 1999	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
192	VIC	Faith Creek	Tanjil Bren Rd	96101205	540	146.1421	-37.5220	KJF collection	12 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
193	VIC	Falls Creek	Telephone Box Junction, Mt Stirling Rd	81110203	1220	146.2743	-37.0652	MV-EPH1572, 1737, 1738, 1739, 1740	02 XI 1981	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	0
194	VIC	Ferny Glade	Sealers Cove Walk, Wilsons Promontory NP	97021503	340	146.2321	-39.0140	KJF collection	15 II 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
195	VIC	Ferrers Creek	Bells Bridge, Rokewood-Shelford Rd	99022705	195	143.4730	-37.5508	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	VIC	Fiery Creek	Glenelg Highway, Streatham	99022707	240	143.0353	-37.4057	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
197	SA	Finniss River	"Riverdale", Finniss River Survey, location 3930	89103102	x	x	x	AWQC	31 X 1989	PS&SS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
198	VIC	First Creek	Warburton-Jamieson Rd	85120700	750	145.5810	-37.2525	MV-EPH1731, 1732, 1733	07 XII 1985	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
199	VIC	Fisher Creek	Anderson Rd	96091901	360	145.3912	-37.3255	KJF collection	19 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	VIC	Fitzroy River	T&W Rd, off Princes Highway	99022801	80	141.2538	-38.0438	KJF collection	28 II 1999	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
201	VIC	Four Mile Creek	Homers Rd, Warburton	97042501	185	145.4156	-37.4533	KJF collection	25 IV 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
202	TAS	Franklin River	location unknown	82030201	x	x	x	MV-EPH0136	02 III 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconspicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
203	VIC	Franklin River	South Gippsland Highway	99021102	20	146.1754	-38.3911	KJF collection	11 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
204	NSW	Friday Flat Creek tributary	near Thredbo	84011900	1380	148.1929	-36.3002	MV-EPH1675	19 I 1984	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0
205	VIC	Frosty Creek	Frosty Creek Rd	96110803	1380	147.0805	-37.0555	KJF collection	08 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
206	VIC	Frying Pan Raceline tributary	Telmark St, Falls Creek	99020505	1560	147.1650	-36.5200	KJF collection	05 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207	VIC	Fyans Creek	Grampians Tourist Rd	99011608	290	142.3230	-37.1259	KJF collection	16 I 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
208	VIC	Fyans Creek	Grampians Tourist Rd	200012202	290	142.3230	-37.1259	KJF collection	22 I 2000	KJF	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
209	VIC	Gellibrand River	pumping station at Carlisle River township	82012500	40	143.2300	-38.3300	MV	25 I 1982	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
210	VIC	Gellibrand River	3km E Gellibrand	82012600	80	143.3300	-38.3100	MV	26 I 1982	RStC &AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
211	VIC	Gellibrand River	Barramunga-Upper Gellibrand Rd	98010301	180	143.3110	-38.3447	KJF collection	03 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
212	VIC	Genoa River	Wangarabell Rd	99021303	100	149.2900	-37.2300	KJF collection	13 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213	TAS	George River	Goshen	95020904	60	148.0500	-41.1600	MV-EPH0178	09 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
214	TAS	George River	Intake Bridge, St Columba Falls Reserve	95020905	150	147.5900	-41.1700	MV-EPH0232, 0239	09 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
215	NSW	Georges River	5km S of Campbelltown	84102802	100	150.4800	-34.0600	MV-EPH1674	28 X 1984	DC	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
216	VIC	German Creek	Bright-Tawonga Rd	96110901	440	147.0325	-36.4358	KJF collection	09 XI 1996	KJF	1	0	1	0	0	0	1	1	0	0	0	1	1	0	1	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
217	VIC	Gibbo River	Benambra-Corryong Rd	99021502	500	147.4200	-36.4500	KJF collection	15 II 1999	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
218	VIC	Glenelg River	Red Hill Rd	99011606	285	142.1930	-37.2047	KJF collection	16 I 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219	VIC	Goongerah Creek	Bonang Rd, N of Goongerah	99021307	260	148.4100	-37.1800	KJF collection	13 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	VIC	Goulburn River	junction Flourbag Creek, 17km upstream Jamieson	81110100	360	146.1200	-37.2300	MV-EPH1658	1 XI 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
221	VIC	Goulburn River	Twin Bridges Caravan Park	99032005	190	145.4233	-37.1428	KJF collection	20 III 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
222	VIC	Goulburn River	4 km S of Jamieson	99022007	320	146.0830	-37.2103	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223	VIC	Grace Burn	downstream weir	75101600	180	145.3300	-37.3900	MV-EPH1640	16 X 1975	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
224	VIC	Grace Burn	downstream weir	78011900	180	145.3300	-37.3900	Mv-EPH1617	19 I 1978	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
225	VIC	Grace Burn	upstream weir	78042700	250	145.3502	-37.3926	MV-EPH1721	27 IV 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
226	VIC	Grace Burn	downstream weir	79101700	180	145.3300	-37.3900	MV-EPH1561	17 X 1975	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
227	VIC	Grace Burn	Wallace Parade, Healesville	97040601	110	145.3218	-37.3916	KJF collection	06 IV 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
228	VIC	Grand Canyon Motel Swimming Pool	Halls Gap	99011501	225	142.3107	-37.0702	KJF collection	15 I 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229	VIC	Grange Burn	below Lake Hamilton, Hamilton	99022709	175	142.0150	-37.4443	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	VIC	Grange Burn	Morgiana Rd	99022803	90	141.4954	-37.4235	KJF collection	28 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
231	VIC	Gravel Pit (Pond)	beside Mt Tamboritha Rd, Alpine NP	96092202	1260	146.4218	-37.2850	KJF collection	22 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
232	TAS	Great Lake	west shore, Duck Point	96121707	1033	146.4217	-41.5510	KJF collection	17 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233	TAS	Great Musselroe River	Rd to Pioneer from St Helens	95020906	60	148.0300	-41.0500	MV-EPH0206	09 II 1995	PS&PG	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
234	VIC	Grey River	Grey River Rd	97030101	190	143.4850	-38.3943	KJF collection	01 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
235	TAS	Groom River	Tasman Highway	94030701	90	148.0500	-41.1500	MV-EPH0228	07 III 1994	PS&PG	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
236	VIC	Growlers Creek	Williams Rd camp site, Wandiligong	96110801	380	146.5910	-36.4654	KJF collection	08 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
237	VIC	Growlers Creek	Williams Rd camp site, Wandiligong	97110801	380	146.5910	-36.4654	KJF collection	08 XI 1997	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
238	VIC	Gulf Stream	downstream Epacris Falls, Mount Victory Rd, Grampians	99011603	440	142.2936	-37.0900	KJF collection	16 I 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
239	VIC	Gulf Stream	downstream Epacris Falls, Mount Victory Rd, Grampians	200012201	440	142.2936	-37.0900	KJF collection	22 I 2000	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
240	NSW	Guthrie Creek	Summit Rd, Mt Kosciusko NP	96120702	1760	148.2300	-36.2500	KJF collection	07 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241	VIC	Haunted Stream	Great Alpine Rd	99021409	180	147.4900	-37.2800	KJF collection	14 II 1999	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
242	TAS	Hellyer River Gorge		82022800	220	145.3600	-41.1600	MV-EPH0151	28 II 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
243	VIC	Hensleigh Creek	Combienbar Rd Ford	98012505	240	149.0108	-37.2136	KJF collection	25 I 1998	KJF	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0
244	SA	Hitchcock Drain		77112501	x	x	x	MV	25 XI 1977	DN&PS	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
245	VIC	Hodgsons Creek	Beechworth-Wangaratta Rd	97022202	240	146.3400	-36.2346	KJF collection	22 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
246	VIC	Holland Creek	Swanpool Rd, near Tatong	99022002	220	146.0557	-36.4412	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
247	VIC	Holland Creek	Fords Bridge, Tatong-Tolmie Rd	99022003	360	146.0813	-36.4937	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
248	VIC	Hope Creek	Tanjil Bren Rd	96101204	550	146.1403	-37.5155	KJF collection	12 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
249	VIC	Hopkins River	Allansford	80031000	10	142.3500	-38.2300	MV-EPH1632, 1633, 1634	10 III 1980	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
250	VIC	Hopkins River	Back Bolac Rd	99022708	220	142.4505	-37.3604	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
251	VIC	House Creek	Mt Beauty Rd	99020501	330	147.0744	-36.4031	KJF collection	05 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
252	VIC	Howqua River	12km SE Merrijig	71113000	420	146.1900	-37.1100	MV	30 XI 1971	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
253	VIC	Howqua River	Running Creek Camping Reserve, Howqua River Rd	98021501	310	146.1341	-37.1418	KJF collection	15 II 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
254	TAS	Huon River	locality 27	82030702	x	x	x	MV-EPH0154, 0155, 0156	07 III 1982	DC	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
255	VIC	Icy Creek	Toorongo Rd	96101103	530	146.0050	-37.4809	KJF collection	11 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
256	TAS	Iris River	Cradle Mountain Rd	96123003	760	145.5742	-41.3303	KJF collection	30 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
257	TAS	Iris River tributary	location unknown	82022600	x	x	x	MV-EPH0165	26 II 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
258	VIC	Jack River	Yarram-Morwell Rd Bridge	99021103	30	146.3409	-38.3312	KJF collection	11 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
259	VIC	Jacksons Creek	Gisborne	97102602	410	144.3517	-37.2904	KJF collection	26 X 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
260	VIC	Jacksons Creek tributary	Waterloo Flat Rd	97102601	470	144.3127	-37.2830	KJF collection	26 X 1997	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
261	VIC	Jacksons Creek tributary	Waterloo Flat Rd	98110101	470	144.3127	-37.2830	KJF collection	01 XI 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
262	VIC	Jamieson River	Gerrans Bridge	98021502	320	146.1028	-37.1738	KJF collection	15 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
263	VIC	Jimmys Creek	Grampians Tourist Rd	96101901	310	142.3018	-37.2229	KJF collection	19 X 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
264	VIC	Jimmys Creek	Grampians Tourist Rd	98101101	310	142.3018	-37.2229	KJF collection	11 X 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
265	VIC	Jimmys Creek	Grampians Tourist Rd	99011607	310	142.3018	-37.2229	KJF collection	16 I 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
266	VIC	Jimmys Creek	Glenelg	94111000	x	x	x	MV	10 XI 1994	MRHI	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
267	VIC	Jimmys Creek	Grampians Tourist Rd	200012203	310	142.3018	-37.2229	KJF collection	22 I 2000	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
268	NSW	Jindabyne		76022100	1000	148.3700	-36.2400	MV	21 II 1976	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
269	VIC	Jingalalla River	Dellicknora Rd, 2km SW of Dellicknora	99021402	520	148.3900	-37.0700	KJF collection	14 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270	VIC	Johnstone Creek	Portland-Nelson Rd	97030401	110	141.1916	-38.1133	KJF collection	04 III 1997	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
271	VIC	Johnstone Creek	Portland-Nelson Rd	97102501	110	141.1916	-38.1133	KJF collection	25 X 1997	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
272	VIC	Kalatha Creek	Kalatha Rd and Kalatha Link Rd intersection	96112902	580	145.3147	-37.2832	KJF collection	29 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
273	VIC	Kangaroo Creek	Kangaroo Rd, 5km E of Daylesford	97010901	600	144.1345	-37.2110	KJF collection	09 I 1997	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
274	VIC	Kennett River	Kennett River , Great Ocean Rd	98010306	20	143.4803	-38.4005	KJF collection	03 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
275	VIC	Keppel Creek	upper site	94091700	800	145.4600	-37.2700	IC Collection	17 IX 1994	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconspicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
											0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
276	VIC	Keppel Creek	upper site	94101000	800	145.4600	-37.2700	IC Collection	10 X 1994	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
277	VIC	Keppel Creek	upper site	94111900	800	145.4600	-37.2700	IC Collection	19 XI 1994	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
278	VIC	Keppel Creek	upper site	94120501	800	145.4600	-37.2700	IC Collection	05 XII 1994	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
279	VIC	Keppel Creek	upper site	95031300	800	145.4600	-37.2700	IC Collection	13 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
280	VIC	Keppel Creek	upper site	95031400	800	145.4600	-37.2700	IC Collection	14 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
281	VIC	Keppel Creek	upper site	95031500	800	145.4600	-37.2700	IC Collection	15 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
282	VIC	Keppel Creek	upper site	95032100	800	145.4600	-37.2700	IC Collection	21 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
283	VIC	Keppel Creek	upper site	95032700	800	145.4600	-37.2700	IC Collection	27 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
284	VIC	Keppel Creek	upper site	95033100	800	145.4600	-37.2700	IC Collection	31 III 1995	SP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
285	VIC	Keppel Creek	upper site	95041000	800	145.4600	-37.2700	IC Collection	10 IV 1995	SP																
286	VIC	Kiewa River east branch tributary	Bogong High Plains Rd	96110903	660	147.1257	-37.4809	KJF collection	09 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
287	VIC	Kiewa River west branch	Blairs Hut	97110701	1010	147.1017	-37.5516	KJF collection	07 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
288	VIC	Kiewa River west branch	West Kiewa Logging Rd, 5km NE of Mt Hotham	97110703	1180	147.1044	-36.5546	KJF collection	07 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
289	VIC	Kiewa River west branch	Logging Rd crossing	97110705	1080	147.0937	-36.5310	KJF collection	07 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290	VIC	Kiewa River west branch	Blairs Hut	97021901	1010	147.1017	-37.5516	KJF collection	19 II 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
291	VIC	Kiewa River west branch tributary	track between Blairs Hut and Westons Hut, Mt Hotham	91110301	1320	147.1000	-36.5500	MV-EPH1755	03 XI 1991	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
292	VIC	Kilmore Creek	Willowmavin Rd	99022301	320	144.5640	-37.1648	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AVT"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
293	VIC	King Parrot Creek	Wallaby Ck Rd	76081600	350	145.1456	-37.2550	MV-EPH1710, 1711	16 VIII 1976	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
294	VIC	King Parrot Creek	4WD track off Whittlesea-Yea Rd, Kinglake West	96100701	340	145.1544	-37.2520	KJF collection	07 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
295	VIC	King Parrot Creek	Wittlesea-Yea Rd, 15km SW of Flowerdale	98030501	350	145.1448	-37.2550	KJF collection	05 III 1998	KJF	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	1
296	VIC	King River	King Valley Rd, Cheshunt	99022004	270	146.2533	-36.4755	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
297	VIC	King River	King Valley Rd, Cheshunt	99022202	270	146.2533	-36.4755	KJF collection	22 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
298	VIC	Koala Park Dam	Mount Alexandra State Park	97111901	630	144.1322	-37.0202	KJF collection	19 XI 1997	NA&FM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
299	VIC	La Trobe River	Big Creek Basin Rd, 5km E of Powelltown	96101002	320	145.5010	-37.5235	KJF collection	10 X 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
300	TAS	Lagoon of Islands	off Interlaken Rd	96122104	760	146.5600	-42.0546	KJF collection	21 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
301	NSW	Lake Albina	Mt Kosciusko	29020200	1920	148.1630	-36.2659	NHM	02 II 1929	RJT	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
302	NSW	Lake Albina	Mt Kosciusko	79042000	1950	147.1600	-36.2600	IC Collection	20 IV 1979	IC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
303	NSW	Lake Albina	inflowing stream, Mt Kosciusko	85020901	1920	148.1630	-36.2659	MV-EPH1778	09 II 1985	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
304	NSW	Lake Albina	outlet stream = Lady Northcotes Creek	85020903	1920	147.1600	-36.2600	MV-EPH1776, 1777	09 II 1985	DC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
305	TAS	Lake Ayr inlet stream	Cradle Mountain-Lake St Clair NP	90011603	880	146.0500	-41.4900	MV-EPH1464, 1471, 1542, 1543	16 I 1990	JD&DC	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
306	TAS	Lake Ayr outlet stream	upstream Douglas Creek, Cradle Mountain-Lake St Clair NP	90011604	640	146.0200	-41.4800	MV-EPH1470	16 I 1990	JD&DC	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
307	TAS	Lake Ayr outlet stream	100m downstream Lake, Cradle Mountain-Lake St Clair NP	90011605	800	146.0300	-41.4900	MV-EPH1467	16 I 1990	JD&DC	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
308	TAS	Lake Botsford	off 4WD track	96122102	1150	146.3019	-41.5317	KJF collection	21 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
309	NSW	Lake Cootapatomba	Mt Kosciusko	30012700	2160	148.1559	-36.2801	NHM	27 I 1930	RJT	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
310	NSW	Lake Cootapatomba	inflowing stream, Mt Kosciusko	84012400	2160	148.1559	-36.2801	MV-EPH1774	24 I 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
311	TAS	Lake Crescent	outlet stream	88110401	900	147.1000	-42.0700	MV-EPH0133	04 XI 1988	DC	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
312	TAS	Lake Dove	Lake Dove Rd, Cradle Mountain-Lake St Clair NP	96122902	934	145.5738	-41.3917	KJF collection	29 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	TAS	Lake Echo	South side of Dam	96122300	846	146.3825	-42.1302	KJF collection	23 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
314	VIC	Lake Elizabeth	inlet stream, Otways	88052200	210	143.4536	-38.3313	MV-EPH1751	22 V 1988	DC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
315	TAS	Lake Leake	Cutting Grass Bay	96122203	580	147.4800	-42.0100	KJF collection	22 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
316	TAS	Lake Lilla	Cradle Mountain-Lake St Clair NP	96122901	922	145.5720	-41.3912	KJF collection	29 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
317	TAS	Lake Paget	below Lake Augusta spillway	96122103	1150	146.3050	-41.5222	KJF collection	21 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
318	TAS	Lake River	Bridge on Highway C522	96121702	160	147.0544	-41.4702	KJF collection	17 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
319	TAS	Lake Sorrell	Interlaken Boat Ramp	88110402	900	147.1000	-42.1100	MV-EPH0158	04 XI 1988	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
320	VIC	Langford East Aqueduct tributary	Bogong High Plains Rd, Langford Gap	96111001	1600	147.1905	-36.5305	KJF collection	10 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
321	VIC	Lardner Creek	Lardners Rd	96040504	80	143.3233	-38.3211	KJF collection	05 IV 1996	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
322	VIC	Lawler Springs	Bright-Tawonga Rd	96110902	760	147.0747	-36.4330	KJF collection	09 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
323	VIC	Learmonth Creek	Yarra Junction-Neerim Rd, Powelltown	96101001	180	145.4433	-37.5143	KJF collection	10 X 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
324	NSW	Leather Barrell Creek	Alpine Way, Kosciusko NP	97120205	1000	148.1100	-36.3100	KJF collection	02 XII 1997	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
325	VIC	Lerderderg River	Lederderg Gorge State Park	97021201	140	144.2506	-37.3742	KJF collection	12 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
326	VIC	Lerderderg River	Lederderg Gorge State Park	97122005	140	144.2506	-37.3742	KJF collection	20 XII 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
327	TAS	Liffey Falls		82022301	470	146.4700	-41.4100	MV-EPH0142, 0143	23 II 1982	DC	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
328	VIC	Light Bound Creek headwaters	Dargo High Plains Rd	96110804	1570	147.0930	-37.0623	KJF collection	08 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
329	VIC	Lilly Pilly Gully	Wilsons Promontory NP	97021504	60	146.2001	-39.0055	KJF collection	15 II 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
330	VIC	Little Ada Creek	Ada River Rd, La Trobe State Forest	96101004	500	145.5207	-37.5045		10 X 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
331	TAS	Little Forester River		94030601	100	147.2100	-41.1100	MNV-EPH0217	06 III 1994	PS	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
332	TAS	Little Navarre River	Lyell Highway	96122801	750	146.1102	-42.1016	KJF collection	28 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
333	TAS	Little Pine Lagoon	Cricket Pitch Shore	96122101	1007	146.3621	-41.5913	KJF collection	21 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
334	VIC	Little River	Maroondah Highway, outside Taggerty	77112200	210	145.4240	-37.1925	MV-EPH1651	22 X 1977	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
335	VIC	Little River	Maroondah Highway, outside Taggerty	77122200	210	145.4240	-37.1925	MV-EPH1651	22 XII 1977	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
336	VIC	Little River	Blue Range Rd	97021401	980	145.4830	-37.2333	KJF collection	14 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
337	VIC	Little River	Maroondah Highway, outside Taggerty	98101702	210	145.4240	-37.1925	KJF collection	17 X 1998	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
338	VIC	Little River	McKillops Rd	99021405	800	148.1800	-37.0300	KJF collection	14 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
339	VIC	Little Snowy Creek	Eskdale	99031203	350	147.1450	-36.2756	KJF collection	12 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	VIC	Little Toorongo River	Toorongo Falls, Toorongo Falls Rd	98020901	420	146.0255	-37.5058	KJF collection	09 II 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
341	VIC	Little Yarra River	Warburton Highway	96092502	120	145.3741	-37.4703	KJF collection	25 IX 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
342	VIC	Loch River	Noojee	93050200	240	145.5900	-37.5300	IC Collection	02 V 1993	SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
343	VIC	Loch River	Poplars Camping Area on Loch Valley Rd	96101101	300	145.5925	-37.4909	KJF collection	11 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
344	VIC	Loch River tributary	Loch River Rd - 1st bridge from Noojee	98020903	290	145.5940	-37.5053	KJF collection	09 II 1998	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
345	VIC	Loch River tributary	Loch River Rd - 2nd bridge from Noojee	98020904	280	145.5943	-37.5030	KJF collection	09 II 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
346	VIC	Loddon River	Guildford Bridge, Midland Highway	97122001	240	144.0958	-37.0855	KJF collection	20 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
347	VIC	Love Creek	Loves Creek Picnic Ground, Colac-Beech Forrest Rd	98010303	100	143.3452	-38.2855	KJF collection	03 i 1998	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
348	VIC	Lyrebird Creek	Olinda Creek Rd, Dandenong Ranges	97032404	220	145.2345	-37.4950	KJF collection	24 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
349	VIC	Macalister River	Cheynes Bridge	97020703	120	146.4004	-37.4546	KJF collection	07 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	VIC	MacKenzie River	Wartook Rd, Grampians	99011605	420	142.2456	-37.0643	KJF collection	16 i 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
351	TAS	Macquarie River	Ross Bridge, Ross	96122201	180	147.2919	-42.0157	KJF collection	22 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
352	VIC	Main Creek - Site 1	Baldrys Rd, Green's Bush National Park	97041601	110	144.5734	-38.2520	KJF collection	16 IV 1997	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
353	VIC	Main Creek - Site 2	Boneo (Rosebud-Flinders) Rd	97041602	30	144.5557	-38.2837	KJF collection	16 IV 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
354	QLD	Malanda		10030002	700	145.3500	-17.2100	SMNH	III 1910-1913	ME	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
355	TAS	Margisons Creek	St Mary's	95021001	280	148.1100	-41.3400	MV-EPH0192	10 II 1995	PS&PG	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
356	VIC	Martins Creek No. 2	Bonang Rd, 0.5kms S of Malinns	99021306	260	148.3600	-37.2500	KJF collection	13 II 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	1	0	1	0
357	VIC	McIvor Creek	6km downstream Heathcote	81091300	250	144.4400	-36.5700	MV-EPH1523	13 IX 1981	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
358	VIC	McIvor Creek	Heathcote	99022303	240	144.4240	-36.5521	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
359	VIC	McKay Creek	Mt McKay-Howmans Gap Rd	80011100	1580	147.1400	-36.5200	MV-EPH1770	11 I 1980	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
360	VIC	McKay Creek ("Roadside Springs")	Mt McKay, Alpine National Park	96110906	1700	147.1539	-36.5225	KJF collection	09 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
361	VIC	McKay Creek ("Roadside Springs")	Mt McKay, Alpine National Park	99020503	1700	147.1539	-36.5225	KJF collection	05 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
362	VIC	McKay Creek tributary waterfall	Mt McKay, Alpine National Park	96110905	1700	147.1520	-36.5219	KJF collection	09 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
363	VIC	McKay Creek tributary waterfall	Mt McKay, Alpine National Park	99020504	1700	147.1520	-36.5219	KJF collection	05 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
364	SA	Meadows Creek	Fingerboard corner, Finniss River Survey, location 3173	89103103	x	x	x	AWQC	31 X 1989	PS&SS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
365	TAS	Meander River	Westwood	60010900	150	146.5700	-41.3000	ANIC	01 I 1960	DS	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
366	VIC	Melba Gully	Annes Cascades, Melba Gully State Park	98010305	340	143.2215	-38.4144	KJF collection	03 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
367	VIC	Melba Gully	Annes Cascades, Melba Gully State Park	99121902	340	143.2215	-38.4144	KJF collection	19 XII 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site no.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
368	VIC	Menzies Creek	Butterfield Wildlife Reserve, Emerald-Monbulk Rd	97032403	160	145.2622	-37.5347	KJF collection	24 III 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
369	VIC	Menzies Creek	Butterfield Wildlife Reserve, Emerald-Monbulk Rd	99032003	160	145.2622	-37.5347	KJF collection	20 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
370	VIC	Merrimu Reservoir	Diggers Rest Rd	97021202	180	144.2944	-37.3800	KJF collection	12 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
371	NSW	Merritts Creek	Charlottes Pass, Mt Kosciusko NP	96120802	1920	148.1900	-36.2500	KJF collection	08 XII 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
372	VIC	Middle Creek	Omeo Highway	96111004	700	147.2750	-37.5519	KJF collection	10 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
373	VIC	Middle Creek tributary	Alpine NP	96111002	1620	147.1805	-36.5455	KJF collection	10 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
374	VIC	Mitta Mitta River	Omeo Valley Rd	99021503	540	147.3600	-36.5600	KJF collection	15 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
375	VIC	Mitta River	Mitta Caravan Park, Mitta	99031201	280	147.2230	-36.3210	KJF collection	12 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
376	VIC	Moggs Creek	Great Ocean Rd	98100801	10	144.0345	-38.2830	KJF collection	08 X 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
377	VIC	Moleside Creek	Nelson-Winnap Rd	96032901	10	141.1619	-38.0324	KJF collection	29 III 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
378	VIC	Moleside Creek	Nelson-Winnap Rd	97030501	10	141.1619	-38.0324	KJF collection	05 III 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
379	VIC	Moleside Creek	Nelson-Winnap Rd	97102502	10	141.1619	-38.0324	KJF collection	25 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	VIC	Mollisons Creek	Northern Highway, Pyalong	99022302	250	144.5129	-37.0717	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
381	VIC	Moroka River	Moroka River Track, Alpine NP	97020603	440	146.5300	-37.2330	KJF collection	06 II 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
382	VIC	Morwell River	Morwell River Rd, 21km S of Morwell	99030403	110	146.1817	-38.2432	KJF collection	04 III 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
383	VIC	Mosquito Creek	Bonfields Bridge, Redesdale-Bendigo Rd	99022307	180	144.2949	-36.5114	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
384	TAS	Mother Logans Creek	Terry Hills Rd	95020907	130	148.0600	-41.1300	MV-EPH0200, 0201	09 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
385	QLD	Mother Moutain	12km SE of Gympie	80102900	100	152.4700	-26.1500	MV-EPH1127	29 X 1980	AN	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
386	VIC	Mount Misery Creek	Rokewood-Skipton Rd	99022704	190	143.3940	-37.5254	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
387	VIC	Mountain Creek	7km E of Tawonga South	90110300	510	147.1400	-36.4200	MV-EPH1584, 1660, 1723	03 XI 1990	DC	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
388	VIC	Mt Baw Baw		75011400	1460	146.1600	-37.5000	IC Collection	14 I 1975	IC	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
389	VIC	Mt Baw Baw		75111900	1460	146.1600	-37.5000	IC Collection	19 I 1975	IC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
390	VIC	Mt Baw Baw		75112900	1460	146.1600	-37.5000	IC Collection	29 XI 1975	IC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
391	VIC	Mt Buller		58011700	1680	146.2500	-37.0800	MV-EPH1756	17 I 1958	AN	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
392	VIC	Mt Buller		95032800	1680	146.2500	-37.0800	IC Collection	28 III 1995	IC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
393	VIC	Muddy Creek	Selby-Aura Rd	96101301	225	145.2315	-37.5515	KJF collection	13 X 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
394	NSW	Murray River tributary	Tom Groggin Picnic Area, Kosciusko NP	80102400	490	148.0600	-36.2100	MV-EPH1649, 1650	24 X 1980	DC	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
395	VIC	Murrindal River	Gelantipy Rd	97101901	220	148.1256	-37.2327	KJF collection	19 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
396	VIC	Murrindindi River	Murrindindi Falls Rd	96113001	300	145.3327	-37.2348	KJF collection	30 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
397	VIC	Myrtle Creek	Donna Buang Rd	97040603	780	145.3642	-37.4235	KJF collection	06 IV 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
398	VIC	Myrtle Creek	Donna Buang Rd	200022602	780	145.3642	-37.4235	KJF collection	26 II 2000	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
399	VIC	Myrtle Creek	Donna Buang Rd	200031901	780	145.3642	-37.4235	KJF collection	19 III 2000	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	in. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
400	VIC	Myrtle Gully	Sylvia Creek Rd, Toolangi State Forest	96112901	620	145.3104	-37.3144	KJF collection	29 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	1
401	VIC	Naringhil Creek	Rokewood-Skipton Rd	99022706	250	143.2930	-37.4540	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
402	TAS	Nelson River	18km E of Queenstown	88110200	500	145.4200	-42.0600	MV-EPH0159	02 XI 1998	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
403	TAS	New River	upstream Ralph Falls	95021003	810	147.5000	-41.1900	MV-EPH0207	10 II 1995	PS&PG	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
404	NSW	No. 1 Creek	6kms downstream Thredbo	78121401	1260	148.2300	-36.2800	MV-EPH1678, 1679	14 XII 1978	JD	0	0	1	0	0	0	1	0	0	0	0	0	NO	0	0	1
405	NSW	No. 1 Creek	upstream Alpine Way	84012301	1400	148.2300	-36.2600	MV-EPH1681	23 I 1984	JD	1	0	0	0	0	0	1	0	0	0	0	0	NO	0	0	0
406	VIC	North Cascade Creek	Thomson Valley Rd	91011300	920	146.2019	-37.4822	MV-EPH1722	13 I 1991	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
407	SA	North East River	near Carnarvon, Kangaroo Island	77111900	40	136.5900	-35.5600	PS collection	19 XI 1977	JEB	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
408	TAS	North Eldon River	Lake Burbury	94110100	x	x	x	MV-EPH1460, 1461	01 XI 1994	MRHI	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
409	TAS	North Esk River		33012100	x	x	x	NHM	21 I 1933	RJT	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
410	TAS	North Esk River	near Perth	60011800	x	x	x	ANIC	?? I 1960	DS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
411	TAS	North George River		94030702	x	x	x	MV-EPH0197, 0198	07 III 1994	PS&MS	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0
412	SA	North Para River	downstream Orlando Ford, winery discharge	83081900	x	x	x	AWQC	19 VIII 1983	PS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
413	SA	North Para River	Tanunda	91102100	250	138.5800	-34.3200	AwQC	21 X 1991	PW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
414	NSW	Ogilvies Creek	Tooma Rd	97120105	1300	148.1900	-36.0300	KJF collection	01 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
415	VIC	Olinda Creek	Olinda Creek Rd, Dandenong Ranges	97032405	260	145.2235	-37.4947	KJF collection	24 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
416	VIC	O'Shannassy River	restricted access	75102401	580	145.4900	-37.3600	MV-EPH1611	24 X 1975	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
417	VIC	O'Shannassy River	restricted access	75111400	580	145.4900	-37.3600	MV-EPH1554, 1555, 1570, 1603, 1610, 1713	14 XI 1975	JD	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	1
418	VIC	O'Shannassy River	restricted access	76102103	580	145.4900	-37.3600	MV-EPH1609	21 X 1976	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
419	VIC	O'Shannassy River	restricted access	76121501	580	145.4900	-37.3600	MV-EPH1567	15 XII 1976	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
420	VIC	O'Shannassy River	restricted access	76121502	580	145.4900	-37.3600	MV-EPH1567, 1581, 1608	15 XII 1976	JD	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
421	VIC	O'Shannassy River	restricted access	80010401	580	145.4900	-37.3600	MV-EPH1553, 1556, 1568, 1569, 1577,1604, 1607, 1759	04 I 1980	JD	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	1
422	VIC	O'Shannassy River	restricted access	94121502	580	145.4900	-37.3600	MV	05 XII 1994	MRHI	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
423	TAS	Ouse River	Grace Nicholas Park, Ouse	96121902	90	146.4245	-42.2912	KJF collection	19 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
424	TAS	Ouse River	outside Waddamana	96122005	530	146.4505	-42.0904	KJF collection	20 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
425	VIC	Ovens River	School Bridge, Harrietville	96111904	500	147.0348	-36.5325	KJF collection	19 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULCPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
426	VIC	Ovens River	School Bridge, Harrietville	97011903	500	147.0348	-36.5325	KJF collection	19 I 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
427	VIC	Ovens River	Germantown Bridge, Bright Tawonga Rd	97110601	340	147.0050	-36.4437	KJF collection	06 XI 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0
428	VIC	Ovens River	6km N of Bright	96111801	340	147.0110	-36.4525	KJF collection	18 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
429	VIC	Ovens River tributary	upstream Harrietville	82091000	540	147.0000	-36.5415	MV-EPH1571, 1579	10 IX 1982	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
430	TAS	Pencil Pine Creek	Enchanted Walk, Cradle Mountain Lodge, Cradle Mountain-Lake St Clair NP	96123002	810	145.5529	-41.3556	KJF collection	30 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
431	TAS	Penstock Lagoon	west bank, Grassy Corner	96122001	920	146.4655	-42.0521	KJF collection	20 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
432	TAS	Penstock Lagoon	west bank, Grassy Corner	96121705	920	146.4655	-42.0521	KJF collection	17 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
433	NSW	Perisher Creek	Smiggin Holes-Guthega Rd	97120203	1520	148.2500	-36.2200	KJF collection	02 XII 1997	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
434	VIC	Perrins Creek	Warwick Rd	97032406	350	145.2200	-37.5200	KJF collection	24 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
435	VIC	Pioneer Creek	Bennetts Track, Tarago-La Trobe State Forest	96101003	330	145.4947	-37.5301	KJF collection	10 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
436	TAS	Pipers Brook		94030602	x	147.1000	-41.0900	MV-EPH0241, 0242	06 III 1994	PS	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inccapsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
437	VIC	Plenty River	Memda	77110900	160	145.0600	-37.3600	MV-EPH1512, 1513, 1515, 1516	09 XI 1997	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
438	VIC	Plenty River	Memda	77120700	160	145.0600	-37.3600	MV-EPH1514, 1517, 1518, 1519, 1520	07 XII 1997	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
439	VIC	Poddy Creek	Princes Highway, S of Club Terrace	99021203	180	148.5400	-37.3500	KJF collection	12 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
440	TAS	Powers Rivulet		94030703	100	148.0500	-41.1900	MV-EPH0225, 0227	07 III 1994	PS&MS	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
441	TAS	Powers Rivulet		95020901	100	148.0500	-41.1900	MV-EPH0228	09 II 1995	PS&MS	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
442	VIC	Pretty Valley Creek	Bogong High Plains Rd, 1.5km S of Bogong	96110904	740	147.1320	-36.4910	KJF collection	09 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
443	QLD	Priors Creek	Atherton	96040600	760	145.2879	-17.1532	MV-EPH1439	06 IV 1995	BH	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
444	VIC	Pyramid Creek	Combienbar Rd, N of Club Terrace	99021304	100	148.5400	-37.3200	KJF collection	13 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
445	NSW	Ramshead Ck	"the Cascades", Merritts Track	84012701	x	x	x	MV-EPH1783	27 I 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
446	NSW	Ramshead Ck	upstream Kosciusko Walking track	84012703	1940	148.1600	-36.2900	MV-EPH1780, 1781	27 I 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
447	TAS	Ransom Creek	Terrys Hill Rd	95020908	90	148.0400	-41.1500	MV-EPH0174, 0175	09 II 1995	PS&PG	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
448	VIC	Raymond Creek	Princes Highway, 12 km E Orbost	81052102	20	148.3400	-37.4200	MV-EPH1657	21 V 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconspicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
449	VIC	Razor Creek	Mt Stirling Rd	89030300	1160	146.2719	-37.0652	MV-EPH1754	30 III 1989	AN	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
450	VIC	Riddells Creek	Gisborne-Kilmore Rd	97102603	360	144.4020	-37.2759	KJF collection	26 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
451	TAS	Ringarooma River	Pioneer	95020909	x	147.5700	-41.0500	MV-EPH0213	09 II 1995	PS&PG	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
452	TAS	River Forth headwaters	0.75km NE of Frog Flats, Cradle Mountain-Lake St Clair NP	90011705	1000	146.0100	-41.5100	MV-EPH1540	17 I 1990	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
453	TAS	River Forth headwaters	0.25km E of Frog Flats, Cradle Mountain-Lake St Clair NP	90011802	760	146.0100	-41.5000	MV-EPH1530, 1541	18 I 1990	JD&DC	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
454	TAS	River Forth headwaters	Frog Flats Overland Track, Cradle Mountain-Lake St Clair NP	90011803	740	146.0000	-41.5000	MV-EPH1479, 1529, 1538, 1539	18 I 1990	JD&DC	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
455	TAS	River Forth tributary	2.75km NW of Pelion Gap, Cradle Mountain-Lake St Clair NP	90011701	760	146.0100	-41.4900	MV-EPH1522	17 I 1990	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
456	VIC	Roadknight Creek	Roadnight Ck Rd	98010302	160	143.4121	-38.3106	KJF collection	03 I 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
457	SA	Rocky River	Flinders Chase National Park, Kangaroo Island	76121300	60	136.4400	-35.5600	PS collection	13 XII 1976	WDW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
458	SA	Rocky River	Flinders Chase National Park, Kangaroo Island	76121800	60	136.4400	-35.5600	PS collection	18 XII 1976	WDW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
459	VIC	Rodger River	Deddick	90112300	560	148.4600	-37.2900	AWT	23 XI 1990	unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
460	VIC	Rose Creek	Rose Creek Rd	96102001	340	142.2200	-37.0737	KJF collection	20 X 1996	BM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
461	VIC	Rose River Site 1	Rose River Rd Bridge	99022201	340	146.3455	-36.4940	KJF collection	22 II 1999	BM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
462	VIC	Rose River Site 1	Rose River Rd Bridge	99031701	340	146.3455	-36.4940	KJF collection	17 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
463	VIC	Rose River Site 2	Rose River Rd	99031702	360	146.3302	-36.5214	KJF collection	17 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
464	VIC	Rose River Site 3	Rose River Rd	99031703	460	146.3212	-36.5701	KJF collection	17 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
465	VIC	Rose River Site 4	Bennies, Upper Rose River/Cobbler Lake Rd	99031704	460	146.3210	-36.5645	KJF collection	17 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
466	VIC	Rubicon River	Rubicon Falls	80112001	560	145.5102	-37.2029	MV-EPH1648	20 XI 1980	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
467	VIC	Rubicon River	Rubicon Bridge, Taggerty-Thornton Rd	98101701	220	145.4756	-37.1655	KJF collection	17 X 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
468	VIC	Rubicon River	Rubicon Bridge, Taggerty-Thornton Rd	98111701	220	145.4756	-37.1655	KJF collection	17 XI 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
469	VIC	Rubicon River	Rubicon Bridge, Taggerty-Thornton Rd	98121601	220	145.4756	-37.1655	KJF collection	16 XII 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
470	VIC	Ruined Castle Springs	Falls Creek	99020502	1755	147.1555	-36.5240	KJF collection	05 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
471	VIC	Rum Creek	Thomson Valley	85041700	640	146.2249	-37.5245	MV-EPH1758	17 IV 1985	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
472	VIC	Running Creek	Warburton-Jamieson Rd	81103102	750	145.5800	-37.2500	MV-EPH1580, 1724	31 X 1981	JD	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
473	VIC	Running Creek	Warburton-Jamieson Rd	85030700	750	145.5800	-37.2500	MV-EPH1644	07 III 1985	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
474	VIC	Running Creek	downstream Running Creek Reservoir	85071000	x	x	x	MV-EPH1639	10 VII 1985	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
475	VIC	Running Jump Creek tributary	Mt Buffalo Rd	96110705	1500	146.4626	-36.4615	KJF collection	07 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
476	VIC	Russell Creek	off Gunn Rd, 3km N of Noojee	96101005	280	145.5926	-37.5045	KJF collection	10 X 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
477	TAS	Russell River	near Lonnavale	82030202	130	146.4700	-42.5600	MV-EPH0124	02 III 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
478	VIC	Sandy Creek	Murrindindi Falls Rd	96112903	390	145.3427	-37.2627	KJF collection	29 XI 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
479	VIC	Sandy Creek	near Lucas Access Rd off Omeo Highway	97102902	220	147.5056	-37.2457	KJF collection	29 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	VIC	Sassafras Creek	1km N of Kallista	74103000	320	145.2200	-37.5200	MV	30 X 1974	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
481	VIC	Sassafras Creek	Monbulk-Olinda Rd, Dandenong Ranges	96101302	320	145.2218	-37.5246	KJF collection	13 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
482	VIC	Sassafras Creek	Kays Picnic Ground, Monbulk Rd, Dandenong Ranges	96101303	250	145.2321	-37.5303	KJF collection	13 X 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
483	VIC	Sassafras Creek	Monbulk-Olinda Rd, Dandenong Ranges	96112101	320	145.2218	-37.5246	KJF collection	21 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
484	VIC	Sassafras Creek	Kays Picnic Ground, Monbulk Rd, Dandenong Ranges	96112102	250	145.2321	-37.5303	KJF collection	21 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
485	VIC	Sassafras Creek	Kays Picnic Ground, Monbulk Rd, Dandenong Ranges	97032402	250	145.2321	-37.5303	KJF collection	24 III 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
486	VIC	Sassafras Creek	Perrins Creek Rd, Dandenong Ranges	97101502	370	145.2218	-37.5246	KJF collection	15 X 1997	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
487	VIC	Sassafras Creek	Kays Picnic Ground, Monbulk Rd, Dandenong Ranges	99032002	250	145.2321	-37.5303	KJF collection	20 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
488	VIC	Sawpit Creek	Donnelly Weir Rd	97040605	100	145.3203	-37.3815	KJF collection	06 IV 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
489	TAS	Scamander River	Upper Scamander	82030900	20	148.1100	-41.2600	MV-EPH0146	09 III 1982	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
490	SA	Scott Creek		94110900	x	x	x	AWQC	09 XI 1994	PG&CM	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
491	VIC	Scrubby Valley Creek	Flat Rock Crossing, Glenelg River Rd	99011604	290	142.2636	-37.0946	KJF collection	16 I 1999	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
492	TAS	Second River	upstream Lilydale Falls	82031100	150	147.1200	-41.1300	MV-EPH0115	11 III 1982	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
493	VIC	Second Wannon River	Grampians	77112502	430	142.3200	-37.1900	MV	25 XI 1977	DN&PS	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
494	NSW	Serpentine River	Point Lookout	48100000	1280	152.2000	-30.2800	AM	X 1948	JH	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
495	TAS	Seven Time Creek	Tasman Highway, near Targa	95020804	400	147.2200	-41.1800	MNV-EPH0216	08 II 1995	PS&PG	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
496	TAS	Shannon Lagoon	Lake Highway	96121706	1017	146.4458	-41.5913	KJF collection	17 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
497	TAS	Shannon Lagoon	Lake Highway	96122004	1017	146.4458	-41.5913	KJF collection	20 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
498	TAS	Shannon River	Waddamana Rd	96121704	910	146.4539	-42.0304	KJF collection	17 XII 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigell	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similiima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
499	TAS	Shannon River	Lake Highway	96122003	1017	146.4458	-41.5913	KJF collection	20 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	VIC	Shaw Creek	oif Dingo Hill Rd near McMillians walking Track, Alpine NP	96092203	1350	146.4215	-37.2730		22 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
501	VIC	Shaw Creek	Kellys Lane Bridge, Alpine NP	97020601	1280	146.4422	-37.2730	KJF collection	06 II 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
502	VIC	Shaw Creek	Howitt Rd, Alpine NP	97020602	1520	146.4448	-37.2342	KJF collection	06 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
503	VIC	Sheoak Creek	below Sheoak Falls, Great Ocean Rd	98100802	10	143.5800	-38.3402	KJF collection	08 X 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
504	VIC	Shicer Creek	West Ovens Track, Bonang NP	96110802	580	147.0230	-37.5520	KJF collection	08 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
505	VIC	Smythes Creek	Great Ocean Rd	97030202	10	143.4538	-38.4231	KJF collection	02 III 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
506	VIC	Snobs Creek	Snobs Rd	81103101	760	145.5400	-37.2100	MV-EPH1573, 1585	31 X 1981	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
507	VIC	Snobs Creek tributary	Snobs Creek Rd	81103103	760	145.5438	-37.2115	MV-EPH1573, 1585, 1708, 1709, 1763	31 X 1981	JD	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
508	VIC	Snowy Creek	Mitta	99031202	280	146.2215	-38.3210	KJF collection	12 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
509	VIC	Snowy River	McKillops Bridge	99021404	180	148.2400	-37.0500	KJF collection	14 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
510	VIC	Snowy River	Wanton Bridge	74031700	x	x	x	MV-EPH1645, 1647	17 III 1974	unknown	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
511	VIC	South Butler Creek headwaters	Mt Butler Summit	97021501	1680	146.2500	-37.0800	KJF collection	15 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigoli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
512	TAS	South Esk River	Clarendon	33030900	160	147.1700	-41.3800	NHM	09 III 1933	ES	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
513	TAS	South George River	St Columba Falls Reserve	94100500	150	147.5800	-41.1800	MV-EPH1473, 1474	05 X 1994	MRHI	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
514	NSW	South Ramshead		82032500	1950	148.1400	-36.3100	IC collection	25 III 1982	RG	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
515	SA	South West River	Brigadoon, Kangaroo Island	77101900	180	136.5000	-35.5200	PS collection	19 XI 1977	JEB	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
516	VIC	Spring Creek	4.5km upstream Alexandra-Yarck Rd	81110400	220	145.3800	-37.0800	MV-EPH1509	04 XI 1981	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
517	SA	Spring Creek		95101100	x	x	x	AWQC	11 X 1995	MRHI	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
518	TAS	St Columbia Falls	Pyengana	82031001	150	148.0000	-41.1700	MV-EPH0162	10 III 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
519	TAS	St Patricks River	Targa	82031002	380	147.2100	-41.1800	MV-EPH0120, 0121, 0177	10 III 1982	DC	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
520	TAS	St Patricks River	Numamara	95020805	350	147.1700	-41.2300	MV-EPH0233, 0236	08 II 1995	PS&PG	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0
521	VIC	Starvation Creek	Warburton-Woods Point crossing	75102402	240	145.4700	-37.4200	MV-EPH1558	24 X 1975	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
522	VIC	Starvation Creek	Warburton-Woods Point crossing	76031900	240	145.4700	-37.4200	MV-EPH1490, 1491, 1492, 1493, 1559, 1616	19 III 1976	JD	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
523	VIC	Starvation Creek	Warburton-Woods Point crossing	76042302	240	145.4700	-37.4200	MV-EPH1495, 1501, 1502, 1560	23 IV 1976	JD	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
524	VIC	Starvation Creek	upstream weir	77102800	340	145.5053	-37.4539	MV-EPH1712	28 X 1977	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
525	VIC	Starvation Creek	upstream weir	77120901	340	145.5053	-37.4539	MV-EPH1566, 1578	09 XII 1977	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
526	VIC	Starvation Creek	upstream weir	79121900	340	145.5053	-37.4539	MV-EPH1621, 1622	19 XII 1979	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
527	VIC	Steavensons Falls	Upper Gellibrand River	82012000	x	x	x	MV	20 1 1982	AN&AW	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
528	VIC	Steavensons River	Buxton-Marysville Rd	98021504	460	145.4502	-37.2853	KJF collection	15 II 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
529	VIC	Steavensons River	Marysville Rd	98101703	320	145.4401	-37.2832	KJF collection	17 X 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
530	VIC	Still Creek	Eildon-Jamieson Rd	96041403	340	146.0225	-37.2243	KJF collection	14 III 1996	ET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
531	TAS	Stoney Creek		82022302	350	146.5100	-42.5100	MV-EPH0110	23 II 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
532	QLD	Stony Creek	Conondale Ranges	77082600	140	152.4100	-26.5100		20 XI 1979	DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
533	QLD	Stony Creek	Conandale Ranges	79112002	140	152.4100	-26.5100		20 XI 1979	DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
534	VIC	Stony Creek	Wonderland Car Park, Grampians	90112600	410	142.3010	-37.0904	MV-EPH1646	26 XI 1990	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
535	VIC	Stony Creek	Shands Rd, Red Hill South	97041603	100	145.0029	-38.2412	KJF collection	16 IV 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
536	VIC	Stony Creek	Wonderland Car Park, Grampians	99011602	410	142.3010	-37.0904	KJF collection	16 I 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
537	QLD	Stony Creek	Conandale Ranges	97082602	140	152.4100	-26.5100	MV-EPH1251, 1259	26 VIII 1997	DC	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
538	QLD	Stony Creek lower	Conondale Ranges	97082600	140	152.4100	-26.5100	MV-EPH1685	26 VIII 1997	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
539	SA	Stunsail Broom River	Kangaroo Island, Coramandel	76121200	8	137.0000	-35.5900	PS collection	12 XII 1976	WDW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
540	SA	Sturt River	Coramandel Valley	76042900	200	138.5700	-35.0300	PS collection	29 IV 1976	PS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0

Appendix 2

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	H. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
541	SA	Sturt River	Bedford Park	76112700	60	138.3300	-35.0200	PS collection	27 XI 1976	JEB	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
542	SA	Sturt River	upstream Minno Creek	94102600	200	138.3300	-35.0200	AWQC	26 X 1994	MRHI	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
543	VIC	Suggan Buggan River	Snowy River Rd, Suggan Buggan	99021406	390	148.1900	-36.5700	KJF collection	14 II 1999	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
544	NSW	Swampy Plains River	Alpine Way, Kosciusko NP	97120206	420	148.1200	-36.2300	KJF collection	02 XII 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
545	VIC	Swindlers Creek	Pump House Rd, beneath Playground Chairlift	96110805	1500	147.0900	-37.5850	KJF collection	08 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
546	VIC	Swindlers Creek tributary	6km from Mt Loch Car Park, Mount Hotham	96111903	1640	147.0940	-37.5842	KJF collection	19 XI 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
547	VIC	Swindlers Creek tributary	6km from Mt Loch Car Park, Mount Hotham	96112501	1640	147.0940	-37.5842	KJF collection	25 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
548	VIC	Swindlers Creek tributary	6km from Mt Loch Car Park, Mount Hotham	97011901	1640	147.0940	-37.5842	KJF collection	19 I 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
549	TAS	Taffys Creek	A10 crossing	96122802	530	146.0337	-42.1304	KJF collection	28 XII 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
550	VIC	Taggerty River	Lady Talbot Drive, outside Marysville	98101704	400	145.4628	-37.3020	KJF collection	17 X 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
551	VIC	Taggerty River headwaters	Royston Gap Rd, Lake Mountain	96102501	1320	145.5235	-37.2939	KJF collection	25 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
552	VIC	Talbot Creek	downstream Thomson River Reservoir	83081000	700	147.2220	-37.5052	MV-EPH1757	10 VIII 1983	DC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
553	VIC	Talbot Creek	downstream Thomson River Reservoir	86040900	700	147.2220	-37.5052	NMC-EPH1752, 1753	09 IV 1986	DC	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
554	VIC	Tambo River	S of Doctors Flat, Omeo Highway	97102901	300	147.4511	-37.1840	KJF collection	29 X 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
555	VIC	Tambo River	Omeo Highway, Ensay South	99030405	320	147.4900	-37.2200	KJF collection	04 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
556	VIC	Tanjil River	5km N of Moe	87100600	60	146.1600	-38.0800	MV-EPH1652, 1659	06 X 1987	KW&AN	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
557	VIC	Tanjil River	Ashdown Rd	96110301	70	146.1433	-38.0548	KJF collection	03 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
558	VIC	Tanjil River east branch headwaters	Mt Baw Baw Alpine Village	96101201	1440	146.1545	-37.5025	KJF collection	12 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
559	VIC	Tanjil River east branch headwaters	Mt Baw Baw Alpine Village	99021603	1440	146.1545	-37.5025	KJF collection	16 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
560	VIC	Tanjil River east branch tributary	Mt Baw Baw Tourist Rd	96101104	500	146.1129	-37.4958	KJF collection	11 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
561	VIC	Tanjil River east branch tributary	Mt Baw Baw Tourist Rd	96101105	490	146.1211	-37.5018	KJF collection	11 X 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
562	VIC	Taponga River	Eildon-Jamieson Rd	99022008	320	146.0250	-37.2242	KJF collection	20 II 1999	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
563	VIC	Target Creek tributary	Heyfield-Jamieson Rd	97020502	720	146.3357	-37.3504	KJF collection	05 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
564	VIC	Tarra River	Tarra-Bulga NP	84010900	340	146.3213	-38.2657	MV-EPH1715, 1716, 1717	09 I 1984	JD	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
565	VIC	Tarra River	20 m upstream Tarra Falls	84120900	320	146.3220	-38.2717	MV-EPH1769	09 XII 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
566	VIC	Tarra River	Yarram	91031200	320	146.3220	-38.2717	MV	12 III 1991	MRHI	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
567	VIC	Tarra River	Tarra-Bulga NP	98012601	340	146.3213	-38.2657	KJF collection	26 I 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
568	VIC	Tarra River	Tarra-Bulga NP	98112101	340	146.3213	-38.2657	KJF collection	21 XI 1998	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0
569	VIC	Tarra River	Tarra-Bulga NP	98112102	340	146.3215	-38.2700	KJF collection	21 XI 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
570	VIC	Tarra River	Tarra-Bulga NP	99021601	340	146.3215	-38.2700	KJF collection	16 II 1999	KJF	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0
571	VIC	Tarwin River East	Mirboo Bridge, Mirboo	99030404	90	146.1237	-38.2825	KJF collection	04 III 1999	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
572	VIC	Thomson River	12km NNW of Walhalla	77111200	290	146.2400	-37.5200	MDFRC	12 XI 1977	unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
573	VIC	Thomson River	Walhalla Rd	99021505	210	146.2508	-37.5735	KJF collection	15 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
574	VIC	Thowgla Creek	upstream Nariel-Thowgla signpost	80102000	420	147.5400	-36.1800	MV-EPH1662	20 X 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
575	NSW	Thredbo River	Bullocks Nature Track	84012302	1140	148.3500	-36.2600	MV-EPH1667	23 I 1984	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
576	NSW	Thredbo River	Thredbo-Khancoban Rd	97120204	1560	148.1700	-36.3100	KJF collection	02 XII 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
577	NSW	Thredbo River	Thredbo Golf Course	84012501	1380	148.1800	-36.3000	MV-EPH1656	25 I 1984	JD	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
578	NSW	Thredbo River, Thredbo	Thredbo Golf Course	78121402	1380	148.1800	-36.3000	MV-EPH1655	14 XII 1978	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
579	NSW	Thredbo River, Thredbo	Thredbo Golf Course	84012502	1380	148.1800	-36.3000	MV-EPH1682	25 I 1984	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
580	NSW	Three Mile Dam	between Cabramurra & Kiandra	97120101	1480	148.2700	-35.1000	KJF collection	01 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
581	VIC	Thurra River	Princes Highway	74033000	140	149.1500	-37.3400	MV	30 III 1974	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
582	VIC	Thurra River west branch tributary	Thurra Junction Rd	97101801	200	149.1741	-37.2735	KJF collection	18 X 1997	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
583	VIC	Tiger Creek	Heyfield-Jamieson Rd	97020503	930	146.3223	-37.3515	KJF collection	05 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
584	VIC	Titania Creek tributary	Wilsons Promontory NP	97021502	220	146.2227	-39.0202	KJF collection	15 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
585	TAS	Tom Creek	locality 16, S of Zeehan	82022801	90	145.2500	-41.5500	MV-EPH0122, 0125	28 II 1982	DC	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
586	SA	Tookayerta Creek	location 3956	84102200	190	138.3900	-35.2200	AWQC	22 X 1984	PS	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
587	SA	Tookayerta Creek	TI AS1	84120501	x	x	x	AWQC	05 XII 1984	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
588	SA	Tookayerta Creek	N7 AS1	84120502	x	x	x	AWQC	05 XII 1984	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
589	SA	Tookayerta Creek	S7 AS1	84120503	115	138.4200	-35.2200	AWQC	05 XII 1984	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
590	SA	Tookayerta Creek	S7 AS2	84120504	115	138.4200	-35.2200	AWQC	05 XII 1984	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
591	SA	Tookayerta Creek	S5	85012300	190	138.3900	-35.2200	AWQC	23 I 1985	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
592	SA	Tookayerta Creek	S5 AS3	85030600	190	138.3900	-35.2200	AWQC	06 III 1985	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
593	SA	Tookayerta Creek	S5 Cleland Gully Rd, location 3956	95051200	190	138.3900	-35.2200	AWQC- MRHI	12 IV 1995	PS	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
594	VIC	Toorongo River	5km NE of Noojee	96101102	280	146.0229	-37.5117	KJF collection	11 X 1996	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
595	VIC	Toorongo River	5km NE of Noojee	98020902	280	146.0229	-37.5117	KJF collection	09 II 1998	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
596	TAS	Tower Rivulet	Rossarden Rd, Pepper Hill	94092700	260	147.5200	-41.3700	MV-EPH1673	27 IX 1994	MRHI	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
597	TAS	Township Creek	near Fingal	95021004	x	x	x	MV-EPH0184	10 II 1995	PS&PG	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
598	VIC	Traralgon Creek	Guntzler Bridge	84052900	110	146.3100	-38.2000	MV-EPH1762	29 V 1984	DC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
599	VIC	Tullaroop Creek	Carisbrook, Pyrenees Highway	97122002	190	143.4857	-37.0304	KJF collection	20 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
600	VIC	Turitable Creek	Devonshire Lane, Mt Macedon	81120100	680	144.3500	-37.2300	MV-EPH1744, 1745, 1746, 1747	01 XII 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
601	TAS	Tyenna River	Westerway	94031100	100	146.4700	-42.4000	MV-EPH0191	11 III 1994	PS	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
602	VIC	Tyers River	Moe-Rawson (Walhalla) Rd, Moondarra State Park	99021507	180	146.1942	-38.0215	KJF collection	15 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
603	VIC	Unnamed Creek	3km W of Genoa	81052203	60	149.3300	-37.2800	EPH-MV1564, 1565	22 V 1981	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
604	VIC	Unnamed Creek	NE slope of Mt Buller	81110300	x	x	x	MV-EPH1728	03 XI 1981	JD	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
605	TAS	Unnamed Creek	Stickland Ave, Hobart	82030800	110	147.1700	-42.5300	MV-EPH0123	08 III 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
606	VIC	Unnamed Creek	2km W of Genoa	82112100	100	149.3400	-37.2800	MV-EPH1563	21 XI 1982	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
607	TAS	Unnamed Creek	Stickland Ave, Hobart	88110300	110	147.1700	-42.5300	MV-EPH0131	03 XI 1988	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
608	SA	Unnamed Creek	Parawa Rd, near Yankalilla	78110200	80	138.2100	-35.2800	PS collection	02 XI 1978	JEB &AW	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
609	TAS	Unnamed Creek	3 miles E of Waratah	82022800	650	145.3300	-41.2600	MV-EPH1061	28 II 1982	DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
610	TAS	Unnamed Creek	E of Waratah	88110100	600	145.3200	-41.2600	MV-EPH0166	01 XI 1998	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
611	VIC	Unnamed creek - "Summit T-Bar" trickle	Mt Baw Baw Alpine Village	96101202	1500	146.1610	-37.5030	KJF collection	12 X 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similllima	THRAULOPHELBIA	N. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
612	VIC	Unnamed icemelt	Mt Buffalo Rd	96110703	1060	146.4806	-36.4239	KJF collection	07 XI 1995	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
613	NSW	Unnamed tributary	south slope of North Ramshead	84012702	1940	148.1600	-36.2800	MV-EPH1787, 1788	27 I 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
614	NSW	Unnamed tributary	small ck crossing track upper Snowy Valley, Ramshead	85020902	1940	148.1600	-36.2800	MV-EPH1785	09 II 1985	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
615	VIC	Unnamed tributary - "Rubbish Tip"	Mt Baw Baw Tourist Rd	96101206	620	146.1300	-37.5038	KJF collection	12 X 1996	KJF	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
616	NSW	Unnamed trickle	small trickle, Cascade Trail, 1km upstream Deadhorse Gap	84012100	1600	148.1600	-36.3100	MV-EPH1782	21 I 1984	JD	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
617	VIC	Upper Broken River	Mansfield-Whitfield Rd, 9km N Mansfield	99022005	340	146.0620	-36.5838	KJF collection	20 II 1999	KJF	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
618	VIC	Upper Perkins Creek		94112100	x	x	x	MV-EPH1748, 1749	21 XI 1994	JBa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
619	VIC	Upper Tambo River	Nunniong Rd	99021504	360	147.4500	-37.1000	KJF collection	15 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
620	QLD	Upstream Falls	Natural Bridge NP	79120602	800	153.1400	-28.1500	MV-EPH1791	06 XII 1979	DC	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
621	VIC	Victoria River	Victoria River Track, Alpine NP	96111804	1010	147.2100	-37.0500	KJF collection	18 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
622	VIC	Victoria River	Victoria River Track, Alpine NP	96111901	1010	147.2100	-37.0500	KJF collection	19 XI 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
623	TAS	Walkers Creek	Mt Saddleback	95021005	750	147.4600	-41.2200	MV-EPH0186	10 II 1995	JD&DC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
624	VIC	Wangarabell Creek	Wangarabell Rd, Wangarabell	99021302	120	149.2800	-37.2200	KJF collection	13 II 1999	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
625	VIC	Wannon River	Serra Rd Bridge, 25km S of Halls Gap	83120400	320	142.3000	-37.2100	MV	04 XII 1983	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
626	VIC	Wannon River	Victoria Valley Rd	200012204	240	142.2000	-37.3700	KJF collection	22 I 2000	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
627	VIC	Wannon River	Wannon Falls	99022804	120	141.5020	-37.4039	KJF collection	28 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
628	VIC	Wannon River tributary	Dunkeld	99022805	240	142.2036	-37.3802	KJF collection	28 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
629	VIC	Watchbed Creek		96031800	1680	147.1900	-36.5100	MV-EPH1693, 1694	18 III 1996	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
630	TAS	Watersmeet	conjunction of Cuvier and Hugel Rivers, Cradle Mountain-Lake St Clair NP	96122701	740	146.0937	-42.0641	KJF collection	27 XII 1996	KJF	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
631	VIC	Watts River	Fernshaw Reserve	74122000	200	145.3600	-37.3700	MV-EPH1642	20 XII 1974	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
632	TAS	Wedge River	locality 23	82030301	x	x	x	MV-EPH0128, 0130	03 III 1982	DC	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
633	TAS	Weld River	E of Weldborough	94030600	360	147.5600	-41.1200	MV-EPH0221	06 III 1994	PS	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
634	VIC	Wellington River	Tamboritha Rd, Alpine NP	96092204	340	146.3815	-37.3102	KJF collection	22 IX 1996	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
635	VIC	Wellington River	Tamboritha Rd, Alpine NP	96092301	320	146.3712	-37.3113	KJF collection	23 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
636	VIC	Wellington River	Tamboritha Rd, Alpine NP	97020401	340	146.3815	-37.3102	KJF collection	04 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
637	VIC	Wellington River	Tamboritha Rd, Alpine NP	97020702	340	146.3815	-37.3102	KJF collection	07 II 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp."AV5"	N. (A) sp."AV7"	N. (A) sp."AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. simillima	THRAULOPHELBIA	M. kaia	M. adamus	MONTIKOLA	GEMMAYALUKA
638	VIC	Wellington River	10km N of Licola, Alpine NP	96092201	280	146.3637	-37.3241	KJF collection	22 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
639	VIC	Wellington River	Tamboritha Rd, Alpine NP	96092302	320	146.3648	-37.3135	KJF collection	23 IX 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
640	NSW	Wentworth Falls	Blue Mountains	82111600	800	150.2200	-33.4300	MV-EPH1130	16 XI 1982	DC	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
641	NSW	Wentworth Falls	Blue Mountains	84111200	800	150.2200	-33.4300	MV-EPH1680	12 XI 1984	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
642	NSW	Wentworth Falls	Blue Mountains	88101900	800	150.2200	-33.4300	MV-EPH1669	19 X 1988	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
643	VIC	Werribee River	Blakeville-Bunding Rd	99022701	550	144.1012	-37.3004	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
644	VIC	Werribee River	Blakeville-Bunding Rd	99032100	550	144.1012	-37.3004	KJF collection	21 III 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645	VIC	Werribee River	Blakeville-Bunding Rd	200032600	550	144.1012	-37.3004	KJF collection	26 III 2000	KJF	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
646	VIC	West Erinundra River	Hammond Rd	82031500	960	148.5100	-37.1800	AWT	15 III 1982	JB	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
647	VIC	West Ovens River	Harrietville	90111200	540	147.0500	36.5100	AWT	12 XI 1990	RBu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
648	VIC	Whitelaw Creek	Whitelaw Portal upstream weir	77021100	470	146.1600	-37.4300	MDFRC	02 XI 1977	unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
649	VIC	Wild Dog Creek	Wild Dog Creek Rd	97030201	10	143.4044	-38.4404	KJF collection	02 III 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
650	VIC	Wild Duck Creek	Heathcote-Redesdale Rd, 1km SW of Heathcote	99022304	210	144.3935	-36.5244	KJF collection	23 II 1999	KJF	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
651	VIC	Wild Duck Creek	Heathcote-Redesdale Rd, 1km SW of Heathcote	200022001	210	144.3935	-36.5244	KJF collection	20 II 2000	KJF	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0

Locality data for all specimens examined

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similllima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
652	VIC	Wild Duck Creek	Heathcote-Redesdale Rd, 1km SW of Heathcote	99040701	210	144.3935	-36.5244	KJF collection	07 IV 1999	KJF	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
653	VIC	William Wallace Creek	Triangle Link Rd, Gembrook Park	97012901	150	145.3538	-37.5903	KJF collection	29 I 1997	KJF	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
654	VIC	Wingan River	Drummer Rd, Coopracambra NP	96112301	180	149.2515	-37.2803	KJF collection	23 XI 1996	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
655	VIC	Wingan River	Drummer Rd, Coopracambra NP	98012501	180	149.2515	-37.2803	KJF collection	25 I 1998	KJF	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
656	VIC	Woady Yaloak Creek	Glenelg Highway, outside Scarsdale	99022703	330	143.3830	-37.4037	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
657	VIC	Wombat Creek	Wombat Creek Dam Picnic Area	97122004	635	144.1022	-37.2325	KJF collection	20 XII 1997	KJF	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
658	VIC	Wombat Creek	Wombat Creek Dam Picnic Area, near Daylesford	98110102	635	144.1022	-37.2325	KJF collection	01 XI 1998	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
659	QLD	Yabba Creek tributary	Brooloo-Imbil Rd	84110800	100	152.4000	-26.2900	MV-EPH1687	08 XI 1984	DC	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
660	VIC	Yackandandah Creek	Osbornes Flat, Gaps Flat Rd	97022201	200	146.5418	-36.1615	KJF collection	22 II 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
661	VIC	Yan Yean Reservoir		76021800	180	145.0800	-37.3300	MV-EPH1522	18 II 1976	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
662	VIC	Yan Yean Reservoir		76032900	180	145.0800	-37.3300	MV-EPH1511	29 III 1976	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
663	VIC	Yan Yean Reservoir		77102600	180	145.0800	-37.3500	MV-EPH1521	26 X 1977	JD	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
664	VIC	Yarra Flats	Healesville	65091400	x	x	x	MV	14 IX 1965	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
665	VIC	Yarra River	near McMahons Creek	76021900	250	145.5000	-37.4200	MV	19 II 1976	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
666	VIC	Yarra River	Willgrove	76022400	x	x	x	MV	24 II 1976	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

No.	State	Site name	Location	Site No.	Altitude	Longitude	Latitude	Collection origin	Date	Collector	N. (A) fusca	N. (A) fuscula	N. (A) nigeli	N. (A) sp. "AV5"	N. (A) sp. "AV7"	N. (A) sp. "AV8"	NOUSIA (A)	T. lucida	T. inconpsicua	T. parva	T. similima	THRAULOPHELBIA	M. kala	M. adamus	MONTIKOLA	GEMMAYALUKA
667	VIC	Yarra River	Reefton Rd	77110300	260	145.5000	-37.4200	MV-EPH1615	03 XI 1977	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
668	VIC	Yarra River	Reefton Rd	78020900	260	145.5000	-37.4200	MV-EPH1500	09 II 1978	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
669	VIC	Yarra River	Peninsula Rd	78122100	230	145.4900	-37.4200	MV-EPH1612	21 XII 1978	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
670	VIC	Yarra River	O'Shannassy Rd	79022100	x	x	x	MV-EPH1498	21 II 1979	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
671	VIC	Yarra River	Reefton Rd	79102400	260	145.5000	-37.4200	MV-EPH1496, 1497, 1499	24 X 1979	JD	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
672	VIC	Yarra River	Peninsula Rd	80010402	230	145.4900	-37.4200	MV-EPH1625	04 I 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
673	VIC	Yarra River	Peninsula Rd	80020600	230	145.4900	-37.4200	MV-EPH1562, 1613, 1624	06 II 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
674	VIC	Yarra River	Hazelwood Rd	80112000	170	145.4400	-37.4400	MV-EPH1614, 1623	20 II 1980	JD	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
675	VIC	Yarra River	upstream of Warburton	97042502	170	145.4243	-37.4503	KJF collection	25 IV 1997	KJF	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
676	NSW	Yarrangobilly River	Near ravine	97120102	560	148.2300	-35.4700	KJF collection	01 XII 1997	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
677	VIC	Yarrowee River	Mt Clear-Sebastapol Rd	99022702	380	143.5002	-37.3731	KJF collection	27 II 1999	KJF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
678	VIC	Yea River	7km S of Glenburn	72120100	330	145.2500	-37.2900	MV	01 XII 1972	AN	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

APPENDIX 3

Description and distribution of a new species of *Nousia* Navás (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) from south-eastern Australia

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Abstract   *Nousia wiltkorringae* sp. n. is described as a new species of the genus *Nousia* (subgenus *Australonousia*) from south-eastern Australia. It is commonly found in macroinvertebrate surveys. Nymphs and adults were associated by rearing. The distribution of the species is recorded along with notes on the apparent habitat requirements.

Key words   Ephemeroptera, Leptophlebiidae, mayfly, *Nousia*, taxonomy.

INTRODUCTION

The taxonomy of Australian mayflies is, at present, poorly known, with at least as many species to be described as are already documented (Dean & Suter 1996; Hubbard & Campbell 1996). This is despite a proliferation of recent publications defining new taxa (Dean 1987, 1988, 1997; Campbell & Peters 1993; Dean *et al.* 1999). The endemic Australian subgenus *Australonousia* (Campbell & Suter 1988) requires significant revision as it presently includes only three described species (Hubbard & Campbell 1996), although it is considered that there may be at least 16 (Dean 1999).

The present contribution documents a new species of *Nousia* Navás (1918) from south-eastern Australia. The nymph has been known for some time and has been variously referred to as *Atalophlebioides* sp. E (Murray Darling Freshwater Research Centre; MDFRC), *Atalonella* sp. 5 (Museum Victoria; MV) and *Nousia* sp. 4 (Monitoring River Health Initiative; MRHI). In the latest guide, however, it is referred to as *Nousia* AV4 (Dean 1999). It is a commonly encountered species in macroinvertebrate survey work, being found in the mid to high altitudes of mountainous regions of eastern Victoria and southern New South Wales, where it generally prefers fast-flowing, unpolluted streams. Formal description of this species is important to prevent further confusion in future publications. This species is presented here in advance of a full revision of the genus. Examination of all life stages has confirmed the new species status of this taxon and its agreement with the generic diagnosis (Pescador & Peters 1985).

MATERIALS AND METHODS

In the field, nymphs were brushed directly from rocks and wood using a paintbrush and either preserved with 70%

ethanol or kept alive. Live nymphs were stored in a bottle of stream water and placed on ice for transportation to the laboratory for rearing. In the laboratory, final-instar nymphs were placed individually in specially designed rearing chambers in a controlled-temperature environment. Resultant subimagos and imagos were associated with the nymphal exuviae.

Whole specimens were examined with the aid of a dissecting microscope, while body parts were mounted in Canada balsam and examined by using a compound microscope. Illustrations were made with the aid of a drawing tube or a microprojector.

Wing venation terminology follows that of Edmunds *et al.* (1976). Leg and palpi segment ratios were calculated using the method of Suter (1986), where each segment is compared to the length of the femur, or first segment, and expressed as a ratio. The absolute length of the femur/first segment is given in parentheses. The labia figures follow the method of Peters and Edmunds (1964), where the dorsal surface is illustrated on the left and the ventral surface on the right.

Material for the scanning electron microscope was prepared by transfer from 70% ethanol to 100% ethanol through a series of washes. The genitalia were dissected and eggs removed without exposing them to air. The eggs were ultrasonicated for 5 min. All material was critical-point dried to minimise distortion. The dried eggs were placed on metal stubs using adhesive and genitalia were mounted on cardboard attached to a metal stub, allowing for maximum rotation so that the dorsal, ventral and lateral sides could be viewed.

Specimens that I collected are referenced by an eight digit code with, where necessary, identification of individuals by two further digits. Other material is referenced by a MV code ('EPH' plus four digits). For material not collected by the author, MDFRC or MRHI, initials are as follows: DC, David Cartwright; JD, John Dean. Specimens are denoted by N (nymph), S (subimago) or I (imago). Multiple combinations of these letters indicate exuviae retained from

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rearing. All type material is lodged in the MV, other material remains in the author's personal collection.

TAXONOMY

Order Ephemeroptera, family Leptophlebiidae, subfamily Atalophlebiinae

Nousia wiltkorringae sp. n.

Types. *Victoria.* Holotype male NI, Cement Creek, Mount Donna Buang Road, outside Warburton, 670 m a.s.l., 145°42′20″E, 37°42′48″S, 5.iii.1998, 98030501.15. Paratypes same locality, 1.xii.1976; EPH1602, one female SI (JD); EPH1587, one male 1 (JD); EPH1588, one male NI (JD); 23.xi.1978: EPH1589, one female NI reared (JD); EPH1590, one male NSI (JD); EPH1591, one male NS (JD); EPH1592, one female NS (JD); EPH1594, one female NI (JD); EPH1596, one female NI (JD); EPH1597, one female NS (JD); EPH1598, one female NS (JD); EPH1599, one male NS, 1(NS (JD); 3.iii.1980: EPH1593, one female NS (JD); 5.iii.1998: 98030503.01, one female SI; 98030503.05, one male N; 29.xi.1998; 98112901.03, one male NSI reared; 23.i.1999: 99012301, two male N, one female N; 20.iii.1999: 99032004, one female N; 23.xi.1978: EPH1599, one male NS, one female, NS (JD).

Other material examined. *Victoria.* Acheron River, Marysville Rd, 560 m a.s.l., 145°43′E, 37°38′S, 5.xi.1997, three N (MRHI); Badger Creek, 5 km south-east of Healesville, 300 m a.s.l., 145°34′04″E, 37°41′17″S, 18.i.1980: EPH1605, one male N, one female N (JD); same locality 20.iii.1980, EPH1606, one male N, one female N (JD); Buller Creek, Mirimbah, 670 m a.s.l., 146°24″E, 37°06′S, 2.xi.1981, EPH1761, 1 female N (JD); Charity Creek, Mount Baw Baw, 700 m a.s.l., 146°13′49″E, 37°50′57″S, 12.xi.1997, three N (MRHI); Charity Creek tributary, Mount Baw Baw Tourist Road, 1180 m a.s.l., 146°15′15″E, 37°50′47″S, 16.ii.1999, 99021602, three male N, seven female N; Deep Creek, 0.5 km north of Uplands, 620 m a.s.l., 147°42′E, 36°49′S, 15.ii.1999, 99021501, one female N; Erinundra River, Erinundra, 320 m a.s.l., 148°53′E,37°22′S, 15.xi.1994, three N; 05.xi.1996, one N (MRHI); Eurobin Creek, Mount Buffalo Road, 440 m a.s.l., 146°50′29″E, 36°43′10″S, 7.xi.1996, 96110702, one male N; Growlers Creek, Wandiligong, 380 m a.s.l., 146°59′10″E, 36°45′54″S, 8.xi.1996, 96110801, one male N; Kiewa River, 5 km north-east of Mount Hotham, 1180 m a.s.l., 147°10′44″E, 36°55′46″S, 7.xi.1997, 97110703, one female N; King Parrot Creek, 15 km south-west of Flowerdale, 350 m a.s.l., 147°14′56″E, 37°25′50″S, 3.v.1988, 98030501, one female N, one female NI, one male NSI; La Trobe River, 5 km east of Powelltown, 320 m a.s.l., 145°50′10″E, 37°52′35″S, 10.x.1996, 96101002, one female NSI; Learmonth Creek, Powelltown, 180 m a.s.l., 145°44′33″E, 37°51′43″S, 10.x.1996, 96101001.04, three female N; Mountain Creek, 7 km east of Tawonga South, 510 m a.s.l., 147°14′E, 36°42′S, 3.xi.1990, EPH1723, one male N, two

female N (DC); Myrtle Gully, 3 km east of Toolangi, 620 m a.s.l., 145°31′04″E, 37°31′44″S, 29.xi.1996, 96112901, one female N; O'Shannassy River, 580 m a.s.l., 145°49′E, 37°36′S, 14.xi.1975, EPH1603, one male N, two female N (JD); 4.i.1980, EPH1604, one male NS (JD); 5.xii.1994, two N (MRHI); Rodger River, Deddick, 560 m a.s.l., 148°27′E, 37°17′S, 23.xi.1990, one female N (MRHI); Snowy River, Wanton Bridge, location unknown, 17.iii.1974, EPH1647, one female N (collector unknown); Steavensons River, 12 km south-east of Buxton, 460 m a.s.l., 146°50′29″E, 36°43′10″S, 15.ii.1998, 98021504.06, one male NSI; Taggerty River, Marysville, 400 m a.s.l., 145°46′28″E, 37°30′20″S, 17.x.1998, 981201704, one male N; Thomson River, 12 km north-northwest of Walhalla, 290 m a.s.l., 146°24′E, 37°52′S, 12.xi.1977, one N (MDFRC); West Ovens River, Harrietville, 540 m a.s.l., 147°04′15″E, 36°54′13″S, 12.xi.1990, two female N (MRHI); Whitelaw Creek, Whitelaw Portal, 470 m a.s.l., 146°16′E 37°43′S, 2.xi.1977, one N (MDFRC). *New South Wales.* No. 1 Creek, near Thredbo, 1260 m a.s.l., 148°23′E, 36°28′S, 14.xii.1978, two female N (JD); Thredbo River, Thredbo, 1380 m a.s.l., 148°18′E, 36°30′S, 14.xii.1978, EPH1655, one male N, two female N (JD).

Diagnostic features. *Male imago (Figs 1–8,25–27).* In ethanol. Body length 7.0–8.9 mm (mean = 8.1 mm, *n* = 8); forewing length 8.6–9.6 mm (mean = 9.0 mm, *n* = 6); hindwing length 1.4–1.6 mm (mean = 1.5 mm, *n* = 6). General body colour ranging from golden brown to orange-brown with darker brown markings. Head brown. Antennae yellow. Ocelli black with white inserts, lateral ocelli larger than medial. Eyes: upper lobes orange, just meeting on meson of head; lower lobes grey black. Thorax and abdomen golden to orange brown with darker brown markings. Abdominal terga golden to orange-brown with distinct dark brown markings forming a W-shaped pattern that becomes more apparent on the posterior segments (Fig. 1). Abdominal sterna with lighter brown markings. Wings: forewing with membrane hyaline (Fig. 2); longitudinal and crossveins brown except for anal veins, which are lighter and yellow coloured; costal and subcostal cells hyaline but slightly darker. Three bullae present on veins Sc, R_2 and R_{4+5} at approximately one-half to one-third the distance from base to wing margin. In the costal region 6–7 cross veins prebulla, 11–14 postbulla; in the subcostal region 5–7 crossveins prebulla, 9–14 postbulla (*n* = 8). Rs forked at approximately one-third of the distance from wing base to wing margin; vein MA symmetrically forked at approximately one-half the distance from base to wing margin; IMP joins MP_1, sometimes recurved but not always; MP_2 recurved to join MP_1 at one-quarter to one-fifth the length of MP_1 from base to wing margin; MP_2 joined by crossvein to CuA; ICu_1 joins CuA, sometimes recurved; ICu_2 recurved to join ICu_1, both attached at base to CuA; CuA and CuP linked by crossvein, CuP strongly curved and linked by crossvein to A_1. Hindwing hyaline (Fig. 3); costal margin slightly convex at midlength followed by shallow concavity. In the subcosta four-fifths maximum length of wing. Costal space with no crossveins in proximal half, 4–5 crossveins in distal half (*n* = 5). Subcostal space with 4–5 crossveins (*n* = 5).
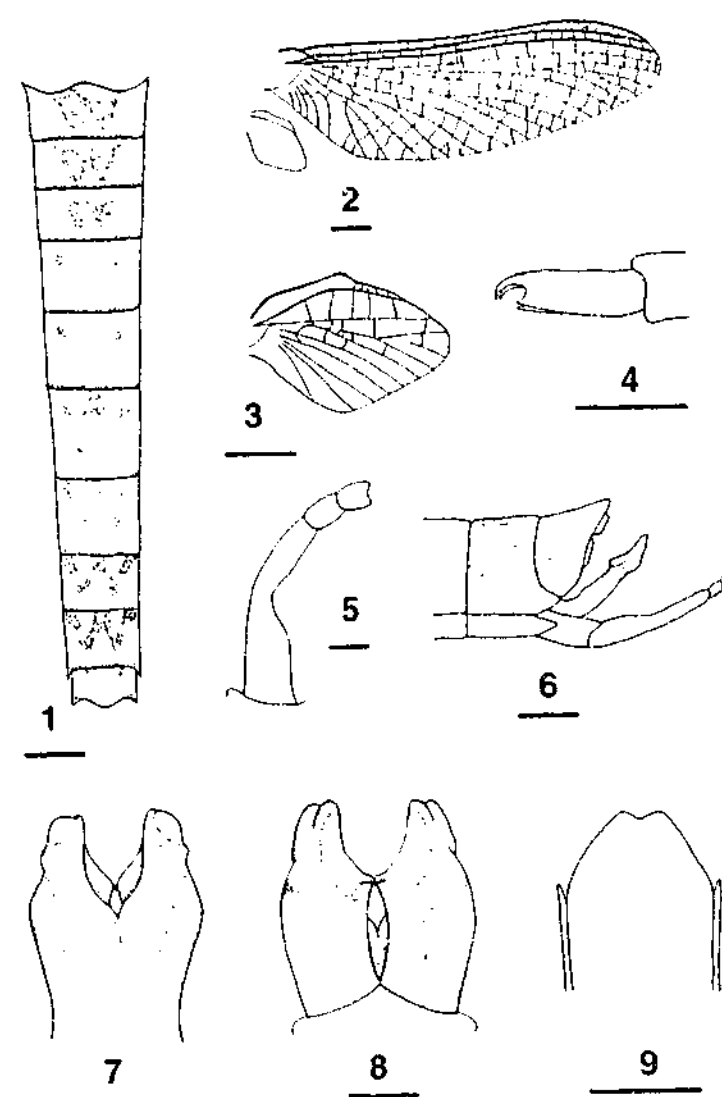
Fig. 1–9. Nousia wiltkorringae. (1–8) male imago: (1) Abdominal segments, dorsal patterning; (2) forewing with hindwing comparatively sized; (3) hindwing; (4) tarsal claws; (5) forceps; (6) genitalia, lateral; (7) genitalia, ventral; (8) genitalia, dorsal. (9) Female imago, ninth sternum, ventral. Scale bars: Fig. 1, 0.5 mm; Fig. 2, 1 mm; Fig. 3, 0.5 mm; Fig. 4, 0.1 mm; Fig. 5–6, 0.2 mm; Fig. 7–8, 0.1 mm; Fig. 9, 0.5 mm.

Fig. 10. Nousia wiltkorringae mature nymph. Scale bar: 1 mm.

Legs golden brown with no markings except for the forelegs where apex of each segment washed with brown. Forelegs with seven segments; mean length ratios 1.00 : 1.37 : 0.10 : 0.43 : 0.36 : 0.30 : 0.16 (1.99 mm, *n* = 5). Tarsal claws of a pair similar, each apically hooked with an opposing smaller hook (Fig. 4). Male genitalia: forceps three-segmented (Fig. 5); yellow, third segment globose and slightly indented at apex. Penes yellow, laterally quite large with penes extending to approximately half the length of forceps (Fig. 6). Ventral surface of penes (Figs 7,25,26) fused in basal third, remainder divided, divergent; dorsal surface (Figs 8,27) separate with two laterally expanded lobes meeting at two-thirds length and two small triangular processes projecting from inner surface. Caudal filaments three, yellow with dark brown at proximal edge of each segment giving a banded appearance. Terminal filament longer than cerci. *Female imago (Fig. 9).* In ethanol. Body length 7.8–9.7 mm (mean = 8.9 mm, *n* = 10); forewing length 9.8–10.9 mm (mean = 10.3 mm, *n* = 10); hindwing length 1.5–2.0 mm (mean = 1.6 mm, *n* = 12).

Colour and markings as in male. Forewings with generally more crossveins in costal and subcostal spaces; costal region with 6–9 crossveins prebulla, 13–16 post bulla; subcostal region with 6–8 crossveins prebulla, 11–16 postbulla (*n* = 9). Hindwings: costal space with no crossveins in proximal half, 5–6 crossveins in distal half, subcostal space with 5–6 crossveins (*n* = 7). Eyes of grey-black, separated on meson of head by a distance of four times maximum width of eye. Total leg length shorter than male. Forelegs with six segments; mean leg length ratios 1.00 : 1.35 : 0.24 : 0.21 : 0.17 : 0.17 (1.85 mm, *n* = 7). Sternum 9 with very shallow apical cleft (Fig. 9). *Egg (Fig. 28).* Ovoid, polar cap absent, chorion with evenly spaced flower-shaped protuberances. *Male and female subimago.* In ethanol. Colour and markings similar to imago although not as apparent. Wings uniformly greyish-yellow, opaque. Forelegs not elongated. Genitalia not fully developed. *Mature nymph (Figs 10–24).* In ethanol. Body length: male 6.2–9.8 mm (mean = 8.3 mm, *n* = 18), female 7.9–11.4 mm (mean = 9.5 mm, *n* = 16). General colour golden to tan brown with dark brown markings. Head prognathous, width 1.6–2.2 mm (mean = 1.7 mm, *n* = 15). Head colour predominantly golden brown with dark brown wash between
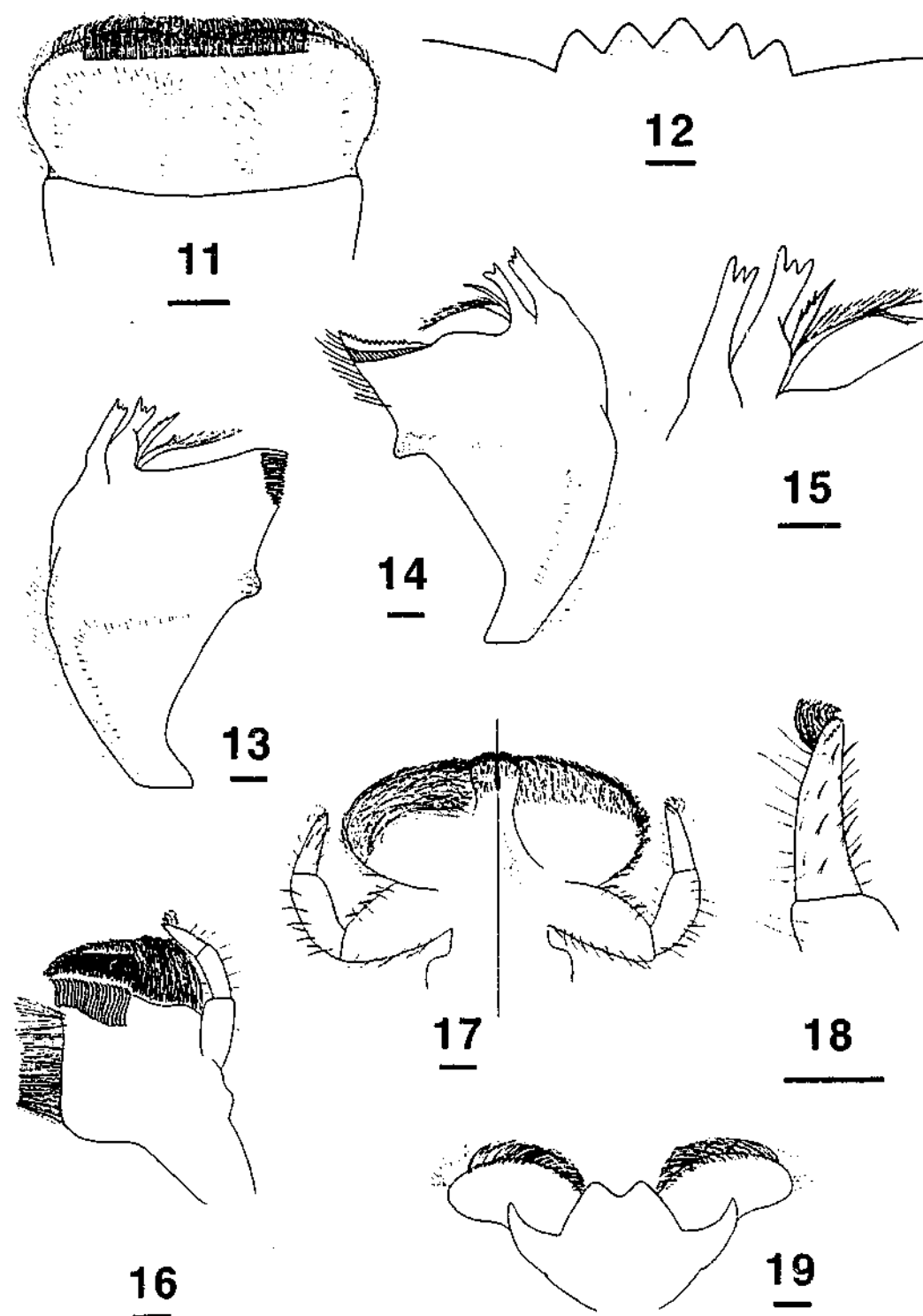
Figs 11–19. Nousia wiltkor-ringae mature nymph: (11) labrum; (12) labrum, anterior margin enlarged showing arrangement of denticles; (13) left mandible, dorsal; (14) right mandible, dorsal; (15) left mandible incisors, enlarged; (16) left maxillae, ventral; (17) labium, dorsal (left of midline) and ventral (right of midline); (18) terminal segment of labial palp, dorsal; (19) hypopharynx. Scale bars: Figs 11,13–19, 0.1 mm; Fig. 12, 0.01 mm.

ocelli and on anterior margin of eyes. Ocelli black. Antennae golden brown. Antennae length 1.7–2.3 mm (mean = 1.9 mm, n = 6), slightly longer than head width; ratio of antennae length to head width 1.0–1.2 (mean = 1.1, n = 6). Upper lobes of male eyes tan, lower lobes grey-black. Eyes of female grey-black. Mouthparts (Figs 11–19): clypeus (Fig. 11) with lateral margins very slightly diverging to anterior; lateral margin of labrum slightly wider than clypeus, width of labrum 2.05–2.46 times the length along the median line (mean = 2.29, n = 10); anterior margin slightly concave with medial convex 'hump', which is 0.08–0.15 times the width of labrum (mean = 0.12, n = 10) and bearing four (or more usually five) small, prominent rounded denticles (Fig. 12). Frontal setae arranged as a broad band, subapical hair fringe clearly separated from frontal band and 0.54–0.73 times the width of the labrum (mean = 0.61, n = 10). Mandibles (Figs 13–15)

with outer margin slightly curved, a small indentation at lateral midpoint with sparse tuft of long spine-like setae and shorter setae along margin between tuft and base. Both mandibles with dark coloured nodule at midpoint on inner margin and row of setae in an inverted L-shape on lower mandible body. Left mandible with robust incisors (Fig. 15) each with three apical teeth; inner incisor very robust with wide base and prostheca wide, serrated. Right mandible with incisors also large; outer incisor with three apical teeth, inner incisor with two teeth and prostheca simple, slender; 12–15 spine-like setae on inner mesal surface. Maxillae (Fig. 16) with galea-lacinae expanded medially with subapical row of approximately 20 pectinate setae; palpi three-segmented, mean palp segment ratios 1.00 : 0.74 : 0.65 (0.23 mm, n = 10); terminal segment has small triangular processes on apex. Labium (Fig. 17) with glossae not turned under ventrally and
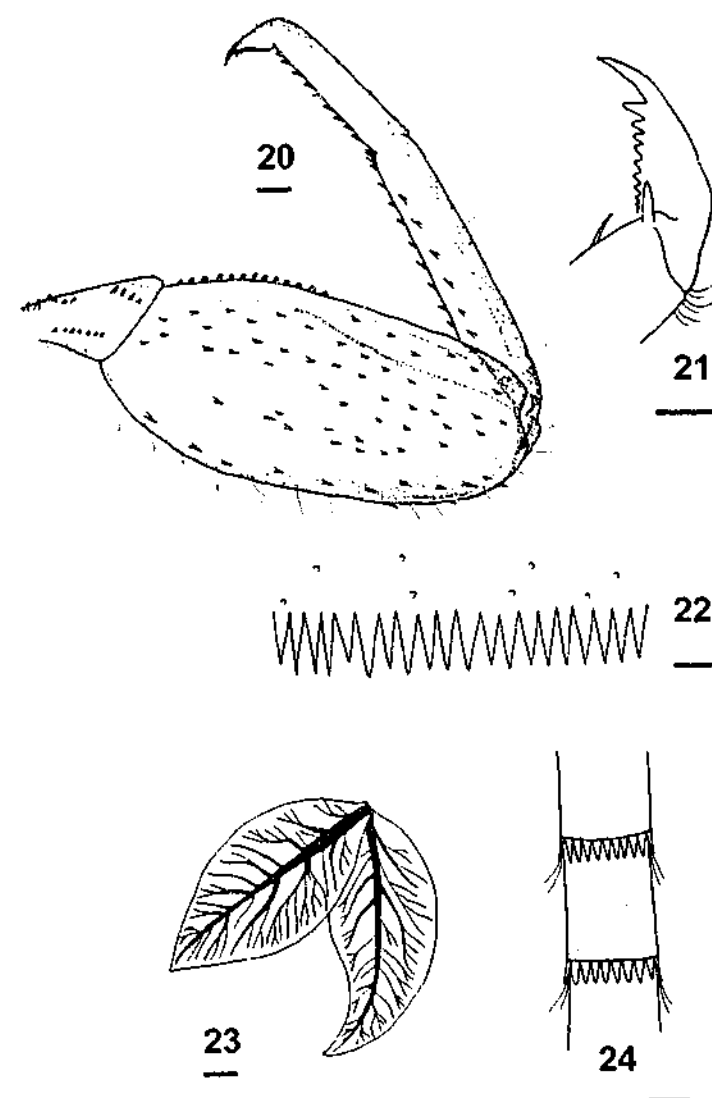
Figs 20–24. Nousia wiltkorringae mature nymph: (20) foreleg; (21) fore-tarsal claw; (22) posterior spines of abdominal terga five; (23) gills from abdominals segment five; (24) cercus at one-third length. Scale bars: Figs 20,21,23,24, 0.1 mm; Fig. 22, 0.01 mm.

lying in same plane as paraglossae; with series of blunted spines apically. Submentum with sparse robust spines. Palpi three-segmented; first segment with stout spines both anteriorly and posteriorly, terminal segment with line of triangular processes almost circling apex (Fig. 18). Labium mean palp segment ratios: 1.00 : 0.81 : 0.61 (0.36 mm, n = 10). Hypopharynx (Fig. 19) with relatively well-developed lateral processes, anterior margin of lingua moderately but noticeably cleft and lined with short setae, superlingua with thick tufts of setae on anterior margins. Thorax: tan brown with darker brown markings. Pronotum width 1.8–2.4 mm (mean = 2.1 mm, n = 15); wider than head (see above). Ratio of pronotum width to head width ranges from 1.06 to 1.25 (mean = 1.30, n = 15). Legs: colour golden to orange brown washed with slightly darker brown at outer lateral margins; femora apex of each leg dark brown; distinct white patches are present on fore-, mid- and hindleg. Fore-femora short and squat, 2.0–2.7 times longer than wide (mean = 2.3, n = 11) with short blunt spines on inner lateral margin for approximately one-half the total length of femur (Fig. 20). Mean

leg-length ratios: foreleg 1.00 : 0.77 : 0.36 (1.38 mm, n = 10), middle leg 1.00 : 0.76 : 0.36 (1.35 mm, n = 10), hindleg 1.00 : 0.80 : 0.32 (1.58 mm, n = 10). Tarsal claws (Fig. 21) with approximately eight ventral teeth, progressively larger apically although apical denticle much larger. Abdominal terga colour golden to tan brown with distinct dark brown markings forming a W-shape especially clear on posterior segments; each tergum with a continuous row of spines along posterior margin (Fig. 22). Posterolateral spines present on segments 2–9, progressively larger apically. Gills (Fig. 23) pale coloured, sometimes slightly tinged pink or yellow; present on segments 1–7, becoming somewhat progressively smaller towards posterior although not significantly so. Gills double with upper and lower lamellae equally developed, each lamella broadly lanceolate. Lateral tracheae strongly developed with main trunk quite thick. Caudal filaments three, golden with darker coloration at segment join giving a slightly banded appearance. Each segment bearing apical whorl of short triangular denticles (Fig. 24). Terminal filament longer than cerci.

Etymology. The species name is derived from the language of the Wurundjeri Woiwurrung, the Aboriginal people who inhabit the area of the type locality. The word wiltkorring means wide and refers to the shape of the gills.

Remarks. This new species, although quite distinct, conforms to the genus diagnosis of Pescador and Peters (1985). It can be distinguished from all other species of Nousia by the following combination of characters. In the imago: (i) MA symmetrically forked at slightly more than half the distance from base to wing margin; (ii) subcosta of hindwing is four-fifths the maximum length of wing; (iii) ventral surface of penes fused in basal third, remainder divided, divergent; (iv) dorsal surface of penes separate with two laterally expanded lobes meeting at two-thirds length; two small triangular processes hook together at this point; (v) terminal segment of forceps globular, indented at apex; (vi) male eyes meeting on meson of head; (vii) distinct abdominal colouring in a W-shaped pattern; and (viii) female sternum nine with very shallow apical cleft. In the nymph: (i) pronotum wider than head; (ii) clypeus width is slightly narrower than labrum width, the lateral margins very slightly diverging to anterior; (iii) width of labrum approximately 2.0–2.5 times the length along the median line; (iv) anterior margin of labrum slightly concave with medial convex 'hump' bearing 4–5 small, rounded denticles; (v) frontal setae of labrum arranged as a broad band with subapical hair fringe clearly separated; (vi) inner incisor of left mandible very robust with wide base; (vii) prostheca of left mandible serrated; (viii) labium with glossae not turned under ventrally and with a series of blunted spines apically; (ix) hypopharynx moderately but noticeably cleft; (x) fore-femora short and squat, twofold longer than wide with short blunt spines on inner lateral margin for about half the total length of femur; (xi) abdomen patterning distinct; (xii) terga with continuous row of minute spines along posterior margin; (xiii) posterolateral spines present on segments 2–9, progressively larger apically; and (xiv) gills large, wide and lanceolate, becoming progressively smaller posteriorly.
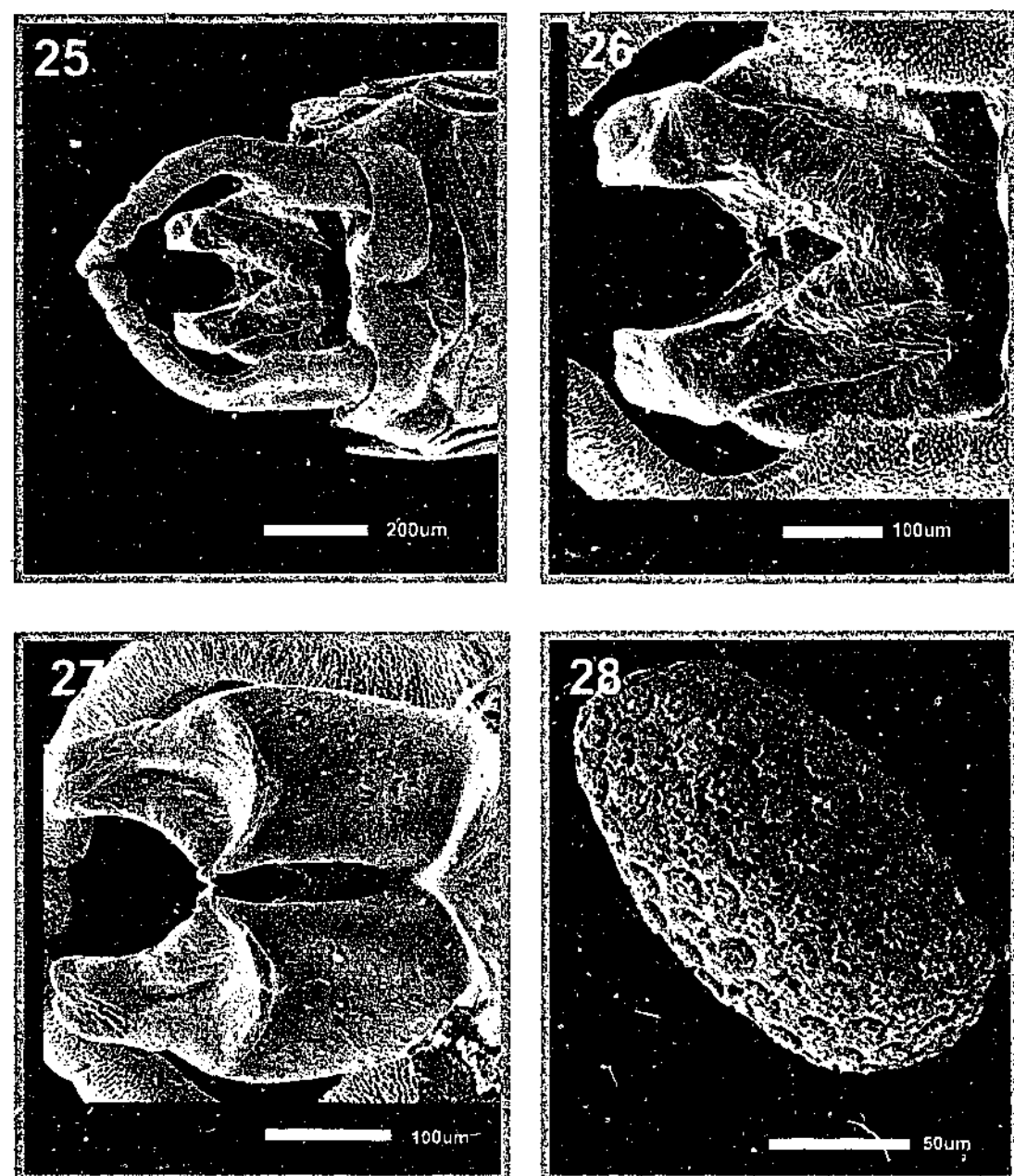
Figs 25–28. Scanning electron micrographs. Male genitalia and egg of *Nousia wiltkorringae*: **(25)** ventral view of genitalia; **(26)** ventral view of penes, enlarged; **(27)** dorsal view of penes, enlarged. **(28)** Egg.
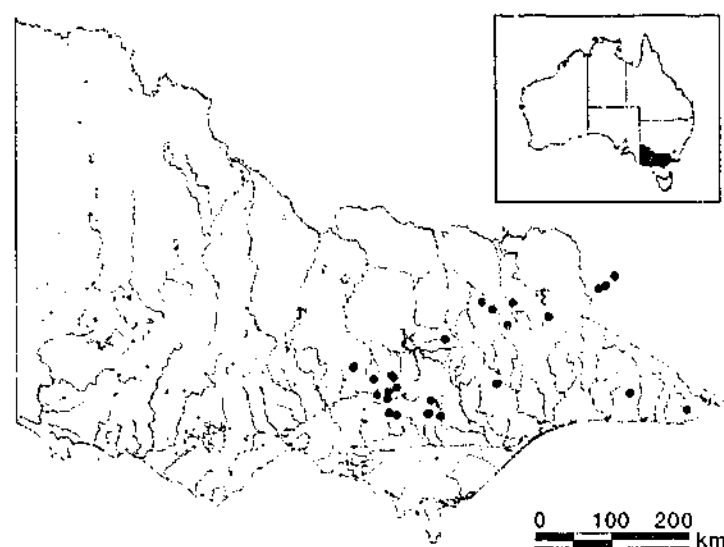
Fig. 29. Distribution of *Nousia wiltkorringae* in Victoria and southern New South Wales.

Habitat. This species has been found exclusively in mountainous areas of the eastern part of Victoria and southern New South Wales (Fig. 29). Animals have been collected at altitudes ranging from 180 to 1380 m a.s.l., but the majority are found between altitudes of 400 and 700 m a.s.l. Nymphs inhabit cold, fast-flowing, undisturbed upland streams (7–15°C) that are heavily shaded with native vegetation. They are generally found clinging to cobbles, large rocks, logs and within leaf litter, generally in association with shallow riffles. It is reasonable to assume that this species is present in other similar areas in neighbouring states. However, MRHI data collected from New South Wales and Tasmania have been identified to family level only, so it is unknown whether this species occurs there.

ACKNOWLEDGEMENTS

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APPENDIX 4

Summary data on site characteristics where each species
was present for all species found at more than 10 sites.

Site characteristic summary data

ALTITUDE

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	10.00	100.00	80.00	110.00	100.00	180.00
max	1740.00	1640.00	1520.00	1500.00	1920.00	1180.00
mean	442.22	522.00	341.25	536.05	1207.33	557.27
SE	40.78	51.77	61.73	93.18	136.57	100.20

SLOPE

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	0.00	0.00	0.20	0.44	1.43	0.65
max	33.33	33.33	20.00	23.53	50.00	13.33
mean	4.28	11.41	3.56	6.82	18.47	4.58
SE	0.62	1.17	0.91	1.54	3.57	1.42

DISTANCE FROM SOURCE

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	0.00	0.00	1.50	0.50	0.50	0.50
max	96.00	59.00	26.50	47.00	3.50	17.50
mean	13.29	11.41	8.25	7.61	1.30	7.91
SE	1.45	1.74	1.17	2.33	0.28	1.60

WATER TEMPERATURE

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	6.00	5.00	9.00	5.00	5.50	6.00
max	26.00	17.00	20.50	14.00	17.00	15.50
mean	13.20	11.44	14.02	10.37	9.20	11.18
SE	0.40	0.37	0.73	0.51	0.81	0.84

STREAM WIDTH

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	0.20	0.30	0.50	0.20	0.30	0.30
max	40.00	10.00	6.00	5.50	20.00	9.00
mean	3.65	3.48	2.22	2.26	2.44	3.85
SE	0.45	0.33	0.31	0.33	1.27	0.68

STREAM DEPTH

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	0.02	0.02	0.02	0.05	0.02	0.08
max	1.00	1.00	1.00	0.40	0.80	1.00
mean	0.31	0.31	0.29	0.18	0.15	0.41
SE	0.02	0.04	0.05	0.02	0.05	0.10

SUBPHI

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	-7.60	-6.45	-7.60	-6.45	-6.45	-6.00
max	6.80	3.63	6.80	0.08	0.40	3.63
mean	-2.21	-2.12	-16.05	-2.80	-3.35	-1.97
SE	0.23	0.29	0.88	0.39	0.52	0.88

ANNUAL MEAN TEMPERATURE

	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	4.90	5.70	5.10	7.40	1.33	12.00
max	14.00	13.60	14.00	13.80	1.88	13.80
mean	11.88	11.76	11.51	11.42	1.53	13.07
SE	0.21	0.25	0.51	0.40	0.05	0.19

Site characteristic summary data

MEAN DIURNAL RANGE					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	6.20	6.70	6.90	7.80	6.20	8.40
max	13.70	13.50	13.50	12.70	14.10	13.50
mean	10.63	10.90	10.47	10.57	10.55	10.90
SE	0.17	0.23	0.39	0.30	0.58	0.57

ISOTHERMALITY (mean diurnal range/mean seasonal range)					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	0.?5	0.37	0.35	0.42	0.35	0.46
max	0.53	0.53	0.52	0.51	0.51	0.52
mean	0.48	0.49	0.48	0.48	0.47	0.49
SE	0.00	0.01	0.01	0.01	0.01	0.01

TEMPERATURE SEASONALITY					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	1.06	1.09	1.10	1.12	1.33	1.21
max	1.89	1.84	1.89	1.75	1.88	1.84
mean	1.45	1.48	1.48	1.45	1.53	1.44
SE	0.02	0.03	0.05	0.03	0.05	0.07

TEMPERATURE ANNUAL RANGE					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	15.30	16.10	16.50	17.50	17.20	18.30
max	27.90	27.60	27.90	25.30	28.10	27.60
mean	21.95	22.41	21.94	21.89	22.38	22.23
SE	0.25	0.59	0.66	0.47	0.79	1.05

MAXIMUM TEMPERATURE OF THE WARMEST PERIOD					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	15.10	16.00	16.60	18.70	15.10	16.50
max	30.00	29.10	29.00	26.10	29.20	20.50
mean	24.26	24.54	23.94	23.78	24.25	18.22
SE	0.27	0.37	0.64	0.38	1.00	0.37

MINIMUM TEMPERATURE OF THE COLDEST PERIOD					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	-4.50	-2.50	-3.70	-1.90	-3.10	1.20
max	6.60	5.20	6.10	6.00	4.20	5.20
mean	2.31	2.13	1.98	1.89	1.88	3.41
SE	0.22	0.25	0.54	0.45	0.57	0.44

MEAN TEMPERATURE OF THE WETTEST QUARTER					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	-0.40	0.40	-0.20	4.50	0.10	7.10
max	15.30	15.00	14.40	12.80	10.60	14.40
mean	8.52	8.31	7.77	8.72	7.37	9.35
SE	0.32	0.41	0.65	0.56	0.77	0.67

MEAN TEMPERATURE OF THE DRIEST QUARTER					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11
min	4.20	8.00	8.00	12.50	9.70	8.00
max	20.80	19.90	19.60	18.00	19.50	20.50
mean	10.03	16.45	16.14	16.26	16.65	17.29
SE	0.30	0.36	0.58	0.35	0.72	0.99

Site characteristic summary data

	MEAN TEMPERATURE OF THE WARMEST QUARTER						MEAN TEMPERATURE OF THE COLDEST QUARTER					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11	106	50	24	19	15	11
min	9.90	10.60	11.00	12.50	9.90	16.50	-0.80	0.40	-0.70	2.50	-0.40	7.10
max	20.80	20.10	20.40	18.00	19.70	20.50	10.00	9.40	9.90	9.90	8.40	9.40
mean	17.00	16.96	16.72	16.50	16.70	18.22	6.82	6.62	6.36	6.36	6.01	8.06
SE	0.20	0.26	0.49	0.34	0.71	0.37	0.24	0.28	0.58	0.48	0.71	0.27

	ANNUAL MEAN PRECIPITATION						PRECIPITATION SEASONALITY					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11	106	50	24	19	15	11
min	491.00	645.00	500.00	758.00	714.00	645.00	9.00	9.00	11.00	9.00	13.00	12.00
max	2201.00	1933.00	2201.00	1595.00	2312.00	1188.00	39.00	39.00	39.00	38.00	40.00	36.00
mean	1047.01	1103.88	1113.67	1074.74	1211.13	945.00	23.02	23.76	24.33	20.32	25.53	22.00
SE	32.30	39.99	73.81	51.14	102.99	53.19	0.81	1.23	1.69	1.72	2.18	2.39

	PRECIPITATION OF THE WETTEST PERIOD						PRECIPITATION OF THE DRIEST PERIOD					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11	106	50	24	19	15	11
min	51.00	68.00	53.00	81.00	85.00	71.00	28.00	30.00	28.00	33.00	30.00	30.00
max	289.00	239.00	289.00	177.00	316.00	154.00	99.00	99.00	88.00	78.00	93.00	70.00
mean	116.42	123.86	127.04	115.63	138.53	102.64	54.59	57.48	56.21	58.68	59.93	50.46
SE	4.20	5.40	10.33	5.49	15.00	7.47	1.55	2.09	3.21	2.86	4.38	2.98

	PRECIPITATION OF THE WETTEST QUARTER						PRECIPITATION OF THE DRIEST QUARTER					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11	106	50	24	19	15	11
min	144.00	197.00	155.00	228.00	248.00	206.00	93.00	104.00	93.00	118.00	107.00	104.00
max	806.00	659.00	806.00	505.00	868.00	434.00	315.00	310.00	303.00	267.00	307.00	235.00
mean	332.08	352.36	360.63	328.63	390.13	295.55	184.04	191.56	191.54	199.47	202.00	170.73
SE	11.61	14.82	28.12	16.39	40.09	20.44	5.06	6.49	10.61	9.18	15.11	9.98

Site characteristic summary data

	PRECIPITATION OF THE WARMEST QUARTER						PRECIPITATION OF THE COLDEST QUARTER					
	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae	N. (A) fusca	N. (A) nigeli	T. lucida	M. kala	M. adamus	G. wiltkorringae
n	106	50	24	19	15	11	106	50	24	19	15	11
min	96.00	104.00	96.00	118.00	107.00	104.00	110.00	149.00	155.00	220.00	240.00	163.00
max	316.00	310.00	303.00	267.00	316.00	235.00	772.00	659.00	772.00	482.00	835.00	434.00
mean	188.98	196.18	195.46	203.74	203.93	174.00	318.47	340.08	345.96	309.63	375.33	285.09
SE	5.08	6.46	10.63	9.19	15.29	10.10	11.80	15.83	27.77	15.97	39.77	23.32

NOTA BENE

1. Throughout the text, the spelling of the genus *Biblumena* should be changed to *Bibulmena*.

2. The genus name *Montikola* should be regarded as temporary (see p.219 – Vol. 1) and therefore will be published under an alternative name.

TAXONOMY, DISTRIBUTION PATTERNS AND PHYLOGENY OF AUSTRALIAN LEPTOPHLEBIIDAE (EPHEMEROPTERA).

Kyla Jane Finlay B.Sc. (Hons).

Department of Biological Sciences
Monash University
September 2002

A thesis submitted in accordance with the requirements for the
Degree of Doctor of Philosophy at Monash University, Victoria, Australia.

VOLUME 2

Figures
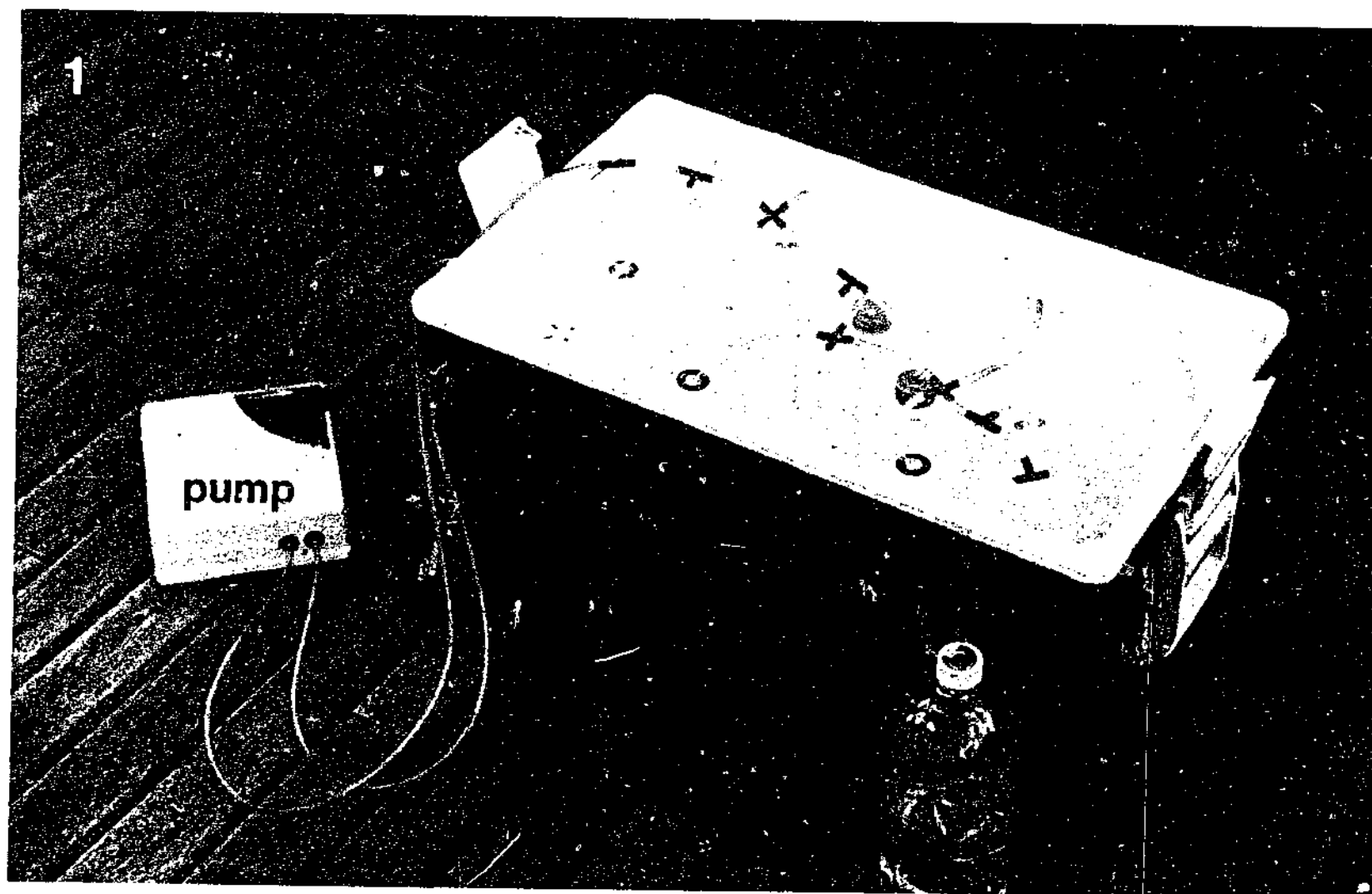
Fig. 1. Equipment for transporting live nymphs from the field.
Each bottle contains nymphs collected from one location. A pump capable
of operating on batteries is connected to each bottle to provide constant aeration.
Photo by K.J. Finlay.
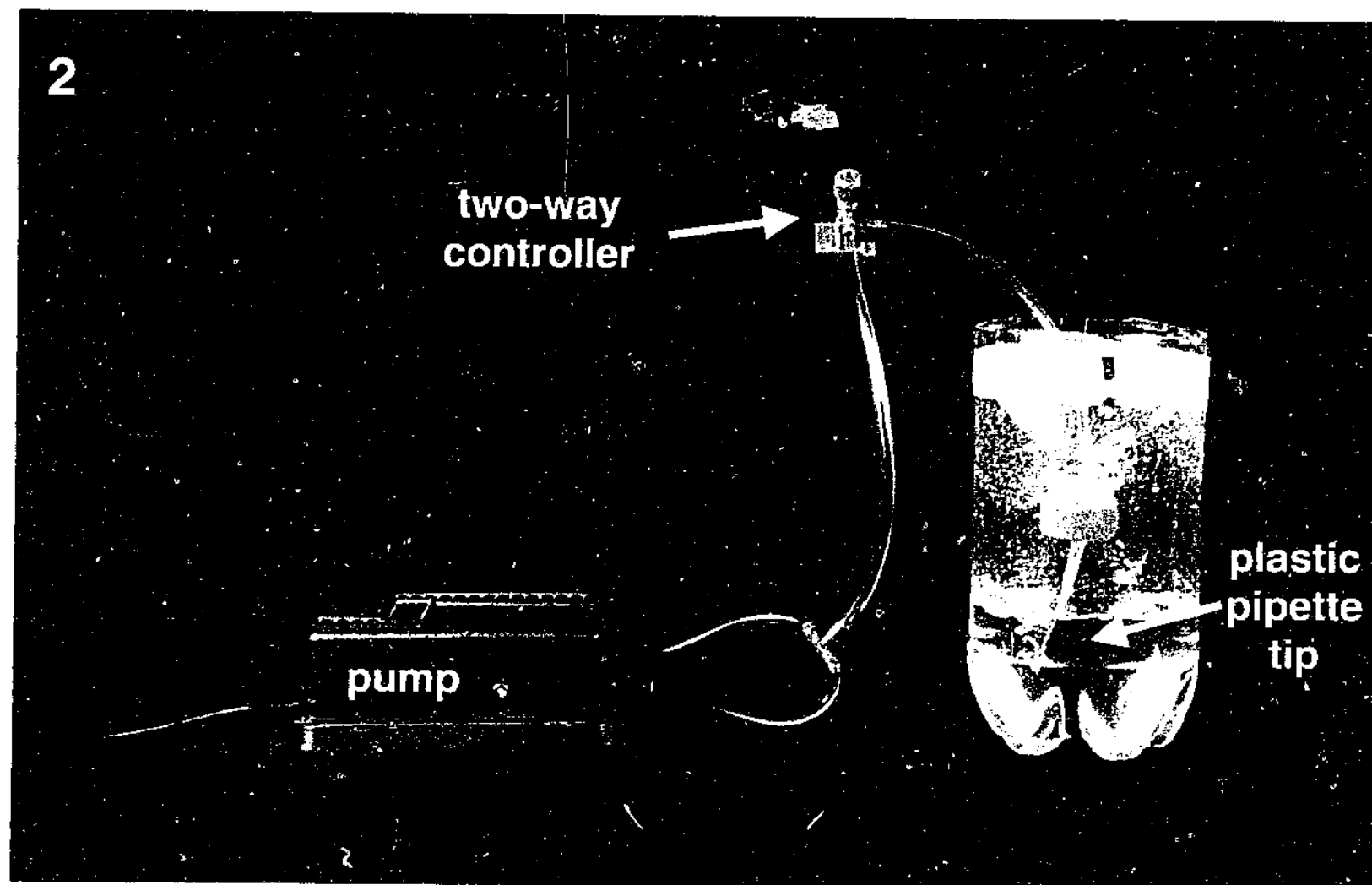
Fig. 2. New rearing chamber design.
Each chamber holds one nymph from a particular site. The electrical pump supplies constant
air flow which can be varied using the two-way controller. A plastic pipette tip attached
to the end of the tubing is useful for restricting the flow of bubbles to a small stream.
Photo by Steve Morton and Adrain Dyer.
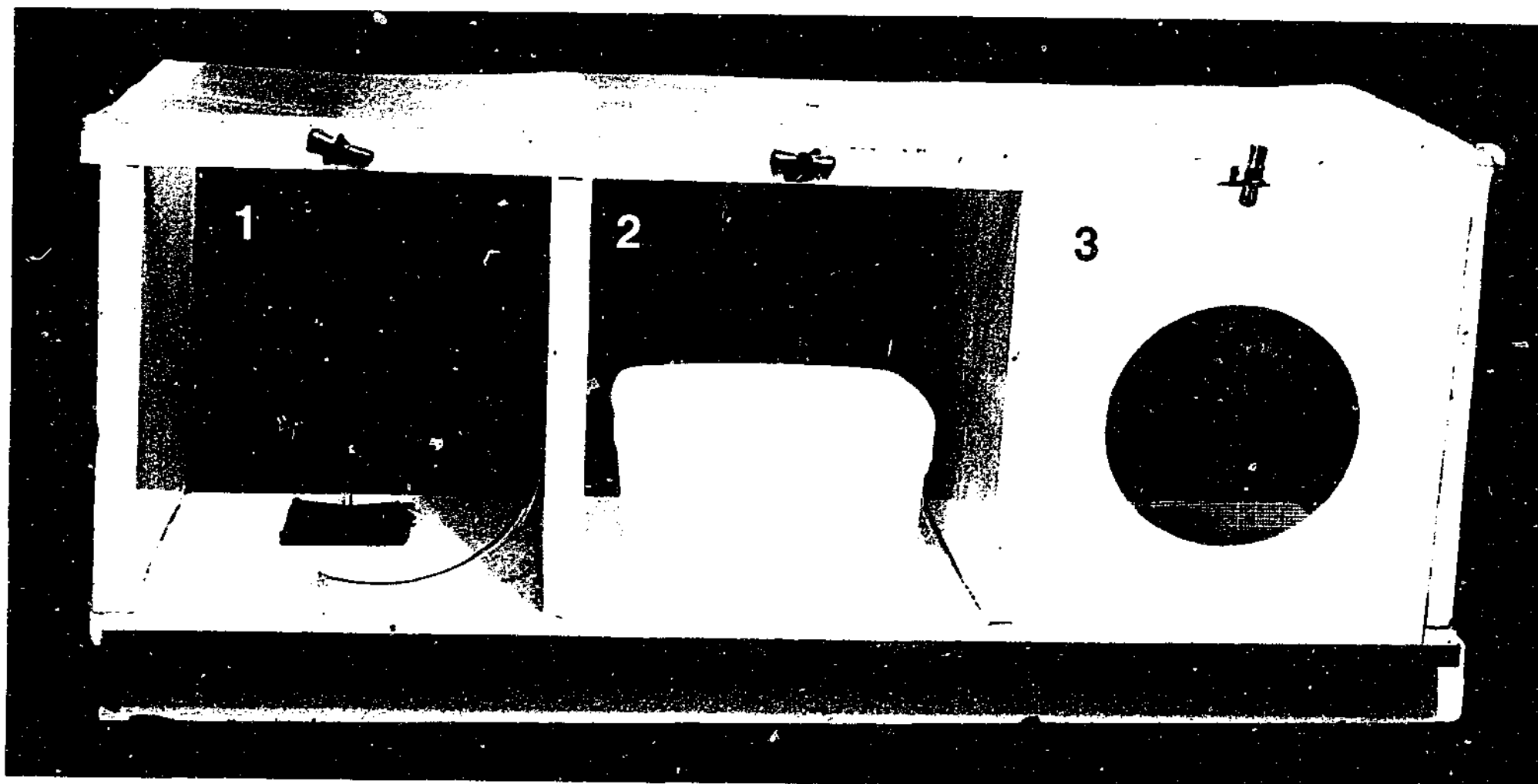
Fig. 3. Rearing chambers designed by I.C. Campbell (see Campbell 1983) showing mode of operation.
Chamber 1 shows tubing which is connected to pump.
Chamber 2 shows container where live nymph is placed for rearing.
Chamber 3 shows removable door with mesh covered viewing hole.
Photo by K.J. Finlay.
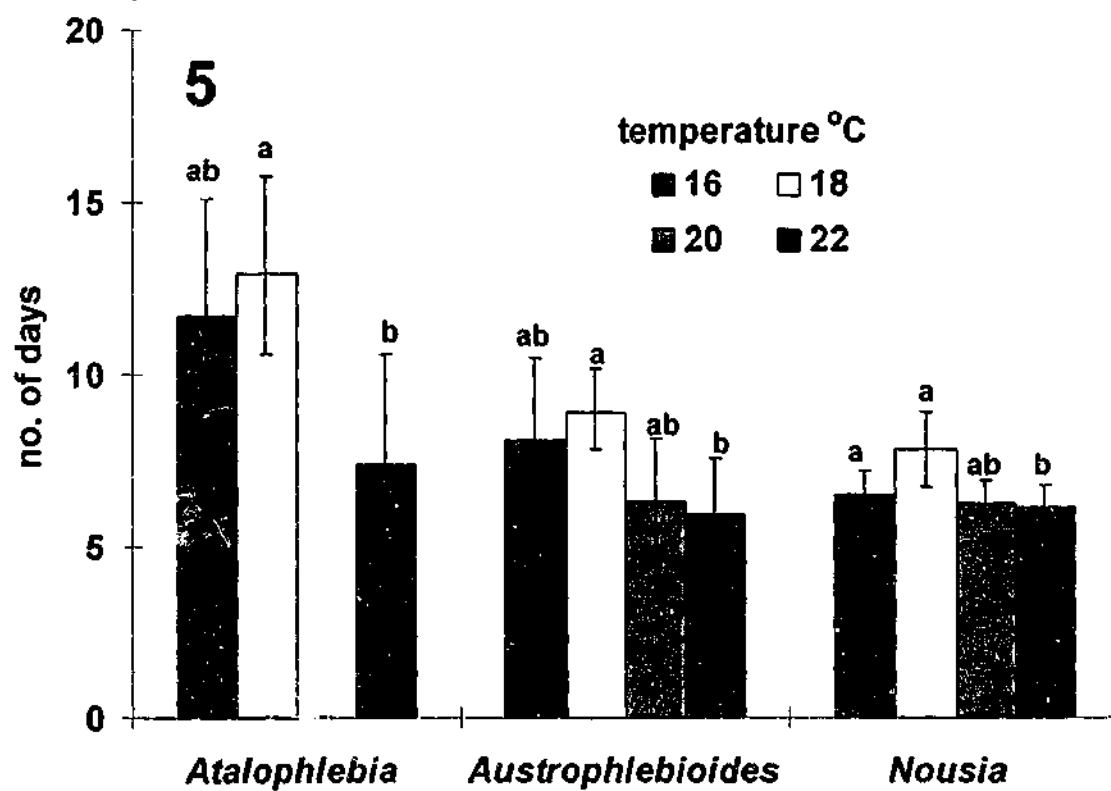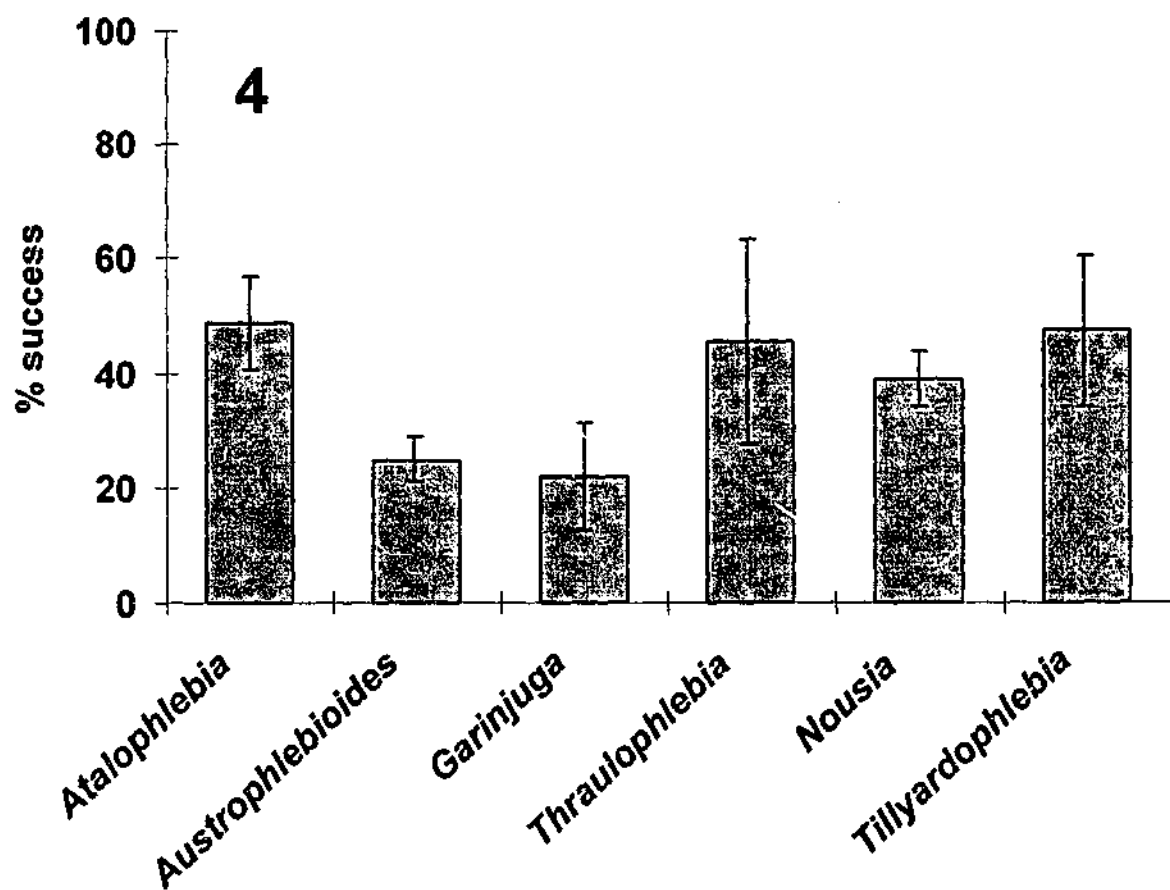
Fig. 4. Imago emergence success by genus.
Bars represent 95% confidence intervals.

Fig. 5. Effect of temperature on time taken to successful emergence by genus.
Data back transformed from logged values. Bars represent back transformed
standard error. Within each genus temperatures without a letter in common are
significantly different (< 0.05) by Tukeys HSD tests.

4
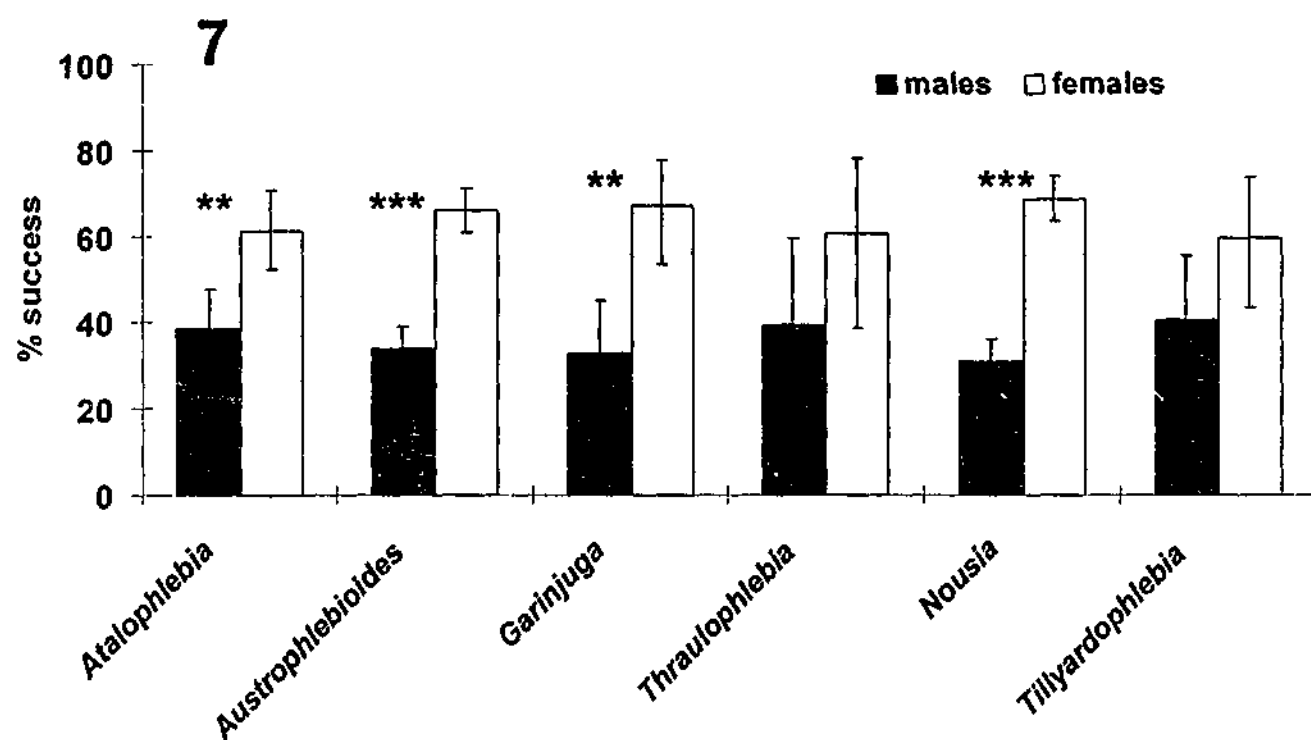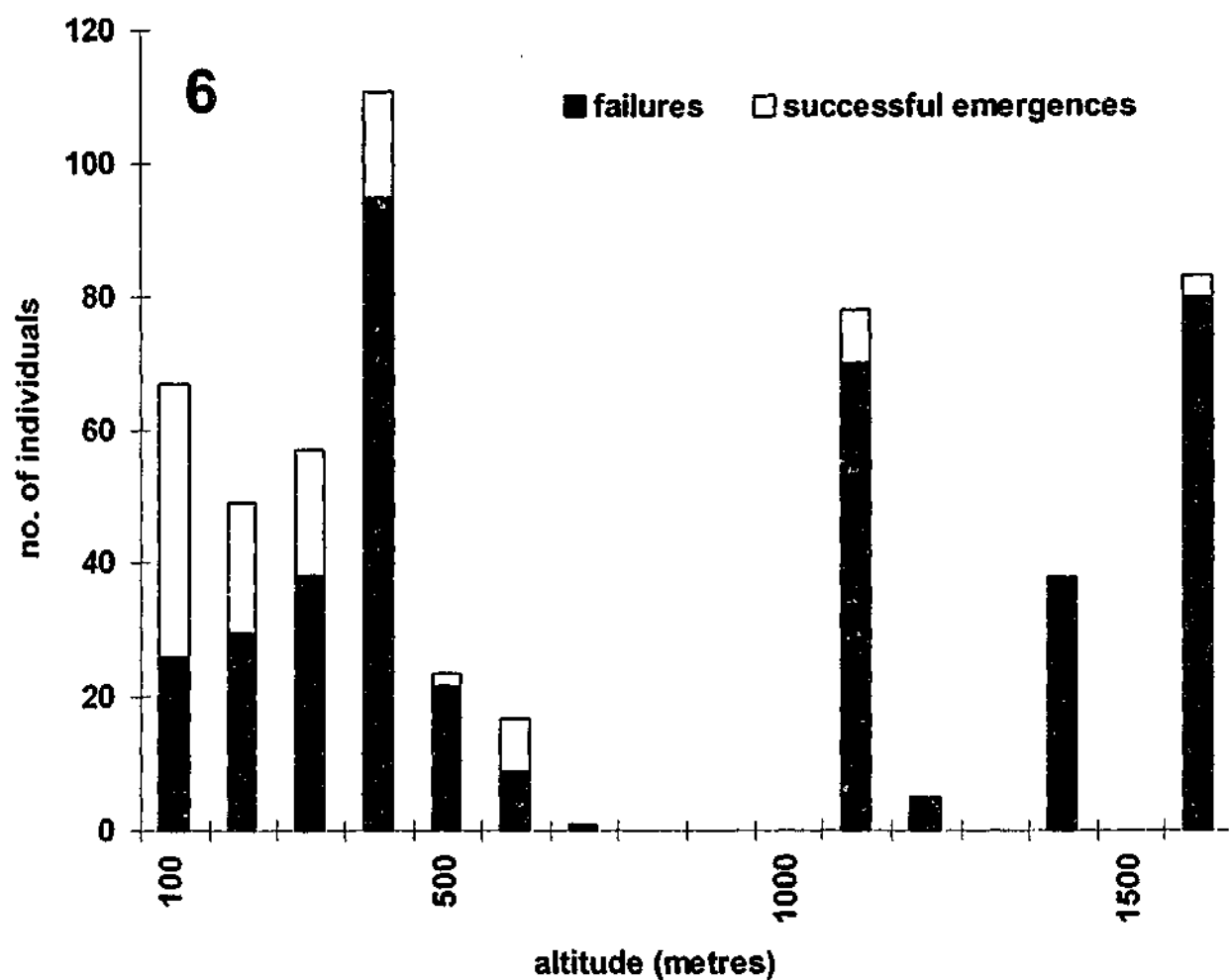
Fig. 6. Effect of altitude of collection on rearing
success of *Austrophlebioides*.

Fig. 7. Mayfly sex-ratios (collected over 2 extended summer periods).
Bars represent 95% confidence intervals.
Asterisks indicate significant departures
(at less than 5% significance levels) from 1:1 ratio by chi-square.
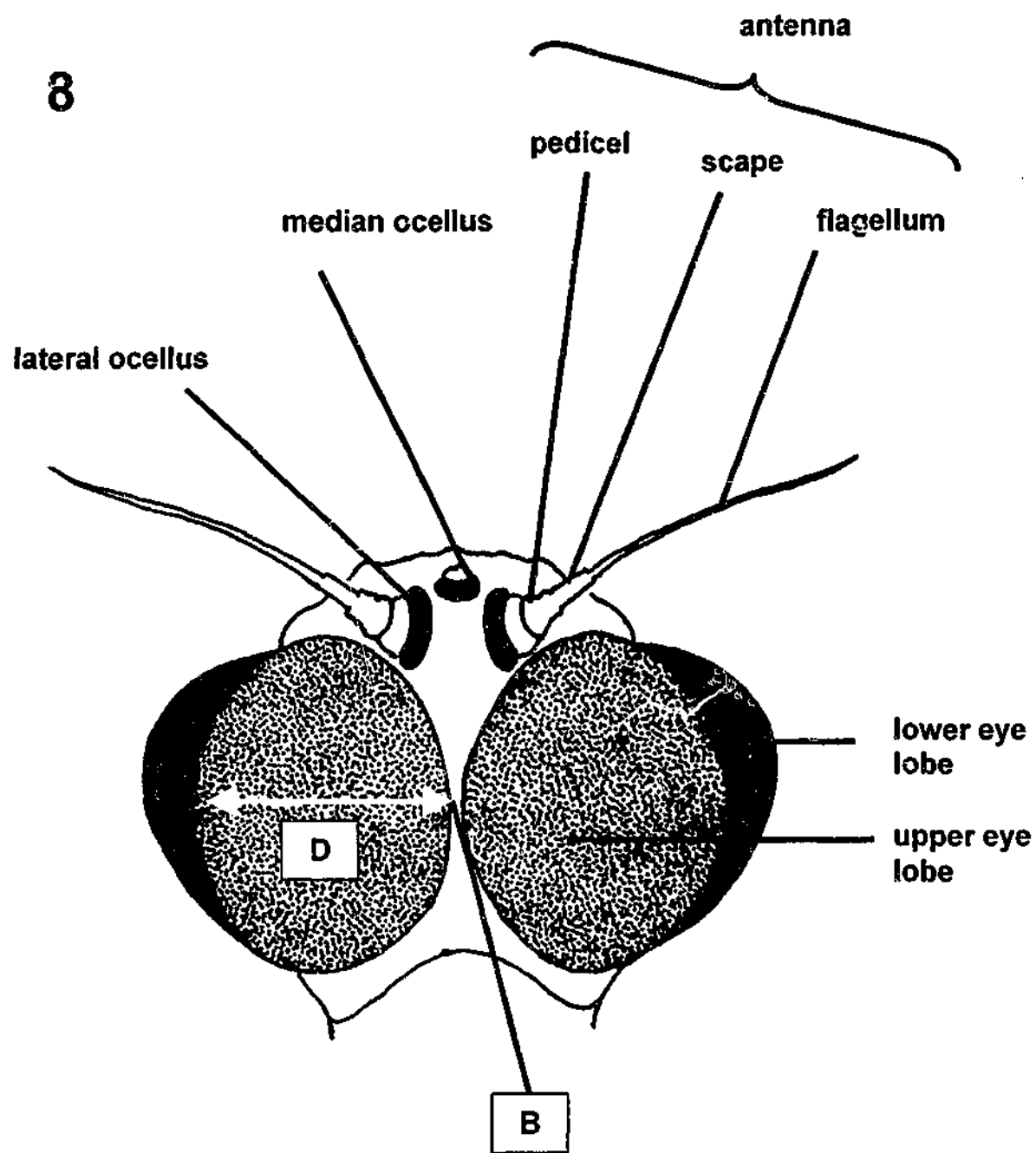
Fig. 8. Important diagnostic features of the male imago head.
Eye size (ES) (*sensu* Bae 1991) = B (shortest distance between
upper lobes) / D (longest diameter of upper lobe).
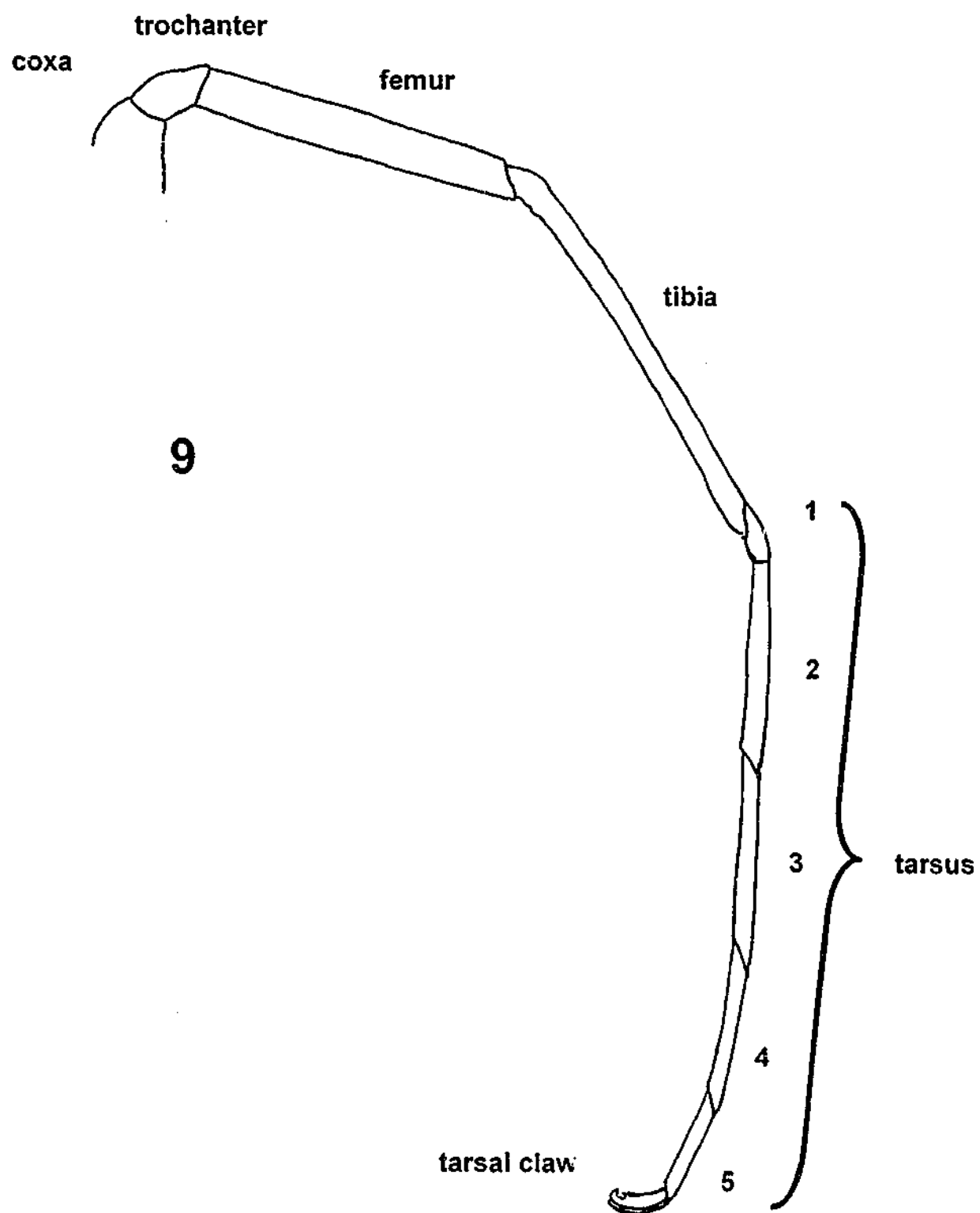
Fig. 9. Segmentation of the male imago foreleg.

coxa
trochanter
femur
tibia

10

1
2
3
4

tarsus
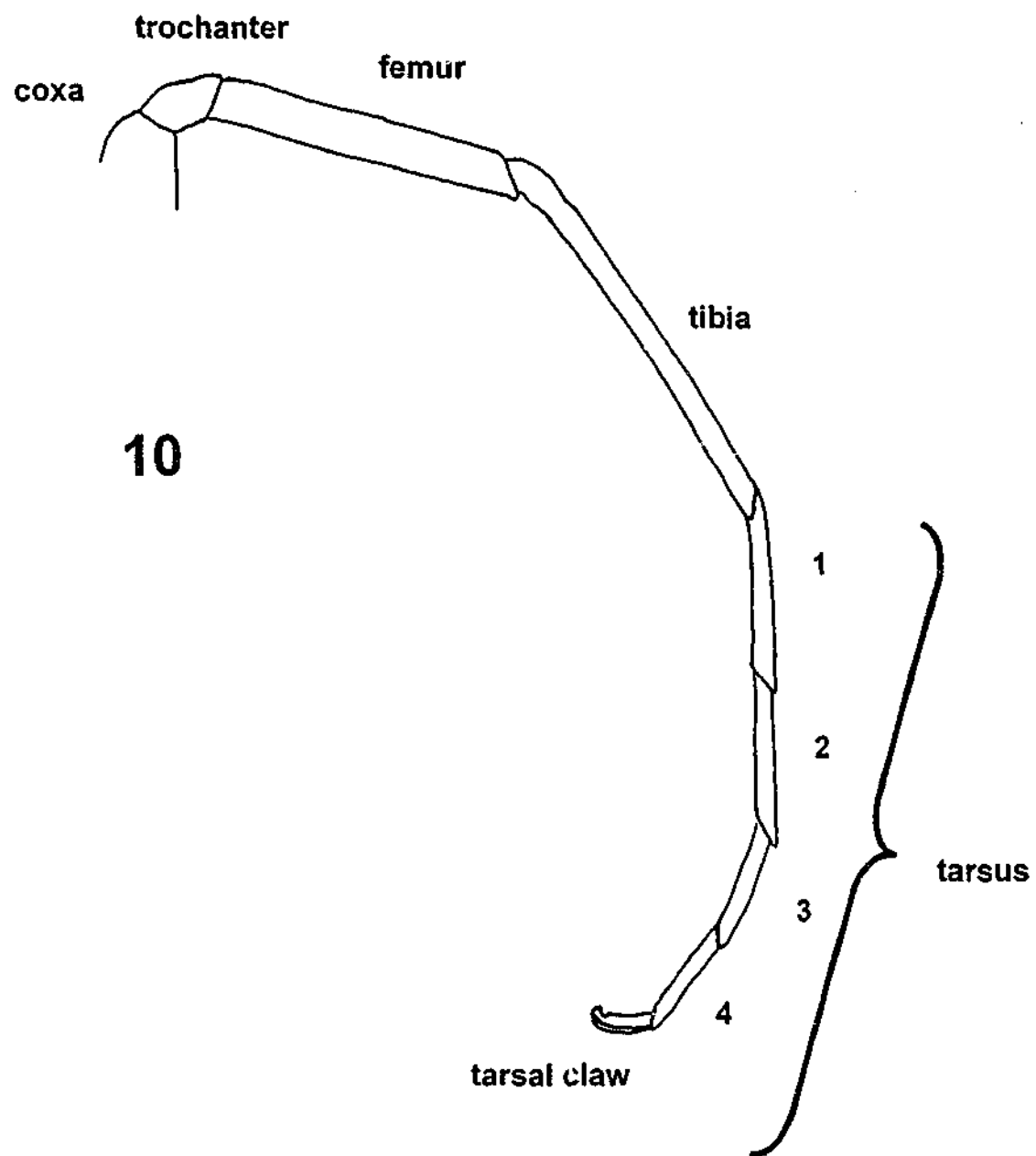
tarsal claw

Fig. 10. Segmentation of the female imago foreleg.

opposing hook

apical hook

11

lower
claw

upper
claw

tarsus
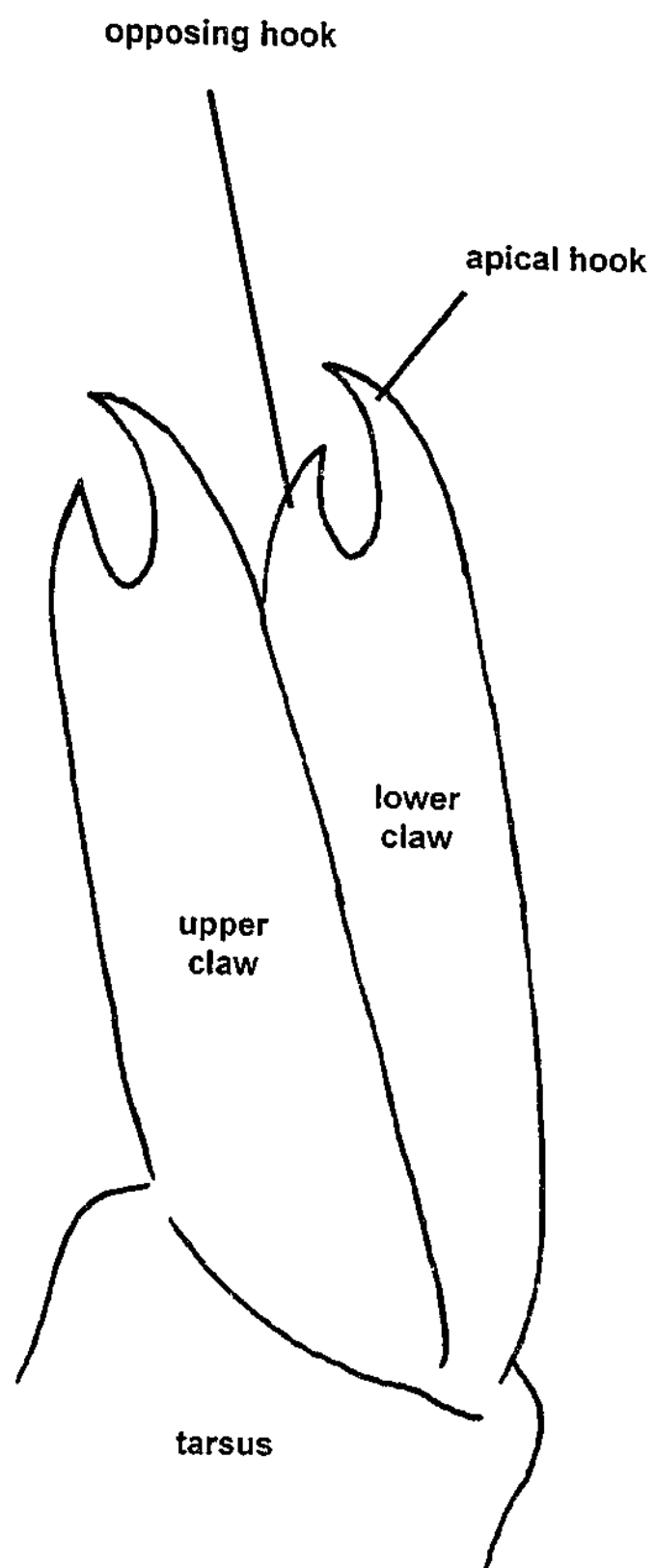
Fig. 11. Imago tarsal claw morphology.
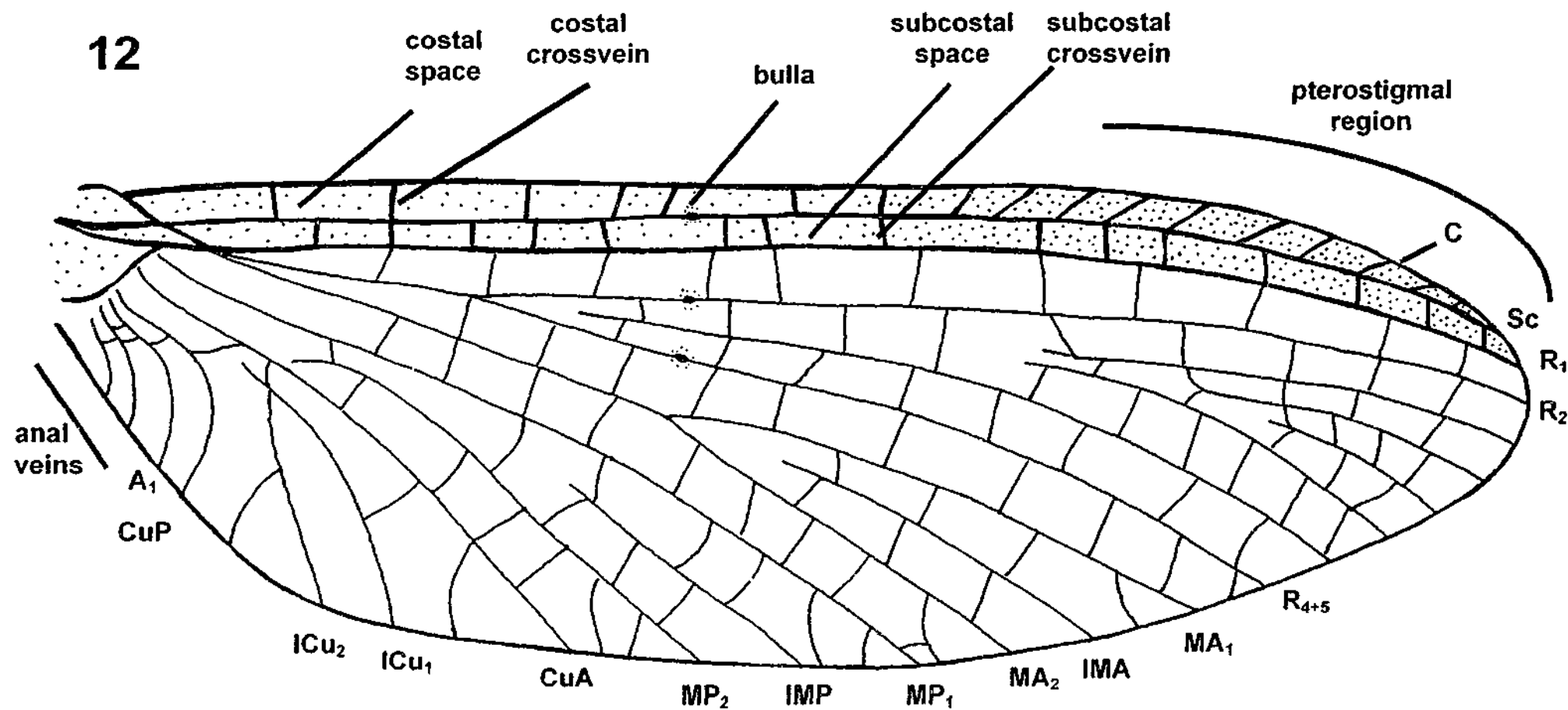
Fig. 12. Forewing venation nomenclature. C= costa, Sc = subcosta, R=radius, MA=medius anterior, IMA=intercalary medius anterior, MP=medius posterior, IMP=intercalary medius posterior, CuA=cubitus anterior, ICu=intercalary cubitus, CuP=cubitus posterior, A₁=anal vein.

