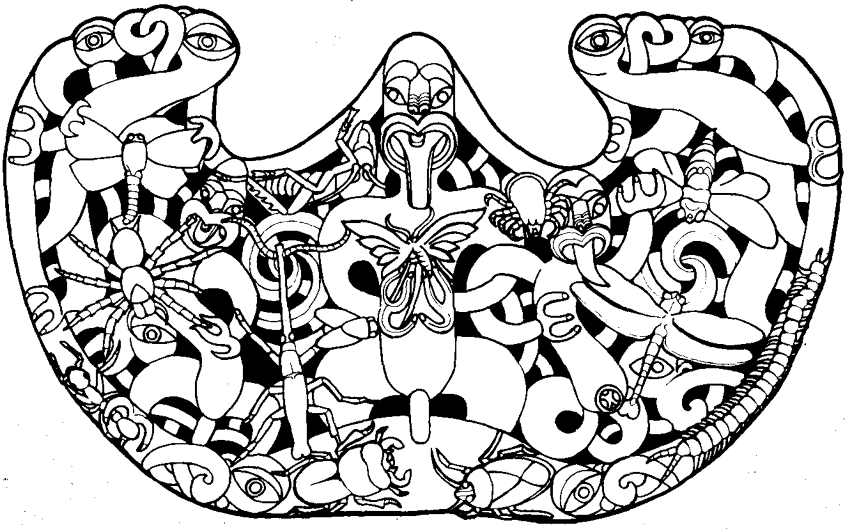


Fauna of New Zealand

Ko te Aitanga Pepeke o Aotearoa

'FAUNA' ADVISORY GROUP

LANDCARE RESEARCH REPRESENTATIVES

UNIVERSITIES REPRESENTATIVE

MUSEUMS REPRESENTATIVE

OVERSEAS REPRESENTATIVE

SERIES EDITOR
'FAUNA OF NEW ZEALAND'

Fauna of New Zealand
Ko te Aitanga Pepeke o Aotearoa

Number / Nama 30

Hepialidae
(Insecta: Lepidoptera)

J.S. Dugdale

Manaaki Whenua - Landcare Research
Native Plants and Animals Division
Mount Albert Research Centre
Private Bag 92170
Auckland, New Zealand

Manaaki
Whenua
PRESS

Lincoln, Canterbury, New Zealand
1994

Cataloguing in publication

DUGDALE, J. S.
Hepialidae (Insecta: Lepidoptera). – Lincoln, N.Z. :
Manaaki Whenua Press, 1994.
(Fauna of New Zealand, ISSN 0111–5383 ; no. 30).
ISBN 0-478-04524-7

I. Title II. Series

UDC 595.787(931)

Prepared for publication by the Series Editor using computer-based text processing, layout, and printing at Landcare Research New Zealand Ltd, Mt Albert Research Centre, Private Bag 92170, Auckland, N.Z.

Maori text by UniServices Translation Centre, Auckland

Published by Manaaki Whenua Press, Landcare Research New Zealand Ltd,
P.O. Box 40, Lincoln, Canterbury, New Zealand

Printed by GP Print Ltd, Wellington

Front cover The insect depicted is *Dumbletonius characterifer*, male. Illustrator: Des Helmore.

Aro mua Ko te ngaarara nei a *Dumbletonius characterifer*, taane. Kai-whakaahua: Des Helmore.

POPULAR SUMMARY — HE WHAKAPOTONGA MA TE MAREA

Class / Karaaihe **Insecta**
Order / Oota **Lepidoptera**

Family / Whaamere

Hepialidae

Ghost moths, swift moths, porina

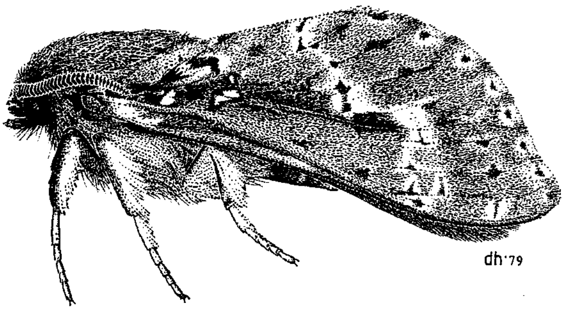


Illustration / Whakaahua: *Wiseana cervinata*, male / taane.
Illustrator / Kai-whakaahua: Des Helmore.

The Hepialidae in New Zealand are well known by the common name porina, but strictly this refers only to the pasture pest genus *Wiseana*. The economic damage to pasture grasses caused by the feeding activity of porina caterpillars is second only to that of grass grubs.

Perhaps better known to many New Zealanders is the puriri moth, *Aenetus virescens*. The large, conspicuous, green-winged adults with glowing red eyes are attracted to street lamps and domestic lighting in the North Island.

Seven genera of Hepialidae are recognised in New Zealand, comprising 27 species, several of them newly described. Some are apparently very localised, and there is a focus of species diversity in the southern South Island, particularly in native forests and in high-country shrub/ grassland and swampy habitats. All species are endemic.

Hepialidae are mostly moderate-sized moths with a wingspan in the range 45–70 mm, though smaller (35 mm) and much larger (up to 150 mm) examples are known. The often highly patterned wings are usually large and strong, and many species are known to be swift fliers, though tending not to disperse far from their place of origin. Large females of the puriri moth are the largest and heaviest Lepidoptera native to New Zealand.

From a conservation perspective it is important to realise that most New Zealand hepialid moths are not pests, but are

(continued overleaf)

Kanui te moohiotia o te Hepialidae i Niutiireni nei i te ingoa noa iho 'porina', heoi ko te ngaarara paaraka kee teenei no te momo whakahoohaa nei i heke iho mai i a *Wiseana.* Ko nga mahi kino ka puta ki nga karaihe o nga paaraka, i nga mahi kaikaitanga o nga anuhe porina, tuarua noa iho ki kite whai hua nga toke kai karaihe.

Teenaa pea ko te mea e moohio whaanuitia ana ki te iwi tini o Niutiireni nei ko te pepe puuriri nei a *Aenetus virescens.* Ko te mea nui, ka kitea tonu, ko te pakeke, oona paakau kaakaariki, kanohi kura whero, roharoha haere ana ki nga raiti tiriti, ki nga raiti kaainga hoki o Te Ika a Maaui.

E whitu nga taatai o Hepialidae e moohiotia ana i Niutiireni, ka heke iho ki roto nei e rua tekau maa whitu momo, e hia anoo katahi anoo ka whakahuatia. Ko eetahi ka noho rawa ki eetahi rohe, aa, ko eetahi ka haangai ki nga aahua momo ki te rohe tonga o Te Waipounamu, i roto i nga ngaaherehere o Taane aa, ki nga whenua tiketike, i nga waahi o nga raakau itiiti/ waahi karaihe me nga reporepo ka nohoina. Ko nga momo katoa no konei anoo, kiihai ki eetahi atu whenua.

Ko Hepialidae ko te nuinga kaahore i rahi rawa nga puurerehua, he whaa tekau maa rima – ki te whitu tekau mira mita (45–70 mm) te roa o nga paakau engari e moohiotia ana nga momo iti atu, toru tekau maa rima mira mita (35 mm) me nga mea tino rahi tae atu ki te kotahi rau e rima tekau mira mita (150 mm) e moohiotia ana. Ko nga paakau kanui te tini o nga tauira, te nunui me te kaha katoa, aa, kanui te tini o nga momo e moohiotia ana mo te rere kaha, heoi, e kore rere ka wewehe tawhiti atu i too raatou kaainga tuuturu ko nga uwha nunui o te pepe puuriri, ko te mea rahi, te mea tino taimaha o Lepidoptera tuuturu mai anoo ki Niutiireni nei.

Mai te tirohanga kaitiaki ko te mea nui anoo kia moohio, ko te nuinga o nga pepe Hepialidae o Niu Tiireni ehara i te

(ara haere tonu)

native species occurring nowhere else. Many are localised, perhaps rare, and possibly threatened with extinction. More information is needed about their biology and status.

The biology of the puriri moth has recently been closely studied. Young larvae hatch from eggs in the forest leaf litter, where they begin their development. They then moult into a conspicuous 'transfer phase' form which moves out of the litter and climbs the trunk of a suitable host tree. Many tree species, both native and introduced, are used as hosts, of which the puriri is but one.

The larva forms a typical '7'-shaped tunnel and a silk-covered external feeding scar over the entrance. Once established the larvae moult into the 'tree phase', in which they complete their growth. The entire larval period may take as much as 4 years, and mature larvae may exceed 100 mm in length. Pupation occurs inside the shaft, and most adults emerge in spring or early summer.

Porina moths too have an early litter-phase larva, which subsequently digs a burrow more or less vertically into the soil. The shaft-phase larva lines the burrow with silk, and constructs a silken 'runway' from the entrance out to its feeding area. Emerging at night, the caterpillar cuts grass shoots at the base and drags them back into the burrow, to be consumed later. Cut plant material and frass (faecal pellets) may be stored in side chambers excavated from within the main burrow. The life cycle is completed in 1 year, and adults may be on the wing between September and April, depending on species and locality.

Adult hepialids have no functional mouthparts, and their lifespan is consequently brief. Allowing for predation by morepork owls, cats, and possums the average is probably less than a week. They emerge and fly in the late afternoon or around dusk, and may be on the wing for only an hour or so, especially the males. For most species emergence is greatest in warm, misty weather, giving rise (in crepuscular species) to 'flight nights'. Females ready for mating attract males to them by releasing a 'sexual scent' called a pheromone. Handling a recently emerged female makes one's fingers attractive to any males circling nearby!

*Contributor **John S. Dugdale** was born in New Zealand, and is an alumnus of Canterbury College (University of New Zealand), Christchurch. John has been employed as an entomologist with the N.Z. Forest Service (1956–67), and subsequently with the Entomology Division of DSIR. He is currently a scientist with the Native Plants and Animals Division of Manaaki Whenua - Landcare Research, specialising in Lepidoptera. John's earlier contribution to the 'Fauna' series – no. 14, 'Lepidoptera: annotated catalogue, and keys to family-group taxa' – has become a best-seller since its publication in 1988.*

orotaa, engari he tuuturu ake no konei, kiihai e kitea ana i hea atu. Ko te nuinga kua tatuu kee te noho i eetahi waahi anahe, kua onge, aa, e ahu atu ana ki te 'ngaro-aa-moa'. E maha nga whakaaturanga ka hiahiatia, i too raatou koiora aahua noho aahua tuu.

Ko te koiora o te pepe puuriri ka aata tauiratia. Ko nga iroiro ka whaanau mai i nga heeki i roto i nga rau taka o te ngahere, ko reira tiimata mai ai te tupu. A muri mai kua tukua te kiri he 'waa whitinga' i te aahua, ka puta ka neke i nga raurau otaota ka kake i te kaatua o teetahi raakau, kei reira noho ai. Kanui te maha o nga momo raakau, no konei anoo, raakau me mau mai no taawahi raanei, ka nohoa, ko te pepe puuriri noa teetahi.

Ko nga pepe porina e pee nei ana anoo ka tiimata wawe ana te waa huhutanga mai anoo i nga rau otaota, aa, ka huri i te keri ara tuu heke tika ki roto i te oneone. Ko te huhu noho waa puta ka hanga kiri hiraka i roto i te puta, aa, me te 'whitinga' hirika mai te urunga tae noa ki te waahi kai. I te poo ka puta te anuhe i te poroporo tupu karaihe mai i te tumu ka tooia mai ki roto i te puta hei kai a muri mai. Ko nga tarutaru otaota me nga (pookarakara tiko) ka kohikohia i nga tahataha koohao i roto o te putanui me kerikeri mai anoo. Kotahi tau ka pau te mauri ora, aa, ka rerere nga mea pakeke eetahi momo o eetahi waahi i waenganui i Hepetema ki Aaperira.

Ko nga Hepialidae kua pakeke, hore kau e mahi ana nga waahi o te waaha, aa, e kore anoo e ora roa. Mehe whakaarotia ana, he kai na te koukou, te ruru, tori, me te *possum*, kaaore pea i koni atu i te wiki te nuinga (e ora ai). E puta ana i te rerere i te ahiahi, muri ahiahi, aa, kotahi anoo pea haaora nga tame rawa atu, rerere ai. Ka puta te nuinga o nga momo i te waa mahana, kohukohu raanei i puta ai ki runga te momo o (*crepuscular*) i te 'rerere poo'. Ko nga uwha ka hiahia taane, ka tukua he 'waikakara mahimahi' ko te ingoa ko *pheromone*. Ka tangotangohia he uwha puta ki oou ringaringa ka taetae mai nga tame e rerere tata mai ana!

*Kai tuhi **John S. Dugdale** i whaanau mai ia i Niutiireni, toona maatauranga i riro mai i te Kaareti o Canterbury (Whare Waananga o Niutiireni), Ootautahi. Ko te mahi a Hoone he tauira i te aahua noho o nga ngaarara i te N.Z. Forest Service (1956–67) aa, i muri atu ka haere ki te Entomology Division o DSIR. Inaininei he puutaiao ia ki te wehenga o Nga Tamariki a Taane o te Taha Manaaki Whenua - taha Kaitiaki Rangahau, tohungatanga i te ngaarara Lepidoptera. Ko te tuhinga a Hoone i te pukapuka o nga honohono o 'Fauna' – (pukapuka) tekau maa whaa, 'Lepidoptera: he pukapuka whakaraarangi whakakaupapa me te huarahi whakamaarama i nga taatai momo roopu whaanau' – he tino maha kua hokoina mai i te putanga i te pereehi mai i te tau 1988.*

ABSTRACT

New Zealand's ghost moths and porina moths are revised. Seven genera are recognised: *Aenetus, Aoraia, Cladoxycanus, Dioxycanus, Dumbletonius, Heloxycanus* new genus, and *Wiseana*. Twenty-seven species are recognised, of which *Aoraia aspina, A. flavida, A. hespera, A. insularis, A. lenis, A. macropis, A. oreobolae, A. orientalis, A. rufivena,* and *Heloxycanus patricki* are new. *Dumbletonius sylvicola* Dugdale, 1988 is reduced to synonymy with *D. unimaculatus* (Salmon, 1948). Morphology of adult, pupa, larva, and male genital musculature is reviewed, along with relationships and biology, including phenology and biotopes. Keys to taxa are given for all life stages authenticated to species, and each genus and species is defined. Habitus and structures are illustrated for each species, and distributions are mapped. Four lineages are represented: *Aenetus*, shared with Australia; *Aoraia* and *Cladoxycanus*, two unrelated terminal taxa; and the *'Oxycanus'* group, or porina moths, with an Australian sister-group. *Wiseana* includes significant pasture pests, and recognition of species has been supported by electrophoretic studies conducted elsewhere; *W. fuliginea* has been 'rediscovered' through these studies.

CHECKLIST OF TAXA

CONTENTS

ACKNOWLEDGMENTS

During tenure of a DSIR Study Award at the British Museum (Natural History) in London I examined type specimens of New Zealand Hepialidae. I thank the then Keeper of Entomology, Dr L.A. Mound, for making facilities available, and Dr G.S. Robinson for assistance and for gifts of exotic Hepialidae. I thank Dr Ebbe S. Nielsen and Mr E.D. Edwards (ANIC, Canberra) for unstinting help and for hospitality during comparison of Australian and New Zealand hepialids. Dr K. Ueda (Kitakyushu, Japan) and D. Wagner (University of Connecticutt) kindly provided valuable material for comparison.

Within New Zealand, I thank Dr Barbara Barratt (Invermay), Dr E.P. Burgess (Mt Albert), Dr Allan Carpenter (Levin), Mr J.M. Clark (Inglewood), Mr Jim Esson (Palmerston North), Prof. Peter Fenemore (Massey University), the late Dr K.J. Fox (Manaia), Dr John R. Grehan, Mr John Herbert (Victoria University), Mr Brian Lyford (Queenstown), Mr Gordon MacArthur (Victoria University), Dr John Marshall (Lincoln), Mr Hugh Oliver (Ruakura), Mr Brian Patrick (Dunedin), Mr Peter Peckham (New Plymouth), Mr David Perrott (Nelson), Mr John Valentine (Upper Moutere), Mrs Elspeth Waghorn (Upper Moutere), and Dr P. Wigley (Auckland) for vital material, sharing of information, and some highly productive joint field trips.

I am particularly grateful to Mr Brian Patrick, whose assiduous collecting and acute observation led to the discovery of a new genus and six new species.

The SEMs were prepared by Mr Paul Sutherland, Hort+Research CRI, Mt Albert.

Des Helmore's habitus drawings are a bonus, and I am grateful for his contribution, as they will be used more than the text, and have saved oceans of verbiage.

As ever, my colleagues Dr Trevor Crosby and Mr Cleveland Duval have provided willing assistance. I also thank my Director / General Manager, Mr John Longworth, for continued support.

I am grateful to Dr Nielsen and Mr Patrick for reading the manuscript and providing valuable suggestions.

This work was latterly supported by the Foundation for Research Science & Technology under contract CO9230.

INTRODUCTION

The ghost moths or swift moths belong to the Hepialidae, the largest family in the lepidopteran superfamily Hepialoidea. The family has around 500 described species worldwide, most of them in South America (Nielsen & Robinson 1983), but there is considerable diversity in South Africa (Janse 1942) and in Australia (Common 1990). In New Zealand twenty-seven species in seven genera are now recognised. The name 'ghost moth' is based on the European *Hepialus humuli* Linnaeus, males of which appear ghostly white.

In New Zealand, Australia, and southern South America swift moths sporadically or regularly occur in huge numbers, and have a significant impact on human activity. Larvae of 'porina' (*Wiseana* species) in New Zealand and 'corbies' (*Oncopera* species) in Australia affect pasture production. The puriri moth, *Aenetus virescens* (Doubleday), is not only our largest moth species (females can exceed 140 mm wingspan) but is abundant in several North Island cities and towns. Damage by its larva to beech *(Nothofagus)* trees has curtailed their use for timber and veneer, and thus assisted the perpetuation of their role as watershed protection forests. In parts of eastern Australia, sale of reared adults of the related lizard-head moth, *Zelotypia stacyi* (Scott), augmented the incomes of some residents in the early 1900s. Even the parasitic fungus *Cordyceps* has – or had – some commercial value: the mummified caterpillars with the elongate fruiting body attached were sold to tourists travelling through the Mamaku Plateau (BP). The ground-up fruiting body was also used by Maori as an ingredient in tattoo pigment (Best 1912).

Hepialidae in New Zealand have several values: (a) scientific – as all our species are endemic, and the genera they are placed in can be distinguished from genera in other countries, their biodiversity and systematic values are high; (b) economic – porina are significant competitors with farm stock for pasture; (c) conservation – many species have restricted distributions, most are striking in appearance and size, and many are restricted to unmodified or relatively unmodified biotopes including forest, shrubland, wetlands and cushion bogs, or penalpine or alpine swards, the last three in the absence of cattle. Above all, they are a distinctive and significant part of Aotearoa / New Zealand, and some of them are among the bigger and more elegantly patterned hepialids on Earth.

Despite their abundance *(Dumbletonius, Wiseana)* or huge size *(Aenetus)*, their presence in lowland sites, their regular periodic adult emergences (flights), and their attraction to light, it is curious that no Hepialidae were brought to England from New Zealand by naturalists on Cook's voyages. Upon each visit, long periods were spent anchored close to shore in Queen Charlotte Sound (SD) during the flight season of *Dumbletonius* and *Wiseana*, and again, Cook's survey of Dusky Sound (FD) took place during the flight season of the large, robust *Aoraia* species. Male *Aoraia* are suicidally attracted to most light sources.

The earliest hepialid specimens from New Zealand were sent to London (and possibly Germany) by Ernest Dieffenbach in 1840 and by J.G. Children at about the same time. Dieffenbach's specimen has not been located; it was described by Doubleday in 1843. With the establishment of Auckland as a major settlement – and, briefly, as capital city – more specimens were sent, collected by Dr Andrew Sinclair and Lt Col. Daniel Bolton. From Hawkes Bay William Colenso sent *D. characterifer*, and more *Aenetus* were sent by Percy Earl in 1845 and by a Mr Churton in 1851. Francis Walker at the British Museum published descriptions of four species, but only one of these is now regarded as valid.

With increasing European settlement and exploration came increasing numbers of specimens. Francis Walker described species (only two now regarded as valid) collected by T.R. Oxley from Nelson, but recorded as from Auckland; Achille Guenée in Paris described material sent from Christchurch by the lawyer R.W. Fereday; and yet another synonym *(fischeri)* of *A. virescens* was described by Dr C. Felder, on the strength of a specimen collected at Auckland during the voyage of the Austrian frigate 'Novara'. By 1880 the British Museum had received two large collections, one from Otago by Dr James Hector, the other from Canterbury and Hawkes Bay by J.D. Enys. A.G. Butler described species of Hepialidae from both collections.

Meanwhile, back in the colony, local expertise was developing. Sir Walter Buller described and illustrated a large ("5 in, 11 lines") hepialid adult found by him in the Ruahine Ranges (HB). Buller's specimen, erroneously reported as lost at sea (Hudson 1898), was probably landed at London (Meads 1990) and may have been purchased by a private buyer. No convincingly similar recent specimen has been collected. Edward Meyrick collected extensively in New Zealand during 1880–86, and struck up a friendship with G.V. Hudson of Wellington and later, by correspondence, with Alfred Philpott of Invercargill. All three described Hepialidae, publishing in the 'Transactions of the New Zealand Institute'.

Up until L.J. Dumbleton's studies (published 1966), three genera were recognised: *Charagia* Walker (for *Hepialus* of authors), *Porina* Walker (a preoccupied name), and *Wiseana* Viette. Dumbleton swept all that away, put the puriri moth in *Aenetus* (following N.B. Tindale's work in Australia), defined four new genera, and recognised and rearranged (or synonymised) the *Wiseana* species. *Wiseana* as a genus was appropriately defined (as *Philpottia*) by Paul Viette in Paris, 98 years after Achille Guenée had worked there on New Zealand Hepialidae. K.A.J. Wise had advised Viette that the name *Philpottia* was preoccupied, so Viette in 1961 gratefully named New Zealand's second most significant pasture pest group after him.

Since Dumbleton's study, most work in New Zealand has concentrated on pasture-inhabiting *Wiseana* (porina) biology in relation to control measures. Interpretations of these studies were affected by the considerable complexity of many porina populations and the large differences in population make-up between localities. These complexities are becoming better understood; for example, compare Helson (1967) and Barratt *et al.* (1990). Today, field work in both production pasture and 'natural' biotopes, notably by B.I.P. Barratt, N. Barlow, A. Carpenter, J. Grehan, and B.H. Patrick, has revealed a highly complex fauna with areas of surprisingly high diversity, e.g., the *Wiseana* complex in the South Island and the *Aoraia* complex in certain contiguous Central Otago mountain ranges.

SYSTEMATIC RELATIONSHIPS

The New Zealand genera are all included in Hepialidae *sensu stricto* (s.s.), one of 12 monophyletic entities recognised in the Exoporia (superfamilies Hepialoidea + Mnesarchaeoidea – Nielsen 1989). Formally, within Hepialoidea, five families are recognised in the literature: Palaeosetidae, Neotheoridae, Anomosetidae, Prototheoridae, and Hepialidae. 'Hepialidae' in the conventional sense (e.g., Janse 1942, Common 1990) is regarded as Hepialidae *sensu lato* (s.l.), and covers (1) the 'primitive Hepialidae', a convenience term for the terminal taxa *Fraus* Walker, *Gazoryeta* Hübner, *Afrotheora* Nielsen & Scoble, and *Antihepialus* Janse, and (2) the Hepialidae s.s., comprising other hepialid genera, including all New Zealand genera and all Australian genera except *Fraus* (Nielsen & Kristensen 1989, p. 113). Nielsen & Scoble (1986) discuss the evidence for the monophyly of each genus in 'primitive Hepialidae' and of the Hepialidae s.s.

Dumbleton (1966) recognised six of the seven genera treated here (*Heloxycanus* was unknown until 1979), and further recognised that *Aenetus* and *Aoraia* are not closely related to the others, which (except for *Cladoxycanus*) form a rather compact group. His primary division into Hepialinae and Oxycaninae has been shown to include paraphyletic assemblages, and is based on a single character "which can only be apomorphic in one state" (Nielsen & Robinson 1983, p. 44). Dumbleton's generic concepts are upheld here, and in many instances the present treatment only refines the evidence.

The seven genera here recognised in the New Zealand fauna represent four discrete lineages, and in only one *(Aenetus)* is any part of their phylogeny 'resolved'.

(1) *Aenetus*, shared with Australia, New Caledonia, New Guinea (Papua-New Guinea + Irian Jaya), and part of the Banda Arc; *Zelotypia* (E. Australia) is regarded as part of this lineage.

(2) '*Oxycanus*' lineages (Oxycaninae of Dumbleton, in part), also present in Australia, New Guinea, Borneo, S.E. Asia, China, and the Himalayas. On the evidence of male genitalia there are two sublineages: (2a) '*Oxycanus*', with *Dioxycanus, Dumbletonius, Heloxycanus*, and *Wiseana*; (2b) *Cladoxycanus*, with no apparent relatives.

(3) *Aoraia*, with no relatives elsewhere so far unequivocally recognised.

(1) *Aenetus* lineage

On larval and pupal characters (see relevant sections below) and on biology (Grehan 1987b) this lineage includes *Zelotypia* and, more distantly, the *Endoclita* group, an allopatric assemblage (Grehan 1987b) in S.E. Asia, as the *Aenetus* and *Endoclita* groups are not known to overlap.

Within *Aenetus* there is a common facies and great similarity of colour pattern and of differences involved in sexual dimorphism. In contrast to the conclusions based on tunnel construction reached by Grehan (1987b, p. 459), *A. virescens* differs from the New Caledonian *A. cohici* and eight Australian species in labial palpus structure, male hind tibial structure, male and female 'postabdomen' (segments 7–10) structure, male valval structure, and female anogenital configuration. The clavate labial palpus, slit-like anogenital field in the female, lack of an apical tooth on the male valva, and lack of a dorso-apical process on the hind tibia in the male (cf. Fig. 212, *A. virescens*, Fig. 213, *A. ligniveren*, and Grehan 1983c, fig. 1) define *A. virescens* in relation to other *Aenetus* species.

There could be a case for reinstating *Charagia* for *virescens*, but it would be a rather uninformative move, and possibly short-lived. There are more than eight Australian species to be considered, and I have not examined in any detail the New Guinean or Banda Arc species.

(2a) '*Oxycanus*' lineage s.s.

In this lineage are included hepialids with the following features.

(i) Forewing veins R_4 and R_5 arising separately from a combined R_2–R_5 stem (Fig. 76–80).

(ii) Antennal flagellomeres with basal and apical setose prominences (but these also in *Parapielus* species: Nielsen & Robinson 1983, fig. 248–252).

(iii) Male pseudotegumen with large twin processes supporting the anal tube.

(iv) Corpus bursae ovoid, with a large or small appendix (Australian *Elhamma* Walker and some *Wiseana* species lack an appendix, possibly a secondary loss).

(v) Antennal flagellomeres unscaled, or if with scales then on the first two or three segments only, and sparse.

(vi) Male pseudotegumen dorsally elaborate, well developed.

(vii) Forewing vein R_{2+3} stalk shorter than free part of R_3.

(viii) Female anogenital field higher than wide, with ovipore at or above mid-field height, and often hidden by the bilobate intergenital lobe dorsal (mesal) apices.

(ix) Female tergum 8 caudal margin with a prominent, dense, broad tuft of long, hair-like scales (though this is susceptible to wear).

In contrast to Australian *Oxycanus* Walker and *Elhamma* Walker, New Guinean *Zauxius* Viette and *Paraoxycanus* Viette, and the Bornean-Oriental genera (Ueda 1988, fig. 6, 7), the New Zealand genera lack paranal sclerites in the male (cf. Fig. 300, 303, *Dumbletonius*, and Ueda 1988, fig. 6, as "subanal" sclerites). Lack of the paranal sclerites clearly defines the New Zealand assemblage from the Australian-Oriental assemblages.

Within the New Zealand assemblage *Dumbletonius* and *Wiseana* have little in common with each other; only *Dioxycanus* and *Heloxycanus* share similar pupal, female dorsal plate, sinus seminalis, and sternum 9 conditions and reduced palpi. The pupal and palpal conditions are loss apomorphies, and the dorsal plate, sinus, and sternum 9 conditions are considered to be plesiomorphous (dorsal plate halves large, drooping, subtriangular, sinus open, and sternum 9 with broad central piece and distinctly demarcated, well developed side pieces). These conditions are observable in, for instance, *Fraus* species (Nielsen & Kristensen 1989, e.g., fig. 127, 405). A phylogenetic reconstruction at this stage would be premature, as most of the Australian *Oxycanus* group has not been examined in detail.

(2b) *'Oxycanus'* lineage, *Cladoxycanus*

Cladoxycanus lacks several conditions listed in (2a), principally (vi) the dorsal part of the pseudotegumen is scarcely developed, (iii) the pseudotegumen twin processes are obsolete (Fig. 289, 290), and (iv) the corpus bursae is globose and non-appendiculate. Several other characters set this genus apart in the New Zealand fauna.

(x) Arolium absent.

(xi) Larva without mesothoracic, metathoracic, or abdominal sternal sclerites.

(xii) No sclerotised bridge between apices of pseudotegumen.

(xiii) Labial palpus basal segments with rami.

(xiv) Forewing discal cell apex (vein r-m) well before half wing length.

(xv) Female dorsal plate with lateral sclerotised setose lips fused in dorsal midline and forming a mesal tubercle.

Cladoxycanus shares characters (x) and (xii) with *Calada fuegensis* Nielsen & Robinson from southern South America, but otherwise lacks resemblances. In the current state of interpretation, *Cladoxycanus* is yet another unresolved terminal taxon, possibly part of the *Oxycanus* group (the female has a strong tergum 8 tuft), but like *Jeana* Tindale and *'Oxycanus' sphragidias* Meyrick in Australia is distant from the typical members of that group.

(3) *Aoraia*

Aoraia is definable within the New Zealand, Australian, and southern South American Hepialidae s.s. on two characters.

(xvi) Larval head capsule setal pit La situated not by seta L_1 but beside epicranial lateral notch (Fig. 162).

(xvii) Trulleum with a basal conical projection (e.g., Fig. 227, 234).

In rough conformation adults of *Aoraia* species look rather like those of *Antihepialus* Janse (cf. Fig. 7–31 and Janse 1942, pl. lix fig. 5), having an intricate forewing pattern and shaggy vestiture on the head, palpi, thorax, and legs (Janse 1942, p. 33). The wing venation is different (R_{2+3} stem relatively short in *Antihepialus*; cf. Janse 1942, pl. xlix fig. 6, and Fig. 75, *Aoraia*). The form of the trulleum in *Antihepialus* – with a long, decurved, free, beak-like apex (Janse 1942, fig. 70) – indicates that this genus is a member of the 'primitive Hepialidae', and therefore seemingly not relevant to *Aoraia*. However, if the conical process on the *Aoraia* trulleum is a reduced 'beak', then *Aoraia* might be considered a member of the primitive Hepialidae. *Aoraia* alone of genera examined has a polygonal katepisternite.

The African genera *Gorgopis* Hübner and *Eudalaca* Viette, which on trulleum structure are members of the Hepialidae s.s., have some characters in common with *Aoraia* (see Janse 1942, pp. 41–42).

(xviii) Shaggy vestiture on head, palpi, thorax, legs, and abdomen.

(xix) Antennal segments long pectinate, with stiff setae on the pectinations.

(xx) A subantennal tuft extending over the eyes (diffuse in some *Aoraia* species).

(xxi) Trulleum basically V-shaped, with a quadrate base (Fig. 234, 247).

(xxii) Pseudotegumen ventral apices free (*Eudalaca ammon*, not in *Gorgopis*).

(xxiii) Female sternum 9 mid-piece massive, rounded, mesally emarginate, with side-pieces well demarcated.

Australian *Abantiades* and *Trictena* have characteristic 'rabbit ear' lobes dorsally at the base of the pseudotegumen, a rectangular trulleum, appressed vestiture (not shaggy), and none of the pupal features of *Aoraia*. None of the South American genera described by Nielsen & Robinson (1983) resembles *Aoraia*. There are possible resemblances to *Sthenopis*, but not enough has been done to establish what, for instance, in pseudotegumen structure constitutes a plesiomorphous condition.

Aoraia appears to share several features with South African *Antihepialus*, *Eudalaca*, and *Gorgopis*, though many shared features may prove to be plesiomorphous. *Aoraia* shows many relatively underived conditions, e.g., maxillary palpus structure (Fig. 88), head sclerites (Fig. 87–89), thoracic structure (Fig. 112, 119, 127), and venation (Fig. 75). Larvae (Fig. 182) show a sclerite pattern on the abdomen that I have seen so far only in a larva of *Antihepialus* (see p. 41) from Storms River National Park, R.S.A.; also on this larva, head capsule setal puncture La is distant from seta L_1 and closer to the lateral epicranial notch (but not as close as in *Aoraia*, Fig. 162). But little can be gleaned from this, except that the *Aoraia* facies is seemingly present in Africa; the relationship – if one exists – may be extremely distant.

MORPHOLOGY

General. All New Zealand species belong to the family Hepialidae s.s. (Nielsen & Scoble 1986, Nielsen & Kristensen 1989), the major constituent of the superfamily Hepialoidea of the Ditrysia: Exoporia. Unlike other groups with homoneurous venation (forewings and hind wings with very similar venation) and a jugate (Fig. 73–80) rather than frenulate wing coupling system, Hepialoidea and Mnesarchaeoidea have a separate copulatory pore (ventral) and ovipore (dorsal) on the anogenital field, and the common oviduct is dorsal to the bursa copulatrix (Dugdale 1974, Common 1990). They differ, however, from the Ditrysia: Endoporia (i.e., the other 95% of Lepidoptera) in that (1) collaterial glands are absent, and (2) sperm is transferred from the bursa copulatrix to the oviduct and spermatheca via a vertical external gutter or sinus (see discussion in Nielsen & Kristensen 1989, p. 75). There is one exception, *Trichophassus giganteus* le Cerf (Brazil), in which there is an internal ductus seminalis (Bourgogne 1949) which originates on the antrum (or vestibule) to the bursa copulatrix. In Ditrysia: Endoporia the ductus seminalis arises on the ductus bursae, anterior to the colliculum or collicular area. In other words, the two functionally analogous structures are not morphologically homologous.

New Zealand hepialids have a distinctive facies, irrespective of genus. The antennae are short, i.e., clearly less than half as long as the forewing, the moth in repose is sleek with the wings held roofwise, the head lacks ocelli, the hind legs are shorter than the fore and middle legs, and the thorax is robust. In dorsal view the adult at rest tapers posteriorly from the wide mesothorax. Ventrally the body, legs, and wings are clothed in a long, often shaggy, pilose vestiture.

Larvae are elongate, with the ocelli arranged in two more or less vertical rows and the antennal base bounded anteriorly by a discrete preantennal bar with a ventral slit (Nielsen & Kristensen 1989, p. 91). Abdominal segment 9 is nearly as long as A8.

The pupa is long, with spine crests on the abdomen and with A3–7 movable, allowing it to travel up and down the silk-lined larval shaft and to protrude itself from the larval shaft at ecdysis. Presence of hepialids at a site is often indicated by the exuviae, which either remain protruding from the tunnel entrance (e.g., *Aenetus*) or are blown about on the turf (e.g., *Aoraia, Wiseana* species).

In the following sections aspects of adult, larval, and pupal morphology are discussed and illustrated, largely in the light of Nielsen & Kristensen (1989). By and large there seem to be in Hepialidae s.s. many repetitive grades (transformation series) and very few reliable apomorphies (see Nielsen & Kristensen 1989, p. 113). The dearth of such apomorphies makes recognition of monophyletic groups difficult.

Adult

Head capsule. All New Zealand genera except *Aenetus* have the compound eyes well separated. The interocular index (Davis 1975) – vertical eye diameter divided by the distance between eye margins at a point halfway between antennal bases and the anterior tentorial pit – is usually 1.6–2.2 in males and less than 1.0 in females. *Aenetus* male indices exceed 3.0, i.e., the eyes are large and close together. In some *Aoraia* species there is eye reduction in females; eyes are reduced in both sexes of *A. orientalis* and *A. senex*. In all genera there is no subgenal process. The compound eyes lack interommatidial setae.

The antennal sockets abut the inner margin of each compound eye, which is more or less shallowly emarginate in this zone. The dorsal and ventral cranial condyles are well developed, and the socket margins are reinforced in all genera.

All New Zealand genera have clearly defined zones on the head capsule. The nomenclature of these zones, which have, in part, a plausible similarity in disposition to the larval head sclerites, has been approached with caution by most workers (e.g., Kristensen 1968). The frons has been defined implicitly by Nielsen & Kristensen (1989, p. 1) as the (scaled) zone above that (unscaled) zone on which the cibarial adductors insert. Proceeding from the ventral (suprabuccal) zone to the occiput, the following regions or zones – all bounded by either sulci or sutures or changes in surface microsculpture – are recognised here (Fig. 84, 87, 89).

Labrum: bituberculate and projecting (most *Aoraia* species, and *Dioxycanus, Cladoxycanus, Heloxycanus*) or greatly reduced (*Aenetus, Dumbletonius, Wiseana*).

Clypeus: a scobinate, unscaled, oblong or dorsomesally emarginate zone, often deflected, facing anteroventrally, and with 1 or 2 pairs of lateral, rimmed pits.

Lower frons: scaled, convex, facing anteriorly and, just below each antennal socket margin, bearing marginally the anterior tentorial pit; ending dorsally at a transverse interantennal socket sulcus or suture. This zone may or may not be equivalent to the larval frons.

Upper frons: a roughly triangular sclerite, narrowed between the antennal sockets and widening posteriorly to abut the vertex; sometimes with a median sulcus, and bearing one or two pairs of small, blunt processes. This zone equates to the 'vertex' of authors.

Vertex: bounded laterally by the compound eyes, anteriorly by the upper frons, and posteriorly by the dorsal rim of the occiput. This planoconvex zone (flat, and in male *Aenetus* reduced to a longitudinal ribbon) bears a pair of nipples (most genera) or is smooth *(Aoraia).*

Occiput: the back of the head; dorsally with a triangular midline area more or less sclerotised. The occipital area bounds the foramen laterally, and may be shallowly or deeply concave. Where the concavity is shallow (e.g., *Heloxycanus*, Fig. 103) the concave area is dorsal to the occipital condyles. Where the concavity is deep (e.g., *Aoraia*, Fig. 88) the concave area extends below the level of the occipital condyles.

The **occipital condyles** arise separate from, and dorsal to, the **corporotentorium**. The corporotentorium may have a more or less developed posteromedian tentorial process (large in *Aenetus*, *Aoraia*, Fig. 82, 88; small in *Cladoxycanus*, *Wiseana*, Fig. 92, 107). The anterior tentorial arms arise on the corporotentorium, which is straight in most genera. In *Aoraia* (Fig. 88) the arms arise on a basal flexure of the corporotentorium.

The **tentorium** (Nielsen & Kristensen 1989, p. 4, fig. 6) ventral process may be absent *(Aenetus, Aoraia)* or present (other genera). If present it may be reduced *(Cladoxycanus, Heloxycanus)*, broadly triangular *(Dioxycanus, Dumbletonius)*, or almost spiniform *(Wiseana)*.

Mouthparts (including post-labium). There are no **pilifers**. The **mandibles** are present in all New Zealand genera except *Dumbletonius* and *Cladoxycanus*, and are large and pyriform in *Heloxycanus* and *Aoraia*. The **maxilla** consists of a palpus, a rudimentary galea, and ventrally a **basal maxillary piece** (or basistipes) which is often more or less sclerotised and prominently displayed on either side of the prelabium.

The **galea** (or proboscis rudiment: Nielsen & Kristensen 1989) is usually reduced to a short, thumb-like process often with apical scales or setae (most genera) or to a minute tubercle *(Heloxycanus)*.

The **maxillary palpi** may be two-segmented and slender *(Dumbletonius, Wiseana)* or stumpy *(Aoraia)*, or one-segmented and apically setose and adze-shaped *(Aenetus, Cladoxycanus)* or mound-like *(Dioxycanus, Heloxycanus)*.

The **labial complex** consists of the labial palpi, the prelabium, the 'post-labium' or mentum (usually very reduced), and the submentum (post-labium of Nielsen & Kristensen 1989).

The **labial palpi** are three-segmented with an apical vom Rath's organ in *Aoraia, Aenetus, Cladoxycanus, Dumbletonius*, and *Wiseana;* in *Cladoxycanus* the basal segment is ramiform (Dumbleton 1966). In *Dioxycanus* and *Heloxycanus* the labial palpi are basically two-segmented (or asymmetrically three-segmented) and lack a sunken apical vom Rath's organ. All segments are covered in a dense vestiture of long or short pilose scales. In genera with a three-segmented palpus the apical segment is clavate (but cf. Australian *Aenetus*, with a tapering apical segment).

The **prelabium** is undivided in all New Zealand genera, and either is strongly *(Cladoxycanus)* or weakly *(Aoraia, Aenetus, Dumbletonius)* bilobed or is roughly turbinate, with an anteromesal small prominence (other genera). The apical prominence is spine-like in *Wiseana* and obscurely bilobed in *Dioxycanus*.

The **post-labium** in all New Zealand genera comprises a small anterior wart (in the sense of Nielsen & Kristensen 1989) separated by a nude strip or fold from the larger, posterior post-labial wart. The anterior post-labial wart may be reduced to a scale-bearing minute tubercle (e.g., *Aenetus*) or to a transverse low ridge *(Dioxycanus)*. Behind the posterior post-labial wart is a large zone between the orbits, somewhat sclerotised anteriorly (ventrally) and membranous towards the foramen. The sclerotised area, reminiscent of the larval hypostoma, is either broadly emarginate mesally *(Cladoxycanus, Dioxycanus, Heloxycanus)* or has a straight posterior margin *(Aenetus, Aoraia, Dumbletonius, Wiseana)*.

Antennae (Fig. M1–22). Quail (1903b) discussed aspects of hepialid antennal structure, and illustrated *Aenetus* (as *Charagia*) and *Wiseana* (as *Porina*) antennae. Flower & Helson (1976) described and illustrated the various sensillae on flagellar segments of *Aenetus, Wiseana*, and *Dumbletonius* (as *Trioxycanus*), noting sexual dimorphism of sensilla arrays. The scape (basal segment) and pedicel (second segment) are larger than the flagellar segments; the scape is wider and longer than the pedicel, which fits into the scape rather as a ball and socket. The intercalary sclerite is as in *Fraus* (Nielsen & Kristensen 1989, p. 5, fig. 14, 15). The flagellum is less than 0.45x forewing length (less than 0.20x in *Aenetus* and female *Dumbletonius*), and in all New Zealand genera except *Aoraia* has fewer than 50 segments, usually 30–45 (e.g., *Dioxycanus*, with about 35). The flagellar segments are unscaled in *Dioxycanus, Heloxycanus*, and *Wiseana;* in *Aoraia, Cladoxycanus, Dumbletonius*, and *Aenetus* the dorsum of the three or four proximal segments is sparsely clothed with linear, truncate scales.

The apical segment is slender *(Aoraia, Heloxycanus)*, spine-like *(Cladoxycanus)*, broadly or narrowly ovate *(Dioxycanus, Dumbletonius, Wiseana)*, or knife-like *(Aenetus)* (Fig. M2). The segments are covered in a dense pile of longer or shorter conical cuticular processes (Flower & Helson 1976; a possible hepialoid apomorphy – Nielsen & Kristensen 1989, p. 9). Interspersed among these are various kinds of sensilla (pl. sensillae).

- Sensilla chaetica: dorsally and apically on each ramus in *Aoraia* (Fig. M4) and *Heloxycanus* (Fig. M16); in ventral midline, on the subapical segments in *Cladoxycanus* (Fig. M8) and *Dumbletonius* (Fig. M14); absent in males of other genera, but present in all females.
- Sensilla trichodea, long: absent in *Aenetus* (Flower & Helson 1976), present as the most obvious 'ciliation' in other genera.
- Sensilla trichodea, short: arising in pits, and of two sorts: (a) very short, almost like sensilla basiconica, and (b) longer, projecting above the pilose cuticular outgrowths; present in all genera except *Aoraia*.
- Sensilla basiconica: sunken in pits, and surrounded by inward-directed cuticular projections (Fig. M18); seen in *Aenetus* only.

The flagellar segments are simple, deeper than long, and compressed in *Aenetus* (Fig. M1), or obscurely to conspicuously pectinate (other genera). In *Aoraia* the segments are bipectinate, with each ramus arising in mid-segment laterally; the 'anterior' rami are longer than the 'posterior' rami. In the other genera each segment is essentially quadripectinate, with a pair of mound-like rami basally and a pair of finger-like (*Heloxycanus*, Fig. M16) or blade-like (other genera) larger rami apically. The dorsal and ventral edges of each ramus, whether basal or apical, are clothed with long sensillae trichodeae, and the segmental shaft and the front and back surfaces of the apical rami have scattered short sensillae trichodeae (Fig. M22).

As well as being the only New Zealand genera with *Oxycanus*-type venation to have many sensillae chaeticae on most flagellar segments of the male antenna, *Cladoxycanus* and *Heloxycanus* are the only genera with tripectinate flagellar segments. In *Heloxycanus* (Fig. M16) the ventral apex of each segment is produced into an obliquely erect, short, finger-like process. In *Cladoxycanus* the apical midline area is produced into a flat, triangular process projecting over the base of the succeeding segment (Fig. M9). For all genera with pectinate antennae, females have shorter pectinations than do males. In *Wiseana* the size and shape (triangular, ovate, rectangular) of the apical rami on flagellar segments is of diagnostic value. In *Aoraia* the number of unipectinate basal flagellar segments is too variable within species to be of clear diagnostic value.

Prothorax (Fig. 111–117). The apices of the paired laterocervicales are joined by a short ligament to the apices of the occipital condyles, and laterally fused by a broad flange to the ventral arms of the pronotal anterior dorsal plate and to the anterior rim of the propleuron. Ventrally they are contiguous with the dorsal margin of the katepisternal area, but not always deeply sclerotised or fused to it. The inner margin of each laterocervicale is either evenly curved *(Dioxycanus, Dumbletonius, Wiseana, Heloxycanus)* or has the ventral apex strongly incurved mesally *(Aoraia, Aenetus, Cladoxycanus)*.

The prothoracic spiracle is on the posterior prothoracic area, posterior to the lateroventral apex of each pronotal sclerite or patagium; there is no associated subdorsal parapatagium (in the sense of Minet 1984, p. 144, fig. 14–21).

The paired pronotal posterior plates or patagia meet mesally either contiguously *(Aenetus, Cladoxycanus, Dumbletonius, Heloxycanus, Aoraia)* or anteriorly only, the mesal margins of each plate diverging posteriorly *(Wiseana, Dioxycanus)*. Irrespective of this condition there is a triangular mesal extension posteriorly, large in *Heloxycanus, Dumbletonius, Dioxycanus, Cladoxycanus,* and *Aoraia*, small in *Wiseana* and *Aenetus*. In *Wiseana* the midline apex of each patagium is produced forwards. Each patagium (posterior plate) bears a dorsal, a subdorsal, and an anterolateral 'nipple' in all genera, and a posterolateral nipple (on a level with the spiracle) in all except *Aenetus* and (possibly vestigially) *Dumbletonius*. It is difficult not to conclude that these 'nipples' are adult versions of the larval chaetotaxy of setal series D, SD, and L. The anterior pronotal plates also meet in the dorsal midline; laterally each extends ventrally, fusing with the unscaled inner (mesal) margin of the propleural sclerite. This fusion is marked by either a transverse seam *(Heloxycanus, Aoraia, Aenetus)* or a long diagonal seam (other genera). The propleural mesal margin (or episternite) divides below the broad lateral attachment of the laterocervicale, with an inner (mesal) process or episternal tooth. The episternal tooth is either triangular *(Aenetus, Cladoxycanus)* or slender (other genera). In genera with a slender episternal tooth, the tooth apex is either distant from the outer ventral margin of the laterocervicale *(Dioxycanus, Heloxycanus, Dumbletonius)* or close or appressed to it *(Aoraia, Wiseana)*.

The katepisternal basal margin is distinctly sclerotised and conical in *Dioxycanus, Heloxycanus, Cladoxycanus,* and *Wiseana* but not obvious in *Aoraia* or *Aenetus*.

Mesothorax (Fig. 118–125). The mesoscutum has a strong mediolongitudinal suture and internal ridge (deepest anteriorly) in all genera.

Laterally, anepisternite 2 is strongly tumid anterodorsally and is posteriorly invaginated, as is the anterodorsal part of epimeron 2; together they form a rather sinuous and deep pit. The anapleural cleft dividing anepisternite 2 from proepisternum 2 is widely open anteriorly in all New Zealand genera, and either abruptly narrowed *(Aenetus)* or more or less evenly narrowed (other genera) to a double-ridged suture which either almost attains the dorsally directed portion of the pleural suture or joins it.

Katepisternite 2 and the mesopleural / paracoxal suture confluence are not easy to interpret. In New Zealand genera the paracoxal suture is seemingly bifurcate (e.g., *Aenetus*, Fig. 118), with the anterodorsal arm joining the mesopleural suture well above the level of the bend in the latter suture. The posterodorsal 'arm' joins the mesopleural suture on the bend (as in *Fraus*: Nielsen & Kristensen 1989, pp. 28, 29, fig. 73). These two arms enclose a convex, scaled sclerite here interpreted by position as katepisternite 2. On the posterior side of the posterodorsal arm of the paracoxal suture is a wide, smooth, unscaled flange (marked with horizontal lines in Fig. 118–125) sometimes nearly as large as the katepisternite and extending ventrally along the basal portion of the paracoxal suture. In *Aoraia*, *Dumbletonius*, *Dioxycanus*, *Heloxycanus*, and *Wiseana* the posterodorsal suture line is incomplete ventrally. It is complete in *Cladoxycanus*, and in *Aenetus* it returns on its length at the ventral apex of katepisternite 2 to fuse with the anterodorsal arm of the paracoxal suture.

Epimeron 2 has, along its ventral and anterior margins, a more *(Aenetus, Cladoxycanus, Dumbletonius, Dioxycanus, Heloxycanus, Wiseana)* or less *(Aoraia)* well defined ridge parallel to the mesopleural suture, the marginopleural ridge. In *Aoraia* the ridge is scarcely evident, and unlike the situation in all other New Zealand genera it does not coalesce at its dorsal apex with the mesopleural suture in the elongate trough or pit formed by the sunken border of mesepimeron and mesepisternum 2 ('pit' in Fig. 118).

Aoraia differs from other New Zealand genera not only in the weak development of the marginopleural ridge (only slightly stronger than in *Fraus polyspila* Meyrick) but also in the course of the anterodorsal arm of the paracoxal suture. Dorsally this is sharply bent posteriorly so that it makes katepisternite 2 rhomboidal or polygonal (or apically truncate), and it joins the mesopleural suture well below and distant from the apex of the anapleural cleft. In all other genera the anapleural cleft and the junction of the paracoxal / mesopleural sutures are very close together (cf. Fig. 119, *Aoraia* and Fig. 125, *Wiseana*).

In most genera an internal, slightly sclerotised spine-like connection is present between the marginal flange of coxa 2 and the internal flange on the posteroventral margin of katepisternite 2.

Metathorax. The only structure compared was the degree of reduction of the mesal part of the metascutum (metascutal bridge). In *Aoraia* the metascutum halves meet broadly at the dorsal midline, at which point the metascutum length is about 0.20x metascutellum length. In *Dioxycanus* and *Aenetus* the metascutum midline length is about 0.12x metascutellum length. In all other New Zealand genera the metascutal bridge is extremely narrow, and in *Cladoxycanus* the metascutal halves are separated, joined by a mesal sclerotised strip bounded laterally by sutures. In addition it was noted that only *Aoraia* has the coxa 3 / eucoxa 3 sclerites of similar height, i.e., the gap between coxa 3 base and the metapleural suture is narrow and posteriorly acute (Fig. 127). In all other New Zealand genera coxa 3 is considerably shorter than eucoxa 3, and the metapleural 'gap' is wide and posteriorly truncate.

Legs. The fore tibia in both sexes of all New Zealand genera except females of some species of *Aoraia* bears a well developed epiphysis. In both sexes the metathoracic leg is shorter than the prothoracic and mesothoracic legs, and only in *Cladoxycanus* does the protarsus lack an arolium. *Aenetus* males have a brush on the dorsal margin of the hind tibia (Fig. 212, 213); *A. virescens* lacks the apical process characteristic of other *Aenetus* species (Fig. 212, 213).

Wings (Fig. 73–80). Wing conformation in New Zealand genera is largely uniform, contributing to an overall characteristic facies (e.g., Fig. 1–72). There is sexual dimorphism in forewing shape, with female wings rather longer in relation to width than those of males. In males, and in female *Aenetus*, the forewing has a rounded or indistinct tornus in the region of the apices of veins M_3 and CuA_1. Only in male *Aenetus* is there a distinct tornus, between the apices of veins M_2 and M_3; also in *Aenetus* the male forewing apex is subfalcate (i.e., the termen is concave). Male forewing width varies from about 0.40x wing length *(Aoraia, Cladoxycanus, Dioxycanus, Dumbletonius characterifer, Heloxycanus)* to about 0.45x *(Aenetus, Dumbletonius unimaculatus, Wiseana)*. *Aenetus* males have the broadest forewings, measured as a perpendicular from the costa (C) to the apex of vein CuA_1.

The male hind wing is conspicuously modified in the costal area in all genera except *Aoraia*. It is most modified in *Aenetus* (Fig. 73), where the costal cell is evenly wide for over half its length and veins Sc and R_1 are displaced distally. In the other genera the costal cell is wide basally but narrows from before half way (e.g., Fig. 75–80).

All genera have a normal, slender, parallel-sided jugum (Fig. 76, jg) and nearby a small, elongate-oval wing-locking microtrichial field (Common 1969). The upper wing surface bears many *(Aoraia)* to few (other genera) widely separated, short setulae along most veins. No aculeae were observed on the membrane between the veins.

Venation (Fig. 75) is typically homoneurous in both wings. Adults of New Zealand species are all fast fliers (hence 'swift moths'), and the forewing particularly is modified into an aerofoil shape, i.e., in cross-section the costal area is thickened, and the thickness of the wing plus scaling lessens towards the hind margin of both wings. Thickening is achieved by (a) a deeply concave costal cell forming a trough; (b) a strongly sclerotised vein Sc at the back of the trough; (c) the area between vein Sc and R_{2+3} (R_{2-5} in genera with 'oxycanine' venation) strongly convex dorsally and, including vein R_1, somewhat reinforced or sclerotised so that the dorsal ridge resembles a vein in descaled dry preparations; (d) all troughs densely filled with upright or oblique stiff scales dorsally and these merging with the dense, short pile on the costa and the R_1–R_{2+3} etc. ridge; and (e) ventrally, the ridge produced by vein Sc with long, dense, backswept pilose scales. The hind wing is similarly elaborated underneath, with long, trailing pilose scales on vein Sc. For a discussion on the physics of lepidopteran flight, see Scoble (1992, pp. 66–68).

The 'hepialine' and 'oxycanine' types of venation (Dumbleton 1966) involve the R (radial) veins. In *Aoraia* and *Aenetus* veins R_4 and R_5 arise on a common stem which splits off from R_{2+3} (Fig. 73, 75). In the remaining genera R_4 and R_5 each arise separately from the R_{2+3} stem (Fig. 76–80). The branches R_2 and R_3 are shorter than the R_{2+3} stem in *Aoraia* (Fig. 75) and in the *Aenetus* forewing (Fig. 73), but longer than the stem in the *Aenetus* hindwing (Fig. 73, 74, 76–80) and in the remaining genera. The apex of the forewing discal cell (crossvein r-m) is at a point before half wing length in *Cladoxycanus*, and at or a little beyond half way in the remaining genera. In *Aoraia* and *Wiseana* (e.g., Fig. 75, 80) the discal cell can be nearly 0.6x forewing length. Cross-veining in the CuA_2-CuP-A region of the forewing is either simple, with a CuA_2-CuP and CuP-A oblique crossvein (e.g., Fig. 73), the condition in most New Zealand genera, or complex as in some *Aoraia* species, with additional CuP-A and CuA_2-CuP crossveins (e.g., Fig. 75) and, occasionally, an A-A crossvein.

In the hind wing, veins Sc and R_1 are fused apically in *Dioxycanus, Dumbletonius, Heloxycanus,* and *Wiseana* (and also in the New Guinea genus *Paraoxycanus* Viette), but not in *Cladoxycanus, Aoraia*, or *Aenetus*.

All New Zealand genera except *Aoraia* have fully winged adults. In *Aoraia* the mainly alpine species (*senex* group) have sub-brachypterous or brachypterous females, as in some alpine European *Gazorycta* species (Sattler 1991).

Thoraco-abdominal junction (Fig. 126–131)

Four areas are significant in relation to the Australian genus *Fraus*.

(a) Abdominal spiracle 1 orientation: lateral in all New Zealand genera except *Aenetus*, which has spiracle 1 facing obliquely posterad.

(b) Closeness of spiracle 1 to the strongly sclerotised metepimeron margin: well separated in *Aoraia* and *Cladoxycanus* but nearly contiguous in other genera; in *Aenetus* the spiracle is partially enclosed by an arc-like emargination in the metepimeron margin.

(c) Position of the lateral tergum 1 lobe (tergosternal bar): this arises near the posterior end of the tergal brace in *Fraus*, and from half way in *Aoraia*. In all other New Zealand genera the lobe arises from the anterior corner of the tergal brace.

(d) Presence or absence of a posterior lobe on the tergal brace: this 'appendage' (illustrated for *Fraus*, but not commented on, in Nielsen & Kristensen 1989, fig. 94) is associated with the posterolateral corner of the tergal brace, and in its complete state (as in *Fraus*, Fig. 131) joins the lateral tergum 1 lobe at about half its length. In New Zealand genera the area between the tergum 1 lobe and the posterior lobe is convex and dorsally sclerotised. This condition is present in all New Zealand genera except *Aenetus* and *Cladoxycanus* (Fig. 126, 128), which lack the posterior lobe. In *Dioxycanus, Heloxycanus, Dumbletonius,* and *Wiseana* the posterior lobe is broad, concave, and apically truncate. In *Aoraia* (Fig. 127) it is apically shortly acuminate, with the point directed to a similar tooth facing it, arising on the posterior margin of the lateral tergum 1 lobe. *Dumbletonius* has a similar tergum 1 lobe posterior tooth (Fig. 130).

No gross differences in size between abdominal spiracles 1 and 2 were seen, and pleuron 2 bears three tuberculate plates: dorsally a prespiracular and a postspiracular plate, and ventrally a prespiracular plate. In all genera except *Aoraia* and *Aenetus* the postspiracular plate is close to or nearly contiguous with the tergum 2 lateral brace. The sinus (lateral intersegmental pouch) between the upper part of the metepimeron and the upper tergum 1 margin is widely open in *Aoraia* and *Aenetus*, narrowly so in the other New Zealand genera.

No significant differences were seen in sternum 2, except that only *Aoraia* (Fig. 127) has the lateral strengthening ridge submarginal, i.e., within the sternum; other New Zealand genera have the strengthening ridge marginal on the sternum or (as in *Dioxycanus*, Fig. 129) absent. The apposition of sternum 2 anterior arms and the lateral tergum 1 lobes is as described for *Fraus* (Nielsen & Kristensen 1989, p. 39); the pouch is present.

Venter 1 is much shorter than the dorsum, and is entirely membranous in all New Zealand genera.

Male genitalia (Fig. 132–147)

The scheme devised by Nielsen & Kristensen (1989, pp. 43–59) is followed here for both integumental structures and gross musculature. Interpretation has been hampered in the past by seeking to homologise the exoporian and endoporian genital structures, but it is clear from the studies on *Fraus* that the essential difference is the virtual obliteration of tergum 9 and structures derived from it.

Segment 8. Tergum 8 is longer than sternum 8, extending over the genitalia at rest like a hood. At least one pair of 'cuticular processes' (setal rudiments), usually the anterior pair, is present in males of most genera (e.g., *Aoraia*). Sternum 8 is usually trapezoid, and is apically or subapically modified in *Dumbletonius* (paired subapical teeth in one species) and *Cladoxycanus* (apically broadly emarginate). The intersegmental area between the sternum 7 apex and the vinculum may be membranous or lightly sclerotised.

Segment 9. Tergum 9 is either seemingly absent as a discrete entity (e.g., *Wiseana*) or is present as a single *(Cladoxycanus)* or paired setose prominence *(Aoraia)*, or as paired midline tubercles *(Aenetus)* and closely associated with tergum 10 (q.v.). Sternum 9 is the vinculum complex (Fig. 132–138), with a more-or-less triangular, never shallowly U-shaped, ventral saccus produced on either side into a dorsal arm. The apodemal area on the saccus and the arms is variable within a genus; the vincular arms in *Aenetus* are very greatly expanded (Fig. 132). The posterior margin of the vinculum base may be straight (e.g., *Wiseana*) or raised mesally (e.g., *Dioxycanus*) or have a midline emargination *(Aoraia)* with folded, lapel-like margins *(Aenetus)*. The cavity of the saccus may be open (most genera, e.g., *Aoraia*, Fig. 139) or occluded, i.e., with the anterior and posterior margins apposed *(Dumbletonius)*, and in this genus the juxta / trulleum hinge is less flexible than in other genera (Fig. 142).

The vinculum arms extend to the region of the intermediate plate (most genera) or curve strongly towards it (*Aenetus*, Fig. 140). Complicated, thickened integumental folds are associated with the vinculum arm apex, the outer flange of the i.p., the dorsal part of the clasper base, and anteriorly the conspicuously thickened, setose fold which possibly represents a combined tergum 9 and 10, and which is intimately associated with the external anterior apex of the intermediate plate complex.

Tergum 10. Present as paired midline prominences, or arcuate sclerites attenuated laterally *(Aoraia, Aenetus, Cladoxycanus)*, or possibly as part of dorsal, paired hood-like extensions (e.g., *Wiseana*) directly anterior to and largely fused with the pseudotegumen. Laterally tergum 10 becomes a thickened fold possibly incorporating tergum 9, and this fold (setose in *Aoraia* and *Cladoxycanus*) ends outwardly by the vinculum arm apex; inwardly it joins the anterior apex of the intermediate plate complex.

Intermediate plate (Fig. 139–143). This appears to be a composite structure (cf. Nielsen & Kristensen 1989), and is the 'processus momenti' (a preoccupied term) of Birket-Smith (1974) and Ueda (1982). Basically it consists of two main parts: (a) an outward, more or less horizontal or oblique flange, fused inwardly, and longitudinally with (b) a vertical (and longer) flange whose dorsal edge is anteriorly fused with the pseudotegumen lower margin, and which in some genera diverges from the pseudotegumen margin posteriorly. The outer flange carries the insertions of muscles G2 and G5; the inner flange with its posterior extension carries the insertion of muscle G9.

There is no condylar articulation with the vinculum arm apex, the trulleum, or the clasper base, but there are zones of thickened, ridged integument between (a) the outer flange and the vinculum apex (or, in some genera, muscle G5.1); (b) the inner flange posterior apex and the trulleum (absent in *Aenetus*, which has no sclerotised trulleum); and (c) the inner flange ventral margin and the dorsal apex of the valva base (Fig. 139–143). The shape of the posterior extension of the inner flange – i.e., the sclerite usually labelled as 'intermediate plate', 'processus momenti', or 'accessory sclerite' (see Nielsen & Kristensen 1989, p. 44, fig. 102; Ueda 1978, p. 200, fig. 5B; Ueda 1982, p. 88; Dumbleton 1966, p. 924, fig. 9, 10) – is diagnostic for *Aoraia*, *Aenetus*, and *Cladoxycanus* but is fairly uniform in the other, 'typical oxycanine' genera. In all New Zealand genera except *Aenetus* the vinculum arm apex rests close to the anterior half of the intermediate plate complex (Fig. 139, 141–143); in *Aenetus* the vinculum apex is beside the decurved posterior apex of the intermediate plate (Fig. 140).

Valvae (claspers). The opposable valvae articulate with the vinculum arms outwardly, the iintermediate plate complex dorsally, the trulleum mesally, and the juxta ventrally. They are moved by the valval adductor (muscle G7) and, when present, the valval abductor (muscle G6). The valvae are setose, and are armed along the 'saccular' (ventral) margin with a serrate carina and a large, decurved, acuminate process on the proximal half in *Aoraia* and *Aenetus*. In the other New Zealand genera the valvae are unarmed, setose, and lobate. As in *Fraus* they are simple, one-segmented structures. There is no sign at the 'costal' base of an anteromesal projection, i.e., no 'tergal extensor muscle, M2' attachment as in tineoid and some tortricoid endoporian Ditrysia (Horak 1984, pp. 34–36; Kuznetsov & Stekol'nikov 1984).

Table 1 Male genital musculature of New Zealand hepialid genera in comparison with that of *Fraus* (Australia; Nielsen & Kristensen 1989, pp. 48–50, fig. 103–105). Key: G1–3, intersegmental muscles; G4–10, intrasegmental muscles; i.p., intermediate plate; +, present; –, absent; V, variable.

Muscle	Origin – insertion	*Aenetus*	*Aoraia*	*Dumbletonius*	*Wiseana*	*Fraus*
G1	T8 – T9/10, mesally	+	?V	?	?+	+
G2	T8 – i.p., dorsal apodeme on anterior apex	+	+	–	– (rarely present on both sides)	+
G3.1	S8 – external vinculum face	+	+	+	+	+
G3.2	S8 – and outer flange vinculum arm base	–	–	+	+	–
G4	Vinculum base – juxta, apical	+	+	+	+	+
G5	Vinculum arm base – anterior face of i.p. anterior apex	+	+	+	+	+
G5.1	Vinculum arm subapically – i.p. outer flange	+	thickened cuticle	thickened cuticle	+	–
G6	Vinculum arm – mesal margin of clasper base	+	+	_	–	+
G7	Juxta laterally – clasper base dorsally	+	+	+	+	+
G8	Pseudotegumen halves, transverse	+	+	+	+	+
G9	Dorsal (inner) piece of i.p. – subphallic	+	+	+	+	+
G10	Pseudotegumen ventrally – subphallic	+	+	?	?	+

Juxta. Bounded outwardly by the base of the valva, dorsally by the trulleum (or trullear area in *Aenetus*), and ventrally by the inner rim of the vinculum base, the juxta is variable in form, usually reflecting the insertion zone of muscle G4. In *Aoraia*, *Aenetus*, *Cladoxycanus*, *Dumbletonius*, and *Wiseana* the insertion zone is apical; in other New Zealand genera it has not been ascertained. In *Aenetus* (Fig. 132, 209) the juxta is far wider than high, not extending dorsally beyond the valva base. In other genera (Fig. 132–138) the juxta extends dorsally as an oblong *(Aoraia, Cladoxycanus)* or apically lobate plate, hinging with the trulleum.

Trulleum. The trullear area is unsclerotised only in *Aenetus*. In other New Zealand genera the trulleum is broadly V-shaped, lightly sclerotised except at the basal margin, which has a small central prominence *(Aoraia)*, or broadly rectangular and centrally widely or deeply concave (other genera), and strongly sclerotised.

The juxta and trulleum are hinged. At rest the two plates oppose each other at an acute angle, but exsertion of the hinge reverses the angle and extends the valva laterally, and opens out the pseudoteguminal halves. Only in *Dumbletonius* is such hinge movement limited (rather as in *Trichophassus* le Cerf), i.e., the hinge is 'open' at rest.

Pseudotegumen. This is the large (paired) sclerite surrounding the membranous anus and phallocrypt, and is referred to as 'pseudotegumen' following Nielsen & Kristensen (1989, p. 53). Posterolaterally the pseudotegumen abuts the intermediate sclerite, and posteroventrally is separated by chitinous integument from the trullear area (and trulleum sclerite, where present). Dorsally the pseudotegumen may be complexly elaborated, often with a pair of twin processes (see next section) anterolateral to the anal papilla (e.g., *Wiseana*, Fig. 313, 315). The dorsal margin usually has at least two paired processes distally, one posterior and one ventral; in some species the ventral processes may be bridged by a transverse sclerotisation, but usually the ventral processes, like the posterior processes, are apically separate. In some genera (e.g., *Aoraia*, Fig. 230) there can be a dorsal posterior process, which supports the extruded phallus ventrally. The conformation of the pseudotegumen is diagnostic at both generic and specific levels, but within (for example) genera in the *Oxycanus*-group there can be convergence in pseudotegumen specialisaton. The *Heloxycanus* pseudotegumen has some features shared with the otherwise unrelated (and extralimital) *Oxycanus sirpus* Tindale.

Anus and phallocrypt. These are borne on the membrane surrounded by the pseudotegumen halves. In all New Zealand genera except *Aenetus* the anus and phallocrypt are widely separated and divergent. In *Aenetus* not only are they closer together (Fig. 209) but the pseudotegumen lacks twin processes anterior to the anal cone. These twin processes are also lacking in *Cladoxycanus*. They are very strongly developed in *Dioxycanus*, *Dumbletonius*, and *Heloxycanus*, variably developed in *Wiseana*, and very reduced or collar-like in *Aoraia*.