13

forceps

3

2

1

penes

penis apical lobe

penis subapical lobe

styliger
plate

14

forceps

penes

penis apical lobe

styliger
plate

sternal segment nine
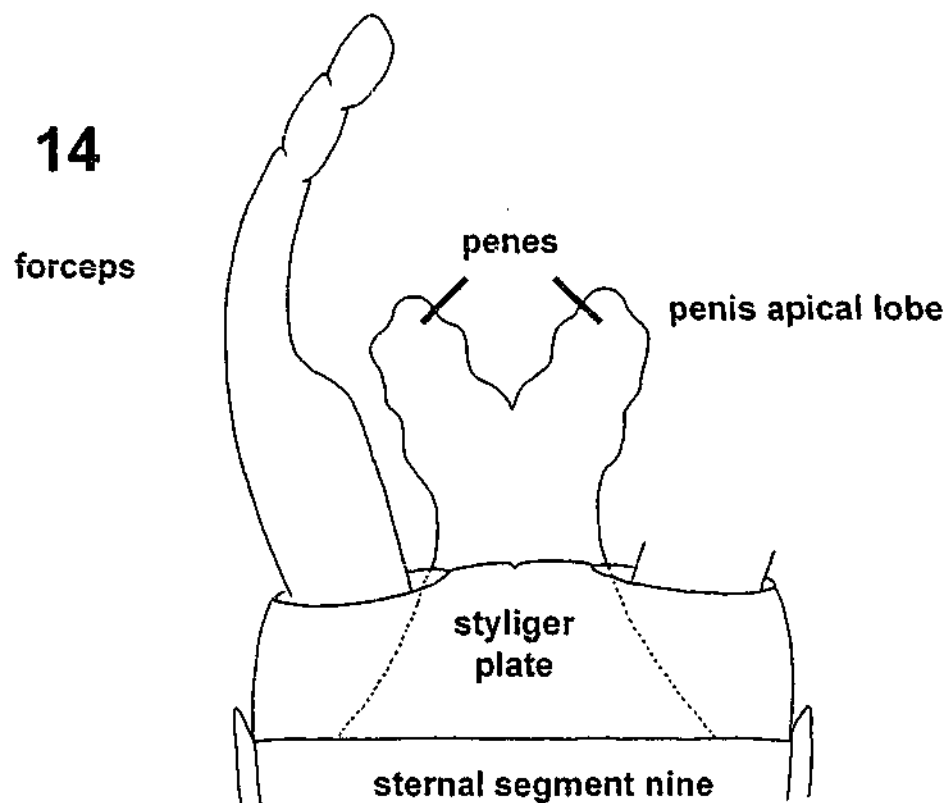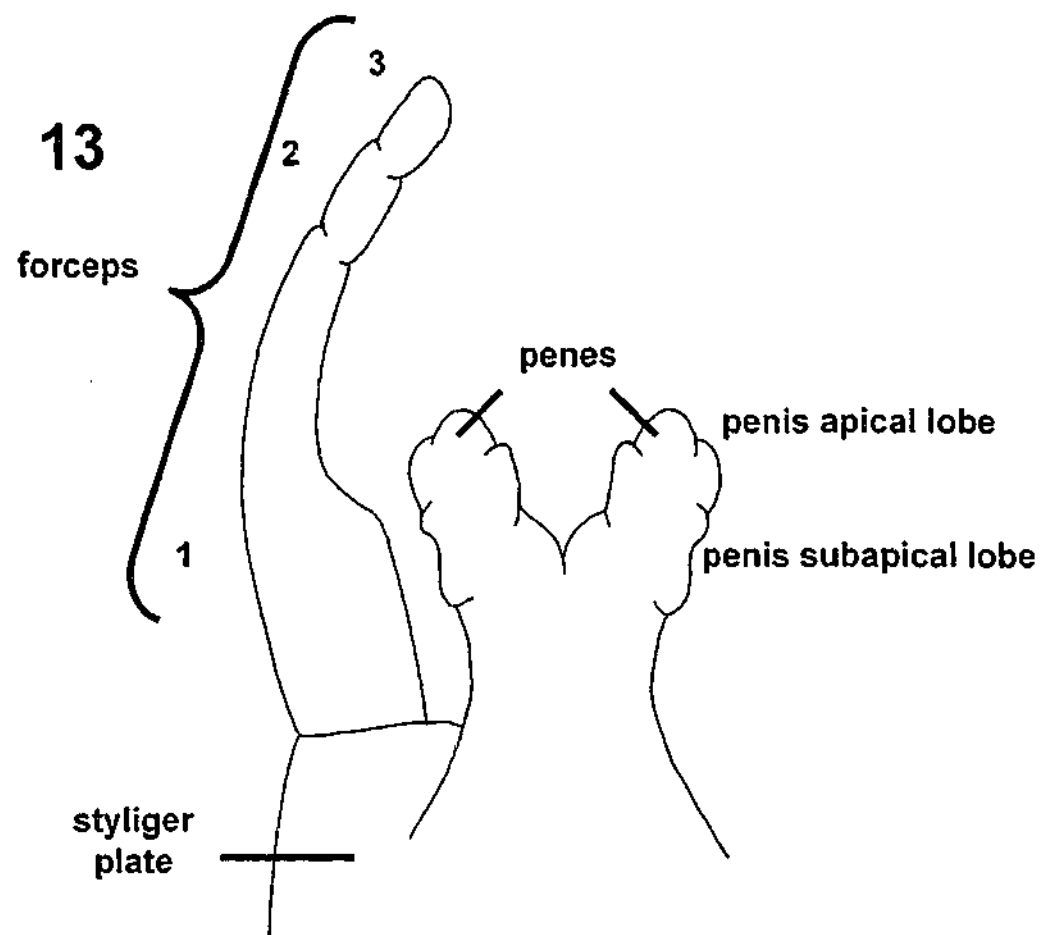
Fig. 13. Male imago genitalia dorsal view, tergal segment ten removed.

Fig. 14. Male imago genitalia ventral view.

DORSAL

15

tergal
segment
nine

tergal
segment
ten

caudal filaments

penis lobe

3

2

1

sternal
segment
nine

styliger
plate

forceps

VENTRAL

16

sternal
segment
nine

genital extension

sternal
segment
seven
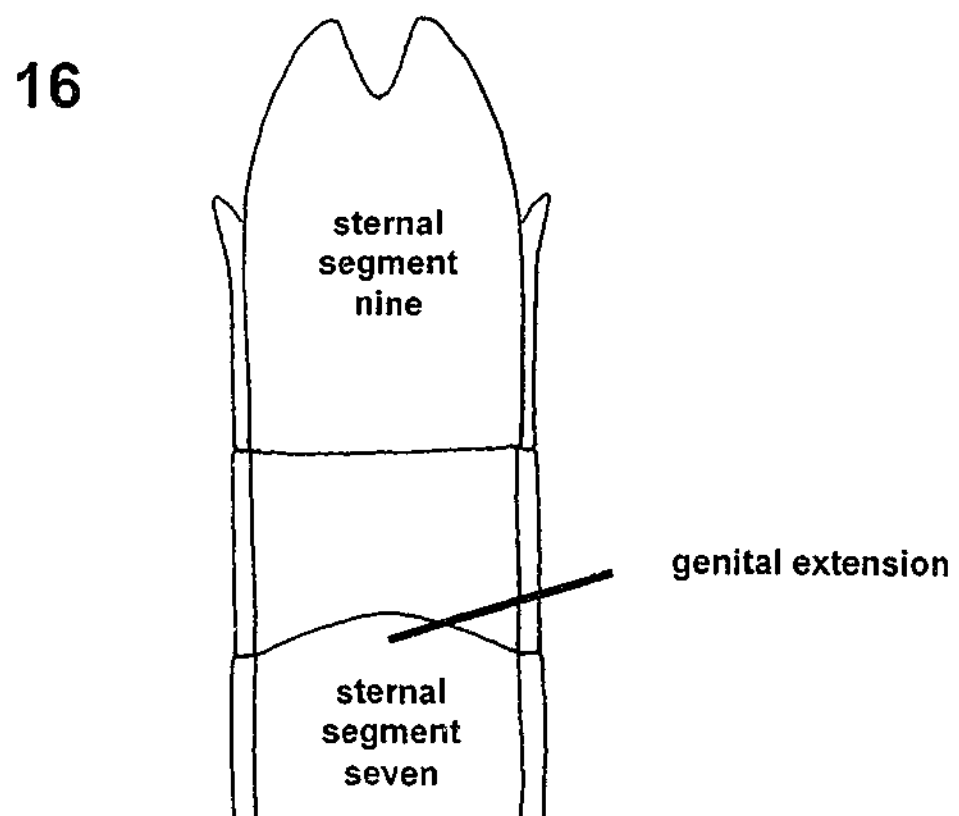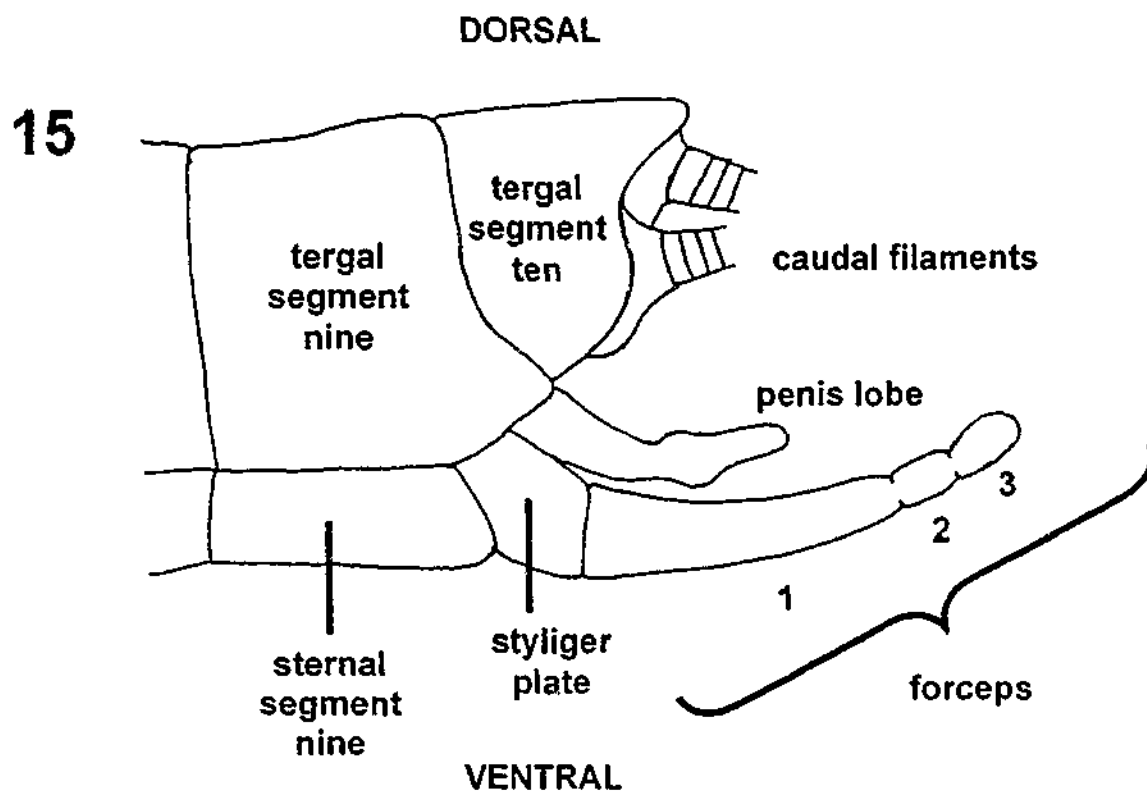
Fig. 15. Male imago genitalia lateral view.

Fig. 16. Female imago abdomen ventral view, sternites seven to nine.

17
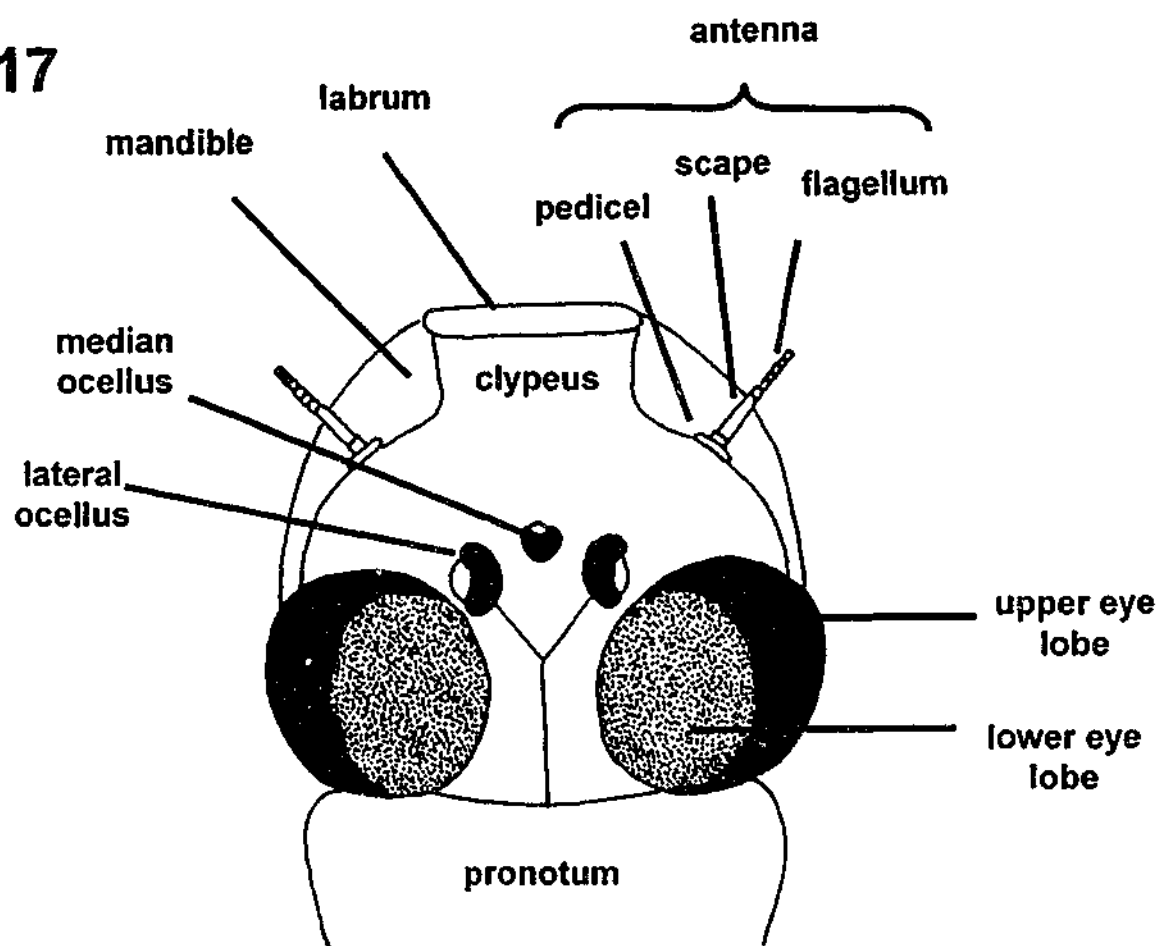
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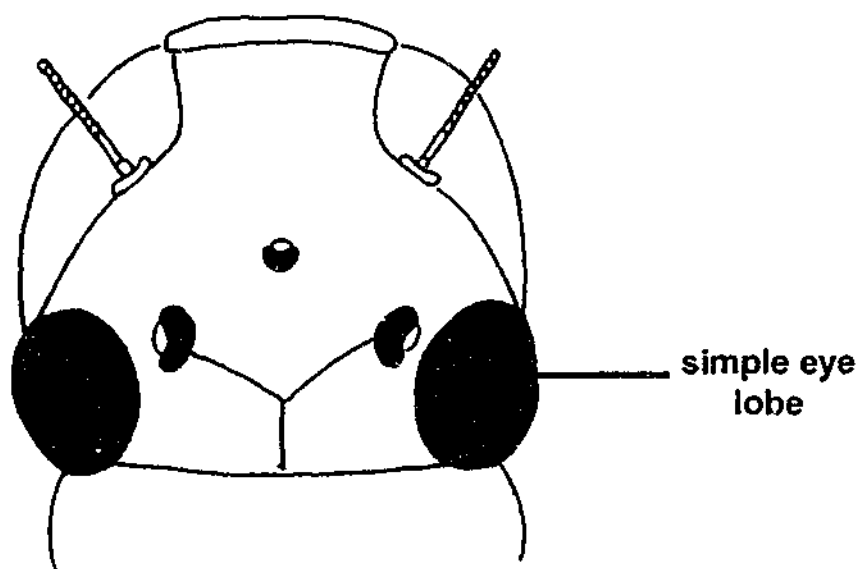
Fig. 17. Important diagnostic features of the male nymph head.

Fig. 18. Important diagnostic features of the female nymph head, characters the same as in the male except for eyes.
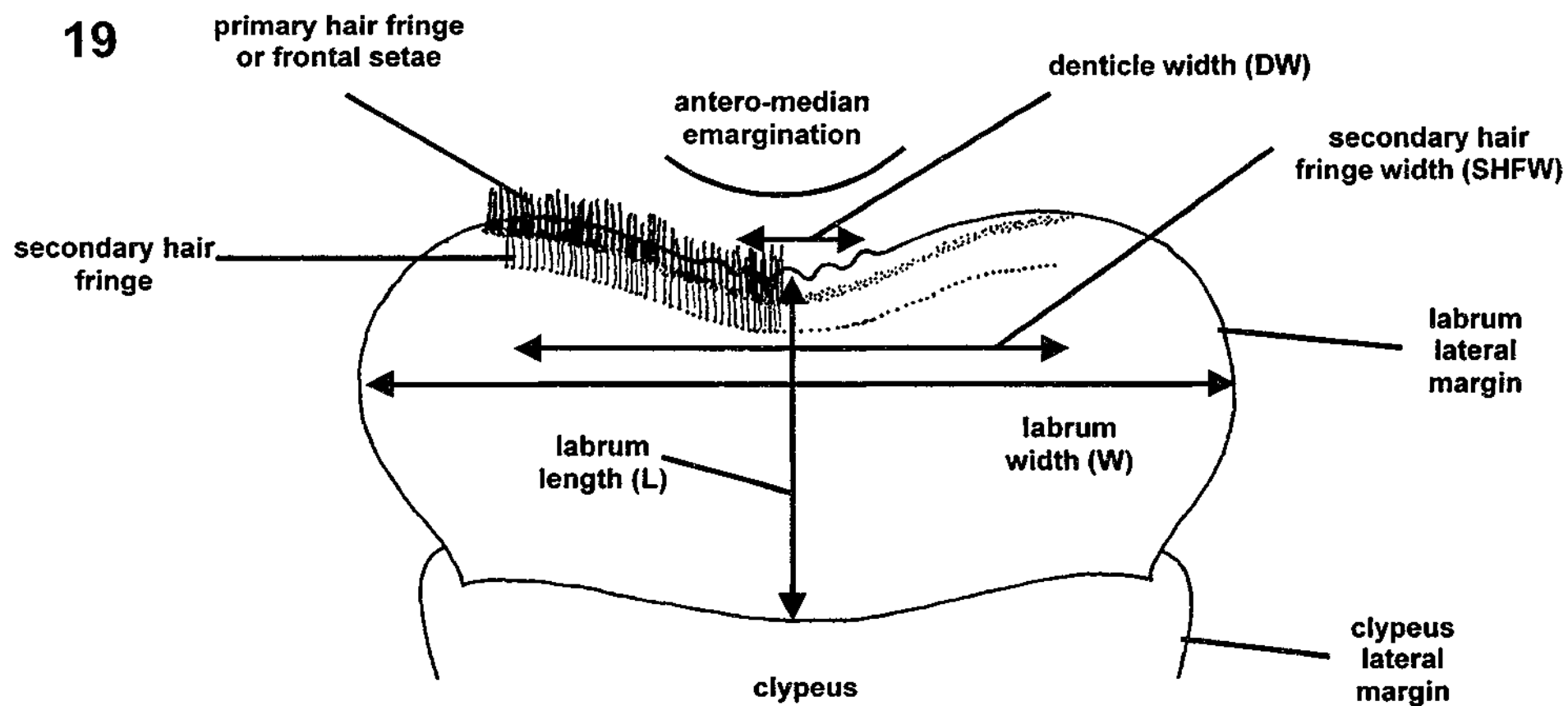
Fig. 19. Important diagnostic features of the nymph labrum and clypeus.
W/L = labrum width length ratio; DW/W = denticle width / labrum width ratio;
SHFW/W=secondary hair fringe width to labrum width ratio.
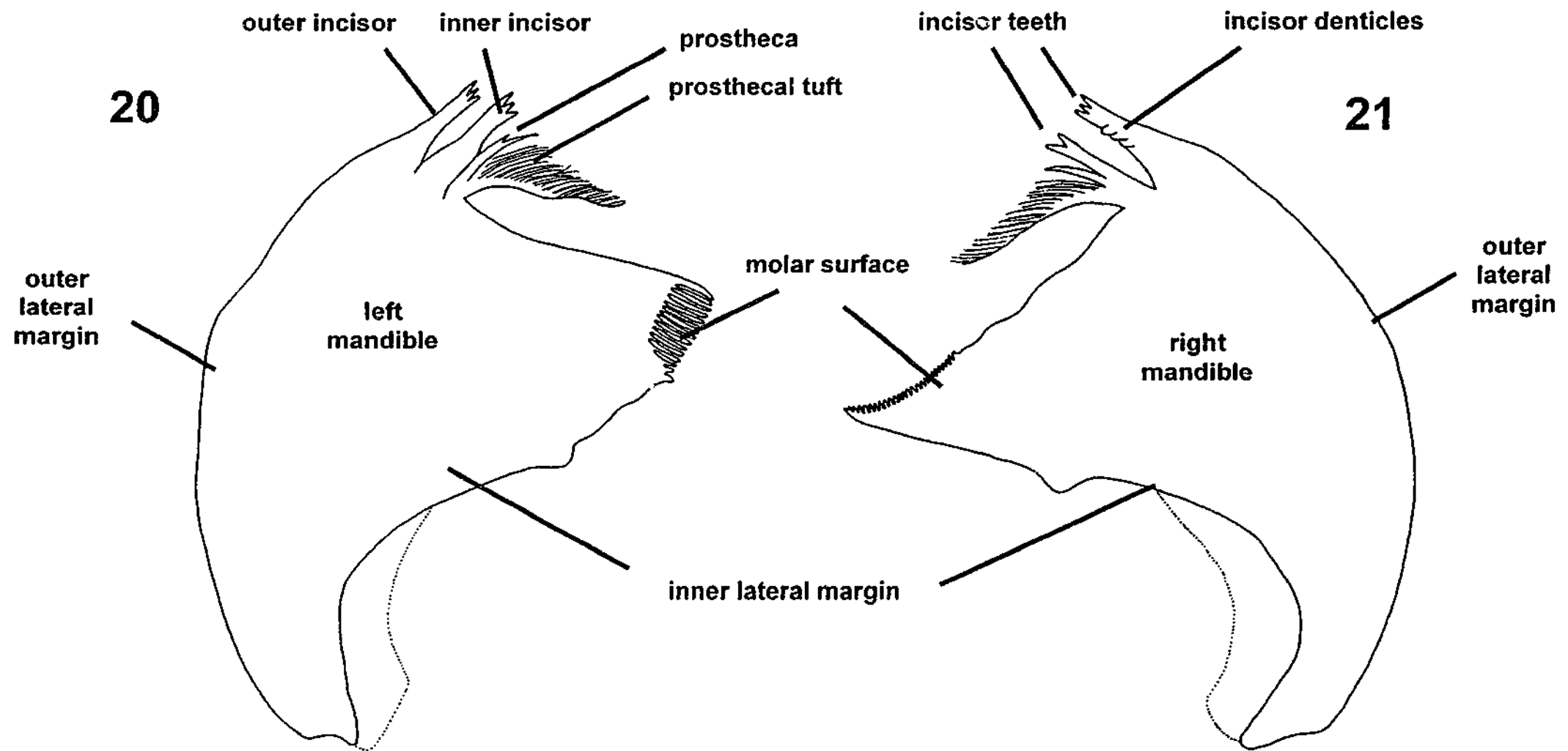
Figs 20-21. Important diagnostic features of the nymph mandibles.

Fig. 20. Left mandible.
Fig. 21. Right mandible.

22

subapical
pectinate
setae

3

2

maxillary
palps

1

galea-
lacina

width (W)

length (L)

23

lateral process   lingua   superlingua
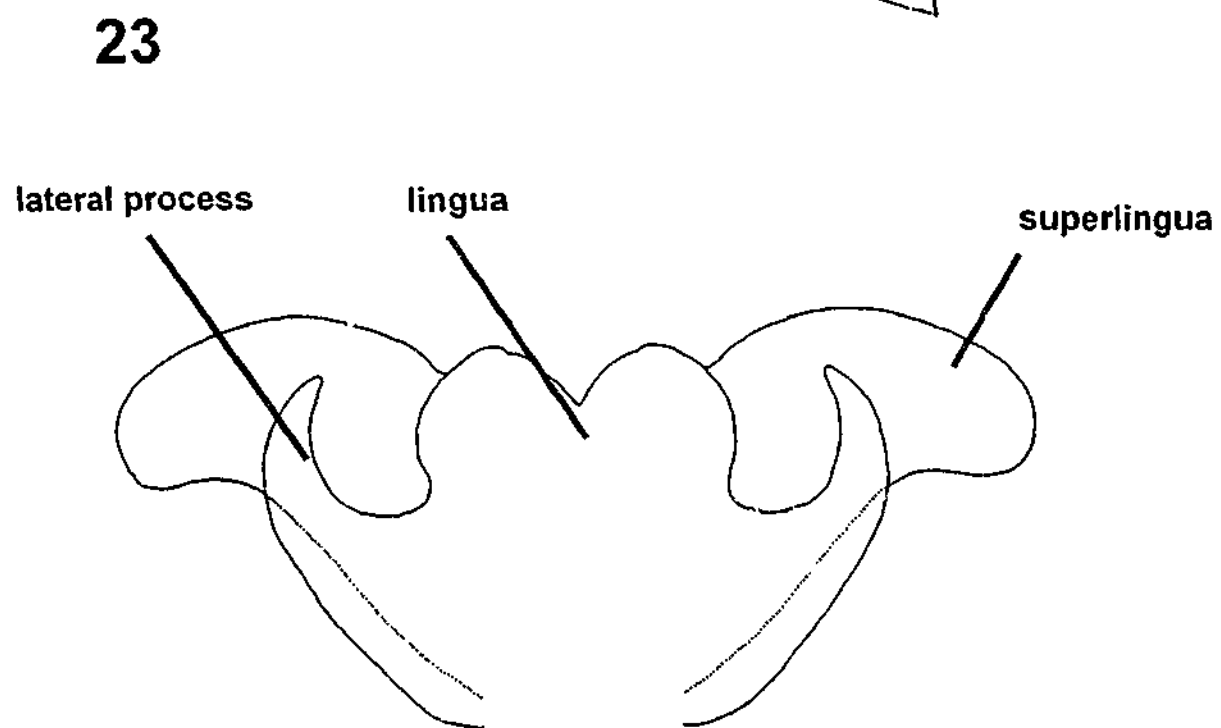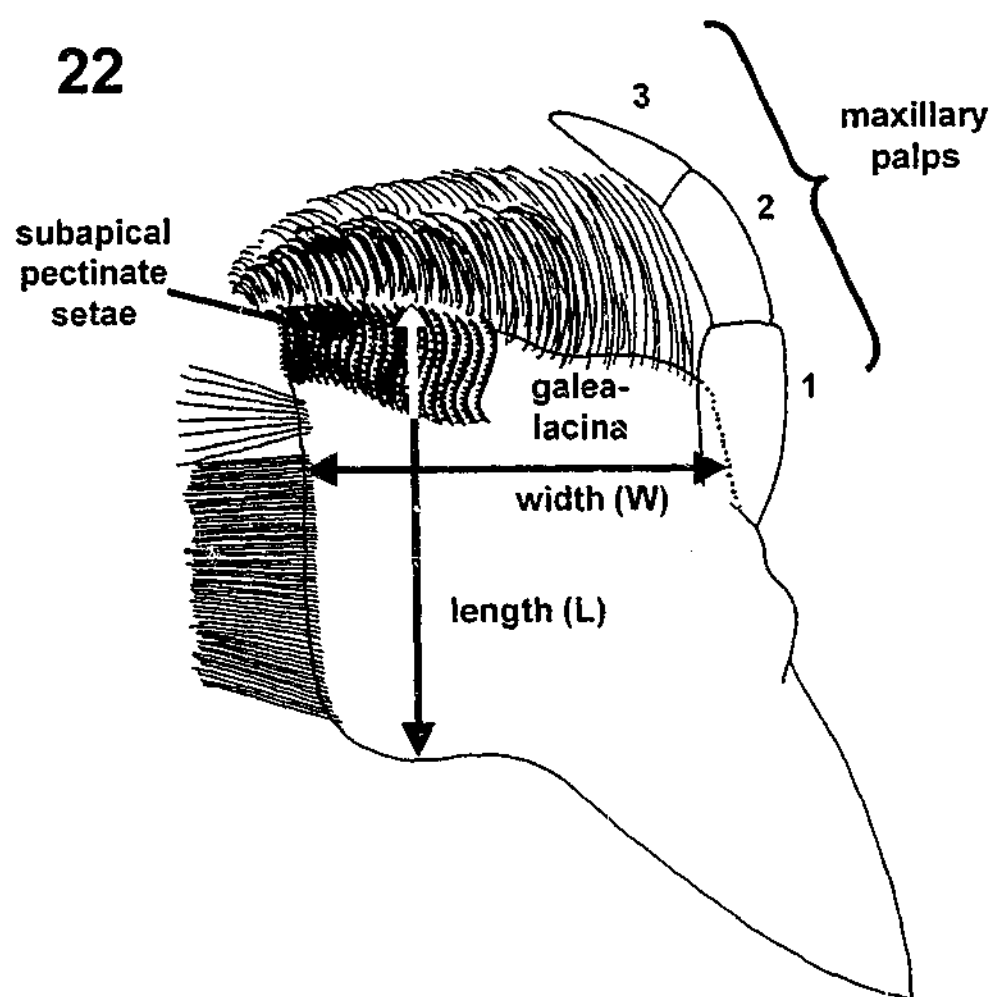
Fig. 22. Important diagnostic features of the nymph maxillae.
W/L= width length ratio of galea-lacina.

Fig. 23. Important diagnostic features of the nymph hypopharynx.
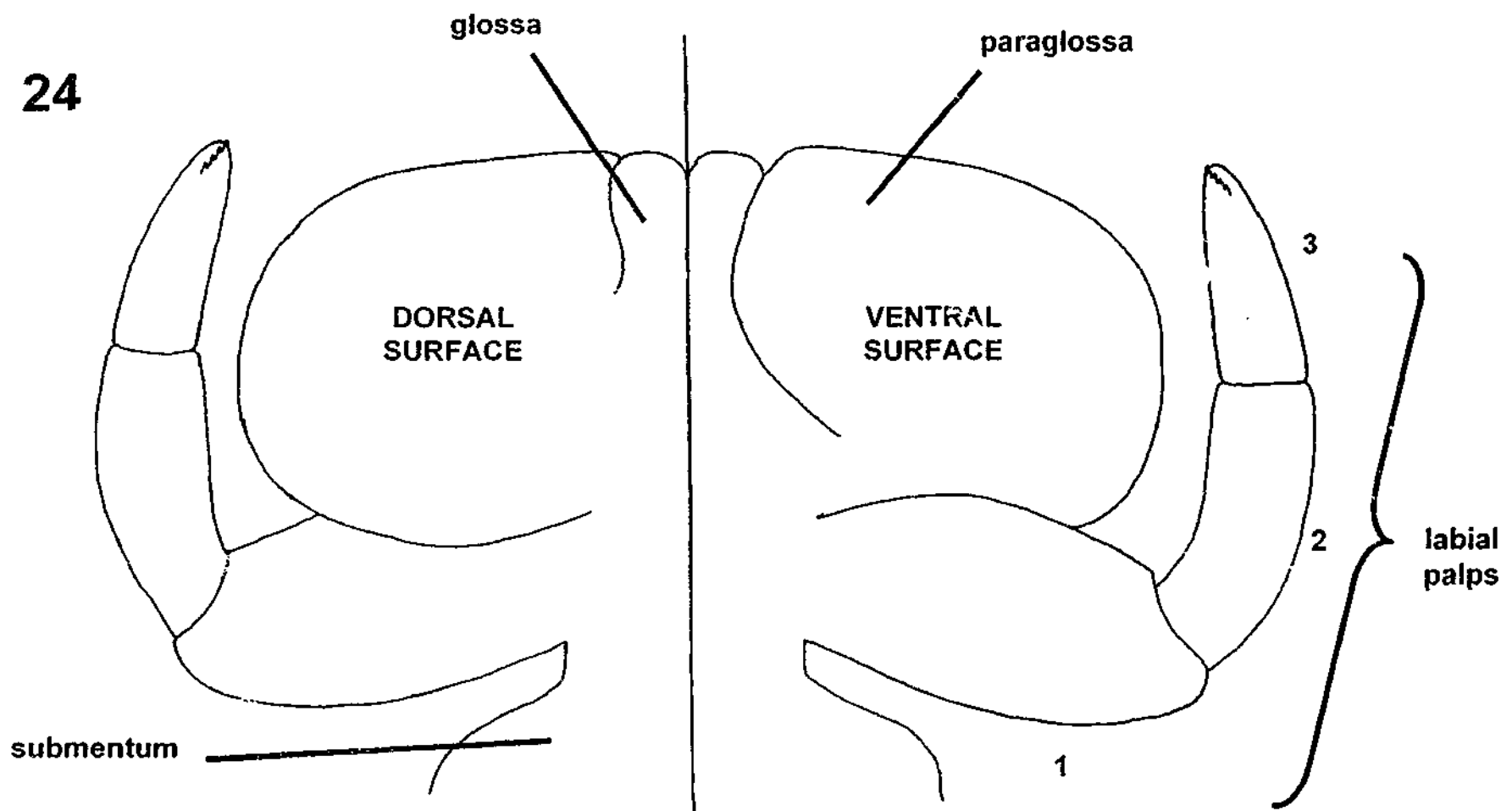
Fig. 24. Important diagnostic features of the nymph labium.
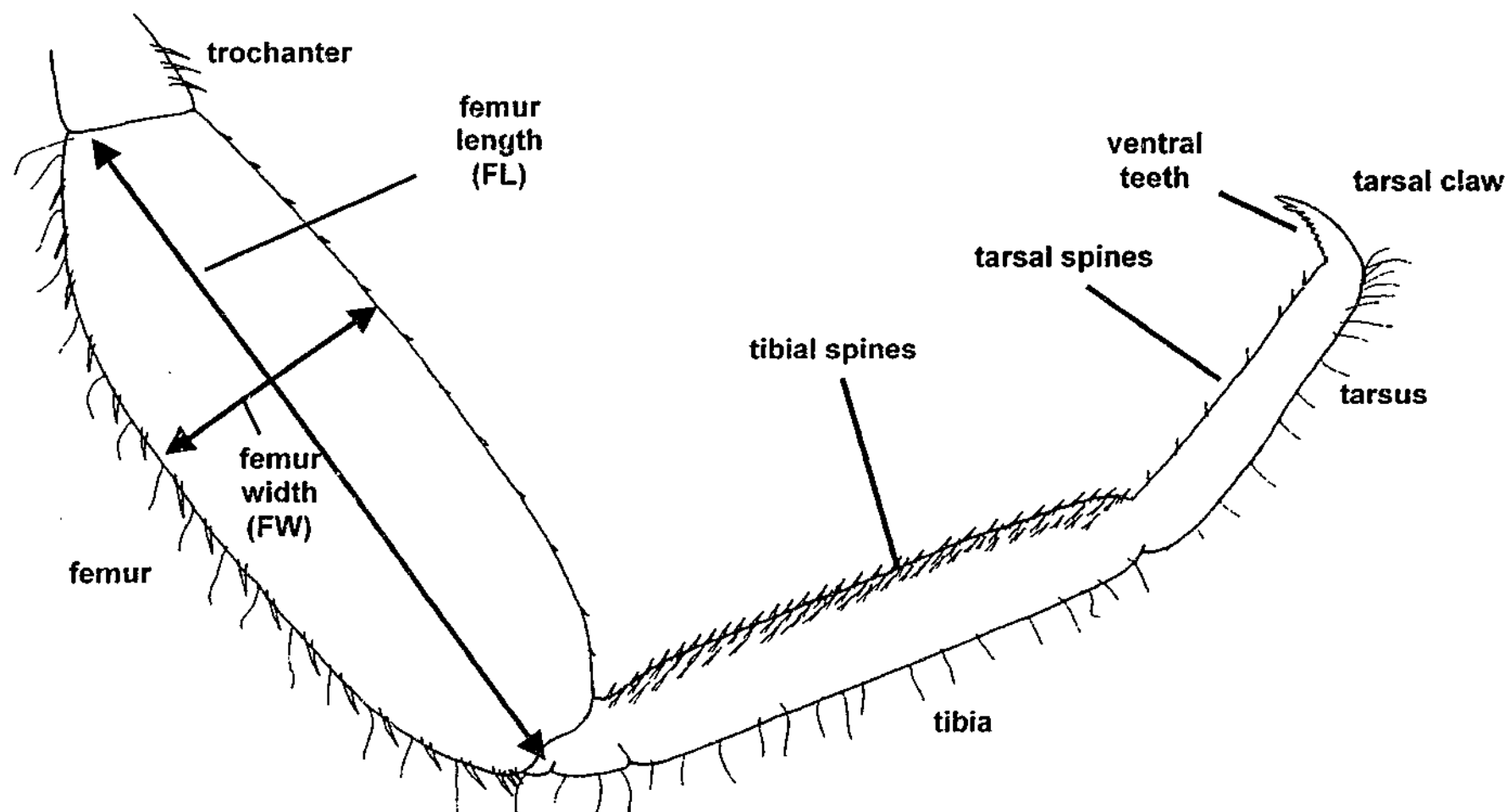
Fig. 25. Important diagnostic features of the nymph foreleg.
FL/FW= femur length width ratio.

26

1
2
3
4
5
6
7
8
9
10

postero-lateral
spines

27

lower
lamella

upper
lamella

lateral
trachea

main
tracheal
branch
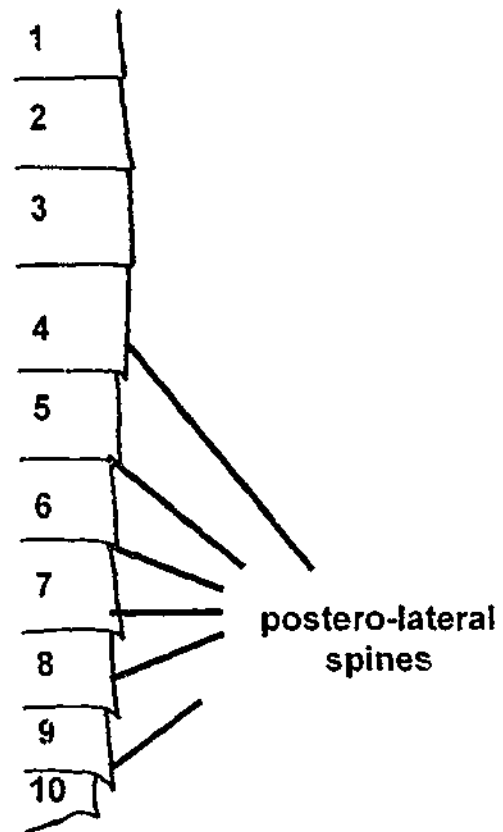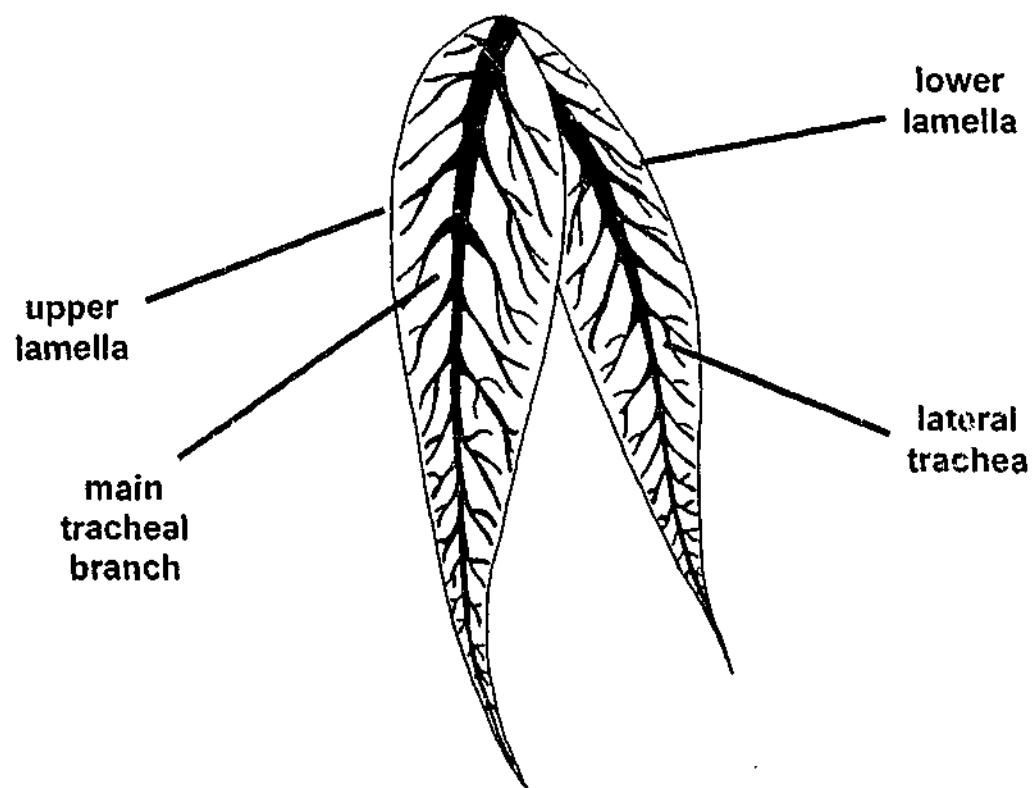
Fig. 26. Nymph abdomen dorsal view showing postero-lateral spines.
Tergal segments one to ten numbered.

Fig. 27. Important diagnostic features of the nymph gill.

28
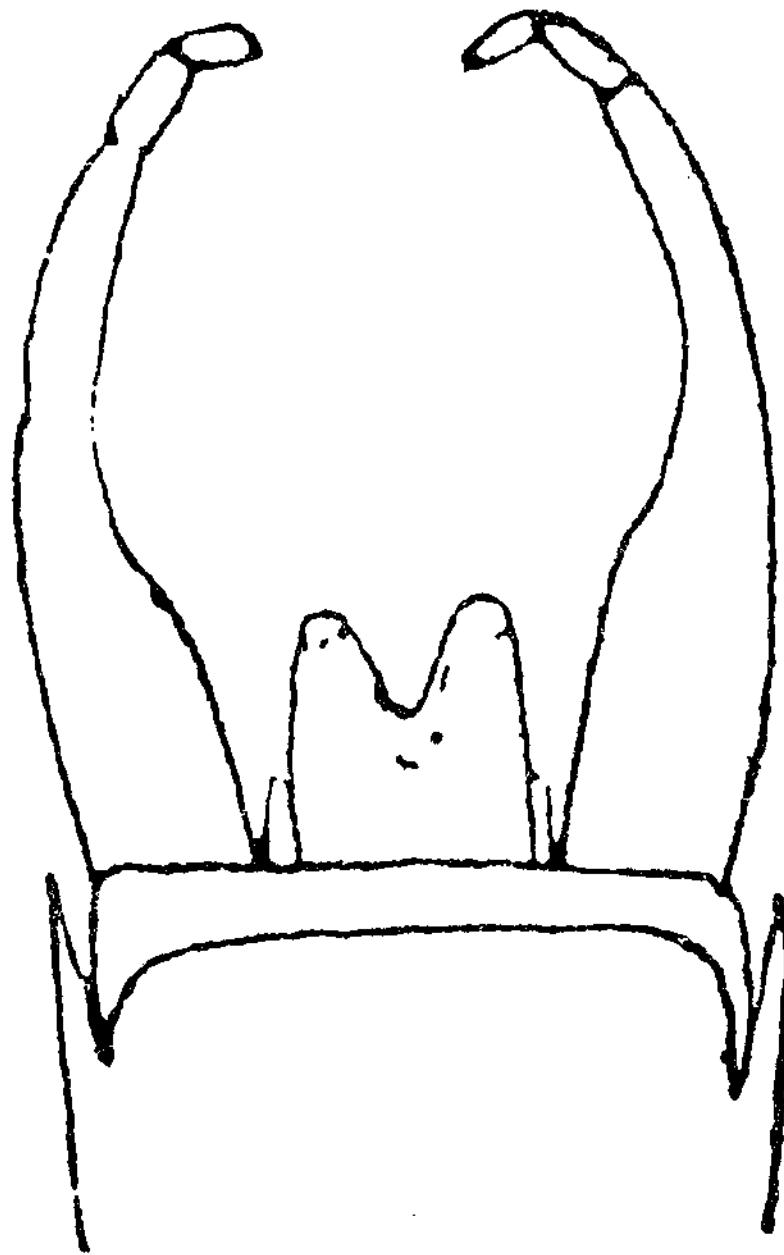
Fig. 28. *Nousia delicata* Navás.

Ventral view of male genitalia.
Reproduction of a drawing from Navás (1925).

Fig. 29. Distribution of the subgenus *Nousia (Australonousia)*.

30
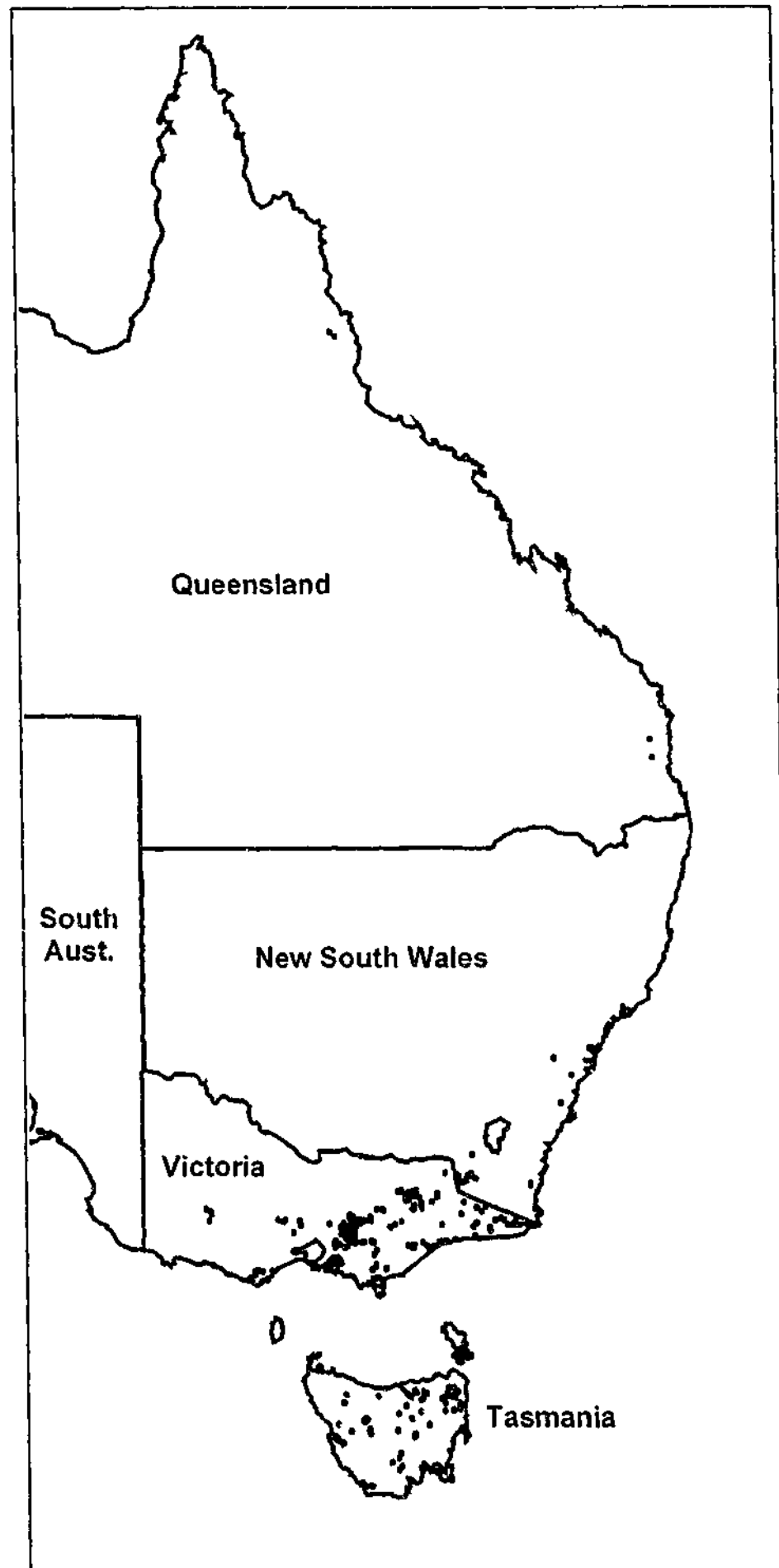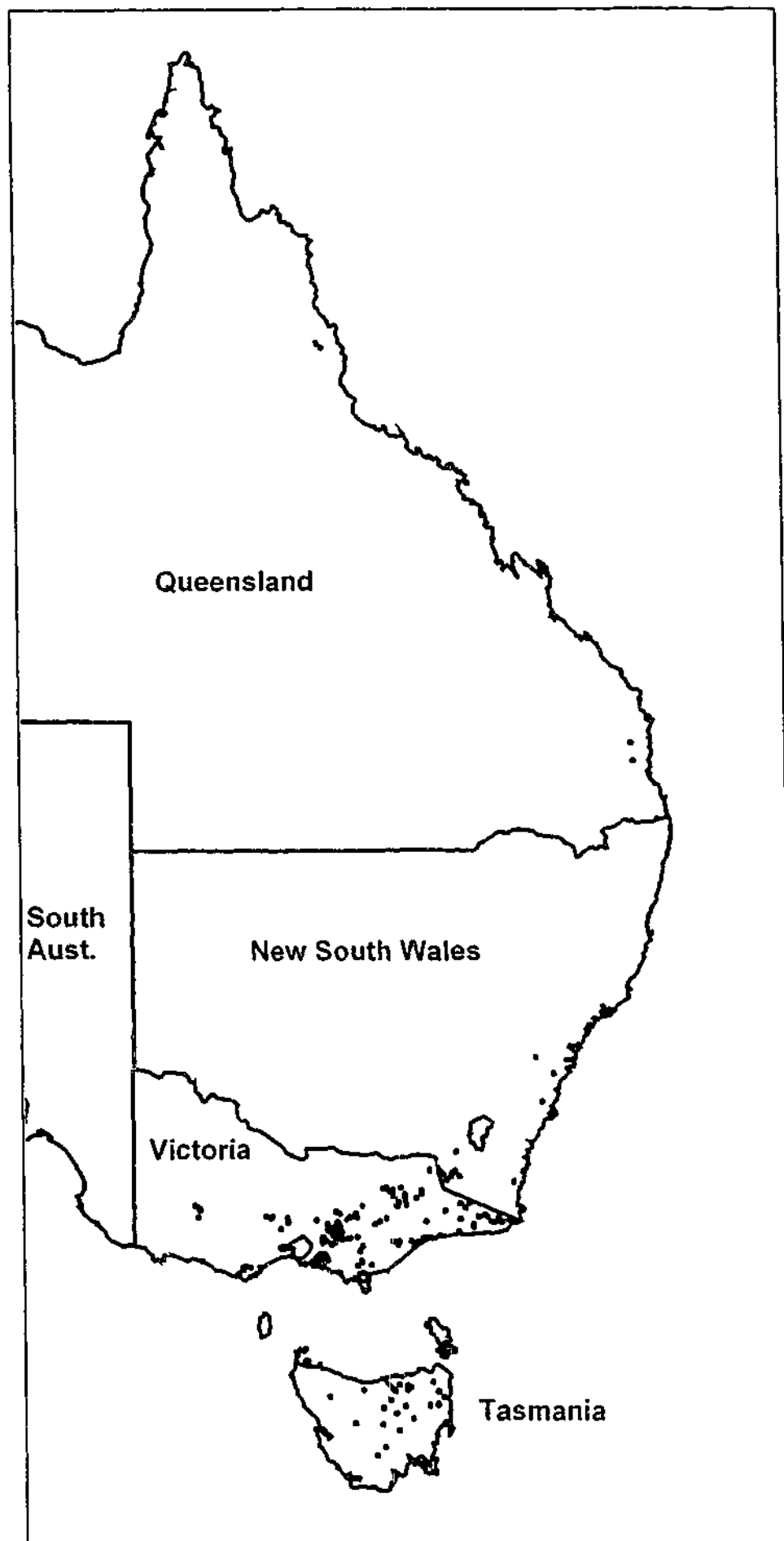
Fig. 30. Distribution of the redescribed
Nousia (Australonousia) fusca.

Fig. 31. Male imago of *Nousia (Australonousia) fusca*.
Reared from nymph collected from Rubicon River, Rubicon, Victoria (98101701).
Photo by K.J. Finlay.

32
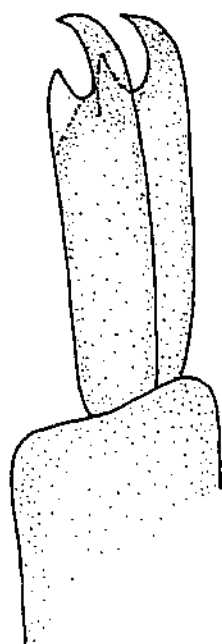
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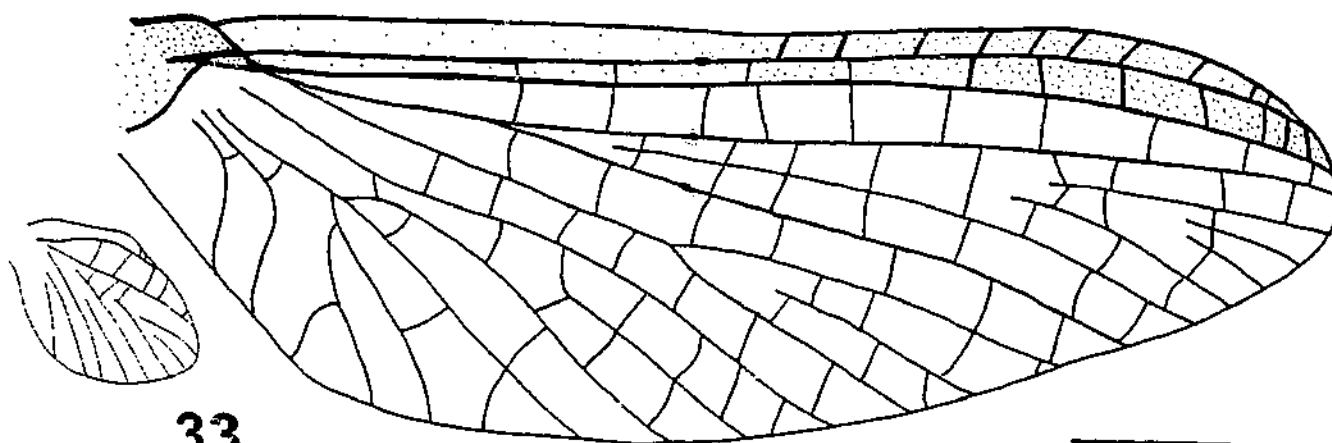
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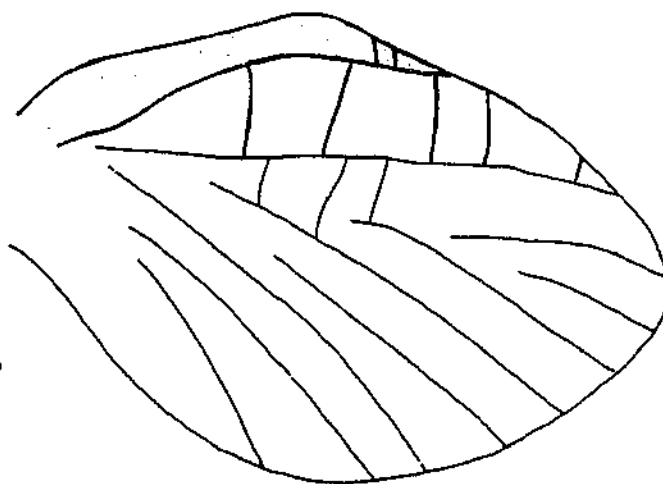
Figs. 32-34. *Nousia (Australonousia) fusca*, male imago.

Fig. 32. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 33. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 34. Hindwing. Scale bar = 500µm.

35
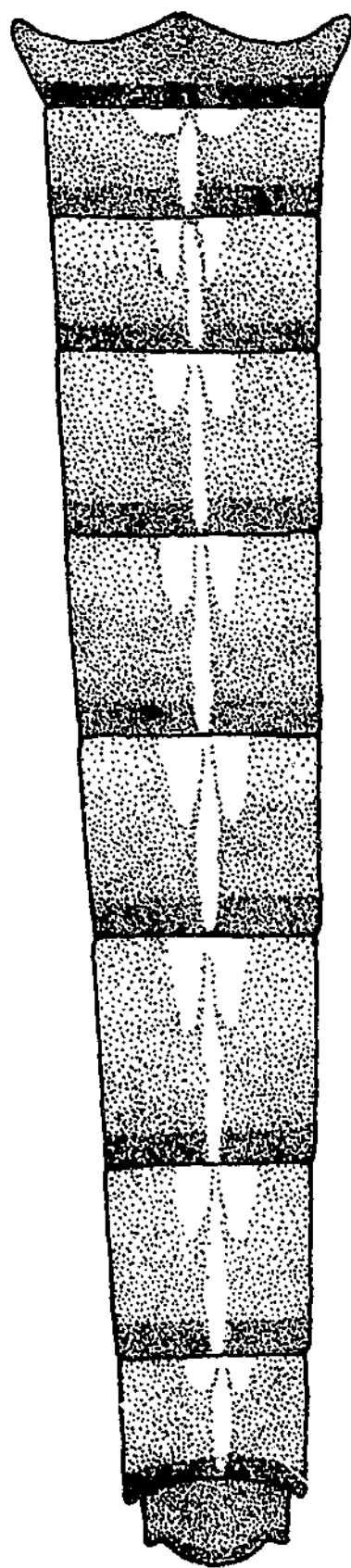
Fig. 35. *Nousia (Australonousia) fusca,* male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

36
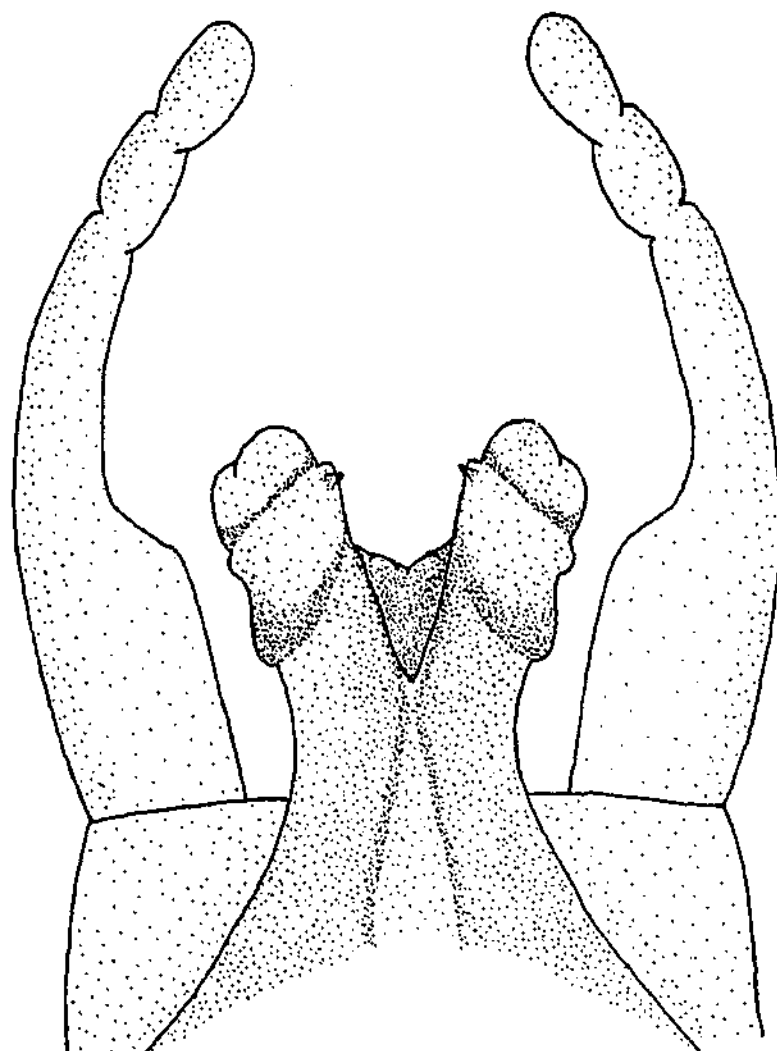
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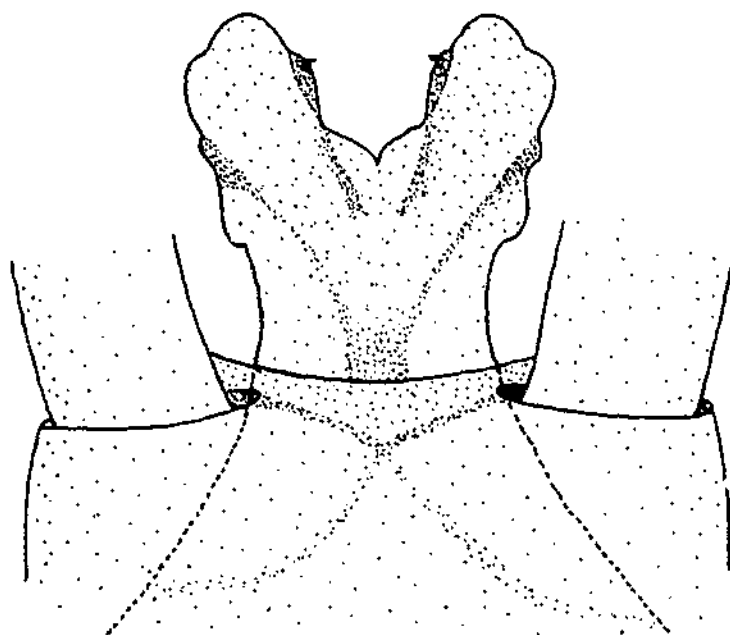
Figs. 36-37. *Nousia (Australonousia) fusca*, male imago.
Scale bar = 200µm.

Fig. 36. Dorsal view of genitalia showing penes and forceps.
Fig. 37. Ventral view of genitalia showing penes.

38
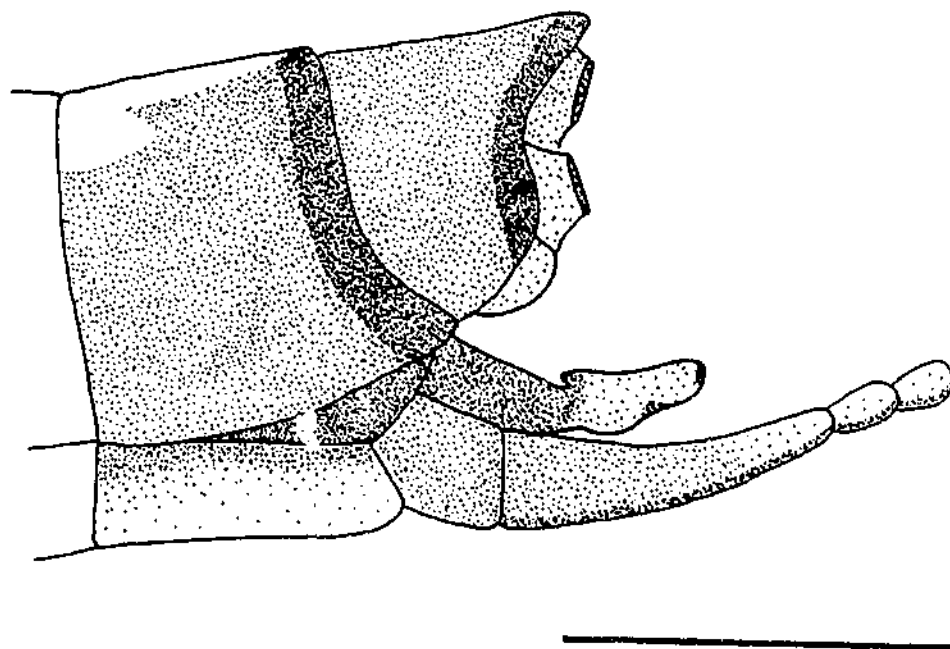
Fig. 38. *Nousia (Australonousia) fusca*, male imago.
Scale bar = 500μm.

Lateral view of genitalia showing penes and forceps.
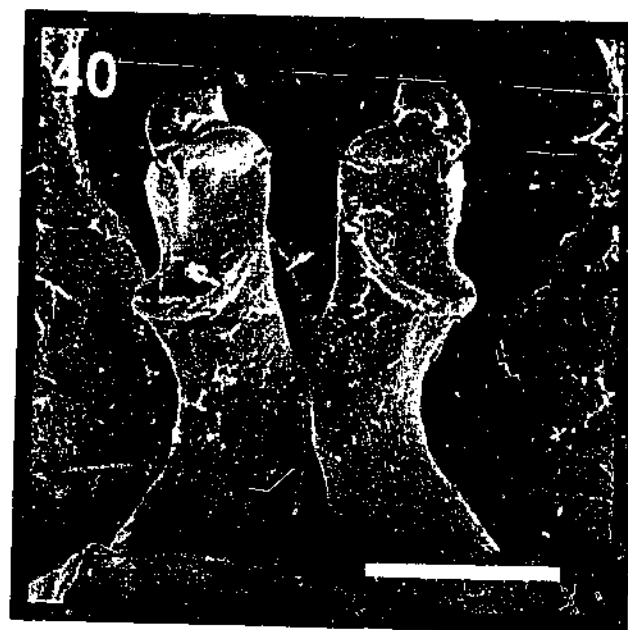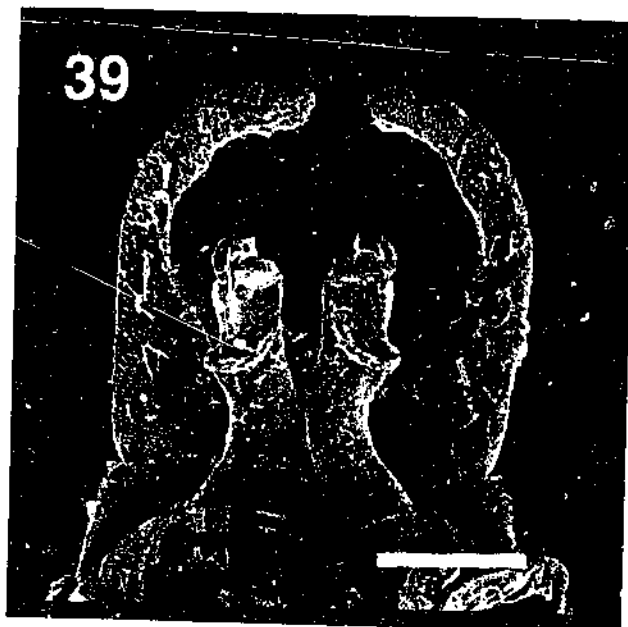
Figs. 39-42: *Nousia (Australonousia) fusca*, male imago.

Individual from Gulf Stream, Grampians National Park, Victoria (00122001).
Scale bars = 100μm.

Fig. 39. Dorsal view of genitalia showing penes and forceps.
Fig. 40. Dorsal view of penes.
Fig. 41. Ventral view of genitalia showing penes and forceps.
Fig. 42. Ventral view of penes.
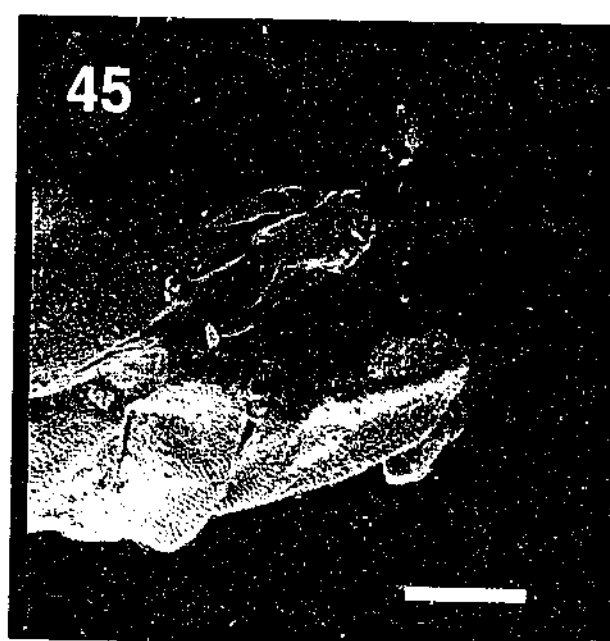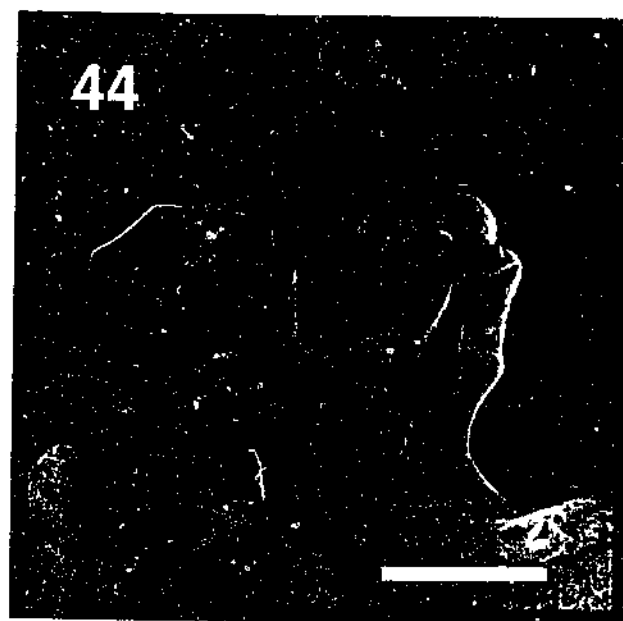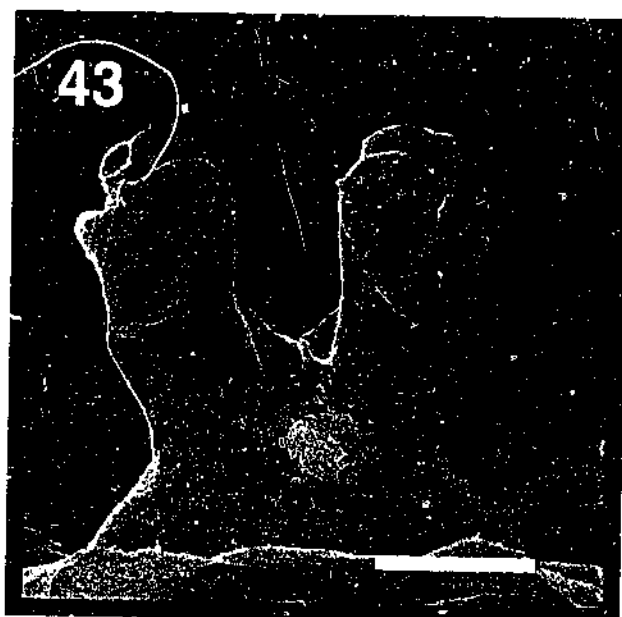
Figs. 43-45: *Nousia (Australonousia) fusca*, male imago.

Individual from Clyde River, Hamilton, Tasmania (96121901).
Scale bars = 100μm.

Fig. 43. Dorsal view of penes.
Fig. 44. Ventral view of penes.
Fig. 45. Lateral view of genitalia showing penes and forceps.
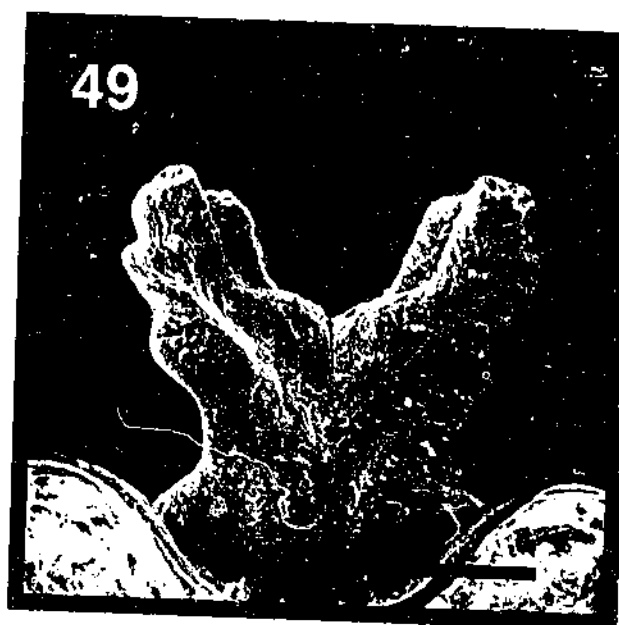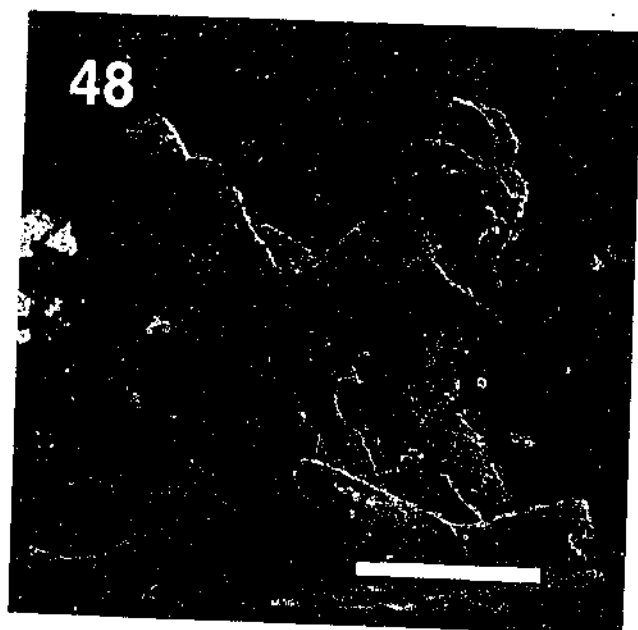
Fig. 46-49: *Nousia (Australonousia) fusca*, male imago.

Fig. 46. Dorsal view of penes.
Fig. 47. Ventral view of penes.
Individual from Brandy Creek, Alpine National Park, Victoria (96111902).
Shape distorted through drying process. Scale bars = 100μm.

Fig. 48. Dorsal view of penes.
Fig. 49. Ventral view of penes.
Individual from Rubicon River, Rubicon, Victoria (98101701).
Scale bars = 100μm.

Fig. 50. Female imago of *Nousia (Australonousia) fusca.*
Reared from nymph collected from Rubicon River, Rubicon, Victoria (98101701).
Photo by K.J. Finlay.

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53
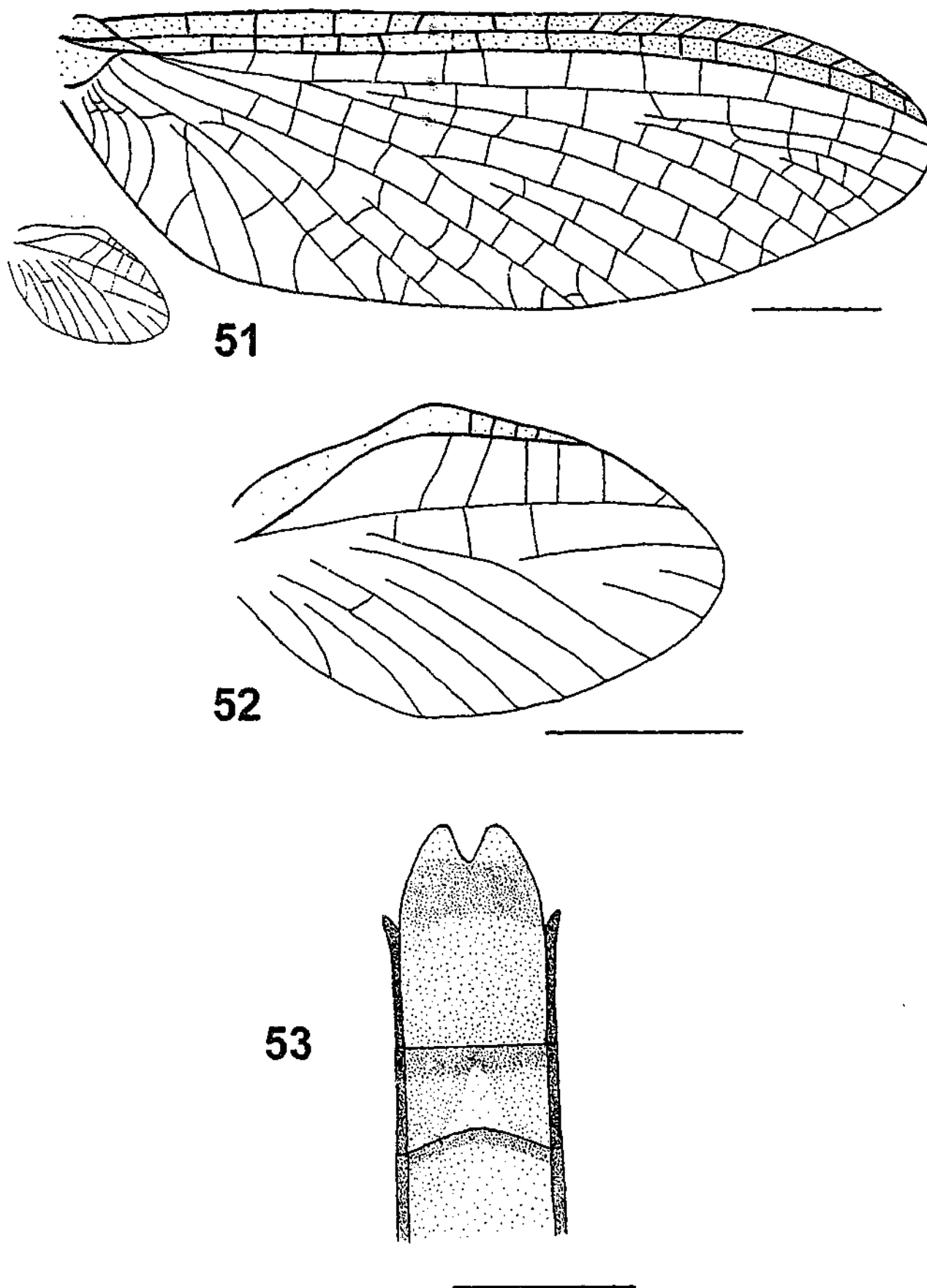
Figs 51-53. *Nousia (Australonousia) fusca*, female imago.

Fig. 51. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 52. Hindwing. Scale bar = 500µm.
Fig. 53. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.
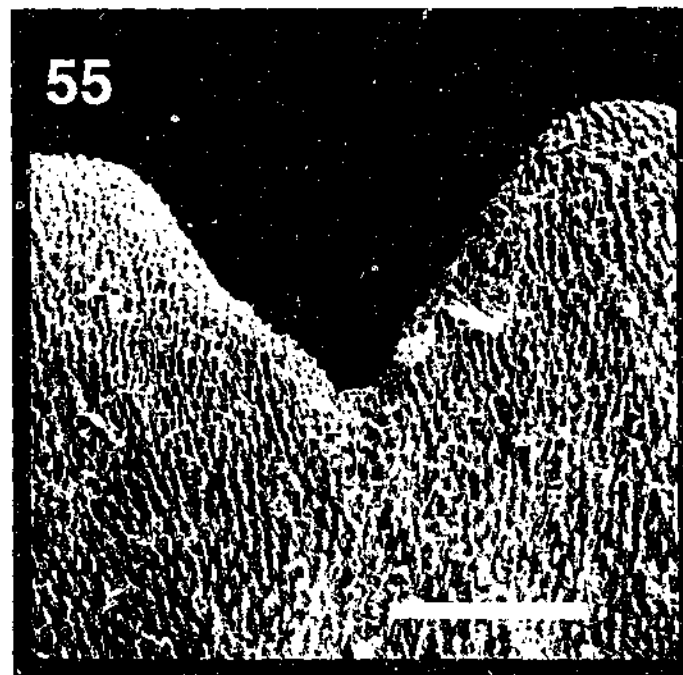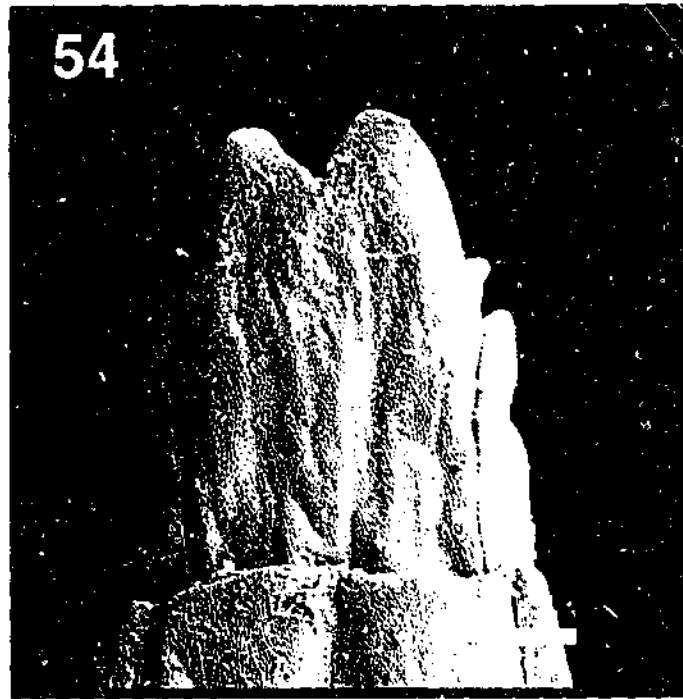
Figs. 54-55: *Nousia (Australonousia) fusca*, female imago.

Individual from Brandy Creek, Alpine National Park, Victoria (97011902).

Fig. 54. Sternites eight to nine. Scale bar = 100µm.
Fig. 55. Close up of apical section of sternite nine. Scale bar = 50µm.
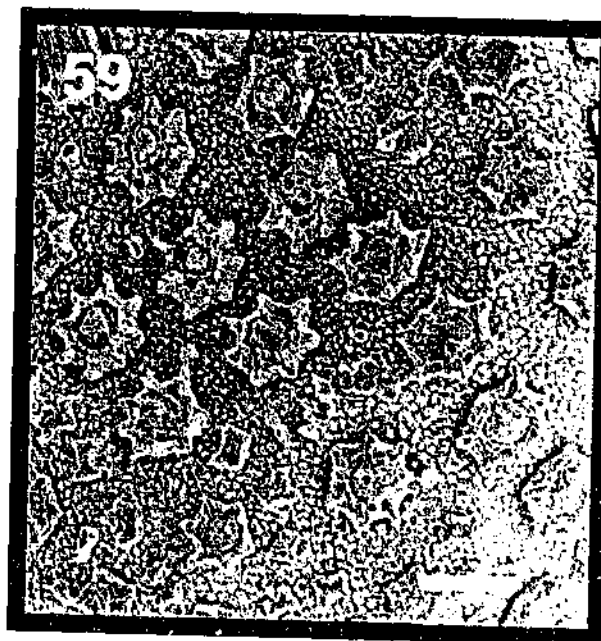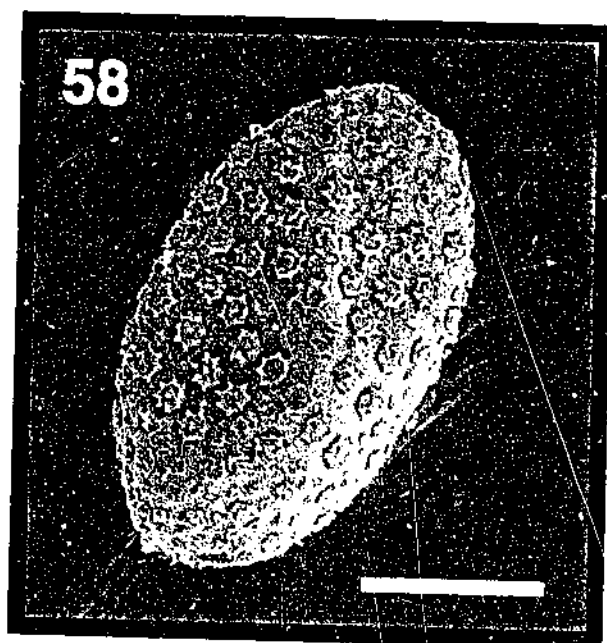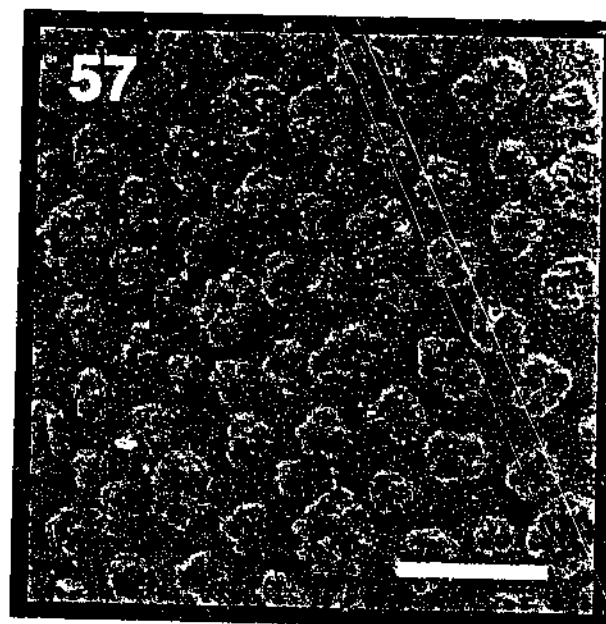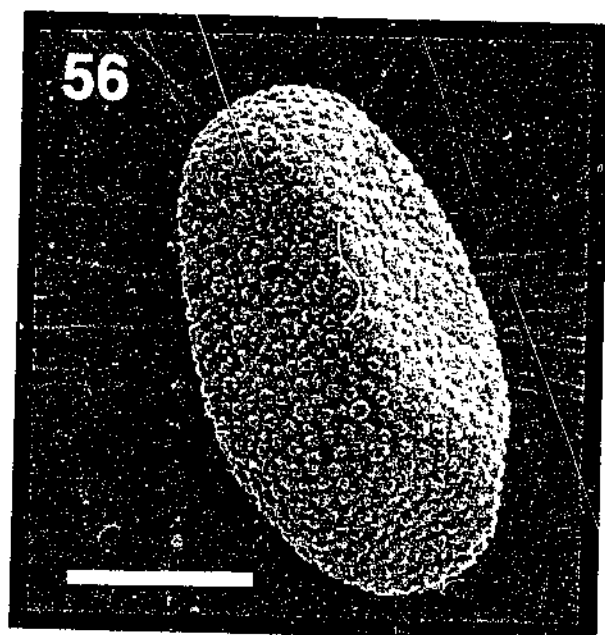
Fig. 56-59. *Nousia (Australonousia) fusca*, eggs taken from female imago.

Fig. 56. Whole egg. Scale bar = 50μm.
Fig. 57. Close up of egg chorion. Scale bar = 10μm.
Individual from Jimmys Creek, Grampians National Park, Victoria (00012203).

Fig. 58. Whole egg. Scale bar = 50μm.
Fig. 59: Close up of egg chorion. Scale bar = 10μm.
Individual from Gulf Stream, Grampians National Park, Victoria (00012201).
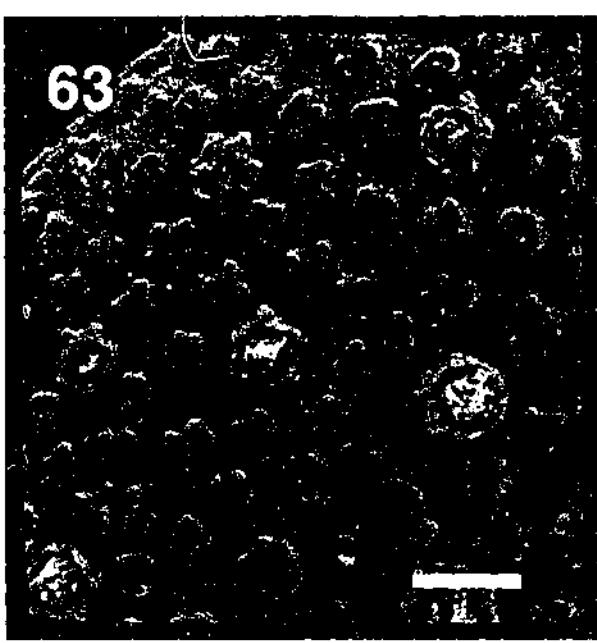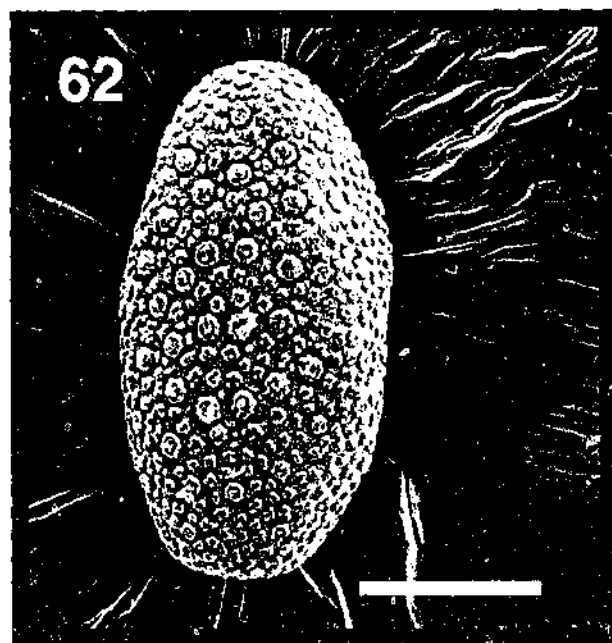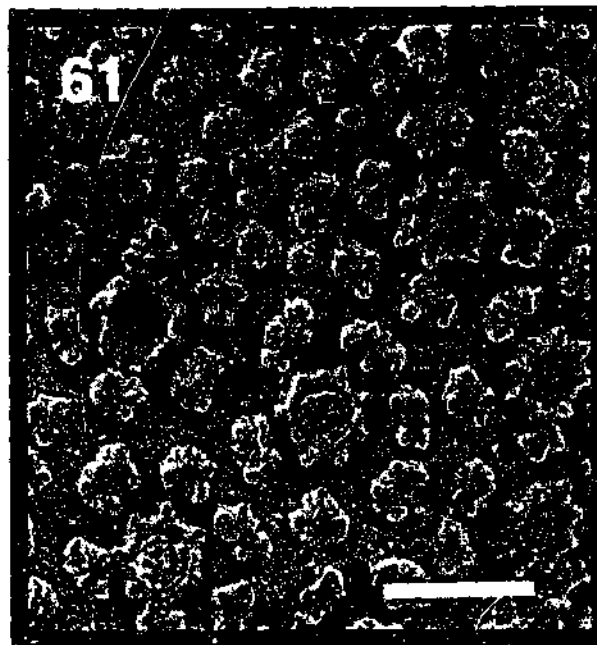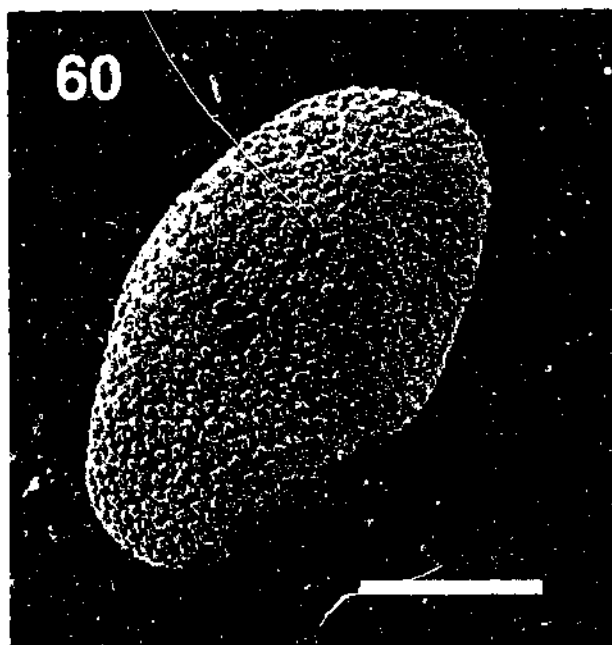
Figs. 60-63. *Nousia (Australonousia) fusca*, eggs taken from female imago.

Fig. 60. Whole egg. Scale bar = 50μm.
Fig. 61. Close up of egg chorion. Scale bar = 10μm.
Individual from Brandy Creek, Alpine National Park, Victoria (97011902).

Fig. 62. Whole egg. Scale bar = 50μm.
Fig. 63 Close up of egg chorion. Scale bar = 10μm.
Individual from Sassafras Creek, Dandenong Ranges, Victoria (97032402).
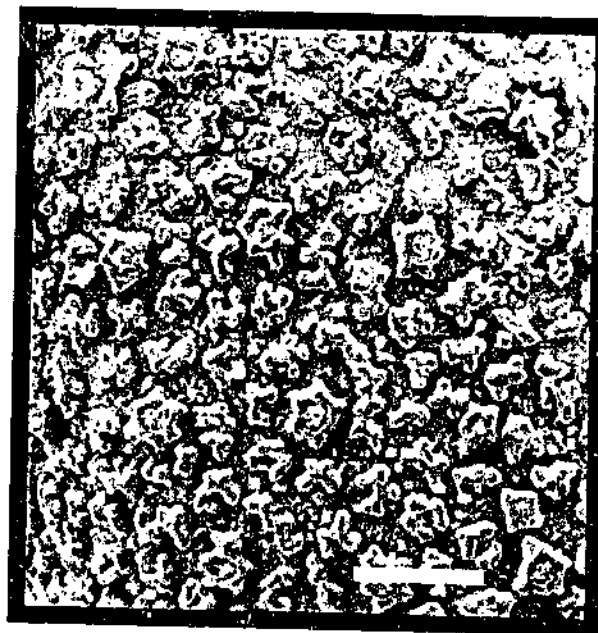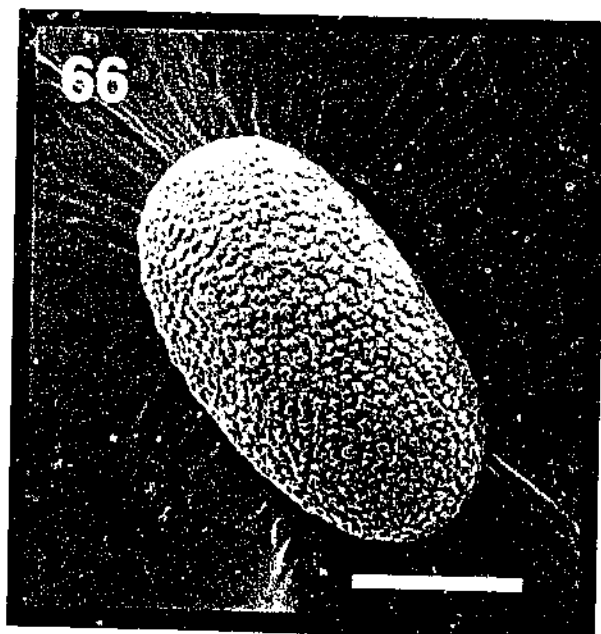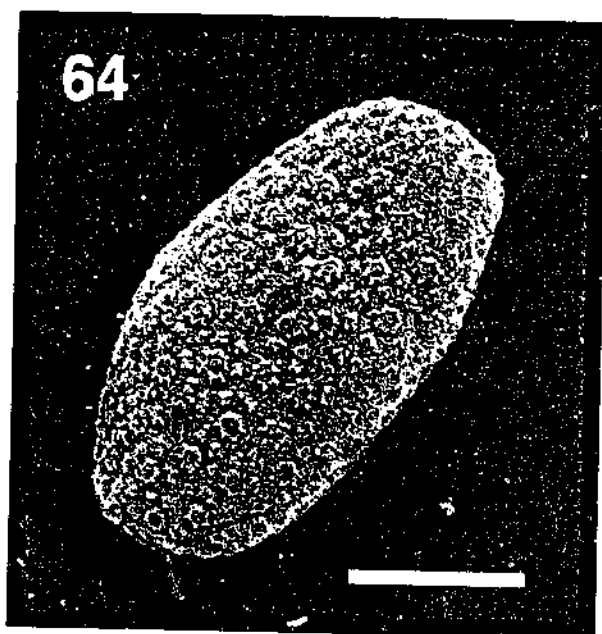
Figs. 64-67. *Nousia (Australonousia) fusca*, eggs taken from female imago.

Fig. 64. Whole egg. Scale bar = 50µm.
Fig. 65. Close up of egg chorion. Scale bar = 10µm
Individual from Carisbrook Creek, Great Ocean Road, Victoria (97030203).

Fig. 66: Whole egg. Scale bar = 50µm.
Fig. 67. Close up of egg chorion. Scale bar = 10µm.
Individual from Steavensons River, Marysville, Victoria (98021504).

Fig. 68. Male subimago of *Nousia (Australonousia) fusca*.
Reared from nymph collected from Rubicon River, Rubicon, Victoria (98101701).
Photo by K.J. Finlay.
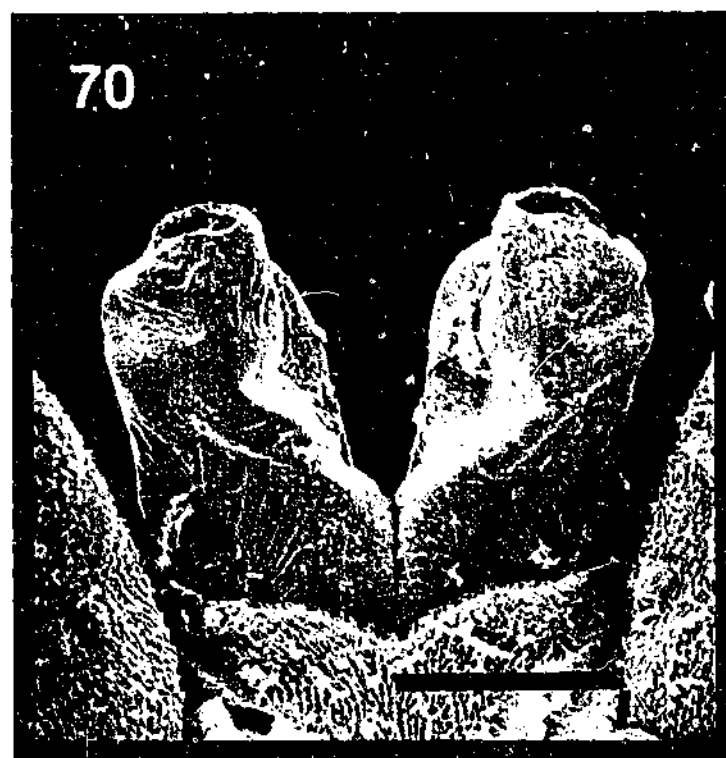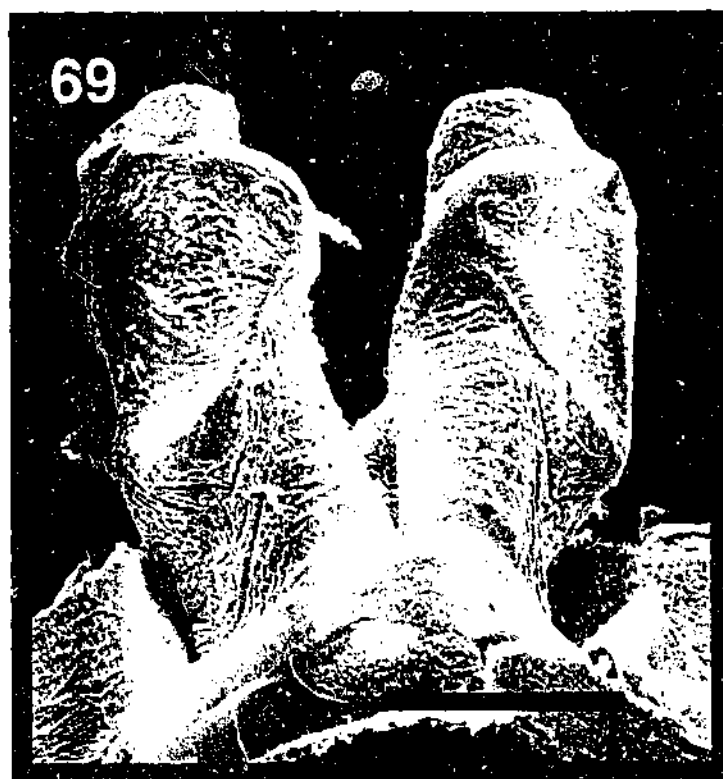
Figs. 69-70. *Nousia (Australonousia) fusca*, male subimago.

Individual from Victoria River, Alpine National Park, Victoria (96111901).
Scale bars = 100µm.

Fig. 69. Dorsal view of penes which are not yet fully developed.
Fig. 70. Ventral view of penes which are not yet fully developed.

Fig. 71. Female nymph of *Nousia (Australonousia) fusca*.
Collected from Rubicon River, Rubicon, Victoria (98101701).
Photo by K.J. Finlay.

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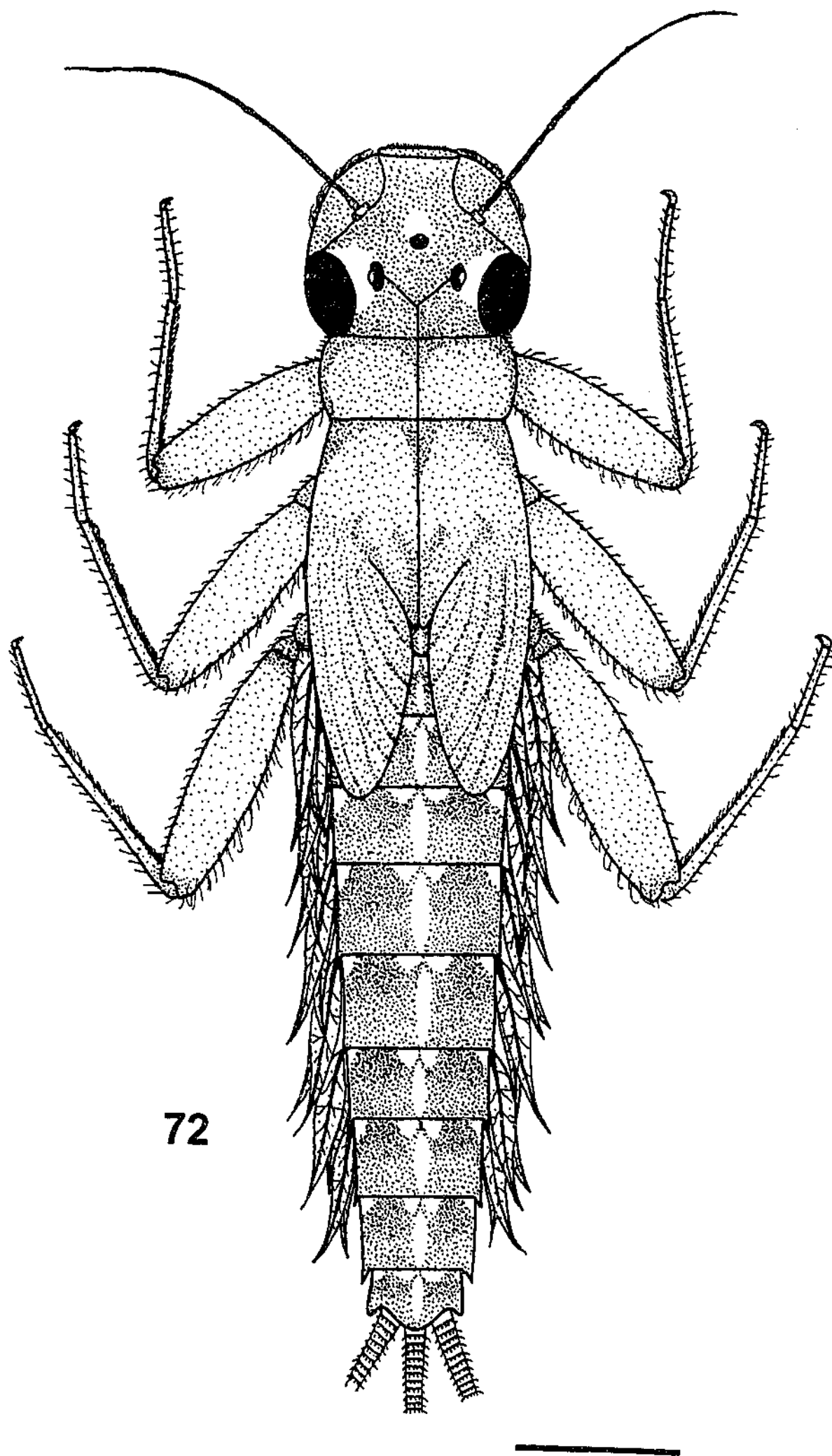
Fig. 72. *Nousia (Australonousia) fusca*, female nymph.
Scale bar = 1mm.

73

74
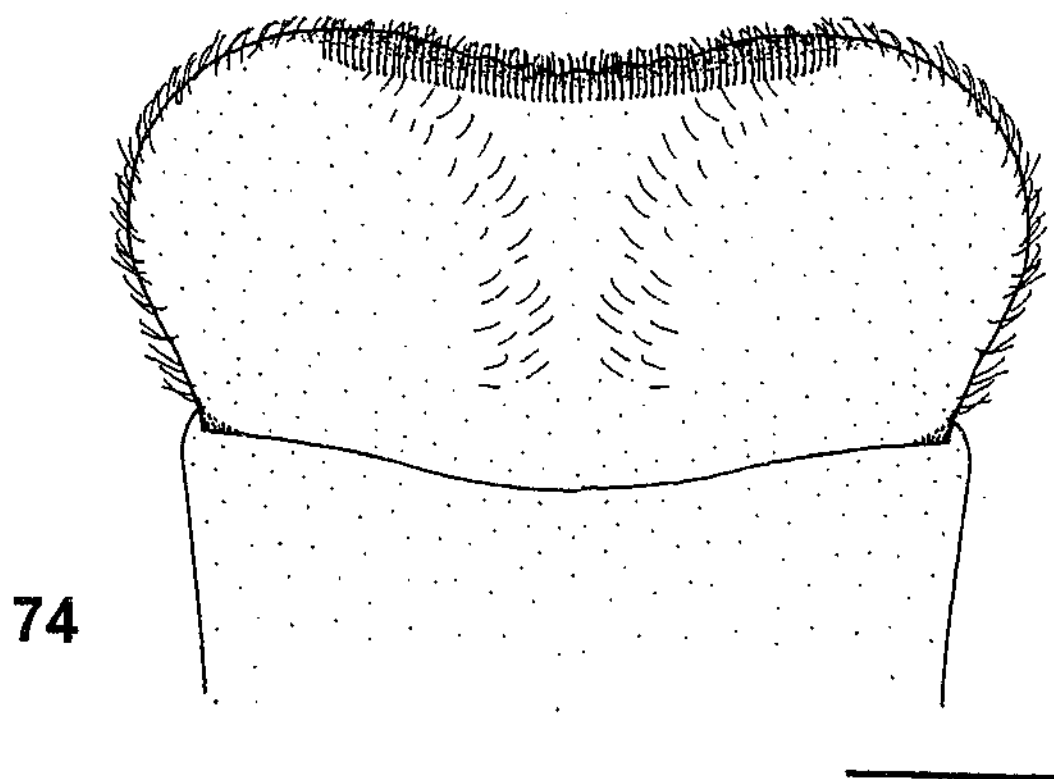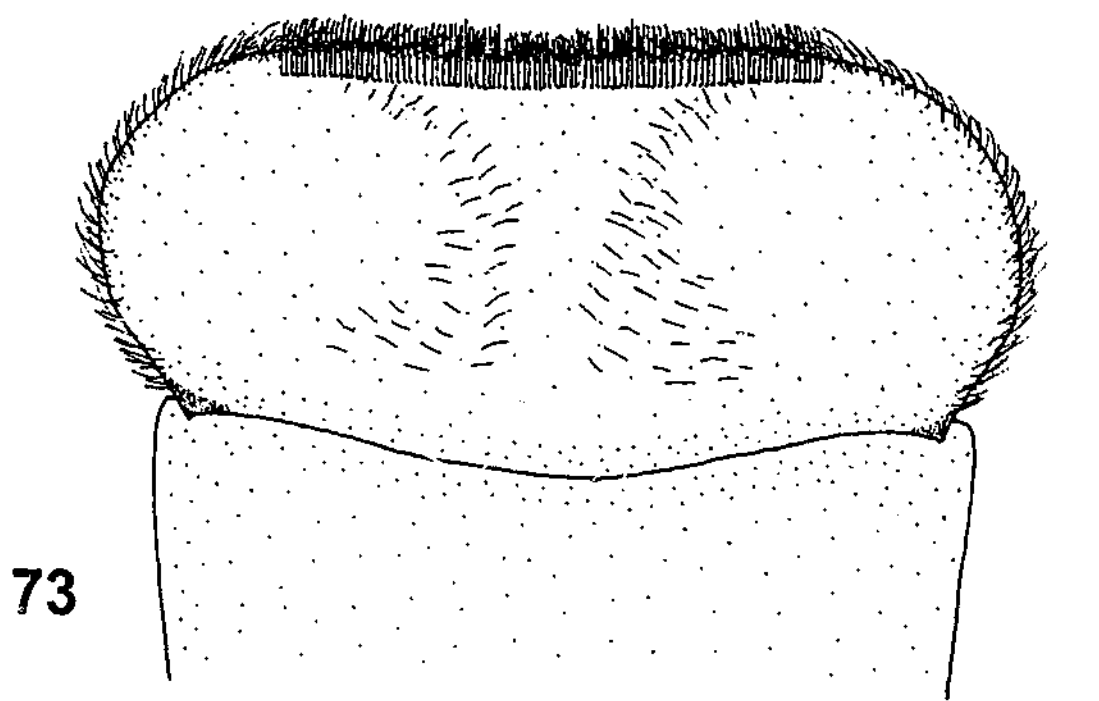
Figs. 73-74. *Nousia (Australonousia) fusca,* nymph mouthparts.
Scale bars = 200µm.

Fig. 73. Labrum and clypeus showing straight anterior margin of labrum.
Fig. 74. Labrum and clypeus showing slight antero-median emargination
of labrum.
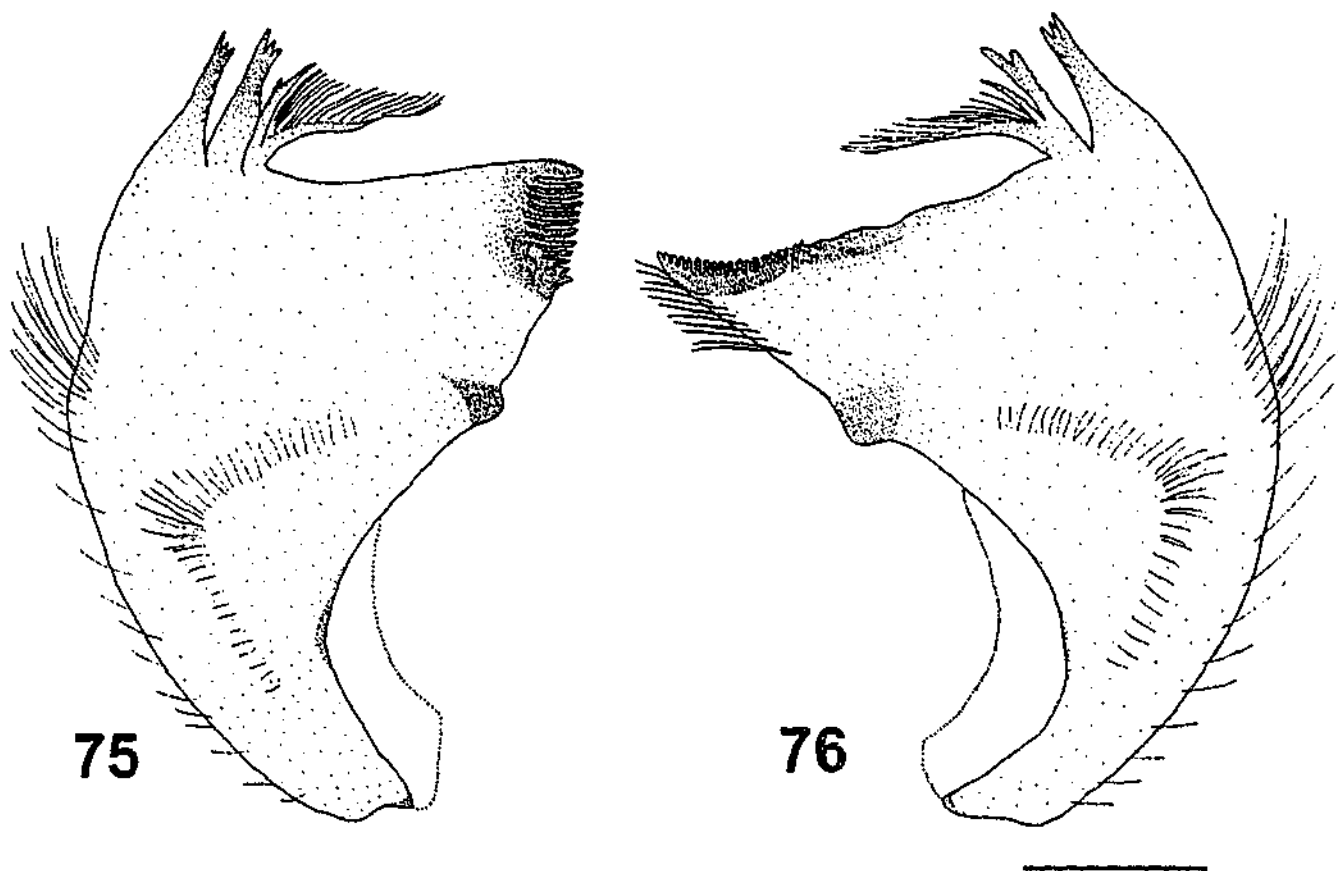
Figs. 75-76. *Nousia (Australonousia) fusca,* nymph mouthparts.
Scale bar = 200µm.

Fig. 75. Left mandible.
Fig. 76. Right mandible.
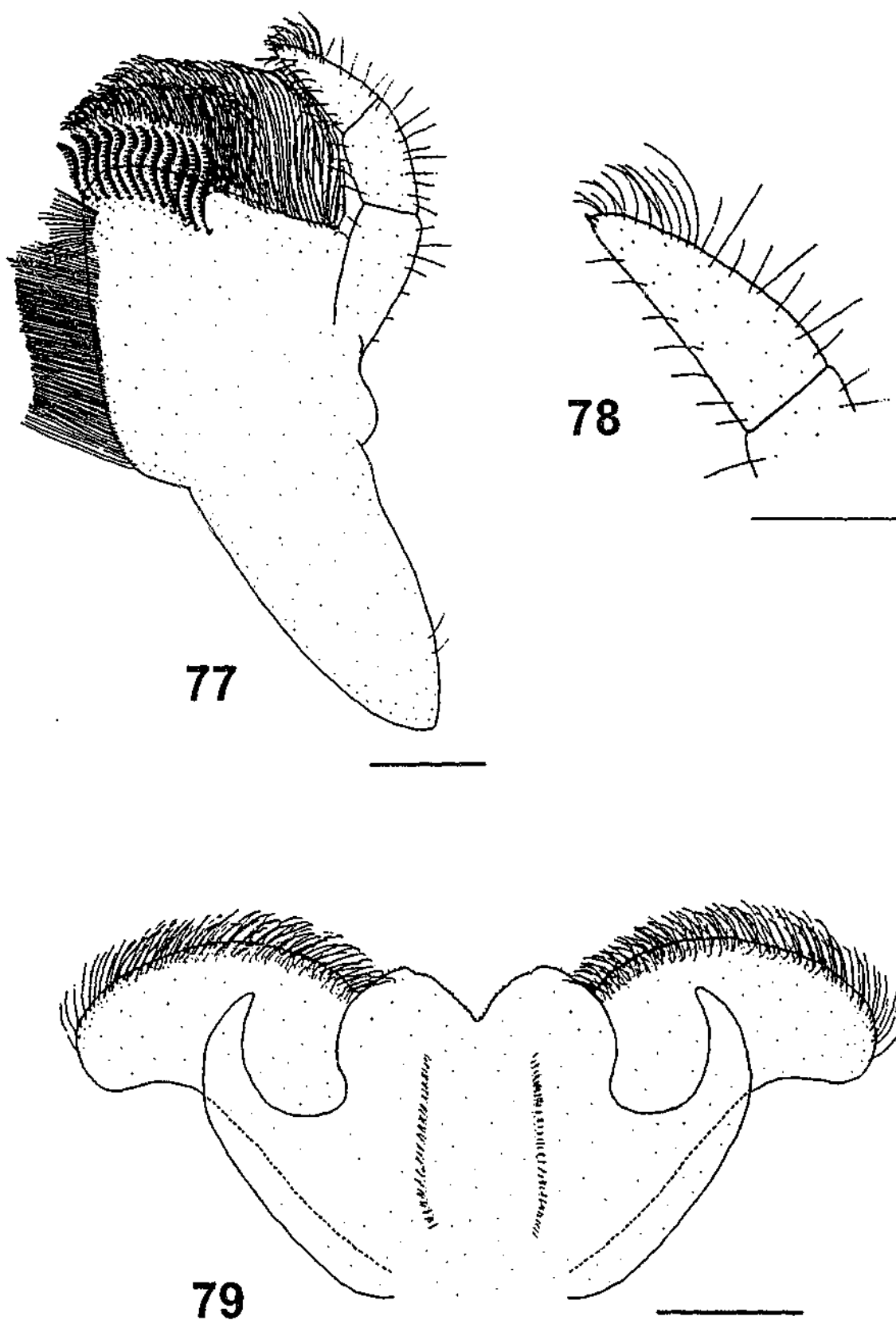
Figs. 77-79. *Nousia (Australonousia) fusca*, nymph mouthparts.

Fig. 77. Right maxilla. Scale bar = 200µm.
Fig. 78. Terminal palp of maxilla showing apical spine. Scale bar = 100µm.
Fig. 79. Hypopharynx. Scale bar = 200µm.
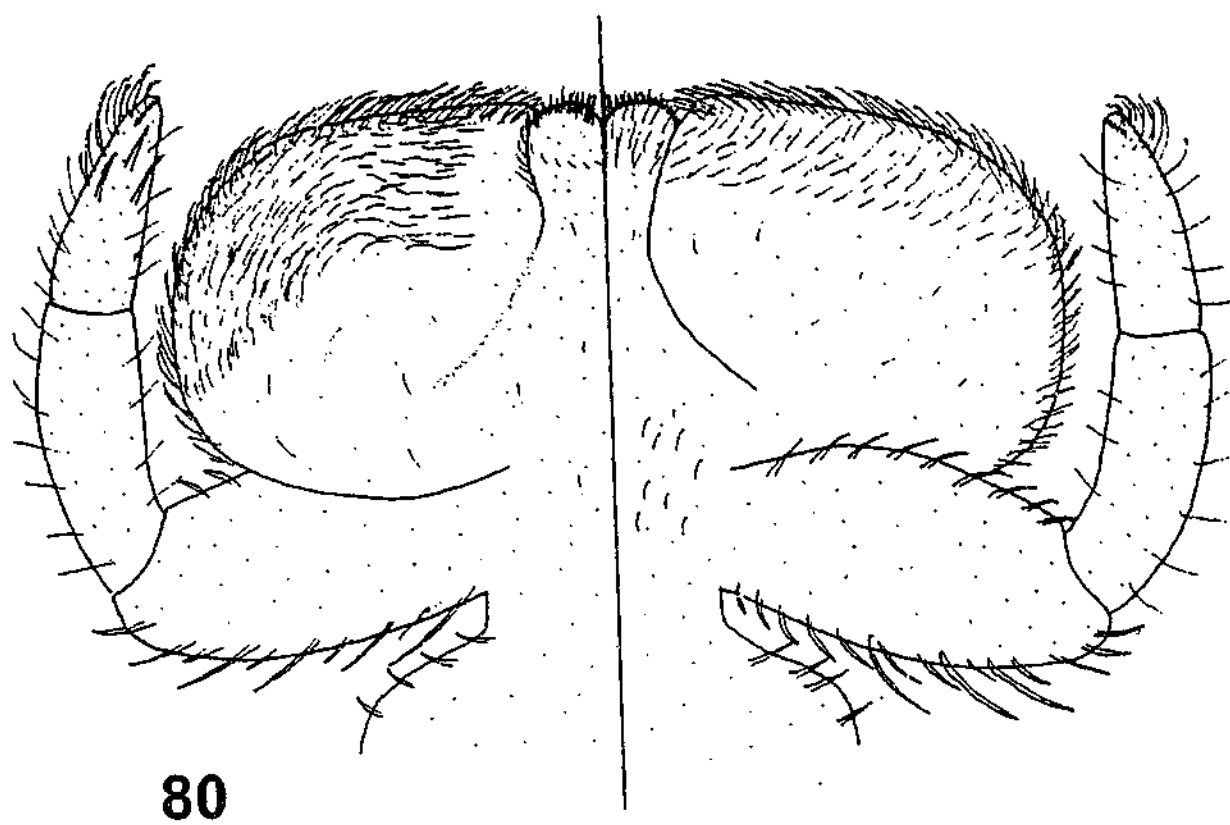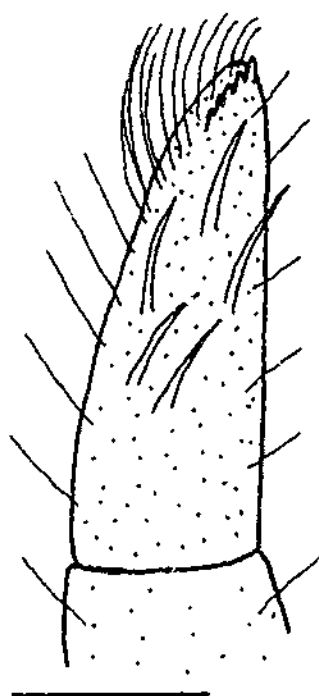
Figs. 80-81. *Nousia (Australonousia) fusca*, nymph mouthparts.

Fig. 80. Labium. Scale bar = 200µm.
Fig. 81. Dorsal view of labial terminal palp showing apical spines.
Scale bar = 100µm.

82
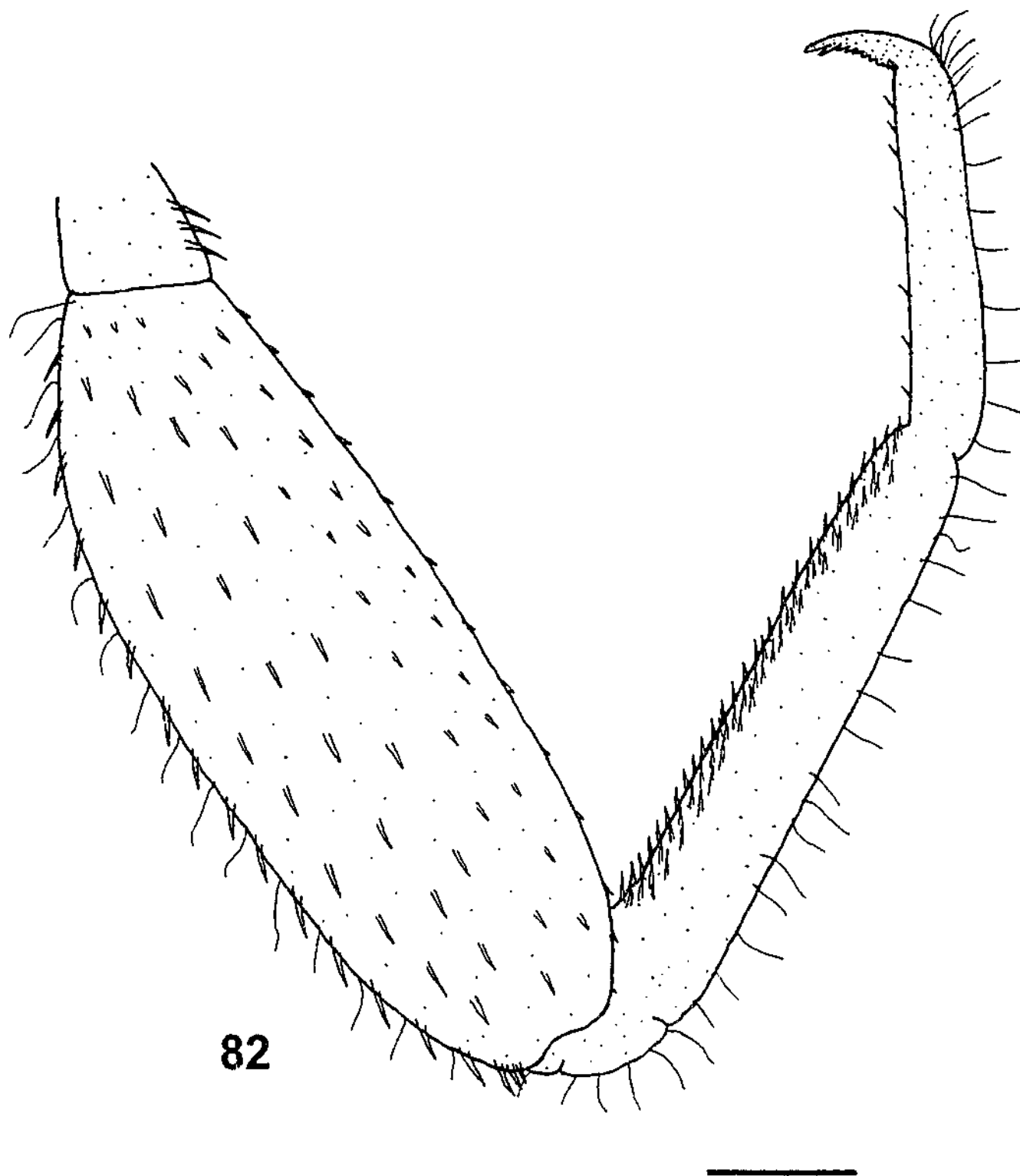
Fig. 82. *Nousia (Australonousia) fusca*, nymph.

Foreleg. Scale bar ≈ 200µm.
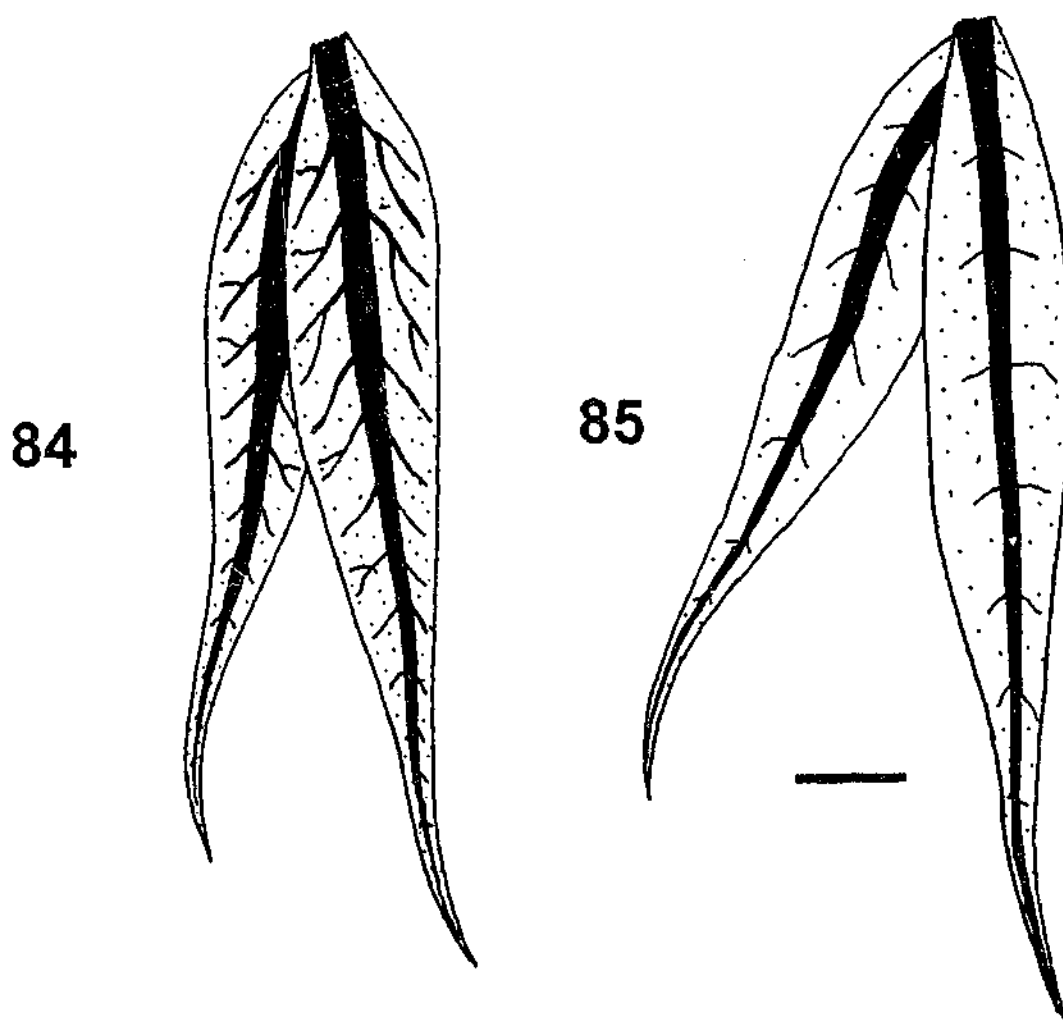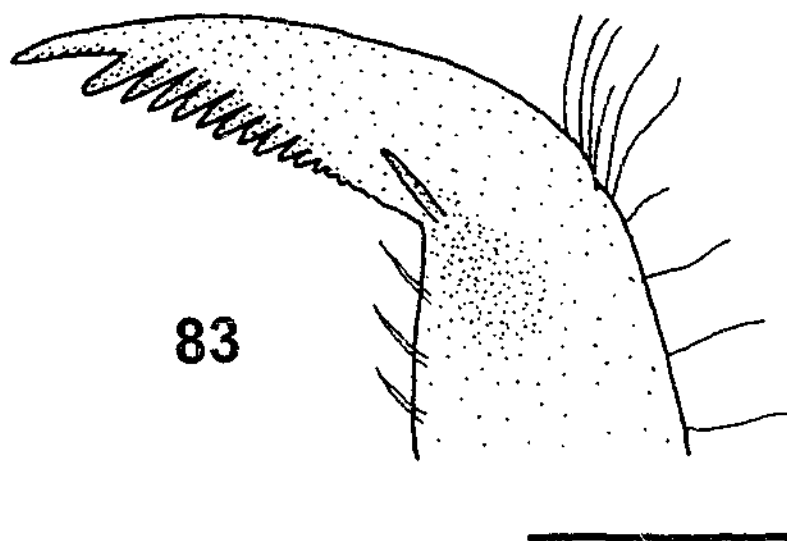
Figs. 83-85. *Nousia (Australonousia) fusca,* nymph.
Scale bars = 100μm.

Fig. 83. Foreleg tarsal claw.
Fig. 84. Gills, lateral tracheae strongly developed.
Fig. 85. Gills, lateral tracheae weakly developed.

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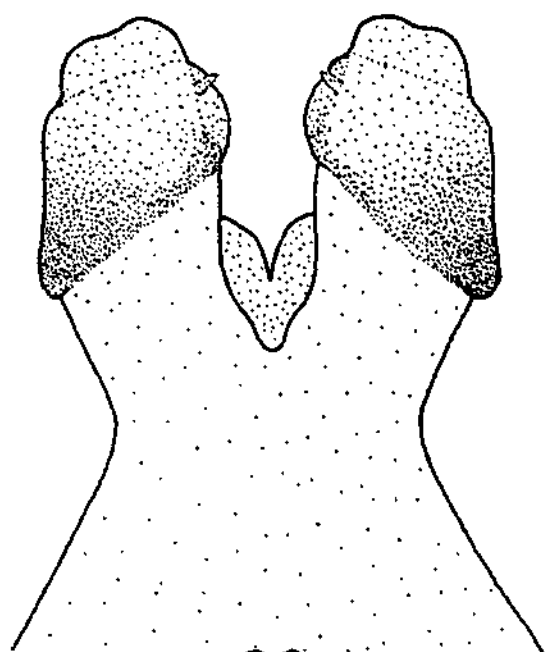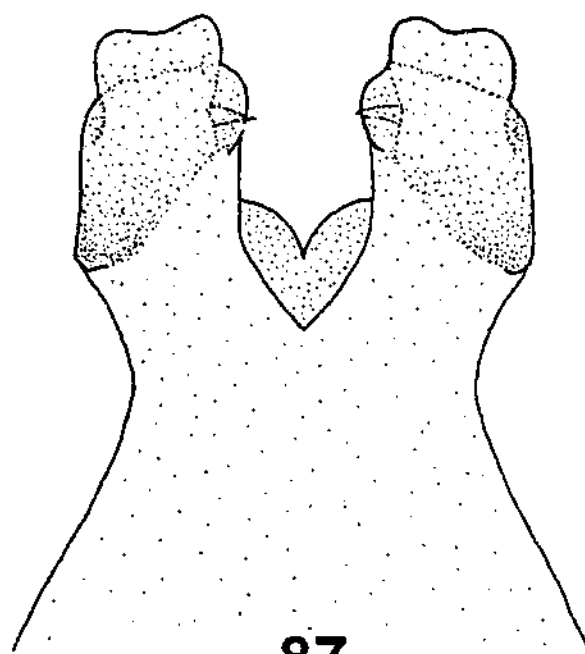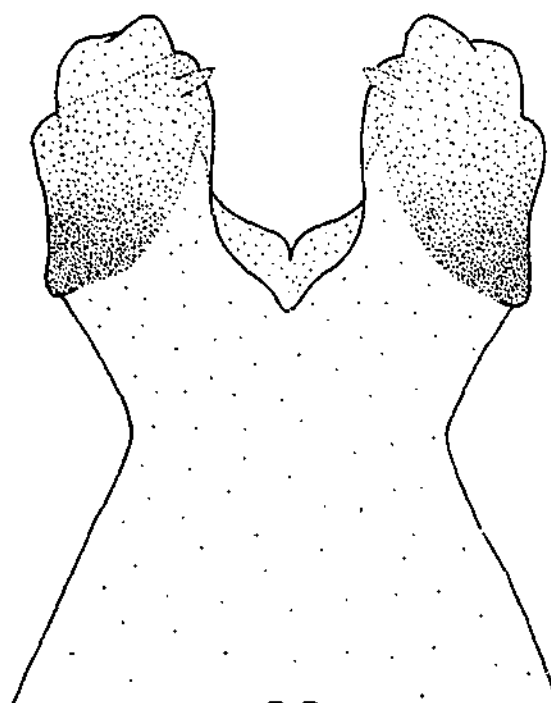
Fig. 86. *Atalophlebia fusca* Ulmer.
Ventral view of male imago genitalia. Drawn from temporary slide mount of paralectotype. Specimen collected from Cedar Creek, Queensland, Mjöberg Expedition to Australia, 1910-1913 (SMNH).

Fig. 87. *Atalonella delicatula* (Tillyard).
Ventral view of male imago genitalia. Drawn from slide mount. Specimen collected from Meander River, Tasmania by David Scholes, 09 i 1960 (ANIC).

Fig. 88. *Atalophlebia brunnea* (Tillyard).
Ventral view of male imago genitalia. Drawn from temporary slide mount of holotype. Specimen collected from Clarendon, Tasmania by Eric Scott, 09 iii 1933 (NHM).

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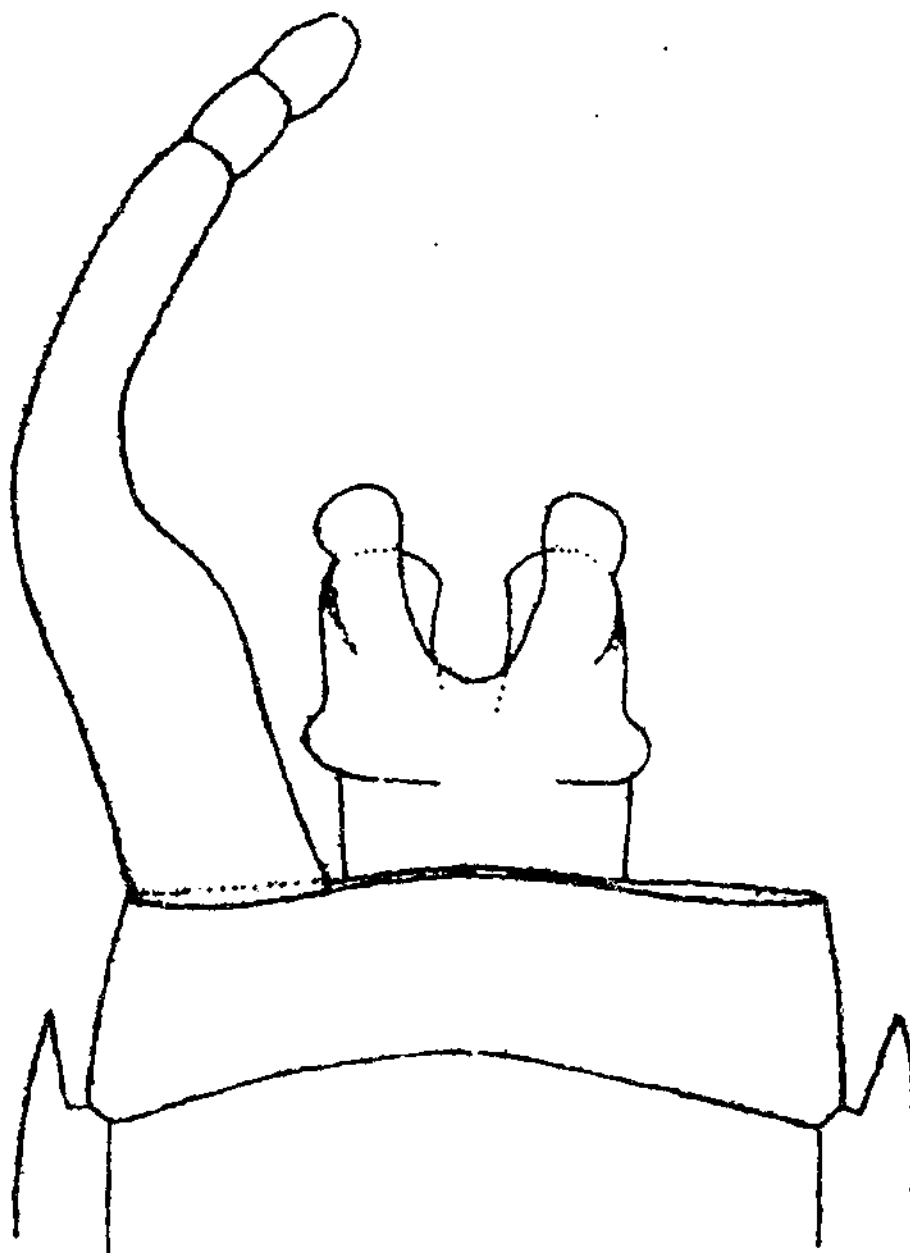
Fig. 89. *Atalophlebia fusca* Ulmer.

Ventral view of male genitalia.
Reproduction of a drawing from Ulmer (1919).
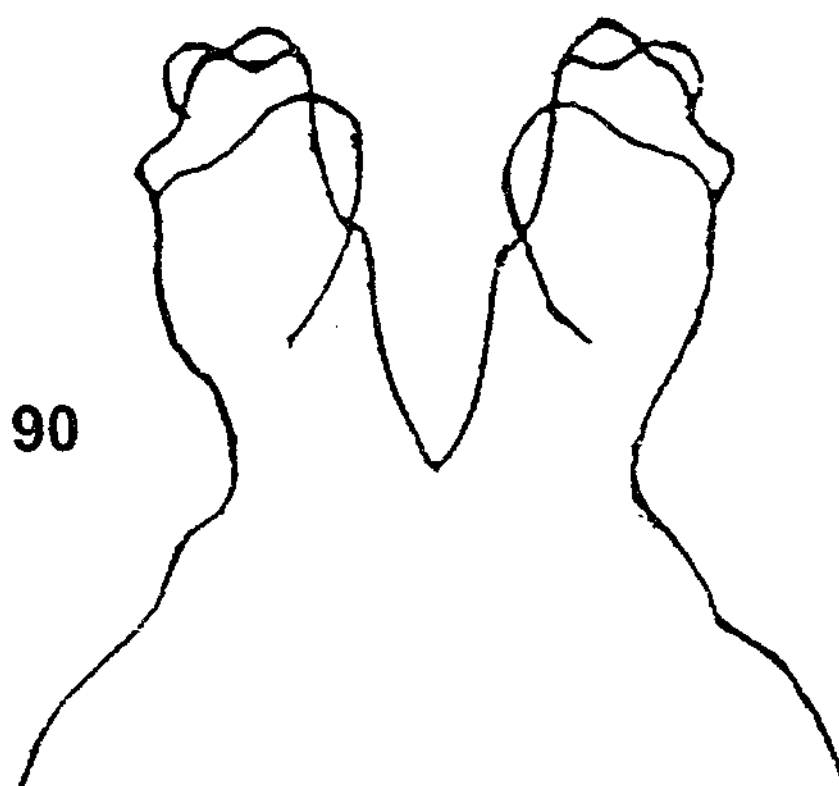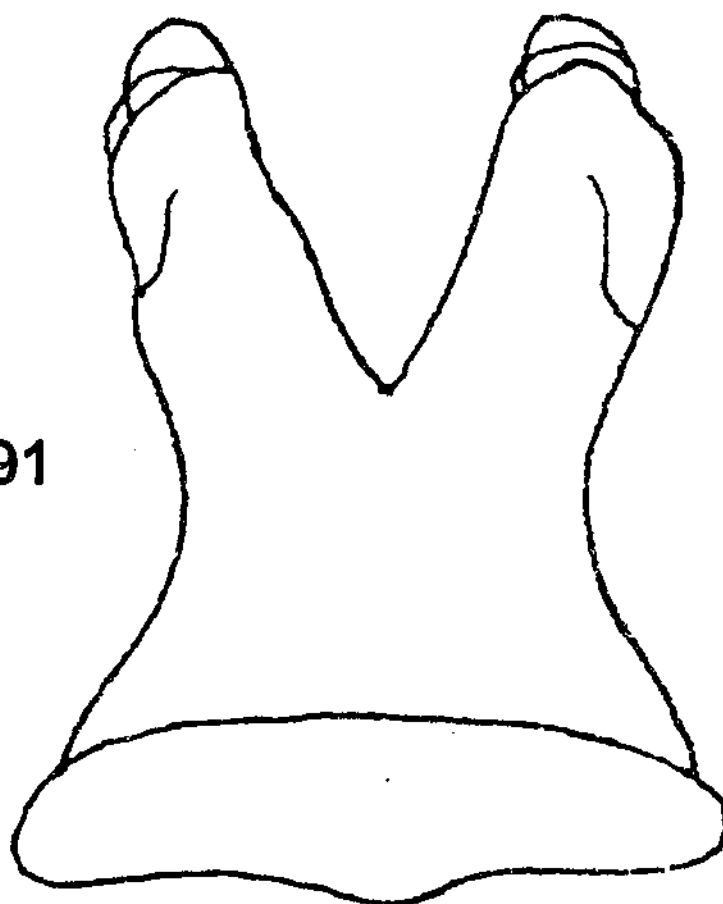
Fig. 90. *Atalophlebia delicatula* Tillyard.
Dorsal view of male imago genitalia.
Reproduction of a drawing from Tillyard (1936).

Fig. 91. *Atalophlebia brunnea* Tillyard.
Ventral view (?) of male imago genitalia.
Reproduction of a drawing from Tillyard (1936).
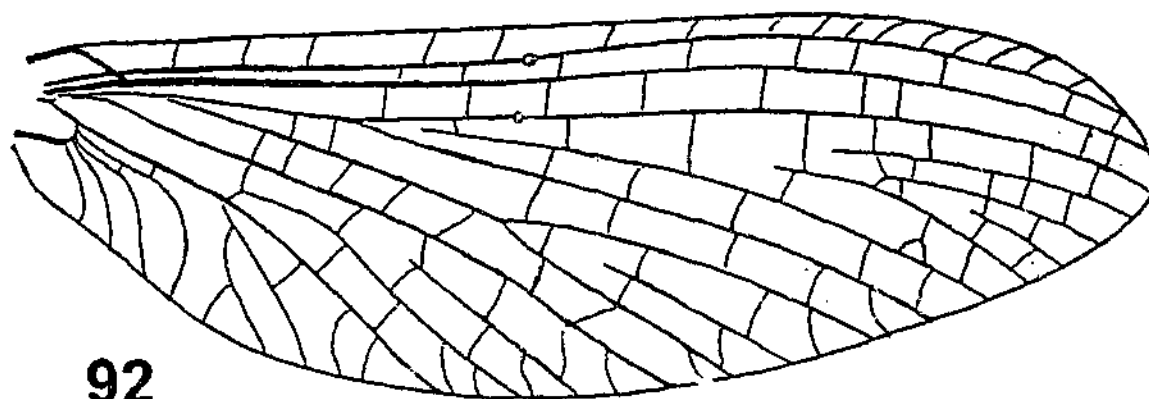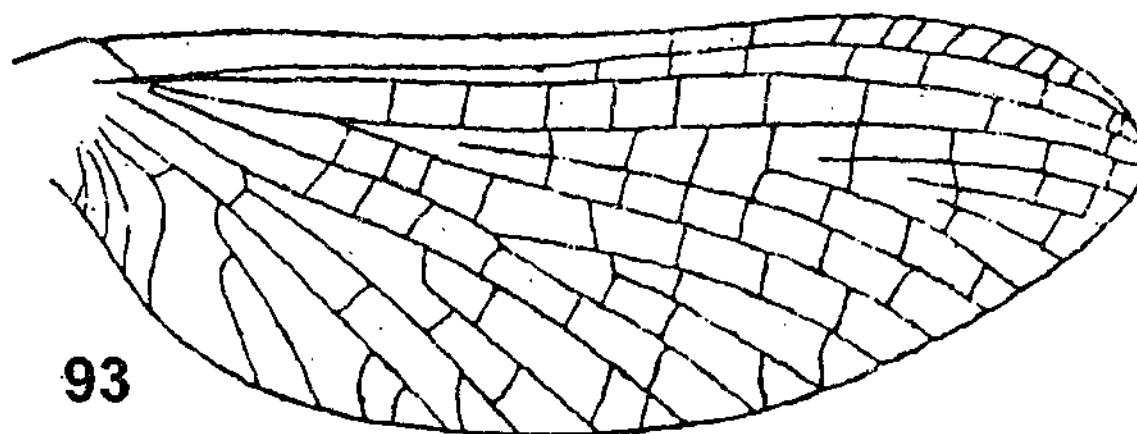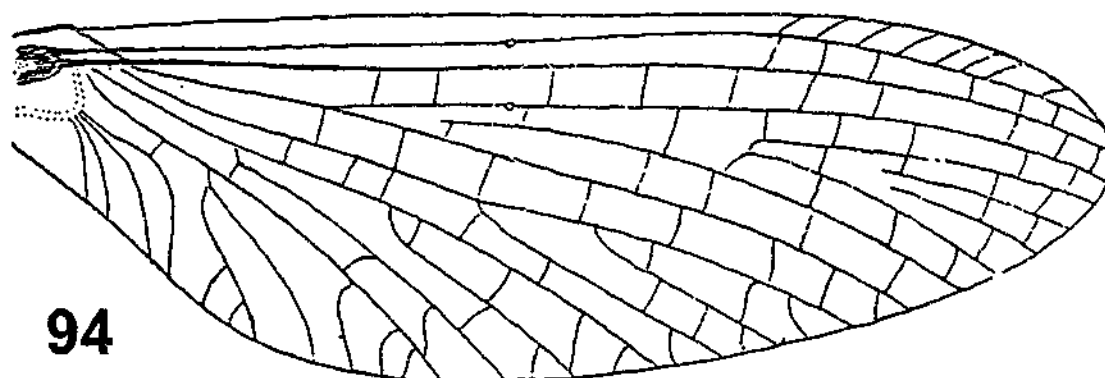
Fig. 92. *Atalophlebia delicatula* Tillyard.
Male imago forewing.
Reproduction of a drawing from Tillyard (1936).

Fig. 93. *Atalophlebia fusca* Ulmer (labelled as *Thraulus dentatus*).
Male imago forewing.
Reproduction of a drawing from Ulmer (1916).

Fig. 94. *Atalophlebia brunnea* Tillyard.
Male imago forewing.
Reproduction of a drawing from Tillyard (1936).

Figs. 95-96. *Nousia (Australonousia) fusca* habitat – OTWAYS.

Fig. 95. Grey River, Otway Ranges, Victoria (97030101).
Fig. 96. Carisbrook Creek, Great Ocean Road, Victoria (97030203).
Photos by K.J. Finlay.

Figs. 97-98. *Nousia (Australonousia) fusca* habitat - GRAMPIANS.

Fig. 97. Gulf Stream, Grampians National Park, Victoria (99011603).
Fig. 98. Fyans Creek, Halls Gap, Victoria (99011608).
Photos by N. Ainsworth.

Figs. 99-100. *Nousia (Australonousia) fusca* habitat - TASMANIA.

Fig. 97. Lake River, 20km S of Perth, Tasmania (96121702).
Fig. 98. Dee River, 10km NW of Ouse, Tasmania (96121903).
Photos by J. Griggs.

Figs. 101-102. *Nousia (Australonousia) fusca* habitat - HIGH ALTITUDE.

Fig. 101. Thredbo River, Thredbo, New South Wales (97120204).
Fig. 102. Eucumbene River, Kosciusko National Park, New South Wales (97120104).
Photos by K.J. Finlay.

Figs. 103-104. *Nousia (Australonousia) fusca* habitat -"THE REST" OF VICTORIA.

Fig. 103. Rubicon River, Rubicon, Victoria (98101701).
Photo by N. Ainsworth.
Fig. 104. Clematis Creek, Dandenong Ranges, Victoria (97032401).
Photo by K.J. Finlay.

Figs. 105-106. *Nousia (Australonousia) fusca* habitat - "THE REST" OF VICTORIA.

Fig. 105. Moroka River, Alpine National Park, Victoria (97020603).
Fig. 106. Jingalgalla River, Dellicknora, Victoria (99021402).
Photos by K.J. Finlay.
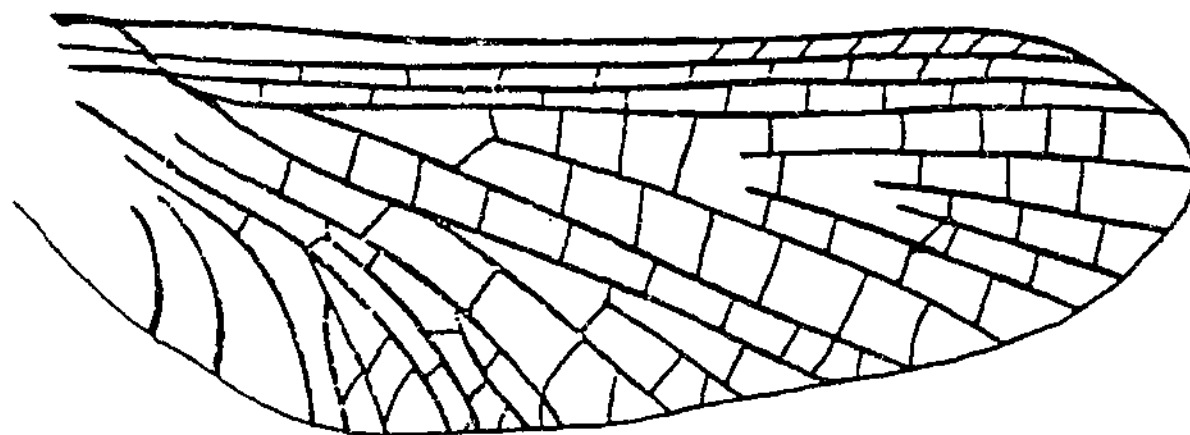
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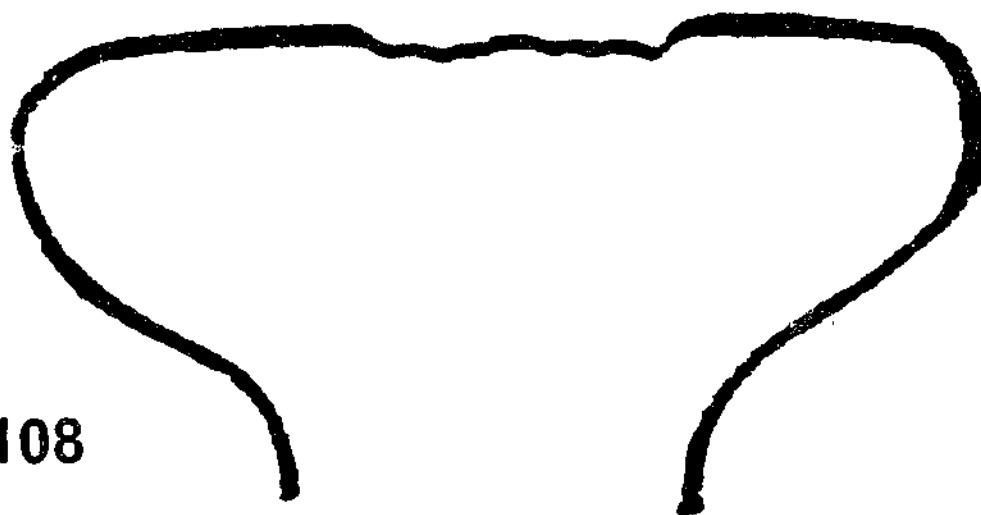
108

Fig. 107. *Atalonella darkara* Harker.
Female subimago forewing.
Reproduction of a drawing from Harker (1957b).

Fig. 108. *Atalonella darkara* Harker.
Nymph labrum.
Reproduction of a drawing from Harker (1957b).
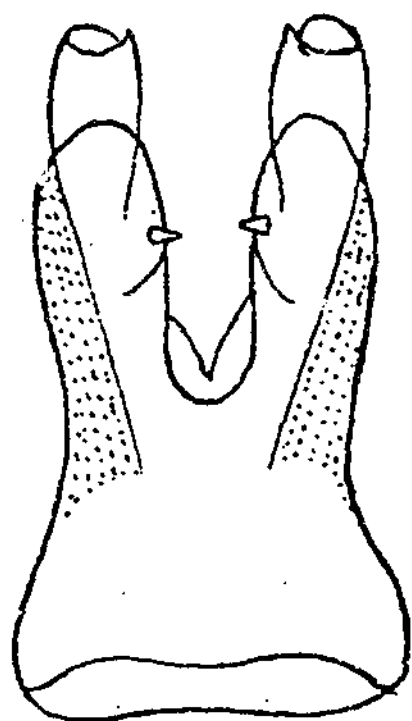
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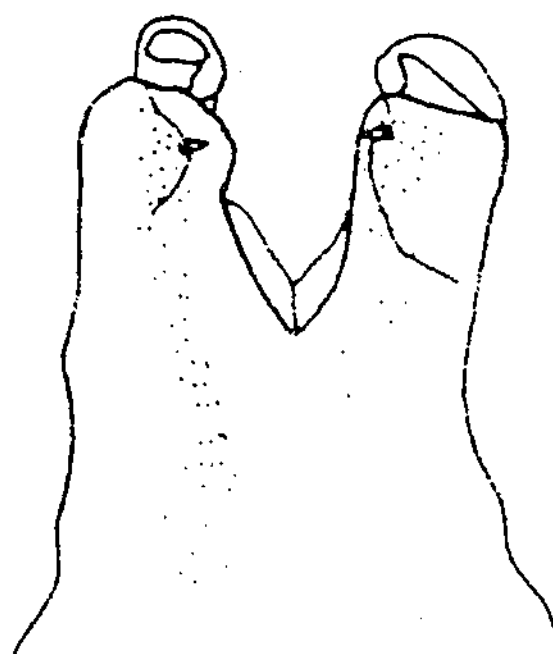
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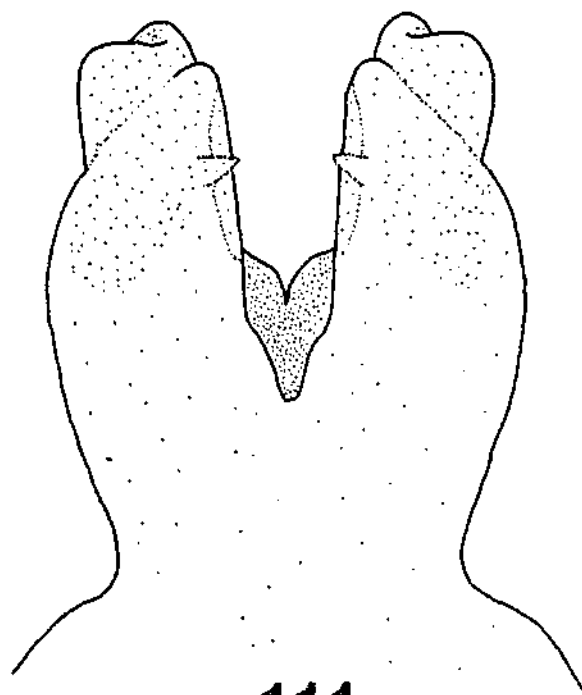
111

Fig. 109. *Atalophlebia fuscula* Tillyard.
Dorsal view of male genitalia.
Reproduction of a drawing from Tillyard (1936).

Fig. 110. *Nousia fuscula* (Tillyard).
Dorsal view of male genitalia.
Reproduction of a drawing from Suter (1986).

Fig. 111. *Atalonella fuscula* (Tillyard).
Dorsal view of male genitalia. Drawn from temporary slide mount. Specimen
collected from North Esk River, Tasmania by David Scholes, 18 ii 1960 (ANIC).

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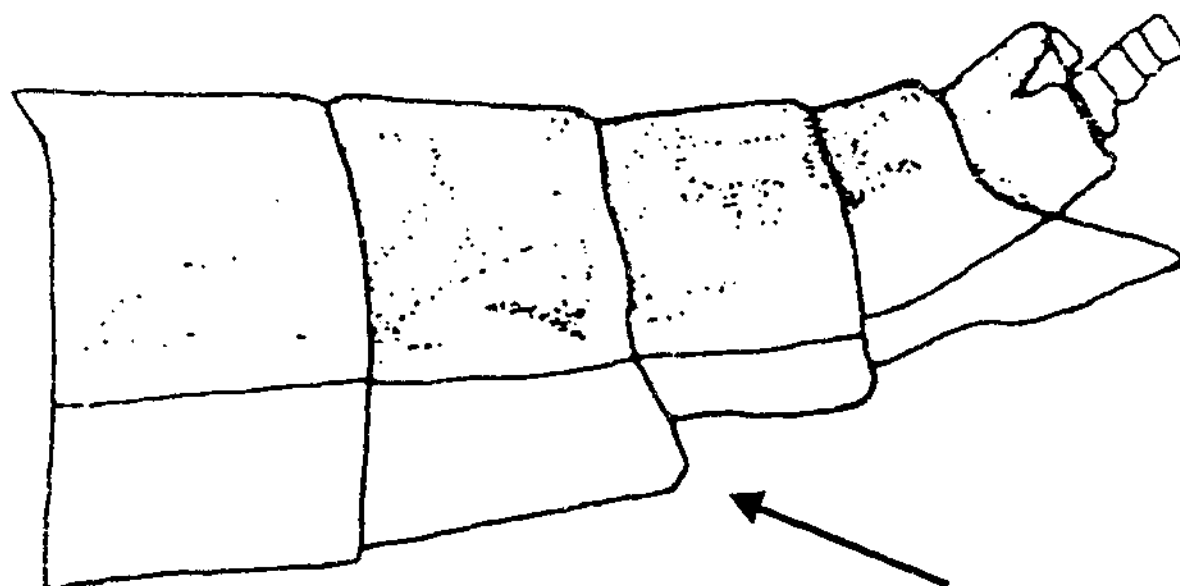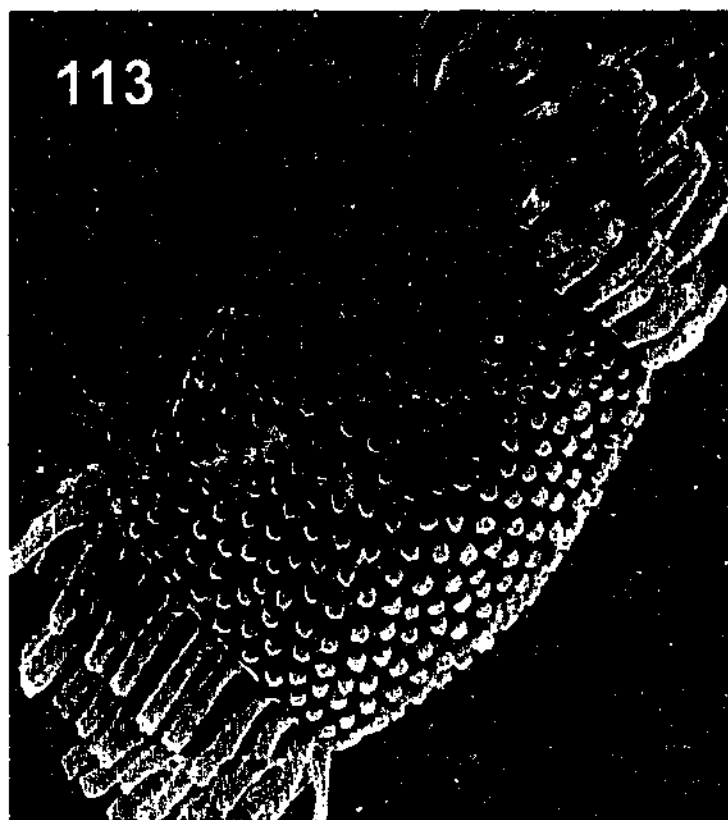
Fig. 112. *Nousia fuscula* (Tillyard).
Lateral view of female imago segments six to nine. Arrow indicates
location of small genital extension at sternum seven.
Reproduction of a drawing from Suter (1986).

Fig. 113. *Nousia fuscula* (Tillyard).
Egg from female imago.
Reproduction of an SEM from Suter (1986).
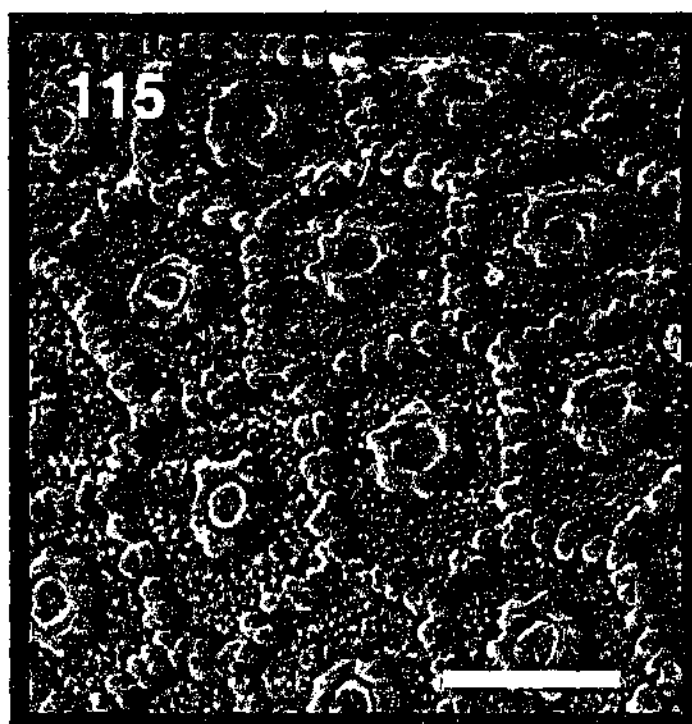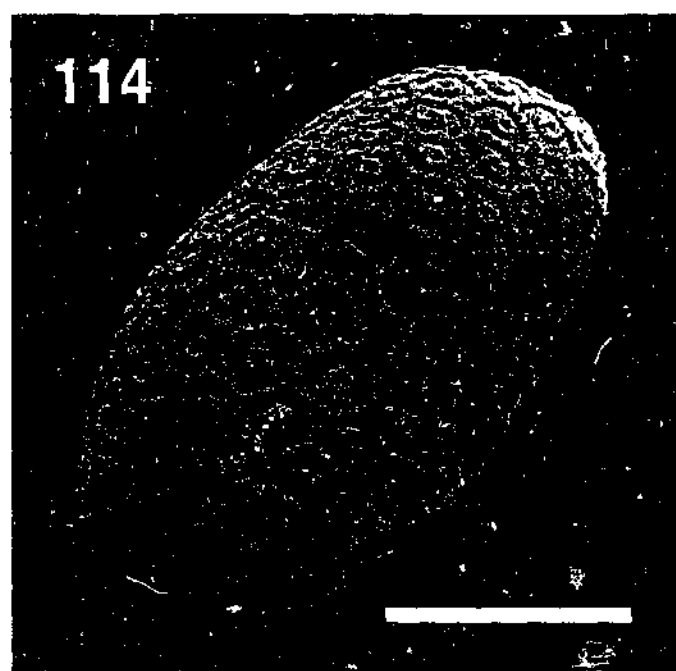
Figs. 114-115: *Nousia (Australonousia) fuscula*, eggs taken from female imago.

Individual from Tookayerta Creek, South Australia (95051200).

Fig. 114. Whole egg. Scale bar = 50μm.
Fig. 115. Close up of egg chorion. Scale bar = 10μm.

Fig. 116. *Nousia (Australonousia) nigeli.*
Type locality, Taggerty River, outside Marysville, Victoria (98101704).
Photo by K.J. Finlay.
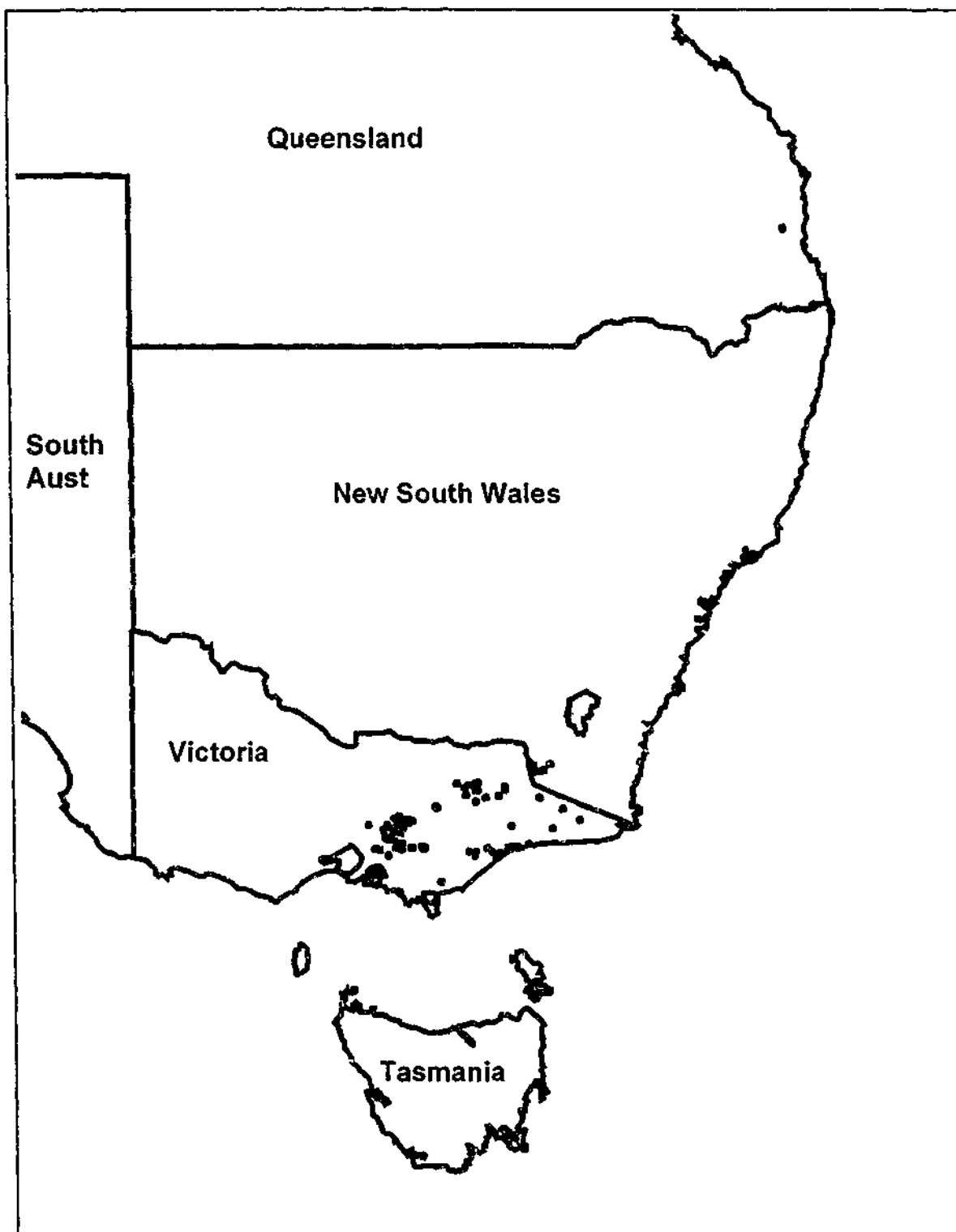
Fig. 117. Distribution of *Nousia (Australonousia) nigeli.*

118
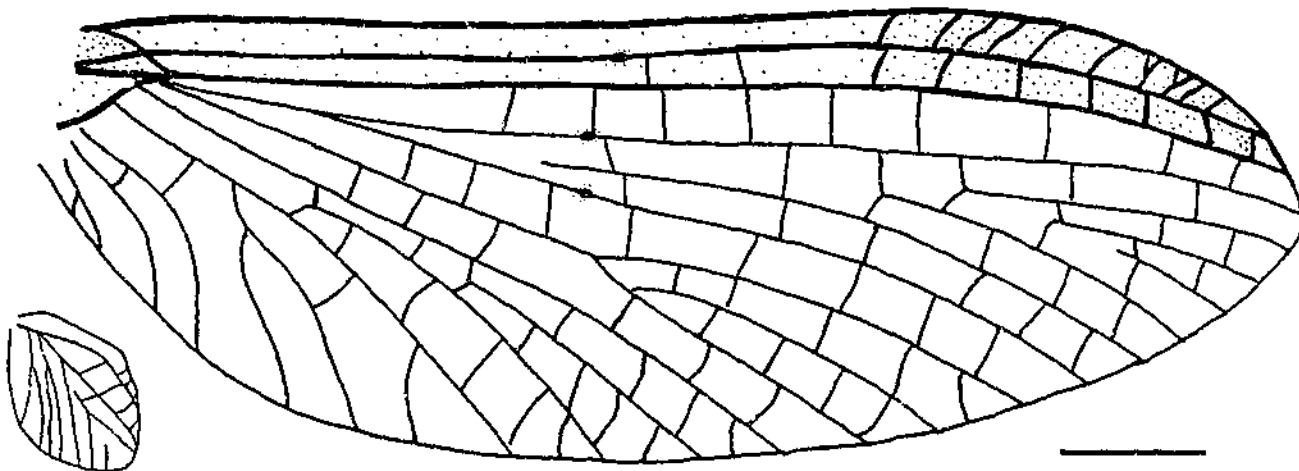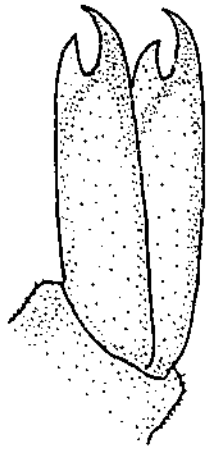
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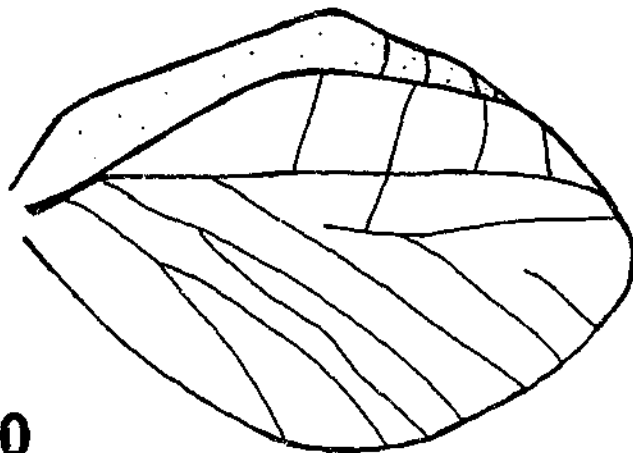
120

Figs. 118-120. *Nousia (Australonousia) nigeli*, male imago.

Fig. 118. Foreleg tarsal claw. Scale bar = 50μm.
Fig. 119. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 120. Hindwing. Scale bar = 500μm.

121
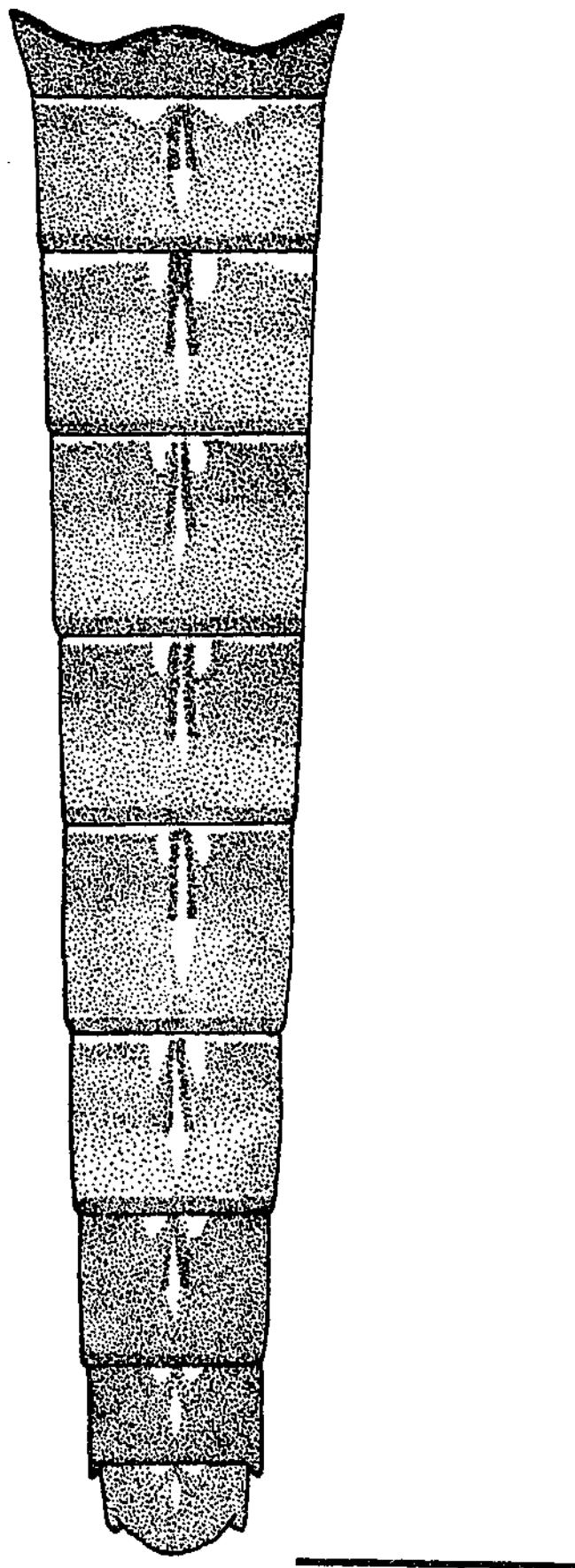
Fig. 121. *Nousia (Australonousia) nigeli,* male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

122
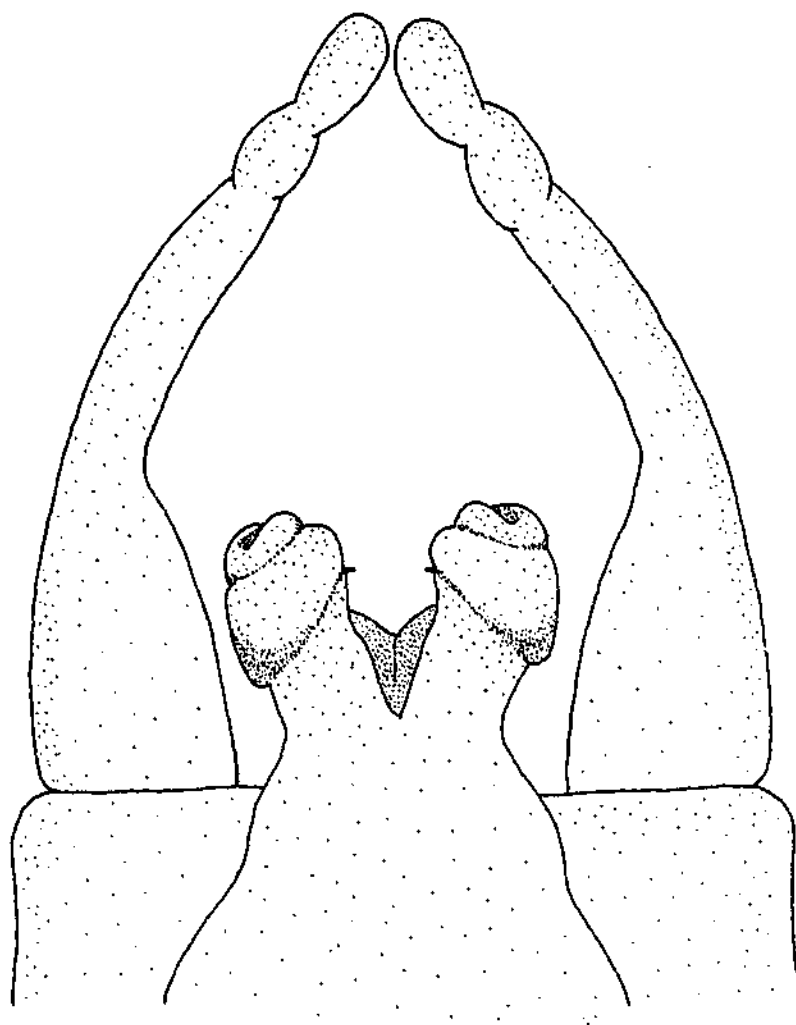
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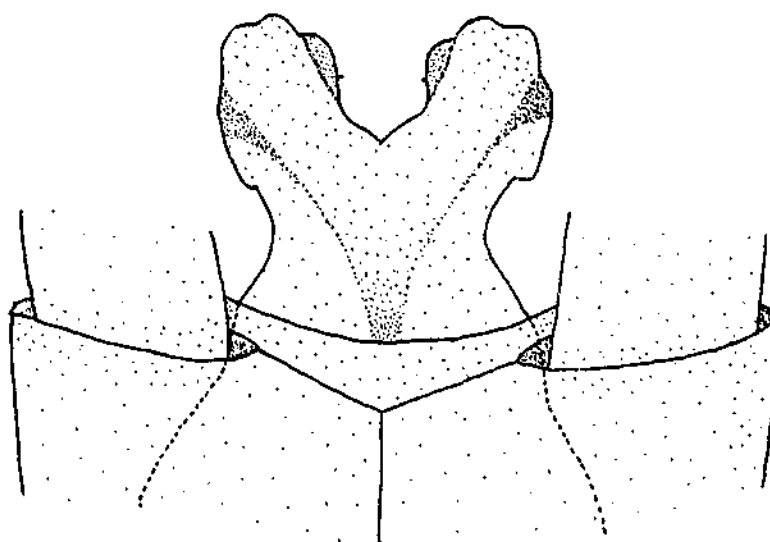
Figs. 122-123. *Nousia (Australonousia) nigeli*, male imago.
Scale bar = 200μm.

Fig. 122. Dorsal view of genitalia showing penes and forceps.
Fig. 123. Ventral view of genitalia showing penes.
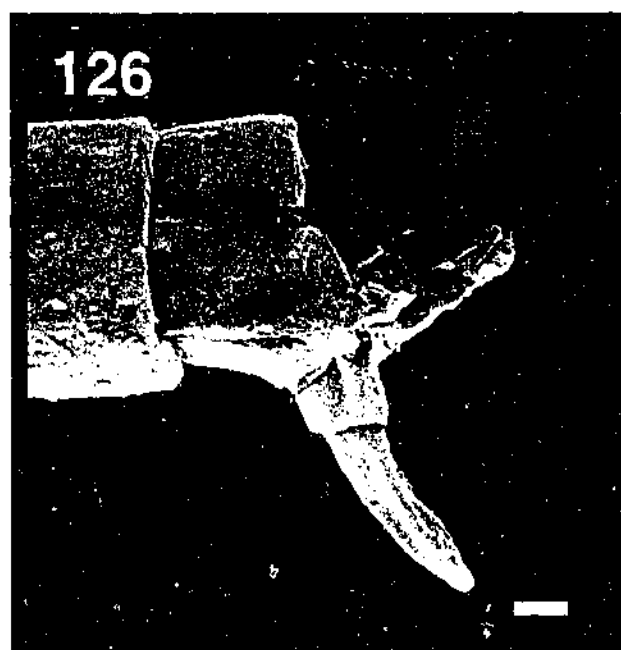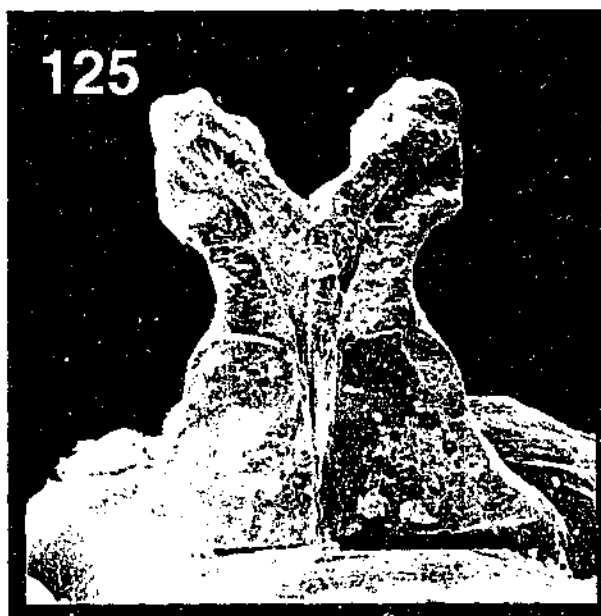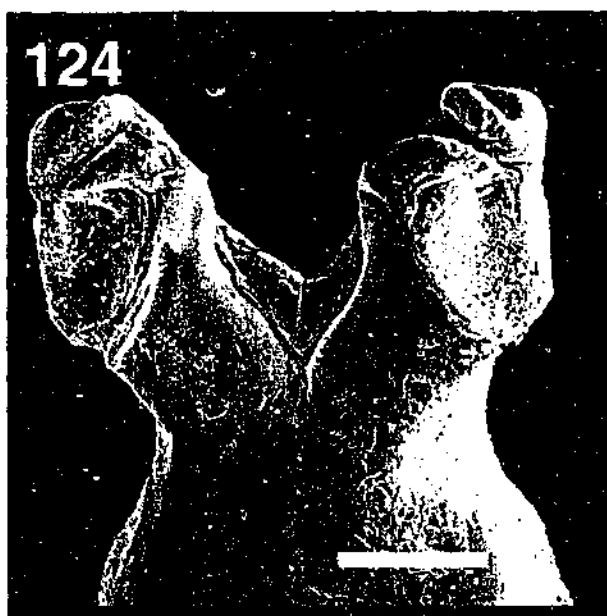
Figs. 124-126. *Nousia (Australonousia) nigeli,* male imago.

Individual from Loch River, Noojee, Victoria (98020903).

Fig. 124. Dorsal view of penes. Scale bar = 50μm.
Fig. 125. Ventral view of penes. Scale bar = 100μm.
Fig. 126. Lateral view of genitalia showing penes and forceps, tergite ten
removed. Scale bar = 100μm.
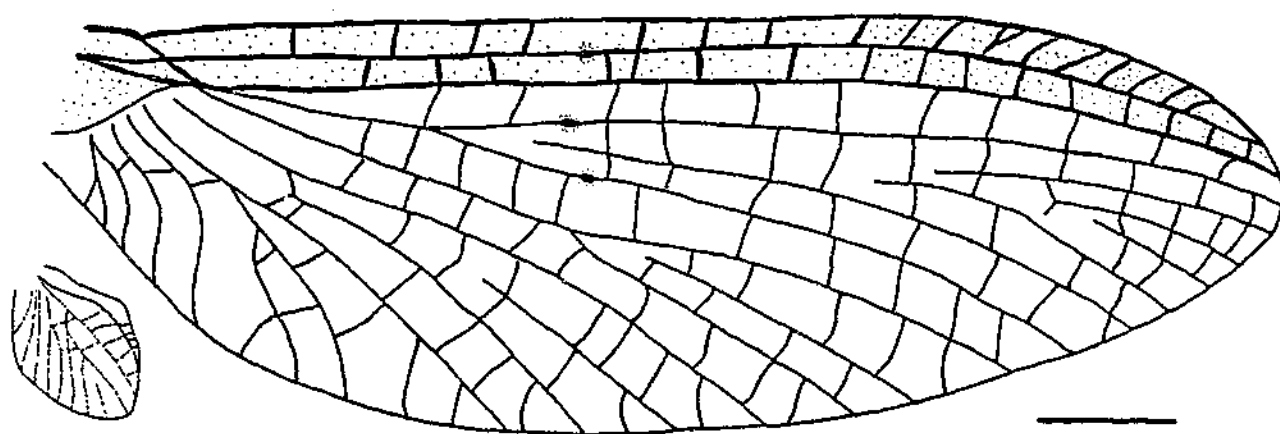
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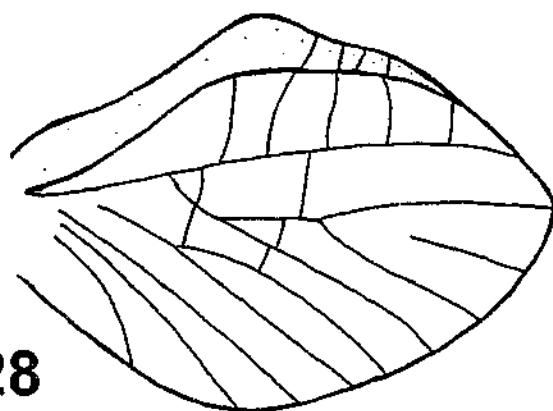
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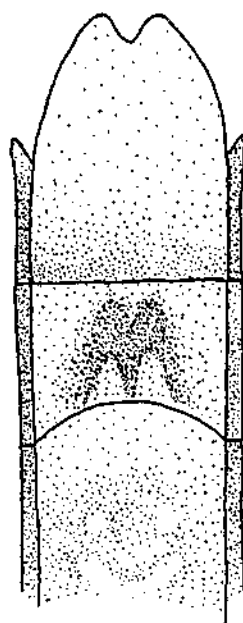
129

Figs. 127-129. *Nousia (Australonousia) nigeli*, female imago.

Fig. 127. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 128. Hindwing. Scale bar = 500µm.
Fig. 129. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.
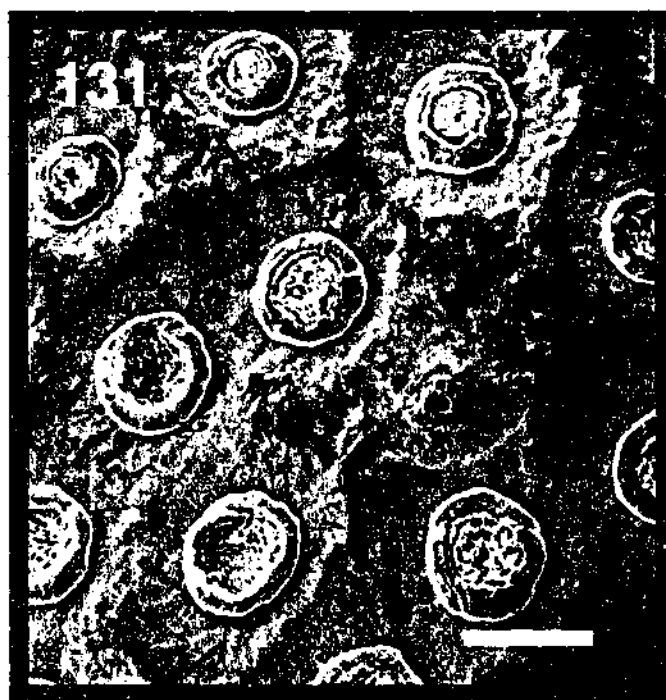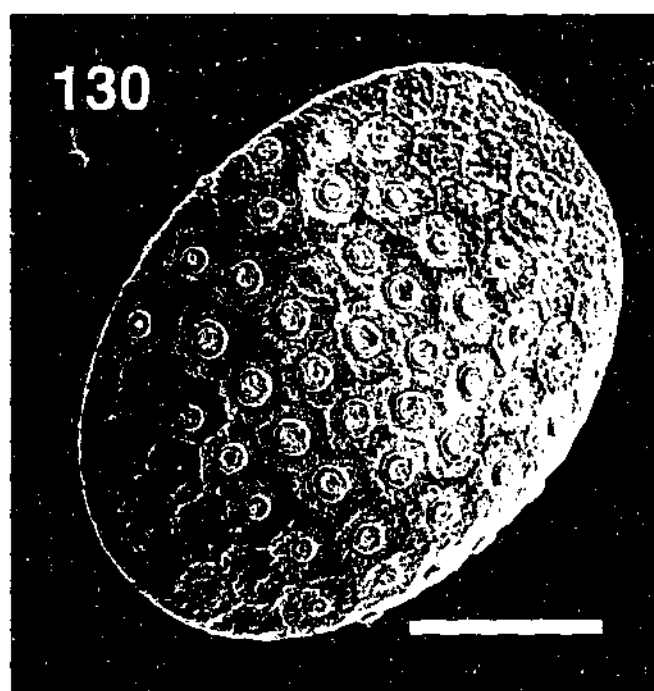
Figs. 130-131. *Nousia (Australonousia) nigeli*, eggs taken from female imago.

Individual from Coranderrk Creek, outside Healesville, Victoria (98030502).

Fig. 130. Whole egg. Scale bar = 50μm.
Fig. 131. Close up of egg chorion. Scale bar = 10μm.
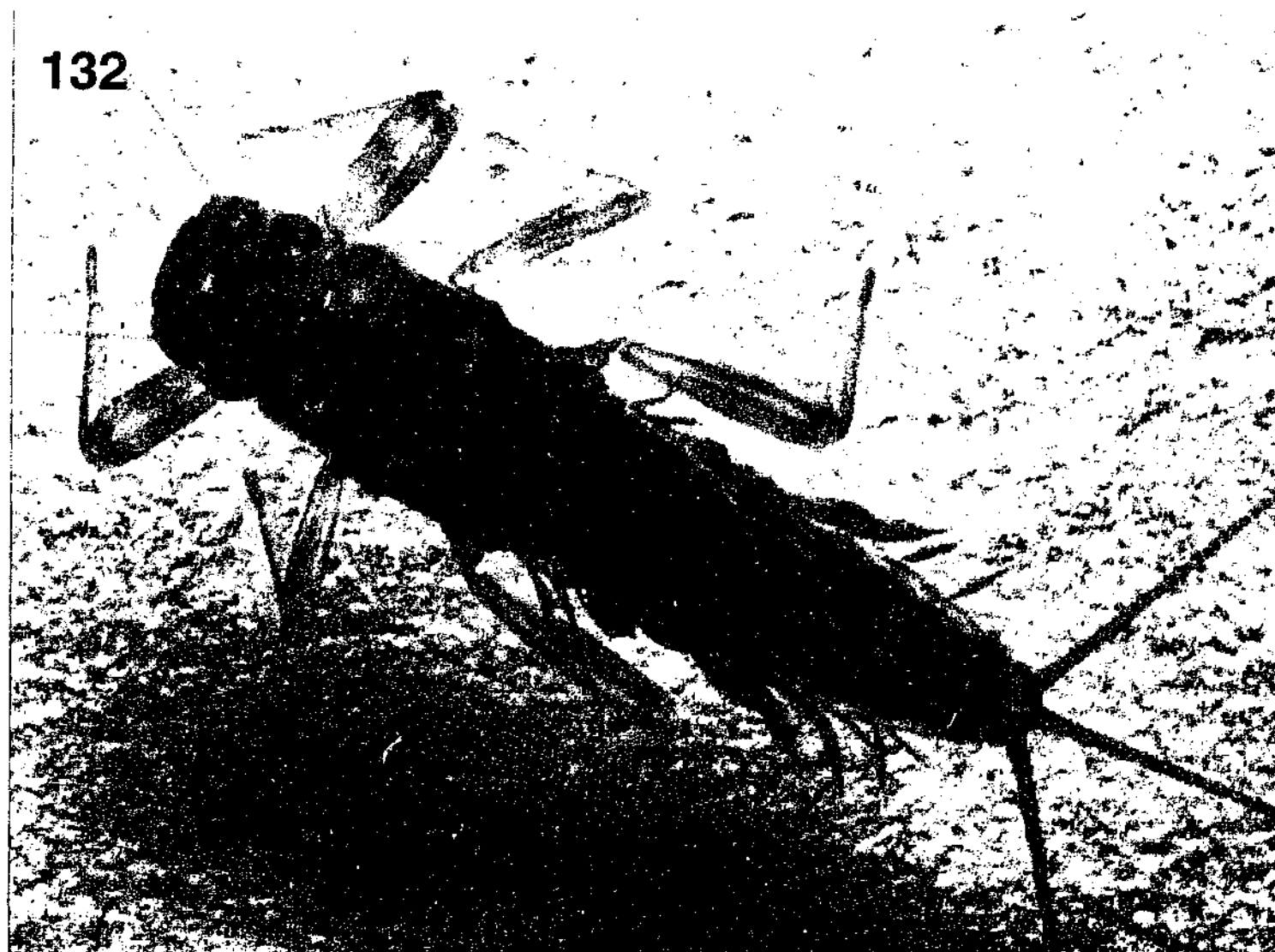
Fig. 132. Female nymph of *Nousia (Australonousia) nigeli*.
Collected from Steavensons River, 12km SE of Buxton, Victoria (98021504).
Photo by K.J. Finlay.
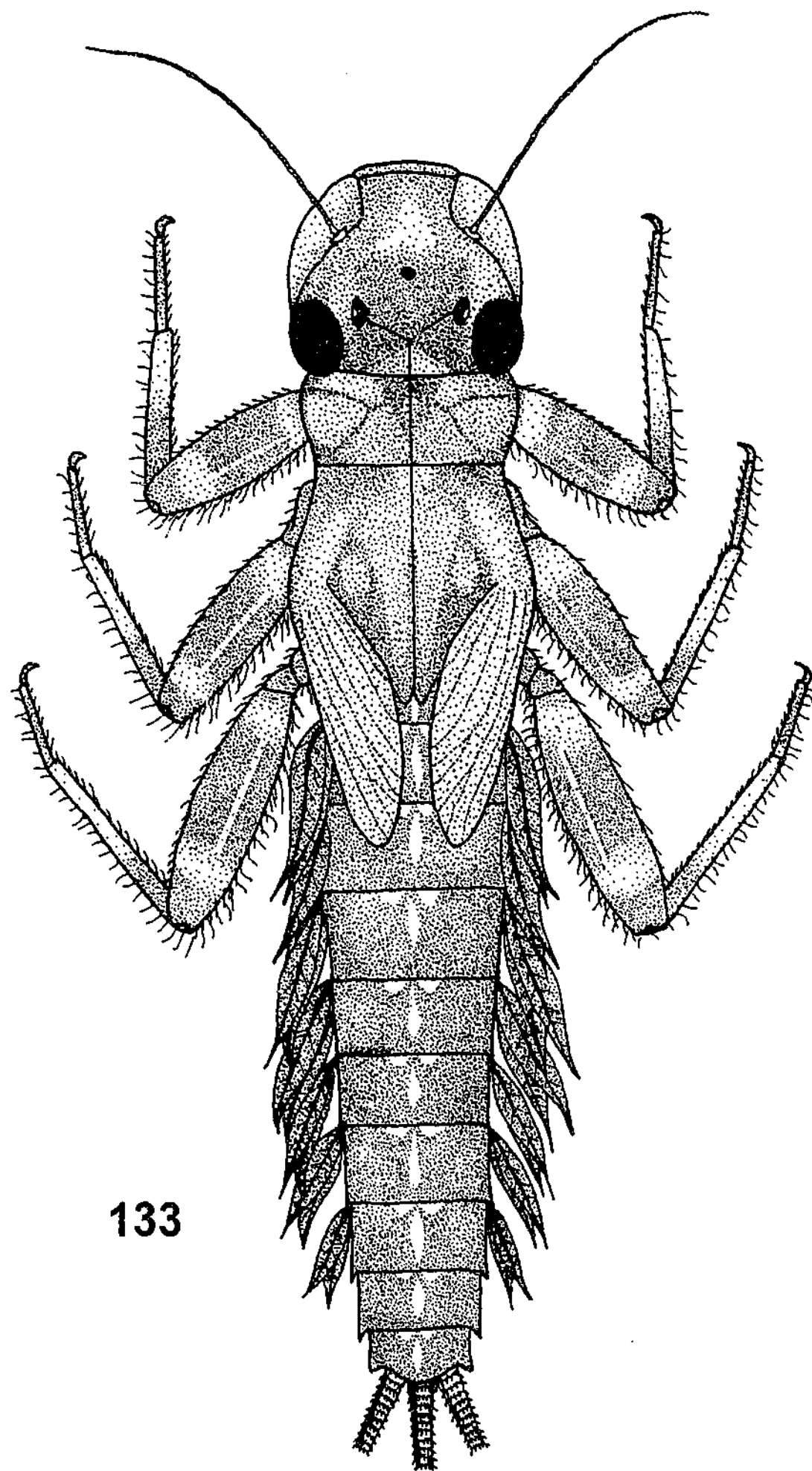
133

Fig. 133. *Nousia (Australonousia) nigeli*, female nymph.
Scale bar = 1mm.
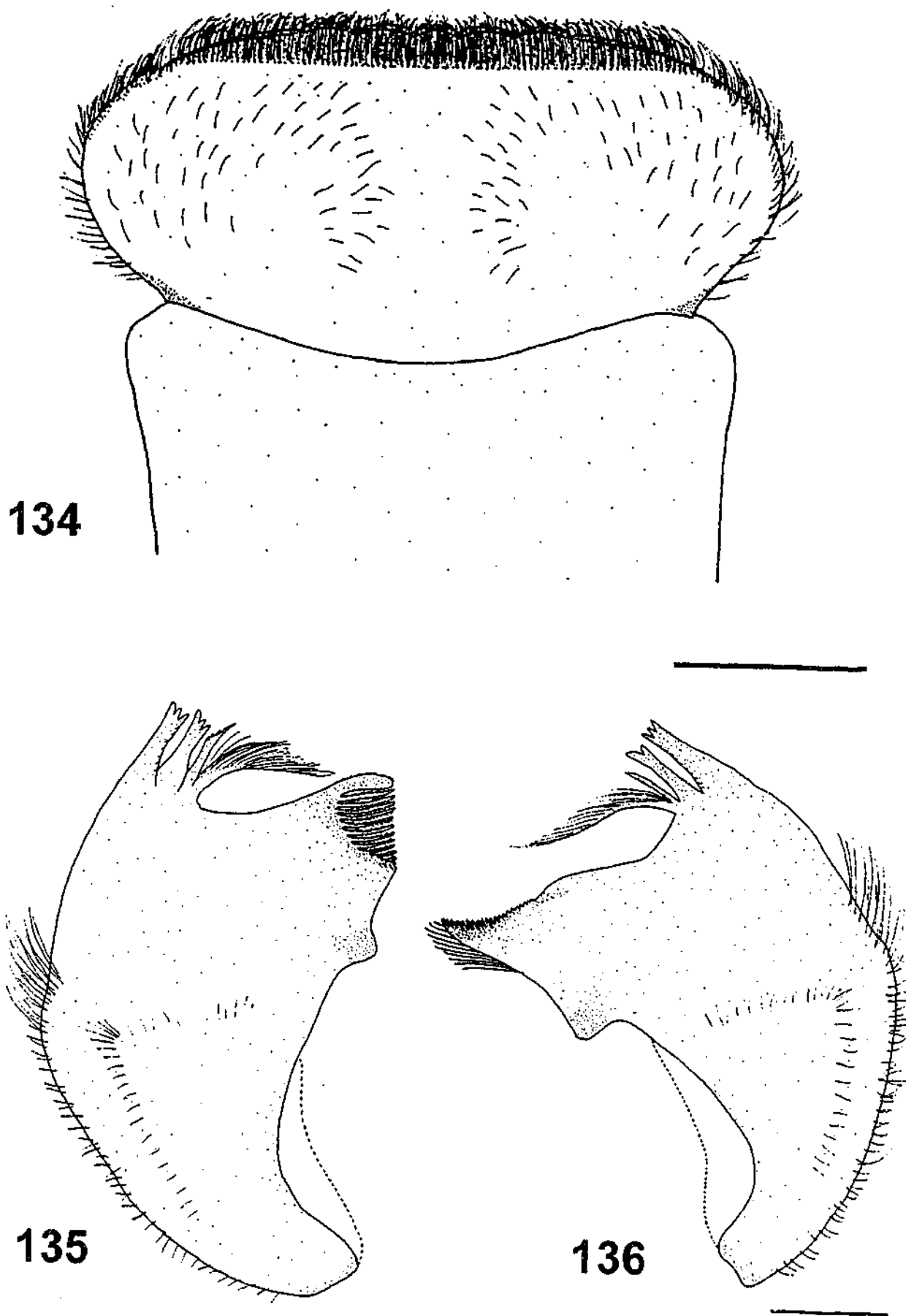
Figs. 134-136. *Nousia (Australonousia) nigeli,* nymph mouthparts.
Scale bars = 200µm.

Fig. 134. Labrum and clypeus.
Fig. 135. Left mandible.
Fig. 136. Right mandible.
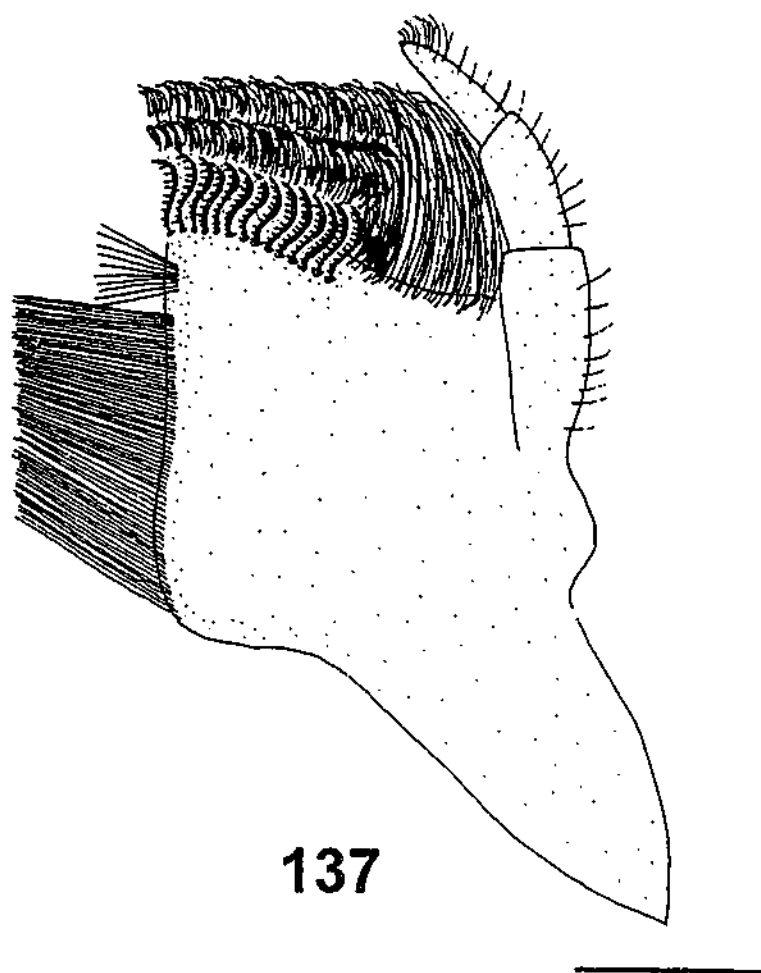
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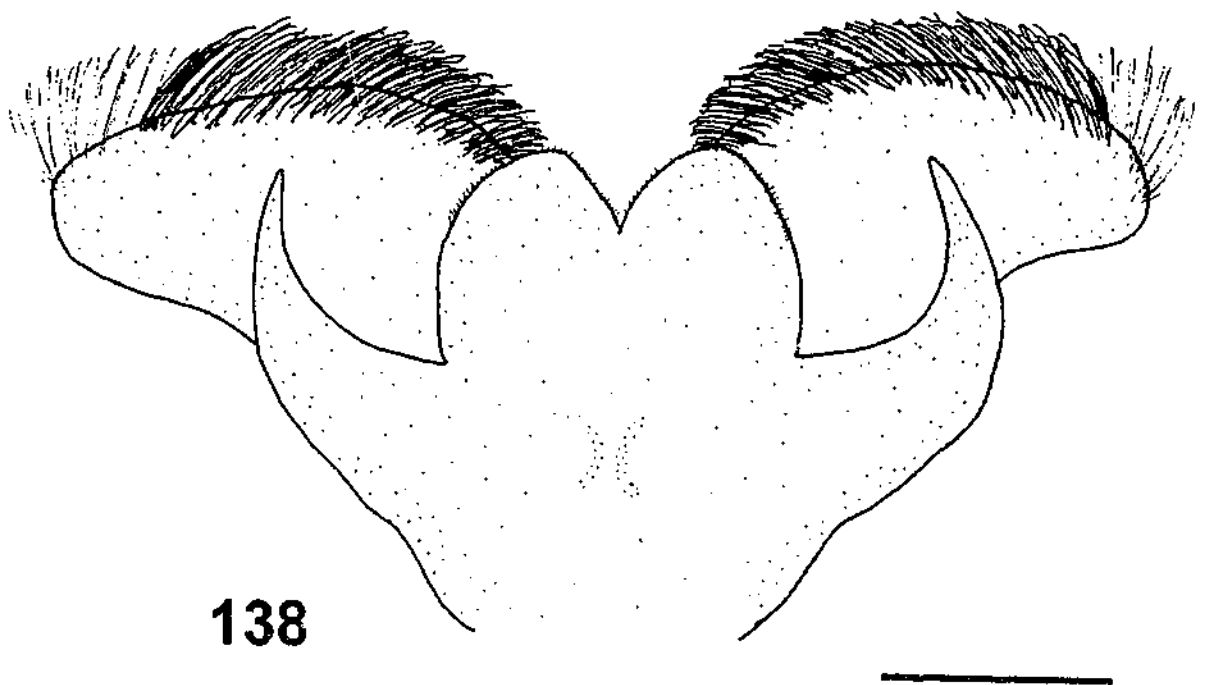
138

Figs. 137-138. *Nousia (Australonousia) nigeli*, nymph mouthparts.
Scale bars = 200μm.

Fig. 137. Right maxilla.
Fig. 138. Hypopharynx.
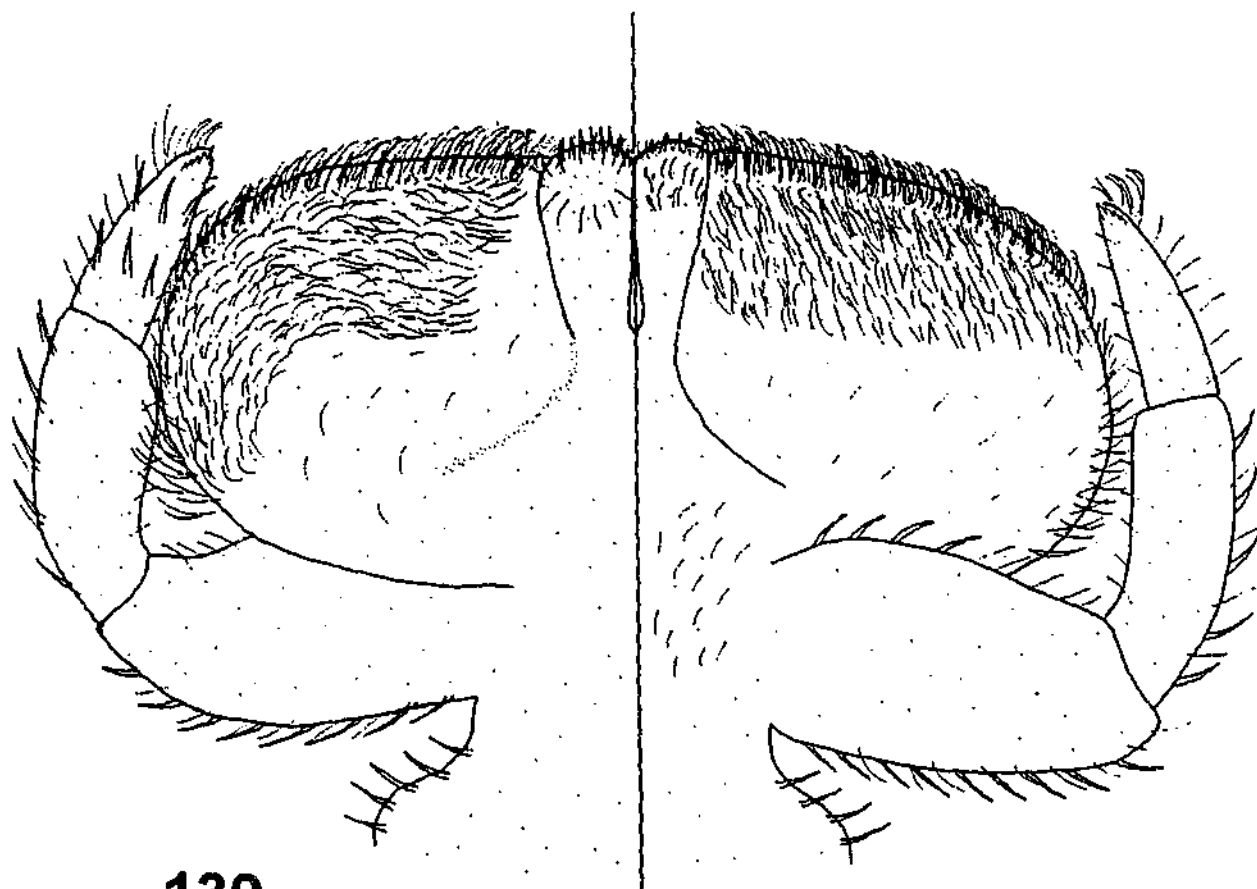
139

Fig. 139. *Nousia (Australonousia) nigeli*, nymph mouthpart.

Labium. Scale bar = 200µm.
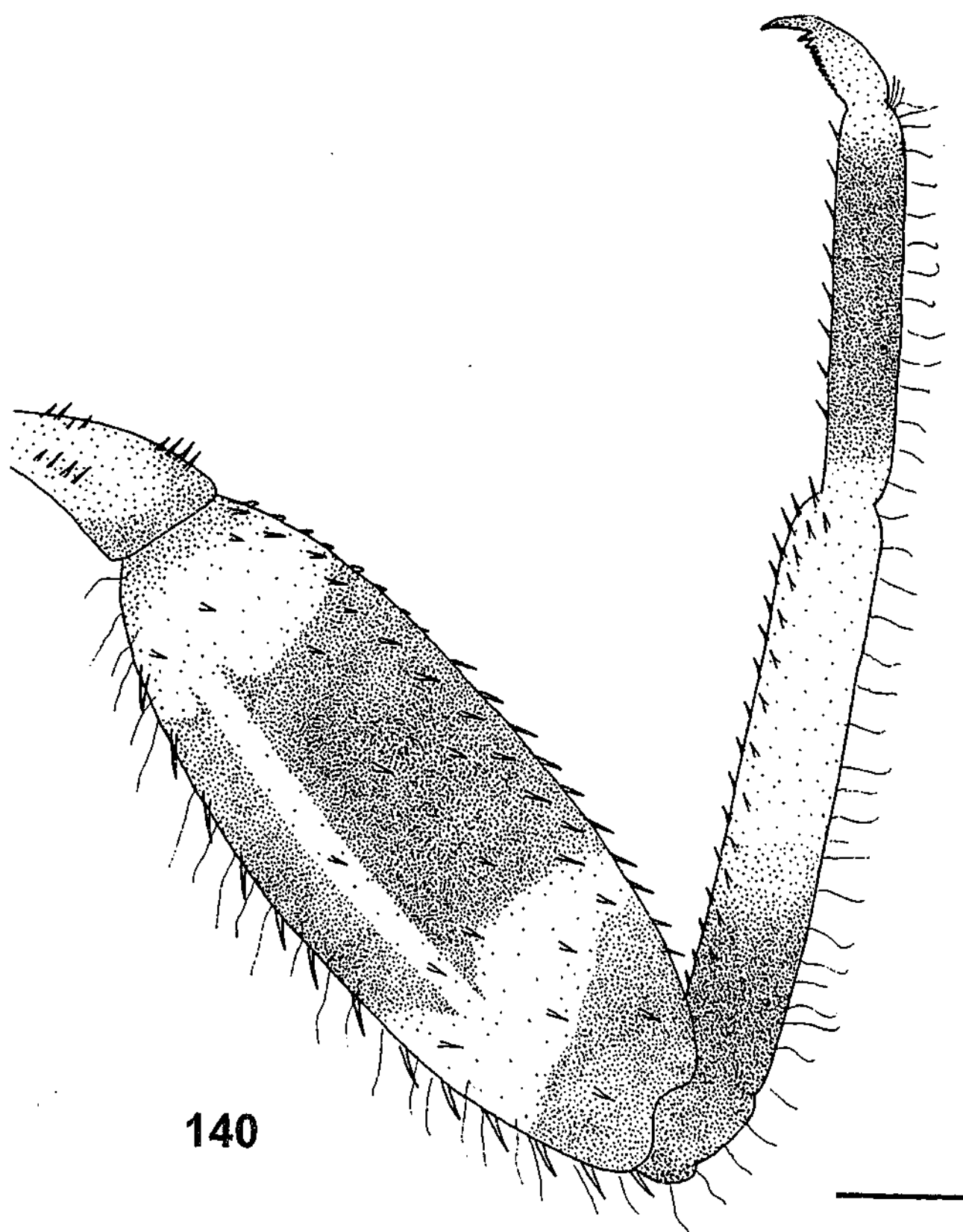
140

Fig. 140. *Nousia (Australonousia) nigeli*, nymph.

Foreleg. Scale bar = 200µm.
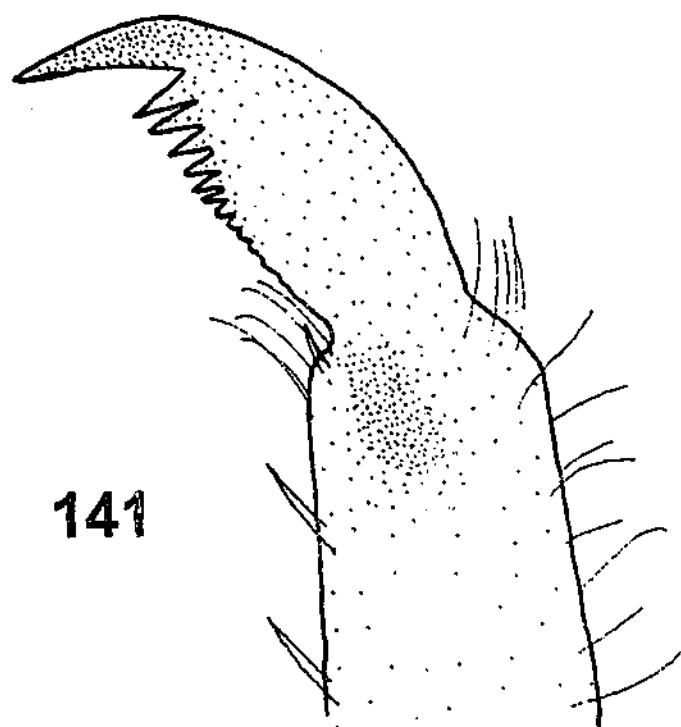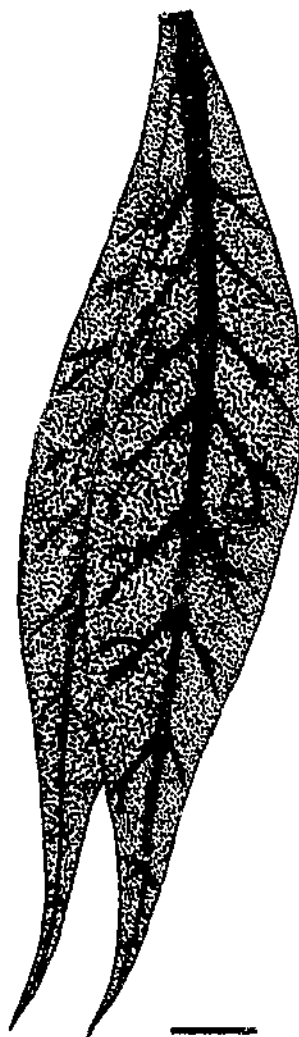
Figs. 141-142. *Nousia (Australonousia) nigeli*, nymph.
Scale bars = 100µm.

Fig. 141. Foreleg tarsal claw.
Fig. 142. Gills.

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Tasmania
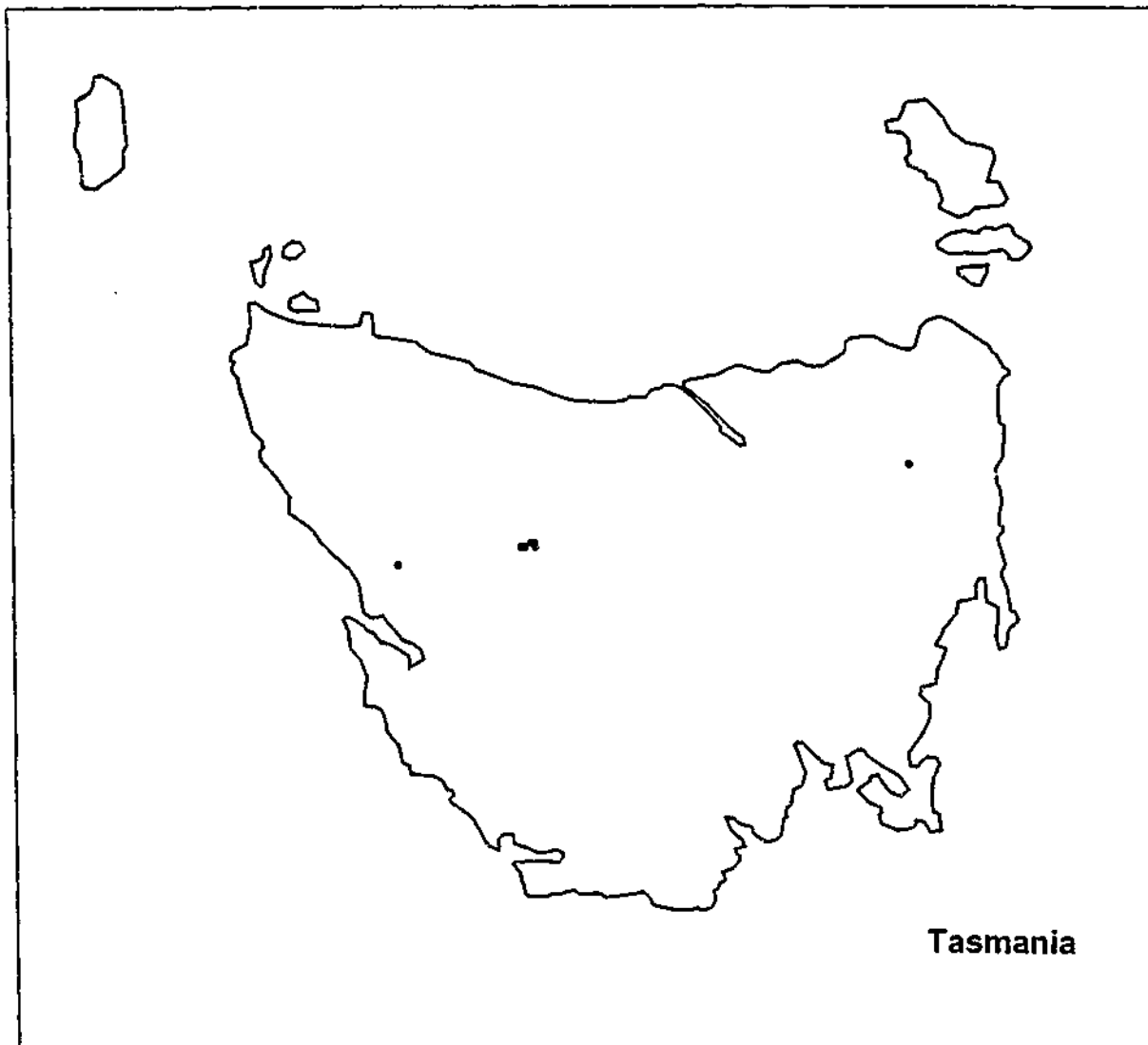
Fig. 143. Distribution of *Nousia (Australonousia)* sp. "AV5".
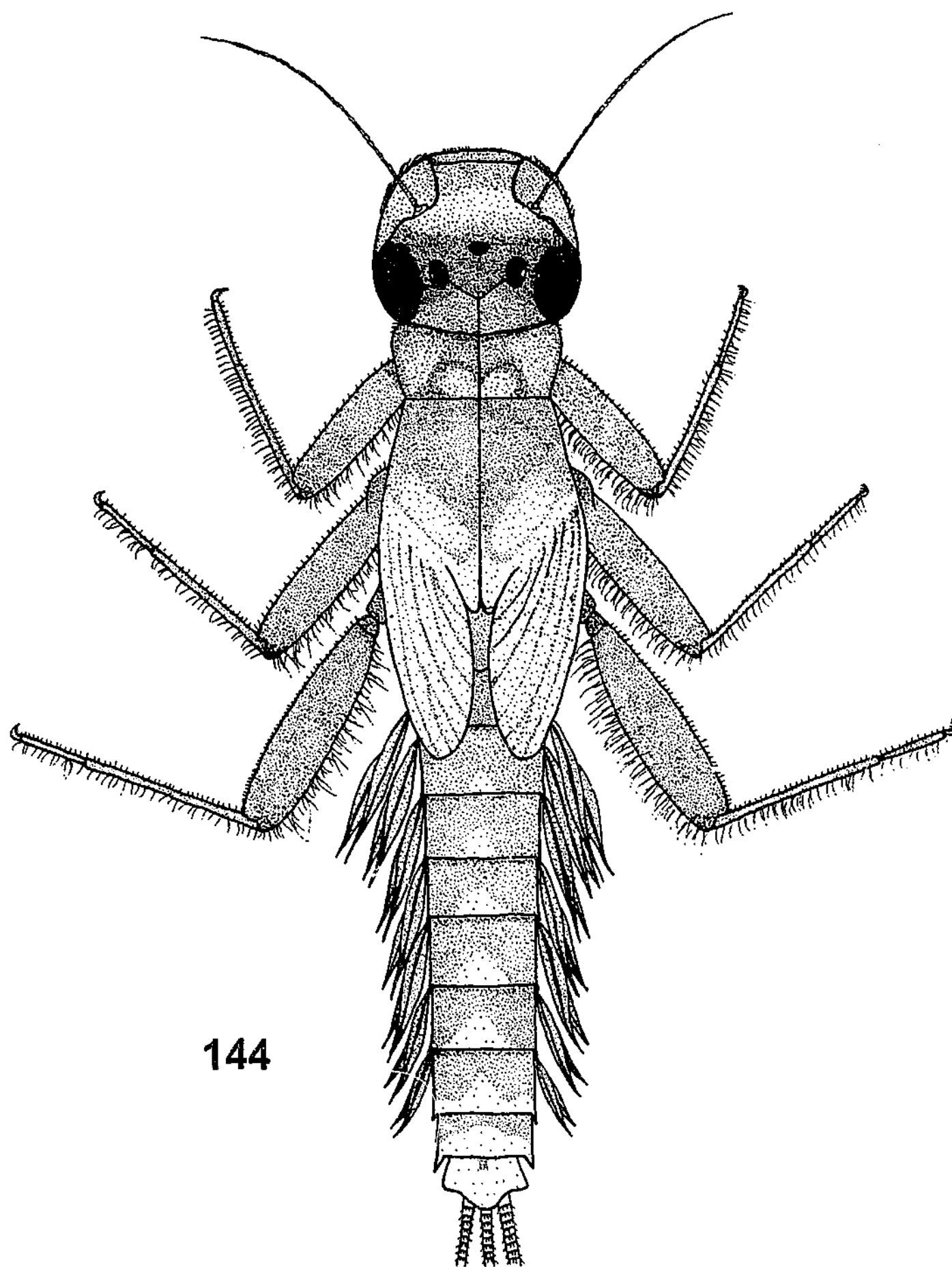
144

Fig. 144. *Nousia (Australonousia)* sp. "AV5", female nymph.
Scale bar = 1mm.
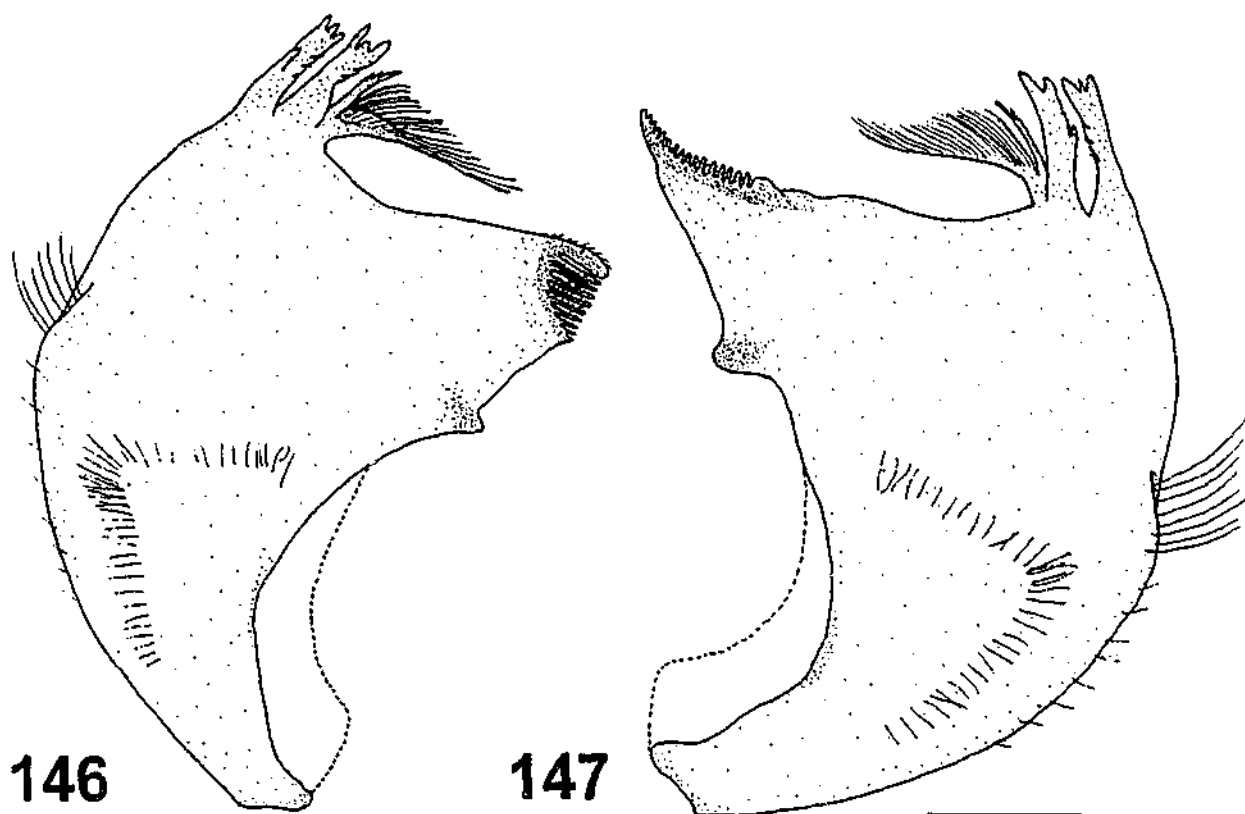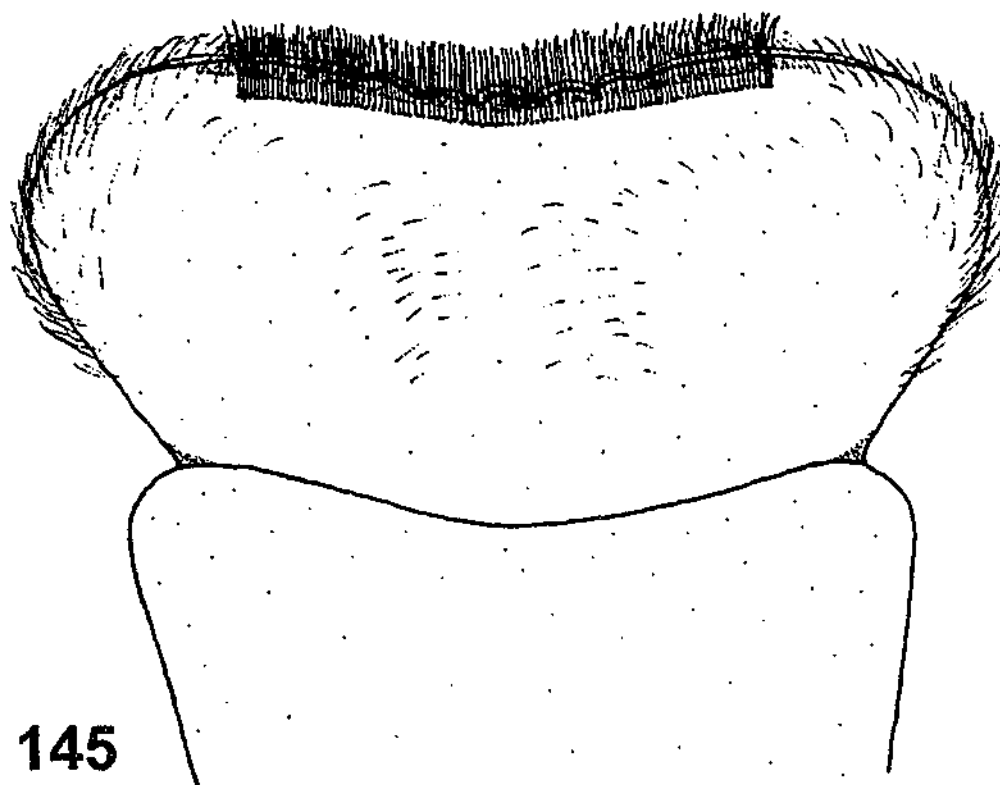
Figs. 145-147. *Nousia (Australonousia)* sp. "AV5", nymph mouthparts.
Scale bars = 200μm.

Fig. 145. Labrum and clypeus.
Fig. 146. Left mandible.
Fig. 147. Right mandible.
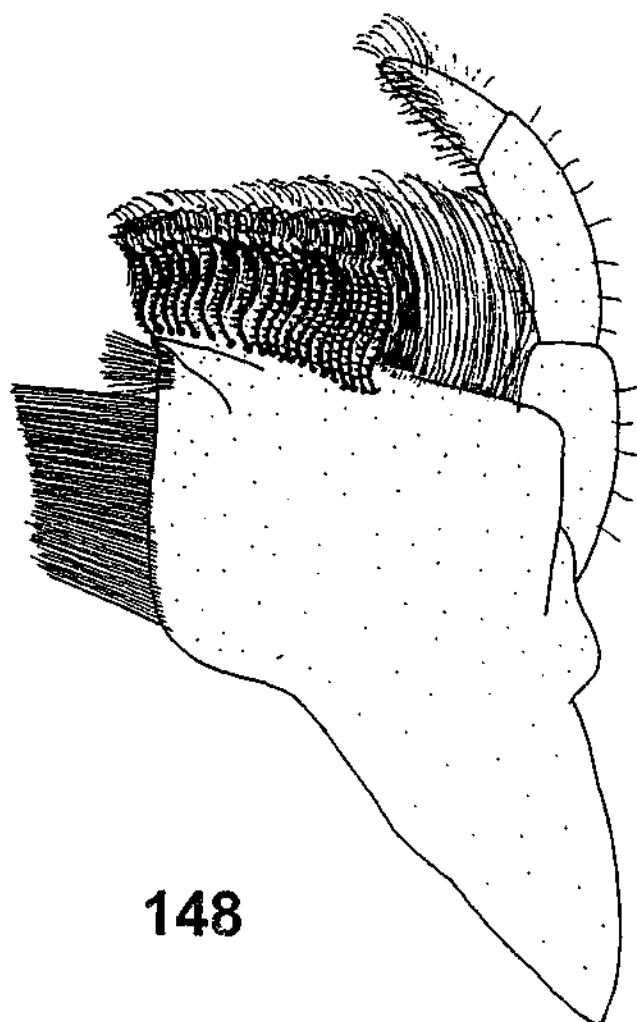
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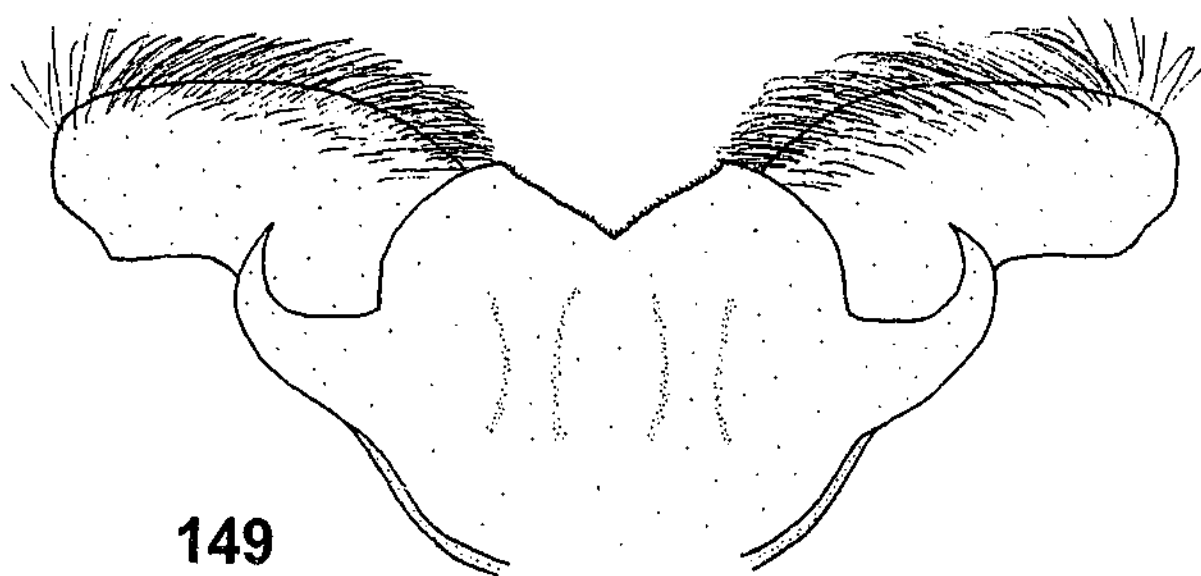
149

Figs. 148-149. *Nousia (Australonousia)* sp. "AV5", nymph mouthparts.
Scale bars = 200µm.

Fig. 148. Right maxilla.
Fig. 149. Hypopharynx.

150
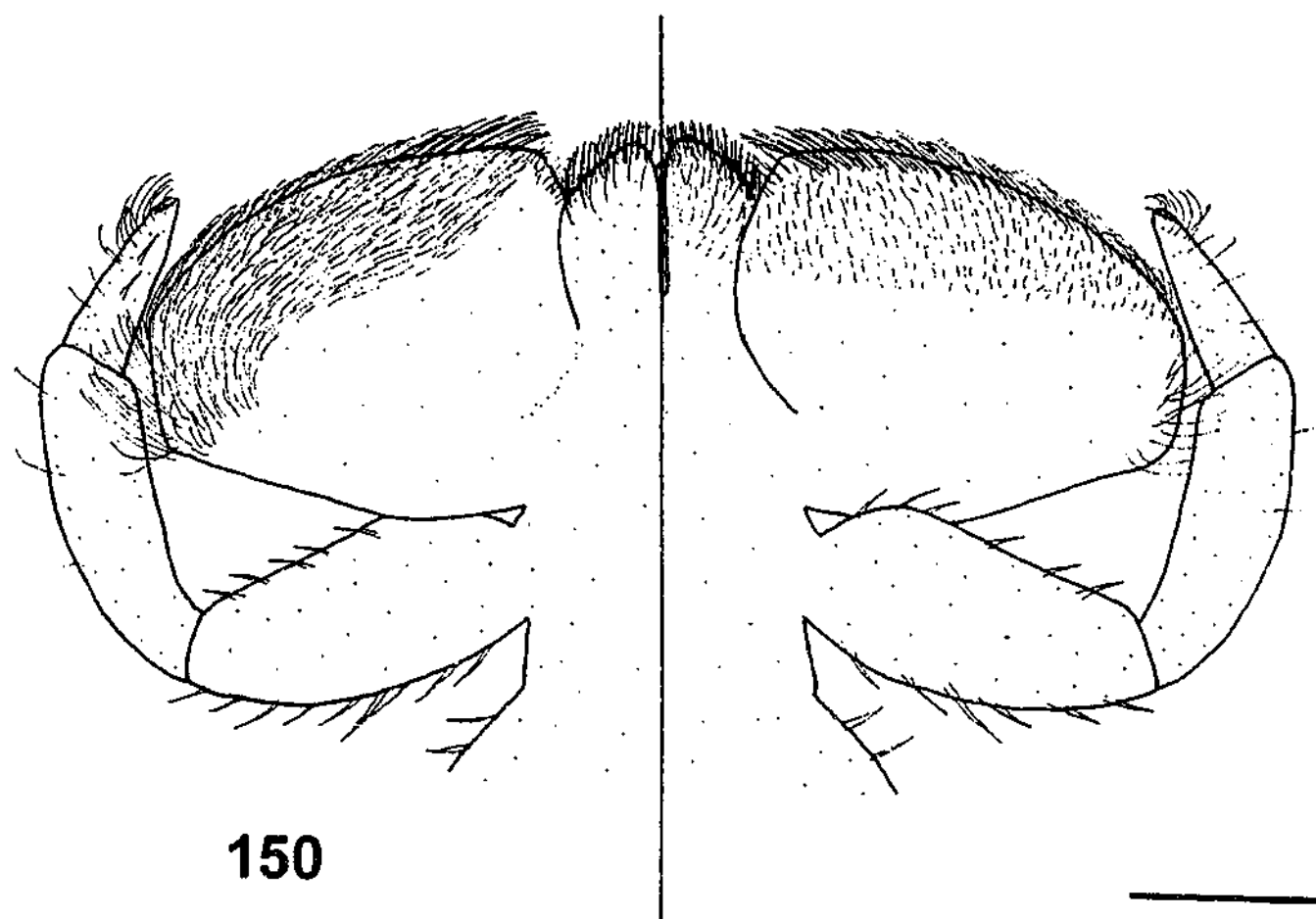
Fig. 150. *Nousia (Australonousia)* sp. "AV5", nymph mouthpart.

Labium. Scale bar = 200μm.

151
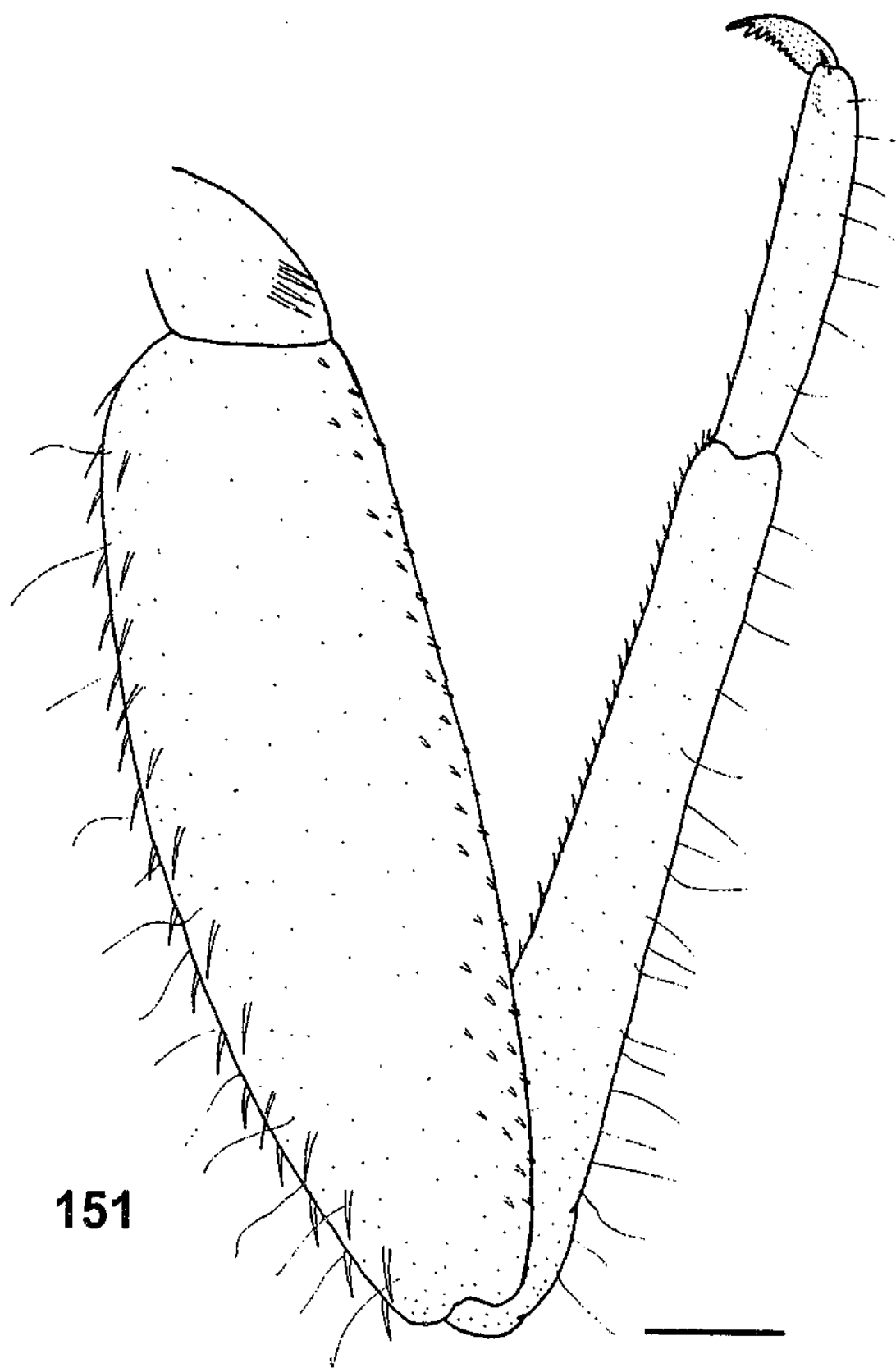
Fig. 151. *Nousia (Australonousia)* sp. "AV5", nymph.

Foreleg. Scale bar = 200µm.
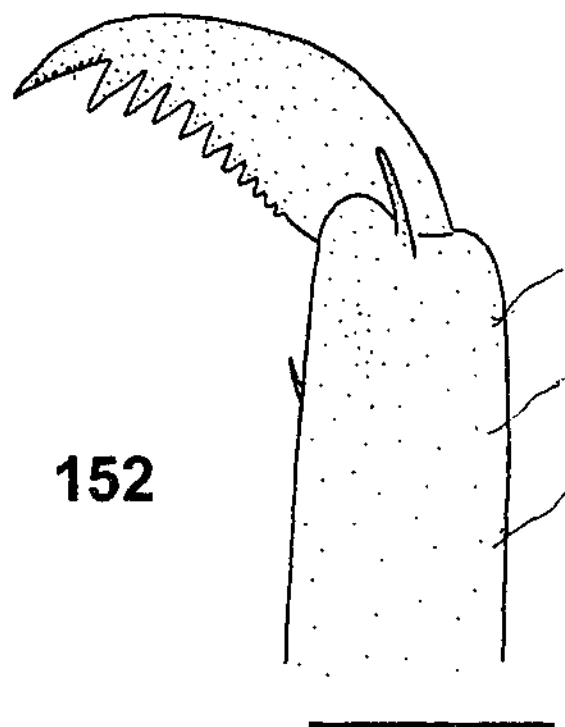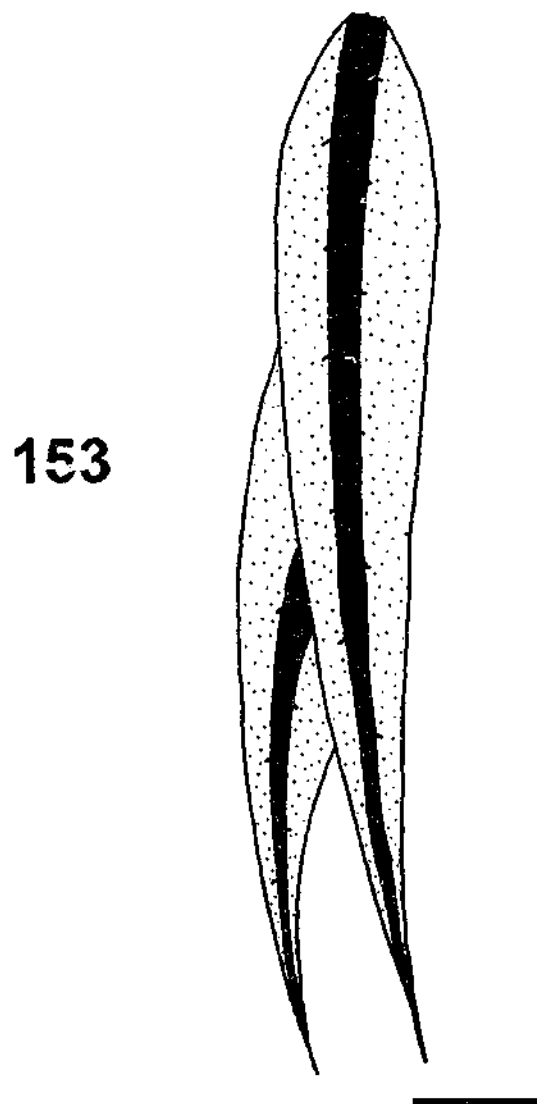
Figs. 152-153. *Nousia (Australonousia)* sp. "AV5", nymph.
Scale bars = 100µm.

Fig. 152. Foreleg tarsal claw.
Fig. 153. Gills.

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Tasmania
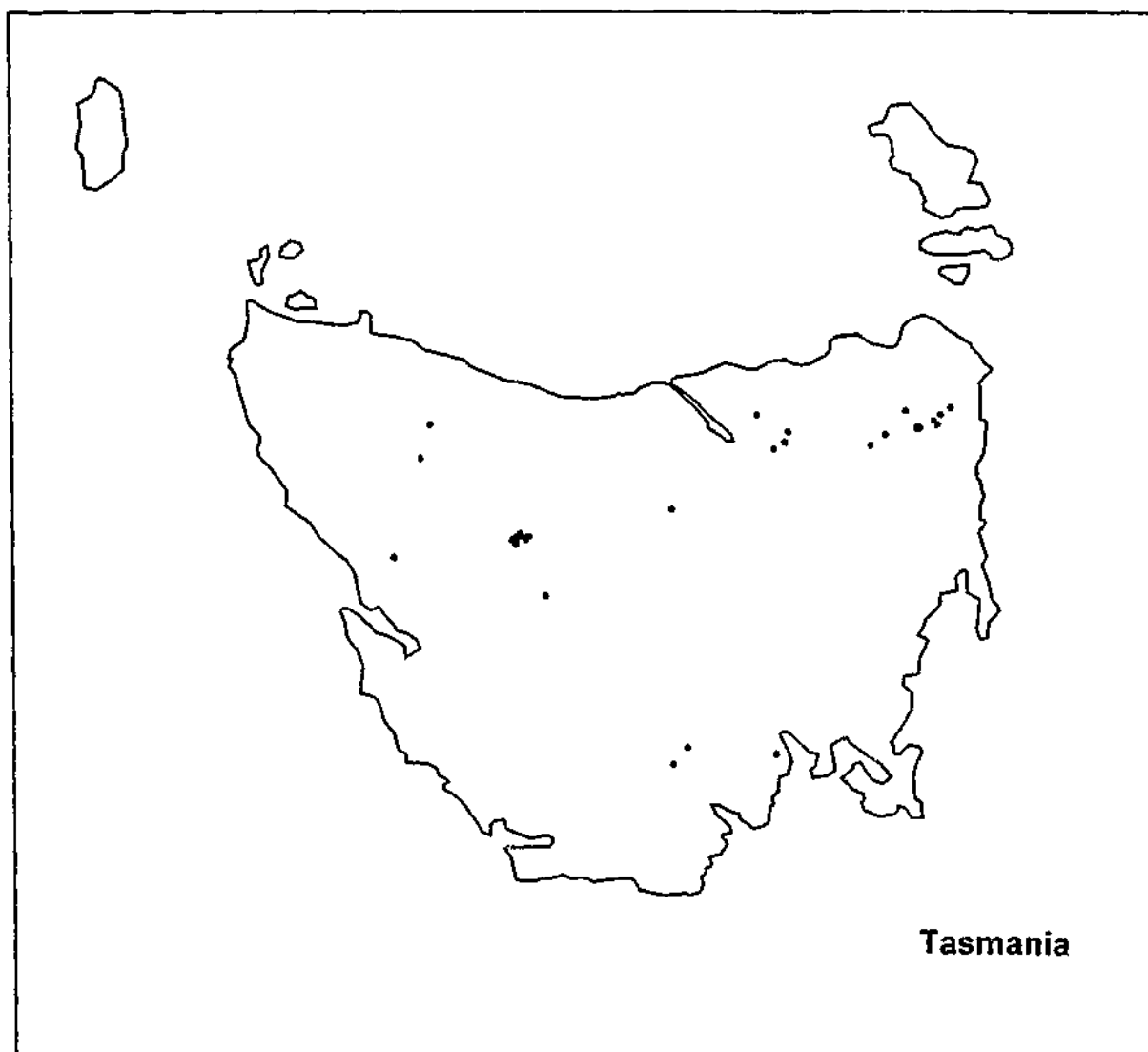
Fig. 154. Distribution of *Nousia (Australonousia)* sp. "AV7".

155
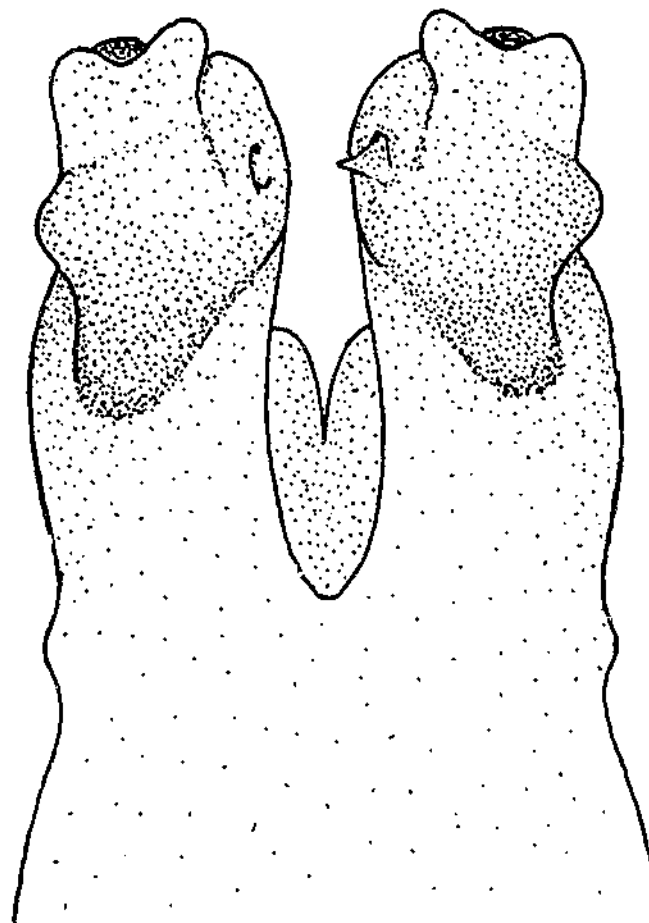
Fig. 155. *Nousia (Australonousia)* sp. "AV7", male imago.
Scale bar = 200μm.

Dorsal view of genitalia showing penes.
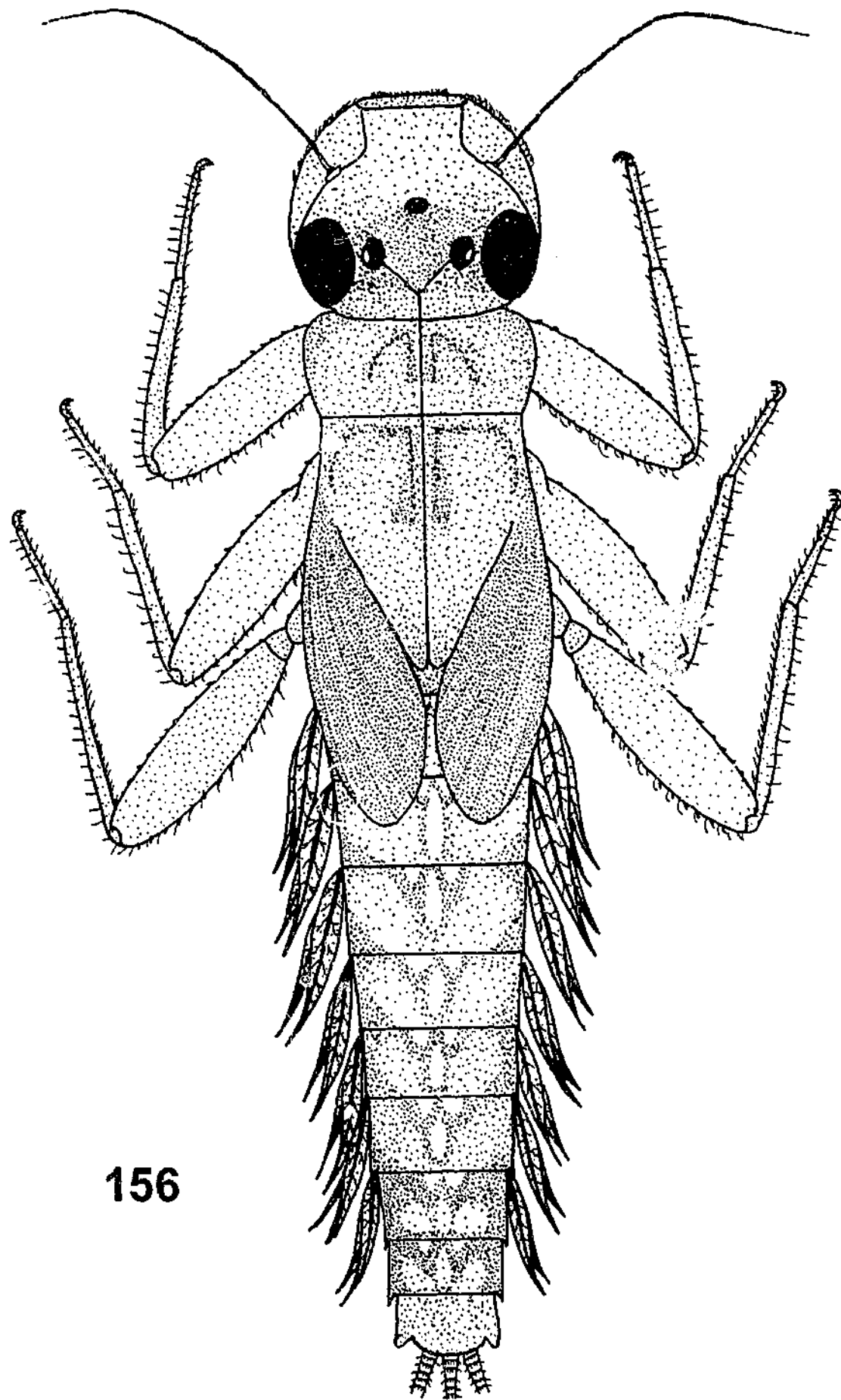
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Fig. 156. *Nousia (Australonousia)* sp. "AV7", female nymph.
Scale bar = 1mm.

157
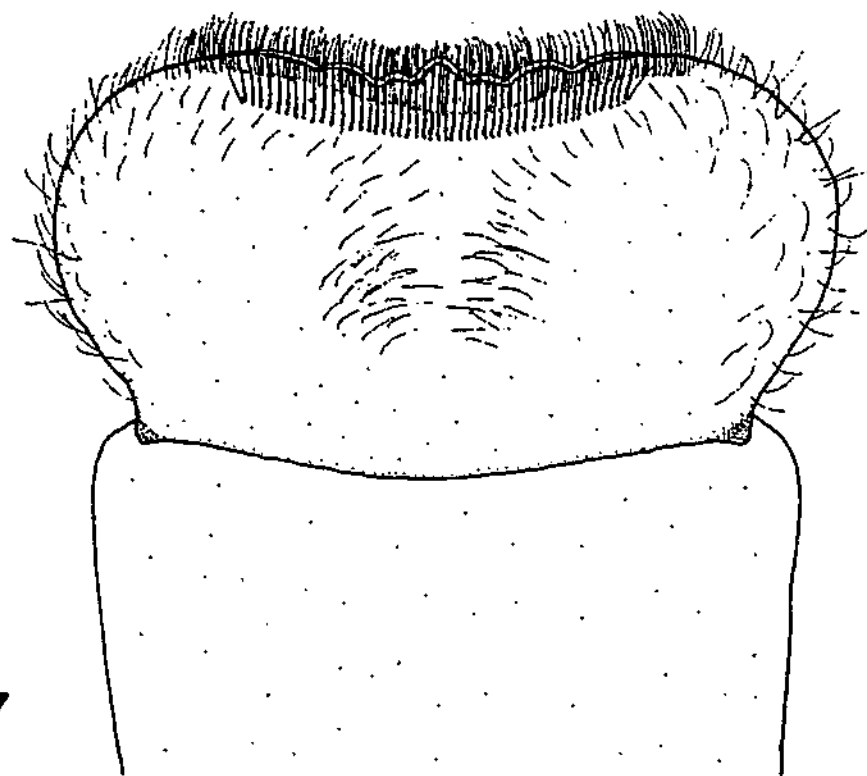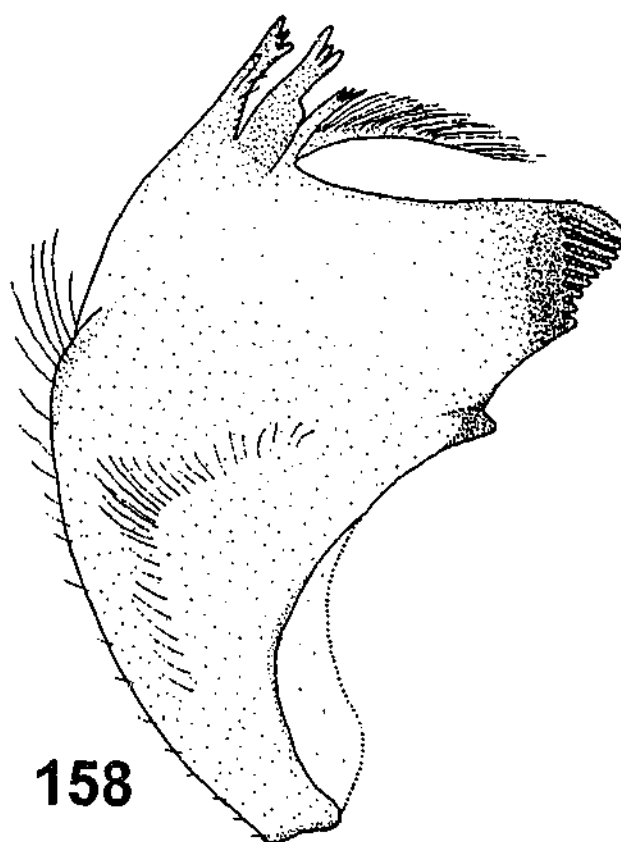
158 **159**
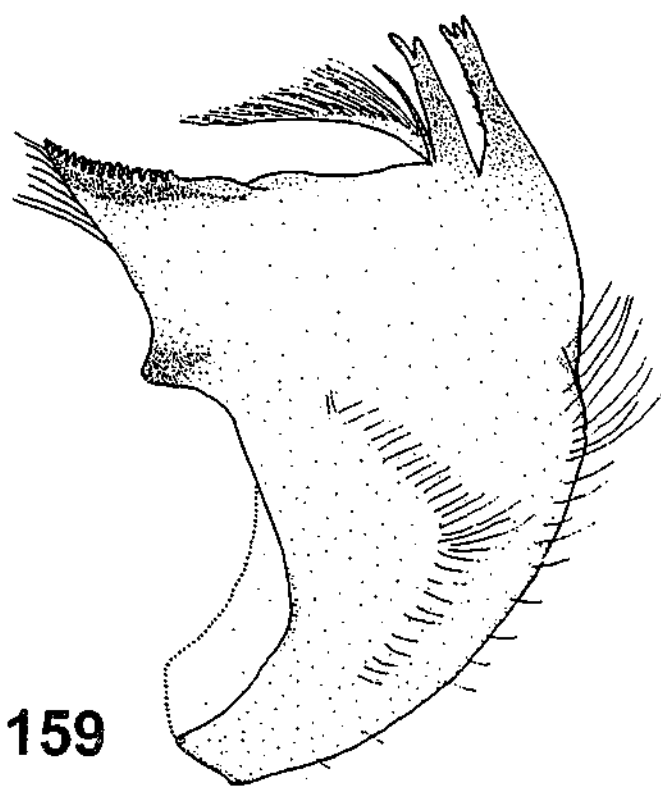
Figs. 157-159. *Nousia (Australonousia)* sp. "AV7", nymph mouthparts.
Scale bars = 200μm.

Fig. 157. Labrum and clypeus.
Fig. 158. Left mandible.
Fig. 159. Right mandible.
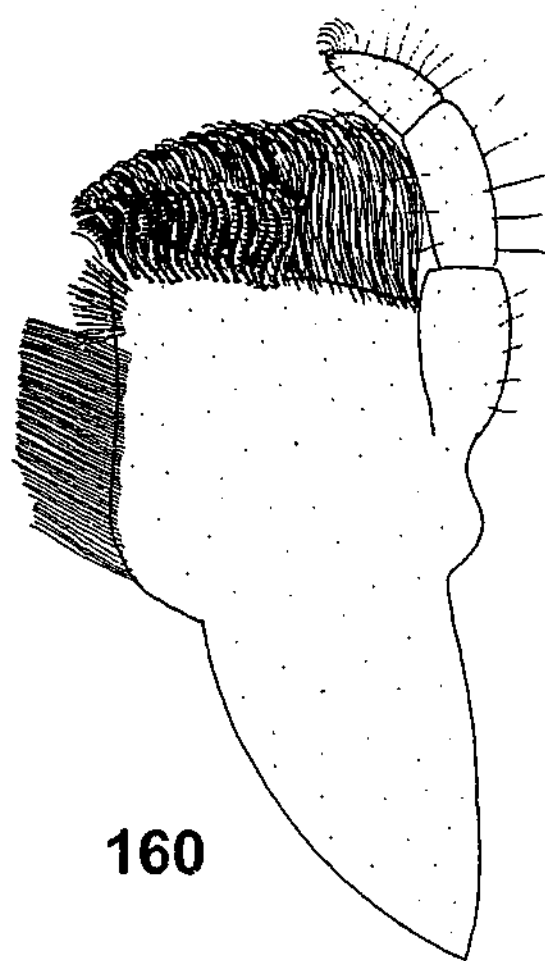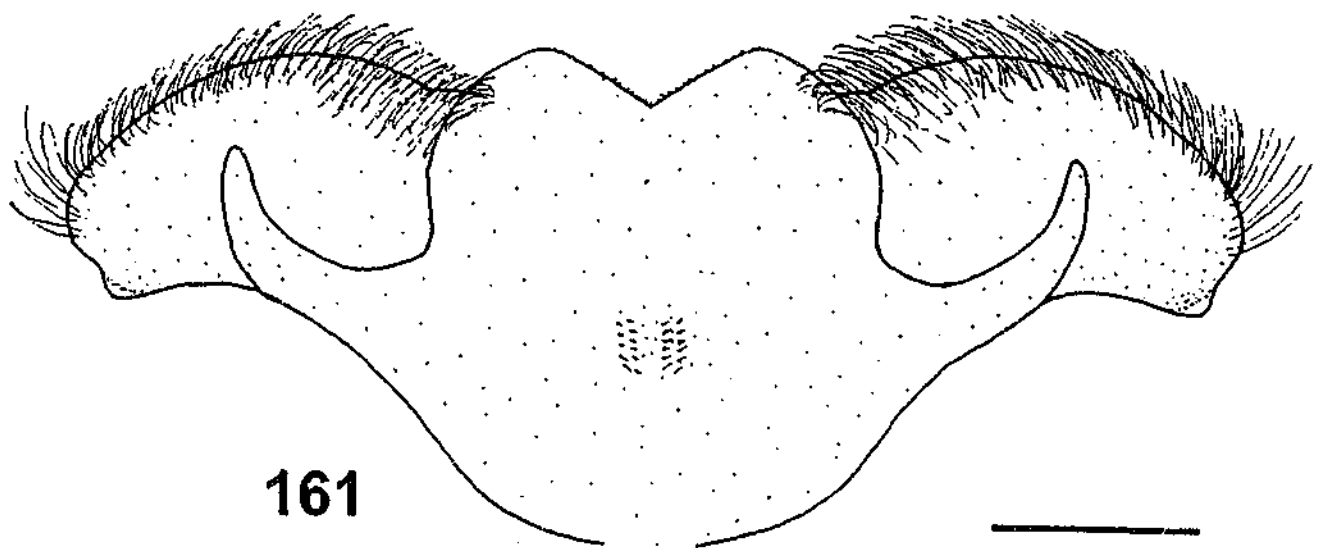
Figs. 160-161. *Nousia (Australonousia)* sp. "AV7", nymph mouthparts.
Scale bars = 200µm.

Fig. 160. Right maxilla.
Fig. 161. Hypopharynx.
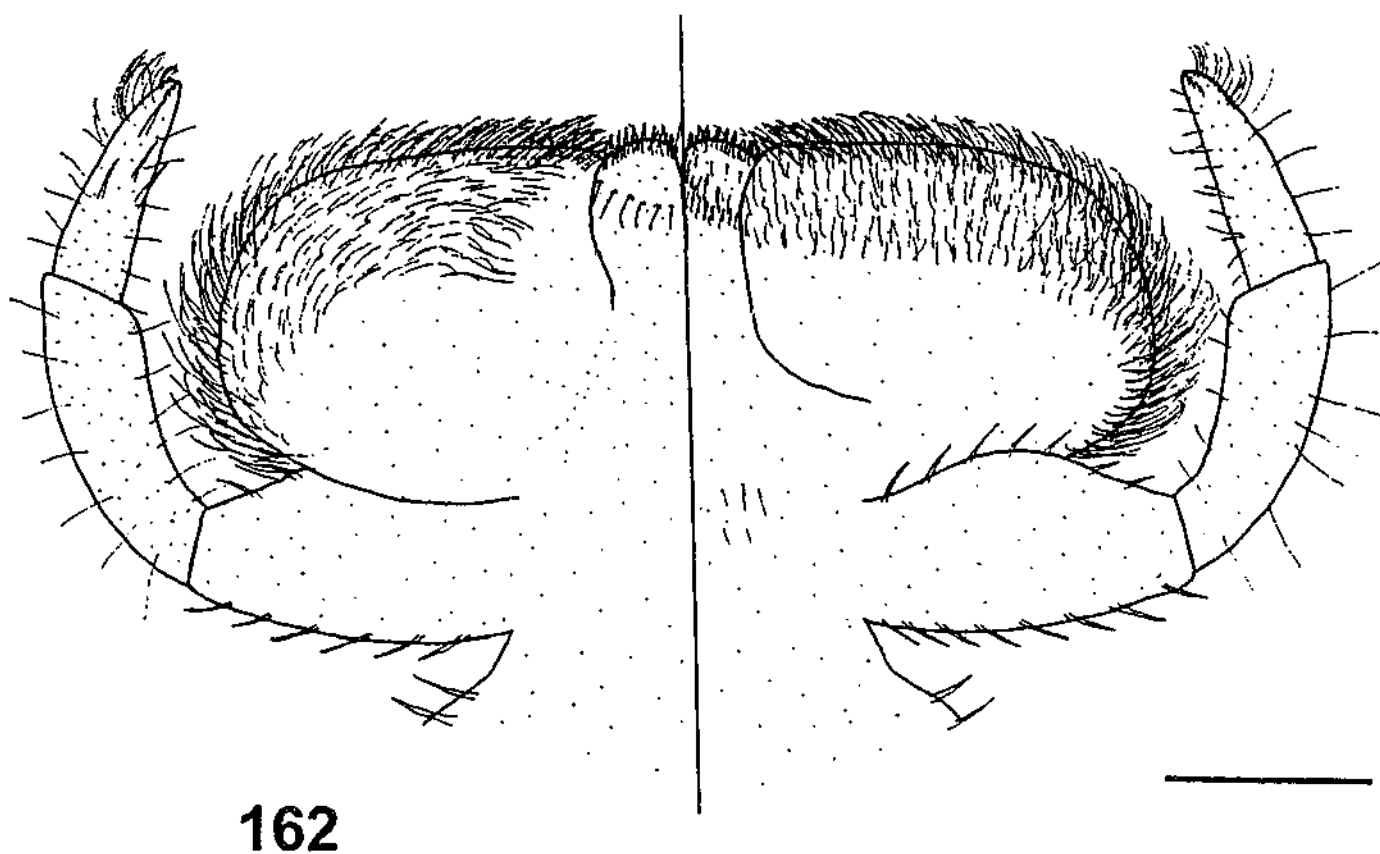
162

Fig. 162. *Nousia (Australonousia)* sp. "AV7", nymph mouthpart.

Labium. Scale bar = 200µm.

163
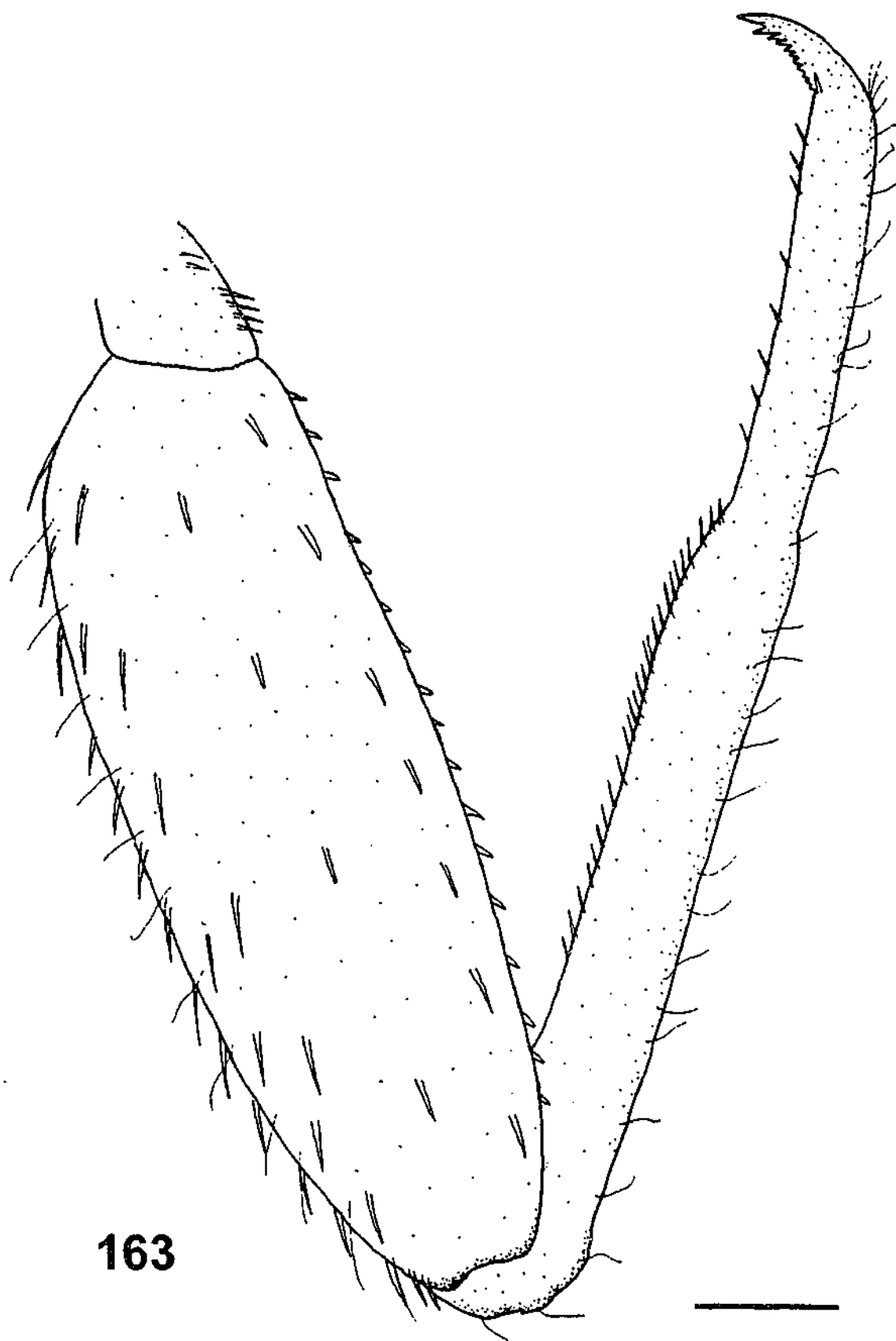
Fig. 163. *Nousia (Australonousia)* sp. "AV7", nymph.

Foreleg. Scale bar = 200µm.

164
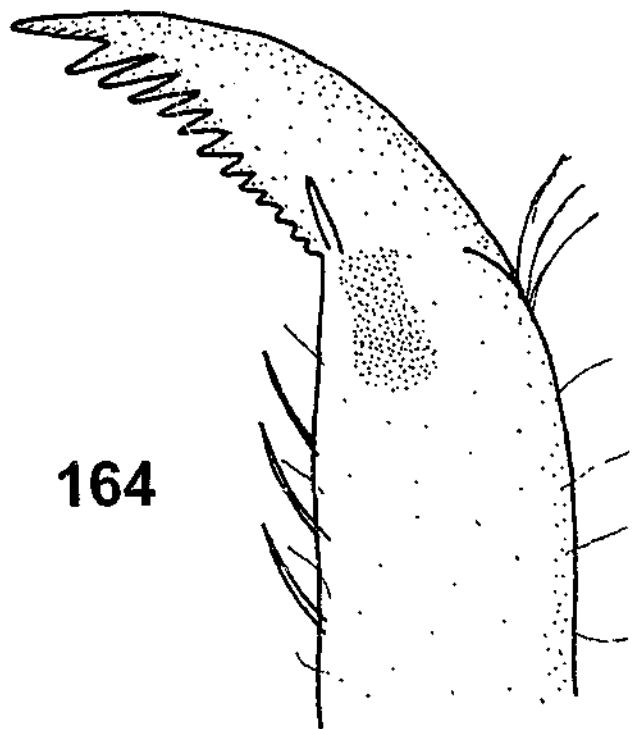
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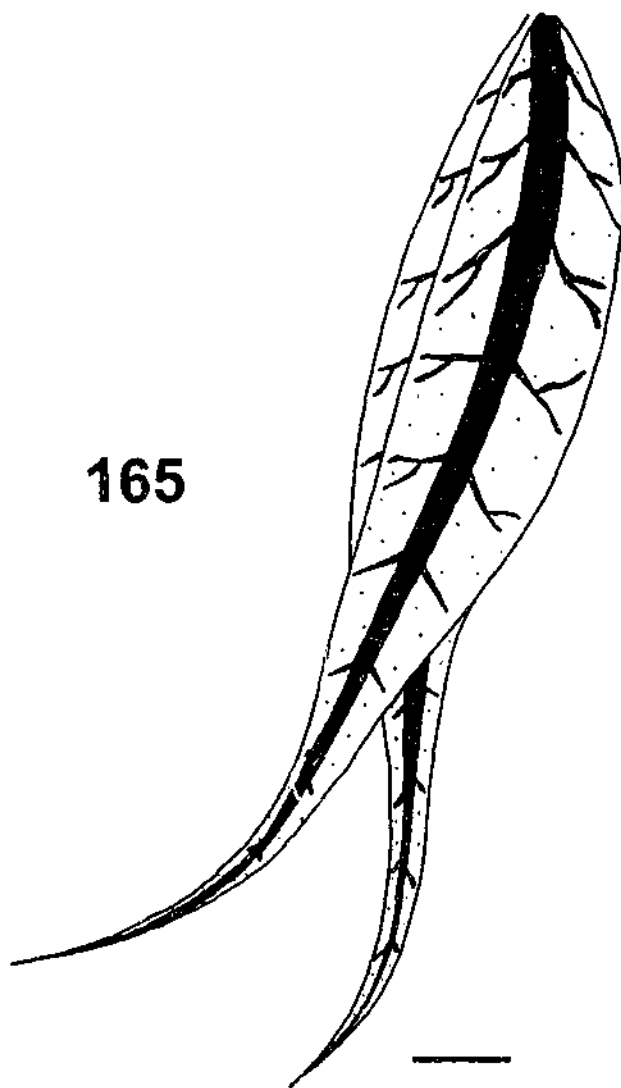
Figs. 164-165. *Nousia (Australonousia)* sp. "AV7", nymph.
Scale bars = 100μm.

Fig. 164. Foreleg tarsal claw.
Fig. 165. Gills.

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Tasmania
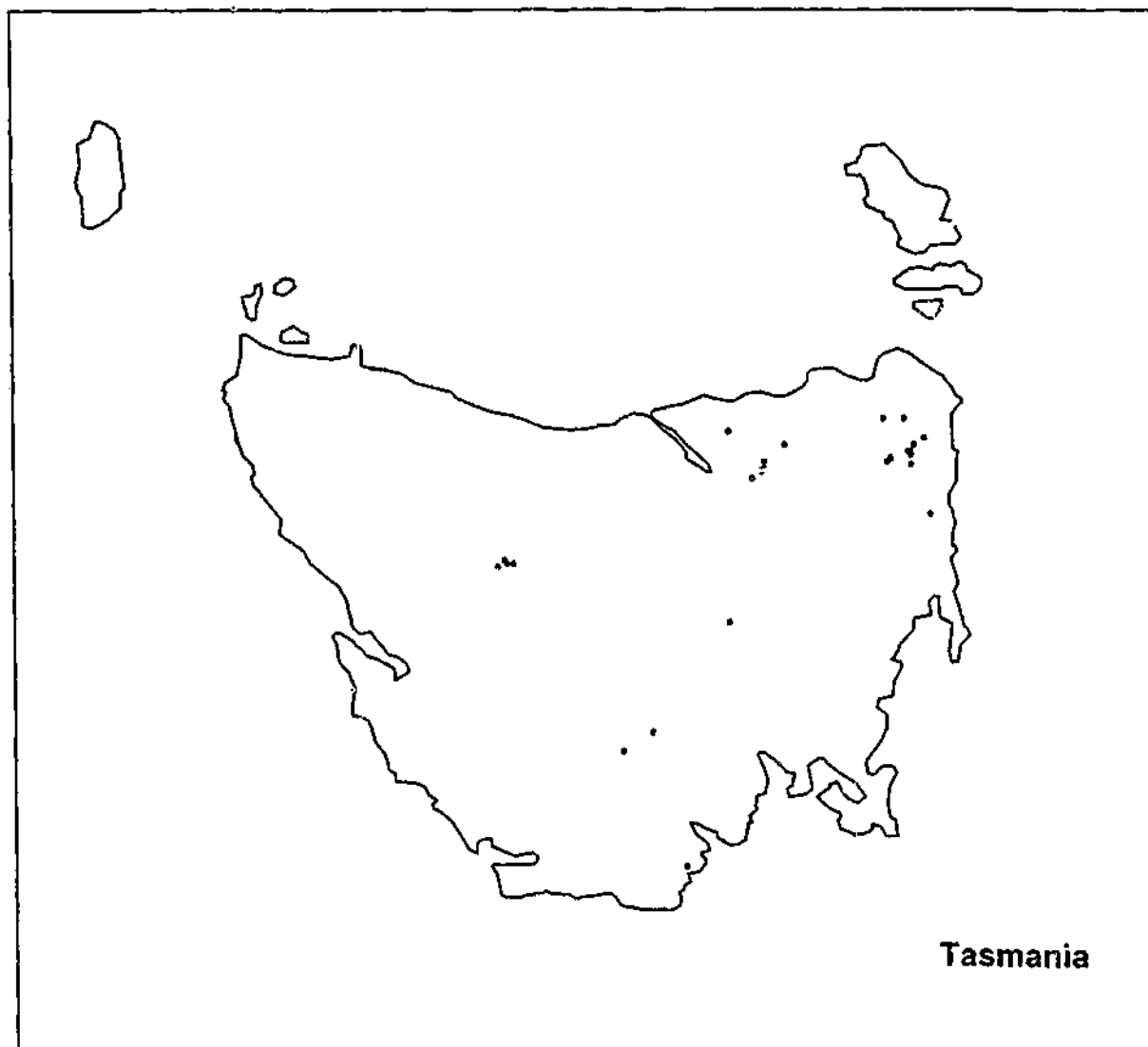
Fig. 166. Distribution of *Nousia (Australonousia)* sp. "AV8".
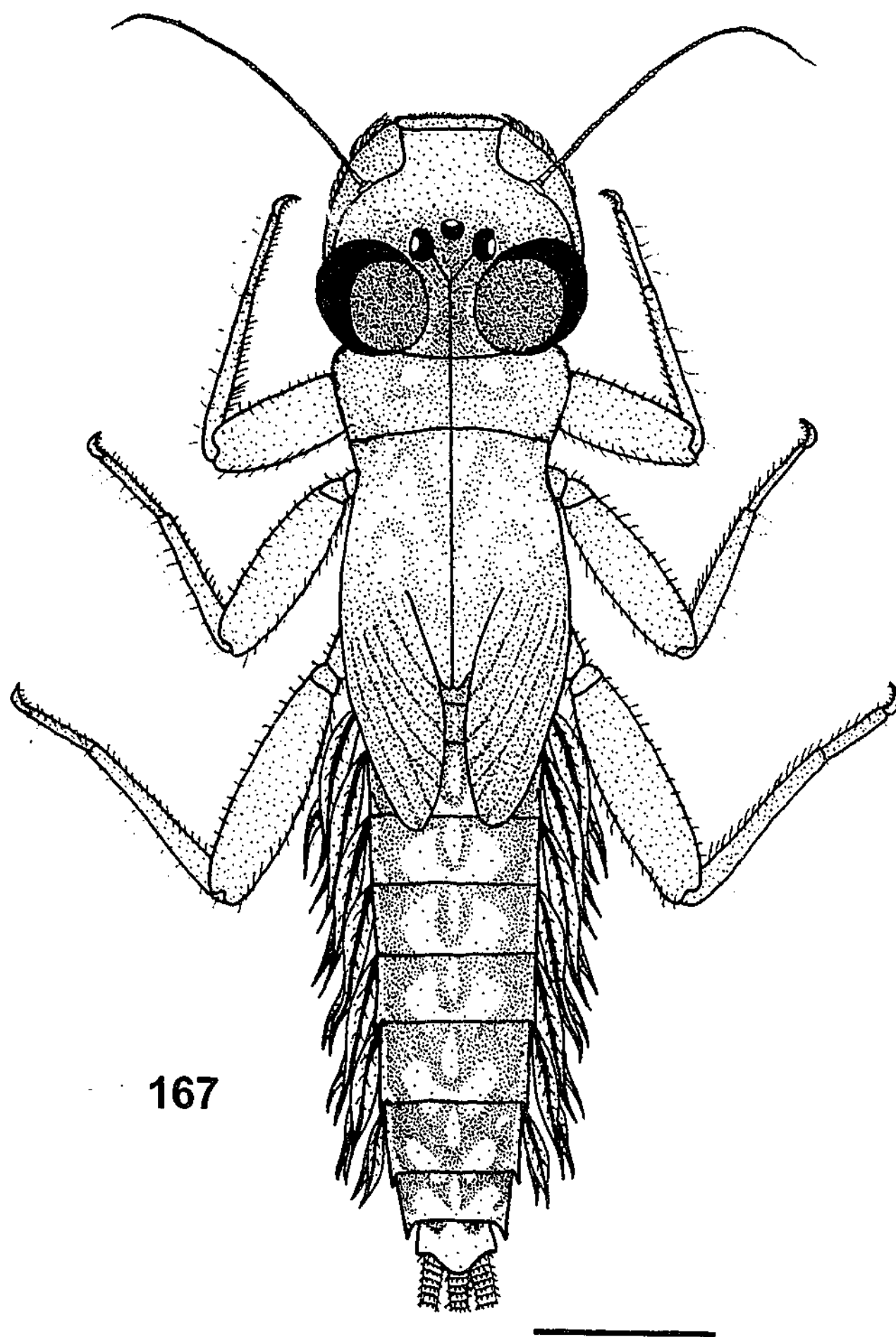
167

Fig. 167. *Nousia (Australonousia)* sp. "AV8", male nymph.
Scale bar = 1mm.
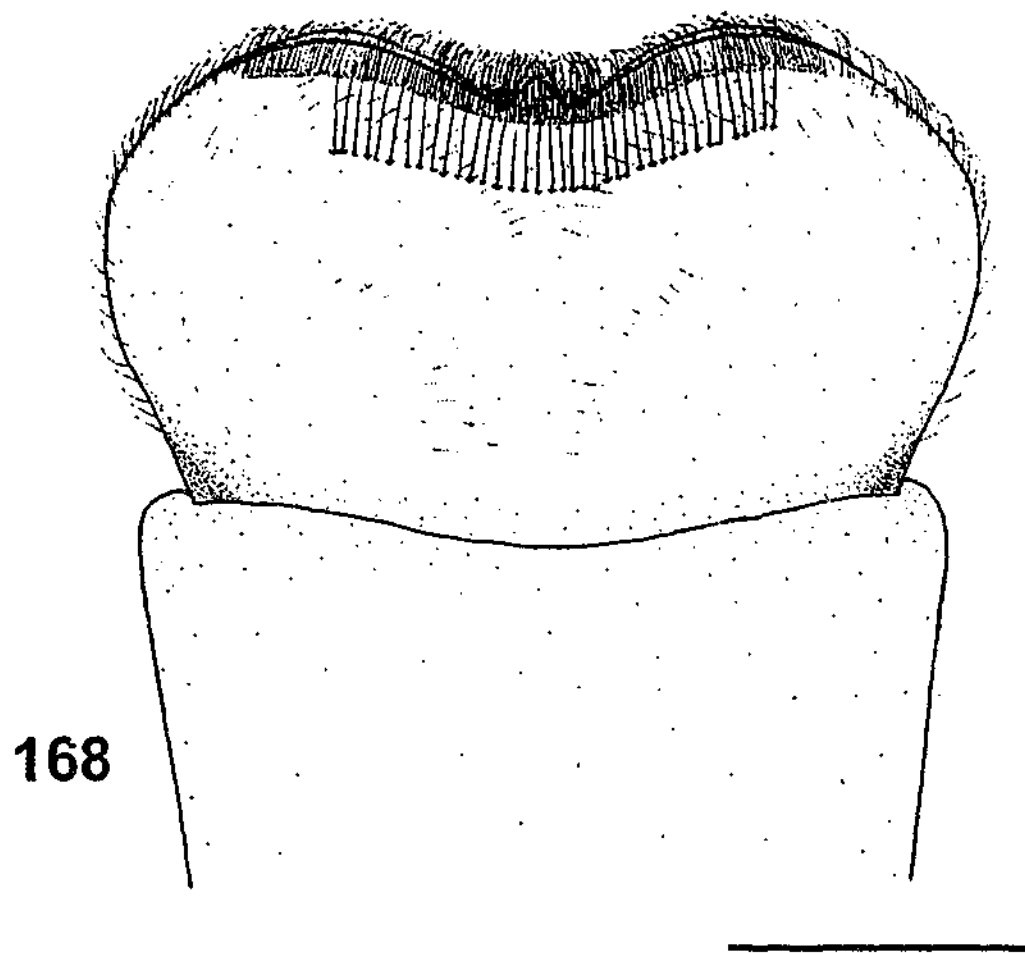
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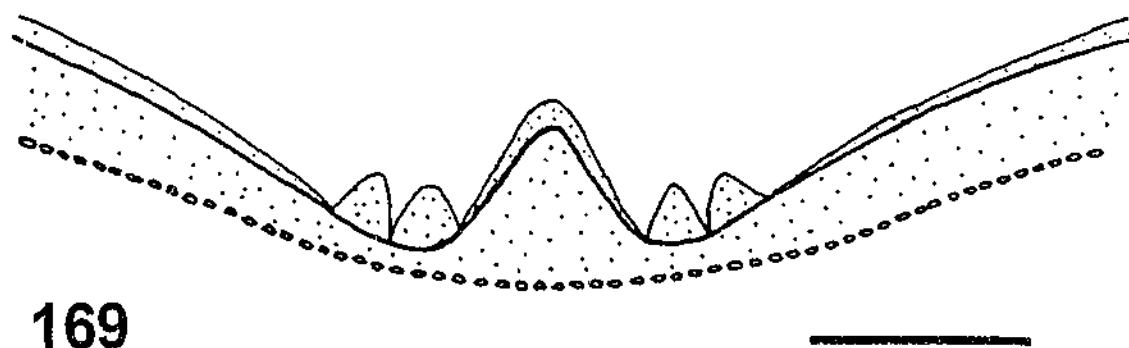
169

Figs. 168-169. *Nousia (Australonousia)* sp. "AV8", nymph mouthparts.

Fig. 168. Labrum and clypeus   Scale bar = 200µm.
Fig. 169. Denticles on anterior margin of labrum.   Scale bar = 50µm.

170

171
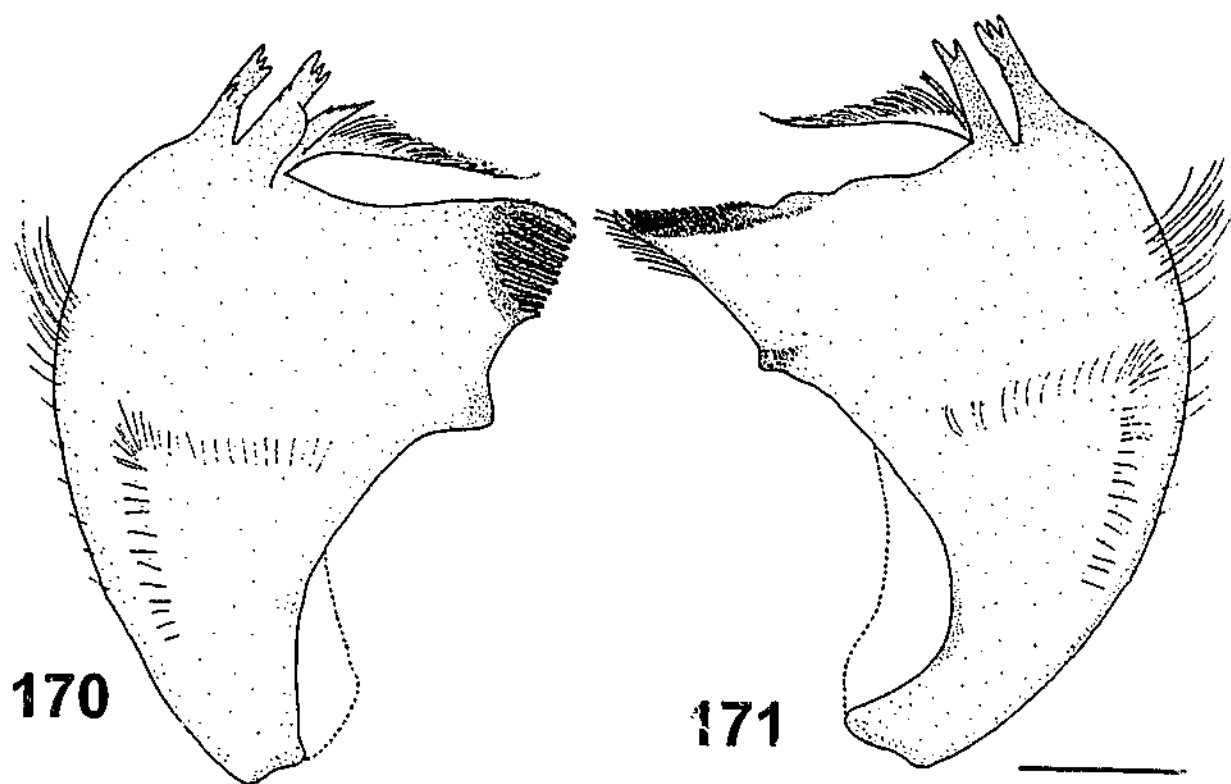
Figs. 170-171. *Nousia (Australonousia)* sp. "AV8", nymph mouthparts.
Scale bar = 200μm.

Fig. 170. Left mandible.
Fig. 171. Right mandible.
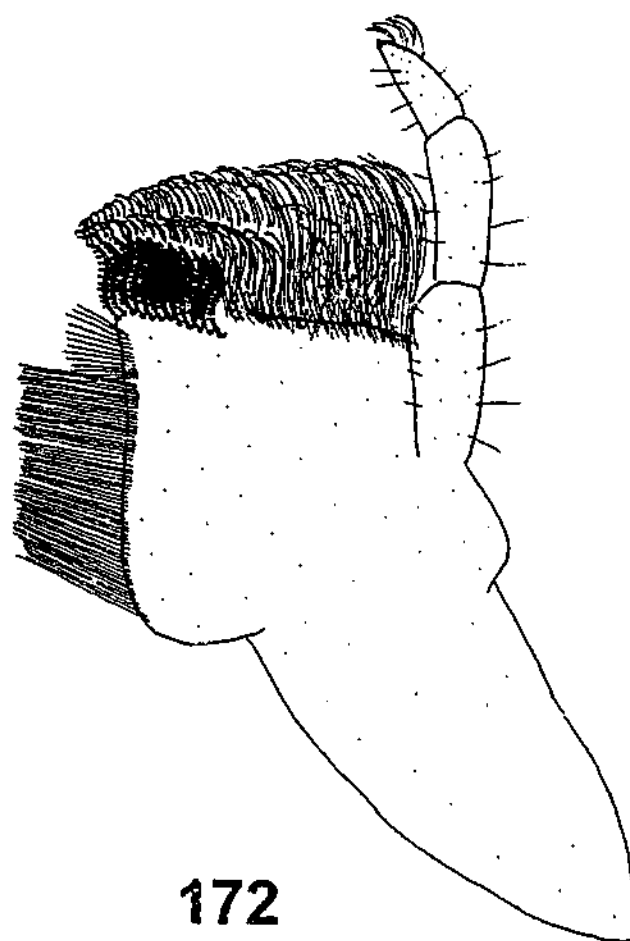
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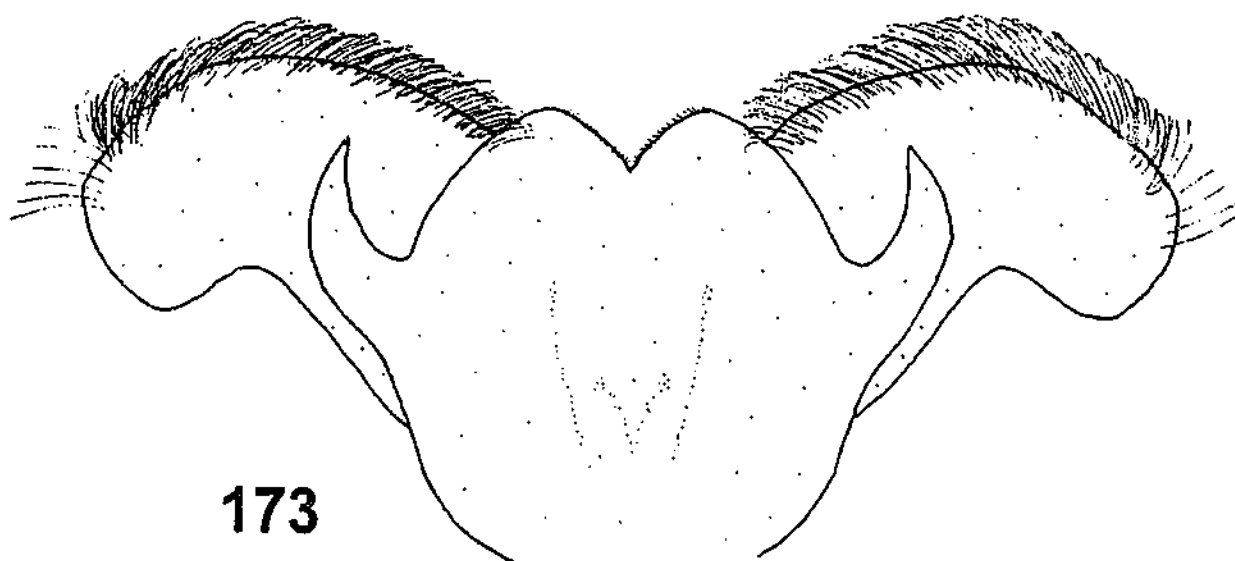
173

Figs. 172-173. *Nousia (Australonousia)* sp. "AV8", nymph mouthparts.
Scale bars = 200μm.

Fig. 172. Right maxilla.
Fig. 173. Hypopharynx.