The anus / phallocrypt zone may be relatively simple (*Aenetus*, Fig. 209) or complex (e.g., *Dumbletonius*, Fig. 300, 303). The paired sclerotised paranal sclerites ("subanal": Ueda 1988, pp. 45, 56, fig. 6, 7) characteristic of genera with *Oxycanus*-type venation in Australia, New Guinea, Borneo, Taiwan, China, and Nepal are absent in *Cladoxycanus*, *Dioxycanus*, *Dumbletonius*, *Heloxycanus*, and *Wiseana*. The anus is on an eversible papilla in all New Zealand genera. Between the anus and the opening to the phallus in all genera except *Aenetus* are two membranous structures: anteriorly the subanal papilla – hypertrophied and ventrally with a complex dark-staining invaginated structure (Fig. 300, 303) in *Dumbletonius*, moundlike or reduced or absent in other genera – and posteriorly the supraphallic papilla (Fig. 220), which at rest appears to cover the phallus opening. This latter papilla is short and thumb-like, with a distinct smooth obovate apical area in *Aoraia*, long and finger-like in *Dioxycanus* and *Dumbletonius*, reduced in *Heloxycanus* and *Wiseana*, and seemingly absent (along with the subanal papilla) in *Cladoxycanus*.

Musculature (Fig. 144–147, Table 1). Musculature of species of *Aenetus* (Fig. 144), *Aoraia* (Fig. 145), *Dumbletonius* (Fig. 146), and *Wiseana* (Fig. 147) was examined. In Table 1 the disposition of muscles G1–10 (notation as in Nielsen & Kristensen 1989, pp. 48–50) is compared with that in *Fraus*. No evidence of muscles G2 or G6 was seen in *Wiseana* (two species examined) or in *Dumbletonius unimaculatus*. *Aoraia* (two species examined) showed no evidence of muscle G1. In *Wiseana* and *Dumbletonius* the broadly attached sheet-like muscles overlying muscle G8 are not convincing homologues of muscle G1 in *Aenetus*.

The course of muscle G4 has been discussed above under 'Juxta'.

Female postabdomen and genitalia (Fig. 148–155)
Musculature was not examined.

Segments 7 and 8. These, the pregenital segments, as with the preceding segments, consist of a wide tergum and sternum separated by an expandable pleural area bearing the spiracles. In life the abdomen of a gravid female is broadly elliptic or circular in cross-section. The expandable pleural area assists accommodation by the abdomen of between 2000 (*Wiseana*) and 25 000 (*Aenetus*) eggs. Tergum 7 and tergum 8 are separate in all New Zealand genera. Tergum 7 lacks 'cuticular processes' (Dumbleton 1966, p. 25, and see below) in all genera except *Dioxycanus* and *Dumbletonius* (Fig. 152, 153), where D_2 is present as a conspicuous subdorsal spine on the posterior margin. The tergum 7 lateral and posterior margins are either more-or-less straight (*Aoraia, Aenetus, Cladoxycanus, Heloxycanus, Wiseana*) or the posterior margin is concave in outline and the lateral margin is oblique, with the posterolateral corner produced posteriorly (*Dumbletonius, Dioxycanus*).

Tergum 8 is shorter than tergum 7 except in *Wiseana*. It is lightly sclerotised, or unsclerotised in *Aoraia*. It is relatively unmodified laterally and posteriorly in *Aenetus*, *Cladoxycanus*, and *Heloxycanus*, but has the posterolateral corners slightly produced in *Cladoxycanus* and bearing a scaled sclerite in *Aoraia*. In the other genera the posterior margin is moderately (*Wiseana*) or strongly (*Dioxycanus*) emarginate, or tergum 8 is membranous along the dorsal midline, i.e., is split mesally (*Dumbletonius*). In these three genera the posterolateral corner is greatly produced ventrally, curving posteroventral of spiracle 8 and abutting the sternum 9 side piece. Cuticular processes (see above) are absent in *Aoraia, Aenetus*, and *Heloxycanus*; D_1, D_2, and SD_1 are present in *Dumbletonius* and *Wiseana*, and D_2 and SD_1 in *Dioxycanus*; in *Cladoxycanus* D_2 or SD_1 may be present. In *Dioxycanus* the intersegmental membrane posterior to tergum 8 is uniformly clad in short, squat scales. The posterior margin of tergum 8 and sternum 8 in all genera except *Aenetus* and *Aoraia* is clad in long, hairlike scales, often contrasting conspicuously in colour with the other abdominal scaling, and forming a distinctive broad apical tuft (Fig. 151, 152, 154, 155). *Aenetus* lacks such an apical tuft; the green scales at the posterior corners of tergum 8 are elongate, giving the abdominal apex a somewhat 'fishtail' appearance (Fig. 148). In *Aoraia* (Fig.

150) the area is clothed in appressed, densely arranged narrow scales, often distinctively coloured. Both *Heloxycanus* and *Wiseana* have a group of setulae pleurally, posterior to the A8 spiracle.

Sterna 7 and 8. These are fused in *Aenetus, Cladoxycanus, Dioxycanus,* and *Dumbletonius,* with the two components faintly demarcated by a discontinuity of sclerotisation and scaling in the latter three genera. In *Aoraia* sterna 7 and 8 are widely separated by a transversely, sinuously wrinkled integument and sternum 8 is emarginate anteriorly. In *Heloxycanus* and *Wiseana* the sterna are narrowly separated, with sternum 9 divided mesally into two lateral plates. In *Wiseana* the width of the separation varies between species (e.g., *W. umbraculata,* Fig. 333 cf. *W. cervinata,* Fig. 332 and *W. copularis,* Fig. 155).

Spiracle 8. This is on the pleural area, and in *Aoraia* is anteroventral to the anterolateral corner of tergum 8; in *Aenetus* and *Heloxycanus* the spiracle is below the anterolateral corner, and in the other genera it is just anterior to the extended posterolateral corner of tergum 8. In no New Zealand genus is spiracle 8 below any part of tergum 7 (cf. *Fraus*: Nielsen & Kristensen 1989, p. 60, fig. 123, 124).

Ano-genital complex. The component parts are **sternum 9**, the bilobed **dorsal plate** (terga 9+10) extending ventrolaterally to near the posterior corners of sternum 9, the **diaphragma** surrounding the anus and joining with the **ovipore**, the paired **intergenital lobes**, often with **subanal plates**, the **sinus seminalis** (or **seminal cleft**), the **antrum**, the **bursa copulatrix**, and the **spermatheca**. All these components show generic and specific characters.

The overall configuration of the ano-genital field may be transversely ovate *(Aoraia)*, compressed into a transverse slit *(Aenetus)*, or basically perpendicularly ovate, i.e., much higher than wide, with the dorsal plate(s) forming an arch (genera with an *Oxycanus*-type wing venation).

Sternum 9. In all genera this is posteriorly modified into a median piece supporting the ventral floor of the antrum, flanked by side-pieces which extend to just under the ends of the downward apices of the dorsal plate. In *Cladoxycanus, Dioxycanus,* and *Heloxycanus* the anterior part of sternum 9 is large, i.e., sternum 9 is long (and broad). In *Aoraia* it is somewhat triangular, and in *Aenetus, Dumbletonius,* and *Wiseana* it is so reduced that sternum 9 is represented only by the side-pieces and the median piece. The side-pieces are separated from the median piece by a weakly sclerotised zone in *Cladoxycanus*, and by clefts in *Aoraia, Dioxycanus,* and *Heloxycanus*; the junctions are not discernible in *Aenetus, Dumbletonius,* and *Wiseana.* The side-pieces in *Aoraia* may be carinate or with from one to three obscure tubercles, subcarinate in *Dioxycanus* and *Heloxycanus*, linear or semicircular in *Dumbletonius*, and not elaborated in the other genera. The median piece is centrally emarginate (obscurely bifid) in at least some species of most genera. Disposition of setae is variable within species.

Dorsal plate. This is a bilobed, sclerotised, setose structure with the sclerotisation at the midline strong *(Cladoxycanus)* or weak *(Aoraia)* or absent (other genera). In all genera each lobe is more-or-less produced (broadest) at about half its length, i.e., each lobe is more-or-less triangular (Fig. 298, 311). The ventral apex of each lobe is enmeshed in a complexly folded cuticular area which also incorporates the outer extremity of each sternum 9 side-piece. *Dumbletonius* and *Wiseana* have a characteristic, scarcely projecting, dorsally slender 'horsecollar'-shaped dorsal plate; other genera with *Oxycanus*-type venation have the plates broader and partially obscuring the diaphragma. The term 'anal papilla' is not used here, as there is no demonstrable homology with the structure in endoporian Ditrysia.

Diaphragma. The membranous field enclosing the anus is unspecialised in all genera except *Dumbletonius, Heloxycanus,* and *Wiseana,* where there are paranal groups of setae (e.g., Fig. 336) which may or may not mark a true anal papilla.

Intergenital lobes, 'subanal plate', and ovipore. The intergenital lobes appose each other, forming a midline groove, cleft, or sinus. Each lobe is strengthened by a sclerotised area: the paired 'subanal' plates (regarded as venter 10 by Nielsen & Kristensen 1989, p. 71, q.v. for a full discussion). Dorsally the sinus leads into the ovipore, ventrally into the vestibule. The ovipore is simple in *Aoraia* and *Aenetus*, but on a more *(Wiseana, Dumbletonius)* or less (other genera) bilobed, erect papilla. The intergenital lobes are fused for part or all of their length, thus converting the seminal cleft into a duct or sinus, in *Cladoxycanus, Dumbletonius,* and *Wiseana*; they are not fused in the other genera, but may be firmly apposed in *Heloxycanus.* The 'subanal' plates are characteristically shaped and oriented in each genus; orientation is influenced by ano-genital field shape. In *Aoraia* and *Aenetus* the long axis of each plate is more-or-less horizontally aligned; in the other genera, where the ano-genital field is higher than wide, the plate's long axis is more or less perpendicular. In *Wiseana* the shape and ridging of the plates are often specifically distinct.

Antrum. The vestibule or antrum of the copulatory pore may have the floor or ventral area membranous *(Aoraia, Aenetus)*, thickened and folded *(Heloxycanus)*, or sclerotised (other genera). In *Dumbletonius* the floor is very strongly sclerotised and narrowly convex mesally (Fig.

307), so that it presses against the basal opening of the intergenital sinus at rest.

In most New Zealand genera, unlike some overseas genera, the antrum is relatively simple, lacking complex folds, diverticula, or other extreme modifications. In *Aoraia* it is asymmetrically plicate in some species, and in *Dumbletonius characterifer* it is obliquely and convergently plicate (Fig. 307).

In *Aoraia* and *Wiseana* the antrum / bursa copulatrix junction is more or less skewed dextrally; in the other genera it is in the midline.

Bursa copulatrix. This structure, which receives the spermatophore, varies in shape and structure between genera. In most genera the proximal part (proximal to the antrum) or ductus bursae is slender, widening distally to an ovoid, globose, or somewhat oblong corpus bursae. The ductus bursae is sparsely spinulose in *Aenetus* and *Dioxycanus*, but appears to lack internal spines in other genera (cf. *Fraus*, species of which have abundant, internal spinules: Nielsen & Kristensen 1989, fig. 143–152).

The genera *Dioxycanus, Dumbletonius, Heloxycanus,* and *Wiseana* all have an appendix at the apex of the corpus bursae. This appendix is rudimentary in *Heloxycanus* and some *Wiseana* species, e.g., *W. fuliginea* (Fig. 337).

Spermatheca. As indicated by Nielsen & Kristensen (1989, p. 75), coiling of the spermathecal duct was misinterpreted by Dugdale (1974). In *Aenetus* (Fig. 150), *Aoraia* (Fig. 249), and *Heloxycanus* the duct is gently sinuous; it is somewhat angulated or has two or three sinuosities in *Cladoxycanus, Dioxycanus, Dumbletonius,* and *Wiseana* (Fig. 336). In all genera the spermathecal duct enters the common oviduct on a flat-topped papilla, and there is no lagena.

Larva (Fig. 156–187)

Hepialoid larval structure, principally the chaetotaxy of the head capsule and body, has been described and illustrated many times (Janse 1939, Hinton 1946, Aitkenhead & Baker 1964, Hasenfuss 1969, Elder 1970, 1978, Hardy 1973, Grehan 1981, Grehan *et al.* 1983, Yasuda & Abe 1986, Wagner 1987, McCabe & Wagner 1988, Nielsen & Kristensen 1989, Wagner *et al.* 1989, Leonard *et al.* 1992). The terms and chaetotaxic nomenclature followed here are those used by Nielsen & Kristensen (1989, pp. 86–98), with one exception. Concerning setae D_2 and SD_1, SD_2 on the prothorax, I regard the coarse seta as D_2 and the two fine setae, each arising from a felted, primarily circular ring-base, as SD_1, SD_2, thereby agreeing with Wagner (1987, p. 349, fig. 26.31z). Setal nomenclature is presently subject to reinterpretation (e.g., Leonard *et al.* 1992), highlighting the need for rigorous testing of postulated homologies between Exoporia and Ditrysia: Endoporia, for example.

Overall, larvae of New Zealand Hepialidae have the same body form as described and figured by, e.g., Tillyard (1926, fig. 29), Wagner (in Stehr 1987, fig. 26.31t), Nielsen & Kristensen (1989, fig. 197), and Nielsen & Common (1991, fig. 41.21B). The lankiness of the fully extended larvae is partly the effect of the long ninth abdominal segment (which is nearly as long as the eighth in this superfamily and in Mnesarchaeoidea). The body is typically elongate and cylindrical, often with contrasting pinacula on the pallid or – especially in ground-dwelling species – dorsolaterally darkened integument. Larvae are very easily ruptured by rough handling as they are being extracted from their burrows. Fully grown larvae of New Zealand species range in length from 30 mm (*Cladoxycanus,* some *Wiseana*) to 40–60 mm (*Dioxycanus, Heloxycanus, Wiseana,* smaller *Aoraia* species) to over 100 mm, rarely exceeding 150 mm (*Aenetus, Dumbletonius,* larger – especially female – *Aoraia* species).

There are differences useful in distinguishing genera in stemmatal (ocellar) arrangement, head capsule structure and chaetotaxy, proleg crotchet conformation, prothoracic sclerotisation, structures associated with prothoracic setae D_2, SD_1, and SD_2, and structure and chaetotaxy of the paraprocts and posterior-facing areas of the anal prolegs. Less reliable differences are present in body chaetotaxy and pinacular size and form. Specific differences have been found in pinacular form (*Wiseana*) and mandibular sculpture (*Dumbletonius*).

Some morphological differences may indicate retention of the first-instar condition. For instance, late-instar larvae of *Aenetus, Zelotypia, Endoclita, Fraus* (Nielsen & Kristensen 1989, fig. 200), *'Hepialus' californicus* species group, *Korscheltellus,* and an *Antihepialus* larva from Storms River, R.S.A., have the hypostomal plates free, not fused, in the ventral midline. This is the condition found in first-instar larvae of *Aoraia, Wiseana, Oxycanus,* and *Abantiades*; in succeeding instars of these genera the plates are fused.

Most differences at first observed between species in a genus such as *Wiseana* were found to be less consistent as material from other localities was examined. While it is possible to distinguish between sympatric taxa in one locality, the same distinctions were found to be erratic when examples of the same sympatric taxa, but from a different locality, were examined. This situation is paralleled in adult genital morphology, where large differences were seen between isozymically congruent (MacArthur 1986) *W. copularis* from Southland and Canterbury. Changes in morphology between instars or phases (such as described for *Aenetus*: Grehan 1981) increases the complexity. Nevertheless, the following notes suggest some order in the apparent chaos.

Head capsule. The hepialid head capsule is generally classed as hypognathous (Nielsen & Kristensen 1989, p. 89), obviously so in later instars (e.g., Fig. 157) but less obviously in the first instar. The epicranium is weakly indented in the dorsal midline, and the midcranial suture is as long as the frontoclypeal plate enclosed by the divergent adfrontal ridges, or longer. The brain and suboesophageal ganglion are not greatly displaced posteriorly in New Zealand genera (cf. *Fraus*: Nielsen & Kristensen 1989, fig. 201). The brain lies posteriorly in the head capsule, on top of the oesophagus, and the suboesophageal ganglion lies in the ventral cervical area posterior to the corporotentorium, separated from the prothoracic ganglion by a trunk shorter than either ganglion (Fig. 156).

The epicranium is generally robust. In *Aenetus* the anterior-facing areas are conspicuously and coarsely rugose, with bluntly triangular prominences in a series in the region of setae A_1-A_3-P_1. The epicranium is flattened rugose in later-instar *Aoraia*, *Dumbletonius*, and *Wiseana*, with the rugosities separated by shallow, irregular longitudinal striae. In *Dioxycanus* the epicranium is irregularly striate, and in *Cladoxycanus* and *Heloxycanus* it appears almost smooth. As noted above, the midcranial suture is long. The adfrontal zone between the cleavage line laterally and the adfrontal ridge mesally is an inverted V-shaped sclerite, anteriorly truncate in *Aoraia* and *Aenetus*, acuminate (tapering to apex) in the other genera. The frontoclypeus – the triangular sclerite enclosed by the adfrontal ridge – may (*Aoraia, Aenetus*, Fig. 159, 161) or may not (other genera, e.g., Fig. 164) have the clypeal area anterior to setae C_1, C_2 demarcated. The labrum is mesally emarginate, i.e., appears apically bilobed in all New Zealand genera except *Aenetus* – and also in Australian and New Caledonian *Aenetus* (e.g., *A. cohici*: Boudinot 1991, fig. 19) and *Zelotypia, Endoclita, Leto* – in which the labrum has a mesal apical prominence, i.e., appears trilobed (Fig. 159). In *Cladoxycanus* there is often a lateral angularity on the labrum (Fig. 164). The epipharynx bears three lateral paleae outwardly, and is variably clad in appressed spinules. The stemmata – always six – are arranged in two vertical rows (Fig. 157, 162) or arcs (Fig. 180). *Aoraia* and *Aenetus* exhibit the first arrangement, *Aoraia* differing only in that in the anterior row the most ventral stemma is displaced anteriorly, so that the axes of the two rows appear to diverge ventrally. In the other genera the anterior and posterior stemmatal series form two arcs, and there is a puncture directly in front of the middle stemma of the anterior arc.

The 'oral frame' – that thickened and strongly sclerotised margin between the lateral edge of the clypeus and the ventral mesal margin of each epicranial half bordering the (central) maxilla / spinneret / labium complex – incorporates the antennal base and the mandibular articulations (Fig. 157, 167). The antennal base, unlike that of the larvae of Ditrysia: Endoporia, is enclosed anteriorly by the oral frame, which here forms a pre-antennal bar. This appears dorsally acuminate but is actually twisted and obscured by cuticular folds, and ends distant from the mandibular dorsal articulation in all New Zealand genera except *Aenetus* (Fig. 157), where it broadly abuts the mandibular dorsal articulation. Halfway along the oral frame there is a lateral slit (Nielsen & Kristensen 1989, pp. 89, 91, fig. 200, ls) which may be occluded by a ventral extension of the pre-antennal bar (*Dumbletonius*, Fig. 174; *Heloxycanus*, Fig. 175). At the apex of the slit, or just ventral to it, are two punctures. The form of the ventral extension of the pre-antennal bar can be diagnostic at the generic level: *Wiseana* larvae usually have the pre-antennal bar base extended to form a melanised securiform process that contrasts with the white integument between the oral frame and the mandible.

(In *Mnesarchaea* the oral 'slit' – here a discontinuity in the oral frame – is directly beside seta SO_1. In New Zealand Hepialidae this seta is well mesal to the lateral slit / antennal bar base complex. Also in *Mnesarchaea* the pre-antennal bar is entirely exposed, so that the antennal base is clearly seen to be entirely surrounded by epicranial sclerotisation.)

The mandibles bear the usual two setae in the scrobe (the outer lateral furrow), and have from four to six cusps, the first (outermost) small and sublateral to the second and largest cusp.

The maxillo-labial zone is bounded posteriorly by the opposing hypostomal plates. These plates are fused in later instars of all New Zealand genera except *Aenetus*, where they are broadly free (Fig. 158); in first-instar *Aoraia, Dumbletonius*, and *Wiseana* they are narrowly free. In *Heloxycanus* (Fig. 176) the mesal length of the hypostoma is at least half its outer length; in other genera the mesal length is a quarter or less the outer length.

Characters of the maxillo-labial complex include: the shape of the large, blade-like 'sensillae' on the lobarium, which are bifid in *Cladoxycanus* (Fig. 165) but unifid in other genera; the presence of sculpturing on the inner face of the dististipes (in *Dioxycanus*, Fig. 169, the face is covered with asperities); and the setal arrangement in relation to the setal puncture on the basistipes. Overall shape of the maxillo-labial complex changes with instar, and thus with head capsule shape.

Head capsule chaetotaxy characters include the disposition of frontoclypeal setae F_1, C_1, C_2, only late-instar

Aoraia having F_1 at or close to a level with the antennal base (Fig. 161); the position of setal puncture La, only *Aoraia* (and the South African *Antihepialus*) having this displaced away from seta L_1 and close to the posterolateral margin of the epicranium, beside the lateral notch (Fig. 162); and the disposition of setae SO_3, G_2, G_1, either in a more-or-less straight line *(Heloxycanus, Aoraia)* or describing a strong curve (other genera). Otherwise, head capsule chaetotaxy (Fig. 157–180) is largely uniform, and resembles that of *Fraus* as figured by Nielsen & Kristensen (1989, fig. 198–200).

Trunk. The prothoracic shield in all New Zealand genera (and in *Mnesarchaea*) is more-or-less saddle-shaped, having a transverse furrow on the posterior third (e.g., Fig. 187). Trunk chaetotaxy is extremely conservative, all New Zealand genera having the same setal pattern (Fig. 181–187). Generic differences involve the occurrence or size of various sternal or lateral sclerites, size or shape or fusion of pinacula, degree of midline fusion of the paraproct sclerites, and degree of fusion of the black, felted pits surrounding prothoracic setae SD_1, SD_2, and (in *Aenetus*) D_2.

Prosterna are present on the prothorax in all genera, and in *Aenetus virescens* and *Cladoxycanus* the prosternum is broadly fused with the post-sternum (Boudinot 1991, fig. 21, shows them separate in *A. cohici*). A small prosternum is present on the mesothorax in all genera except *Cladoxycanus* and *Heloxycanus*, and on the metathorax in all genera except *Cladoxycanus, Heloxycanus*, and (usually) *Wiseana*. The mesothoracic and metathoracic post-sternal sclerite (or V_1 pinaculum) is paired in all genera except *Aenetus*, which has the sclerites fused mesally on the mesothorax. Abdominal segments 3–6 bear a small, separate prosternum in *Dioxycanus, Dumbletonius, Heloxycanus*, and *Wiseana;* this is fused with the V_1 pinacula in *Aenetus* and *Aoraia*. Posterior to the seta L_3 pinaculum on abdominal segments 1–7 is an elongate, equally large sclerite in *Aoraia;* in *Dumbletonius*, and often in *Wiseana*, there is a small sclerite in this position on A1 and A2, but it is not as large as the L_3 pinaculum.

Between the anal prolegs there is a fused or weakly divided V_1 pinaculum in *Aoraia, Dioxycanus, Dumbletonius*, and *Wiseana;* the pinacula are separate in other genera. The anal shield posterior margin sclerotisation is conspicuously emarginate at the midpoint in *Heloxycanus*, entire or irregularly and obscurely emarginate in other genera. The paraproct sclerites meet in the midline, and the junction is fused in *Cladoxycanus, Dioxycanus, Dumbletonius, Heloxycanus*, and *Wiseana*.

Some elements of pinacular fusion and size vary between instars, usually with earlier (e.g., antepenultimate, penultimate) instars having larger or more distinct or less eroded pinacula. At least one character – metathoracic seta L_3 on or separate from the usually rhomboidal SD_1, SD_2 pinaculum – distinguishes *Aoraia* and *Aenetus* from other New Zealand genera. Some elements do not change: in all New Zealand genera except *Aoraia*, abdominal segment 1 setae L_1, L_2 are on a fused pinaculum, and on succeeding segments they are on separate pinacula. In all New Zealand genera except *Aenetus*, abdominal proleg seta SV_1 is on a separate pinaculum and SV_2, SV_3 are on a common pinaculum.

There are two features of hepialid chaetotaxy often noted in the literature, as follows.

(a) Prothoracic felted pits (Fig. 182, fp), and their setal nomenclature. In this study, all hepialoid genera examined possess black, felted (pilose) pits. Where there are two felted pits, the setae are exceptionally fine and not obviously pigmented. The seta in the third pit, usually anterodorsal, and occasionally intermediate in position, is long, stout, and pigmented, and usually lacking any surrounding pilosity. In *Aenetus, Zelotypia*, and *Endoclita* all three setae are enclosed by an elongate felted pit or melanised depression. On the *Mnesarchaea* (Mnesarchaeoidea) pronotum two setae are long, fine, and curved (SD_1, SD_2) and lie on a pilose mound; seta D_2 is at an intermediate level between the two, and arises beside the anterior edge of the mound. Hinton (1946), and lately Nielsen & Kristensen (1989, p. 92, fig. 209) give an essentially topographic notation, i.e., seta D_2 is the most dorsal, SD_2 the intermediate, and SD_1 the ventral. Wagner (1987) reversed the notation for D_2 and SD_2, and I have followed this on the basis that this links the setae invariably set in felted pits and invariably setulose and unpigmented, over a wide range of genera and in two exoporian superfamilies. In Geometridae (Dugdale 1961) the SD setal group tends to be setulose, elongate, and in at least one genus (*Sarisa* Fletcher, as *Gargaphia*) capable of movement.

(b) The relative proportions of the proprioceptor setae MD_1, MSD_1, and MSD_2 on the mesothorax and metathorax (Nielsen & Kristensen 1989, pp. 93, 94). Except in *Aenetus*, New Zealand genera have the mesothoracic proprioceptor setae all small and MD_1 longer and darker on the metathorax. In *Aenetus* MD_1 is longer and darker on both mesothorax and metathorax. (*Endoclita excrescens* Butler has the same state.) Seta MD_1 in particular is prone to damage in preserved specimens, and the MD_1-MSD_1-MSD_2 zone is also often hidden by folds, making examination difficult.

A strictly cladistic approach to setal relationships between the lepidopterous groups Exoporia and Endoporia is explored by Leonard *et al.* (1992), and it is clear that a major study establishing homologies and discarding (or at least recognising) homonymies is overdue.

Pupa (Fig. 188–208)
The hepialoid pupa (Mosher 1916, p. 26) is cylindrical with all appendage sheaths soldered, and is characterised by having the wing-cases extending to the posterior margin of the second abdominal segment (or partly on to the anterior part of the third). In most endoporian Lepidoptera the wing cases extend to the fourth abdominal segment. As Mosher noted, abdominal segments 2–7 are of nearly equal length and diameter. Abdominal segments 3–7 (male) and 3–6 (female) are movable (free) according to the literature; in practice, in both sexes abdominal segments 3–7 are synchronously movable, producing a twirling movement which allows the abdominal crests to push the pupa up the close-fitting shaft. Anyone who has clutched a live porina pupa in the hand will be aware of the considerable power exerted by the movable abdominal segments through the segmental crests.

Unlike other ditrysian pupae in New Zealand, the hepialid pupa has very short antennal sheaths; these reach either to the middle leg sheath base *(Aenetus)* or to no further than halfway along the middle leg sheath (other genera). The integument is either uniformly sclerotised and shiny brown (most genera) or the head and thoracic area are very strongly sclerotised, almost black, and the rest of the integument is pallid, almost flimsily sclerotised *(Aenetus* – e.g., Boudinot 1991, fig. 23, *Endoclita, Zelotypia).*

The head piece (e.g., Fig. 189, 193) breaks away from the rest of the pupal exuviae during adult eclosion (emergence); most exuviae collected in the field lack the head piece. It shows many possibly useful characters; the following terminology is from Mosher (1916, pl. xix fig. 8). The shape of the maxillary plate, and its length relative to that of the labial plate, the condition of the mandibular plates (basally separated by either the labrum or the labial plate; longitudinal axis parallel with or oblique to the mesal midline), the size and distinctness of the labrum versus the clypeal plate, and the occurrence of processes on these and on the frons, vertex, gena, and antennal scape / pedicel sheath can differ between genera, or groups of genera, or species. Chaetotaxy is reduced: one pair of labral setae, two pairs of upper lateral clypeal setae, and in some genera – a presumed plesiomorphy – one pair of lower frontal setae. Between the antennal bases the vertex bears two pairs of setae. The postvertex area, which remains attached to the exuviae, has two pairs of lateral setae.

In *Cladoxycanus* (Fig. 195), *Dumbletonius* (Fig. 201), and *Wiseana* (Fig. 206–208) the antennal scape and pedicel each bear a broad, stout, outwardly decurved, thorn-like process dorsally; in *Aenetus* (Fig. 189) the scape, pedicel, and part of the antennal sheath form a crenulate carina or blade; in the other three genera the antennae are relatively smooth. The vertex is produced into two divergent, strongly sclerotised cones in *Aoraia* (Fig. 192), *Wiseana* (Fig. 206–208), *Heloxycanus* (Fig. 204), and to some extent *Cladoxycanus* (Fig. 195), but is more or less plane or sunken, with a mesal furrow, in the other genera. *Aenetus virescens* differs from other *Aenetus*, and from *Endoclita* and *Zelotypia*, in having a sunken vertex; this is enlarged and bifurcate or quadrifurcate in the exotic genera. The frons may be plane *(Aenetus, Zelotypia, Endoclita)*, or convex *(Aoraia, Dumbletonius, Heloxycanus)*, or convex with a conical process (*Dioxycanus*, Fig. 197) or a decurved, bifurcate process (*Cladoxycanus*, some *Wiseana*). The frons is nude in all New Zealand genera except *Aenetus*, which has a pair of lower frontal setae (also present in *Endoclita* and *Zelotypia*, but absent or represented by pits in Australian *Aenetus*, cf. Fig. 189, 190). Lower frontal setae are also present in Nearctic species of genus *Korscheltellus* and the *'Hepialus' californicus* species group.

The mandibular sheaths are either separated basally by the labrum *(Aenetus, Dumbletonius, Cladoxycanus, Dioxycanus, Wiseana)* or are basally contiguous *(Aenetus, Heloxycanus).* In all New Zealand genera except *Aenetus* the longitudinal axis of each mandibular sheath is oblique to the mesal midline; in *Aenetus* (and *Endoclita*) the mandibular plate axis is parallel to the mesal midline.

The gena is either planoconvex *(Aoraia, Aenetus, Dioxycanus, Heloxycanus)* or has a prominent mound *(Cladoxycanus, Dumbletonius, Wiseana).* The compound eye plate is divided vertically into glazed (inner) and sculptured (outer) zones.

The length of the labial plate cf. the maxillary plate can vary between species; only in *Cladoxycanus* and *Heloxycanus* does the labial plate conspicuously extend further than the maxillary plate. In all New Zealand genera the labrum apex is well anterior to the lower margin of each eye plate mesally. (*Leto* from South Africa is the only genus known to me in which the labrum and lower mesal apex of the eye plate are on a level.)

Prothoracic and mesothoracic (notal) plates have a reduced chaetotaxy and are variously sculptured; above the forewing base on the mesonotum there may be a low prominence (*Aoraia*, Fig. 191; *Dumbletonius*, Fig. 198; *Wiseana*, Fig. 205). As mentioned above, the prothorax and anterior mesothorax in *Aenetus* are very strongly sclerotised, and contrast with the rest of the pupal integument. The metathorax is unmodified, with setae D_1 and SD_1

present (most genera), or just seta D_1 *(Aenetus)*. (South African *Leto* has D_1, SD_1, and D_2 present.)

The pupal abdominal segments (hereafter A1–9+10) in exoporian Ditrysia (Mnesarchaeoidea + Hepialoidea) exhibit "three states in a single transformation series" (Nielsen & Kristensen 1989, p. 100) in regard to segmental armature. All New Zealand genera (except *Aenetus*) can be included in their State 3, i.e., A3–7 with two transverse rows (anterior and posterior) of spines dorsally, with a prominent ventral (anterior) row on A7, which is often connected with the dorsal anterior row in front of the A7 spiracle. *Aenetus, Zelotypia*, and *Endoclita* may represent a further state, characterised by (a) an anterior spine crest dorsally on A1 and A2 (not in *Endoclita*), (b) the A7 ventral spine crest reduced, interrupted mesally, and aligned posterior to the spiracle, and (c) the presence in *Aenetus virescens*, some Australian *Aenetus* and *A. cohici* (Boudinot 1991, fig. 23), and *Endoclita* of a posteroventral spine crest on A7. Chaetotaxy indicates that the anterior spine crest on A7 is homologous with that in other State 3 hepialids, i.e., it snakes between the same setae / setal groups (V/SV) in both groups of genera (Fig. 188).

Characteristically in State 3 pupae the A7 anterior crest is enlarged, forming a prominent toothed shelf or ledge (e.g., Fig. 191, 205; also Mosher 1916, pl. xix fig. 9, Wagner 1987). In *Cladoxycanus* the spines are long and slender, forming the bulk of the ledge; in other New Zealand genera the shelf is solid, formed from the long, fused basal portions of the spines.

The abdominal setae are generally persistent and often prominent, particularly in *Cladoxycanus* (Fig. 194), where they are long – the D setae are nearly as long as the segment they are on – and wiry. In the other New Zealand genera they are shorter, stiff, and straight (e.g., Fig. 205). A1 has reduced chaetotaxy in all genera, with *Aoraia, Aenetus*, and *Cladoxycanus* having setae D_1 and D_2, and the other genera only D_1.

A2–7 have the same chaetotaxy in all New Zealand genera (e.g., Fig. 191, 196, 205), with *Aenetus* differing in that A4–7 have reduced SV representation (Fig. 188).

In all New Zealand genera except *Cladoxycanus*, A4–7 ventrally have a pair of short transverse carinae, posterior to the SV setae. In *Aenetus* these are more or less fused mesally and are sinuous. Also sublaterally on A4–6, but only in *Dioxycanus, Dumbletonius, Heloxycanus*, and *Wiseana*, there is a short carina anteroventral of the spiracle (Fig. 196, 198, 203, 205). The disposition of the genital openings is as described by Mosher (1916, p. 26) and illustrated by Waller (1966) and Wagner *et al.* (1989, fig. 14c,d).

BIOLOGY

Phenology (Table 2). Life cycles have been studied in detail for *Aenetus* (Grehan 1987a; also Hudson 1885, Quail 1903a, Grehan 1983a) and *Wiseana* (Barratt *et al.* 1990; also Dumbleton 1945, French 1973, Carpenter 1978). For other genera the phenology is more speculative, as it is based on adult occurrence and larval size noted during collecting. As regards *Heloxycanus*, the estimated 2-year cycle (Table 3) is also based on the virtual absence of adults in alternate years, as observed by Mr B. Patrick (pers. comm.) and myself.

Aenetus differs from *Wiseana* (and possibly other genera) in the extremely long and variable pupal period (50–200 days, mean 151 ± 43 for males, 173 ± 41 for females: Grehan 1987a, p. 214), averaging about 15% of total development time. *Wiseana* species are univoltine, and for *W. cervinata* at Nelson (NN) pupation occupies about 40 days, 11% of total development time (Dumbleton 1945, p. 114).

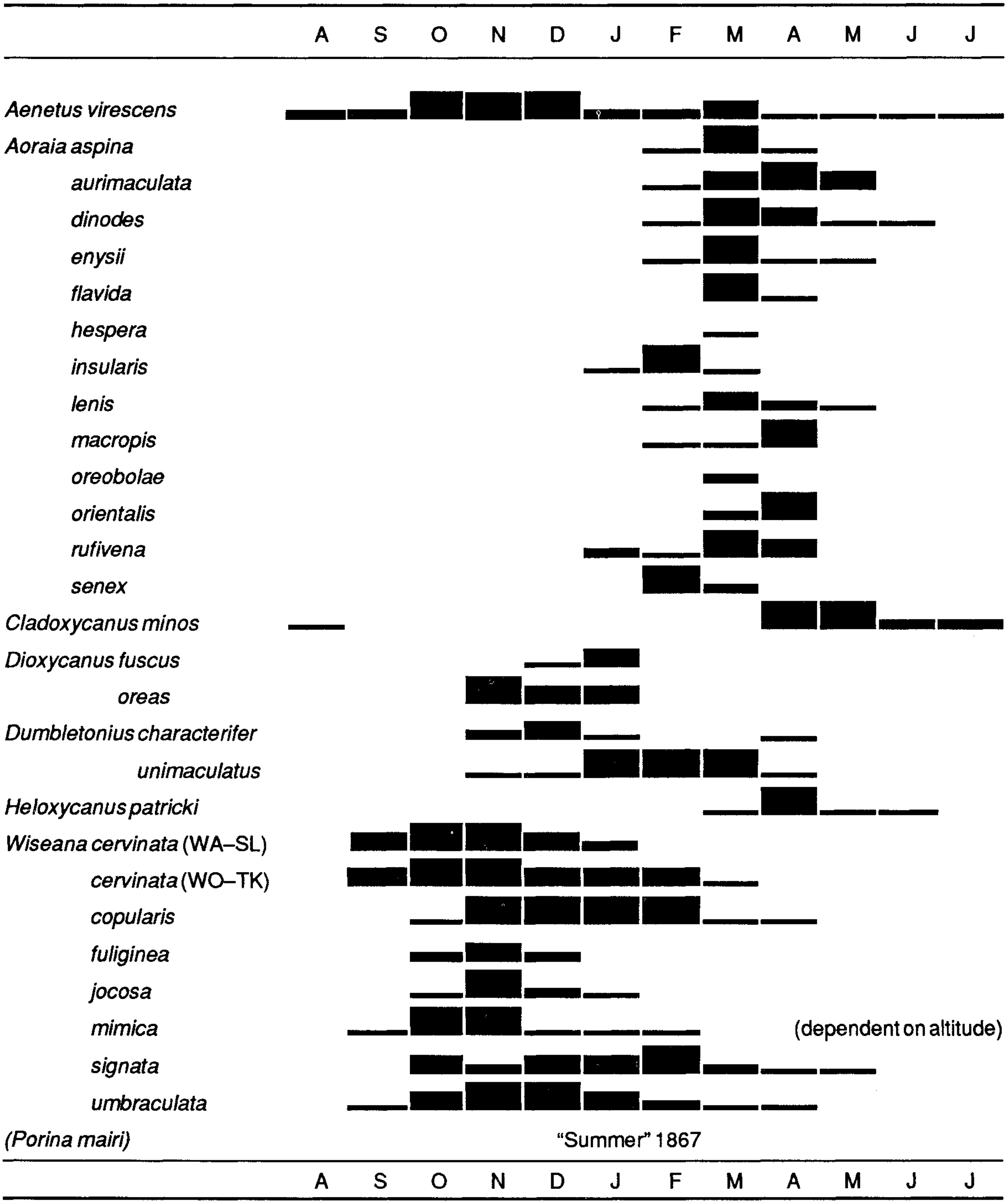
Adult flight periods are listed in Table 2 for all species. Again, *Aenetus* is unusual in that adults are encountered in all months (Grehan 1987a; DSIR Land Resources records from Orongorongo Valley Research Station, WN; NZAC specimens), with a major peak in late spring and a minor peak in the northern North Island in late summer. *Aoraia, Cladoxycanus*, and *Heloxycanus* species emerge in autumn, with *Cladoxycanus* in upland sites peaking in May; by April, such larval/pupal sites are frozen on frosty nights, and emergence is physically possible only on frost-free, usually drizzly nights. *Dioxycanus, Dumbletonius*, and *Wiseana* emerge over spring and summer, often with a clear sequence of species over time in any one locality for the *W. cervinata* group. In Canterbury, for instance, *W. cervinata* and *W. fuliginea* are contemporaneous, but are temporally isolated from the later emerging *W. copularis*.

Forest-dwelling sympatric *Aoraia* species (*aurimaculata, enysii, dinodes* groups) are contemporaneous (NZAC records), as are some members of the penalpine and alpine *A. senex* group, although there is some degree of temporal isolation between, e.g., *A. senex* (usually early) and *A. macropis* (usually late).

In *Dioxycanus* the species are allopatric. Daytime activity of female *D. oreas* has been observed in high-rainfall red tussock *(Chionochloa rubra)* and low-rainfall *Poa / Rhytidosperma* subalpine communities, but males have not been observed to be active in the daytime.

In *Aenetus* and *Wiseana cervinata*, eggs take about 15 days to hatch (*Aenetus*: Grehan 1987a) or from 35 to 52 days (*Wiseana*: Dumbleton 1945, French & Pearson 1979), depending on temperature. Larval life can take from 665 ± 217 days (males) to 935 ± 188 days (females) in *Aenetus*

Table 2 Adult flight periods of New Zealand Hepialidae, based on frequency distribution of records. Thinnest bars are records based on single specimens, thickest bars are greatest number of records, other two bars are intermediate records on either side of median. Time scale begins / ends at the coldest month of winter.



(Grehan 1987a) or about 267 (mean) days in *Wiseana* (Dumbleton 1945). *Aenetus* larvae have attained 'transfer phase' – i.e., have passed through three or four instars – within 3 months (Grehan 1987a, p. 213); in *Wiseana cervinata* (Dumbleton 1945, p. 115) the first instar alone appears to last at least 1 month.

Larva

Larvae pass through a variable number of instars, and a precise count has not been made, largely because (a) larvae tend to eat their cast skins and (b) rearing is a difficult and lengthy process in the laboratory. The laboratory mass-rearing methods recently devised by Dr P. Wigley (pers. comm.) produce average-sized *Wiseana* adults. Barratt *et al.* (1990, p. 52) note that the number of moults is thought not to be constant, and may be between six and ten. Clear head capsule width differences between the first to third instars were seen in *W. cervinata* by Fenemore & Allan (1969, fig. 2). Most observers – e.g., Dumbleton (1945), Wood (1970), Grehan (1987a), Barratt *et al.* (1990) – use body length as a guide. In pesticide research body weight or a combination of weight and length was used (e.g., Perrott 1974).

Hepialid larvae can attain great size. While first-instar caterpillars range from about 3 mm *(Wiseana)* to 4 mm *(Aenetus, Aoraia)*, final-instar caterpillars of *Cladoxycanus, Dioxycanus*, and *Heloxycanus* can exceed 40 mm (50 mm in *Heloxycanus*), and *Wiseana* larvae can exceed 60 mm (80 mm in *W. umbraculata* and *W. signata*). *Aoraia, Aenetus*, and *Dumbletonius* larvae exceed 80 mm, some attaining over 110 mm and a diameter in excess of 10 mm.

Hepialid larval life passes through 'phases': in New Zealand, *Aenetus* has the more complex life habit, with an initial litter phase, a migratory transfer phase, and a tree phase (Grehan 1987a,b, 1989). *Wiseana*, the other most studied genus in New Zealand, has two recognisable phases: a litter phase or non-shaftmaking (burrowing) phase and a shaft phase (e.g., Dumbleton 1945, Barratt *et al.* 1990). A similar two-phase life habit has been observed in both alpine and forest *Aoraia* species.

The transfer phase in *Aenetus* is morphologically distinct, with enlargement of the dorsal setal pinacula giving an armoured, often 'zebra crossing' appearance. No morphological distinctions other than increasing globosity of the head capsule from the ovoid first-instar condition are apparent between the litter phase and earliest shaft phase larvae of the other genera. The habit change is from rambling horizontal silk (or silk-lined) galleries to a single shaft, more or less perpendicularly excavated into the soil, silk-lined and with a silk runway of variable length leading from the entrance to a feeding area. *Wiseana cervinata* larvae can feed over a wide area, but keep at least the anal prolegs on the runway or inside the entrance (Esson 1970, time-lapse photography). Larvae of *Dumbletonius* and *Aoraia* may wander, as indicated by their presence in pit traps and emergence traps.

Food categories of New Zealand hepialid caterpillars are broadly summarised in Table 3. It is becoming evident (Grehan 1989) that Hepialidae, if not Exoporia as a whole, oscillate between mycophagy and phytophagy. Mycophagy – possibly better termed saprophagy – is known for litter-phase *Aenetus* (Grehan 1979, 1987a), presumed for all instars of *Dumbletonius unimaculatus* (Grehan *et al.* 1983), and observed for earlier to at least middle instars of forest-dwelling *Aoraia*. Wood (1970) noted that, in the laboratory, first-instar *W. cervinata* preferred wilted plant material, only older larvae (? third instar) readily feeding on freshly cut foliage. Evidence of at least initial mycophagy in other hepialid genera is given by Grehan (1989).

Barratt *et al.* (1990), following French (1973) and Carpenter (1978), notes that "after 4–6 weeks in late summer or early autumn, by which time the caterpillars are 10–15 mm long, they start to build burrows." It is noteworthy that, irrespective of genus, hepialid larvae suddenly change their habits – very greatly in the case of *Aenetus* – at much the same point in their lives.

Field observations indicate that *Dumbletonius* (Grehan *et al.* 1983) and forest *Aoraia* feed probably entirely on fallen leaves, which are host to many species of fungi. Larvae of *A. insularis* on Big South Cape Island (SI) were found associated with clumps of *Poa foliosa*, the lower leaves of which showed browsing damage, but *A. insularis* has been collected from sites elsewhere that lack *Poa*. Other *Aoraia* species are associated with short grasses (e.g., *A. senex* and *Poa colensoi*), intertussock swards *(A. lenis)*, and cushion bogs with *Oreobolus (A. rufivena, A. oreobolae)*, with obvious browse damage to live vascular plants (Grehan & Patrick 1984). *Dioxycanus* and *Wiseana*, at least beyond the third instar, browse on live vascular plants, and *Cladoxycanus* and *Heloxycanus* do likewise on mosses and on higher plants growing as cushions in the moss-bog communities.

The complex life history of the *Aenetus* caterpillar (Grehan 1983, 1987a) involves a litter phase usually under a silk tent on bracket fungi or rotten wood; the 'armoured' transfer phase, in which the larva vacates the litter habitat and establishes a shaft and a peripheral feeding scar, with induction of callus tissue by the host tree, also under a distinctive silk tent, and finally a tree (-dwelling) phase. Miller (1971), Sharell (1971), and Grehan (1987a, 1989) all illustrate the distinctive 7-shaped burrow of the *Aenetus*

Table 3 Host categories of post-establishment phase larvae of New Zealand Hepialidae, with development time (egg–adult) in years. *Grehan (1987), **Barratt *et al.* (1990)

	— Mycophagy —		**Phytophagy**				**Development time (years)**
	Fungi, rotten wood	Fallen leaves	Callus tissue on trunks	Vascular plant 'turf'	Vascular plant tubers	Mosses (semi-aquatic)	
Aenetus	+		+				1–4*
Aoraia		+		+			2–?3
Cladoxycanus						+	1
Dioxycanus				+			1
Dumbletonius		+					2–?3
Heloxycanus				(+)		+	2
Wiseana				+	(?+)		1**

larva with its characteristic external feeding scar. The tree-phase *Aenetus* larva has reduced dorsal setal pinacula relative to those of the transfer phase, but develops increased rugosity of the head capsule.

Feeding damage and shaft construction are figured for *Heloxycanus* by Grehan & Patrick (1984), for *Aoraia* by Grehan (1989), and for *Wiseana* by Barratt *et al.* (1990). Soil- or moss-inhabiting larvae excavate a silk-lined shaft; a feature of the shaft, for many genera, is the construction of side chambers (e.g., Grehan 1989, p. 809, fig. 4). While these may be used to store faecal pellets, in *Wiseana* – and in Australian *Oncopera brachyphylla* Turner (Elder 1970) and South African *Eudalaca rufescens* (Hampson) (Joubert 1975) – one chamber may be used to store cut plant material. Feeding by soil-inhabiting larvae can be erratic (Esson 1970); nightly foraging can be suspended for over ten consecutive nights (Esson 1970, French & Pearson 1981). The nature of the living site may be such that the shaft is at the centre of a large feeding and faecal pellet storage area, as in *Cladoxycanus* and *Heloxycanus* in deep *Sphagnum* bogs (e.g., Grehan 1989, p. 808, fig. 2). In that situation, as the sphagnum bog surface absorbs radiant heat, larvae can be found in the daytime up in the chamber, where the temperature is several degrees above ambient (i.e., the moss is warm to the touch).

A variation on the shaft sunk into the soil or substrate is developed by *Dioxycanus oreas*, where the larval refuge is a detritus-encrusted blind silk tube at the base of a tussock, in amongst the dead tiller bases (Grehan 1989, p. 807). Pupation occurs within the tube.

Moss bog-inhabiting genera *(Cladoxycanus, Heloxycanus)* have larval shafts that descend to or penetrate the water table (Grehan & Patrick 1984), as do, usually temporarily, the shafts of *Wiseana umbraculata*. I have collected *W. umbraculata* from shafts constructed in the raised heads of *Carex secta* (niggerhead) in the middle of a swamp, suggesting that *W. umbraculata* will avoid high water tables.

Root feeding has not been observed (Grehan *et al.* 1983) despite supposition that this occurs (Hudson 1928). Examination of roots of recently uprooted trees has been fruitless, and my experiences mirror those of Grehan, Moeed, and Meads, above. One possible example of tuber feeding involving *W. signata* has been reported (Grehan 1983b), where tubers of *Muehlenbeckia australis* were found damaged, in association with larvae. Residents of Oban, Stewart Island, have mentioned to me that potato tubers are chewed by 'porina' (probably *W. jocosa*).

Development time of larvae appears to be stable within a genus (Table 3); genera are either univoltine *(Cladoxycanus, Dioxycanus, Wiseana)* or take 2 years for a generation *(Heloxycanus)*, with one year in which adults are abundant followed by a year of virtual absence (similar to the abundant / rare sequence described for *Korscheltellus gracilis* (Grote) by Wagner *et al.* 1989). *Aoraia* and *Dumbletonius* larvae found in litter samples and pit traps span a range of sizes, suggesting at least a 2-year cycle and probably 3 years (Table 3). In these genera no 'abundant / rare' sequence is evident from NZAC records, and it is likely that populations (or cohorts: Wagner *et al.* 1989) are mixed and / or there is variation in length of larval life.

Such variation has been amply demonstrated for *Aenetus* (Grehan 1987a), where tree-phase generation time is 1–4 years, and possibly longer in cooler upland sites.

Pupa

After the larval stage, the pupal stage is the next longest in the life of New Zealand hepialids (see previous section). Pupation occurs in the larval shaft or burrow. As this shaft is silk-lined, and the pupa is beset with spine bands which act as 'creeping welts' – rather as on a dipteran maggot – and has abdominal segments 3–7 mobile, the pupa is capable of considerable movement. By twirling its abdomen and jerking the body back and forth a pupa disturbed from its shaft can bury itself in loose soil, admittedly rather clumsily. *Wiseana* pupae ready to emerge are poised in the upper part of the shaft (Dick 1945, p. 4). A similar condition has been seen in *Aoraia, Cladoxycanus*, and *Heloxycanus*.

In *Aenetus* (Grehan 1987a, and references therein) the pupa pushes away a silken plug at the angle of the 7-shaped shaft, and just before adult emergence projects itself through the entrance hole, retaining a grip on the shaft with the dorsal and ventral spine bands.

In the ground-dwelling genera the pupa projects partly out of the shaft at first. Depending on the actions of the emerging adult, the pupal skin either remains erect, gripping the silk-lined shaft entrance with the enlarged A7 ventral comb (see section Morphology: Pupa) or is torn loose and lies on the turf. The integument quickly fades, and has generally disintegrated within 2–3 months.

Adult behaviour, mating, and oviposition

Adults have no functional mouthparts in New Zealand genera, and adult life is therefore brief. Despite records of adults observed alive for up to 23 days (French 1973), given the range of predators – morepork owls, cats, possums – the usual lifespan is probably less than a week.

Adults emerge in the late afternoon (*Aoraia orientalis, A. senex, Aenetus virescens*: Grehan 1987a and references therein) or at dusk or shortly before (*Wiseana*, Dick 1945; *Dumbletonius*, Grehan *et al.* 1983; *Heloxycanus*, Grehan & Patrick 1984) or up to an hour after dusk *(Aoraia lenis, A. dinodes, A. aurimaculata, A. rufivena)*. Males emerge shortly before females (e.g., *Wiseana*, Dick 1945) on a 'flight night'. Male activity usually finishes within 1–1.5 hours of onset; female activity may continue until midnight (*Dioxycanus oreas*, Tararua Range). In several *Aoraia* species the male flight activity period can be as brief as 20 minutes, or at any rate less than 1 hour. By and large a 'flight' or 'mass emergence' of *Wiseana* occurs with the onset of a frontal weather system (Helson 1972), or after a warm day with cloudy nights and an air temperature of about 8°C (Dick 1945). *Aenetus* and *Aoraia* emergences also peak under such conditions, especially if rain occurs, or mist.

Adults mate shortly after emergence, and males seek out emerging and pheromonally dispensing females. Female calling pheromones are involved in *Wiseana* and *Aoraia* mating; handling the emergent female makes one's fingers attractive to the circling males. Mating starts off side by side, but the male very soon positions himself back to back. Females support themselves while the male hangs "downwards from the female by [his] genitalia, with legs completely free" (Grehan *et al.* 1983).

Oviposition starts very soon after mating is accomplished. Dick (1945, pp. 35–36) gives detailed notes on oviposition behaviour of *Wiseana*, and Grehan (1987a) tried to establish whether *Aenetus* broadcast its eggs in flight, concluding that it probably does not. In both genera, and in *Aoraia orientalis* (with brachypterous females), most eggs were seen to be laid as the female rested or crawled along the ground. The structure of the female anogenital field in *Dumbletonius* and *Wiseana* appears to allow the eggs to be released both singly and in groups (Dick 1945, p. 35 gives a most detailed account). Nothing specific is known for other genera.

The eggs of New Zealand species are globular, lack any sort of sticky coating, and thus roll around freely. Fertilised and unfertilised eggs turn black within 24 h in all genera. They come to rest deep in the litter or turf, where humidity is highest. For *Wiseana* eggs 90–100% RH ensured highest survival (Dumbleton 1945). First-instar larvae were found to have a similar requirement.

For most genera, after the initial egg-burden has been lost, females' flight activity increases. On Chatham Island females are suspected of laying eggs on the backs of sheep (or possibly dropping them there while in flight), for when sheep are shifted to distant pastures during the porina flight period these previously uninfested pastures are seen to have become severely infested by the next winter (Mr R. Holmes, pers. comm.).

Biotopes (Table 4). New Zealand hepialids require humid conditions for oviposition and larval establishment, plant debris with a copious fungal flora, presence of bryophytes and / or vascular plants, and soil (or humus) of sufficient depth in which to construct a larval shaft or retreat. They can exist – and indeed, one genus flourishes – above the bushline. Yet the one biotope they do not exist in is that of the subantarctic islands at 50–52°S. Other Hepialidae (*Calada* Nielsen & Robinson, *Parapielus* Viette) exist at higher latitudes in South America, south to Staten Island at 55°S.

Table 4 summarises the broad biotopes, divided into altitudinal vegetation belts as defined by Wardle (1991, pp. 74–76), inhabited by each species. At least nine species in

Table 4 Vegetational zones ("belts" as in Wardle 1991, pp. 74–76) within broad ecological sites (biotopes) used by New Zealand Hepialidae. Key: WT, warm temperate; CT, cool temperate; SA, subalpine; PA/A, penalpine/alpine above timberline); (+), revegetating slips, or mossy seepages or bogs within the 'forest' biotope.

	Forest			Shrub-grassland				Bogs / seepages				Urban
	WT	CT	SA	WT	CT	SA	PA/A	WT	CT	SA	PA/A	
Aenetus virescens	+	+										+
Aoraia aspina							+					
aurimaculata			+			+	+					
dinodes		+	+									
enysii			+				+					
flavida											+	
hespera							+					
insularis	+											
lenis							+					
macropis											+	
oreobolae											+	
orientalis							+					
rufivena		+	+			+	+					+?
senex							+				+	
Cladoxycanus minos	(+)	(+)						+	+	+		+
Dioxycanus fuscus		(+)		+	+	+	+					
oreas						+	+					
Dumbletonius characterifer		+	+									
unimaculatus	+											
Heloxycanus patricki								+	+	+	+	
Wiseana cervinata	(+)	(+)		+	+							+
copularis	(+)	(+)		+	+							+
fuliginea		(+)		+	+							+
jocosa		+		+	+							+
mimica				+	+	+	(+)			+	+	
signata	(+)	(+)		+	+							+
umbraculata	(+)	(+)						+	+			+

four genera are found in urban areas, although *Aoraia rufivena* is probably restricted to forested reserves rather than urban gardens.

Cladoxycanus and *Heloxycanus* are specialised, restricted to bogs, with adults emerging in autumn-winter. *Heloxycanus* is unknown north of the Waitaki Valley (CO–DN) and is not known from forested areas, whereas *Cladoxycanus* is known as far north as Hawera (TK), and is present in both shrub-grassland and forest localities. *Dioxycanus* is essentially a subalpine-penalpine shrub-grassland genus, extending north to Mt Taranaki (TK). *Dumbletonius* is a northern, forest-dwelling genus with altitudinally separated species, one of which extends to the northern South Island. *Wiseana*, which along with *Aenetus* has succeeded in urbanised areas, is found from ND to Stewart Island (SI), and is adventive on Chatham Island. Most species are essentially inhabitants of shrub-grassland or revegetating forest landslide / river bank / floodplain biotopes, with one at least *(W. umbraculata)* specialising in boggy ground or swamp margins, another *(W. signata)* in the most freely draining soils, and a third *(W. jocosa)* in forest margins, clearings, and forest-shrub ecotones. The other species occupy moist to seasonally dry sites, and have clearly flourished with the widespread adoption of pastoral farming based on introduced grasses and clovers.

At least one hepialid genus is represented in all major biotopes from sea level to the alpine zone, excepting the subnival and nival zones. Of the seven genera, only *Heloxycanus* has not been found in the forest biotopes, and four are not found in penalpine biotopes, except possibly where these are altitudinally depressed, as at Arthurs Pass (NC–WD). Only *Wiseana* has a species found all over New Zealand; other genera are restricted to a greater *(Heloxycanus)* or lesser (e.g., *Aenetus, Aoraia, Dumbletonius*) degree.

Pathogens and parasites

Over 20 micro-organisms pathogenic on Hepialidae have been recorded from New Zealand (Glare *et al.* 1993, and included references), including at least seven fungi, a bacterium, a nematode, four viruses, and seven protozoans, including the gregarine *Diplopseustis oxycani* Dumbleton). Of these, two have been investigated as possible control agents: the fungus *Metarrhizium anisopliae* (Metschnikoff) Sorokin (Latch & Kain 1983) and the baculovirus *Borrelinavirus* sp. (Kalmakoff 1980). The record of *Cordyceps* sp. (as *Sphaeria*) in *Aenetus virescens* (Hudson 1906) appears incontrovertible, but there are no recent records (Grehan & Wigley 1984). Other fungi, including *Beauveria bassiana*, and a bacterium have been recorded (Grehan & Wigley 1984). *Cordyceps* species have been recorded on *Aoraia* and *Dumbletonius* (the record on "Porina signata" (Salmon 1951) may refer to a misidentified host), and can be locally abundant, as in Forest Hills Reserve SL and parts of Taranaki National Park TK.

Few parasite species have been recorded from Hepialidae (Valentine 1967, and references therein); such records as there are refer to *Wiseana*. Three Hymenoptera, all large ichneumonid species, and five Diptera, all in Tachinidae, are known. The soil-dwelling staphylinid *Thyreocephalus chloropterus* Erichson has been observed preying on porina larvae. The parasites regularly encountered are all in Tachinidae:

- *'Occisor' versutus* Hutton;
- *Pales usitata* (Hutton);
- *Plagiomyia* sp.;
- *Protohystricia* spp. (*alcis* Walker, *signata* Walker).

No parasites have yet been reared from *Aenetus, Aoraia, Cladoxycanus,* or *Heloxycanus.* A puparium associated with a dead *Dioxycanus* larva did not rear through.

METHODS AND CONVENTIONS

Species concept. Mishler & Donaghue (1974), following Marston Bates, made a plea for taxonomists to state, in any particular study, what species concept they used. With the exception of *Wiseana* species, I have stuck with a morphological species concept, bolstered where possible with biological and ecological information but untested by genetic, biochemical, or mating system investigations or experiments.

In *Wiseana* the isozyme studies of MacArthur (1986) and currently of Mr J. Herbert (Victoria University of Wellington) have demonstrated the genetic uniqueness of *W. fuliginea* (previously treated as a synonym of *W. cervinata*) and confirmed, on a genetic basis, the uniqueness of the six other species recognised on morphological grounds. Though the basis of this revision of *Wiseana* is morphological, the characters chosen are those that accord with the genetic analyses of MacArthur and Herbert.

Abbreviations and conventions

AMNZ	Auckland Institute and War Memorial Museum, Auckland, New Zealand
ANIC	Australian National Insect Collection, CSIRO Division of Entomology, Canberra, Australia
BLNZ	B. Lyford private collection, Queenstown, New Zealand
BMNH	British Museum (Natural History), now The Natural History Museum, London, England
BPNZ	B.H. Patrick private collection, Dunedin, New Zealand
CMNZ	Canterbury Museum, Christchurch, New Zealand
FRNZ	Forest Research Institute, N.Z. Forest Service, Rotorua, New Zealand
HCOE	Hope Collection, Oxford University, England
LUNZ	Dept of Entomology, Lincoln University, Lincoln, New Zealand
MNHN	Museum National d'Histoire Naturelle, Paris, France
NMNZ	National Museum of New Zealand, Wellington, New Zealand
NZAC	New Zealand Arthropod Collection, Manaaki whenua - Landcare Research, Mount Albert Research Centre, Auckland, New Zealand
RMVA	Royal Imperial Museum, Vienna, Austria
SAMA	South Australian Museum, Adelaide, Australia

Two-letter codes used to define collection areas (e.g., NN, CO) are after Crosby *et al.* (1976): see the map on p. 160. Abbreviations for morphological features used in the illustrations are defined in the list on p. 87.

KEY TO GENERA OF HEPIALIDAE KNOWN FROM NEW ZEALAND

ADULTS

1 Forewing veins R_4 and R_5 on a common stem separate from the R_{2+3} stem (Fig. 73); antennae either without pectinations (Fig. M1) or bipectinate in both sexes, the pectinations slender; female abdomen without an apical tuft of long, hair-like scales (e.g., Fig. 149) ... 2

—Forewing veins R_2, R_3, and R_4 on a common stem separate from R_5 (Fig. 76–80); antennae subpectinate, shortly bipectinate with the pectinations triangular or rectangular, or tripectinate (2 lateral pectinations, 1 median) (Fig. M8, M16); female abdomen with a conspicuous apical tuft of long, hair-like scales (e.g., Fig. 151) ... 3

2(1) Antennal segments compressed; head and thorax clothed above in densely packed, short, usually green scales, giving a smooth appearance (Fig. 1); forewings with termen concave (Fig. 1); male with a slender, pink hair pencil on hind tibia, and hind wings largely white or very pale green; female with brownish to reddish-brown hind wings, and abdomen tapering to apex, which bears short lateral tufts of normal scales (Fig. 3) ... (p. 37) .. ***Aenetus*** (1 species)

—Antennae with long pectinations in both sexes; head and thorax clothed above in long, shaggy, fur-like scaling, in shades of brown and ashy grey-white (Fig. 4–32); forewings with termen not concave; male lacking a hind tibial hair pencil; female fully winged or brachypterous, and with abdomen of even diameter, its apex rounded and clothed in short, stiff, appressed scales ... (p. 40) .. ***Aoraia*** (13 species)

3(1) Tarsal claws lacking an arolium; labial palpus basal segments each with an anteriorly projecting or ventral process (Fig. 93). Adults emerging late autumn-winter ... (p. 51) .. ***Cladoxycanus*** (1 species)

—Tarsal claws with an arolium; labial palpus segments lacking rami (e.g., Fig. 110). Adults not present in winter ... 4

4(3) Labial palpus reduced to 2 segments or 1, often asymmetrically (Fig. 96, 104); female sternum 9 with median piece demarcated by a constriction from side-pieces, tumid (Fig. 312); sinus seminalis open along entire length, i.e., sides not fused in midline ... 5

—Labial palpus 3-segmented (Fig. 110); female sternum 9 median piece and side-pieces fused to form a single structure, the median piece triangular, ovate, or rectangular and flat (e.g., Fig. 307, 334); sinus seminalis closed to form a duct, i.e., sides fused in midline, at least on apical third ... 6

5(4) Male antennae bipectinate, the lateral pectinations flat-triangular (Fig. M11); colour pattern of both sexes intricate (Fig. 37–39); male pseudotegumen with margin a 'normal' vertical crest, not explanate; female sterna 7 and 8 fused (Fig. 152). Emerging in summer (Nov–Jan) ... (p. 53) .. ***Dioxycanus*** (2 species)

—Male antennae tripectinate, the lateral pectinations finger-like, slender (Fig. M16); colour pattern of both sexes simple, longitudinal (Fig. 45–48); male pseudotegumen with explanate margins; female sternum 8 divided, and separate from sternum 7 (Fig. 154). Emerging in autumn (Apr, May) ... (p. 59) .. ***Heloxycanus*** (1 species)

6(4) Male antennal segments subpectinate (Fig. M13); male genitalia with a large, apically bilobed, ventrally elaborated subanal papilla (Fig. 300, 303); sternum 8 with subapical spines or heavily sclerotised posterior margin; female tergum 8 split mesally from posterior margin ... (p. 56) .. ***Dumbletonius*** (2 species)

—Male antennal segments pectinate, the pectinations triangular to subrectangular; male genitalia without a subanal papilla (Fig. 313); sternum 8 simple, lacking spines and with the posterior margin unmodified; female tergum 8 entire ... (p. 61) .. ***Wiseana*** (7 species)

LATE-INSTAR LARVAE

Note. Larvae of Mnesarchaeidae (Exoporia: Mnesarchaeoidea) may be encountered in litter / bryophyte samples along with *Aoraia*, *Aenetus*, and *Dumbletonius*. They have a similar stemmatal (ocellar) arrangement (two vertical rows or arcs each of three stemmata), a pre-antennal bar, an oral frame slit, similar chaetotaxy (abdominal seta L_3 anteroventral of the spiracle), and a relatively long A9. They differ in having the prothoracic shield and the prothorax usually markedly narrower than either the head capsule or the rest of the body, forming a neck, and on the prothoracic shield setae D_2, SD_1, SD_2 on a common felted mound, not in a felted pit or separate pits.

1 Stemmata in 2 vertical rows (Fig. 157, 162), the rows either parallel or ventrally divergent; paraproct sclerites free, or fused only ventrally in midline ... 2

—Stemmata in 2 parallel arcs (e.g., Fig. 166); paraproct sclerites fused in midline along entire length ... 3

2(1) Labrum with a midline apical 'tooth', appearing W-shaped in outline; stemmata in 2 parallel rows; hypostomal halves widely separated mesally, not meeting in midline (Fig. 158); head capsule with setal puncture La close to seta L_1; proleg crotchets biserial (Fig. 181); SV setae on proleg on a common pinaculum; anal proleg crotchet series ending laterally (Fig. 181) ... (p. 37) .. ***Aenetus***

—Labrum normal, with no midline tooth (Fig. 161); stemmata in 2 vertical rows which diverge ventrally (Fig. 162); hypostomal plates fused in midline, except in earliest instars; head capsule with setal puncture La displaced posteriorly to beside epicranial lateral notch (Fig. 162); proleg crotchets multiserial; proleg SV setae on 2 pinacula; anal proleg crotchet series extending along hind margin of proleg planta (only 7 of the 13 species with larvae unequivocally associated; no consistent differences observed) ... (p. 40) .. ***Aoraia***

3(1) A pinaculum-like sclerite posterior to L_3 pinaculum (Fig. 185) on abdominal segments 1 and 2; either paraproct sclerites tumid and strongly sclerotised or prothoracic shield setae SD_1, SD_2 in a common, kidney-shaped felted pit (Fig. 185, see caption). Larvae in forest or montane tall shrubland, not alpine or subalpine ... (p. 56) .. ***Dumbletonius***

—No sclerite posterior to L_3 pinaculum (e.g., Fig. 183, 184); prothoracic setae SD_1, SD_2 always on separate pinacula ... 4

4(3) Head capsule with fused hypostomal mesal apices broad, i.e., inner (mesal) length of hypostoma at least half length of outer (lateral) margin (Fig. 176); anal shield apical margin with a narrow V-shaped emargination in sclerotised zone mesally. Larvae in sphagnum / cushion bogs ... (p. 59) .. ***Heloxycanus***

—Head capsule with hypostomal mesal apices narrow, i.e., inner length of hypostoma less than half length of outer margin; anal shield apical margin sclerotisation entire ... 5

5(4) Abdominal seta SD_2 far longer than greatest width of SD_1–SD_2 pinaculum; abdomen lacking sternal plates. Larvae in sphagnum moss cushion bogs ... (p. 51) .. ***Cladoxycanus***

—Abdominal seta SD_2 length not exceeding greatest width of SD_1–SD_2 pinaculum, or SD_1, SD_2 on separate or greatly reduced pinacula (Fig. 187); abdomen with sternal plates ... 6

6(5) Head capsule with basistipes 'puncture' (setal socket but no seta) slightly less than halfway between basal and apical basistipes setae and scarcely 'offset' (Fig. 169); oral frame slit in some examples occluded by pre-antennal bar base *(D. oreas)*; integument not greatly darkened dorsally ... (p. 53) .. ***Dioxycanus***

—Basistipes 'puncture' twice as close to basal seta as to apical seta and greatly offset (Fig. 179); oral frame slit not occluded, even if pre-antennal bar base produced into a securiform process; integument in penultimate and final instars dark dorsally, pallid or often creamy ventrally ... (p. 61) .. ***Wiseana***

PUPAE

1 Bicolorous, with head, prothorax, and anterior two-thirds of mesothorax very dark brown or black and remainder of body pallid (Fig. 188); frons with a pair of lower frontal setae; antennal sheaths just reaching base of middle leg sheath; abdomen with A1, A2 each bearing a single transverse carina dorsally and A7 lacking a shelf-like, transverse, toothed crest. Arboreal ... (p. 37) .. ***Aenetus***

—Unicolorous bright chestnut brown in life; frons lacking any setae; antennal sheaths extended to about halfway along middle leg sheath; abdomen with A1, A2 each lacking a dorsal carina and A7 bearing a prominent, transverse, strongly toothed crest, far larger than other segmental spiny carinae. Terrestrial, including semi-aquatic ... 2

2(1) Setae conspicuous, long, wiry (irregularly crinkled); abdomen with venter of A4–6 lacking carinae or crests; antennal pedicel with a strong tooth; frons with a large, decurved, bifurcate process. In or beside sphagnum bogs and mossy seepage areas ... (p. 51) .. ***Cladoxycanus***

—Setae not conspicuous, short, straight; A4–6 with short oblique or transverse carinae on either side, posterior to SV setal group ... 3

3(2) Abdomen with A8 lacking a subventral carina or short, blade-like ridge and A3–6 with anterior dorsal carina (spine crest) not extending ventrally beyond setae SD_1, SD_2 (Fig. 191) ... (p. 40) .. ***Aoraia***

—Abdomen with A8 bearing a subventral carina, sometimes very short, posteroventral of seta L3, and A4–6 with anterior dorsal carina extending ventrally to below spiracle as a fine ridge, ending at a short, blade-like or crenulate ridge (Fig. 196) ... 4

4(3) Antennal scape and pedicel lacking a spine or thorn-like process; gena unmodified, planoconvex ... 5

—Antennal pedicel with a large, anterodorsal appressed thorn; gena with a large central mound ... 6

5(4) Frons with a central conical process; mandibles widely separated basally by a distinctly demarcated labrum ... (p. 53) .. ***Dioxycanus***

—Frons planoconvex; mandibles contiguous basally, with labrum and clypeus usually appearing fused ... (p. 59) .. ***Heloxycanus***

6(4) Vertex flattened on either side of midline furrow ... (p. 56) .. ***Dumbletonius***

—Vertex raised, conical or thorn-like, on either side of midline furrow ... (p. 61) .. ***Wiseana***

KEY TO SPECIES-GROUPS AND SPECIES OF HEPIALIDAE FROM NEW ZEALAND

ADULTS

Aoraia

1 Thorax width over 8 mm, or male forewing length over 28 mm ... 2

—Thorax width under 6 mm, or male forewing length under 26 mm ... 8

2(1) Male genitalia with a linear plate (Fig. 243, 245, lp), either sclerotised or strongly chitinised, between A8 posterior margin and vinculum arms; pseudotegumen dorsal margin deeply emarginate, irregularly serrate; female fully winged; forewing colour pattern similar in both sexes; forewing subdiscal dark blotch outwardly right-angled; female foretibial strigil well developed ... 3

—Male genitalia lacking a linear sclerite or strip anterior to vinculum arms; pseudotegumen dorsal margin shallowly emarginate, horizonal, or convex; female either fully winged and wingspan often greater than in male, or more or less brachypterous, in all instances paler and differently patterned from male; forewing subdiscal dark blotch usually outwardly oblique; female fore tibial strigil obsolete or, if well developed, then female brachypterous ... 4

3(2) Male linear plate sclerotised; forewing patterned in chocolate, ash white, and tan, hind wing variable. BP, TO, TK, WN, WA, NN, MB, BR, WD, MC, OL ... (p. 43) .. ***enysii***

—Male linear plate chitinised; forewing patterned in brown and yellowish tan, hind wings yellow-fawn; female unknown. SI ... (p. 45) .. ***insularis***

4(2) Male pseudotegumen dorsal margin either straight (horizontal) or shallowly concave, ending in apposed, strap-like, apically truncate, incurved dorsal processes; posterior and ventral processes also present, sharp; female with wings either fully developed or sub-brachypterous (wings as long as contracted abdomen). Forest or lower subalpine species ... 5

—Male pseudotegumen dorsal margin convex, with no demarcated dorsal process but posterior and ventral processes well developed; males with forewing pattern simplified, body very woolly; female sub-brachypterous ... 7

5(4) Pseudotegumen dorsal margin straight; dorsal process emarginate ventrally at base; trulleum with basal process usually bifid; female sub-brachypterous; foretibial strigil absent. MK, FD to sea level, SL, SI ... (p. 42) .. ***dinodes***

—Pseudotegumen dorsal margin irregularly and shallowly concave; dorsal process incurved but lacking a deep basal emargination; trulleum basal process usually unifid, rarely bifid; female either fully winged or sub-brachypterous; foretibial strigil strap-like or as a small lobe ... 6

6(5) Male forewing pattern usually with one or more subterminal patches of yellow scales, veins Sc and R_1 not contrastingly red-brown; pseudotegumen with incurved dorsal apices shallowly concave basally, posterior processes parallel; females fully winged; foretibial strigil minute. WD, MC, MK, OL, FD ... (p. 42) .. ***aurimaculata***

—Male forewing pattern lacking yellow scale patches, veins Sc and R_1 strongly to weakly rufous-scaled; pseudotegumen with dorsal apices incurved but not emarginate basally, posterior processes divergent; female brachypterous, with foretibial strigil well developed, strap-like. MK, OL, CO, DN, SL ... (p. 49) .. ***rufivena***

7(4) Male pseudotegumen with twin processes vestigial, dorsal / posterior margin forming an even curve to the bluntly rounded posterior process, ventral process slender, smooth apically; [female unknown]. FD ... (p. 45) .. ***hespera***

—Male pseudotegumen with twin processes prominent, dorsal / posterior margin right-angled to sharp posterior process, ventral process stout, spinose apically; female brachypterous (wings not extending past A3); foretibial strigil long. NN, MB, BR, MC, DN ... (p. 46) .. ***lenis***

8(1) Compound eyes subglobose, elliptic, with a broad nude margin; genal area exposed anteroventrally in lateral view ... 9

—Compound eyes globose, more or less circular, with a narrow nude margin; genal area hidden anteroventrally in lateral view ... 10

9(8) All forewing scales ovate/elongate ovate, pointed or tapering to a truncate apex (some dark scales broadly truncate); female sub-brachypterous, ground colour dark fawn to brown. CO ... (p. 49) .. ***orientalis***

—Forewing with at least the white or yellow scales broad, abruptly truncate (spade-shaped); female sub-brachypterous, ground colour black. OL, CO ... (p. 50) .. ***senex***

10(8) Male valva lacking a basal spine; forewing pattern lacking a pale anal streak, and labial palpus not longer than eye width; female brachypterous, with sternum 9 produced caudally. CO, OL ... (p. 41) .. ***aspina***

—Male valva with a basal spine; either forewing with a pallid anal streak or labial palpus longer than eye width; female sub-brachypterous or brachypterous, with sternum 9 normally oriented ... 11

11(10) Male with labial palpus longer than eye width; forewing without an anal streak; valva geniculate, not expanded apically, with an outer, lateral, strongly sclerotised carina ending abruptly at half length of narrow part of valva; female sub-brachypterous, with forewings uniformly smoky grey, scales sparse and hair-like, and foretibial epiphysis well developed, half tibial length. SL ... (p. 48) .. ***oreobolae***

—Male with labial palpus as long as eye width; forewing with a distinct white anal streak; valva curved, widened apically, lacking an outer lateral carina (sometimes outer lateral margin more strongly sclerotised than rest of valva); female brachypterous, with forewings patterned and scales densely arranged, elongate, stiff; foretibial epiphysis very small to obsolete ... 12

12(11) Male with trulleum dorsal arms straight, forming a V-sclerite; valva outer margin smooth above basal spine; female sternum 9 median piece about as long as wide and with a narrow, shallow median furrow, side-pieces in length about half width of median piece. CO, SL ... (p. 44) .. ***flavida***

—Male with trulleum dorsal arms curved, forming a lyre-shaped sclerite; valva outer margin darkly sclerotised and subcarinate on proximal third above basal spine; female sternum 9 median piece wider than long, with a broad, deep median furrow (median piece appearing apically bifid), side-pieces in length over half width of median piece. CO ... (p. 47) .. ***macropis***

Dioxycanus

Antennae dark; male pseudotegumen with twin processes apically subclavate and axes of dorsal and ventral processes subparallel; female with a truncate triangular dorsal elongation on sternum 9 median piece, corpus bursae with a large appendix. MK, OL, CO, DN, SL, FD ... (p. 54) .. ***fuscus***

—Antennae pallid; male pseudotegumen twin processes apically simple and axes of dorsal and ventral processes strongly divergent; female with sternum 9 median piece dorsally tumid, subtriangular, not elongate, corpus bursae appendix reduced to a pimple. TK, WN, NN, MB, NC–WD, MC ... (p. 55) .. ***oreas***

Dumbletonius

Hind wings dark brown; forewings with termen strongly oblique, apically pointed and intricately, ocellately patterned, with fields of bicoloured scales (basally yellow, apically red); female abdominal segments dark, with hind margin fringed in contrasting pallid scales. WO, TO, TK, WN, NN, SD, MB, BR, WD ... (p. 57) .. ***characterifer***

—Hind wings yellow, orange, brick red, or pink; forewings with termen convex, apically rounded; colour pattern intricate but not ocellate; no fields of bicoloured scales; female abdomen uniform in colour. Three Kings Is, ND-WN ... (p. 58) .. ***unimaculatus***

Wiseana

1 Antennae pallid, buff; hind wings often yellowish, pink, or reddish ... 2

—Antennae pale to dark brown or almost black; hind wings brown-buff ... 3

2(1) Male anterior head scaling directed towards midline; forewing discal white marking as a broken white stripe; scales short, ovate-truncate; pseudotegumen posterior processes slightly clavate, twin processes reduced; strip-like female sternum 9 with median piece broad, subrectangular dorsal margin undulate, ductus bursae gradually widening to corpus bursae. ND–NN, SD, MB ... (p. 68) .. ***signata***

—Male anterior head scaling directed forwards; forewing discal white marking usually as a complete stripe edged with blackish scales; white scales slender, pointed; pseudotegumen posterior processes apically upturned, twin processes large, hoodlike; female sternum 9 median piece area narrow-triangular, i.e., apically tapering; ductus bursae narrower than corpus bursae along entire length. ND–SL, SI ... (p. 69) .. ***umbraculata***

3(1) Forewing scales in both sexes elongate, pointed, either divergent (SL) or normal (other areas); ground colour usually dark grey-brown, with conspicuous patterning in ash white; male with antennal pectinations long triangular and twin processes absent (MK–SL) or small (NC). BR–SL ... (p. 66) .. ***mimica***

—Forewings with scales overlapping, densely packed, not divergent; male antennal pectinations subrectangular or subtriangular ... 4

4(3) Male antennal pectinations subrectangular, basally not as wide as flagellomere thickness (i.e., pectinations appearing stepped at base); female ductus bursae narrow, about 2x longer than corpus bursae. WN, WA, NN–SL ... (p. 64) .. ***copularis***

—Male antennal pectinations subtriangular, basally as wide as flagellomere thickness (i.e., pectinations sloping evenly from mid flagellomere to pectination apex); female ductus bursae broad, evenly expanding to corpus bursae ... 5

5(4) Male with forewing scales largely short, truncate-ovate, antennae usually deeply pigmented (appearing almost black); female with entire bursa copulatrix very short, ductus bursae less than 0.5x length of corpus bursae. NN–SL, SI ... (p. 66) .. ***jocosa***

—Male with forewing scales elongate-ovate, pointed, subacute or narrowly truncate, antennae pale brown to dark brown, rarely blackened; female bursa copulatrix with ductus bursae length 1.75–2.0x that of corpus bursae ... 6

6(5) Twin processes large (length over 0.4x, usually about 0.5x posterior process length); pseudotegminal complex parallel-sided; female corpus bursae with a large, ovoid appendix (Fig. 335). WO–DN ... (p. 62) .. ***cervinata***

—Twin processes reduced (length less than 0.3x posterior process length); pseudotegminal complex in face view with sides convex; female corpus bursae with a minute appendix (Fig. 338). MC, CO, DN ... (p. 65) .. ***fuliginea***

LARVAE (AND PUPAE, *DUMBLETONIUS*)

Dioxycanus

Head capsule with preantennal bar base securiform, not obliterating or narrowing subantennal cleft. Larvae known from MK, OL, CO, DN, SL, FD ... (p. 54) .. ***fuscus***

—Head capsule with preantennal bar base extended ventrally and either nearly or completely occluding subantennal cleft. Larvae known from TK, WN, NN, MB, NC, MC ... (p. 55) .. ***oreas***

Dumbletonius

Larva: prothoracic shield with setae SD_1, SD_2 in separate felted pits; upper surface of mandibles creased or furrowed. Pupa: A3 with anterior dorsal crest straight ... (p. 57) .. ***characterifer***

—Larva: prothoracic shield with setae SD_1, SD_2 in a common, reniform felted pit; upper surface of mandibles with a discal rugose patch, the rugosities rounded, pebble-like. Pupa: A3 with anterodorsal crest concave, curving posteriorly ... (p. 58) .. ***unimaculatus***

Wiseana (penultimate and final instars)

1 A1+2 setae SD_1 and SD_2 pinacula narrowly fused or, if separate, then SD2 pinacula excavate ... 2

—A1+2 setae SD_1 and SD_2 pinacula broadly fused or, if separate, then pinacula entire (*cervinata* group) ... 3

2(1) Mesal (inner) paraproct setae further apart than posterior setae on anal proleg base; A2–8 with SD_1 and SD_2 pinacula narrowly fused. Larva in bogs and swamps, associated with large monocotyledonous plants (e.g., *Carex, Juncus*). North I., South I., Stewart I. ... (p. 69) .. ***umbraculata***

—Mesal paraproct setae and posterior seta on anal proleg base equally far apart; if SD_1 and SD_2 pinacula on A2–8 narrowly fused then SD_2 excavate around setal base. Larvae in well drained soils, particularly sand, volcanic ash, and pumice. Throughout North I. (incl. Kapiti I.), and SD, NN, KA; usually coastal ... (p. 68) .. ***signata***

3(1) SD_1, SD_2 on a common pinaculum on all abdominal segments ... (p. 64) .. ***copularis***

—SD_1, SD_2 pinacula fused on A1 and A2, sometimes A1–3, and SD_2 separate from, or at margin of, SD_1 pinaculum on A3–7 ... (p. 62) .. ***cervinata***

Note. No material of authenticated *mimica, fuliginea,* or *jocosa* was available.

DESCRIPTIONS

Genus *Aenetus* Herrich-Schaeffer

Aenetus Herrich-Schäffer, 1855: 85. Type species *Hepialus ligniveren* Lewin, by subsequent designation (Kirby 1892, p. 891, as *Oenetus*); Australia.

Charagia Walker, 1856: 1570. Type species *Aenetus virescens* Doubleday, by subsequent designation (Kirby 1892, p. 891); New Zealand. Synonymised by Kirby 1892, p. 891.

Adult. Basically green-patterned, sleekly pilose-scaled, moderately large to very large moths (45)–90–150 mm in wingspan. Interocular index 3.0 or greater, i.e., frons area narrow; antennal flagellomeres moniliform or compressed, of even width, the basal ones with dorsal scales; antennal length less than 0.2X forewing length; vertex with a median longitudinal suture; labial palpi 3-segmented, the apical segment with a vom Rath's organ; maxillary palpus obscurely 2-segmented. Prothoracic patagium lacking a posterior ventrolateral tubercle, i.e., patagium with 3 tubercles only; mesothorax with anapleural cleft occluded over most of its length; metascutum halves with a narrow bridge of depth approx. 0.12X metascutellum length. Forewing venation with R_4+R_5 stem separate from R_2–R_3 stem; forewing termen in male moderately emarginate, i.e., apex subfalcate; male hind wing costal cell expanded for over half length. Foretibia with an epiphysis; tibiae and tarsi fringed with stiff scales, the fringe longer on outer side; male hind tibia slightly to grossly swollen, with a distinctively coloured brush of long scales on a longitudinal dorsal strip, and with (most species) or without *(A. virescens)* a dorsoapical knobbed process (Fig. 213, pr). Abdomen in female tapering to truncate apex, with apical margin of abdominal segment 8 lacking a modified scale tuft or field and with at most longer scales at lateral corners of posterior margins of A8, giving a somewhat 'fish-tailed' appearance; male abdomen tapering to apex.

Male genitalia (Fig. 209, 210): sterna 7 and 8 separate or fused; saccus bilobed; valva with 1–3 decurved, acute processes; pseudotegumen apices either knife-like or with an apical, ventrally and inwardly directed narrow process; juxta, where sclerotised, broader than high (long); trulleum unsclerotised (absent).

Female genitalia (Fig. 211, 214–217): sterna 7 and 8 fused; anogenital field transverse (wider than long); subanal sclerites horizontal; sinus seminalis open; sternum 9 strip-like, either with weak (or no) demarcation between median piece and side-pieces or with distinct median piece and side-pieces; vestibule only slightly skewed; spermathecal duct sinuous; ductus bursae long, slender, sparsely spinulose apically; corpus bursae obovoid, with a posteriorly directed prolongation at ductus / corpus junction, but lacking an apical (i.e., anterior) appendix.

Larva. Head capsule in later instars perpendicular, with strong rugosities; stemmata in 2 vertical rows; oral frame slit uniformly broad, and pre-antennal bar broad; frontoclypeal setae F_1 distinctly dorsal to clypeal seta (C_2); hypostoma halves widely separated mesally in all instars. Pronotum with setae D_2, SD_1, SD_2 in line and included in a blackened, micropilose pit; setae L_1, L_2 on A1–3 on a common pinaculum; proleg crotchets in 2 series, an inner series of long hooks and an outer series of minute hooklets. Paraproct sclerites not fused in midline, separated by a perpendicular membranous strip.

Pupa strongly bicoloured, with head shield, prothorax, and most of mesothorax darkly sclerotised, rugose to coarsely scobinate, and rest of body integument pallid. Abdominal dorsal spine crests single (and anterior) on A1 and A2, double (anterior and posterior) on A3–7; ventral spine crests single on A4–6, equal and posterior (i.e., behind setae SV and V), double (anterior and posterior) and interrupted mesally on A7 and not larger or thicker than those on preceding segments. Head piece with paired setae on frons, clypeus, labrum, and mandible sheaths; either antennal scape (*A. virescens*, Fig. 189) or vertex (Australian species, Fig. 190) with 'operculum burster' processes or carina.

Remarks. *Aenetus, Zelotypia,* and *Endoclita* share many characters – particularly larval and pupal – suggestive of their possible close relationship relative to other hepialid genera. Derived features, e.g., prothoracic SD_1, SD_2, D_2 in a common pit, the lack of an enlarged A7 spine crest (present in another stem-dwelling genus, *Leto*), the subfalcate forewings, the reduced, often rather compressed antennae, and the weak trulleum are suggestive. The complete pupal head shield chaetotaxy is regarded here as a plesiomorphy, and is therefore uninformative. The crotchet arrangement and the separated hypostomal condition are first-instar states.

Aenetus species have a distinctive adult facies (e.g., as in Common 1990, pl. 1, 2), the males with triangular, usually green-patterned forewings and pallid hind wings, the females with rather more elongate forewings and more deeply coloured hind wings, and both sexes with an emarginate termen. Males have a more (e.g., *A. mirabilis*) or less (e.g., *A. virescens*) developed dorsal tuft of hair-like scales on the hind tibia. All species for which the life history is known have a three-phase larval life (fungus phase, transfer phase, tree phase). The tree-phase larvae live in a burrow or refugium bored into the tree, and eat the callus tissue induced around the burrow entrance, under a camouflaged silken canopy or tent (Grehan 1987b, Boudinot 1991, fig. 22).

In New Zealand, *Aenetus* is distinguished from other genera by the green adults with reduced, compressed antennae, the bicolorous pupa lacking an enlarged spine-crest on A7, and the larva with three setae (D_2, SD_1, SD_2) in the prothoracic felted pit and with biserial crotchets in all instars.

Economic significance. *A. virescens* tree-phase larvae weaken stems of young stands of *Eucalyptus* species, including *E. saligna* and *E. botryoides*, leading to breakage of the stems during high winds or at least the formation of kino pockets in the wood. Consistently frequent invasion of *Nothofagus* species, and eventual extension of burrows and affected wood by wetas, aradid bugs, and associated fungi, curtailed milling of North Island beech forests, which now are regarded as soil conservation protection forests.

Conservation values. The puriri moth, *Aenetus virescens*, is clearly not threatened so long as suitable litter-phase larval sites are present. It represents one of two basic divisions within the genus *Aenetus*, and is our largest endemic moth.

Aenetus virescens (Doubleday)

Puriri moth

Fig. 1–3, 73, 74, 81–86, 111, 118, 126, 132, 140, 144, 148, 157–159, 181, 188–191, 209–217, M1–3; Map 1

virescens Doubleday, 1843, p. 284 *(Hepialus)*. Walker 1856, p. 1569 *(Charagia)*. Meyrick 1890, p. 211 *(Hepialus)*. Hudson 1898, p. 129, pl. iii fig. 23, 30, pl. xiii fig. 16, 17 *(Hepialus)*; —1928, p. 357, pl. xlii fig. 13, 14, pl. xliii fig. 13, 14 *(Hepialus)*. Dumbleton 1966, p. 929, fig. 13–17 *(Aenetus)*.

rubroviridans Walker 1856, p. 1570 *(Hepialus)*. Meyrick 1890, p. 211, as synonym. Synonymised by Kirby 1892, p. 891.

ingens Walker, 1856, p. 596 *(Charagia)*. Doubtful synonym; see Remarks, below.

fischeri Felder & Rogenhofer, 1874, pl. lxxx fig. 1 *(Charagia)*. Synonymised by Meyrick 1890, p. 211.

hectori Butler, 1877, p. 380 *(Charagia)*. Synonymised by Meyrick 1890, p. 211.

virescens ab. *albo-extremis* Quail, 1903a, p. 252 *(Charagia)*. Synonymised by Hudson 1928, p. 357, footnote. Palmerston North WI–WN, A. Quail.

Adult wingspan (45)–80–100 mm in males, (60)–90–150 mm in females. Colour pattern as in Fig. 1–3, Hudson (1928, pl. xlii fig. 13, 14, pl. xliii fig. 13, 14), and Sharell (1971). Male head, thorax, and forewing ground colour green (rarely white, blue-white, yellow, or orange), patterned in a darker ground colour or (e.g., '*albo-extremis*') in white; hind wings and abdomen white (but see Remarks). Female invariably green, with fewer or more markings in pale to dark brown on forewings; abdomen patterned in green and dark brown; hind wings greenish brown or reddish-brown. Labial palpus apical segment clavate. Male hind tibia with a narrow tuft of long, pink hair-scales that are scarcely widened basally. Eyes in both sexes very close together (interocular index >3.0); some male specimens with eyes horizontally divided.

Male genitalia (Fig. 209, 210): sternum 8 shorter and narrower than sternum VII, separate; valva with apical lobe thumb-like, and a single decurved, thorn-like, acuminate process at mid length; pseudoteguminal apices blunt triangular; trulleum unsclerotised.

Female genitalia (Fig. 148, 211, 216, 217): anogenital field width 3x height, i.e., a narrow transverse slit.

Larva (Fig. 157–159, 181) as in generic description. Stemmata in 2 vertical rows; late fungal, transfer, and tree-phase larvae with strong rugosites between setae P_1, A_2 and setae A_2, A_1. Length full-grown 60–120 mm.

Pupa (Fig. 188, 189) as in generic description. In larval refugium, with shaft blocked by operculum; arboreal.

Type data. *virescens:* holotype male not located; identity not in doubt.

rubroviridans: holotype female (wingspan 151 mm; wings frayed, partly denuded) labelled "47 104 / New Zealand" (circular white label), BMNH.

fischeri: holotype female labelled "Felder Colln" (white disc), "Charagia Fischeri, No. 6 in tab" (white rectangle), BMNH.

hectori: holotype female (wingspan 146 mm; very battered, abdomen eaten away, no antennae), BMNH.

albo-extremis: holotype male [Palmerston North], SAMA, Illidge Colln.

Material examined. Type specimens of *rubroviridans*, *fischeri*, and *hectori* (BMNH), plus 200+ non-type examples (140 adults, 50+ larvae, NZAC; 4 males, 6 females, NMNZ, Hudson Colln).

Distribution: North I., ND–WN, to 1100 m (Grehan 1987a). No specimens seen from Three Kings Is, Poor Knights Is, Little Barrier I., Great Barrier I., Kapiti I.

Flight period (NZAC records): Jan (6), Feb (7), Mar (9), Apr (1), May (1), Jun (1), Jul (1), Aug (8), Sep (5), Oct (55), Nov (18), Dec (22).

Host plants. (a) Litter phase (Grehan 1979, p. 583): *Phomes* sp., *Echinochaete russiceps* (fungi on wood).

(b) Tree phase. Complete development to adult. Indigenous hosts: *Aristotelia serrata*, *Carpodetus serratus*, *Styphelia fasciculata*, *Hoheria populnea*, *Kunzea ericoides*, *Leptospermum scoparium*, *Myoporum laetum*, *Nestegis* species, *Nothofagus* species (esp. *N. menziesii*), *Pseudowintera colorata*, *Vitex lucens*. Introduced hosts: *Buddleia davidii*, *Casuarina* sp., *Cornus capitata*, *Eucalyptus saligna* (?), *Fraxinus excelsior*, *Ligustrum* species, *Paulonia elongata*, *Pyrus malus*, *Quercus* spp. including *Q. robur*, *Q. rubra*, *Ulmus procera*.

Larval development incomplete. Indigenous hosts: *Coprosma grandifolia*, *Coriaria arborea*, *Olearia rani*, *Pennantia corymbosa*, *Pomaderris apetala*, *Weinmannia* species. Introduced hosts: *Alnus* species, *Eucalyptus* species, *Juglans ailanthifolia*, *Liquidambar styracifolia*, *Persea americana*, *Pyrus* species, *Weigelia* sp.

Apocryphal records: *Acacia (Rhachispermum)* species, *Acer* species, *Alectryon excelsus*, *Astelia solandri* (!), *Betula* species, *Citrus* species, *Cytisus* species, *Dacrydium cupressinum*, *Dysoxylum spectabile*, *Elaeocarpus* species, *Freycinetia banksii*, *Griselinia* species, *Hebe salicifolia* (?*stricta*), *Litsea calicaris*, *Malus sylvestris*, *Melicope* species, *Melicytus* species, *Metrosideros* species, *Plagianthus* species, *Populus* species, *Prunus* species, *Quintinia* species, *Salix* species.

Remarks. *A. virescens* is distinguished from Australian species and from New Caledonian *A. cohici* by its clavate (club-shaped) labial palp apical segment, reduced sternum 8 in the male, lobate apex to the valva, lack of an apical process on the male hind tibia, uniformly slender hair-scales forming the male hind-tibial brush, and slit-like female anogenital field together with a mesally emarginate, strip-like sternum 9 and relatively simple corpus bursae (cf. Fig. 217 and Boudinot 1991, fig. 7).

Charagia ingens Walker, presented by J.G. Children Esq., is ostensibly from New Zealand, but Children's collections are a mixture of Australian and New Zealand specimens. No specimen labelled with the Children accession number, nor agreeing with the description of *ingens*, was seen in the *virescens* series in BMNH.

Although a typical species of warm and cool temperate forests, *A. virescens* has accommodated to European settlement and urbanisation so long as there is a supply of fungus-ridden logs, stumps, or fallen large branches close to or under suitable host trees. Old overgrown gardens in urban areas, neglected orchards surrounded by bush or broken-down shelter belts, even isolated puriri trees in cow pasture can all support *A. virescens*.

The name 'puriri moth' gives scant appreciation of the host range of tree-phase larvae. In beech forests *Nothofagus menziesii* is a major host, with *N. fusca* less readily attacked. In all areas *Carpodetus serratus* is the most commonly attacked indigenous host, as its name putaputaweta ('full of weta holes') implies; tree wetas (*Hemideina* spp.) take over the shafts after the pupa has emerged. In Taranaki *Hoheria* is a favoured host (J.M. Clark, pers. comm.). Other forest trees often showing high numbers of old scars are *Nestegis* species, *Aristotelia serrata*, and, surprisingly, *Styphelia fasciculata*.

Details of biology and phenology are discussed and summarised by Grehan (1987a, 1989). *A. virescens* is not only New Zealand's largest moth but possibly has the longest-lived larva (up to 5 years), although adult life is brief. In size some females of *A. virescens* approach those of *Zelotypia stacyi* in Australia, and in the male some colour varieties (especially the yellow and 'blue' ones) are particularly striking. Quail's "ab. *albo-extremis*" refers to males with several series of transverse white forewing markings, as opposed to the medium-length series in 'normal' males. There is no convincing evidence that the '*albo-extremis*' pattern is geographically restricted; nor, for that matter, are any of the non-green forms. No males seen at light at warm temperate forest sites (Te Rereauira Swamp BP, Otanga BP, Waioroko BP, and Te Koau BP) during spring and summer 1992–93 (*n* >300) were of the '*albo-extremis*' pattern.

Two males in NMNZ from Long Acre WA have the wings infumate (smoky), and one male from Feilding WI has vivid green wings with the white pattern elements reduced and well defined (eulegnic), the termen bordered by eight fine white lunules, and the hind wings sharply bordered in lime green.

A. virescens males are readily attracted to light, females markedly less so. I have counted up to 700 males at light on a 'flight night', in contrast to 3–5 females, yet pupae encountered in a sampling invariably give a 1:1 sex ratio (e.g., Grehan 1987a). Emergence has been recorded in all months, but in any one area there will be either one emergence period (upland sites, in spring) or two (lowland sites, in spring and a smaller peak in late summer).

Genus *Aoraia* Dumbleton

Aoraia Dumbleton, 1966, pp. 930-931. Type species *Porina dinodes* Meyrick, by original designation; New Zealand.

Trioxycanus Dumbleton, 1966: 943. Type species *Porina enysii* Butler, by original designation (misidentified type species); New Zealand.

Brown-patterned, bulky moths with deep, shaggy, pilose vestiture on head, thorax, abdomen, and femora; wingspan moderate (40 mm) to large or very large (60–110 mm); adults autumn-emerging (Feb–Apr); most species crepuscular. Eyes widely spaced (interocular index approx. 1.8 in males, 1.6 in females), reduced, with a periorbital nude strip in one species. Antennae (Fig. M4–6) conspicuously pectinate in both sexes, 0.3–0.45x forewing length; flagellomeres exceeding 50, with long, finger-like lateral pectinations arising at midlength; pectinations with several long sensillae chaeticae; basal 3 or 4 flagellomeres sparsely scaled dorsally. Labial palpi 3-segmented; basal segment with long, hair-like scales ventrally; maxillary palpi reduced to a pair of stumps. Mesothorax (Fig. 119, 120) with marginopleural ridge weakly developed, and posterior end of anapleural cleft distant from junction of mesopleural and paracoxal sutures. Metathorax with metascutum in midline at least 0.20x metascutellum length. Female foretibia with epiphysis an appressed strap-like process, or vestigial, or absent; male hind tibia bearing a broad, densely pilose tuft (but no scales modified for scent dissemination). Venation (Fig. 75): forewing with veins R_{2+3} and R_{4+5} separate, veins R_2, R_3 shorter than R_{2+3} stem, and often additional cross-veins CuP-A, CuA_2-CuP, A-A present; hind wings with veins $Sc + R_1$ separate apically. Females of several species weakly to strongly brachypterous (wings about as long as abdomen to half abdominal length). Thoraco-abdominal junction (Fig. 127) with tergosternal bar arising halfway along tergal brace on tergum 1; sternum 2 enclosing submarginal strengthening ridge (venula). Male tergum 8 with a subdorsal anterior cuticular process (= seta D_1).

Male genitalia: muscle G1 absent, G6 present (Fig. 145); valva elongate, curved or elbowed, in some species carinate on outer (saccular) edge and, except for 2 species, with a strong 'saccular' spine on proximal third; trulleum dorsally V-shaped, with a transverse base bearing a single or obscurely bifid projecting cone; pseudotegumen halves each with dorsoposterior process evident or not, but always with an acute mid-posterior process and a slender, elongate ventral process; vinculum arms (Fig. 133) broadly truncate apically; saccus area variable, but basically V-shaped.

Female genitalia: tergum and sternum 8 clad in dense, appressed, short scales; tergum 8 lacking cuticular processes D_1, D_2, and SD_1, either lightly sclerotised or unsclerotised, and with a small posterolateral sclerite; sterna 7 and 8 widely separated, with S8 often emarginate anteriorly; sternum 9 with side-pieces clearly demarcated from median piece, dorsally smooth, carinate, or tuberculate; median piece subtriangular, obscurely to clearly bifid (emarginate) apically, setose; anogenital field wider than high, with intergenital lobes free (i.e., sinus 'open'), subanal plates arranged horizontally; antrum / bursa copulatrix junction either central or more or less skewed dextrally; ductus bursae elongate, slender, not spinulose; corpus bursae elongate ovoid or more or less globose, without an appendix.

Larva. Stemmata arranged in 2 vertical rows, diverging ventrally; hypostomal plates fused in midline; head capsule with setal puncture La displaced posteriorly to beside lateral epicranial notch; abdominal segments 1–6 (at least) with 2 longitudinal pinacula at the level of seta L_3, one anterior (bearing L_3), the other (Fig. 182, p) posterior to it.

Pupa. Eyecases planoconvex; abdominal segment 8 without a subventral carina, and A3–6 with anterodorsal spine crest not extending ventrally beyond setae SD_1, SD_2.

Remarks. *Aoraia*, with thirteen species, is the largest hepialid genus in New Zealand. A few species are widely distributed, but most occupy restricted habitats. The single North Island species, *A. enysii*, is there restricted to cool temperate or subalpine ridge-crest forest, nowhere descending below 300 m. On Mt Te Aroha (WO–BP) it is probable that the resident population is restricted to the *Nothofagus menziesii* / *Dracophyllum* (summit) community. On Station Ridge, Orongorongo Valley (WN), larvae have been found (in litter) only on the upper, *N. menziesii*-dominated slopes and the ridge crest. In the South Island some species are similarly forest-dwelling, descending to sea level in Westland *(A. enysii)*, Otago-Southland *(A. dinodes)*, and Stewart Island *(A. insularis)*. *A. aurimaculata* is characteristic of subalpine forests and penalpine headwater basins along the Southern Alps. *A. rufivena* is found in forest, penalpine shrubland, and moors in Otago. The group distinguished from the primarily forest-dwelling species by their convex pseudotegumen and brachypterous females are alpine or penalpine, with larvae living in tussock grassland and snow-bank communities *(A. senex, A. orientalis, A. lenis, A. aspina)* or associated with cushion bogs *(A. macropis, A. flavida, A. hespera, A. oreobolae)*.

Larvae and pupae have so far yielded no consistent characters diagnostic of species or species-groups. Immature stages have been unequivocally associated with adults for only seven of the thirteen recognised species.

The only satisfactory way of identifying adult males – by far the commoner sex encountered – is by examining the genitalia. The state of the epiphysis on the foretibia is of use in species with fully winged females; in species with brachypterous females epiphysis state, wing scale shape, and conformation of sternum 9 can also be diagnostic. Associating females with males can be done with confidence in South Island sites only if both sexes are taken either *in copulo* or (rather less surely) on the same date, at the same site, in the same plant community.

Aoraia species, with their plumose antennae, richly and intricately brown, tan, and white-patterned wings, and characteristically shaggy (woolly) bodies are a distinctive and easily recognised element in the New Zealand fauna. Although there is some superficial resemblance to Australian *Abantiades*, differences in characters of the antennae, cranium, mouthparts, venation, and genitalia do not support this. On male genital characters *Aoraia* is closest in most regards to southern African *Antihepialus* Janse, a terminal taxon in Hepialidae s.l.; the spout-like trulleum of that genus might be interpreted as one end of a transformation series in which *Aoraia*, with its trullear cone, represents the other end-point. Larvae of *Antihepialus* reared from eggs from Storms River, R.S.A., by Dr G.W. Gibbs show head capsule setal puncture La displaced posteriorly and most abdominal segments with a posterior pinaculum at the seta L_3 level, a combination not seen in other genera examined. However, as the similarities between the two might also be interpreted as plesiomorphies, the argument is at present left aside.

Economic significance. Genus *Aoraia* has no obvious economic significance in relation to 1993 values.

Conservation values are inherent in several features.

(a) It is a terminal taxon, i.e., no close relatives can be recognised; it is therefore isolated taxonomically and unique to New Zealand.

(b) Particularly in the South Island it occupies a diverse range of sites (cool temperate to subalpine forest, penalpine shrublands, subalpine to alpine grasslands, cushion bogs and mires), with a diverse range of larval foods.

(c) It is the largest hepialid genus in New Zealand, with seven of its thirteen species of striking size and appearance.

(d) Species can be locally abundant and afford a rich source of food for vertebrate predators, particularly before the onset of winter.

(e) There are striking differences in species diversity between regions.

(f) There is good evidence that at least one species is locally extinct (*A. dinodes* at and around Invercargill SL).

A. Hamilton's son noted that the capture of an *Aoraia* male (*A. senex* in this instance) put the rigours of an exhausting day quite out of his mind (Hamilton 1909).

Aoraia aspina new species

Fig. 4–6, 219–224; Map 2

Male moderate-sized, 46–53 mm in wingspan with forewing length 21–24 mm. Antennal length about 0.35x forewing length. Female (association equivocal) brachypterous, with hind wings extending beyond forewing (Fig. 6), thorax width less than 7 mm, and foreleg epiphysis reduced to a short, longitudinally folded flap. Both sexes with eyes globose, covering genal area in lateral view. Male labial palpus scarcely exceeding eye width; apical segment half length of 2nd segment or shorter. Forewing scales elongate-oval, pointed or apically blunt; colour pattern (Fig. 4, 5) ash-white on chocolate brown, without a pallid streak or patch on dorsum above jugum (cf. *A. flavida*); hind wings variable, from nearly as dark as forewings to yellowish buff. Thorax concolorous with forewing ground colour, abdomen concolorous with hind wings.

Male genitalia: pseudotegumen (Fig. 221) with margin sparsely spinulose, posterior and ventral process short, acuminate, about equal in length; supraphallic papilla (Fig. 220) with apex strongly sclerotised and setose, obovate; valva (Fig. 219) lacking a basal spine, and with saccular margin weakly carinate; trulleum with a reduced median process, and arms not longer than basal plate, broad.

Female genitalia: sternite 9 protruding, extending well beyond dorsal plate (Fig. 223, 224); side-pieces nude laterally; median piece recumbent, with a narrow, nude median furrow; ductus bursae skewed dextrally from asymmetrical vestibule, twice as long as irregularly ovoid corpus bursae (Fig. 222).

Type data. Holotype male labelled "New Zealand CO, Umbrella Mtns, Gem Lake 1300 m 9 March 1986 B.H. Patrick", NZAC.

Paratypes (NZAC, BPNZ): 5 males, 3 females, same data as HT; 1 male, Mt Benger CO, 1160 m, 16 April 1986, B.H. Patrick; 1 male, Mt Tennyson CO, 1520 m, 7 March 1987, B.H. Patrick; 2 males, Snowdon Peak, Snowdon State Forest OL, 1500 m, 22 February 1987, B. Lyford.

Material examined. Type series only.

Distribution: — / OL, CO.

Flight period: Feb (2), Mar (10), Apr (1).

Remarks. *A. aspina* is a member of the group of species with moderate-sized males, and females with the thorax narrower than in males and with reduced wings. From the other species *A. aspina* differs in its lack of a basal spine on the male valva and the posteriorly extended female sternum 9 with anterodorsally directed median piece. Males also differ in having the apex of the supraphallic papilla strongly sclerotised and setulose. In other species the papilla may or may not be sclerotised apically, and nude. Males (the commoner sex so far collected) externally closely resemble those of *A. flavida*, but differ in their lack of a pallid streak close to the anal area of the forewing (cf. Fig. 4, 18).

Males fly at dusk from late February up to mid April, among snowgrass *(Chionochloa)* communities in penalpine grassland. Females were found crawling in the same plant community at Gem Lake (Patrick 1988).

Aoraia aurimaculata (Philpott)

Fig. 7–9, 225–229; Map 3

aurimaculata Philpott, 1914, p. 121 *(Porina)*. Hudson 1928, p. 360, pl. xlii fig. 12 *(Porina)*. Dumbleton 1966, pp. 936-937 (*Aoraia;* redescription).

Male (Fig. 7–9) large, 62–67 mm in wingspan, with forewing length 29–32 mm; antennal length 0.3x forewing length; forewing often with 1 or more small patches of yellow scales subterminally between veins R_5 and M_{1-3}; abdominal segment 8 as in Fig. 228. Female fully winged, 85–94 mm in wingspan, with forewing length 37–42 mm; foretibial epiphysis reduced to a short, elongate stump.

Male genitalia: pseudotegumen in lateral view shallowly concave, with dorsal process short-lobate, incurved towards midline (Fig. 227), apically slightly rounded or truncate; posterior process narrow-triangular, deeply emarginate ventrally; ventral process elongate, slender, subspinose on apical half; valva (Fig. 226) more or less geniculate, the saccular area with a basal spine, and distally irregularly serrate; inner face of valva with setae and setulae extending towards base in a strip; supraphallic papilla unsclerotised.

Female genitalia (Fig. 229): sternum 9 median piece rounded-triangular, evenly setose basally, coarsely setose dorsally, with a nude furrow in midline; side-piece about as long as wide, as long as width of median piece, dorsally somewhat carinate, lacking tubercles, scaled on face, and with a discal sensilla; furrow separating median piece and side-pieces broad, with a few setulae at mid-height; details of vestibule and bursa copulatrix unknown (based on 1 female, CMNZ, prepared by L.J. Dumbleton).

Type data. Neotype male (wingspan 63.5 mm) labelled "NEOTYPE male *Aoraia aurimaculata* (Philpott)" (red card), "Mt Cook Nat. Pk, Gov. Bush 810 m, 18 Apr. 1977, light, W.J. Sweney" (white card), "Entomological Museum Lincoln College" (blue card), CMNZ.

The original type specimen, collected by Mr F.S. Oliver at The Hermitage on 28 March [1912?] was described by Philpott and returned to Mr Oliver, whose collection has not been located. The neotype male, collected at the same general site and 21 days later in the season, is a good match for G.V. Hudson's portrayal of the type (Hudson 1928, pl. xlii fig. 12), and stands until Oliver's specimen is found.

Material examined. Neotype male, plus 75 non-type examples (73 males, 2 females; NZAC, CMNZ, LUNZ, BPNZ, BLNZ) from Craigieburn Forest Park, Browning Pass, Franz Josef, Landsborough Vly, Mt Cook Nat. Park, Governors Bush, L. Ohau, headwaters of Hunter R., L. Hawea, Queenstown, Snowy R. / Dart Vly junction, Homer, Hollyford / Eglinton Divide, L. Fergus, Murchison Mtns, Deep Cove, Thompson Sound, and Deas Cove.

Distribution: — / MC, WD, MK, OL, FD.

Flight period: Feb (2), Mar (10), Apr (40), May (23).

Remarks. *A. aurimaculata* is a member of the group of large species with fully winged females. The females assigned to this species by Dumbleton (1966, p. 937) are still the only two known; both have the foretibial epiphysis vestigial and stump-like (cf. *A. enysii, A. lenis, A. oreobolae*, which have the epiphysis reduced to an elongate strap). Most adult males have conspicuous post-discal or subterminal patches of yellow ('gold') scales, but in a series of 24 males from the Thomas River MC only 10 specimens had gold patches. Such gold patches can be present in other species, e.g., *A. senex* from Dunstan Mountains CO and *A. enysii* from Mt Te Aroha BP and Mt Patriarch MB.

So far *A. aurimaculata* is known (as adults) from along the Southern Alps and western Fiordland in cool temperate to subalpine forest and lower penalpine shrubland. The two males recorded from Dunedin DN by Dumbleton (1966, p. 937) are assigned to *A. rufivena*.

Aoraia dinodes (Meyrick)

Fig. 10–14, 230–239; Map 4

dinodes Meyrick, 1890, p. 206 *(Porina)*. Philpott 1927b, fig. 29 *(Porina)*. Hudson 1898, p. 132, pl. xiii fig. 8 *(Porina)*. Hudson 1928, pp. 360–361, pl. xlii fig. 6, 7 *(Porina)*. Dumbleton 1966, p. 935, fig. 23–26, 97 *(Aoraia)*.

Male large, 62–70 mm in wingspan, with forewing length 27–32 mm; antennal length approx. 0.35x forewing length; forewing pattern (Fig. 10–13) intricate or (rarely) simplified, fawn-brown to chocolate brown with markings in ash-white; hind wings concolorous with abdomen, fawn to smoky brown. Female large, 70 mm in wingspan, with thorax 9.0 mm wide between forewing bases; forewings slightly narrower than in male, with apex subacute (termen more oblique); hind wings narrow, subacute; foretibial epiphysis absent or vestigial, as a minute ovate flap.

Male genitalia: pseudotegumen in lateral view (Fig. 230, 231) with anterior margin overhanging, dorsal margin largely horizontal, dorsal apical processes lobate, incurved, deeply emarginate ventrally, posterior and ventral processes irregularly spinose, ventral process slender on distal half or third, basally stout; trulleum (Fig. 232, 233) basal process usually bifid in some southern populations, elsewhere unifid; valva slightly expanded apically, with a basal saccular spine, its saccular edge coarsely and irregularly serrate to about half or two-thirds valval length; saccus lacking a flange; supraphallic papilla unsclerotised.

Female genitalia (Fig. 236–239): sternum 9 median piece distinctly narrowed to a central dorsal prominence; side-pieces less than twice as long as wide, and with a prominent dorsal tubercle; face with or without a reduced discal sensilla, setulose. Details of vestibule, ductus bursae, and corpus bursae unknown (based on 2 females, prep. L.J. Dumbleton).

Type data. Lectotype male labelled "Invercargill from Hutton", "Porina (?) dinodes Meyr.", "Fereday Collection", "5", "Canterbury Museum LECTOTYPE selected LJD 15/6/64", CMNZ.

Paralectotype male selected by Dumbleton, CMNZ.

Material examined. Type specimens, plus 78 non-type examples (76 males, 2 females; NZAC, NMNZ, CMNZ, LUNZ, BPNZ) from Ball Hut, Tasman Vly, Mt Cook, Franz Josef, Eyre Mtns, Jane Peak, Burwood Forest, Homer, L. McKenzie, Murchison Mtns, Deep Cove, Breaksea I., Mt Burns, Bald Hill, Longwood Range 800 m, Invercargill, Orepuki, West Plains, ['vegetable caterpillars' seen, Forest Hills, JSD, and Seaward Downs Scenic Reserve, B.H. Patrick], and Oban.

Distribution: — / WD, MK, OL, FD, SL / SI.

Flight period: Feb (1), Mar (45), Apr (26), May (25+), Jun (3).

Remarks. *A. dinodes* may now be extinct in the area of its type locality ("Invercargill"). West Plains – Philpott's recorded locality – is now covered in adventive pasture, and despite several years of constant trapping at nearby (and less modified) Otatara, Mr B.H. Patrick did not collect any, nor observed any pupal exuviae. Occasional trapping at Thomsons Bush, Invercargill, was also fruitless (B.H. Patrick, pers. comm.).

A. dinodes females have the foretibial epiphysis reduced to a minute mound or scale-like flap, unlike the female of *A. aurimaculata*, where the epiphysis is reduced to a knife-like flap. Both differ in this from the *A. rufivena* female, which has a short, strap-like epiphysis. Males of *A. dinodes* are characterised by the incurved, rather narrow, lobate posterior dorsal process of the pseudotegumen, deeply emarginate below. There are no consistent pattern differences that distinguish *A. dinodes* from *A. aurimaculata* and *A. rufivena*.

The female's forewing size (32 mm in length) suggests that she might fly once most of the egg-complement has been laid, but there is no field evidence. No females were attracted into an automatic light trap on Bald Hill, Longwood Range, over March to May, during which time 293 males were trapped (Patrick *et al.* 1987). As 'vegetable caterpillars' – i.e., caterpillars mummified by the fungus *Cordyceps* sp. – have been observed at Forest Hill Reserve north of Invercargill, this site would be a useful place to undertake field observations of this large, attractive moth.

Aoraia enysii (Butler)

Fig. 15–17, 145, 240–251; Map 5

enysii Butler, 1877, p. 381, pl. xlii fig. 7 *(Porina)*. Dumbleton 1966, fig. 106 *(Trioxycanus)*. Dugdale 1988, p. 56 *(Aoraia;* misidentified type species of *Trioxycanus* Dumbleton).

leonina Philpott, 1927a, p. 709 *(Porina)*. Hudson 1928, p. 361; —1950, p. 114, pl. vi fig. 3 *(Porina)*. Dumbleton 1966, pp. 937–938, fig. 32–41, 98 *(Aoraia)*. Synonymised by Dugdale 1988, p. 56.

Male large, 60–74 mm in wingspan, with forewing length 26–32 mm; antennal length approx. 0.33x forewing length; forewing pattern intricate, in varying shades of brown with ash-white markings, sometimes with subterminal patches of yellowish scales; hind wings yellowish-brown, fawn, or smoky, especially on disc and basally (Fig. 15, 16). Female as large as male or larger, 78–110 mm in wingspan, with thorax 8–10 mm wide between forewing bases; hind wings not noticeably narrower in proportion than male hindwings, with ground colour as dark as in male or paler, and pattern rather more elongate (Fig. 17); fore-tibial epiphysis approximately one-third of tibial length, slightly sinuous, apically acute.

Male genitalia (Fig. 240–247): a slender sclerite between vinculum arm and posterior margin of abdominal segment 8 pleural area (Fig. 244–247); pseudotegumen with dorsal margin deeply emarginate (concave) in lateral view, posteriorly convex and spinose, caudal margin and posterior process spinose, ventral process slender, irregularly spinose, ventrally thickened on proximal third to half; trulleum with basal process unifid; saccus with a flange, widest near origin of vinculum arms; sacculus with a basal spine, carinate / irregularly serrate to angle (Fig. 244–247); valvae geniculate, on outer face often with a prominent discal carina, on distal portion (above angle) scarcely wider than below angle; supraphallic papilla not sclerotised.

Female genitalia (Fig. 248–251): sternum 8 deeply emarginate anteriorly; tergum 8 scarcely sclerotised, with a lateral oval sclerite posteriorly (Fig. 250, 251); sternum 9 side-pieces scarcely longer than wide, with face weakly concave and sparsely setulose, and with a low, outer setose prominence offset from more or less even margin; furrow between median piece and side-pieces deep, strongly oblique, nude (or with 1 or 2 setae); median piece weakly bifid dorsally, with a nude concave strip centrally; ductus bursae arising on vestibule, slightly skewed to the right, slender, longer than the more-or-less elongate-oval corpus bursae.

Type data. *enysii:* holotype male (60 mm wingspan) labelled "North Island", "*Porina enysii* Butler, Type", BMNH.

leonina: holotype male (61 mm wingspan) labelled "*Porina leonina* Philpott" (red card), "Salisbury's Op[en]ing 3, 4, 25 A. Philpott", "*Porina leonina* Philp. HOLOTYPE [male]", NZAC. Genitalia (fragmented) on 2 celluloid strips, prep. L.J. Dumbleton.

Material examined. Type specimens, plus 57 non-type examples (45 males, 12 females, 4 pupae, and larvae; NZAC, NMNZ, VUNZ, CMNZ, LUNZ, BLNZ) from Mt Te Aroha 940 m, Tongariro National Park, Mahuia Camp, Mt Taranaki [Egmont], Coonoor, Rimutaka Saddle, Orongorongo Vly 725 m (larva), Sphinx Vly, Balloon Hut, Flora Hut, Mt Arthur, Denniston, Mt Patriarch, Blenheim, Paparoa Range, Atbara Creek in beech/podocarp forest, Mt Baldy bushline, St Arnaud, Arthurs Pass, Craigieburn Forest Park HQ, Long Spur, Paroa, Waiho Gorge, Franz Josef, Canavans Knob, and Makarora.

Distribution: BP, TO, WA, WN / NN, MB, BR, NC, WD, OL.

Flight period: Feb (1), Mar (30), Apr (2), May (1).

Remarks. *A. enysii* males are best distinguished from those of other large *Aoraia* species by characters of the pseudotegumen, and by the presence of a strongly sclerotised lateral sclerite between the abdominal segment 8 pleural area and the vinculum arm. Females often attain great size, are fully winged, and have the foretibial epiphysis well developed, slightly curved, and apically subacute.

Larvae may be encountered in pit traps or in litter on the forest floor. One male and one female pupa were found each in their larval shaft beside a half-buried log, but no evidence of chewing on the log was seen. It is presumed that the larval diet consists largely of fallen leaves. Presence of at least two larval sizes in spring, coupled with the regular annual flights of adults, suggests a larval life of at least 2 years, possibly 3. Males are on the wing about an hour after sunset, and are attracted to light during the ensuing hour or less; they can range widely (e.g., the male caught in urban Blenheim).

A. enysii is the only *Aoraia* species known from the North Island, and all North Island records are from montane or tree-line sites. In the South Island the species is known from upland and tree-line sites (NN, MB, MC, OL), descending to sea level along the West Coast (WD).

The Mt Patriarch (MB) population is unusual in that several male specimens not only have prominent gold patches on the forewing but often have some of the pattern elements suffused with pale blue-grey scales. No consistent genital difference between these and 'normal' males was seen.

Aoraia flavida new species

Fig. 18, 19, 252–257; Map 6

Male moderate-sized, 47–50 mm in wingspan, with forewing length 21–23 mm; antenna about 0.45x forewing length; forewing scales elongate, apically rounded or narrowly truncate; forewing pattern ash-white or creamy white on chocolate brown, often rather blotchy or coarse; hind wings smoky brown; vestiture on abdomen and ventrally on thorax dull yellowish fawn, contrasting with smoky brown undersides of wings (Fig. 18). Females brachypterous; thorax width 3–4 mm (almost half that of male); foretibial epiphysis represented by a small basal flange or mound; vestiture of body smooth, dull brown; forewings patterned in broad, irregular fields of dark brown and brownish fawn (Fig. 19).

Male genitalia (Fig. 252–255): pseudotegumen in profile as in Fig. 252–254, with posterior process reduced to a small projection and ventral process short, evenly narrowed to acuminate apex; valva (Fig. 255) with a strong, darkened basal spine, elbowed (geniculate), setose, slightly expanded apically, its saccular (outer) margin weakly and irregularly serrate (with a weak flange at central third of valva in one population); trulleum (Fig. 255) with process unifid, base narrow, arms straight; saccus with a marginal flange; supraphallic papilla nude, weakly sclerotised.

Female genitalia (Fig. 256, 257): postabdominal structures directed posteriorly (Fig. 256); sternum 9 not expanded caudally, with side-pieces wider than long, dorsal margin without a tubercle, more-or-less smooth, and face largely nude; furrow between side-piece and median piece sinuous; median piece shallowly emarginate mesally, entirely setose; ductus bursae arising on vestibule centrally, slender, twice length of irregularly elongate-ovoid corpus bursae (Fig. 257).

Type data. Holotype male labelled "New Zealand CO Umbrella Mts Gem Lake 1300 m 8 March 1986 B.H. Patrick", "HOLOTYPE *Aoraia flavida* Dugdale" (red card), NZAC.

Paratypes: 13 males, 6 females, same data as holotype, NZAC, BPNZ.

Material examined. Type series, plus 11 non-type examples (10 males, 1 female; NZAC, BPNZ) from Garvie Mtns, Blue L., L. Scott 1450 m, and Ajax Swamp 680 m.

Distribution: — / CO, SL.

Flight period: Mar (28), Apr (5).

Remarks. *A. flavida* is known only from adults emerging after dark from cushion bogs and mires (Patrick *et al.* 1984, 1988). Males are distinguished from the similar-sized and sympatric *A. aspina* by the prominent spine at the base of the valva, the lack of setae on the supraphallic sclerite, the pallid stripe along the forewing jugal area, and the consistently yellowish body vestiture. Females lack a flap-like epiphysis and do not have sternum 9 hypertrophied, nor is the anogenital field directed upwards.

A. flavida is a member of the group of moderate-sized *Aoraia* species characteristic of Otago–Southland. It is sympatric with *A. aspina* on the Umbrella Mountains CO (Patrick *et al.* 1984), and is the only species recorded from Ajax Swamp, Catlins SL (Patrick *et al.* 1988). It is nocturnal in adult activity, and appears to be confined to cushion bogs, as distinct from *A. aspina*, which is crepuscular and was collected in grassland (B.H. Patrick, pers. comm.).

The name refers to the yellowish ventral body vestiture of most males.

Aoraia hespera new species

Fig. 258, 259; Map 7

Male large, 55 mm in wingspan (estimated), with forewing length 23.5 mm; thorax width between wing bases 8.3 mm; antennal length about 0.42x wing length; forewing scales elongate, broadly to narrowly truncate apically; colour pattern simplified, largely ash-white on grey-brown ground (specimen recovered from alcohol storage), with a pale subterminal band broken at half length, and with a conspicuous, pallid (pale ash-white) basal patch; hind wings smoky brown. Female unknown.

Male genitalia (Fig. 258, 259): pseudotegumen in lateral view as in Fig. 259, with dorsal margin convex, apically produced as a rounded lobe, and with no vestige of dorsal or posterior processes; ventral process short, evenly slender; valva strongly curved, apically acute, relatively stout, lacking a basal saccular spine, with remainder of saccular margin carinate, irregularly toothed; trulleum lyre-shaped (Fig. 258), with base strongly sclerotised, arcuate, and basal cone unifid; supraphallic papilla unsclerotised.

Type data. Holotype male labelled "New Zealand FD Mt George 2 km N 25 March 1977, D.R. Given" (white card), "HOLOTYPE [male] *Aoraia hespera* Dugdale" (red card), NZAC.

Remarks. *A. hespera* is known from only the one specimen. The site is penalpine (1400 m approx.) and, being in western Fiordland, has a very high rainfall.

A. hespera is distinguished from all other *Aoraia* species by the distinctive pseudotegumen, which lacks acuminate posterior processes. It resembles *A. aspina* in its lack of a basal saccular spine on the valva. There is a superficial resemblance to *A. lenis* (very woolly vestiture, and a prominent ash-white basal patch on the forewing on a dark smoky brown ground), but genital characters do not corroborate this.

The name refers to the far western type locality.

Aoraia insularis new species

Fig. 20, 75, 87–89, 112, 119, 127, 139, 160–163, 182, 191, 192, 260–262, M4–6; Map 8

Male large, 54–65 mm in wingspan, with forewing length 24–29 mm; antenna about 0.3x wing length; forewing pattern intricate, in tan and yellow-brown on a darker brown ground, with subterminal band often prominently pale or sometimes with pale yellow patches by subterminal line; hind wings tending yellowish fawn, rarely smoky brown

(Fig. 20). Female unknown.

Male genitalia (Fig. 260–262): intersegmental sclerite present as a strongly chitinised band; pseudotegumen in lateral view with dorsal margin deeply concave, apically finely serrate, and with a distinct break in outline between dorsoapical area and posterior process; ventral process long, spinose, apically blunt; valva stout, geniculate; sacculus strongly carinate to above bend, with a basal spine; valva with a strong ridge dorsally extending to two-thirds of valval length; trulleum with arms straight, basal area with a blunt, flange-like median process; supraphallic papilla unsclerotised.

Larva. Head capsule as in Fig. 160–163; chaetotaxy as in Fig. 182.

Pupa as in Fig. 191, 192.

Type data. Holotype male labelled "N.E. Big South Cape I. 25 Feb. 1968 J.G.R. McBurney" (white card), "Holotype *Aoraia insularis* Dugdale", NZAC.

Paratypes: 52 males, 1 pupal exuviae, 4 larvae from Stewart Island localities – 2 males, Easy Cove [Harbour] (NMNZ, NZAC), 1 male, [old fish factory at] Port Pegasus (NZAC), 2 males, Codfish Island (BPNZ, NZAC), 46 males, Big South Cape Island (NZAC), 1 male, Ernest Island (CMNZ).

Material examined. Type series only.

Distribution: — / SI / —.

Flight period: Jan (1), Feb (48), March (2).

Remarks. *A. insularis* is known only from males; a few larvae were collected from shafts associated with tussocks on *Poa foliosa* on Big South Cape Island. The apparently restricted distribution (Map 8) may be an effect of the lack of collecting in the outermost parts of western Fiordland; February appears to be a useful time. It is noteworthy that the large series of males, and the larvae, were collected on Big South Cape Island after rats had become established (and pervasive) there, indicating that this species can survive in the presence of adventive rodents.

A. insularis, though very similar to *A. enysii*, is distinguished by its chitinous rather than sclerotised intersegmental strip and by the discontinuity in outline between the apical dorsal margin and the posterior process of the pseudotegumen.

The name *insularis* alludes both to the type locality and to the apparent restriction of this species to Stewart Island and its outliers.

Aoraia lenis new species

Fig. 21, 263–266; Map 9

"sp." Dumbleton, 1966, p. 939, fig. 42–47 *(Aoraia)*, in part.

Male large, 62–73 mm in wingspan, with forewing length 26–32 mm; antenna 0.3x forewing length; thorax and abdomen with very thick, woolly vestiture; forewing scales slender, blunt or acuminate; colour pattern (Fig. 21) ash-white on smoky brown ground, the ash-white elements partly or wholly coalescing as a conspicuous white longitudinal bar on proximal fifth of wing, along vein CuA; hind wings fawn or smoky brown, with veins outlined in darker scales. Female brachypterous, with epiphysis long, straight, broadly rounded apically.

Male genitalia (Fig. 263–265): pseudotegumen planoconvex in lateral view (Fig. 264), with no dorsal process or lobe; posterior process smooth apically, irregularly serrulate or roughened dorsally on margin, ventral process subspinose apically, irregularly serrulate on upper margin; trulleum with arms reduced, scarcely longer than height of basal plate; base more or less rectangular; cone variable, with 3 points (Black Birch MB) or 1 (elsewhere), or reduced to a small conical prominence (Gordons Knob NN); valva (Fig. 265) arcuate, distally finger-like, only slightly expanded apically; saccus without a wide flange; sacculus with a darkened basal spine, and with a sclerotised, subdentate carina extending to angle; supraphallic papilla nude, not sclerotised.

Female genitalia (Fig. 266): sternum 9 side-pieces nearly as long as median piece, twice as long as wide, with 4 prominences on dorsal margin and a discal sensilla on the sparsely setulose face; median piece scarcely emarginate at apex, with a short, nude mesal strip; furrow separating median piece and side-pieces shallow, broad, nude; subanal plates reduced to an irregularly sclerotised, fragmented field; ductus bursae arising slightly skewed to right on vestibule, twice as long as irregularly elongate-ovoid corpus bursae.

Type data. Holotype male (wingspan 64 mm) labelled "573 k" [Gordons Knob NN, 1 April 1924, S. Hudson], "Genitalia Preparation No. 372", "Holotype [male] *Aoraia lenis* Dugdale n.sp.", NMNZ.

Paratypes (16 males, 2 females, 1 in alcohol) as follows: 1 male, Cobb Dam, 1961, G. Lord (NZAC); 1 male, Peel Ridge (M26/742091), 28 February 1989, M.J. Meads (NZAC); 2 males, Paparoa Range, Buckland Peaks, 7 April 1984, B.P. Stephenson (NZAC); 1 male, dead in Observatory Building, Altimarlock, Black Birch Range, 15 January 1973, J.S. Dugdale (NZAC); 8 males, Craigieburn Range, Camp Creek Basin, 1300 m, 30 March 1985, J.S. Dugdale

(NZAC); 2 males, same locality, forest edge at 1200 m, same date, K.J. Fox; 2 females, same locality, dead on track, 28 March 1985, K.J. Fox (NZAC); 1 male, Craigieburn Range, Nervous Knob, 1550 m, 3 May 1968, E.G. White (LUNZ); 1 male, Craigieburn, Camp Stream, [date?], 1200 m, D. Watson (LUNZ); 1 male, Danseys Pass, 8 April 1979, B.H. Patrick (BPNZ).

Material examined. Type series only.

Distribution: — / NN, BR, MB, MC, CO–DN.

Flight period: Feb (1), late Mar (10), Apr (5), May (1).

Remarks. *A. lenis* is distinguished from other *Aoraia* species by pseudotegumen shape (Fig. 264, and Dumbleton 1966, p. 939, fig. 42–45) and the conspicuous white basal streak or stripe on the forewing (Fig. 21). From other large species (except some *A. dinodes*) it is distinguished by its more-or-less uniform dull brown ground colour on the forewing, patterned in ash-white, sometimes broadly so, and with a pallid fringe on the termen. The brachypterous female is bulky, with a long, straight foretibial epiphysis that is apically broadly rounded, not narrowed or vestigial as in similarly large females of other species.

The only known females definitely associated with males are brachypterous. The females tentatively associated with this species by Dumbleton (1966, p. 939) are now assigned to *A. enysii* on foretibial epiphysis characters, but until field association is observed the assignment of the Rotoiti and Dun Mountain (NN) females remains tentative. Dumbleton's slide of the Rotoiti female has not been located, but another specimen with an identical foretibial epiphysis is assigned to *A. enysii*, in which the female is variable in size.

A. lenis is confined to the penalpine zone on South Island mountain ranges in Nelson, Marlborough, northern Westland, and inland Canterbury to St Marys Range / Danseys Pass in northern Otago. Males from high-rainfall mountains are darker in ground colour than those from lower-rainfall (eastern) ranges. Males fly for a short time (approx. 1 hour) in mist or light rain, about 1 hour after sunset. Larvae have been collected in well drained penalpine grassland. Males have been found in the daytime resting on bushes of snow totara, *Podocarpus nivalis* (Patrick 1982).

The name refers to the soft, woolly appearance of the body.

Aoraia macropis new species

Fig. 22, 23, 267–272; Map 10

Male moderate-sized, 38–45 mm in wingspan, with forewing length 17–19 mm; antenna about 0.33x forewing length; eyes globose (cf. *senex*); forewing scales elongate, narrow, apically rounded or narrowly truncate; ground colour a uniform smoky brown with a dull ash-white pattern, sometimes reduced to a few thin 'scribbles'; hind wings contrasting pale brown or yellowish-fawn (Fig. 22, 23). Female brachypterous, dull brown; forewings dull brown blotched with paler fawn; foretibial epiphysis (Fig. 270) vestigial as an acute, blade-like structure more-or-less fused with tibia along most of its length (about 0.16x tibia length).

Male genitalia (Fig. 267–269): pseudotegumen dorsal margin planoconvex, either evenly rounded posteriorly or (rarely) somewhat abruptly angled to posterior process; posterior process short, acuminate or subspinose apically; ventral process short, slightly decurved and sharp-pointed apically (Fig. 267, 269); trulleum lyre-shaped (arms sinuous), with base narrow rectangular and basal cone small, unifid; valva strongly geniculate (elbowed), apically slightly expanded; sacculus with a prominent basal spine but no observable carina; saccus with flange evident basally (Fig. 268); supraphallic papilla lightly sclerotised, nude.

Female genitalia (Fig. 271, 272): orientation normal (i.e., directly posterior); dorsal plate (Fig. 271) with strong setae extending from posterior margins to close to anterior margin on either side of dorsal midline; sternum 9 (Fig. 271) with side-pieces as long as median piece, widest mesally; dorsal margin undulate, with a few setae; face largely nude, with a discal sensillum; furrow between side-piece and median piece shallow; median piece emarginate at apex, with a nude midline furrow; vestibule more or less symmetrical, with slender ductus bursae arising symmetrically, about 1.5x longer than the elongate-ovoid corpus bursae (Fig. 272).

Type data. Holotype male (wingspan 41 mm) labelled "New Zealand CO Old Man Range Sthn end 5 April 1986 B.H. Patrick 1350 m" (white card), "Holotype [male] *Aoraia macropis* Dugdale", NZAC.

Paratypes: 26 males, 10 females, same data as holotype, NZAC, BPNZ.