174
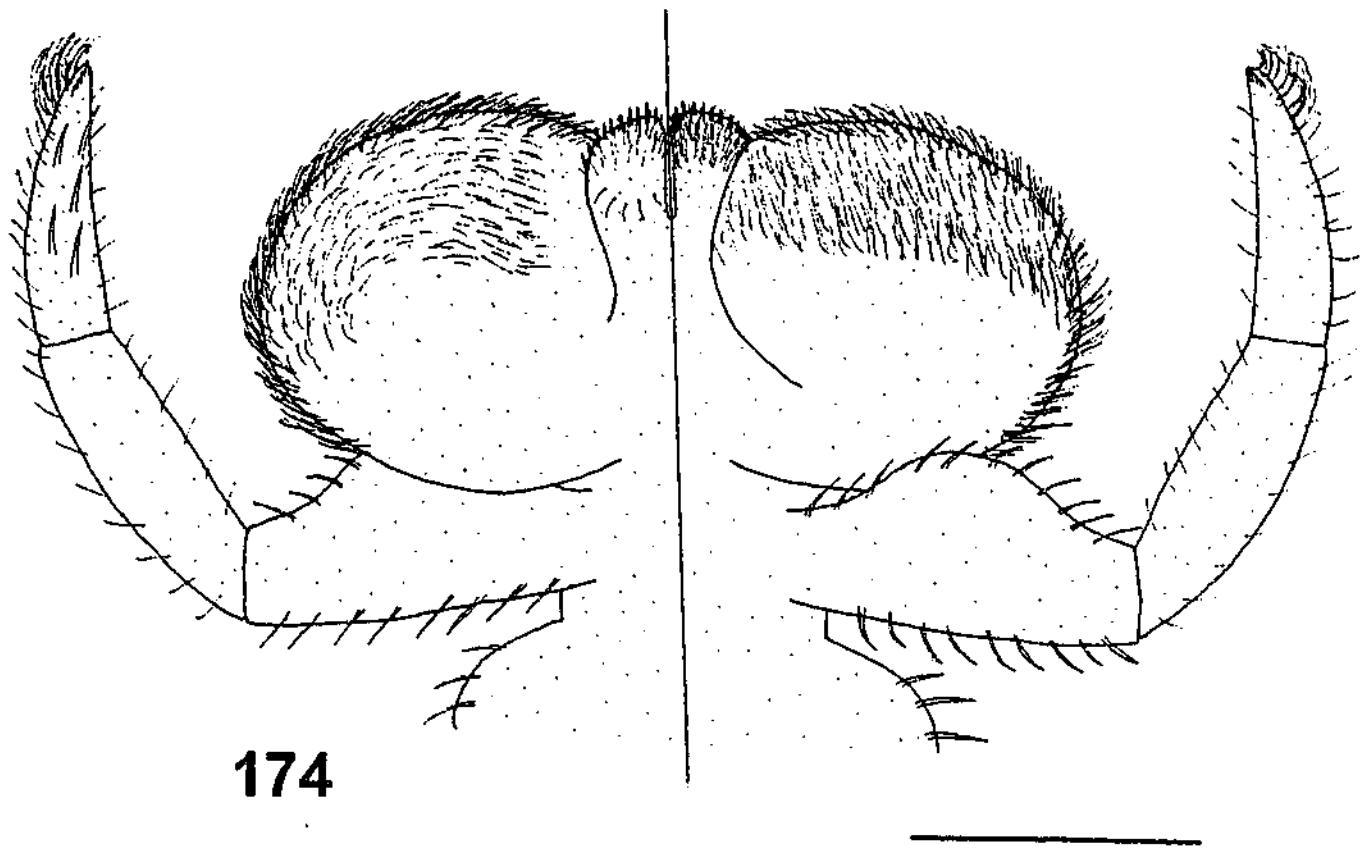
Fig. 174. *Nousia (Australonousia)* sp. "AV8", nymph mouthpart.

Labium. Scale bar = 200μm.
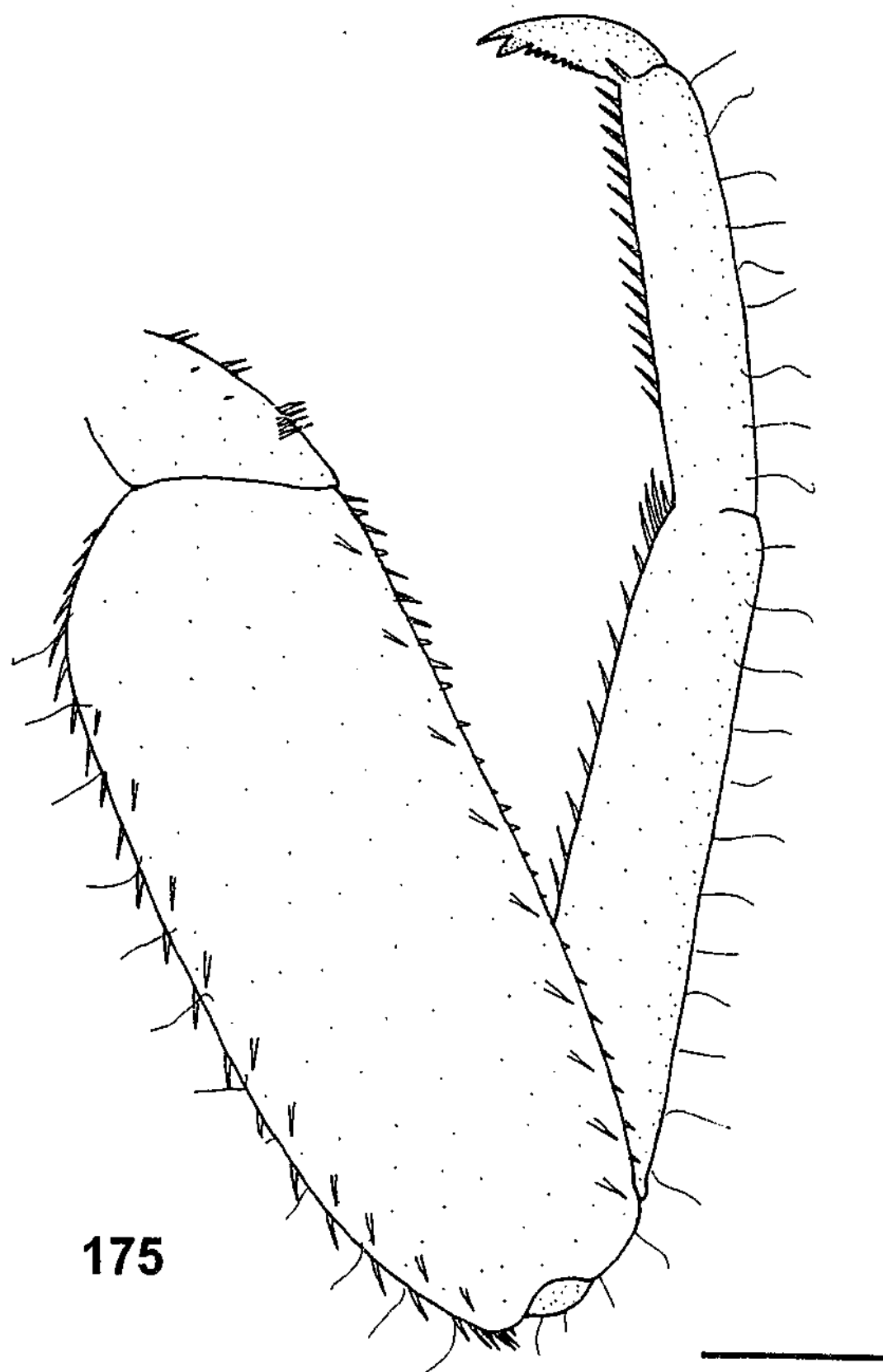
175

Fig. 175. *Nousia (Australonousia)* sp. "AV8", nymph.

Foreleg. Scale bar = 200μm.
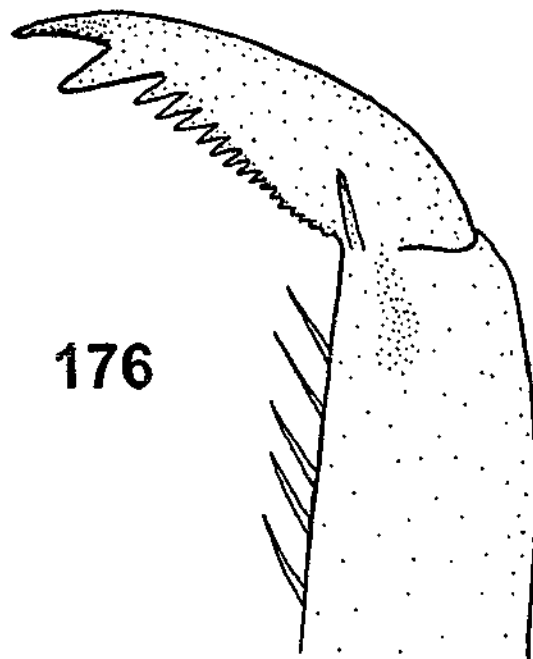
176

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Figs. 176-177. *Nousia (Australonousia)* sp. "AV8", nymph.
Scale bars = 100μm.

Fig. 176. Foreleg tarsal claw.
Fig. 177. Gills.

178
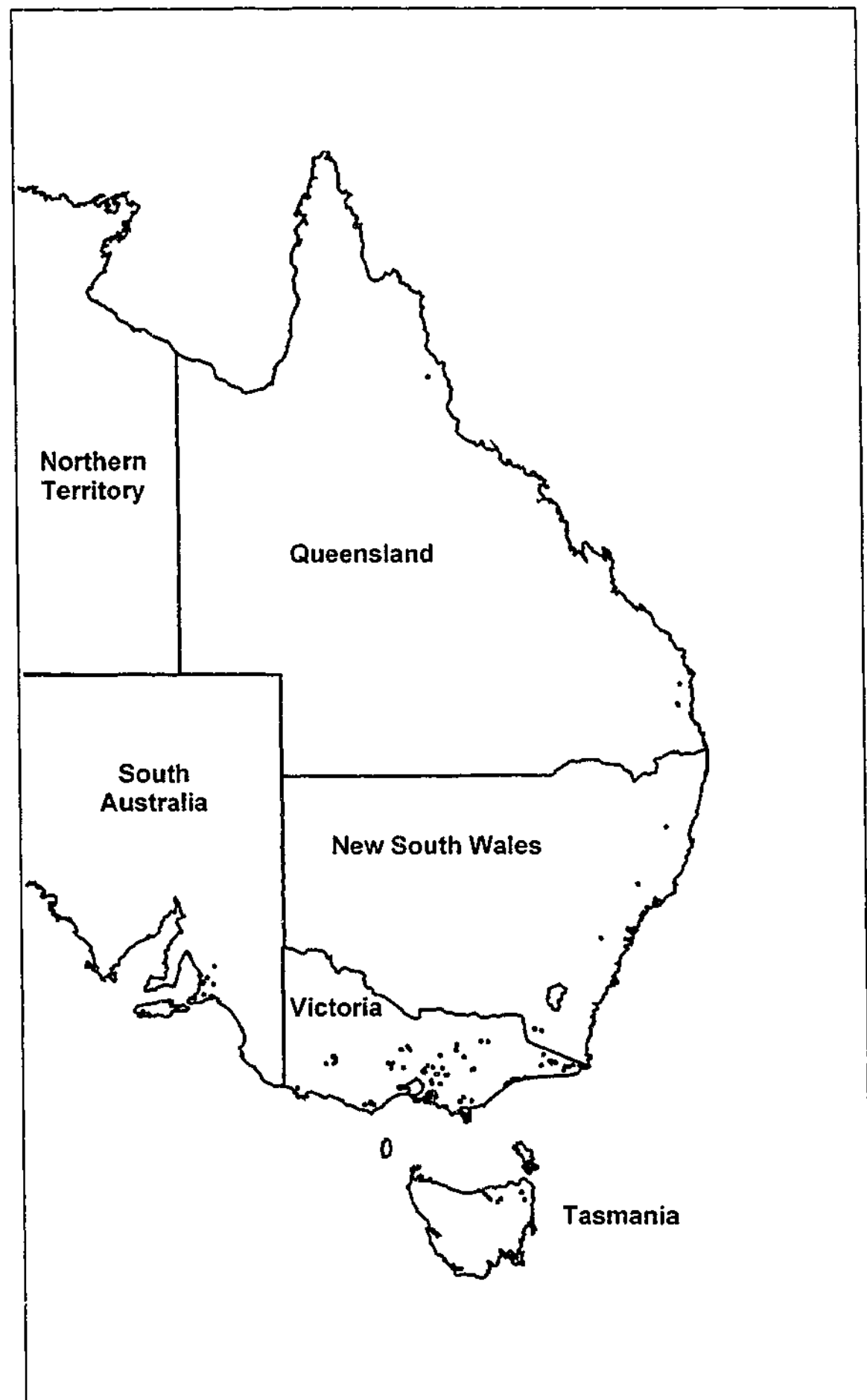
Fig. 178. Distribution of the genus *Thraulophlebia*.

179
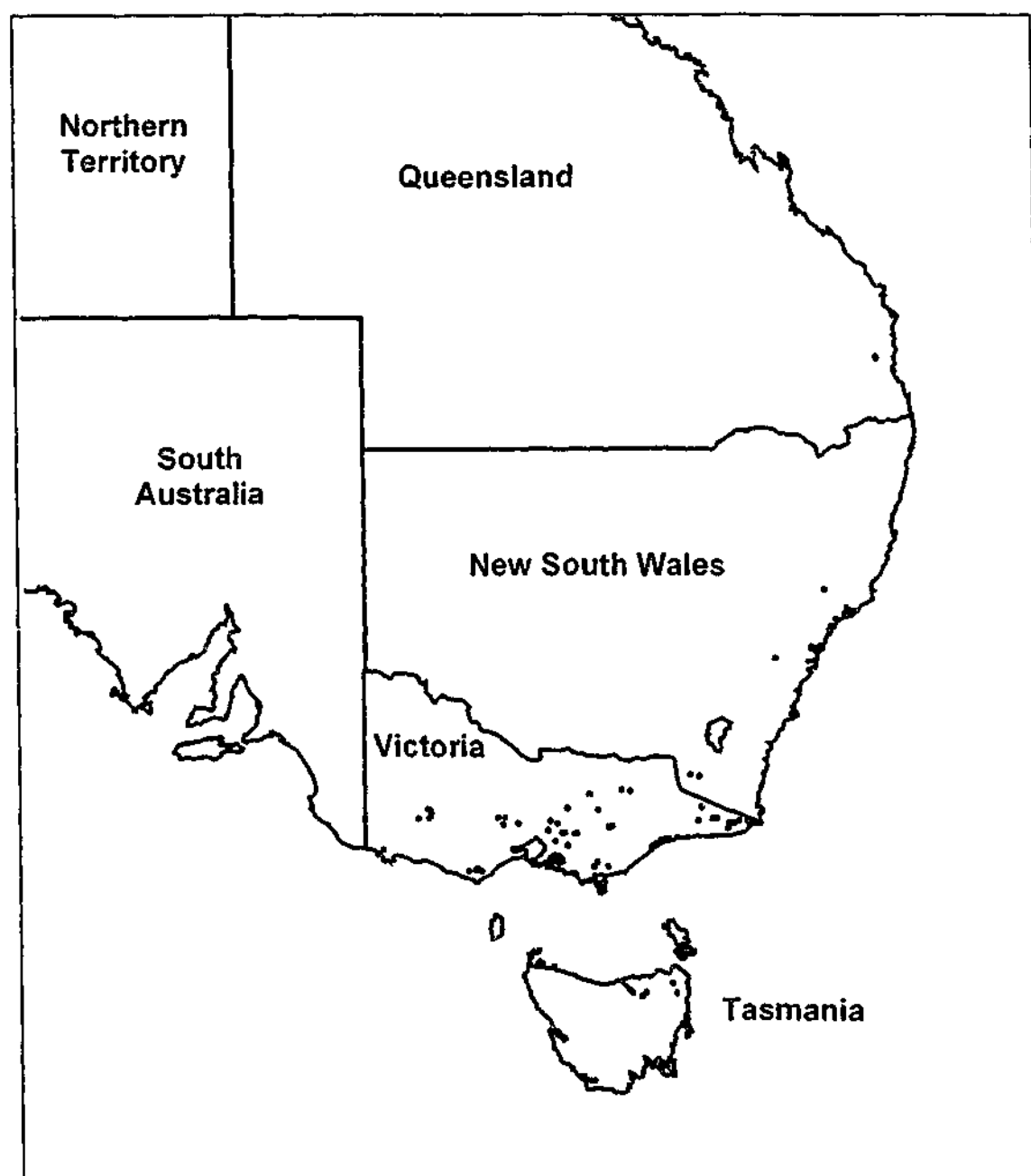
Fig. 179. Distribution of *Thraulophlebia lucida*.

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181

182
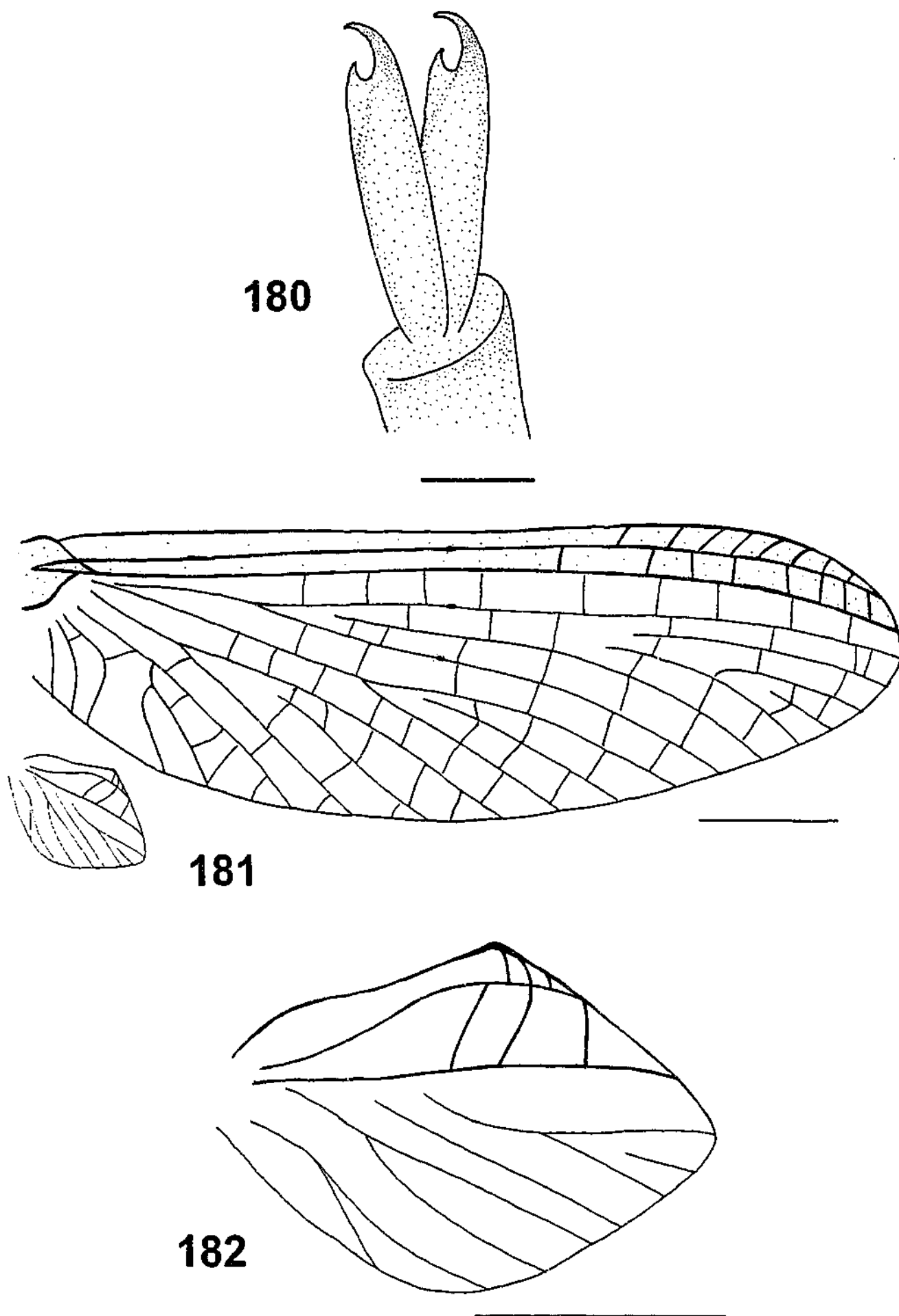
Figs 180-182. *Thraulophlebia lucida*, male imago.

Fig. 180. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 181. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 182. Hindwing. Scale bar = 500µm.

183
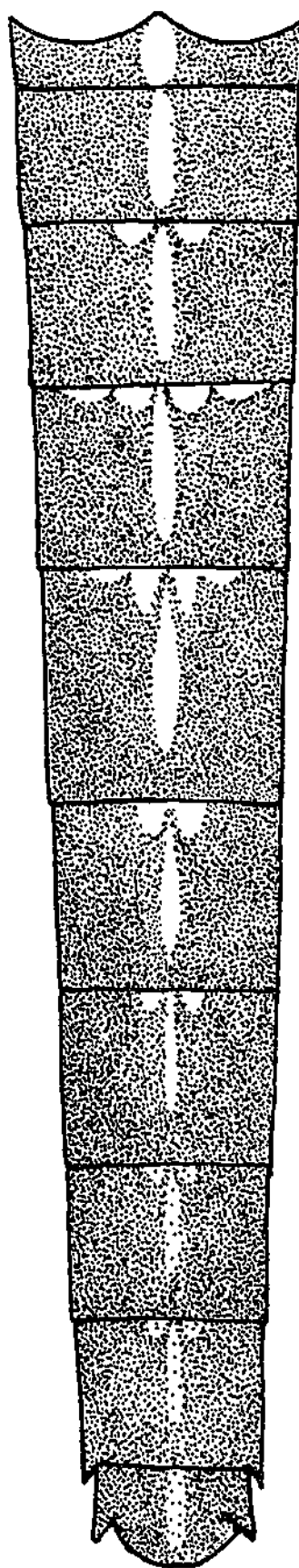
Fig. 183. *Thraulophlebia lucida*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

184
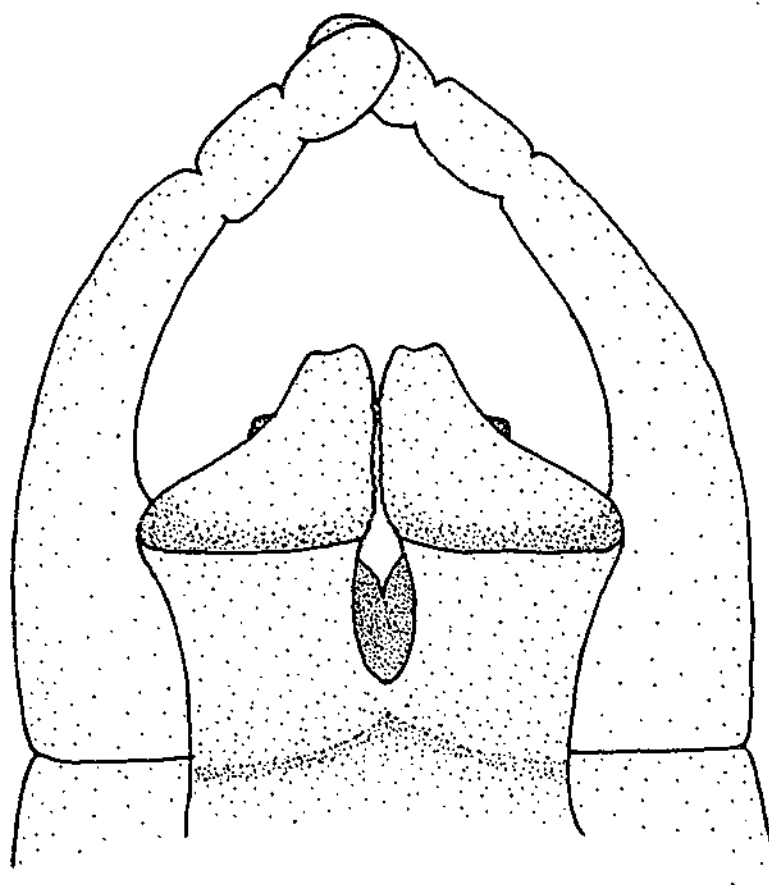
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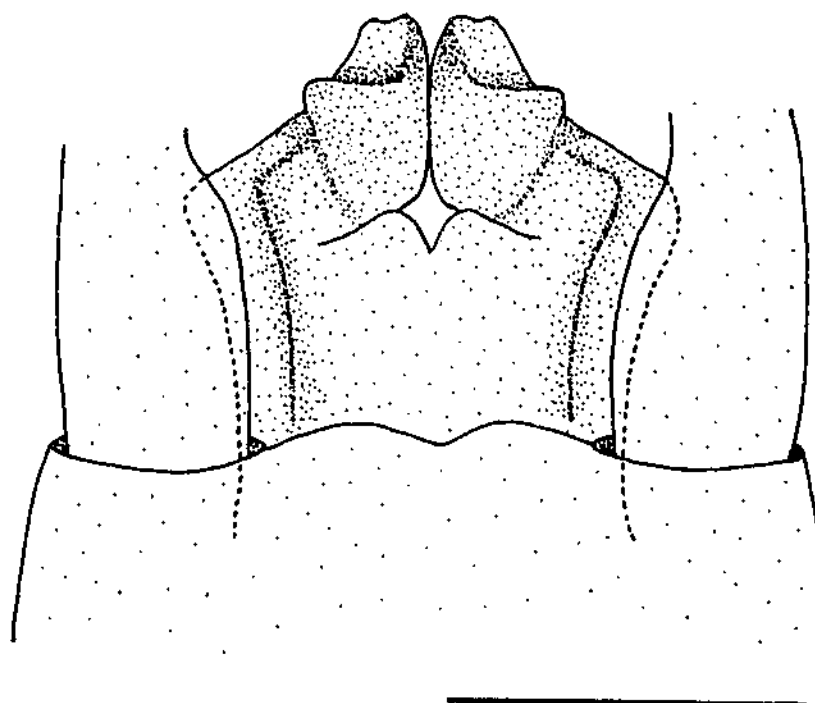
Figs. 184-185. *Thraulophlebia lucida*, male imago.
Scale bar = 200µm.

Fig. 184. Dorsal view of genitalia showing penes and forceps.
Fig. 185. Ventral view of genitalia showing penes.
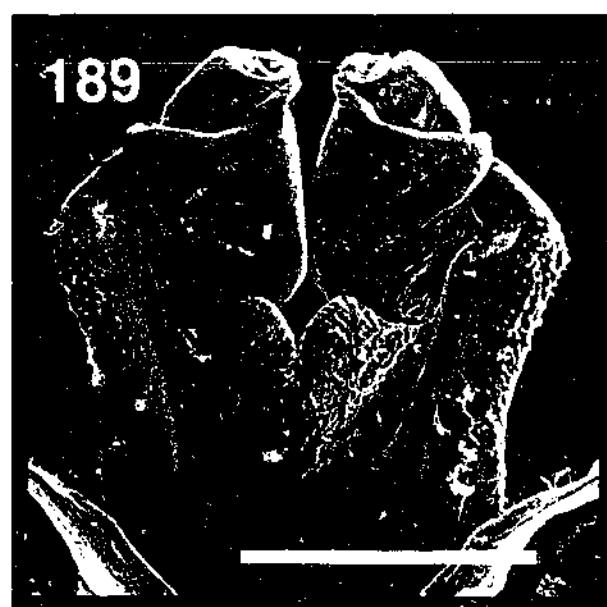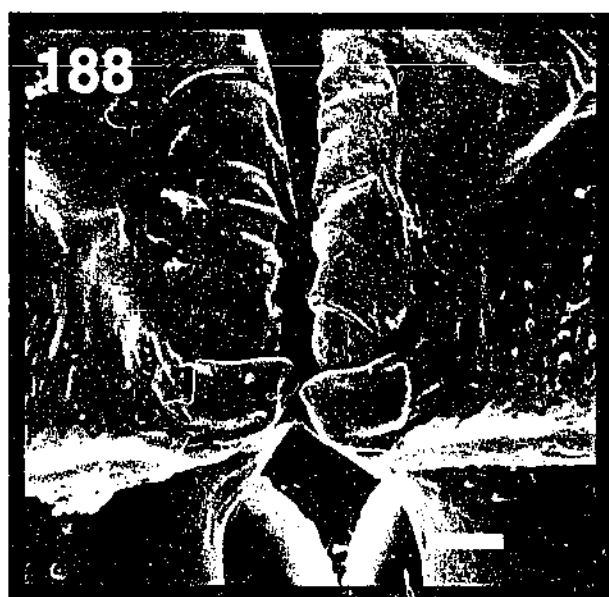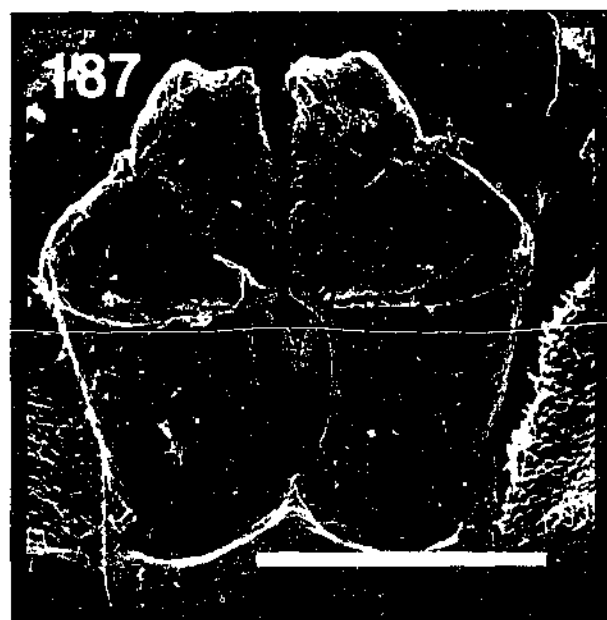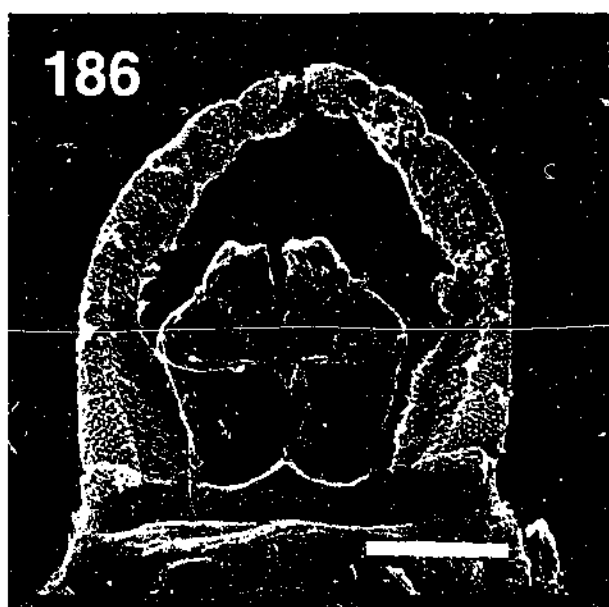
Figs. 186-189. *Thraulophlebia lucida*, male imago.

Individual from Gulf Stream, Grampians National Park, Victoria (00122001).

Fig. 186. Dorsal view of genitalia showing penes and forceps. Scale bar = 100µm
Fig. 187. Dorsal view of penes. Scale bar = 100µm.
Fig. 188. Dorsal view of teeth on subapical lobes of penes. Scale bar = 10µm.
Fig. 189. Ventral view of penes. Scale bar = 100µm.
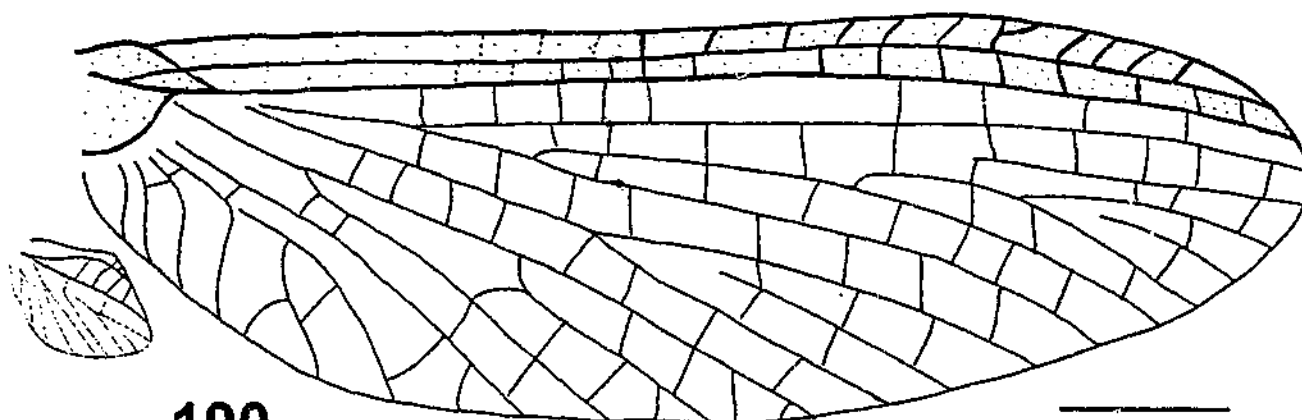
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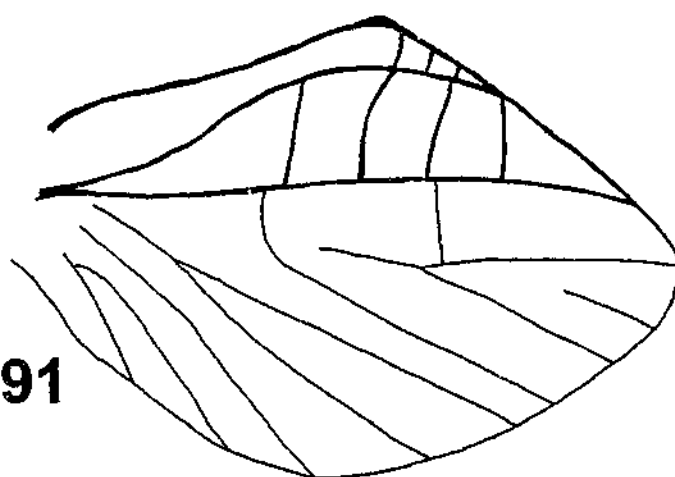
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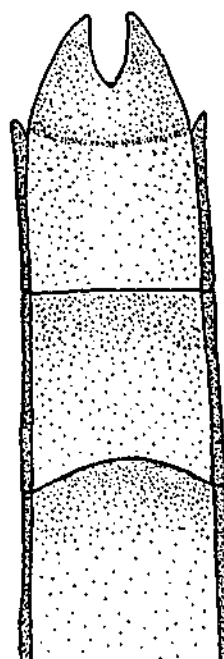
192

Figs. 190-192. *Thraulophlebia lucida,* female imago.

Fig. 190. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 191. Hindwing. Scale bar = 500µm.
Fig. 192. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.
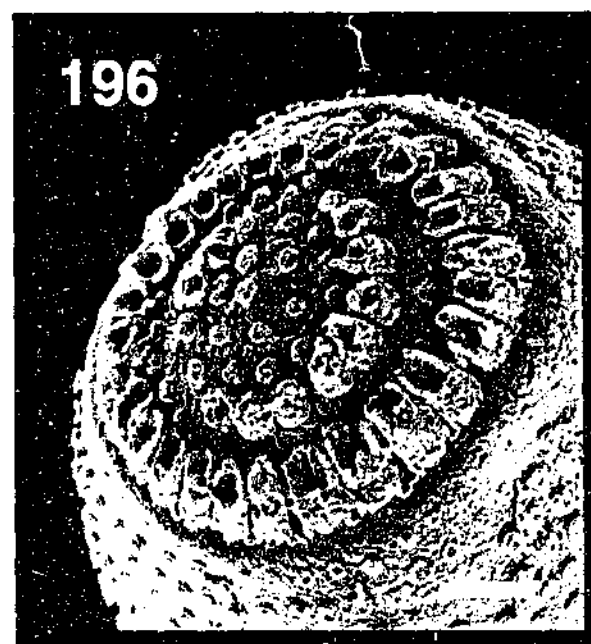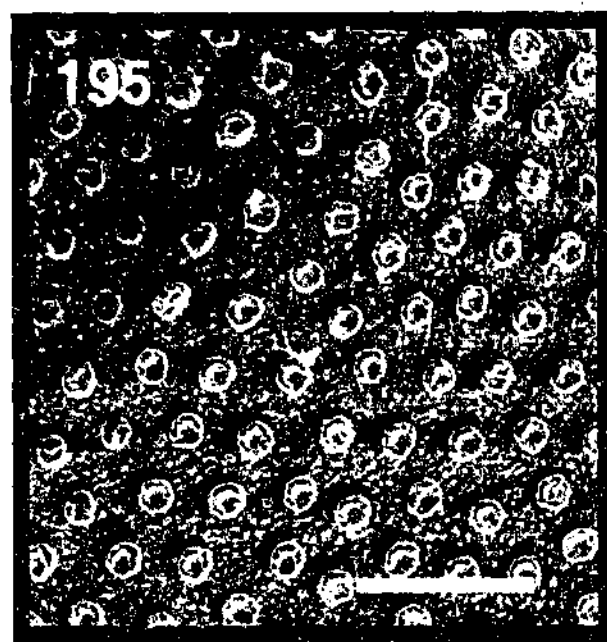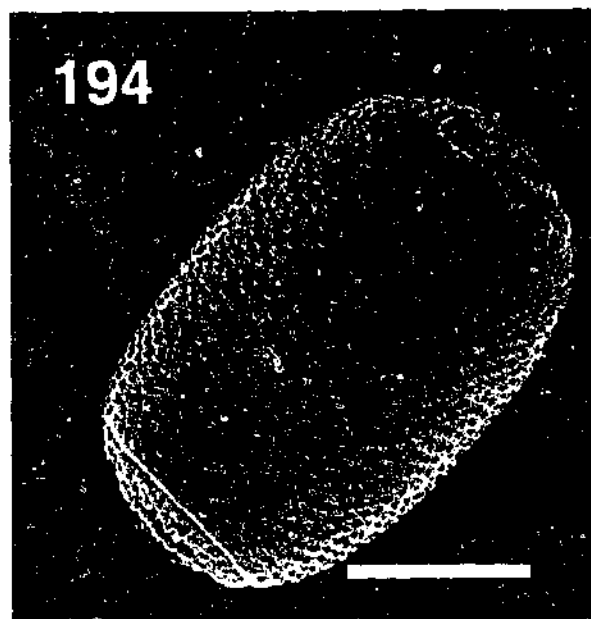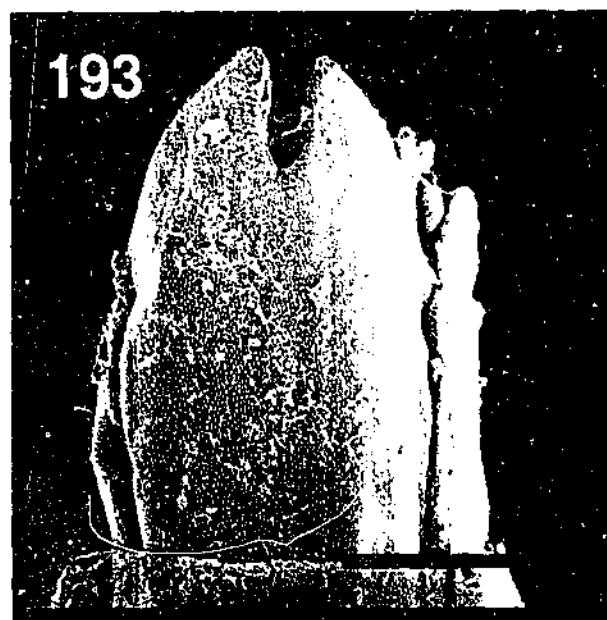
Figs. 193-196. *Thraulophlebia lucida*, female imago.

Fig. 193. Ventral view of abdomen showing sternite 9. Scale bar = 200μm.
Individual from Kangaroo Creek, near Daylesford, Victoria (97010901).

Fig. 194. Whole egg. Scale bar = 50μm.
Fig. 195. Close up of egg chorion. Scale bar = 10μm.
Fig. 196. Apical view of egg showing two rings of tubular projections. Scale bar = 10μm.
Individual from Gulf Stream, Grampians National Park, Victoria (00012201).
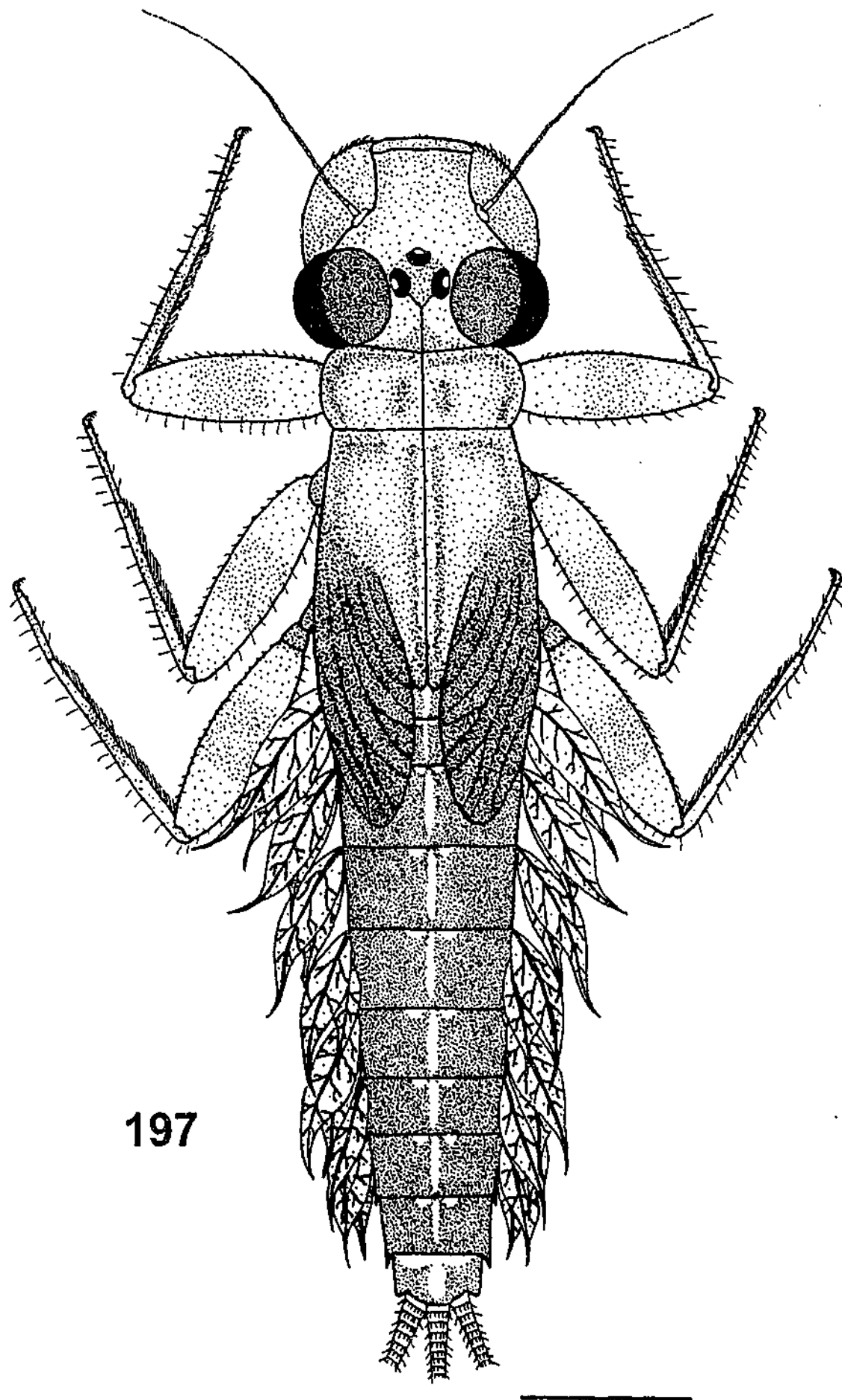
197

Fig. 197. *Thraulophlebia lucida*, male nymph.
Scale bar = 1mm.
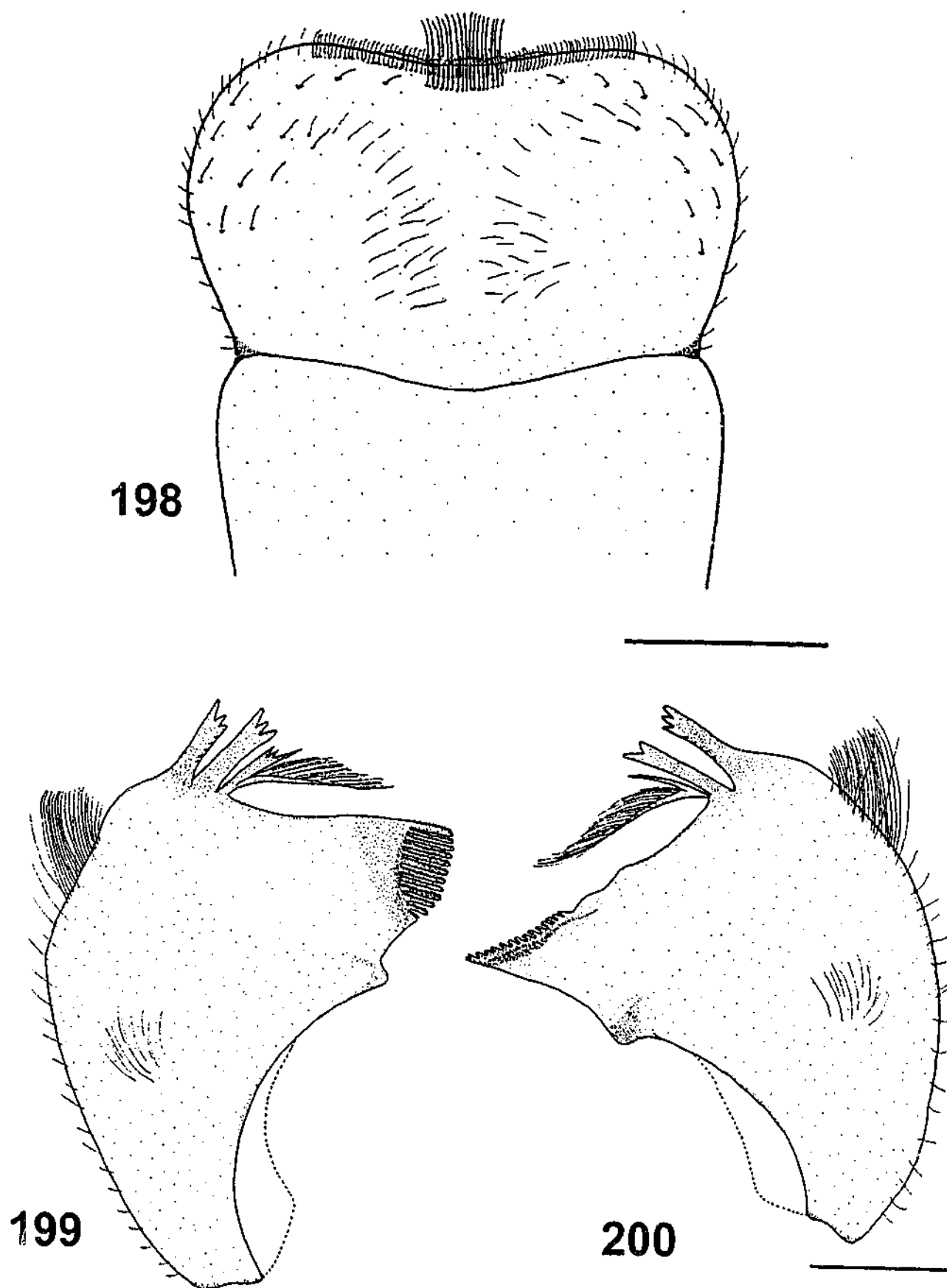
Figs. 198-200. *Thraulophlebia lucida,* nymph mouthparts.
Scale bars = 200μm.

Fig. 198. Labrum and clypeus.
Fig. 199. Left mandible.
Fig. 200. Right mandible.
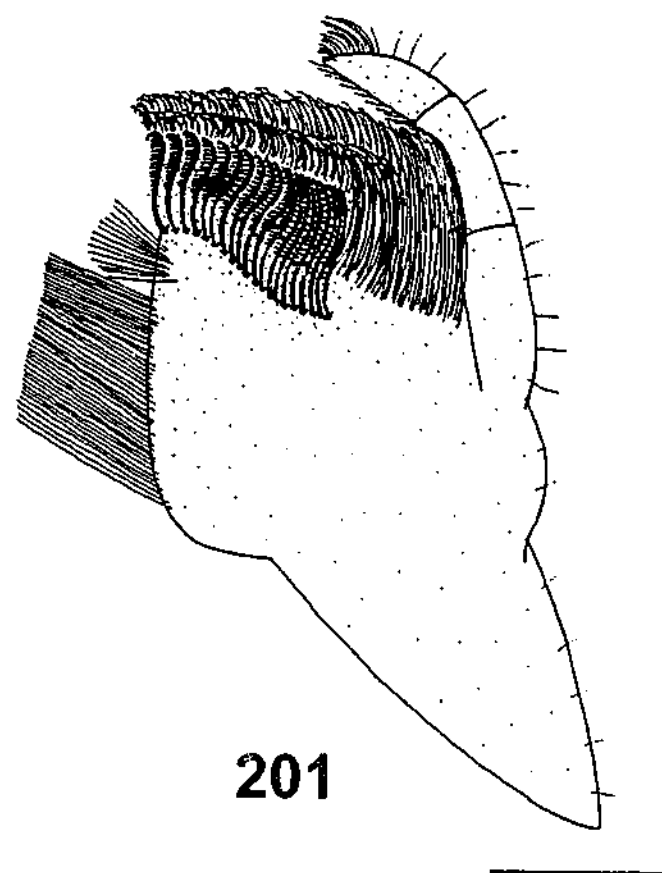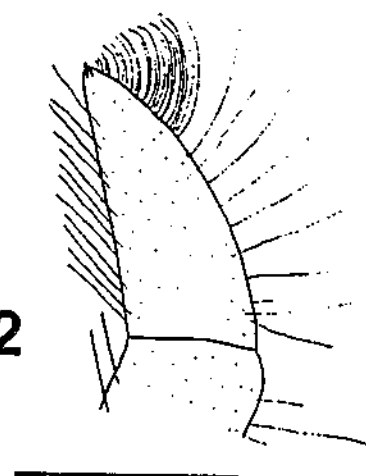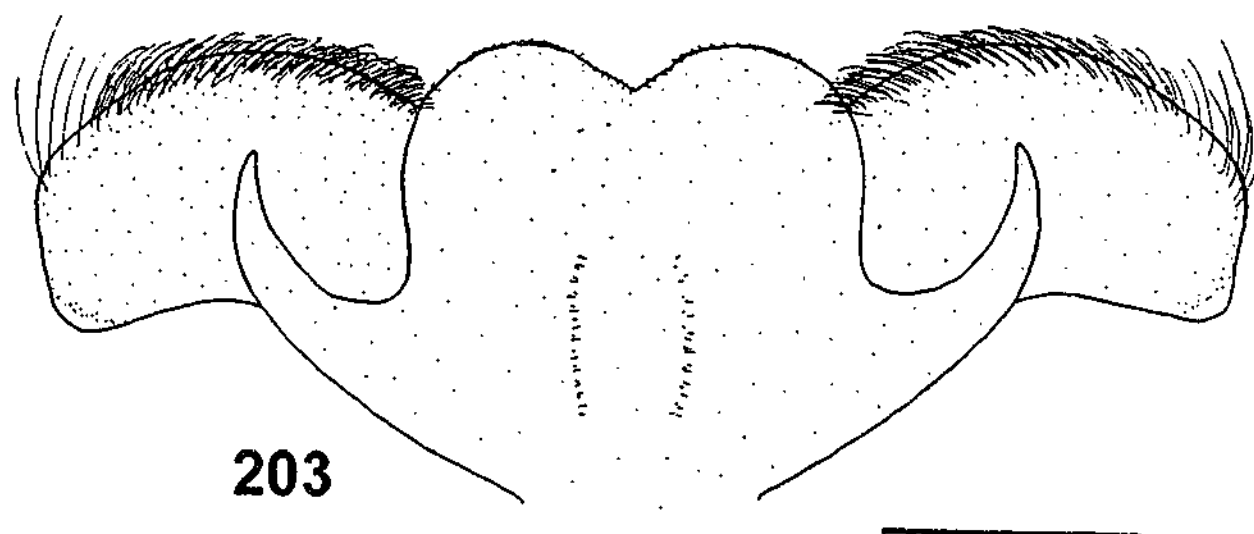
Figs. 201-203. *Thraulophlebia lucida*, nymph mouthparts.

Fig. 201. Right maxilla. Scale bar = 200μm.
Fig. 202. Terminal palp of maxilla showing apical spine. Scale bar = 100μm.
Fig. 203. Hypopharynx. Scale bar = 200μm.

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205
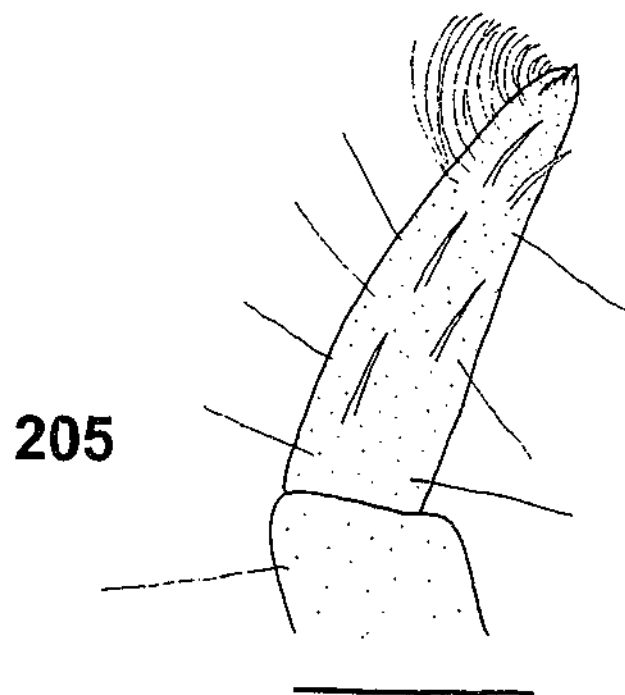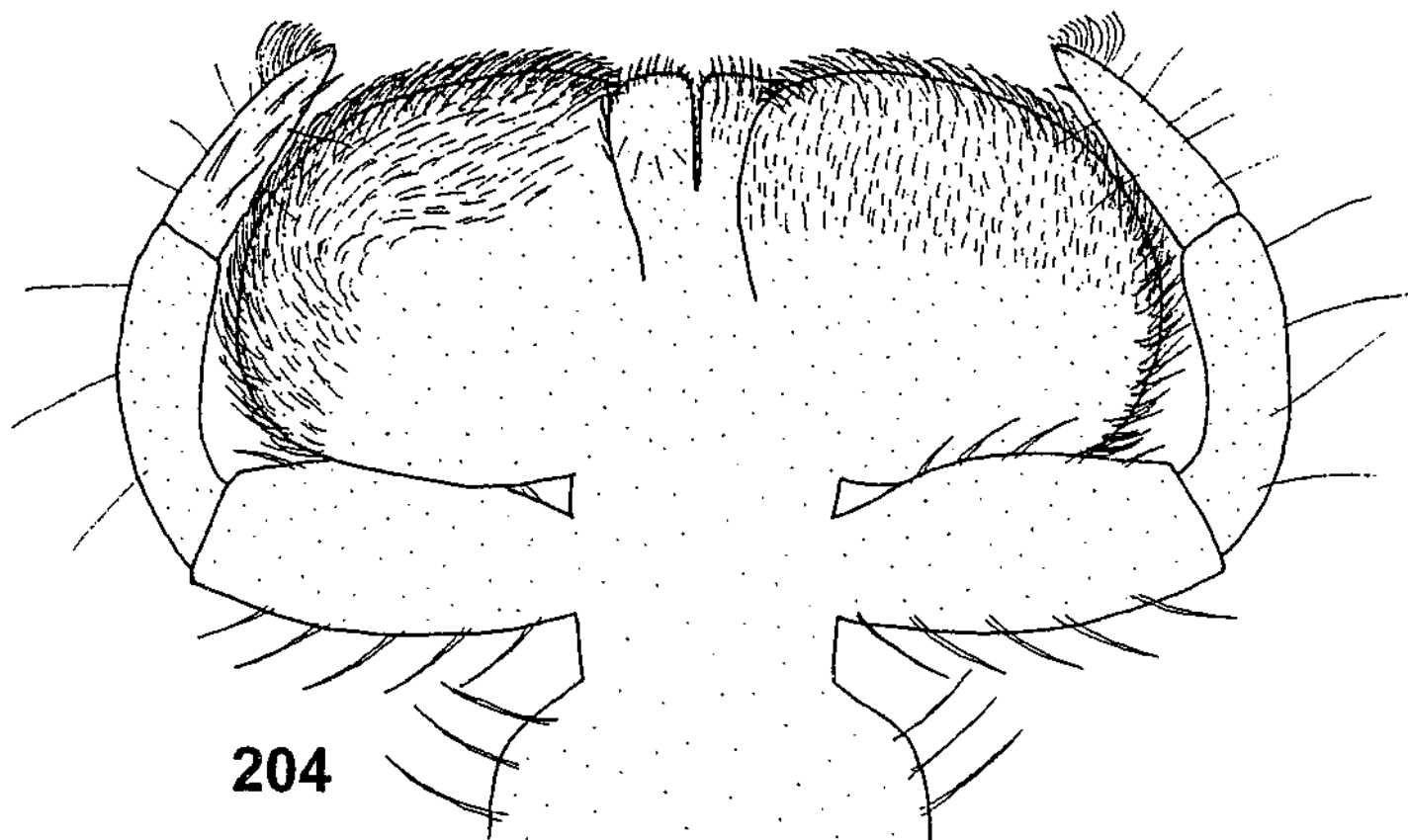
Figs. 204-205. *Thraulophlebia lucida*, nymph mouthparts.

Fig. 204. Labium. Scale bar = 200μm.
Fig. 205. Dorsal view of labial terminal palp showing apical spines.
Scale bar = 100μm.
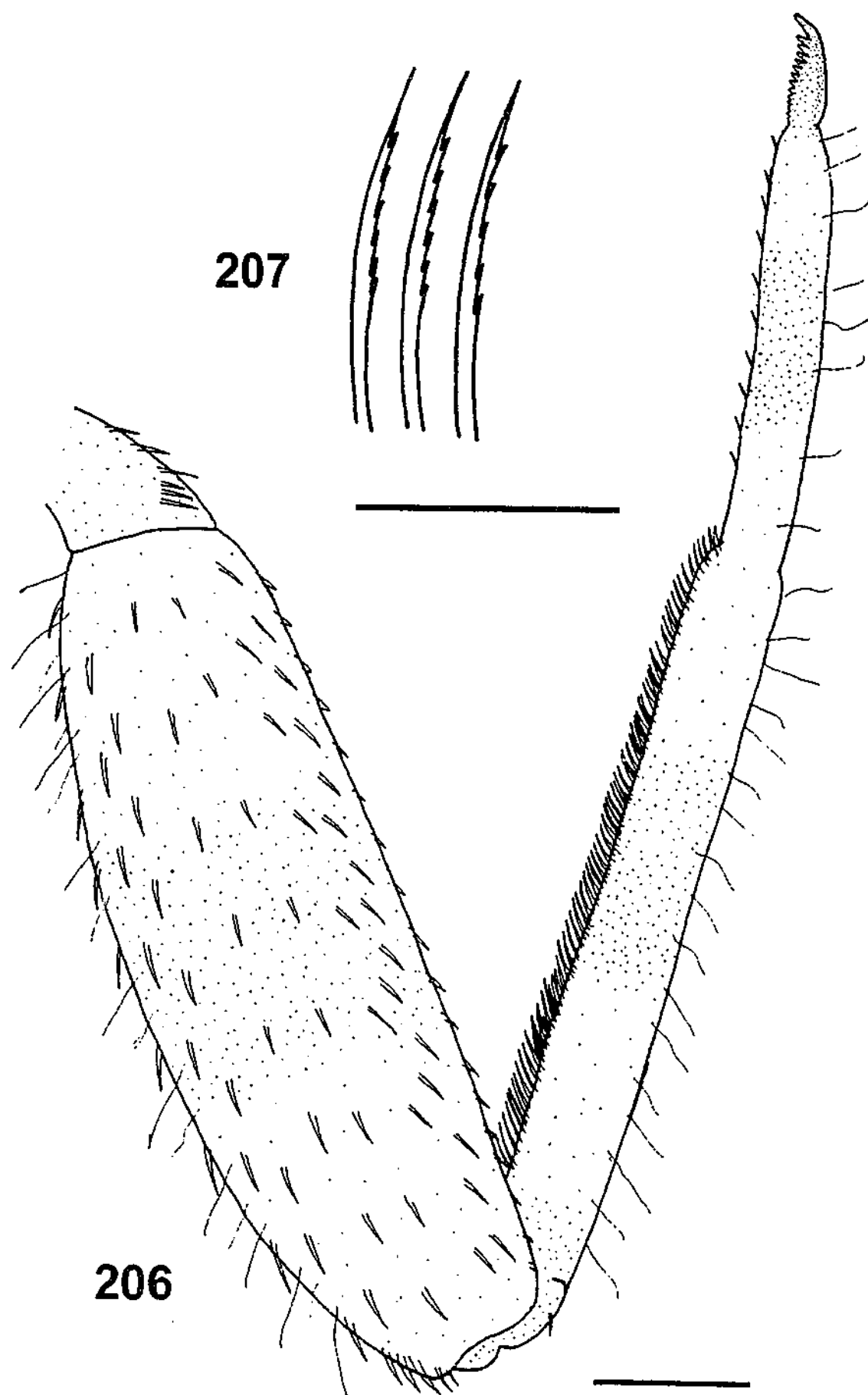
Figs. 206-207. *Thraulophlebia lucida,* nymph.

Fig. 206. Foreleg. Scale bar = 200µm.
Fig. 207. Fore tibial spines. Scale bar = 50µm.

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208
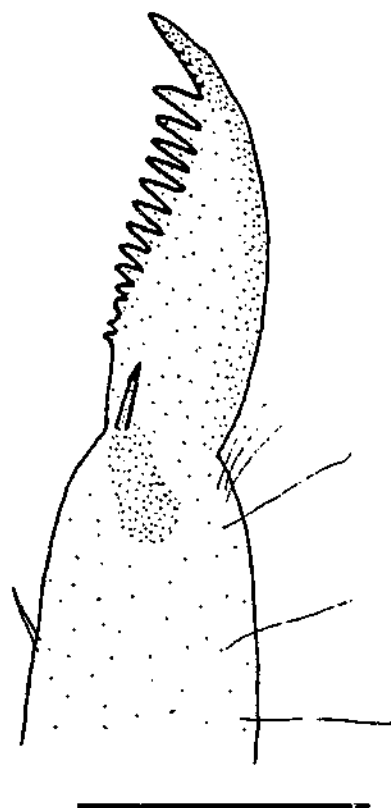
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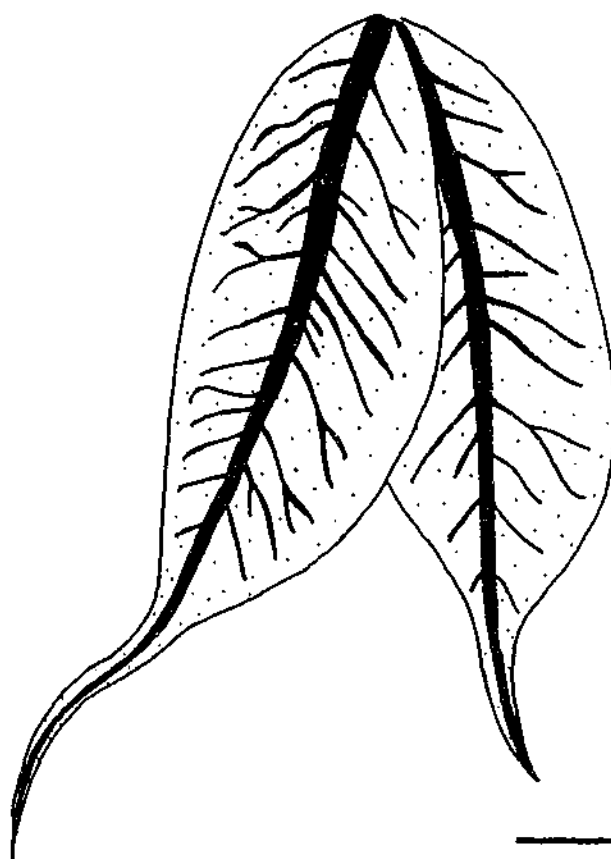
Figs. 208-209. *Thraulophlebia lucida*, nymph.
Scale bars = 100μm.

Fig. 208. Foreleg tarsal claw.
Fig. 209. Gills.

210
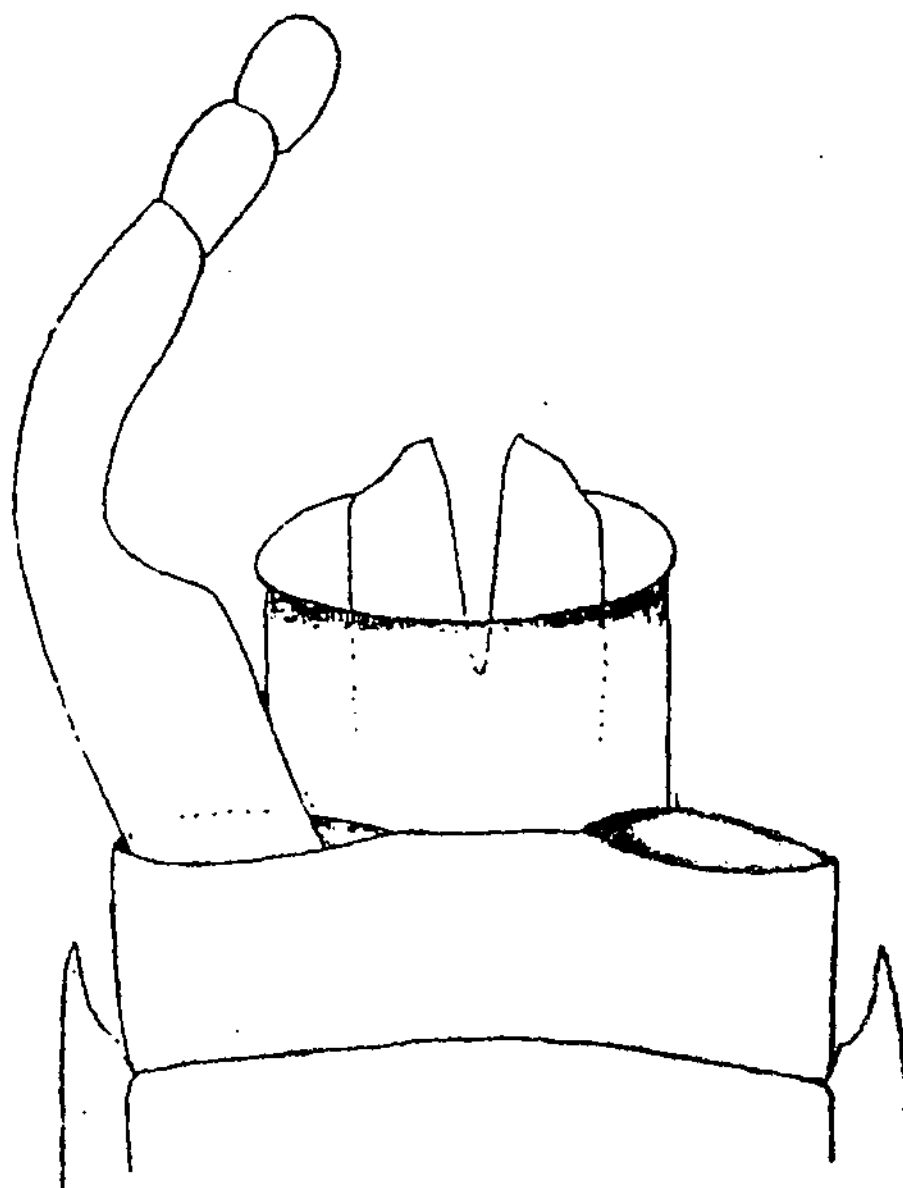
Fig. 210. *Atalophlebia lucida* Ulmer.

Ventral view of male genitalia.
Reproduction of a drawing from Ulmer (1919).

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211
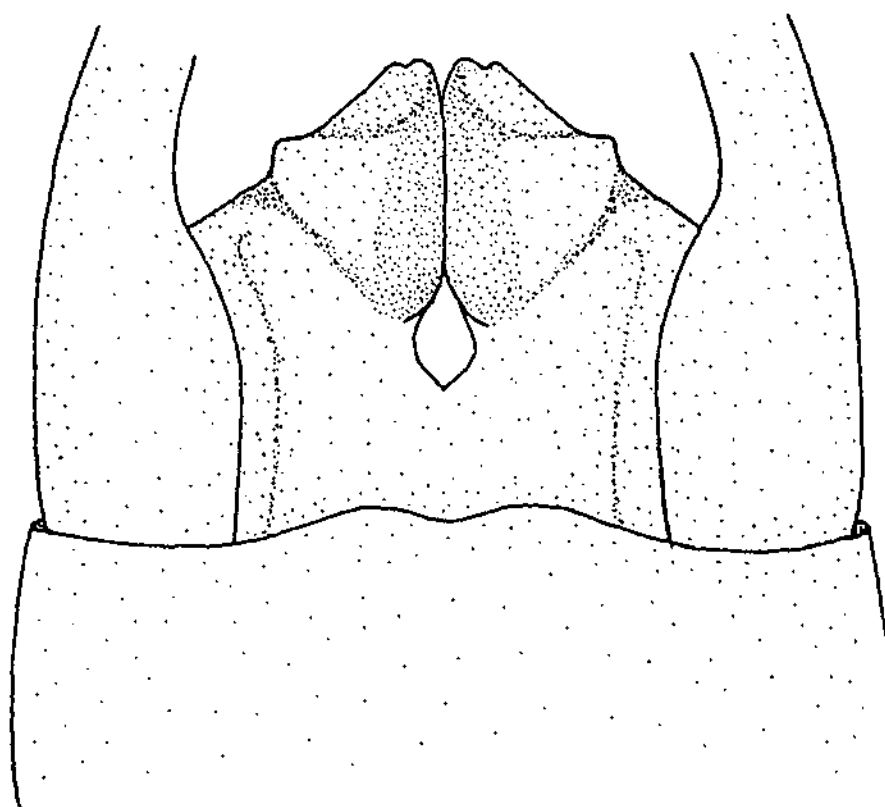
Fig. 211. *Nousia pilosa* Suter.

Ventral view of male imago genitalia. Drawn from temporary slide
mount of holotype. Specimen collected from Second Wannon River,
Victoria by D.N. & P.J. Suter, 25 xi 1977 (MV).
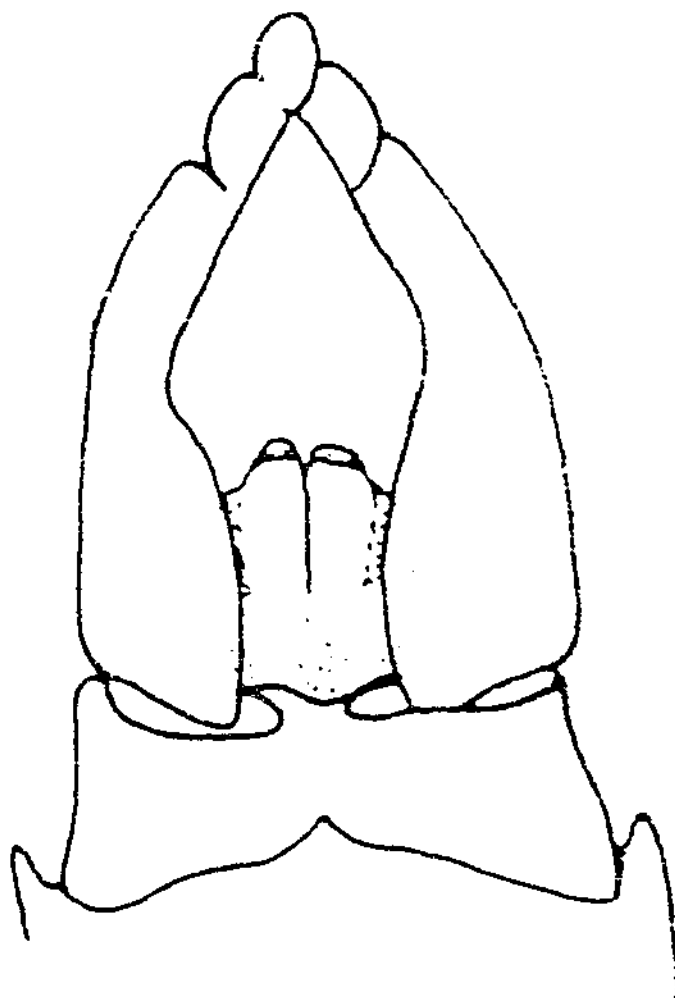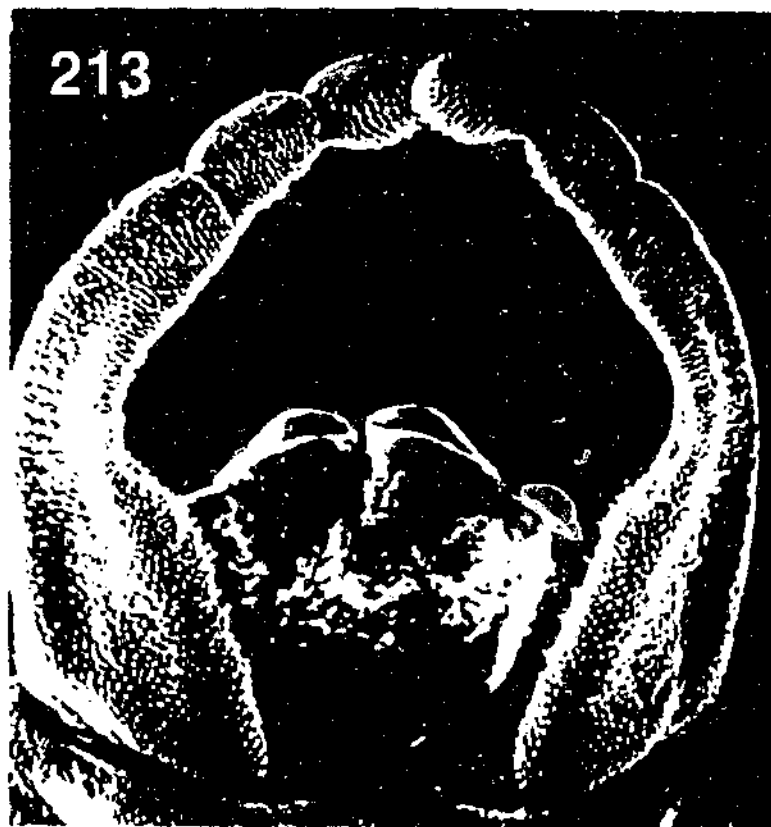
Figs. 212-213. *Nousia pilosa* Suter, male imago.

Ventral view of genitalia showing penes and forceps.
Reproduction of a drawing and an SEM from Suter (1986).

214
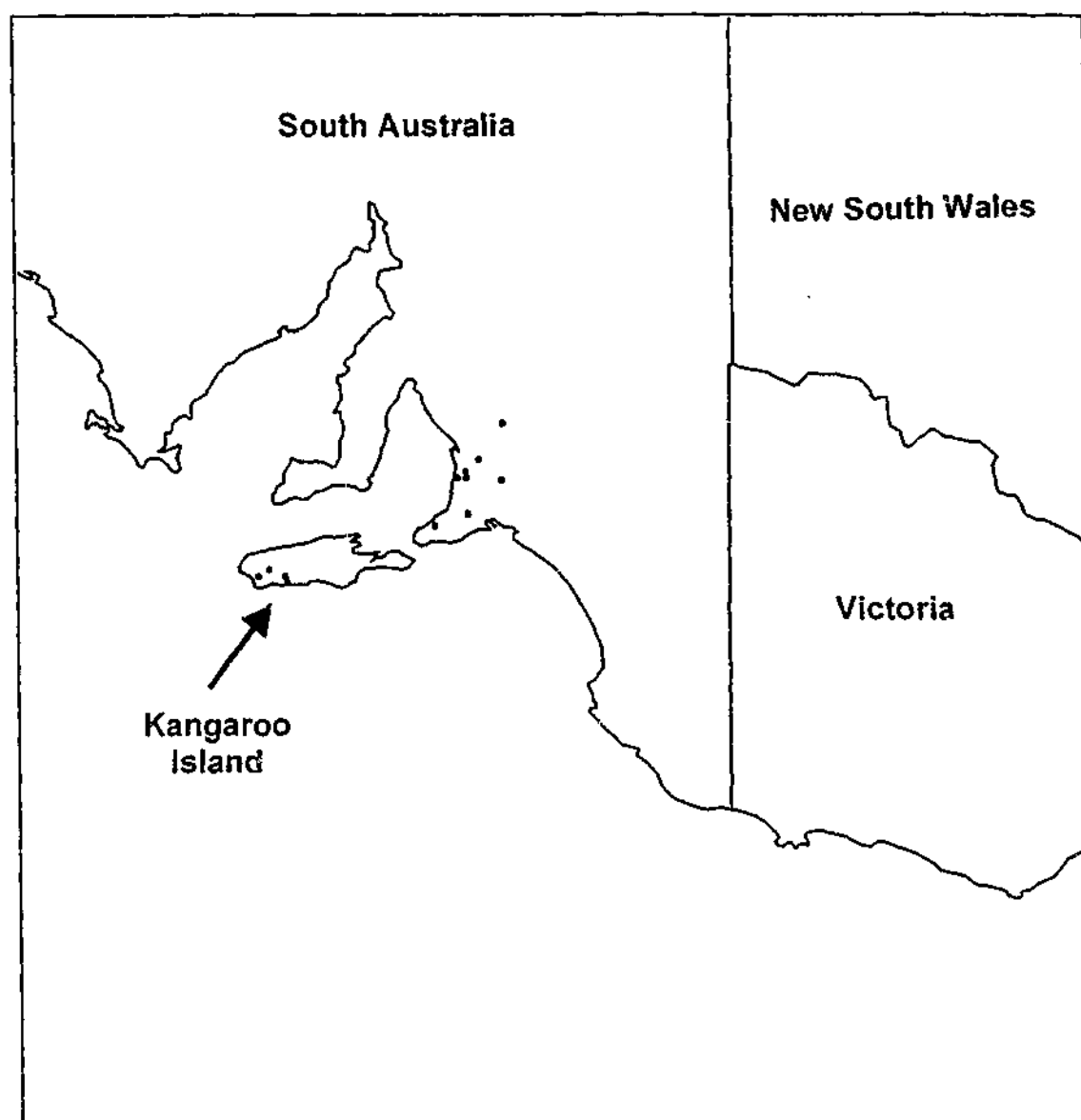
Fig. 214. Distribution of *Thraulophlebia inconspicua*.

215
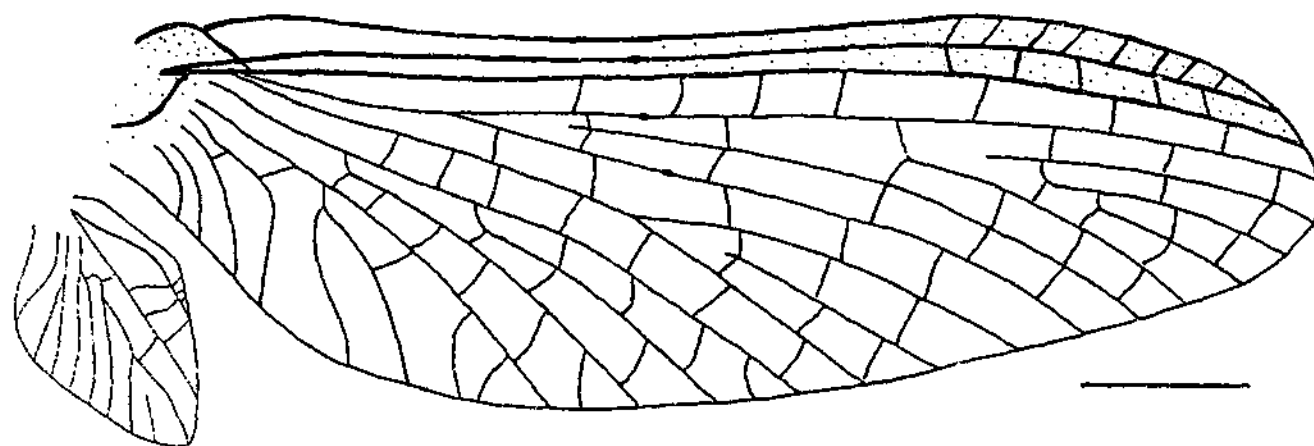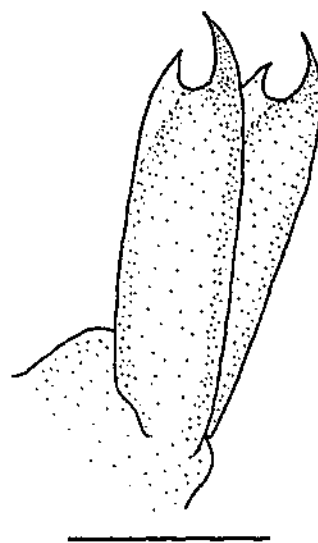
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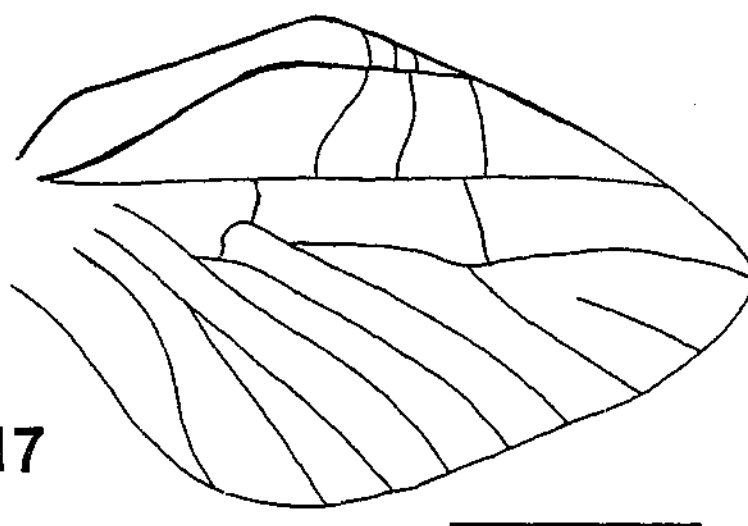
217

Figs. 215-217. *Thraulophlebia inconspicua*, male imago.

Fig. 215. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 216. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 217. Hindwing. Scale bar = 500µm.

218
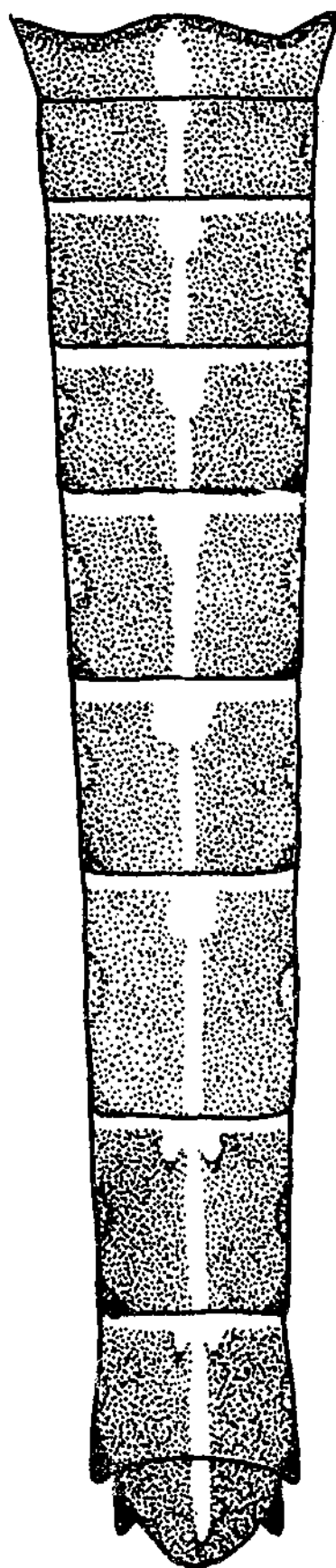
Fig. 218. *Thraulophlebia inconspicua*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

219
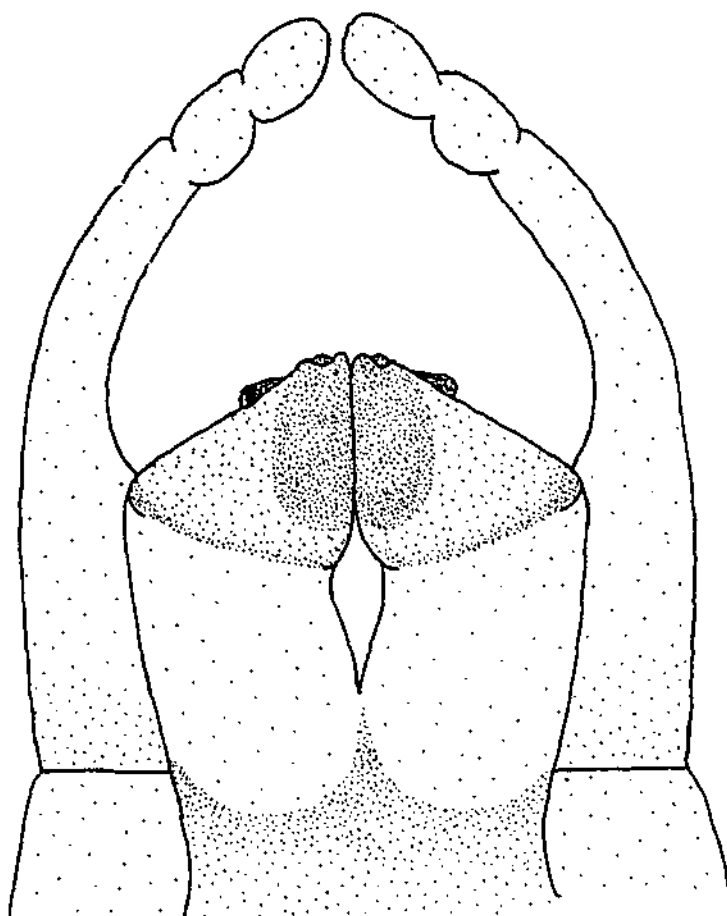
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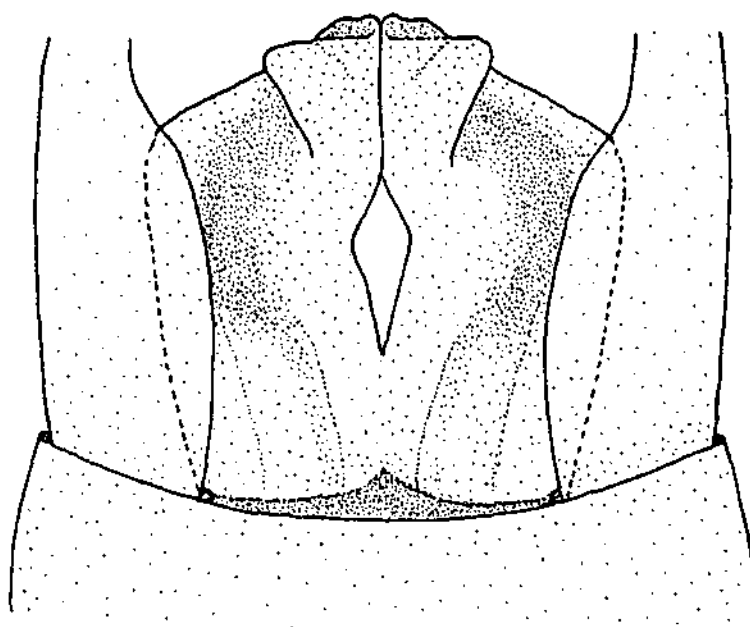
Figs. 219-220. *Thraulophlebia inconspicua*, male imago.
Scale bar = 200μm.

Fig. 219. Dorsal view of genitalia showing penes and forceps.
Fig. 220. Ventral view of genitalia showing penes.
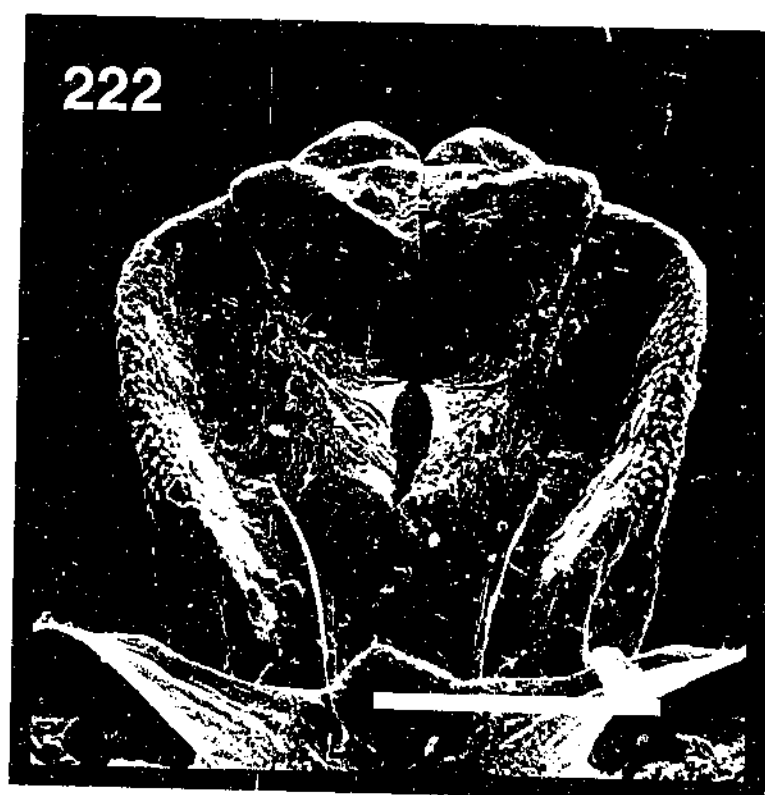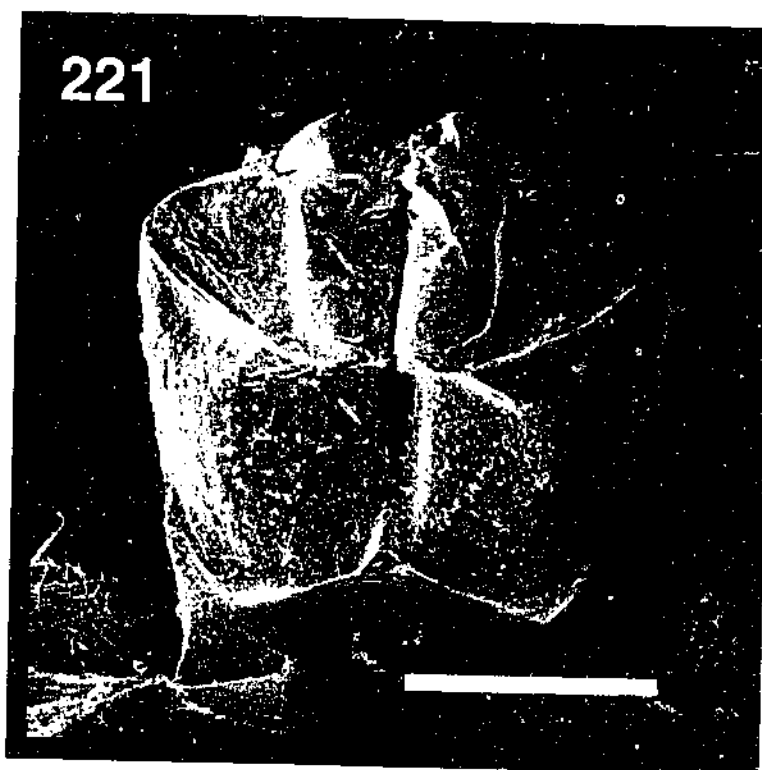
Figs. 221-222. *Thraulophlebia inconspicua*, male imago.

Individual from Sturt River, Coramandel Valley, South Australia (76042900).
Scale bars = 100µm.

Fig. 221. Dorsal view of penes.
Fig. 222. Ventral view of penes.
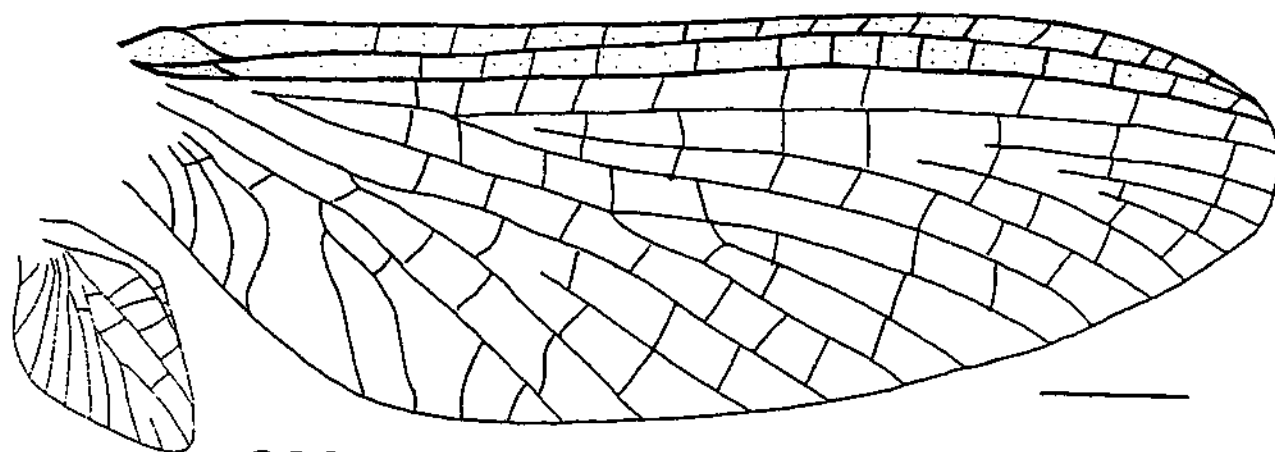
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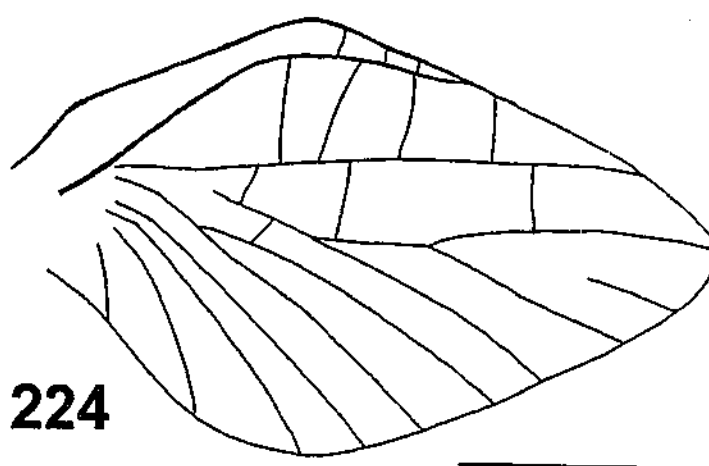
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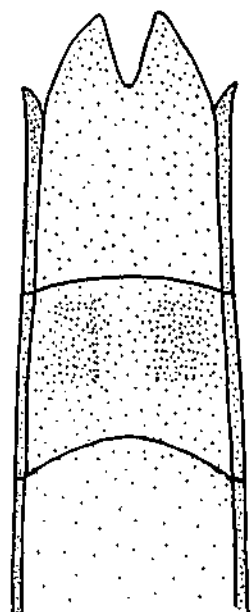
225

Figs. 223-225. *Thraulophlebia inconspicua*, female imago.

Fig. 223. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 224. Hindwing. Scale bar = 500µm.
Fig. 225. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.
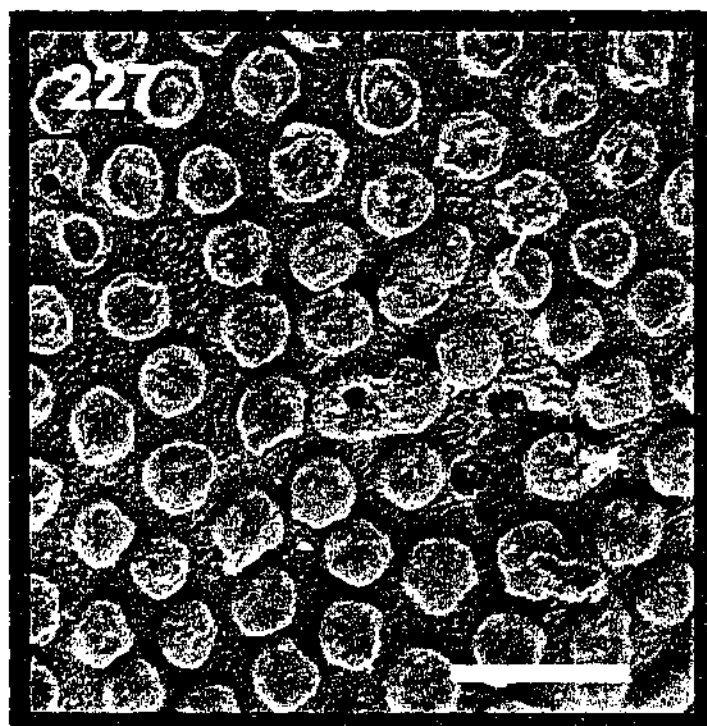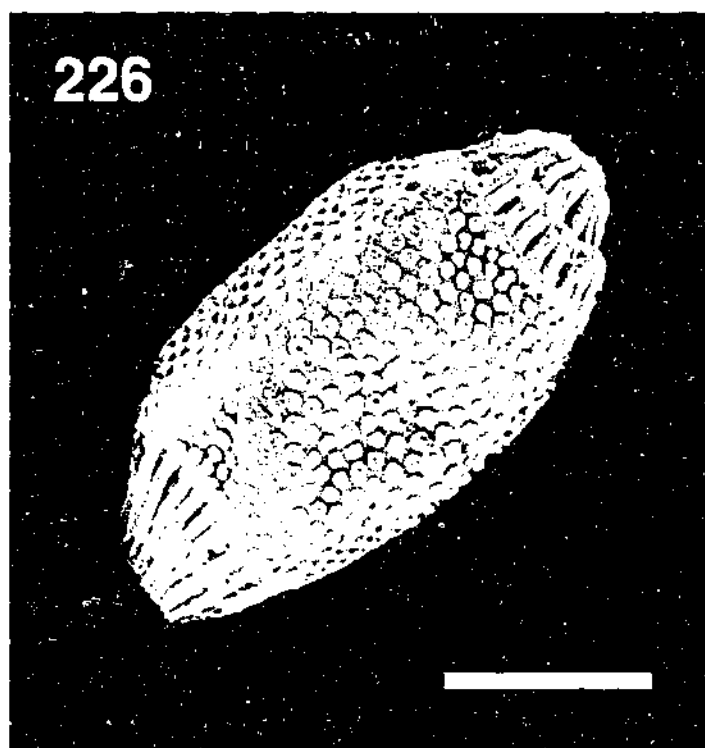
Figs. 226-227. *Thraulophlebia inconspicua*, eggs taken from female imago.

Individual from Sturt River, Coramandel Valley, South Australia (76042900).

Fig. 226. Whole egg. Scale bar = 50μm.
Fig. 227. Close up of egg chorion. Scale bar = 10μm.
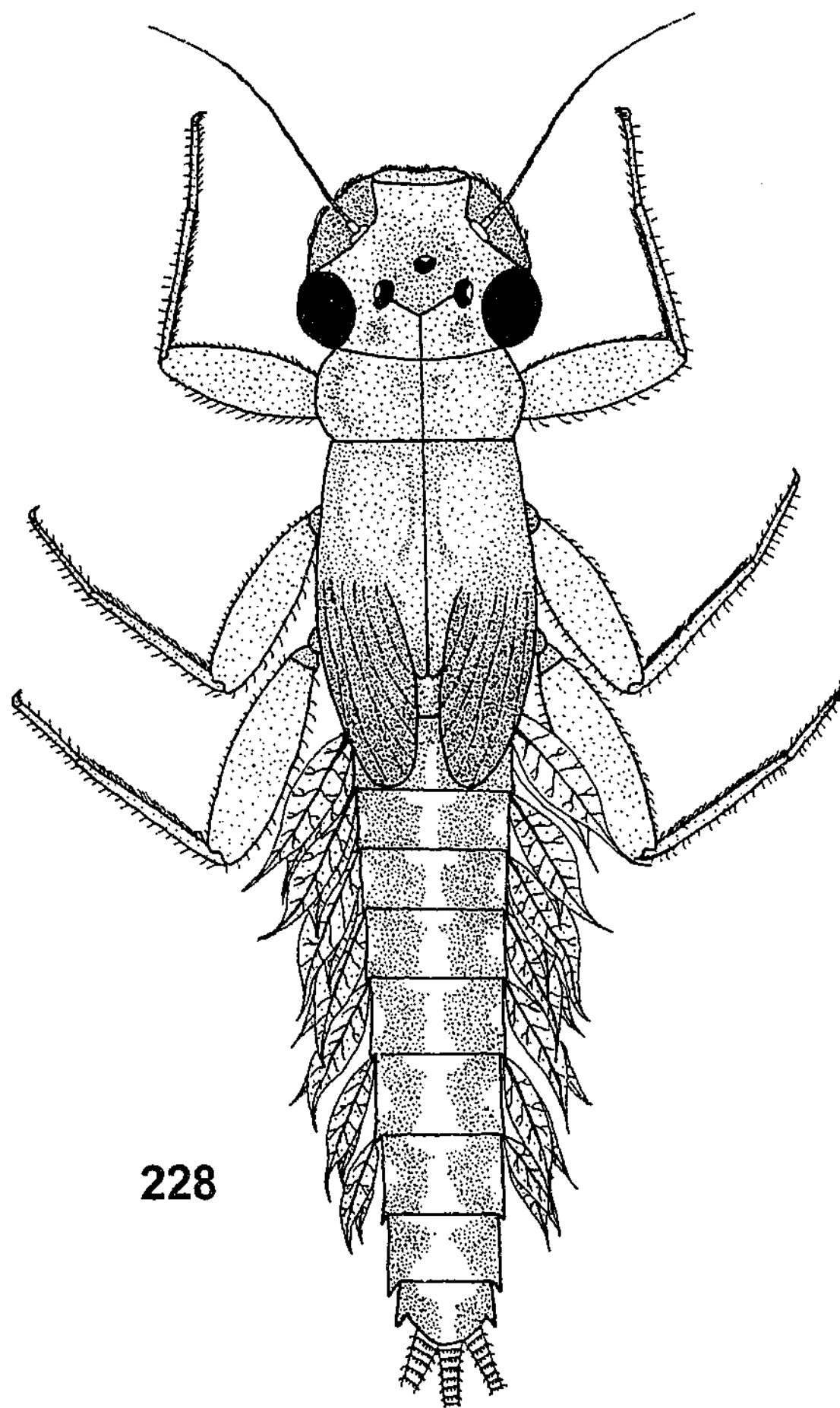
228

Fig. 228. *Thraulophlebia inconspicua*, female nymph.
Scale bar = 1mm.
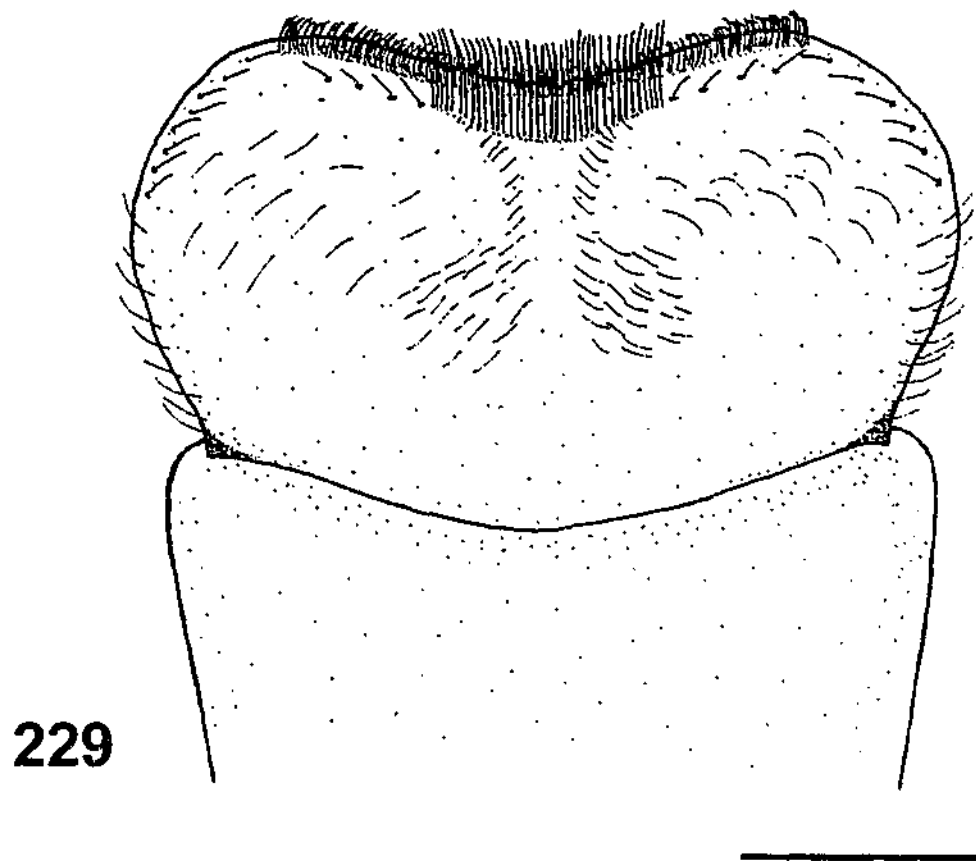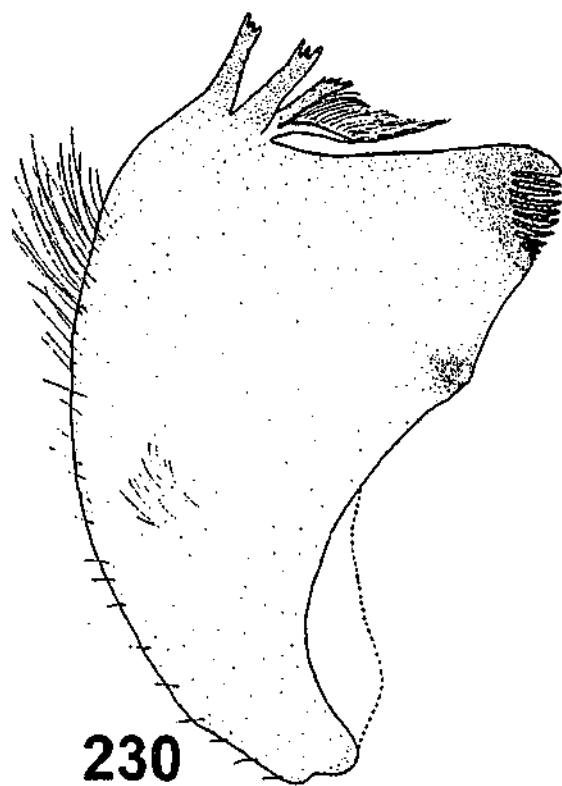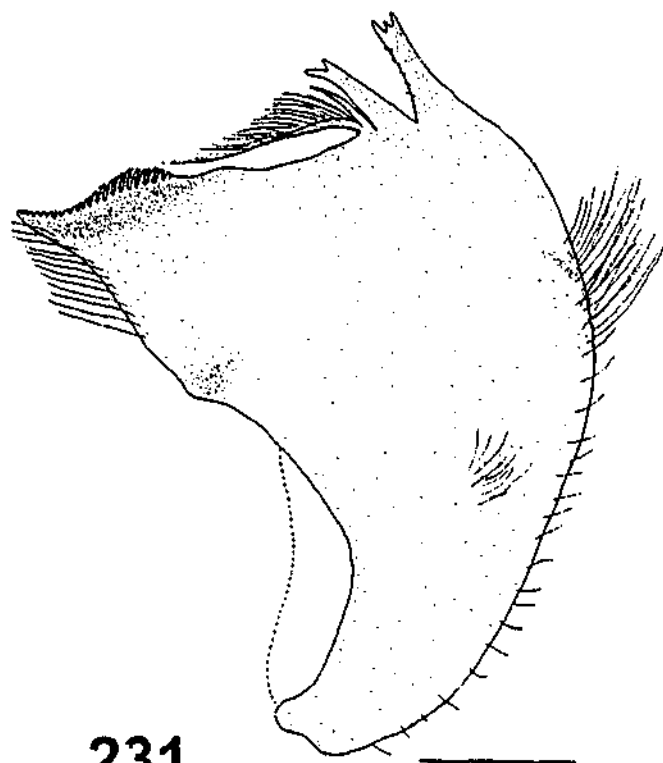
Figs. 229-231. *Thraulophlebia inconspicua*, nymph mouthparts.
Scale bars = 200μm.

Fig. 229. Labrum and clypeus.
Fig. 230. Left mandible.
Fig 231. Right mandible.

124
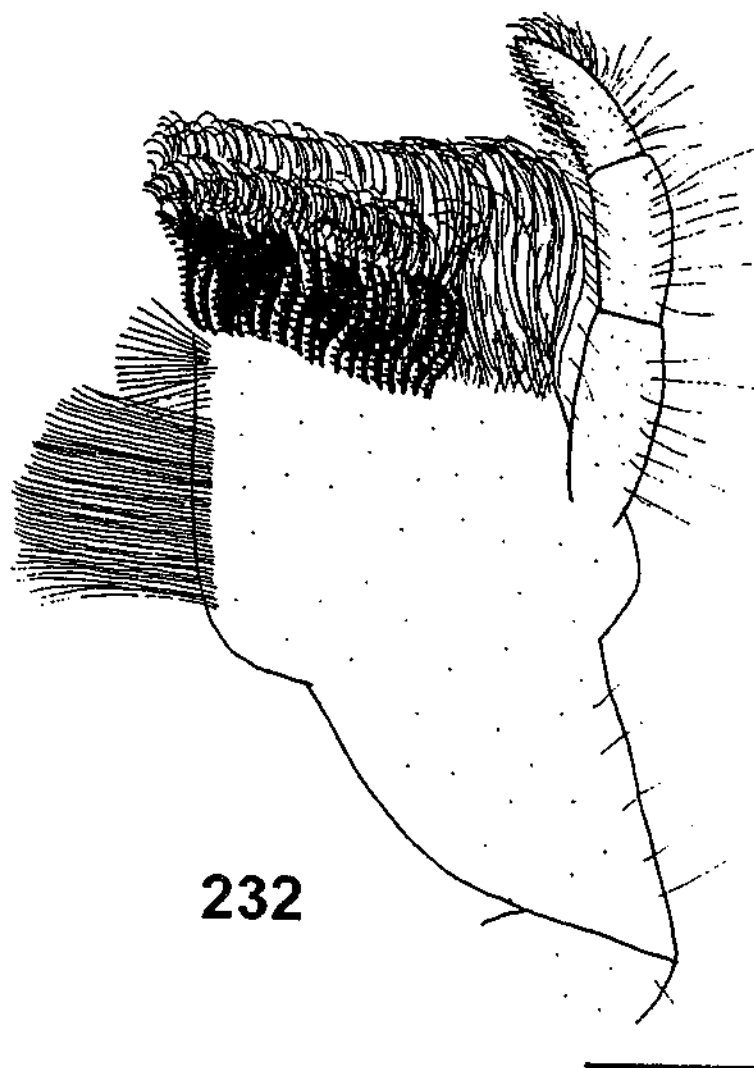
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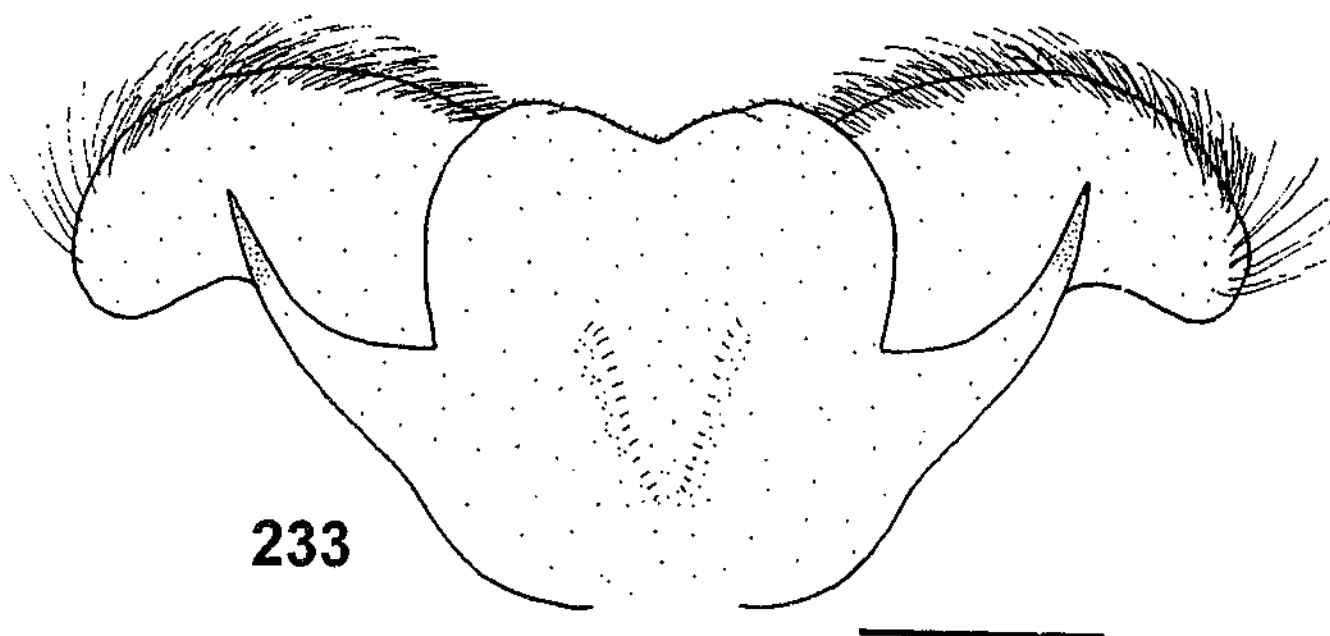
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Figs. 232-233. *Thraulophlebia inconspicua*, nymph mouthparts.
Scale bars = 200μm.

Fig. 232. Right maxilla.
Fig. 233. Hypopharynx.
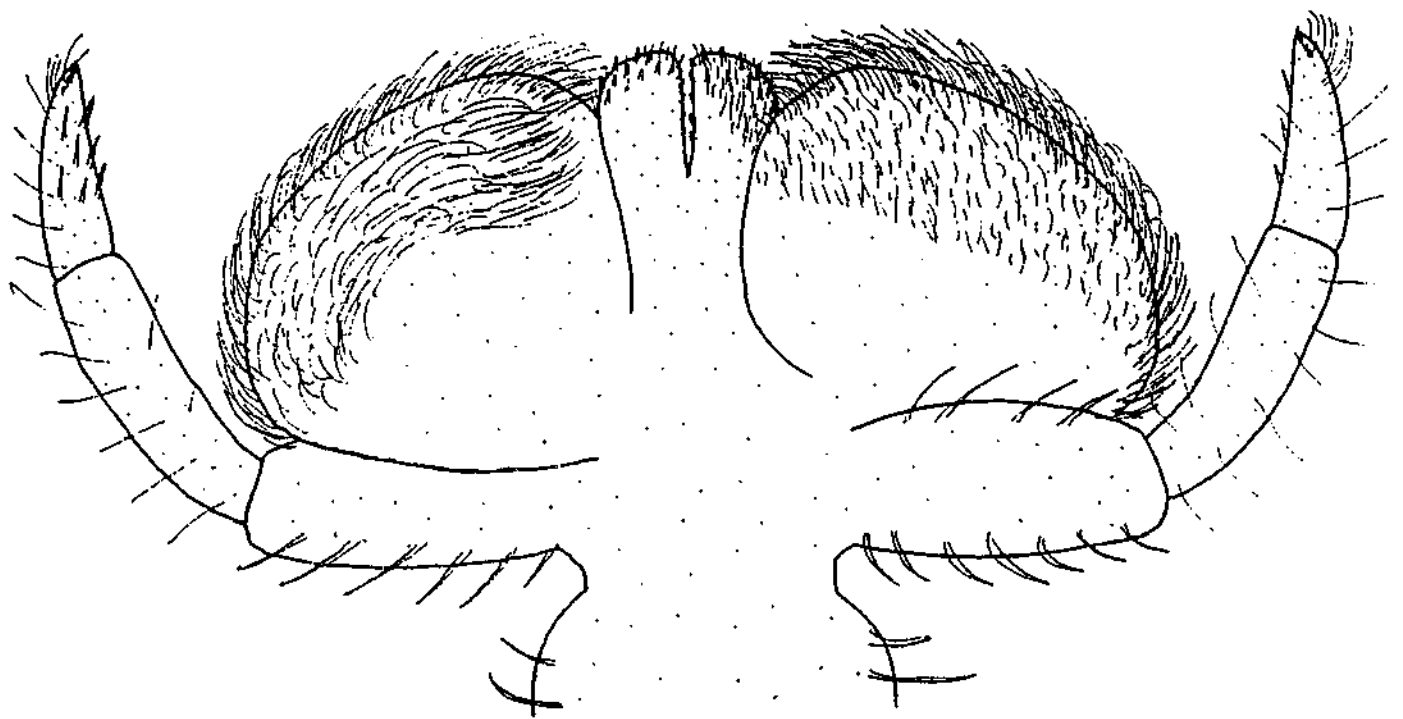
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Fig. 234. *Thraulophlebia inconspicua*, nymph mouthpart.

Labium. Scale bar = 200μm.

235
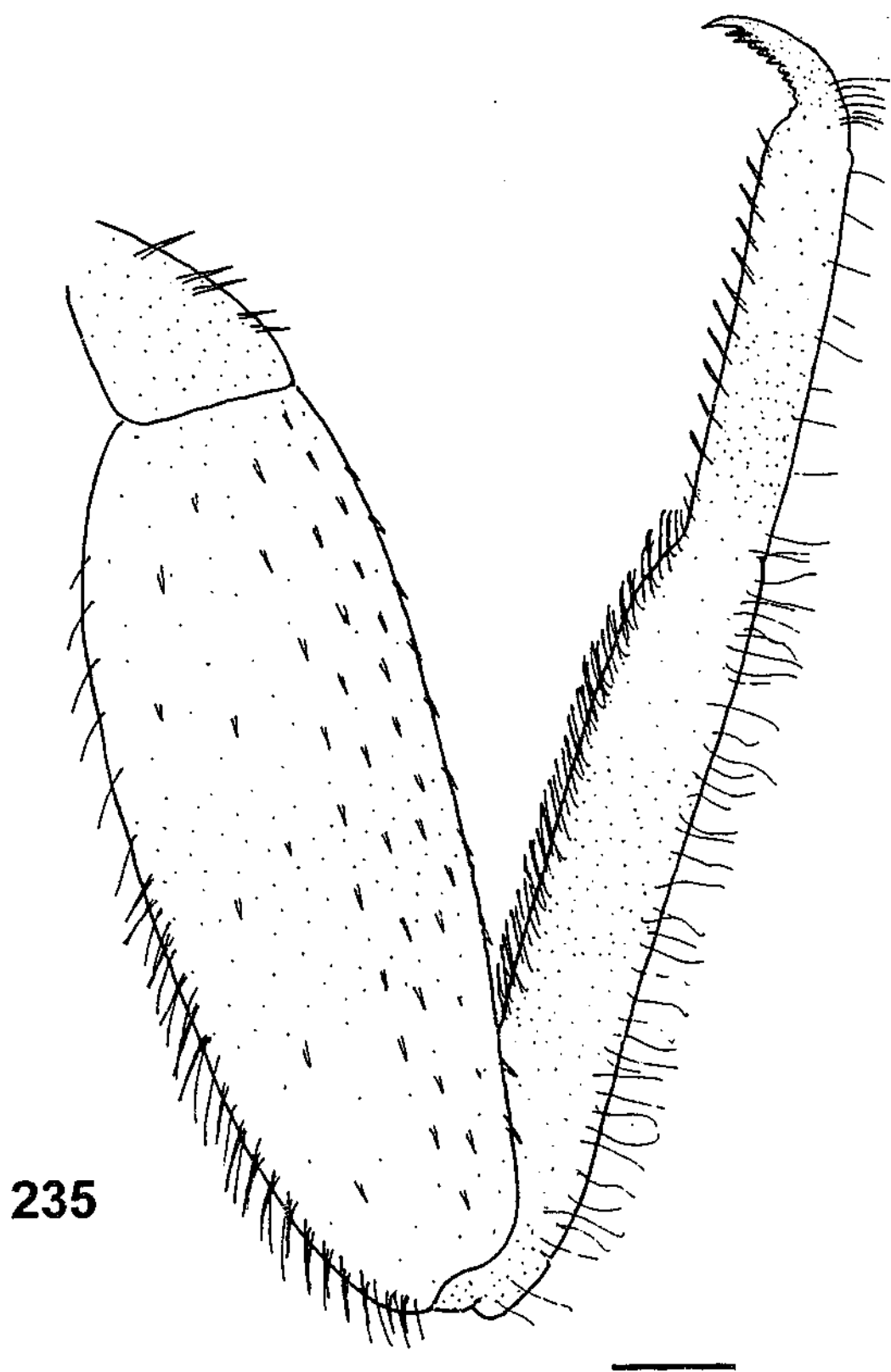
Fig. 235. *Thraulophlebia inconspicua*, nymph.

Foreleg. Scale bar = 200μm.
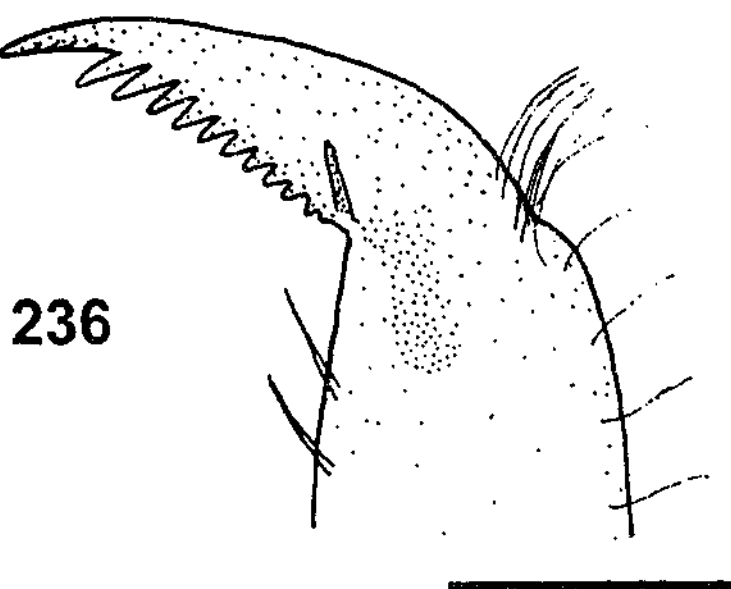
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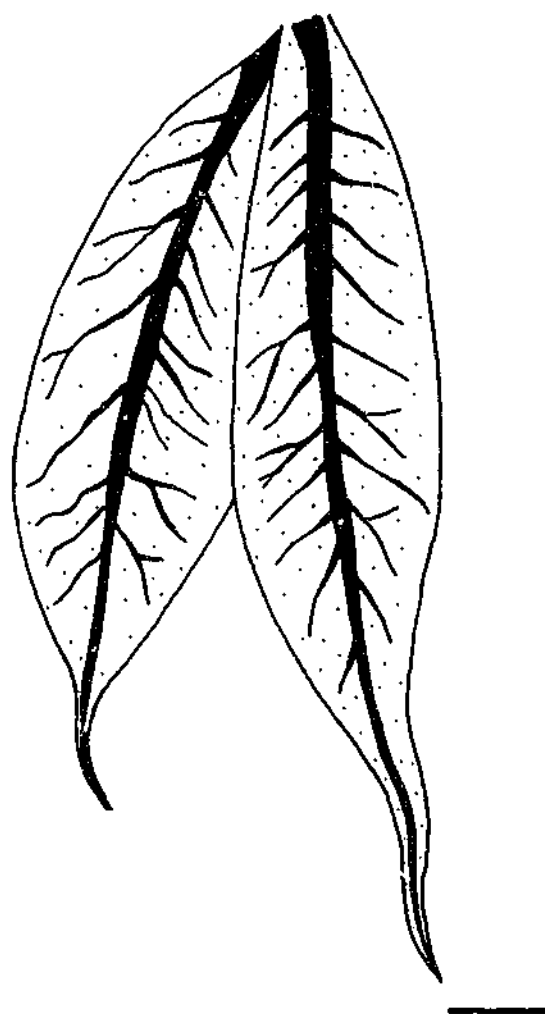
237

Figs. 236-237. *Thraulophlebia inconspicua*, nymph.
Scale bar = 100µm.

Fig. 236. Foreleg tarsal claw.
Fig. 237. Gills.

238

239
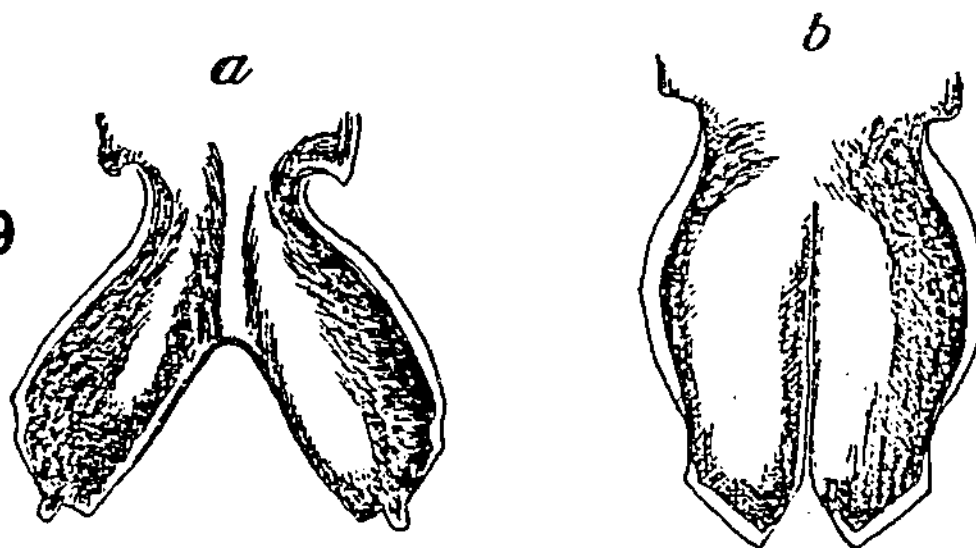
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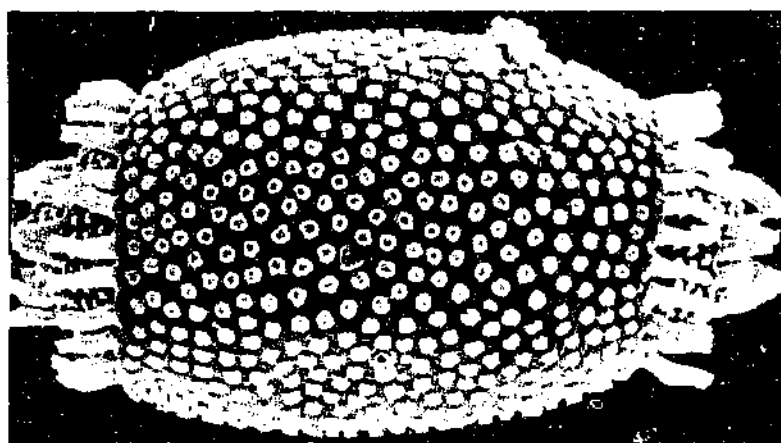
Fig. 238. *Nousia inconspicua* (Eaton).
Ventral view of male imago penes.
Reproduction of an SEM from Suter (1986).

Fig. 239. *Atalophlebia inconspicua* (Eaton).
Ventral view of male imago penes.
a) penes divided through drying process, b) penes in natural state.
Reproduction of a drawing from Ulmer (1908).

Fig. 240. *Koorrnonga inconspicua* (Eaton).
Egg from female imago.
Reproduction of an SEM from Campbell and Suter (1988).

241
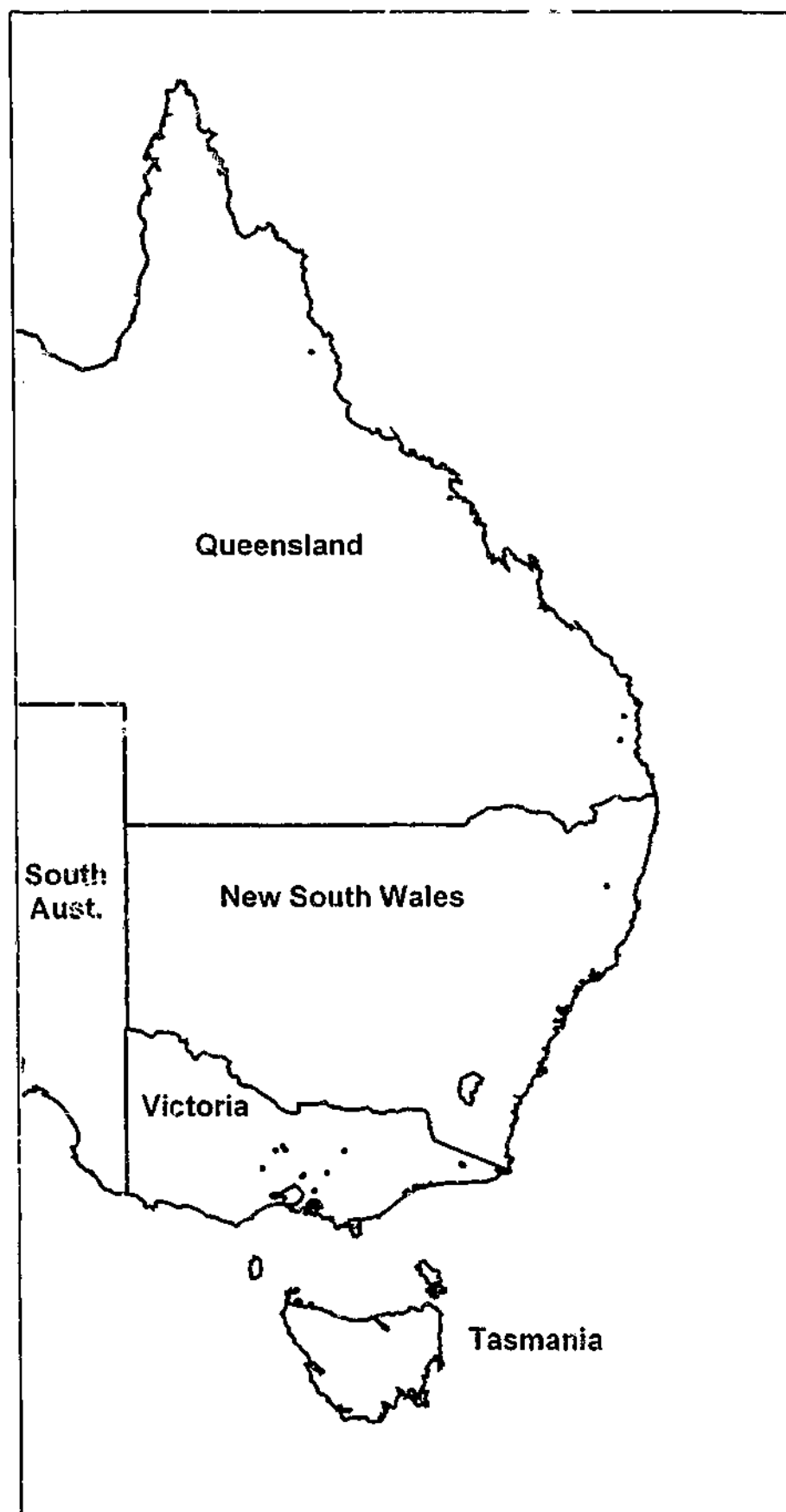
Fig. 241. Distribution of *Thraulophlebia parva*.

242
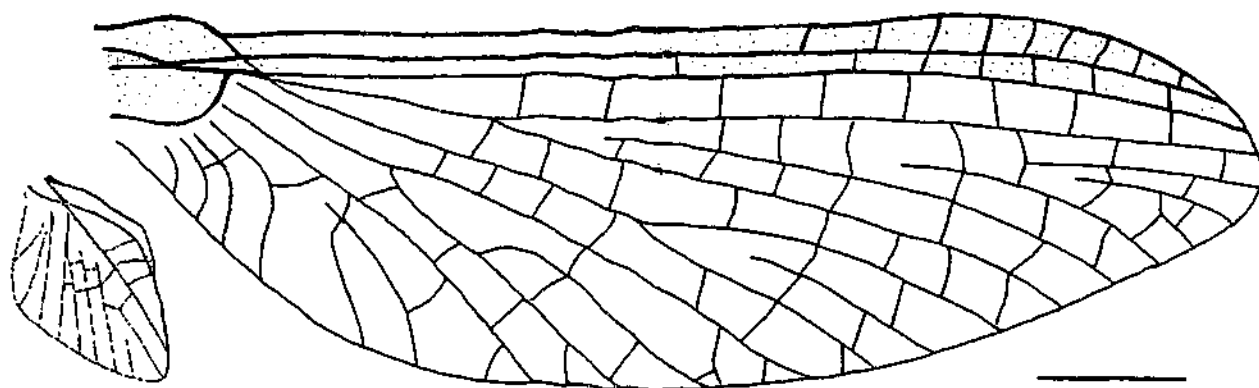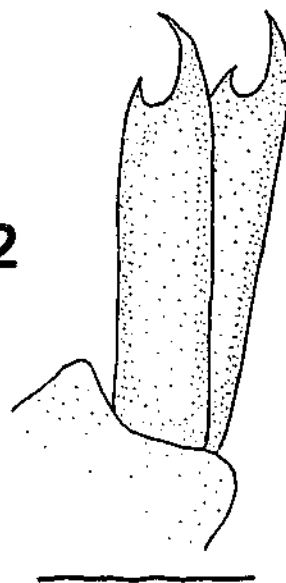
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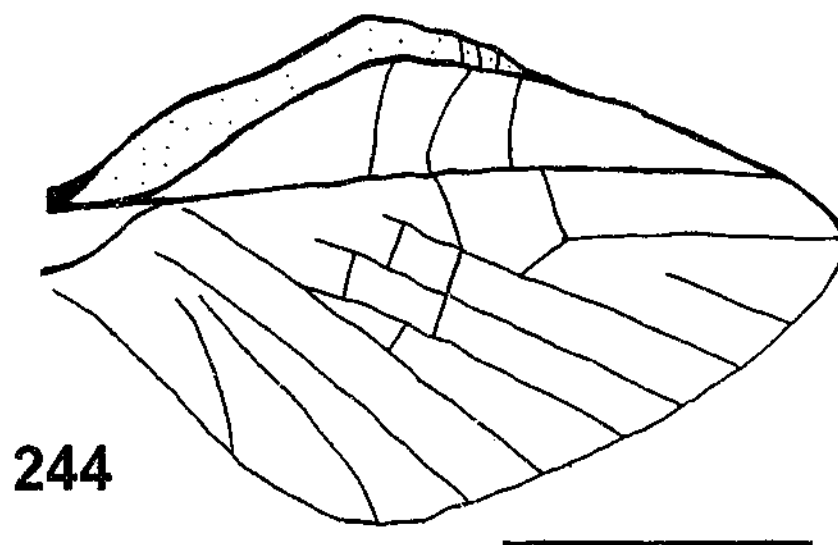
244

Figs 242-244. *Thraulophlebia parva*, male imago.

Fig. 242. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 243. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 244. Hindwing. Scale bar = 500µm.

245
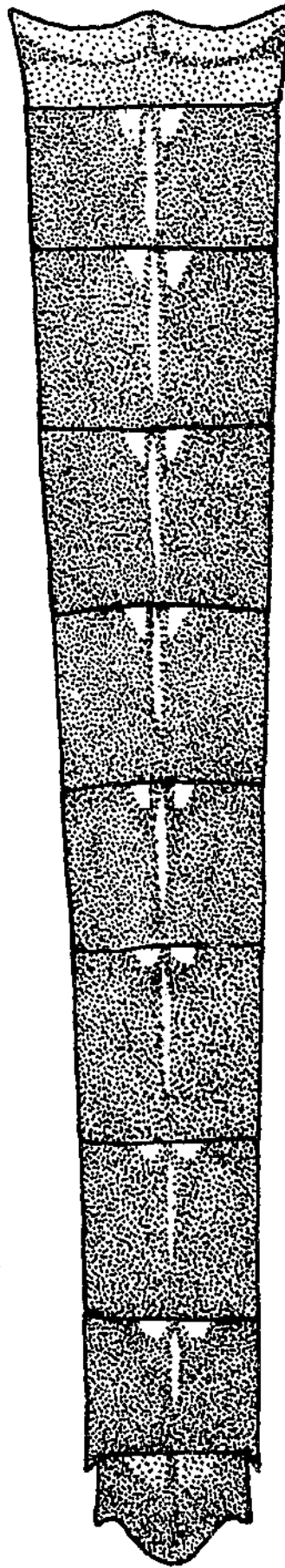
Fig. 245. *Thraulophlebia parva*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

246
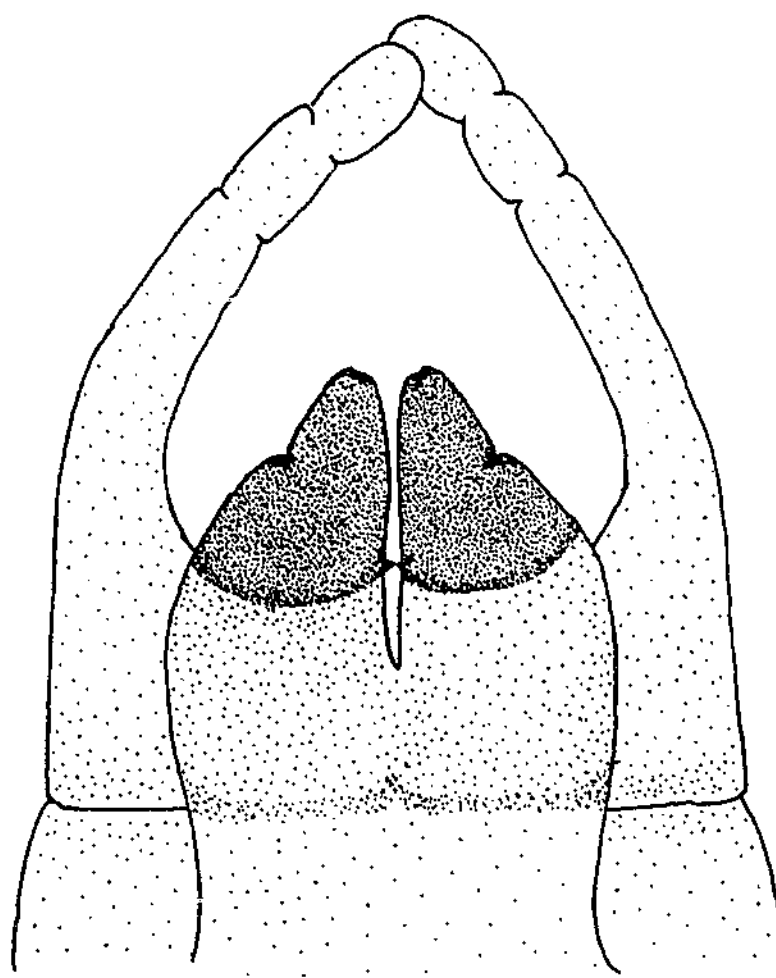
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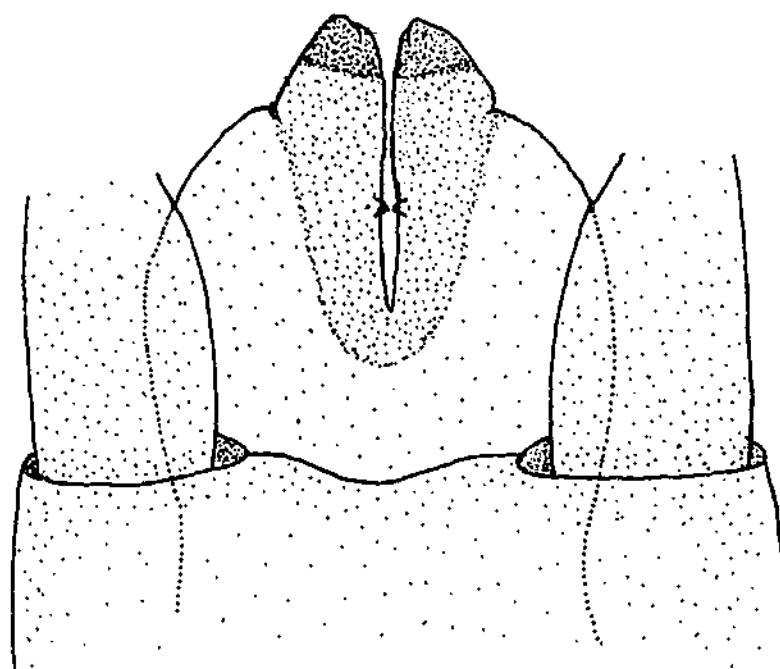
Figs. 246-247. *Thraulophlebia parva*, male imago.
Scale bar = 200μm.

Fig. 246. Dorsal view of genitalia showing penes and forceps.
Fig. 247. Ventral view of genitalia showing penes.
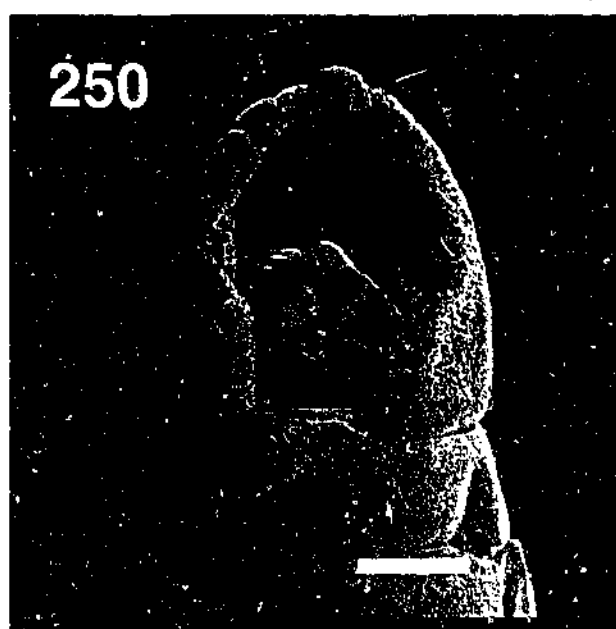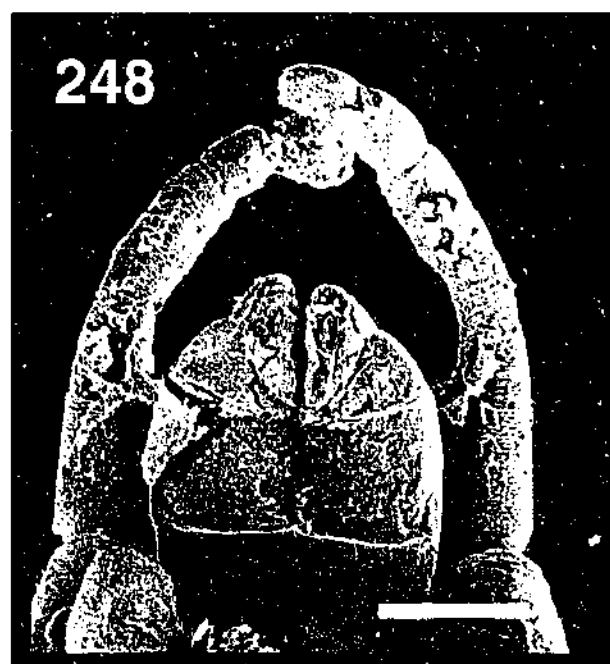
Figs. 248-251. *Thraulophlebia parva*, male imago.

Individual from Wild Duck Creek, outside Heathcote, Victoria (99022304).
Scale bars = 100µm.

Fig. 248. Dorsal view of genitalia showing penes and forceps.
Fig. 249. Dorsal view of penes.
Fig. 250. Ventral view of genitalia showing penes and forceps.
Fig. 251. Ventral view of penes.

134
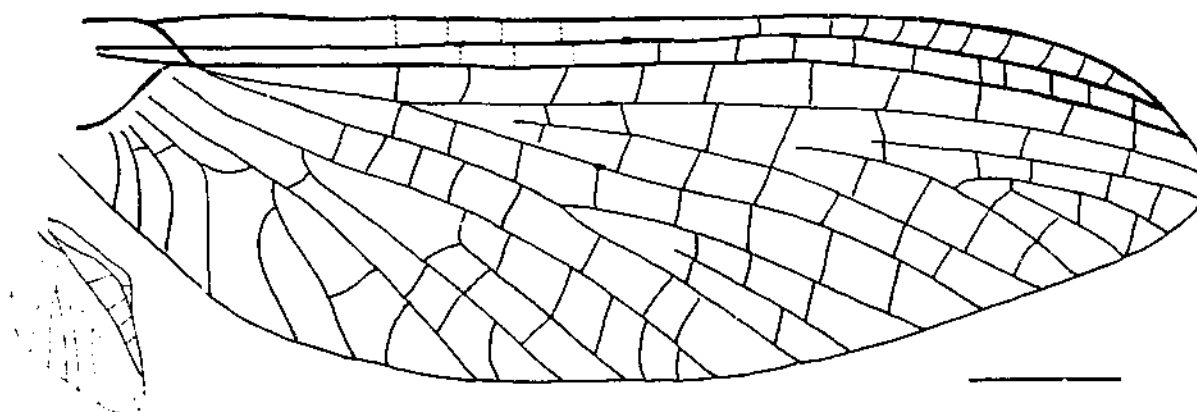
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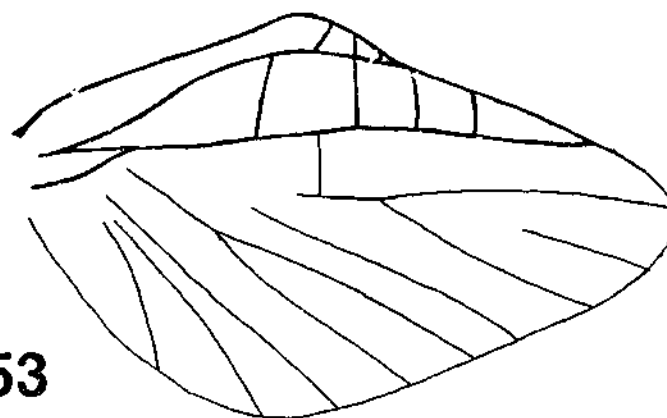
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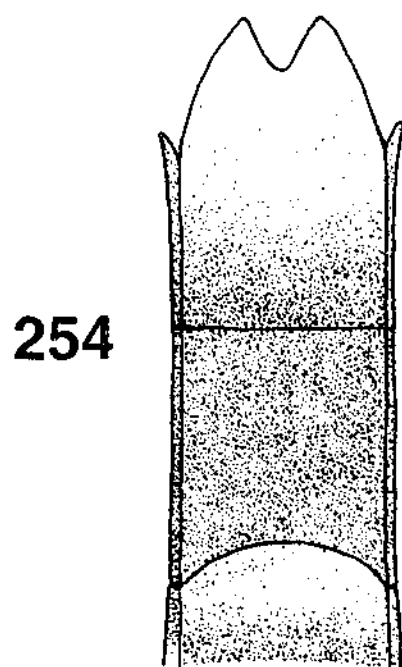
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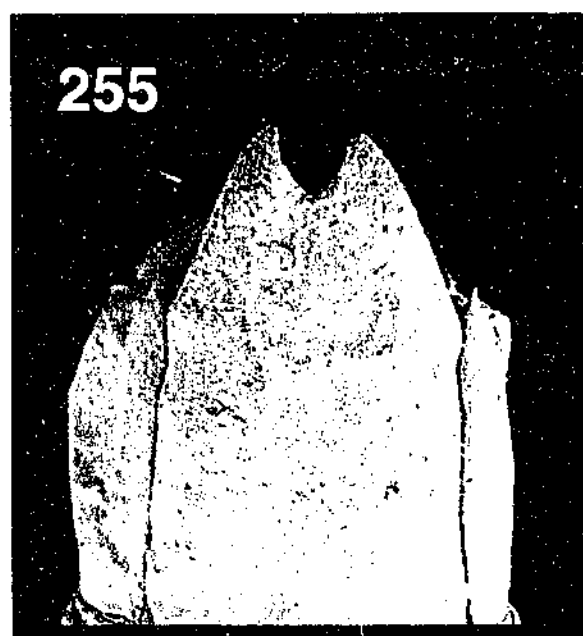
255

Figs. 252-255. *Thraulophlebia parva*, female imago.

Fig. 252. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 253. Hindwing. Scale bar = 500µm.
Fig. 254. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.

Fig. 255. Ventral view of abdomen showing sternite 9. Scale bar = 200µm.
Individual from Wild Duck Creek, outside Heathcote, Victoria (00022001).
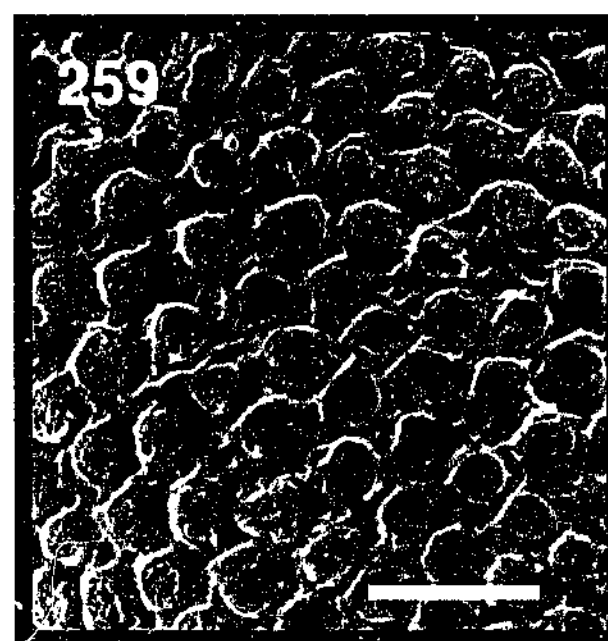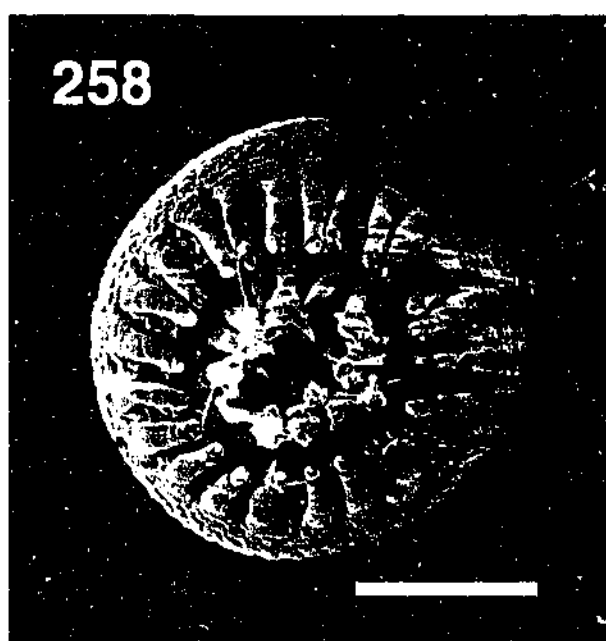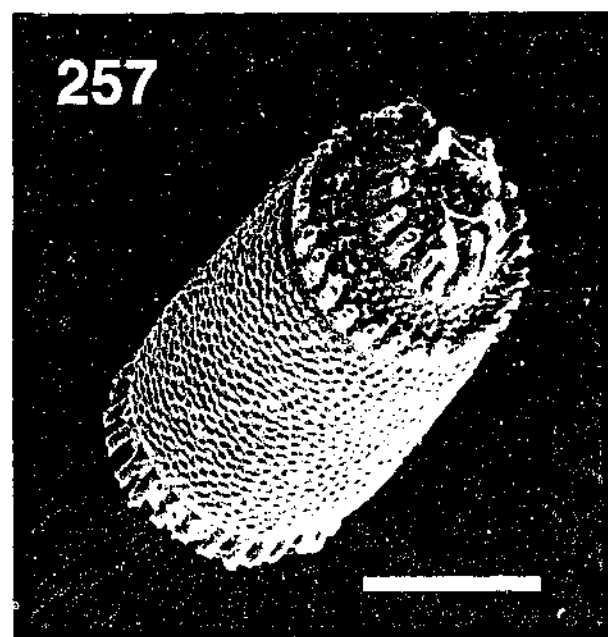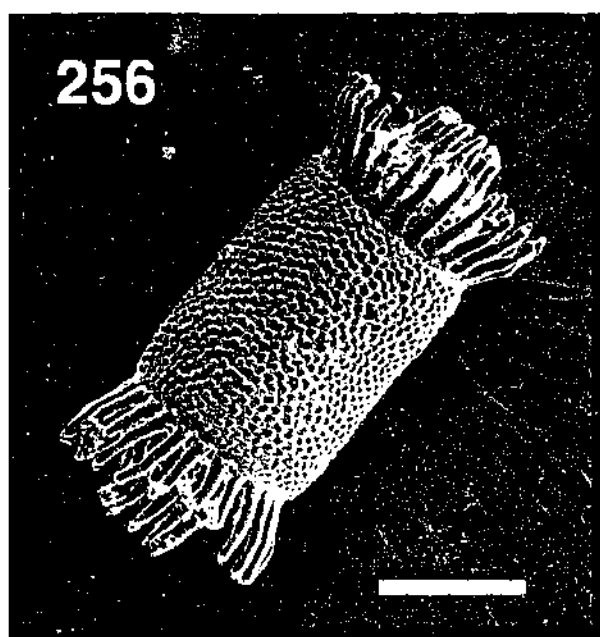
Figs. 256-259. *Thraulophlebia parva*, eggs taken from female imago.