Material examined. Type series, plus the following non-type examples: 1 male, 5 pupal cases, Old Man Range, 1500 m, ex moss, 3 Apr 1982, B.H. Patrick (NZAC); 1 female, Old Man Range, south end, 1350 m, bred from pupa in *Poa*, 20 Mar 1987, B.H. Patrick & B. Rance (NZAC); 2 males, Old Man Range, 1420 m, 23 Feb 1986, B.H. Patrick (NZAC); 1 male, 1 female, ridge W of Whitcoombe Creek, 1100 m, 19 Mar 1986, B. Patrick & B.

Rance. Also reported from Fraser Creek, Old Man Range and Mt Benger (B.H. Patrick, pers. comm.).

Distribution: — / CO.

Flight period: Feb (2), Mar (3), Apr (36).

Remarks. *A. macropis* is a member of the moderate-sized *Aoraia* species-group, restricted to southern Central Otago mountains (Patrick 1988) and abundant in cushion-bogs on the rounded summits. It is sympatric with *A. senex*, from which it is distinguished by its more elongate forewing scales and well developed (globose) compound eyes, which in lateral view hide the genal area. Its lyre-shaped trulleum is diagnostic, distinguishing it from *A. flavida*, and its possession of a basal spine on the valva distinguishes it from *A. aspina;* both species may prove to be sympatric with *A. macropis*.

On the summit cushion-bogs and mires of the Old Woman Range CO, and on similar bogs on the Old Man Range, in late March, I found rotting adults and drowned larvae. These were probably *A. macropis*; the semiaquatic sites contrast with the well drained sites where *A. senex* is found. Adults have been observed "swiftly flying in rain at 3.30 pm, low and fast ... freshly hatched pupa found in bog"; and on another occasion "... many fresh pupae hatched in bog" (B.H. Patrick, pers. comm.). Mr Patrick also found "empty pupae" in similar sites on Mt Benger CO.

The name refers to the large size of the compound eyes, in contrast to their reduced state in the sympatric *A. senex*.

Aoraia oreobolae new species

Fig. 24, 273–276; Map 11

Male moderate-sized, 52–56 mm (estimated) in wingspan, with forewing length 22–25 mm; antennae nearly half (0.45x) forewing length; forewing scales slim, oval, apically rounded; colour pattern rather simplified, ash-white on a more-or-less uniform dull dark brown ground. Female (Fig. 24) weakly sub-brachypterous, narrower-winged than male, 39–55 mm in wingspan, with forewing length 18–24 mm; thorax bulky; foretibial epiphysis a slender, slightly curved blade, apically rounded, extending to at least half tibial length; forewings immaculate, smoky brown, with sparse, hair-like scales (as on hind wings).

Male genitalia (Fig. 273, 274): pseudotegumen with dorsal margin planoconvex, posterior margin more-or-less at right angles to dorsal margin, with posterior process short, spinose, and ventral process short, slightly decurved apically, gradually widened to base (Fig. 273); trulleum with arms straight, basal cone unifid; valva slender, strongly elbowed, with a strong, blackened basal saccular spine; sacculus strongly sclerotised, carinate to elbow, with an outer ridge beyond this (Fig. 274); supraphallic papilla nude, unsclerotised.

Female genitalia (Fig. 275, 276): sternum 9 side-pieces almost triangular, sparsely setose, and with a sensilla on outer face (Fig. 275); dorsal margin unmodified, half as long as median piece width; furrow between side-piece and median piece very oblique and broad (hence the 'triangular' side-piece shape); median piece not indented in midline, uniformly setose; a setose tubercle present laterally between dorsal plate and sternum 9 side-piece, just outward from subanal sclerite (Fig. 276); ductus bursae slender, arising at midline from symmetrical vestibule, about 1.5x length of globose corpus bursae.

Type data. Holotype male (left fore and hind wings missing; genitalia in glycerol in plastic minivial) labelled "New Zealand SL Tapanui Blue Mountains 8 Mar 1987 N. Hudson" (white card), "found nearly dead in tarn in cushion bog, cloudy, light to moderate gusty wind, mild" (white card), "*Aoraia* sp. [male] det. B.H. Patrick 4/4/1987" (white card), "Holotype *Aoraia oreobolae* Dugdale NZAC" (red card), NZAC.

Paratypes (2 males, 4 females, NZAC): 1 male (removed from pupal case), "New Zealand SL Blue Mountains 1000 m f. 1 March 1987 B.H. Patrick"; 1 male (forewings only), "New Zealand SL Blue Mountains 1000 m, 18 March 1985 B.H. Patrick", and 4 females (3 ex pit trap picric acid), same data except 5 March 1985.

Material examined. Type series only.

Distribution: — / SL.

Flight period: Mar (6).

Remarks. *A. oreobolae* differs from other moderate-sized *Aoraia* species, except *A. flavida*, in its long male antennae (nearly half forewing length), fully winged female with sparse, hair-like forewing scales and long, immaculate forewings, and elongate foretibial epiphysis. The slender and strongly carinate valva in the male, and the prominent setose tubercle outward from the subanal sclerites in the female, are diagnostic. *A. oreobolae* resembles *A. senex* and *A. orientalis* in its globose corpus bursae, but in those species the setose tubercle is represented by a patch of setae.

A. oreobolae is so far known only from the northern and higher ("Tapanui No. 2") end of the Blue Mountains, in cushion bogs with *Oreobolus pectinatus* (comb sedge), *Gaimardea setacea*, and *Dracophyllum muscoides* (Patrick *et al.* 1985). Damage to *Oreobolus* was described by

Grehan (1989, pp. 807–808, fig. 3). Adult activity has not so far been observed. A night search on Tapanui No. 2 in March 1989, during a period of male *A. rufivena* activity, proved fruitless.

The name reflects the association with comb sedge (*Oreobolus pectinatus*).

Aoraia orientalis new species

Fig. 25, 26, 120, 149, 150, 193, 286–288; Map 12

Male moderate-sized, 45–55 mm in wingspan, with forewing length 20–24 mm; antenna 0.33–0.35x forewing length; compound eyes elliptic; genal (lower) eye margin exposed in lateral view; forewing scales oval or elongate-oval, apically rounded or truncate; colour pattern ash-white on smoky brown, with outer discal band sometimes paler brown between ash-white markings, some of which include patches of yellow scales; hind wings smoky grey, the veins with darker scales (Fig. 25). Female sub-brachypterous, 48–56 mm in wingspan, with forewing 21–24 mm in length, pointed, with scales as in male, and pattern and ground colour similar, although pattern elements along margins weak or absent; hind wing narrow; thorax robust, often with a buff anterior margin (Fig. 26); foretibial epiphysis variable, 0.1–0.25x tibial length, or vestigial.

Male genitalia (Fig. 286, 287): pseudotegumen dorsal margin planoconvex or horizontal, with anterior apex overhanging or perpendicular, rarely obliquely sloping to pseudotegumen base, posterior process short, and ventral process short, acuminate apically, with shaft slender (Fig. 287); trulleum with arms variable, usually long and straight or slightly arcuate, basal cone usually blunt; valva (Fig. 286) curved, with a basal saccular spine; arm narrow at bend, apically wider than at bend; supraphallic papilla unsclerotised, nude.

Female genitalia (Fig. 149, 288): sternum 9 basally narrowed between side-pieces and median piece; side-pieces setulose, scaled; furrow separating side-pieces from median piece broad, shallow, setose; median piece concave mesally, narrowly emarginate apically, with or without a nude central area; corpus bursae globose.

Type data. Holotype male labelled "New Zealand CO McPhees Rock 1300 m 14 April 1983 J.S. Dugdale" (white card), "Illustrated D.W. Helmore 6.9.85" (green card), "Holotype *Aoraia orientalis* Dugdale NZAC" (red card), NZAC.

Paratypes (20 males, 4 females, NZAC): same collection data as holotype.

Material examined. Type series, plus 6 non-type examples (4 males, 2 females; NZAC, BPNZ) as follows: Rock & Pillar Range, McPhees Rock, 2 Apr 1983, B. Barratt; Rock & Pillar Range, 10 Mar 1982, B. Patrick; South Rough Ridge, 1130 m, 22 Mar 1986, B. Patrick; Lammermoor Range, 1100 m, 2 Mar 1986, B.H. Patrick; north Dunstan Mountains, 1300 m, 10 Mar 1990, B. Patrick & P. Enright.

Distribution: — / CO.

Flight period: Mar (5), Apr (25).

Remarks. *A. orientalis* shares with *A. oreobolae* and *A. senex* the sub-brachypterous female condition, short ductus bursae, and globose corpus bursae. It shares with *A. oreobolae* the rather slender, apically slightly expanded valva. *A. orientalis* differs from *A. oreobolae* in its shorter antennae, unmodified female wing scaling, reduced foreleg epiphysis in the female, setose sternum 9 furrow, and lack of a flange-like saccular margin on the valva.

Males fly in the late afternoon in cloudy weather, and females crawl over the turf (Patrick 1989, and illustration). Adults have been found emerging from well drained sites (cf. *A. oreobolae*).

One male referable to this entity from the northern end of the Dunstan Mountains CO is unusual only in that the pseudotegumen dorsal margin is not cliff-like (perpendicular, or right-angled) anteriorly. In all other characters (e.g., valva, Fig. 286) it agrees with *A. orientalis* from the eastern side of the Manuherikia Valley, rather than with *A. senex* from the southern (higher) end of the Dunstan Range.

The name refers to the distribution of the species in eastern Central Otago.

Aoraia rufivena new species

Fig. 27–29, 277–280; Map 13

Male large, 60–74 mm in wingspan, with forewing length 26–33 mm; antenna about 0.31–0.33x forewing length; forewing scales slender, apically blunt or narrowly truncate; ground colour in shades of pale and dark brown, with ash-white pattern complete, complex, intricate, usually sharply delineated; veins Sc and R_1 usually covered in red-brown scales, forming a distinctive streak parallel with costa; termen in fresh specimens conspicuously barred in dark brown and pallid or yellowish fawn; hind wings yellowish fawn to smoky brown (Fig. 27–29). Female robust, more or less sub-brachypterous, 55–68 mm in wingspan, with forewing length 24–37 mm; thorax up to 9 mm wide between wing bases; forewing apically subacute, with termen very oblique; scales stiff, bristle-like, densely arranged, patterned in fawn and brown, with costal area usually yellowish-fawn (along veins Sc, R_1, Rs); hind wings narrow, apically subacute; foretibial epiphysis variable, 0.25–0.33x foretibial length, apically acute.

Male genitalia (Fig. 277, 278): pseudotegumen with anterior margin perpendicular (cf. *dinodes*), dorsal margin undulate, subserrate to subspinose; dorsal process area perpendicular, with margins straight, not produced mesally (Fig. 278); posterior process porrect, long, tapering steeply from a wide base to a sharp point; ventral process long, thickened on basal two-thirds, apically blunt, spinose; trulleum with arms long, straight, cone unifid or bifid; saccus lacking a flange; valva (Fig. 277) curved, stout (appearing narrow at midlength in dry specimens); apical portion slightly widened apically, and with a dorsal longitudinal ridge extending along central third of valva length; sacculus base with a strong spine, and saccular margin strongly sclerotised, irregularly dentate to bend in valva; supraphallic papilla unsclerotised, nude.

Female genitalia (Fig. 279, 280): sternum 8 shallowly emarginate anteriorly; sternum 9 side-pieces shorter than anterior margin of median piece; side-piece with face sparsely setose, and dorsal margin with 3 low mounds, the outermost sometimes conical, setose; furrow between median piece and side-piece very oblique, setose; median piece broadly triangular in face view, narrowly emarginate apically, with a nude strip (or a strip with fewer setae) mesally; subanal plates large, strongly sclerotised (cf. *A. lenis*); dorsal plates with a setulose patch on either side of midline, sometimes somewhat truncate on posterior margin; ductus bursae slender, arising mesally on symmetrical vestibule, at least 1.5x longer than the elongate, irregularly ovoid corpus bursae (Fig. 279).

Type data. Holotype male (68.5 mm wingspan; right hindwing apex broken) labelled "Swampy Summit DN 20–23 April 1982 B. Patrick" (white card), "Illustrated D.W. Helmore 27.4.84" (green card), "Holotype *Aoraia rufivena* Dugdale, n.sp.", NZAC.

Paratypes (17 males, 1 female, all DN): 1 male "ex 268, Helensburgh Road DN 22.3.69" (NZAC); 1 male "Porina, Halfway Bush, Otago 2.II.49" = genitalia preparation L69 (NZAC); 1 male "Woodhaugh Dunedin 16.3.11", "Fenwick Colln", "Genitalia preparation 366" (NMNZ); 1 male, no data and 1 male, Dunedin, 18 April 1924 (NMNZ); 1 male, no data (CMNZ); 3 males, Dunedin, 9 March 1982, 19 March 1986, 22 March 1982, B. Patrick (NZAC); 6 males, Swampy Summit, 720 m, 7–9 April 1982 (3), 14–16 April 1982 (3), B.H. Patrick (NZAC); 1 male (abdomen tip missing), "Invermay 28 March 1963" (NZAC); 1 female, "Dunedin 3.4.39 W.A. Thomson", "L252" (NZAC).

Material examined. Type series, plus 42 non-type examples (39 males, 3 females; NZAC, BPNZ, CMNZ, AMNZ) from L. Ohau; Coronet Peak, 1160 m; Mt Benger, 1160 m; Ida Range, 850 m; Black Rock, 600 m; Rock & Pillar Range, 1100 m; St Mary's Range, 1180 m; Burgan Creek, Great Moss Swamp; Lammermoor Range, 1100 m; Pisa Range, 1680 m (found dead); The Remarkables, Rastus Burn, 1640 m; Garvie Mtns, 1300 m; Old Man Range, 1600 m (found dead); ridge W of Whitcoomb, 1100 m; Umbrella Mtns, Gem Lake; Whitcoomb, 1550 m; Awatere Stm; Nokomai Stm, 250 m; Danseys Pass; Dunedin; Mt Cargill, 680 m; Waipori Vly, 150 m; Maungatua, 850 m; Moeraki; Blue Mtns, Tapanui No. 2, 920 m; and Owaka, in light trap.

Distribution: — / MK, OL, CO, DN, SL.

Flight period: Jan (several, B.H. Patrick), Feb (1), Mar (25), Apr (15).

Remarks. *A. rufivena* is distinguished from other large *Aoraia* species by the perpendicular dorsal process area on the pseudotegumen and its lack of an infolded lobe. The female in wing shape, pattern, and bulkiness resembles *A. dinodes*, but has a longer, more developed foretibial epiphysis. The usually vivid pattern and prominent rust-coloured subcostal streak in the male forewing make this a distinctive species.

A. rufivena has a predominantly south-eastern distribution (Map 13), and is characteristic both of subalpine grasslands and mires and upland forest, descending to areas of cool temperate forest around and in Dunedin (e.g., Woodhaugh, Macandrews Bay), the only city with a resident *Aoraia*.

Dumbleton (1966, p. 937) noted that two specimens of *Aoraia* from Dunedin "closely resemble *aurimaculata*"; these are here assigned to *A. rufivena*. While Dumbleton regarded them as unusual because of the saccus ("base of the vinculum") shape, this structure is rarely of consistent shape within species.

The name refers to the often prominently rufous-scaled veins Sc and R_1 on the forewing.

Aoraia senex (Hudson)

Fig. 30–32, 281–285; Map 14

senex Hudson, 1908, p. 107 *(Porina)*; —1928, p. 360, pl. xliii fig. 1, pl. xlix fig. 20 *(Porina)*. Dumbleton 1966, pp. 934–935, fig. 18–22, 95 *(Aoraia)*.

annulata Hamilton, 1909, p. 48 *(Porina)*. Synonymised by Hudson 1928, p. 360.

Males moderate-sized, 43–50 mm in wingspan, with forewing length 19–22 mm; antenna 0.36-0.38x forewing length; forewing scales short, broadly truncate; forewing pattern rather blotchy, with yellowish markings and blotches on dark brown ground; hind wings often with yellowish markings on outer half of costal / apical area (Fig. 30, 31). Female (Fig. 32) sub-brachypterous, 30–34 mm in wingspan, with forewing length 12–15 mm; thorax not smaller proportionately than that of male; foretibial epiphysis reduced to a stump (Fig. 285).

Male genitalia (Fig. 281, 282): pseudotegumen with anterior margin sloping to dorsal margin, which is more or less evenly convex around to the short, spine-like posterior process; ventral process slender, apically acute (Fig. 281); supraphallic papilla not sclerotised, nude; valva as in Fig. 282.

Female genitalia (Fig. 283, 284): sternum 9 with furrow between side-pieces wide, shallow, setose; anterior margin not indented between side-piece and median piece; side-pieces sparsely setulose on face; median piece mesally concave, apically nude, sometimes emarginate; ductus bursae arising slightly skewed to the right, slender, about 1.25x longer than greatest dimension of subglobose corpus bursae (Fig. 284); a group of setulae present laterally, between lateral corners of dorsal plate and subanal plates.

Type data. *senex:* holotype male labelled "730a" [Old Man Range CO, 4000 ft, J.H. Lewis] (white card), "*P. senex* Holotype [male]" (pink card), NMNZ.

annulata: holotype male labelled "*P. annulata* type A.H., [Stony Creek], Mt Aurum Wakatipu 4000 ft Nov 1907" [? Feb 1908] (white card), "Museum Coll, Coll. Hamilton" (white card), red circular label, NMNZ. Note: The collector, H. Hamilton, was in the Queenstown district from November 1907 to March 1908.

Material examined. Type specimens, plus 24 non-type examples (11 males, 13 females; NZAC, NMNZ, BPNZ) from Coronet Peak, 1500 m; The Remarkables, Rastus Burn, 1800 m; Pisa Range, 1890 m; Old Man Range, W side, 1570 m; Dunstan Mtns, summit, 1590 m; Mt Tennyson, 1595 m; Umbrella Mtns, Gem L., 1300 m; and Mid Dome, 1450 m. Larvae have been collected on the Pisa Range, in the Roaring Meg headwaters at 1500 m.

Distribution: — / OL, CO.

Flight period: Feb (22), Mar (5).

Remarks. *A. senex* is distinguished from other members of the penalpine, moderate-sized *Aoraia* species *(aspina, flavida, macropis, oreobolae, orientalis)* by the short, broadly truncate forewing scales in both sexes and the distinctively dull yellow (gold) maculation on the male forewing. Females are distinguished from those of other species (except *orientalis*) by their blackish-brown coloration and the conspicuous ash-white patterning and truncate scales on the forewings. From *A. orientalis* females, *A. senex* is distinguished by its darker coloration, smaller size, and distinctive scale shapes.

On female characters *A. senex*, *A. oreobolae*, and *A. orientalis* form a group defined by the globose corpus bursae and the presence of a lateral setose tubercle *(oreobolae)* or patch of setae outward from the subanal plate, and between the outer corners of the dorsal plate sclerite and the sternum 9 side-piece. *A. senex* and *A. orientalis* are the only species known with reduced eyes in the male. The species are largely allopatric, and *A. senex*, like *A. orientalis*, is characteristic of well drained alpine soils supporting grasses such as *Poa colensoi*. The larval shaft is often capped with a short, squat 'operculum'.

Males fly on warmer cloudy, misty, or drizzly days from early afternoon; females crawl over the alpine turf.

Genus *Cladoxycanus* Dumbleton

Cladoxycanus Dumbleton, 1966: 948–949. Type species *Porina minos* Hudson, by original designation; New Zealand.

Shaggy-pilose moths with wingspan not exceeding 55 mm. Antennae (Fig. M7–9) tripectinate, with median pectination appressed, triangular, and lateral pectinations (rami) with many sensillae chaeticae; basal flagellar segments with sparse dorsal scaling; apical flagellomere spine-like. Labial palpi (Fig. 93) porrect, elongate; basal segment with a long ramus, and prelabium strongly bilobed. Tarsal claws lacking an arolium. Wing venation (Fig. 76) of *Oxycanus* type, i.e., veins R_4 and R_5 each arising separately from a common R_{2-5} stem; discal cell ending before half wing length; hind wing with veins Sc and R_1 ending separately. Metascutum completely divided by metascutellum. Abdominal segment 1 lacking a posterior lobe on tergal brace (Fig. 128).

Male genitalia (Fig. 134, 289–291): sternum 8 broadly emarginate; intermediate plate more or less oblong; pseudotegumen basally lacking twin processes anterior to anus, the halves smooth, broadly knife-like, with apices acute, free, pointing ventrally; claspers lobate, lacking a basal spine; subanal membranous processes and supraphallic papilla absent.

Female genitalia (Fig. 151, 292): tergum and sternum 8 posterior margin clad in long, pallid (yellow-fawn), hair-like scales; sterna 7 and 8 fused; sternum 9 long, broad, with side-pieces separate and median piece obscurely emarginate in midline; sinus seminalis enclosed by fused intergenital lobes; dorsal plate halves fused and sclerotised in dorsal midline, forming a midline papilla; bursa copulatrix short, contained within segment A8; corpus bursae globose, without an appendix; ductus bursae as wide as long, subequal in length to corpus.

Larva (Fig. 164–167, 183). Head capsule in later instars appearing smooth; labrum angular laterally; blade-like lobarial sensillae bifid. Prosternum broadly fused with poststernum; pronotum with SD_1, SD_2 in separate felted pits; mesothoracic, metathoracic, and abdominal segments lacking sternal plates. Larvae in or at margin of moss-covered bogs and seepages, in forest or open country.

Pupa (Fig. 194, 195). Setae long, wire-like. Scape, pedicel, and vertex each with a conical, often sharp-pointed process; frons with a prominent, sharply bifurcate process. Abdominal segments 4–7 lacking ventral carinae; spine crest on A7 venter formed of long, slender spines, but with no pronounced transverse ledge bearing them (cf. other genera).

Remarks. *Cladoxycanus* is distinguished from other genera with *Oxycanus*-type venation by its lack of an arolium between the tarsal claws, ramiform labial palpi, sparsely scaled wings in the female, drooping, knife-like pseudotegumen, and female dorsal plates sclerotised in the midline. It is also unique in New Zealand in having the metascutellum completely dividing the metascutum anteriorly.

The larva, with its lack of mesothoracic, metathoracic, and abdominal sterna and its wire-like crinkled setae in later instars, is distinct from *Heloxycanus*, with which it is often associated in bogs dominated by *Sphagnum* species in DN, OL, and SL. (*Heloxycanus* also has the hypostomal plates broadly fused mesally, rather than narrowly; cf. Fig. 165, 176.)

Cladoxycanus is an isolated member of the group of genera characterised by *Oxycanus*-type venation (see p. 11). There is one species, *C. minos*, rather widely distributed from southern Taranaki to eastern Southland but not so far recorded from Marlborough.

Economic significance. The larva crops sphagnum, and is present in areas – e.g., WD – where this moss is harvested.

Conservation values. *Cladoxycanus* is a cladistically unresolved taxon. Its unusual semi-aquatic larval life is most closely approached in New Zealand by the apparently unrelated genus *Heloxycanus*, but *Cladoxycanus* has a more extensive geographic range. Adults of both genera emerge in autumn or winter, and both are characteristic of cold sites. The conservation value of *Cladoxycanus* is high, because of its isolated status, unusual biology, and membership of the winter-emerging wetland biota. It is probably not at risk in most areas, as the consistent catches over many years at Invermay (Mosgiel DN) at a highly developed site indicate.

Cladoxycanus minos (Hudson)

Fig. 33–36, 76, 90–93, 121, 128, 134, 141, 151, 164–167, 183, 194, 195, 289–292, M7–9; Map 15

minos Hudson, 1905, p. 357 *(Porina).* Philpott 1927b, fig. 17 *(Porina).* Hudson 1928, p. 365, pl. xlii fig. 3–5 *(Porina).* Dumbleton 1966, pp. 950–951, fig. 61–66, 104 *(Cladoxycanus).*

autumnata Hudson, 1920, p. 277 *(Porina).* Synonymised by Hudson 1928, p. 365. Dumbleton 1966, p. 950, as synonym of *minos.*

Small to moderate-sized moths, males 31.5–42 mm in wingspan with forewing length 13–19 mm, females 39–54 mm in wingspan with forewing 17–24 mm. Antennae pallid, about 0.33x forewing length. Forewing scales elongate-ovate with pointed apices, arranged loosely in males to sparsely – i.e., not hiding wing membrane – in females. Males variably patterned, with irregular ashy and / or dull yellow ('gold') markings or large yellow-fawn areas on dark brown (North Island, Westland) or paler, smoky brown (eastern South Island) ground colour, and forewing termen with a conspicuously barred fringe; females unpatterned, with forewings uniformly fawn to smoky brown and veins distinct. Many individuals of both sexes with distinctly yellow-fawn abdominal and hindwing base vestiture. Female abdomen with a conspicuous, large, yellow-fawn tuft apically on tergum 8 (Fig. 151).

Genitalia as in generic description.

Larva, pupa as in generic description.

Type data. *minos*: holotype male (wingspan 27 mm) labelled "575a" [Ophir CO, J.H. Lewis] (white card), "Holotype *P. minos* Huds." (pink card), NMNZ.

autumnata: holotype male (wingspan 44 mm) labelled "575c" (white card), "856a" [Lower Hutt WN, A.V. Clere] (white card), "Genitalia preparation No. 361 Holotype [male]" (yellow card), "Holotype [male] *Porina autum-*

nata Huds. LJD genitalia taken" (pink card), NMNZ.

Material examined. Type specimens, plus 122 non-type examples (85 males, 37 females; NZAC, NMNZ, BLNZ, LUNZ) from Hawera; Paiaka; Masterton; Ballantrae (DSIR, Palmerston North); Orongorongo Vly; Pretty Bridge Vly; Nelson; Paroa; Canavans Knob; Haast; Haast Pass; Springfield; Burwood Forest area, sphagnum bogs (larvae); Great Moss Swamp; Black Rock; Moa Creek; Ida Vly; Crawford Range; Lammermoor Range; Glenleith; Dunedin; Waipori Falls; Maungatua, 800–890 m; Invermay; Mt Cargill; Swampy Summit; Portobello; Owaka; Purakaunui; Ajax Swamp (larva); and Seaward Moss (pupal headpiece?).

Distribution: TK, WI, WA, WN / NN, WD, MC, OL, CO, DN, SL.

Flight period: late Apr (62), May (54), Jun (7), Jul (7), Aug (1); records from June to August from high-rainfall / forested areas.

Remarks. Adults of *C. minos* from high rainfall / forested localities north and west of the Waitaki River are larger, darker, more contrastingly coloured, and emerge later in the winter than those from south of the Waitaki (DN, CO, SL). There are no consistent genital differences, and Hudson's synonymy is upheld. Adults at Ballantrae WA were collected only at a light trap by a large, moss-covered seepage and a water storage pond beside indigenous forest, and it is likely that *C. minos* from forest localities has a similarly moss-dwelling larva, as has *C. minos* from open country moss-bogs in OL, CO, DN, and SL. Recent winter collecting by Dr J. Early (LUNZ) and Mr B. Lyford (BLNZ) in Westland confirm the widespread occurrence there of *C. minos* and its winter adult emergence, extending into August. The sole record from Seaward Moss rests on three pupal headpieces found by Mr B. Patrick on sphagnum, but he has never found adults, despite light trapping at suitable times in suitable weather conditions at appropriate sites around Invercargill. Winter collecting for adults, or searching for the distinctive, wiry-haired larvae in moss-covered seepages in other North Island localities, may show the distribution to be more general.

Genus *Dioxycanus* Dumbleton

Dioxycanus Dumbleton, 1966, pp. 951–952. Type species *Porina fusca* Philpott, by original designation; New Zealand.

Sleekly pilose moths with wingspan not exceeding 50 mm. Antennae (Fig. M10–12) obscurely (rarely strongly) bipectinate; basal flagellomeres lacking scales, apical flagellomere ovate. Labial palpus (Fig. 96) with 2 segments (occasionally obscurely 3-segmented on one side); apical segment lacking a vom Rath's organ. Forewing venation (Fig. 77) of *Oxycanus* type; stalk of vein R_{2+3} shorter than free R_2 or R_3; discal cell ending at half wing length; hindwing veins Sc and R_1 apically fused. Abdominal segment 1 (Fig. 129) with a posterior lobe on tergal brace, broad, apically truncate; sternum 2 lacking a strengthening ridge.

Male genitalia: sternum 9 vinculum base (Fig. 139) raised mesally; intermediate plate tapering anteriorly; trulleum broadly rectangular, plano-concave; pseudotegumen with twin processes well developed, with posterior and ventral apices, the latter bridged, and with dorsal margin not reflexed. A membranous, tumid or bilobed subanal area and a thumb-like supraphallic papilla present.

Female genitalia: tergum and sternum 8 with a posteromarginal broad, hair-like scale tuft (Fig. 152); sternum 9 long, broad, with side-pieces carinate, median piece convex or truncate (and obscurely bifid) apically; intergenital lobes free mesally (Fig. 298, 299), thus sinus seminalis a gutter; antrum vestibule sclerotised; vestibule / ductus bursae junction central; ductus bursae sparsely spinulose on anterior quarter; corpus bursae with an apical appendix; bursa copulatrix ensemble enclosed within abdominal segment 8.

Larva (Fig. 168–171, 184). Head capsule (epicranium) irregularly striate; basistipes setal puncture about equidistant between basistipes setae; inner face of distipes with a patch of asperities; prothorax with SD_1, SD_2 in separate felted pits and prosternum and poststernum separate; mesothorax, metathorax, and abdominal segments 3–6 with sternal plates.

Pupa (Fig. 196, 197). Headpiece (except frons) lacking prominences; vertex plane; frons convex, with a conical process; abdominal segments 1–8 with short setae; sublaterally on A4–6 a short carina anteroventrad of spiracle, and another sublaterad of setal group SV; ventral spine crest on A7 borne on a large, stout ledge.

Remarks. *Dioxycanus* is characterised by its basically two-segmented labial palpi visible to the unaided eye (cf. *Heloxycanus*). Forewing colour pattern is reminiscent of *Wiseana* but differs in the presence of a strong pattern element in the proximal third of the Cu-A region (Fig. 37). With moderate-sized to small adults, emerging in summer, *Dioxycanus* occupies the *Wiseana* niche in subalpine and penalpine areas. The two species are allopatric, one southern, one northern. Precise boundaries between them – possibly between MK and SC/MC – are not known, but Mr B. Patrick has found several contact zones with *Wiseana* species. These include association with *W. mimica* on many Central Otago ranges, and with *W. umbraculata* at Seaward Moss: adults were collected on the same day.

Dioxycanus is a typical member of the New Zealand cluster of genera with oxycanine-type venation and the pseudotegumen with distinct mid-posterior and ventral apices. It and *Heloxycanus* are the only members of this group with the female intergenital lobes free mesally; the lobes are fused in the midline in other genera. Larvae of *Dioxycanus* are difficult to distinguish from those of *Wiseana*, but the more-or-less median position of the basistipes setal puncture between the basal and apical basistipes setae in *Dioxycanus* seems diagnostic.

Economic significance. None, while subalpine / alpine pastures are not used for intensive production.

Conservation values. *Dioxycanus* 'replaces' *Wiseana* in subalpine / alpine localities. There is a strong likelihood that the populations of *D. oreas* south of the Rakaia River may warrant specific status. At present *Dioxycanus* species are not known to be at risk over the greater part of their range.

Dioxycanus fuscus (Philpott)

Fig. 37, 168–171, 183, 293, 294, 298; Map 16

fuscus Philpott, 1914, p. 121 *(Porina,* as *fusca).* Hudson 1928, p. 364, pl. xlii fig. 10,11 *(Porina).* Philpott 1927b, p. 39, fig. 16 *(Porina).* Dumbleton 1966, pp. 954–955, fig. 73–77, 103 *(Dioxycanus).*

Small to moderate-sized moths, males 26–33 mm in wingspan with forewing length 11–14 mm, females more uniform in size, about 38 mm in wingspan. Male antennae about 0.33x forewing length, dark. Forewing scales broadly ovate, mostly pointed on distal half of wing; pattern as in Fig. 37.

Male genitalia (Fig. 293, 294): valva with a truncate, sclerotised basal saccular process; costal (upper) margin mostly straight; pseudotegumen dorsal and ventral processes with axes only slightly divergent, almost parallel; twin processes apically subclavate; juxta with basal lateral lobes extending beyond level of valval saccular process.

Female genitalia (Fig. 298): sternum 9 median piece wider than high, with a truncate-triangular (or almost bifid) dorsal process; side-pieces more or less rhomboidal, over half as long as median piece; corpus bursae with appendix large; entire bursa copulatrix not extending anteriorly beyond abdominal segment 7.

Larva. Head capsule with preantennal bar base (Fig. 171) securiform, i.e., not obliterating or narrowing subantennal cleft. Larva occupying a shaft in the ground.

Pupa as in generic description.

Type data. Holotype male designated by Philpott (1914, p. 121), not found in NMNZ. Lectotype male here designated, labelled "*Porina fusca* Philpott, Paratype" (white card), "Bold Pk 27/12/12" (white card), "Illustrated D.W. Helmore 5.11.85" (green card), "Lectotype, *Porina fusca* Philpott" (pink card), originally in NZAC, now transferred to NMNZ. There are, in addition, five males (but without Philpott's labels) in NMNZ.

Material examined. Lectotype, plus 22 non-type examples (17 males, 5 females; CMNZ, BPNZ, NZAC) from 'Mt Cook'; above Temple Forest, L. Ohau; Bold Peak; Routeburn; Symmetry Peaks, Eyre Mtns, 1500 m; Humboldt Range; St Marys Range; Danseys Pass; Lammermoor Range; Pisa Range, 1800 m and 1500 m, Roaring Meg headwaters (larva); Rock & Pillar Range, 1250 m; Homer; Borland Saddle, 990 m; Invermay; Swampy Summit; Waipori; Mt Cargill; Longwood Range; Slopedown Range, 715 m; Otatara; Seaward Moss; Waituna Reserve; and Owaka.

Distribution: — / MK, OL, CO, FD, DN, SL.

Flight period: Dec (19), Jan (16), Feb (1) (B. Patrick, pers. comm.).

Remarks. *D. fuscus* is distinguished from *D. oreas* by its usually dark antennae and by the elaborated apex of the twin processes in the male, the distinctive process on the median piece of sternum 9, and the presence of a large appendix on the corpus bursae of the female.

D. fuscus is known as larvae from penalpine short-tussock turf on the Pisa Range, where amongst short *Poa* tussocks larvae were found to be abundant, living in shafts in the soil (as do *Wiseana* species). Each year a few adults – of both sexes, but largely females – are collected in the light trap at Invermay DN, in the lower Taieri Valley, and adults have been collected from nearby Swampy Summit DN. Larval sites in these localities are unknown. Mr B. Patrick has observed that adults fly at dusk, or even earlier (1630 h) on rainy / misty days.

Dioxycanus oreas Hudson

Fig. 38, 39, 77, 94–97, 114, 122, 129, 135, 152, 196, 197, 295–297, 299, M10–12; Map 17

oreas Hudson, 1920, p. 277 *(Porina)*; —1928, pp. 364–365, pl. xliv fig. 19, 20 *(Porina)*. Dumbleton 1966, p. 952, fig. 67–72, 99 *(Dioxycanus)*.

ascendens Meyrick, 1921, p. 336 *(Porina)*. Hudson 1928, p. 365, pl. xlix fig. 21 (*Porina*, as species). Dumbleton 1966, p. 952, fig. 101 *(Dioxycanus*, as synonym of *oreas)*.

descendens Hudson, 1923, p. 180 (*Porina*). Hudson 1928, p. 364, pl. li fig. 19 (*Porina*, as species). Dumbleton 1966, p. 952, fig. 100 *(Dioxycanus*, as synonym of *oreas)*.

gourlayi Philpott, 1931, p. 36 *(Porina)*. Hudson 1939, p. 470, pl. lxii fig. 5, 6 (*Porina*, as species). Dumbleton 1966, p. 952, fig. 102 *(Dioxycanus*, as synonym of *oreas)*.

Moderate-sized moths, males 32–40 mm in wingspan with forewing length 14–18 mm, females 42–50 mm and 18–22 mm. Antennae short, about 0.3x forewing length, pallid (except for Mt Hutt specimens). Forewing scales broadly ovate, mostly truncate; pattern (Fig. 38, 39) always with a dark sinous or notched bar on proximal third near dorsum.

Male genitalia (Fig. 295–297): valva with basal saccular margin smoothly rounded, costal (upper) margin angulate; pseudotegumen ventral process directed at right angles to dorsal process; twin processes simply lobate; membranous subanal area tumid, often with a pair of dome-like processes laterally; supraphallic papilla large, thumb-like; juxta with basal lateral lobes short, not extending beyond level of valval saccular base.

Female genitalia (Fig. 299): sternum 9 median piece tumid, higher than wide, apically subtriangular; side-pieces reduced to a pair of more-or-less oval or subtriangular plates, less than half as long as median piece; corpus bursae extending into abdominal segment 6, with appendix reduced to a small tubercle.

Larva. Head capsule with pre-antennal bar base obliterating or occluding subantenal cleft. Larva in a silken tube at base of tussocks.

Pupa (Fig. 196, 197) as in generic description.

Type data. *oreas:* lectotype male (wingspan 36 mm) labelled "376a" [Mt Egmont TK, A. Lysaght] (white card), "Lectotype selected LJD 30/7/64" (white card), "Lectotype ~~holo~~type [sic] *Oxycanus oreas*" (pink card), NMNZ.

ascendens: lectotype female (wingspan 50 mm) labelled "Meyrick Coll. accession no. 1938-290" (white card), "Mt Arthur New Zealand GVH 2.89" (white card), "ascendens Meyr" (white card), "Lectotype" (red-rimmed disc), "Type" (ditto), BMNH.

descendens: holotype male (wingspan 42 mm) labelled "847 m" [Arthurs Pass NC–WD, 914 m, Dec. 1922, H. Hamilton], "Genitalia preparation No. 120" (yellow card), "Holotype [male] *Porina descendens* Huds. genitalia taken LJD" (pink card), NMNZ.

gourlayi: holotype male (wingspan 35 mm) labelled "Flora Camp 3000 ft 5.1.30 E.S. Gourlay" (white card), "*Porina gourlayi* Philp. Holotype [male]" (white card), red disc, "Holotype [male] *Porina gourlayi* Philpott" (red card), NZAC; also 3 paratypes (2 male, 1 female), same locality data, NZAC.

Material examined. Type specimens, plus 59 non-type examples (44 males, 15 females; NZAC, BPNZ, CMNZ, FRNZ) from Mt Taranaki [= Egmont], Holly Hut, 950 m; Pouakai Range summit, Pouakai Hut, 1250 m; Tararua Range, Dundas Hu; Cobb Vly, Cobb Hut, 914 m; Balloon Hut; Mt Owen, 1520 m; St Arnaud Range, Rainbow Skifield, 1530 m; Paparoa Range, Buckland Peaks, 1100 m; Island Pass, 1490 m; Craigieburn Range, Camp Stm Basin, 1250 m; and Mt Hutt, 1000 m. Locality in doubt: Homer (FD), J.T. Salmon (CMNZ).

Distribution: TK, WN / NN, BR, MB, MC.

Flight period: Nov (20+), Dec (18), Jan (15).

Remarks. *D. oreas* is more variable in wing pattern than *D. fuscus*, and except at Mt Hutt has the antennae pallid. The unique specimen from Mt Hutt is also different in that the antennal pectinations are longer than usual. Adults (usually females) have been observed flying in the daytime, in subalpine red tussock communities at the head of the Cobb River NN, and in alpine short tussock communities at Island Pass MB. At Dundas Hut WN males were first observed flying at dusk, continuing until 2100 h, and females came to light until 2400 h, but no diurnal activity was seen.

Larvae live in a blind silken tube encrusted with plant and soil debris, constructed amongst tussock bases. At Altimarlock MB, in *Poa* tussocks at 1460 m on a steep slope, larval tubes were in the downhill side of the tillers, and browsing damage to the live leaves included cropping almost to the tiller bases.

Although *D. oreas* and *D. fuscus* appear to be widely separated geographically, the 'blank area' (MC–SC–MK) may be no more than a collecting artefact, as may well be the apparent absence of *D. oreas* from the Ruahine Range

RI, Kaweka Range HB, and Tongariro National Park TO. The Mt Hutt MC male is unusual in having *fuscus*-like dark antennae with rather long pectinations, and the forewing basal white streak downcurved rather than straight, but on genitalia is undoubtedly *oreas*.

The specimens from Mt Grey NC mentioned by Dumbleton (1966, p. 955) have not been located. In CMNZ one male, labelled as from 'Homer' and collected by J.T. Salmon, is clearly not *D. fuscus* and may be mislabelled.

Genus *Dumbletonius* Dugdale

Dumbletonius Dugdale, 1986, p. 48 and 1988, p. 57, as new name for *Trioxycanus* Dumbleton (wrongly identified type species). Type species *Dumbletonius sylvicola* Dugdale, 1986, p. 49, as new name for *Porina enysii* in the sense of Meyrick (1890, p. 207) and subsequent authors.

Trioxycanus Dumbleton, 1966, p. 943. Type species *Porina enysii* of authors (not of Butler, 1877, p. 381), by original designation; New Zealand.

Large, sleekly pilose moths 52–90 mm in wingspan. Antennae (Fig. M13–15) short, in male less than 0.3x forewing length and in female very short, less than 0.2x forewing length; flagellomeres shorter than deep, each with vertical and apical setiferous bands, and with sensillae chaeticae along apical band; apical segment ovate. Mandible (Fig. 101) rudimentary; labial palpi 3-segmented. Tarsal claws with an arolium. Wing venation of *Oxycanus* type; vein R_{2+3} stem shorter than free part of R_2 or R_3; discal cell ending slightly before half forewing length; hind wing with veins Sc+R_1 fused apically (Fig. 78). Abdominal segment 1 (Fig. 130) with a posterior, broad, apically truncate lobe on tergal brace.

Male genitalia: sternum 8 posterior margin (Fig. 301, 304) either with paramedian teeth or sinuous and thickened; pseudotegumen with well developed twin processes; dorsal margin in part serrate, expanded; subanal papilla (Fig. 300, 303) hypertrophied, columnar, with a strongly chitinised longitudinal invagination; supraphallic papilla finger-like; claspers lobate.

Female genitalia: tergum 7 (Fig. 153) laterally emarginate, with a prominent spinose process (= seta D_2?) subdorsally; tergum 8 (Fig. 153) ventroapically lobate and dorsally split, the split widest posteriorly; apical scale tuft partially hidden in life by tergum 8 ; sterna 7 and 8 fused; sternite 9 with a triangular median piece and tapering side-pieces fused to form a single sclerite; side-pieces with broad lateral lobes in one species; anogenital field higher than wide; dorsal plates free in dorsal midline, extending ventrally as 2 tapering lobes; antrum / vestibule symmetrical; sinus basally open, or closed for entire length; ductus bursae widening to corpus and about equalling it in length; corpus bursae with an appendix, extending into abdominal segment 5.

Larva (Fig. 185). Head capsule stemmata arranged in 2 displaced arcs; abdominal segments 1 and 2 with an elongate sclerite posterior to L_3 setal pinaculum; pronotum with setae SD_1, SD_2 felted pits fused in one species, separate in the other; paraproct sclerites fused in midline.

Pupa (Fig. 198–201). Headpiece with vertex flat on either side of median furrow; antennal pedicel with a large, appressed, thorn-like process, and gena with a large central mound; abdominal segment 8 with a subventral carina, A7 with a prominent ventral spine crest.

Remarks. *Dumbletonius* is a replacement name proposed by Dugdale (1986, p. 48) for *Trioxycanus*, which Dumbleton based on a misidentified type species (see *D. unimaculatus*, below). Examination of the holotype of *Porina enysii* Butler showed that it is a member of the genus *Aoraia*, and its portrayal in Butler (1877, pl. xlii fig. 7) is fanciful regarding the antennae. The fabricated antennae misled the first reviser (Meyrick 1890) into equating Butler's *enysii* with another, equally large, North Island hepialid. Dumbleton accepted Meyrick's concept, for all his information on Butler's type was at second hand (Dumbleton 1966, p. 979). This situation highlights the dangers of type examination by proxy, and is gone into by Dugdale (1986). *Dumbletonius* was listed as a valid genus by Dugdale (1988, p. 57), erroneously as new.

Dumbletonius is a distinctive genus: large size, unusual colour patterns (extremely complex and ocellate in *D. characterifer*), and, in *D. unimaculatus*, a tendency for males to have bright red or pink hind wings. The presence of an elongate subanal papilla in the male, and the split tergum 8 in the female, are diagnostic. Male antennae also are distinctive, lacking lateral pectinations. Absence of paranal (or subanal) sclerites in the male distinguishes this genus – and other New Zealand genera with *Oxycanus*-type venation and habitus – from *Oxycanus* s.s. and also *Paraoxycanus*, many species of which are superficially indistinguishable from *D. unimaculatus* in wing shape and colour pattern.

Dumbletonius has a northern distribution, with *D. unimaculatus* on islands off the northern and north-eastern coasts and in lowland to upland forest of the North Island. *D. characterifer* is present in cool temperate montane forest of the North Island, descending to lowland warm temperate forest in the Marlborough Sounds and northwestern South Island south to the Buller Valley at Murchison BR. Larvae are associated with forest litter, and can attain 100 mm in length. The adult emergence period is summer to early autumn; males hawk over the forest canopy at dusk with a characteristically swift and swooping flight.

Economic significance. Nil.

Conservation values. *Dumbletonius* is endemic, and is virtually entirely dependent on forest and tall shrubland for survival. At least one species is a major host for the distinctive 'vegetable caterpillar' fungus *Cordyceps robertsii.*

Dumbletonius characterifer (Walker)

Fig. 40, 41, 185, 198, 199, 201, 300–302, 305, 306; Map 18

characterifer Walker, 1865, p. 594 *(Hepialus).* Hudson 1898, p. 133, pl. xiii fig. 11; —1928, p. 362, pl. xli fig. 11, 12 *(Porina).* Philpott 1927b, pp. 39, 40, fig. 18 *(Porina).* Salmon 1958, pp. 18–19 *(Oxycanus).* Dugdale 1988, p. 57 *(Dumbletonius).*

impletus Walker, 1865, p. 598 *(Oxycanus).* Hudson 1898, p. 133; —1928, p. 362 *(Oxycanus;* synonymised with *characterifer).* Dumbleton 1966, p. 947 *(Oxycanus;* as synonym).

Large moths, males 56–70 mm in wingspan with forewing length 24–31 mm, females 72–95 mm and 31–44 mm. Antennae short, about 0.25x forewing length (males) to 0.17x (females). Forewings in both sexes apically acute; scale pattern complexly ocellate, with a sinuous, often broken, dark chocolate longitudinal band basally parallel with dorsum (Fig. 40, 41); scales short, broad, with apices broadly rounded, the paler scales bicoloured (basally pallid, apically brick-red); hind wings dark brown, often ocellately patterned in contrasting fawn towards margin. Abdomen usually (males) or invariably (females) dark brown, with posterior margin of A2–6 sharply margined in buff; female posterior tuft usually buff, sometimes grey-buff or brown-buff but always contrasting with abdominal ground colour (Fig. 40, 41).

Male genitalia (Fig. 300–302) as in Philpott (1927b, fig. 18) and Dumbleton (1966, fig. 57–59); sternum 8 (Fig. 302) posterior margin thickened, strongly sclerotised, weakly undulate; pseudotegumen with twin processes geniculate, narrow towards base; margins irregularly toothed, and with 4 paired, elongate, sometimes bifid processes supporting ventral base of phallus; ventral process short, acute, fused with dorsal margin of trulleum; trulleum concave, heavily sclerotised; phallocrypt with an enlarged, ventrally invaginated subanal papilla, the invagination parallel-sided.

Female genitalia (Fig. 305, 306): dorsal plates broadly opposed in dorsal midline; sternum 9 side-pieces fused with median piece, forming a single sclerite, the median piece triangular, apically truncate, the sidepieces linear, forming a slender arm on either side; vestibule obliquely pleated, more-or-less triangular; sinus seminalis open in proximal two-thirds.

Larva (Fig. 185) as in generic diagnosis. Upper surface of mandibles furrowed/ridged; prothoracic shield with setae SD_1, SD_2 each in a circular, shallow felted (black) pit.

Pupa as in generic diagnosis. Abdominal segment 3 (Fig. 199) with anterior dorsal crest straight.

Type data. *characterifer:* holotype male (wingspan 70 mm; re-pinned JSD, 1980) labelled "*Hepialus characterifer*" (white), "60-73 / Auckland N. Zeal" [Nelson NN, T.R. Oxley] (pale blue disc), "Type" (green-rimmed disc), "Type" (red-rimmed disc), BMNH.

impletus: holotype female (wingspan 80 mm; repinned JSD, 1980) labelled "Type" (green-rimmed disc), "Auckland N. Zeal / 60-73" [Nelson NN, T.R. Oxley] (pale blue disc), "Type" (red-rimmed disc), BMNH.

Material examined. Type specimens, plus 41 non-type examples (23 males, 18 females; NZAC, BMNH, CMNZ, FRNZ) from Auckland Railway Station; Puahoe, Te Awamutu; Matea (wings); Horopito; Pokaka; Mt Ruapehu, Whakapapa Hut; Mt Egmont [Mt Taranaki], Holly Hut; Makairo; Wainuiomata, Moores Vly; Orongorongo Vly, Rimutaka Range, 700 m (larvae); Nelson, Mariri; Pretty Bridge Vly; Gouland Downs; Karamea; Opouri Vly; L. Rotoiti; Murchison (larva); Greymouth (Hudson 1898); Kumara; and Harihari.

Distribution: WO, TO, TK, WA, WN / NN, SD–MB, BR, WD.

Flight period: Nov (8), Dec (13), Jan (1), Apr (1).

Remarks. *D. characterifer* is a striking and distinctive moth. With its complex ocellate pattern, bicoloured scales, and sphingiform appearance it closely resembles *Andeabatis chilensis* (Ureta) (cf. Fig. 40, 41 and Nielsen & Robinson 1983, p. 109, fig. 73, p. 143, fig. 212). The dark hind wings, narrower forewings, and banded abdomen distinguish it from *D. sylvicola.* Males are seen at dusk hawking swiftly over the forest canopy or along forest margins or roadsides. Earlier-instar larvae are encountered in forest leaf litter samples and pit traps, and late-instar larvae are host to the fungus *Cordyceps*.

In the North Island *D. characterifer* has a generally montane forest distribution, and it is present at lower altitudes in the South Island at least to Greymouth (Hudson 1898, p. 133). The NMNZ female from Auckland Railway Station may well have boarded the night train from Wellington at some central North Island station. Around Wellington WN it has been reported from the suburb of Wadestown (Hudson 1898, p. 133) and at Days Bay (Salmon 1958, p. 18). The unicolorous forewings of the Days Bay female made Salmon suspect hybridisation, but the specimen has the sharp forewing apices, patterned hind wings, and bicoloured abdomen characteristic of *D. characterifer*. The golden-brown suffusion noted by Salmon (1958, p. 18) is not uncommon in females; a good example is in CMNZ.

Dumbletonius unimaculatus (Salmon)

Fig. 42–44, 78, 98–101, 115, 123, 130, 136, 142, 146, 153, 172–177, 200, 303, 304, 307, M13–15; Map 19

unimaculata Salmon, 1948, p. 309 *(Porina)*. Dumbleton 1966, pp. 944–946, fig. 48–51 (*Trioxycanus*, as species).

enysii Meyrick, 1890, p. 207, not Butler, 1877 *(Porina)*. Hudson 1898, p. 133, pl. xiii fig. 9, 10 *(Porina)*. Philpott 1927b, p. 39, fig. 19 *(Porina)*. Hudson 1928, pp. 361–362, pl. xli fig. 4–10 *(Porina)*. Dumbleton 1966, pp. 946–497, fig. 52–56 *(Trioxycanus)*.

sylvicola Dugdale, 1986, p. 49 (new name for *Porina enysii* of authors). New synonymy.

Adults large, males 51–67 mm in wingspan with forewing length 23–30 mm, females 74–90 mm and 35–42 mm. Antennae pallid, short, about 0.25–0.27x forewing length in males, 0.19x in females. Forewing scales generally elongate, abruptly truncate or narrowed to a truncate apex; forewing apex broadly rounded, with termen convex, slightly oblique (males), or apex sharp and termen strongly oblique, almost straight; colour pattern complex in male (e.g., Hudson 1928, pl. xli fig. 4–10), usually reduced or obsolete in female. Hind wing unicolorous yellow, orange-yellow, or pink; fringe barred (Fig. 42–44). Abdomen more-or-less concolorous with hind wings. Female apical tuft largely or entirely hidden within cleft tergite 8.

Male genitalia (Fig. 303, 304) more-or-less as in Philpott (1927b, fig. 19) and Dumbleton (1966, fig. 48–55); sternum 8 longer than wide (cf. Dumbleton 1966, p. 946), its posterior margin strongly sclerotised, with a mesal emargination flanked by 'paramedian' short, thorn-like processes (Fig. 304); pseudotegumen with anterodorsal extension on either side roughly triangular to lobate, directed dorsally (often hidden by intersegmental membrane); dorsal margin with 4–10 teeth in mainland and island populations; posterodorsal apices rounded, obscurely truncate, or pointed (all states can be found in specimens from the one locality); ventral processes with apices narrowly separated from dorsal margin of deeply convex, strongly sclerotised and almost inflexible trulleum; claspers variable, more-or-less geniculate; juxta variable, usually wider than high; phallocrypt and anal field with an elongate, tumid, apically bilobed subanal papilla, this ventrally and mesally deeply invaginated into a long, laterally cumuloid pseudoseptate internal structure (Fig. 303), and posterior to its base an elongate, apically narrowed supraphallic papilla; twin processes supporting anal papilla directed obliquely posterad; vinculum base variable.

Female genitalia (Fig. 307): dorsal plates narrowed at dorsal midline; sternum 9 with median piece narrow-triangular, side-pieces as 2 semicircular flaps; vestibule transverse, more-or-less rectangular; sinus seminalis closed along entire length.

Larva (Fig. 172–177) as in generic description. Mandible with part of dorsal surface bearing cobblestone-like sculpturation; pronotal shield with setae SD_1, SD_2 in a common, oval, black felted pit.

Pupa (Fig. 200) as in generic description. Abdominal segment 3 with anterodorsal crest arcuate, curving posteriorly.

Type data. *unimaculatus:* holotype male (60 mm wingspan) labelled "Great Island Three Kings 24.4.46 E.G. Turbott" (white card), "Porina unimaculata Type det. J.T. Salmon" (white card with red disc), "[male] Genitalia removed for mounting LJD 31/7/64" (white card), "Trioxycanus unimaculatus (Salmon) det. L.J. Dumbleton 1964-66" (white card), AMNZ.

sylvicola: holotype male (wingspan 62 mm) labelled "Wellington 25.1.10" (white card), "Holotype Dumbletonius sylvicola Dugdale nom nov pro Aoraia [sic] enysii auct", NZAC. Note: The holotype has forewing markings reminiscent of *enysii* Butler, and the pinkish-brown hind wings described as "diagnostic" by Hudson (1898, p. 133).

Material examined. Type specimens, plus 133 non-type examples (113 males, 20 females; AMNZ, larva NZAC) from North I. localities below 800 m.

Distribution: Three Kings Is / Cuvier I. / ND–WN / —.

Flight period: Nov (1), Dec (1), Jan (36), Feb (59), Mar (40), Apr (3).

Remarks. Meyrick's (1890) concept of *Porina enysii* was based on a misinterpretation of *Porina enysii* Butler. Subsequent authors have perpetuated this misconception. Meyrick's "*enysii*" – subsequently put in *Trioxycanus* by Dumbleton (1966) – was shown to be different from Butler's species, and a new name, *sylvicola*, was proposed by Dugdale (1986, p. 49) and listed (erroneously) as a new name by Dugdale (1988, p. 57). The synonymy with *unimaculatus* – an older available name – is new, and the reasons are detailed below.

The holotype of *unimaculatus* is still the only known adult specimen from the Three Kings Islands. On genitalia it falls well within the range of pseudotegumen shape and spine count and valva, juxta, and vinculum shape found in mainland North Island specimens. The month of capture (April) is also not exceptional. The only larva known agrees with larvae from the Poor Knights Islands and Cuvier Island, and the only difference between these and mainland larvae noted – the degree of ventrolateral strong sclerotisation of the prothoracic shield – is not consistent nor easy to evaluate. The male genitalia of mainland or island populations are extremely variable for pseudotegumen shape (pointed, rounded, or truncate) and spine count, trulleum shape, and armature (some specimens have a small tubercle on the internal face). All the above, and the fact that the forewing pattern of the holotype male is one repeated in many mainland specimens, leads me now to synonymise *unimaculata* of Salmon and *sylvicola*. Salmon's name takes precedence, being the older available epithet.

D. unimaculatus males emerge at dusk, and will hawk over the forest canopy like *D. characterifer*, but more usually (Grehan *et al.* 1983) are encountered within the forest. Unlike *D. characterifer, D. unimaculatus* comes readily to light. The large females with their rather leaf-like pointed wings tightly appressed to the body can be found sheltering in the dead pendant fronds of tree ferns, the colours of which they closely resemble. The species is abundant in warm temperate forests and forest remnants in cities, e.g., greater Auckland, Wellington, Whangarei. Males with deep pink-red hind wings are particularly striking, as are those with the forewing pattern incorporating a longitudinal, cream or yellowish broad stripe from the base to near the termen.

Larvae up to 80 mm long have been found in pit traps, and one presumably fully grown larva dug from its shaft measures 100 mm, with a greatest diameter of 12 mm. Because of the variety of sizes found at any one time in summer in pit traps, the larval lifespan is presumed to be in excess of 2 years. There is no evidence to suggest that the larva subsists on other than fallen leaves on the forest floor.

Heloxycanus new genus

Type species *Heloxycanus patricki* n.sp.; New Zealand.

Etymology: Greek *helos*, a marsh, and *oxycanus*, the name for a similar genus; gender masculine.

Moderate-sized, sleek moths 40–55 mm in wingspan, with strongly pectinate antennae and a simplified, longitudinal wing pattern. Antennae (Fig. M16–18) about 0.4x forewing length, tripectinate, with apical segment slender; lateral rami finger-like, at least 2x longer than flagellomere; ventral ramus erect, about 0.3–0.5x flagellomere length, apically with 1–4 sensillae chaeticae. Compound eyes obscured at mid-height by a long pre-antennal scale tuft. Labial palpi (Fig. 104) reduced, clad in long, hair-like scales, obscurely 1- or 2-segmented; apex darkened, turbinate; vom Rath's organ absent. Mandible rudiment pyriform. Maxillary palpi (Fig. 103) as scaled mounds, with maxillary piece reduced. Protarsus with an arolium. Forewings with *Oxycanus*-type venation; discal cell ending a little beyond half wing length; hind wing with veins Sc and R_1 fused apically (Fig. 79).

Male genitalia (Fig. 137, 308–310): sternum 8 quadrate or trapezoidal, equilateral or wider than long; posterior margin thickened. Pseudotegumen with twin processes erect, supporting anus; each half with vertical dorsal margin flanked by an explanate toothed ledge ending posteroventrally in a sharp, tooth-like ventral apex; no sclerotised bridge between left and right apices; trulleum quadrate; valva lobate; saccus variably U-shaped, rounded V-shaped, or laterally angulate in outline; phallocrypt with both anal and supraphallic papillae reduced, widely separated.

Female genitalia (Fig. 311, 312): tergum 7 with posterior margin unmodified; sterna 7 and 8 separate; sternum 8 sclerotisation weakened mesally, hence appearing to be in two halves; sternum 9 incrassate, with median piece and side-pieces broadly fused; median piece produced to form a broad, truncate or rounded subtriangular margin; side-pieces broadly lobate; intergenital lobes folded one over the other in midline; sinus ending at a bilobed papilla, and genital field higher than wide, with long axes of subanal plates vertical; dorsal plates broadest ventrally from half length, apically not fused in midline, with apices free, directed posteriorly; ductus bursae arising on right side of vestibule, shorter than corpus bursae, sinuous; corpus bursae ovoid, with an appendix.

Larva (Fig. 175–177, 186). Head capsule appearing almost smooth; stemmata arranged in 2 displaced arcs; hypostomal plates broadly fused at midline, the fused zone at least half as long as the hypostoma / epicranium junction; setae SO_3, S_2, S_1 in a straight line. Prothorax alone with a sternal plate, and with setae SD_1, SD_2 in separate felted pits. Abdominal segments 3–6 each with a small sternal plate. Anal shield sclerotisation conspicuously emarginate at apex; paraproct sclerites fused mesally.

Pupa (Fig. 202–204). Vertex produced into 2 divergent cones; frons convex, lacking setae; mandible sheaths basally contiguous, obliquely directed; gena planoconvex; labial plate extending beyond maxillary plate; abdominal spine crests normal, including the pronounced A7 ventral spine crest on a ledge; segments A4–6 with a sublateral short carina anteroventral to spiracle.

Remarks. The monotypic new genus *Heloxycanus* is distinguished from other genera by its tripectinate antenna; reduced, obscurely two-segmented labial palpi hidden beneath long, hair-like head vestiture; explanate, spinose ledge on the pseudotegumen; lobate sternum 9 and widely separated sterna 7 and 8 (with sternum 8 longitudinally divided) in the female; pyriform mandibles; and reduced maxillary piece. The pupa is distinguished by its lack of a thorn on either the scape or pedicel of the antenna, its unmodified gena, and the contiguous bases of the mandibular sheaths. The larva is distinguished most easily by the broad midline fusion of the hypostoma.

Adult colour pattern (Archibald 1984, Patrick 1985, illustrations) also distinguishes *Heloxycanus* from all other New Zealand genera, being essentially longitudinal and lacking any transverse series of ocellate markings, although a partial subterminal series of irregular white semicircles or arcs is present in some specimens.

The single species (as defined on morphological grounds) is distributed in isolated communities through DN, OL, FD, SL, and SI, where it is restricted to sphagnum and other moss bogs from sea level (e.g., Seaward Moss, near Invercargill) to the alpine zone (e.g., Old Man Range, 1525 m). Adult emergence is biennial, with peak emergence in odd-numbered years for all known populations.

Economic significance. The larvae eat sphagnum as well as other mosses (Patrick *et al.* 1987) and, like *Cladoxycanus*, cut the stems, thus fragmenting the stem and potentially reducing the value of sphagnum harvested from sites south of the Waitaki Valley. Since this moth occurs in areas where sphagnum is not legally harvested, its significance is probably negligible.

Conservation values. High, since this is a member of the autumn / winter-emerging wetland biota. It also has a restricted and, in some areas, threatened distribution through bog modification and sphagnum 'harvesting'.

Heloxycanus patricki new species

Fig. 45–48. 79, 102–105, 116, 124, 137, 154, 175–177, 186, 202–204, 308–312, M16–18; Map 20

Wingspan in males 40–45 mm, in females 48–55 mm. Male forewing colour pattern (Fig. 45, 46) a central, elongate, broad, pallid stripe tapering basally and apically, with margins sometimes irregular, bordered costally and dorsally by dark scales; ground colour either yellowish fawn or smoky grey-brown, often infuscate towards termen; scales slender, pointed; hind wings yellowish-fawn, brownish-fawn, or smoky brown, often with slightly darker infuscation basally; antennae pallid to yellow-brown; abdomen concolorous with hind wings. Female (Fig. 47, 48) with forewing scales very slender, pointed, sparse; pattern reduced, often to an oblique basal stripe along vein CuA; abdomen terminal tuft short, not contrastingly coloured.

Genitalia as in generic description (male Fig. 308–310, female Fig. 311, 312).

Larva (Fig. 175–178, 186) and **pupa** (Fig. 202–204) as in generic description.

Type data. Holotype male (wingspan 44 mm) labelled "Dansey Pass 8.4.79 B. Patrick" (white card), "NZAC slide prep. L38" (white card), "Holotype [male] *Heloxycanus patricki* Dugdale" (red card), NZAC. Paratype female: same data as holotype except "NZAC slide prep. L37", NZAC.

Material examined. Type specimens, plus 115 non-type examples (78 males, 37 females; NZAC, BPNZ) from Centre Hill; Rock & Pillar Range; Great Moss Swamp; Lammermoor Range; Lammerlaw Range; South Rough Ridge; Old Man Range, Fraser Basin; Danseys Pass; Swampy Hill; Mt Maungatua; Black Swamp Road; Longwood Range, Bald Hill; Pukerau Bog; Slopedown Range, Mokoreta No. 2; Catlins – Cairn Road, Hokonui Hill Bog, Tussock Creek Mire, Ajax Bog; Seaward Moss; Manapouri, Home Creek Bog; Blue Mtns; and Scolloys Flat. Larvae also from Takahe Vly FD, Table Hill SI; pupa from Mt Luxmore FD.

Distribution: — / OL, CO, DN, SL, FD / SI.

Flight period: Mar (2), Apr (122), May (1), early Jun

(B.H. Patrick, pers. comm.).

Remarks. *H. patricki* is a member of the autumn / winter-emerging assemblage of New Zealand Lepidoptera. Populations are confined to bogs and mires, whether on flat ground (e.g., Great Moss Swamp, Home Creek Bog, Seaward Moss) or blanket bogs on sloping ground (e.g., Bald Hill area on the Longwood Range). It is so far known only from localities south of the Waitaki River (SC–DN), where the landforms are such that many streams and gullies have moss bogs along their courses.

Although the female is large-winged, has a bulky thorax, and appears capable of dispersal flights beyond the 'home' bog or catchment, there is a distinction between northern / western and southern populations. The first are paler-coloured, with rather more pattern submarginally on the male forewing, and the apical segment of the antenna is usually elongate. The second are consistently smoky brown, with the pattern usually reduced to the pallid central stripe, and the apical antennal segment is usually short. Populations with the latter characters are found in Seaward Moss, Home Creek Bog, and Tussock Creek Mire, and on Stewart Island. A large series taken at a light trap on Bald Hill, Longwood Range, included specimens with a largely smoky ground colour on the forewings, and in all populations at least a few males have the apical antennal segment differently shaped from the rest. For both forms, month and year of emergence are the same.

Mr B.H. Patrick has observed female flight activity at Seaward Moss on two occasions, one in the daytime, when the female was fluttering ('taxi-ing') across the moss, almost airborne, the other at night, when females were coming to a light 1 m off the ground.

The male pseudotegumen is variable in the degree of development or angularity of the lateral toothed shelf. No consistent differences were seen between the pale- and dark-coloured populations, nor were the pseudotegumen differences associated with the apical antennal segment state. At present *H. patricki* is regarded as a definable morphological entity, existing as isolated populations or groups of intermittently isolated populations. The north-and-west (pale) and southeastern (dark) groups may be a result of some past event producing an intervening hostile – i.e., bog-less in this instance – tract. On morphological evidence I have no choice but to regard the two as one species. Pheromone studies may well shed light on the status of the two apparently allopatric colour forms.

H. patricki was discovered by Mr B.H. Patrick, and it is a pleasure to name this most elegant species after him. The known distribution and ecology were determined by him (Patrick 1982, 1989; Patrick *et al.* 1984, 1986, 1987, 1992).

Genus *Wiseana* Viette

Wiseana Viette, 1961, pp. 38–39, replacement name for *Philpottia* Viette (preoccupied by *Philpottia* Broun, 1915, Coleoptera).

Philpottia Viette, 1950, pp. 72–73. Type species *Pielus umbraculatus* Guenée, by original designation; New Zealand.

Moderate-sized, sleek-bodied moths, 35–65 mm in wingspan, with forewings often intricately patterned. Antennae (Fig. M19–22, and see Archibald 1984) short, less than 0.33x forewing length, subpectinate; pectinations lateral, broad-based, arising distally on each flagellomere, blade-like, triangular, subtriangular, or rectangular. Compound eyes partly obscured centrally by a pre-antennal scale tuft. Labium with a central apical spike; labial palpi 3-segmented; mandible reduced to a small mound; maxillary galea and palpi thumb-like, apically setose; basal maxillary piece prominent (Fig. 109, 110). Protarsus with an arolium. Forewing venation (Fig. 80) of *Oxycanus* type; discal cell ending beyond half wing length; hind wing with veins Sc and R_1 fused on distal third. Abdominal tergum 1 with posterior lobe on tergal brace broad and apically truncate.

Male genitalia: sternum 8 plane, quadrangular, or trapezoidal, variable in shape and proportion within species and populations. Pseudotegumen with twin processes supporting unmodified anal tube, its halves expanded dorsolaterally at base to form a 'dorsal hood' (Dumbleton 1966, p. 956, fig. 78); pseudotegumen dorsal margin evenly and deeply emarginate, forming a low, strongly sclerotised carina, and with blade-like, posteriorly projecting processes, apically free, overshadowing the apically dentate inner ventral processes, which are bridged by a more-or-less strongly sclerotised bar (sometimes narrowly membranous in midline); trulleum quadrate, more-or-less concave; valvae lobate; vinculum base and saccus proportions variable, but basically U-shaped or broadly V-shaped (Fig. 138); supraphallic 'papilla' represented by an obovate, nude, chitinous plate.