Individuals from Wild Duck Creek, outside Heathcote, Victoria (99040701 & 00022001).

Figs. 256-257. Whole eggs. Scale bar = 50μm.
Fig. 258. Apical view of egg showing two rings of tubular projections.
Scale bar = 30μm.
Fig. 259. Close up of chorion. Scale bar = 10μm.
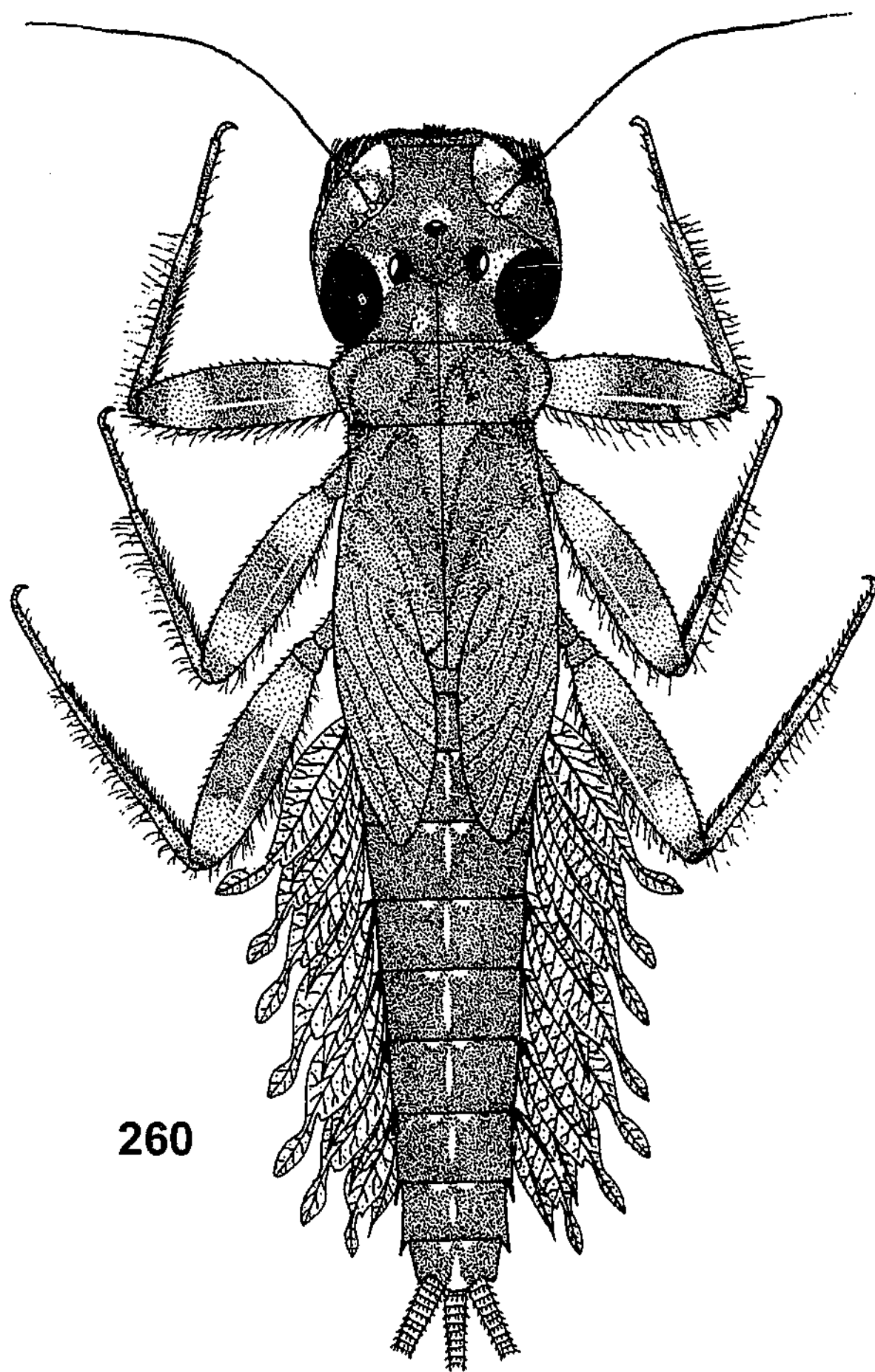
260

Fig. 260. *Thraulophlebia parva*, female nymph.
Scale bar = 1mm.
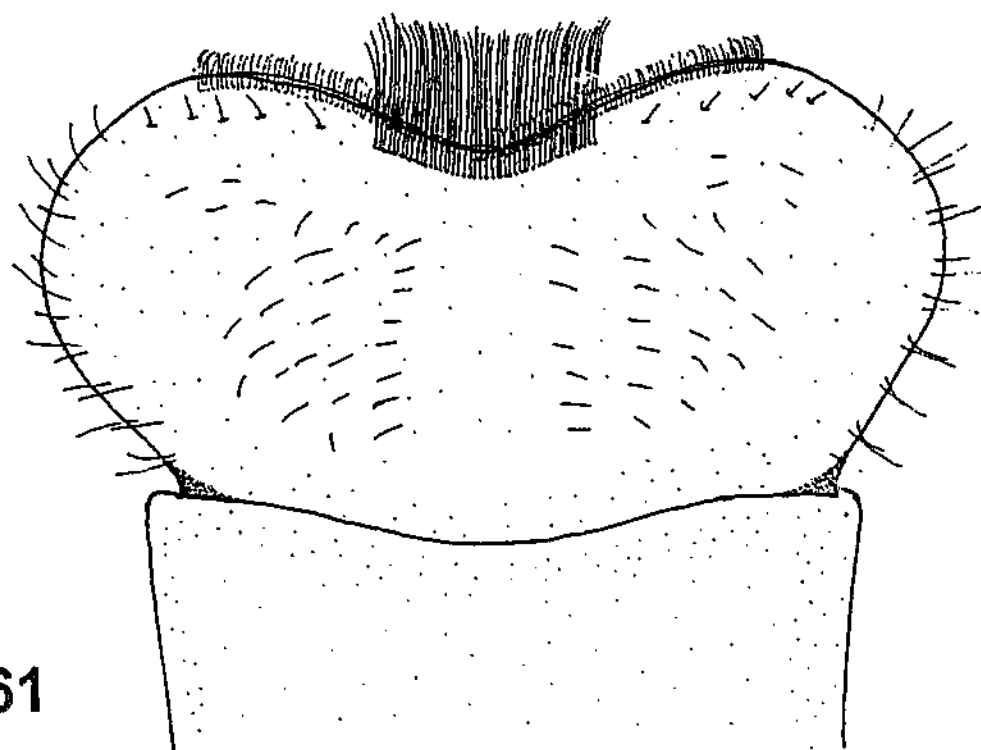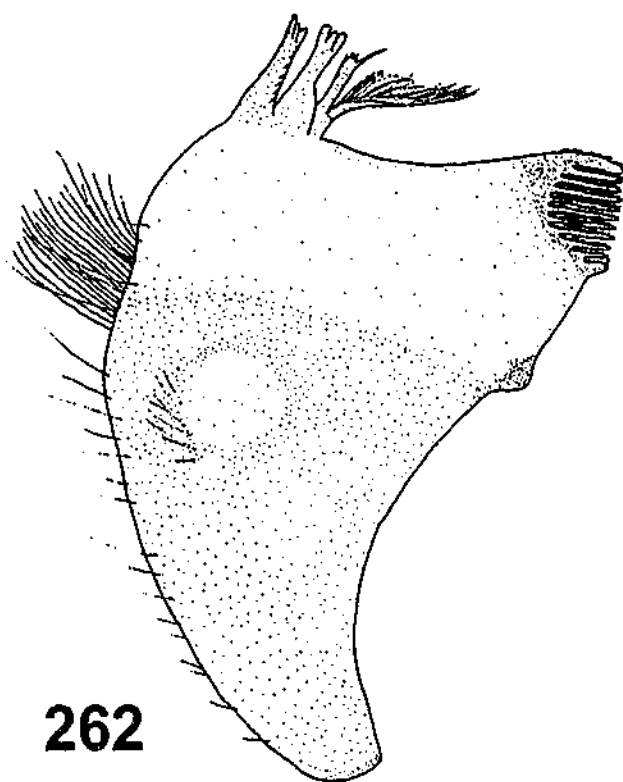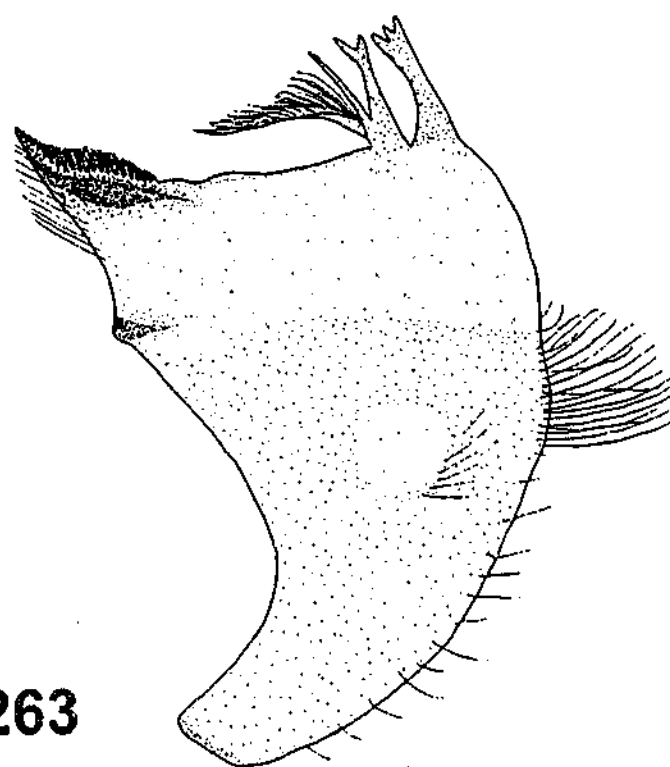
Figs. 261-263. *Thraulophlebia parva*, nymph mouthparts.
Scale bars = 200μm.

Fig. 261. Labrum and clypeus.
Fig. 262. Left mandible.
Fig. 263. Right mandible.
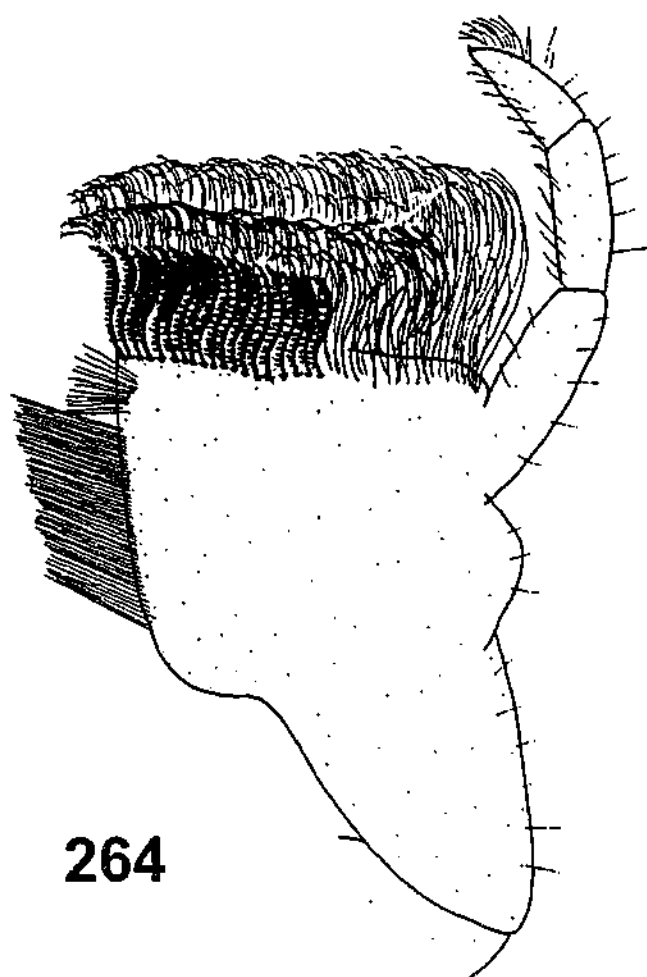
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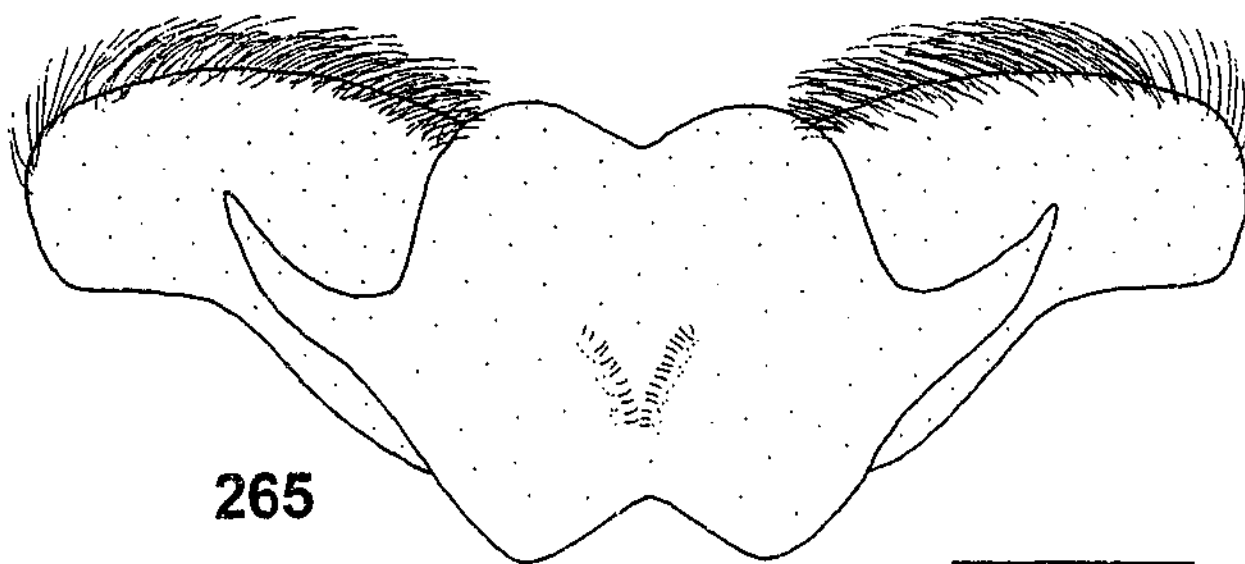
265

Figs. 264-265. *Thraulophlebia parva*, nymph mouthparts.
Scale bars = 200μm.

Fig. 264. Right maxilla.
Fig. 265. Hypopharynx.
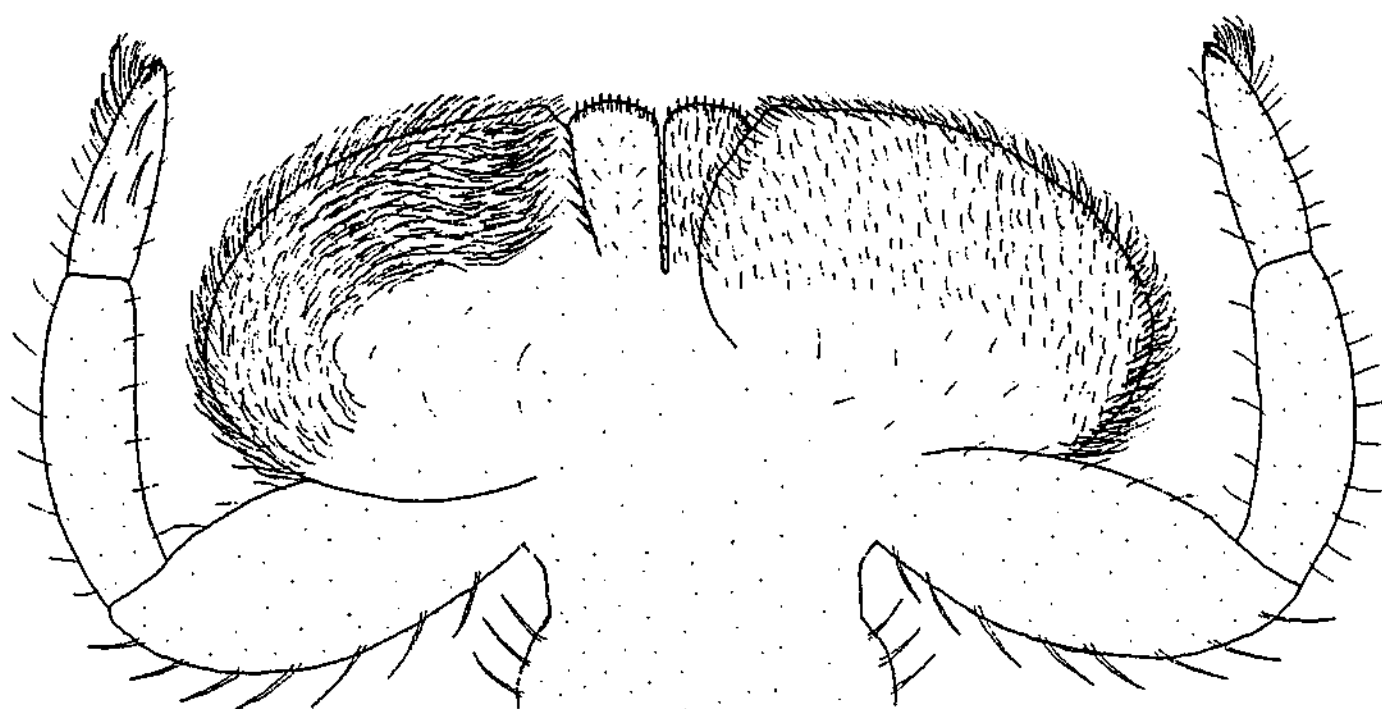
266

Fig. 266. *Thraulophlebia parva*, nymph mouthpart.

Labium. Scale bar = 200µm.
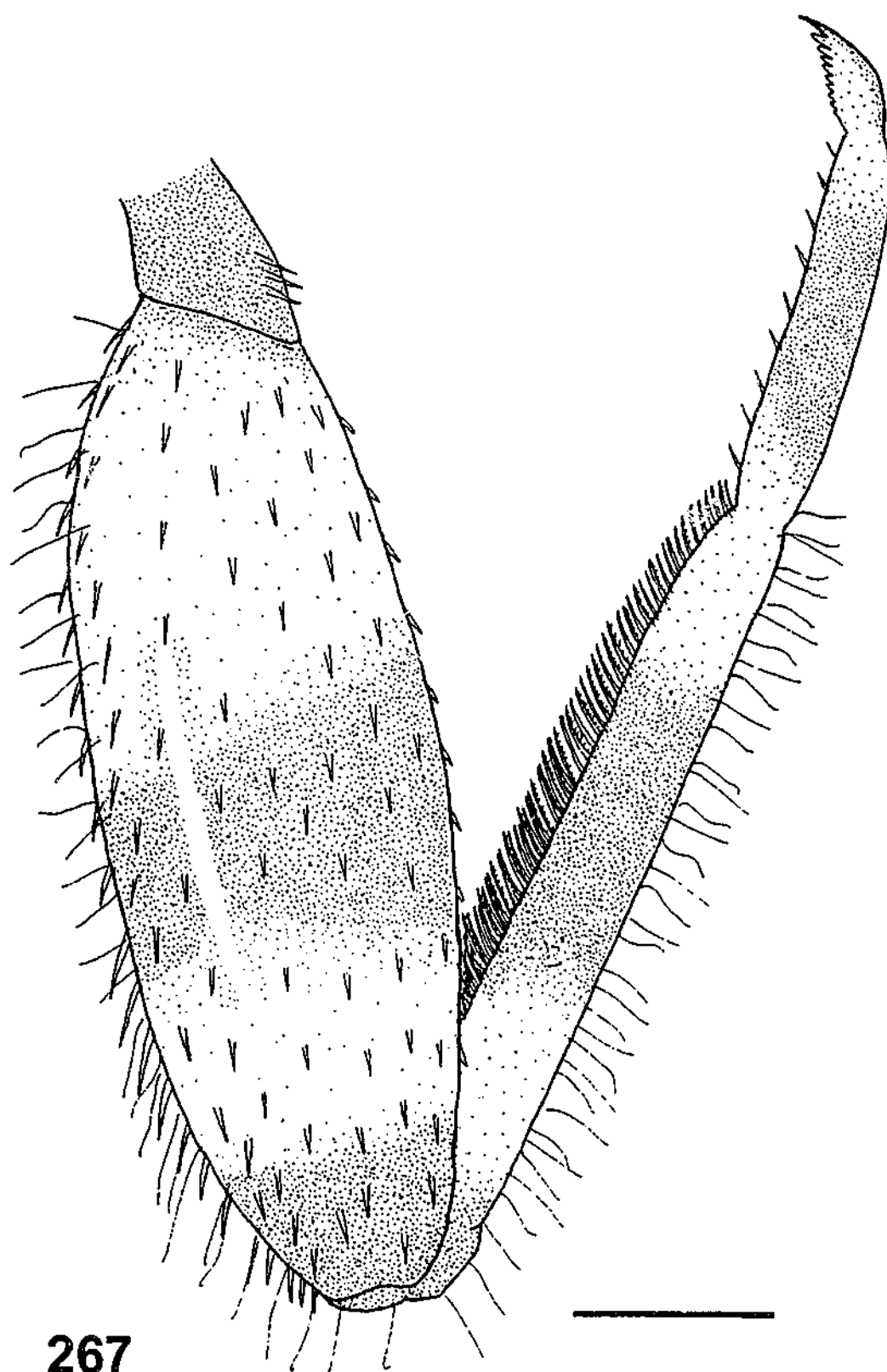
267

Fig. 267. *Thraulophlebia parva*, nymph foreleg.
Scale bar = 200µm.

268
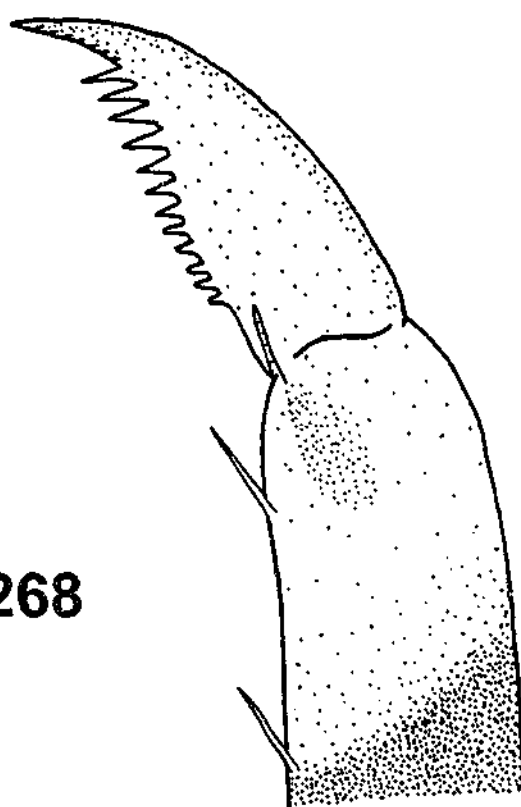
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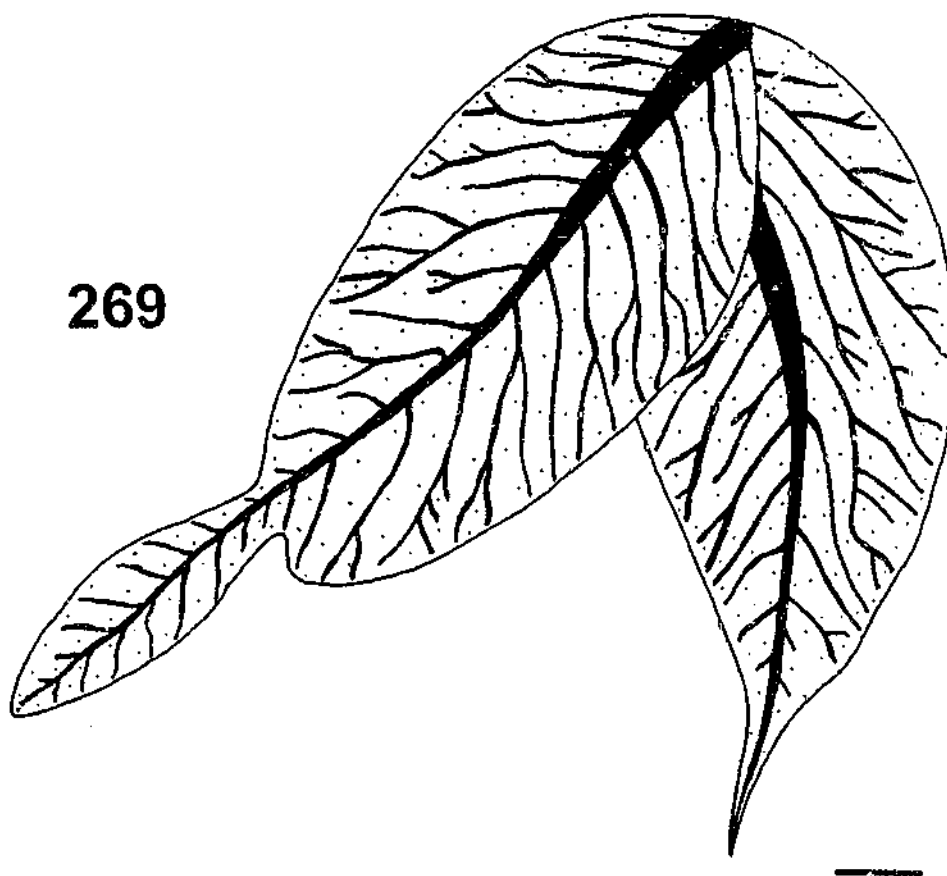
Figs. 268-269. *Thraulophlebia parva*, nymph.
Scale bars = 100μm.

Fig. 268. Foreleg tarsal claw.
Fig. 269. Gills.

270
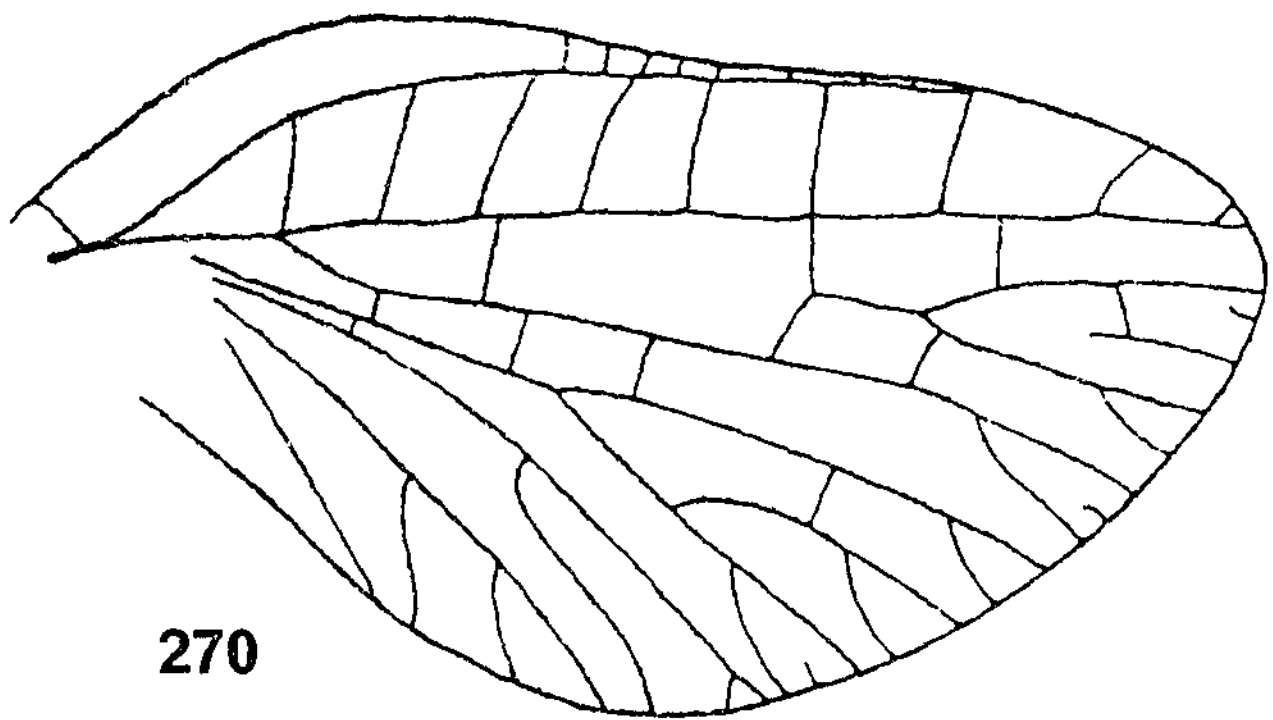
Fig. 270. *Atalophlebia australasica* Ulmer.

Hindwing.
Reproduction of a drawing from Ulmer (1916).

271
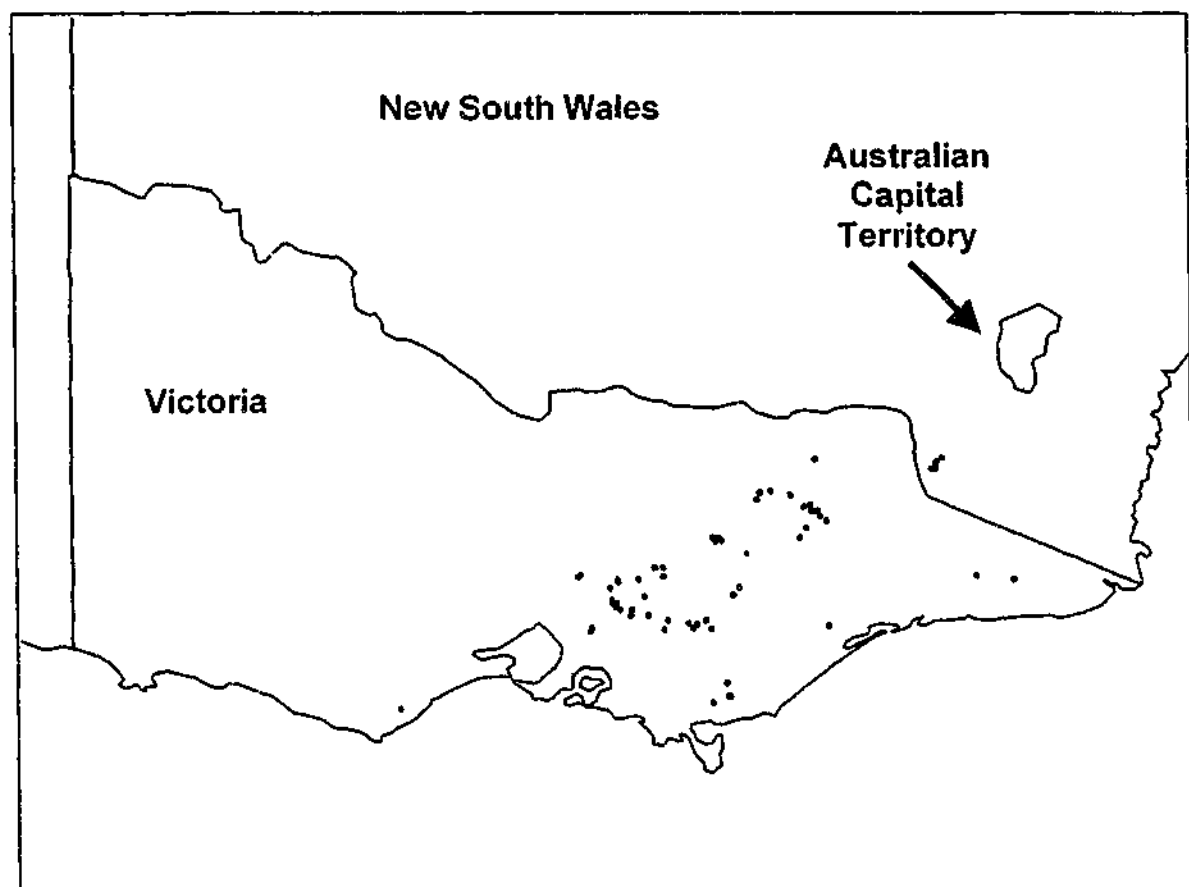
Fig. 271. Distribution of the genus *Montikola.*

272
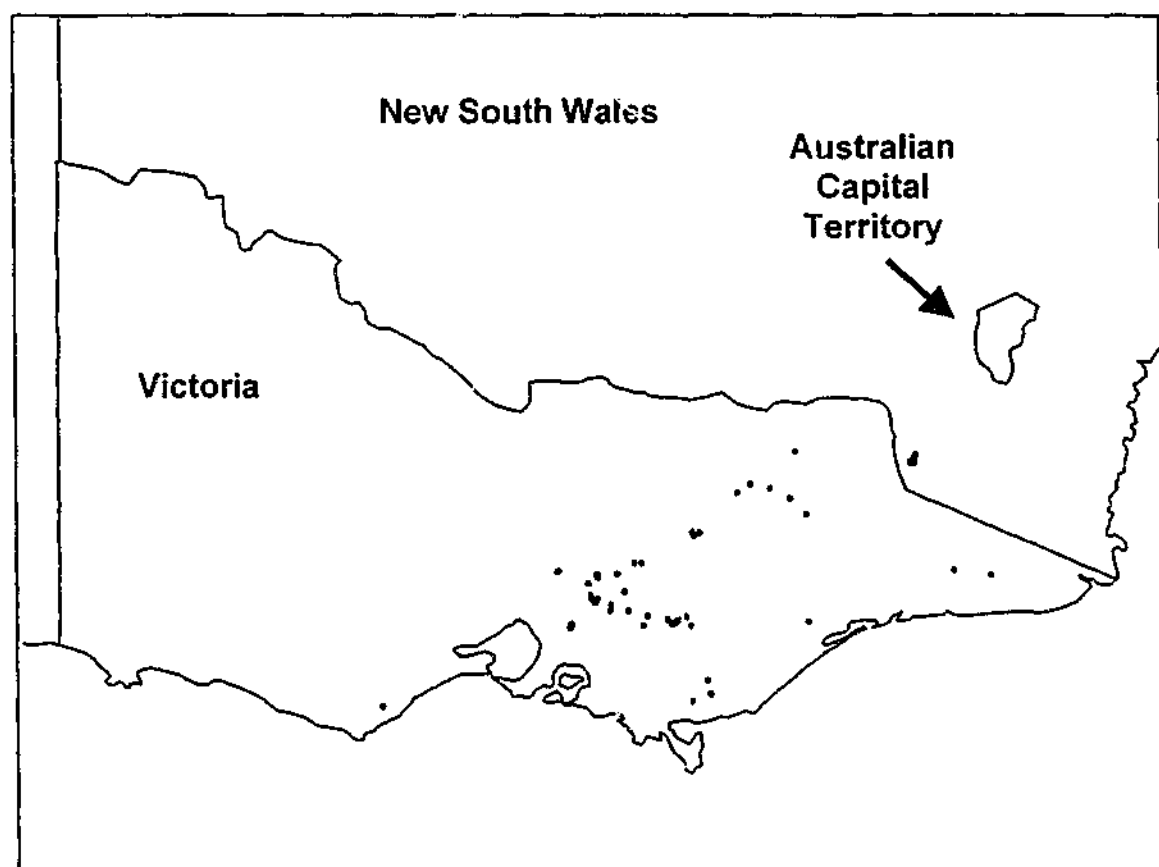
Fig. 271. Distribution of *Montikola kala.*
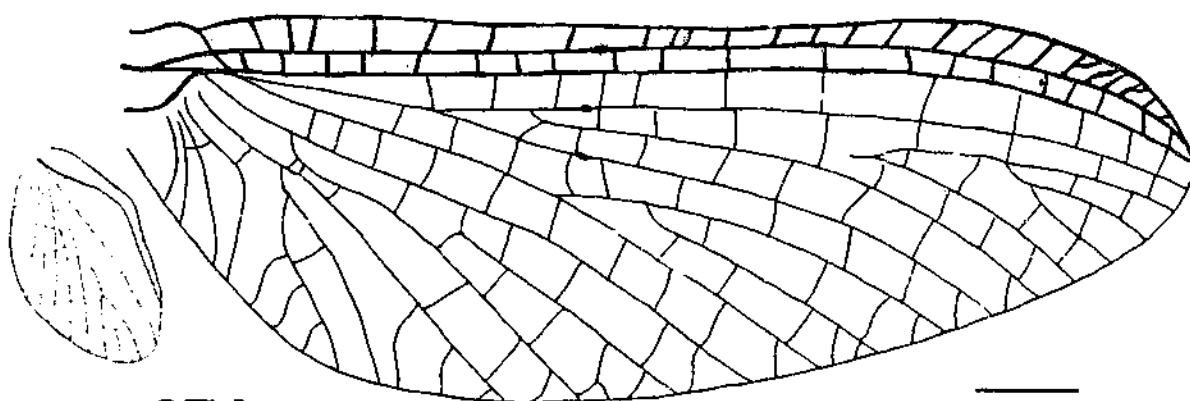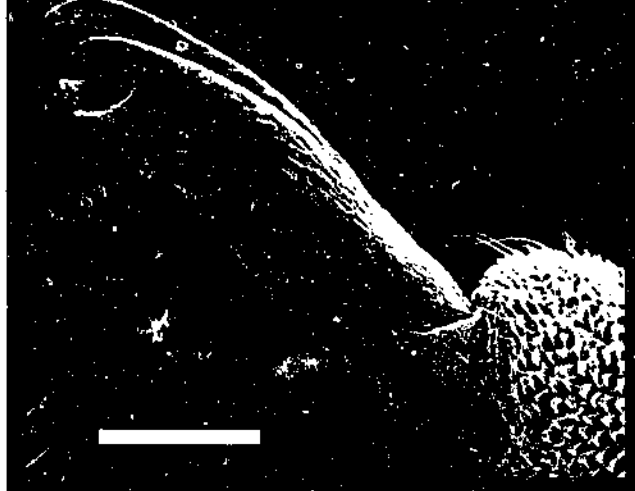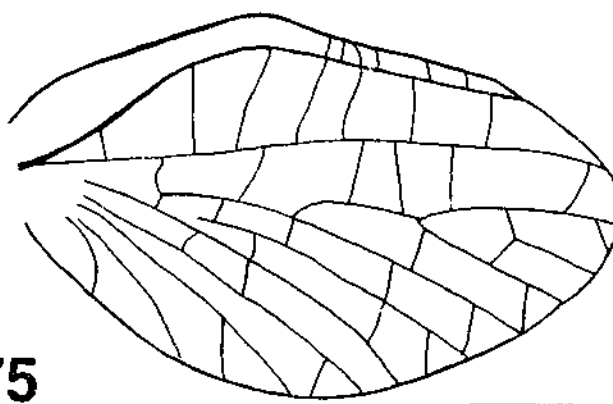
Figs 273-275. *Montikola kala*, male imago.

Fig. 273. Foreleg tarsal claw. Scale bar = 50μm.
Individual from Cement Creek, Mount Donna Buang, Victoria (80030300).

Fig. 274. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 275. Hindwing. Scale bar = 500μm.

276
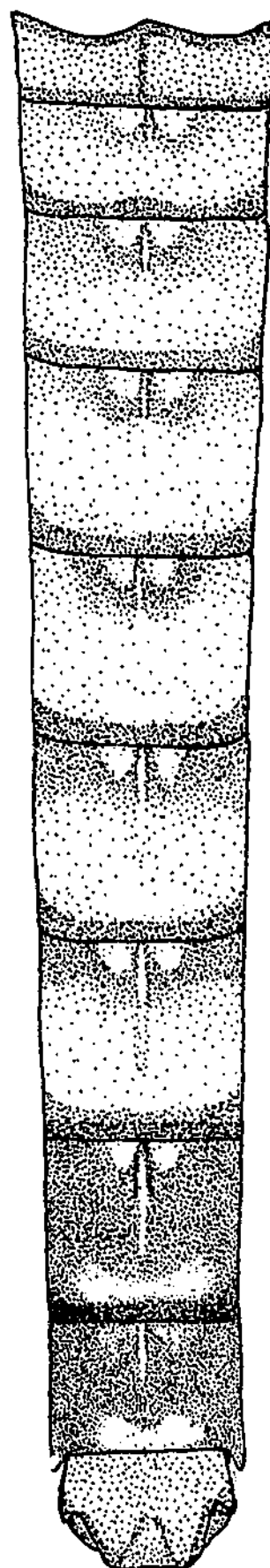
Fig. 276. *Montikola kala*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

147
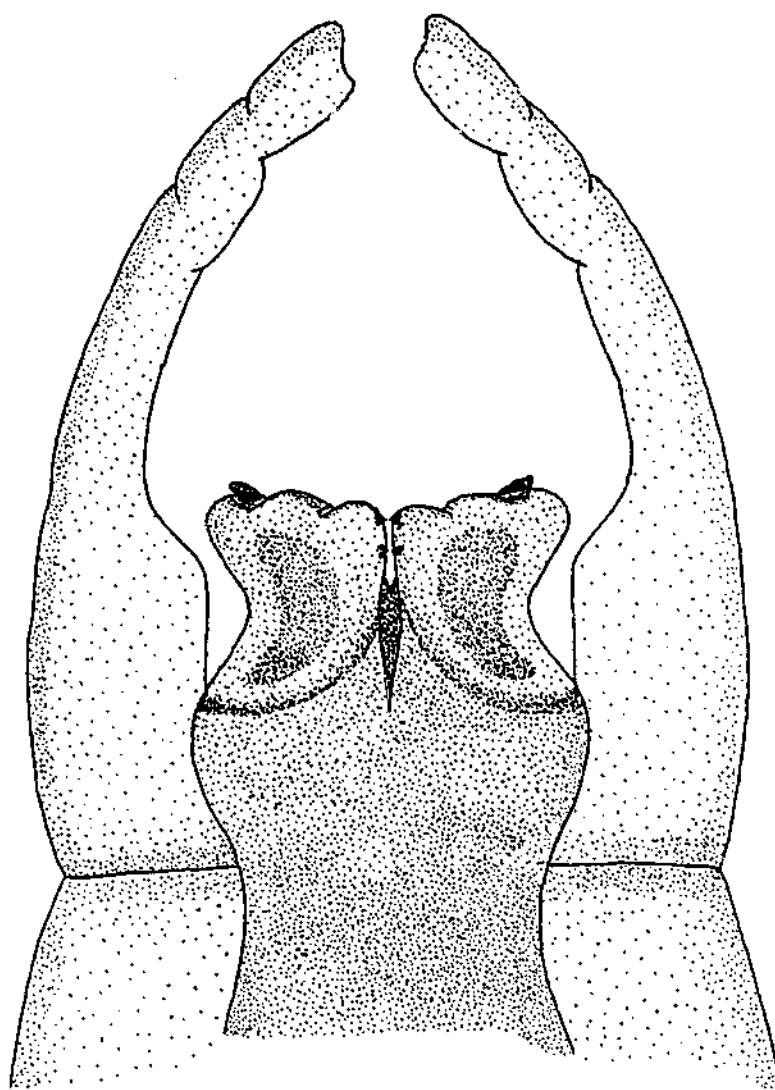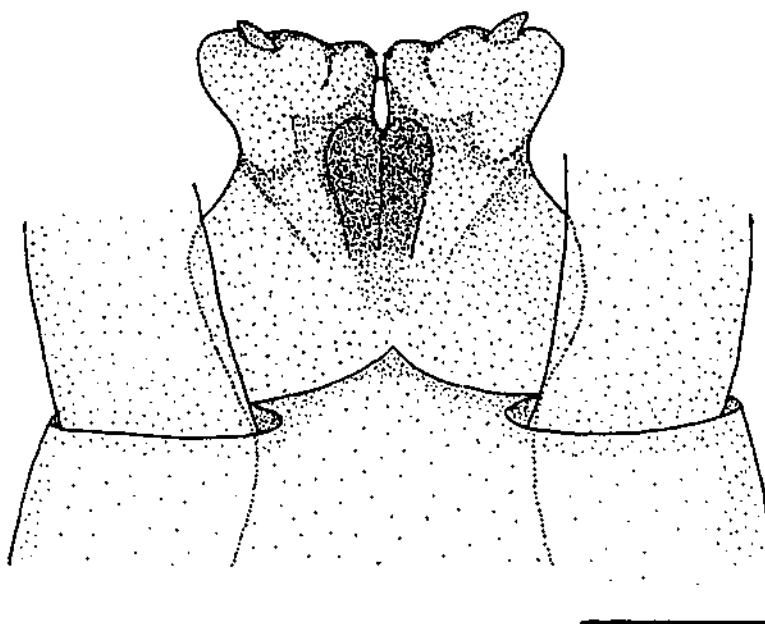
Figs. 277-278. *Montikola kala*, male imago.
Scale bar = 200μm.

Fig. 277. Dorsal view of genitalia showing penes and forceps.
Fig. 278. Ventral view of of genitalia showing penes.
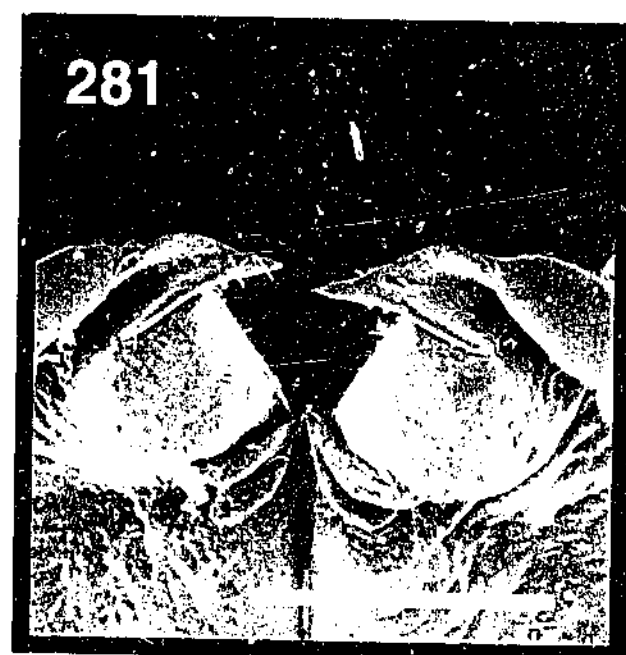
Figs. 279-281. *Montikola kala*, male imago.

Fig. 279. Dorsal view of penes. Scale bar = 100µm.
Individual from Cement Creek, Mount Donna-Buang, Victoria (80030300).

Figs. 280. Dorsal view of right lobe of penes showing missing
apical process and internal spines. Scale bar = 50µm.
Fig. 281. Close up of internal penes spines. Scale bar = 50µm.
Individual from Loch River, Noojee, Victoria (93050200).
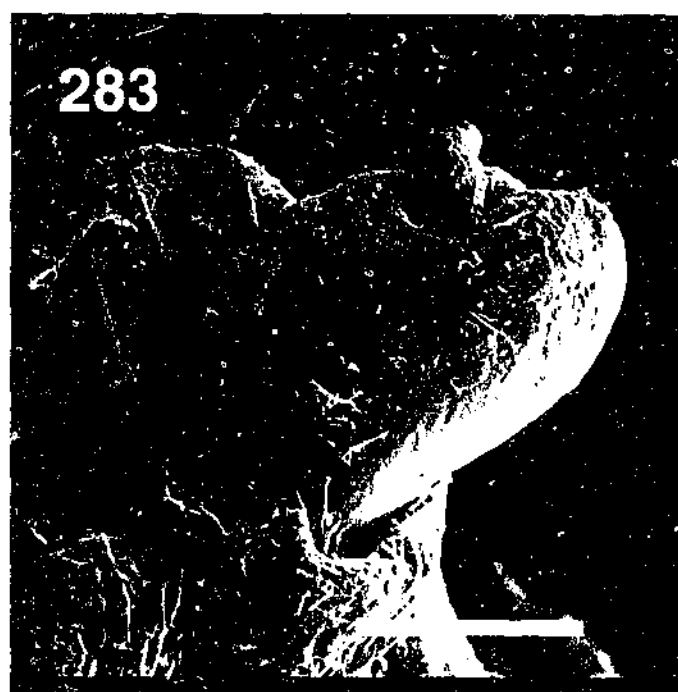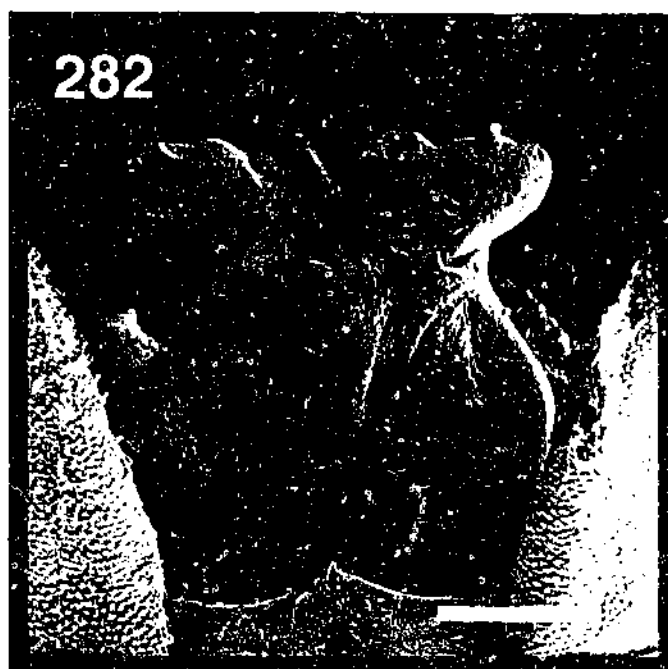
Figs. 282-283. *Montikola kala*, male imago.

Individual from Perrins Creek, Dandenong Ranges, Victoria (97032406).

Fig. 282. Ventral view of penes. Scale bar = 100μm.
Fig. 283. Close up of right lobe of penes showing apical process. Scale bar = 50μm.
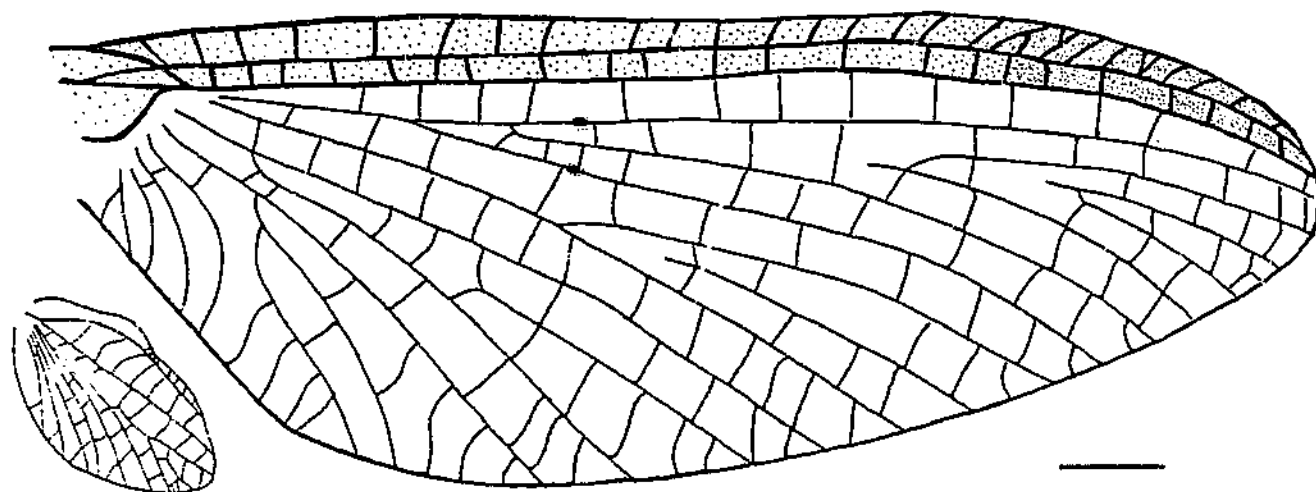
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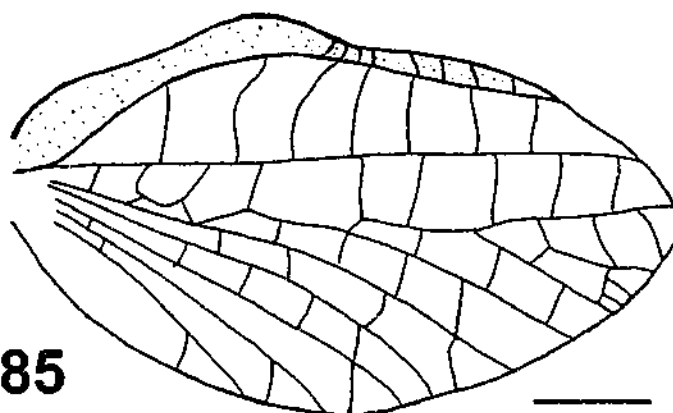
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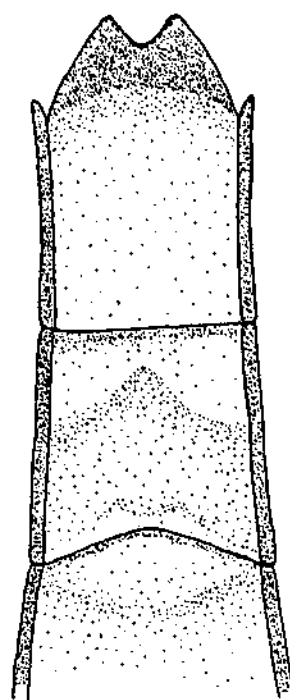
286

Figs. 284-286. *Montikola kala*, female imago.

Fig. 284. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 285. Hindwing. Scale bar = 500μm.
Fig. 286. Ventral view of abdomen showing sternites 7-9. Scale bar = 500μm.
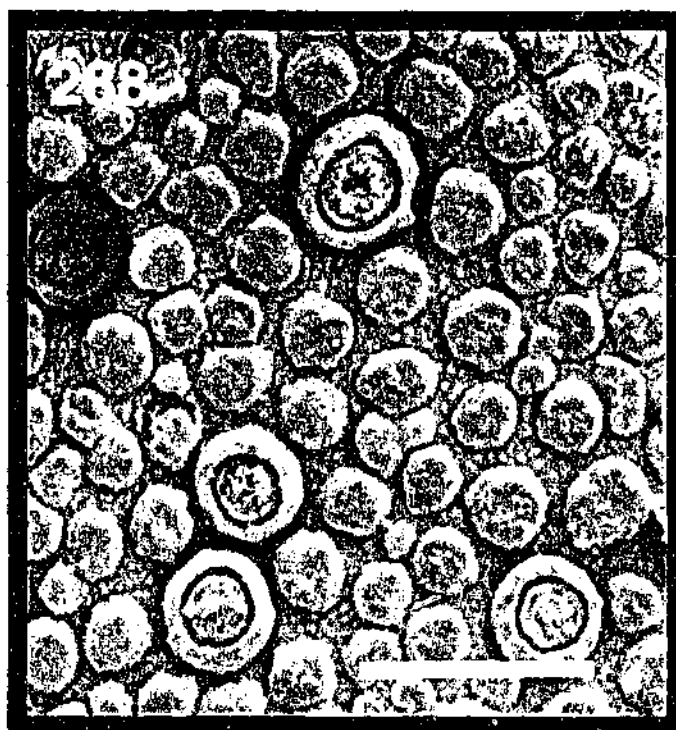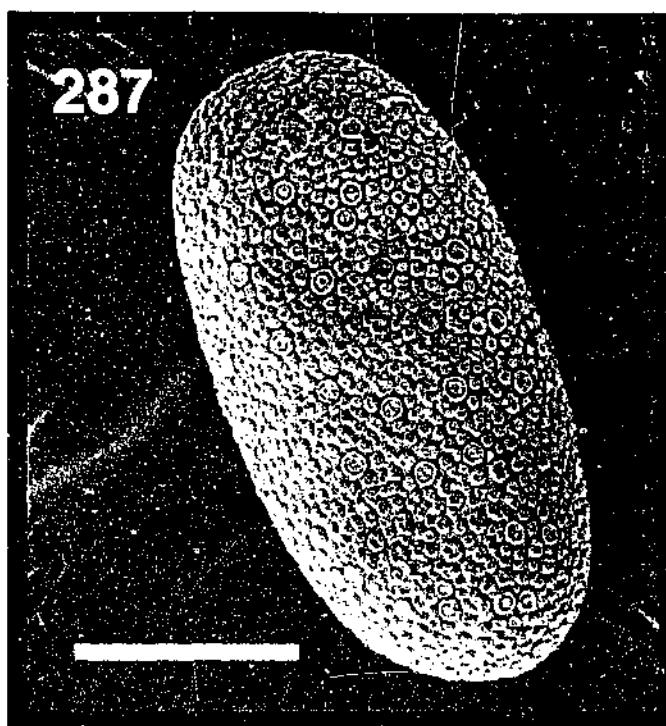
Figs. 287-288. *Montikola kala*, eggs taken from female imago.

Individual from Clematis Creek, Dandenong Ranges, Victoria (97101501).

Fig. 287. Whole egg. Scale bar = 50μm.
Fig. 288. Close up of egg chorion. Scale bar = 10μm.
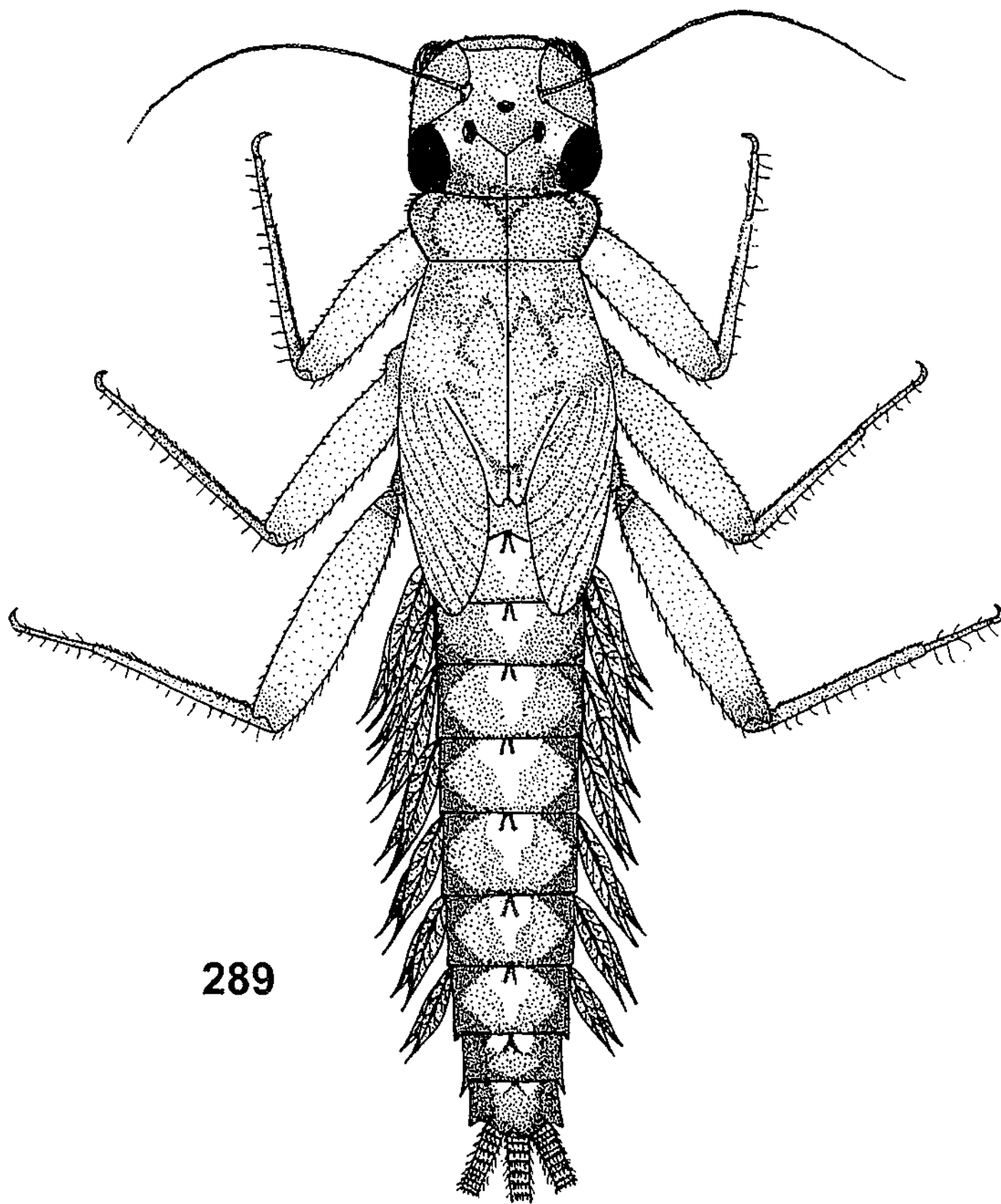
289

Fig. 289. *Montikola kala*, female nymph.
Scale bar = 1mm.
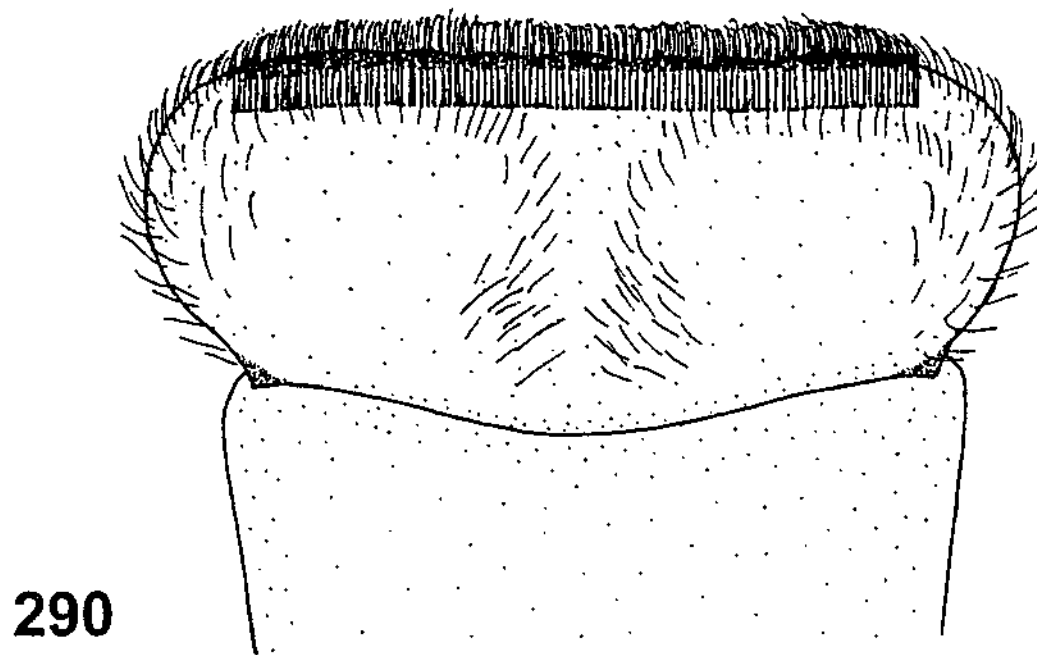
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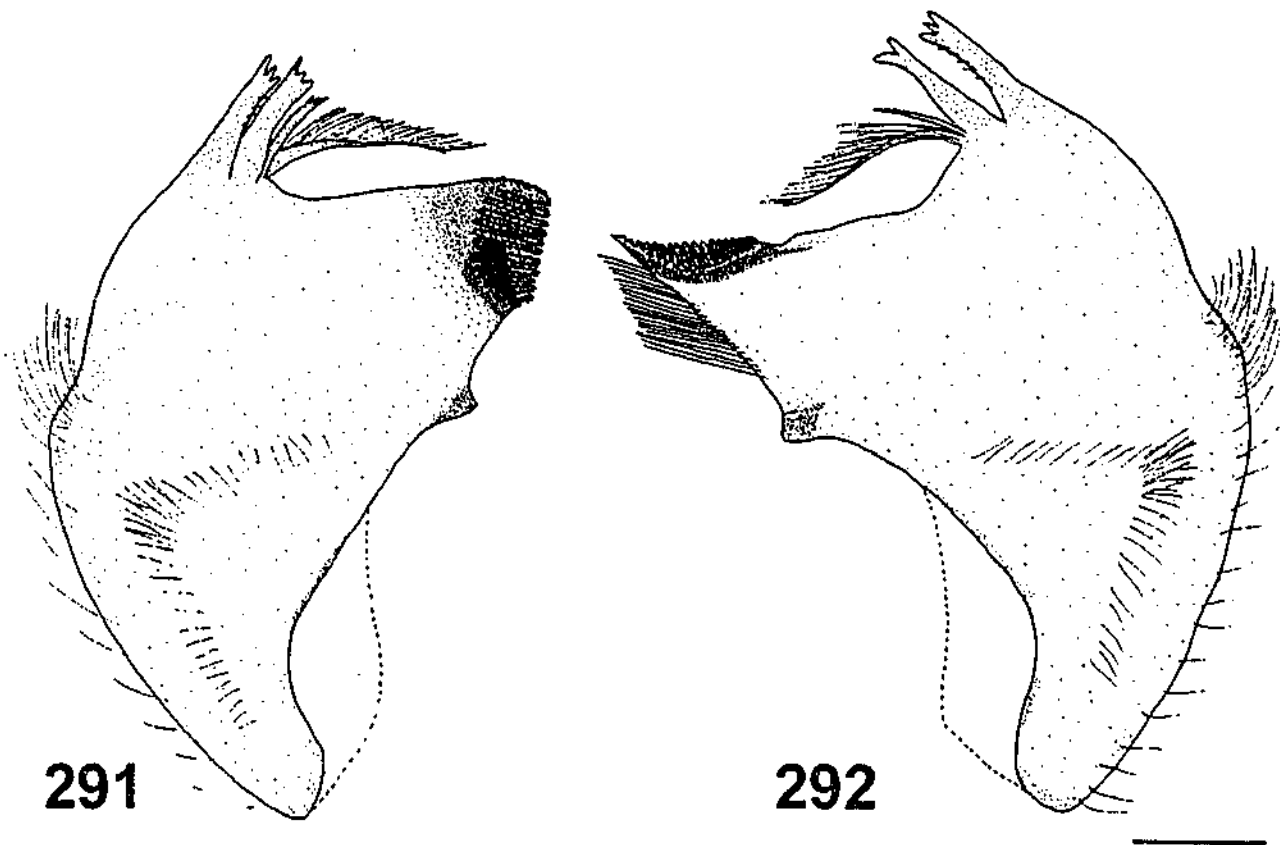
291 **292**

Figs. 290-292. *Montikola kala*, nymph mouthparts.
Scale bars = 200µm.

Fig. 290. Labrum and clypeus.
Fig. 291. Left mandible.
Fig. 292. Right mandible.
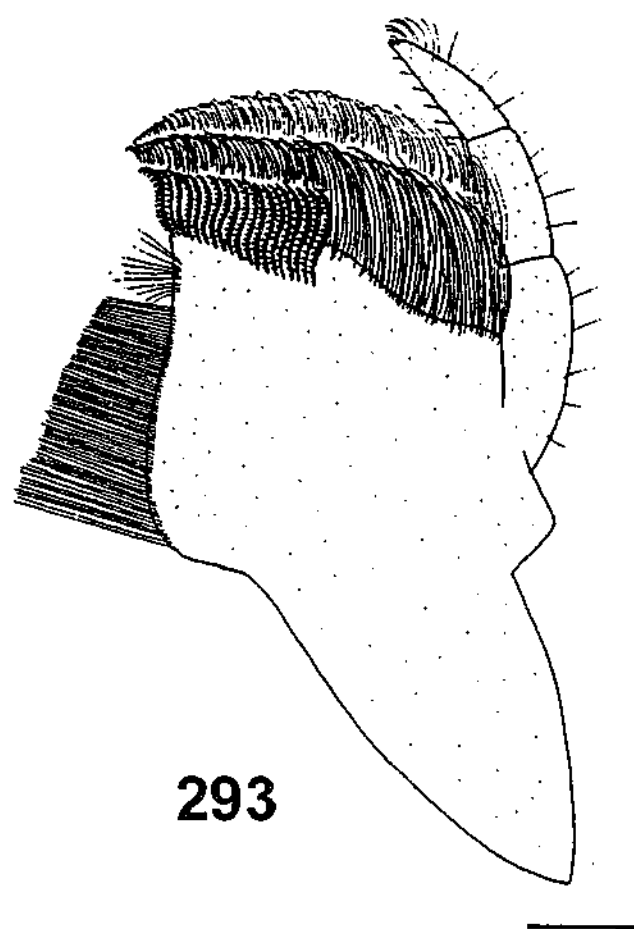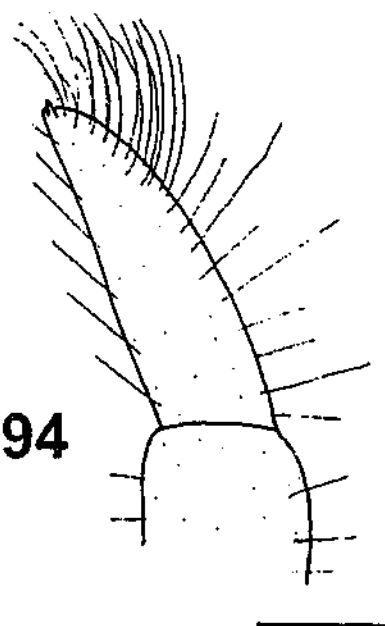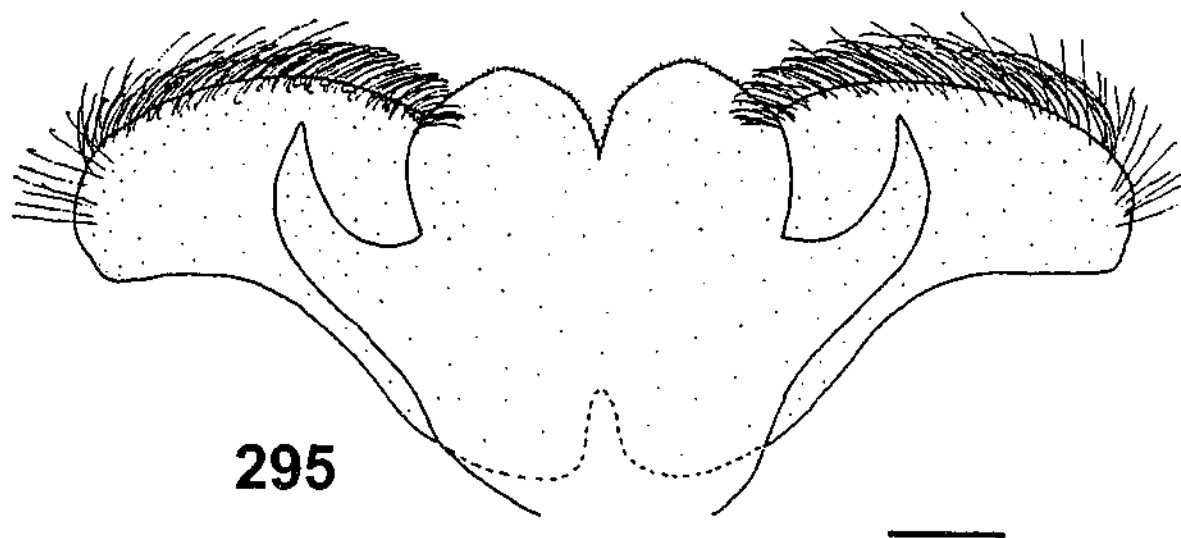
Figs. 293-295. *Montikola kala*, nymph mouthparts.

Fig. 293. Right maxilla. Scale bar = 200µm.
Fig. 294. Terminal palp of maxilla showing apical spine. Scale bar = 100µm.
Fig. 295. Hypopharynx. Scale bar = 200µm.
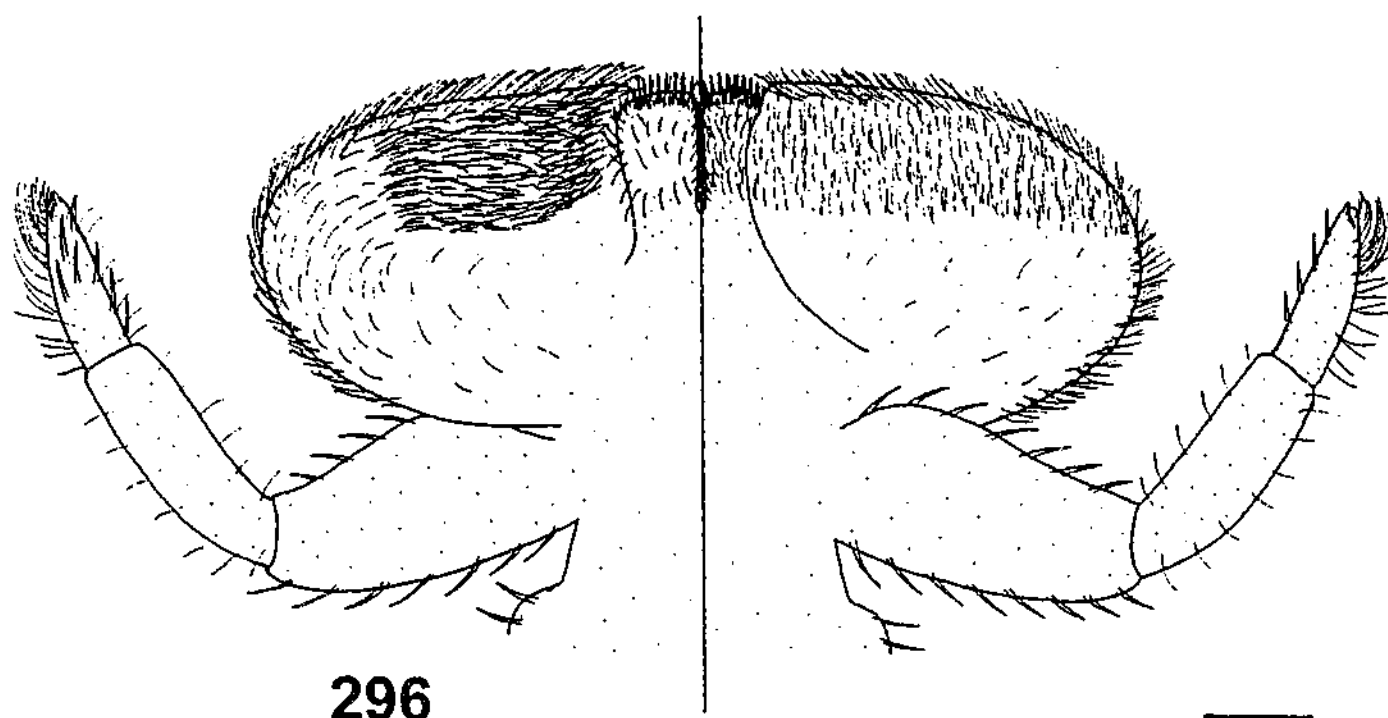
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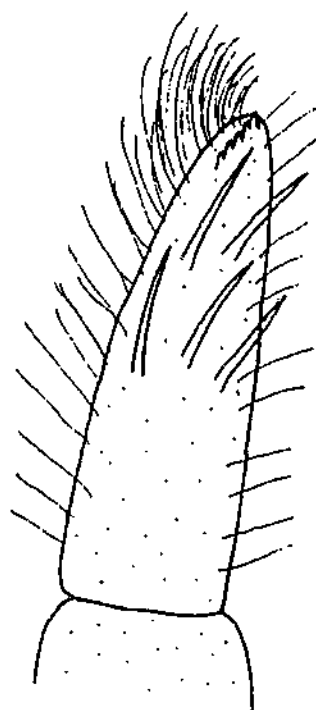
297

Figs. 296-297. *Montikola kala*, nymph mouthparts.

Fig. 296. Labium. Scale bar = 200μm.
Fig. 297. Dorsal view of labial terminal palp showing apical spines.
Scale bar = 100μm.
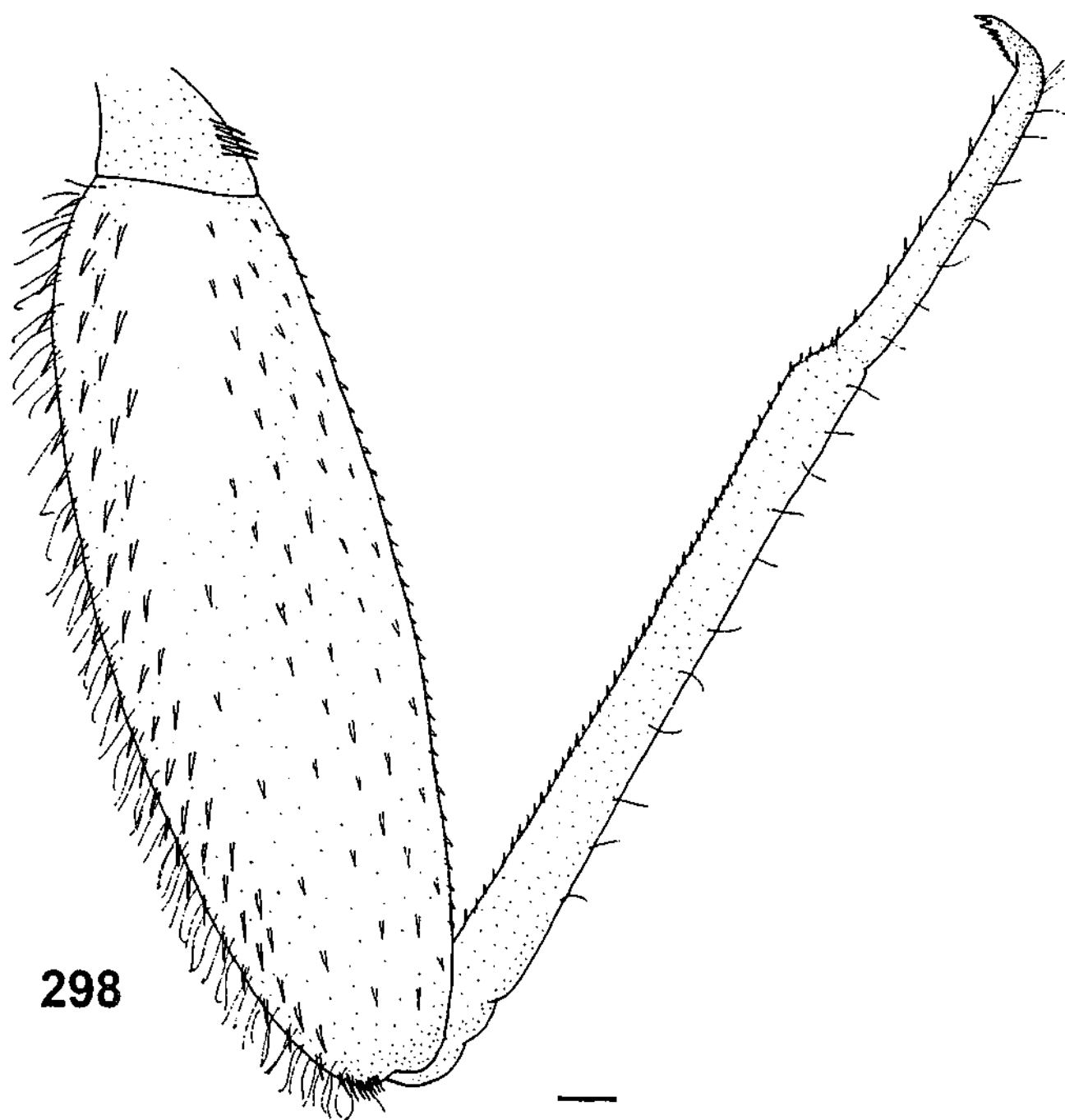
298

Fig. 298. *Montikola kala*, nymph.

Foreleg. Scale bar = 200µm.
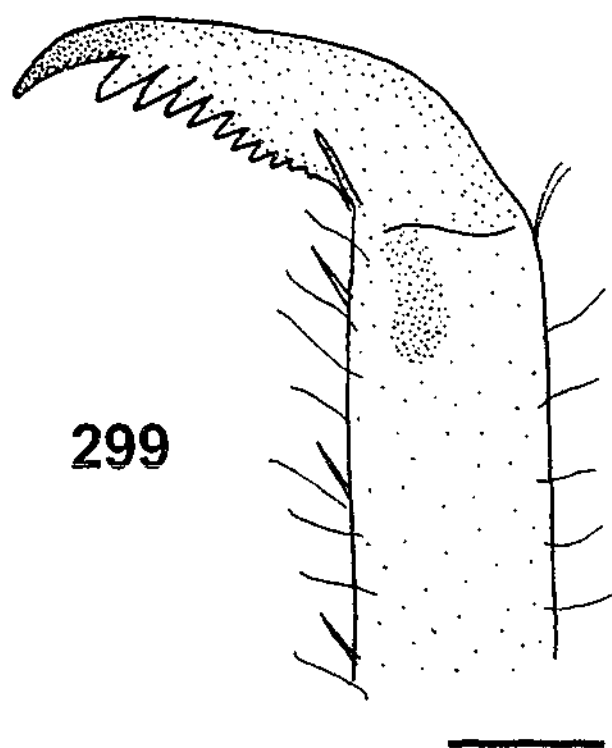
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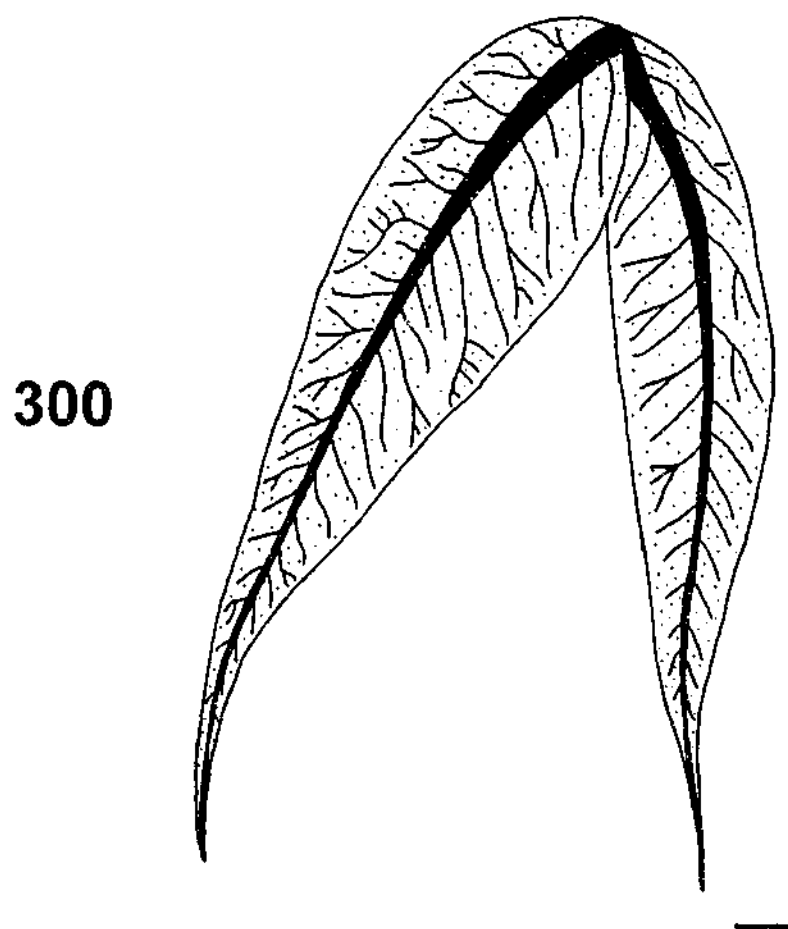
300

Figs. 299-300. *Montikola kala*, nymph.
Scale bars = 100μm.

Fig. 299. Foreleg tarsal claw.
Fig. 300. Gills.

301
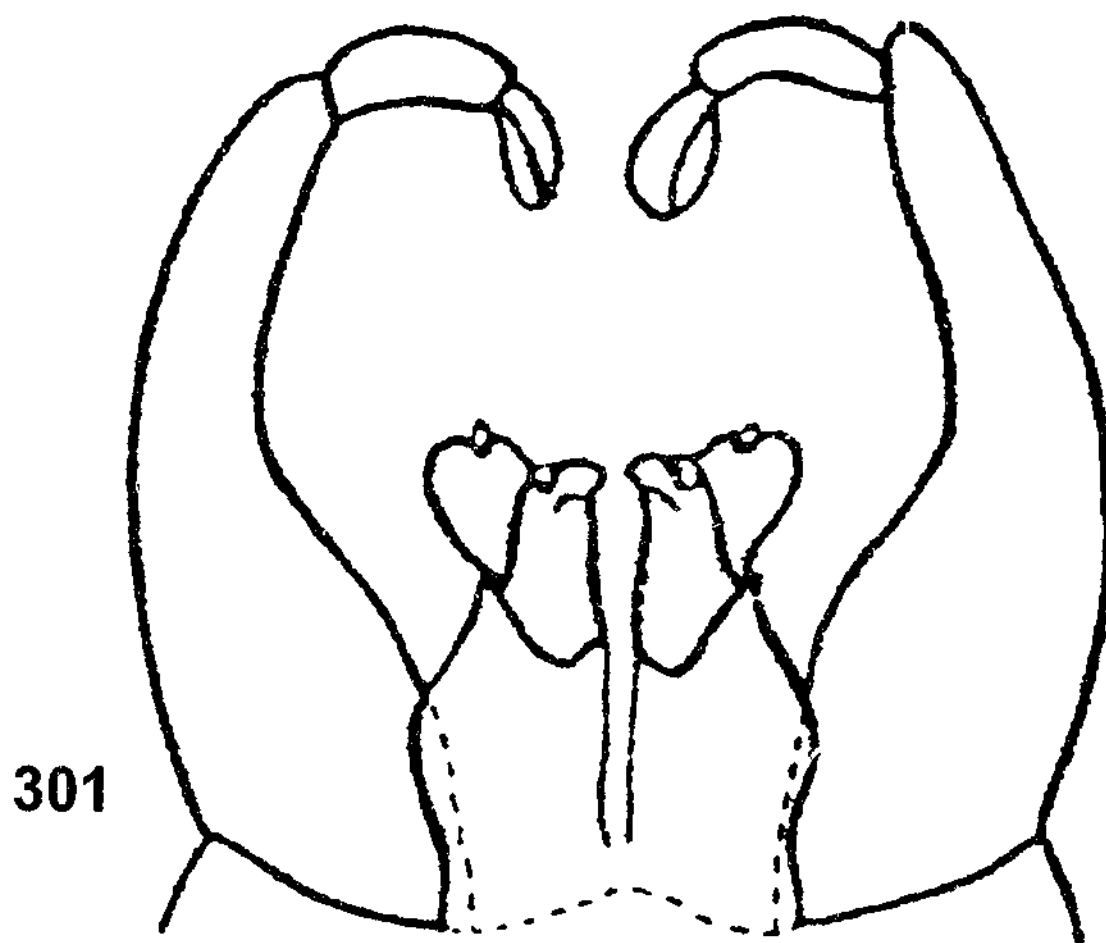
Fig. 301. *Atalophlebia kala* Harker.

Dorsal view of male genitalia showing penes and forceps.
Reproduction of a drawing from Harker (1954).

Fig. 302. *Montikola kala.*
New collection site, Charity Creek tributary, Mount Baw Baw,Victoria (99021602).
Photo by K.J.Finlay.

Figs. 303-304. *Montikola adamus*.
Type locality, Frying Pan Raceline tributary, Falls Creek, Victoria (99020505).
Photos by A. Slocombe.

305
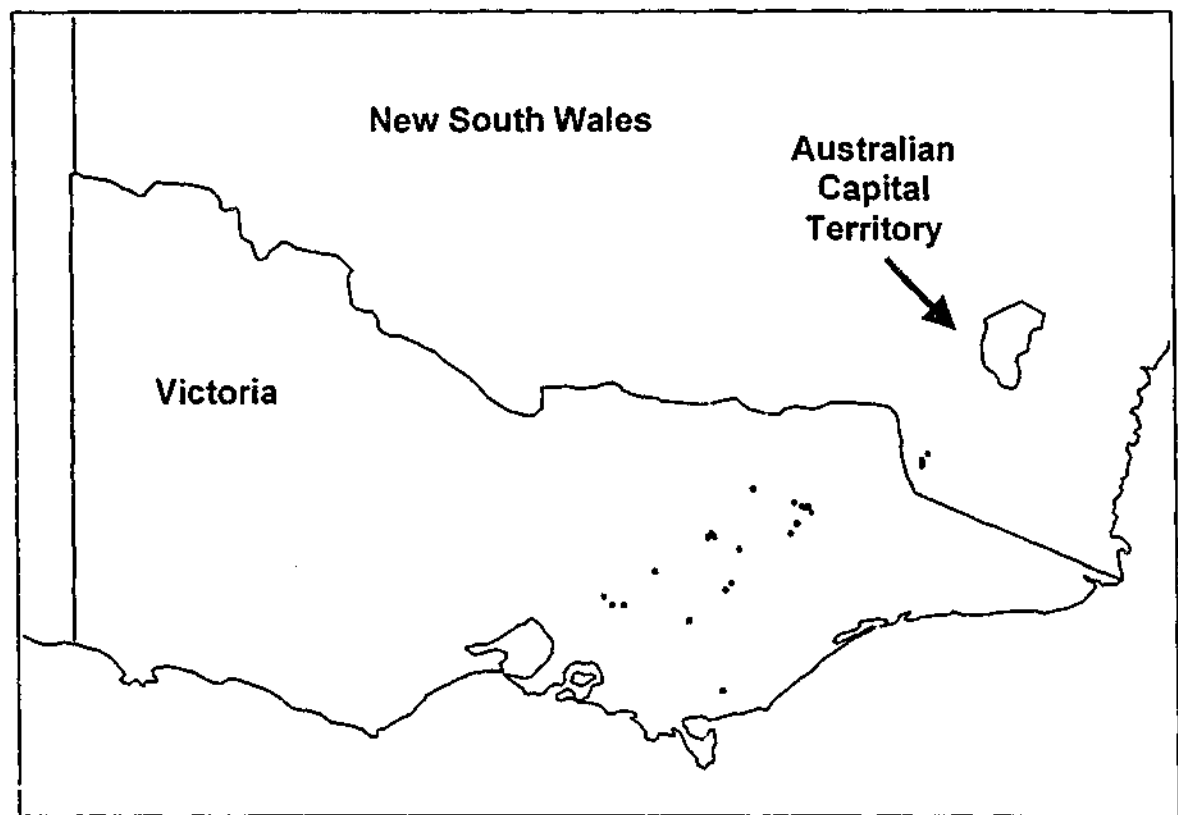
Fig. 305. Distribution of *Montikola adamus*.

306
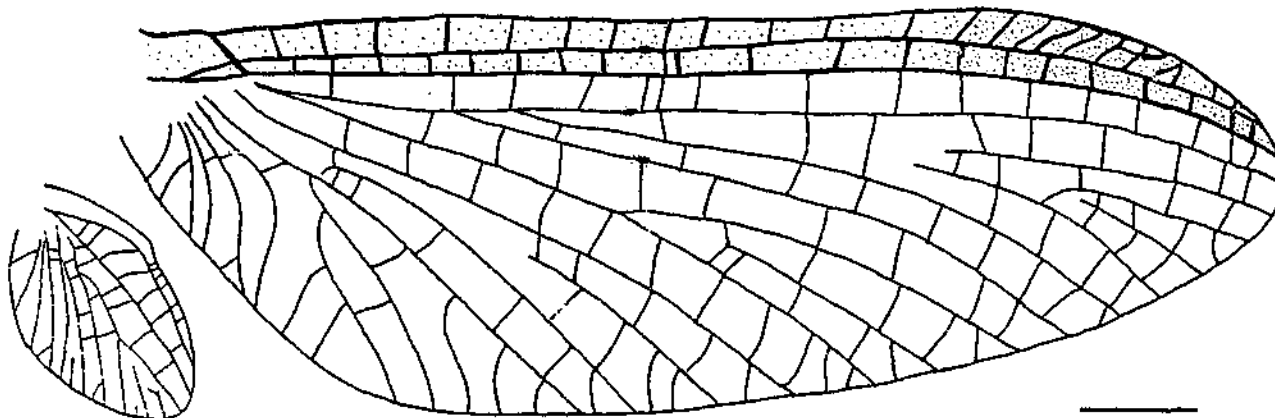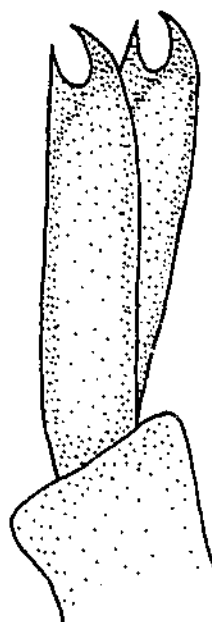
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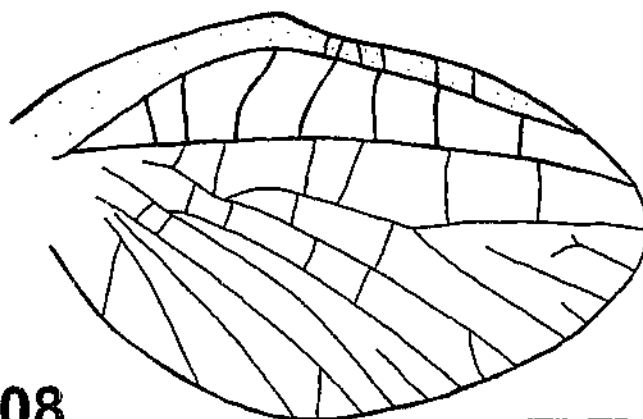
308

Figs. 306-308. *Montikola adamus*, male imago.

Fig. 306. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 307. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 308. Hindwing. Scale bar = 500µm.

309
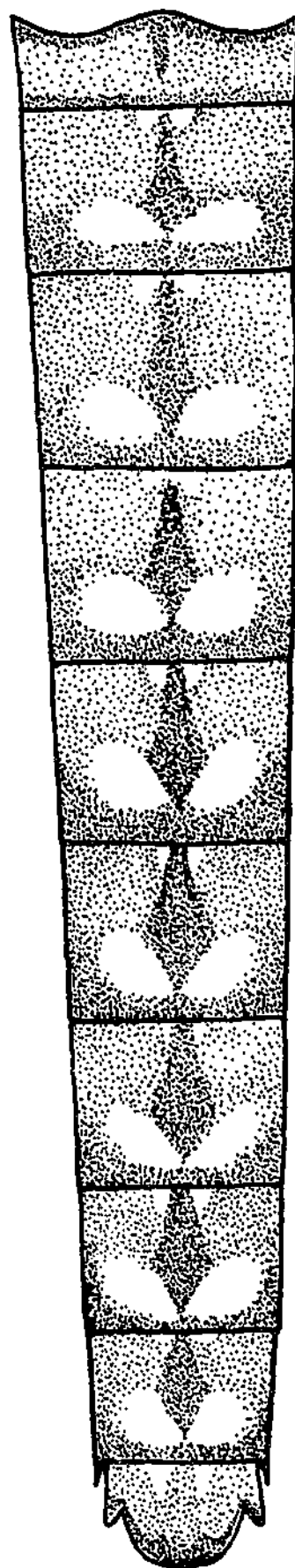
Fig. 309. *Montikola adamus*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

310
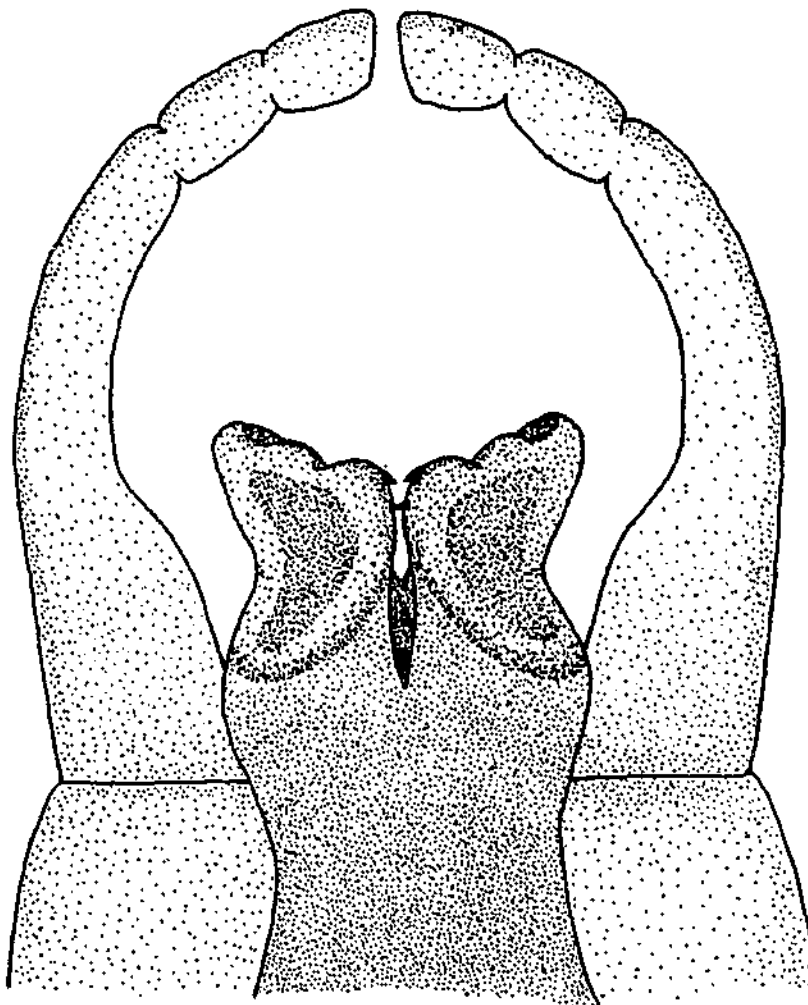
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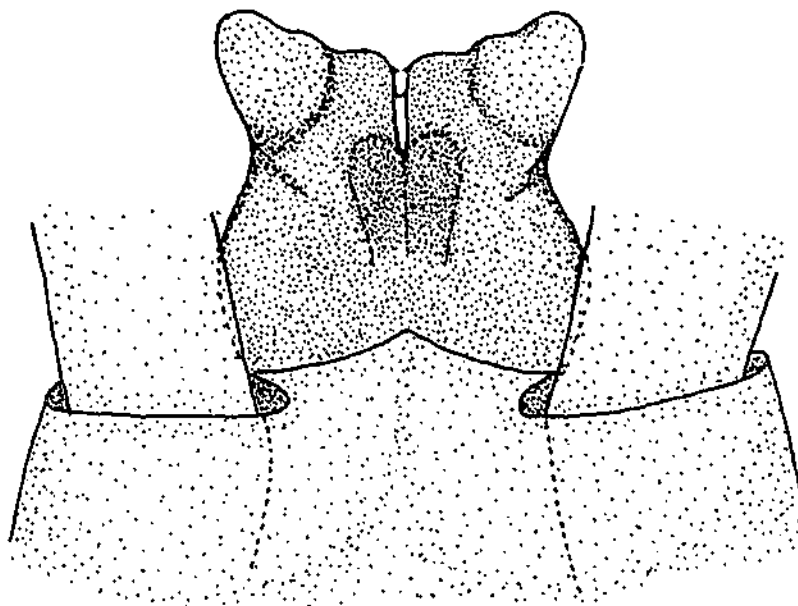
Figs. 310-311. *Montikola adamus*, male imago.
Scale bar = 200µm.

Fig. 310. Dorsal view of genitalia showing penes and forceps.
Fig. 311. Ventral view of genitalia showing penes.
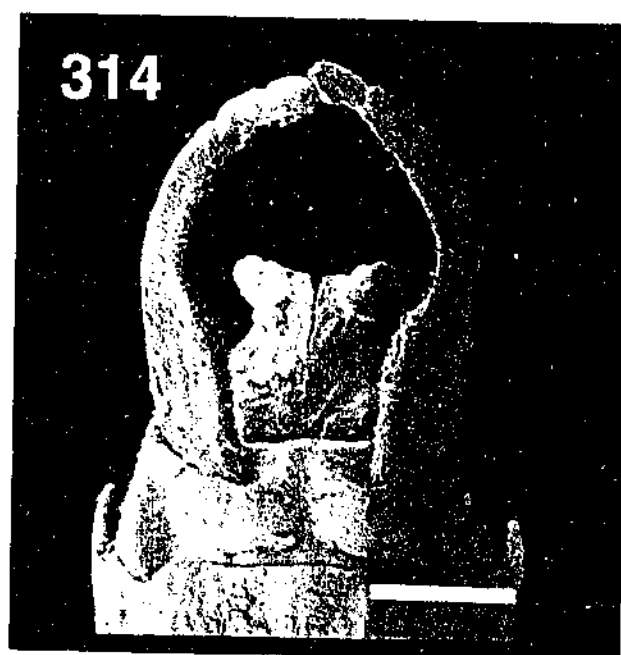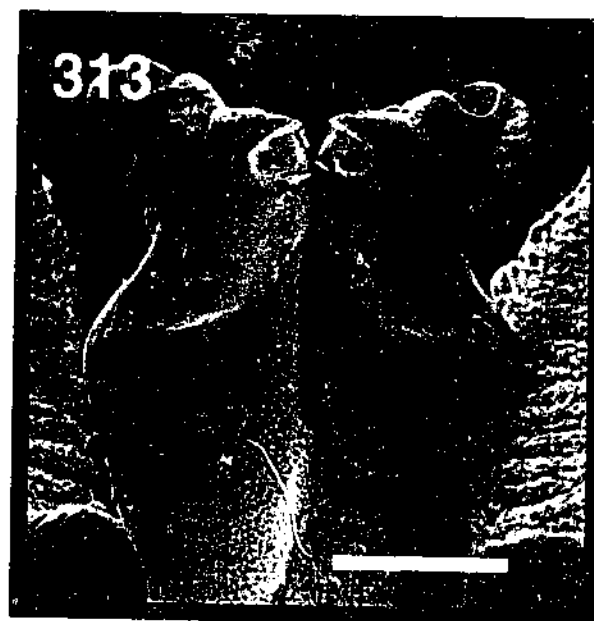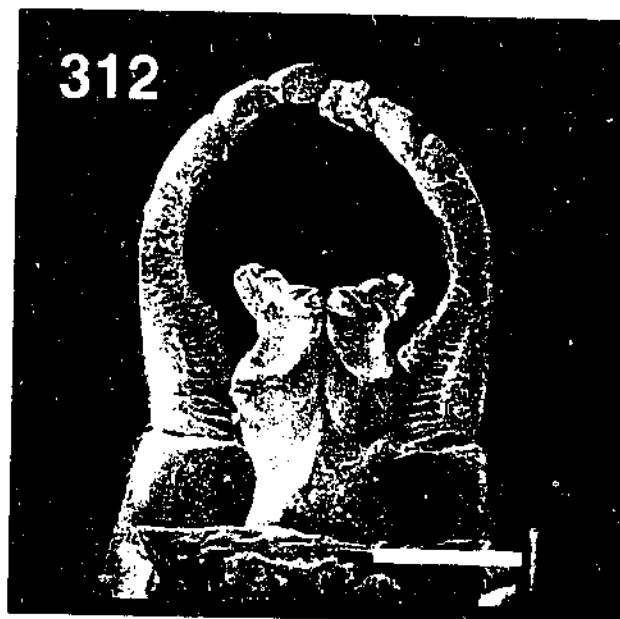
Figs. 312-315. *Montikola adamus*, male imago.

Individual from type locality, Frying Pan Raceline tributary,
Falls Creek, Victoria (99020505).

Fig. 312. Dorsal view of genitalia showing penes and forceps. Scale bar = 200μm.
Fig. 313. Dorsal view of penes. Scale bar = 100μm.
Fig. 314. Ventral view of genitalia showing penes and forceps. Scale bar = 200μm.
Fig. 315. Ventral view of penes. Scale bar = 100μm.
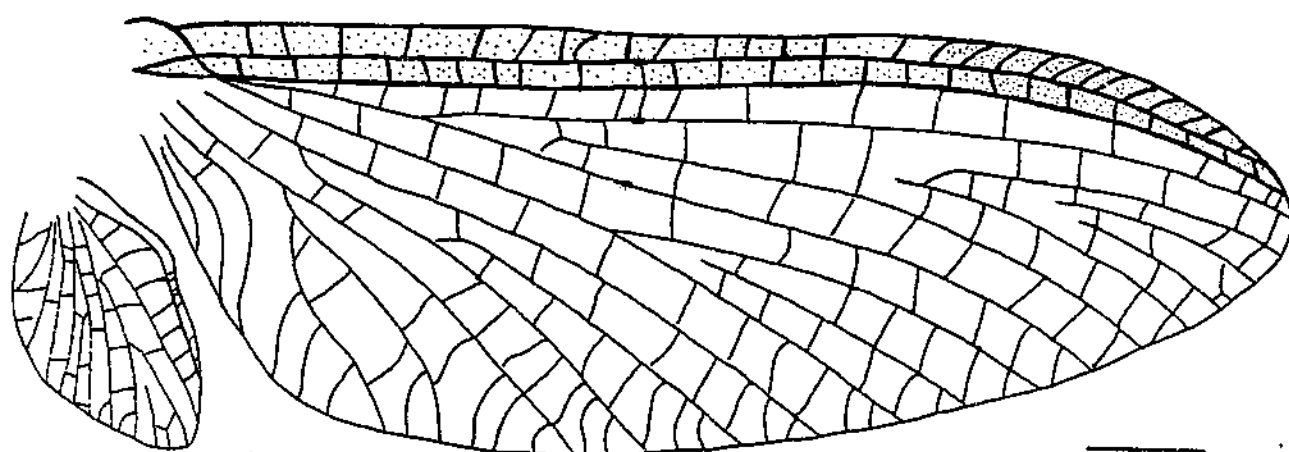
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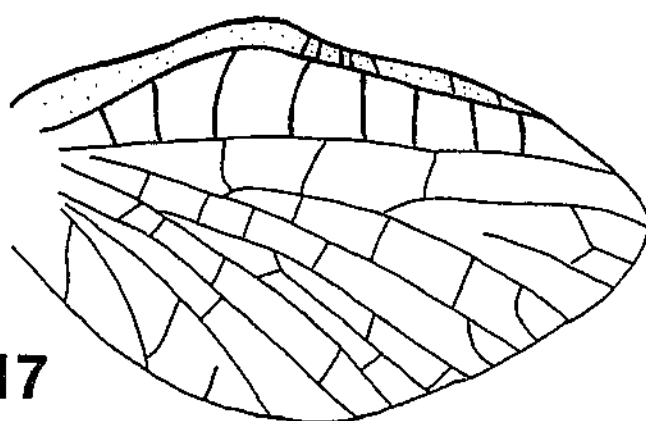
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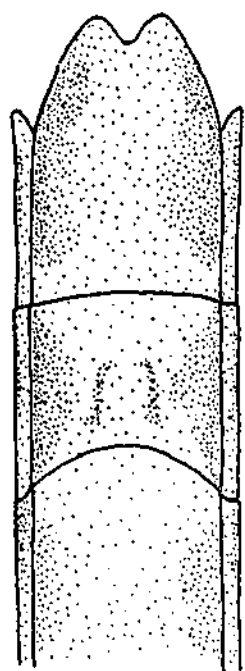
318

Figs. 316-318. *Montikola adamus*, female imago.

Fig. 316. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 317. Hindwing. Scale bar = 500µm.
Fig. 318. Ventral view of abdomen showing sternites 7-9. Scale bar = 500µm.
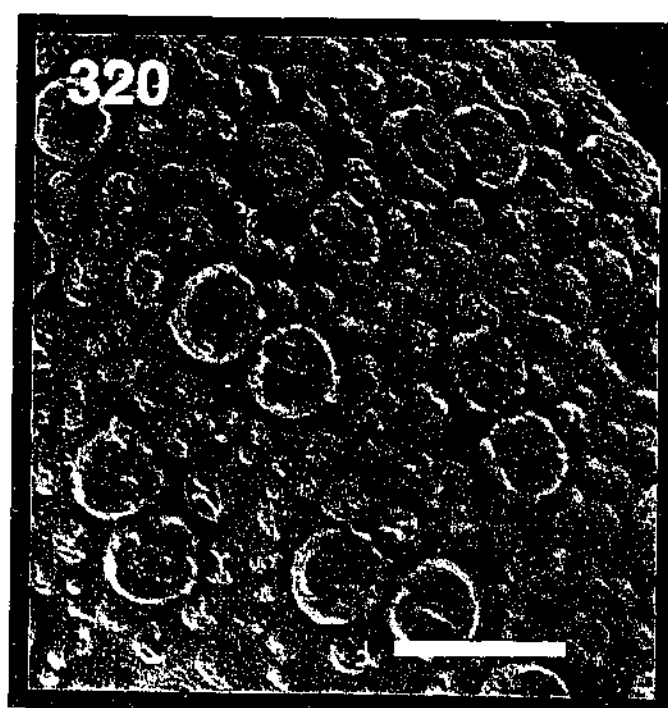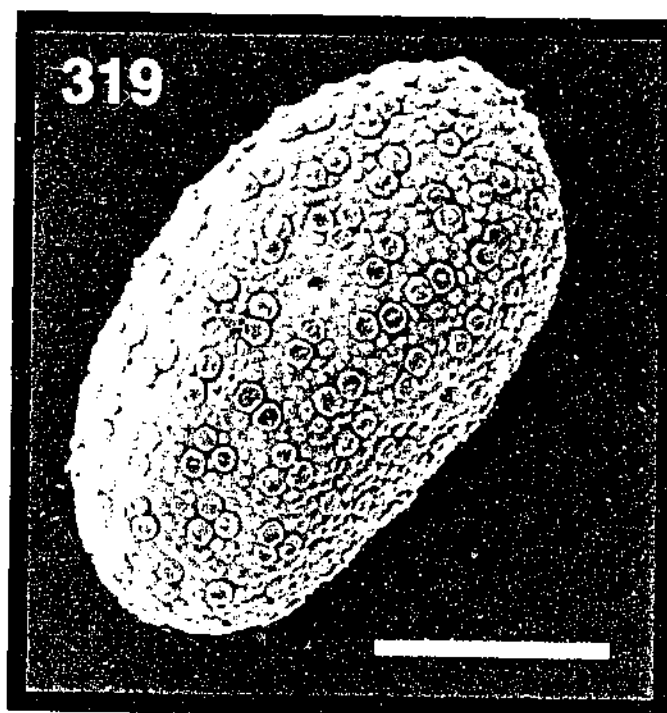
Figs. 319-320. *Montikola adamus*, eggs taken from female imago.

Individual from type locality, Frying Pan
Raceline tributary, Falls Creek, Victoria (99020505).

Fig. 319. Whole egg. Scale bar = 50μm.
Fig. 320. Close up of egg chorion. Scale bar = 10μm.
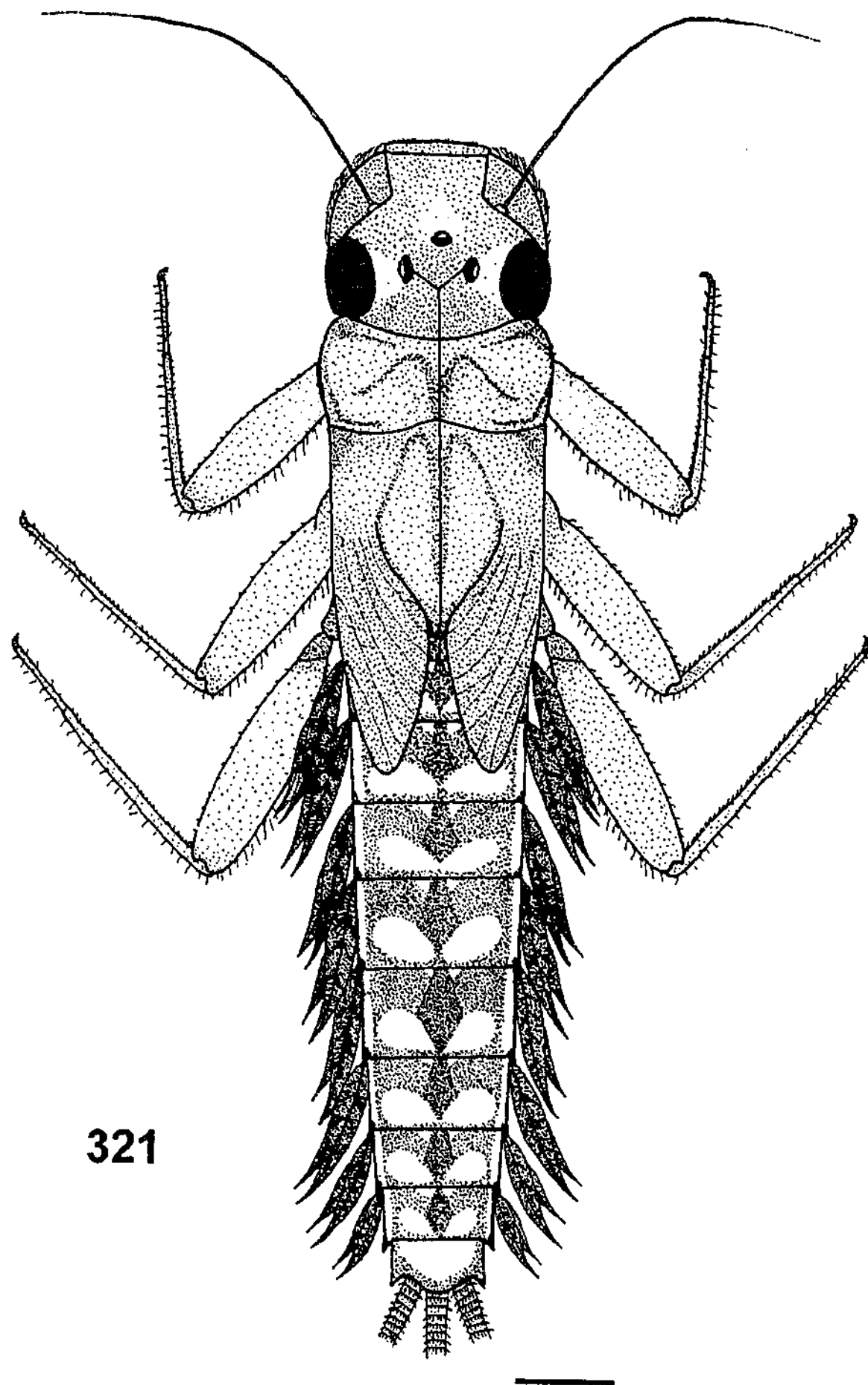
321

Fig. 321. *Montikola adamus*, female nymph.
Scale bar = 1mm.
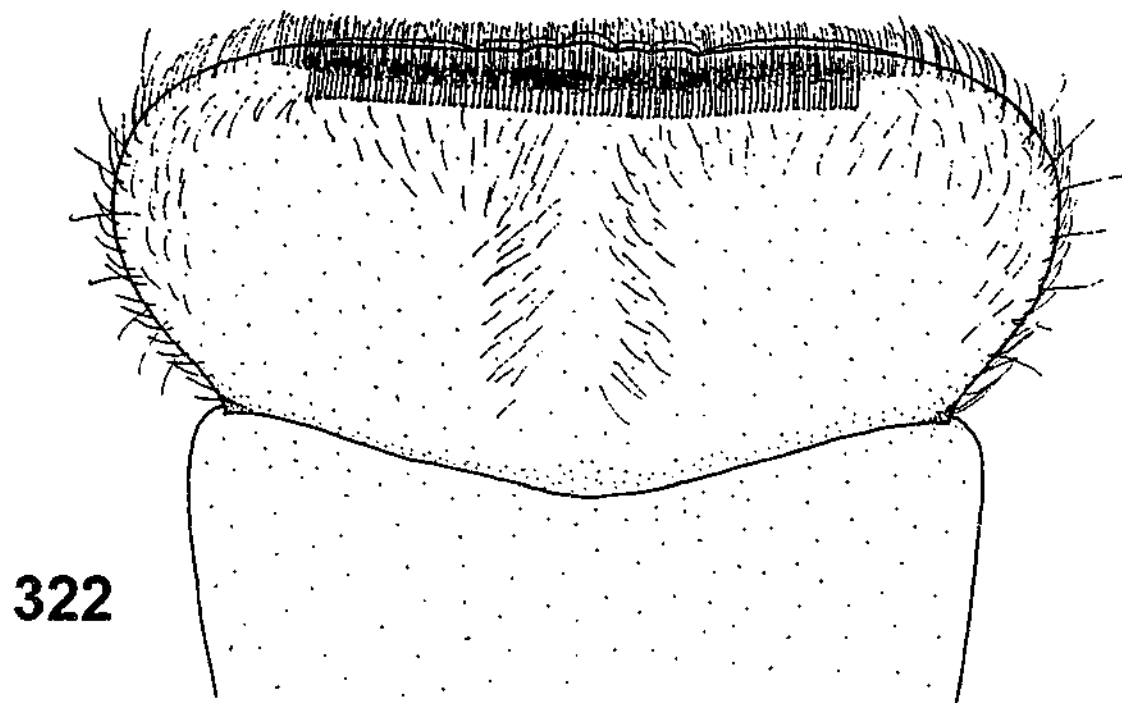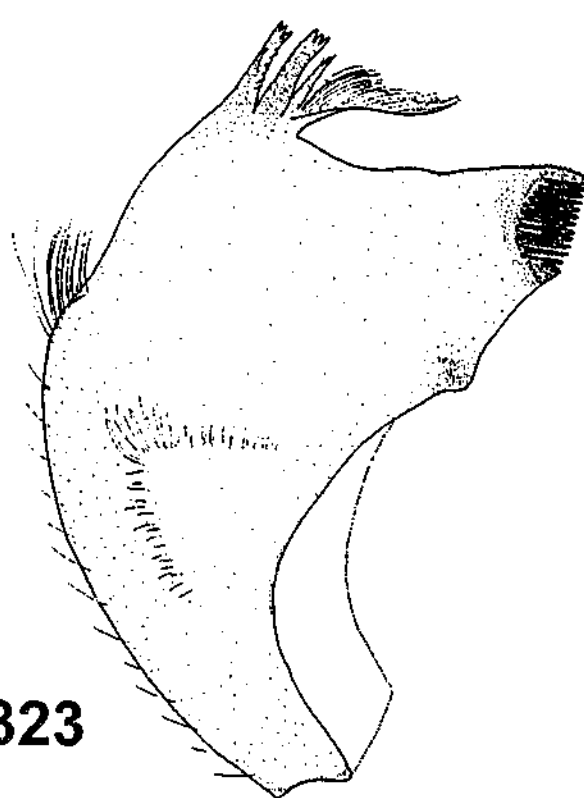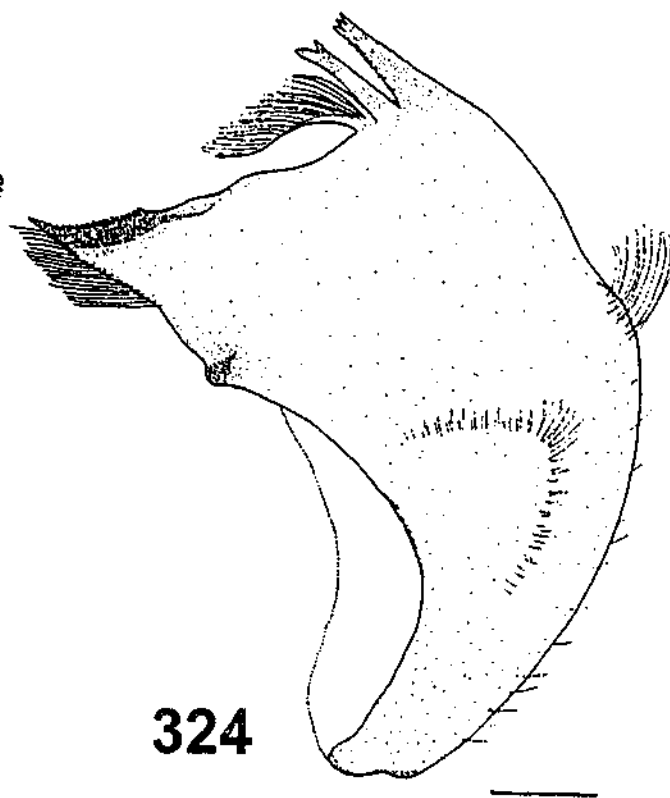
Figs. 322-324. *Montikola adamus*, nymph mouthparts.
Scale bars = 200μm.

Fig. 322. Labrum and clypeus.
Fig. 323. Left mandible.
Fig. 324. Right mandible.

325

326
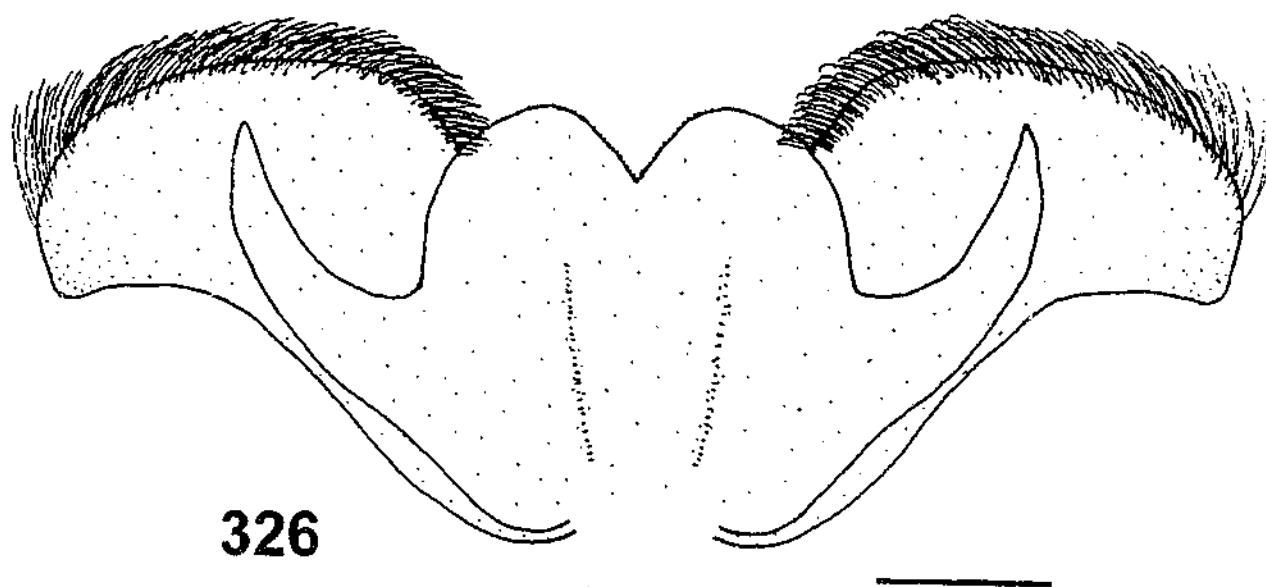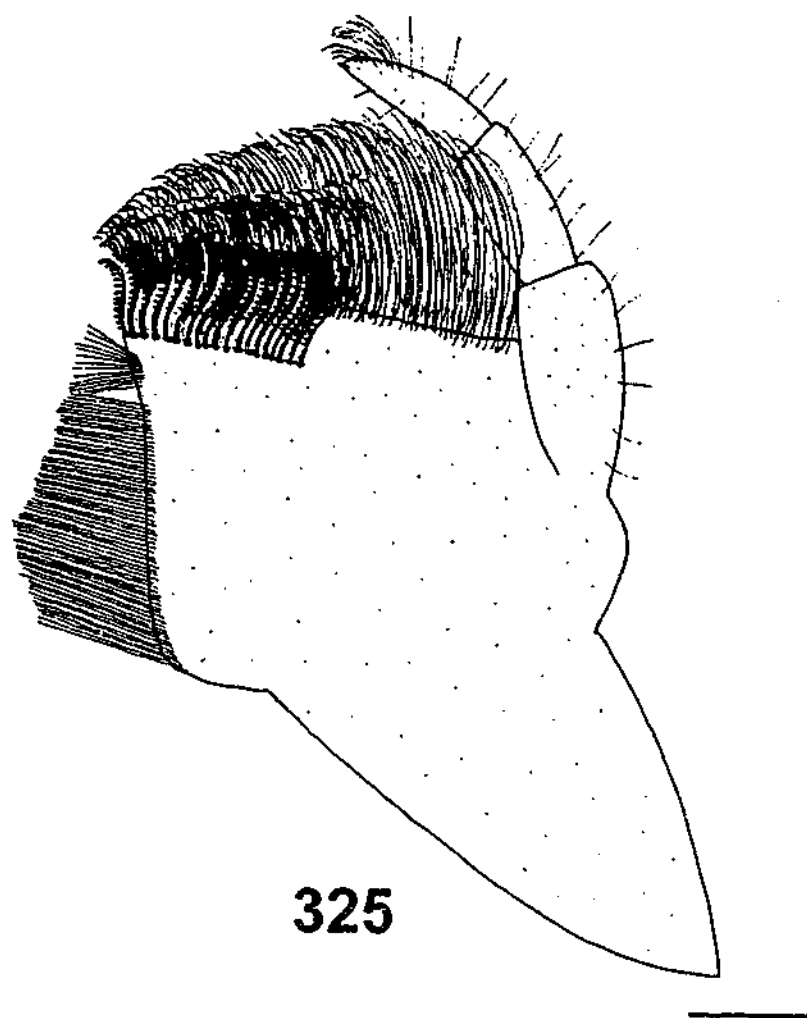
Figs. 325-326. *Montikola adamus*, nymph mouthparts.
Scale bars = 200µm.

Fig. 325. Right maxilla.
Fig. 326. Hypopharynx.
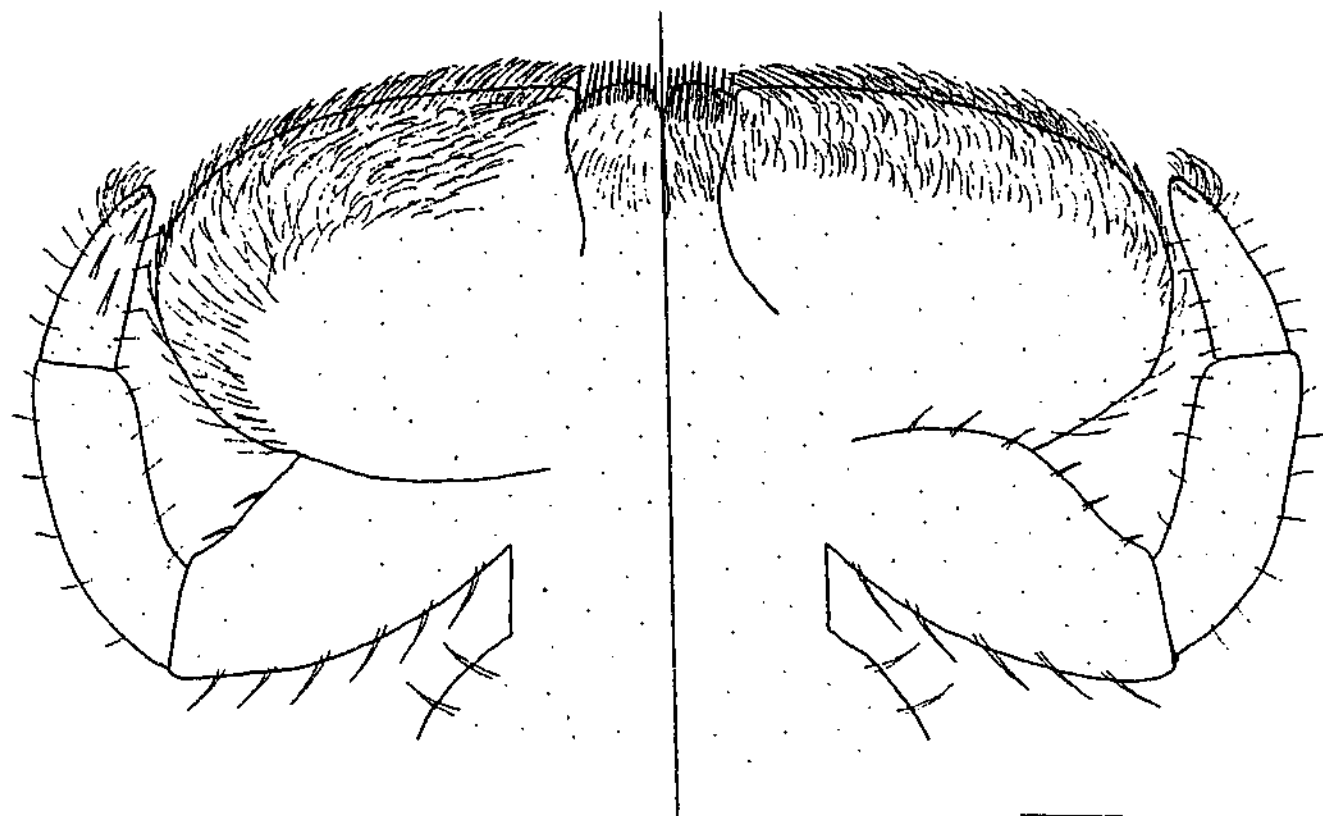
327

Fig. 327. *Montikola adamus,* nymph mouthpart.

Labium. Scale bar = 200μm.

328
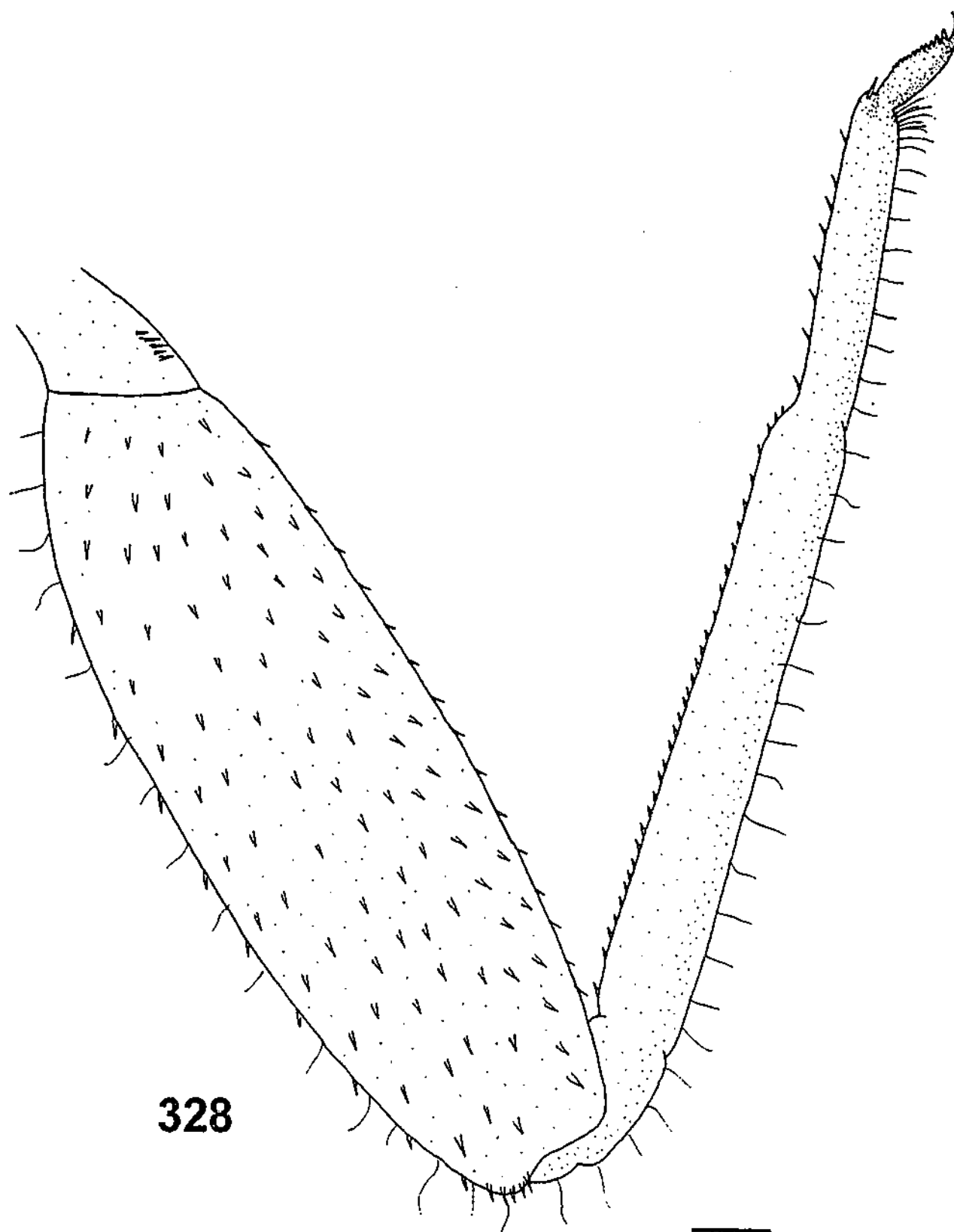
Fig. 328. *Montikola adamus*, nymph.

Foreleg. Scale bar = 200µm.

329
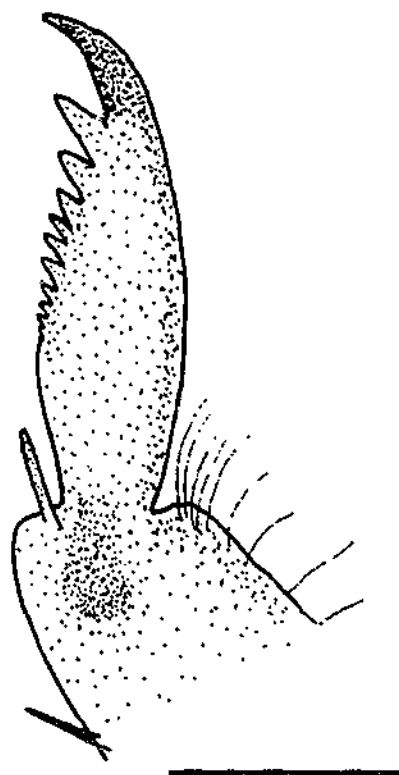
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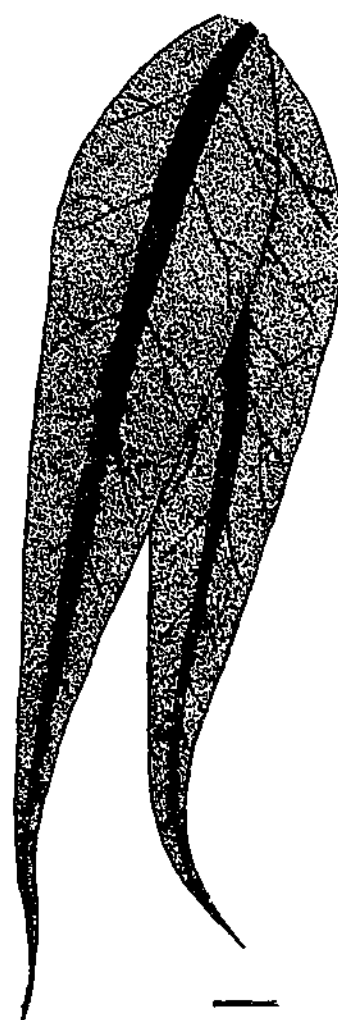
Figs. 329-330. *Montikola adamus*, nymph.
Scale bars = 100μm.

Fig. 329. Foreleg tarsal claw.
Fig. 330. Gills.

331
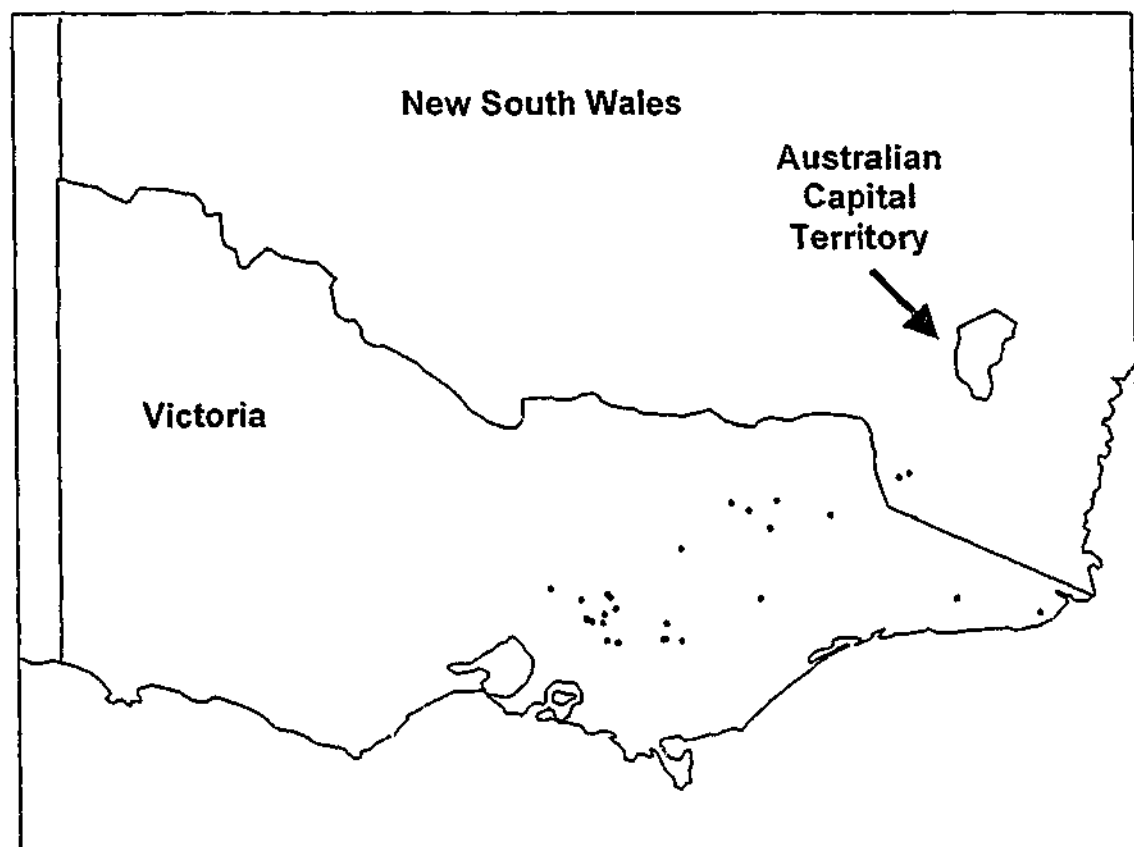
Fig. 331. Distribution of the monotypic genus *Gemmayaluka*.

Fig. 332. *Gemmayaluka wiltkorringae.*
Type locality, Cement Creek, Mount Donna-Buang, Victoria (98030503).
Photo by K.J.Finlay.

333
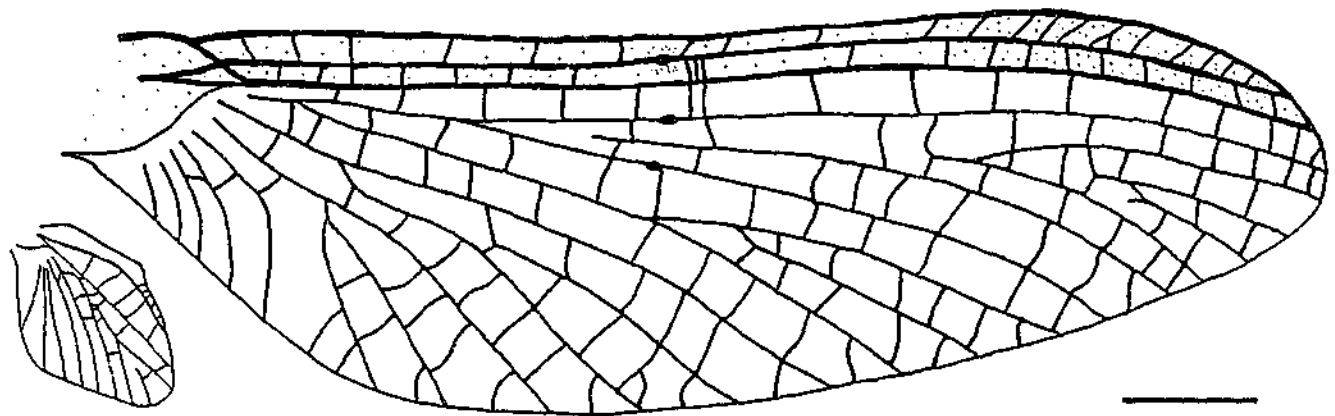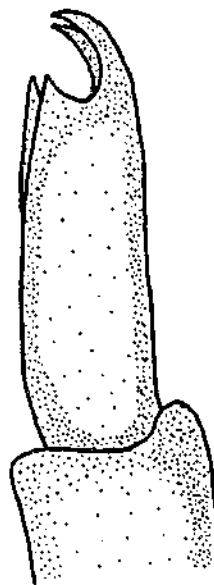
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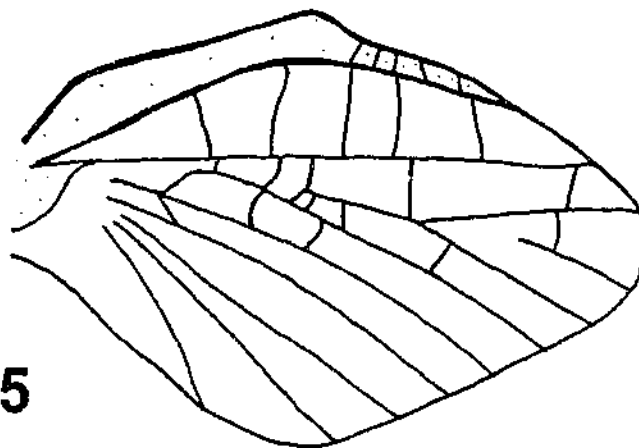
335

Figs 333-335. *Gemmayaluka wiltkorringae*, male imago.

Fig. 333. Foreleg tarsal claw. Scale bar = 50µm.
Fig. 334. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 335. Hindwing. Scale bar = 500µm.

336
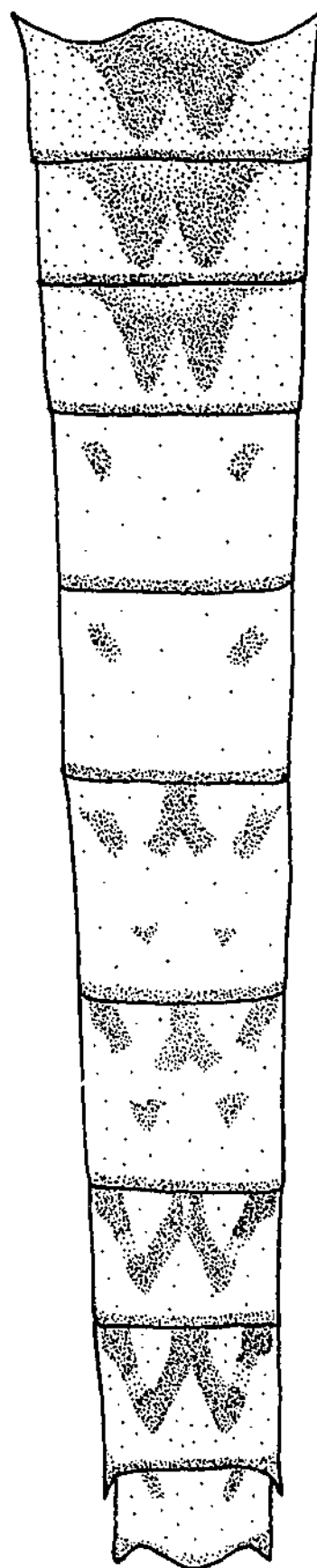
Fig. 336 *Gemmayaluka wiltkorringae*, male imago.

Dorsal view of abdomen.
Scale bar = 1mm.

337
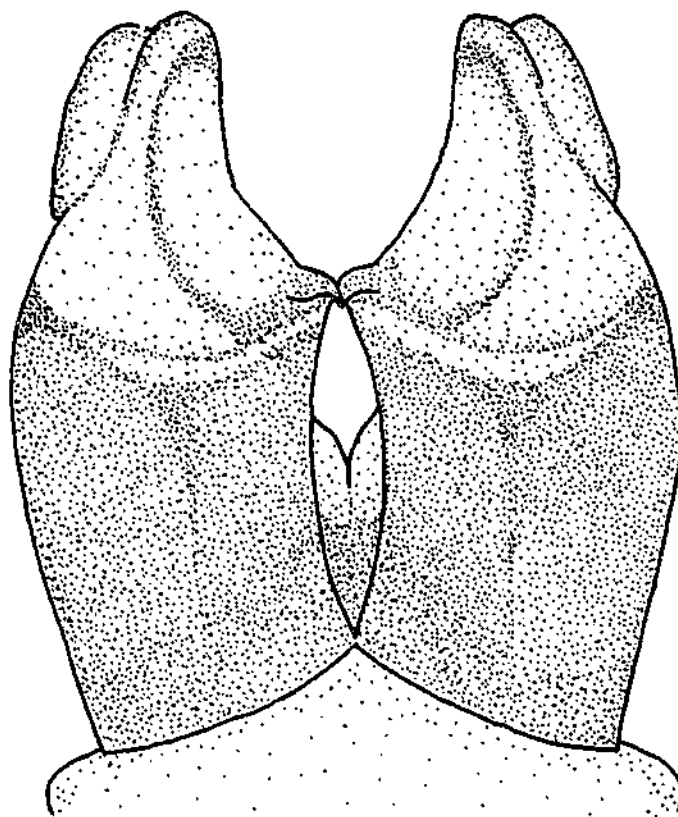
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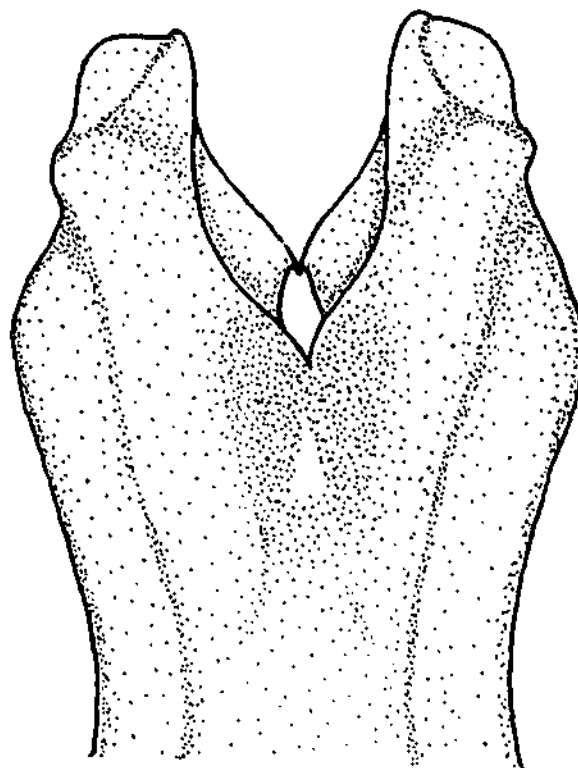
Figs. 337-338. *Gemmayaluka wiltkorringae*, male imago.
Scale bar = 200μm.

Fig. 337. Dorsal view of penes.
Fig. 338. Ventral view of penes.
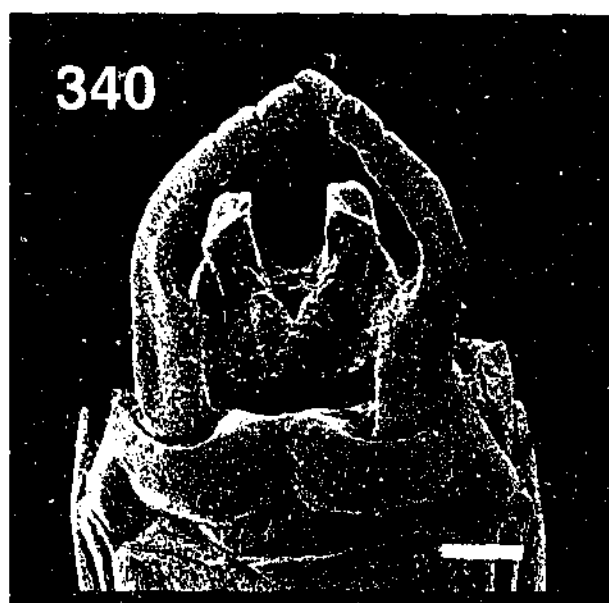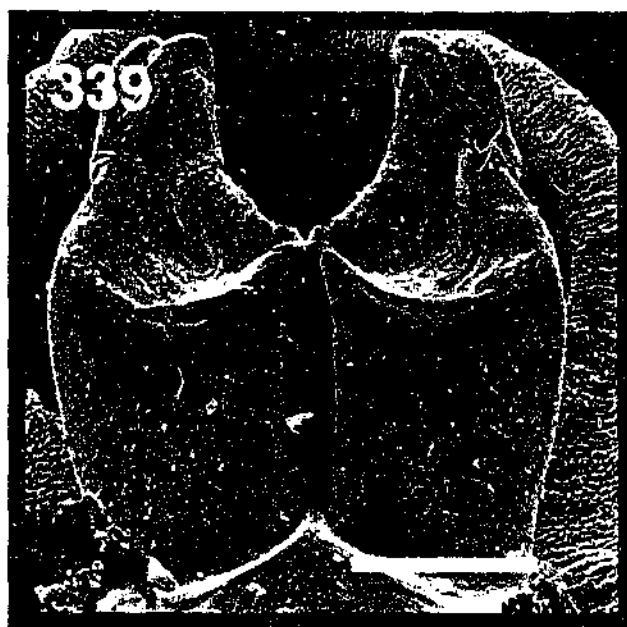
Figs. 339-341. *Gemmayaluka wiltkorringae*, male imago.

Individual from King Parrott Creek, 15km SW of Flowerdale, Victoria (98030501).
Scale bars = 100μm.

Fig. 339. Dorsal view of penes.
Fig. 340. Ventral view of genitalia showing penes and forceps.
Fig. 341. Ventral view of penes.

342

343

344
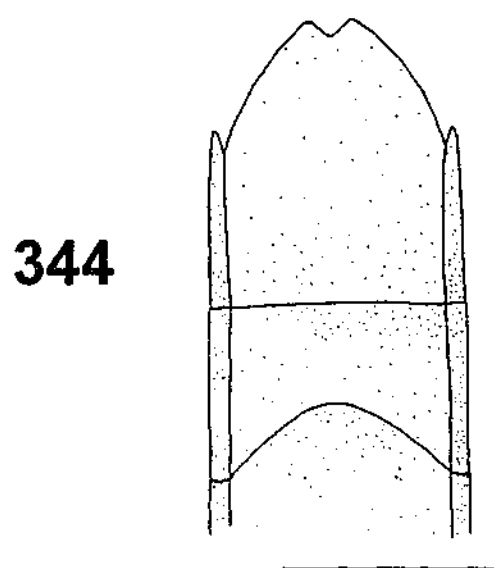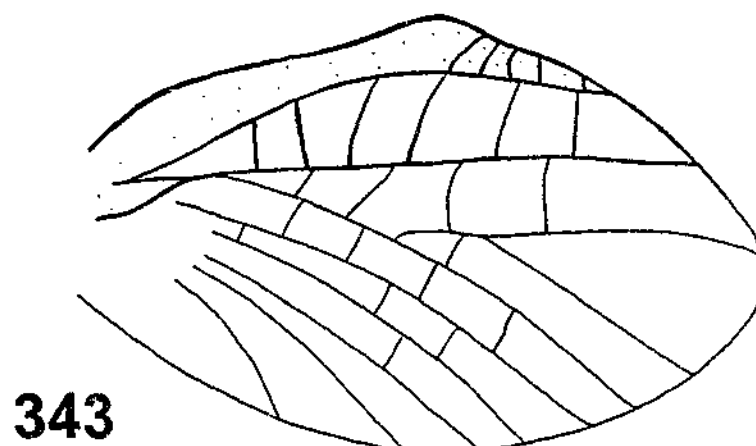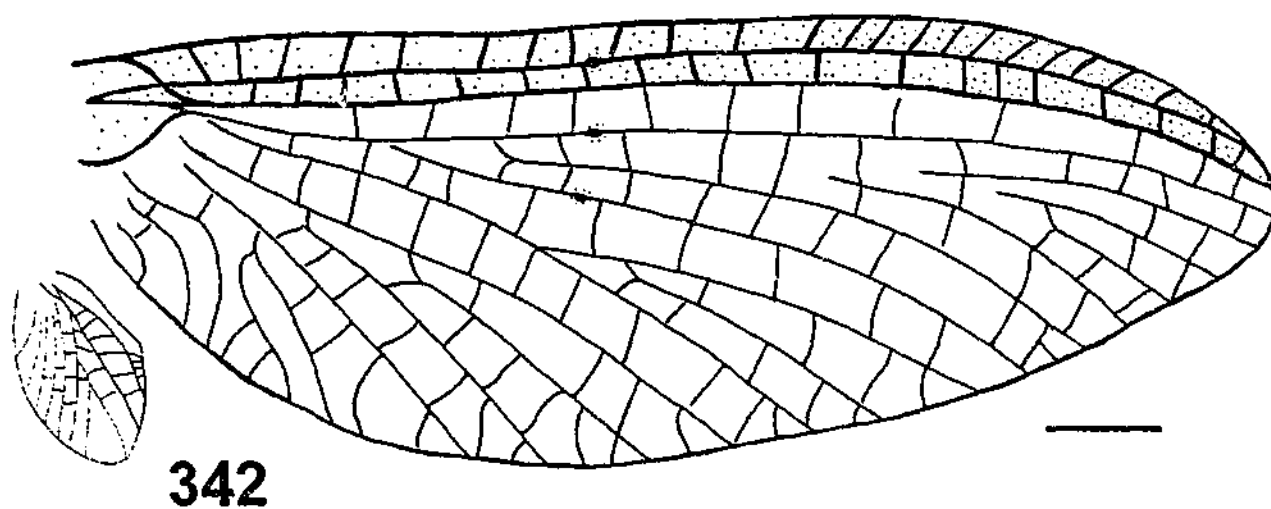
Figs. 342-344. *Gemmayaluka wiltkorringae*, female imago.

Fig. 342. Forewing showing relative size of hindwing. Scale bar = 1mm.
Fig. 343. Hindwing. Scale bar = 500μm.
Fig. 344. Ventral view of abdomen showing sternites 7-9. Scale bar = 500μm.
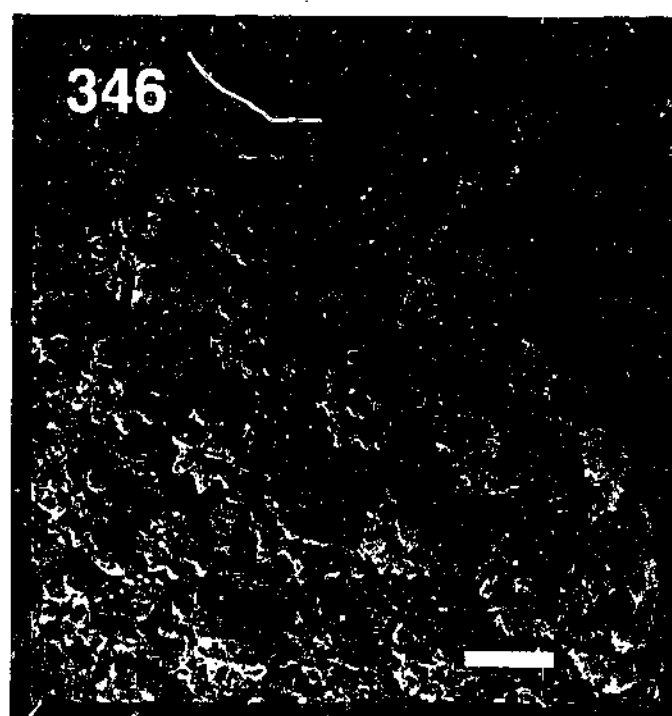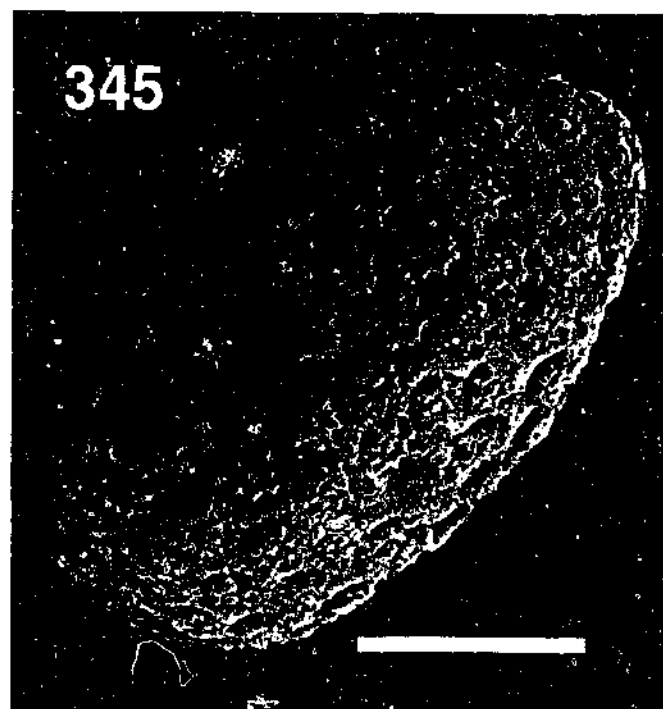
Figs. 345-346. *Gemmayaluka wiltkorringae*, eggs taken from female imago.

Individual from type locality, Cement Creek, Mount Donna Buang.
Victoria (98030503).

Fig. 345. Whole egg. Scale bar = 50μm.
Fig. 346. Close up of egg chorion. Scale bar = 10μm.
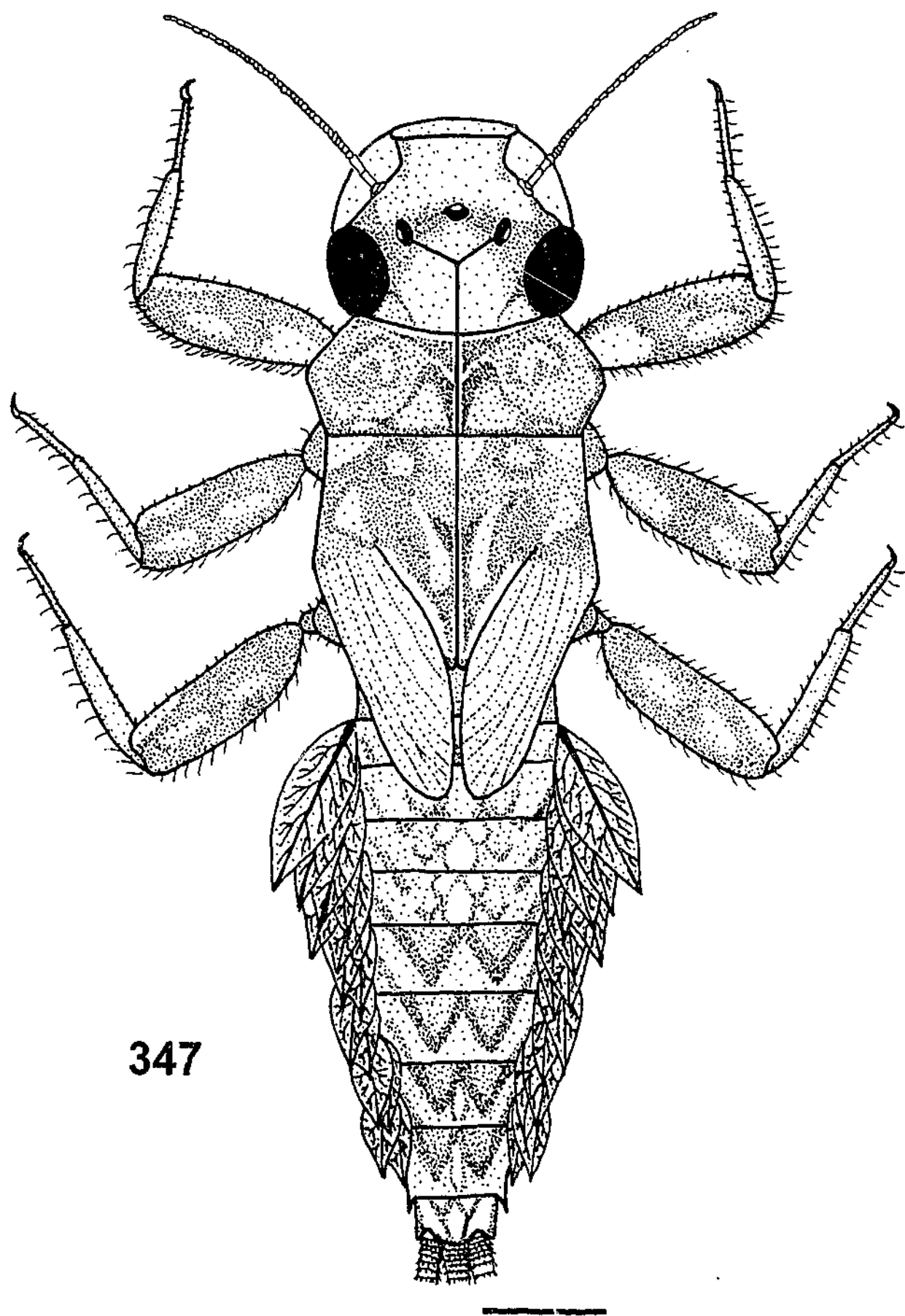
347

Fig. 347. *Gemmayaluka wiltkorringae*, female nymph.
Scale bar = 1mm.
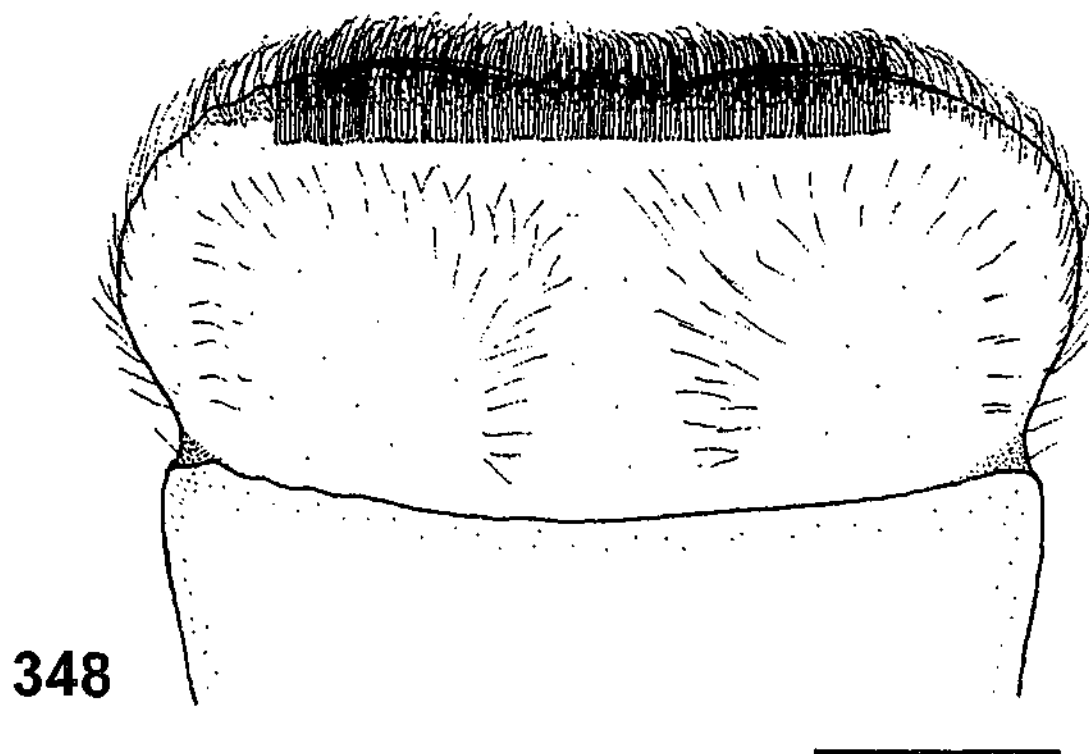
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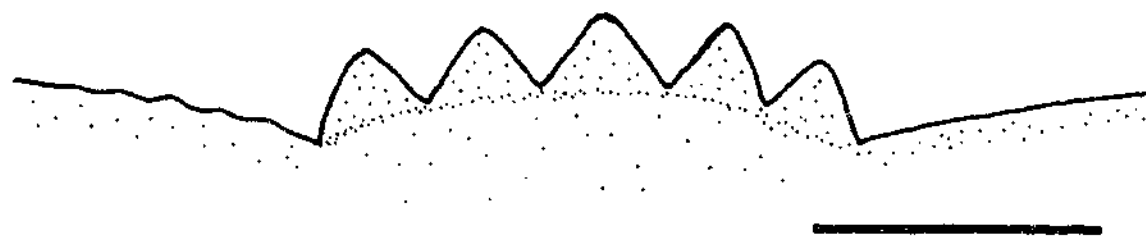
349

Figs. 348-349. *Gemmayaluka wiltkorringae*, nymph mouthparts.

Fig. 348. Labrum and clypeus. Scale bar = 200μm.
Fig. 349. Denticles on anterior margin of labrum. Scale bar = 50μm.
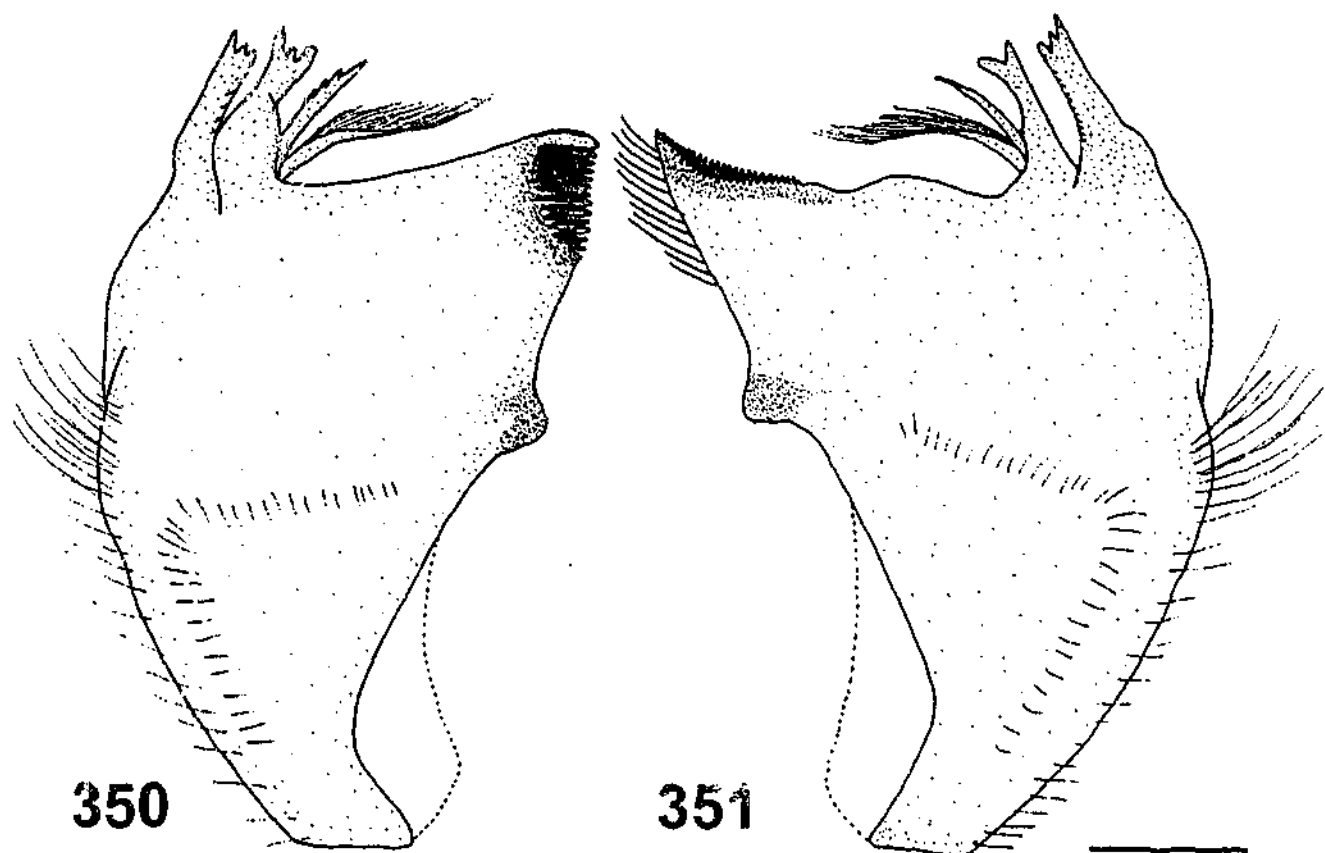
Figs. 350-351. *Gemmayaluka wiltkorringae*, nymph mouthparts.
Scale bar = 200µm.

Fig. 350. Left mandible.
Fig. 351. Right mandible.

185
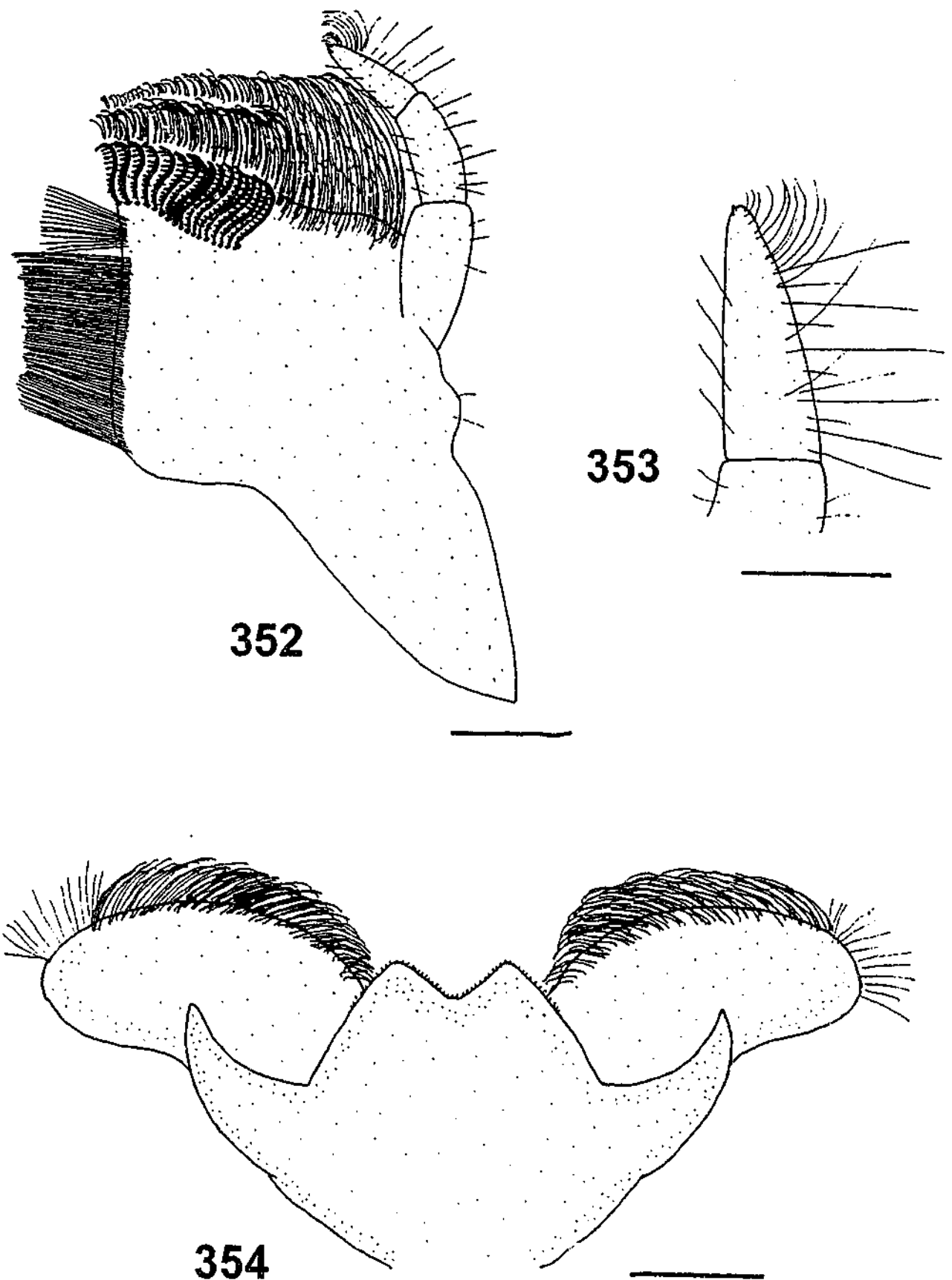
Figs. 352-354. *Gemmayaluka wiltkorringae*, nymph mouthparts.

Fig. 352. Right maxilla. Scale bar = 200μm.
Fig. 353. Terminal palp of maxilla showing apical spine. Scale bar = 100μm.
Fig. 354. Hypopharynx. Scale bar = 200μm.

355
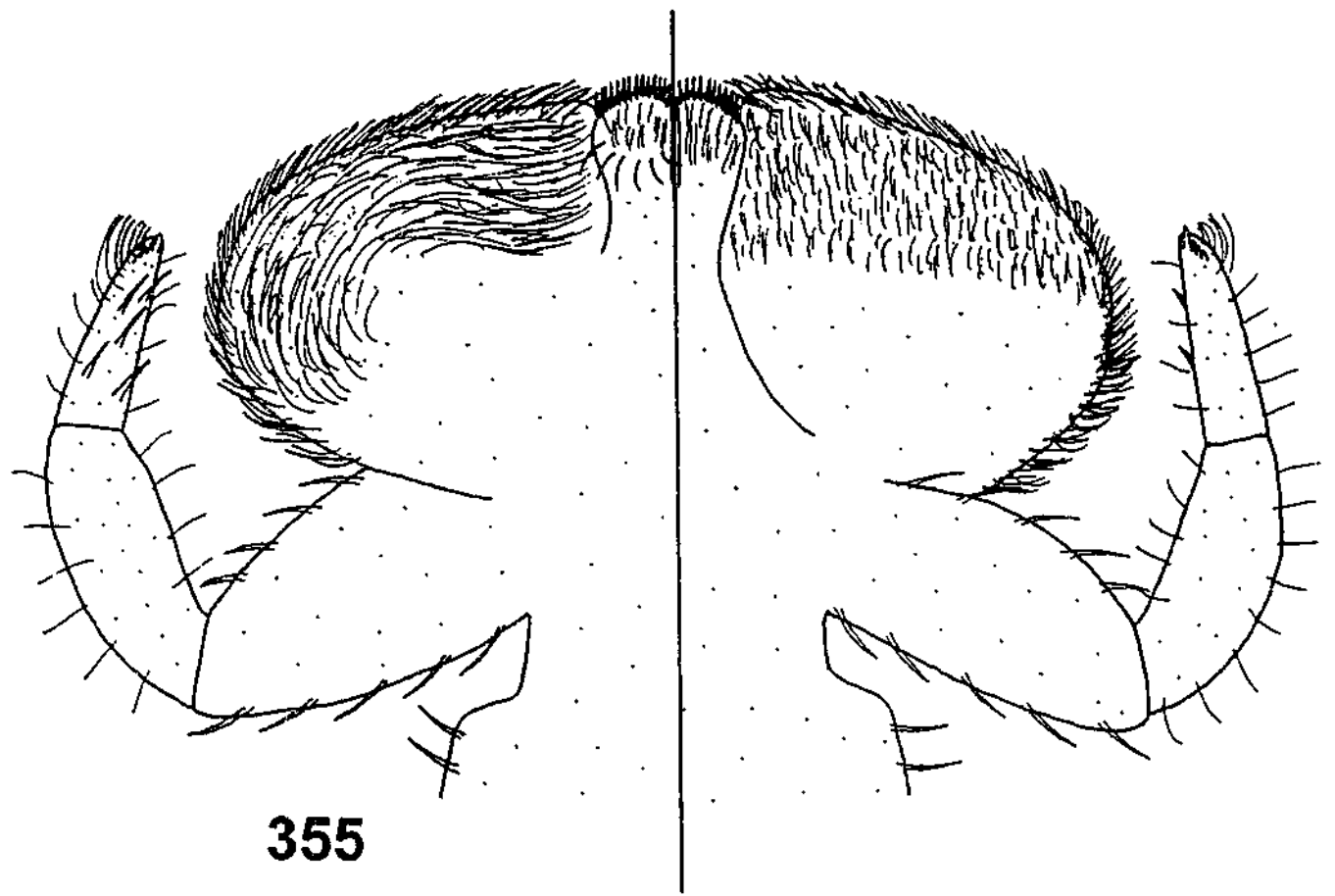
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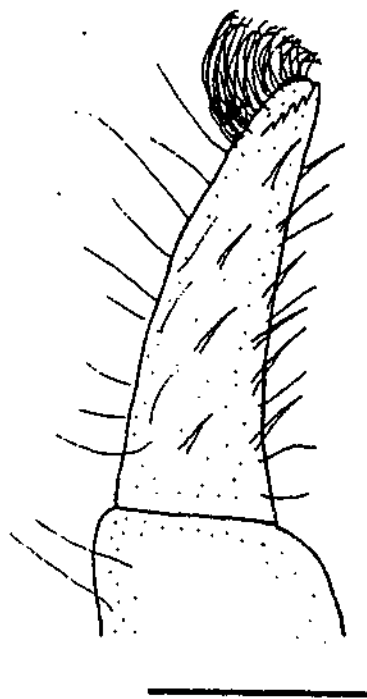
Figs. 355-356. *Gemmayaluka wiltkorringae*, nymph mouthparts.

Fig. 355. Labium. Scale bar = 200µm.
Fig. 356. Dorsal view of labial terminal palp showing apical spines.
Scale bar = 100µm.
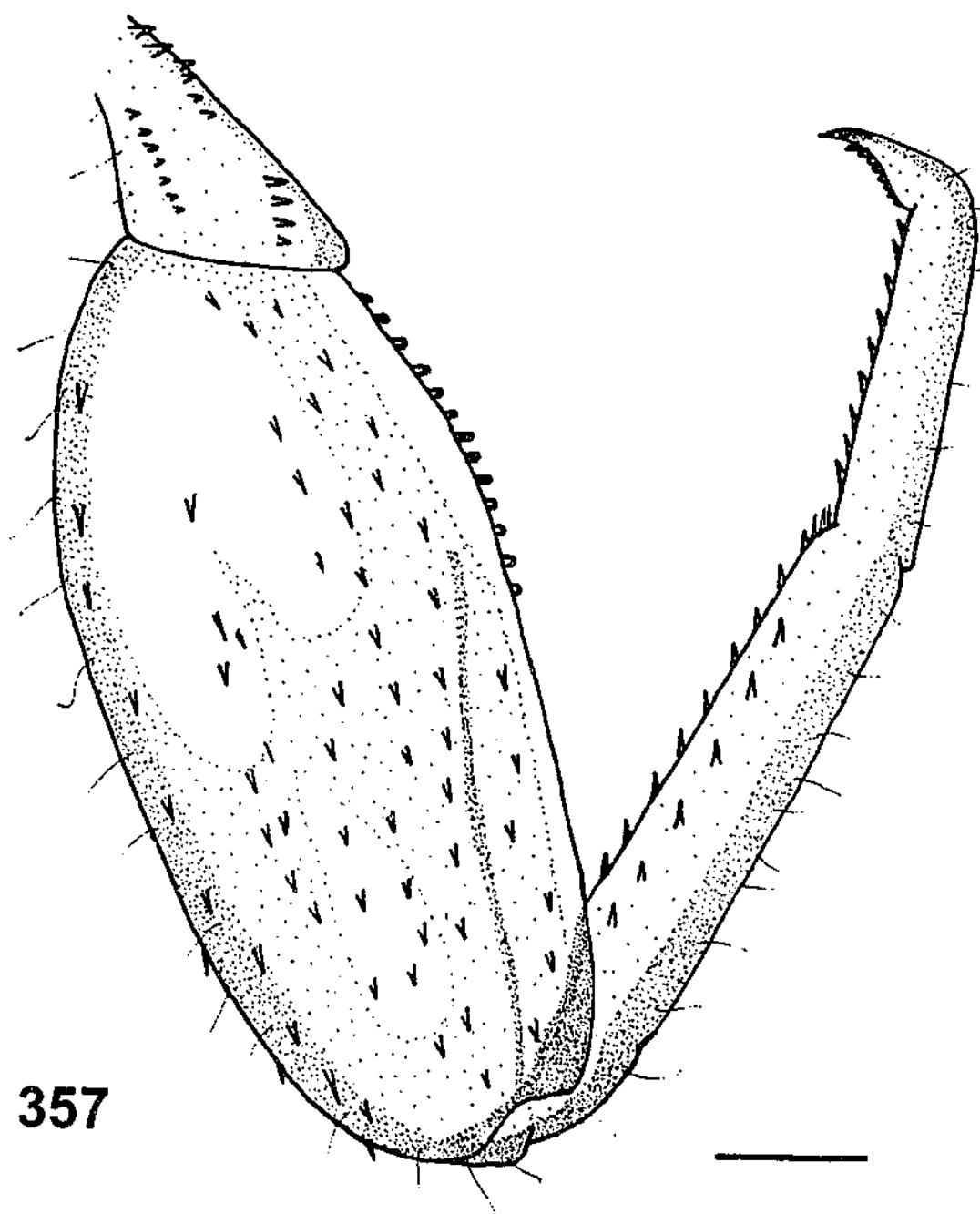
357

Fig. 357. *Gemmayaluka wiltkorringae*, nymph.

Foreleg. Scale bar = 200μm.

358
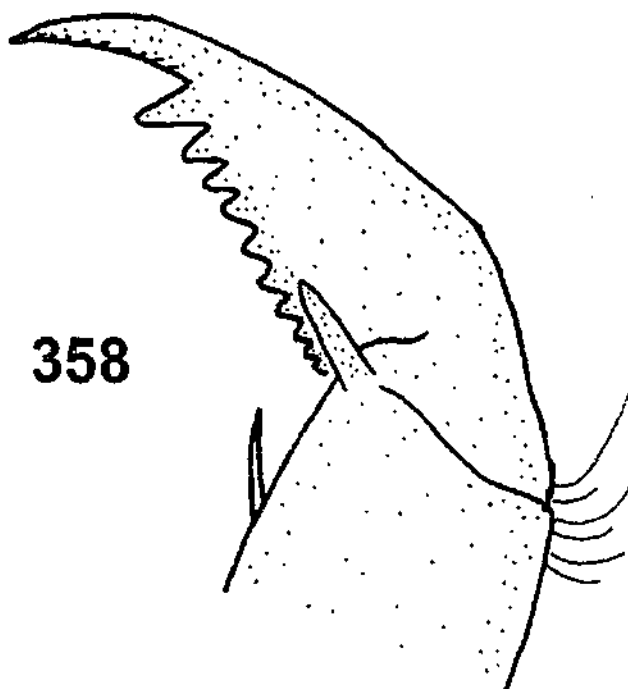
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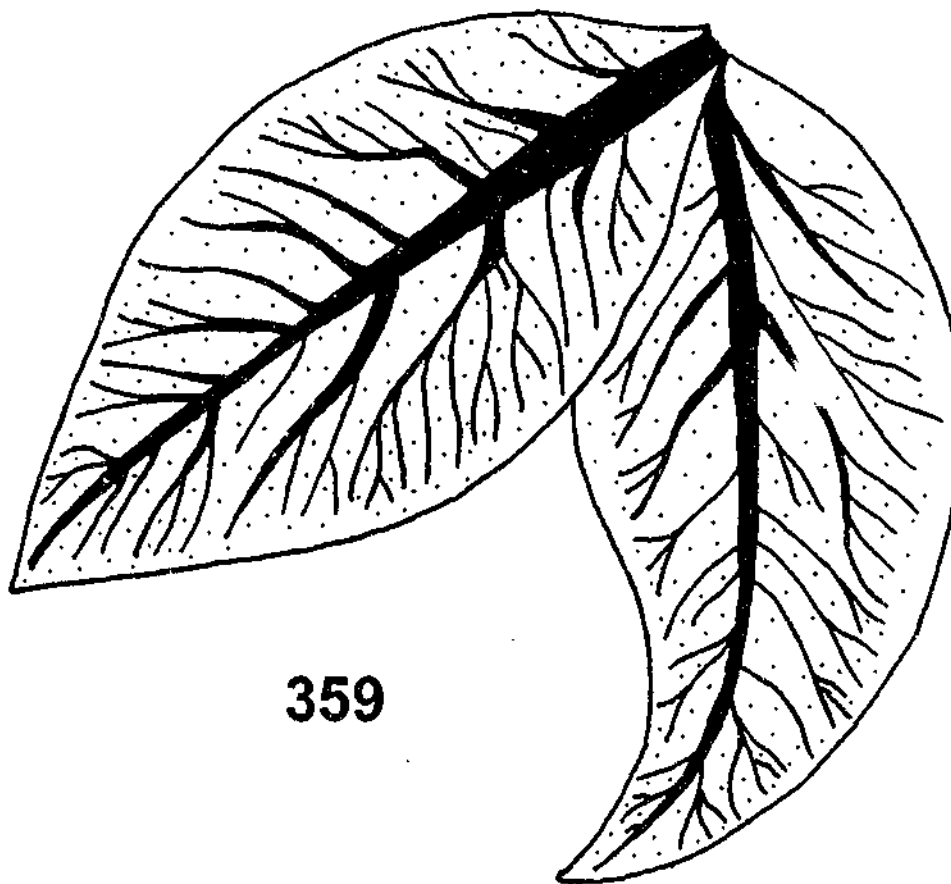
Figs. 358-359. *Gemmayaluka wiltkorringae*, nymph.
Scale bars = 100μm.

Fig. 358. Foreleg tarsal claw.
Fig. 359. Gills.

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MURRAY-DARLING DIVISION
1. Upper Murray River
2. Kiewa River
3. Ovens River
4. Broken River
5. Goulburn River
6. Campaspe River
7. Loddon River
8. Avoca River
14. Mallee
15. Wimmera-Avon Rivers

SOUTH-EAST COAST DIVISION
21. East Gippsland
22. Snowy River
23. Tambo River
24. Mitchell River
25. Thomson River
26. La Trobe River
27. South Gippsland
28. Bunyip River
29. Yarra River
30. Maribyrnong River

31. Werribee River
32. Moorabool River
33. Barwon River
34. Lake Corangamite
35. Otway Coast
36. Hopkins River
37. Portland Coast
39. Glenelg River
39. Millicent Coast

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Fig. 360. Drainage basin divisions of Victoria as defined by the
Australian Water Resources Council (AWRC).
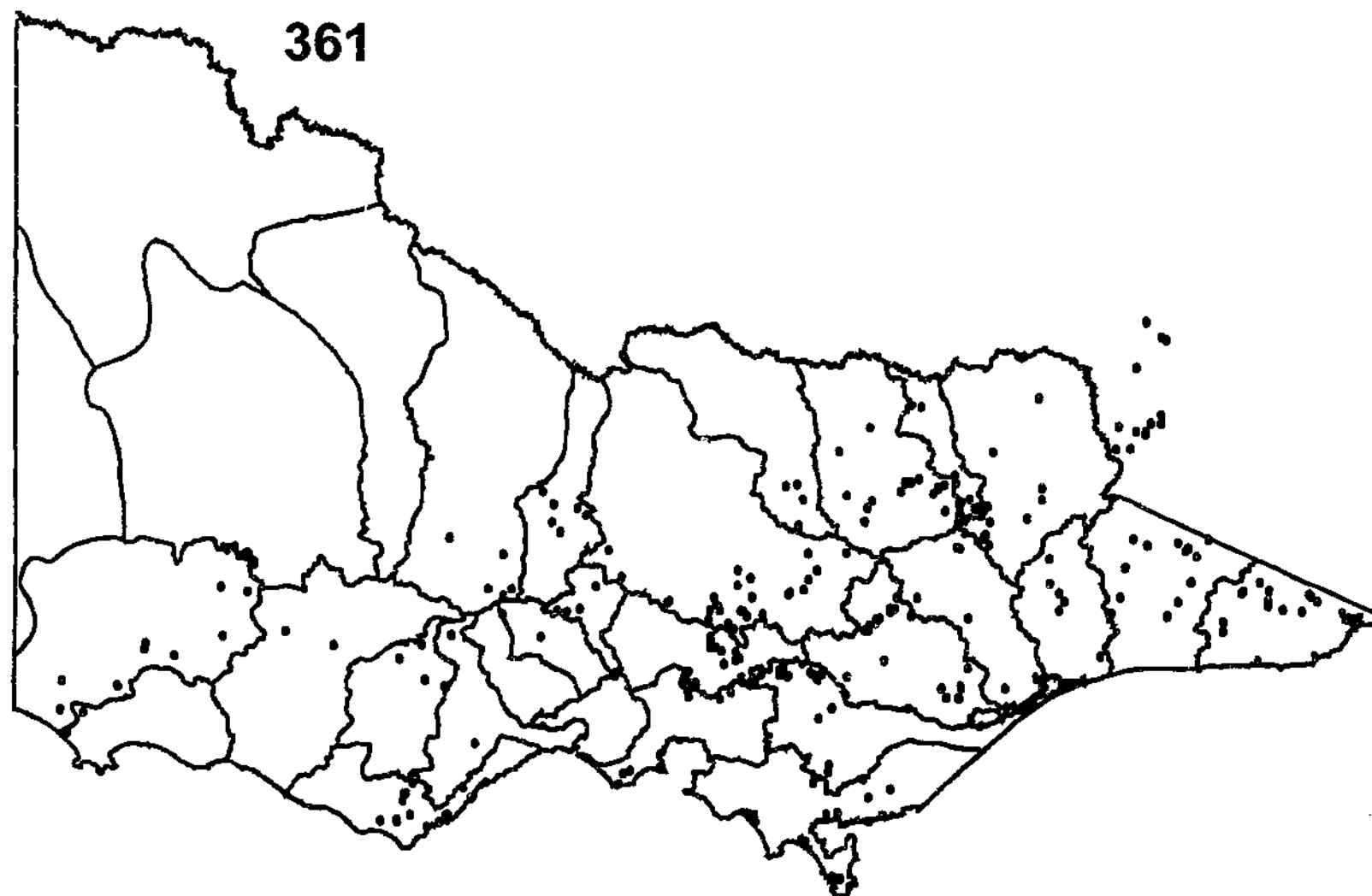
Fig. 361. Location of mayfly collecting sites where environmental data was collected.
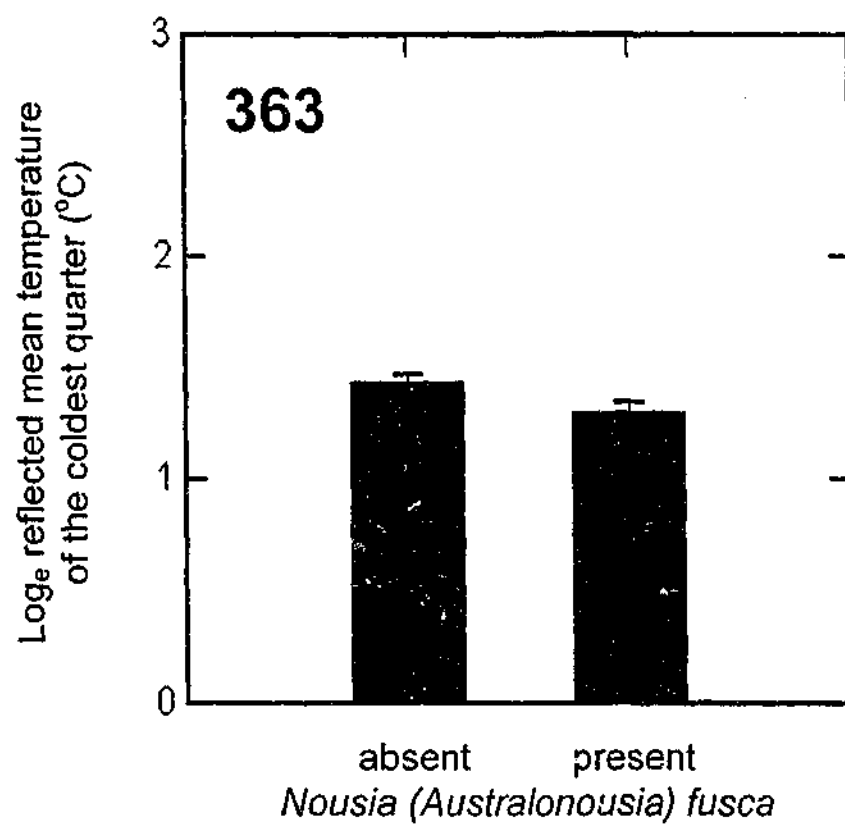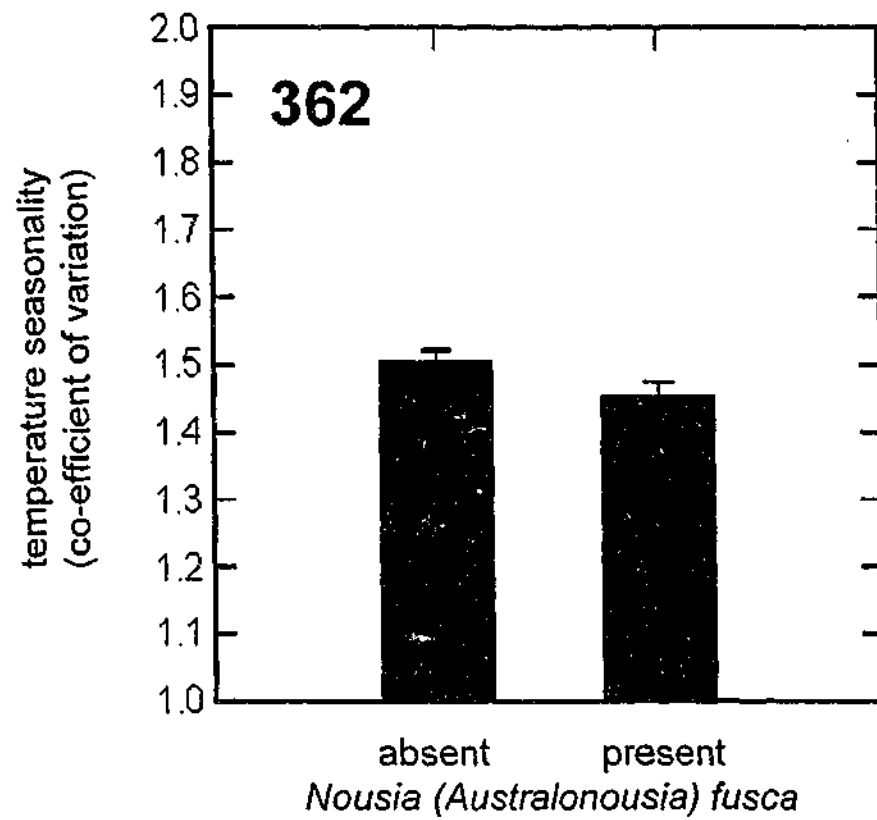
Fig. 362. Relationship between the presence of *Nousia (Australonousia) fusca* and temperature seasonality.

Fig. 363. Relationship between the presence of *Nousia (Australonousia) fusca* and mean temperature of the coldest quarter.

Bars show mean values, error bars represent one standard error.
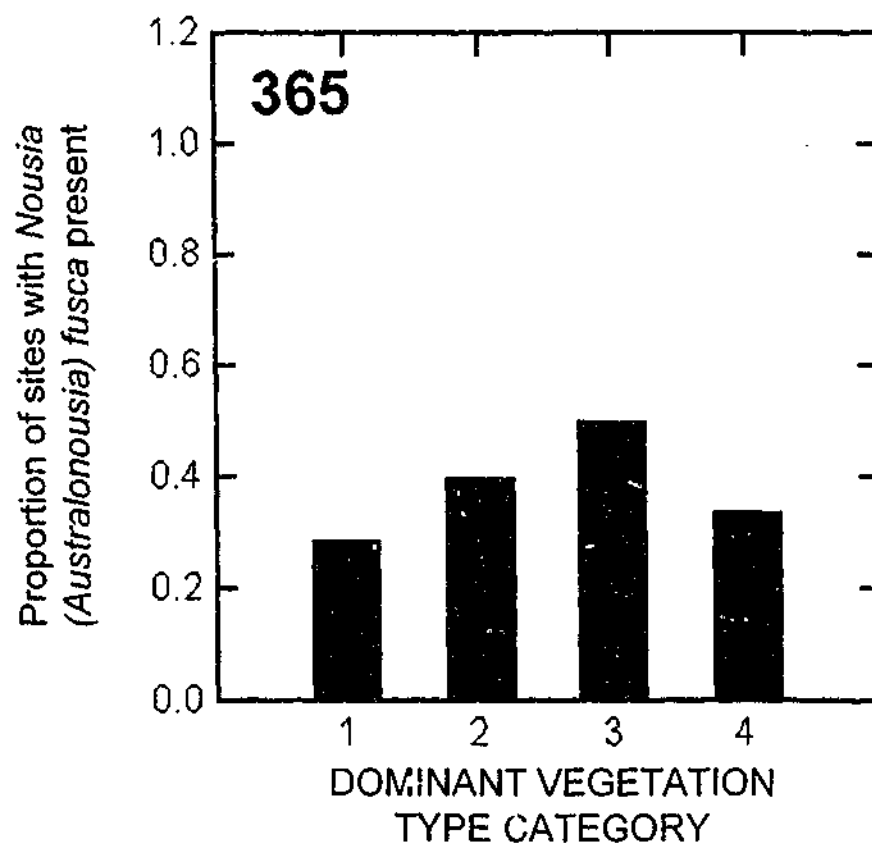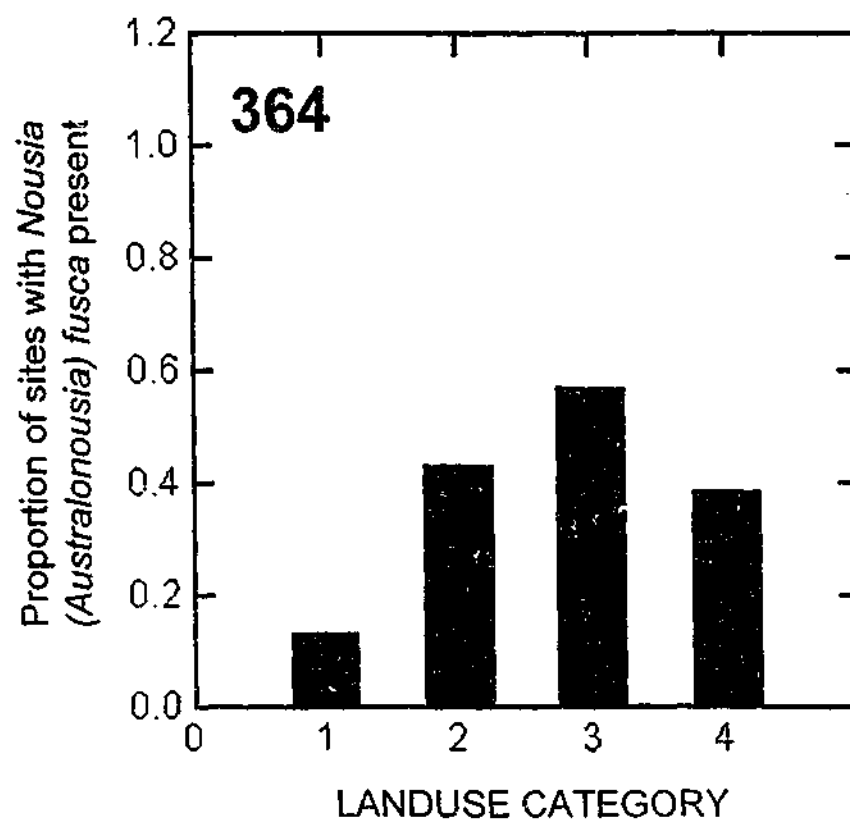
Fig. 364. Proportion of sites with *Nousia (Australonousia) fusca* present in each landuse category.

Fig. 365. Proportion of sites with *Nousia (Australonousia) fusca* present in each dominant vegetation category.
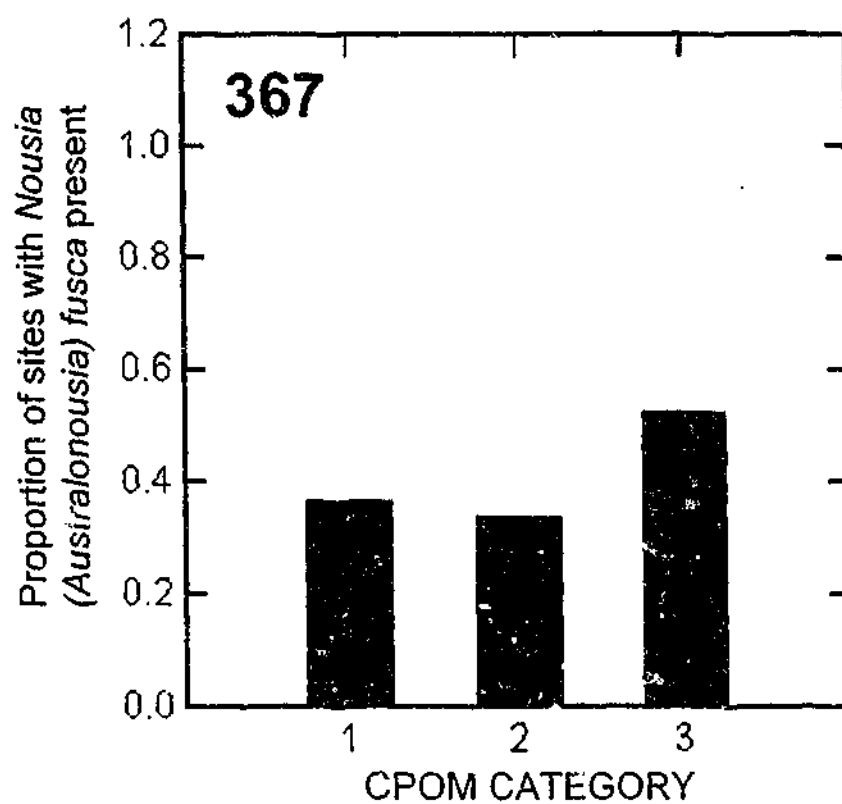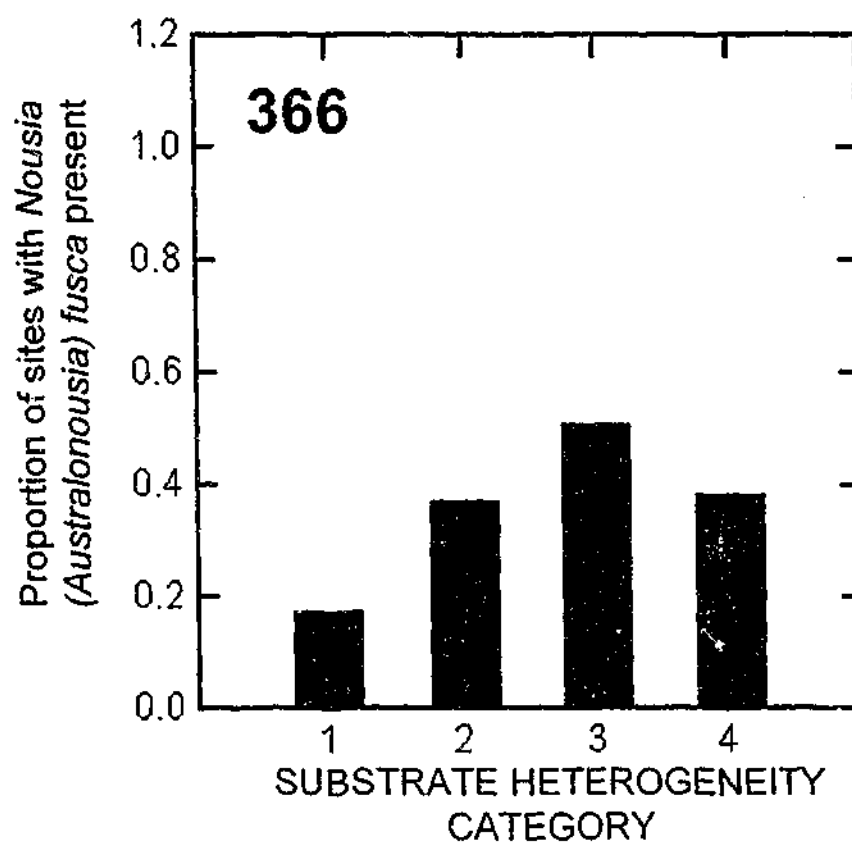
Fig. 366. Proportion of sites with *Nousia (Australonousia) fusca* present in each substrate heterogeneity category.

Fig. 367. Proportion of sites with *Nousia (Australonousia) fusca* present in each CPOM category.
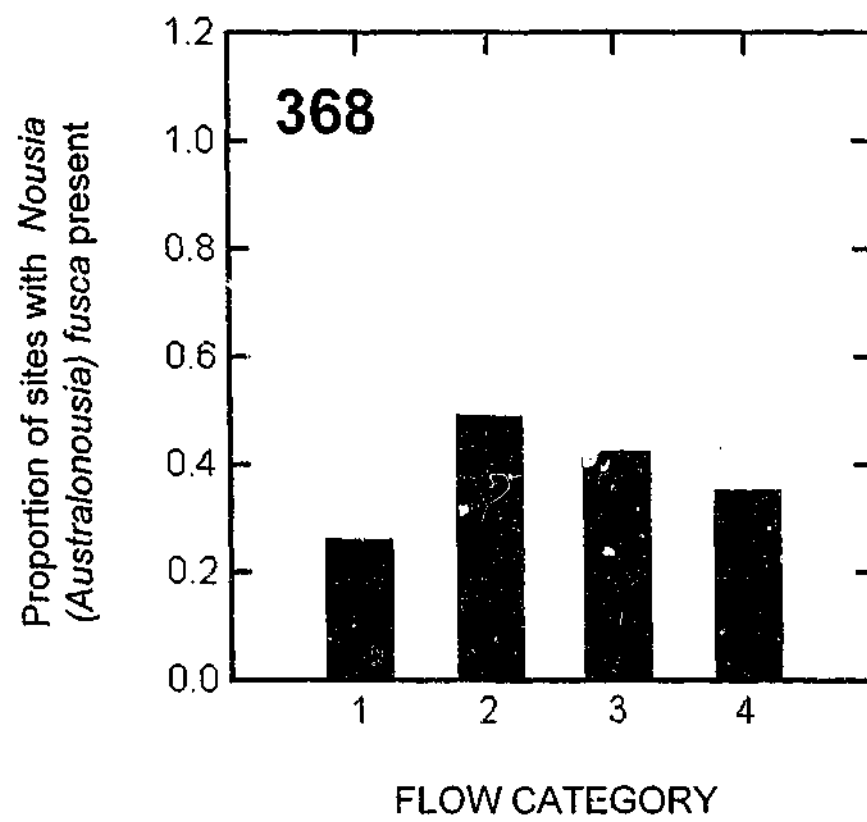
Fig. 368. Proportion of sites with *Nousia (Australonousia) fusca* present in each flow category.
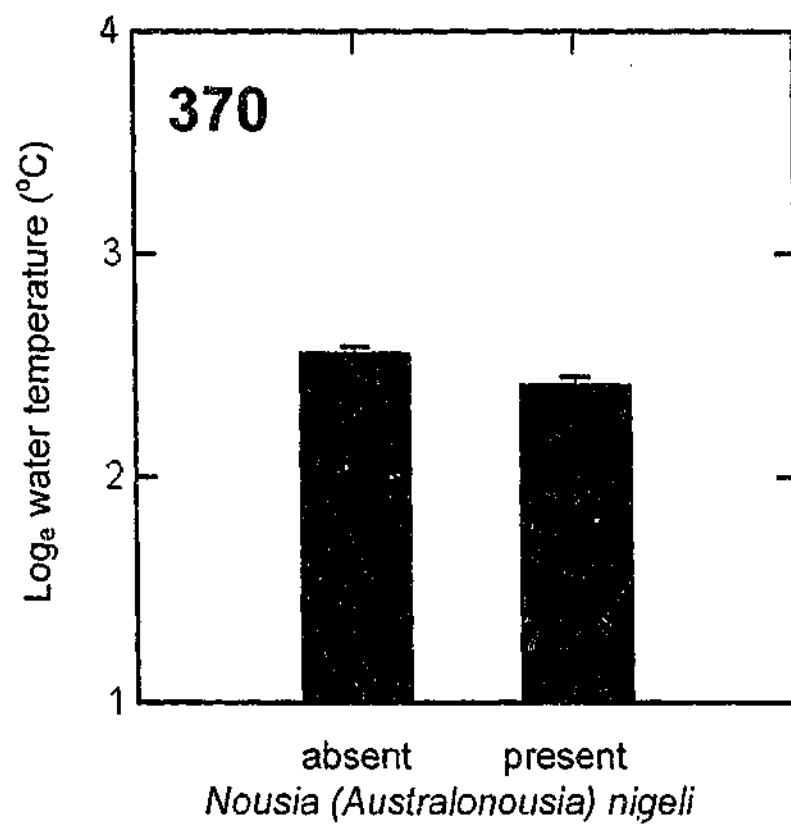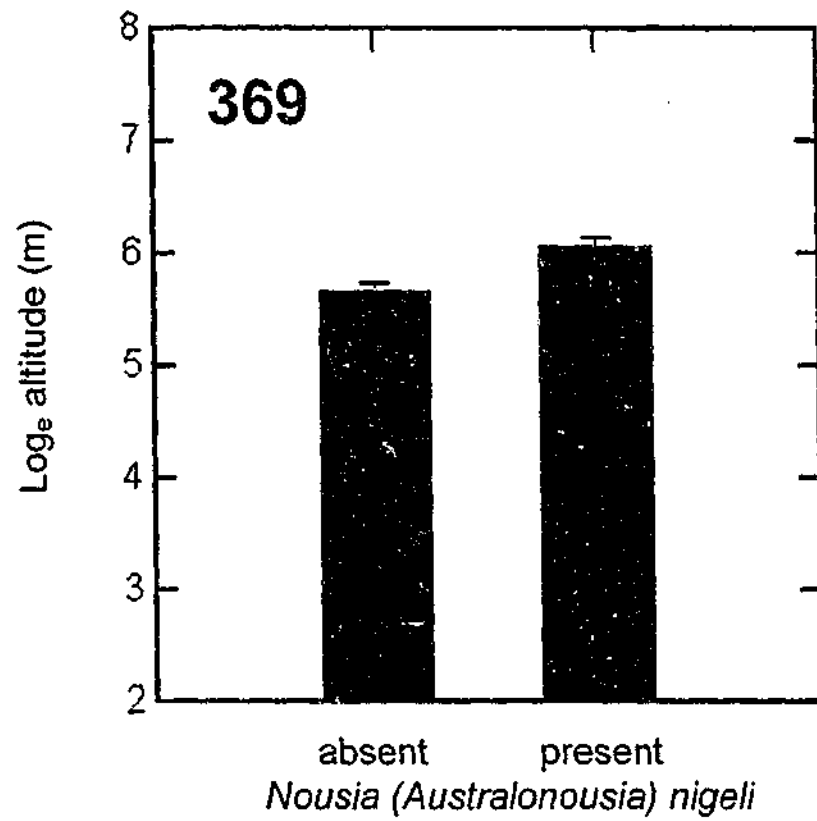
Fig. 369. Relationship between the presence of *Nousia (Australonousia)
nigeli* and altitude.

Fig. 370. Relationship between the presence of *Nousia (Australonousia)
nigeli* and water temperature.

Bars show mean values, error bars represent one standard error.
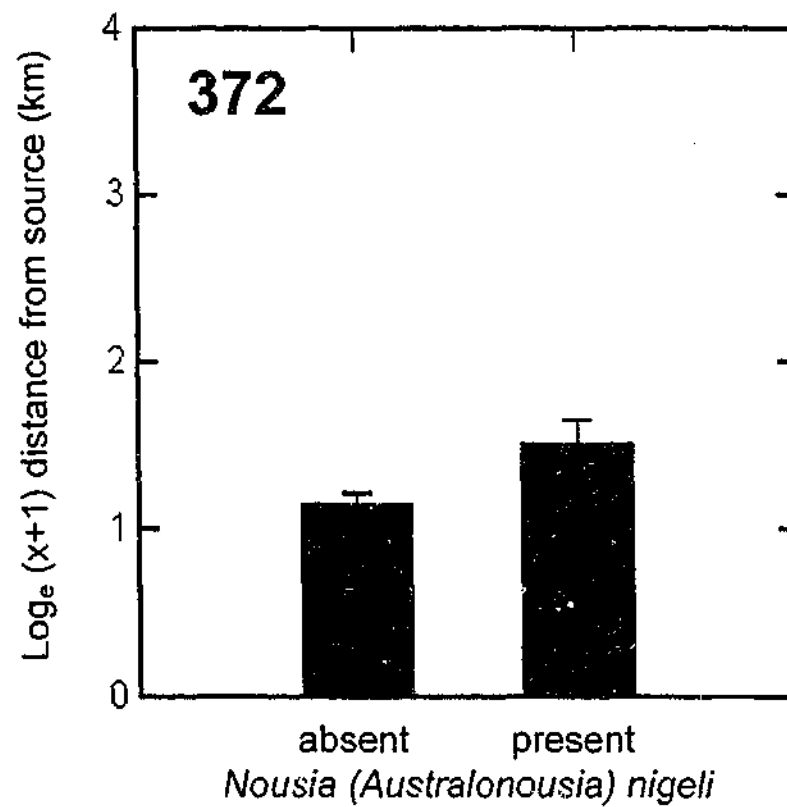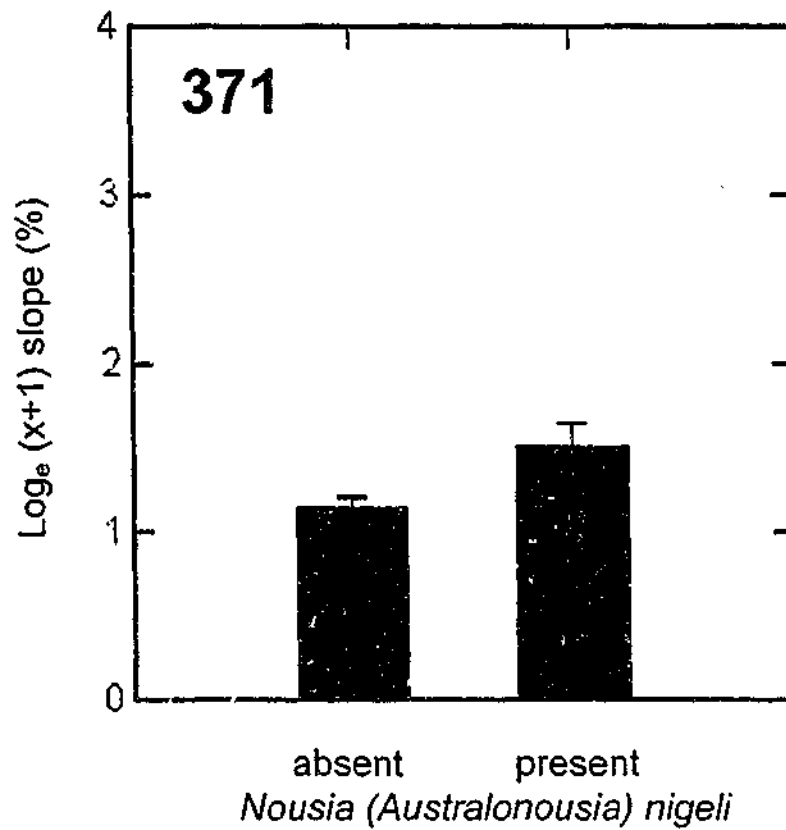
Fig. 371. Relationship between the presence of *Nousia (Australonousia)*
nigeli and slope.

Fig. 372. Relationship between the presence of *Nousia (Australonousia)*
nigeli and distance from source.

Bars show mean values, error bars represent one standard error.
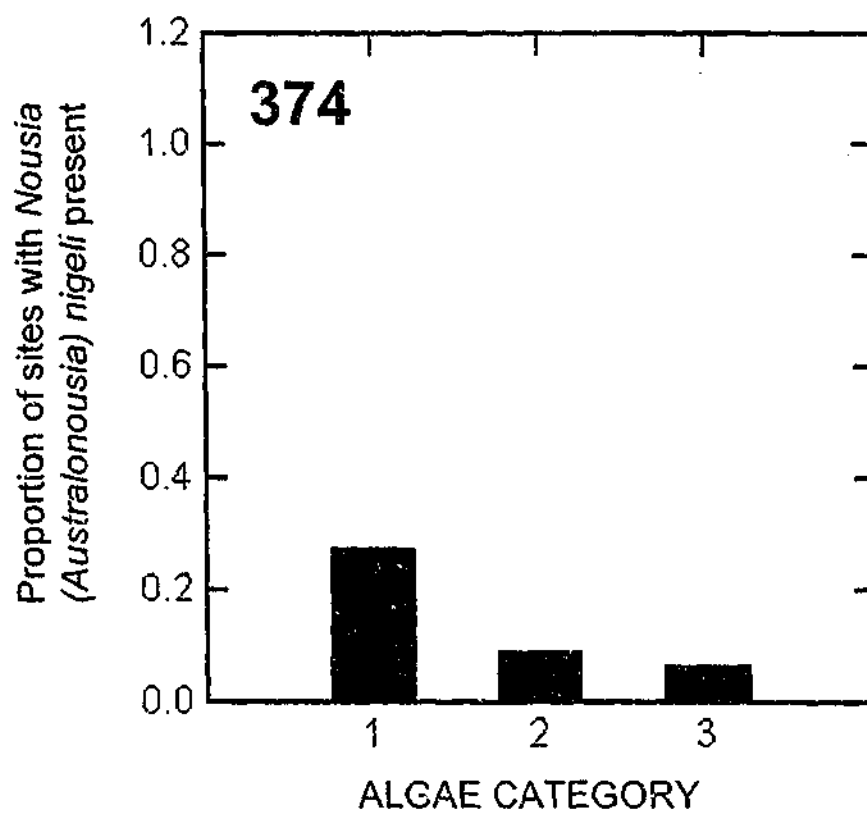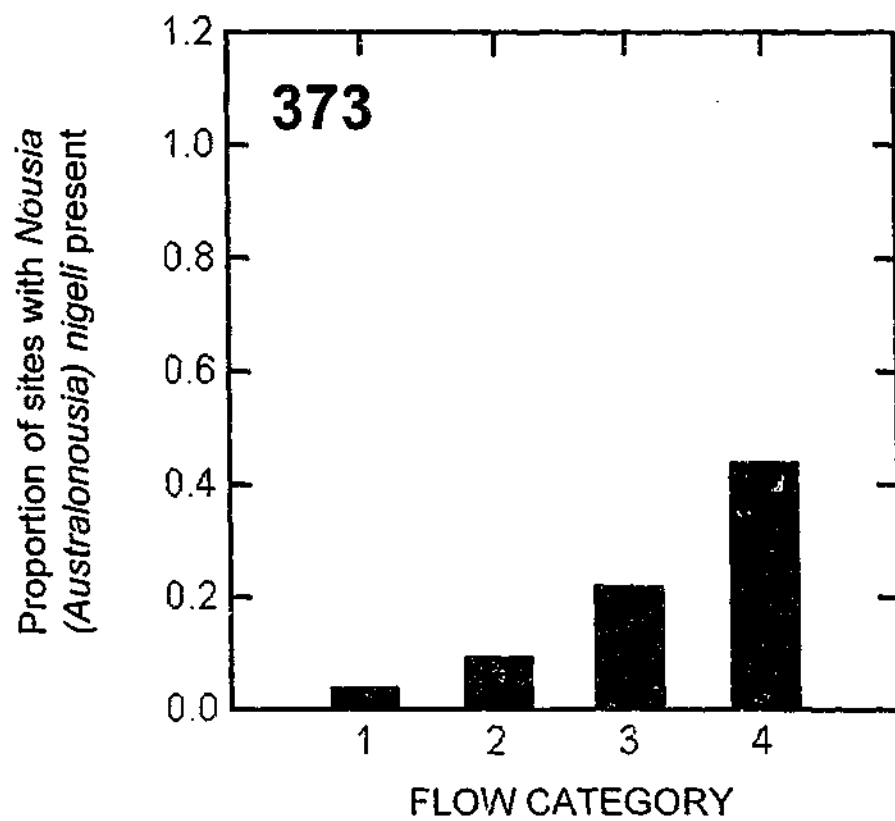
Fig. 373. Proportion of sites with *Nousia (Australonousia) nigeli* present in each flow category.

Fig. 374. Proportion of sites with *Nousia (Australonousia) nigeli* present in each algae category.
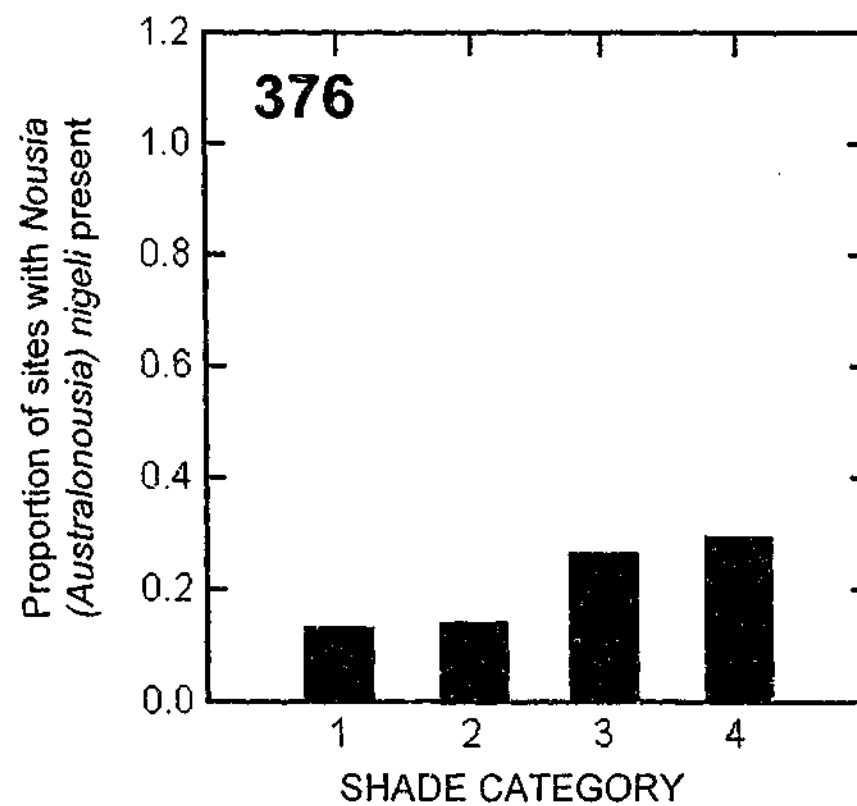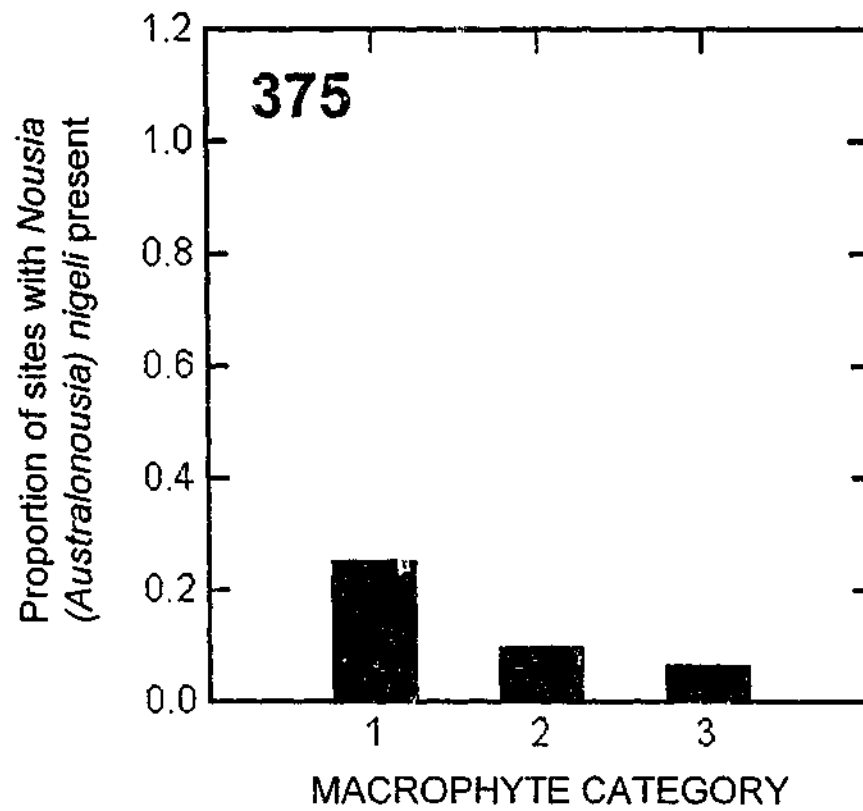
Fig. 375. Proportion of sites with *Nousia (Australonousia) nigeli* present in each macrophyte category.

Fig. 376. Proportion of sites with *Nousia (Australonousia) nigeli* present in each shade category.

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Proportion of sites with *Nousia*
(Australonousia) nigeli present
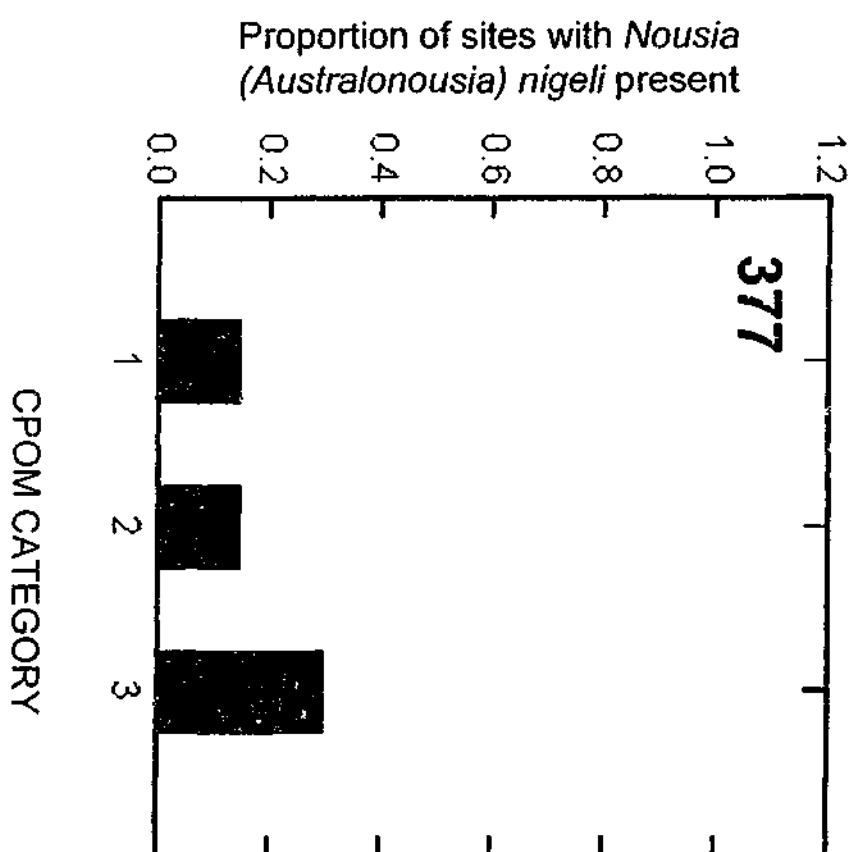
Fig. 377. Proportion of sites with *Nousia (Australonousia) nigeli* present in each CPOM category.

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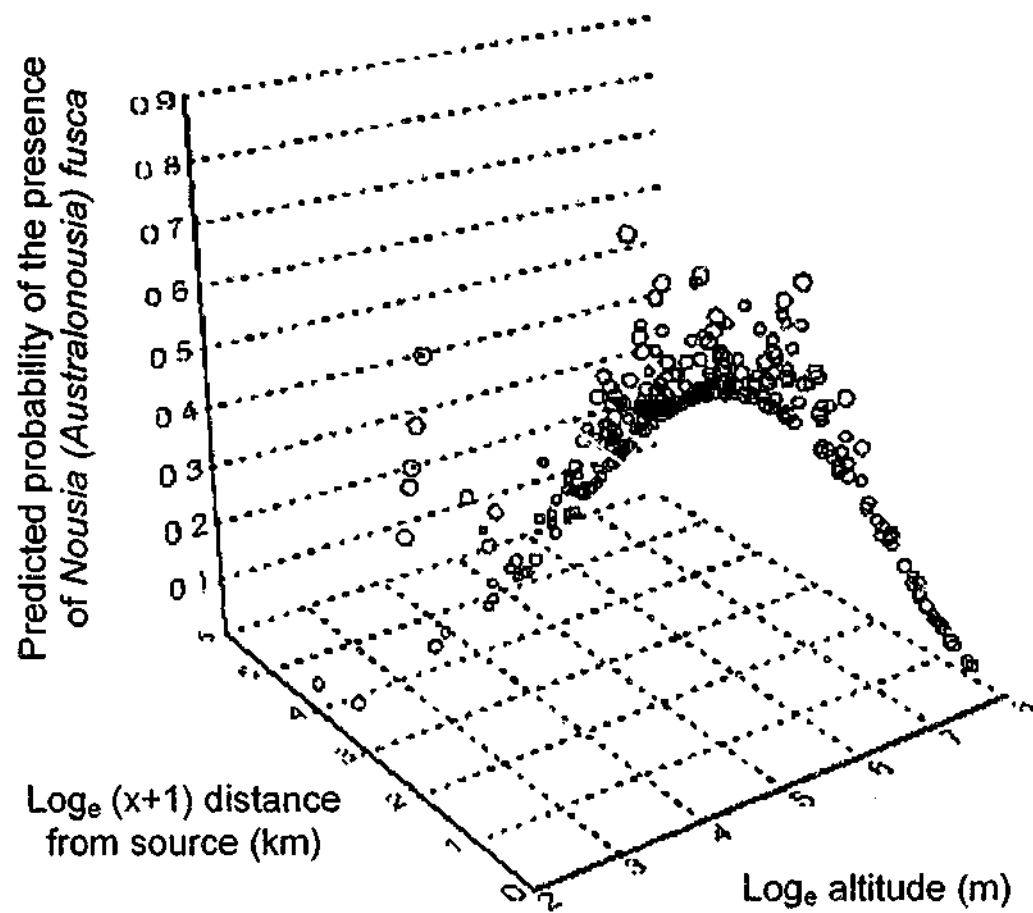
Fig. 378. Predicted probability of the presence of
Nousia (Australonousia) fusca in a logistic model containing the factors
altitude, distance from source and the interaction of the two variables.
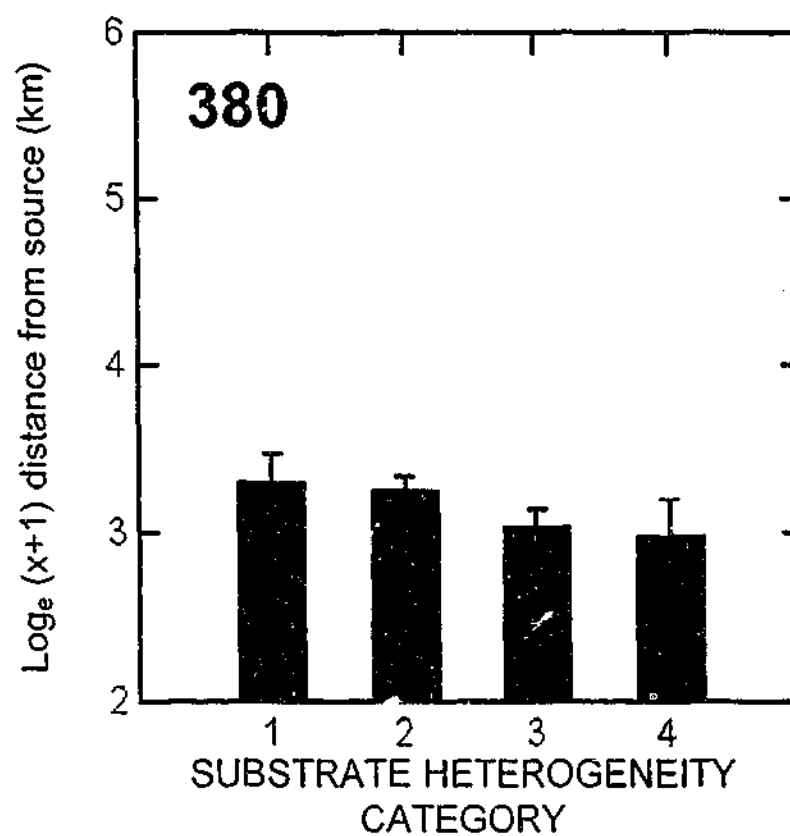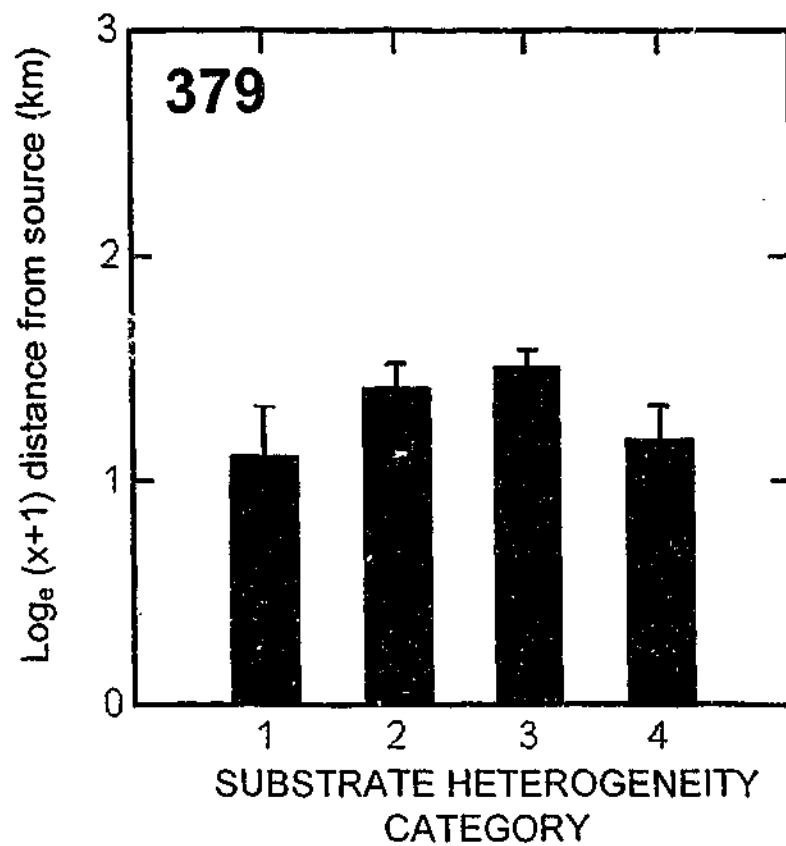
Fig. 379. Relationship between distance from source and substrate heterogeneity at sites less than 9km from source.

Fig. 380. Relationship between distance from source and substrate heterogeneity at sites 9km or more from source.
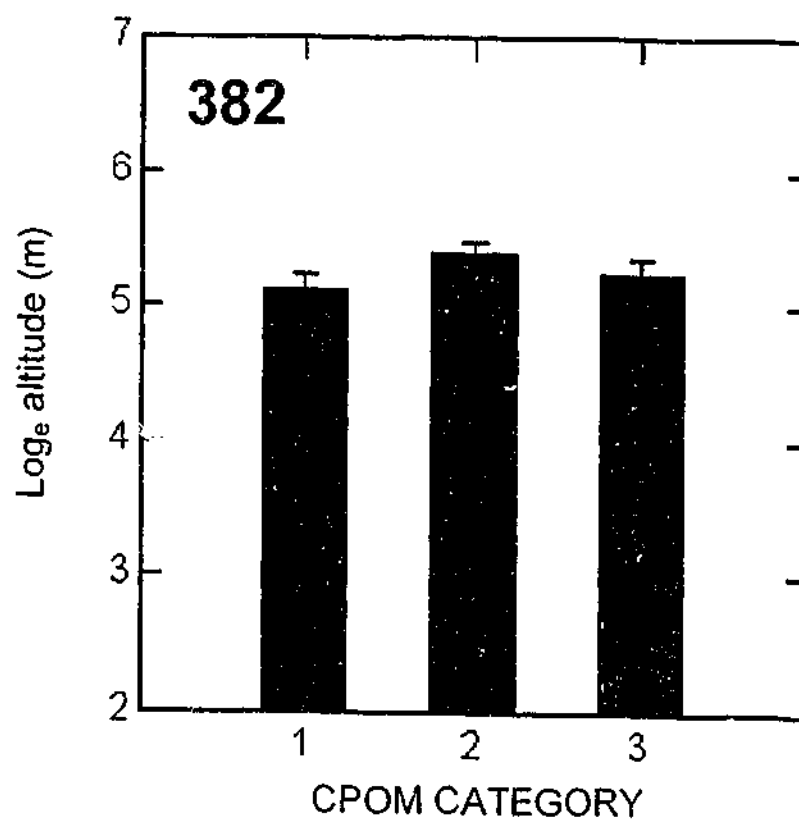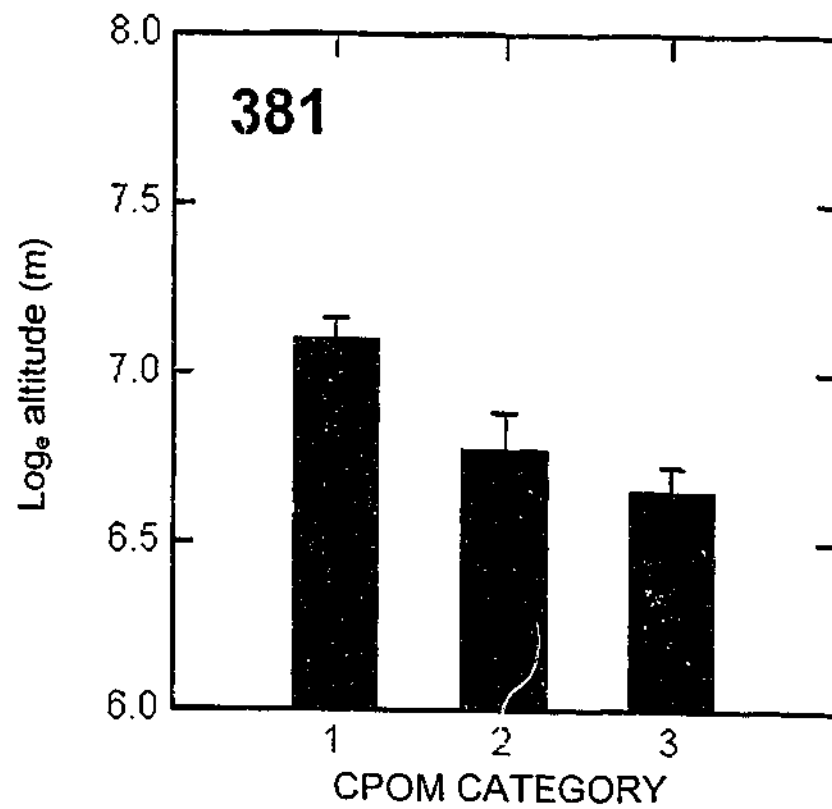
Fig. 381. Relationship between altitude and CPOM at sites above 500m.

Fig. 382. Relationship between altitude and CPOM at sites below 500m.

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Meridialaris
Austrophlebioides,
Kirrara, Tillyardophlebia

Dactylophlebia
no Australian
representatives

Atalonella
Nousia, Nyungara

Penaphlebia
Garinjuga

Hapsiphlebia
Atalomicria, Atalophlebia,
Jappa, Ulmerophlebia
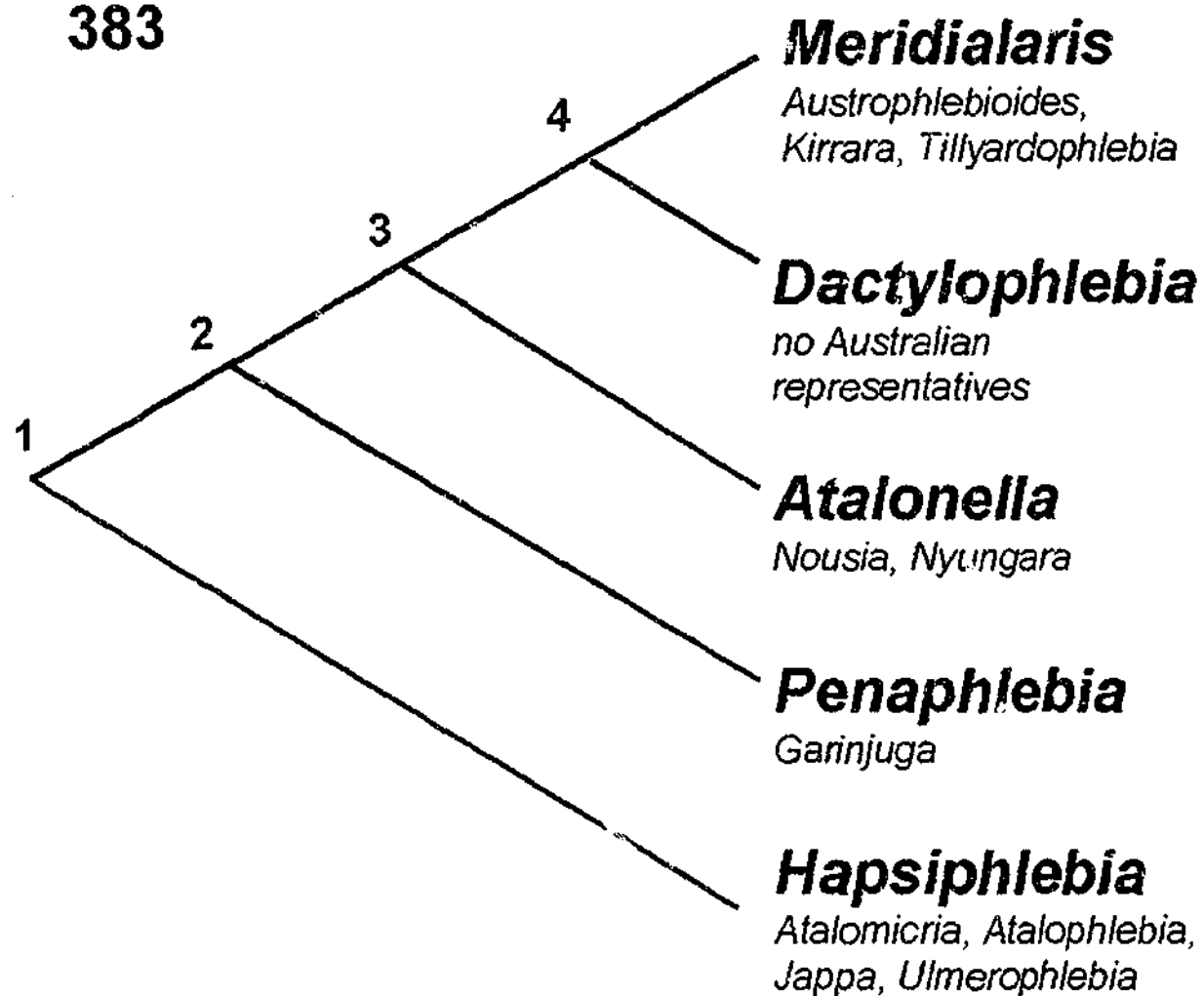
Fig. 383. Phylogenetic lineages developed for the cool-adapted Leptophlebiidae
of southern South America and related Southern Hemisphere fauna (figure
adapted from Pescador and Peters 1980a). Numbers refer to furcations.
Australian taxa considered to have affinities with each lineage are added.
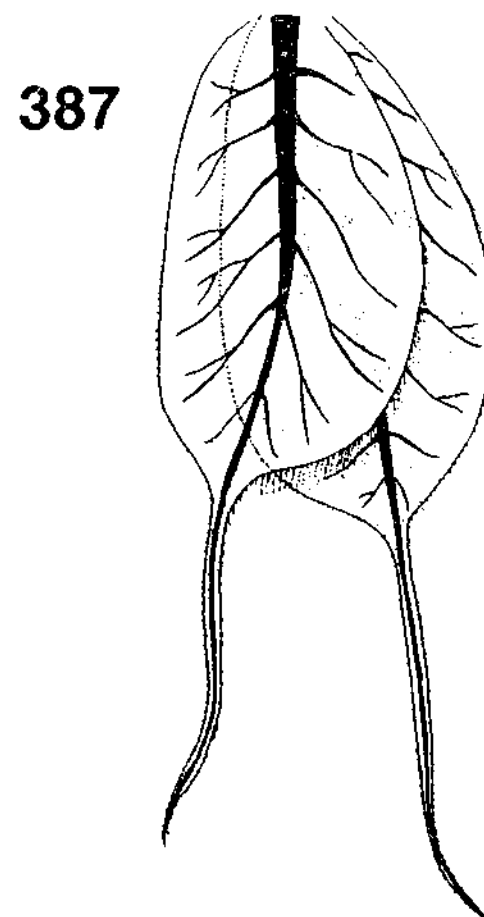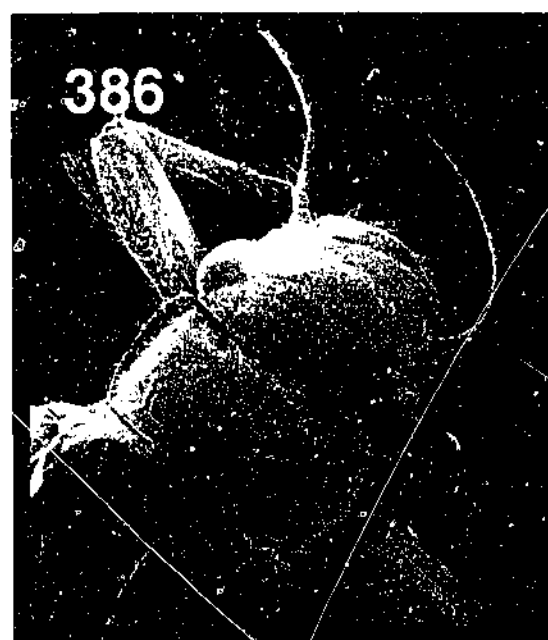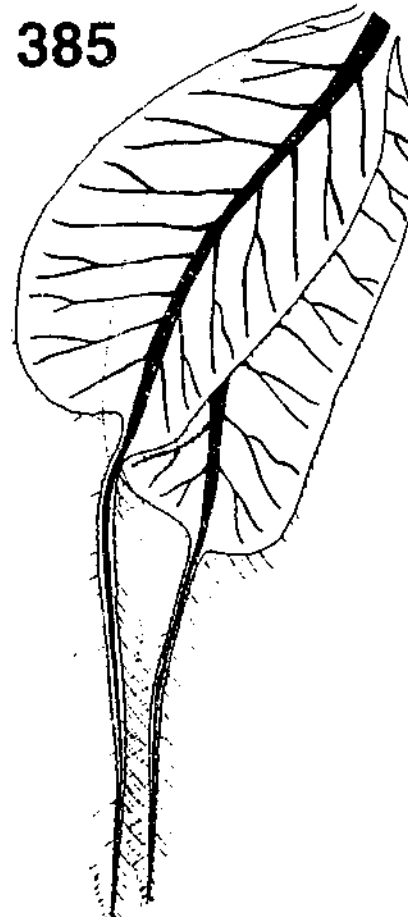
Figs. 384-387. Genera that have body and gills fringed with fine setae.

Fig. 384. *Jappa* sp. "AV3" - body setation.
Fig. 385. *Jappa kutera* - gill setation.
Fig. 386. *Ulmerophlebia* sp. - body setation.
Fig. 387. *Ulmerophlebia* sp. - gill setation.
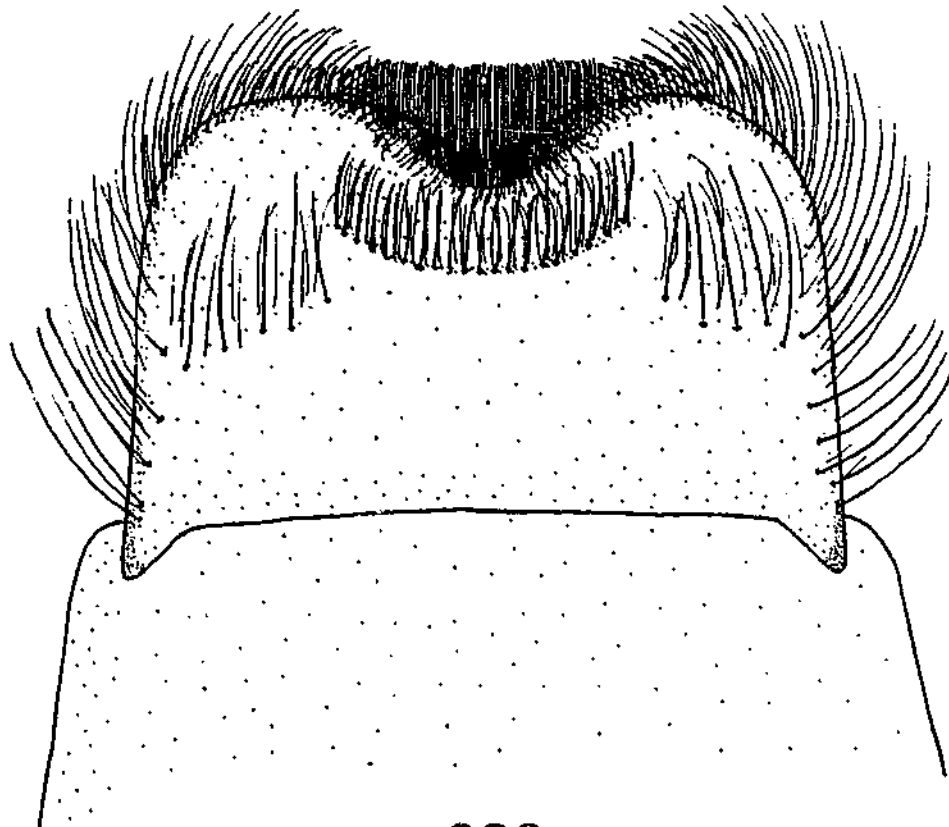
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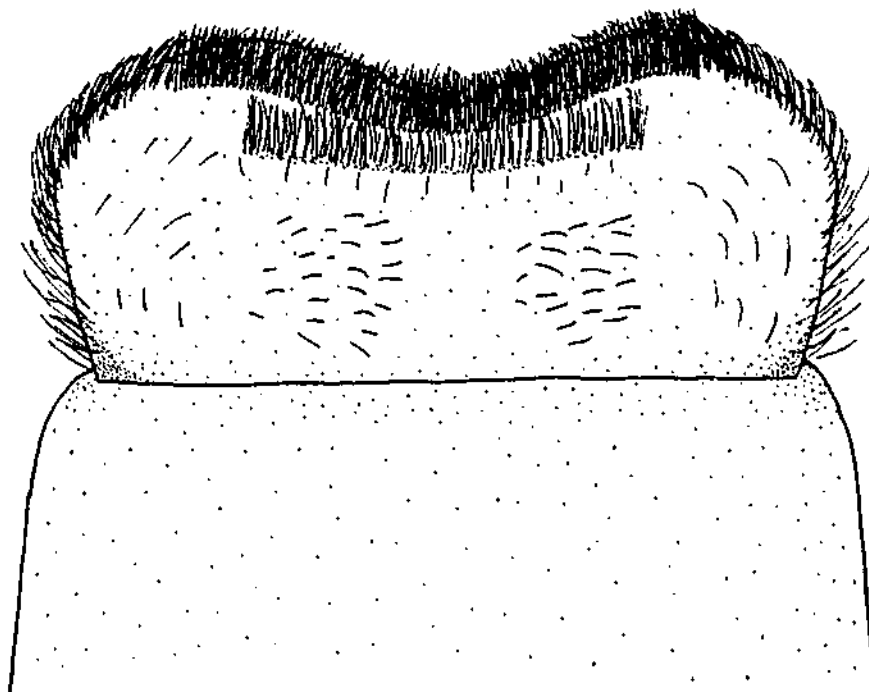
389

Figs. 388-389. Labrum and clypeus morphology.

Fig. 388. *Atalomicria*
Fig. 389. *Atalophlebia*

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391
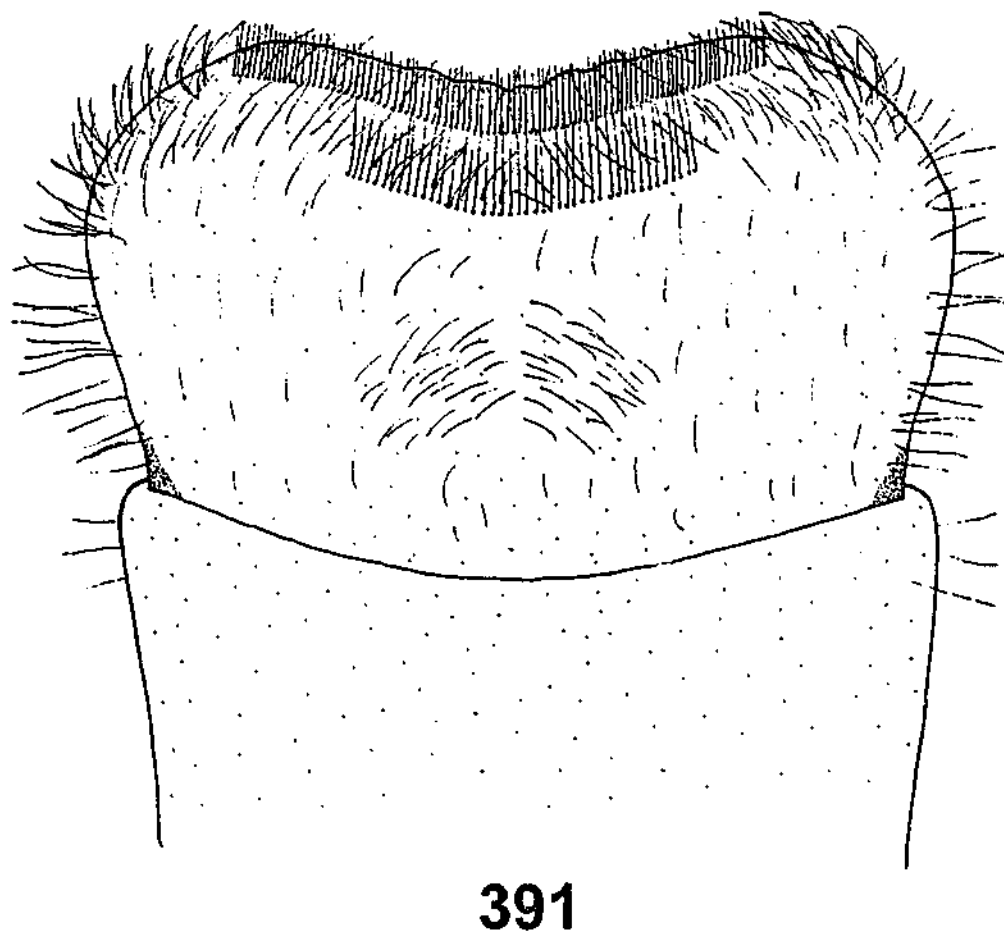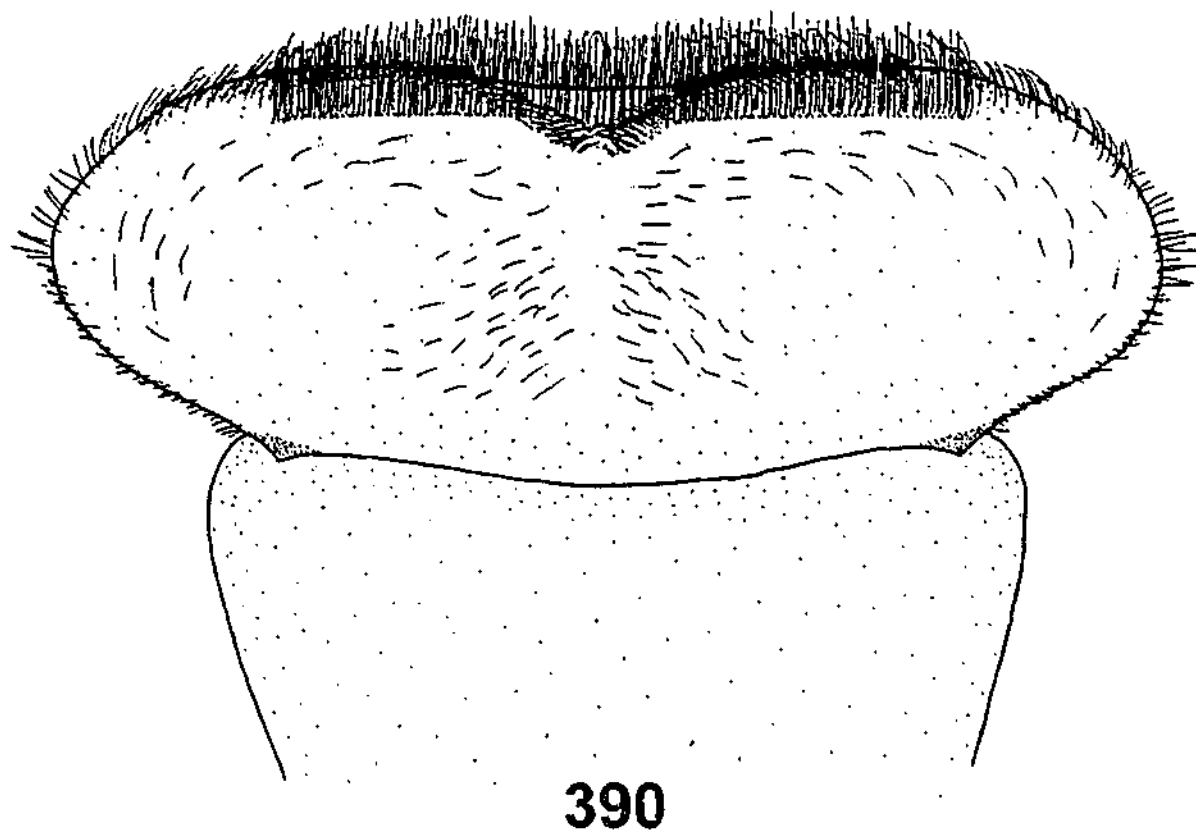
Figs. 390-391. Labrum and clypeus morphology.

Fig. 390. *Austrophlebioides*
Fig. 391. *Bibulmena*
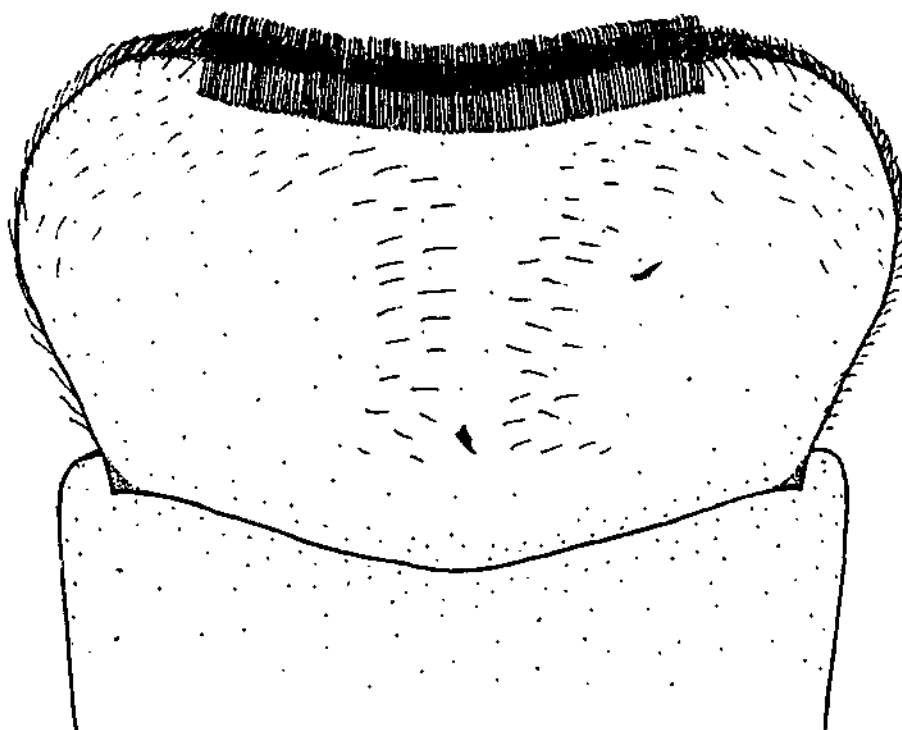
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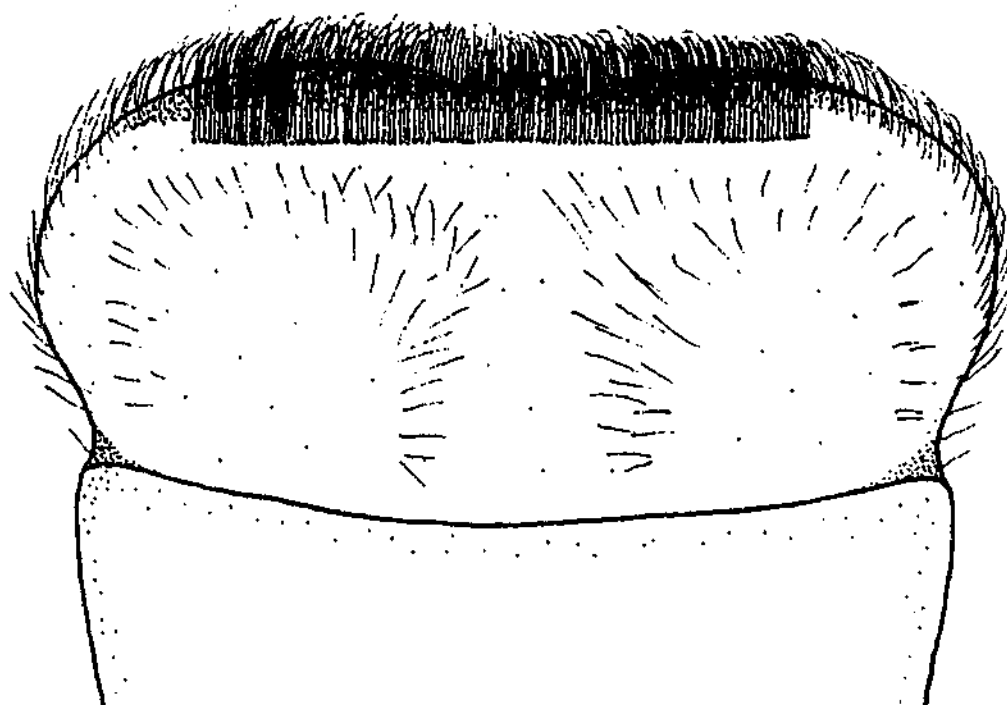
393

Figs. 392-393. Labrum and clypeus morphology.

Fig. 392. *Garinjuga*
Fig. 393. *Gemmayaluka*
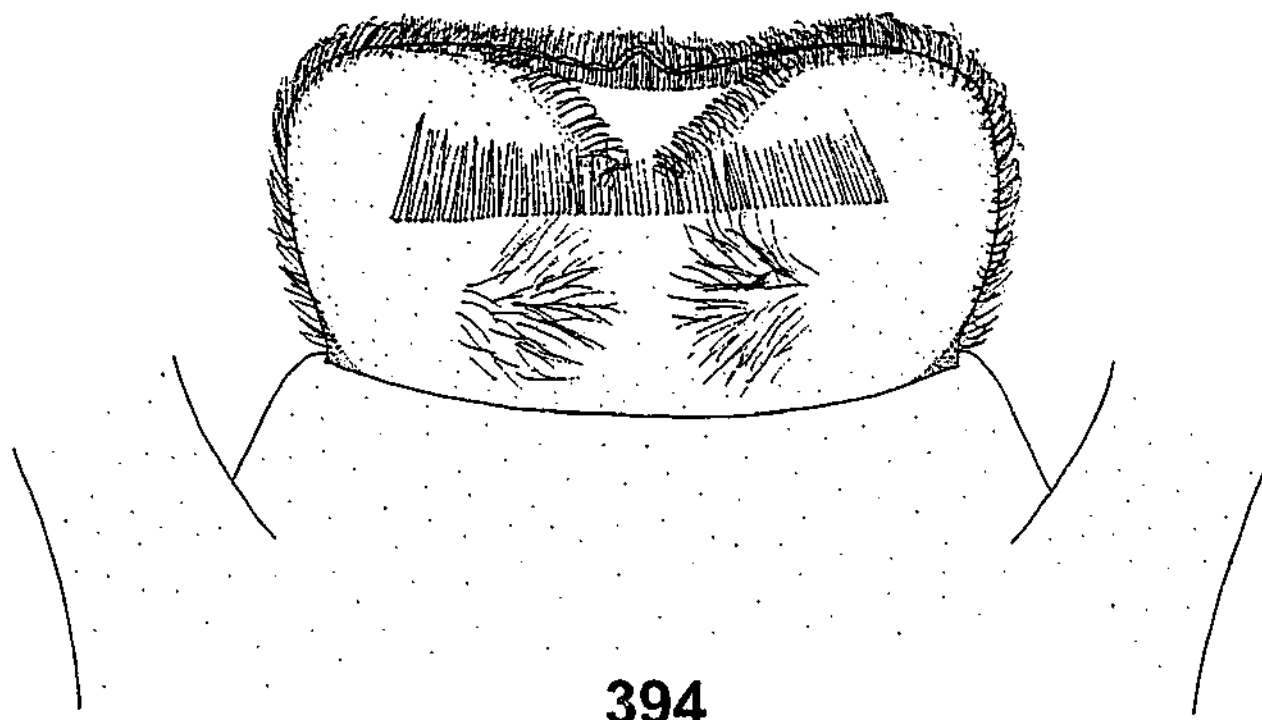
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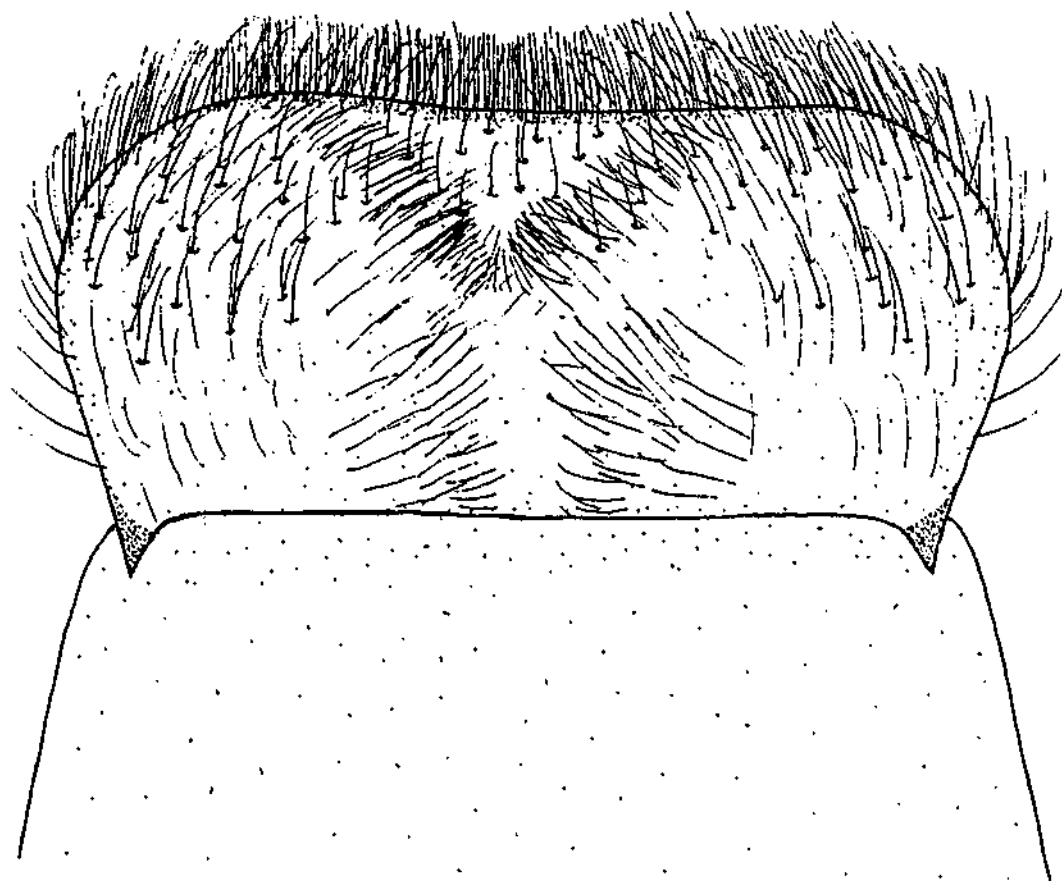
395

Figs. 394-395. Labrum and clypeus morphology.

Fig. 394. *Jappa*
Fig. 395. *Kalbaybaria*
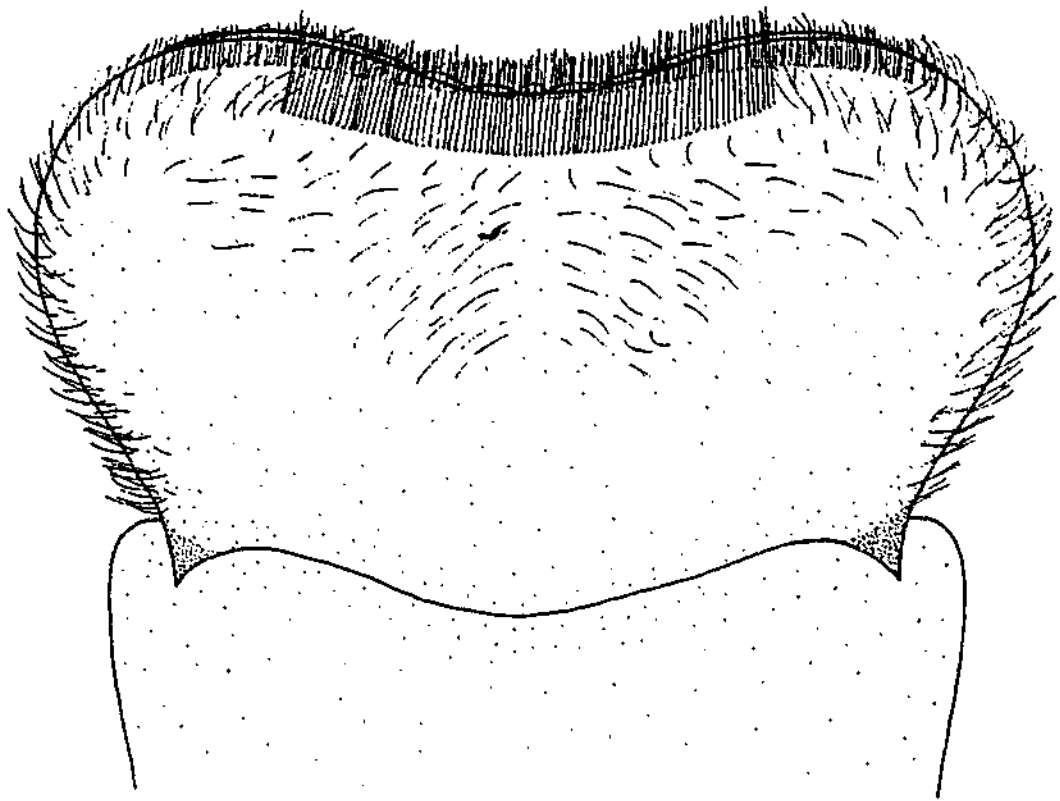
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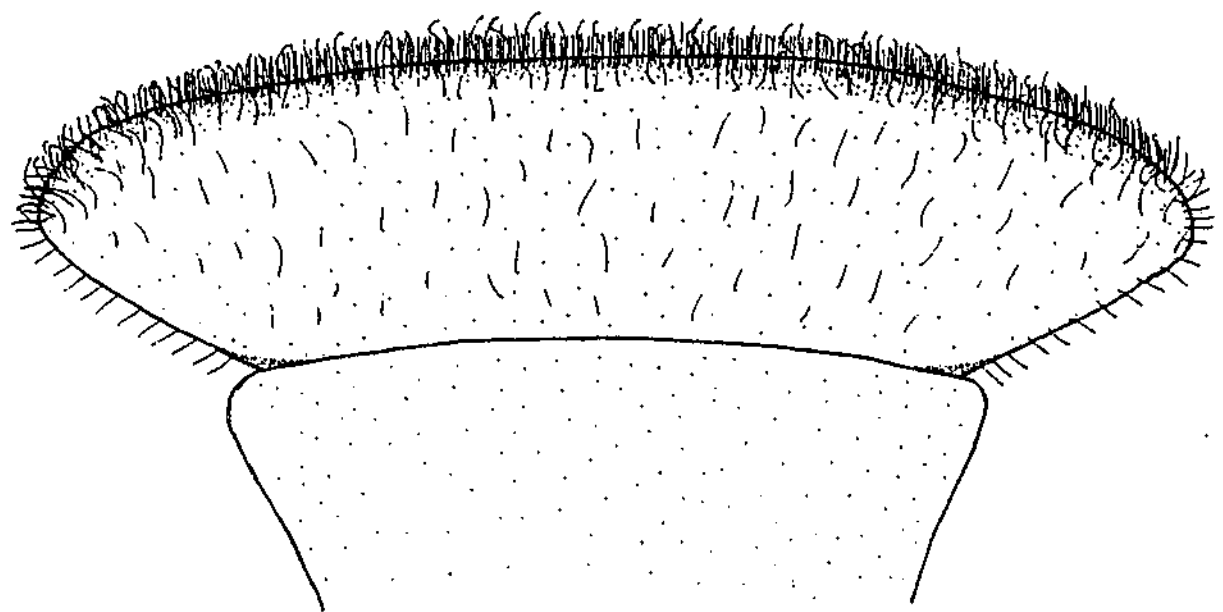
397

Figs. 396-397. Labrum and clypeus morphology.

Fig. 396. *Kaninga*
Fig. 397. *Kirrara*
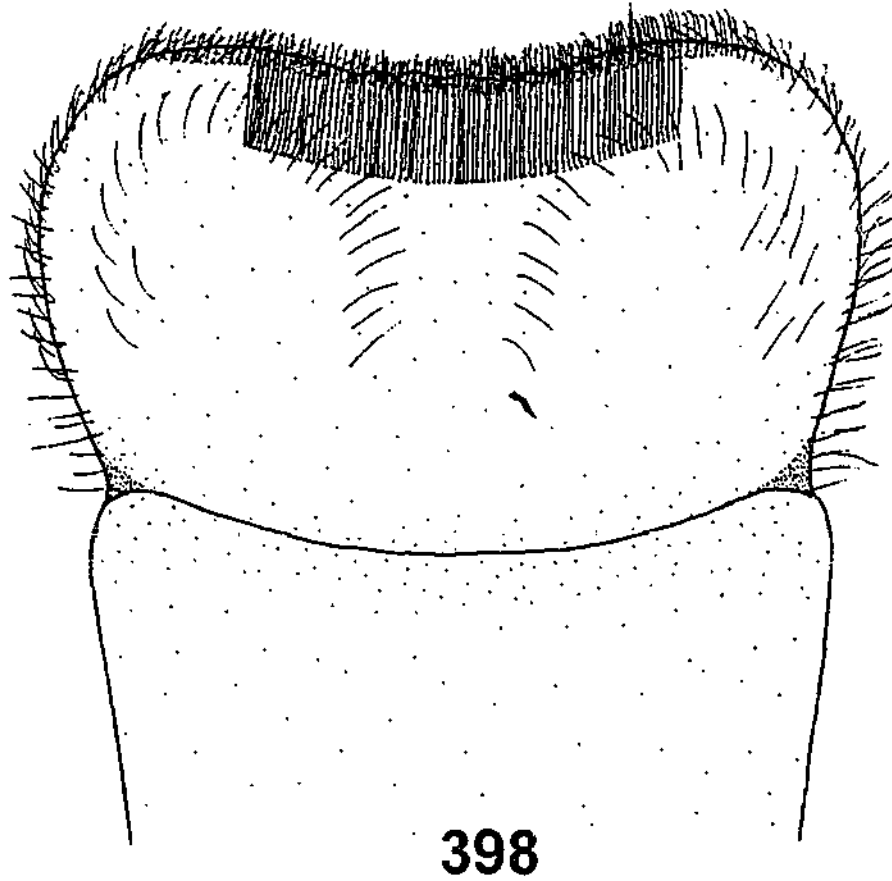
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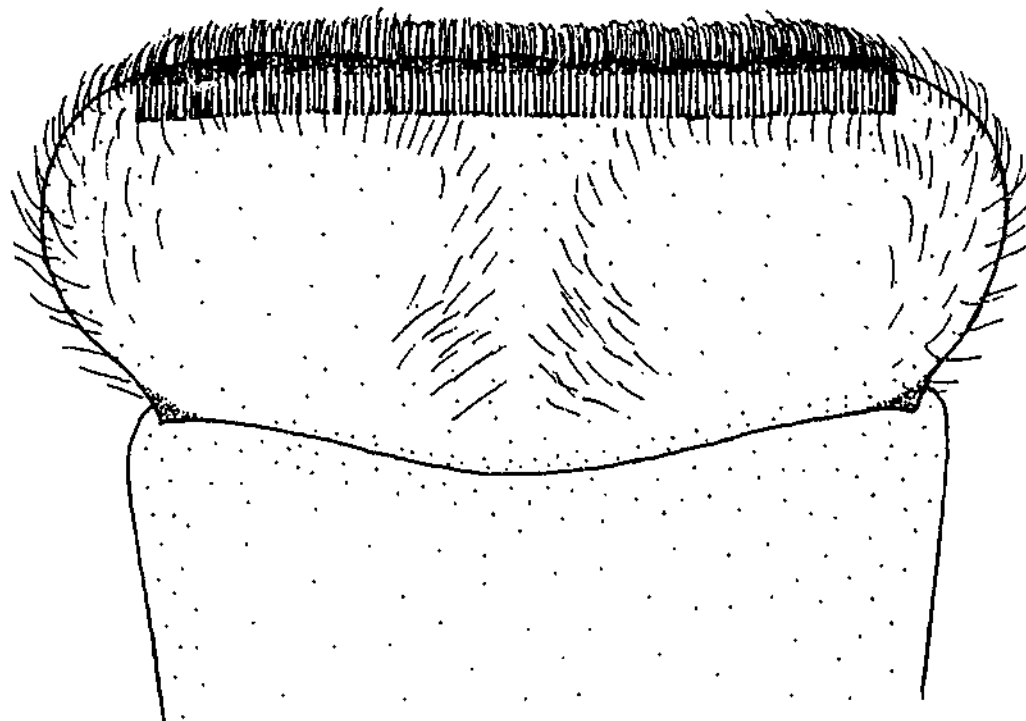
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Figs. 398-399. Labrum and clypeus morphology.

Fig. 398. *Loamaggalangta*
Fig. 399. *Montikola*
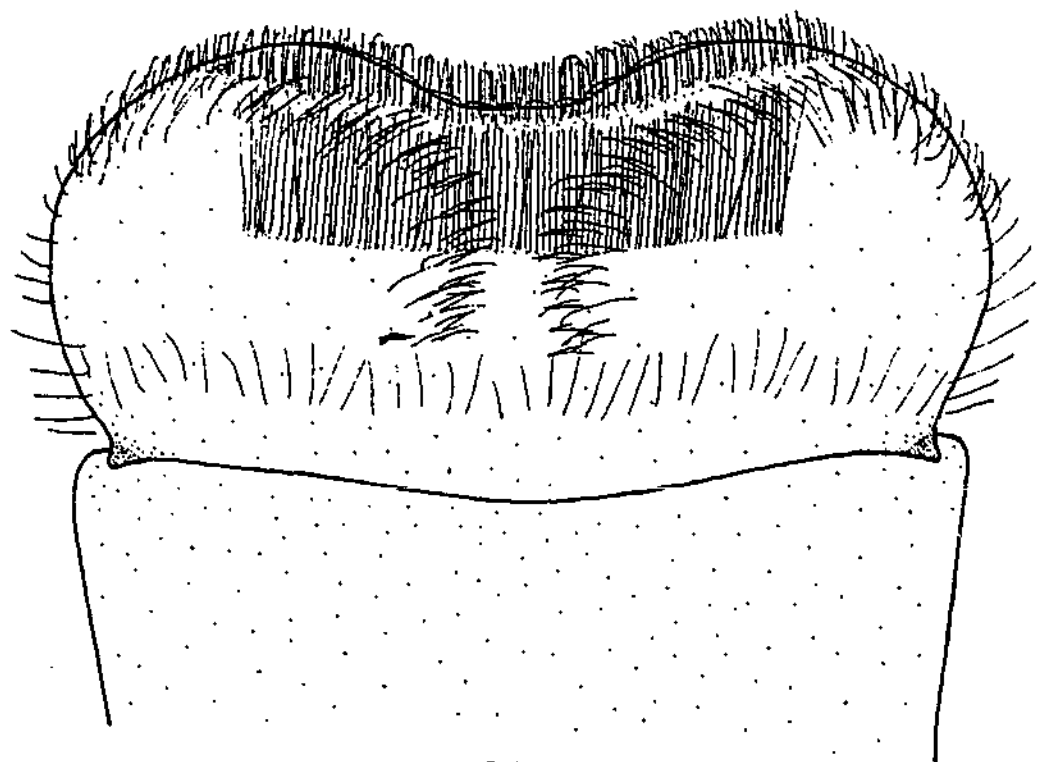
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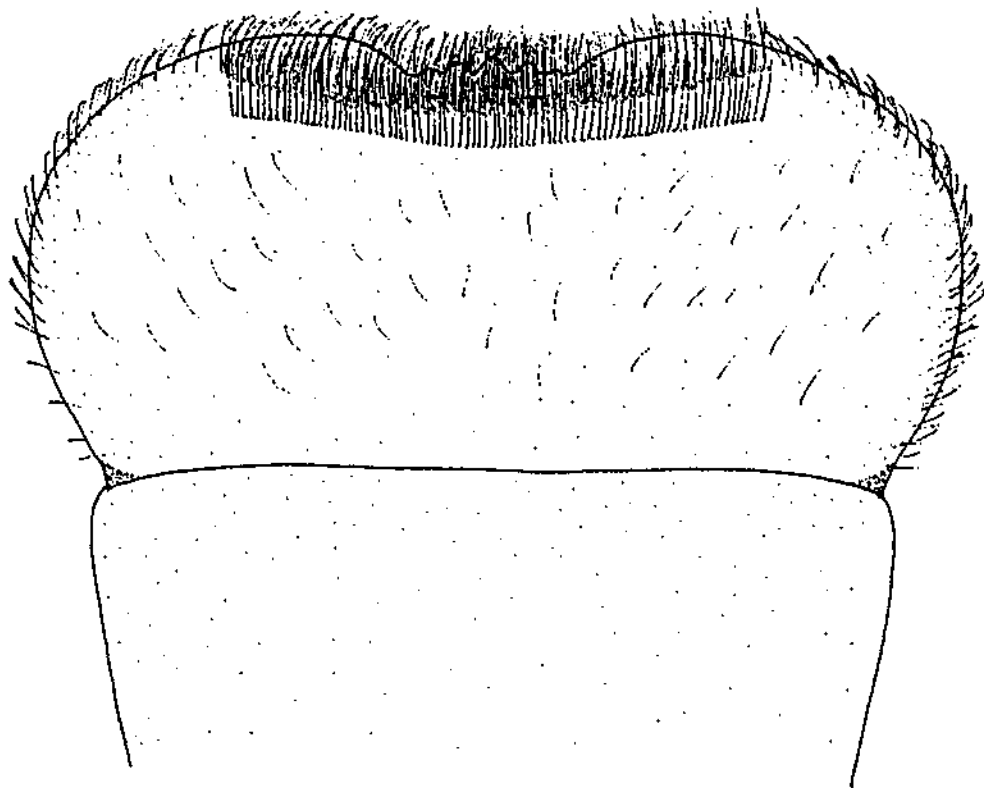
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Figs. 400-401. Labrum and clypeus morphology.

Fig. 400. *Neboissophlebia*
Fig. 4012. *Nousia (Nousia)*
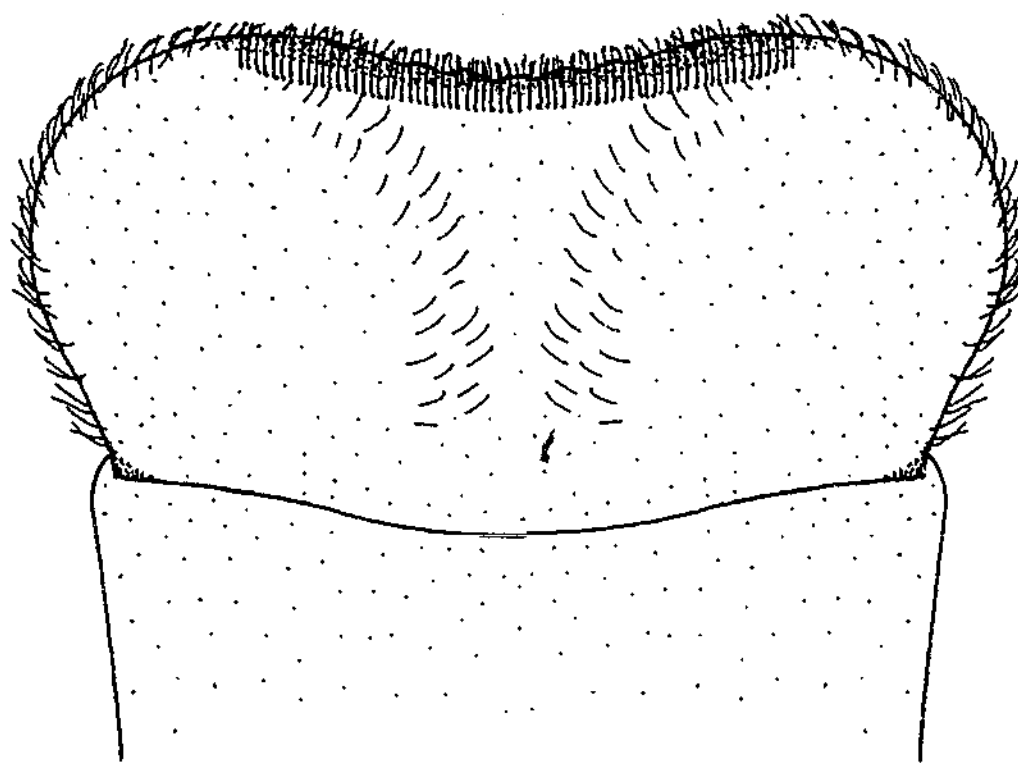
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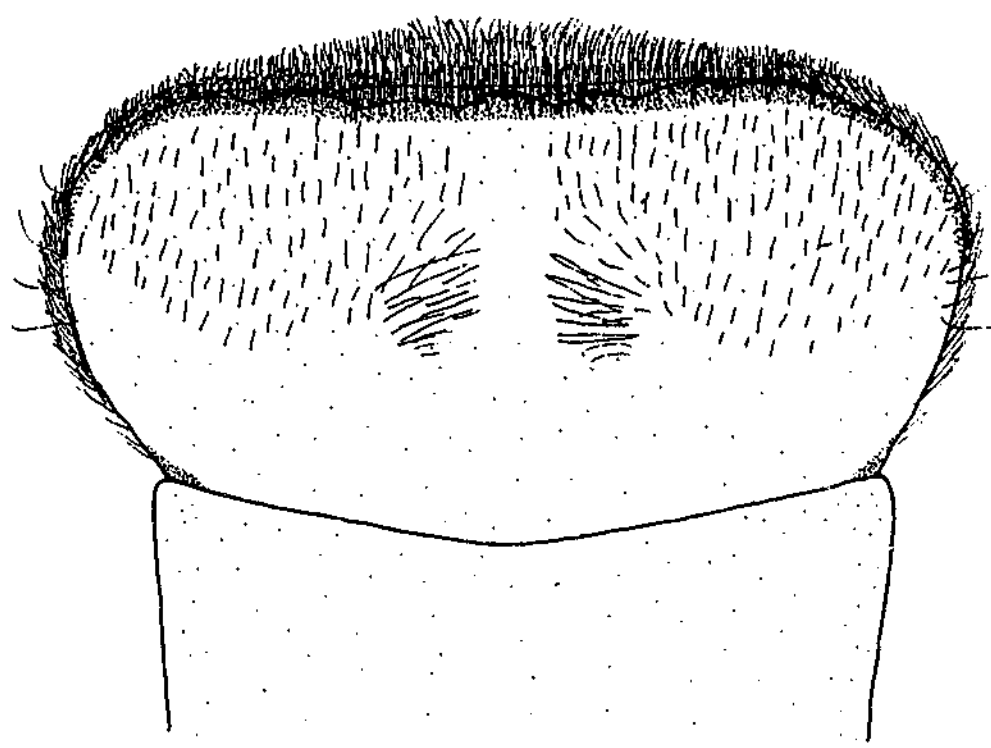
403

Figs. 402-403. Labrum and clypeus morphology.

Fig. 403. *Nousia (Australonousia)*
Fig. 404. *Nyungara*
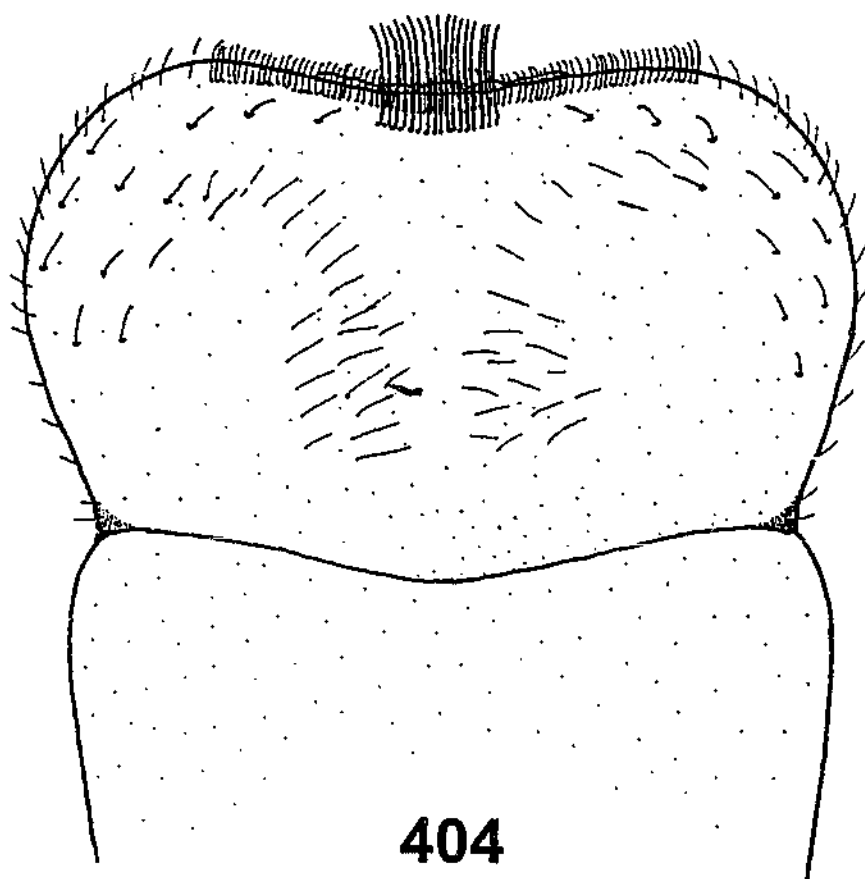
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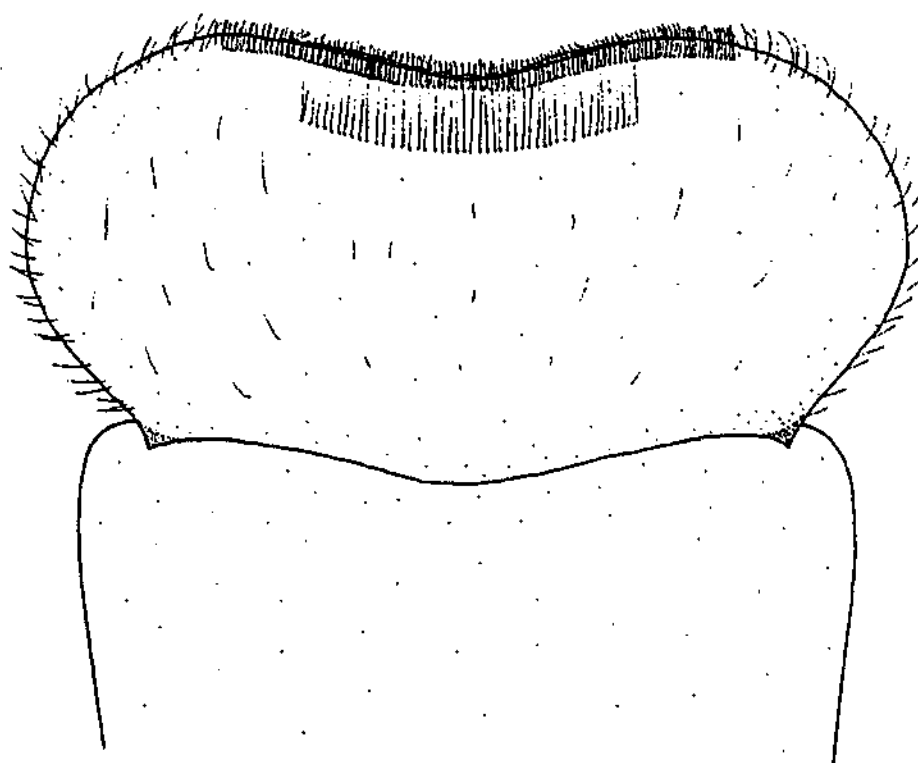
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Figs. 404-405. Labrum and clypeus morphology.

Fig. 404. *Thraulophlebia*
Fig. 405. *Thraulus*

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407
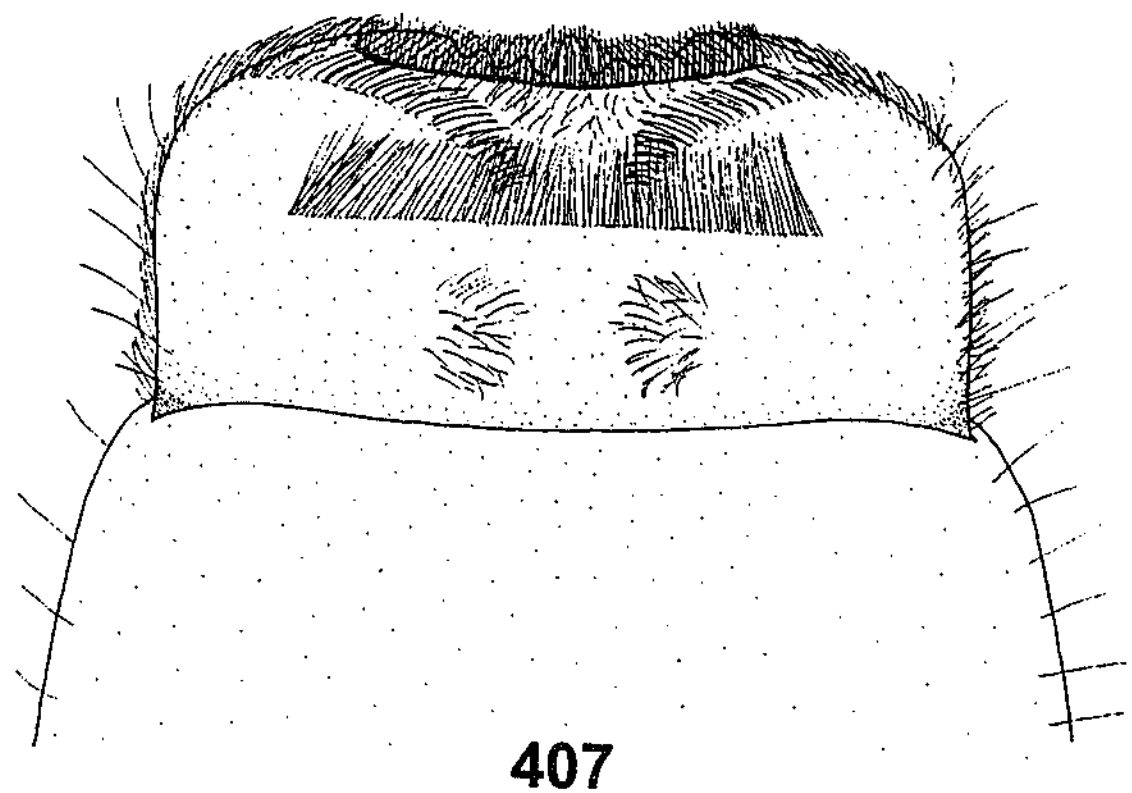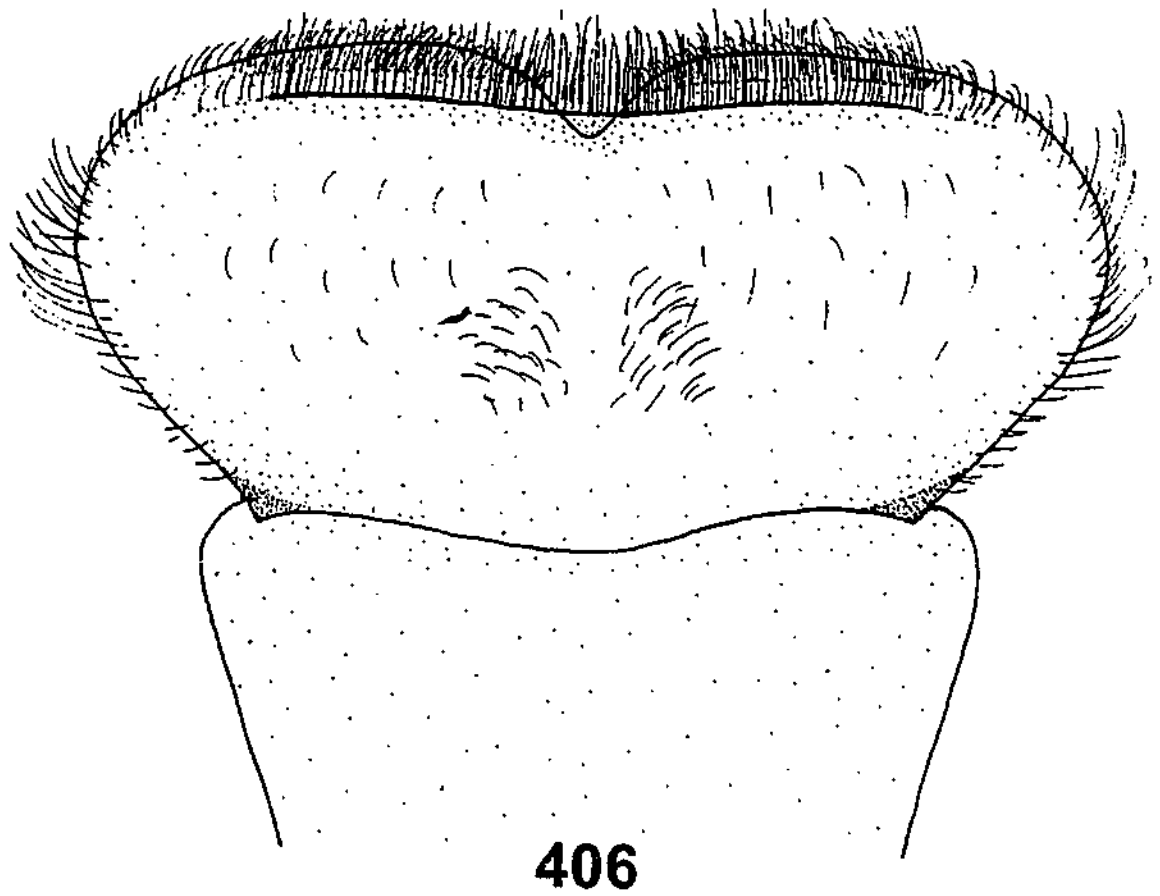
Figs. 406-407. Labrum and clypeus morphology.