Female genitalia: tergum and sternum 8 with a long, dense tuft of hairlike scales on their posterior third (Fig. 153); tergum 8 ventrolaterally lobate, and spiracle 8 partly enclosed by anterior margin of lobe; sternum 8 narrowly separated from sternum 7; sternum 9 strongly sclerotised, basically an inverted 'T'; side-pieces narrowing laterally, mesally broadly fused with median piece, which is narrowly to broadly triangular or truncate-triangular, often apically shallowly emarginate; anogenital field over twice as high as wide; intergenital lobes fused (sinus seminalis enclosed), with a dorsal papilla in midline covering ovipore; subanal plates with long axes vertical; anus often flanked by setose areas (e.g., Fig. 336); ductus bursae arising dextrally on vestibule, longer or shorter than corpus bursae, which has a short terminal appendix.

Larva (Fig. 178–180, 187). Stemmata arranged in 2 displaced arcs; basistipes 'puncture' obviously closer to basal basistipes seta than to apical seta and greatly offset; hypostomal halves narrowing and fused mesally; oral frame slit always open; pronotum with setae SD_1, SD_2 on separate felted pits; abdominal segments 3–8 without a posterior sclerite at level of seta L_3; this sclerite sometimes present on A1 and A2. Final and penultimate instars with integument darkened dorsally, pallid or cream-white ventrally.

Pupa (Fig. 205–208). Antennal pedicel and scape sheath with an appressed, thorn-like process; gena with a large central mound; vertex raised, conical or thorn-like on either side of midline furrow; abdominal segment 8 with a subventral carina (A7 with a hypertrophied, ventral to sublateral spine crest on a strong ledge).

Remarks. On female sternum 9 shape *Wiseana* is closer to *Dumbletonius* than to *Dioxycanus* / *Heloxycanus*. On male genitalia this genus is distinct from the others, having the pseudotegumen dorsal flange narrow, with bridged (or partially bridged) ventral pseudoteguminal processes, and in the hood-like development of the dorsolateral pseudoteguminal base.

As noted under *Dioxycanus*, few contact zones between that genus and *Wiseana* have been found. Larvae of the two genera can be distinguished primarily on position of the basistipal setal puncture relative to the basal and apical basistipal setae (cf. Fig. 169, 179) and, less readily, by the lack of darkening of the dorsal integument in the last instar of *Dioxycanus*.

Wiseana is represented by seven species, two of which *(cervinata, fuliginea)* are superficially indistinguishable but have genital differences coincident with enzyme electromorph differences (MacArthur 1986; Mr J. Herbert, pers. comm.). The genus is represented by two or more species in all regions from ND to SL and SI. One species is adventive on Chatham Island, and is the only representative of the family collected there. There are no species on the subantarctic islands, and none have been collected as larvae, or as live adults, above 1200 m. *W. mimica* is present at 1100 m on the Lammermoor Range CO and at 1200 m on the Kyeburn (Mt Buster) diggings CO, and a dead specimen was found at 1700 m on Mt Pisa by Mr B. Patrick. With the exception of *W. jocosa*, other species are characteristic of open ground or forest clearings rather than forest. Populations of most species have probably increased following conversion of forested areas to pasture.

As Meyrick (1890, p. 206) noted, for porina generally, "the species are troublesome to distinguish, owing to their great variability of marking and colour." The combination of a lack of clear understanding of what is a type specimen, erroneous locality labels, and lack of means to use tests of specificity other than morphology have over the years haplessly contributed to a confused application of names for *Wiseana* species involved in pasture damage. Archibald (1984) successfully used antennal structure and forewing scale shape to distinguish adults of *W. copularis*, *W. jocosa*, and *W. mimica*. The use of the name 'porina' for 'subterranean grass caterpillar' stems from the fact that most species were included in genus *Porina* by Meyrick (1890). Its brevity and euphony made it instantly popular.

Economic significance. *W. cervinata*, *W. fuliginea*, and *W. mimica* (also possibly *W. copularis*) are of economic importance because the penultimate and final-instar larvae compete with stock for spring pasture growth (Barratt *et al.* 1990). Other species (e.g., *W. signata*) may be present in high numbers in well drained subsites within a site, or in ash, sand, or pumice soils, generally attaining their greatest size during vigorous pasture growth, but spring droughts, affecting pasture growth, can make defoliation apparent. *W. copularis* is present in moister sites and in high-rainfall areas, where again there may be little effect on pasture growth, but its importance may be greater in Central Otago. There are occasions when pasture damage is severe, but pasture management now, aided by use of movable electric fences, is much more flexible than it was 20 years ago. Pasture damage by *Wiseana* larvae at a population density of 30 late-instar larvae per m^2 is estimated to be equivalent to grazing one ewe per ha for 280 days (French 1973).

Conservation values. *Wiseana* is a distinct entity, and is endemic. It must represent a large food reserve for certain bird species. Each species has its own distribution pattern, and again there is a concentration of species in Otago–Southland. These distribution patterns must reflect at least aspects of Quaternary plant community events.

Wiseana cervinata (Walker)

Fig. 49–52, 80, 178–180, 187, 205, 208, 313–315, 332, 335, 336, M24; Map 21

cervinata Walker, 1865, p. 595 *(Wiseana)*. Meyrick 1890, p. 208 *(Porina)*. Hudson 1898, p. 133, pl. xiii fig. 12, 18 *(Porina)*; —1928, p. 362, pl. xliii fig. 5 *(Porina)*.

Viette 1950, p. 73 *(Philpottia)* [Viette 1961, pp. 38–39, as *Wiseana*]. Dumbleton 1966, p. 959 (in part), fig. 110 HT male *(Wiseana)*.

despectus Walker, 1865, p. 594 *(Hepialus)*. Dugdale 1988, p. 58 *(Wiseana*, as synonym of *cervinata)*.

vexata Walker, 1865, pp. 597–598 *(Porina)*. Meyrick 1890, p. 208 *(Porina*, as synonym of *cervinata)*.

variolaris Guenée, 1868, p. 1 *(Pielus)*. Meyrick, 1890, p. 208 *(Porina*, as synonym of *cervinata)*.

Sleek, variably patterned moths (Fig. 49–52), males 34–38 mm in wingspan with forewing length 15–16 mm, females 44–55 mm and 20–25 mm. Male antennae short, 0.30x forewing length; colour variable from pale tan to blackened (but not buff or yellow-buff); major pectinations triangular; apices rounded; anterior (forward-facing) margin straight on basal flagellomeres to weakly concave or slightly emarginate on distal flagellomeres; white forewing scales mostly broad truncate (northern populations) to narrow truncate (MC–DN populations). Female forewing variably patterned, with white scales narrow, blunt, or truncate. Both sexes with hind wings infuscate except in very pallid males.

Male genitalia (Fig. 313–315): pseudotegumen with outer margins bare, more or less parallel (Fig. 313, 315); posterior processes flanking point of exsertion of phallus, apically oblique; ventral processes normally separate; twin processes supporting anus elongate, at least half as long as posterior processes, and sclerotised in a narrow longitudinal strip.

Female genitalia (Fig. 332, 335, 336): anogenital field as in Fig. 336, but conformation of fused subanal plates variable, either furrowed or plane; ductus bursae / vestibule junction skewed dextrally; ductus bursae over 1.5x longer than corpus, stout; corpus bursae ovoid, with a well developed, broad basal appendix (Fig. 335, 336).

Larva (Fig. 178–180, 187). Final and penultimate instars with body often contrastingly coloured dorsally (dark grey) and ventrally (buff or cream); abdominal segments 1 and 2 (rarely 3 and 4) with setal pinacula SD_1, SD_2 broadly fused, but separate on distal segments (Nelson population).

Pupa (Fig. 205, 208). Male antennal sheath not as wide as mandibular sheath; strong, paired carinae in front of genital aperture in both sexes; antennal scape and pedical each with a dorsal process or, rarely, the process not discernible on scape; frons process apex deeply to shallowly emarginate, i.e., appearing bifurcate, rarely evenly truncate; gena centrally bulbous.

Type data. *cervinata:* holotype male (wingspan 40 mm; no antennae, body skeletonised, in vial) labelled "El-hamma cervinata" (printed strip), "New Zealand / 60-73" (pale blue disc), "Type" (green-rimmed disc), "Type" (red-rimmed disc), BMNH.

despectus: holotype female (wingspan 47 mm; no antennae, abdomen skeletonised, in vial) labelled "Hepialus despectus" (printed strip), "New Zealand / 60.73" (pale blue disc), "Type" (green-rimmed disc), "Type" (red-rimmed disc), BMNH.

vexata: holotype male (wingspan 59.5 mm; body skeletonised, frail) labelled "New Zealand / 60.73" (pale blue disc), "Type" (green-rimmed disc), "Type" (red-rimmed disc), BMNH. There is a "Cotype" with the label "New Zealand / 60.73" (pale blue disc).

variolaris: holotype male (wingspan 39 mm; in good condition) labelled "Hepialus (Pielus) variolaris Gn Nouvelle Zélande M Fereday" (white card), red card, MNHN.

Material examined. Type specimens, 3 topotypic males of *variolaris* labelled "Christchurch New Zealand RWF/84" in Meyrick Collection (BMNH), plus 1943 non-type examples (1128 males, 815 females; NZAC).

Distribution: (AK), WO, BP, TK, TO, GB, HB, WI, WN, WA / NN, MB, NC, MC, SC, DN, to 46°S / Chatham I. (adventive).

Flight period: (Aug, 1 reared), Sep (23), Oct (73), Nov (40), Dec (24), Jan (21), Feb (18), Mar (4). (Numbers refer to collectings in that month, not specimens.)

Remarks. *W. cervinata* is the second most widespread species in the genus, its distribution being exceeded only by *W. umbraculata*. So far no reliable morphological characters have been found to distinguish larvae and pupae from those of *W. copularis* (SD_1, SD_2 setal pinacula separate on abdominal segments 5–8 in *W. cervinata*, fused in *W. copularis*), but *W. cervinata* larvae on Chatham Island exhibited the *copularis* character, as did larvae from Ballantrae WN–WA.

The record from Epsom, Auckland, is problematic. No other records of *W. cervinata* are known from north of the Hunua Ranges, and this one may represent an adventive specimen introduced as a larva. Flight periods of 'northern' *cervinata*, i.e., populations north of latitude 40°S, extend from September to March, and while in most areas the bulk of the population may emerge before January, significant flights can occur up to late March. Flight periods of 'southern' *cervinata* occur from September to December, usually with peak flights in October. Two males (Fairlie SC, Christchurch MC) were collected in January.

The distribution of *W. cervinata* in the South Island is northern and eastern (Map 21). In Nelson I have seen no specimens from west of Motueka, and specimens previously regarded as *cervinata* from Central Otago are now included in *fuliginea* (q.v.). The gaps in the mapped distribution in the lower central North Island, and between Blenheim and North Canterbury are 'collecting gaps', and therefore artificial.

Probably the Epsom record, and certainly the Chatham Island records represent adventive populations. None of the early collectors in Auckland (Col. Bolton, A.J. Hipwell, A. Sinclair) and on Chatham Island (Schauinsland, J. Fougère, S. Lindsay) took *W. cervinata*, and none of its tachinid parasites (Diptera) have been collected on Chatham Island, despite repeated searching.

In the male the elongate dorsal processes on the pseudotegumen and the parallel-sided pseudotegumen outer margin, and in the female the combination of a short ductus bursae and large corpus bursae appendix, are diagnostic for *W. cervinata* in relation to *W. fuliginea*. Externally male scale shape (apically blunt) largely distinguishes *W. cervinata* from *W. fuliginea*. MacArthur (1986) indicated that using classification functions derived from multivariate analysis of 11 head, forewing, and hind wing dimensions, reliable separation could be achieved. Both MacArthur (1986) and current work by Mr J. Herbert indicate the genetic distinctiveness of *W. cervinata* vis-à-vis other *Wiseana* species.

Wiseana copularis (Meyrick)

Fig. 53, 54, 106–110, 117, 125, 138, 155, 207, 316, 317, 334, M19–22; Map 22

copularis Meyrick, 1912, p. 123 *(Porina)*. Hudson 1928, p. 363, pl. xlii fig. 8, 9 *(Porina)*. Viette 1950, p. 73 *(Philpottia)*. Dumbleton 1966, p. 961, fig. 84–86 *(Wiseana)*.

despecta of authors (not Walker 1865). Philpott 1927, p. 40, fig. 25 *(Porina)*. Viette 1950, p. 73. Dumbleton 1966, p. 962, fig. 87 *(Wiseana)*. Dugdale 1988, p. 58, (*Wiseana*, as misidentification).

Sleek, variably patterned, sometimes nearly unicolourous moths (Fig. 53, 54), males 34–40 mm in wingspan with forewing length 15–17 mm, females 43–52 mm and 20–24 mm. Male antennae short, 0.30–0.31x forewing length, variably dark to pale brown; major pectinations long, subrectangular, apically rounded to truncate, narrower than flagellomere shaft (Fig. M20); forewing scales narrow, apically pointed or truncate. Female forewings pallid or (especially northern populations) conspicuously infuscate, with costal area contrasting pallid or rust-coloured; forewing scales variable, either long and slender or short, narrowly ovate, apically pointed. Hind wings in both sexes pallid to infuscate.

Male genitalia (Fig. 316, 317): pseudotegumen twin processes variable, either not longer than width of posterior process arm or up to 1.5x longer; inner margin strongly angulate at midlength, often with 1–4 strong teeth; outer margin curved, and anogenital field more-or-less diamond-shaped; posterior processes weakly to strongly emarginate dorsally, apically with a small, sometimes obscure dorsal tooth; ventral process often with additional irregular sclerotisation inner membrane (Fig. 316).

Female genitalia (Fig. 334): ductus bursae slender, angulate at midlength, 2x length of rather pear-shaped corpus bursae; appendix large, rather broad-based on corpus bursae; sternum 9 with anterior apex variable; median piece often with apical portion demarcated by a fold from remainder, which is laterally convex.

Larva as in *W. cervinata*; final instar with a tendency for SD_1, SD_2 pinacula to be fused on all abdominal segments.

Pupa (Fig. 207). Male antennal sheath as wide as mandibular sheath; no strong carinae anterior to genital aperture – at most a low ridge in male and a short, weak carina in female; gena centrally rounded-conical, not bulging; antennal scape usually lacking a process; frons process shallowly bifurcate; dorsal posterior line of 4 spines on abdominal segment 9 small, widely separated.

Type data. Lectotype male (selected by W.H.T. Tams; wingspan 34 mm; in good condition but antennae fungus-coated) labelled "Meyrick Collection accession 1938-290" (white card), "Invercargill New Zealand AP.10) (white rectangle), "copularis Meyr" (white strip), "Lectotype" (red-rimmed disc), BMNH.

Also 4 "Cotypes" (paralectotypes), 2 males, 2 females, same data, BMNH.

Material examined. Type specimens, plus 1817 non-type examples (1032 males, 785 females; NZAC).

Distribution: WN, WA / SD, NN, MB, BR, KA, WD, NC, MC, DN, CO, OL, FD (northern), SL. Larvae from NN, pupae from NN, MC.

Flight period: Oct (4), Nov (35), Dec (36), Jan (43), Feb (33), Mar (5), Apr (1).

Remarks. *W. copularis* males are readily distinguishable from other *Wiseana* species by the characteristic long, rectangular antennal pectinations (Archibald 1984). Females, while often characteristically with a pallid-scaled forewing costal cell, are best distinguished by the long, slender ductus bursae. *W. umbraculata* females also have this character, but have a slender, tapering sternum 9 median piece, no obvious appendix on the corpus bursae, and the long, straight, white forewing discal streak characteristic of *umbraculata*.

W. copularis – as *W. despecta* of authors – has been implicated in pasture damage (Helson 1967), but as the larvae reach maturity during ample pasture growth, i.e., later than most *W. cervinata*, their effect on pasture production may not be significant, except in Central Otago.

The species is widespread in the South Island (Map 22), but has not yet been reported from most of Fiordland. In the North Island its northern limit needs checking both along the Wellington coast (Feilding) and in the Wairarapa (Masterton). The colour pattern is variable, southern populations having predominantly fawn males and fawn-grey females. Northern and eastern populations tend to have dark, infuscate females and brownish males. Populations in forested or high-rainfall areas tend to have richly coloured males and often very infuscate, sometimes black-grey females.

Wiseana fuliginea (Butler)

Fig. 55–58, 318–320, 337, 338; Map 23

fuliginea Butler, 1879, p. 488 *(Porina)*. Meyrick 1890, p. 208 *(Porina*, as synonym of *cervinata)*. Hudson 1898, p. 133, *(Porina*, as synonym of *cervinata)*;—1928, p. 362 *(Porina*, as synonym of *cervinata)*. Dumbleton 1966, p. 959 *(Wiseana*, as synonym of *cervinata)*. Dugdale 1988, p. 58 (*Wiseana*, as species).

Sleek, variably patterned moths (Fig. 55–58), males 27–38 mm in wingspan with forewing length 14–16 mm, females 33–47 mm and 14–21 mm. Male antennae short, approx. 0.33x forewing length, variably pale to dark brown; pectinations subtriangular (dorsal margins not emarginate), wider than flagellomere shaft; forewing scales pointed (cf. *cervinata*). Female externally not distinguishable from locally sympatric *cervinata*.

Male genitalia (Fig. 318–320): pseudotegumen twin processes short; vinculum arms basally with a strong lateral apophysis; saccus margin laterally angulate (cf. *cervinata*).

Female genitalia (Fig. 337, 338): sternum 9 median piece strap-like, with margins subparallel; ductus bursae gradually widening to elongate corpus bursae; appendix of corpus reduced.

Larva. No authenticated material.

Pupa. Abdominal segment 9 without transverse carinae ventrally (1 specimen, Conroys Gully CO).

Type data. Holotype male (wingspan 33 mm; in good condition) labelled "Porina fuliginea Butler, Type / Otago 79.19" (white rectangle), "79" (white rectangle), "Type" (red-rimmed disc), BMNH.

Material examined. Holotype, plus 227 non-type examples (136 males, 91 females, NZAC) from Banks Peninsula; Lincoln; Earnscleugh; Lauder; Roxburgh; Weston; Dunedin; Mosgiel, Invermay (16 males, 12 females from G. MacArthur thesis study); and Hindon.

Distribution: — / MC, CO, DN.

Flight period: Oct (8), Nov (14), Dec (6). (Figures refer to collectings, not specimens.)

Remarks. *W. fuliginea* in this concept largely follows that of MacArthur (1986), who first defined the entity on possession of a specific complement of enzyme loci. He also discerned male genital characters, and provided a set of 'morphological' measurement sites, calibration of which, when treated by discriminant function analysis, distinguish male *fuliginea* from the superficially indistinguishable and locally sympatric *cervinata*. It is possible, however, to use scale shape to distinguish males (truncate in *cervinata*, pointed in *fuliginea*), the size of the twin processes (long and arcuate in *cervinata*, short and stout in *fuliginea*), the presence of a strong lateral apophysis on the vinculum base in *fuliginea* (weak in *cervinata*), and the shape of the outer margin of the pseudotegumen (parallel in *cervinata*, bowed in *fuliginea*). MacArthur's character – an angulate saccus margin – is also largely consistent in distinguishing *fuliginea* (present) from *cervinata* (weak or absent).

Females of the two species can be satisfactorily distinguished only by the size of the corpus bursa appendix: small or pimple-like in *fuliginea*, large and thumb-like in *cervinata*. So far, *W. fuliginea* is recognised from localities in CO and DN (north of the Clutha) and from MC (Banks Peninsula, Lincoln). With the exception of that from Invermay (Mosgiel DN), which was first distinguished electrophoretically (MacArthur 1986), all populations have been distinguished morphologically.

Wiseana jocosa (Meyrick)

Fig. 59–63, 321–323, 339–343, M23; Map 24

jocosa Meyrick 1912, p. 124 *(Porina)*. Hudson 1928, p. 363, pl. xlii fig. 1, 2 *(Porina)*. Philpott 1927b, p. 39, fig. 20 *(Porina)*. Viette 1950, p. 72 *(Philpottia)*. Dumbleton 1966, p. 960, fig. 115 (*Wiseana*, as synonym of *cervinata*). Dugdale 1988, p. 58 (*Wiseana*, as species).

Sleek, usually intricately patterned moths (Fig. 59–63); wingspan and size range as for *W. cervinata*, but females usually robust, with thorax exceeding 6 mm in width and forewing length 24–27 mm. Male antennae approx. 0.34x forewing length, variable in colour, usually dark brown; pectinations triangular, basally wider than flagellomere shaft, with dorsal margin emarginate. Male and female forewing scales short, usually broad and truncate in male (Fig. M23), narrower and subacute in female; males from western and northern localities with most forewing scales subacute, few truncate. Males (and some females) richly patterned in orange-brown or yellow-brown and darker brown, with white areas reduced; females with forewing costal margin sometimes contrastingly coloured, and anal tuft pallid, contrasting with infuscate abdomen.

Male genitalia (Fig. 321–323): pseudotegumen with dorsal twin processes short to very short, i.e., not longer than width of a posterior process in lateral view); ventral processes broadly fused mesally; vinculum bases with a more or less pronounced lateral apophysis; saccus margin lacking an angular lateral expansion (cf. *fuliginea*).

Female genitalia (Fig. 339–343): sternum 9 median piece usually ovate, i.e., sides convex, and apical portion demarcated (southern populations) or truncate, with sloping sides, but apical portion differentially setose (northern populations); ductus bursae broad, shorter than corpus bursae; appendix variable – pedicellate, thumb-like, or reduced.

Larva, pupa. No authenticated material.

Type data. Lectotype male (selected by L. J. Dumbleton; wingspan 36.5 mm; genitalia mounted on celluloid strip) labelled "Invercargill New Zealand AP .. 10" (white rectangle), "Lectotype LJD 12 April 1965" (white rectangle), "Oxycanus jocosa Meyr. det P.E.S. Whalley 1965, SYNTYPE" (white rectangle), "Lectotype" (red-rimmed disc), BMNH (Meyrick Collection accession label).

Material examined. Lectotype, 3 paralectotypes (1 male, 2 females, same locality and collector as HT), and 523 non-type examples (226 males, 297 females; NZAC, BPNZ) from Flora R.; Cobb Vly; Capleston; Tauhai; Franz Josef; Weston; Hindon; Clutha Vly, E side, lower gorge; Roxburgh; Kawarau Gorge, Roaring Meg; Arrowtown; Lauder; Waikaia Vly; Piano Flat; Queenstown; L. Howden; Doubtful Sound, Deep Cove; Tisbury, West Plains (6 Philpott specimens, NZAC); Invercargill; Otatara; Beaumont Forest; Black Gulley; Tapanui; Owaka; Gore; and Oban, Horseshoe Bay.

Distribution: — / NN, BR, WD, OL, CO, DN, SL, FD / SI.

Flight period: Oct (3), Nov (28), Dec (9), Jan (2). (Numbers refer to collectings, not specimens.)

Remarks. *W. jocosa* males are possibly the most easily distinguishable after *W. copularis*. The usually dark, short pectinate antennae (and dorsally somewhat emarginate pectinations), the short, densely arranged, broad, usually truncate scales (Archibald 1984), and the rather richly patterned forewings are characteristic. Females tend to be very robust, with a wide thorax, forewings either fawn-brown or orange-brown dappled or infuscate, and anal tuft contrastingly pallid.

From *W. copularis* (with which it is partly sympatric) *W. jocosa* is distinguished by antennal pectination shape and scale shape in the male and by its very short, broad ductus bursae in the female.

MacArthur (1986) noted that "electrophoretically, this species is quite distinct", and is characterised by two fixed unique electromorphs.

W. jocosa is restricted to the South Island and Stewart Island, with a southern and western distribution. The population at Weston, south of Oamaru DN, is at present assigned to *jocosa* on some genital characters and scale shape. While the association with forested areas has been noted (Hudson 1928, p. 363), and many localities indicated on Map 24 are in areas of forest or shrubland, others are not (e.g., Hindon and Weston DN, Earnscleugh CO).

There is a tendency for western populations to have males with pointed (but still short) forewing scales, as opposed to the typical truncate scales of eastern populations.

Wiseana mimica (Philpott)

Fig. 64, 65, 324–329, 344–346, M25; Map 25

mimica Philpott, 1923, p. 153 *(Porina)*. Philpott 1927b, p. 39, fig. 21 *(Porina)*. Hudson 1928, p. 362, pl. xliv fig. 15 *(Porina)*. Viette 1950, p. 73 *(Philpottia)*. Dumbleton 1966, pp. 960–961, fig. 109 (*Wiseana*, as synonym of *cervinata*). Dugdale 1988, p. 58 (*Wiseana*, as species).

Sleek, intricately patterned moths (Fig. 64, 65), males 29–40 mm in wingspan with forewing length 13–18 mm, females 41–48 mm and 19–22 mm. Antennae approx. 0.35x forewing length, variable, usually darkest brown in higher-altitude populations; pectinations rounded triangular, longer than deep, basally a little deeper than flagellomere shaft. Male forewing scales narrow ovate, acuminate (Fig. M25); female forewing scales the same, often widely spaced (especially in higher-altitude populations) and tending to be arranged divergently. Lowland populations sparsely, and upland populations preponderantly with patches of ash-grey maculation, and females fawn-grey to dark infuscate grey; upland populations often strikingly maculated in ash and dark grey in both sexes.

Male genitalia (Fig. 324–329): sternite 8 posterior margin weakly to moderately emarginate or inrolled mesally, in some northern populations appearing obscurely bidentate (Fig. 326), and with sclerotised lateral portions of posterior margin strongly oblique; pseudotegumen dorsal twin processes stubby, lobate (cf. *cervinata*), with sclerotisation irregular; anogenital area and phallocrypt variable from broader than long to longer than broad; vinculum arm base rarely with a strong apophysis except in southern populations (cf. *fuliginea*, some *jocosa*); saccus lateral margin not angulate (cf. *fuliginea*).

Female genitalia (Fig. 344–346): sternum 9 median piece strap-like, apically truncate or rounded truncate, with lateral margins subparallel to oblique; ductus bursae subequal in length to corpus bursae, and half its diameter; corpus ovoid, with a thumb-like appendix.

Larva. No authenticated material.

Pupa. Abdominal segment 9 with a pair of transverse ventral carinae; mandibular sheaths rounded-conical (4 specimens, Mt Kyeburn / Mt Buster Diggings CO).

Type data. Holotype male (wingspan 34 mm) labelled "Porina mimica Philp. Holotype male" (white rectangle), "West Plains" (white rectangle), "Holotype male Porina mimica Philpott" (red rectangle), NZAC.

Material examined. Holotype, 1 male paratype ("Tisbury 28 October 1914", "Porina mimica Philp. Paratype", NZAC), and 406 non-type examples (210 males, 96 females; NZAC, NMNZ, BPNZ) from Speargrass Creek, 1095 m; Arthurs Pass, 760 m; L. Grassmere, Cass, 610 m; Craigieburn Forest Park, 600 m, 880 m, 900 m; Mt Cook, Hermitage, 820 m; Tara Hills SW of Omarama, 490 m; L. Wanaka; Queenstown, Ben Lomond; Moke Lake; Five Rivers; Rock and Pillar Range, 1200 m, 1250 m; Great Moss Swamp [lake], 1000 m; Mt Kyeburn / Mt Buster 'diggings', 1200 m; Lammermoor Range, 1080 m, 1100 m; Conroys Gully, 300 m; Roxburgh; Lauder; Mt Teviot, 300 m; Nevis Vly, 800 m; Roaring Meg, powerhouse; Earnscleugh; Pisa Range, 1700 m; Invermay, Mosgiel; West Plains; Otatara; Gore; and Tapanui, Black Gully.

Distribution: — / BR, NC, MC, MK, OL, CO, DN, SL.

Flight period: Sep (3), Oct (23), Nov (21), Dec (5), Jan (1), Feb (1). (Numbers refer to collectings, not specimens. Note that at higher altitudes emergence is more likely to start in late November or early December.)

Remarks. *W. mimica* is characteristic of open country east of Fiordland and the Southern Alps. It has not (yet) been recognised in lowland Nelson or Marlborough, nor on the Canterbury Plains (Map 25). In any one locality it is the first *Wiseana* species to appear as adults. There are at present no authenticated larval specimens, and hence there is no clear idea of what soil moisture regimes the larvae tolerate or seek at lower altitudes. Higher-altitude populations appear to be associated with moss / sedge bogs – e.g., the Mt Kyeburn / Mt Buster Diggings. Such populations are sympatric with *Dioxycanus fuscus* (B.H. Patrick, pers. comm.).

W. mimica males are variable in colour pattern, and lowland populations (below 800 m) resemble *W. fuliginea* – sympatric in CO and DN – and *W. cervinata* in colour pattern, but generally have patches of ash-white scales. The narrowly ovate, apically sharp-pointed, divergently arranged forewing scales are characteristic, as are the long triangular antennal pectinations (pectination length greater than vertical width: Archibald 1984).

The stubby twin processes of the pseudotegumen also distinguish *W. mimica* from *W. cervinata*. Females are difficult to distinguish, but generally the bursa copulatrix (corpus + ductus bursae) length is less than 1.5x the height of the external genital region (over 1.5x in *W. fuliginea*), and the forewing scales are as in the male.

Higher-altitude populations (over 800 m) tend to have both sexes with dark grey or blackish ground colour, relieved by rather striking ash-white maculation (cf. *Aoraia senex*).

Southern populations differ from western and northern populations in the degree of development to the apophysis on the vinculum arm base (Fig. 00). This is variable for Invercargill populations, being either well developed or weak, and is quite strong in specimens from Conroys Gully CO. Material from Craigieburn showed little or no apophysis development.

Wiseana signata (Walker)

Fig. 66–69, 147, 330, 347, 348; Map 26

signata Walker, 1856, p. 1563 *(Elhamma)*. Meyrick 1890, p. 210 *(Porina)*. Hudson 1898, p. 134, pl. xiii fig. 15, pl. iii fig. 6, larva *(Porina)*. Philpott 1927b, p. 40, fig. 26 *(Porina)*. Hudson 1928, pp. 363–364, pl. xliii fig. 2–4 *(Porina)*. Viette 1950, p. 73 *(Philpottia)*. Gaskin 1964, pp. 397–403 *(Wiseana)*. Dumbleton 1966, p. 963, fig. 88–90, 113 *(Wiseana)*.

novaezealandiae Walker, 1856, p. 1573 *(Porina)*. Meyrick 1890, p. 210 (*Porina*, as synonym of *signata*).

Very sleek, robust moths with rather sharp-pointed forewings, males 44–64 mm in wingspan with forewing length 19–29 mm, females 58–75 mm and 26–34 mm. Antennae yellow-fawn; head with frontal scales directed to midline, i.e., frontal tuft with a perpendicular 'furrow' mesally. Forewing white scales mostly truncate; hind wing yellow-fawn or pinkish fawn, with a narrow, distinct dark marginal line. Male colour pattern (Fig. 66–69) more strongly evident and distinct than in female, which also is usually paler. Forewing white discal stripe usually broken into 2 or 3 widely separated bits (e.g., Gaskin 1964, p. 401, fig. 6–10), rarely complete; forewing and hind wings ventrally lacking discrete infuscate zones (cf. North I. *W. umbraculata*).

Male genitalia (Fig. 330): pseudotegumen dorsal twin processes either undeveloped or very small (cf. *W. umbraculata*); posterior processes variably clavate, rectangular truncate, or subacute; trulleum deeply concave, sometimes globose in lateral view (cf. *W. umbraculata*).

Female genitalia (Fig. 347, 348): tergum 8 with 2 cuticular processes ('setae' D_1, D_2); sternum 9 median piece twice as broad as high, with a truncate, sinuous dorsal margin and an internal, strongly sclerotised transverse portion basally, obstructing entrance to copulatory pore; ductus bursae more or less straight, stout, subequal to corpus bursae in length; corpus elongate ovoid, its appendix pedicellate, about 0.3x corpus length.

Pupa. No authenticated material available.

Larva. Abdominal segments 1 and 2 with SD_1, SD_2 setal pinacula narrowly fused, or SD_2 pinaculum excavate; mesal paraproct seta and anal proleg base mesal seta equally far apart; final-instar larva approx. 60–65 mm long; integument dorsally darkened, ventrally pallid.

Type data. *signata:* lectotype male (selector unknown; wingspan 49 mm) labelled "Elhamma signata" (printed strip), "Elhamma signata" (white rectangle), "54.4 / New Zeal" (blue disc), "Type" (green-rimmed disc), "Type" (red-rimmed disc), BMNH.

novaezealandiae: lectotype male (selector unknown; wingspan 46.5 mm) labelled "Porina novae zealandiae" (printed strip), "45.61 / New Zealand" (white disc), "Type" (green-rimmed disc), BMNH.

Material examined. Lectotypes, 2 male paralectotype *signata* from Auckland ("54.4") and Hawkes Bay ("53.19"), 3 male paralectotype *novaezealandiae*, 1 from Auckland ("45.61"), 1 from Wellington ("44.63") and 1 from (?)Wellington ("44.3"), plus 197 non-type examples (186 males, 11 females; NZAC, NMNZ, CMNZ).

Distribution: ND, AK, WO, BP, GB, TK, TO, HB, WI, WA, WN / SD, NN, MB, KA, BR (to Claverly Stm, Westport).

Flight period: Oct (12), Nov (6), Dec (17), Jan (19), Feb (23), Mar (9), Apr (1), May (1). (Figures refer to collectings, not specimens.)

Remarks. *W. signata* is variable in size, but even small individuals have a robust thorax. Generally this is the species with the largest adults encountered. It is characteristic of coastal (sandy) soils, ash, pumice, and other freely draining soils. Like *W. umbraculata*, males can be distinguished from the *cervinata* group by the pale antennae. From *W. umbraculata*, with which it can share a common colour pattern, it is distinguished by its mesally directed frontal scales and the truncate white forewing scales, particularly on the discal stripe. On male genitalia it is distinguished from *W. umbraculata* by the reduced (sometimes undeveloped) pseudotegumen twin processes; females can be distinguished by the stout ductus bursae and the appendix on the corpus bursae. In the North Island, north of WI–HB, *W. signata* can be distinguished from *W. umbraculata* by its lack of a rectangular infuscation ventrally on the forewings and hind wings. Final-instar larvae are usually larger (up to 65 mm) than coincident *W. cervinata* larvae. Although darkened dorsally, *W. signata* larvae lack the olive-grey 'oily' look of *W. umbraculata*.

W. signata is northern in distribution (Map 26), not recorded south of Clarence Bridge KA (42°12'S) and Denniston NN (41°45'S). Males are wide-ranging: specimens have been collected at light on the summits of the Pouakai Range TK and on the Red Hills MB. Females are rarely encountered at light, and my observations agree with those of Gaskin (1964, p. 397), who also noted (p. 407) that *W. signata* flies later at night than do other *Wiseana* species, and possibly under different weather conditions.

Grehan (1983b) provides notes on larval biology, including evidence of feeding on 'tubers' of *Muehlenbeckia* in sand.

Wiseana umbraculata (Guenée)

Fig. 70–72, 206, 331, 333, 349; Map 27

umbraculatus Guenée, 1868, p. 1 *(Pielus)*. Meyrick 1890, p. 209 *(Porina)*. Hudson 1898, p. 134, pl. xiii fig. 14. Philpott 1927b, p. 39, fig. 24 *(Porina)*. Hudson 1928, p. 363, pl. xli fig. 1–3 *(Porina)*. Viette 1950, p. 73 (*Philpottia* type species). Gaskin 1964, pp. 396–408 *(Wiseana)*. Dumbleton 1966, p. 964, fig. 91–93, 114 *(Wiseana)*.

Sleek, robust moths, males 38–50 mm in wingspan with forewing length 16–23 mm, females 49–66 mm and 22–29 mm. Antennae yellow-fawn, pallid. Head with frontal tuft scales largely directed forwards. Forewings in male with white scales tapering to a pointed or rounded apex; forewing with a white discal streak, usually unbroken, rarely broken (Gaskin 1964, fig. 1–5), shaded below with a dark strip; ground colour variable, usually fawn, pinkish fawn, or infuscate, uniform in low-rainfall localities, patterned in high-rainfall (forest) localities (Fig. 70, 71); females usually uniform or obscurely patterned (Fig. 72). Hind wings pinkish-fawn to yellow-fawn; margin with an obscure to discrete darkened line. Both forewings and hind wings either uniform in colour ventrally (South Island and Stewart Island localities) or with a more-or-less strongly developed rectangular infuscate patch (North Island localities, e.g., Fig. 72), most obvious north of WI–HB.

Male genitalia (Fig. 331): pseudotegumen dorsal twin processes hood-like, broadly sclerotised; posterior processes apically more or less upcurved; trulleum moderately concave.

Female genitalia (Fig. 333, 349): tergite 8 with 3 'cuticular processes' (D_1, D_2, SD_1) laterally; sternum 9 with median piece bluntly triangular, higher than wide; ductus bursae slender, about 2x length of corpus; corpus bursae lacking an appendix.

Larva. Final-instar integument dorsally darkened, usually appearing olive-grey and somewhat oily; mesal (inner) paraproct setae further apart than posterior setae on anal proleg base; abdominal segments 2–8 with seta SD_1,SD_2 pinacula narrowly fused. Larva up to 65 mm in length, living in bogs, swamps, and marshy paddocks.

Pupa. No authenticated male pupae; female abdominal segment 9 as in *W. copularis*; head piece as in Fig. 207 (Wainakarua DN).

Type data. Lectotype male (selected by L.J. Dumbleton : 1966, p. 964) labelled "Hepialus (Pielus) umbraculatus Gn, Nouvelle Zélande M. Fereday" (white card), "Lectotype" (red card), MNHN. Colour slide of lectotype seen, identity not in doubt.

Material examined. Lectotype (as photograph), 2 paralectotypes (1 male, 1 female: "syntypes", Dumbleton 1966, p. 965), same data as lectotype, MNHN, plus 194 non-type examples (160 males, 34 females; NZAC).

Distribution: AK, WO, BP, TO, TK, HB, WI, WN / SD, NN, KA, BR, NC, MC, SC, WD, MK, OL, CO, DN, SL, FD / SI. Absence from RI and MB reflects lack of collecting, but ND needs checking.

Flight period: Sep (1), Oct (14), Nov (33), Dec (31), Jan (11), Feb (6), Mar (1), Apr (1).

Remarks. *W. umbraculata* is the most widely distributed species (AK–SI, including Codfish Island) in the genus, and generally the forewing pattern is diagnostic. In the North Island (Gaskin 1964) the typical complete discal streak can be broken, as in *W. signata*, making quick identification difficult. (Both species have pallid antennae.) In such instances the surest external diagnostic features are: (a) shape of white scales (pointed in *umbraculata*, blunt or truncate in *signata*); (b) frons scaling directed largely anteriorly, or weakly towards midline *(umbraculata)*, or strongly towards midline *(signata)*; (c) in the North Island, forewings and hind wings underneath with a weak to strong apical infuscate area *(umbraculata)*, or unicolorous *(signata)*.

Genital characteristics of *umbraculata* include the presence of large dorsal twin processes on the pseudotegumen (absent or reduced in *signata*), the elongate, tapering sternum 9 median piece (rectangular and wider than long in *signata*), and the slender, elongate ductus bursae and non-appendiculate bursa (ductus bursae stout, and corpus bursae with an appendix in *signata*).

W. umbraculata is variable in colour pattern in most localities, often varying from basically fawn or "nut brown" (Gaskin 1964) to infuscate. Guenée (1868) and Gaskin (1964) noted variation, and Dumbleton (1966, p. 965) raised the possibility of the presence of definable subspecies within the current concept of *umbraculata*. The extensive material in NZAC shows that North Island specimens, particularly those from high-rainfall areas, e.g., WO, are richly and darkly patterned, often approaching *W. signata* in pattern depth and intricacy, and having the apical costal quarter of the forewing and hind wing underneath conspicuously infuscate. This character is not uniformly present; it is lacking in some coastal sites in BP and WN. The colour pattern differences are not associated consistently with genital variation.

W. umbraculata larvae are characteristic of moist to swampy sites. In rush communities the larval shaft and runway is usually beside the outer tillers, occasionally in the centre of the rush clump, and can be up to 1 cm in diameter. Other shafts have been found in *Carex secta* 'heads' 0.5 m above standing water. Because of the rather extended flight period and low numbers relative to, e.g., *W. cervinata*, *W. umbraculata* is not regarded as an economically significant species, but in conservation terms it is one which has survived exploitation of wetlands.

Species *incertae sedis*

Porina mairi Buller, 1873, pp. 279–280, and lithograph illustration.

The one specimen was found in "the summer of 1867" by Sir W.L. Buller, on a wooded summit in the Ruahine Range RI. The specimen is not in the Natural History Museum (BMNH, London). Meads (1990, pp. 52, 53) notes that Hudson's statement that the specimen was lost at sea with the wreck of the barque 'Assaye' is wrong. The 'Assaye' was wrecked on its return voyage from England, and Meads concludes that the specimen was landed in England.

The principal feature that precludes association of the illustration given by Buller with, e.g., *Dumbletonius characterifer* is the wingspan, given by Buller as "5 in, 11 lines" or about 150 mm. Meads (1990) has suggested that hepialid larvae found at sites on the summit ridge of the Rimutaka Range may be of *P. mairi*, but all extant specimens are clearly either *D. characterifer* or *Aoraia enysii*.

Meads (1990, p. 53) gives an excellent reproduction of Buller's plate, which should aid recognition when someone rediscovers this enigmatic behemoth.

REFERENCES

Aitkenhead, P.; Baker, C.R.B. 1964: The larvae of British Hepialidae. *Entomologist 97:* 25–38.

Archibald, R.D. 1984: Some Eugregarinida (Apicomplex) from New Zealand Melolonthinae (Scarabaeidae: Coleoptera) and Hepialidae (Lepidoptera). Unpubl. PhD thesis, University of Otago, Dunedin. 206 pp.

Barratt, B.I.P.; van Toor, R.F.; Ferguson, C.M.; Stewart, K.M. 1990: Grass grub and porina in Otago and Southland. A guide to management and control. MAF Technology, Invermay / N.Z. Tablet, Dunedin. 104 pp.

Best, E. 1912: Maori Forest Lore: Being some account of native forest lore and woodcraft, as also of many myths, rites, customs, and superstitions, connected with the flora and fauna of the Tuhoe or Ure-wera District, part II. *Transactions and proceedings of the N.Z. Institute 41:* 231–285.

Birket-Smith, S.J.R. 1974: Morphology of the male genitalia of Lepidoptera, II. Monotrysia, Zeugloptera, and discussion. *Entomologica Scandinavica 5:* 161–183.

Boudinot, J. 1991: Biologie d'*Aenetus cohici* Viette (Lepidoptera Hepialidae). Pp. 167–175 *in* J. Chazeau & S. Tillier *eds*, 'Zoologia Neocaledonica 2'. *Memoires du Museum Nationale d'Histoire Naturelle (A) 149.*

Bourgogne, J. 1949: Un Type nouveau d'appareil génital femelle chez les Lépidoptères. *Annales de la Société Entomologique de France 115:* 69–80.

Broun, T. 1915: Descriptions of new genera and species of Coleoptera. *Bulletin of the N.Z. Institute 1(4):* 267–346.

Buller, W.L. 1873: Notice of a new species of moth from New Zealand. *Transactions and proceedings of the N.Z. Institute 5:* 279–280, colour plate.

Butler, A.G. 1877: On two collections of heterocerous Lepidoptera from New Zealand with descriptions of new genera and species. *Proceedings of the Zoological Society of London, 1877:* 379–407.

——— 1879: On a small collection of heterocerous Lepidoptera from New Zealand. *Cistula entomologica 2:* 487–511.

Carpenter, A. 1978: A review of the biology and control of porina (*Wiseana* spp.) with particular reference to the southern North Island. Internal report, Ministry of Agriculture and Fisheries Research Division, Palmerston North. 18 pp. + unnumbered bibliography.

Common, I.F.B. 1969: A winglocking or stridulatory device in Lepidoptera. *Journal of the Australian Entomological Society 8:* 121–125.

——— 1990: Hepialoidea. Pp. 140–150 *in:* 'Moths of Australia'. Melbourne University Press. 533 pp.

Crosby, T.K.; Dugdale, J.S.; Watt, J.C. 1976: Recording specimen localities in New Zealand: an arbitrary system of areas and codes defined. *N.Z. journal of zoology 3:* 69 + map.

Davis, D.R. 1975: A review of the West Indian moths of the family Psychidae with descriptions of new taxa and immature stages. *Smithsonian contributions to zoology 188.* 66 pp.

Dick, R.D. 1945: Ecological observations on *Oxycanus cervinata*. *N.Z. journal of science and technology A 27(1):* 32–38.

Doubleday, E. 1843: Lepidoptera. Pp. 283–289 *in* Dieffenbach, E. *ed.*, 'Travels in New Zealand, with contributions to the geography, geology, botany and natural history of the country', vol. 2. London, John Murray.

Dugdale, J.S. 1961: Larval characters of taxonomic significance of New Zealand Ennomines (Lepidoptera: Geometridae). *Transactions of the Royal Society of N.Z., zoology 1:* 215–233.

——— 1974: Female genital configuration in the classification of Lepidoptera. *N.Z. journal of zoology 1:* 127–146.

——— 1986: *Trioxycanus* Dumbleton, 1966 (Lepidoptera), a genus based on a misidentified type species, with proposal of new names for the taxonomic genus and species involved. Z.N.(S.) 2462. *Bulletin of zoological nomenclature 43:*46–49.

——— 1988: Lepidoptera – annotated catalogue, and keys to family-group taxa. *Fauna of N.Z. 14.* 262 pp.

Dumbleton, L.J. 1945: Contribution to the ecology of *Oxycanus cervinata* Walk. *N.Z. journal of science and technology a 27(2):* 114–128.

——— 1966: Genitalia, classification, and zoogeography of the New Zealand Hepialidae (Lepidoptera). *N.Z. journal of science 9(4):* 920-981.

Elder, R.J. 1970: Larval taxonomy of *Oncopera brachyphylla* Turner and its distinction from *Oncopera mitocera* (Turner). *Queensland journal of agricultural and animal sciences 27:* 123–128. (Also published as *Queensland Department of Primary Industries, Division of Plant Industry bulletin no. 533.)*

——— 1978: Notes on the biology and descriptions of the life stages of *Oncopera parva* Tindale (Lepidoptera: Hepialidae). *Journal of the Australian Entomological Society 17:* 5–11.

Esson, M.J. 1970: Time lapse photography for the observation of porina caterpillar behaviour. *Proceedings of the 23rd N.Z. Weed and Pest Control Conference:* 200–204.

Felder, C.; Rogenhofer, A.F. 1874: Reise der österreichischen Fregatte 'Novara' um die Erde (zoologischer Theil), Band 2 (Abteilung 2) Hefte 4 [Plates 15–107].

Fenemore, P.G.; Allen, V.A.L. 1969: Oviposition preference and larval survival in *Wiseana cervinata* (Walker), Hepialidae. *N.Z. journal of agricultural research 12:* 146–161.

Flower, N.E.; Helson, G.A.H. 1976: Variation in antennal sensilla of some hepialid moths; a scanning electron microscope study. *N.Z. journal of zoology 3:* 327–331.

French, R.A. 1973: Some aspects of the population dynamics, biology and economic status of *Wiseana* spp. Unpubl. Ph.D. thesis, Lincoln College, Canterbury.

French, R.A.; Pearson, J.F. 1979: Influence of temperature on the rate of development of porina (*Wiseana* spp.: Hepialidae) eggs and timing of larval emergence in the field. *N.Z. journal of experimental agriculture 7:* 315–319.

——— 1981: Food intake and feeding behaviour of porina (*Wiseana* spp.: Hepialidae). *N.Z. journal of experimental agriculture 9:* 383–386

Gaskin, D.E. 1964: Distinction between *Wiseana umbraculata* and *W. signata* (Lepidoptera: Hepialidae) with light trapping records for Wellington. *N.Z. journal of science 7(3):* 396–408.

Glare, T.R.; O'Callaghan, M.; Wigley, P.J. 1993: Checklist of naturally occurring entomopathogenic microbes and nematodes in New Zealand. *N. Z. journal of zoology 20:* 95–120.

Grehan, J.R. 1979: Larvae of *Aenetus virescens* (Lepidoptera: Hepialidae) in decaying wood. *N.Z. journal of zoology 6(4):* 583–586.

——— 1981: Morphological changes in the tree-phase development of *Aenetus virescens* larvae (Lepidoptera: Hepialidae). *N.Z. journal of zoology 8:* 505–514.

——— 1983a: Larval establishment behaviour in live trees. *N.Z. entomologist 7(4):* 413–417.

——— 1983b: Record of *Wiseana signata* (Walker) (Lepidoptera: Hepialidae) larvae in sand dunes. *N.Z. entomologist 7(4):* 417–418.

——— 1983c: Description of the male of the endemic New Caledonian species *Aenetus cohici* (Lepidoptera: Hepialidae).

——— 1987a: Life cycle of the woodborer *Aenetus virescens* (Lepidoptera: Hepialidae). *N.Z. journal of zoology 14:* 209–217.

——— 1987b: Evolution of arboreal tunnelling by larvae of *Aenetus* (Lepidoptera: Hepialidae). *N.Z. journal of zoology 14:* 441–462.

——— 1989: Larval feeding habits of the Hepialidae (Lepidoptera). *Journal of natural history 23:* 803–824.

Grehan, J.R.; Moeed, A.; Meads, M.J. 1983: Observations on *Trioxycanus enysii* (Butler) (sensu Meyrick, 1890) (Lepidoptera: Hepialidae) on Kapiti Island, New Zealand, with a description of larval chaetotaxy. *N.Z. entomologist 7(4):* 408–413.

Grehan, J.R.; Patrick, B.H. 1984: Notes on bog-inhabiting Hepialidae (Lepidoptera) of New Zealand. *N.Z. entomologist 8:* 63–67.

Grehan, J.R.; Wigley, P.J. 1984: Fungal and bacterial diseases of puriri moth, *Aenetus virescens* (Lepidoptera: Hepialidae) larvae. *N.Z. entomologist 8:* 61–63.

Guenée, A. 1868: New species etc., of heterocerous Lepidoptera from Canterbury, New Zealand, collected by Mr R.W. Fereday. *Entomologists' monthly magazine 5:* 1–6.

Hamilton, A. 1909: Notes on Lepidoptera collected by H. Hamilton in various localities in the Queenstown District, Otago, between November 1907 and March 1908. *Transactions and proceedings of the N.Z. Institute 41:* 44–48.

Hardy, R.J. 1973: Larval chaetotaxy of thorax and abdomen of *Fraus simulans* Walker (Lepidoptera: Hepialidae). *Journal of the Australian Entomological Society 12:* 121–123.

Hasenfuss, I. 1969: Zur Homologie der Borstenmusterelemente der larven Kopfkapsel einiger monotrysischer Lepidoptera. *Beitrage zur Entomologie 19:* 289–301.

Helson, G.A.H. 1967: Adult periodicity of *Wiseana* species (family Hepialidae) in New Zealand as revealed by light traps. *Transactions of the Royal Society of N.Z., zoology 9(8): 79–91.*

——— 1972: An hypothesis on the effect of atmospheric small air ions and weather fronts on the emergence of *Wiseana cervinata. Abstract, 14th International Congress of Entomology:* 341.

Herrich-Schaeffer, G.A.W. 1855: Synopsis familiarum lepidopterorum. Pp. 82–132 *in* Systematische Bearbeitung der Schmetterlinge von Europa, zugleich als Text Revision und Supplement zu Jacob Hübner's Sammlung europäischer Schmetterlinge. Vol. 6.

Hinton, H.E. 1946: On the homology and nomenclature of the setae of the lepidopterous larvae, with some notes on the phylogeny of the Lepidoptera. *Transactions of the Royal Entomological Society of London 97:* 1–37.

Horak, M. 1984: Assessment of taxonomically significant structures in Tortricinae (Lep.: Tortricidae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft 57:* 3–64.

Hudson, G.V. 1885: Life history of *Charagia virescens. Entomologist, London, 18:* 30–36.

——— 1898: New Zealand moths and butterflies (macrolepidoptera). London, West, Newman & Co. xix + 144 pp.

——— 1905: On some new species of macrolepidoptera in New Zealand. *Transactions and proceedings of the N.Z. Institute 37:* 355–358.

——— 1906: Recent observations respecting the origin of the vegetable caterpillars. *Transactions and proceedings of the N.Z. Institute 39:* 195–196.

——— 1908: Recent observations on New Zealand macrolepidoptera including descriptions of new species. *Transactions and proceedings of the N.Z. Institute 40:* 104–107.

——— 1920: Descriptions of two new species of Hepialidae from New Zealand. *Entomologists' monthly magazine 56:* 277.

——— 1923: Descriptions of three new species of Lepidoptera from New Zealand. *Entomologists' monthly magazine 59:* 179–181.

——— 1928: The butterflies and moths of New Zealand. Wellington, Ferguson & Osborn. xi + 386 pp.

——— 1939: A supplement to the butterflies and moths of New Zealand. Wellington, Ferguson & Osborn. Pp. 387–481, pl. 53–62.

——— 1950: Fragments of New Zealand entomology. Wellington, Ferguson & Osborn. 188 pp., ii + 17 pl.

Janse, A.J.T. 1939: On the structure of lepidopterous larvae, with special reference to the mature larva of *Leto venus* Stoll. *Journal of the Entomological Society of South Africa 2:* 165–175.

——— 1942: Sub-order Jugata. Pp. 1–78 *in* Janse, A.J.T. 'The moths of South Africa', vol. 4(1).

Joubert, P.C. 1975: The 'ghost moth' (*Dalaca rufescens* Hampson) in Natal (Lepidoptera: Hepialidae). *Dept of Agricultural Technical Services technical communication 130.*

Kalmakoff, J. 1980 (1979): Enzootic virus control of *Wiseana* spp. (Lepidoptera: Hepialidae) in the pasture environment. Pp. 202–204 *in* Crosby, T.K., & Pottinger, R.P. (eds), "Proceedings of the 2nd Australasian Conference on Grassland Invertebrate Ecology." Wellington, Government Printer.

Kirby, W.F. 1892: A synonymic catalogue of Lepidoptera Heterocera (moths). Vol. 1: Sphinges and Bombyces. London. 951 pp.

Kristensen, N.P. 1968: The anatomy of the head and the alimentary canal of adult Eriocraniidae. *Entomologiske Meddelelser 36:* 239–315.

Kuznetsov, V.I.; Stekol'nikov, A.A. 1984: The evolution and system of higher taxa of tortricid moths (Lepidoptera: Tortricidae) of the world fauna with reference to the comparative morphology of genitalia. (36th Cholodkovsky Memorial Lecture, 1 April 1983, pp. 51–91. Leningrad, Nauka. [P. Auckland, CSIRO translation, 1986.]

Latch, G.C.M.; Kain, W.M. 1983: Control of porina caterpillar (*Wiseana* spp.) in pasturte by the fungus *Metarrhizium anisopliae. N.Z. journal of experimental agriculture 11:* 351–354.

Leonard, J.G.; Grehan, J.R.; Parker, B.L. 1992: First instar description of *Korscheltellus gracilis* (Grote) and *Sthenopis auratus* (Grote) (Lepidoptera: Hepialidae) with a consideration of cladistic relationships between setae. *Journal of the New York Entomological Society 100(4):* 594–614.

MacArthur, G. 1986 (Nov.): An electrophoretic contribution to the systematics of the genus *Wiseana* Viette (Lepidoptera: Hepialidae). Unpubl. Ph.D. thesis, Victoria University of Wellington.

McCabe, T.L.; Wagner, D.L. 1988: The biology of *Sthenopis auratus* (Grote) (Lepidoptera: Hepialidae). *Journal of the New York Entomological Society 96(4):* 256–273.

Meads, M.J. 1990: Forgotten fauna: the rare, endangered, and protected invertebrates of New Zealand. Wellington, DSIR Land Resources / DSIR Publishing. 95 pp.

Meyrick, E. 1890: Descriptions of New Zealand Lepidoptera. *Transactions of the N.Z. Institute 22:* 204–220.

——— 1912: Descriptions of New Zealand Lepidoptera. *Transactions and proceedings of the N.Z. Institute 44:* 117–126.

——— 1921: Notes and descriptions of New Zealand Lepidoptera. *Transactions and proceedings of the N.Z. Institute 53:* 334–336.

Miller, D. 1971: Common insects in New Zealand. Wellington, Reed. 178 pp.

Minet, J. 1984: Contribution à l'analyse phylogenetique des Néolépidoptères (Lepidoptera: Glossata). *Nouvelle revue d'entomologie (n.s.) 1(2):* 139–149.

Mishler, B.D.; Donaghue, M.J. 1974: Species concepts: a case for pluralism. *Systematic zoology 31:* 491–503.

Mosher, E. 1916: A classification of the Lepidoptera based on characters of the pupa. *Bulletin of the Illinois State Laboratory of Natural History 12 (II).* 147 pp.

Nielsen, E.S. 1989: Phylogeny of major lepidopteran groups. Chapter 21 (pp. 281–294) *in* Fernholm, B.; Bremer, K.; Jörnvall, H. *eds*, 'The hierarchy of life'. Amsterdam, Elsevier.

Nielsen, E.S.; Common, I.F.B. 1991: Lepidoptera (moths and butterflies). Chapter 41, pp. 817–915, *in:* 'The insects of Australia: a textbook for students and research workers' (2nd edition), vol. II.

Nielsen, E.S.; Kristensen, N.P. 1989: Primitive ghost moths. Morphology and taxonomy of the Australian genus *Fraus* Walker (Lepidoptera: Hepialidae *s.lat.*). *Monographs on Australian Lepidoptera 1.* 206 pp.

Nielsen, E.S.; Robinson, G.S. 1983: Ghost moths of southern South America (Lepidoptera: Hepialidae). *Entomonograph 4.* 192 pp.

Nielsen, E.S.; Scoble, M.J. 1986: *Afrotheora*, a new genus of primitive Hepialidae from Africa (Lepidoptera: Hepialoidea). *Entomologica Scandinavica 17:* 29–54.

Patrick, B.H. 1982: Lepidoptera of Danseys Pass, Otago. *New Zealand entomologist 7(3):* 332–336.

——— 1988: Lepidoptera of the Umbrella Ecological District. Pp. 37–50 *in:* K.J.M. Dickinson *ed.*, Umbrella Ecological District, survey report for the Protected Natural Areas Programme. Department of Conservation, Wellington.

——— 1989: Lepidoptera, Cicadidae, Acrididae of the Manorburn Ecological District. *N.Z. Department of Conservation: Science & Research no. 60.*

Patrick, B.H.; Barratt, B.I.P.; Heads, M.; Child, J. 1984: Entomological survey of Mt Pye–Ajax Bog, Catlins State Forest Park. N.Z. Forest Service, Invercargill.

Patrick, B.H.; Barratt, B.I.P.; Heads, M. 1985: Entomological survey of the Blue Mountains. N.Z. Forest Service, Invercargill.

Patrick, B.H.; Rance, B.D.; Barratt, B.I.P.; Tangey, R. 1987: Entomological survey, Longwood Range. Department of Conservation, Dunedin. 86 pp.

Patrick, B.H.; Rance, B.D.; Barratt, B.I.P. 1992: Alpine insects and plants of Stewart Island. *Department of Conservation, Dunedin, miscellaneous series no. 9.* 57 pp.

Perrott, D.C.F. 1974: Susceptibility to three organophosphorus insecticides of *Wiseana* spp. larvae (Lepidoptera: Hepialidae). *N.Z. journal of zoology 1(3):* 355–364.

Philpott, A. 1914: Descriptions of new species of Lepidoptera. *Transactions and proceedings of the N.Z. Institute 46:* 118–121.

——— 1923: Notes and descriptions of New Zealand Lepidoptera. *Transactions and proceedings of the N.Z. Institute 54:* 148–154.

——— 1927a: New Zealand Lepidoptera: notes and descriptions. *Transactions and proceedings of the N.Z. Institute 57:* 703–709.

——— 1927b: The male genitalia of the Hepialidae. *Transactions of the Entomological Society of London 75:* 35–41.

——— 1931: Notes and descriptions of New Zealand Lepidoptera. *Transactions and proceedings of the N.Z. Institute 62:* 26–36.

Quail, A. 1903a: On *Charagia virescens*, Dbld. *Transactions and proceedings of the N.Z. Institute 35:* 249–255.

——— 1903b: On the antennae of Hepialidae – Lepidoptera Jugatae. *Transactions of the Entomological Society of London, 1903:* 499–508.

Salmon, J.T. 1948: New species and records of Lepidoptera from the Three Kings Islands, New Zealand. *Records of the Auckland Institute and Museum 3:* 309–311.

——— 1951: Vegetable caterpillars. *Tuatara 4:* 1–3.

——— 1958: Hybridisation between two species of *Oxycanus*. *N.Z. entomologist 2(2):* 18–19.

Sattler, K.R. 1991: A review of wing reduction in Lepidoptera. *Bulletin of the British Museum of Natural History (ent.) 60 (2):* 243–288.

Sharell, R. 1971: New Zealand insects and their story. Collins, Auckland and London. 268 pp.

Tillyard, R.J. 1926: The insects of Australia and New Zealand. Sydney, Angus & Robertson. xi + 560 pp.

Ueda, K. 1978: The male genitalia structure of some hepialid moths with a historical review of their terminology [in Japanese, with English summary]. *Tyo Ga 29:* 191–206.

——— 1982: Male and female external genital structure of *Aenetus virescens* (Doubleday) and its male genital musculature. *Tyo Ga 33:* 87–96.

——— 1988: New species of the genus *Hepialiscus* Hampson (Lepidoptera: Hepialidae) from Taiwan. *Bulletin of the Kitakyushu Museum of Natural History 8:* 39–54.

Valentine, E.W. 1967: A list of the hosts of entomophagous insects of New Zealand. *N.Z. journal of science 10:* 1100–1209.

Viette, P.E.L. 1950: Contribution à l'étude des Hepialidae (22ème note). Hepialidae du Musée de Leiden. *Zoologische Mededelingen 31(7):* 67–77 [N.Z. references pp. 71–73].

——— 1961: Notes on some synonymous or preoccupied names in the Lepidoptera. *The entomologist, London, 94:* 38–39.

Wagner, D. 1987: Hepialidae (Hepialoidea). Pp. 347–349 *in* Stehr, F.W. *ed.*, 'Immature insects,' vol. 1. Dubuque, Kendall/Hut. xiv + 754 pp.

Wagner, D.; Tobi, D.R.; Parker, B.L.; Wallner, W.E.; Leonard, J.G. 1989: Immature stages and natural enemies of *Korscheltellus gracilis* (Lepidoptera: Hepialidae). *Annals of the Entomological Society of America 82(6):* 717–724.

Waller, J.B. 1966: Sexing of pupae of *Wiseana cervinata* (Walker), Hepialidae. *N.Z. entomologist 3(1):* 5.

Walker, F. 1856: List of the specimens of the lepidopterous insects in the collection of the British Museum, vol. VII (pp. 1509–1808).

——— 1865: List of the specimens of the lepidopterous insects in the collection of the British Museum, vol. XXXII, supplement, part 2 (pp. 323–706).

Wardle, P. 1991: Vegetation of New Zealand. Cambridge, Cambridge University Press. xx + 672 pp.

Wood, J. 1970: Rearing *Wiseana* species in the laboratory. *N.Z. entomologist 4(4):* 3–7.

Yasuda, T.; Abe, K-i 1986: *Endoclita hosei* Tindale (Lepidoptera: Hepialidae) attacking Eucalyptus in Sabah, with descriptions of the immature and imaginal stages. *Applied entomology and zoology 21(3):* 417–423.

APPENDIX: non-New Zealand taxa examined

(A, adult; L, larva; P, pupa)

AFRICA
Antihepialus (according to G.W. Gibbs), L; *Eudalaca ammon* (Wallengren), A; *Gorgopis auratilis* Janse, A; *Leto venus* Stoll, AP.

AUSTRALIA
Abantiades (includes *Trictena* – E.S. Nielsen, pers. comm.), 3 spp., A; *A. labyrinthica* of authors, PL; *Aenetus ligniveren* Herrich-Schäffer, ALP; *A. astathes* of authors, A; *A. daphnandrae* of authors, A; *A. dulcis* of authors, L; *A. mirabilis* of authors, AP; *A. ramsayi* of authors, A; *A. scotti* of authors, A; *A. scriptus* of authors, A; *Elhamma australasiae* (Walker), AP; *Fraus*, 7 spp., A; *Jeana delicatula* Tindale, A; *Jeana* sp., SW Tasmania, A; *Oncopera mitocera* Turner, A; *O. rufobrunnea* Tindale, A; *Oxycanus* spp. indet., L; *O. australis* (Walker), APL; *O. diremptus* Walker, AP; *O. silvanus* Tindale, A; *O. sirpus* Tindale, A; *O. sordidus* (Herrich-Schäffer), A; *O. stellans* Tindale, A; *O. subvarius* (Walker), A; *Zelotypia staceyi* Scott, ALP.

EUROPE
Hepialus humuli Linnaeus, A; *Korscheltellus fusconebulosus* (de Geer), A; *K. lupulinus* (Linnaeus), A.

NEW CALEDONIA
Aenetus cohici Viette, ALP.

NEW GUINEA
Paraoxycanus, 3 spp., A.

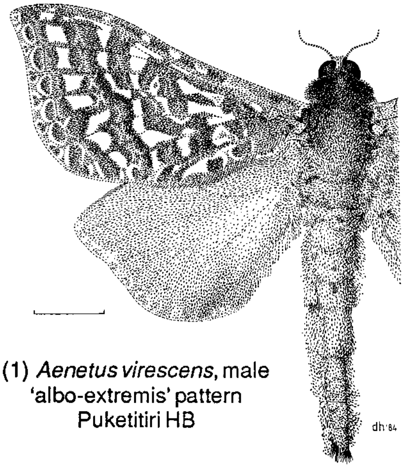
NORTH AMERICA
'Hepialus' californicus (Boisduval) species group, ALP; *'H.' hectoides* Boisduval, AL; *'H.' roseicaput* Neumoegen & Dyar, A; *Korscheltellus gracilis* Grote, A(female)LP; *'Sthenopis argentomaculatus* (Harris), A; *S. thule* Strecker, A.

OCEANIA
Phassodes vitiensis Rothschild, A.

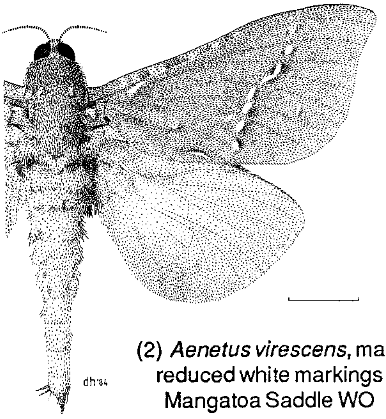
ORIENTAL
Endoclita excrescens Butler, ALP.

SOUTH AMERICA
Calada fuegensis Nielsen & Robinson, A; *Callipielus vulgaris* Nielsen & Robinson, A; *Dalaca pallens* (Blanchard), A; *Parapielus luteicornis* (Berg.), A; *Phassus triangularis* Edwards, A(female); *Trichophassus giganteus* (Herrich-Schäffer), A.