Fig. 406. *Tillyardophlebia*
Fig. 407. *Ulmerophlebia*

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**DORSAL
SURFACE**
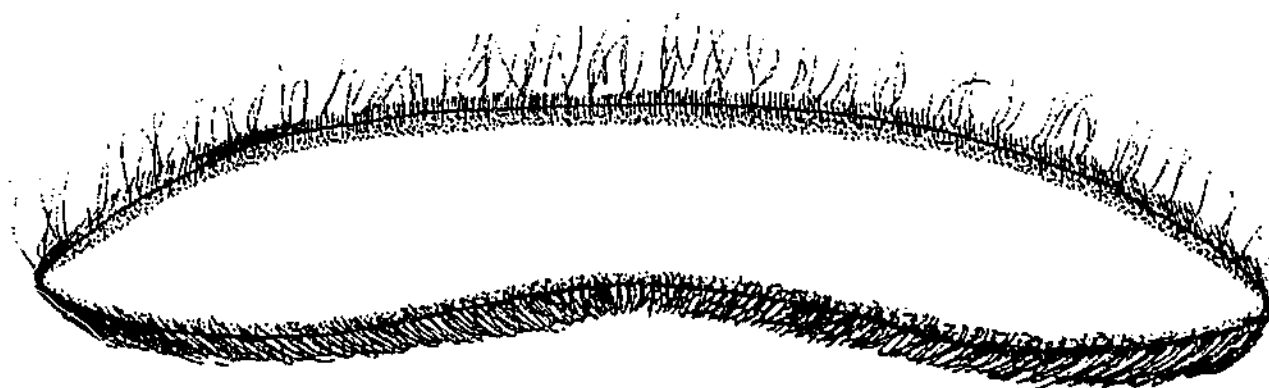
**VENTRAL
SURFACE**

Fig. 408. Apical view of *Kirrara procera* labrum.
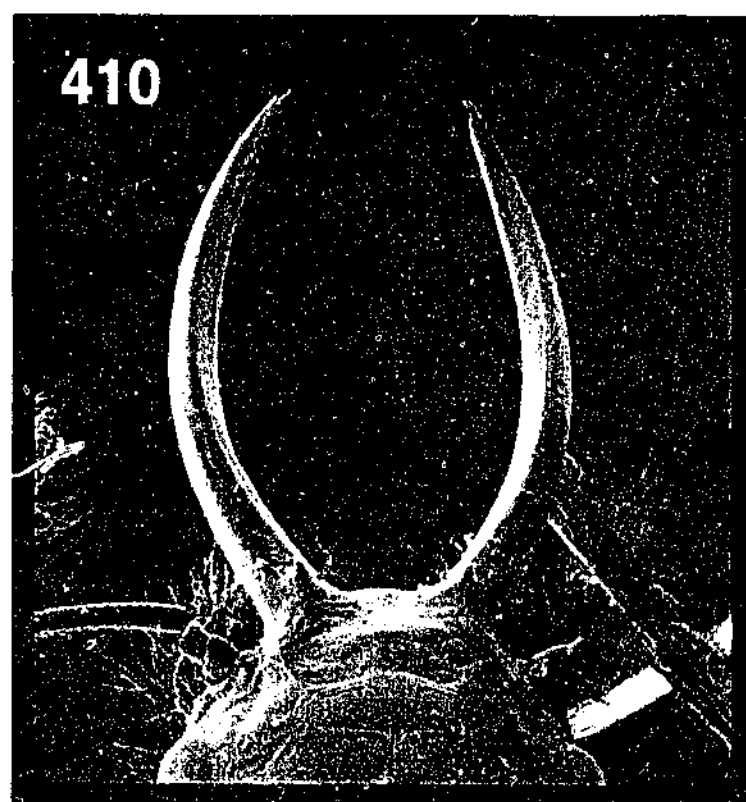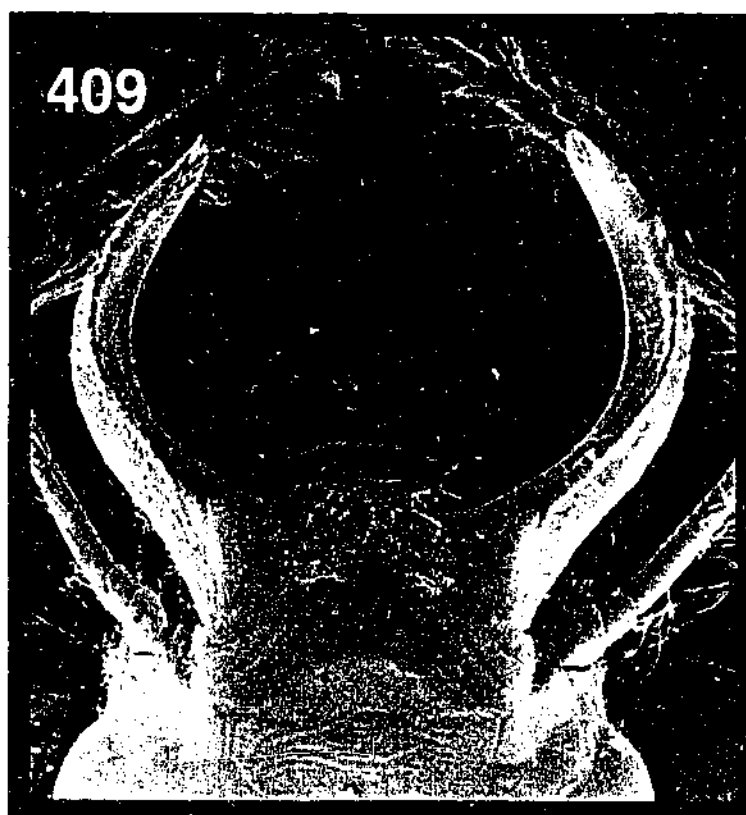
Figs. 409-410. Frontal horns of two undescribed species of the genus *Jappa.*

Fig. 409. *Jappa* sp. "AV4".
Fig. 410. *Jappa* sp. "AV3".
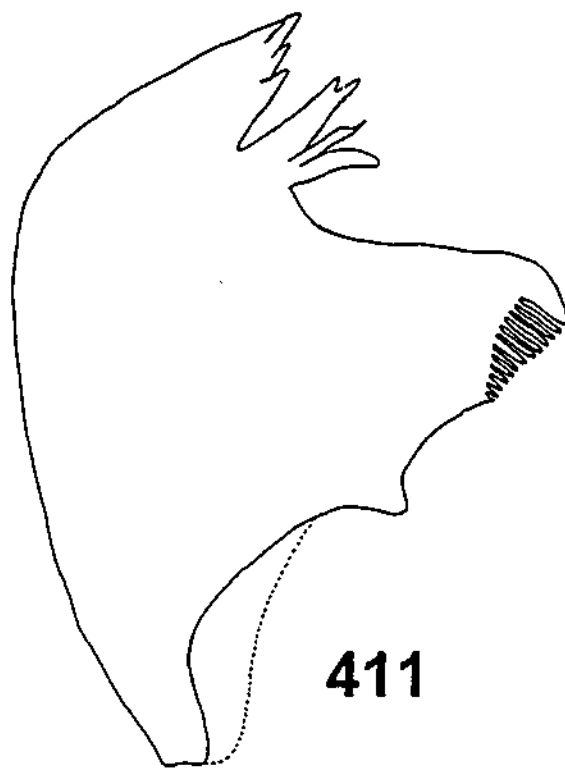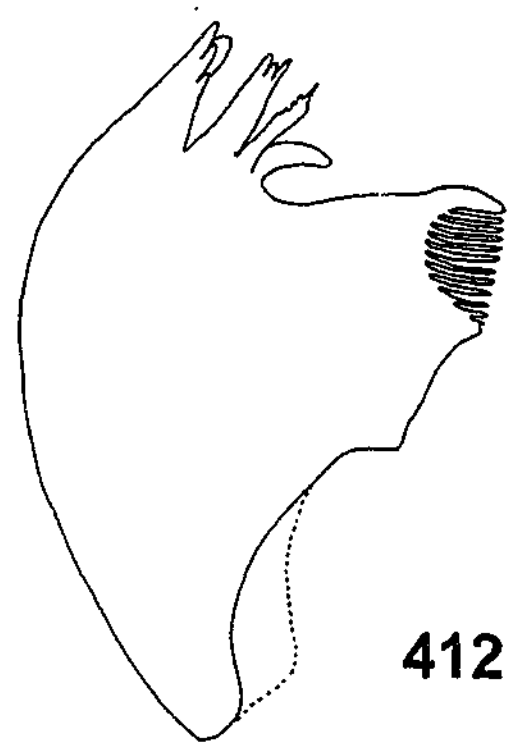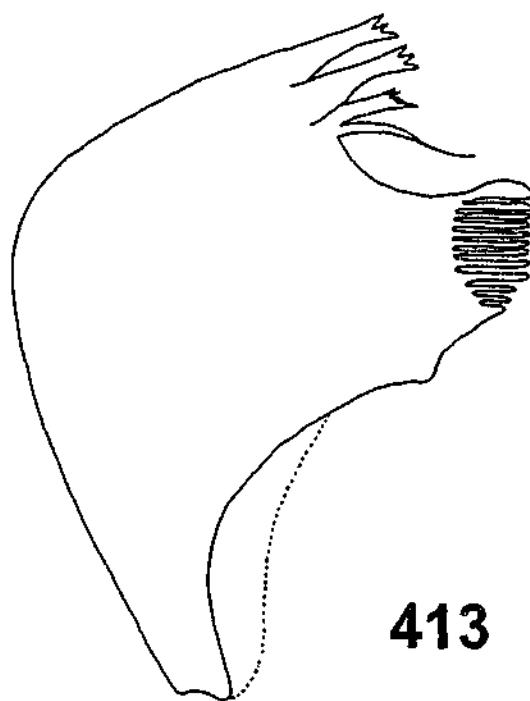
Figs. 411-414. Mandible morphology.

Fig. 411. *Atalomicria*
Fig. 412. *Atalophlebia*
Fig. 413. *Austrophlebioides*
Fig. 414. *Bibulmena*
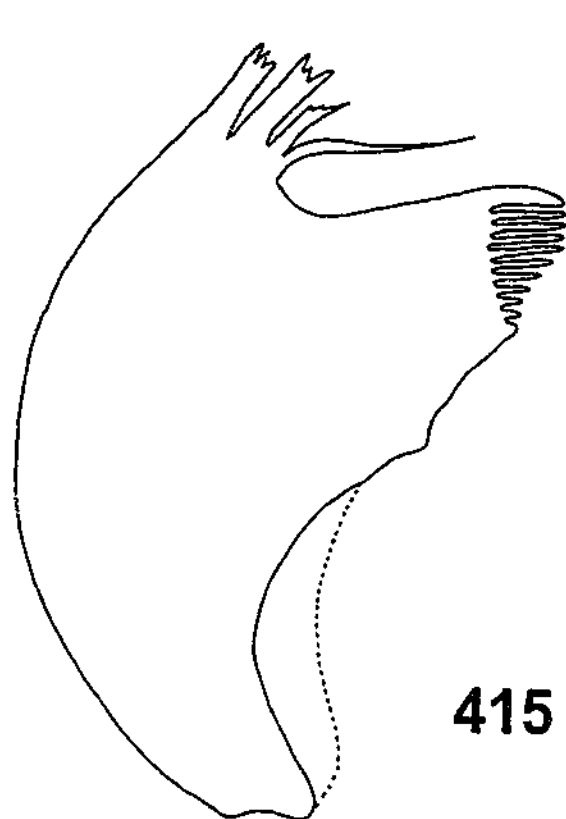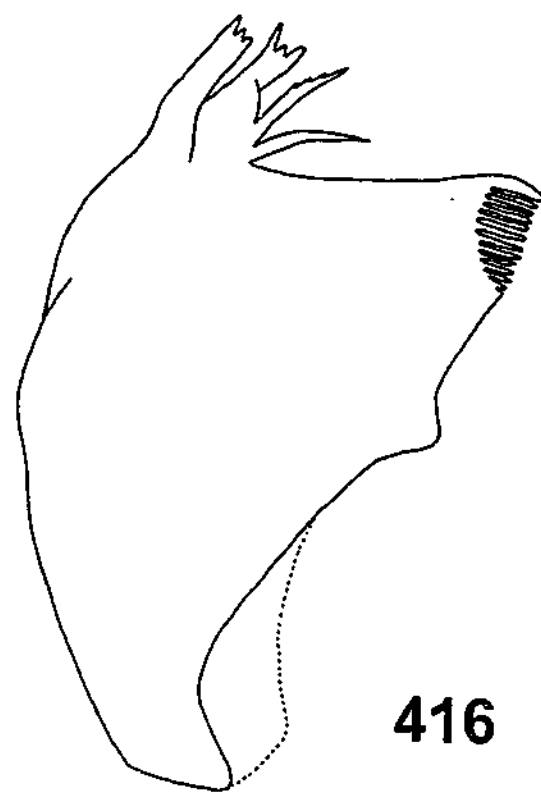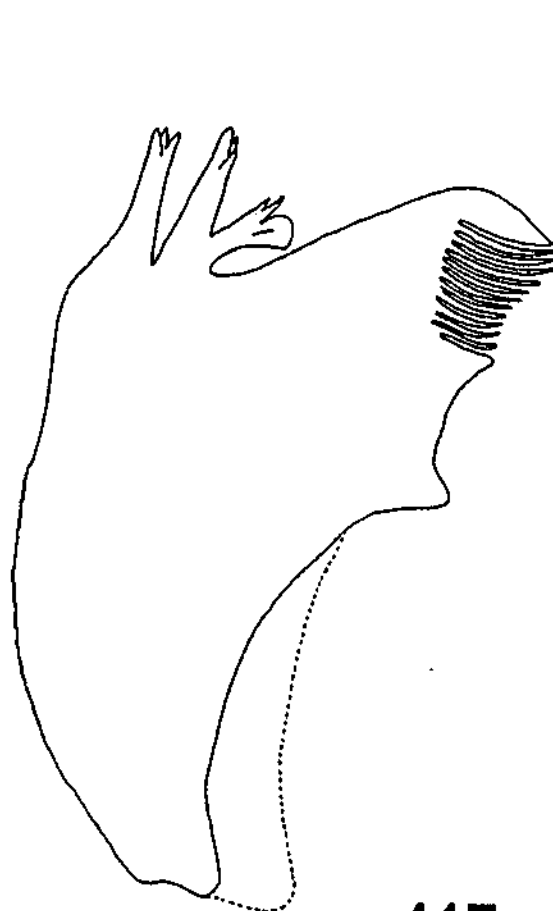
Figs. 415-418. Mandible morphology.

Fig. 415. *Garinjuga*
Fig. 416. *Gemmayaluka*
Fig. 417. *Jappa*
Fig. 418. *Kalbaybaria*
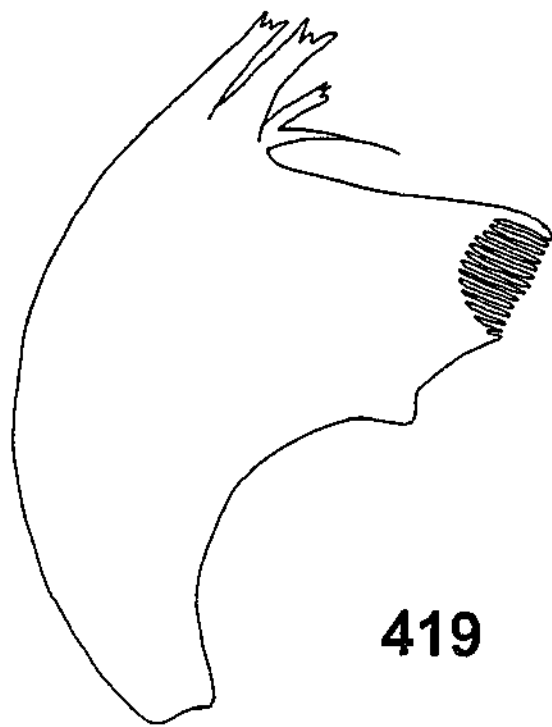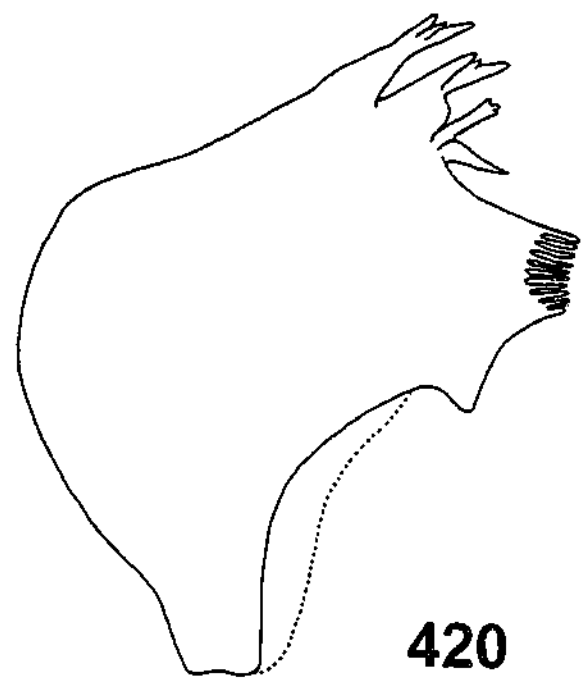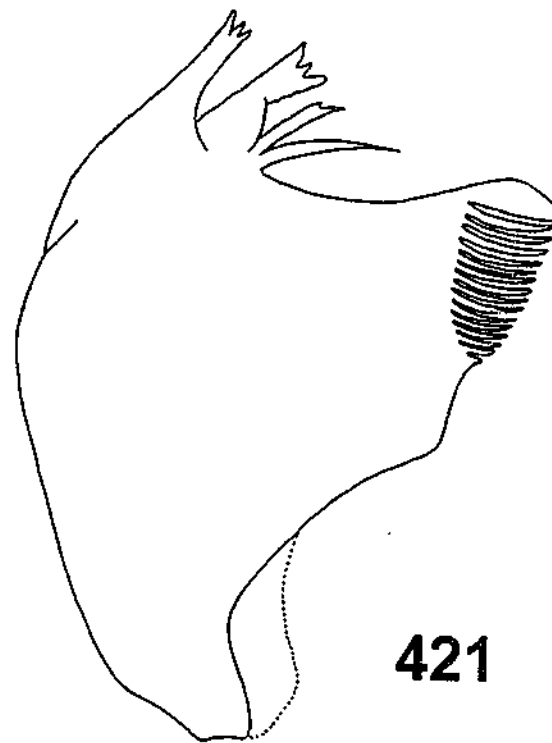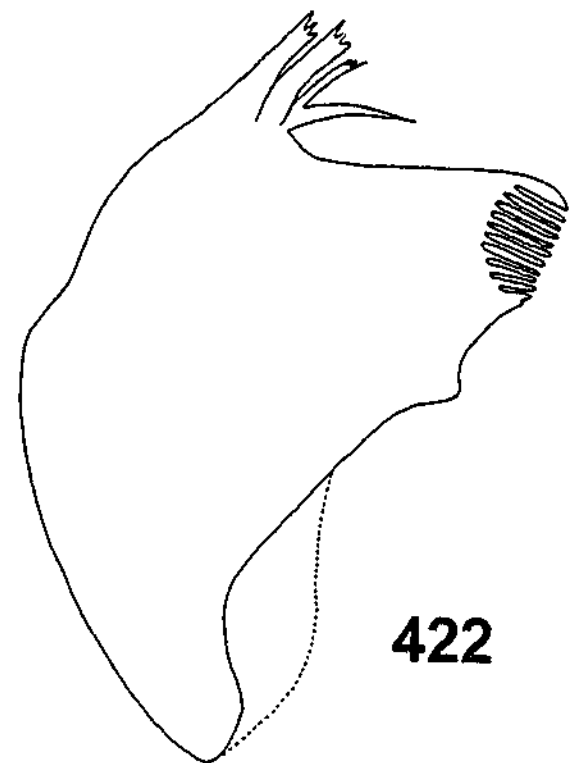
Figs. 419-422. Mandible morphology.

Fig. 419. *Kaninga*
Fig. 420. *Kirrara*
Fig. 421. *Loamaggalangta*
Fig. 422. *Montikola*
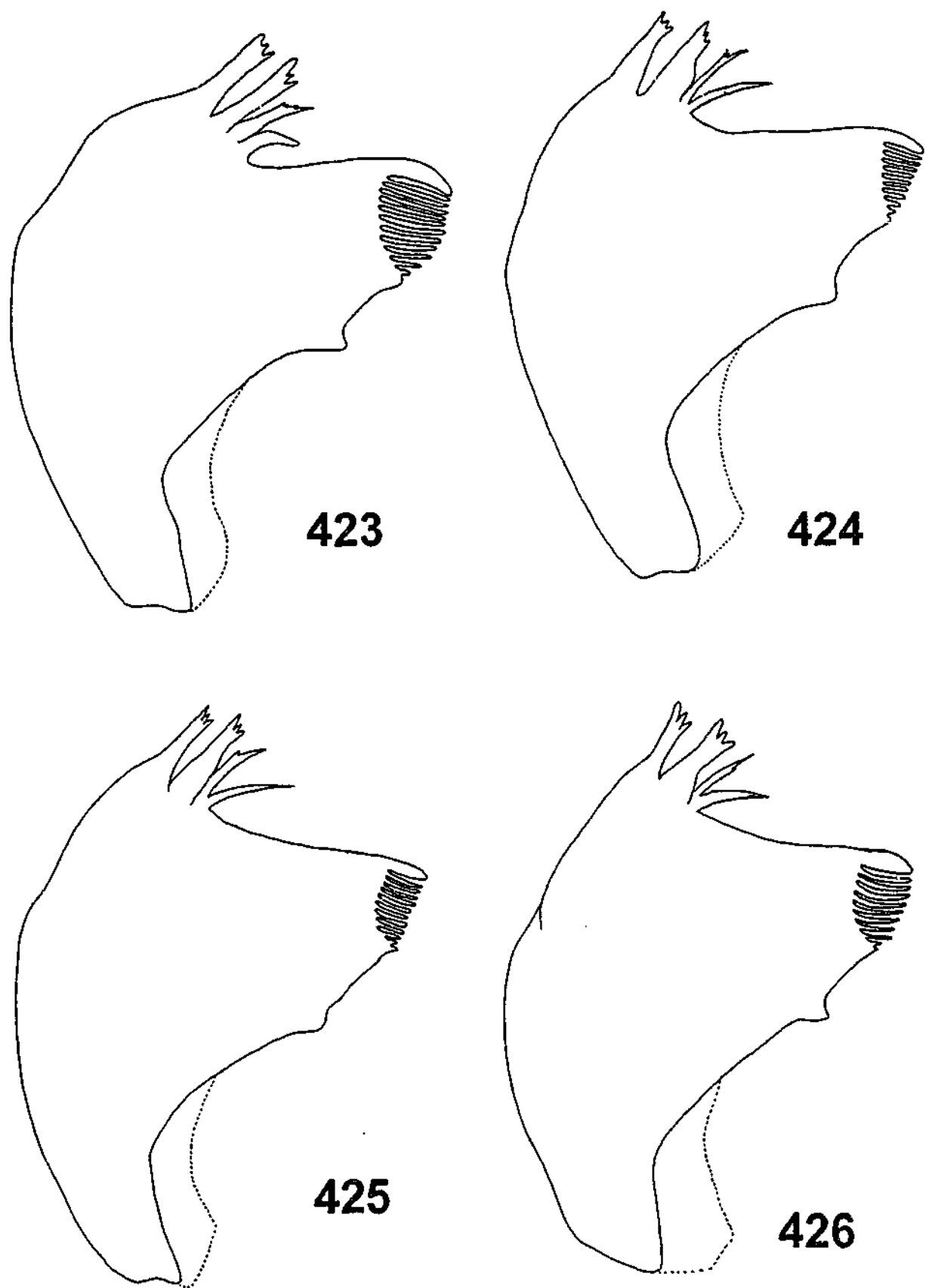
Figs. 423-426. Mandible morphology.

Fig. 423. *Neboissophlebia*
Fig. 424. *Nousia (Nousia)*
Fig. 425. *Nousia (Australonousia)*
Fig. 426. *Nyungara*
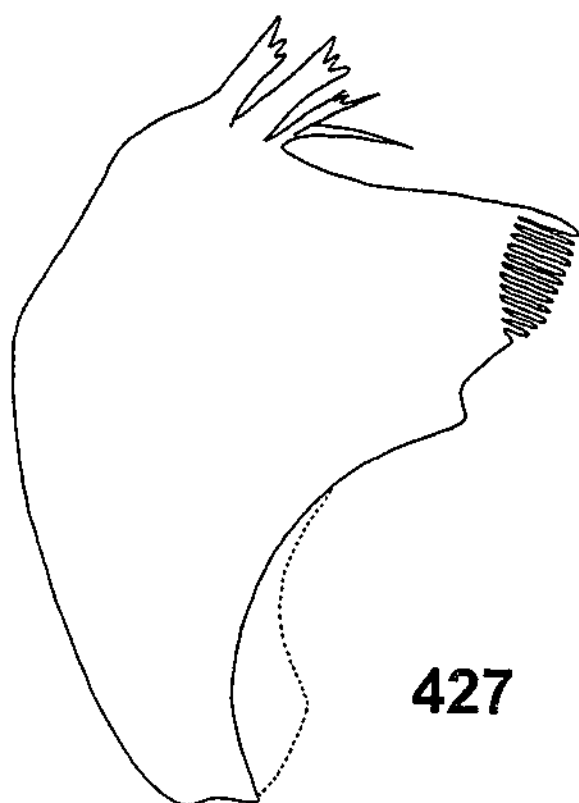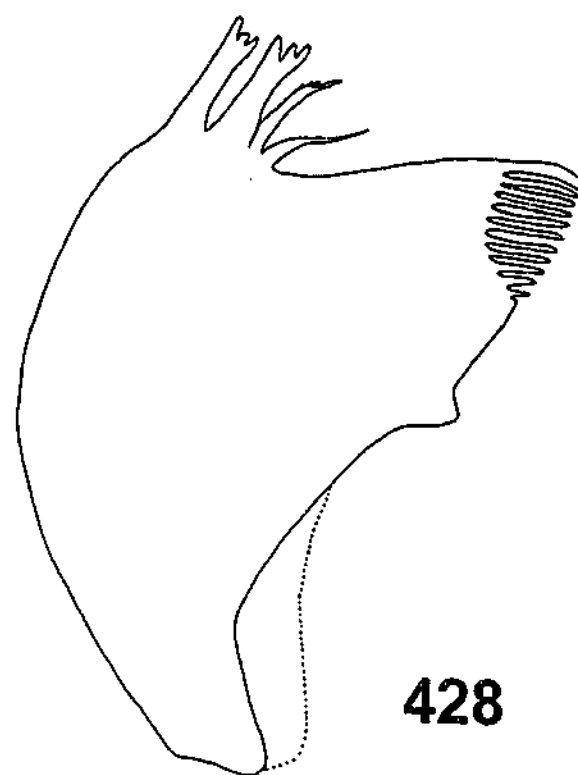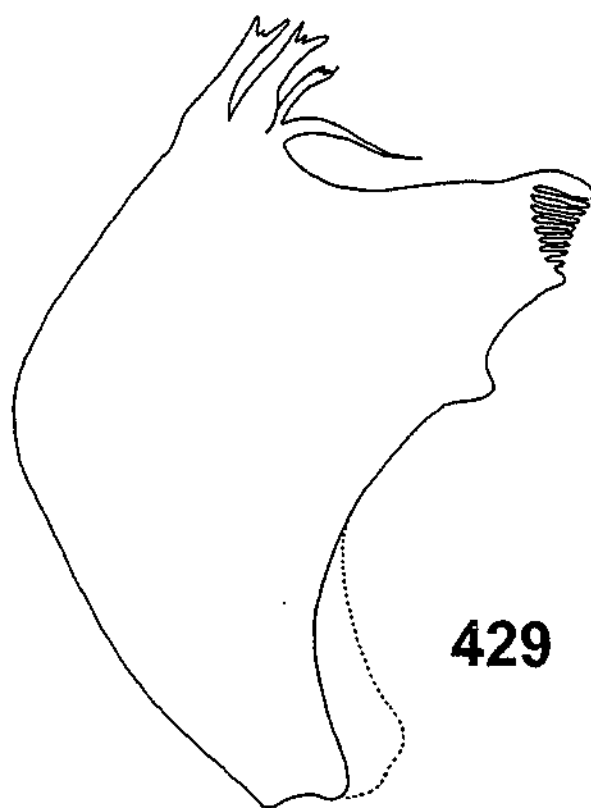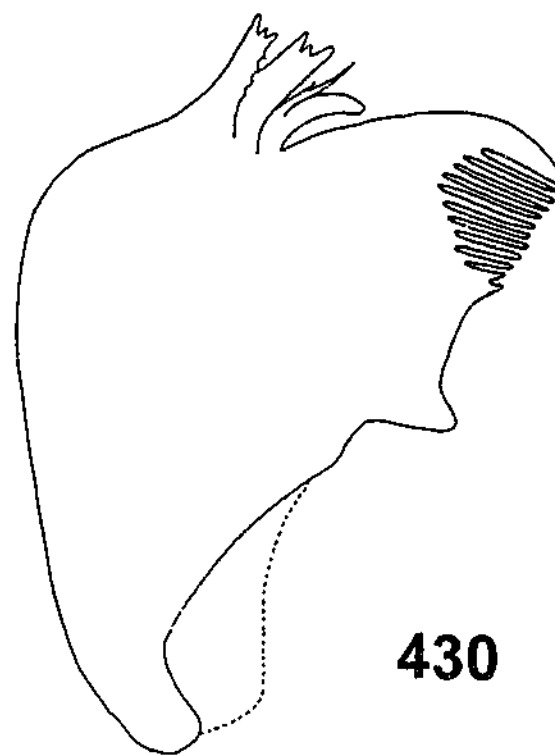
Figs. 427-430. Mandible morphology.

Fig. 427. *Thraulophlebia*
Fig. 428. *Thraulus*
Fig. 429. *Tillyardophlebia*
Fig. 430. *Ulmerophlebia*
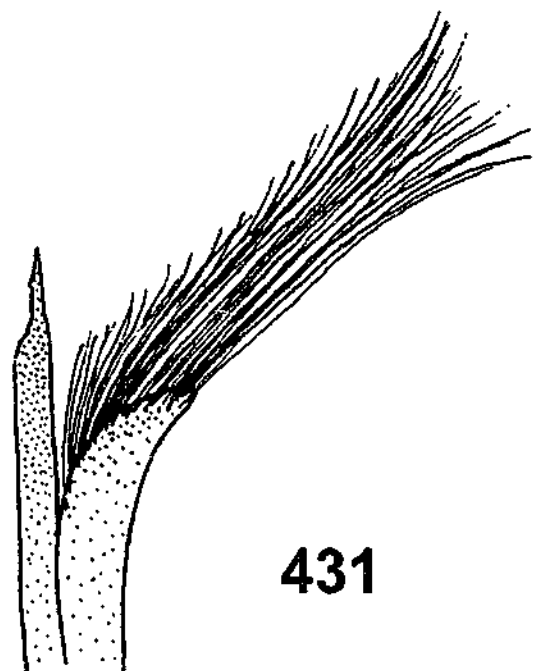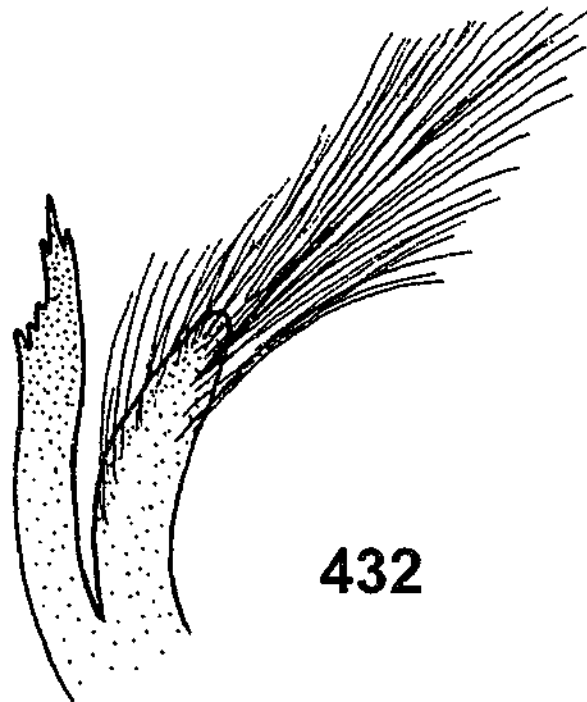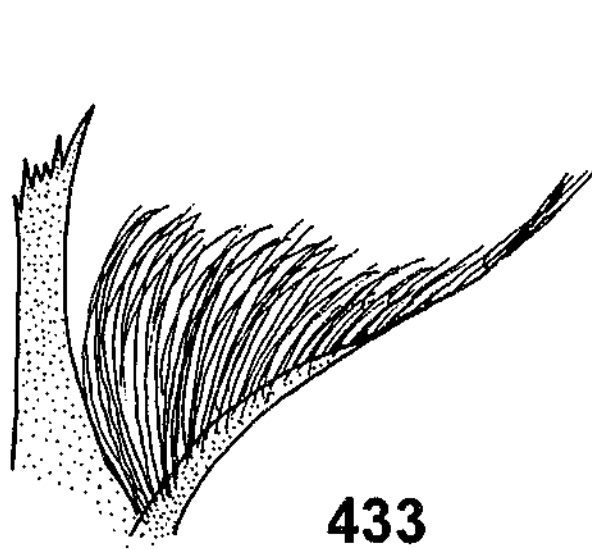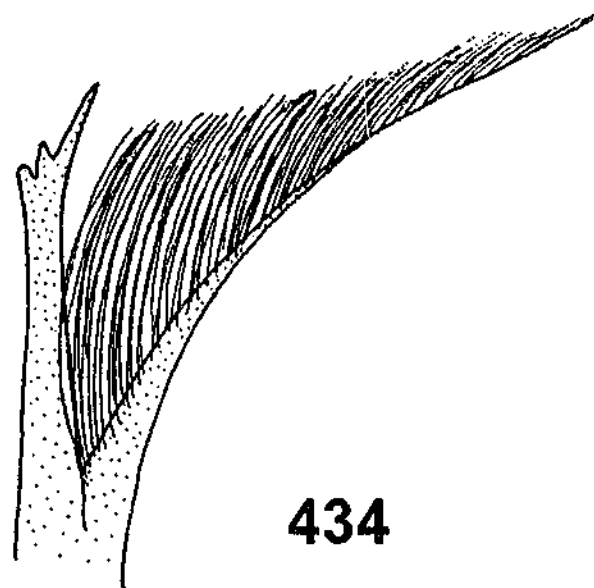
Figs. 431-434. Mandible prosthecal tuft morphology.

Fig. 431. *Atalomicria*
Fig. 432. *Atalophlebia*
Fig. 433. *Austrophlebioides*
Fig. 433. *Bibulmena*
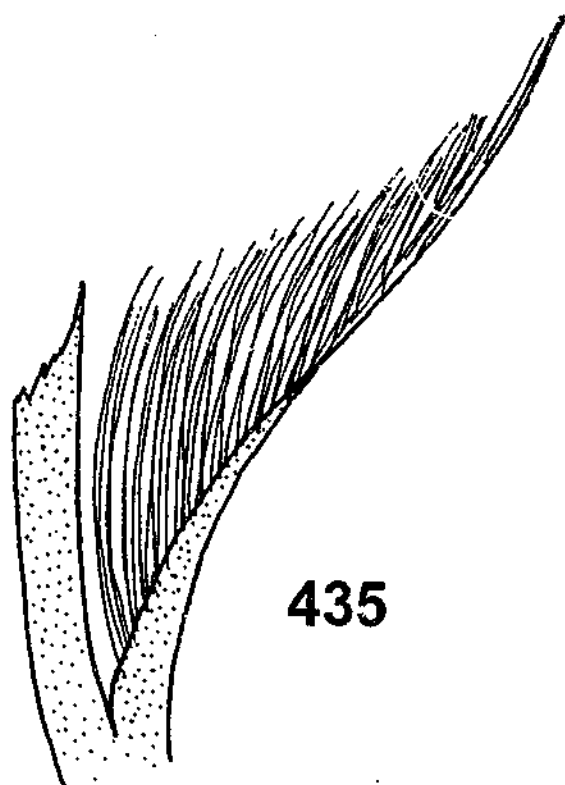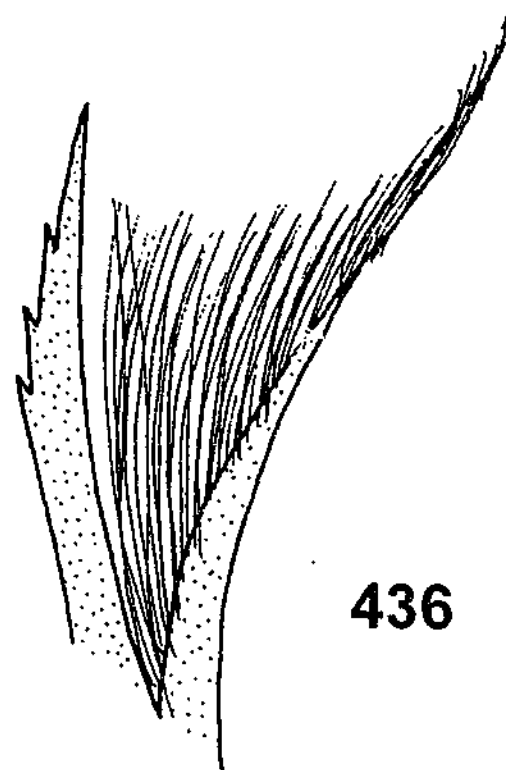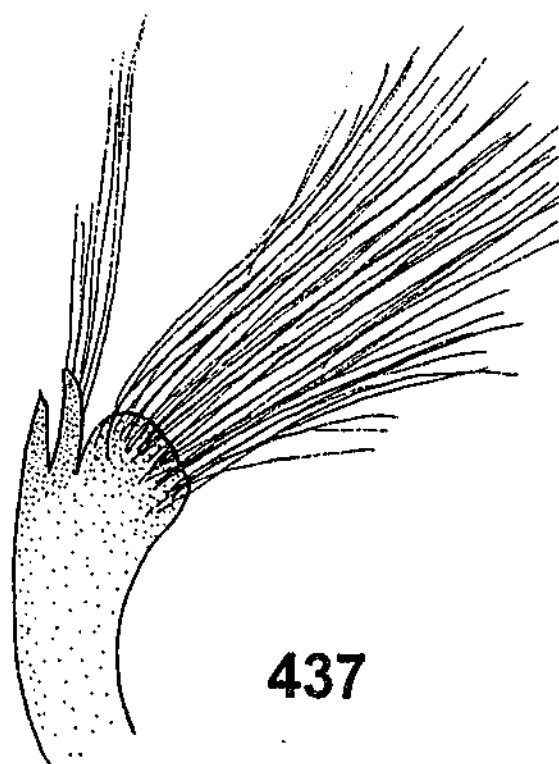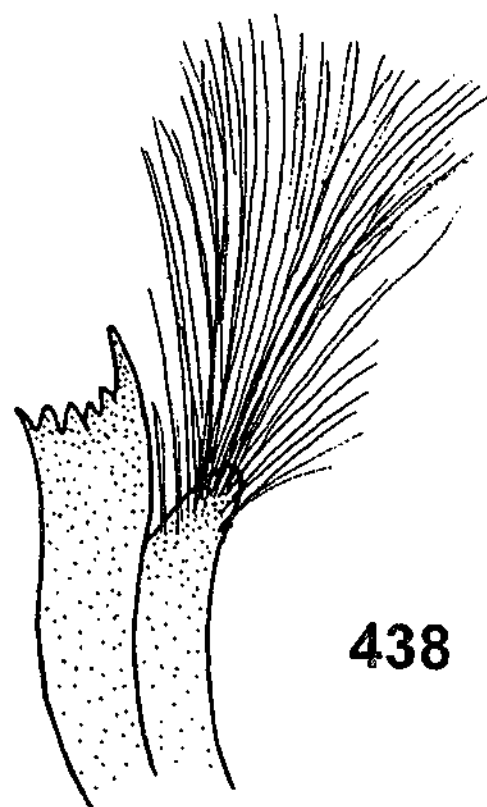
Figs. 435-438. Mandible prosthecal tuft morphology.

Fig. 435. *Garinjuga*
Fig. 436. *Gemmayaluka*
Fig. 437. *Jappa*
Fig. 438. *Kalbaybaria*
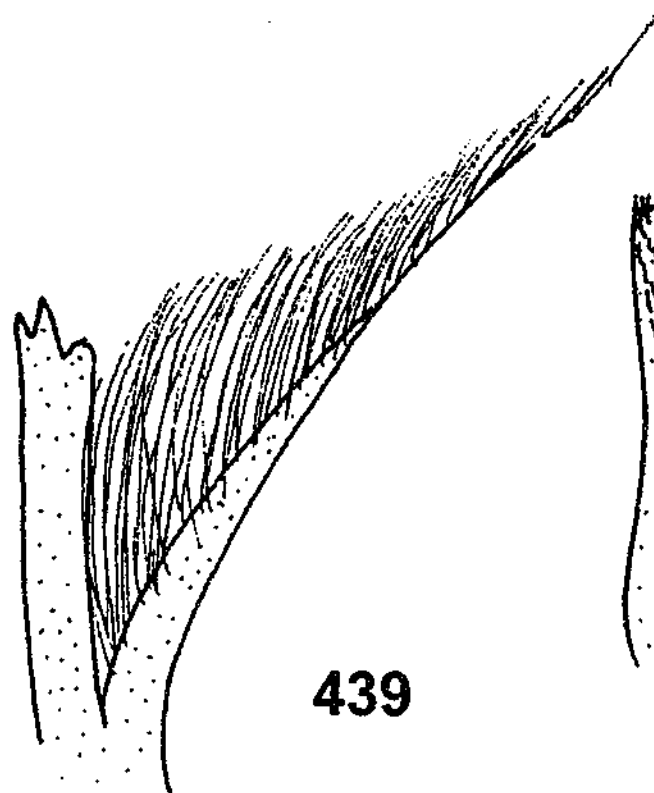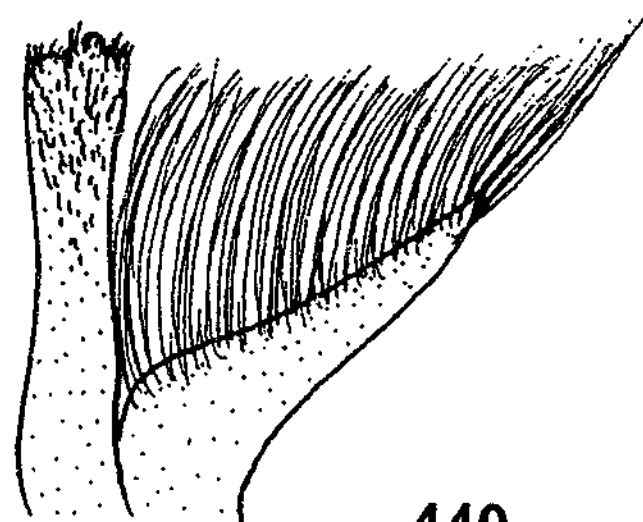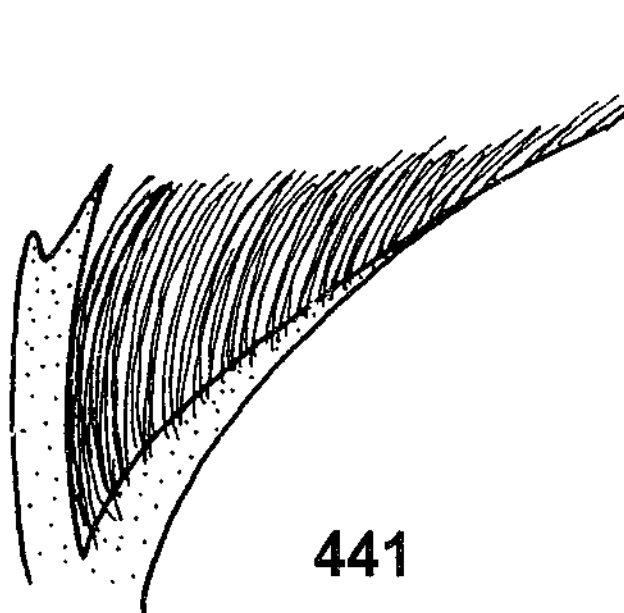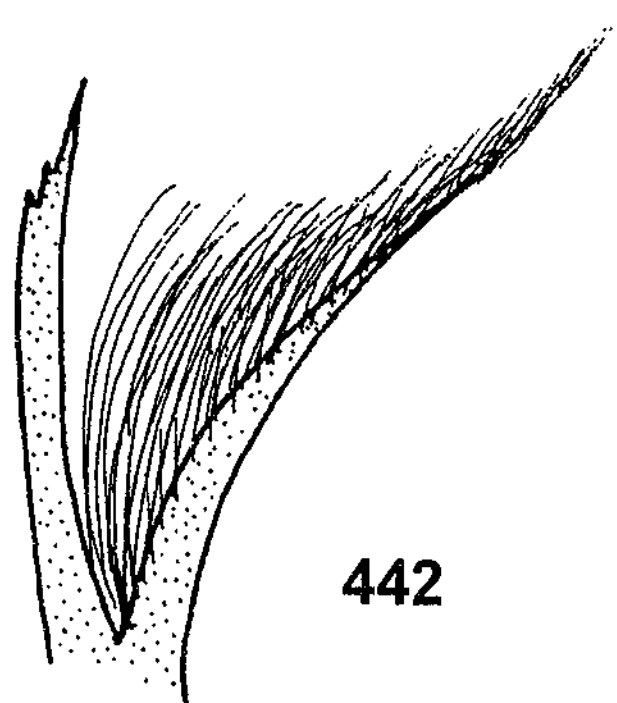
Figs. 439-442. Mandible prosthecal tuft morphology.

Fig. 439. *Kaninga*
Fig. 440. *Kirrara*
Fig. 441. *Loamaggalangta*
Fig. 442. *Montikola*
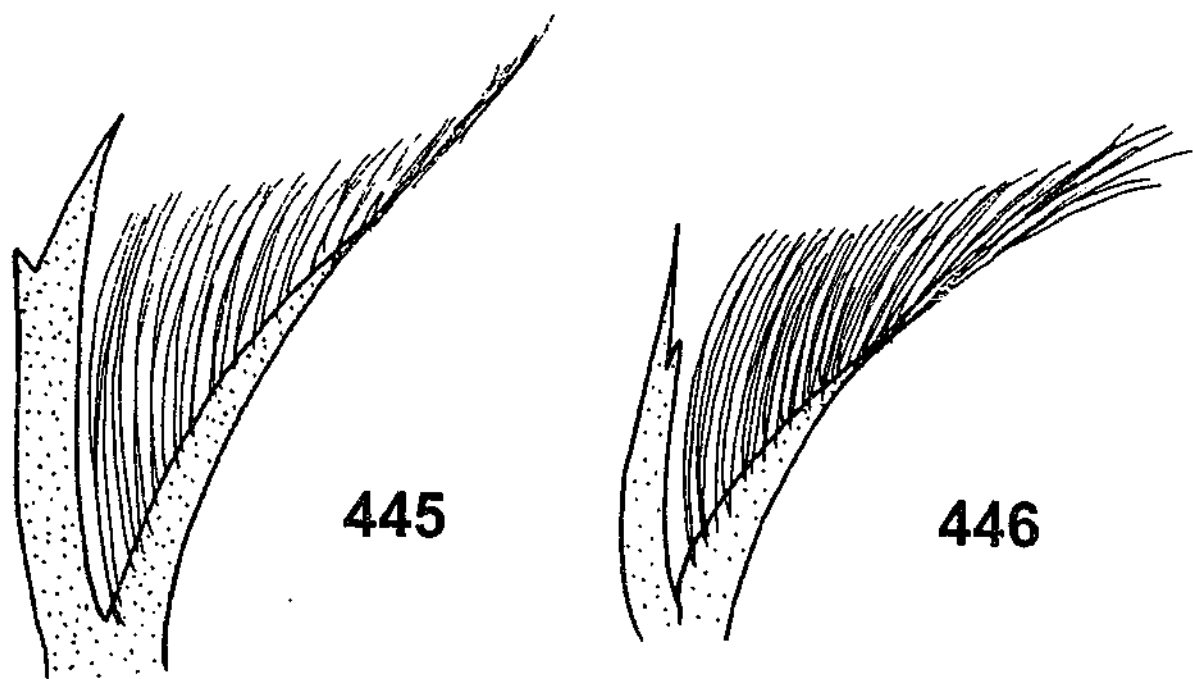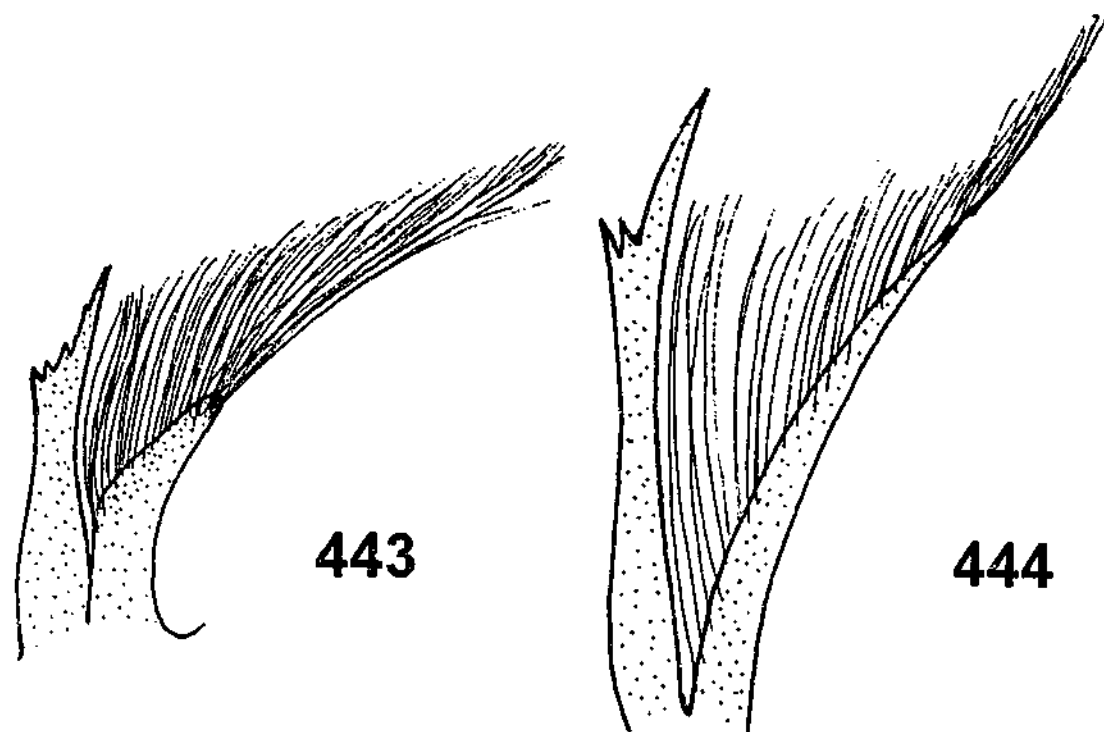
Figs. 443-446. Mandible prosthecal tuft morphology.

Fig. 443. *Neboissophlebia*
Fig. 444. *Nousia (Nousia)*
Fig. 445. *Nousia (Australonousia)*
Fig. 446. *Nyungara*
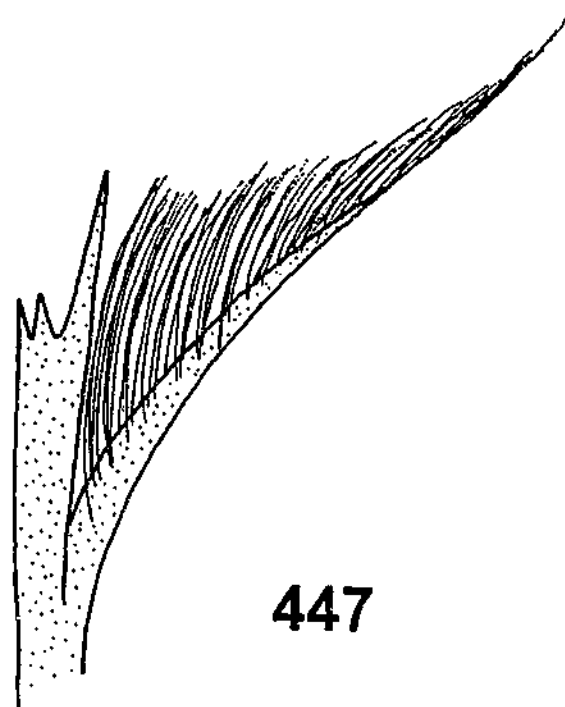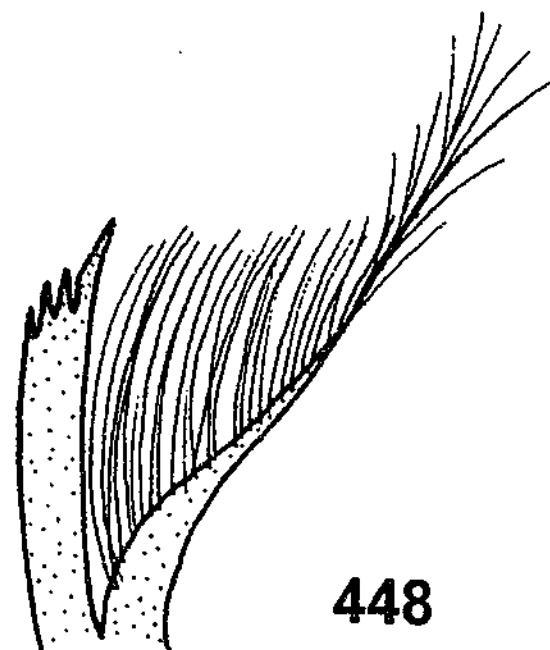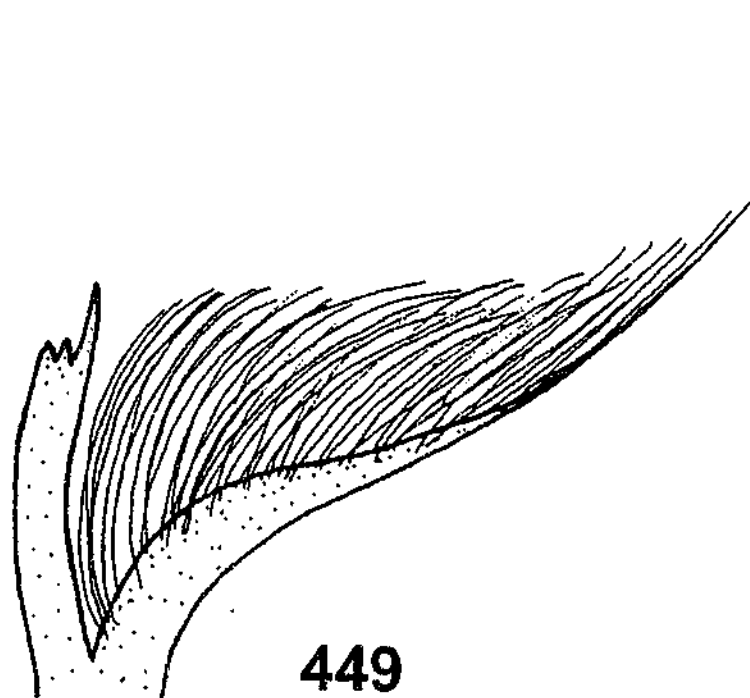
Figs. 447-450. Mandible prosthecal tuft morphology.

Fig. 447. *Thraulophlebia*
Fig. 448. *Thraulus*
Fig. 449. *Tillyardophlebia*
Fig. 450. *Ulmerophlebia*
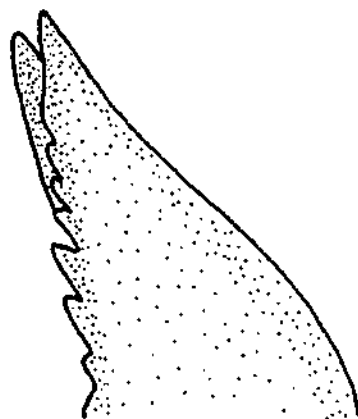
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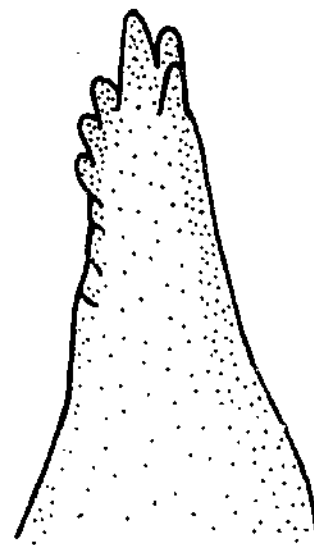
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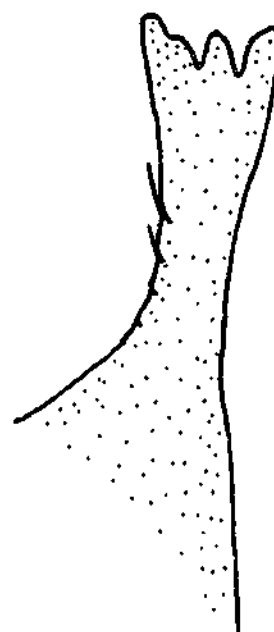
454

Figs. 451–454. Right mandible outer incisor morphology.

Fig. 451. *Atalomicria*
Fig. 452. *Atalophlebia*
Fig. 453. *Austrophlebioides*
Fig. 454. *Bibulmena*
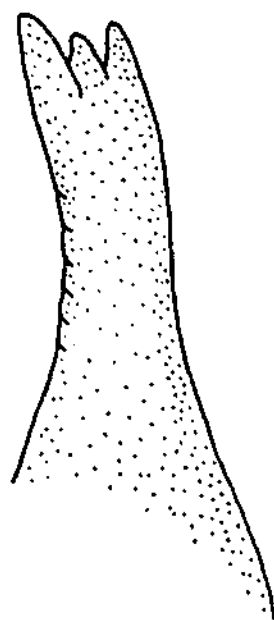
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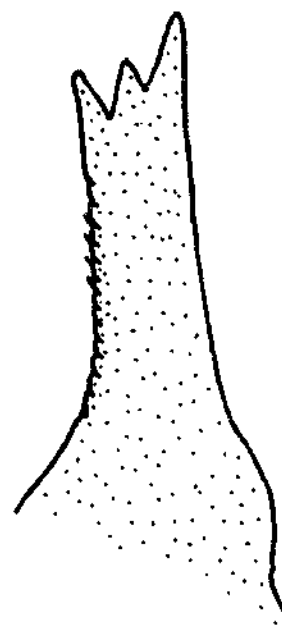
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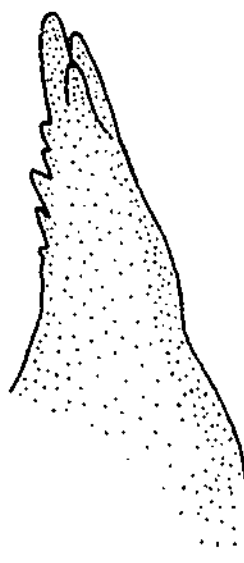
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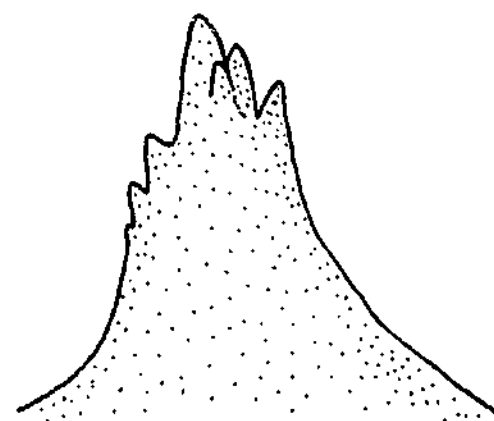
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Figs. 455-458. Right mandible outer incisor morphology.

Fig. 455. *Garinjuga*
Fig. 456. *Gemmayaluka*
Fig. 457. *Jappa*
Fig. 458. *Kalbaybaria*
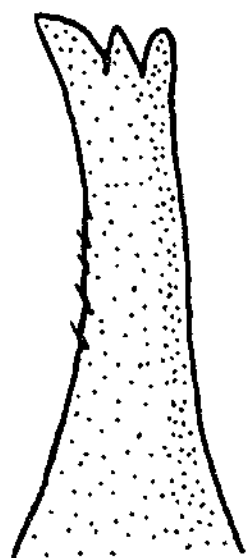
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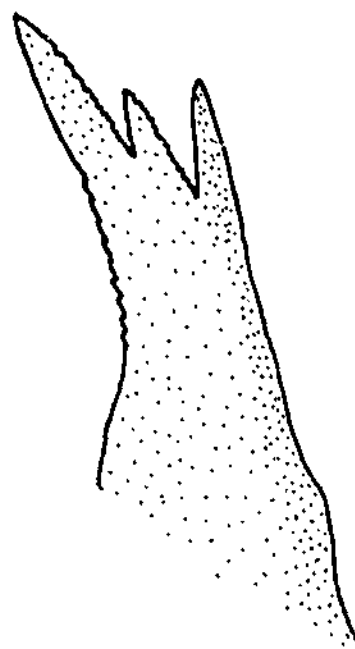
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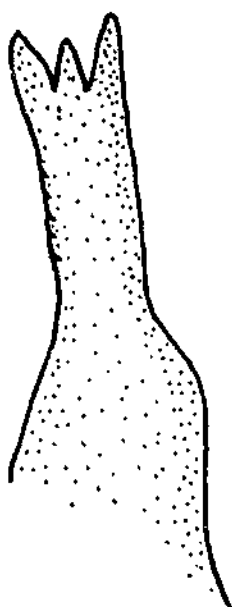
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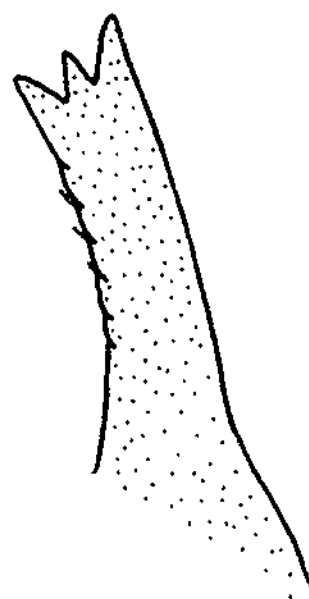
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Figs. 459-462. Right mandible outer incisor morphology.

Fig. 459. *Kaninga*
Fig. 460. *Kirrara*
Fig. 461. *Loamaggalangta*
Fig. 462. *Montikola*
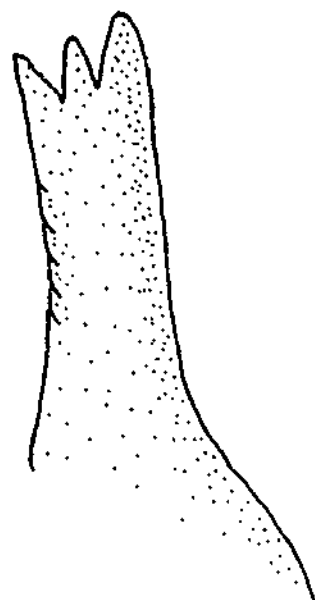
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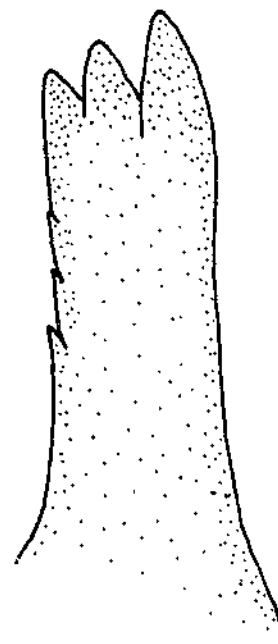
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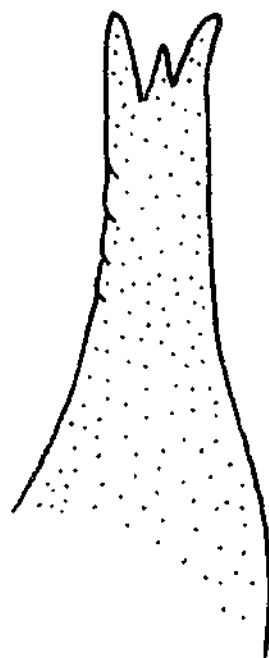
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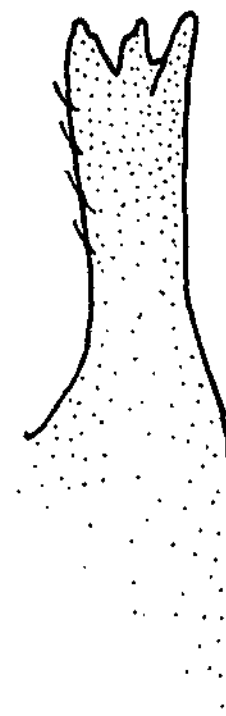
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Figs. 463-466. Right mandible outer incisor morphology.

Fig. 463. *Neboissophlebia*
Fig. 464. *Nousia (Nousia)*
Fig. 465. *Nousia (Australonousia)*
Fig. 466. *Nyungara*
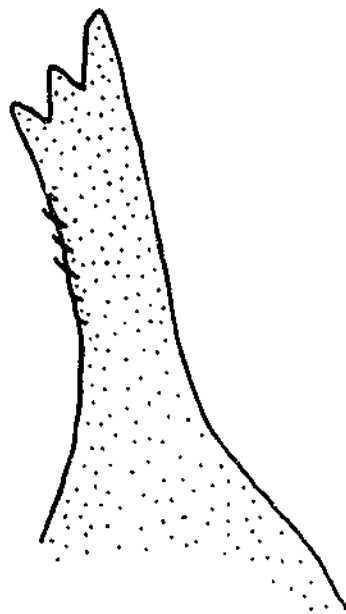
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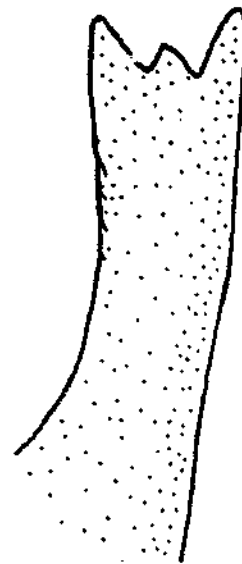
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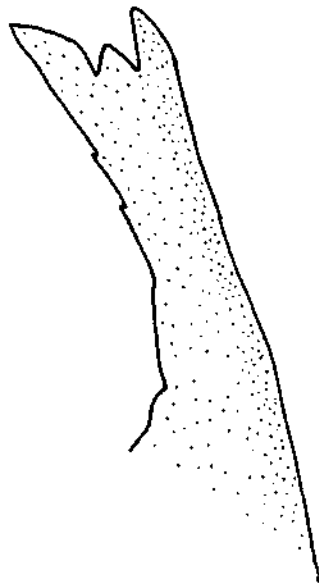
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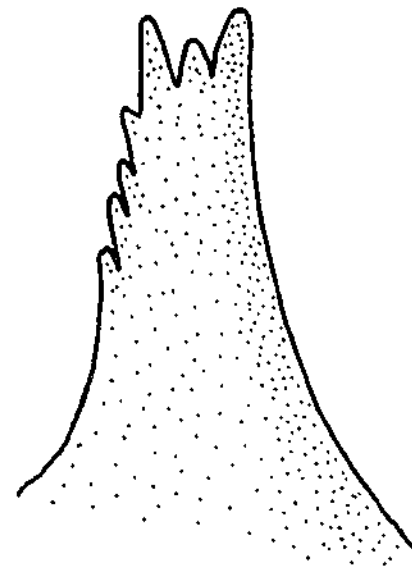
470

Figs. 467–470. Right mandible outer incisor morphology.

Fig. 467. *Thraulophlebia*
Fig. 468. *Thraulus*
Fig. 469. *Tillyardophlebia*
Fig. 470. *Ulmerophlebia*
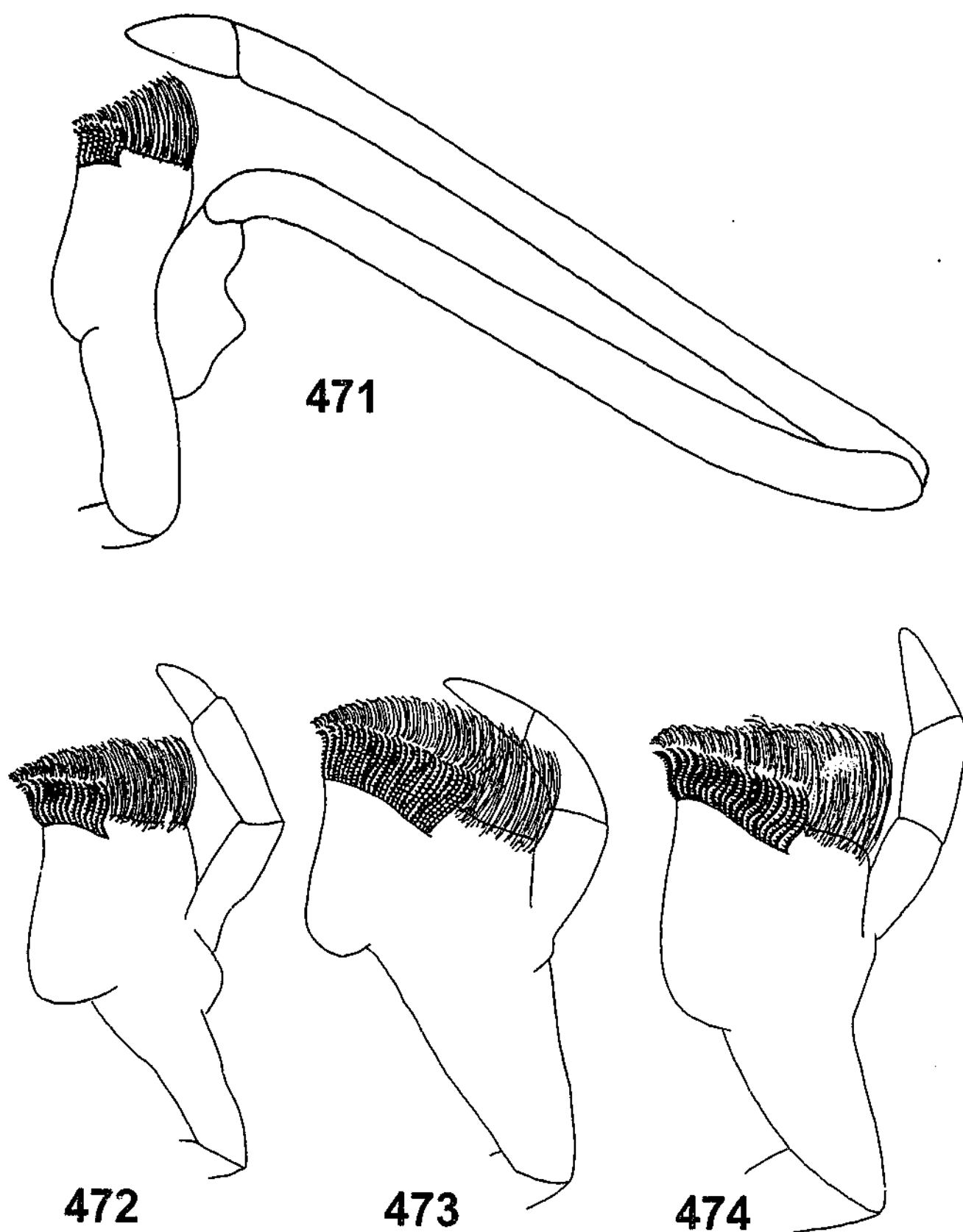
Figs. 471-474. Maxilla morphology.

Fig. 471. *Atalomicria*
Fig. 472. *Atalophlebia*
Fig. 473. *Austrophlebioides*
Fig. 474. *Bibulmena*
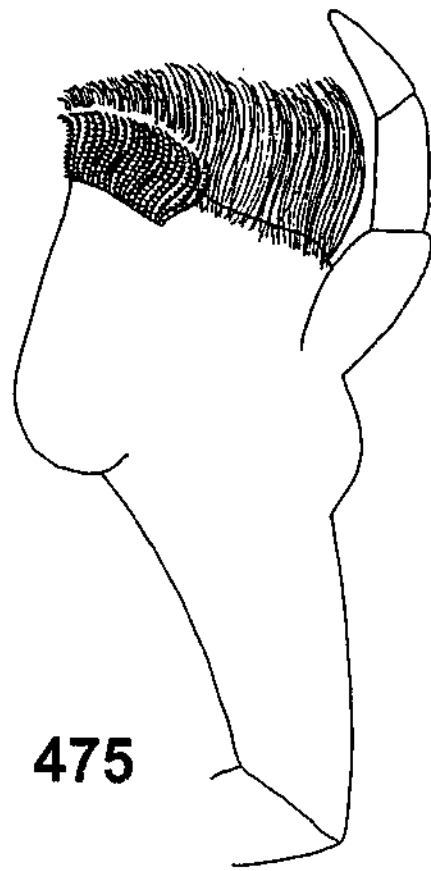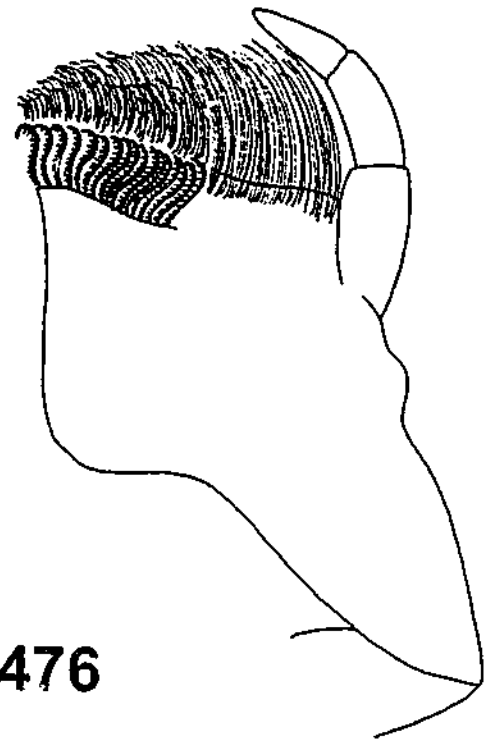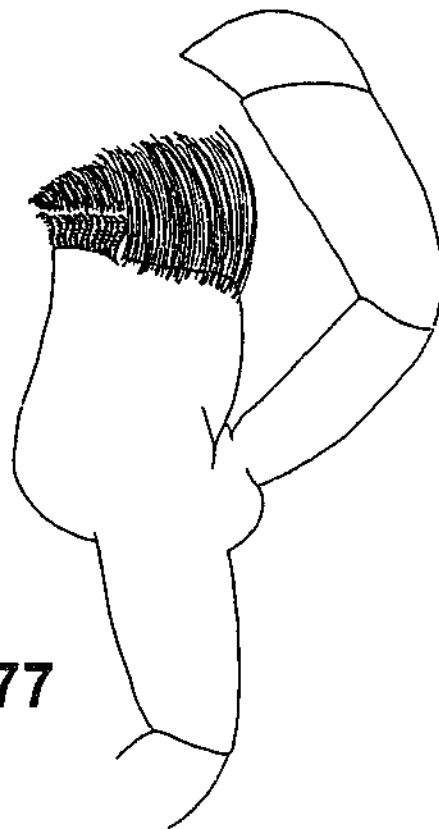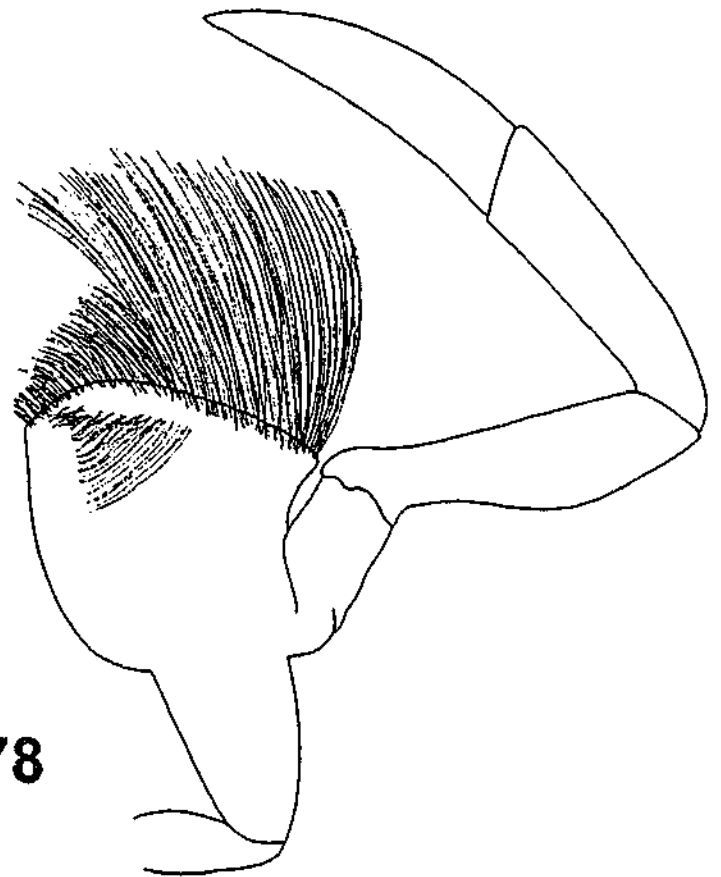
Figs. 475-478. Maxilla morphology.

Fig. 475. *Garinjuga*
Fig. 476. *Gemmayaluka*
Fig. 477. *Jappa*
Fig. 478. *Kalbaybaria*
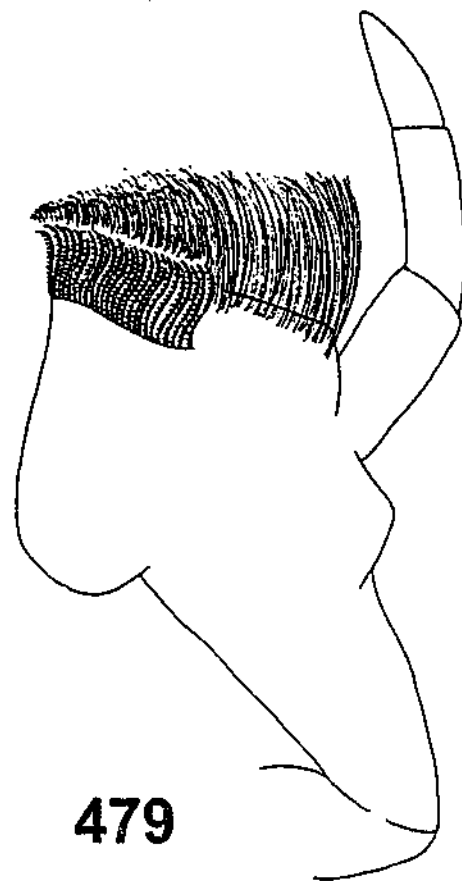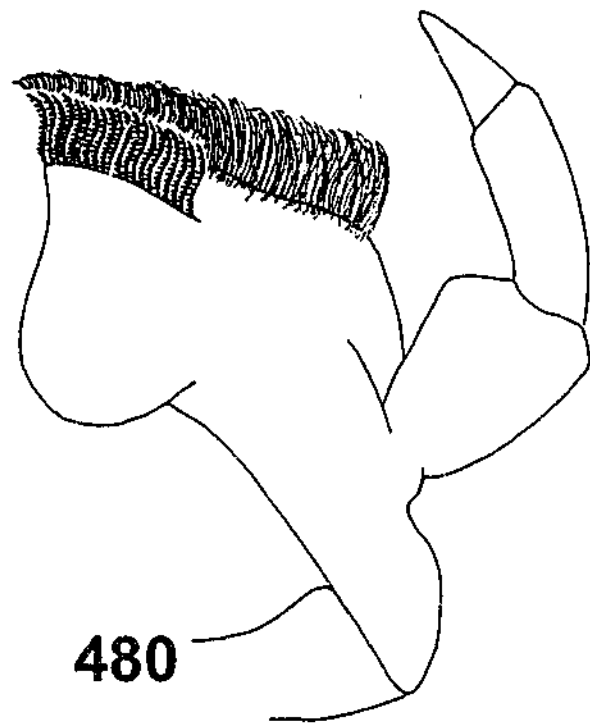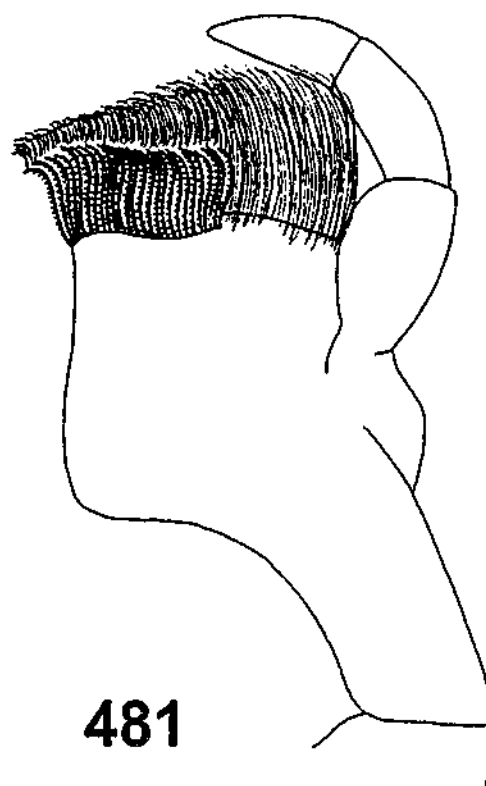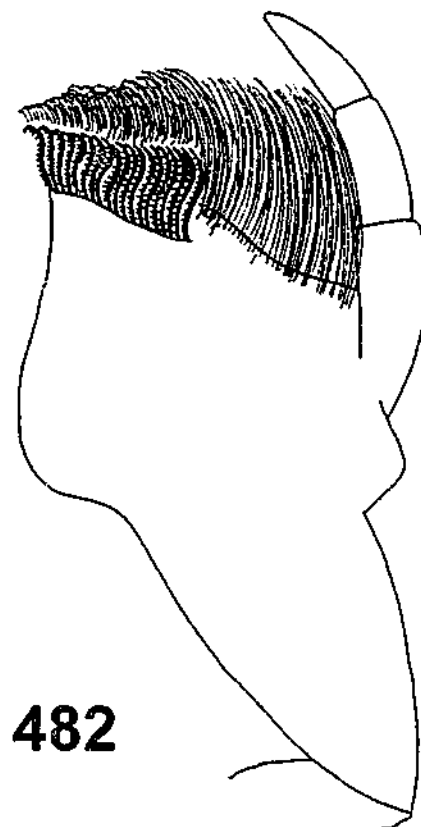
Figs. 479-482. Maxilla morphology.

Fig. 479. *Kaninga*
Fig. 480. *Kirrara*
Fig. 481. *Loamaggalangta*
Fig. 482. *Montikola*
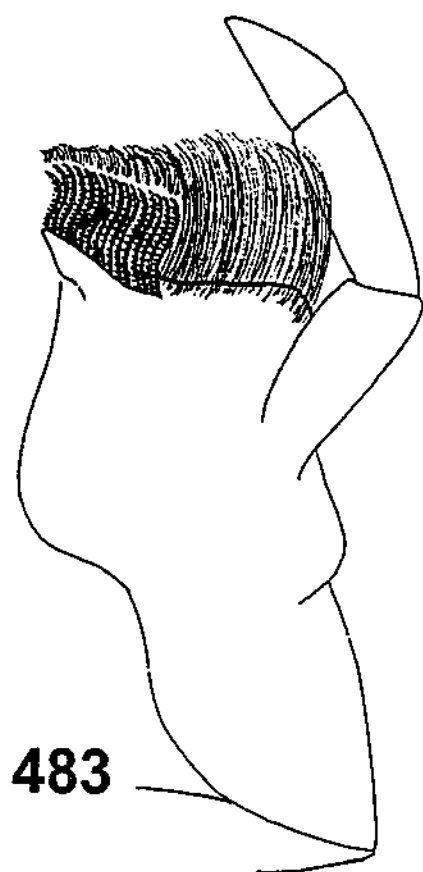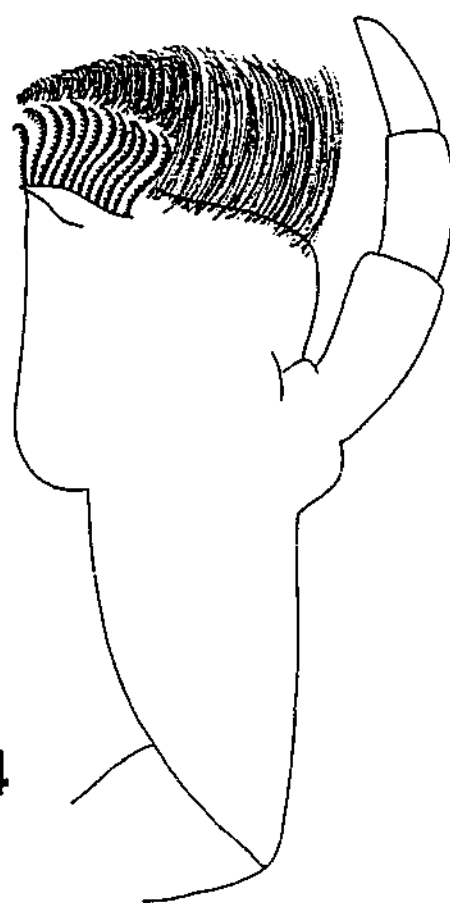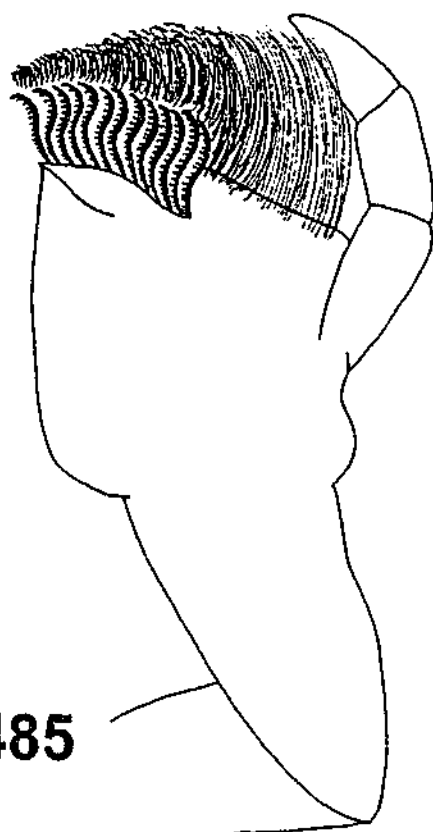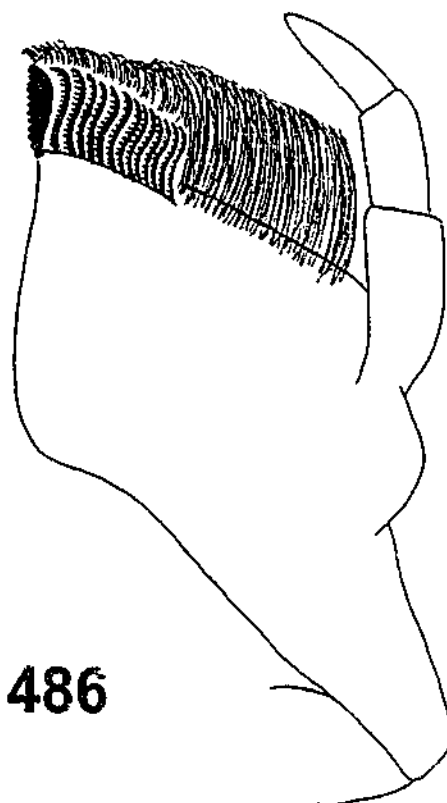
Figs. 483-486. Maxilla morphology.

Fig. 483. *Neboissophlebia*
Fig. 484. *Nousia (Nousia)*
Fig. 485. *Nousia (Australonousia)*
Fig. 486. *Nyungara*
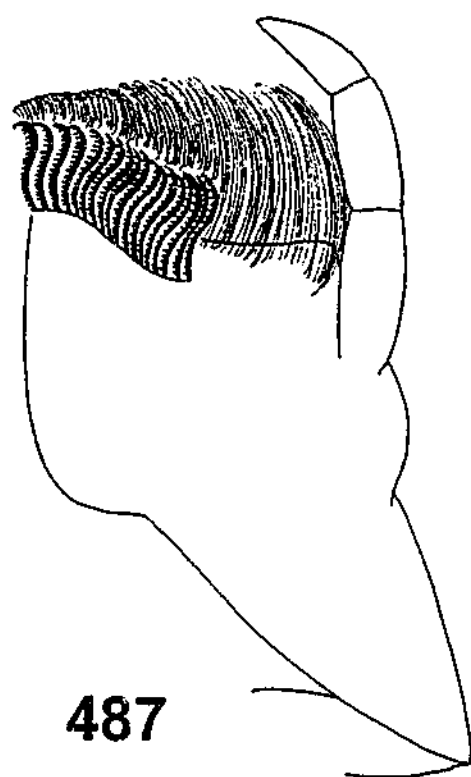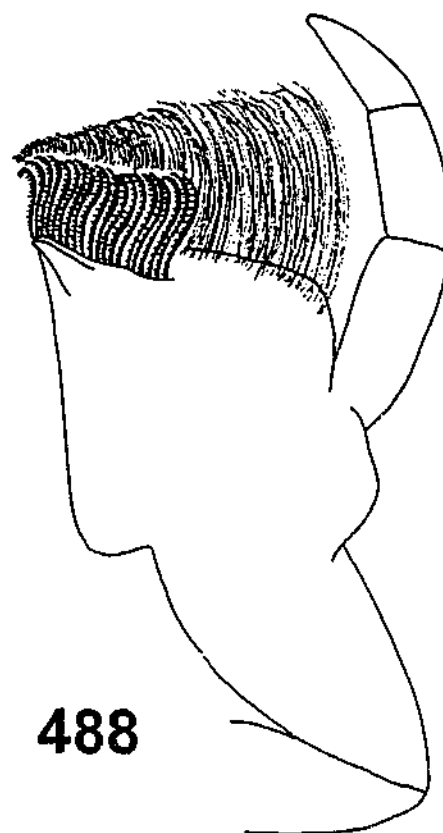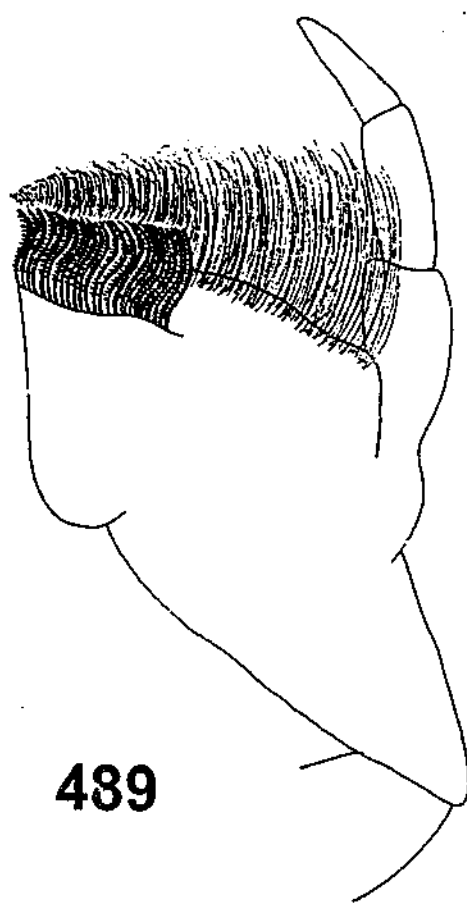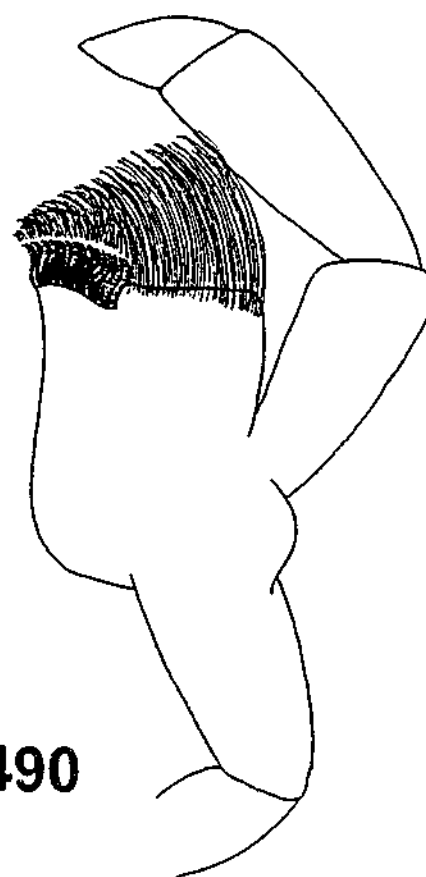
Figs. 487-490. Maxilla morphology.

Fig. 487. *Thraulophlebia*
Fig. 488. *Thraulus*
Fig. 489. *Tillyardophlebia*
Fig. 490. *Ulmerophlebia*
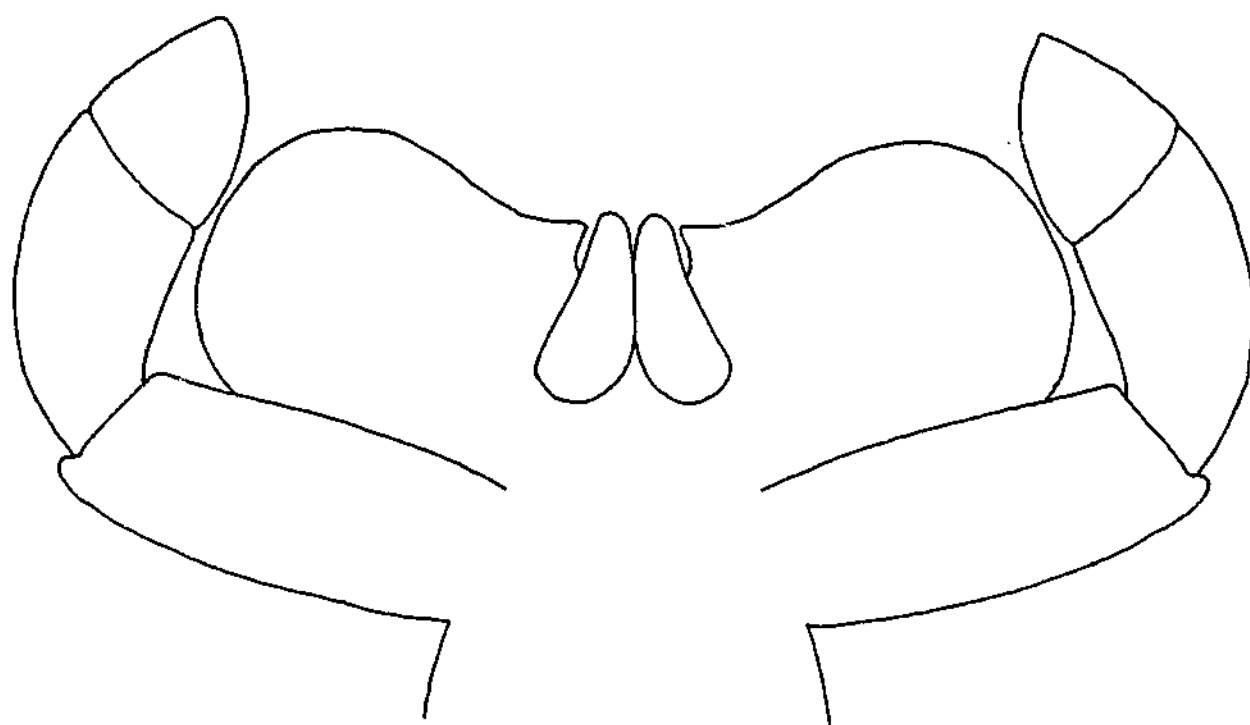
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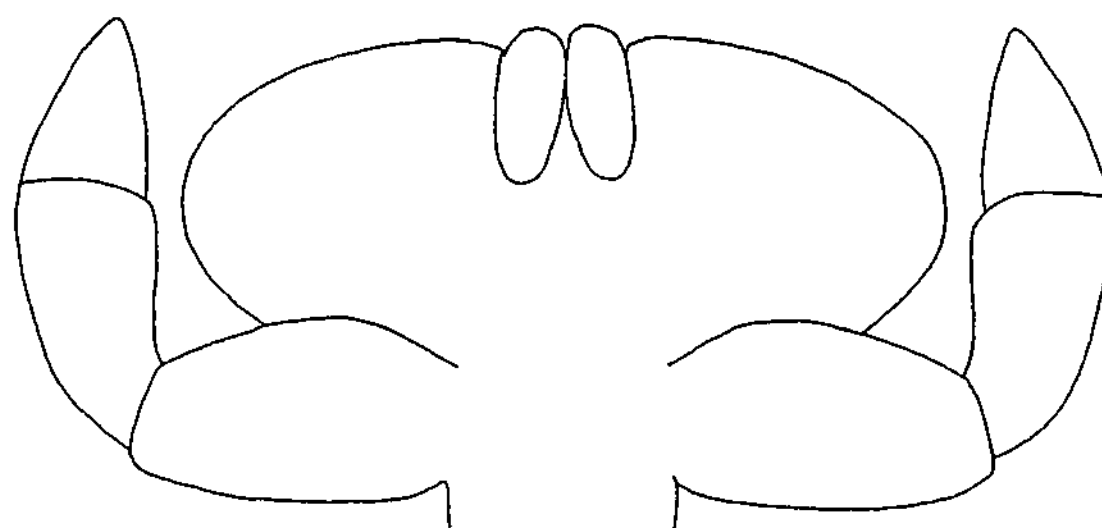
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Figs. 491-492. Labium morphology.

Fig. 491. *Atalomicria*
Fig. 492. *Atalophlebia*
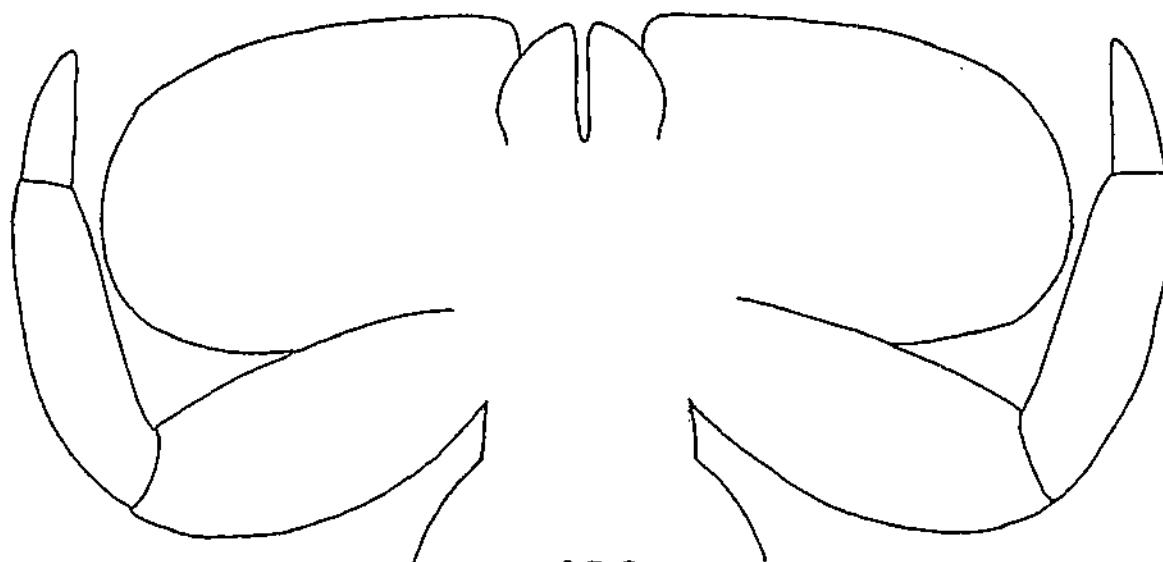
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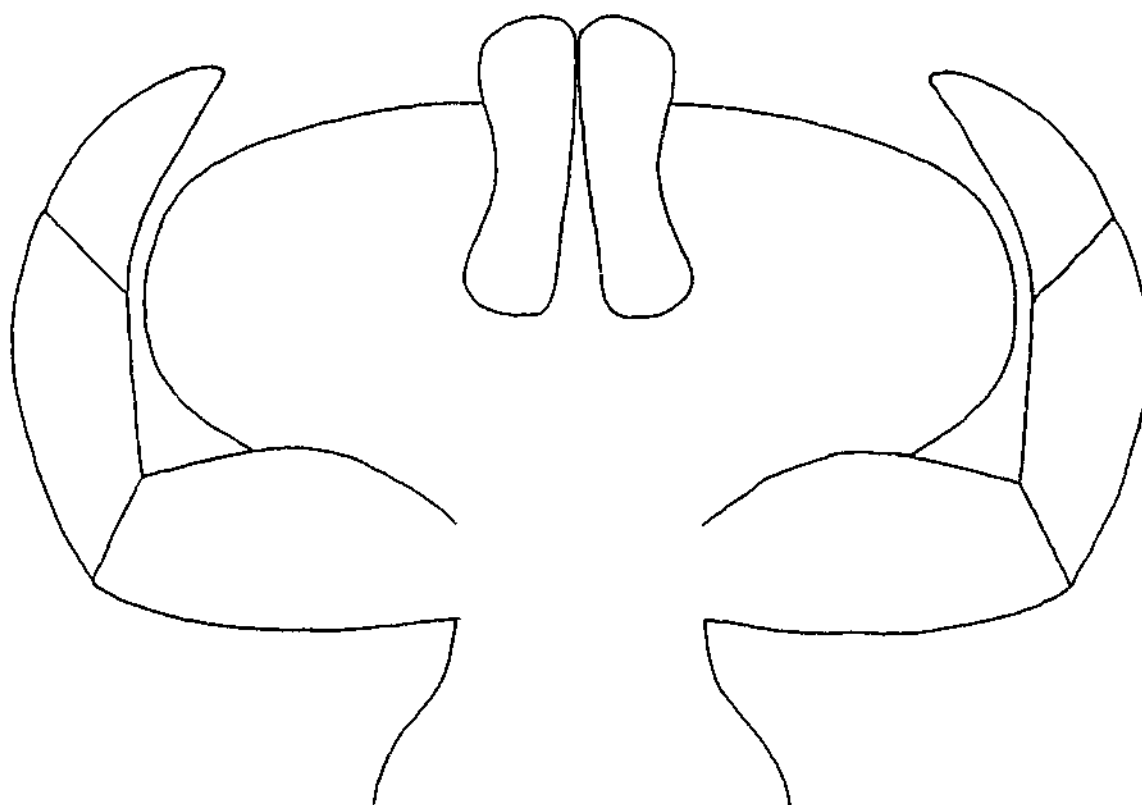
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Figs. 493-494. Labium morphology.

Fig. 493. *Austrophlebioides*
Fig. 494. *Biblumena*
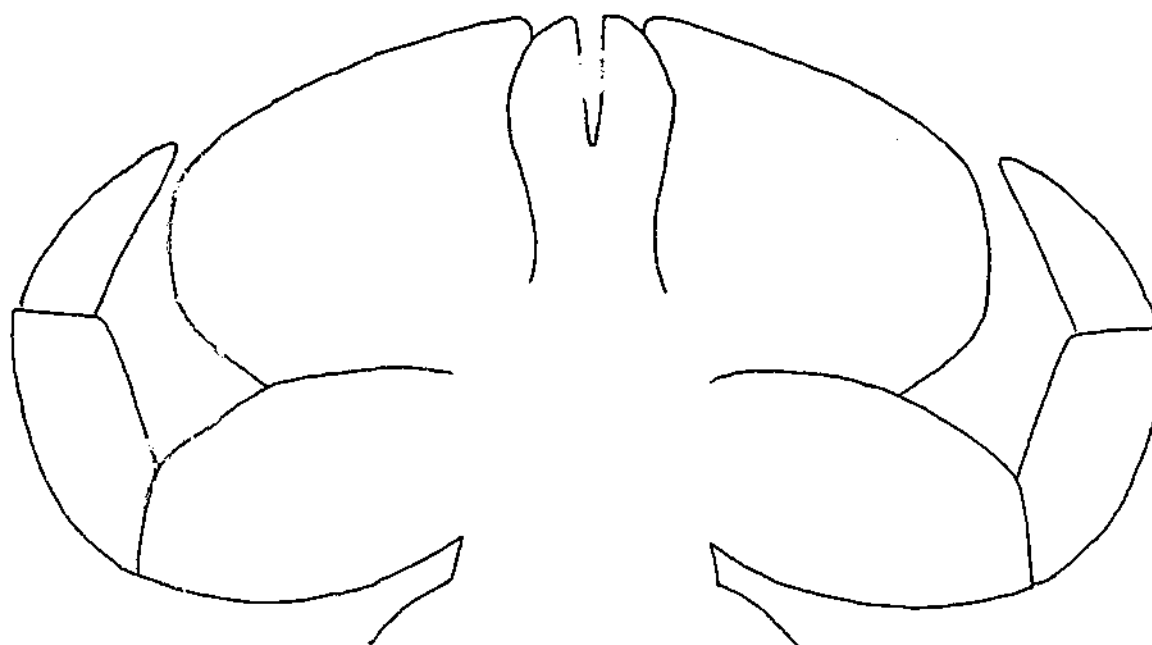
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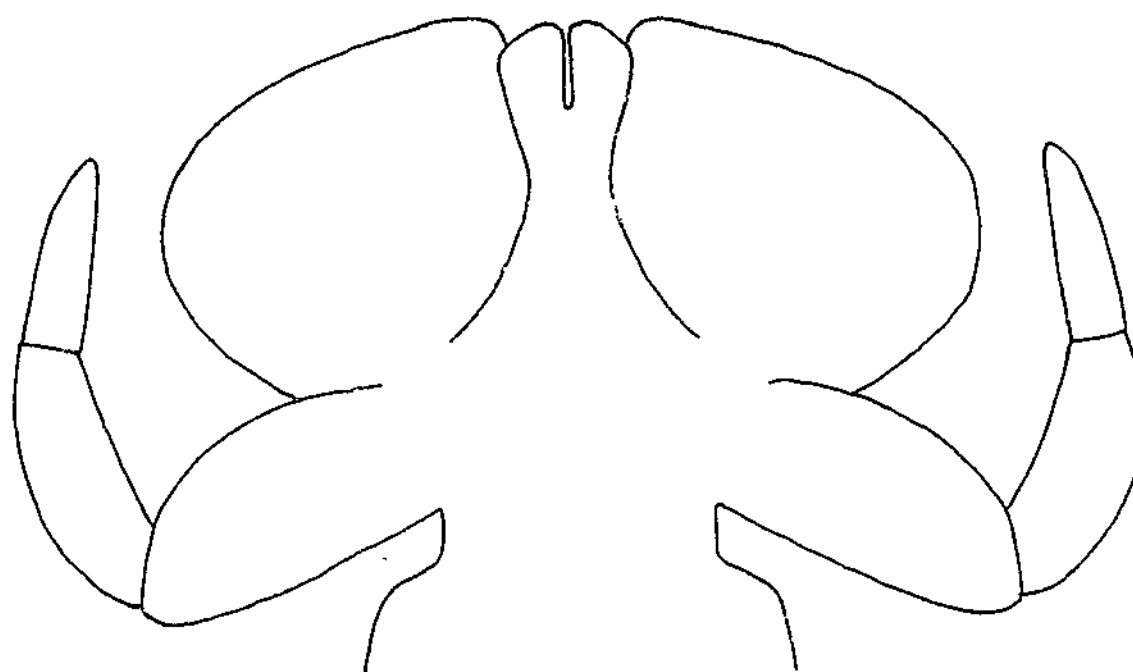
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Figs. 495-496. Labium morphology.

Fig. 495. *Garinjuga*
Fig. 496. *Gemmayaluka*
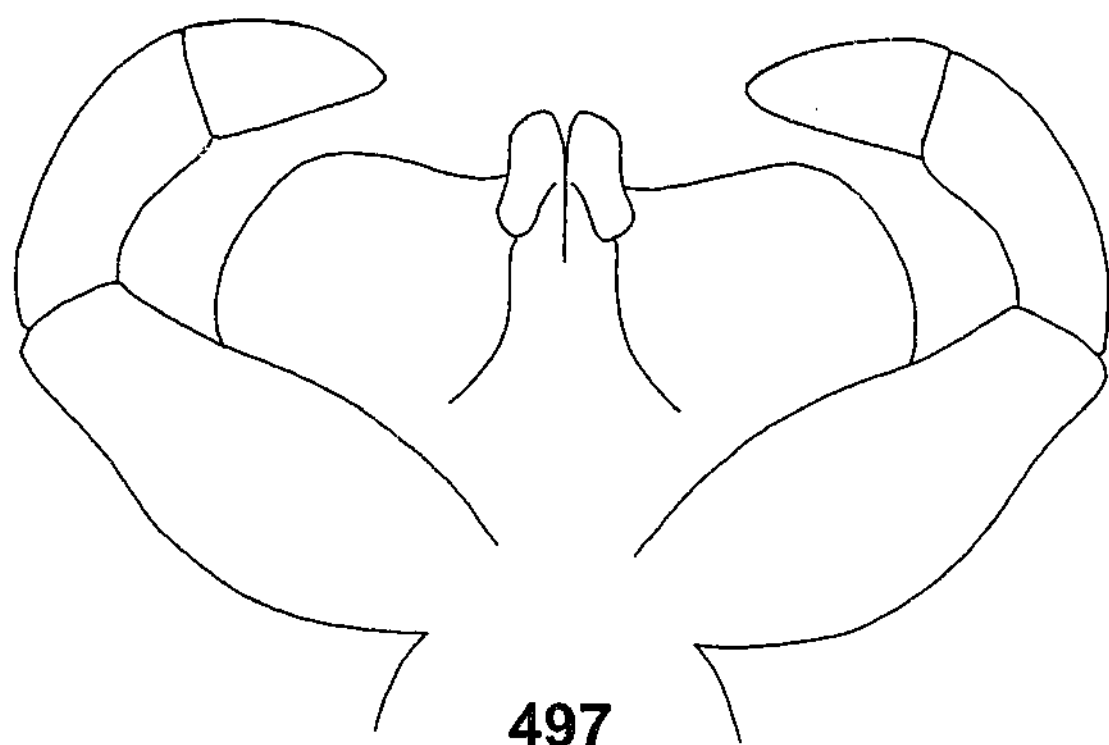
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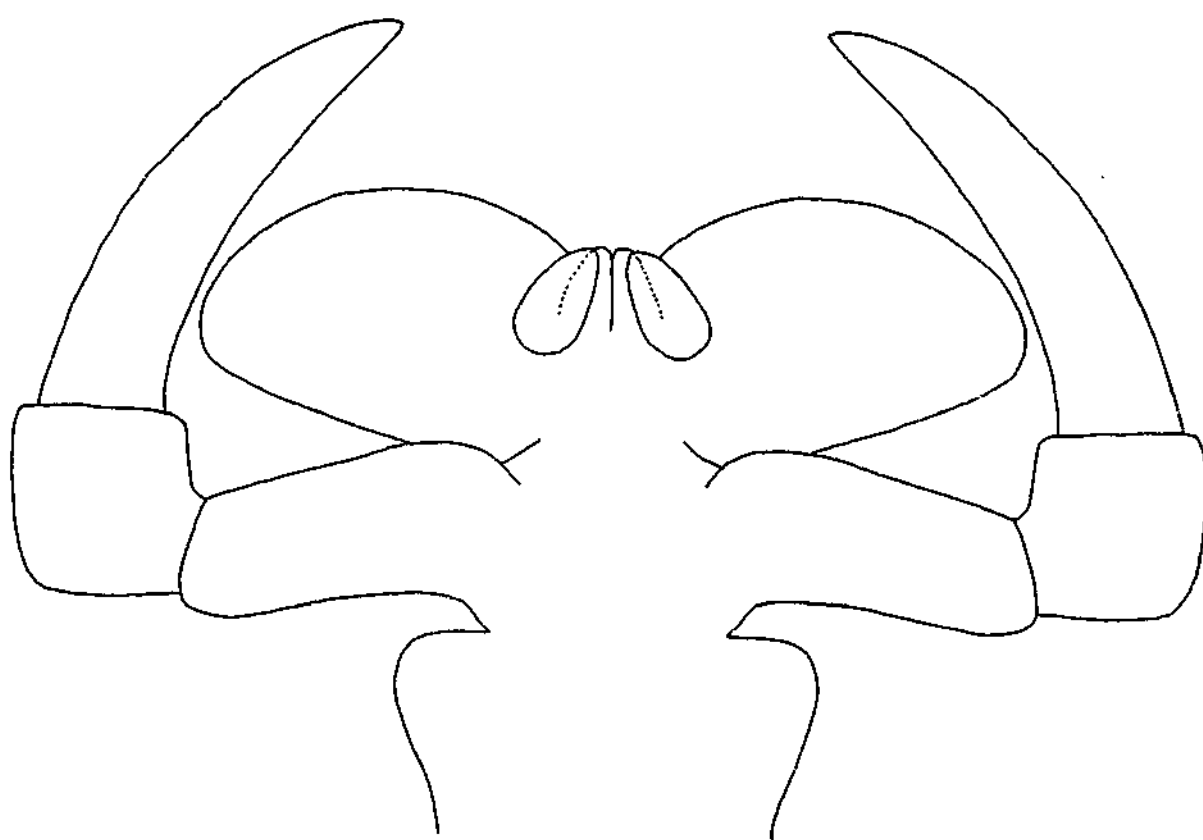
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Figs. 497-498. Labium morphology.

Fig. 497. *Jappa*
Fig. 498. *Kalbaybaria*

499

500
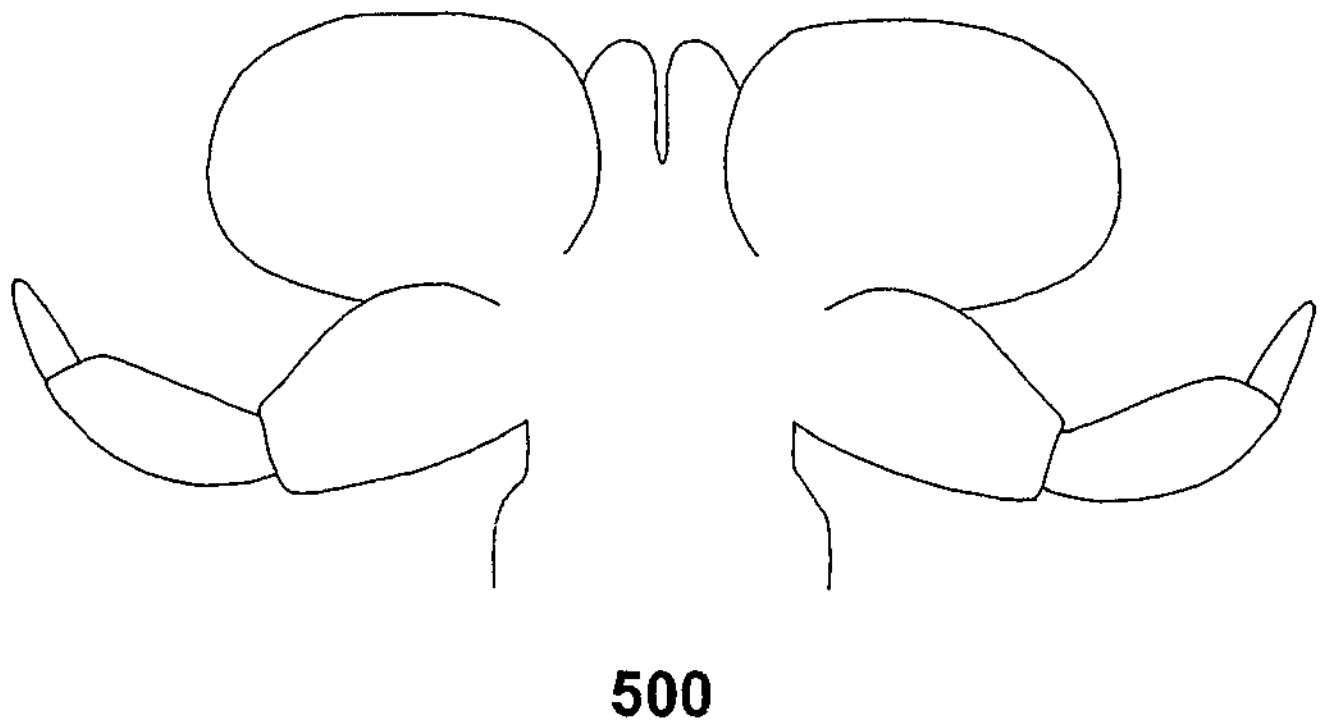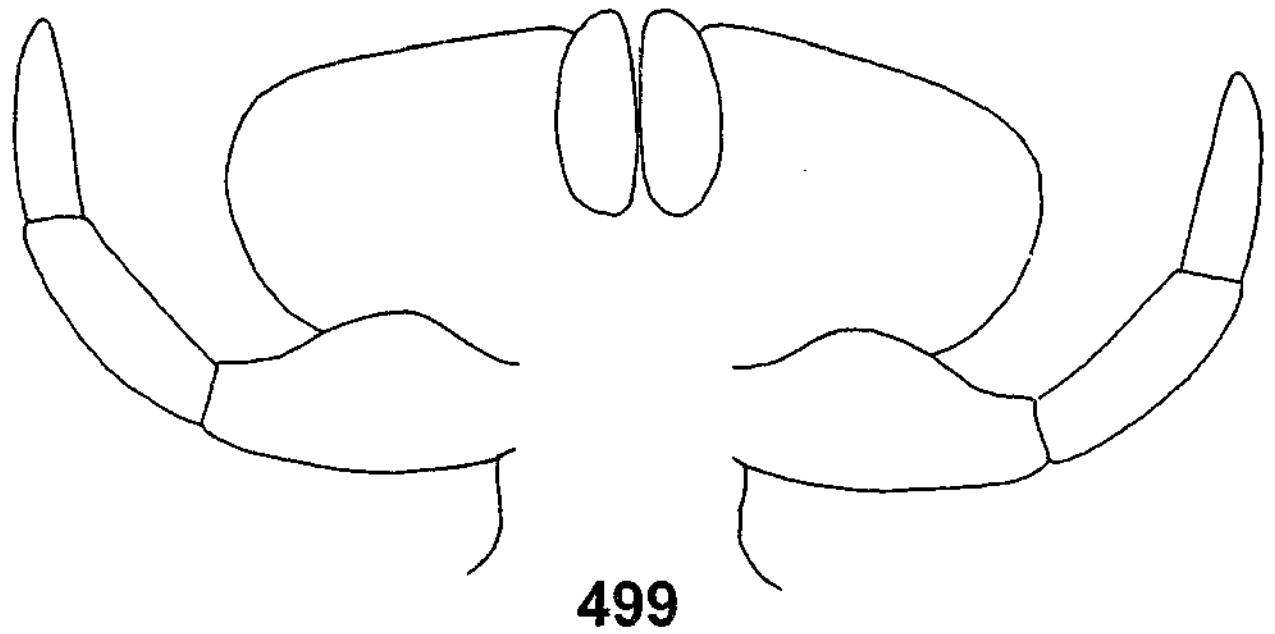
Figs. 499-500. Labium morphology.

Fig. 499. *Kaninga*
Fig. 500. *Kirrara*
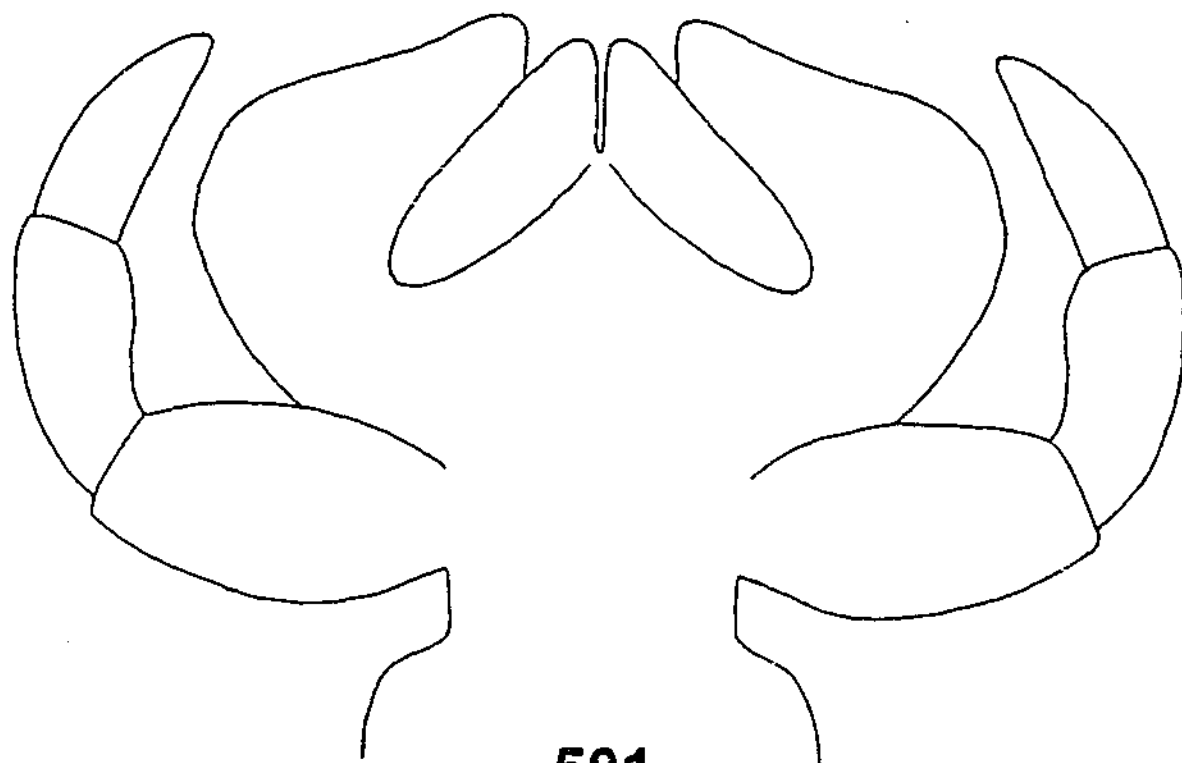
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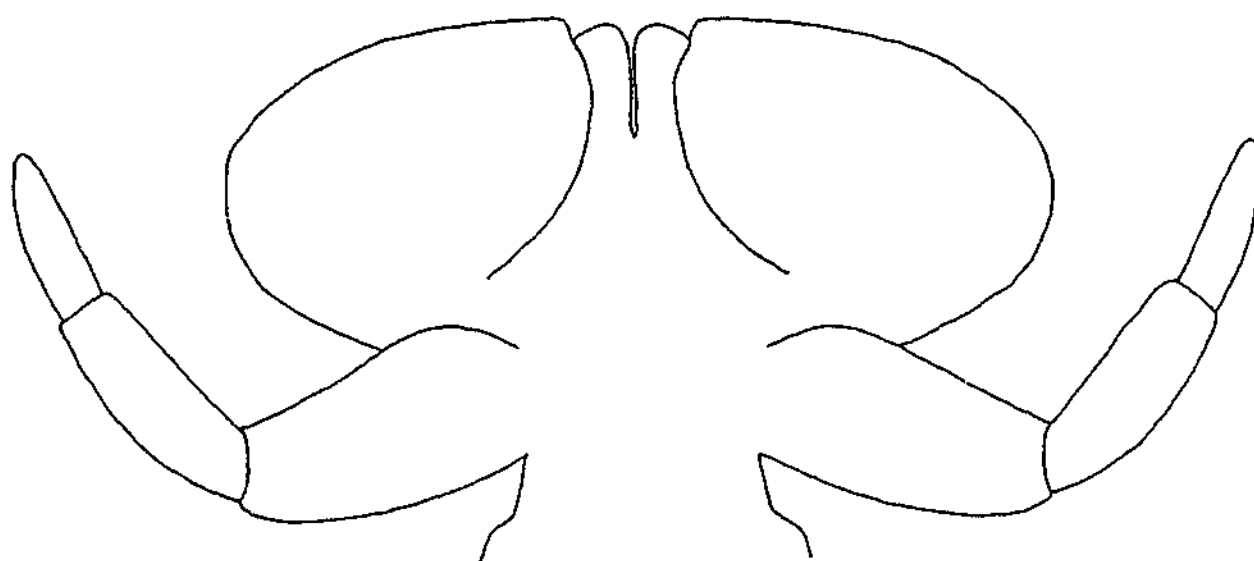
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Figs. 501-502. Labium morphology.

Fig. 501. *Loamaggalangta*
Fig. 502. *Montikola*
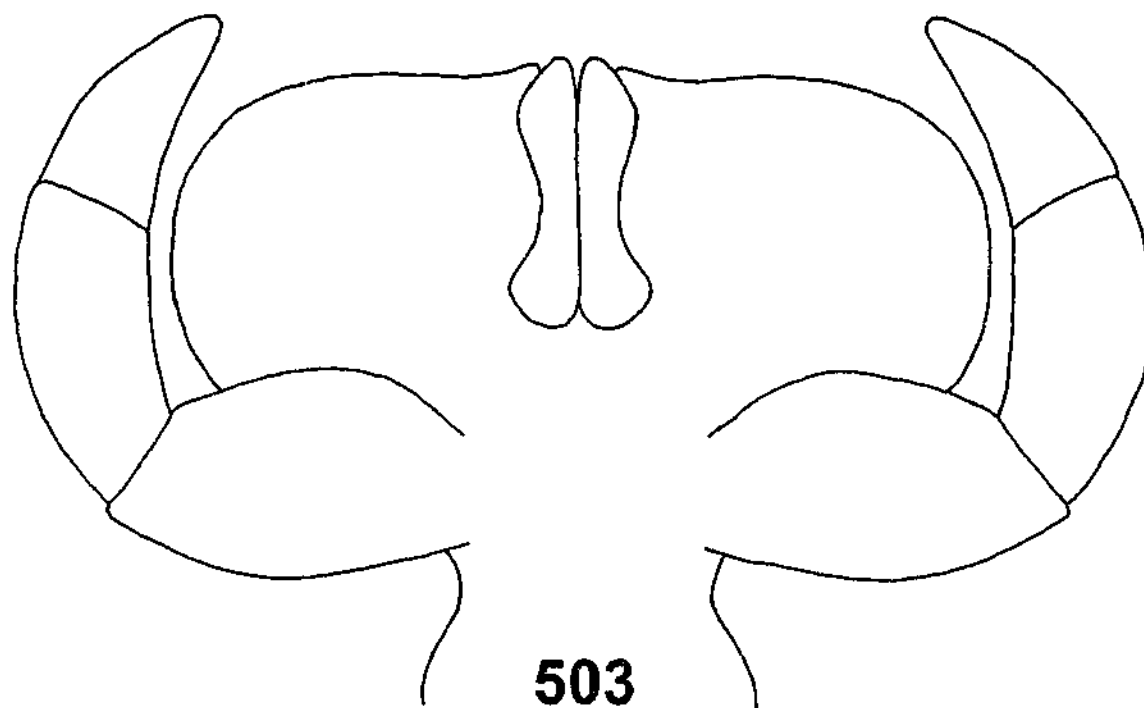
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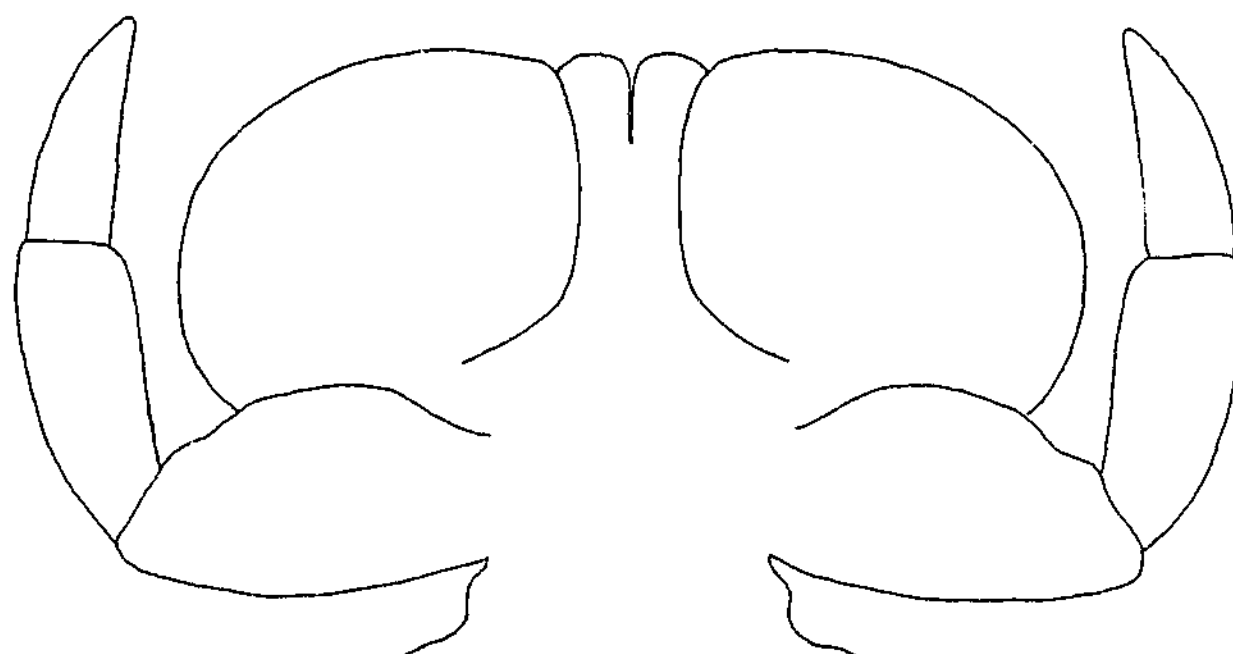
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Figs. 503-504. Labium morphology.

Fig. 503. *Neboissophlebia*
Fig. 504. *Nousia (Nousia)*
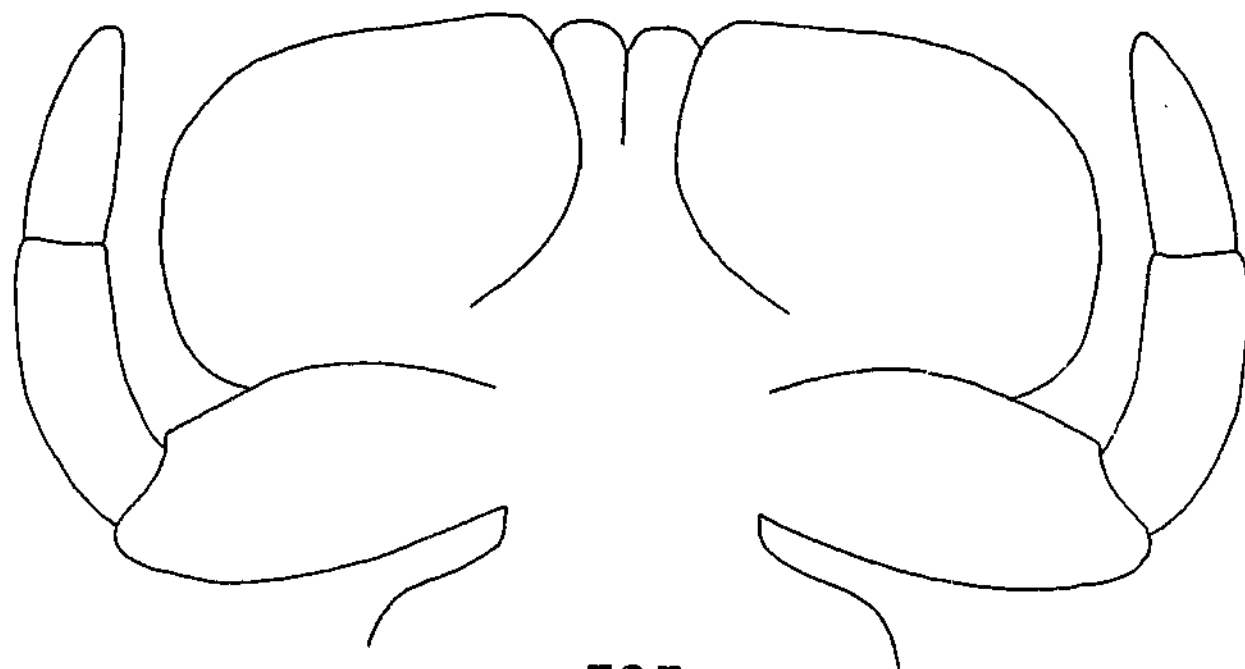
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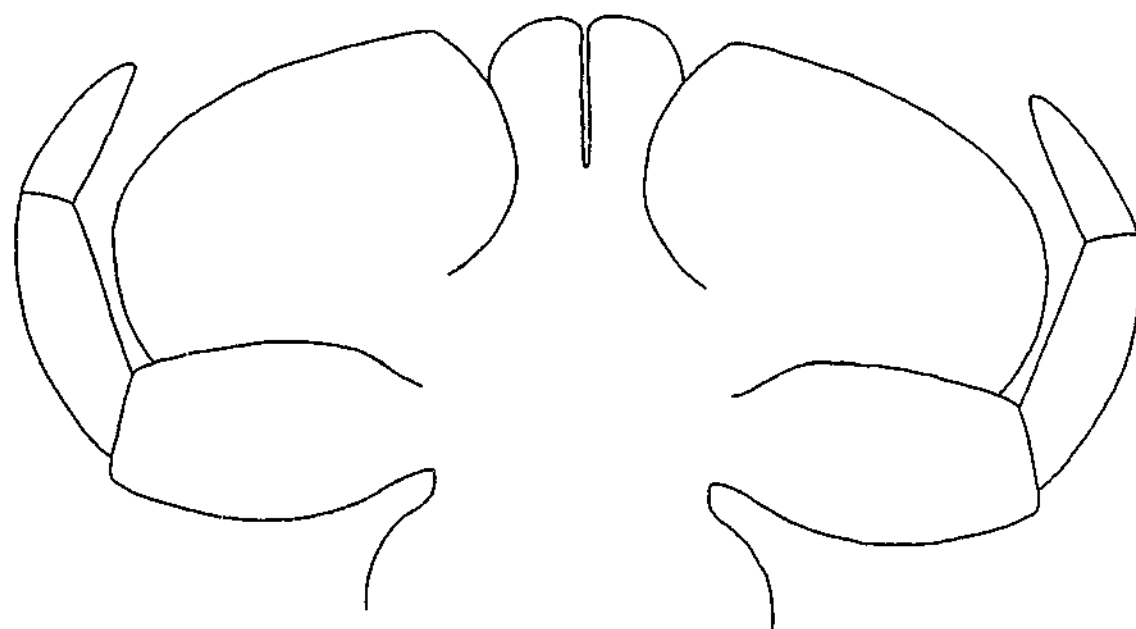
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Figs. 505-506. Labium morphology.

Fig. 505. *Nousia (Australonousia)*
Fig. 506. *Nyungara*

507
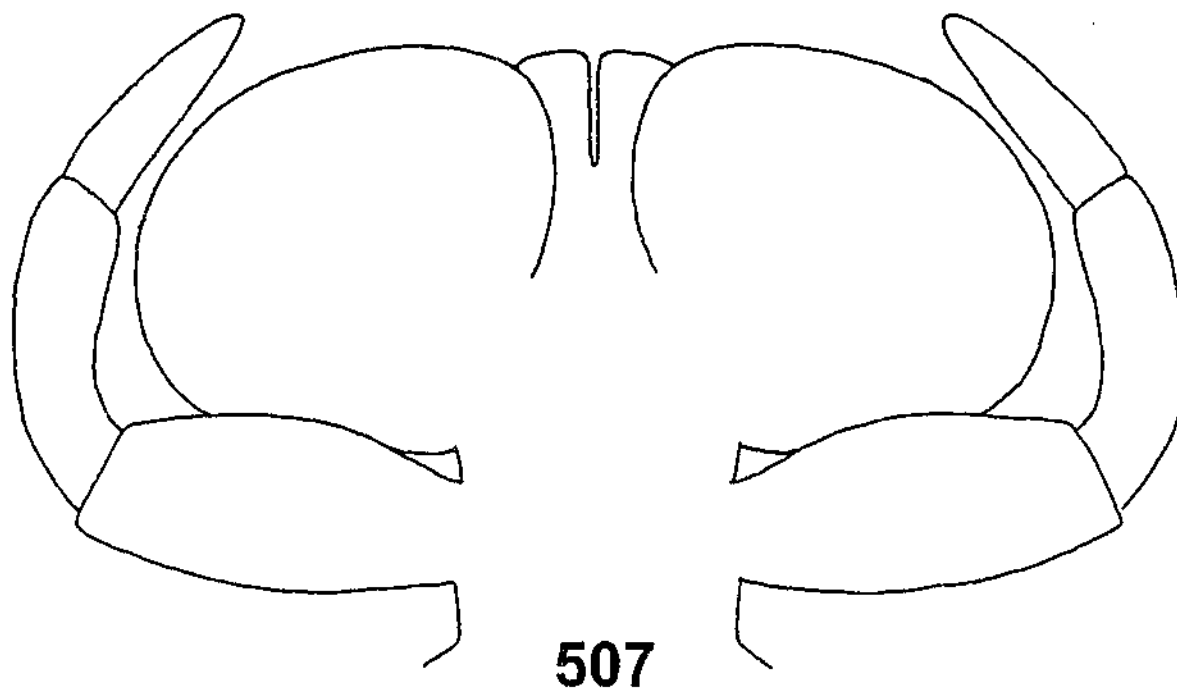
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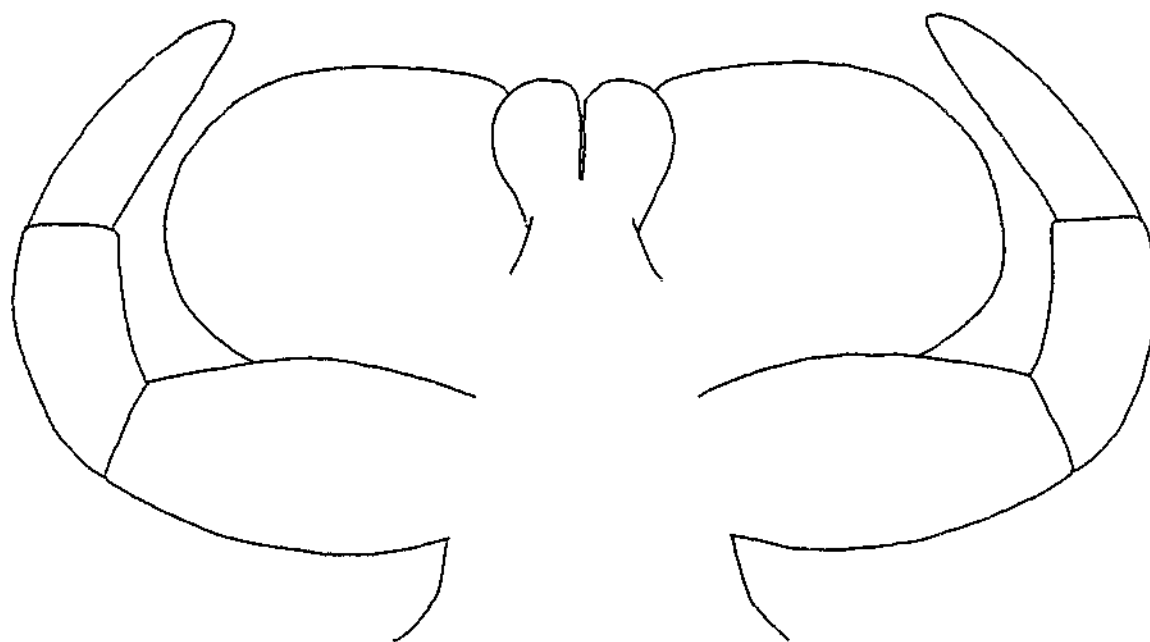
Figs. 507-508. Labium morphology.

Fig. 507. *Thraulophlebia*
Fig. 508. *Thraulus*
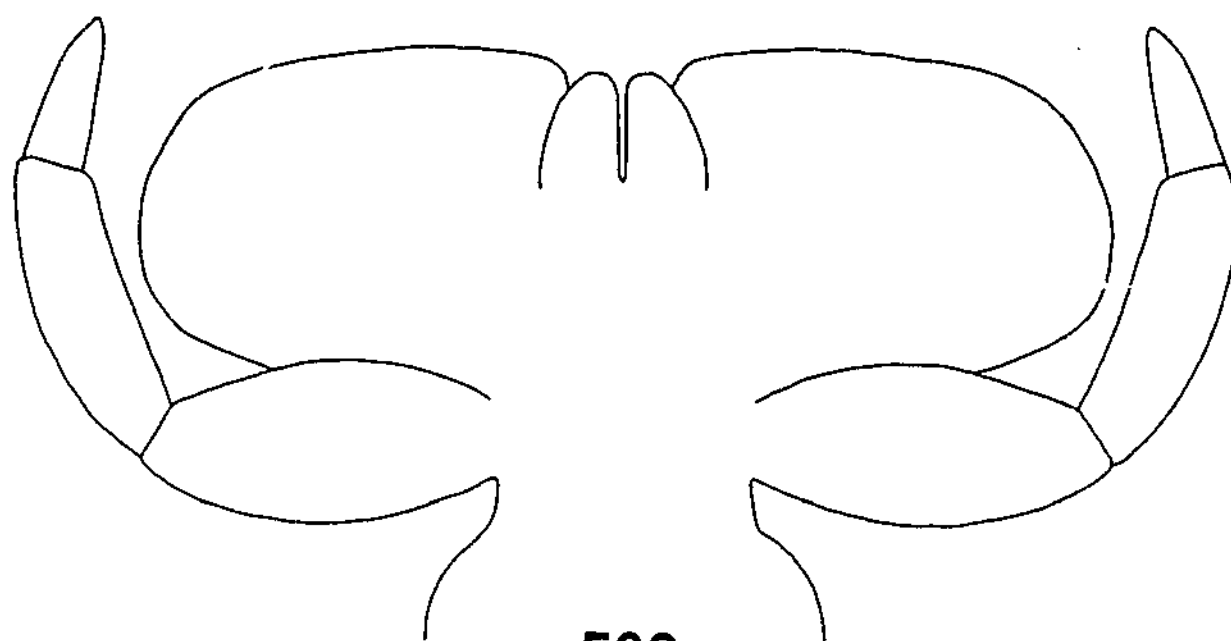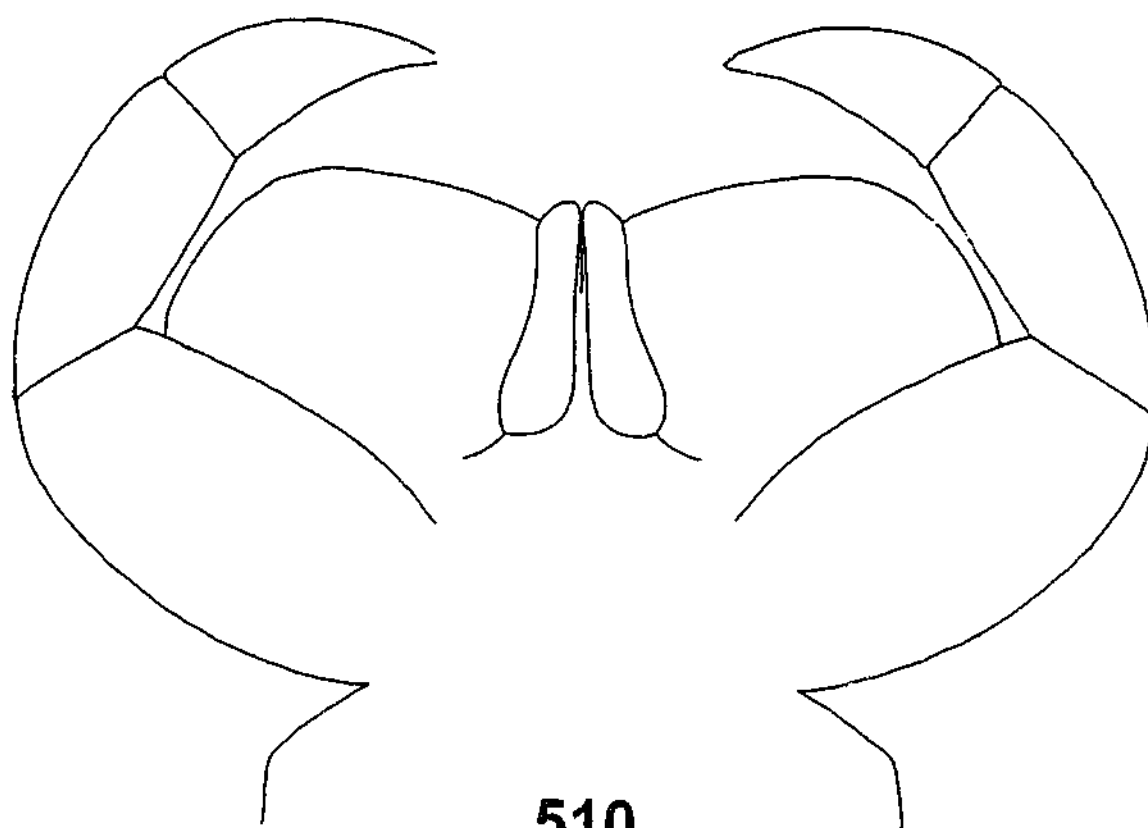
Figs. 509-510. Labium morphology.

Fig. 509. *Tillyardophlebia*
Fig. 510. *Ulmerophlebia*
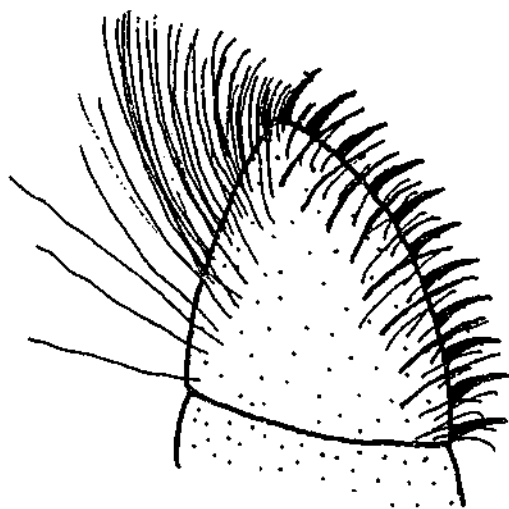
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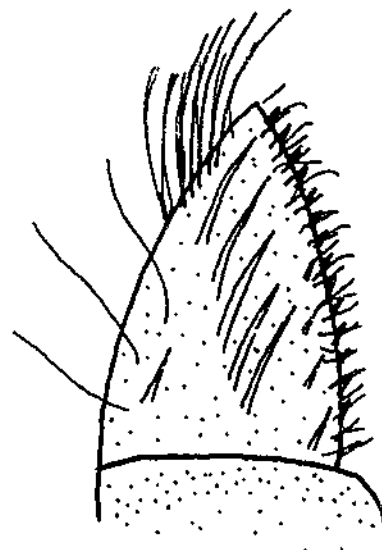
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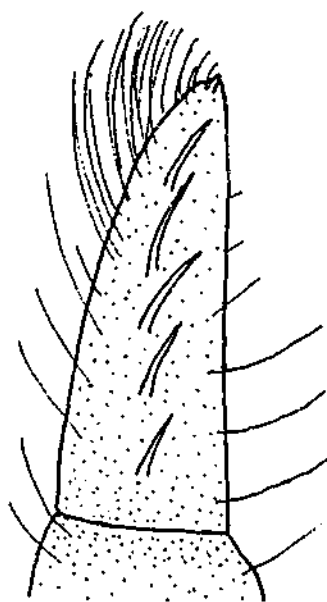
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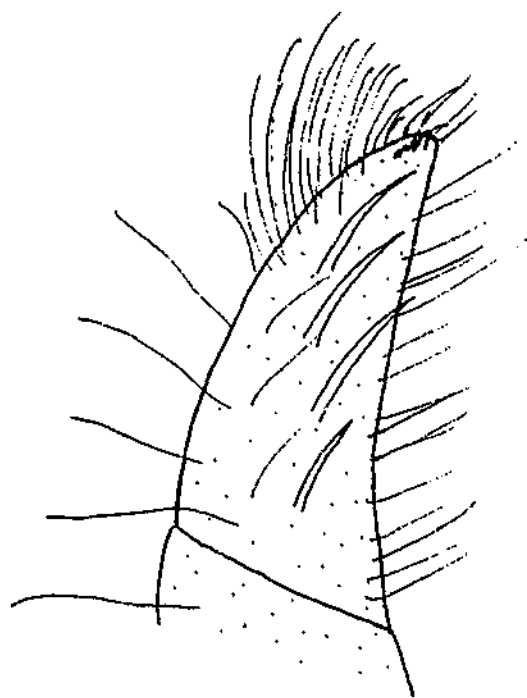
514

Figs. 511-514. Labial terminal palp morphology.

Fig. 511. *Atalomicria*
Fig. 512. *Atalophlebia*
Fig. 513. *Austrophlebioides*
Fig. 514. *Bibulmena*
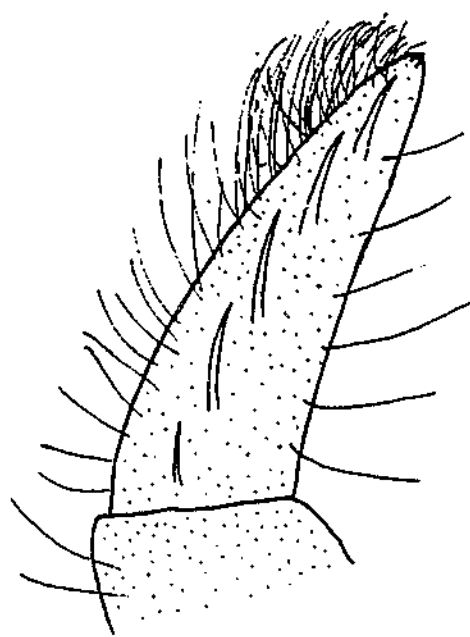
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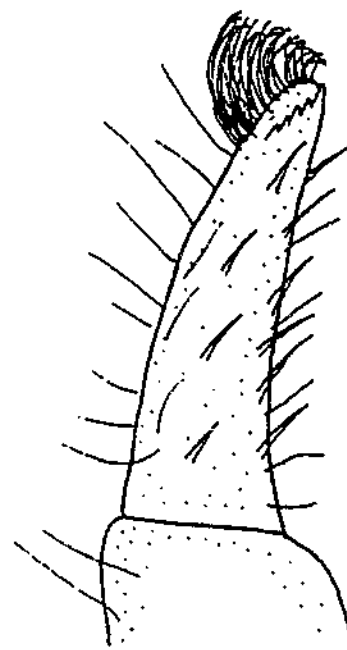
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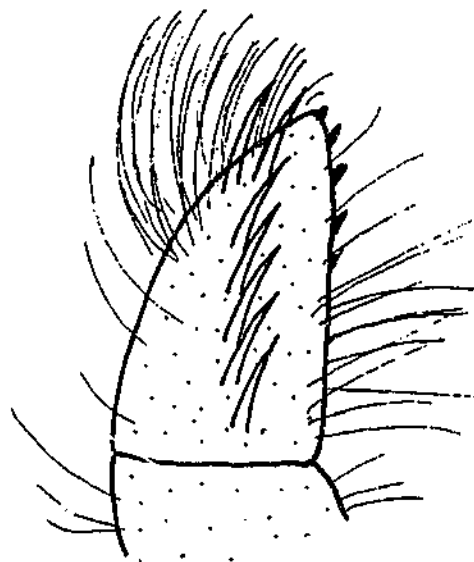
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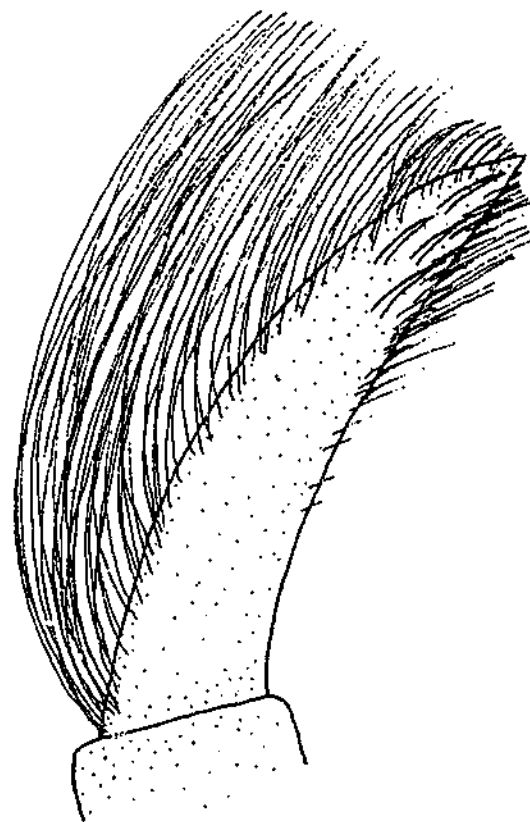
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Figs. 515-518. Labial terminal palp morphology.

Fig. 515. *Garinjuga*
Fig. 516. *Gemmayaluka*
Fig. 517. *Jappa*
Fig. 518. *Kalbaybaria*
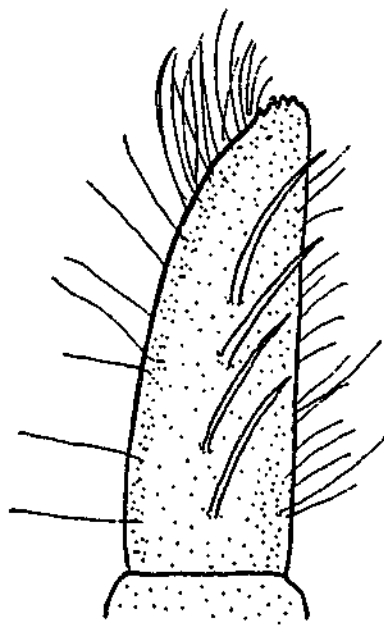
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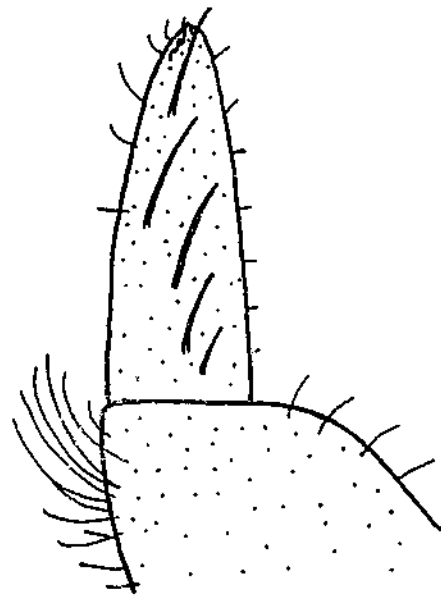
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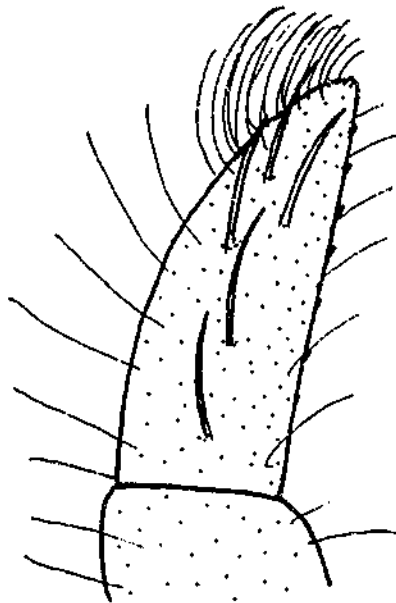
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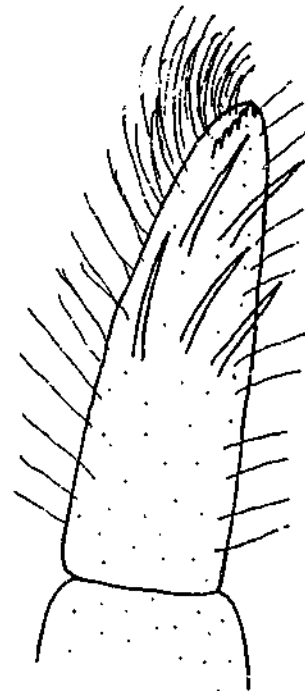
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Figs. 519-522. Labial terminal palp morphology.