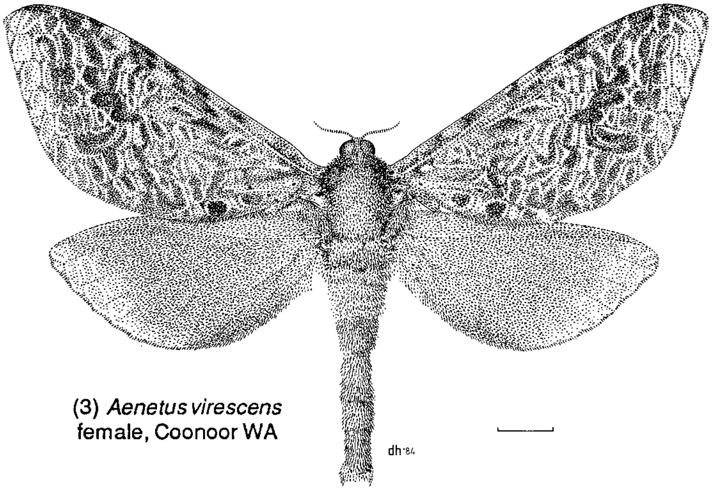
ILLUSTRATIONS



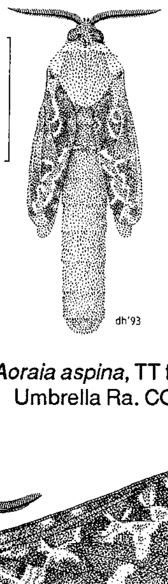
(1) *Aenetus virescens*, male
'albo-extremis' pattern
Puketitiri HB



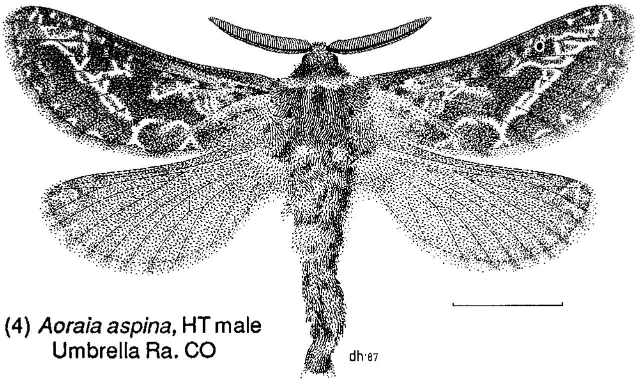
(2) *Aenetus virescens*, male
reduced white markings
Mangatoa Saddle WO



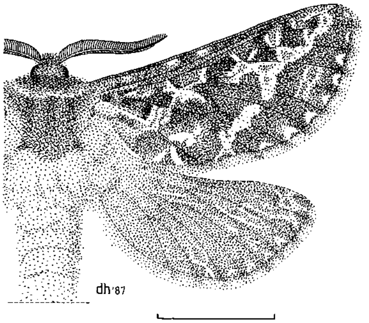
(3) *Aenetus virescens*
female, Coonoor WA



(6) *Aoraia aspina*, TT female
Umbrella Ra. CO

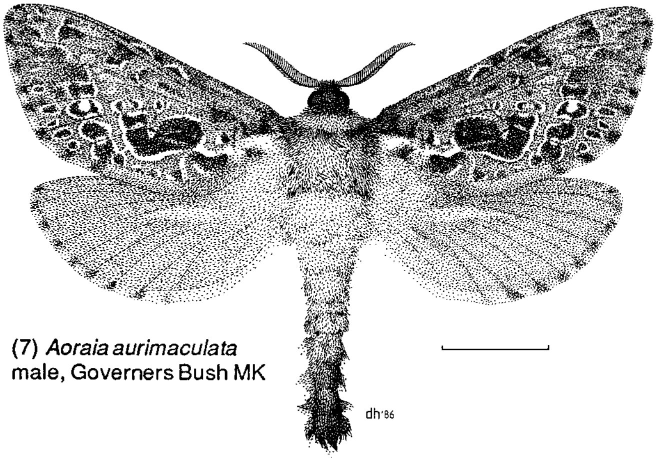


(4) *Aoraia aspina*, HT male
Umbrella Ra. CO

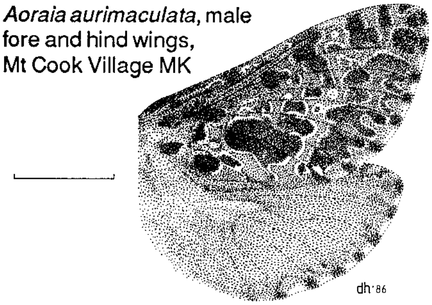


(5) *Aoraia aspina*, male, enlarged
pattern, Umbrella Ra. CO

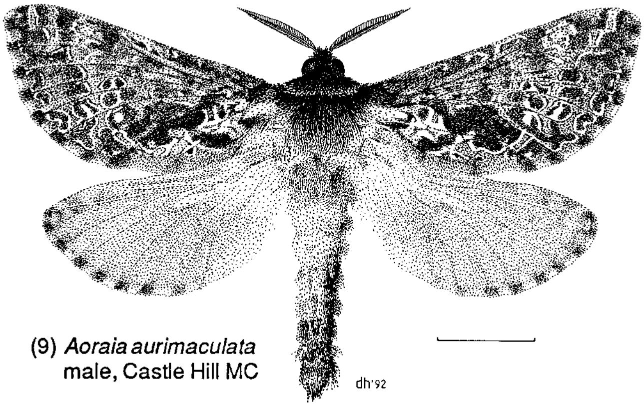
Fig. 1–72 Habitus drawings of New Zealand Hepialidae, adults. Scale lines: 10 mm. *Illustrator: D. Helmore.*



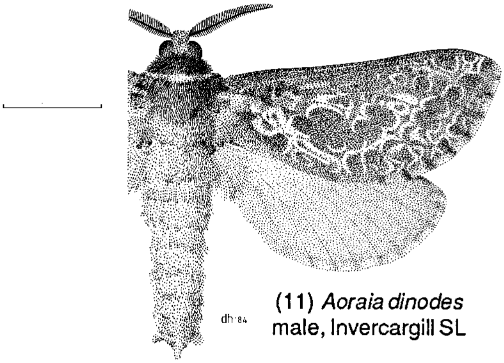
(7) *Aoraia aurimaculata*
male, Governers Bush MK



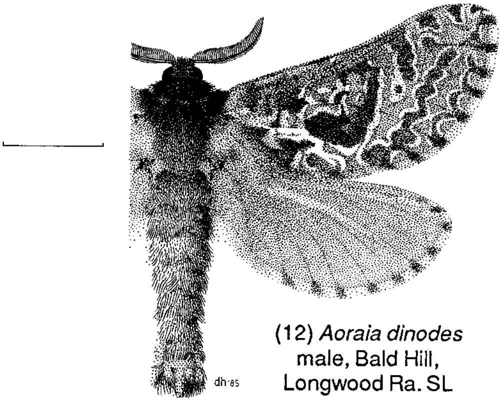
(8) *Aoraia aurimaculata*, male
fore and hind wings,
Mt Cook Village MK



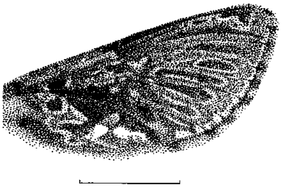
(9) *Aoraia aurimaculata*
male, Castle Hill MC



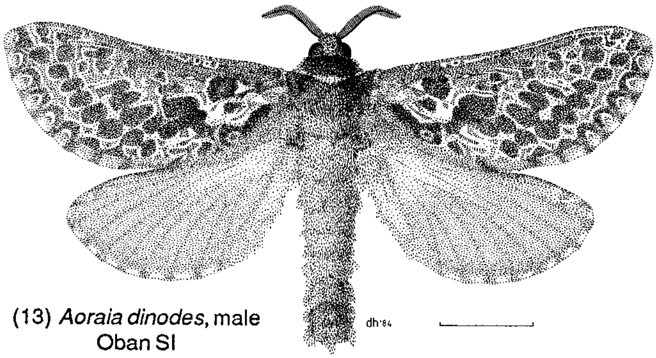
(11) *Aoraia dinodes*
male, Invercargill SL



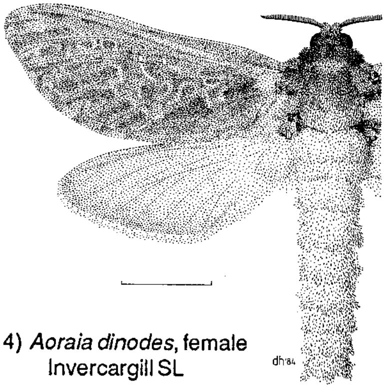
(12) *Aoraia dinodes*
male, Bald Hill,
Longwood Ra. SL



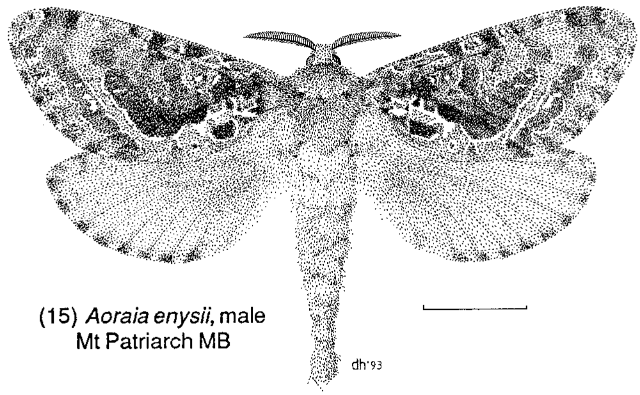
(10) *Aoraia dinodes*, male
forewing, The Divide FD



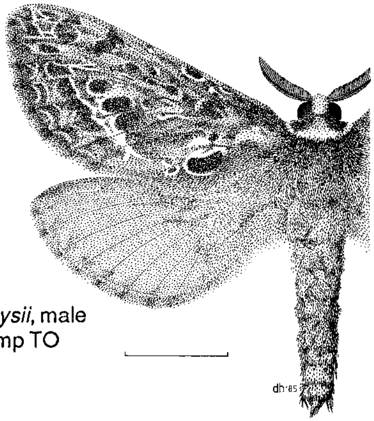
(13) *Aoraia dinodes*, male
Oban SI



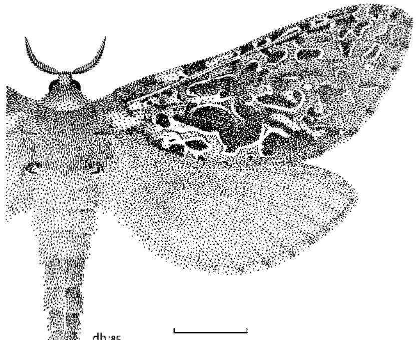
(14) *Aoraia dinodes*, female
Invercargill SL



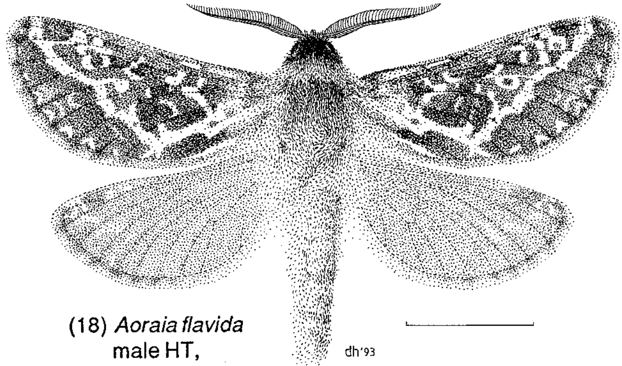
(15) *Aoraia enysii*, male
Mt Patriarch MB



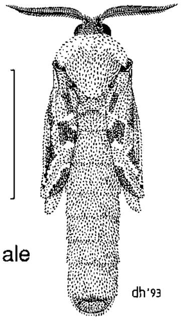
(16) *Aoraia enysii*, male
Mahuia Camp TO



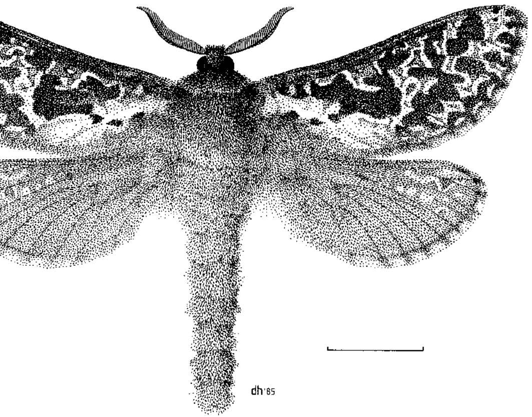
(17) *Aoraia enysii*, female
Taranaki (Mt Egmont) TK



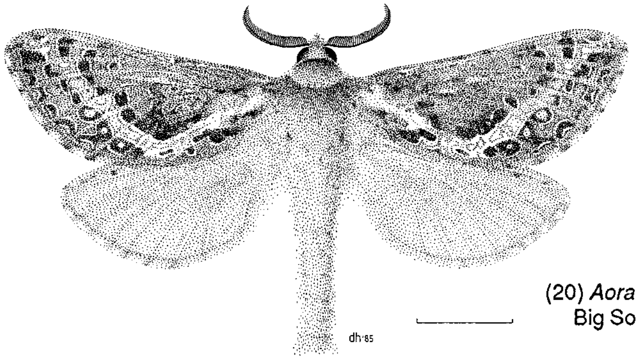
(18) *Aoraia flavida*
male HT,
Umbrella Ra. CO



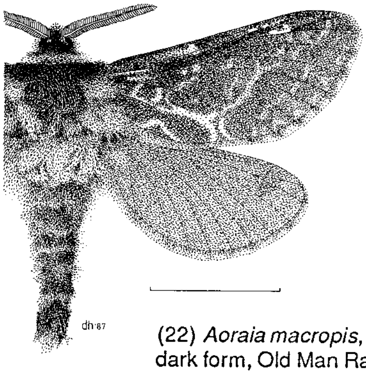
(19) *Aoraia flavida*, female
Umbrella Ra. CO



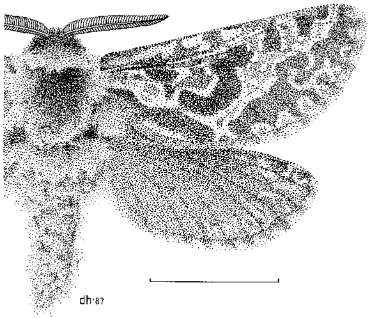
(21) *Aoraia lenis*, male
Craigieburn Ra. MC



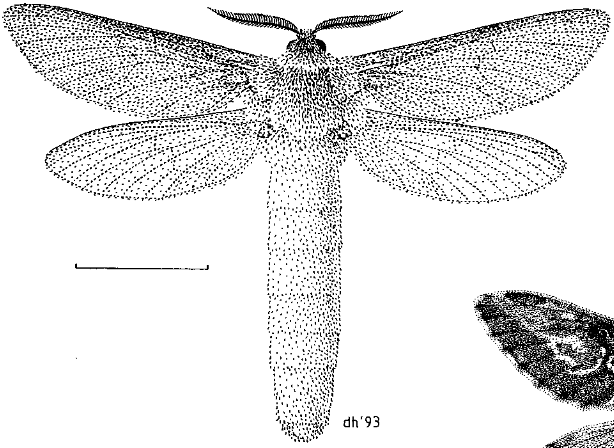
(20) *Aoraia insularis*, male
Big South Cape I. SI



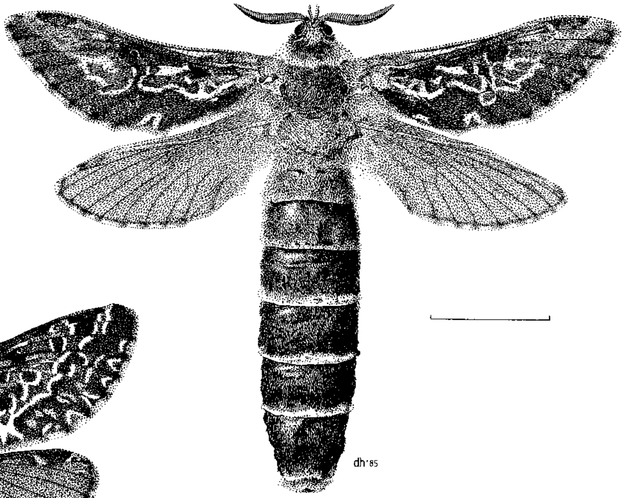
(22) *Aoraia macropis*, male
dark form, Old Man Ra. CO



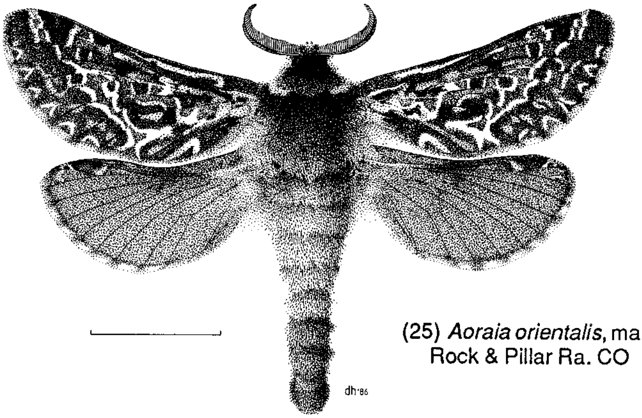
(23) *Aoraia macropis*, male
paler form, Old Man Ra. CO



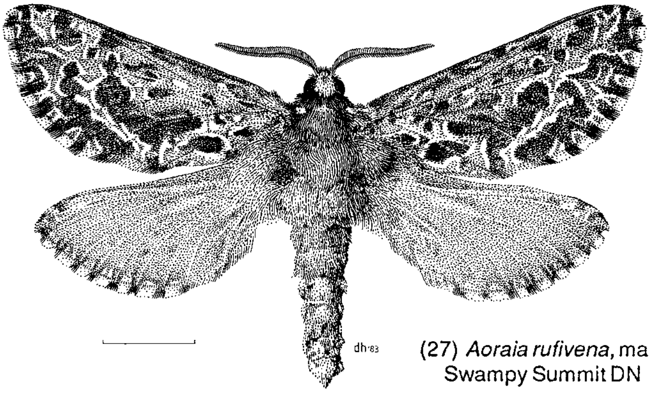
(24) *Aoraia oreobolae*, female
Blue Mtns SL



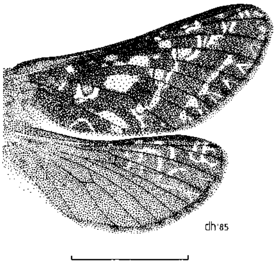
(26) *Aoraia orientalis*, female
Rock & Pillar Ra. CO



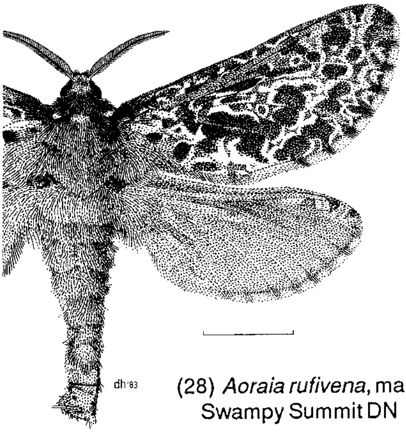
(25) *Aoraia orientalis*, male
Rock & Pillar Ra. CO



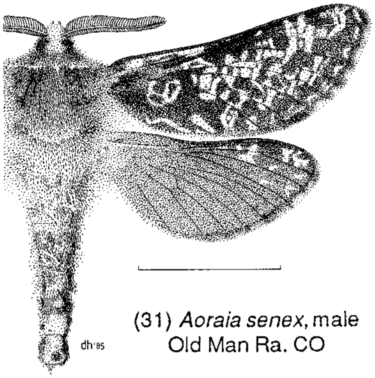
(27) *Aoraia rufivena*, male
Swampy Summit DN



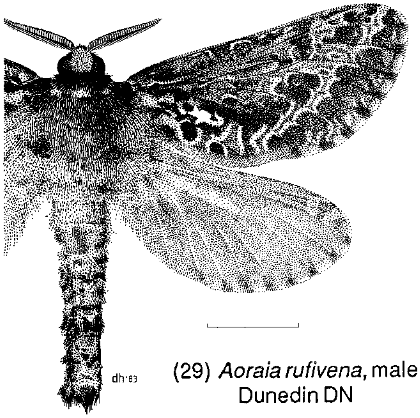
(30) *Aoraia senex*
male wings
Dunstan CO



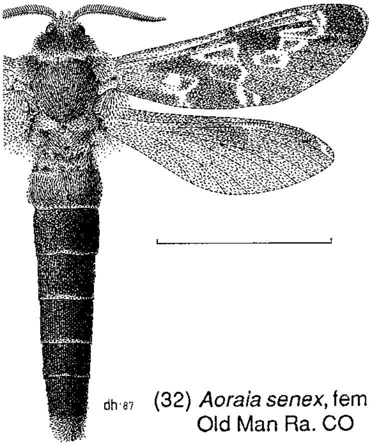
(28) *Aoraia rufivena*, male
Swampy Summit DN



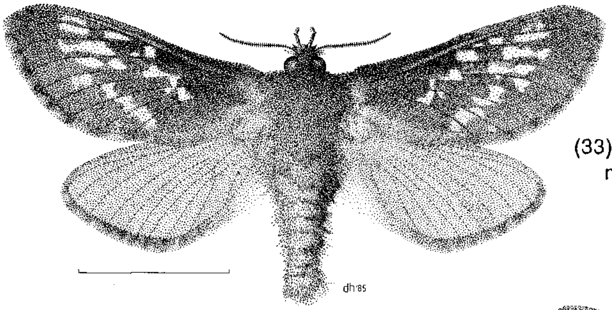
(31) *Aoraia senex*, male
Old Man Ra. CO



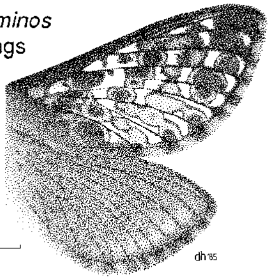
(29) *Aoraia rufivena*, male
Dunedin DN



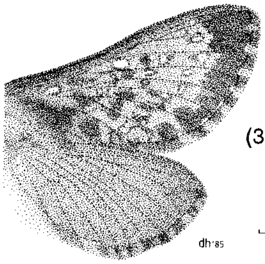
(32) *Aoraia senex*, female
Old Man Ra. CO



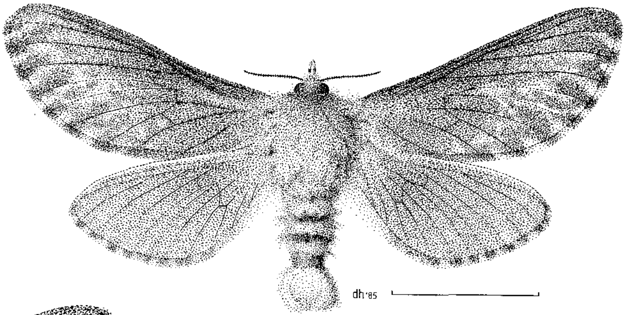
(33) *Cladoxycanus minos*
male, Glenleith DN



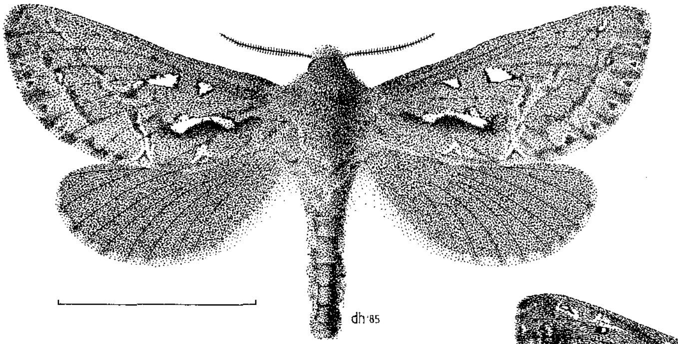
(34) *Cladoxycanus minos*
male, ocellate wings
Invermay DN



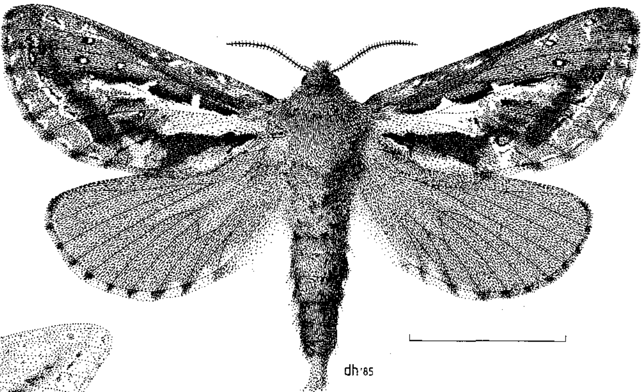
(35) *Cladoxycanus minos*
male, brown-shaded
wings, Invermay DN



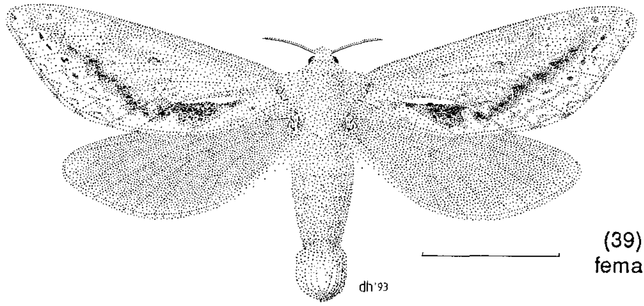
(36) *Cladoxycanus minos*
female, Invermay DN



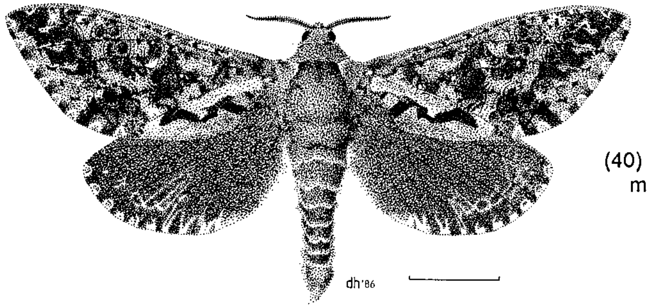
(37) *Dioxycanus fuscus*
male, Ben Lomond OL



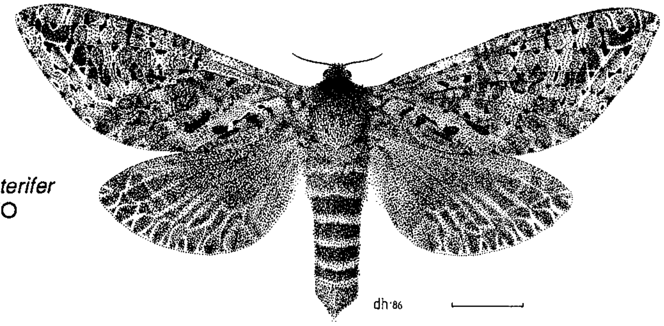
(38) *Dioxycanus oreas*
male, Tararua Ra. WN



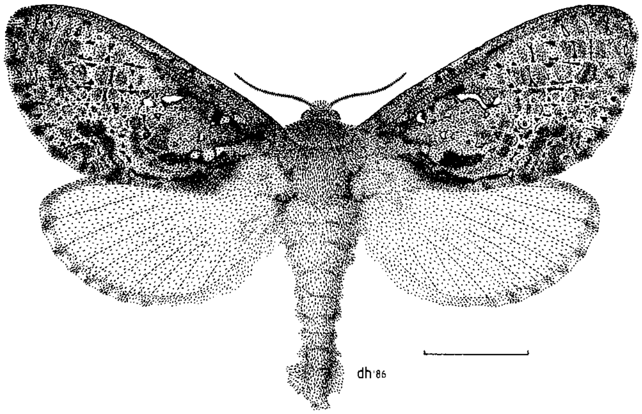
(39) *Dioxycanus oreas*
female, Tararua Ra. WN



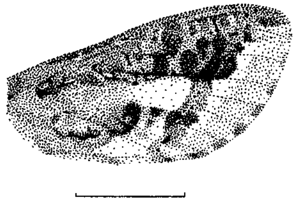
(40) *Dumbletonius characterifer*
male, Gouland Downs NN



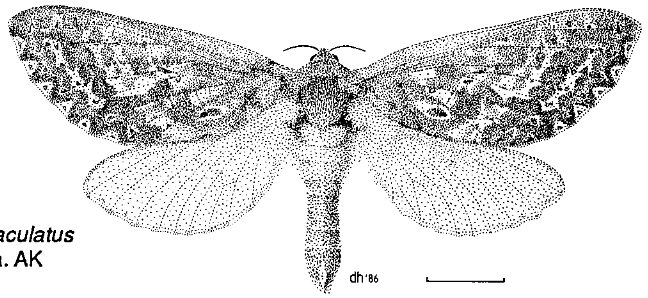
(41) *Dumbletonius characterifer*
female, Mt Ruapehu TO



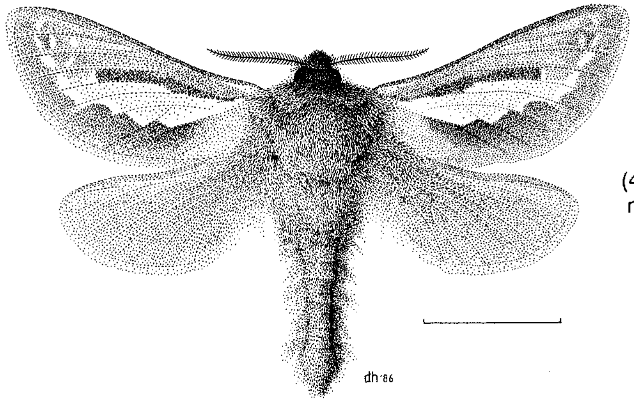
(42) *Dumbletonius unimaculatus*
male, Puketitiri HB



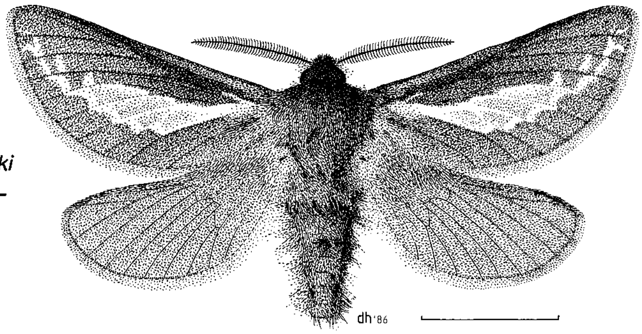
(43) *Dumbletonius unimaculatus*
male forewing, Onehunga AK



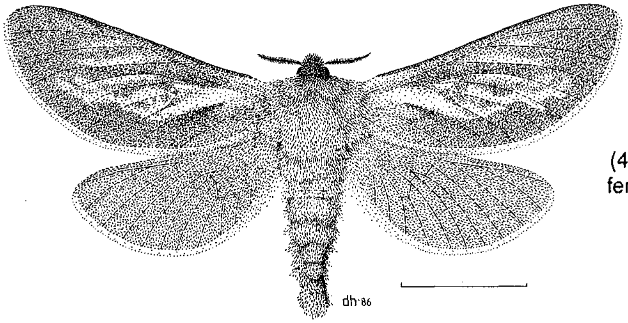
(44) *Dumbletonius unimaculatus*
female, Waitakere Ra. AK



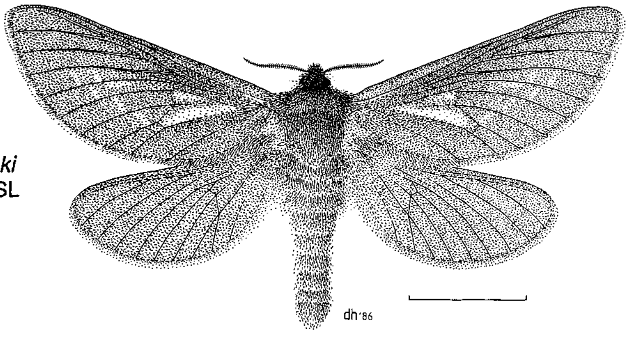
(45) *Heloxycanus patricki*
male, Burgan Creek CO



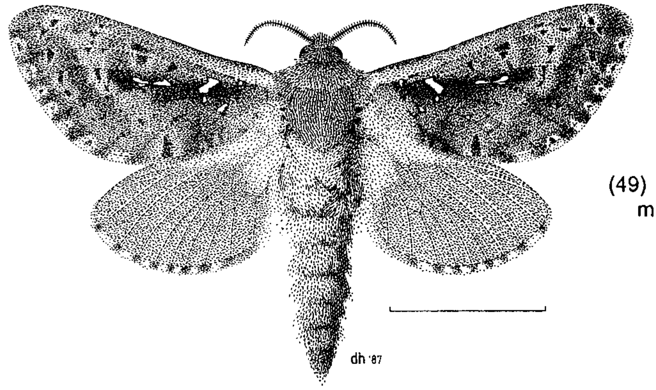
(46) *Heloxycanus patricki*
male, Seaward Moss SL



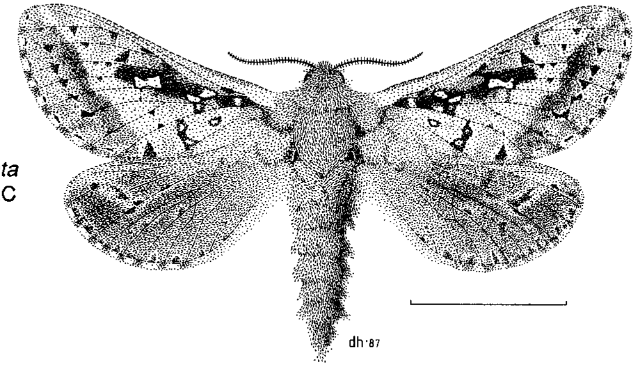
(47) *Heloxycanus patricki*
female, Burgan Creek CO



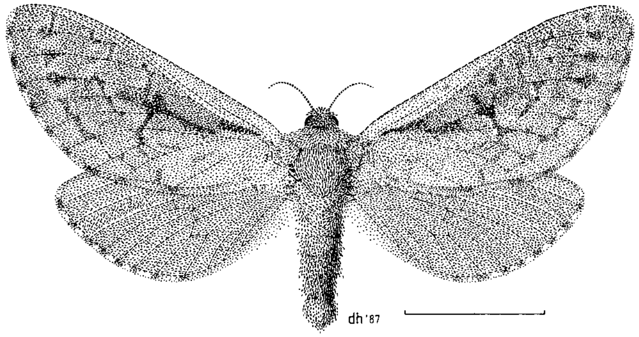
(48) *Heloxycanus patricki*
female, Seaward Moss SL



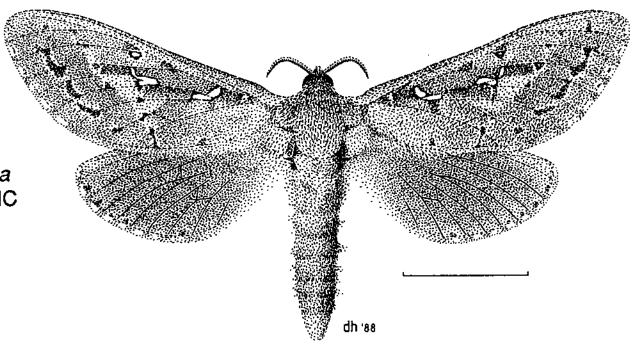
(49) *Wiseana cervinata*
male, Nelson NN



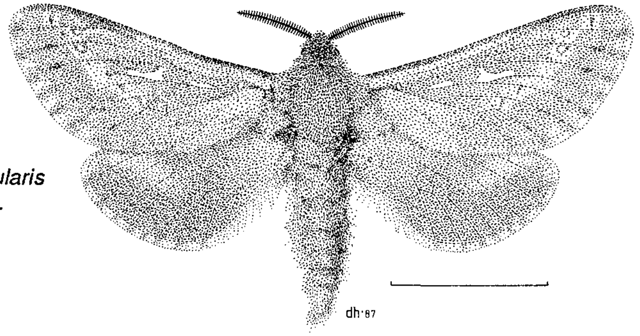
(50) *Wiseana cervinata*
male, Christchurch MC



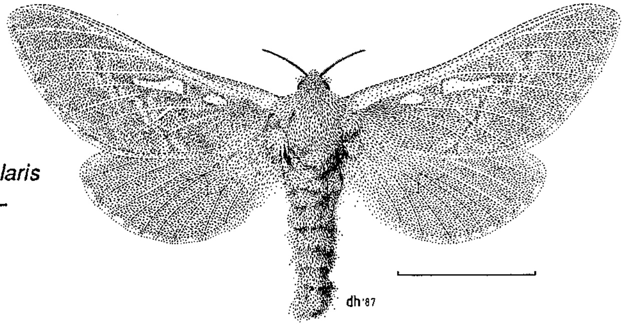
(51) *Wiseana cervinata*
female, Nelson NN



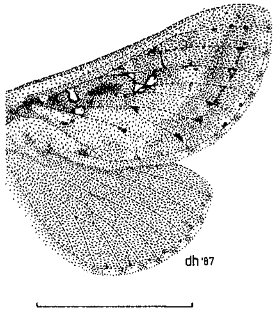
(52) *Wiseana cervinata*
female, Christchurch MC



(53) *Wiseana copularis*
male, Gore SL

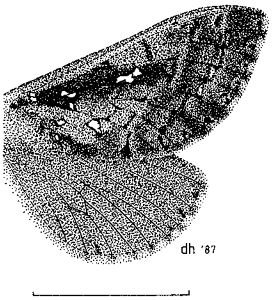


(54) *Wiseana copularis*
female, Gore SL

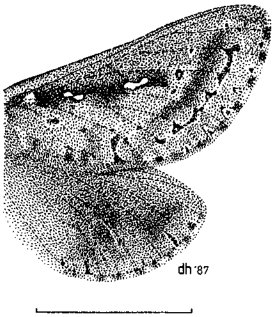


(55) male

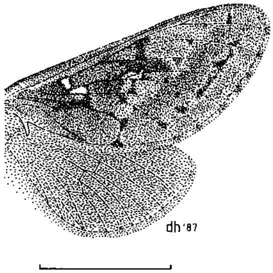
(55–58) *Wiseana fuliginea*
wing patterns, Invermay DN



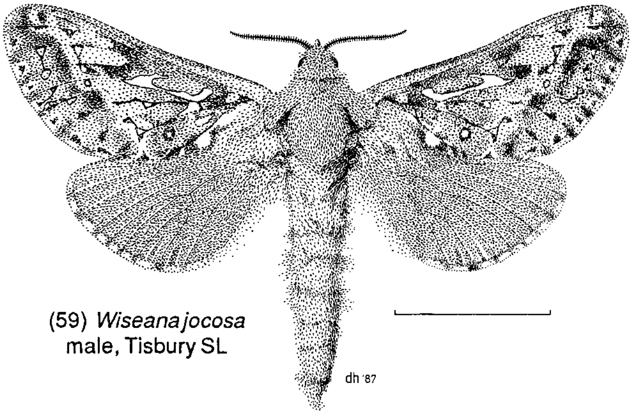
(56) male



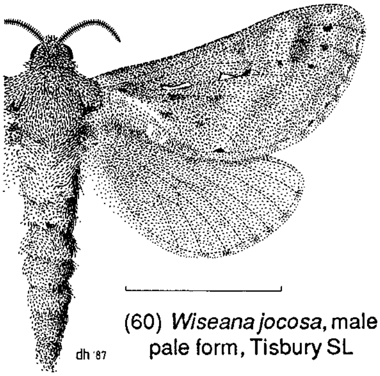
(57) male



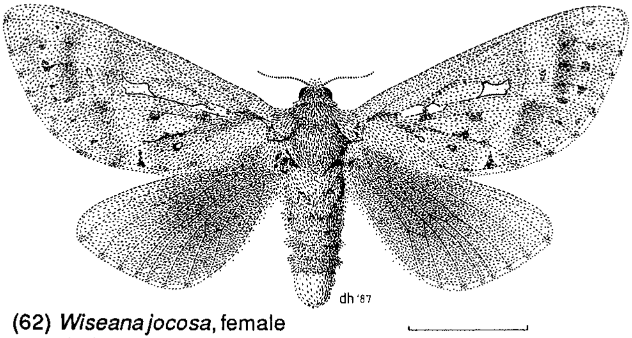
(58) female



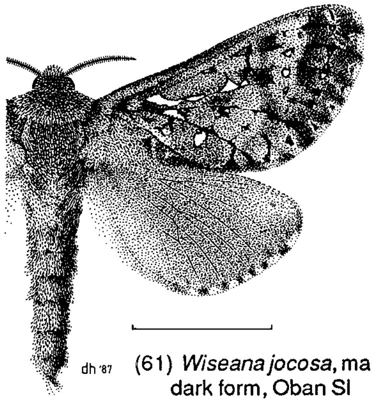
(59) *Wiseana jocosa* male, Tisbury SL



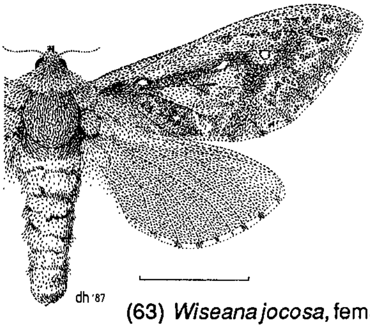
(60) *Wiseana jocosa*, male pale form, Tisbury SL



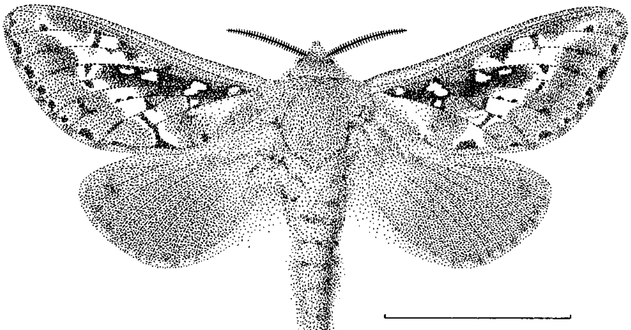
(62) *Wiseana jocosa*, female pale form, Tapanui SL



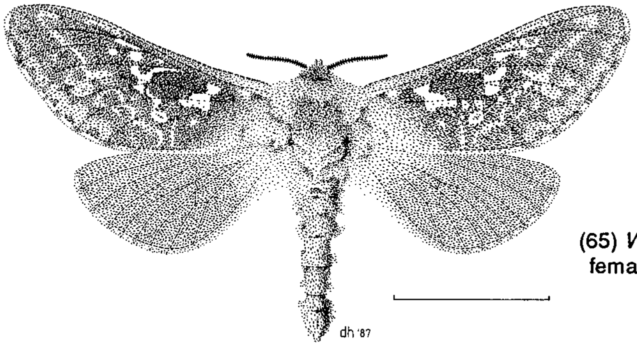
(61) *Wiseana jocosa*, male dark form, Oban SI



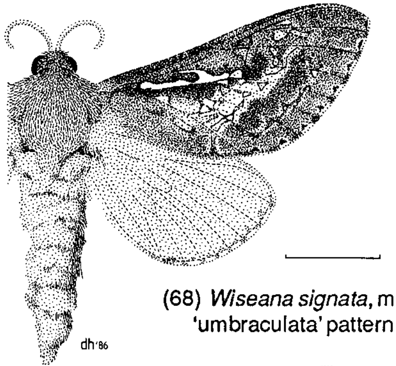
(63) *Wiseana jocosa*, female dark form, Beaumont SL



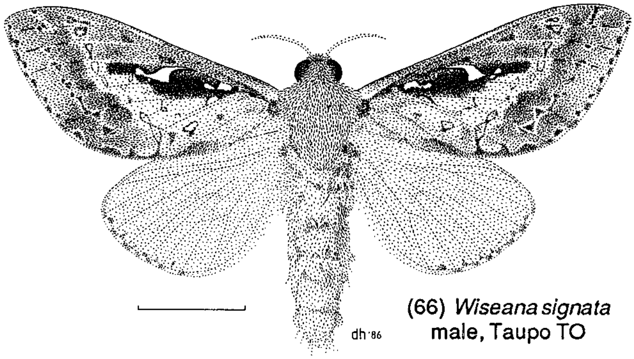
(64) *Wiseana mimica* male, West Plains SL



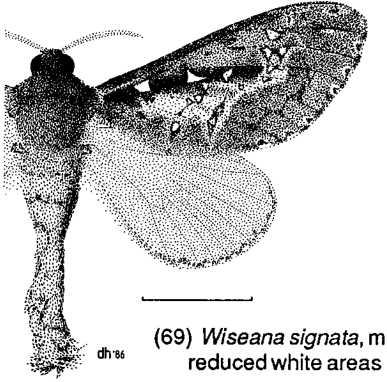
(65) *Wiseana mimica* female, Kapuka SL



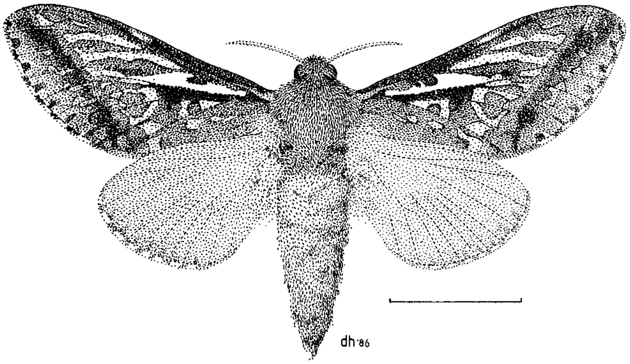
(68) *Wiseana signata*, male 'umbraculata' pattern



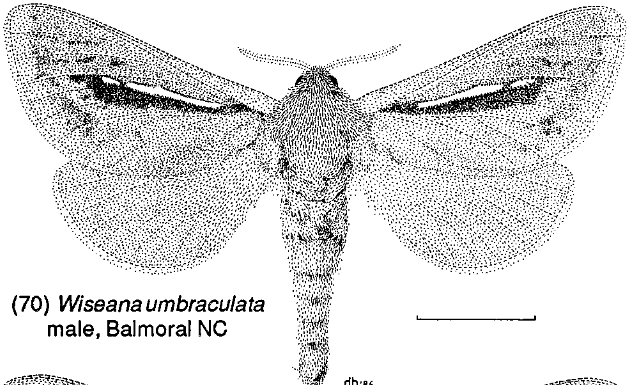
(66) *Wiseana signata* male, Taupo TO



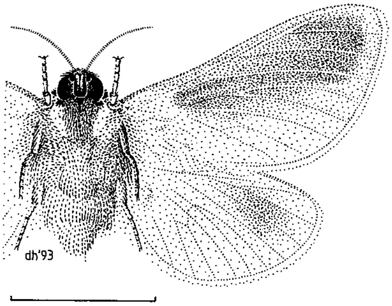
(69) *Wiseana signata*, male reduced white areas



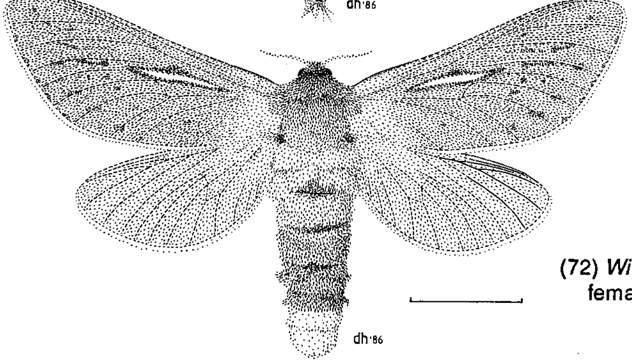
(67) *Wiseana signata*, male striped form, Taupo TO



(70) *Wiseana umbraculata* male, Balmoral NC



(71) *Wiseana umbraculata*, male wing underside, Mangapehi WO



(72) *Wiseana umbraculata* female, Kaikoura KA

ABBREVIATIONS USED IN ILLUSTRATIONS

ac	anapleural cleft (adult mesothorax)
adp	anterior dorsal plate (adult prothorax)
adr	adfrontal zone (larva)
ae2	anepisternite (prothorax)
an	anus (male/female terminalia)
ap	appendix bursae (female genitalia)
Asp1,2	abdominal spiracle 1, 2, etc.
bmp	basal maxillary piece (adult head capsule)
br	brain (larva)
bs	basistipes (larval head capsule)
c2,3	meso-/metathoracic coxa (adult)
cb	corpus bursae (female genitalia)
cl	clypeus (adult and larval head)
clp	clypeal plate (pupa)
cp	cuticular process (female genitalia)
ct	corporotentorium (adult / larval head)
d	diaphragma (female genitalia)
db	ductus bursae (female genitalia)
dh	dorsal hood (male genitalia)
dp	dorsal plate (female genitalia)
dpp	dorsal posterior process (male genitalia)
ds	dististipes (larval head)
ec3	eucoxa 3 (adult metathorax)
ep2,3	epimeron 2, 3 (adult thorax)
ep	epicranium (larval head capsule)
eps	episternite (adult prothorax)
ept	episternal tooth (adult prothorax)
fcp	frontoclypeus (larval head)
fp	felted pits (larval pronotum)
fr	frons (adult / larval head)
G1–10	genital muscles (male)
g	galea or proboscis rudiment (adult head)
ge	genal plate (pupa)
hs	hypostoma (larval head capsule)
igl	intergenital lobes (female genitalia)
ip9,10	intermediate plate (male genitalia)
is	invaginated sclerite (male genitalia)
j	juxta (male genitalia)
jg	jugum (adult forewing)
k1,2	katepisternite 1, 2 (adult pro-/mesothorax)
la	labrum (adult / pupal / larval head)
lap	labial plate (pupal head)
lc	laterocervicales (adult prothorax)
lf	lower frons (adult head)
lo	lobarium (larval head capsule)
lp	labial palpi (adult / larval head)
lpl	lateral plate (male genitalia)
ls	lateral slit (larval head capsule)
lsr	lateral strengthening ridge (adult A1)
mcs	midcranial suture (larval head)
md	mandible (adult / larval head)
mdp	mandibular plate (pupal head)
mep.m	metepimeral margin (adult metathorax)
mp	median piece, sternum IX (femalegenitalia)
mpp	mid posterior process (male genitalia)
mpr	mesopleural ridge (adult mesothorax)
mps	mesopleural suture (adult mesothorax)
mxp	maxillary palpi (adult, larva), palp plate (pupa)
oc	occiput (adult head)
oco	occipital condyle (adult head)
ov	ovipore (female genitalia)
pa	patagia (adult prothorax)
pab	pre-antennal bar (larval head capsule)
pcs	paracoxal suture (adult mesothorax)
pep2	proepisternum (adult mesothorax)
ph	phallus (adult)
pit	pit or trough formed by sunken ae2 and mep2 border (adult mesothorax)
plo	posterior lobe (adult A1)
pol	postlabium (adult head)
pp	posterior process (male genitalia)
pps	propleural sclerite (adult prothorax)
pr	tibial process (adult)
prl	prelabium (adult head)
prsp	prothoracic spiracle (adult)
pst	pseudotegumen (male genitalia)
r	rectum (adult)
sa	saccus (male genitalia)
sba	subanal plate (female genitalia)
sg	suboesophageal ganglion
sinus	lateral intersegmental pouch (adult metathorax / abdomen junction)
sp	subanal papilla (male genitalia)
spd	spermatheca (female genitalia)
spe	side piece of sternum 9 (female genitalia)
spp	supraphallic papilla (male genitalia)
ss	seminal sinus (female genitalia)
ssp	sinus seminalis papilla (female genitalia)
st	strigil (adult)
S1–9	abdominal sternites 1–9 (adult)
T1–8	abdominal tergites 1–8 (adult)
tb	tergal brace (adult abdomen)
tbp	tuberculate plates (adult abdomen)
tpr	twin processes (male genitalia)
tr	trulleum (male genitalia)
tsb	tergosternal bar (adult abdomen)
uf	upper frons (adult head)
va	valva (male genitalia)
ve	vestibule (female genitalia)
vi	vinculum arms (male genitalia)
vp	ventral process (male genitalia)
vro	vom Rath's organ (adult head)
vx	vertex (adult head)

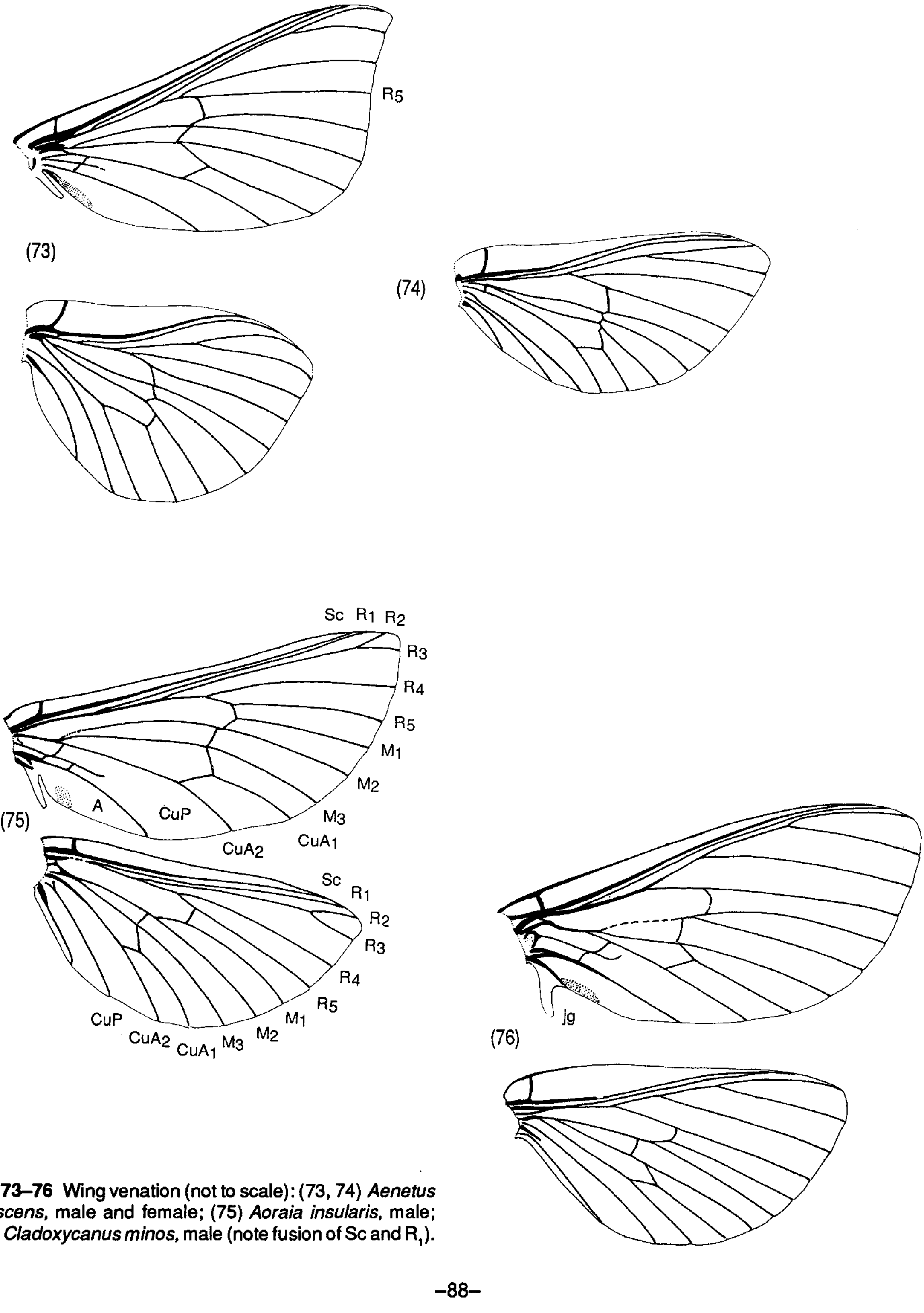
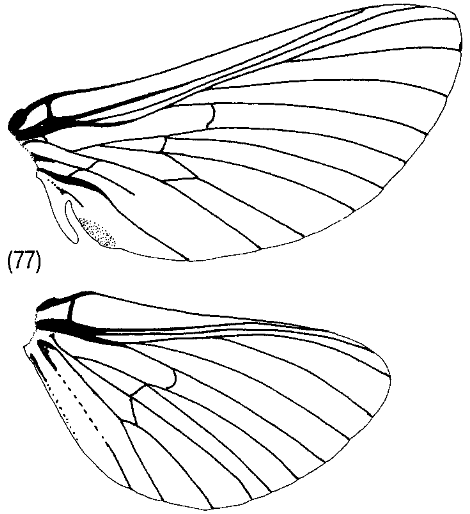
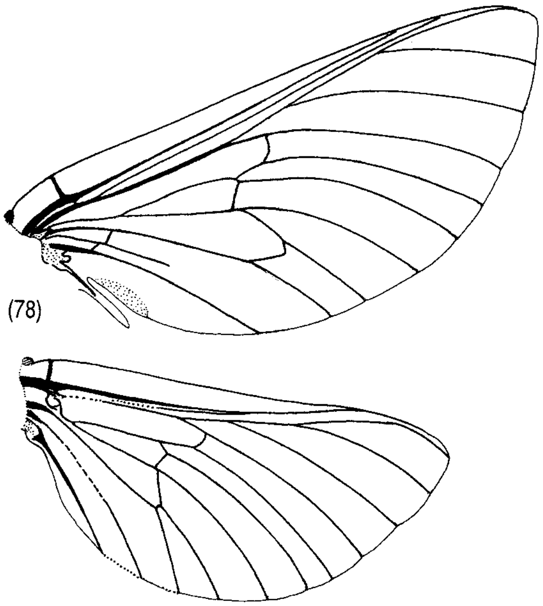
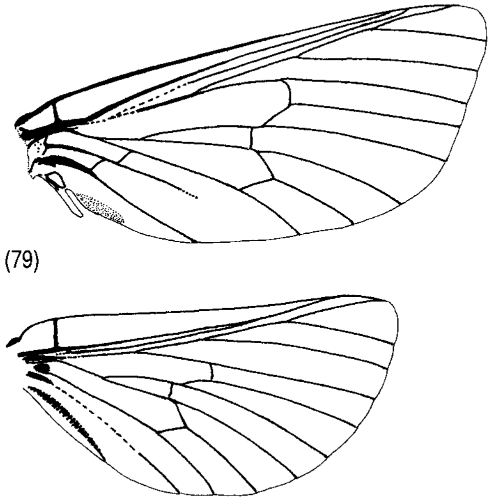


Fig. 73–76 Wing venation (not to scale): (73, 74) *Aenetus virescens*, male and female; (75) *Aoraia insularis*, male; (76) *Cladoxycanus minos*, male (note fusion of Sc and R_1).


(77)


(78)


(79)

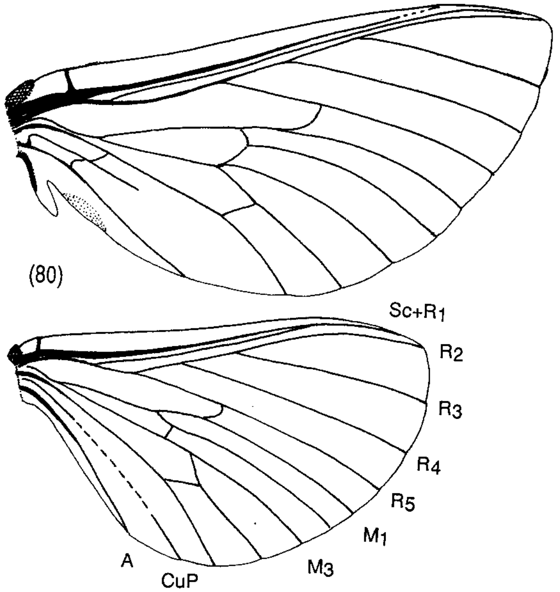

(80)

Fig. 77–80 Wing venation, male (not to scale): (77) *Dioxycanus oreas*; (78) *Dumbletonius unimaculatus*; (79) *Heloxycanus patricki*; (80) *Wiseana cervinata*.

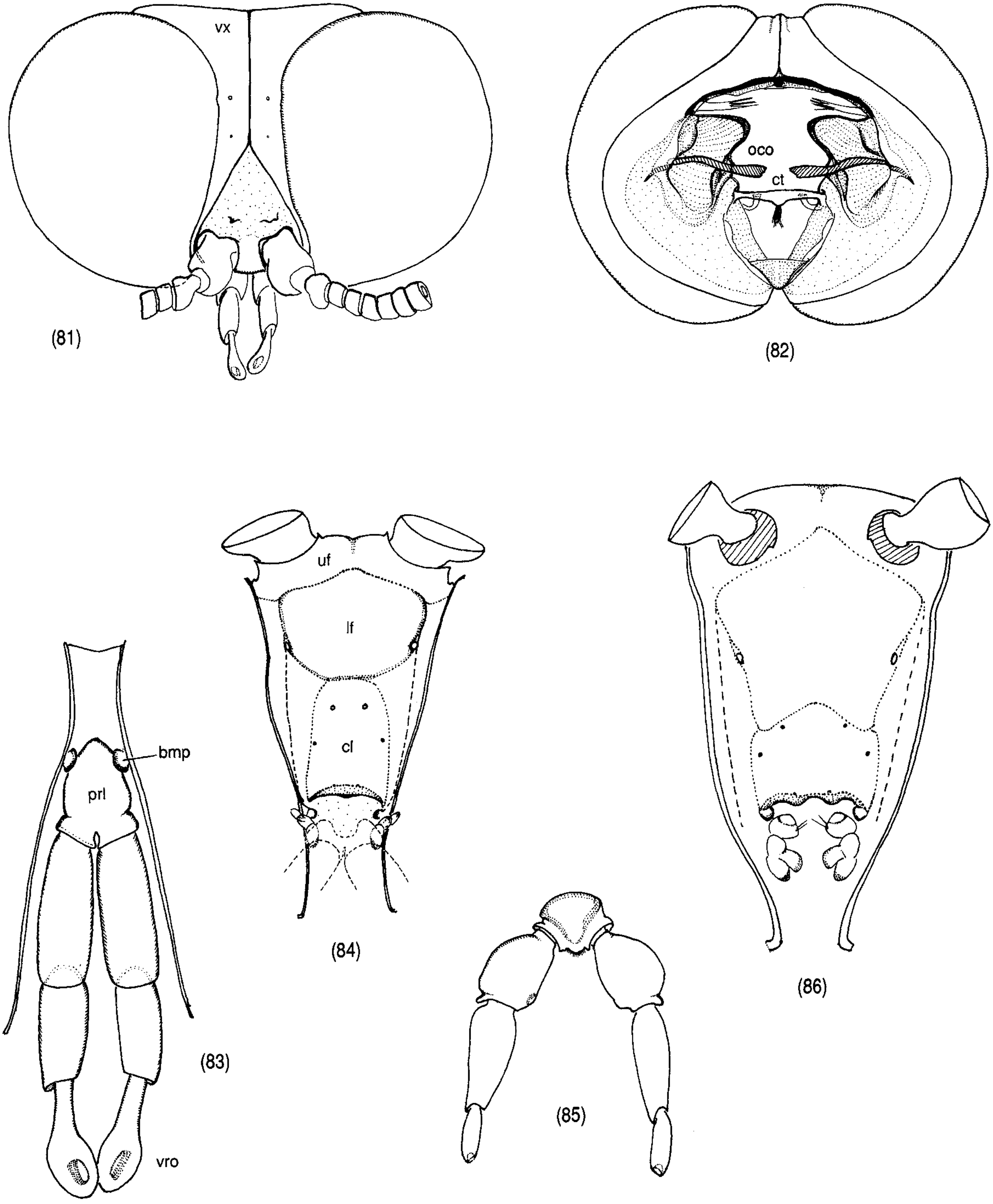


Fig. 81–86 Adult head structure, *Aenetus:* (81) *A. virescens*, male, dorsal; (82) *A. virescens*, male, posterior; (83) *A. virescens*, labial palpi, ventral; (84) *A. virescens*, frontal; (85) *A. ligniveren*, labial palpi; (86) *A. ligniveren*, frontal.

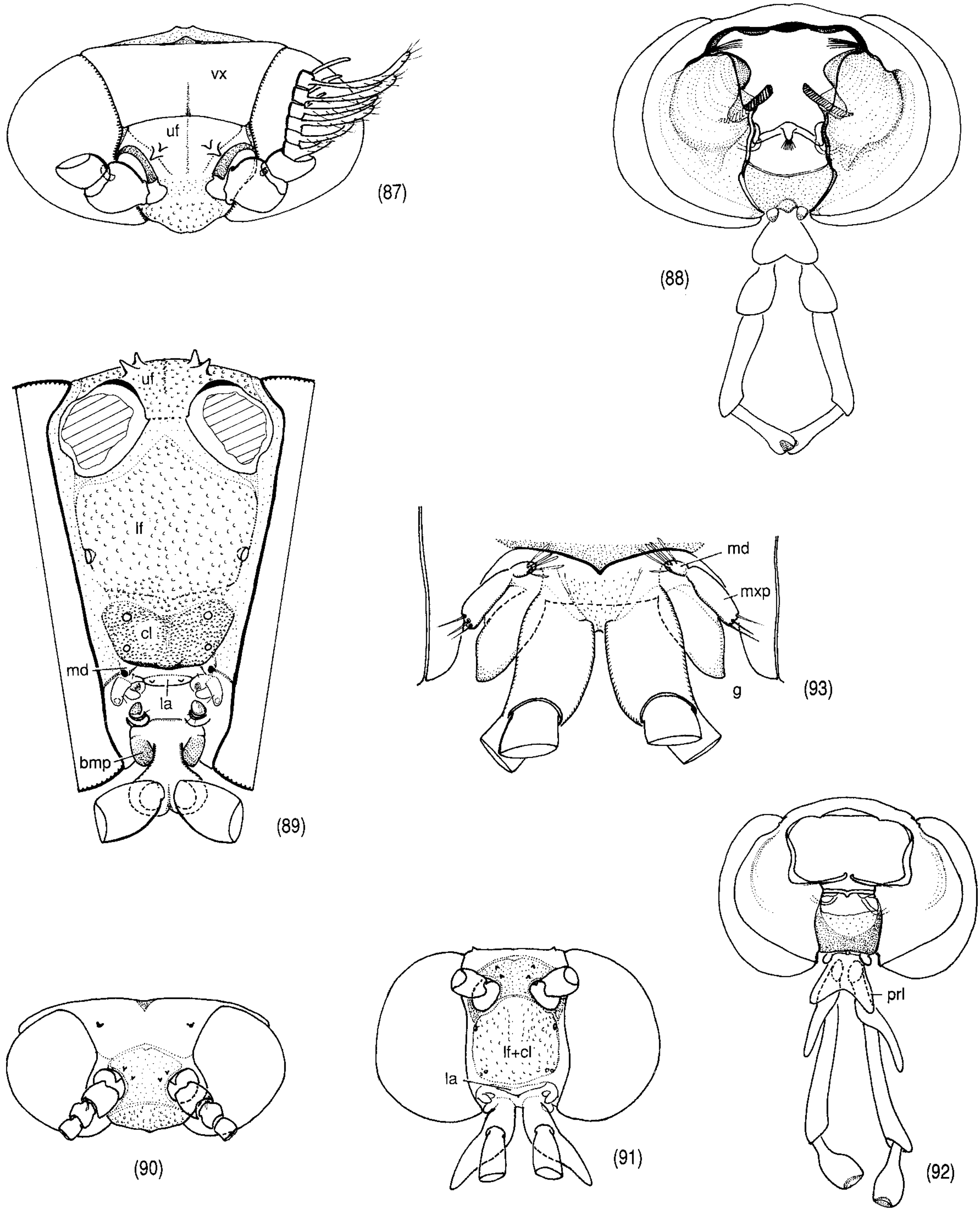


Fig. 87–93 Adult head structure: (87–89) *Aoraia insularis*, male, dorsal, posterior, and frontal; (90–93) *Cladoxycanus minos*, dorsal, frontal, posterior, and mouthparts.

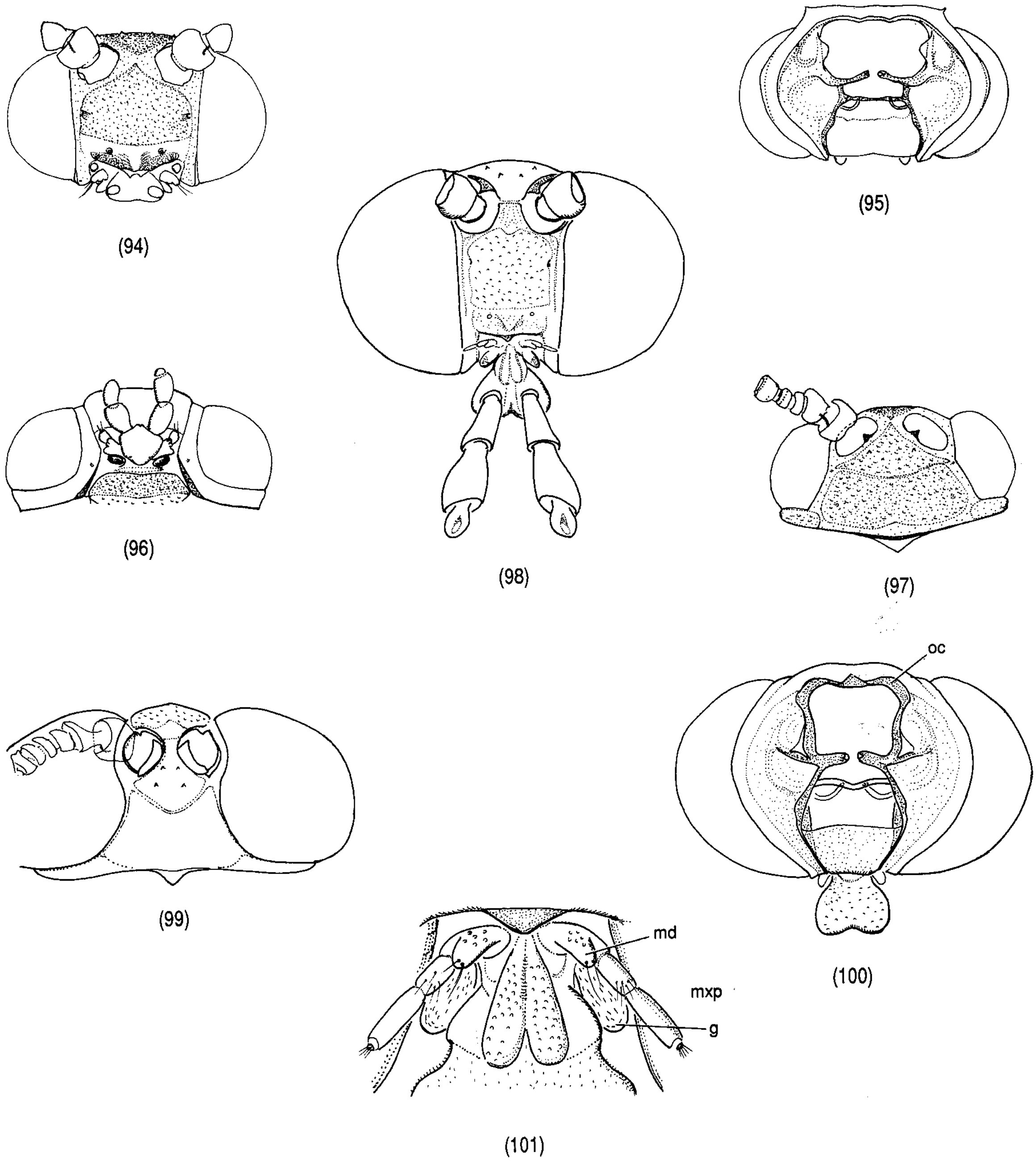


Fig. 94–101 Adult head structure: (94–97) *Dioxycanus oreas*, frontal, posterior, ventral, and dorsal; (98–101) *Dumbletonius unimaculatus*, frontal, dorsal, posterior, and mouthparts.

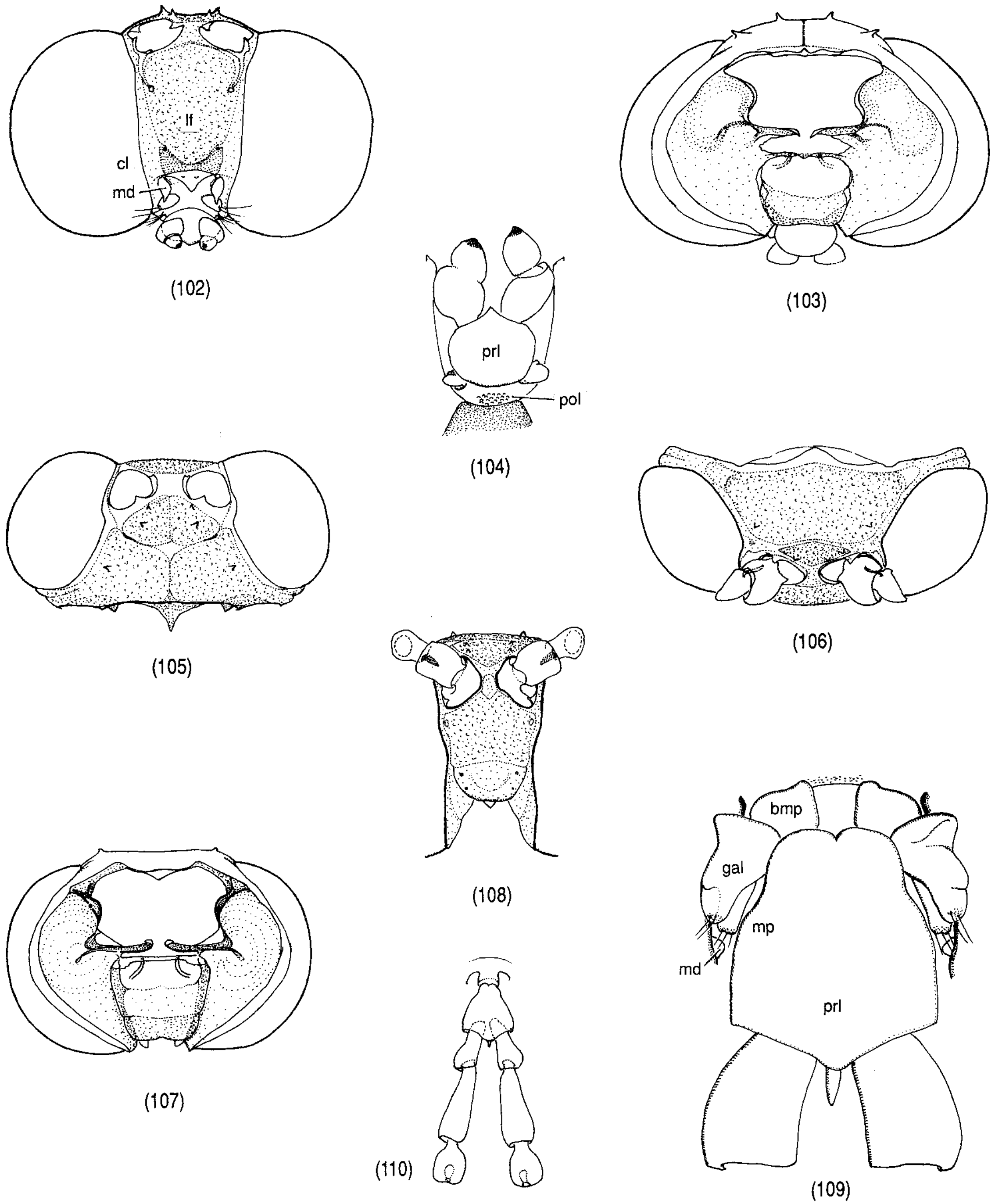
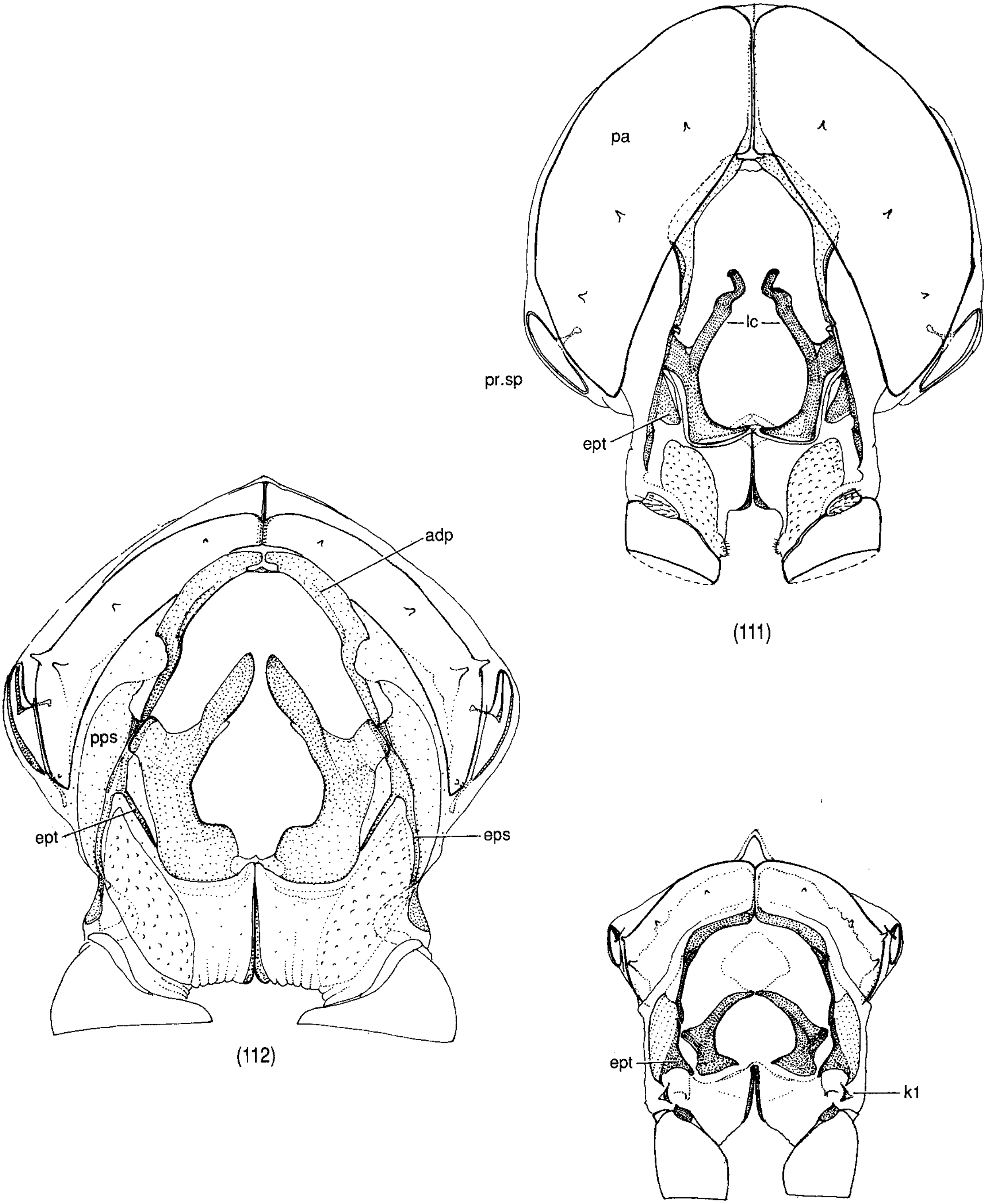


Fig. 102–110 Adult head structure: (102–105) *Heloxycanus patricki*, frontal, posterior, labial palpi, and dorsal; (106–110) *Wiseana copularis*, dorsal, posterior, frontal, mouthparts (labium, maxillae), and labial palpi.

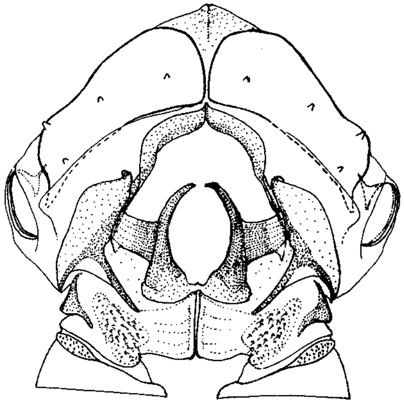


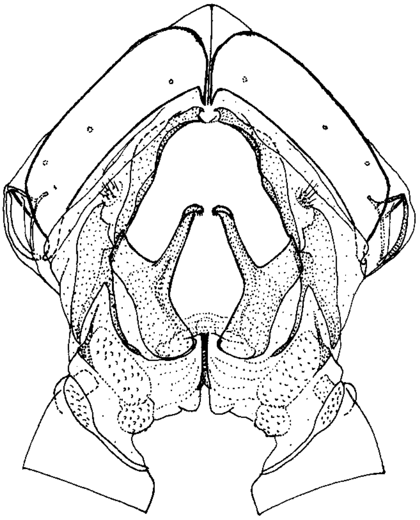
(111)

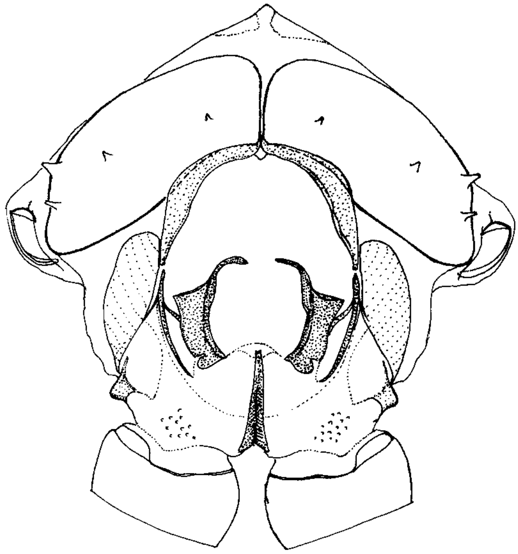
(112)

(113)

Fig. 111–113 Adult prothorax: (111) *Aenetus virescens;* (112) *Aoraia insularis;* (113) *Cladoxycanus minos.*


(114)


(115)


(116)

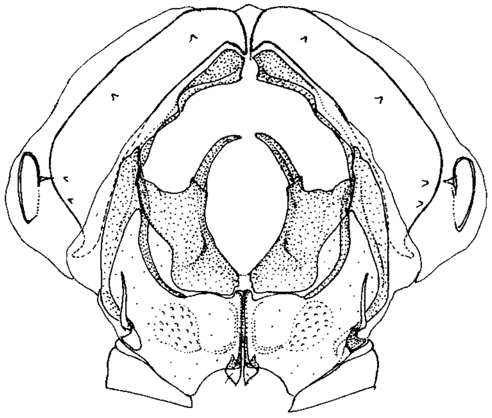

(117)

Fig. 114–117 Adult prothorax: (114) *Dioxycanus oreas;* (115) *Dumbletonius unimaculatus;* (116) *Heloxycanus patricki;* (117) *Wiseana copularis.*

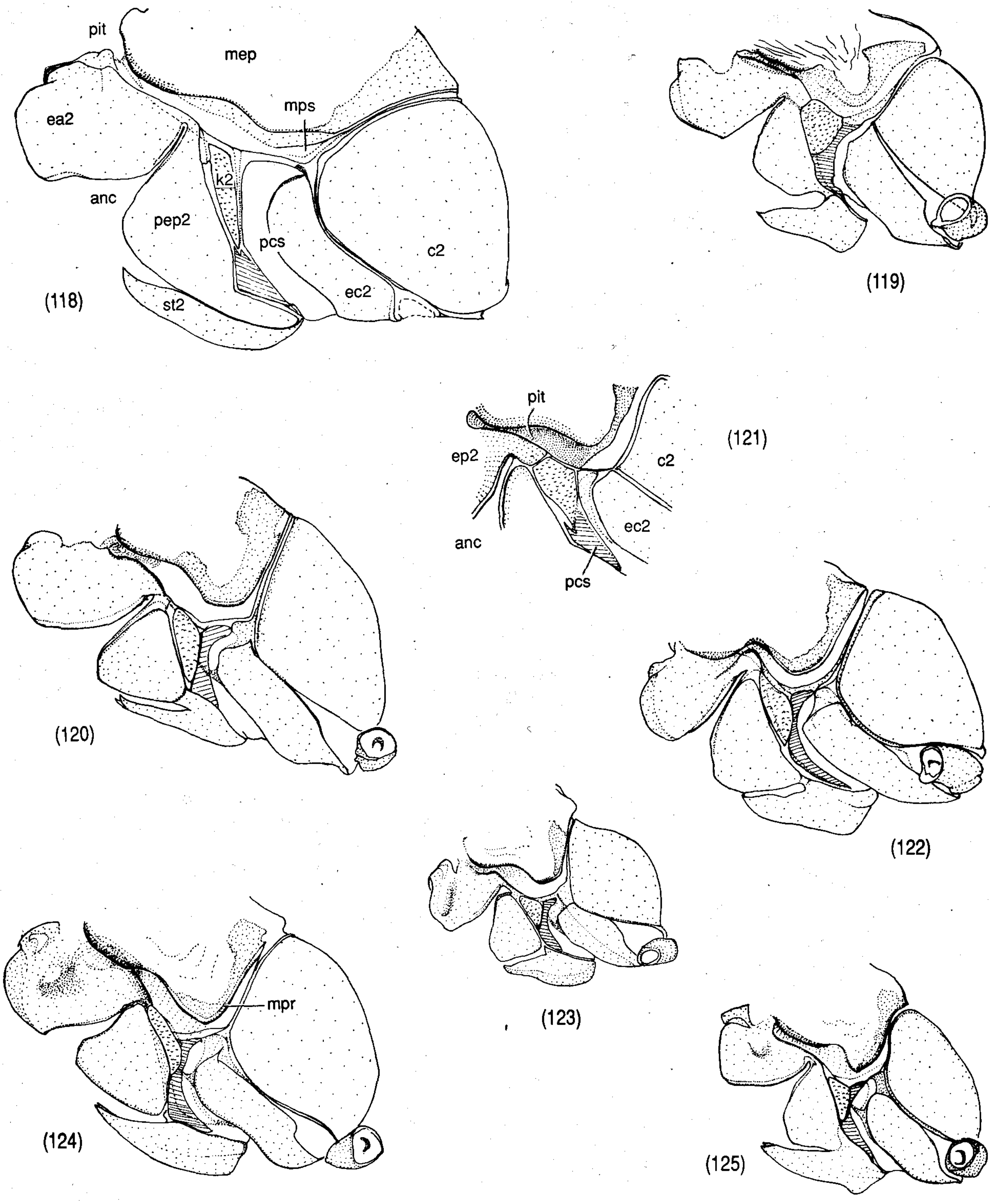


Fig. 118–125 Adult mesothorax, lateral: (118) *Aenetus virescens*, male; (119) *Aoraia insularis*, male; (120) *Aoraia orientalis*, male, detail of katepisternite; (121) *Cladoxycanus minos*; (122) *Dioxycanus oreas*; (123) *Dumbletonius unimaculatus*; (124) *Heloxycanus patricki*; (125) *Wiseana copularis*.

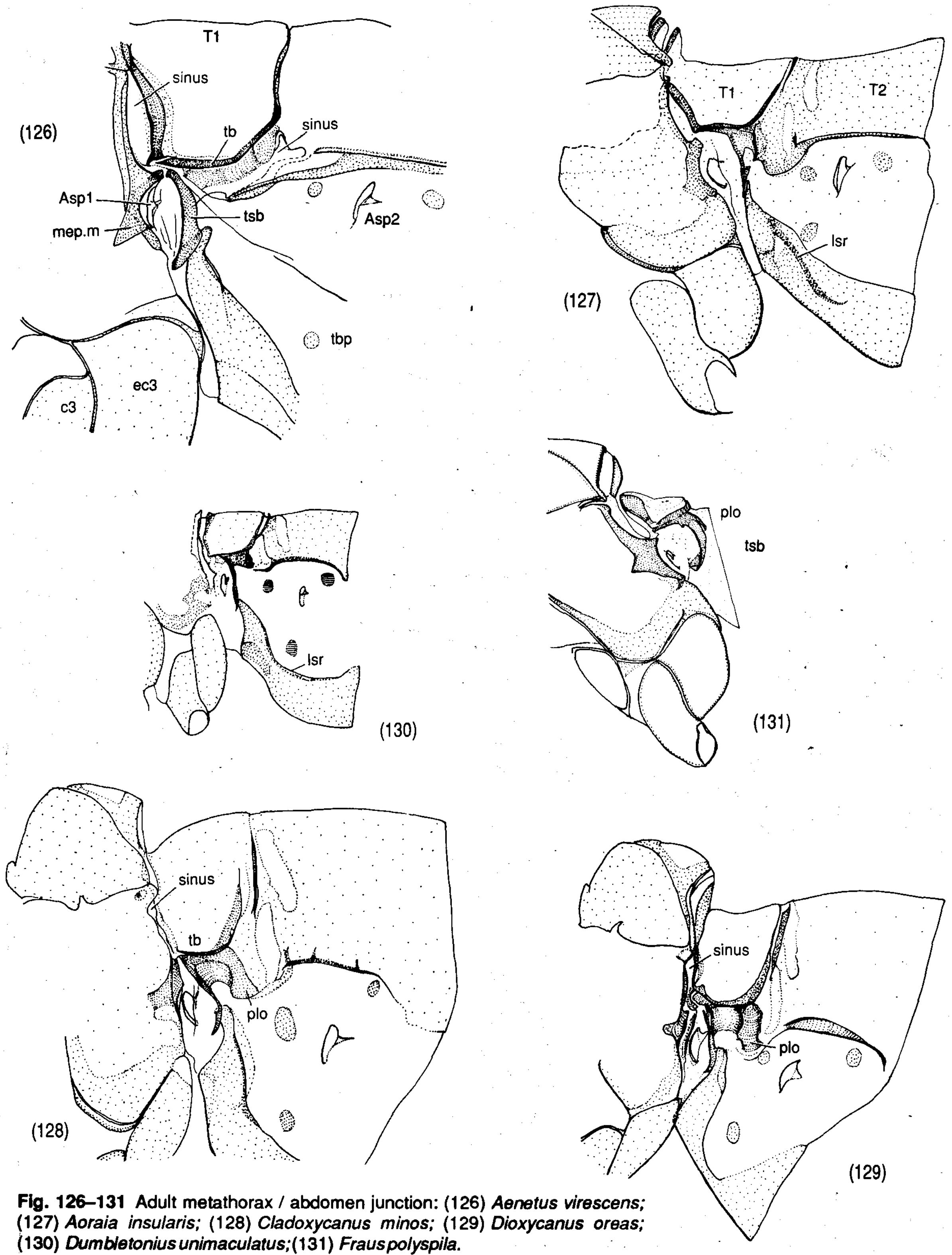
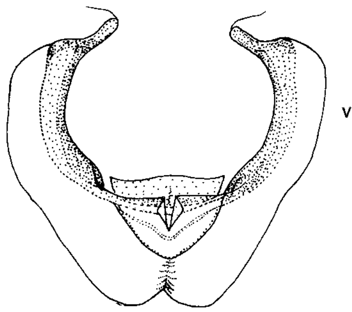
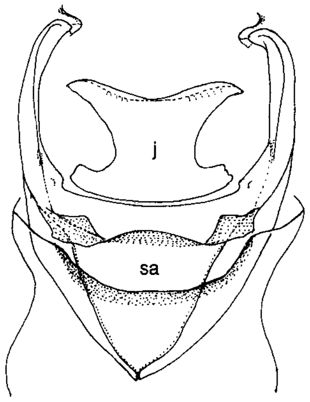


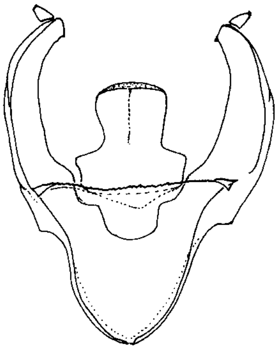
Fig. 126–131 Adult metathorax / abdomen junction: (126) *Aenetus virescens;* (127) *Aoraia insularis;* (128) *Cladoxycanus minos;* (129) *Dioxycanus oreas;* (130) *Dumbletonius unimaculatus;* (131) *Fraus polyspila.*



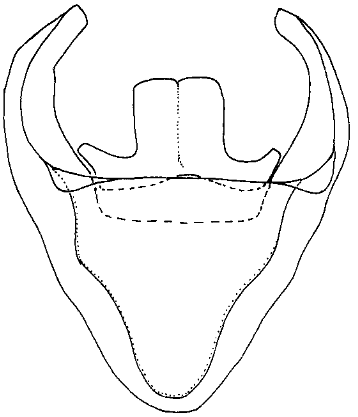
(132)



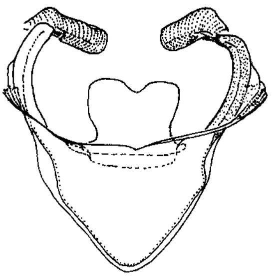
(134)



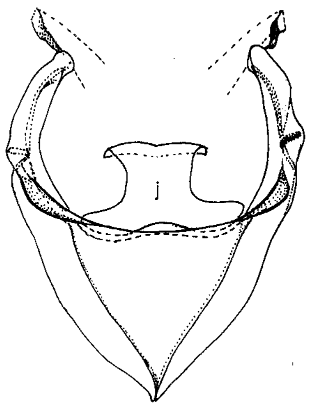
(133)



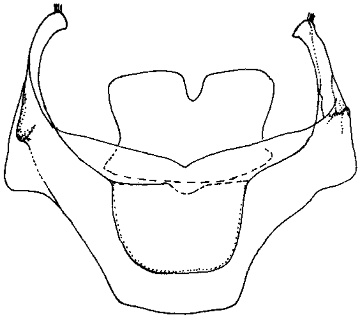
(135)



(137)



(136)



(138)

Fig. 132–138 Male genitalia,vinculum and juxta: (132) *Aenetus virescens;* (133) *Aoraia* sp.; (134) *Cladoxycanus minos;* (135) *Dioxycanus oreas;* (136) *Dumbletonius* sp.;(137) *Heloxycanus patricki;*(138) *Wiseana copularis.*

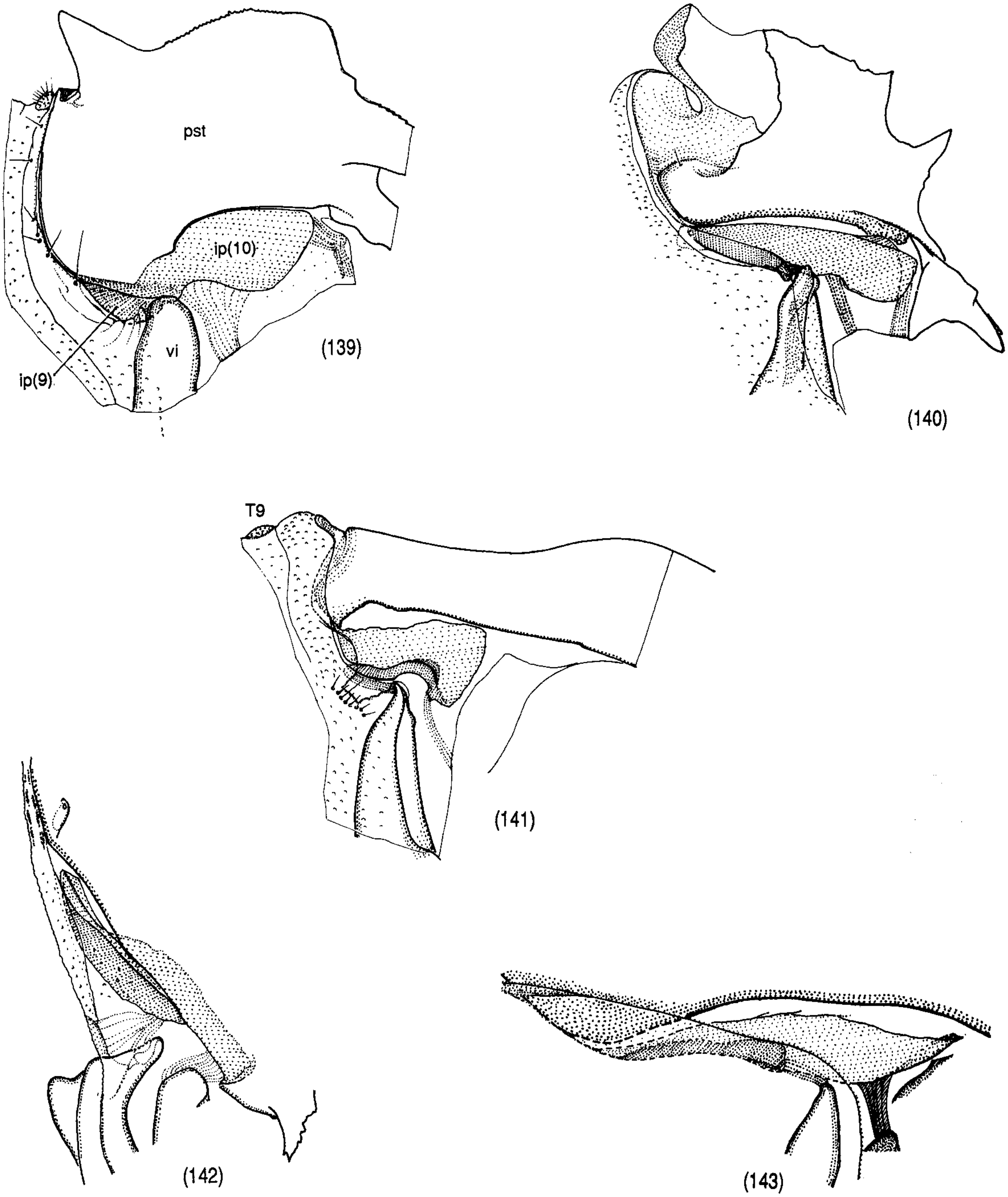


Fig. 139–143 Male genitalia, vinculum articulation, incl. intermediate plate and tegumen, lateral: (139) *Aoraia insularis*; (140) *Aenetus virescens*; (141) *Cladoxycanus minos*; (142) *Dumbletonius* sp.; (143) *Wiseana copularis.*

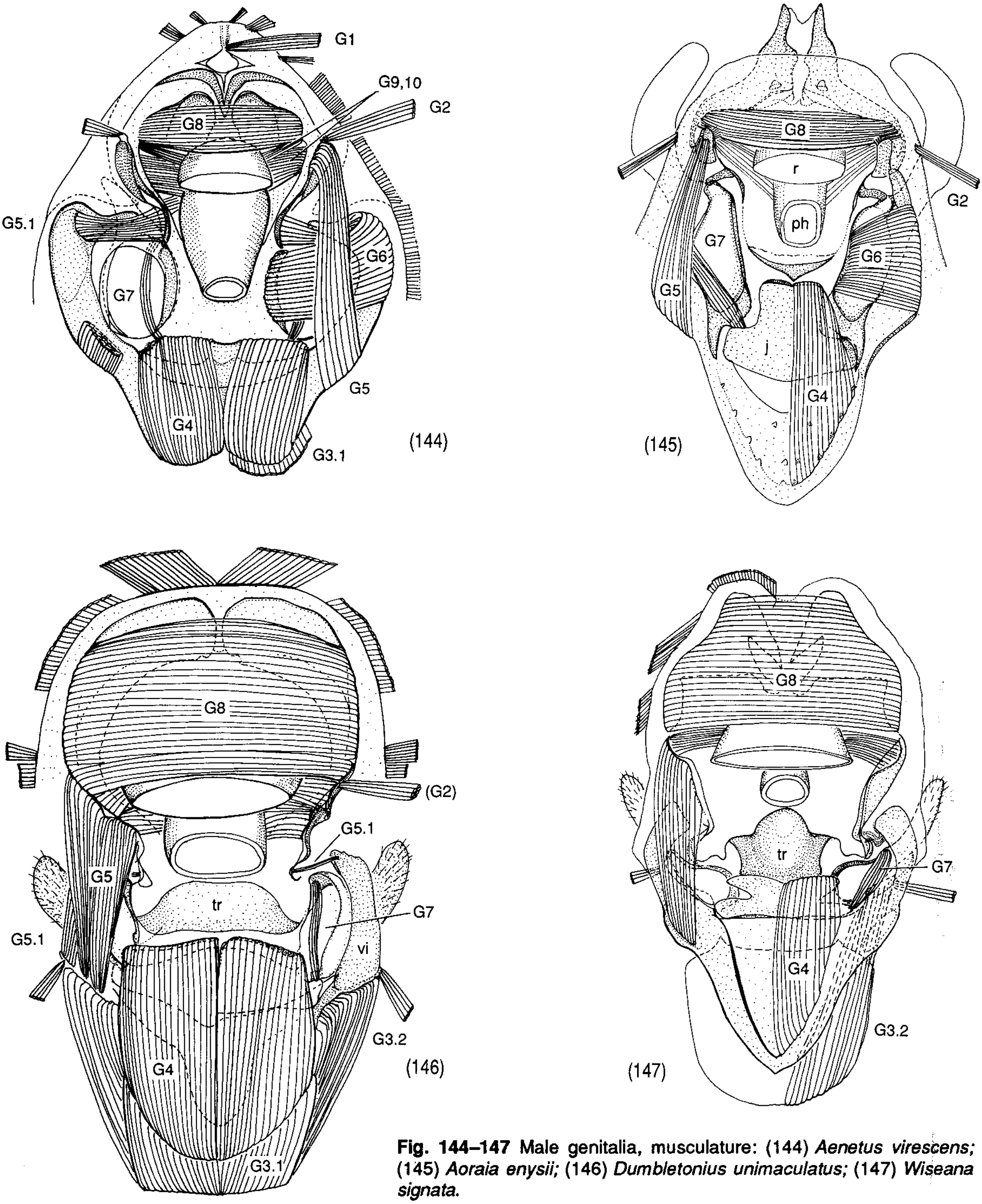
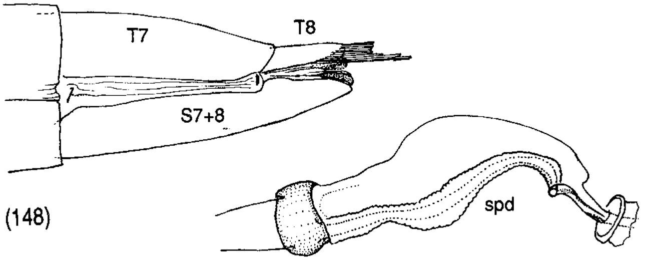
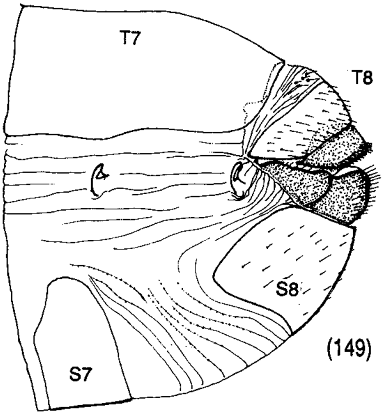


Fig. 144–147 Male genitalia, musculature: (144) *Aenetus virescens;* (145) *Aoraia enysii;* (146) *Dumbletonius unimaculatus;* (147) *Wiseana signata.*

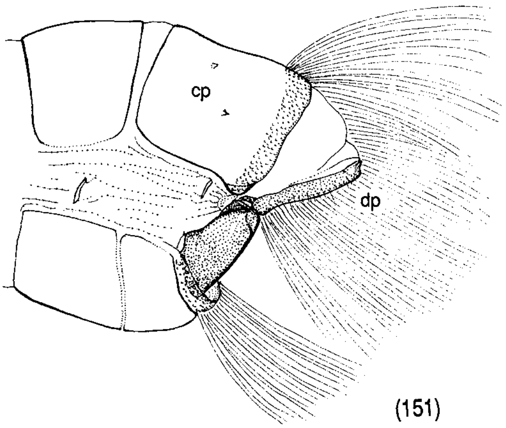


(148)

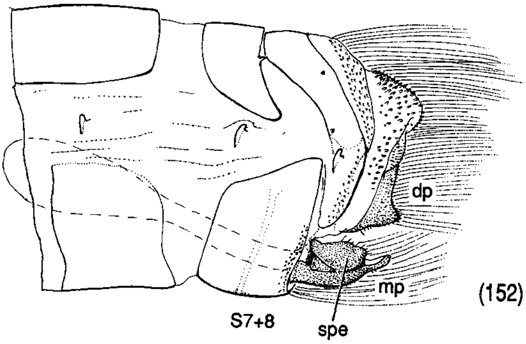
(150)



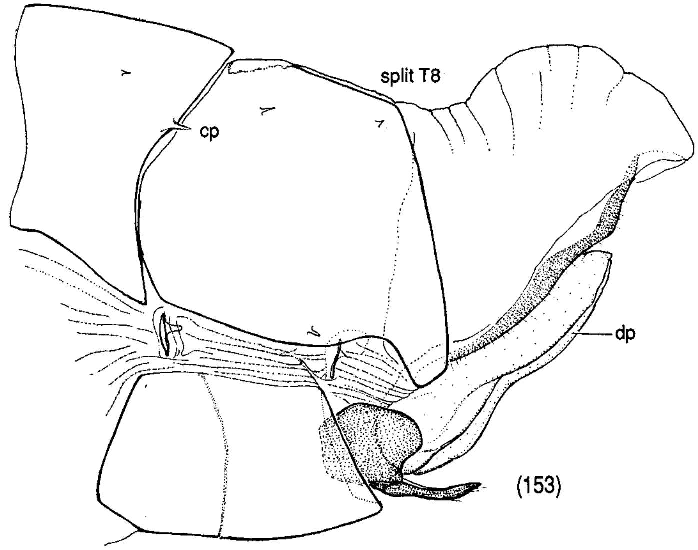
(149)



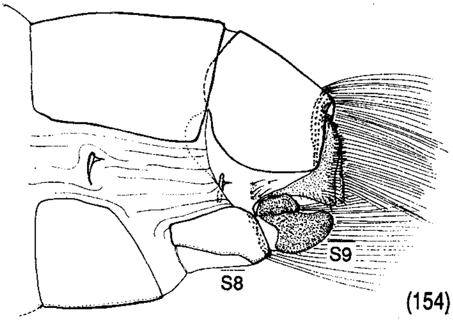
(151)



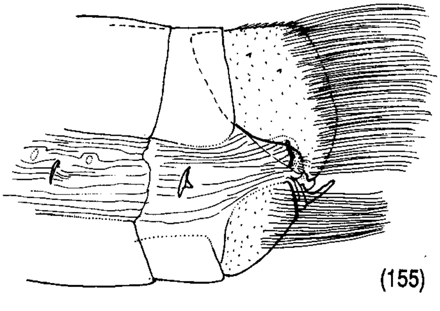
(152)



(153)

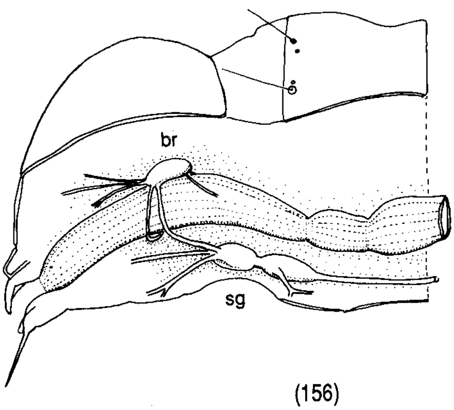


(154)

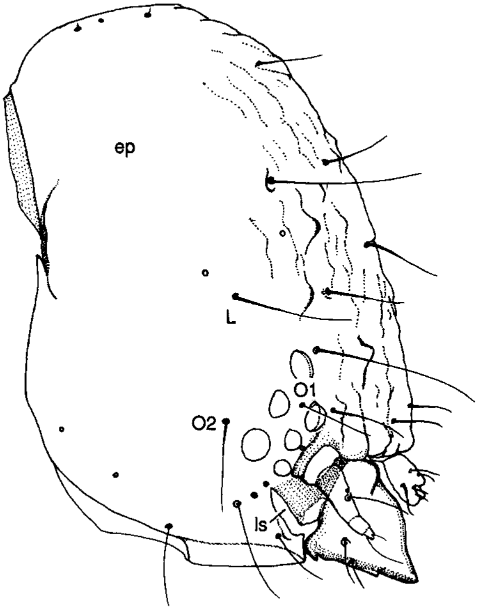


(155)

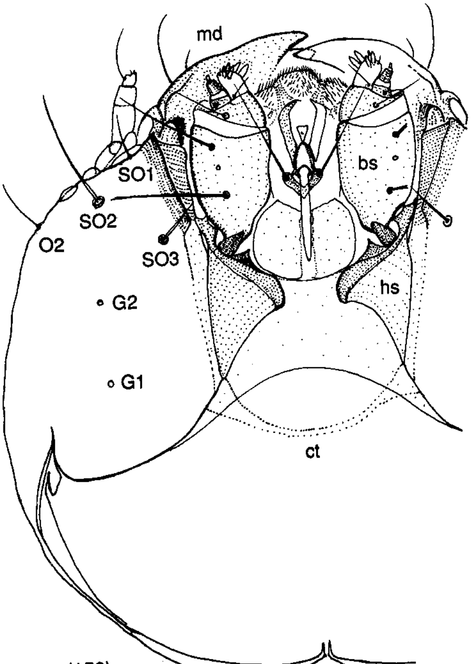
Fig. 148–155 Female postabdomen, lateral: (148) *Aenetus virescens;* (149, 150) *Aoraia orientalis,* and spermatheca; (151) *Cladoxycanus minos;* (152) *Dioxycanus oreas;* (153) *Dumbletonius unimaculatus;* (154) *Heloxycanus patricki;* (155) *Wiseana copularis.*



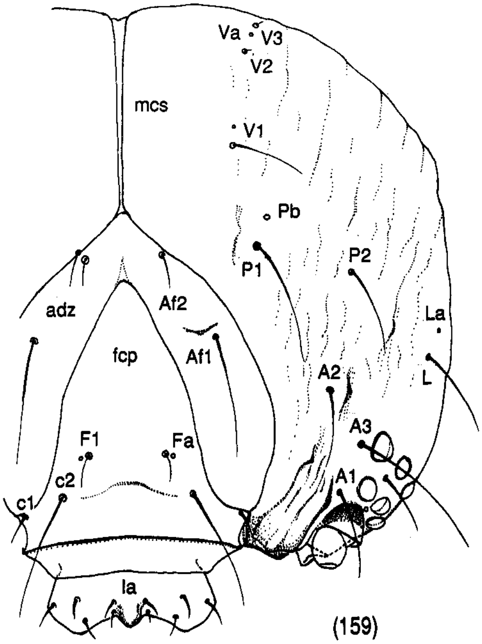
(156)



(157)



(158)



(159)

Fig. 156 Position of brain and suboesophageal ganglia, generalised hepialid larva (*Aenetus, Aoraia, Wiseana*). **157–159** Larval head capsule, *Aenetus virescens:* (157) lateral; (158) ventral; (159) anterior.

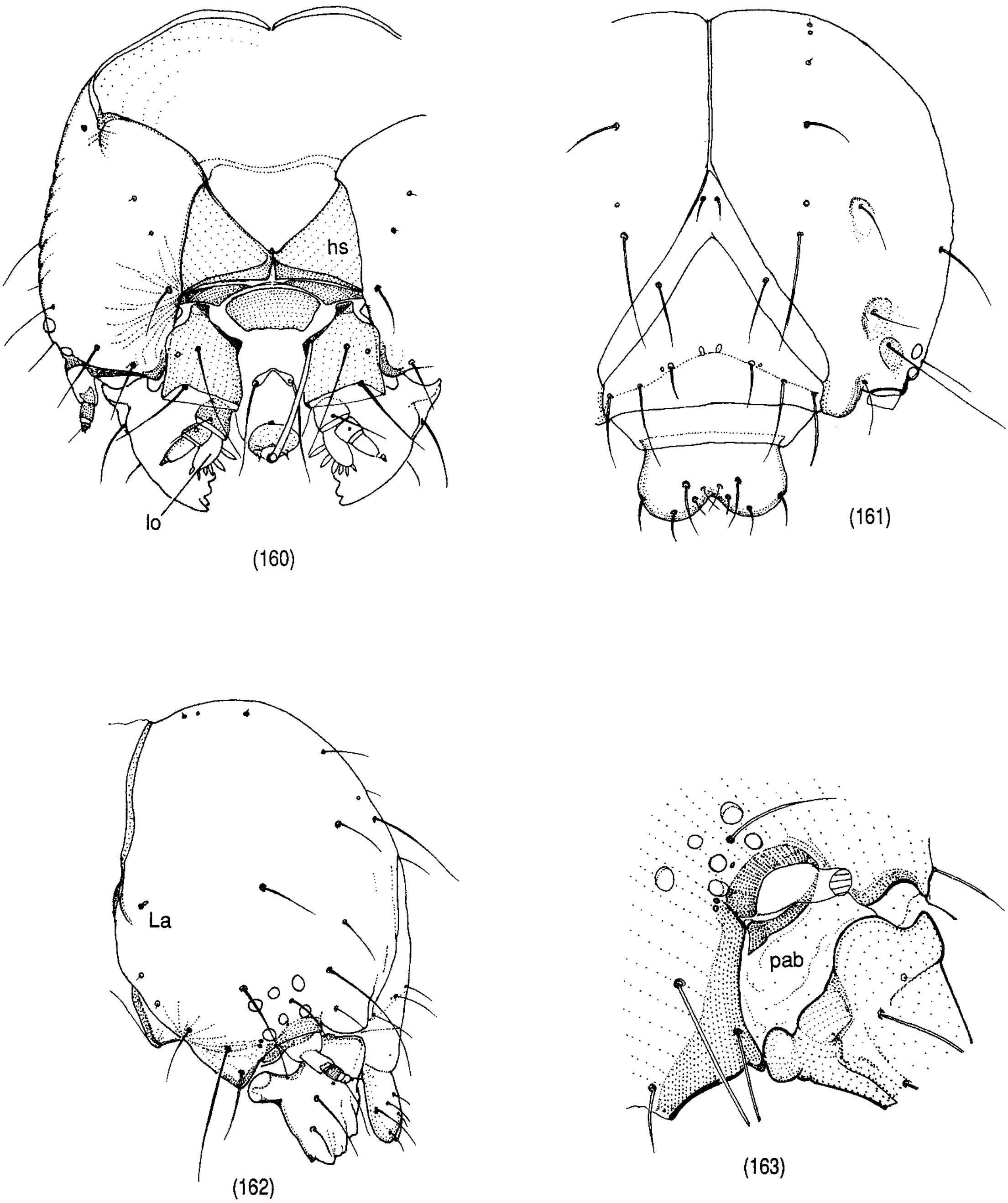
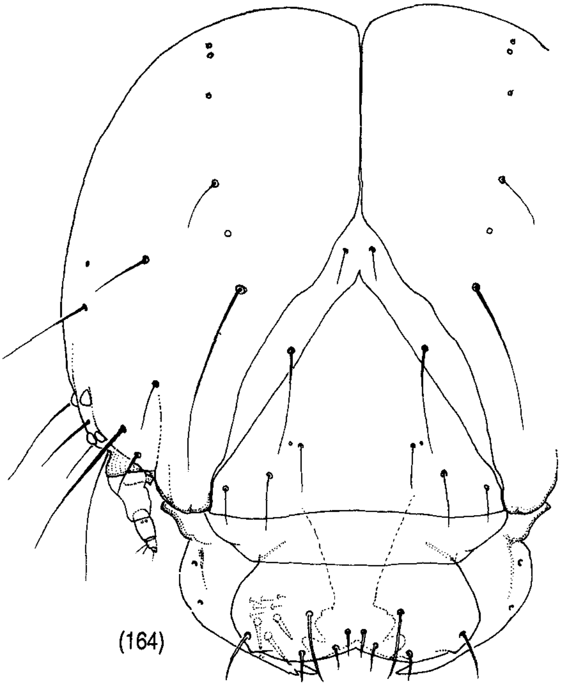
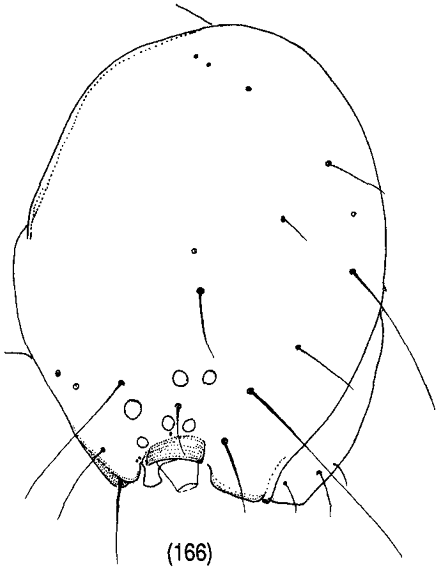
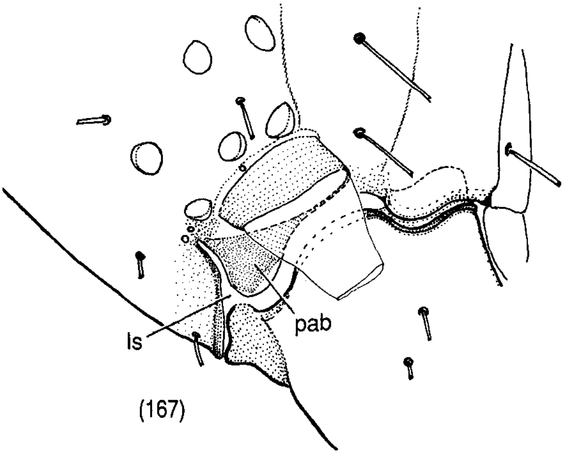


Fig. 160–163 Larval head capsule, *Aoraia insularis:* (160) ventral; (161) anterior; (162) lateral; (163) detail of oral frame, antennal slit, and preantennal bar.


(164)


(166)



(167)

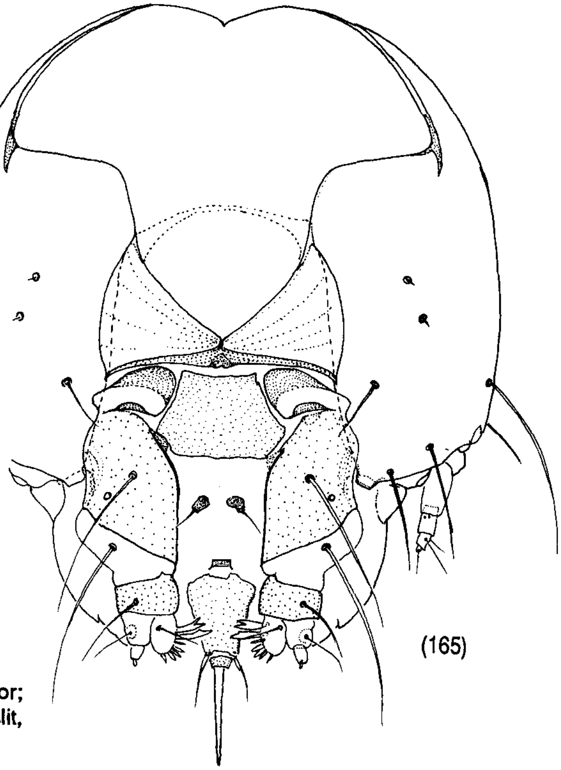
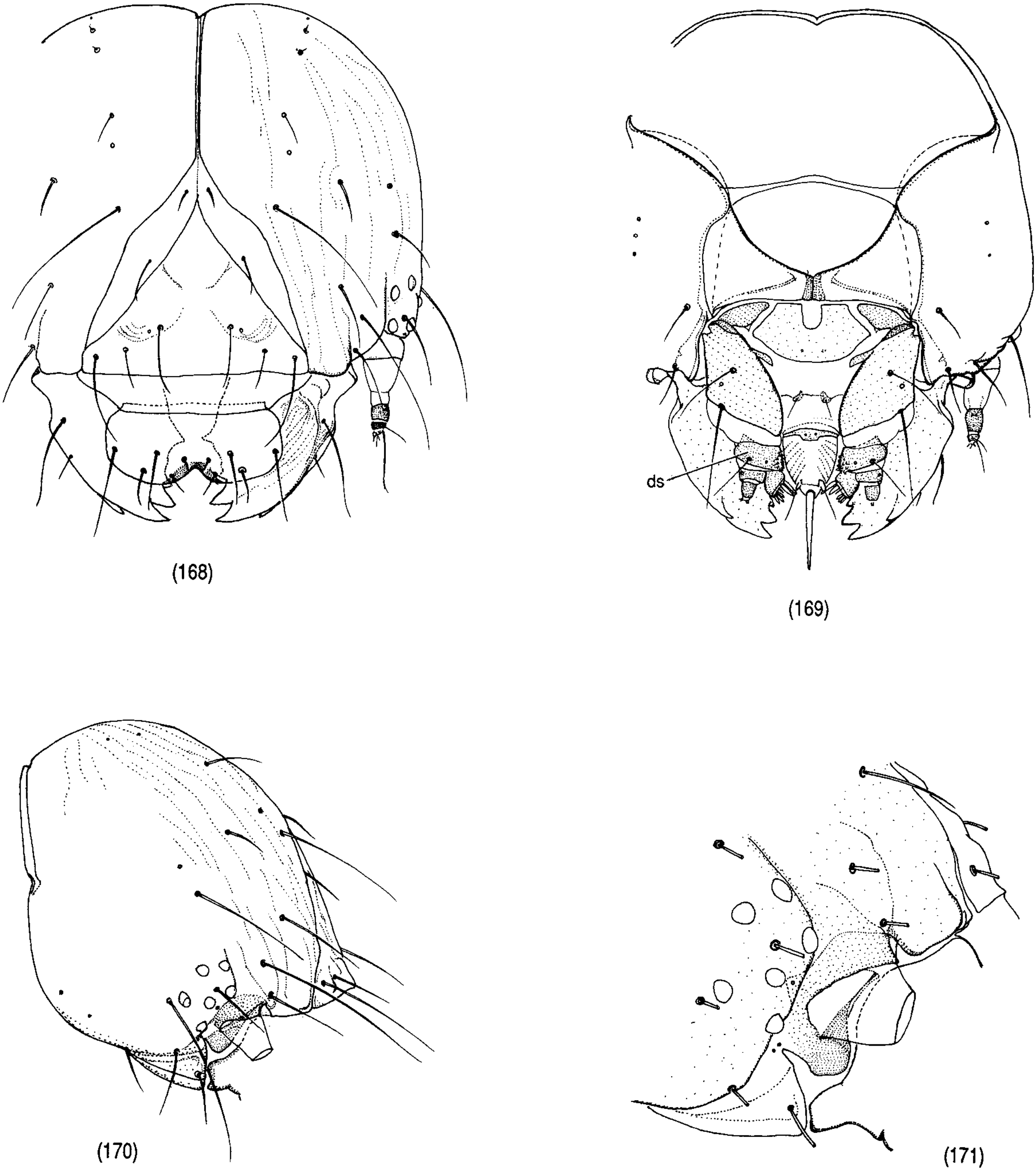

(165)

Fig. 164–167 Larval head capsule, *Cladoxycanus:* (164) anterior; (165) ventral; (166) lateral; (167) detail of oral frame, antennal slit, and preantennal bar.



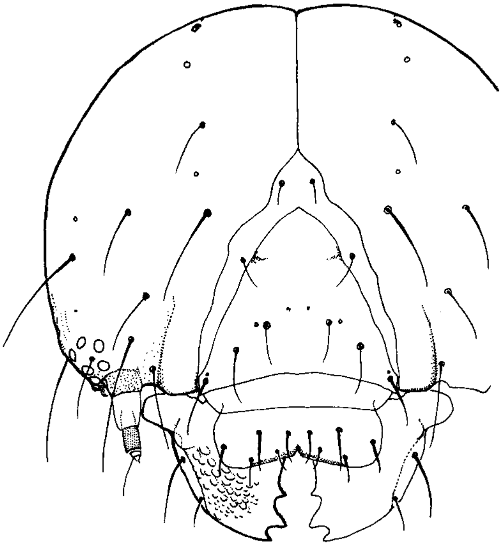
(168)

(169)

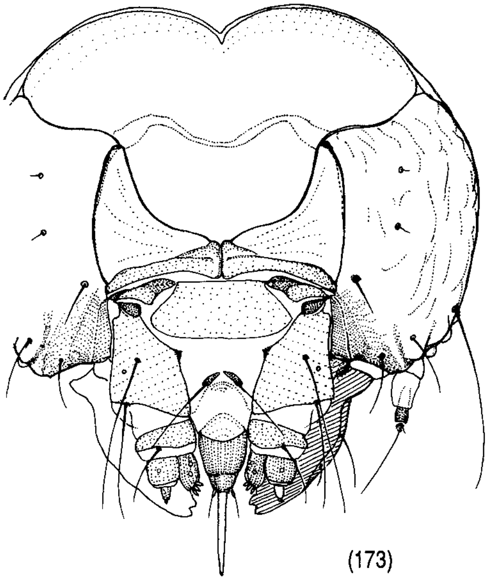
(170)

(171)

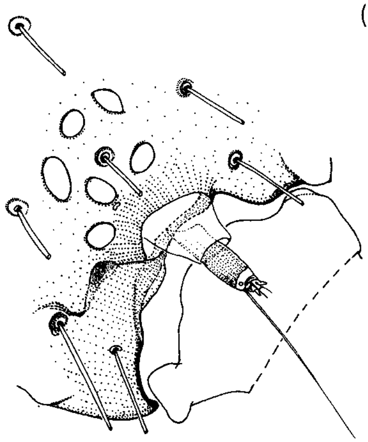
Fig. 168–171 Larval head capsule, *Dioxycanus fuscus*: (168) anterior; (169) ventral; (170) lateral; (171) detail of oral frame, antennal slit, and preantennal bar.



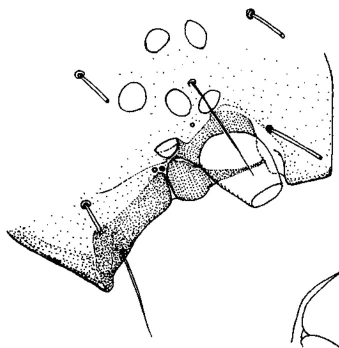
(172)



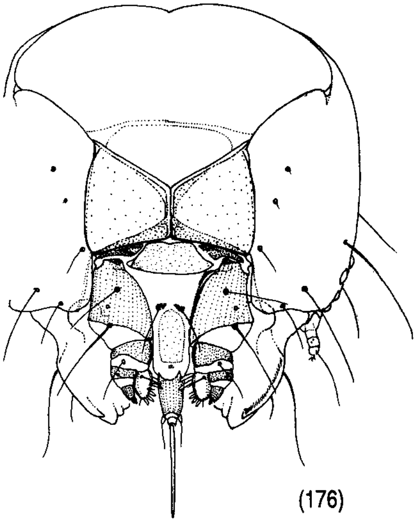
(173)



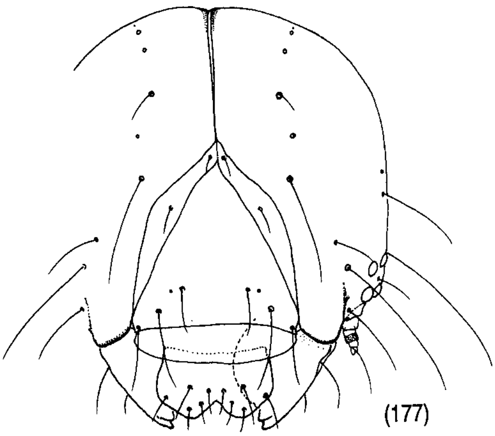
(174)



(175)

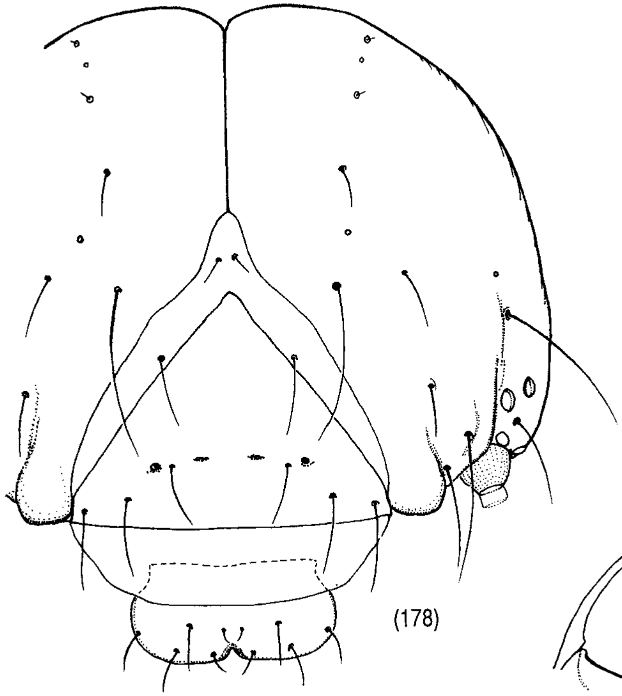


(176)

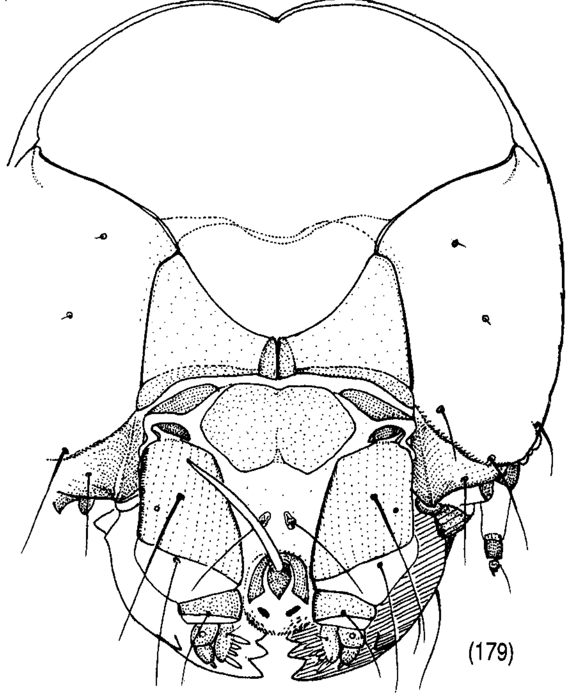


(177)

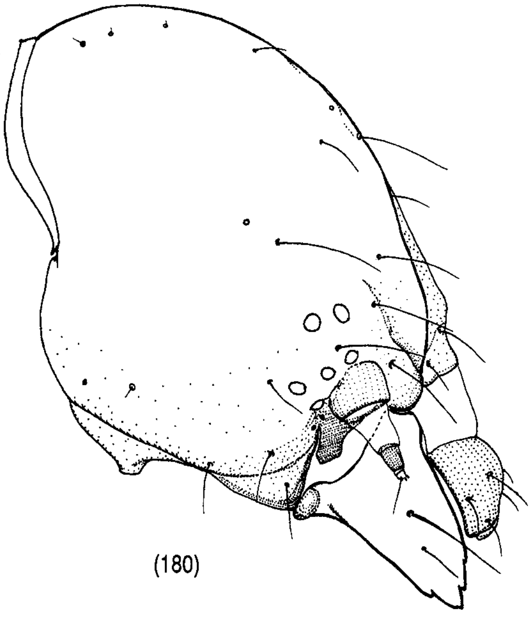
Fig. 172–177 Larval head capsule: *Dumbletonius unimaculatus* – (172) anterior; (173) ventral; (174) oral frame, occluded antennal slit; *Heloxycanus patricki* – (175) detail of oral frame, antennal slit, and preantennal bar; (176) ventral; (177) anterior.



(178)

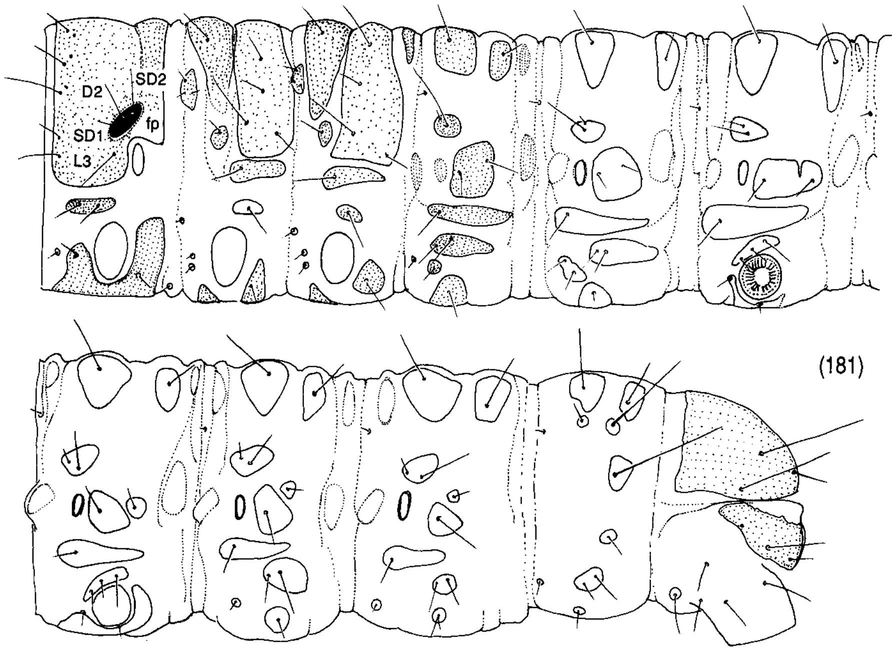


(179)

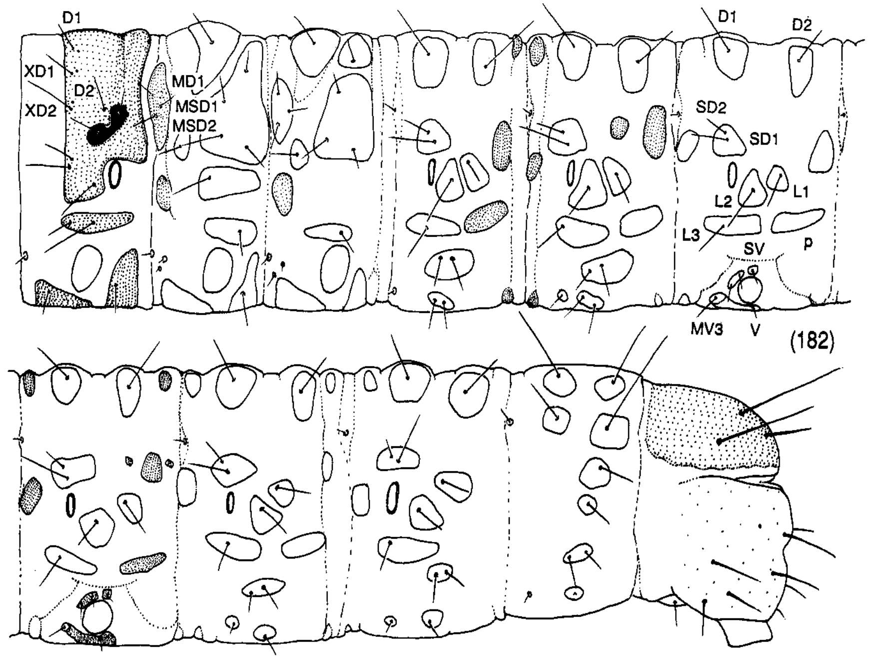


(180)

Fig. **178–180** Larval head capsule, *Wiseana cervinata:* (178) anterior; (179) ventral; (180) lateral.

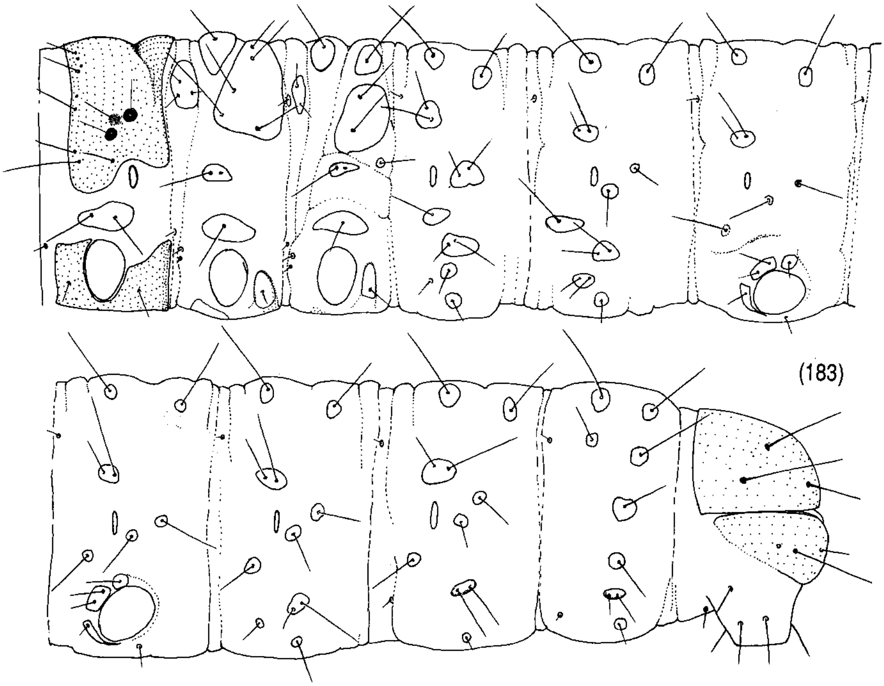


(181)



(182)

Fig. 181, 182 Larval chaetotaxy, *Aenetus virescens* and *Aoraia insularis.*


(183)

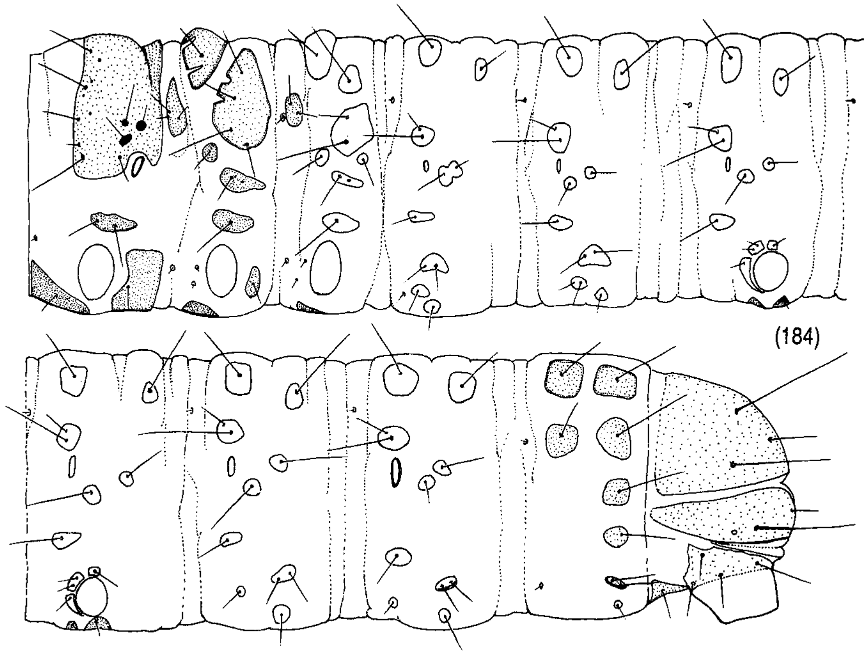
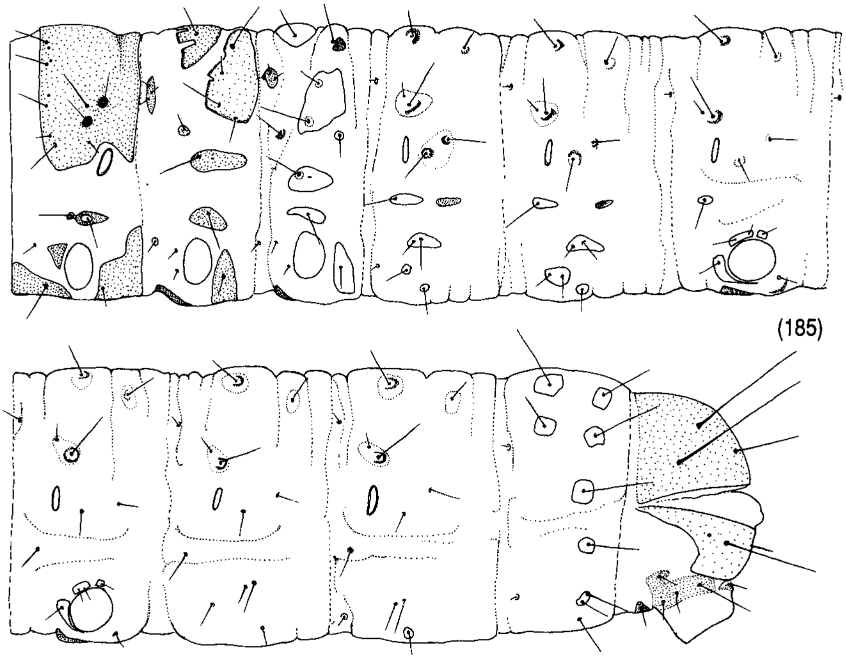
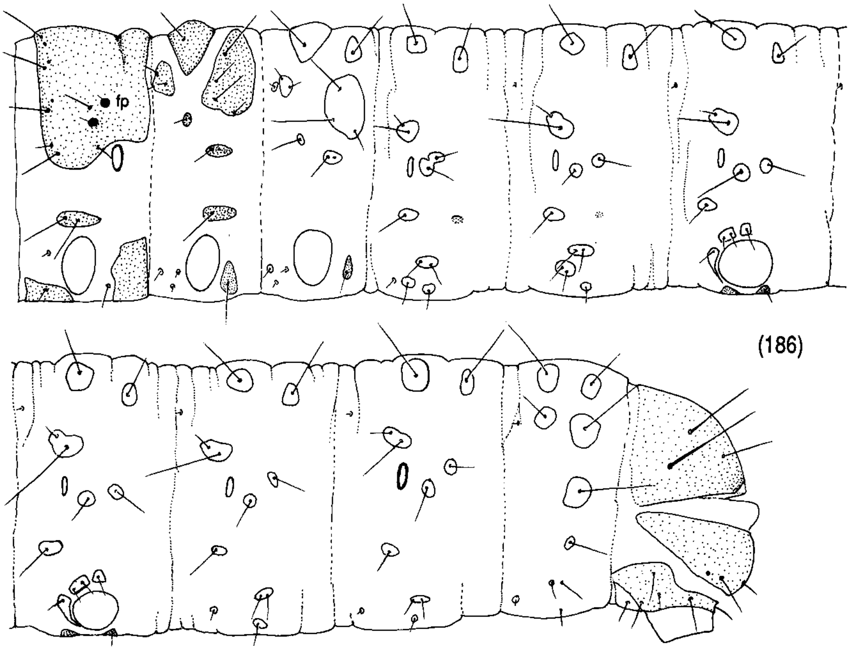

(184)

Fig. 183, 184 Larval chaetotaxy, *Cladoxycanus minos* and *Dioxycanus fuscus*.