Fig. 519. *Kaninga*
Fig. 520. *Kirrara*
Fig. 521. *Loamaggalangta*
Fig. 522. *Montikola*
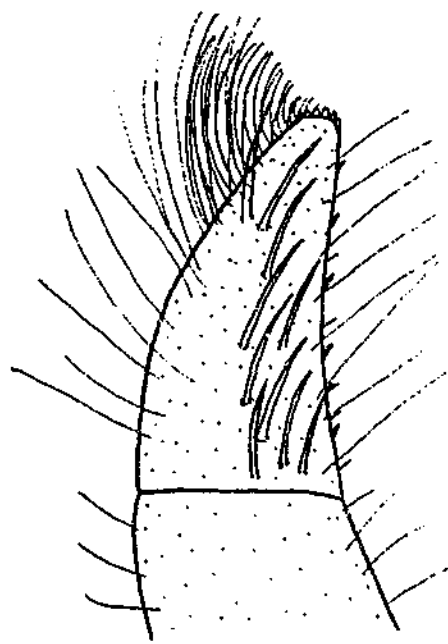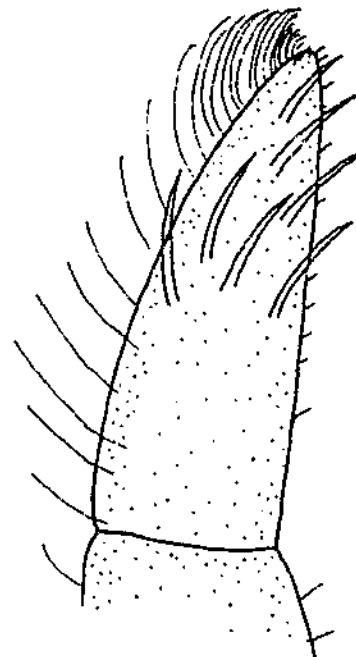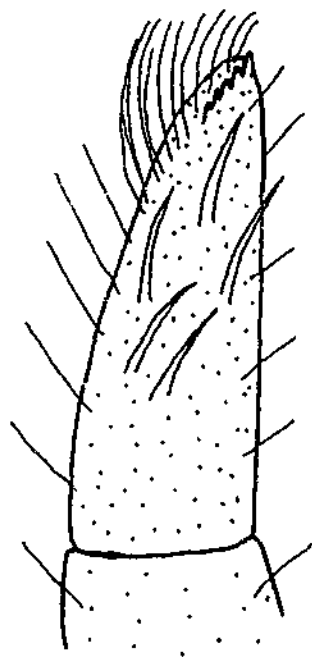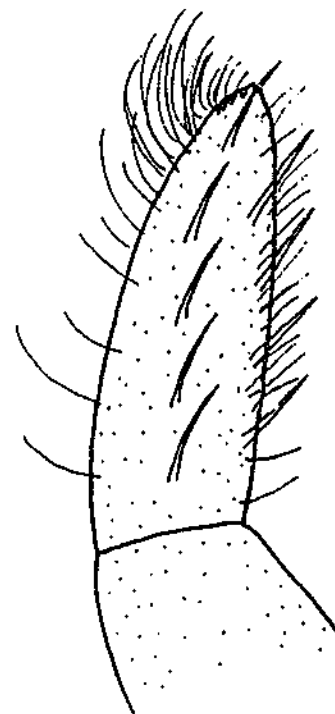
Figs. 523-526. Labial terminal palp morphology.

Fig. 523. *Neboissophlebia*
Fig. 524. *Nousia (Nousia)*
Fig. 525. *Nousia (Australonousia)*
Fig. 526. *Nyungara*
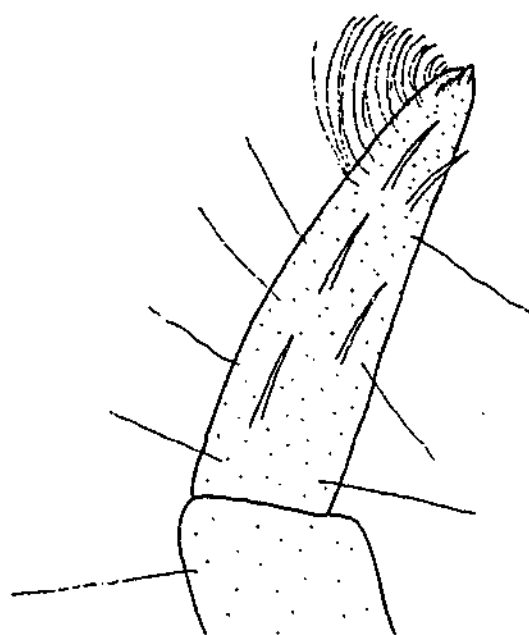
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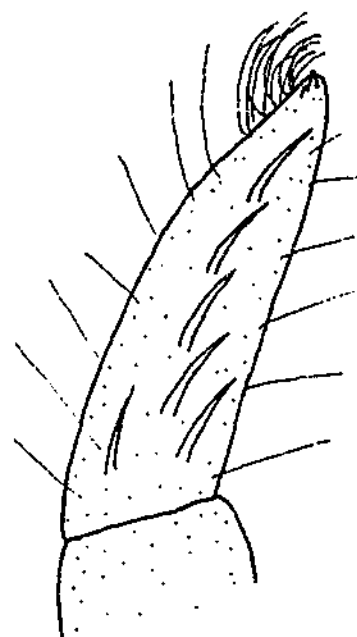
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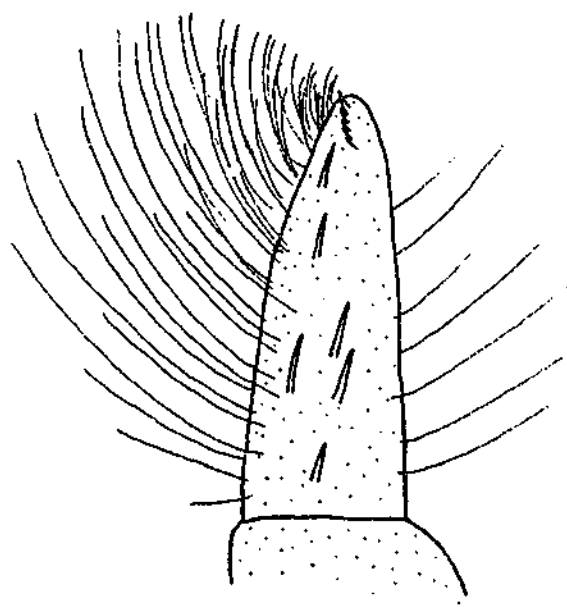
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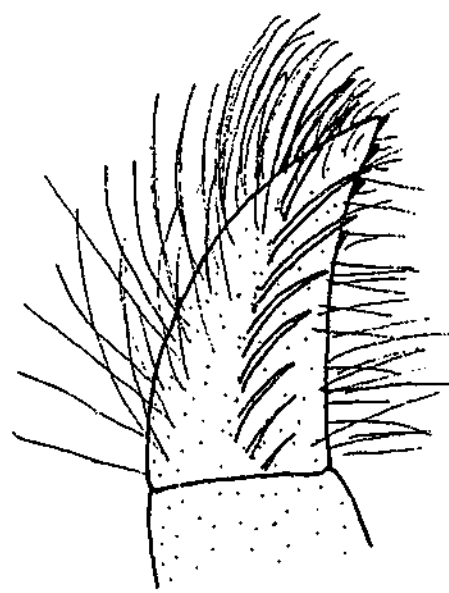
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Figs. 527-530. Labial terminal palp morphology.

Fig. 527. *Thraulophlebia*
Fig. 528. *Thraulus*
Fig. 529. *Tillyardophlebia*
Fig. 530. *Ulmerophlebia*
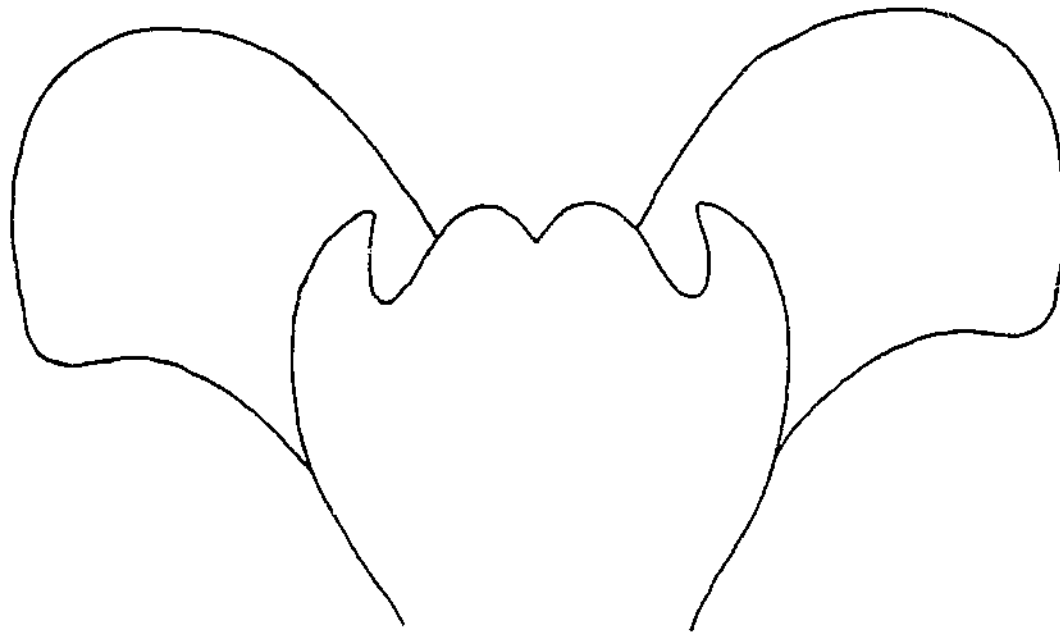
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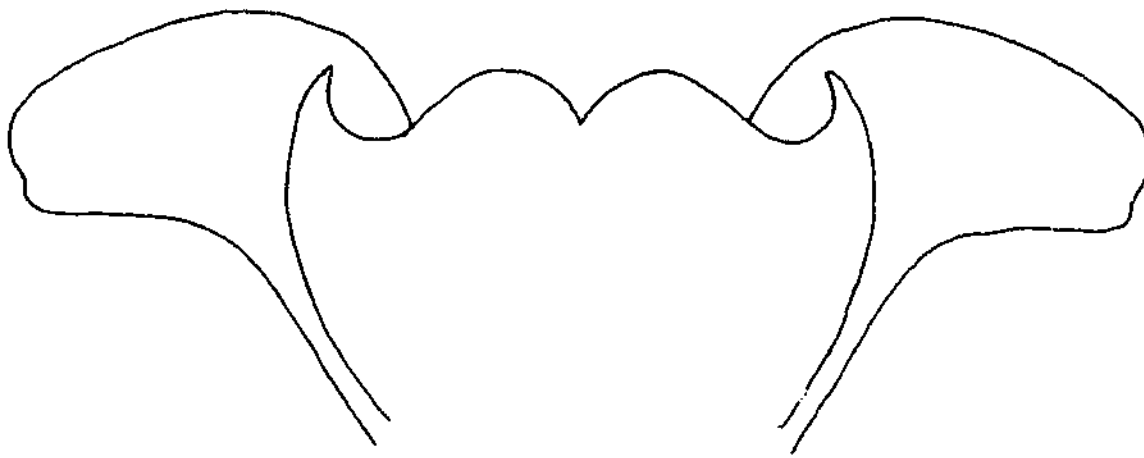
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Figs. 531-532. Hypopharynx morphology.

Fig. 531. *Atalomicria*
Fig. 532. *Atalophiebia*
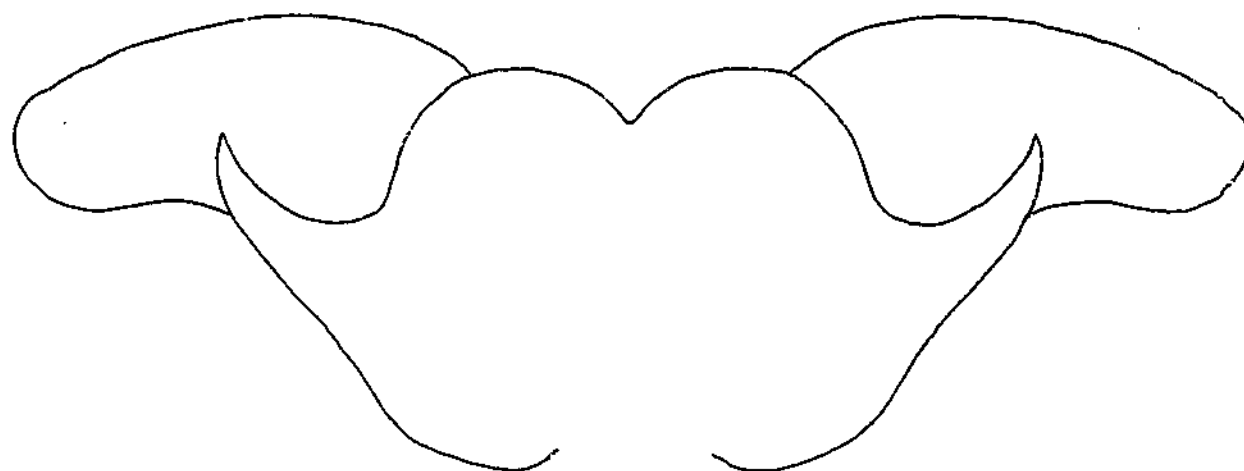
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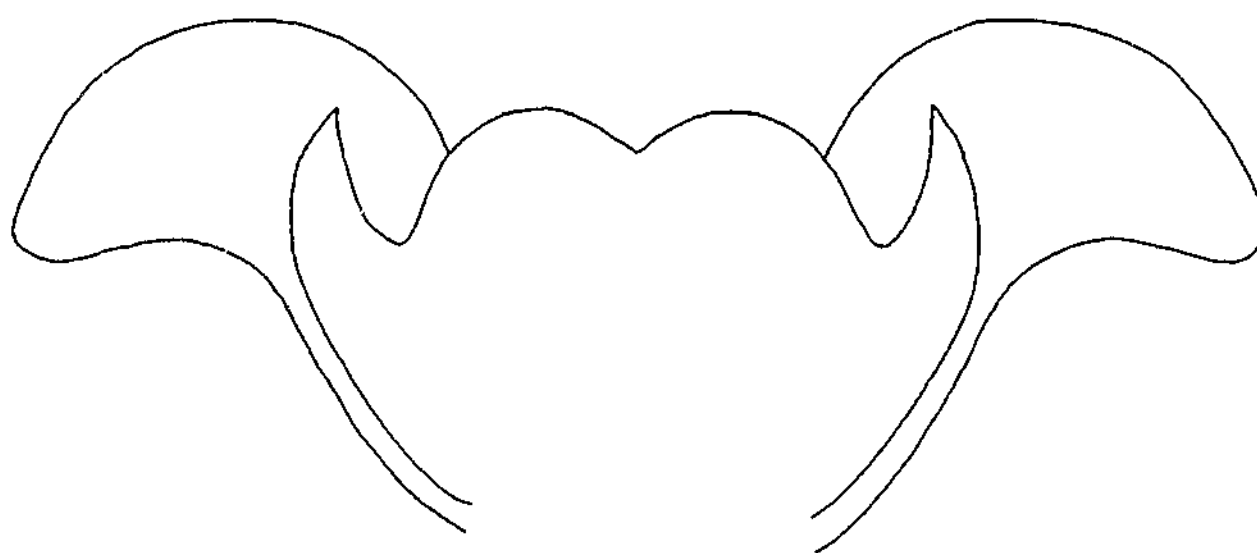
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Figs. 533-534. Hypopharynx morphology.

Fig. 533. *Austrophlebioides*
Fig. 534. *Biflumena*
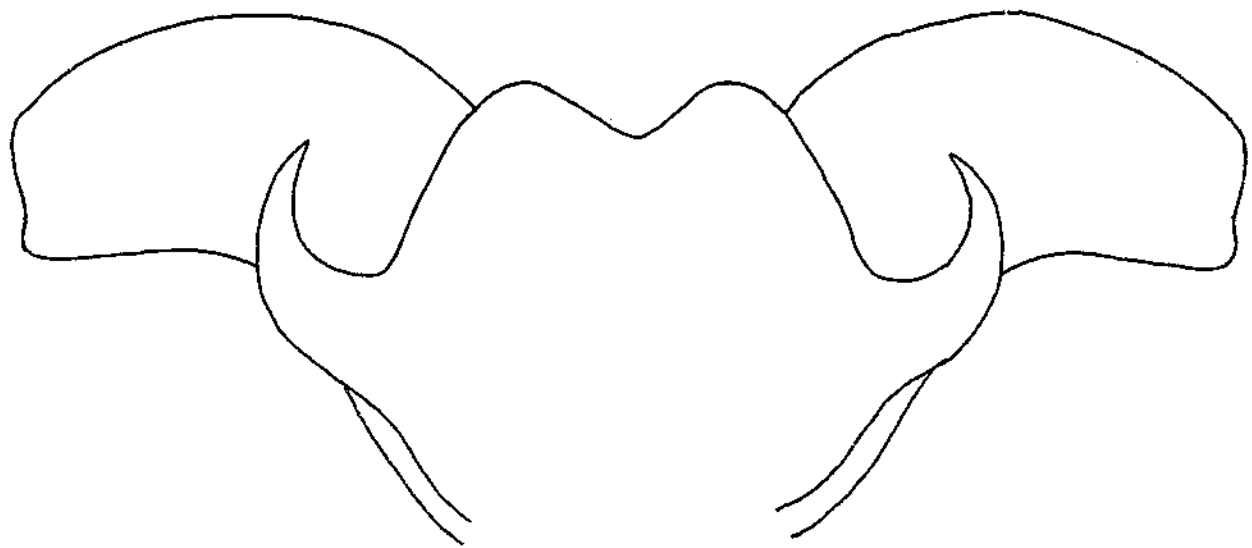
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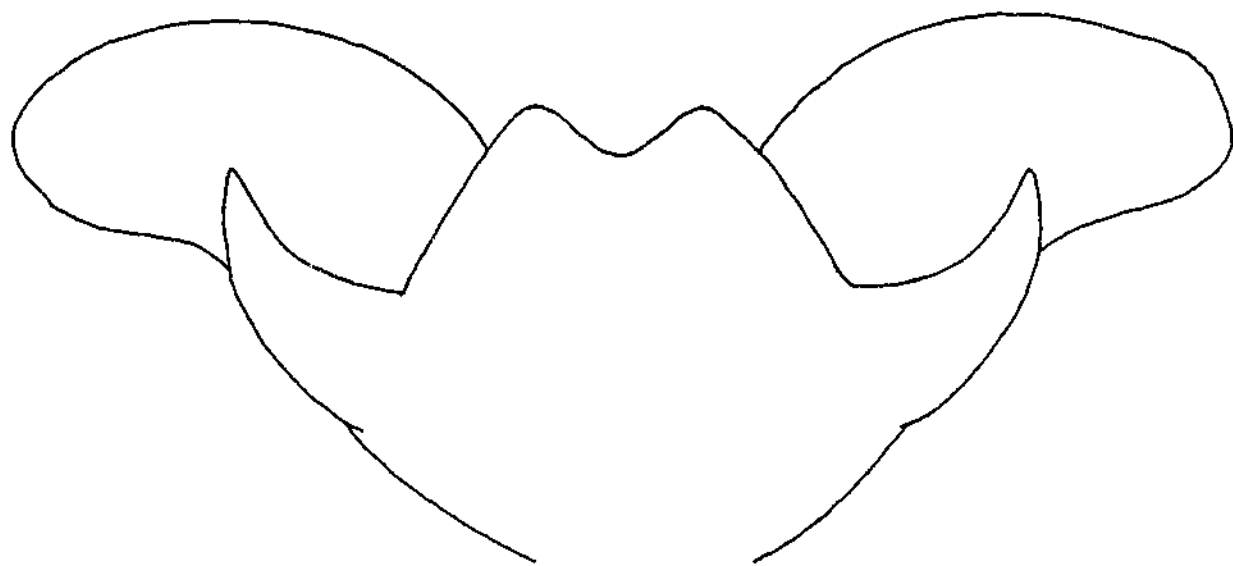
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Figs. 535-536. Hypopharynx morphology.

Fig. 535. *Garinjuga*
Fig. 536. *Gemmayaluka*
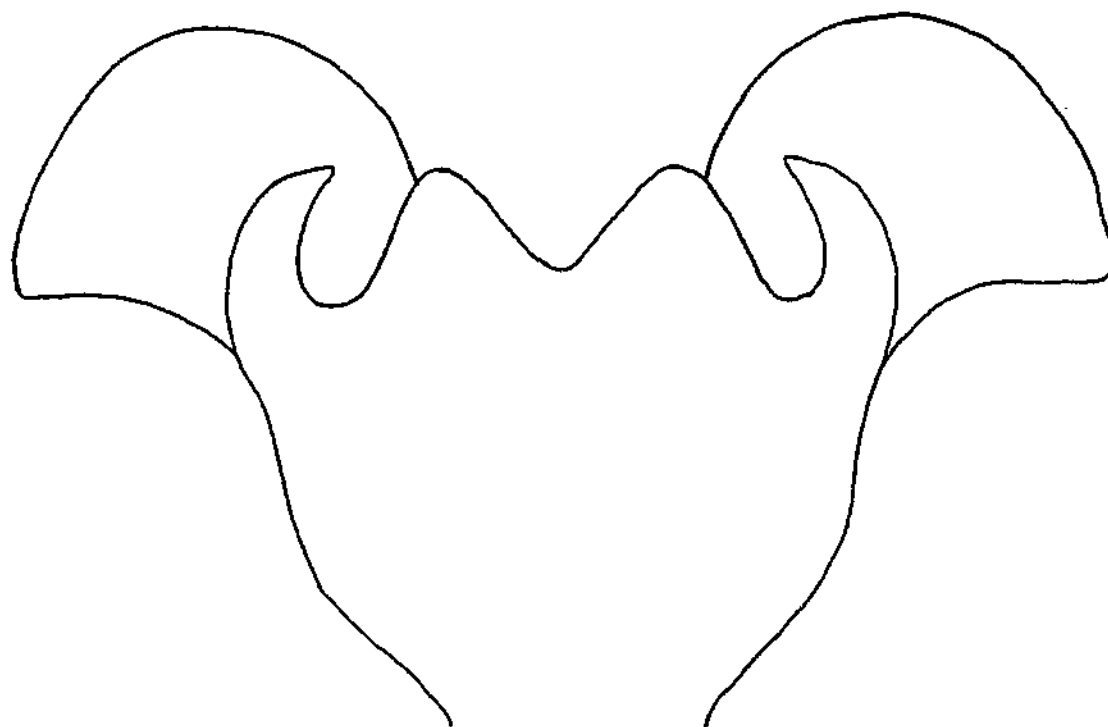
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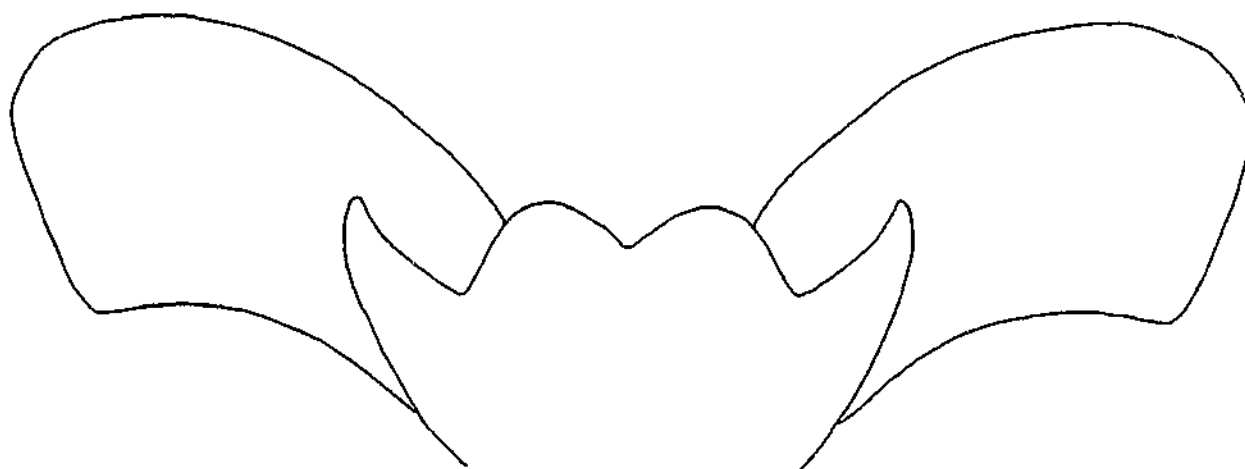
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Figs. 537-538. Hypopharynx morphology.

Fig. 537. *Jappa*
Fig. 538. *Kalbaybaria*
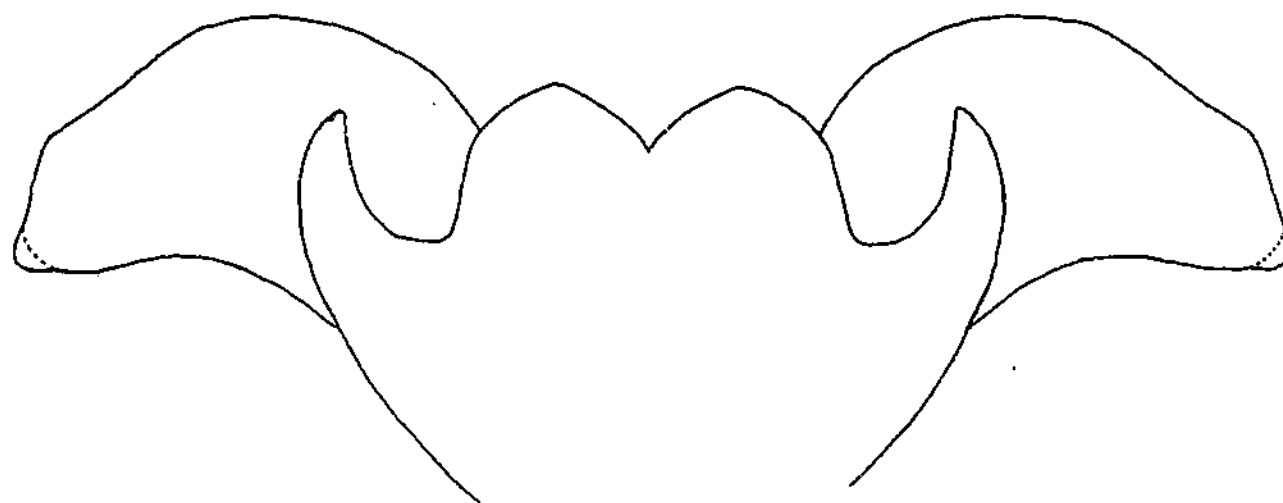
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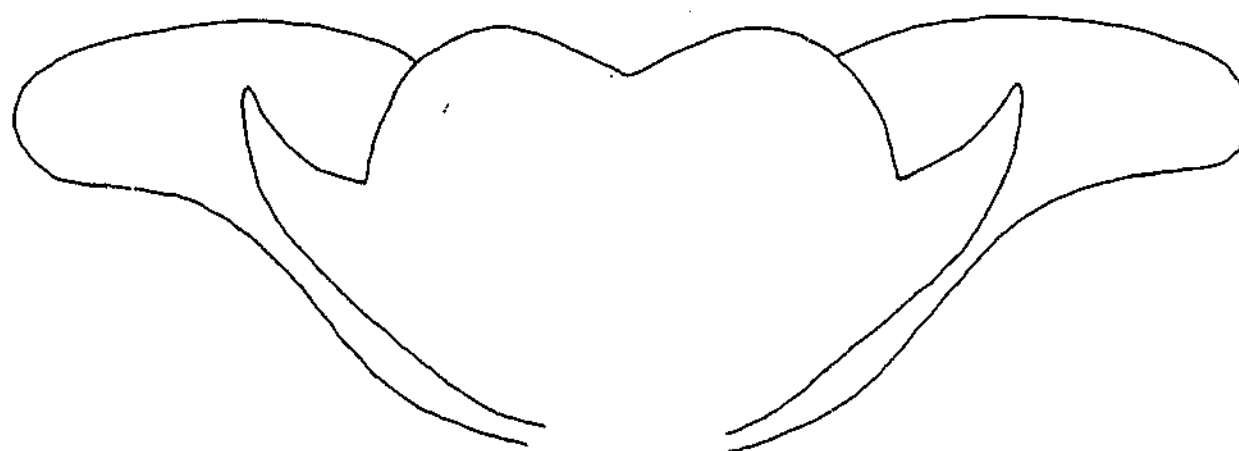
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Figs. 539-540. Hypopharynx morphology.

Fig. 539. *Kaninga*
Fig. 540. *Kirrara*
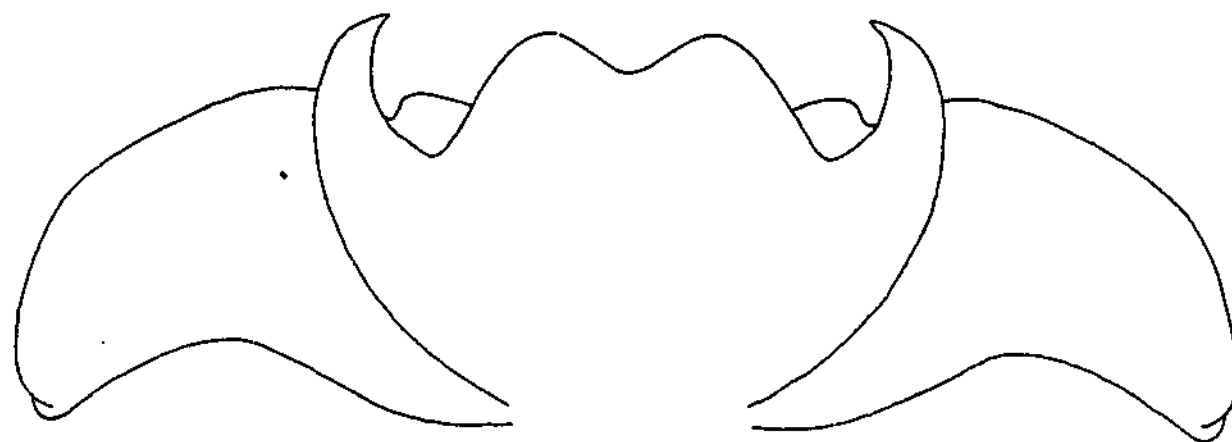
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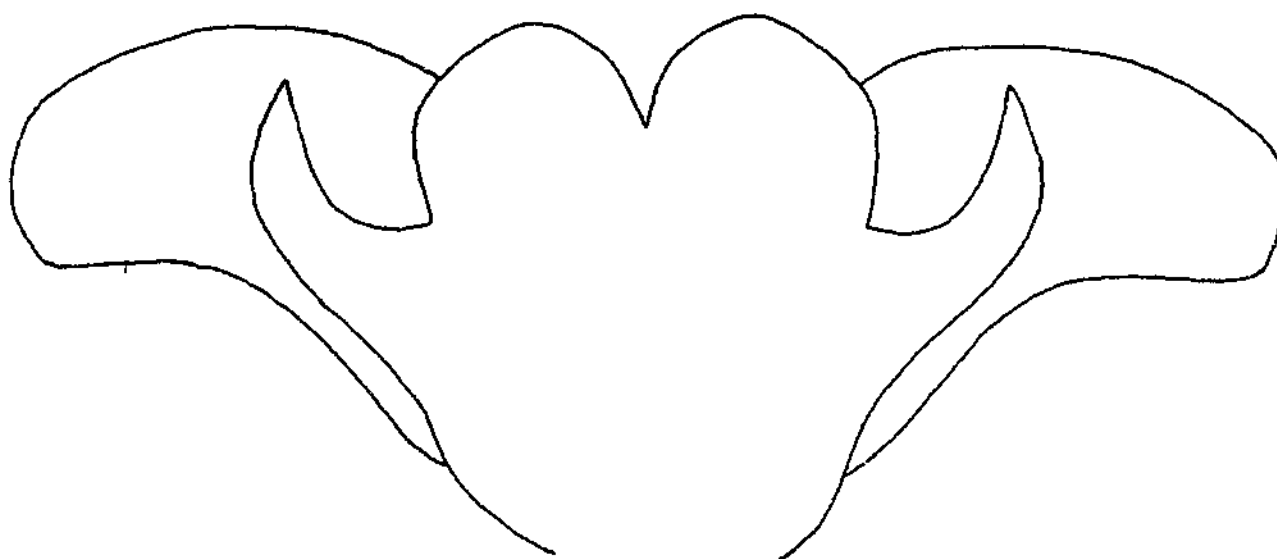
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Figs. 541-542. Hypopharynx morphology.

Fig. 541. *Loamaggalangta*
Fig. 542. *Montikola*
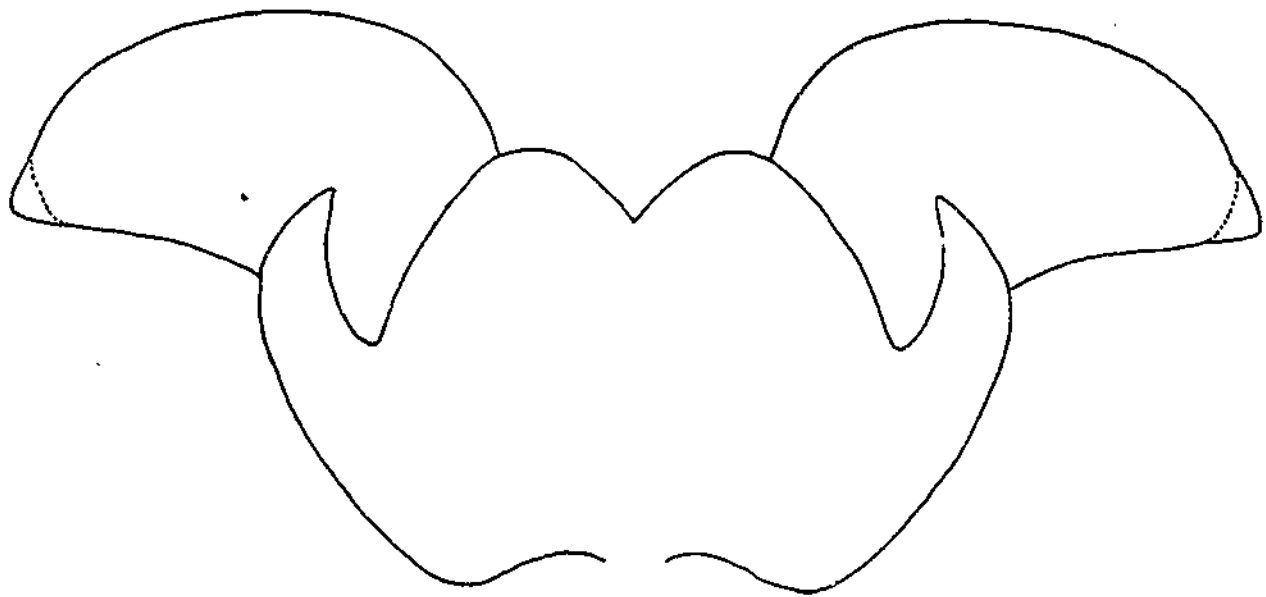
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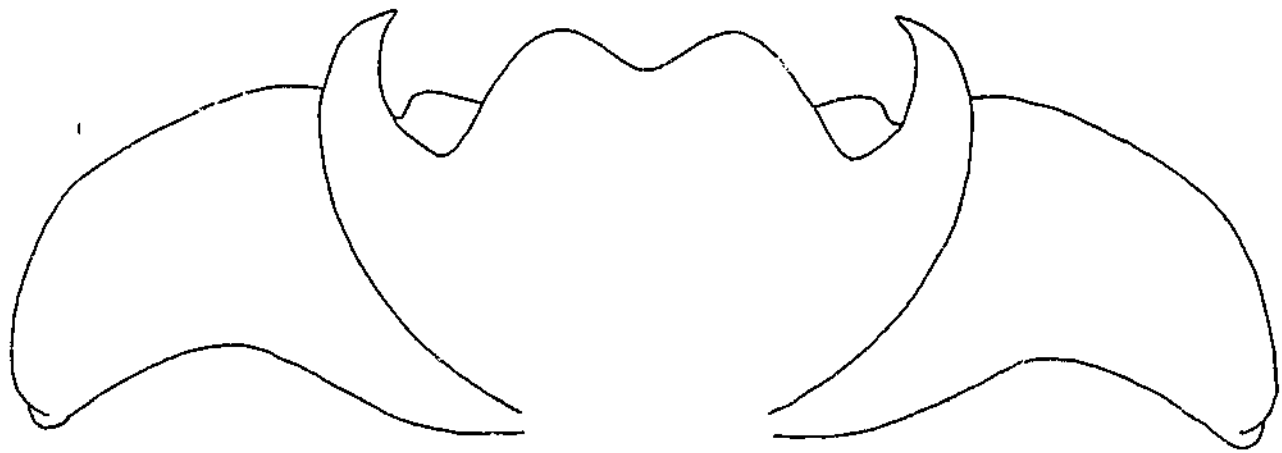
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Figs. 543-544. Hypopharynx morphology.

Fig. 543. *Neboissophlebia*
Fig. 544. *Nousia (Nousia)*
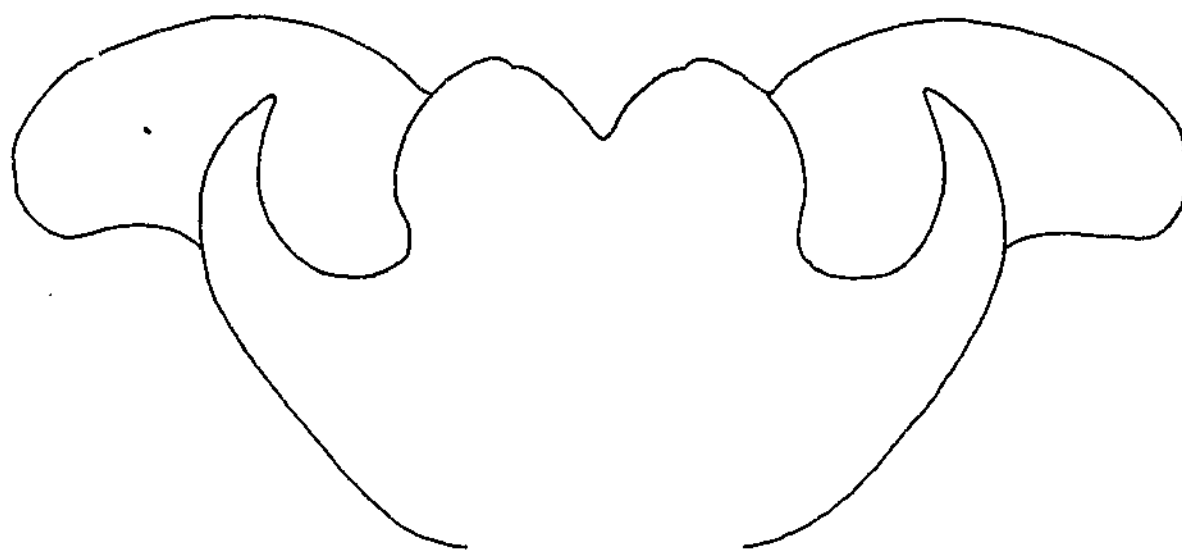
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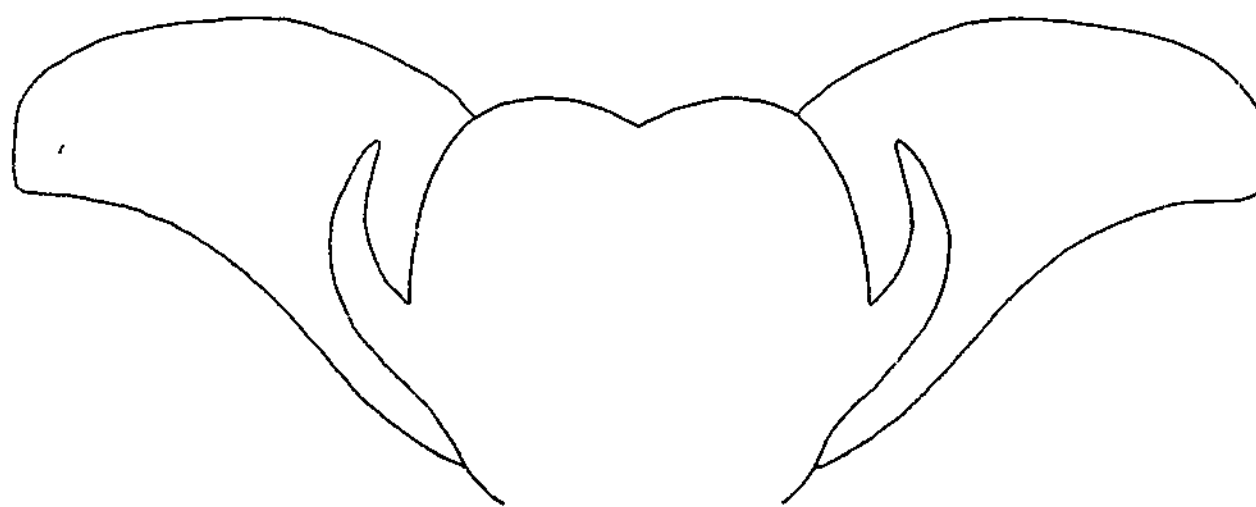
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Figs. 545-546. Hypopharynx morphology.

Fig. 545. *Nousia (Australonousia)*
Fig. 546. *Nyungara*
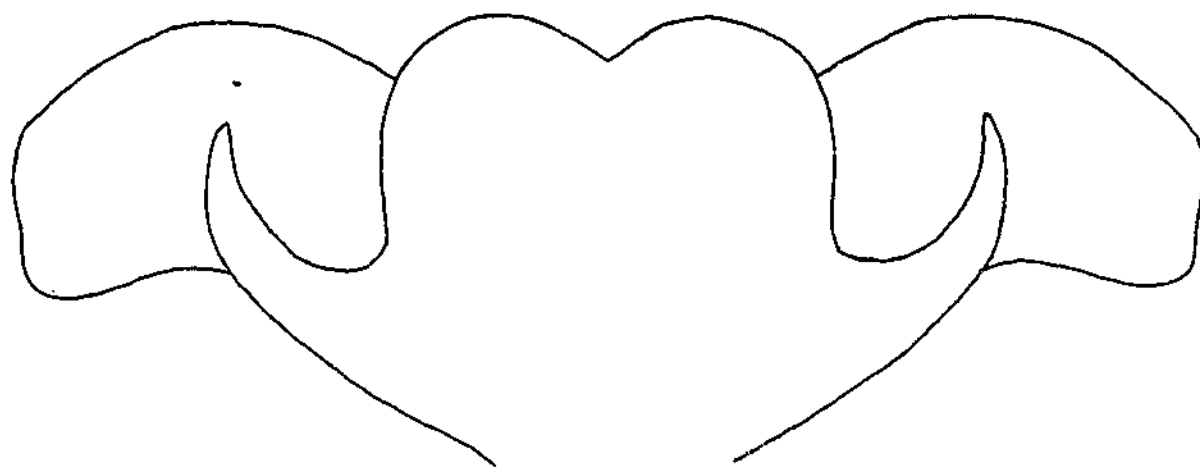
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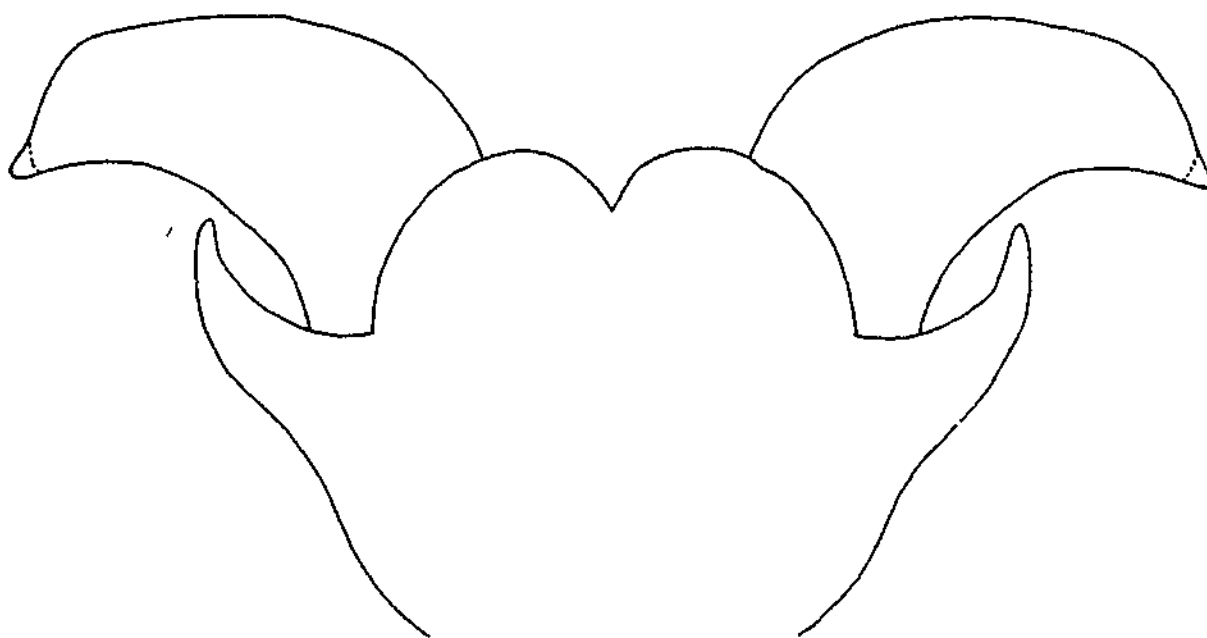
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Figs. 547-548. Hypopharynx morphology.

Fig. 547. *Thraulophlebia*
Fig. 548. *Thraulus*
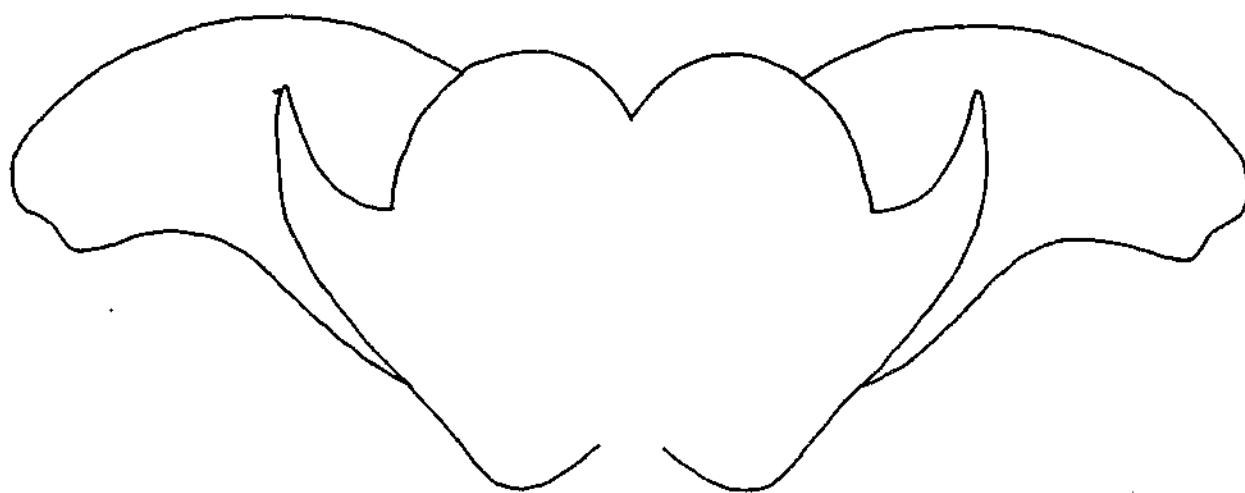
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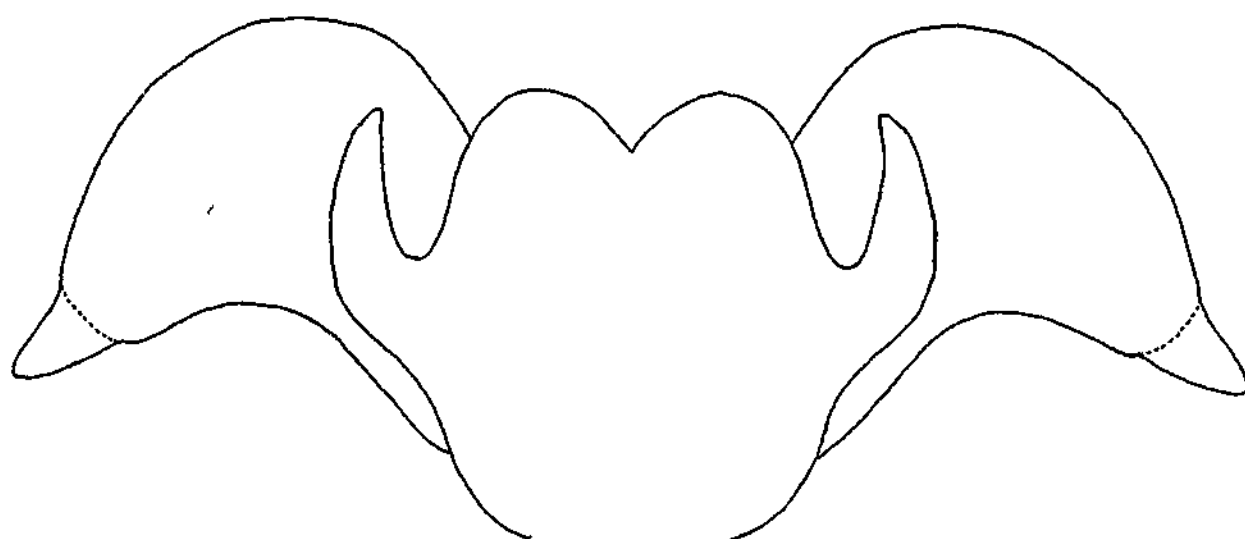
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Figs. 549-550. Hypopharynx morphology.

Fig. 549. *Tillyardophlebia*
Fig. 550. *Ulmerophlebia*
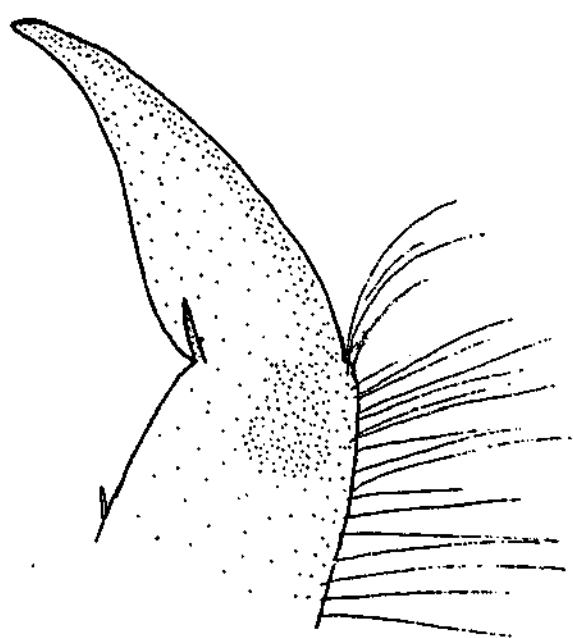
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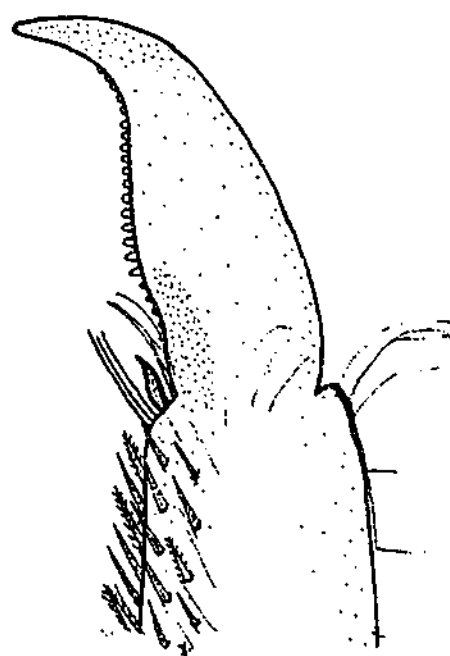
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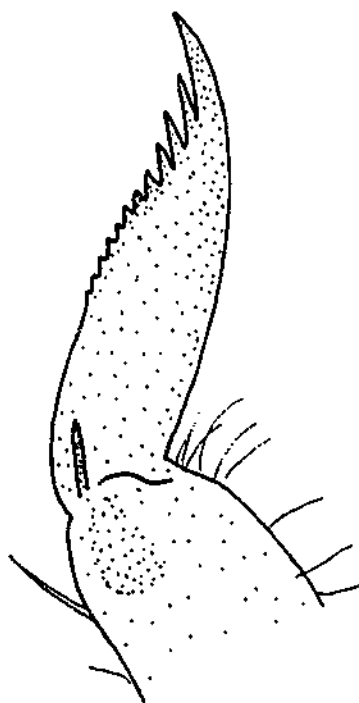
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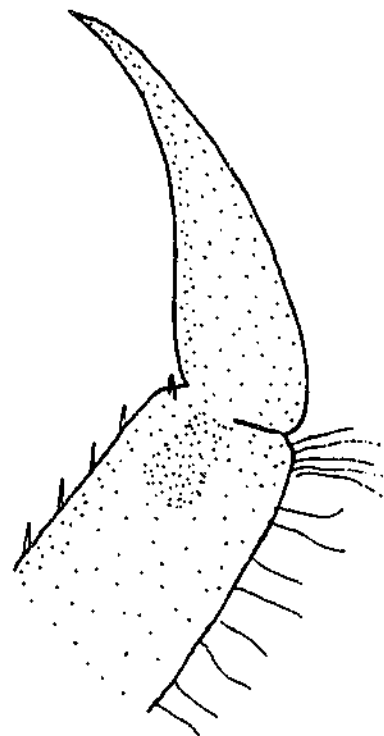
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Figs. 551-554. Nymph tarsal claw morphology.

Fig. 551. *Atalomicria*
Fig. 552. *Atalophlebia*
Fig. 553. *Austrophlebioides*
Fig. 554. *Bibulmena*
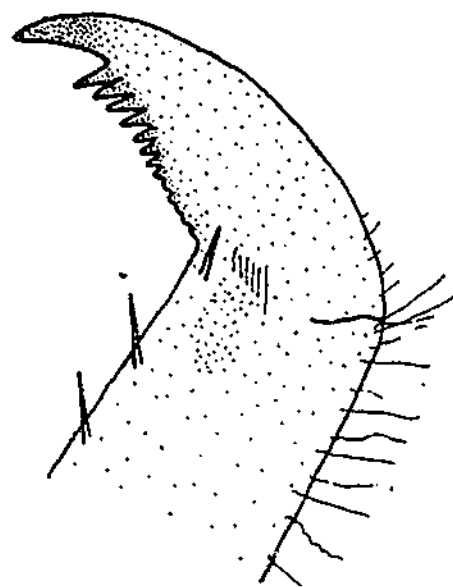
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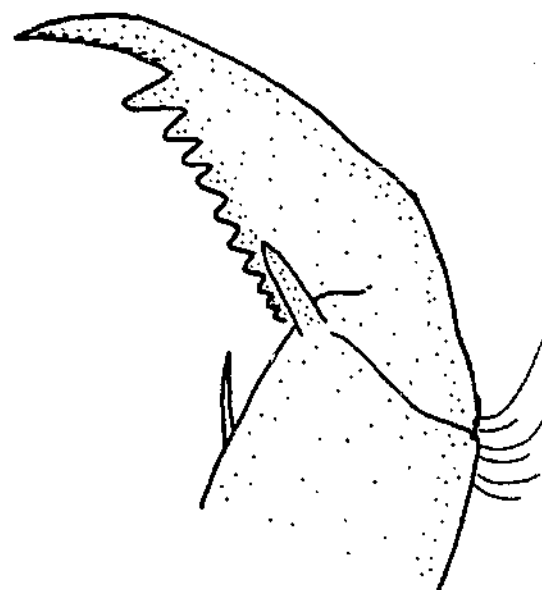
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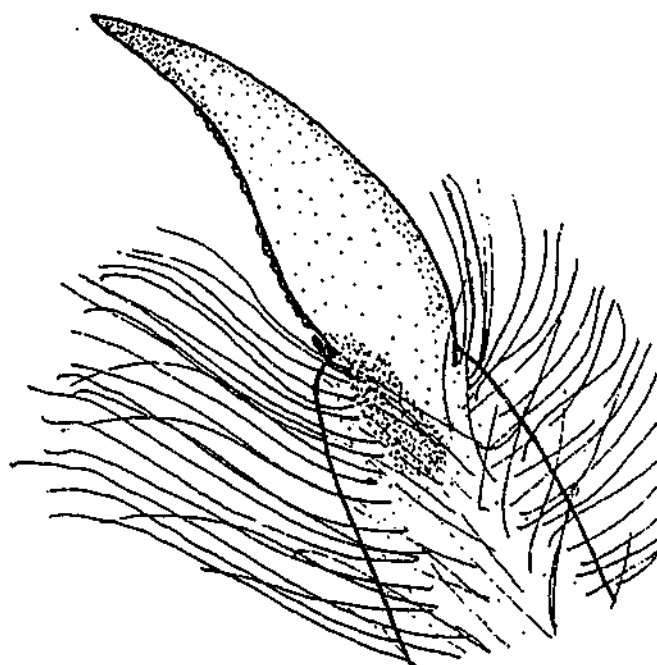
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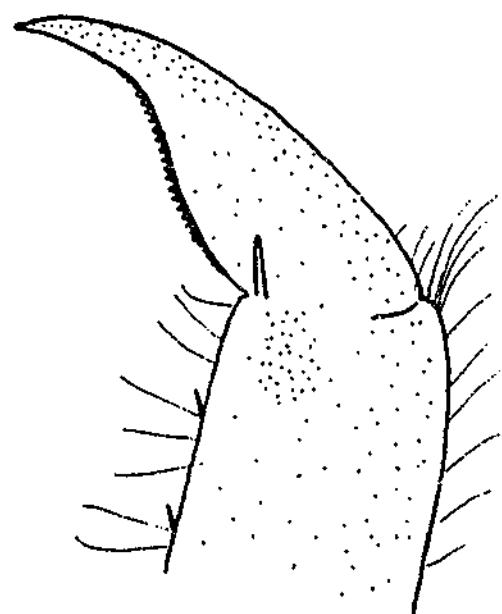
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Figs. 555-558. Nymph tarsal claw morphology.

Fig. 555. *Garinjuga*
Fig. 556. *Gemmayaluka*
Fig. 557. *Jappa*
Fig. 558. *Kalbaybaria*
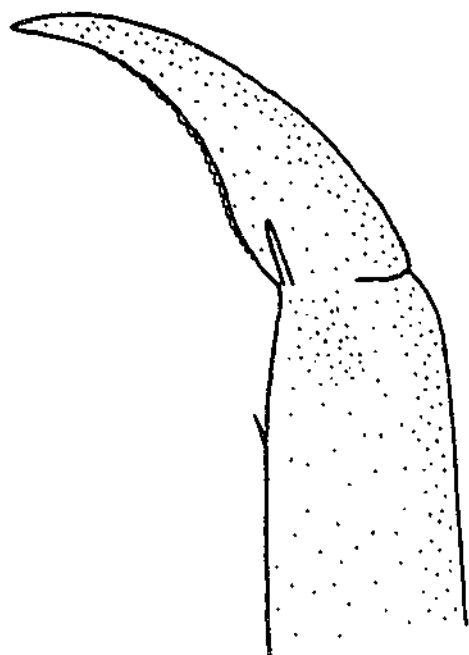
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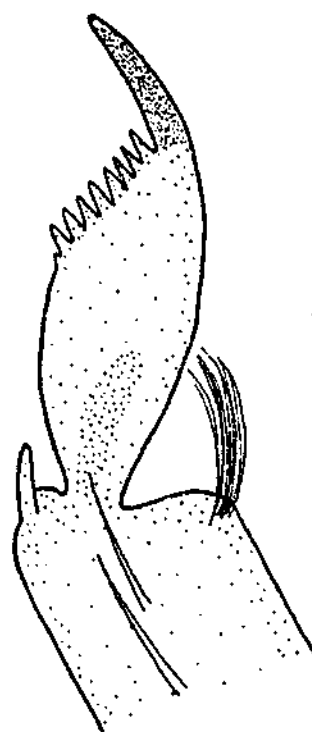
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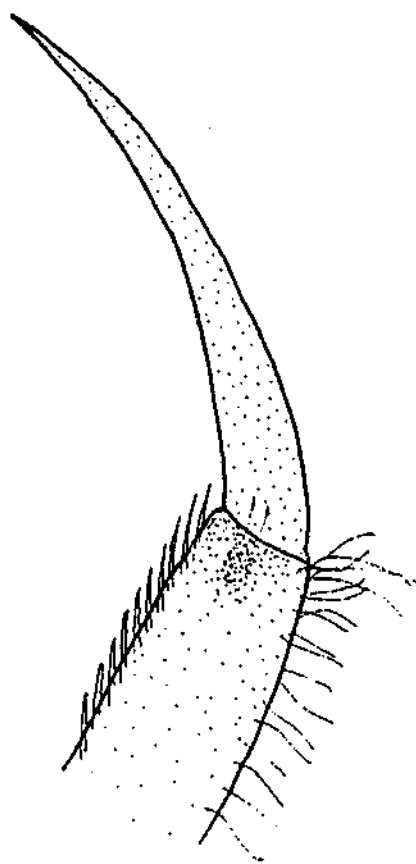
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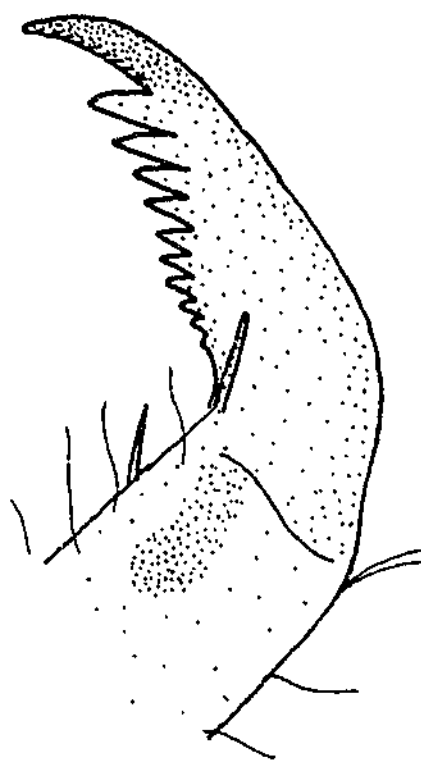
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Figs. 559-562. Nymph tarsal claw morphology.

Fig. 559. *Kaninga*
Fig. 560. *Kirrara*
Fig. 561. *Loamaggalangta*
Fig. 562. *Montikola*

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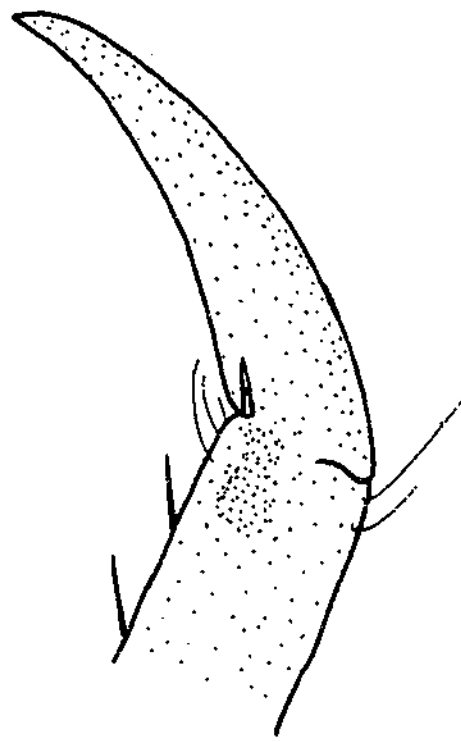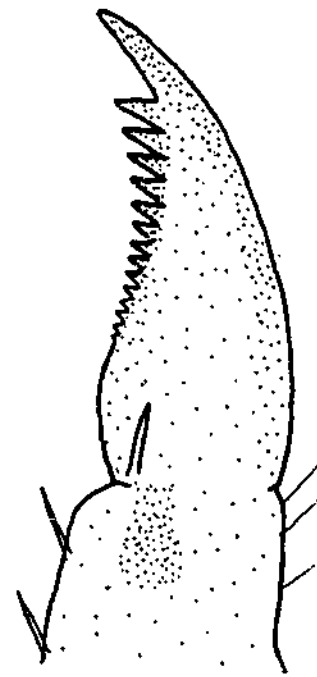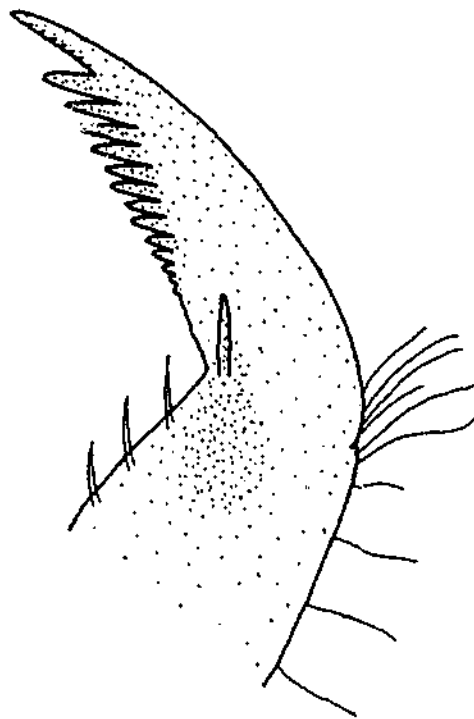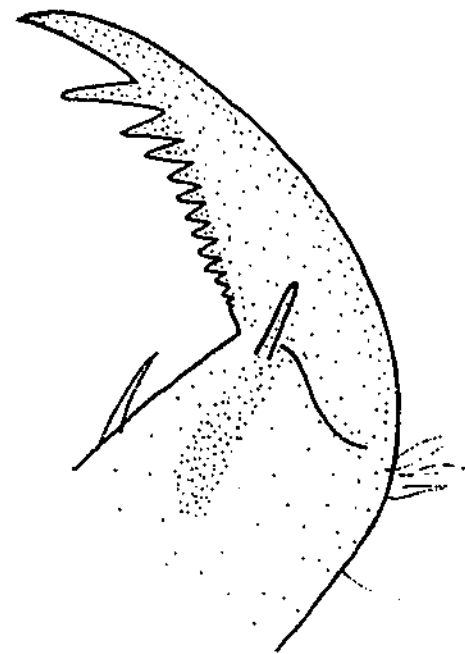
Figs. 563-566. Nymph tarsal claw morphology.

Fig. 563. *Neboissophlebia*
Fig. 564. *Nousia (Nousia)*
Fig. 565. *Nousia (Australonousia)*
Fig. 566. *Nyungara*
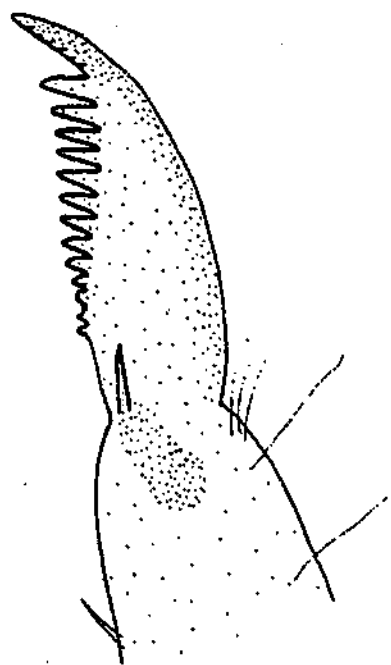
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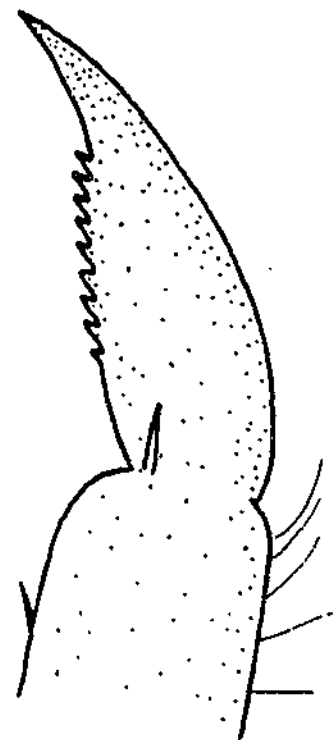
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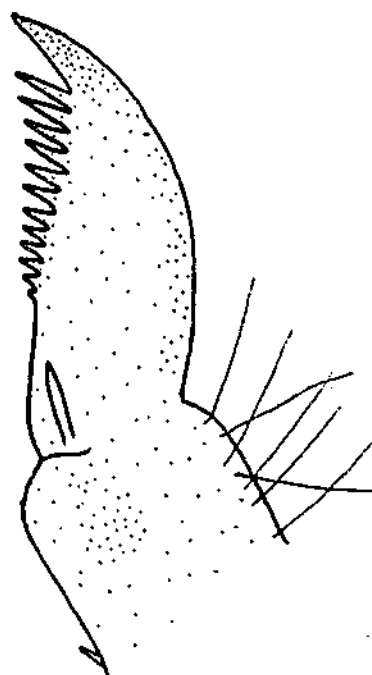
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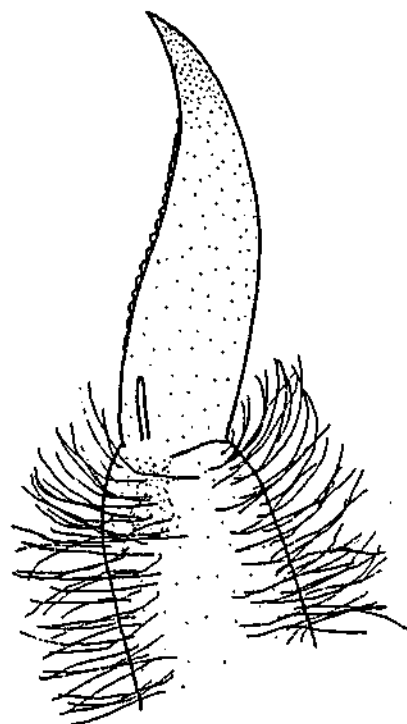
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Figs. 567-570. Nymph tarsal claw morphology.

Fig. 567. *Thraulophlebia*
Fig. 568. *Thraulus*
Fig. 569. *Tillyardophlebia*
Fig. 570. *Ulmerophlebia*
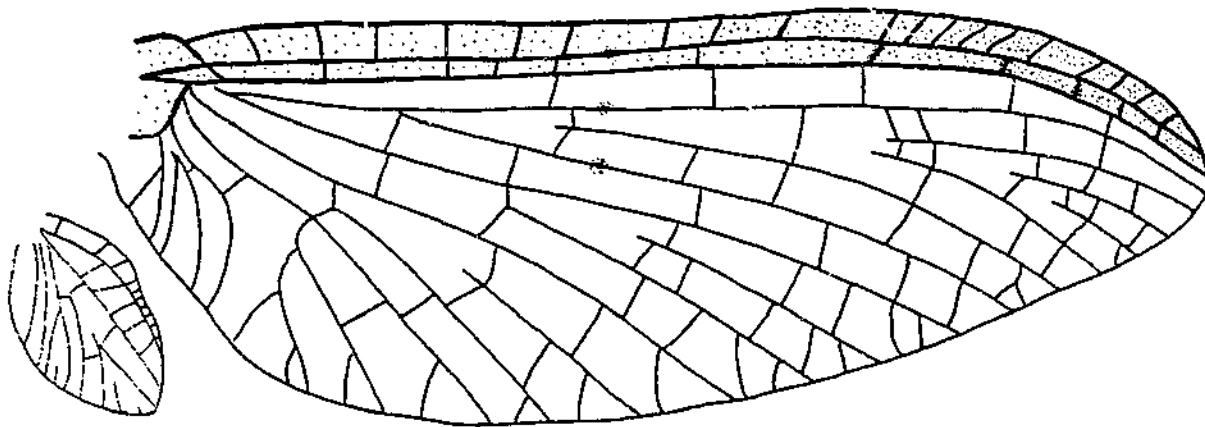
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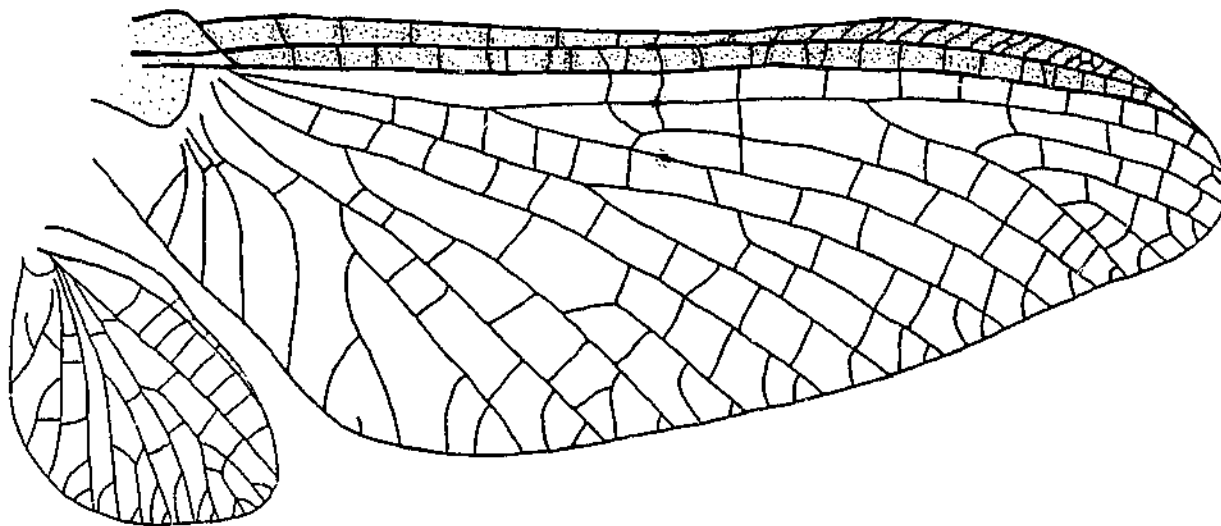
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Figs. 571-572. Male imago forewing showing relative size of hindwing.

Fig. 571. *Atalomicria*
Fig. 572. *Atalophlebia*
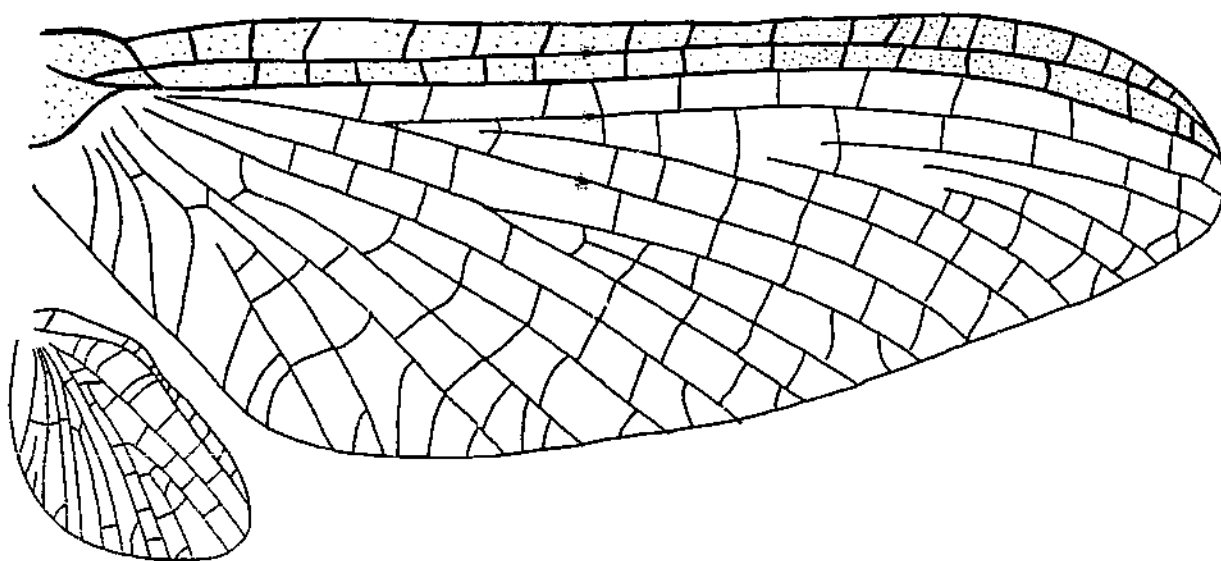
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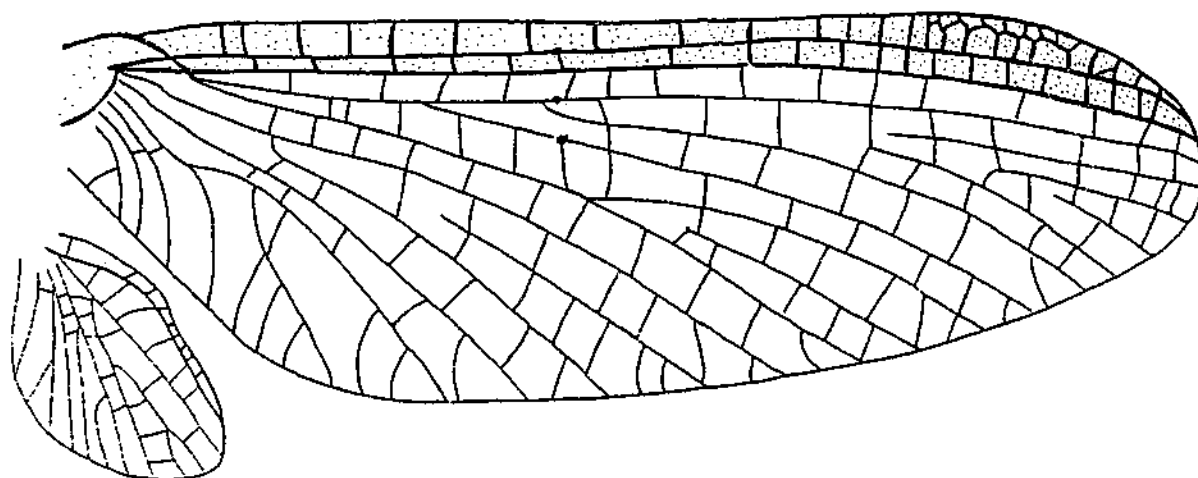
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Figs. 573-574. Male imago forewing showing relative size of hindwing.

Fig. 573. *Austrophlebioides*
Fig. 574. *Bibulmena*
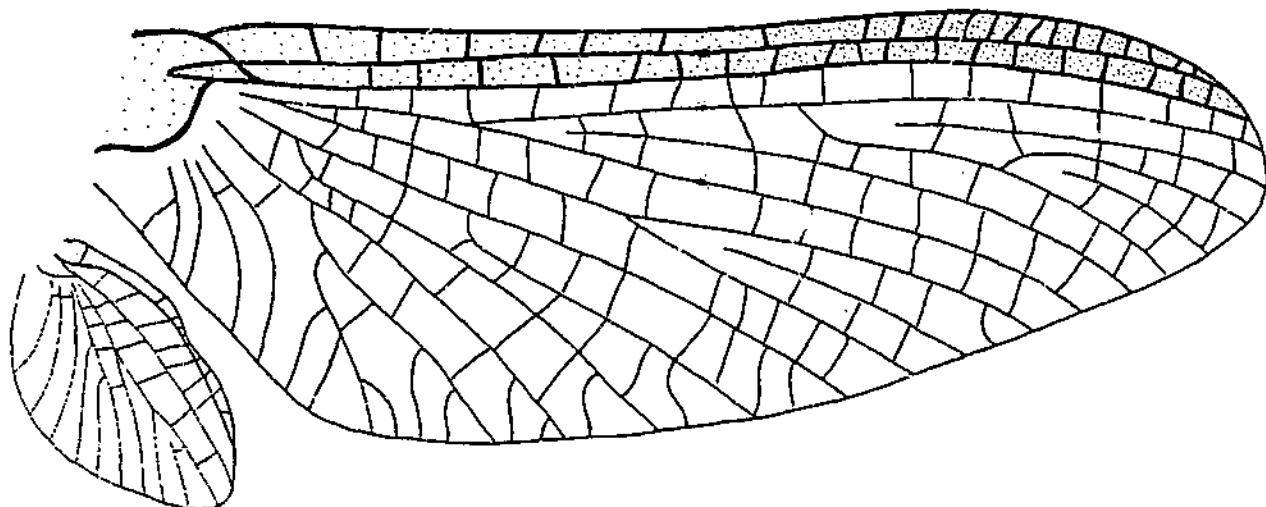
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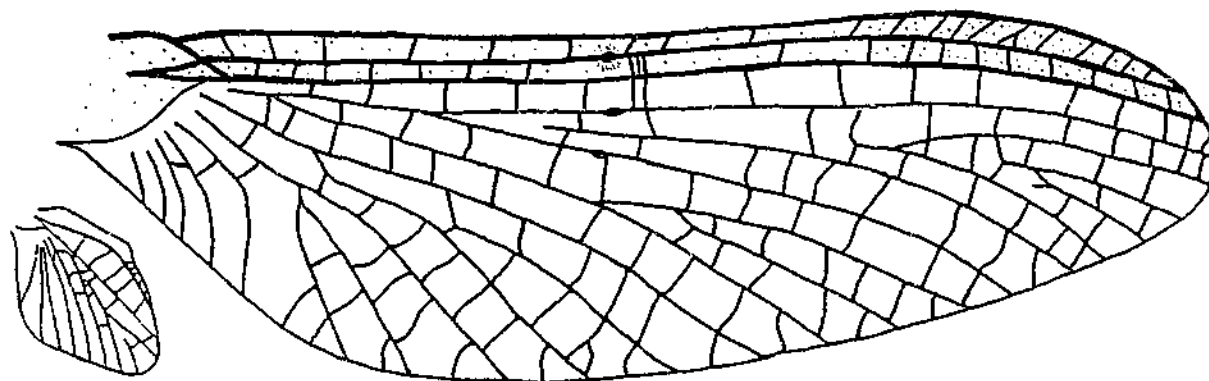
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Figs. 575-576. Male imago forewing showing relative size of hindwing.

Fig. 575. *Garinjuga*
Fig. 576. *Gemmayaluka*
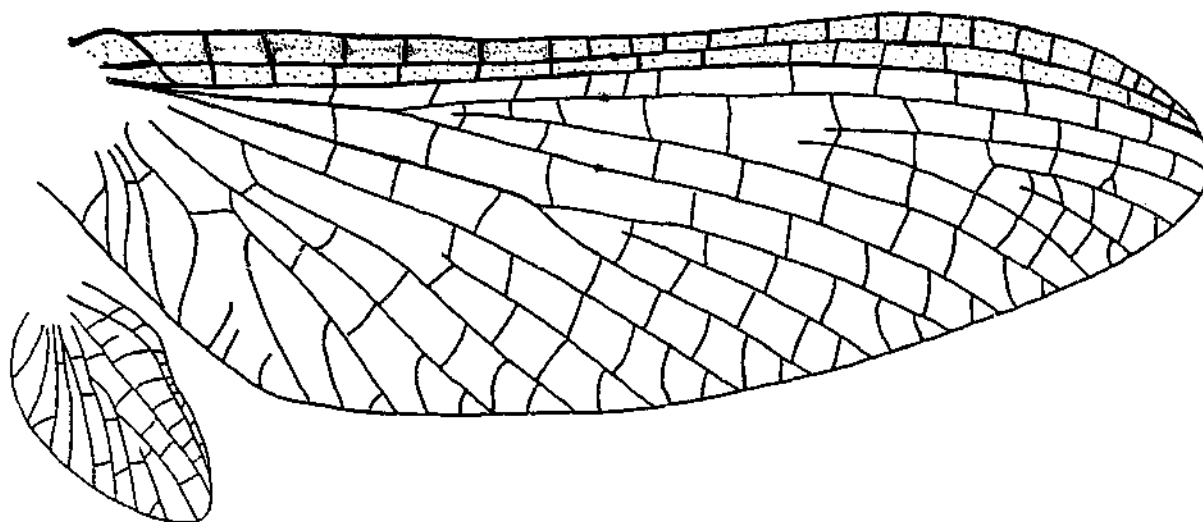
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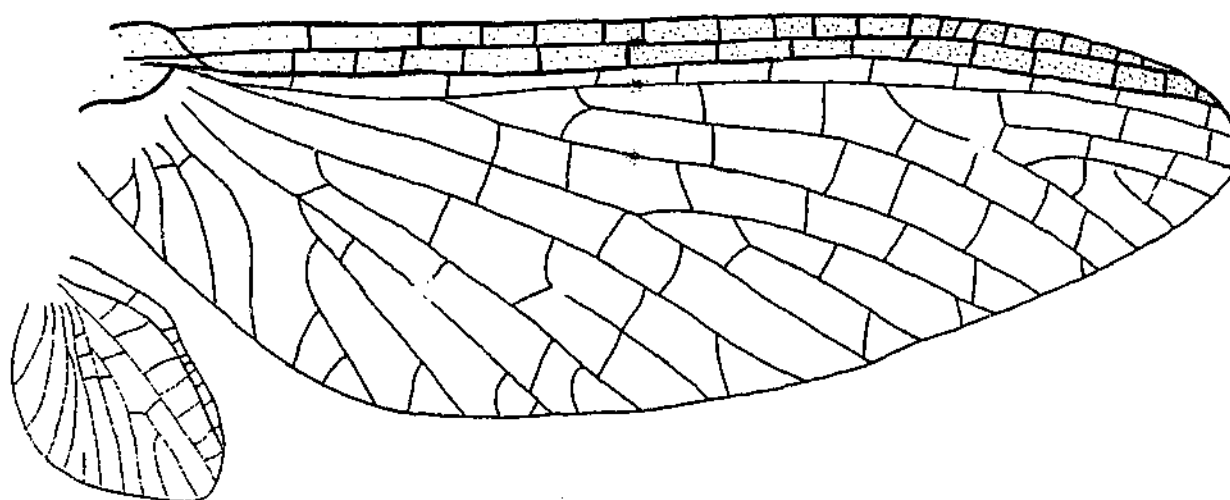
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Figs. 577-578. Male imago forewing showing relative size of hindwing.

Fig. 577. *Jappa*
Fig. 578. *Kalbaybaria*
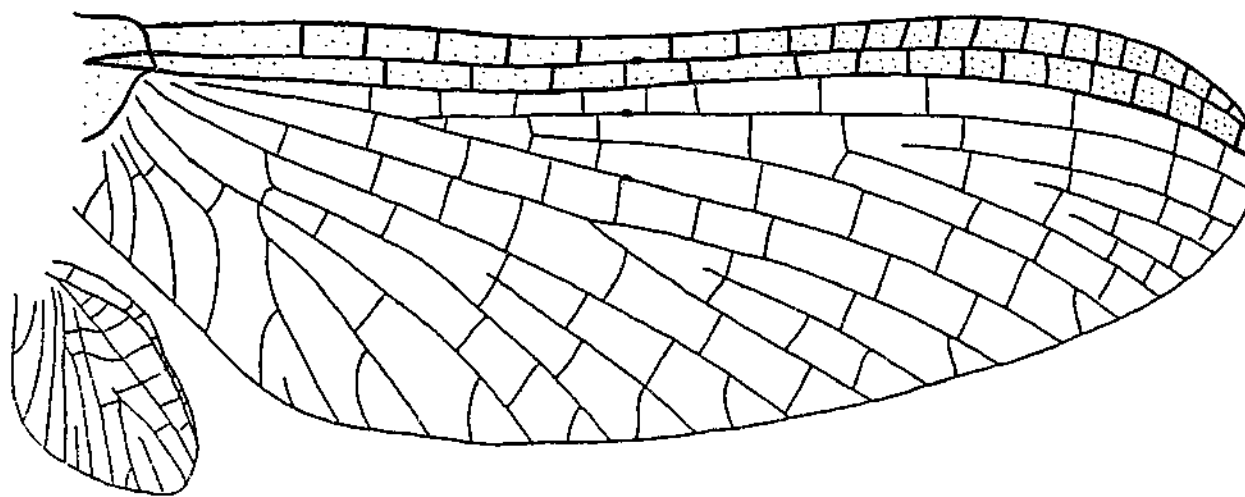
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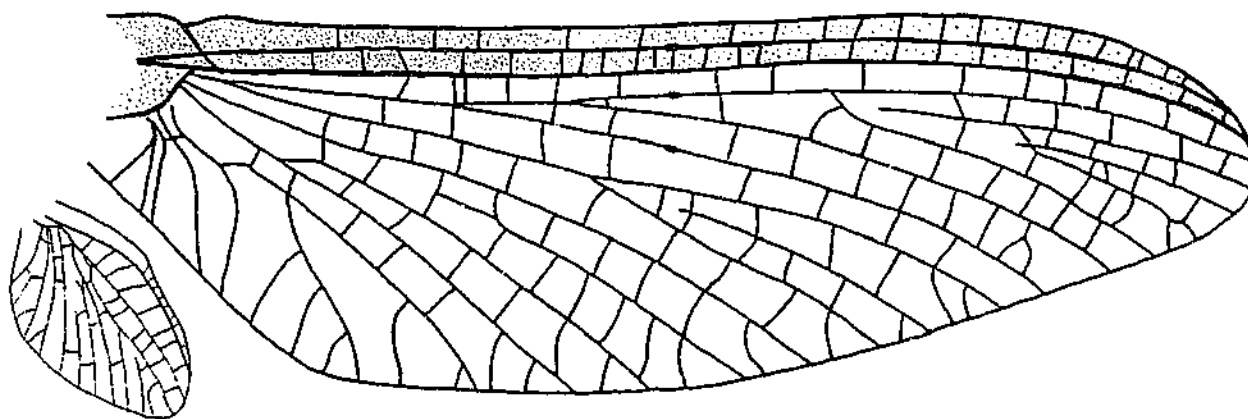
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Figs. 579-580. Male imago forewing showing relative size of hindwing.

Fig. 579. *Kaninga*
Fig. 580. *Kirrara*
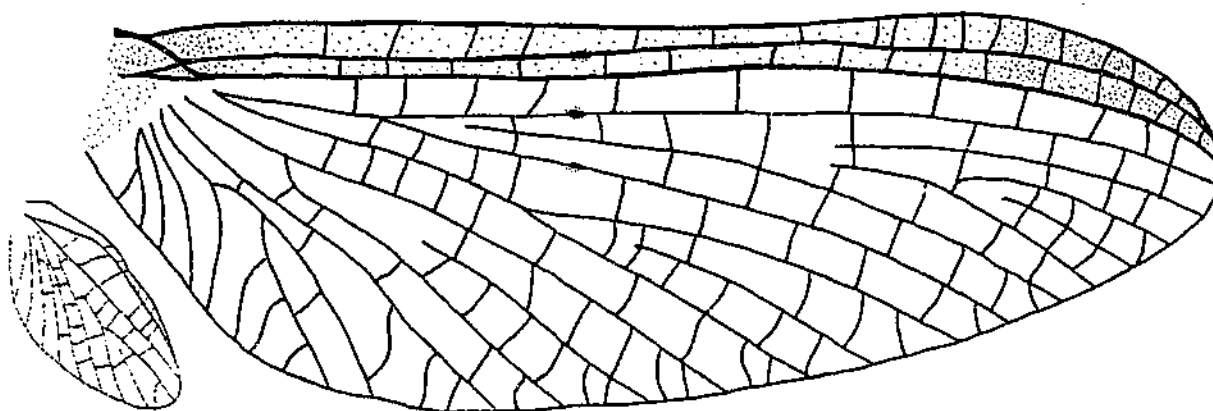
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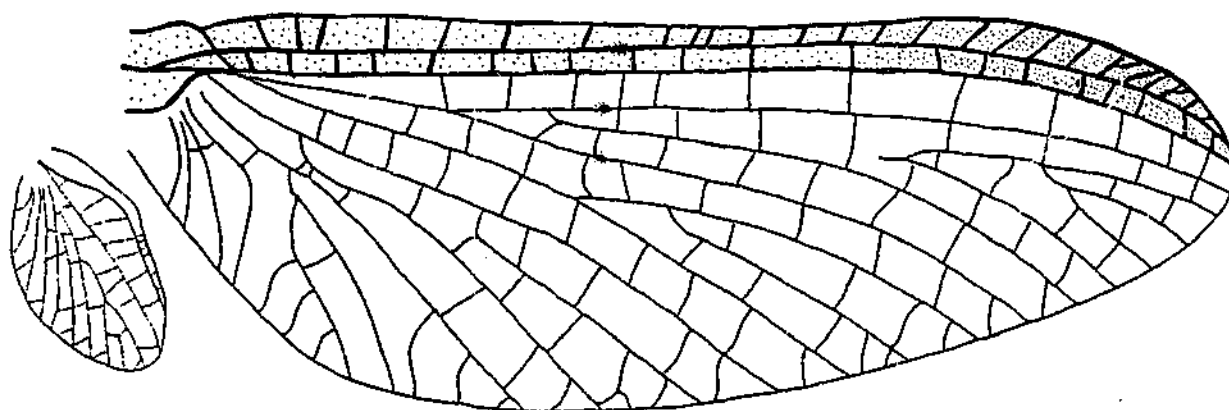
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Figs. 581-582. Male imago forewing showing relative size of hindwing.

Fig. 581. *Loamaggalangta*
Fig. 582. *Montikola*
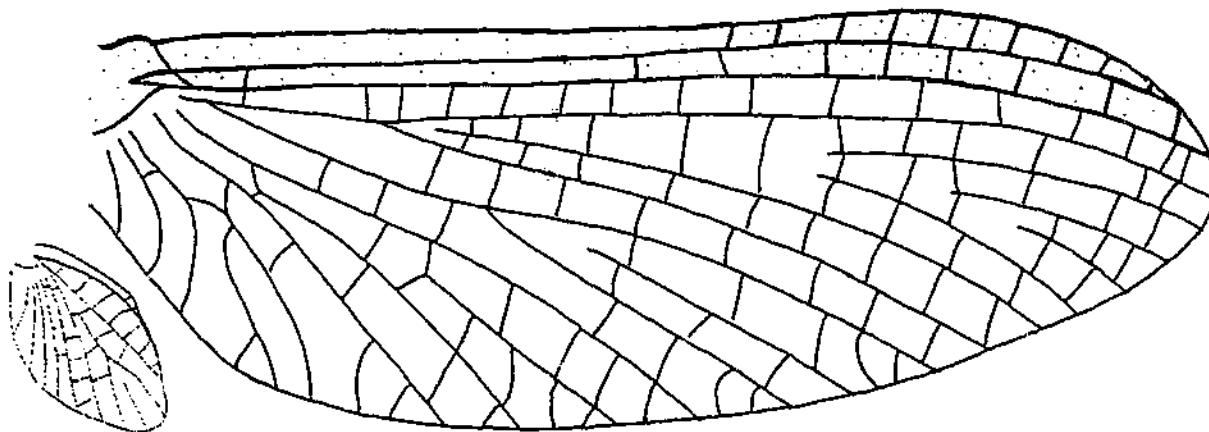
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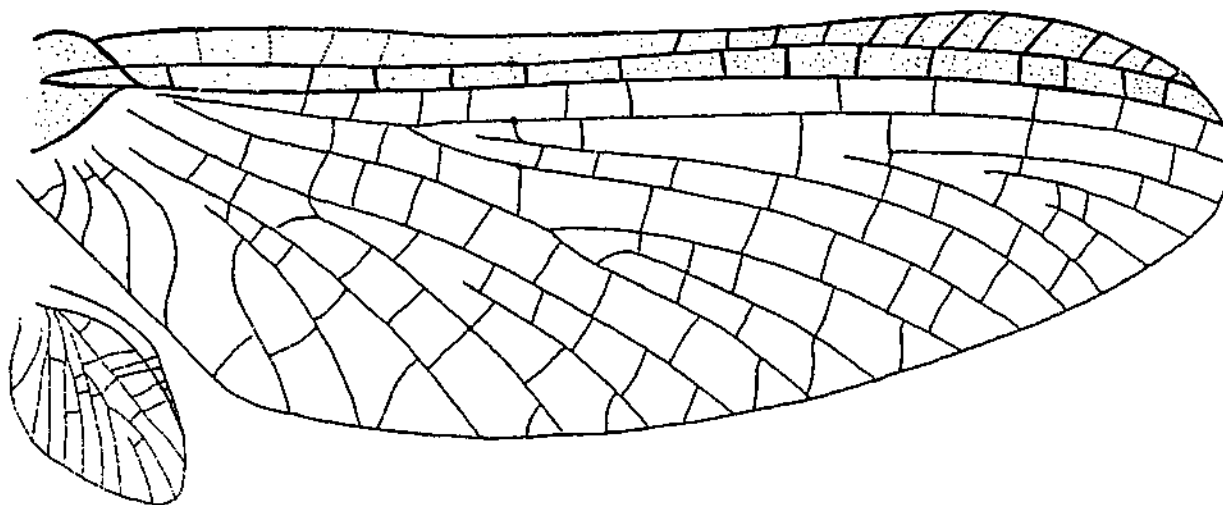
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Figs. 583-584. Male imago forewing showing relative size of hindwing.

Fig. 583. *Neboissophlebia*
Fig. 584. *Nousia (Nousia)*
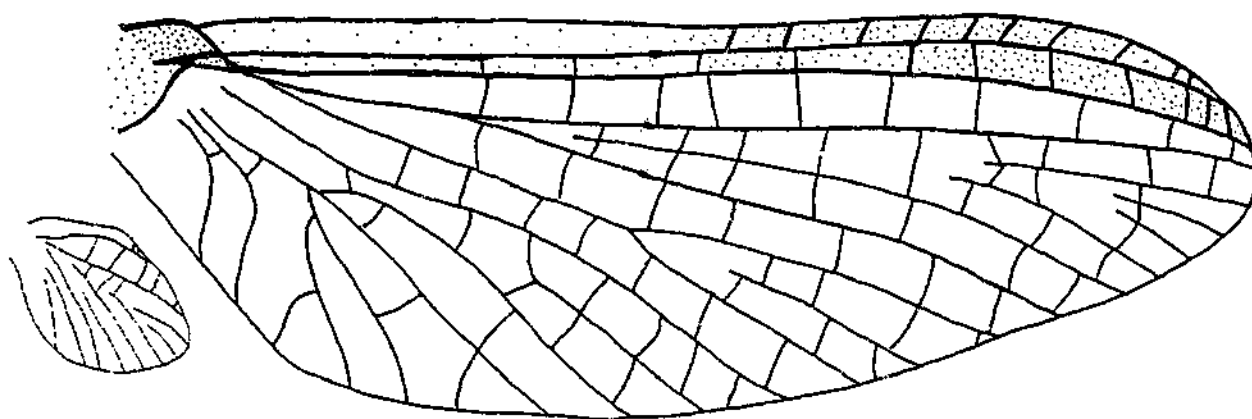
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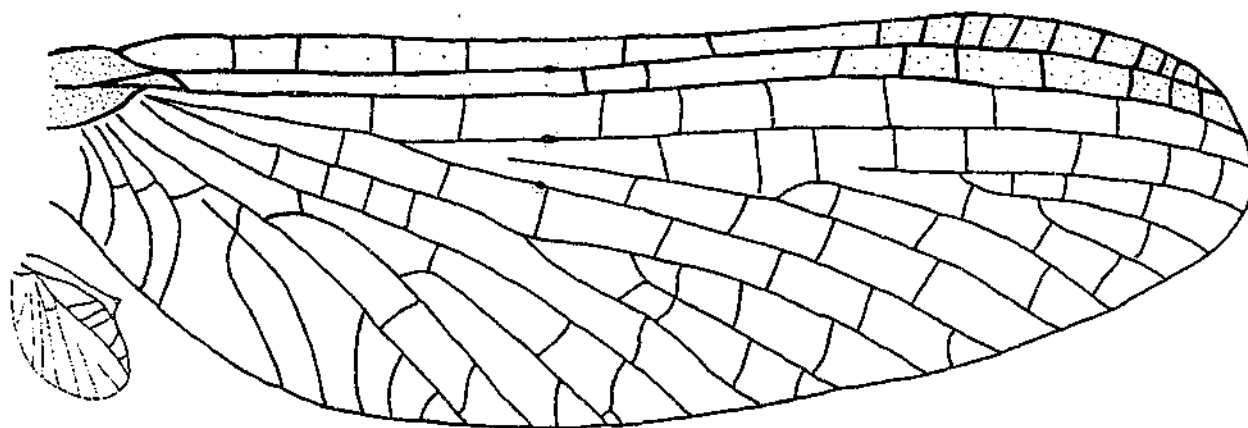
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Figs. 585-586. Male imago forewing showing relative size of hindwing.

Fig. 585. *Nousia (Australonousia)*
Fig. 586. *Nyungara*
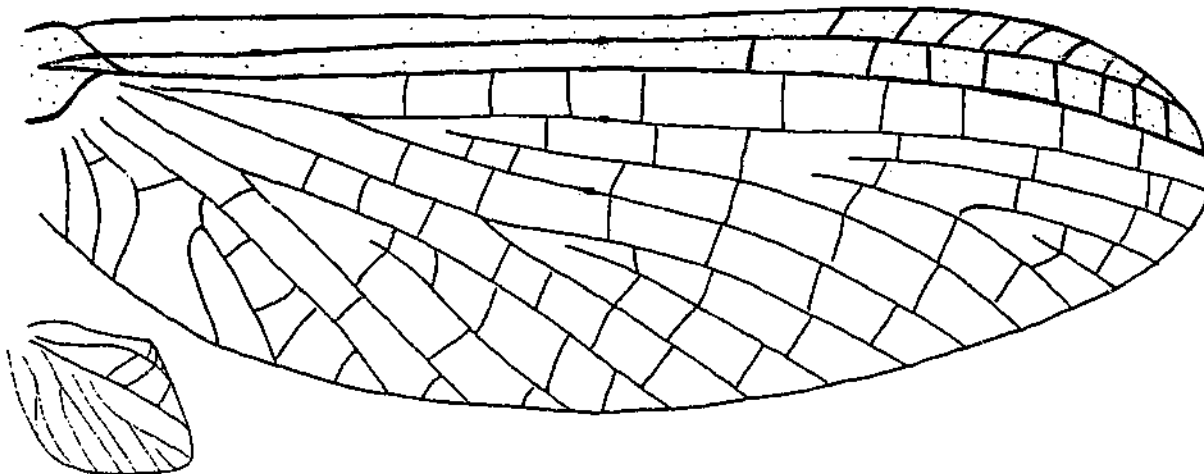
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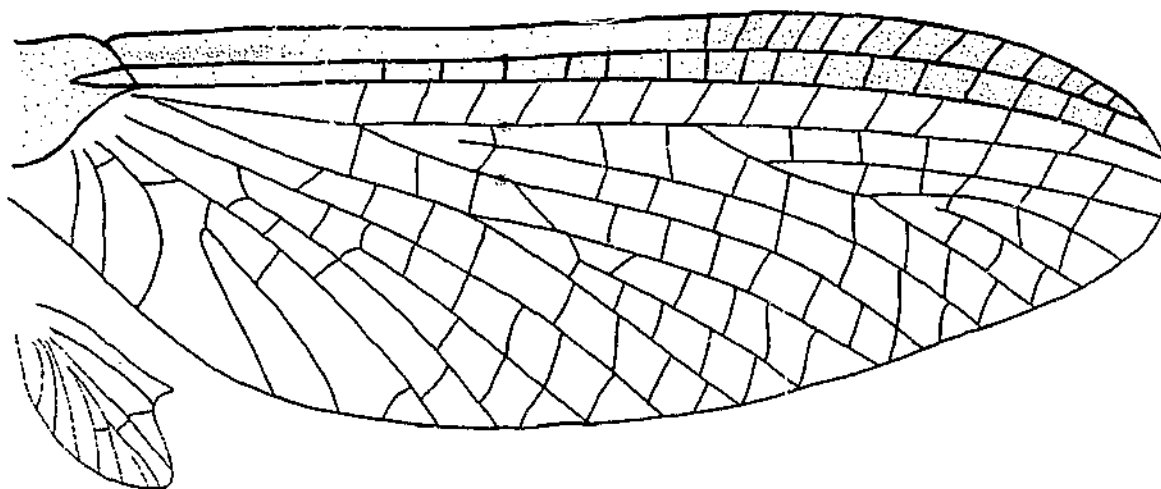
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Figs. 587-588. Male imago forewing showing relative size of hindwing.

Fig. 587. *Thraulophlebia*
Fig. 588. *Thraulus*
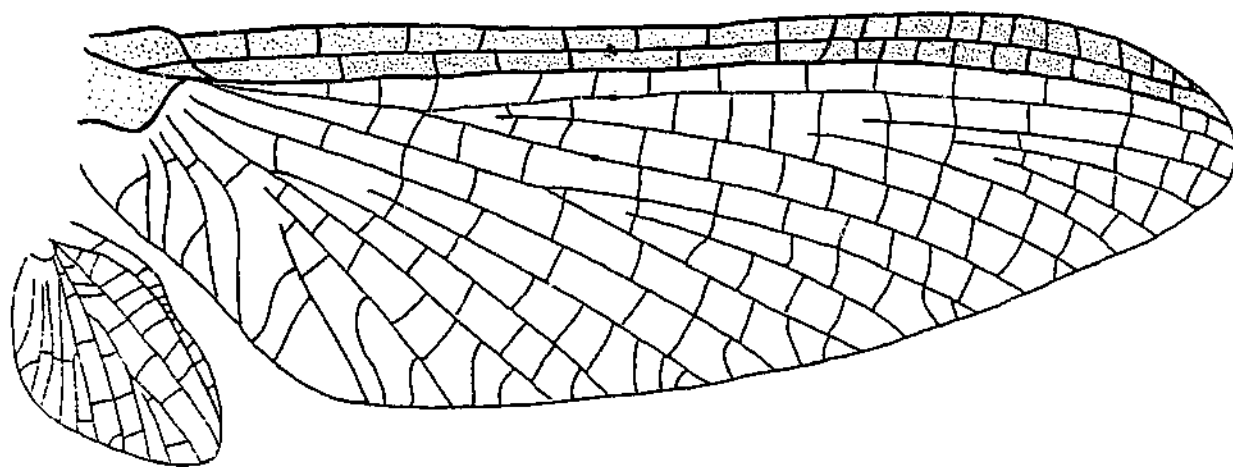
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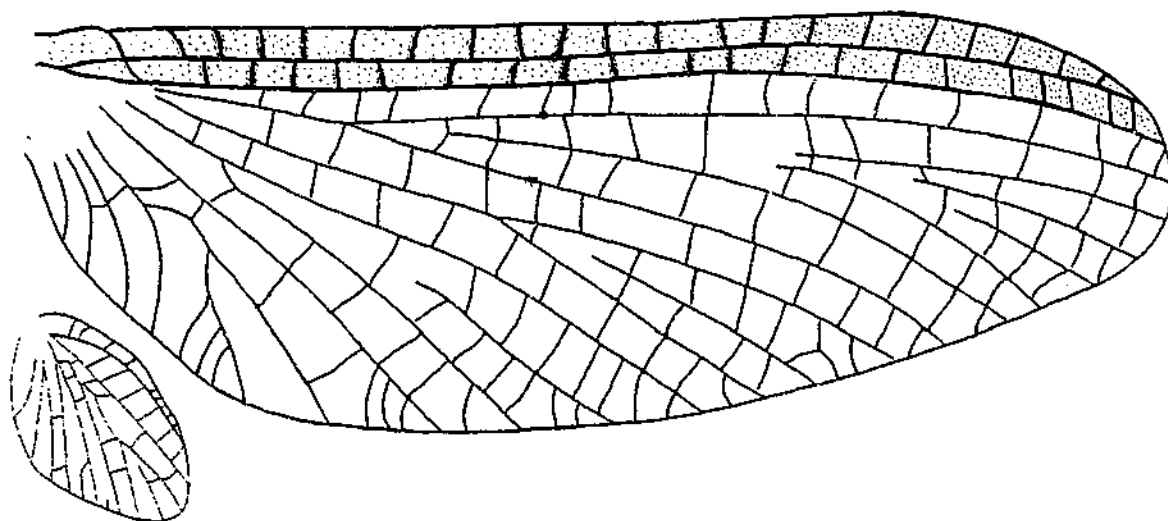
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Figs. 589-590. Male imago forewing showing relative size of hindwing.

Fig. 589. *Tillyardophlebia*
Fig. 590. *Ulmerophlebia*
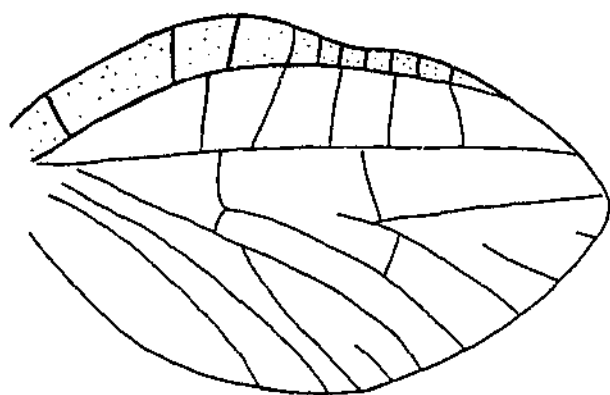
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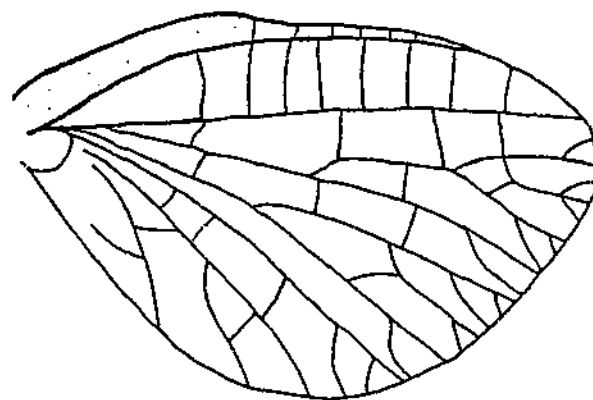
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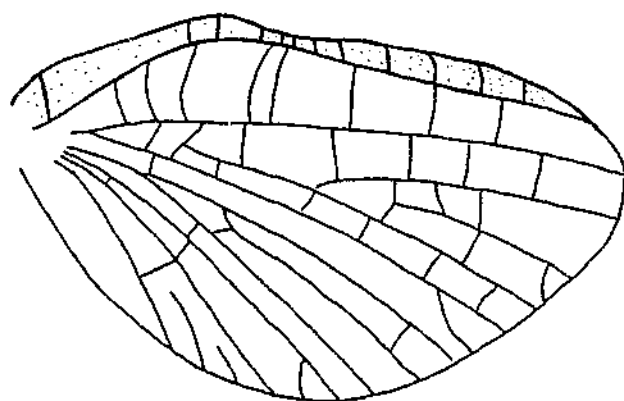
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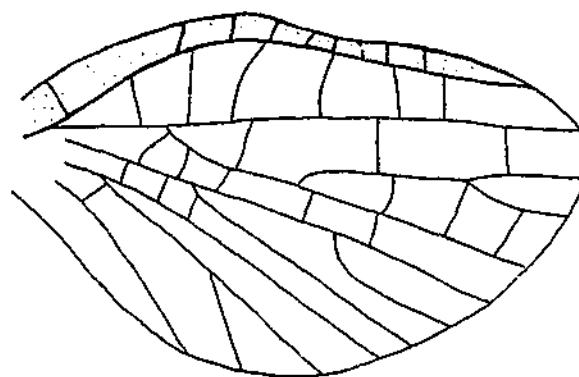
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Figs. 591-594. Male imago hindwing.

Fig. 591. *Atalomicria*
Fig. 592. *Atalophlebia*
Fig. 593. *Austrophlebioides*
Fig. 594. *Bibulmena*
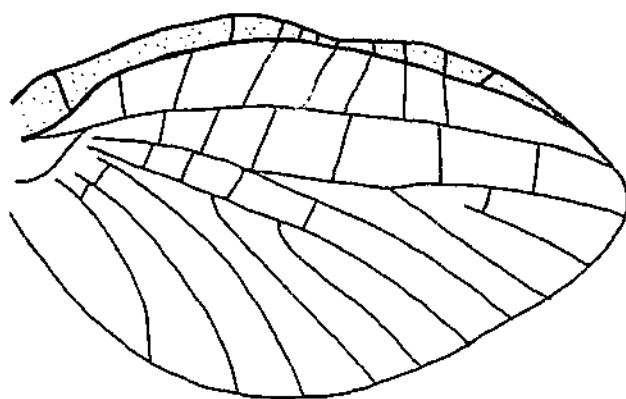
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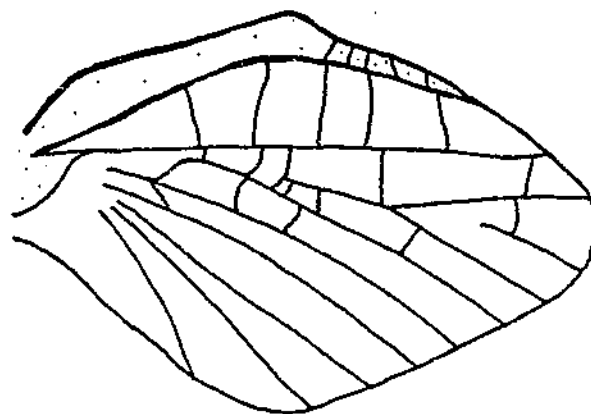
596
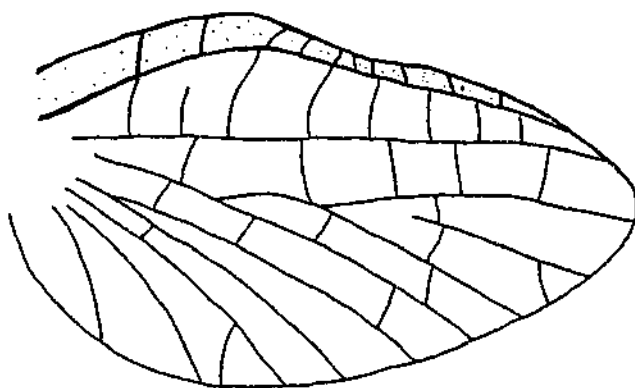
597
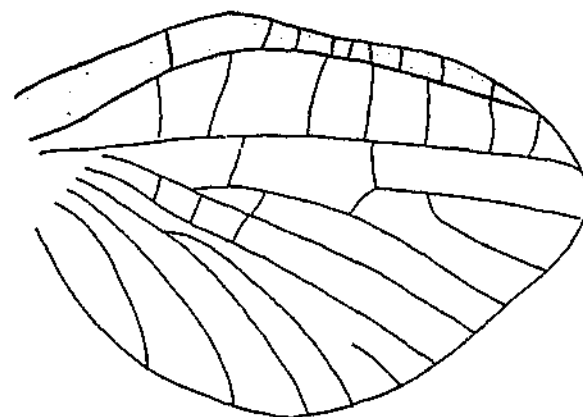
598

Figs. 595-598. Male imago hindwing.

Fig. 595. *Garinjuga*
Fig. 596. *Gemmayaluka*
Fig. 597. *Jappa*
Fig. 598. *Kalbaybaria*
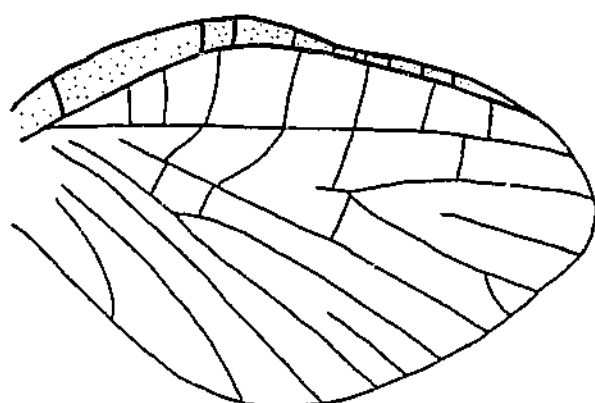
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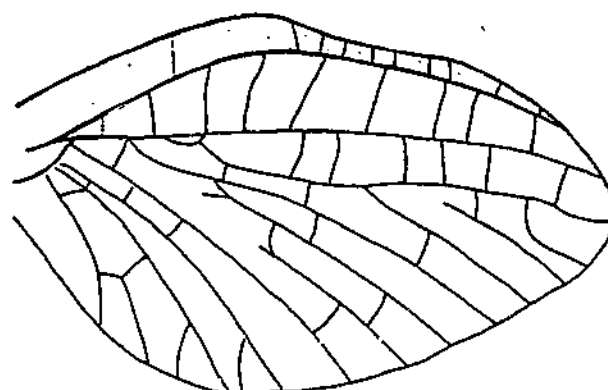
600
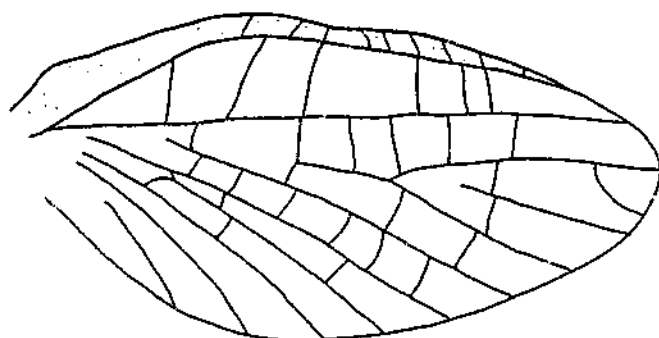
601
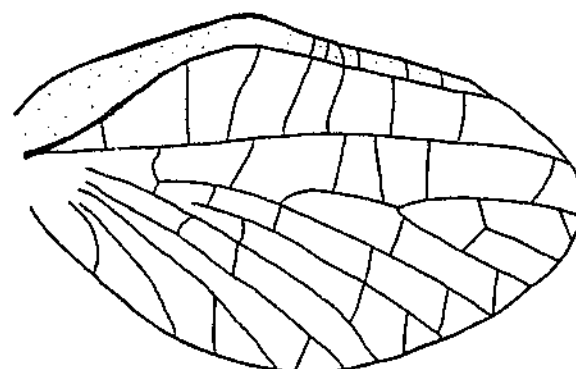
602

Figs. 599-602. Male imago hindwing.

Fig. 599. *Kaninga*
Fig. 600. *Kirrara*
Fig. 601. *Loamaggalangta*
Fig. 602. *Montikola*
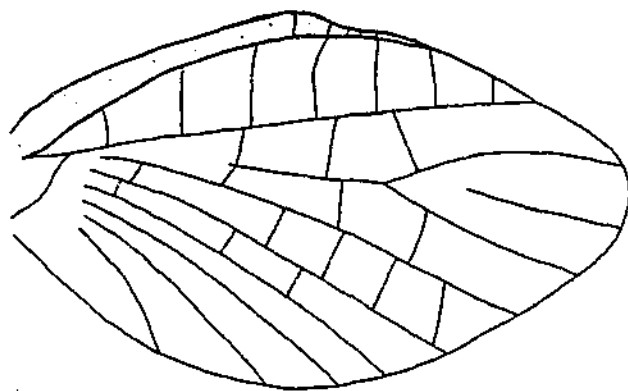
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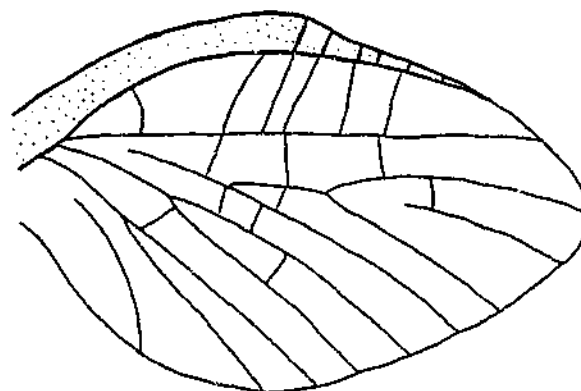
604
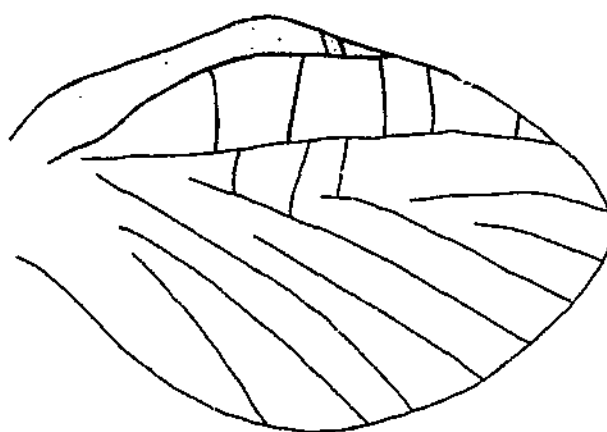
605
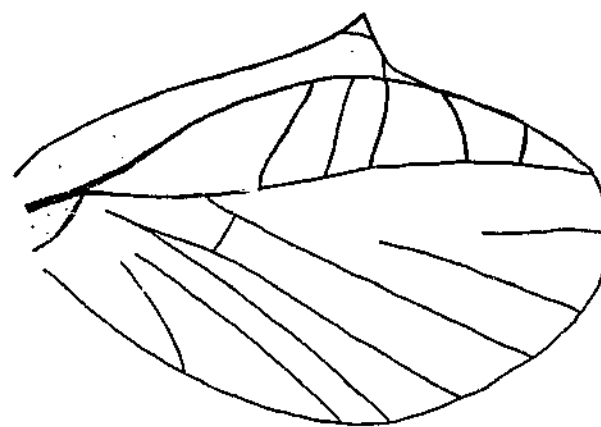
606

Figs. 603-606. Male imago hindwing.

Fig. 603. *Neboissophlebia*
Fig. 604. *Nousia (Nousia)*
Fig. 605. *Nousia (Australonousia)*
Fig. 606. *Nyungara*
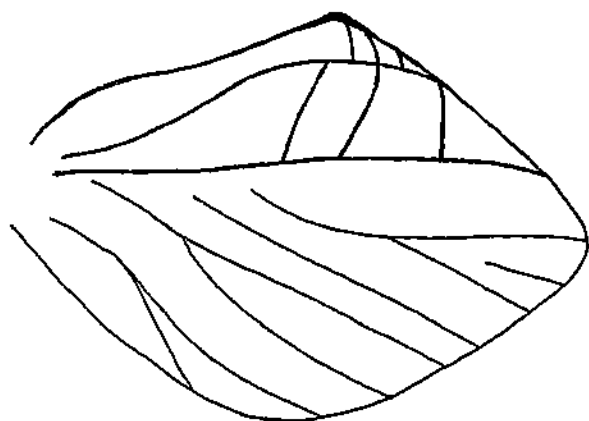
607
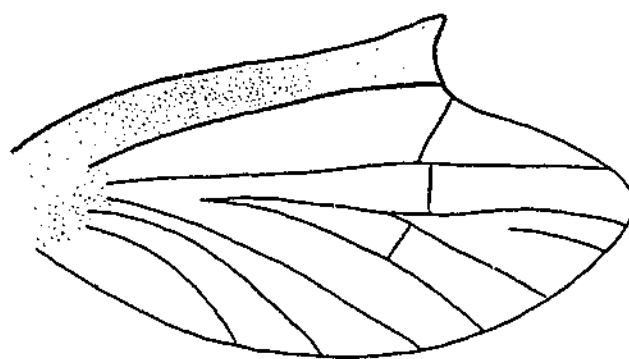
608
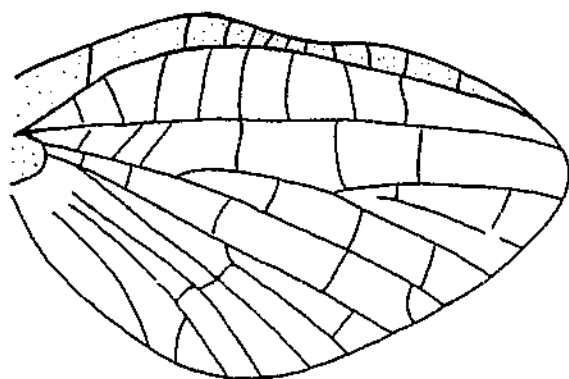
609
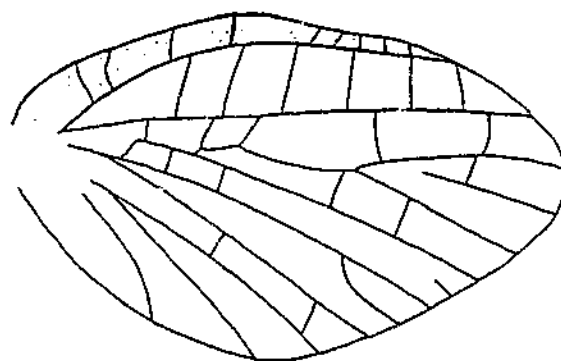
610

Figs. 607-610. Male imago hindwing.

Fig. 607. *Thraulophlebia*
Fig. 608. *Thraulus*
Fig. 609. *Tillyardophlebia*
Fig. 610. *Ulmerophlebia*
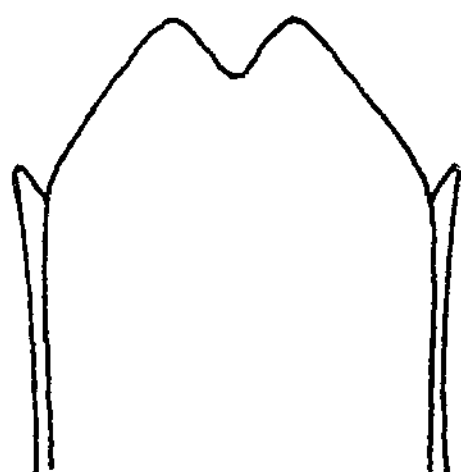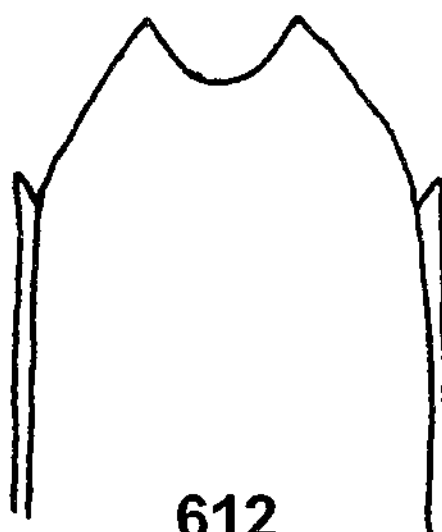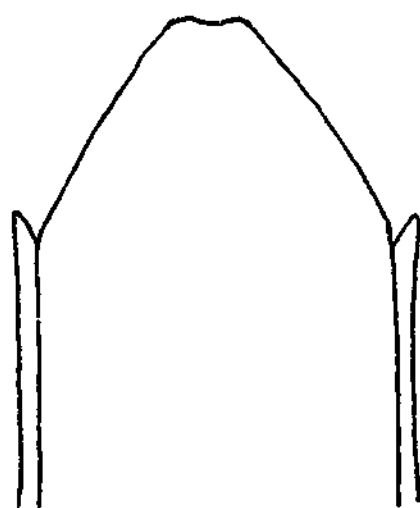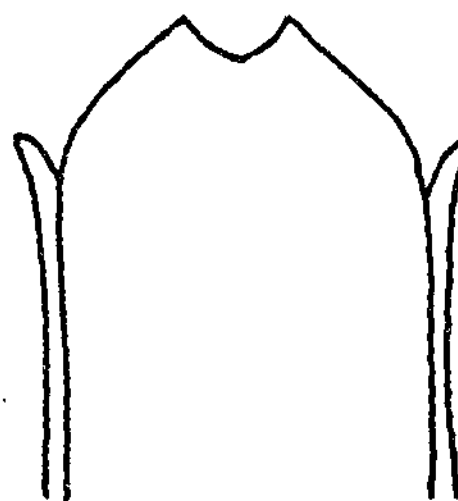
Figs. 611-614. Female imago sternum nine.

Fig. 611. *Atalomicria*
Fig. 612. *Atalophlebia*
Fig. 613. *Austrophlebioides*
Fig. 614. *Bibulmena*
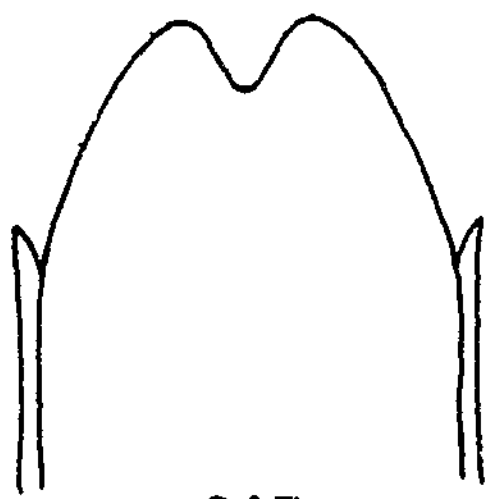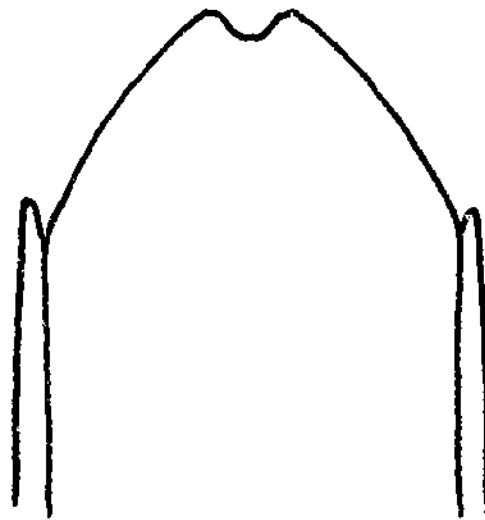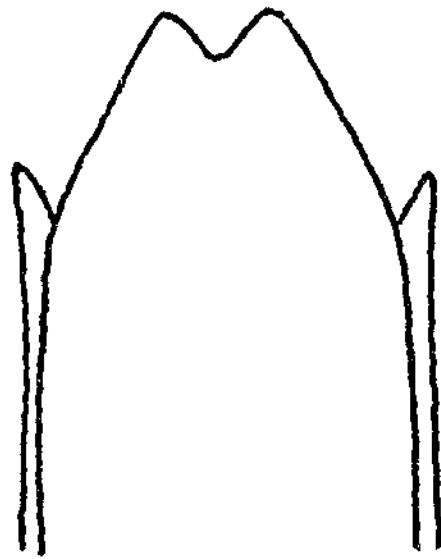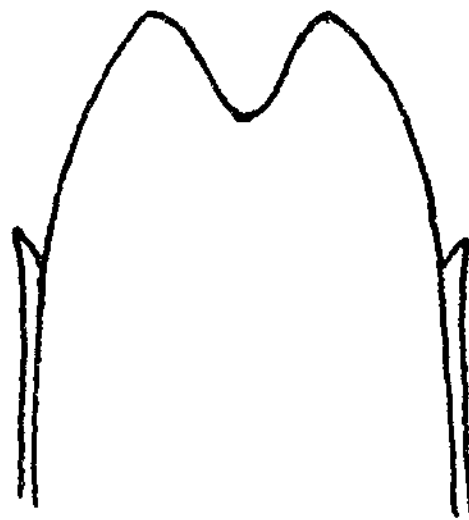
Figs. 615-618. Female imago sternum nine.

Fig. 615. *Garinjuga*
Fig. 616. *Gemmayaluka*
Fig. 617. *Jappa*
Fig. 618. *Kalbaybaria*
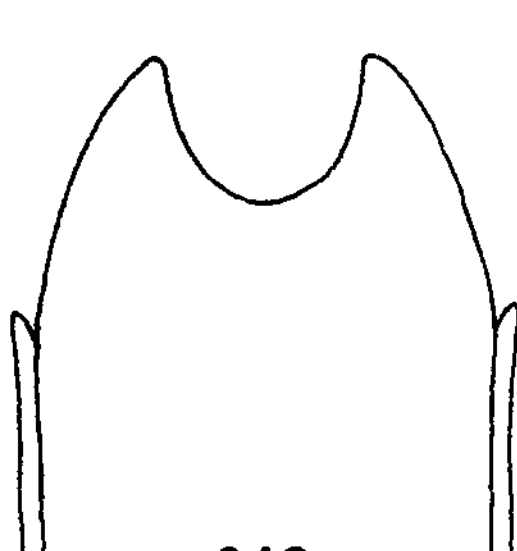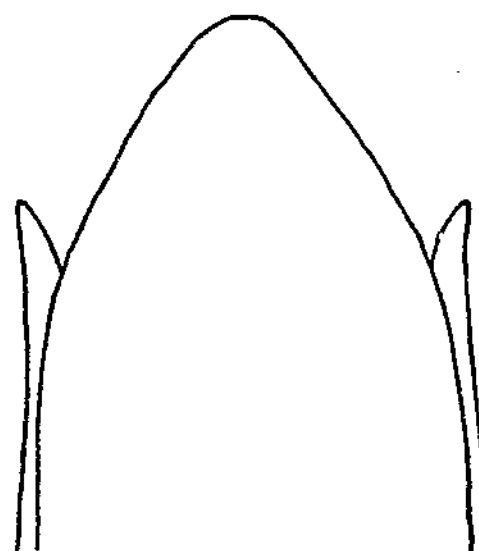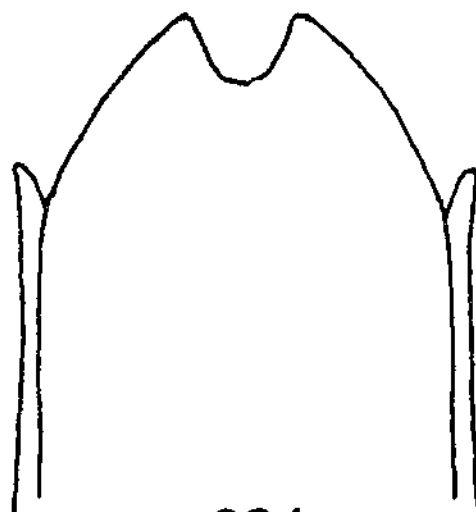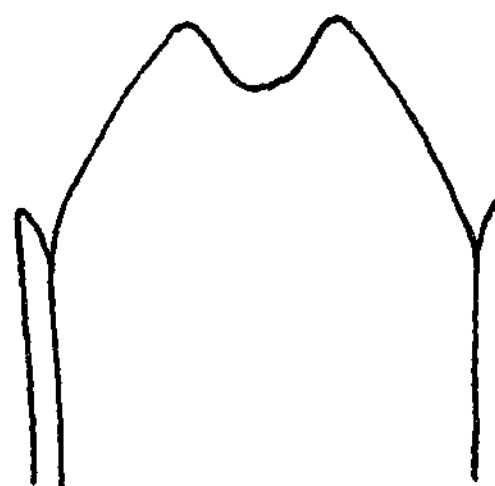
Figs. 619-622. Female imago sternum nine.

Fig. 619. *Kaninga*
Fig. 620. *Kirrara*
Fig. 621. *Loamaggalangta*
Fig. 622. *Montikola*
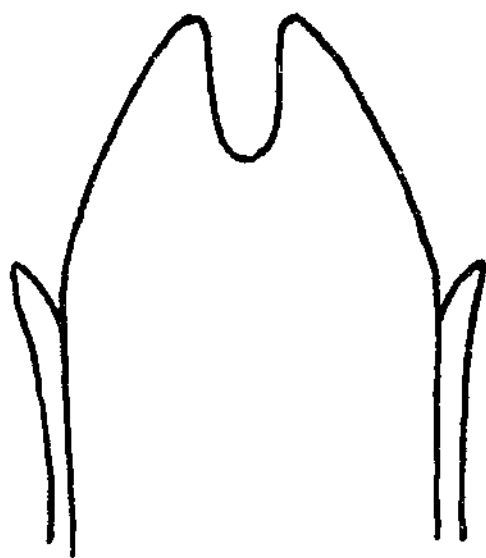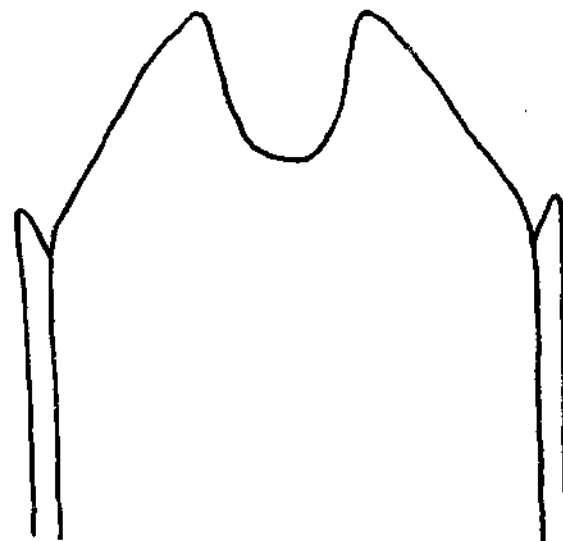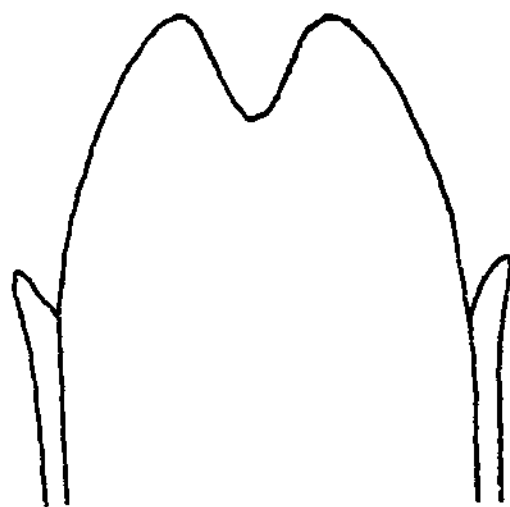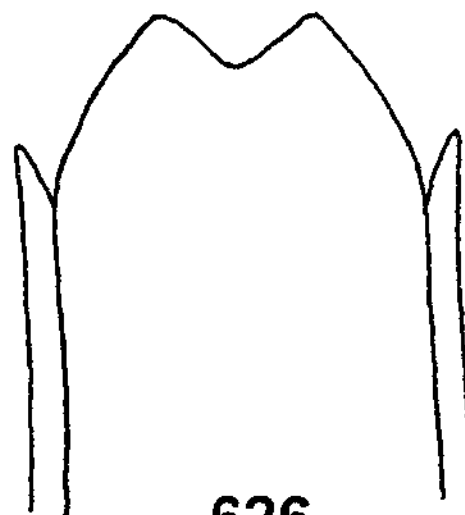
Figs. 623-626. Female imago sternum nine.

Fig. 623. *Neboissophlebia*
Fig. 624. *Nousia (Nousia)*
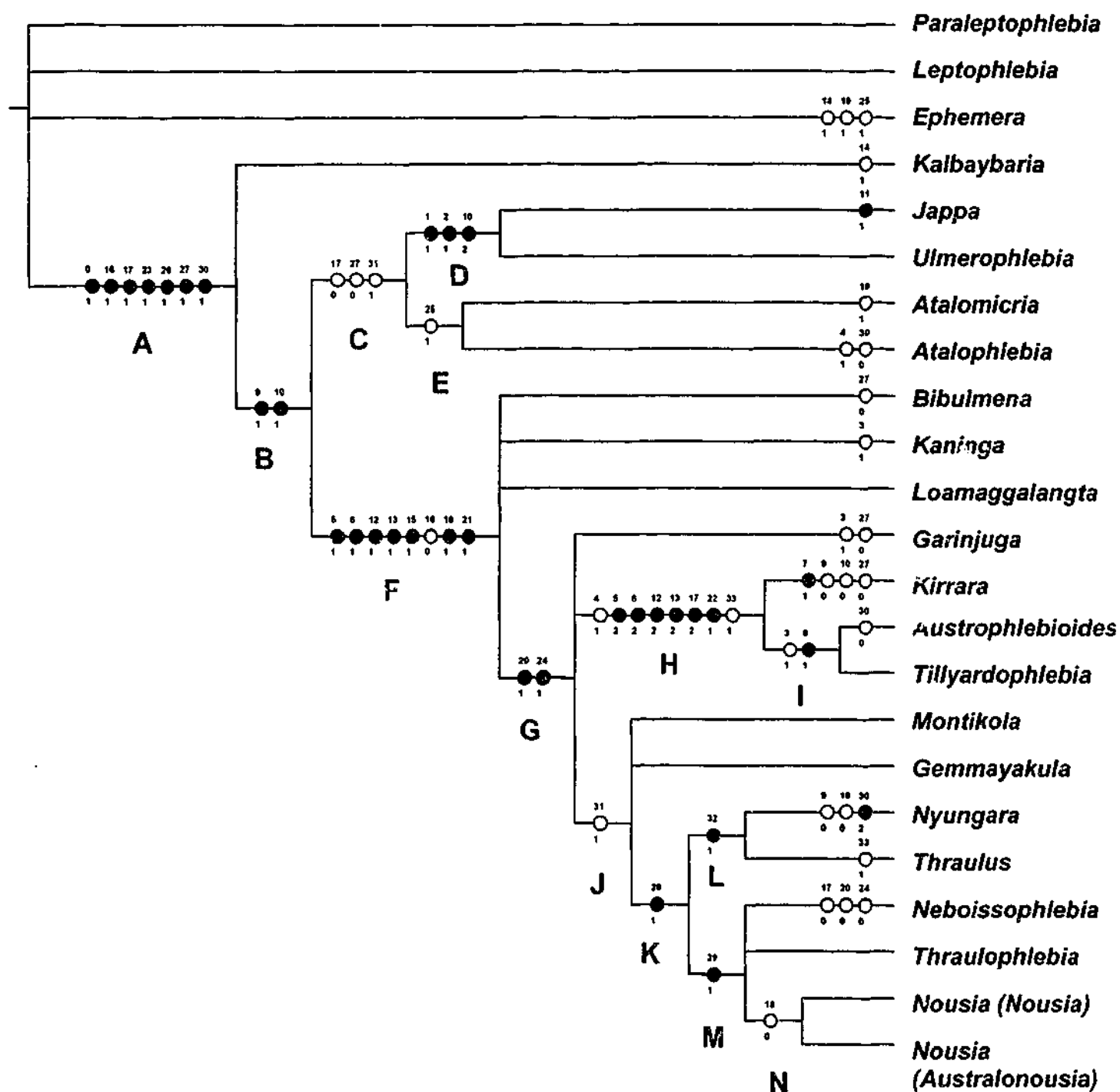Fig. 625. *Nousia (Australonousia)*
Fig. 626. *Nyungara*
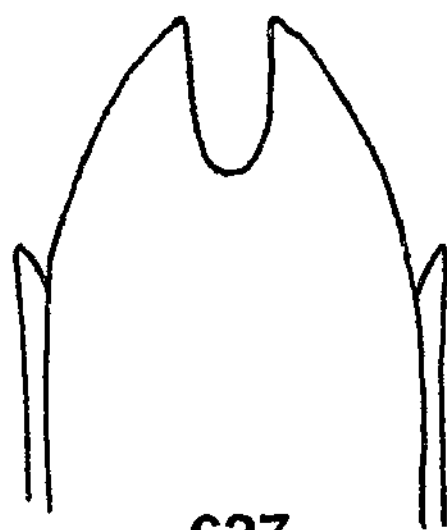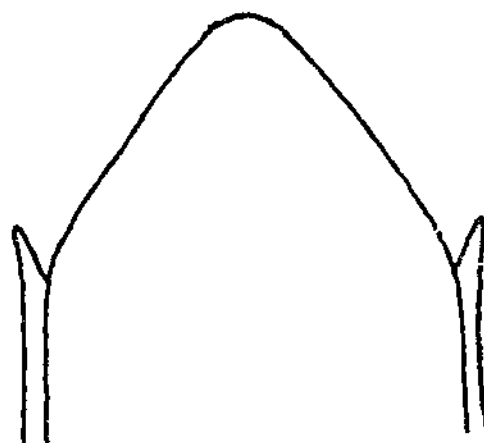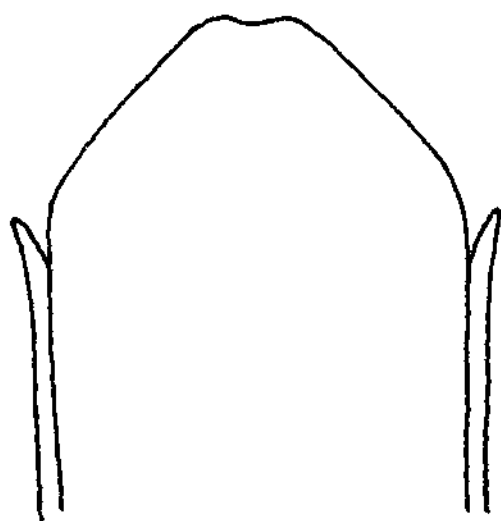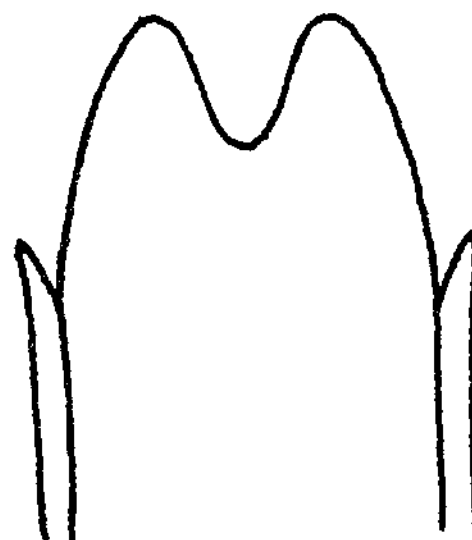
Figs. 627-630. Female imago sternum nine.

Fig. 627. *Thraulophlebia*
Fig. 628. *Thraulus*
Fig. 629. *Tillyardophlebia*
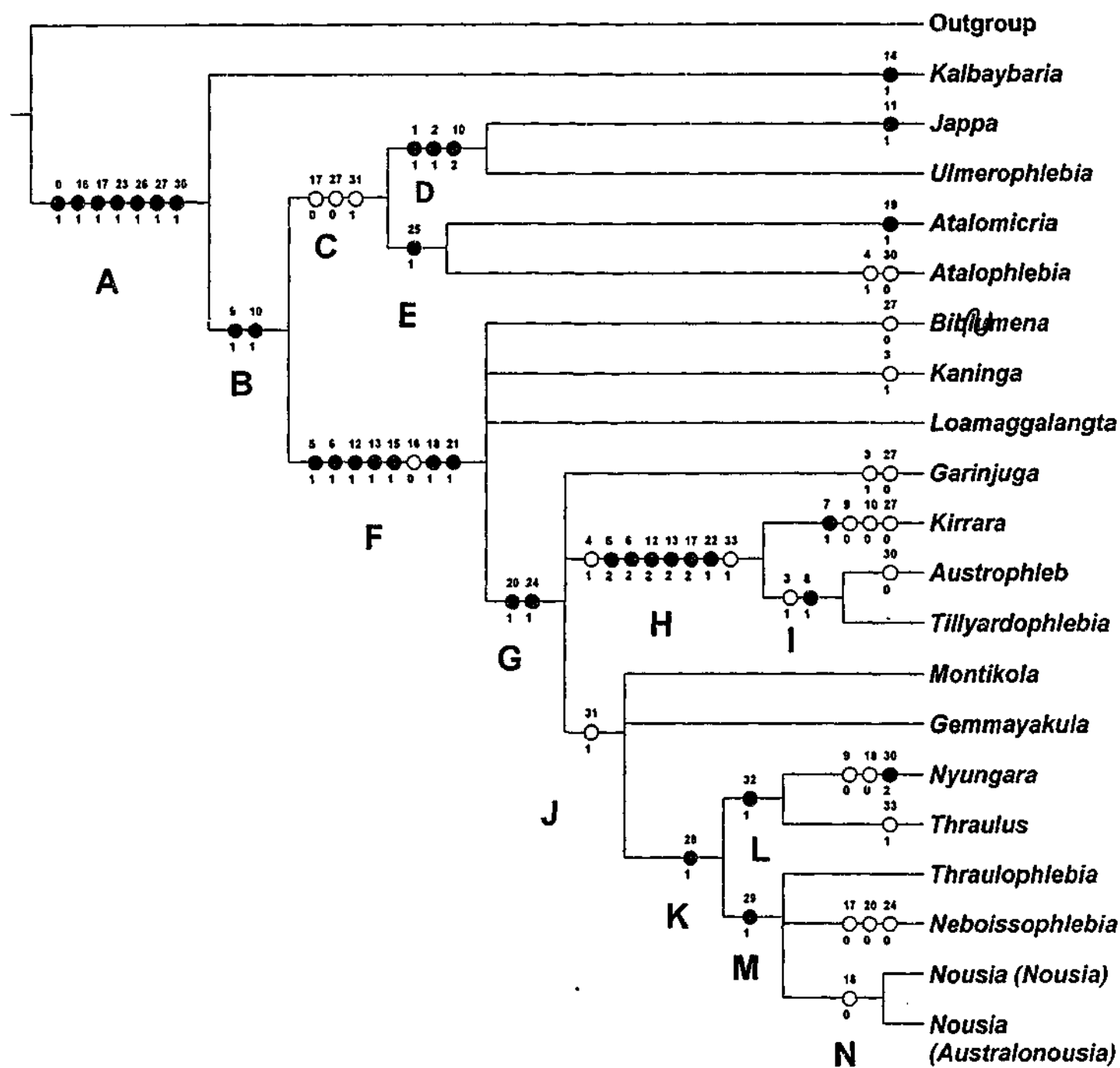Fig. 630. *Ulmerophlebia*

Alternative Fig. 631. Strict consensus tree of the relationships of the Australian Leptophlebiidae. Letters refer to clades. Circles refer to mapped character states where ● = apomorphy and ○ = homoplasy (convergence, reversals). Numbers above circles refer to characters listed in Table 33, numbers below refer to the character state.

Fig. 631. Strict consensus tree of the relationships of the
Australian Leptophlebiidae. Letter refer to clades. Circles refer to mapped
character states where ● = apomorphy and ○ = homoplasy (convergence,
reversals). Numbers above circles refer to characters listed in Table 33, number
below to the character state where 0 = plesiomorphic condition, 1 = apomorphic
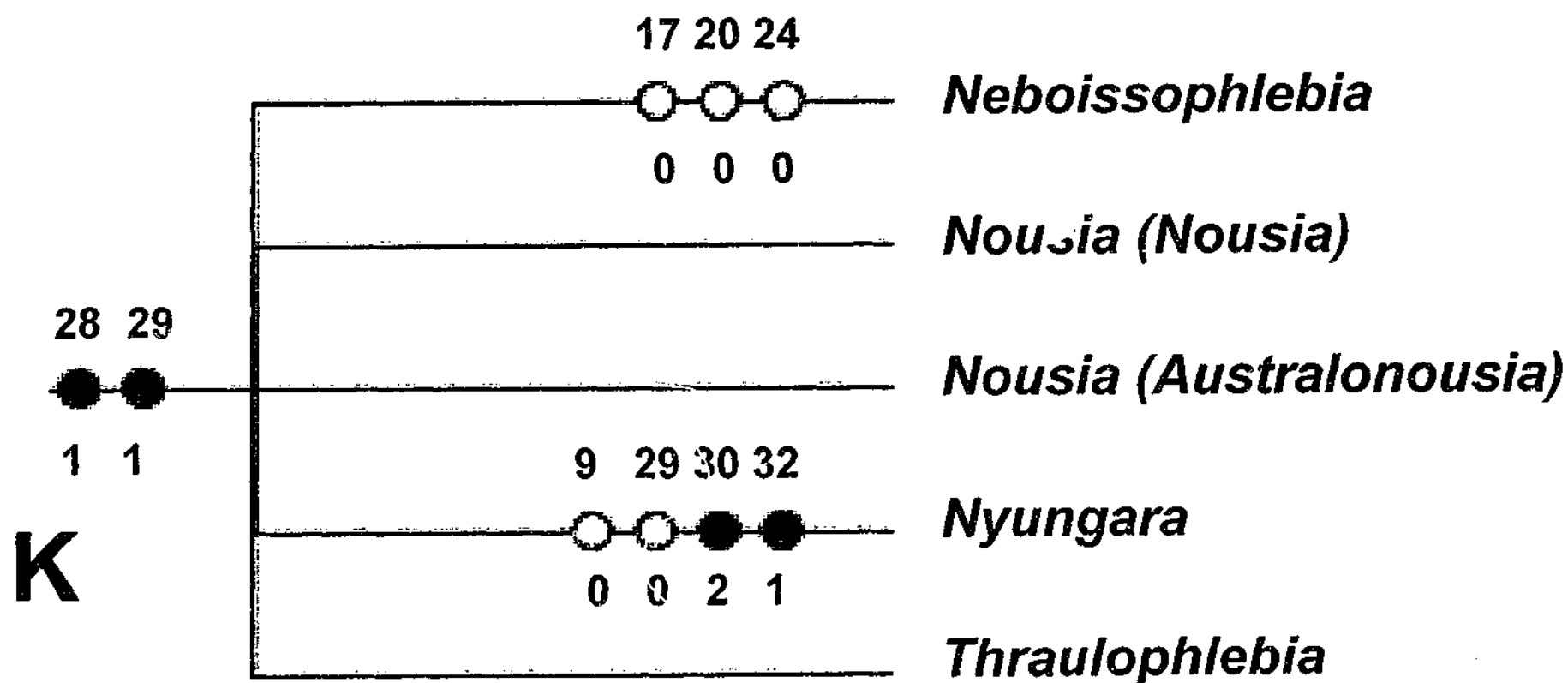condition, 2 = represents a multi-state apomorphy.

Fig. 632: Alternative strict consensus tree of the relationships of the Australian
Leptophlebiidae, without the inclusion of *Thraulus*, which is considered to have
Northern Hemisphere origins. Only clade K of original tree (Fig. 631) shown.