(185)



(186)

Fig. 185, 186 Larval chaetotaxy, *Dumbletonius characterifer* (*unimaculatus*: T1 SD pits coalesced) and *Heloxycanus patricki*.

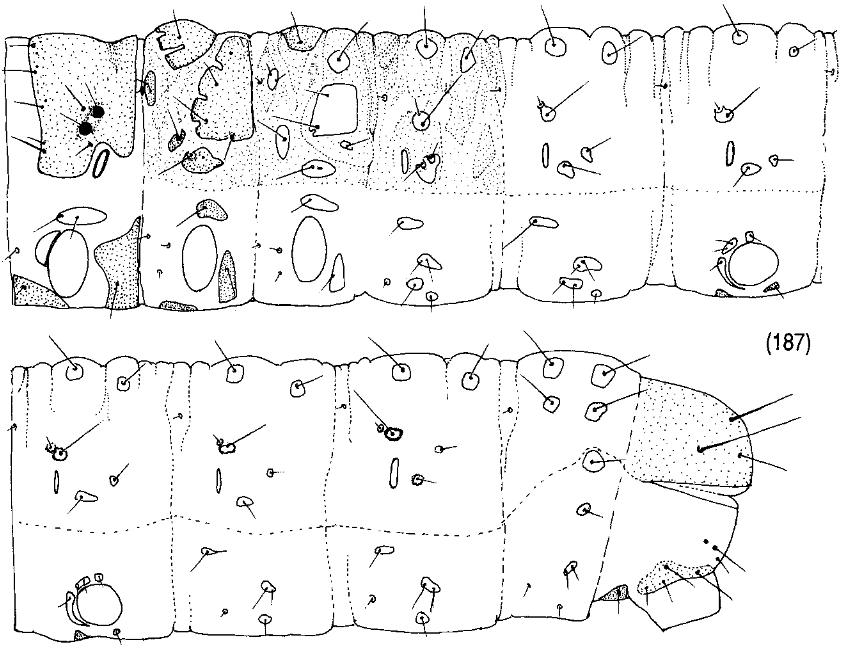


Fig. 187 Larval chaetotaxy, *Wiseana cervinata*, Ballantrae WN–WA.

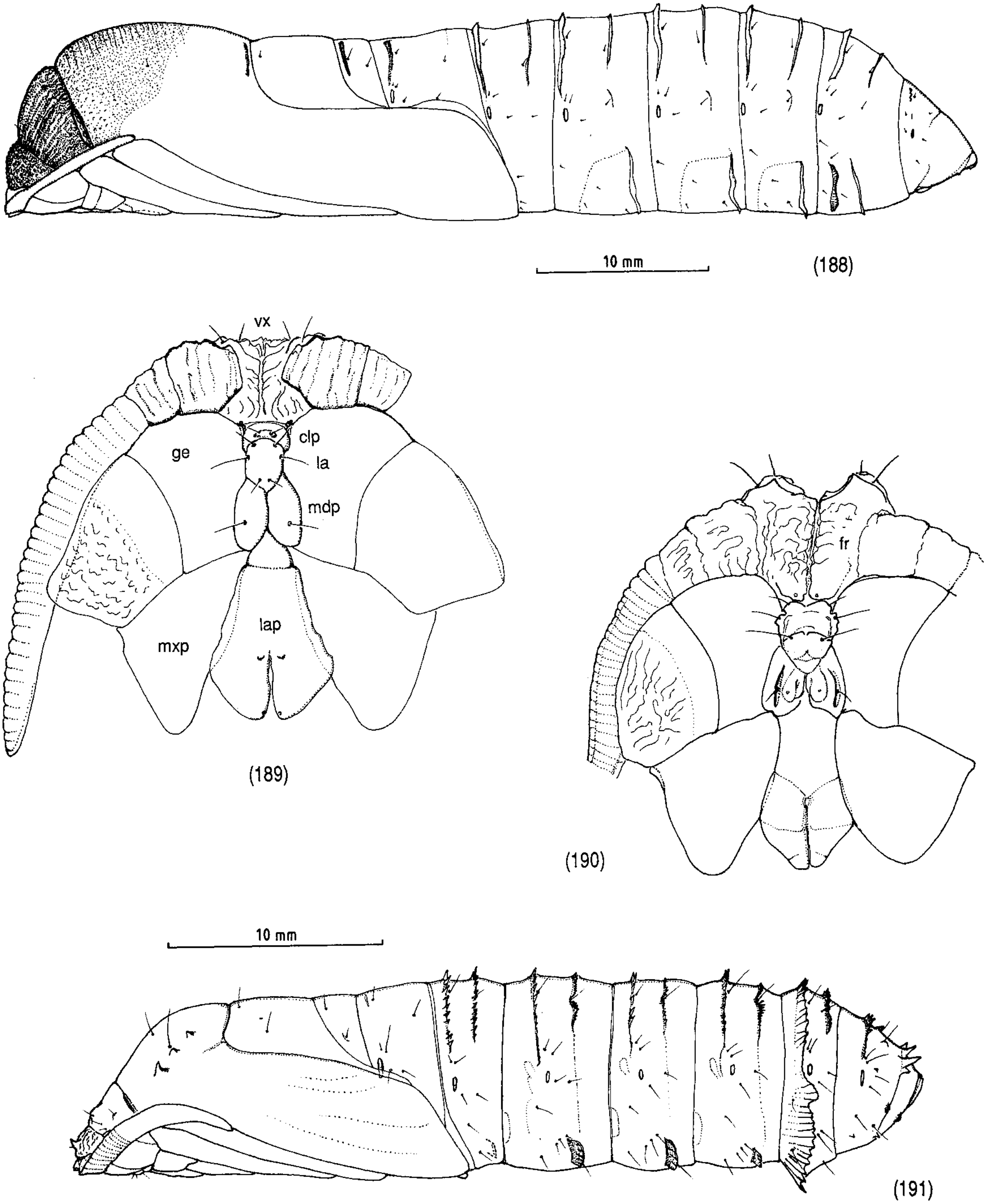


Fig. 188–191 Pupae: (188) *Aenetus virescens*, male; (189) *A. virescens*, head piece; (190) *A. mirabilis*, head piece; (191) *Aoraia insularis*.

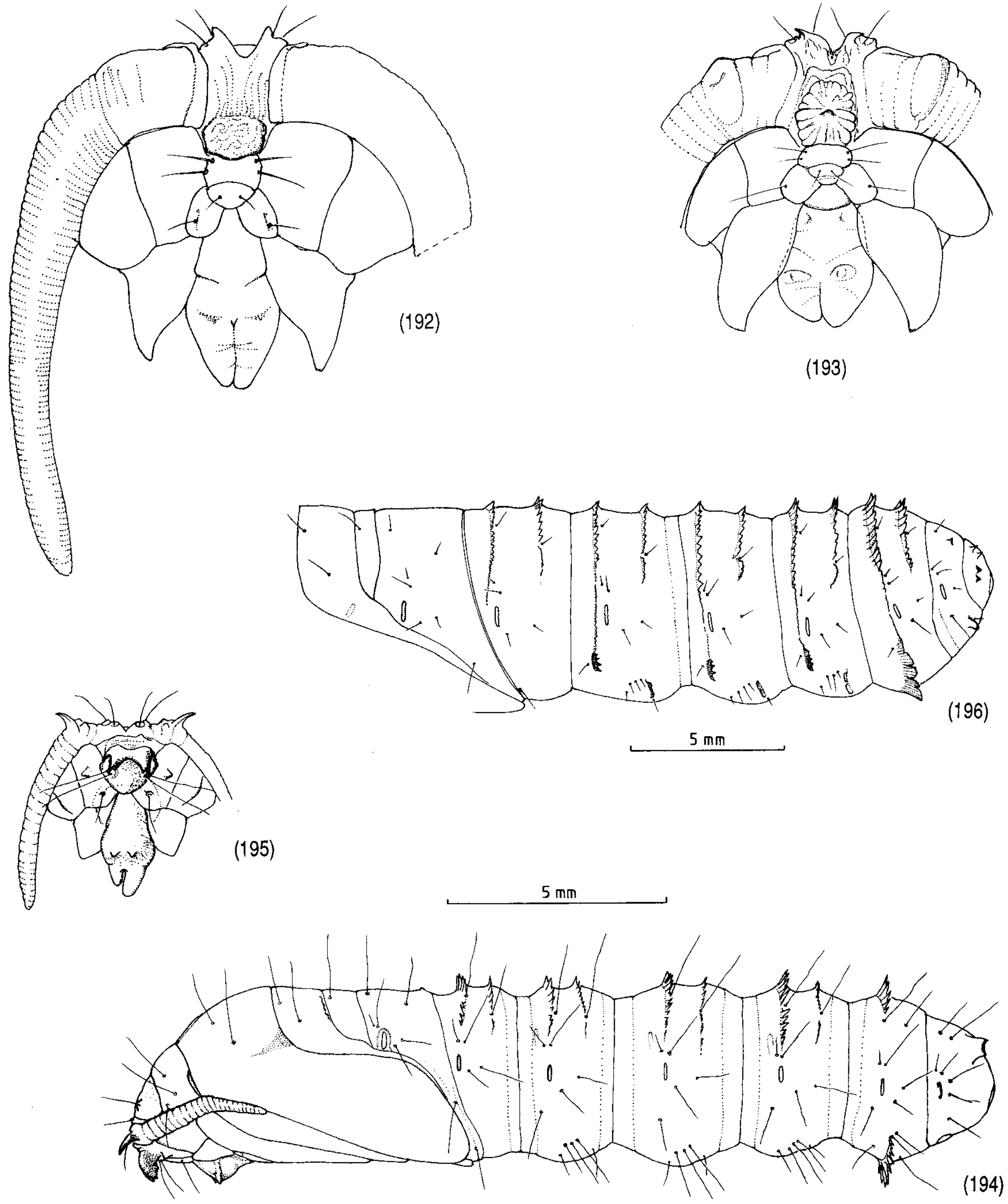


Fig. 192–196 Pupae: (192) *Aoraia insularis*, head piece; (193) *A. orientalis*, head piece; (194) *Cladoxycanus minos*; (195) *C. minos*, head piece; (196) *Dioxycanus oreas*, Tararua Ra, WN.

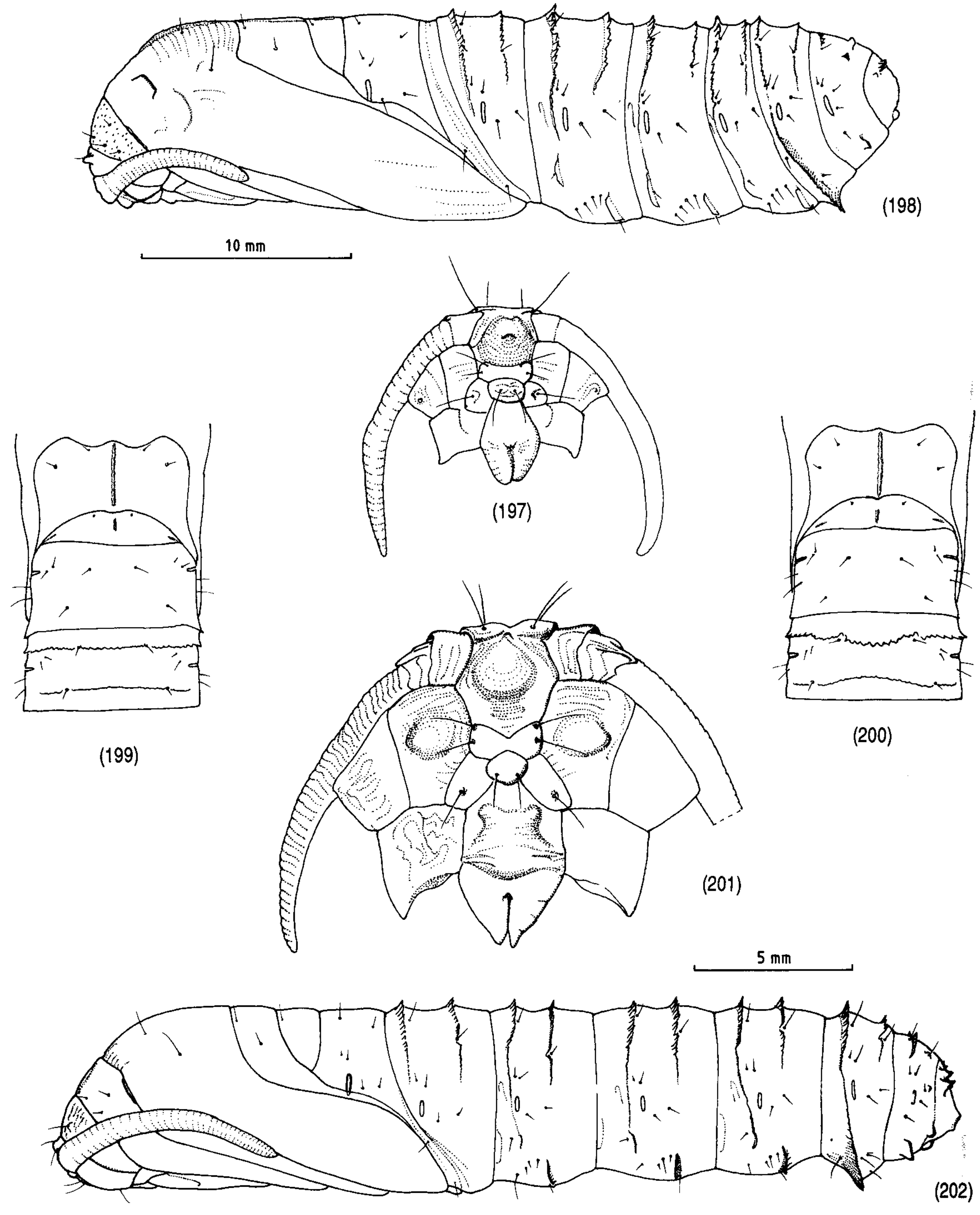


Fig. 197–202 Pupae: (197) *Dioxycanus oreas*, head piece; (198) *Dumbletonius characterifer*; (199, 200) *D. characterifer* and *D. unimaculatus*, T3, A1–A3, dorsal; (201) *D. characterifer*, head piece; (202) *Heloxycanus patricki*, Great Moss Swamp CO.

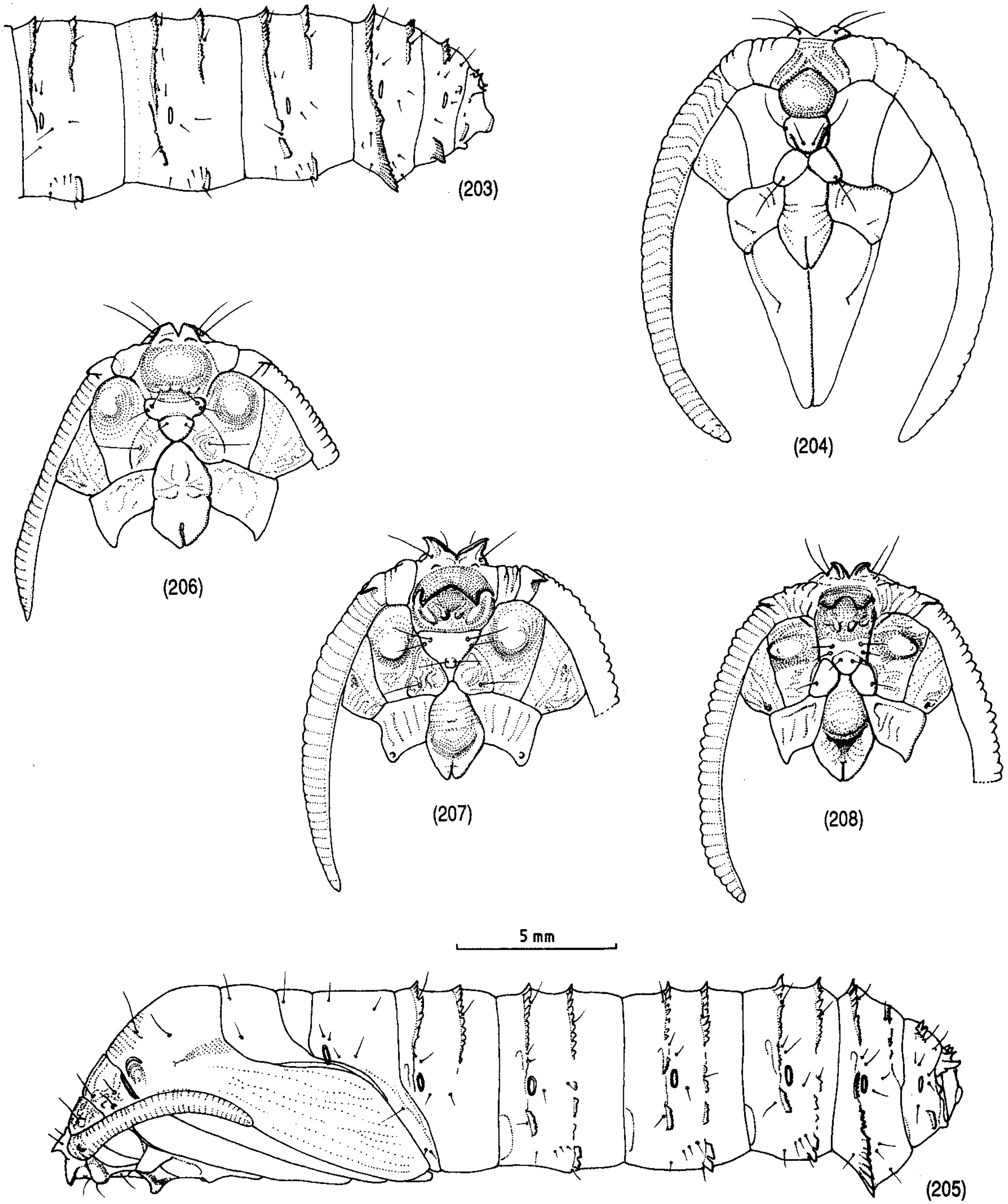


Fig. 203–208 Pupae: (203) *Heloxycanus patricki*, A4–A10, Seaward Moss SL; (204) *H. patricki*, head piece, Great Moss Swamp, CO; (205) *Wiseana cervinata*, Lincoln MC; (206) *W. umbraculata*, head piece, Waimakarua DN; (207) *W. copularis*, head piece, Riccarton MC; (208) *W. cervinata*, head piece, Lincoln MC.

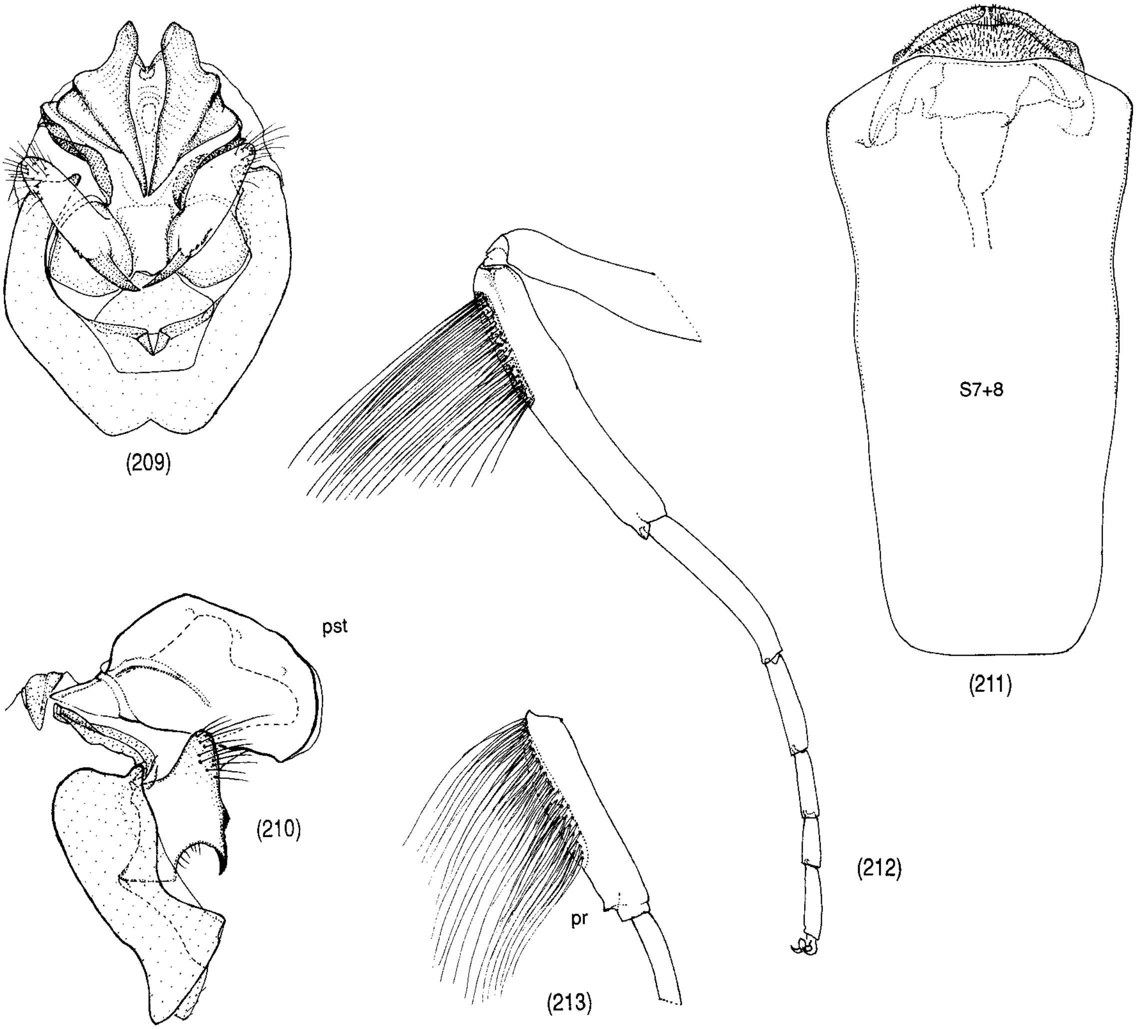


Fig. 209–212 *Aenetus virescens:* (209, 210) male genitalia, posterior and lateral; (211) female postabdomen, ventral; (212) male hind tibia. **213** *A. ligniveren*, male hind tibia.

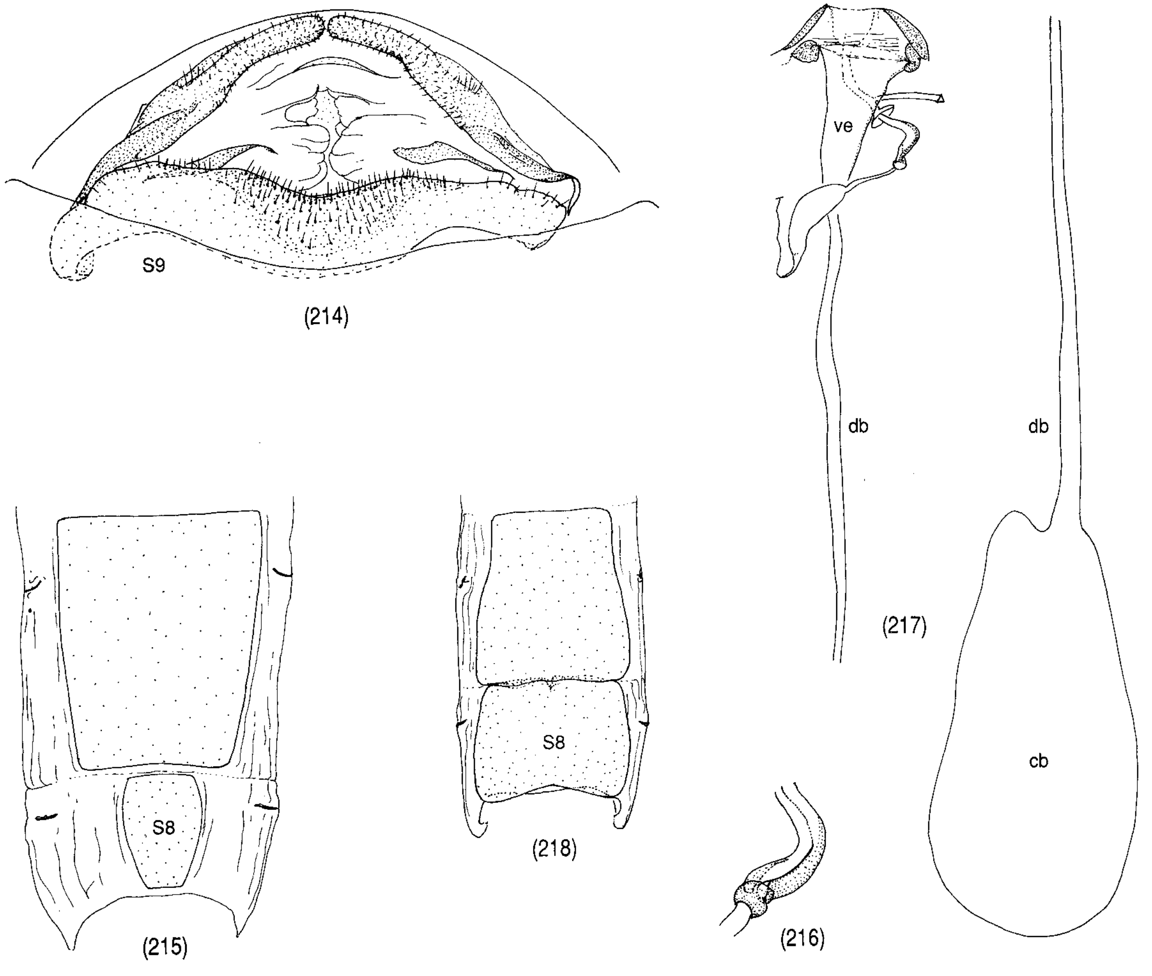


Fig. 214–217 *Aenetus virescens:* (214) female anogenital field; (215) male S7 and S8; (216) female, spermatheca, detail; (217) bursa copulatrix. **Fig. 218** *A. ligniveren,* male S7 and S8.

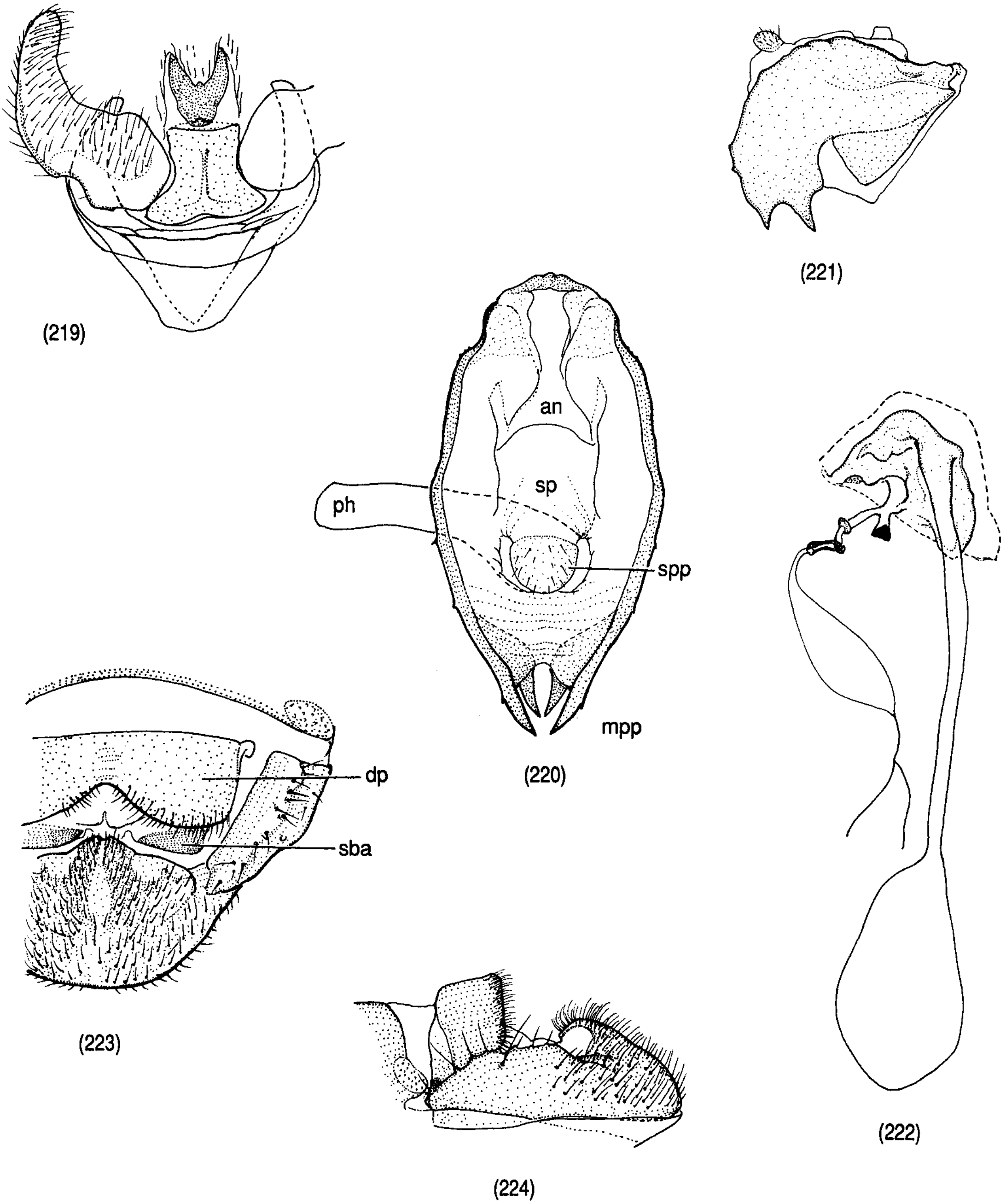


Fig. 219–224 *Aoraia aspina*: male – (219) trulleum, juxta, valvae, vinculum, saccus; (220, 221) pseudotegumen and phallocrypt, dorsal and lateral; female – (222) bursa copulatrix; (223, 224) postabdomen, dorsal and lateral.

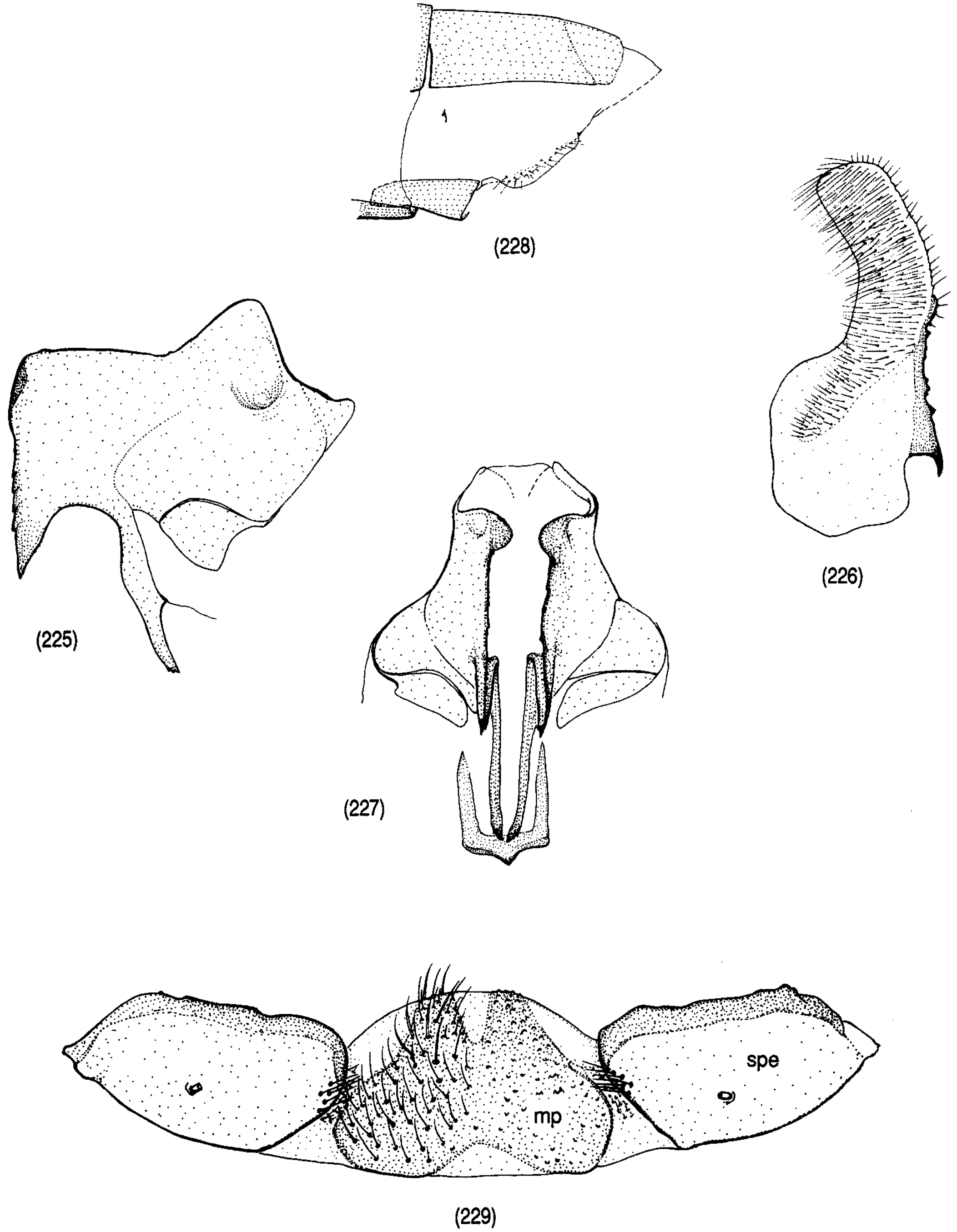


Fig. 225–229 *Aoraia aurimaculata:* male – (225) pseudotegumen, lateral; (226) valva; (227) pseudotegumen and trulleum, posterior; (228) A8, with chitinised intersegmental lateral strip; female – (229) S9.

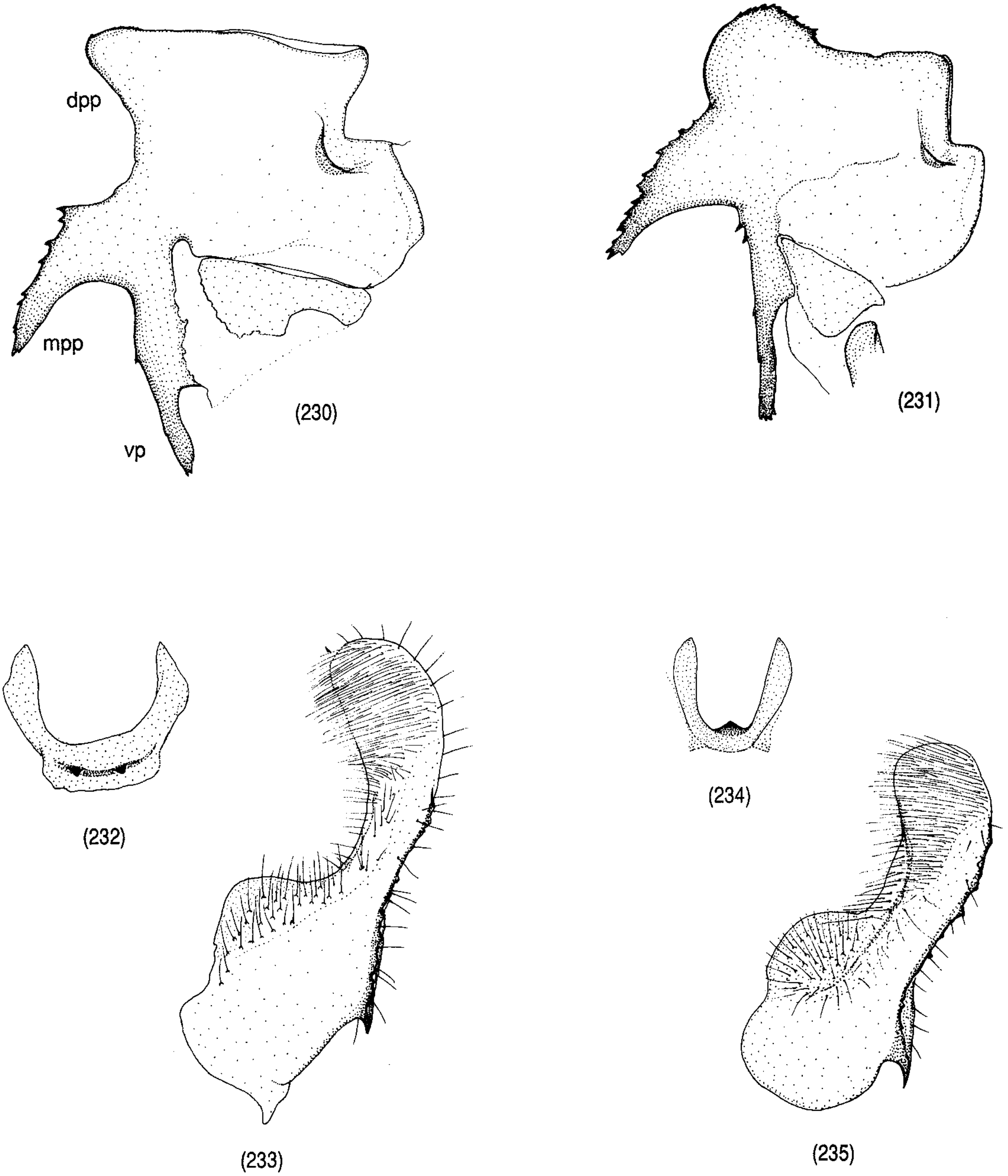
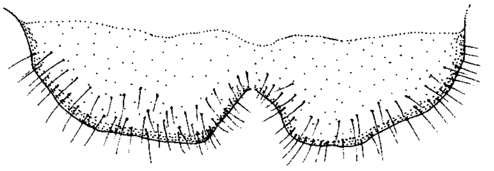
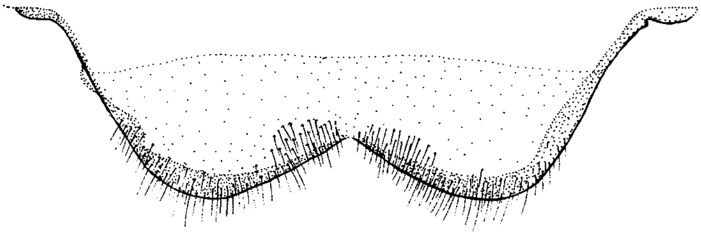


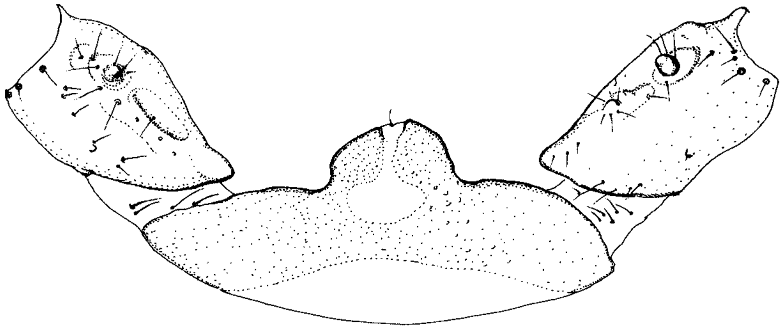
Fig. 230–235 *Aoraia dinodes*, male: (230, 231) pseudotegumen, lateral, topotype and Mt Cook; (232, 233) trulleum, Invercargill and Mt Cook; (234, 235) valva, Invercargill and Mt Cook.



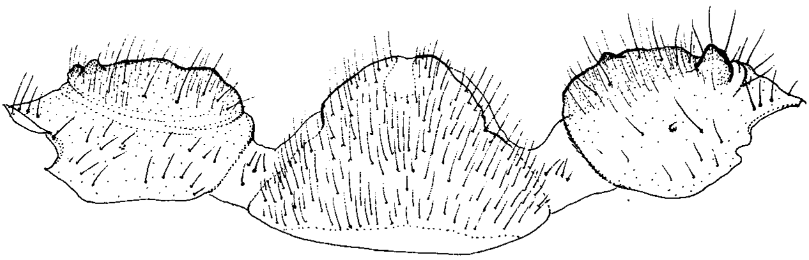
(236)



(237)



(238)



(239)

Fig. 236–239 *Aoraia dinodes*, female: (236, 237) dorsal plate, and (238, 239) S9, topotype and Franz Josef WD.

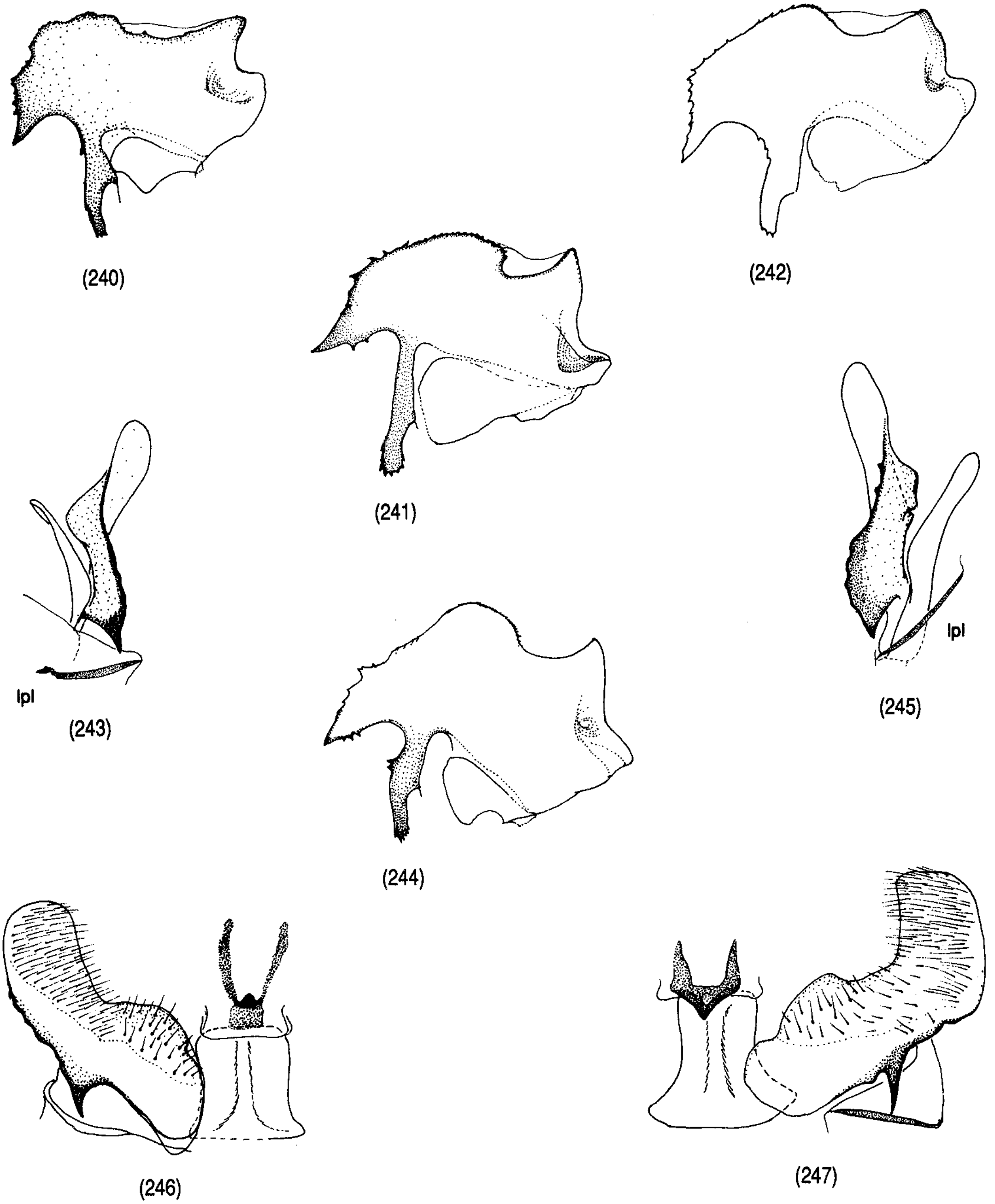


Fig. 240–247 *Aoraia enysii*, male: (240–243) pseudotegumen – Mahuia Camp TO (*enysii* topotype), Mt Arthur NN (*leonina* topotype), Rimutaka Saddle WN, and Canavans Knob WD; (244, 245) valva and intersegmental strip, lateral Mahuia Camp and Mt Arthur; (246, 247) valva, intersegmental strip, trulleum, and juxta, Mahuia Camp and Mt Arthur.

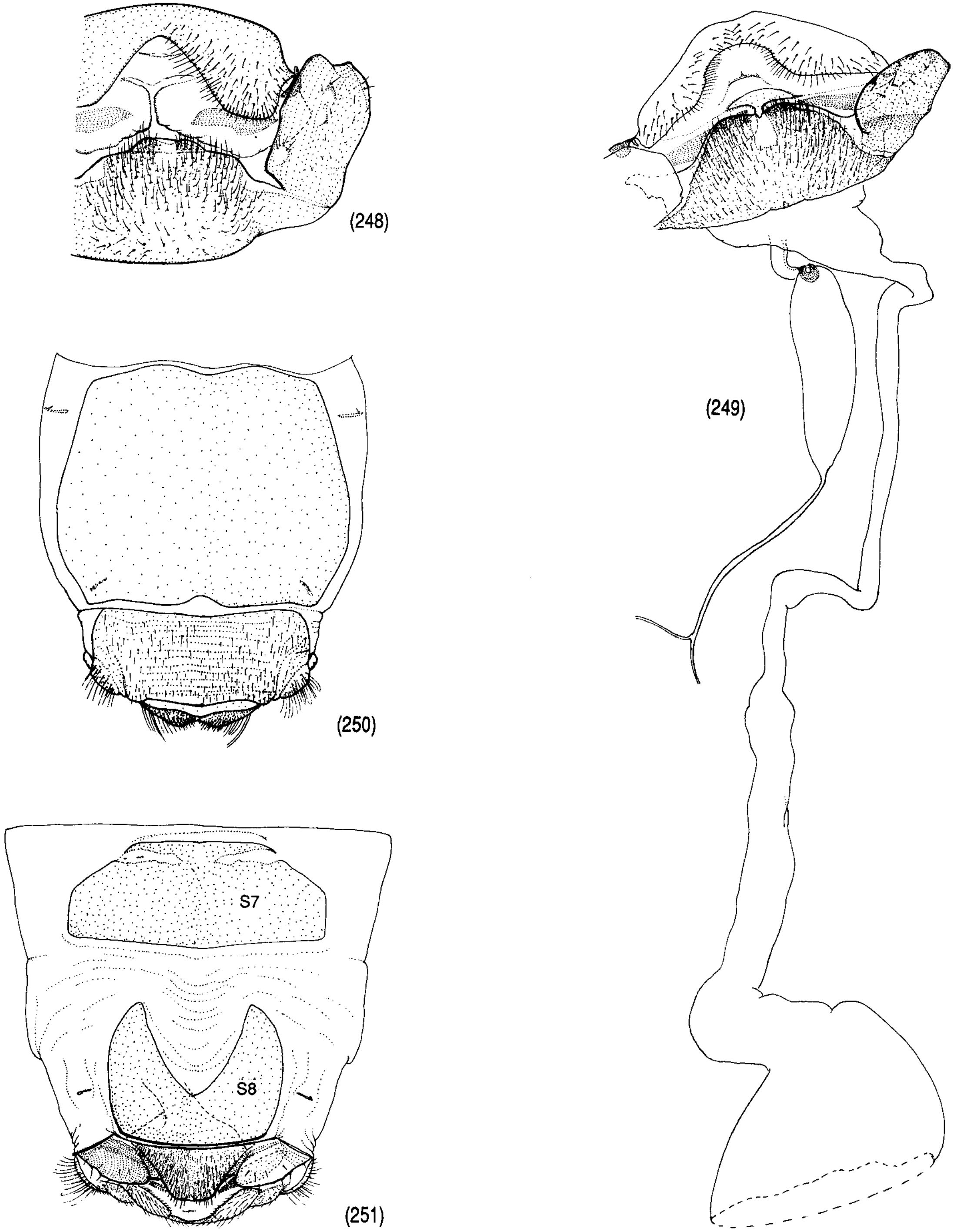


Fig. 248–251 *Aoraia enysii*,fe male: (248) anogenital field, Mt Arthur NN (*leonina* topotype); (249) anogenita field and bursa copulatrix, Mt Taranaki TK; (250, 251) postabdomen, dorsal (T7, T8) and ventral (S7, S8).

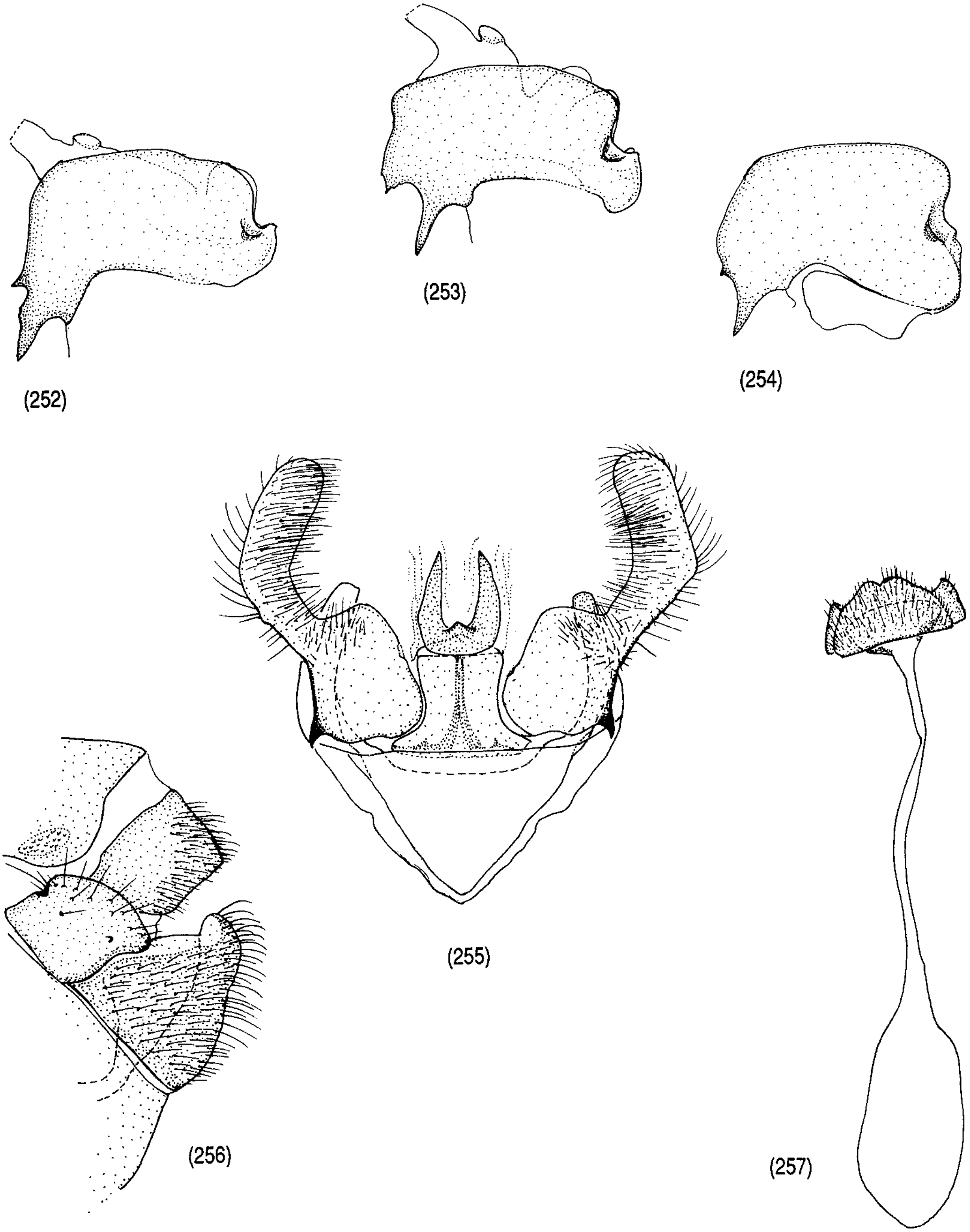
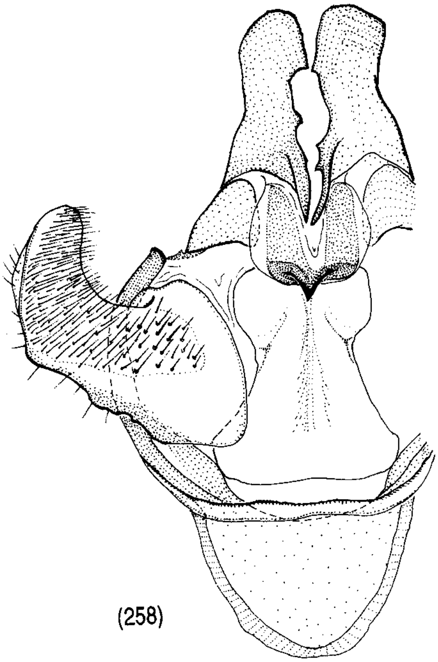
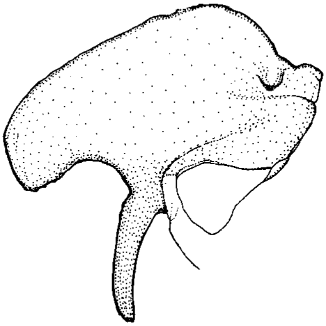


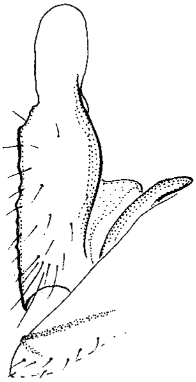
Fig. 252–257 *Aoraia flavida:* male – (252–254) pseudotegumen, lateral, Umbrella Mtns CO, ditto, and Ajax Swamp SL; (255) trulleum, juxta, valva, and vinculum/saccus, Umbrella Mtns female – (256) postabdomen, lateral; (257) bursa copulatrix and S9, ventral.



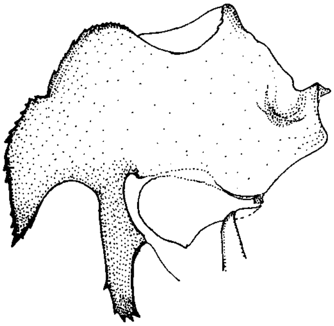
(258)



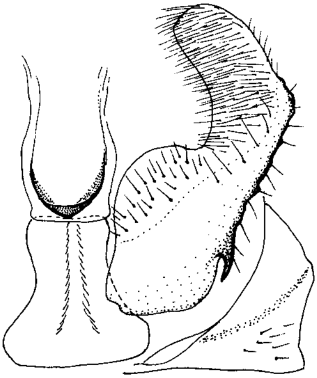
(259)



(261)



(260)



(262)

Fig. 258, 259 *Aoraia hespera*, male: (258) genitalia, posterior; (259) pseudotegumen, lateral. **260–262** *A. insularis*, male: (260) pseudotegumen, lateral; (261) valva, lateral; (262) trulleum, juxta, valva, and intersegmental strip.

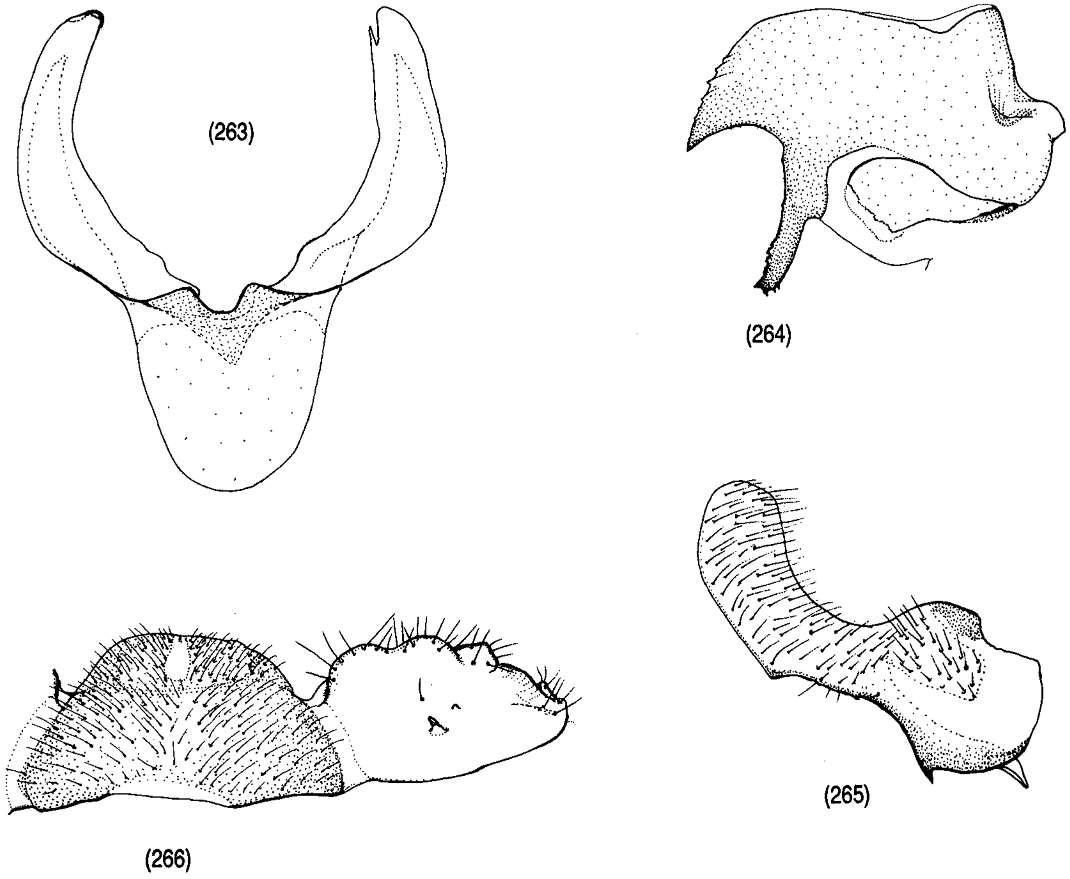


Fig. 263–266 *Aoraia lenis*, Camp Creek MC: male – (263) vinculum/saccus; (264) pseudotegumen, lateral; (265) valva, face view; female – (266) S9, mid piece and right side piece.

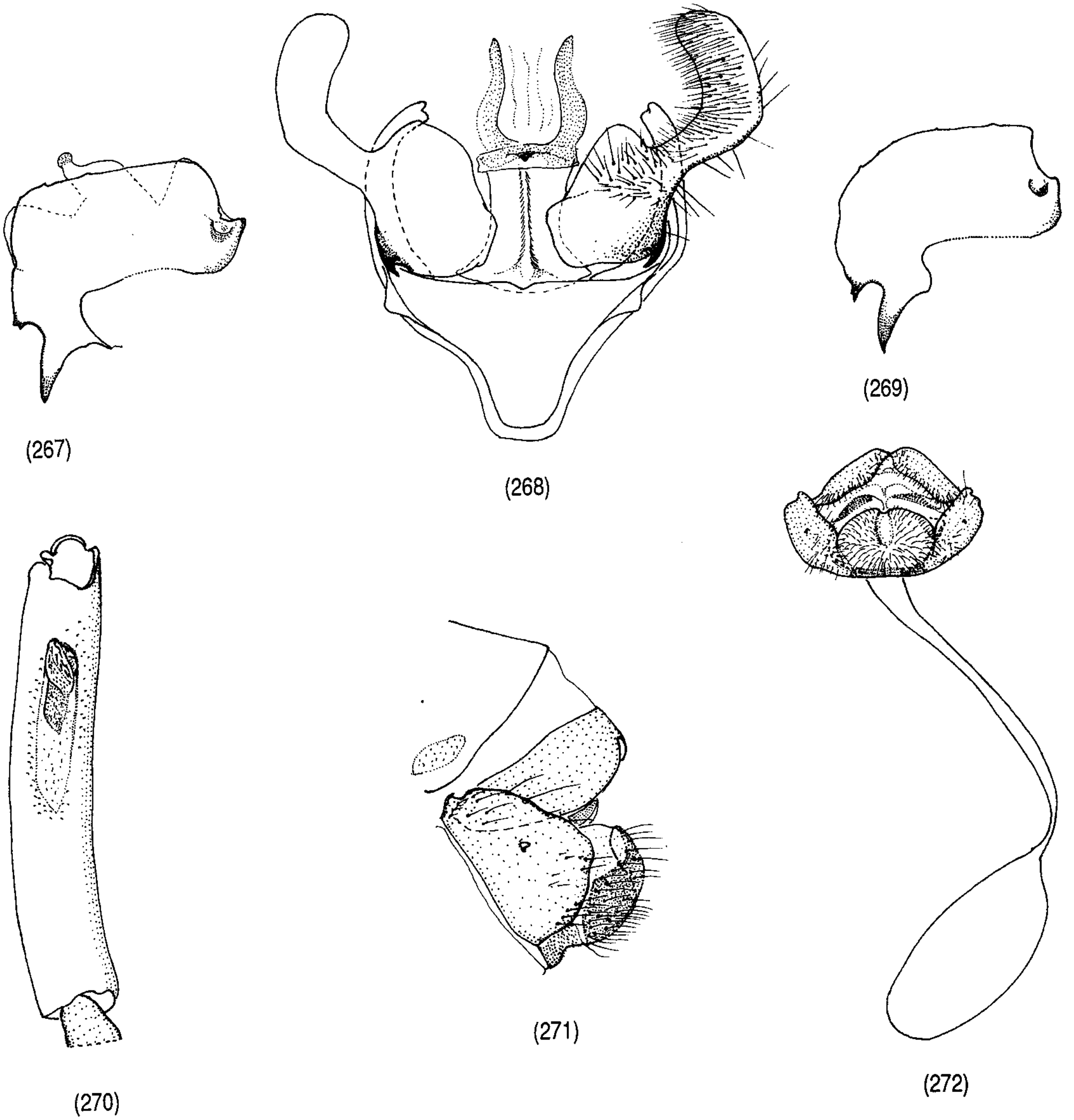


Fig. 267–272 *Aoraia macropis:* male – (267) pseudotegumen, lateral, topotype; (268) valva, trulleum, juxta, vinculum/saccus; (269) pseudotegumen, lateral; female – (270) foretibia, with reduced epiphysis; (271) dorsal plate and S9, lateral; (272) anogenital field and bursa copulatrix.

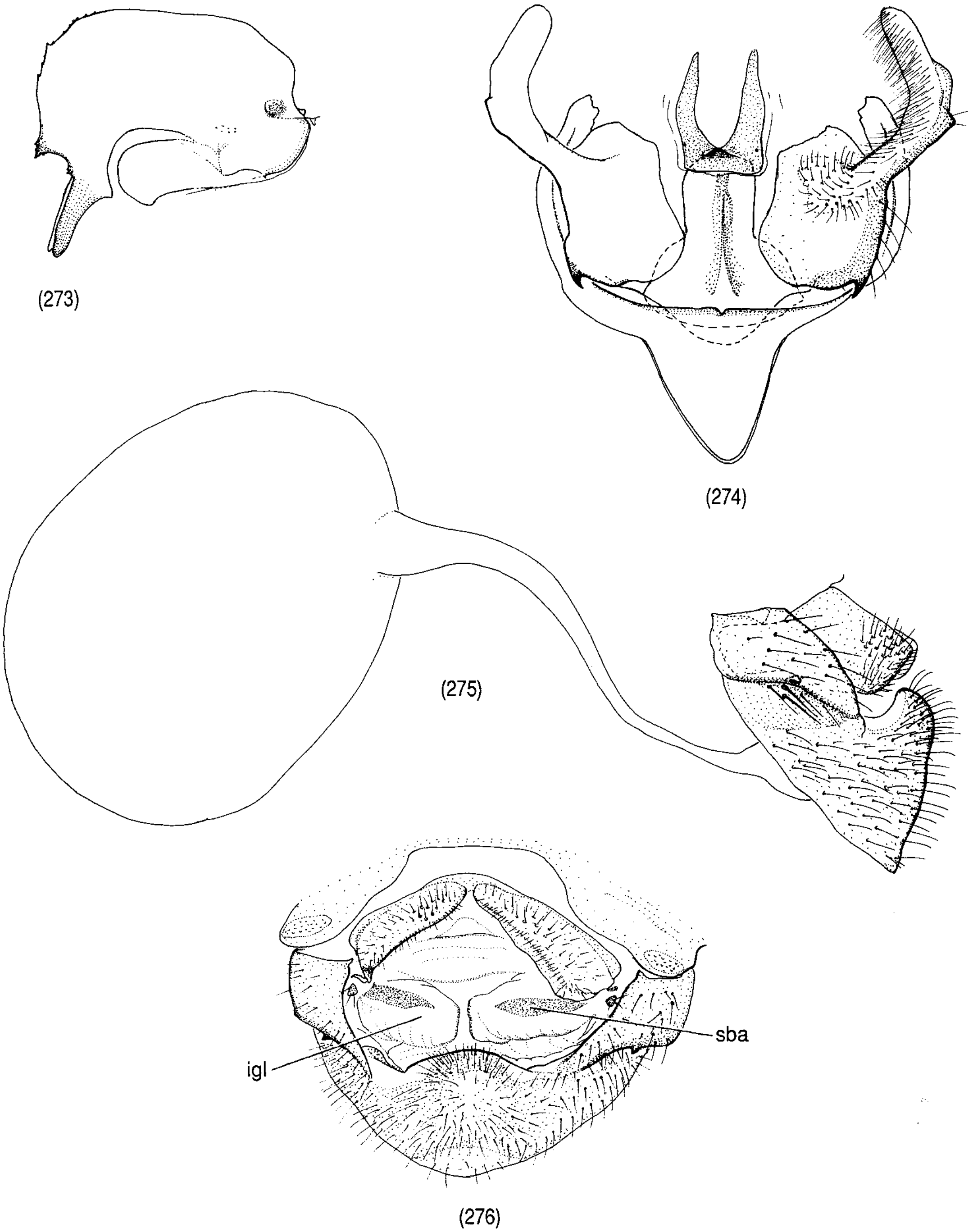


Fig. 273–276 *Aoraia oreobolae:* male – (273) pseudotegumen, lateral, HT; (274) valva, trulleum, juxta, vinculum/saccus; female – (275) dorsal plate, S9, and bursa copulatrix, lateral; (276) anogenital field, posterior.

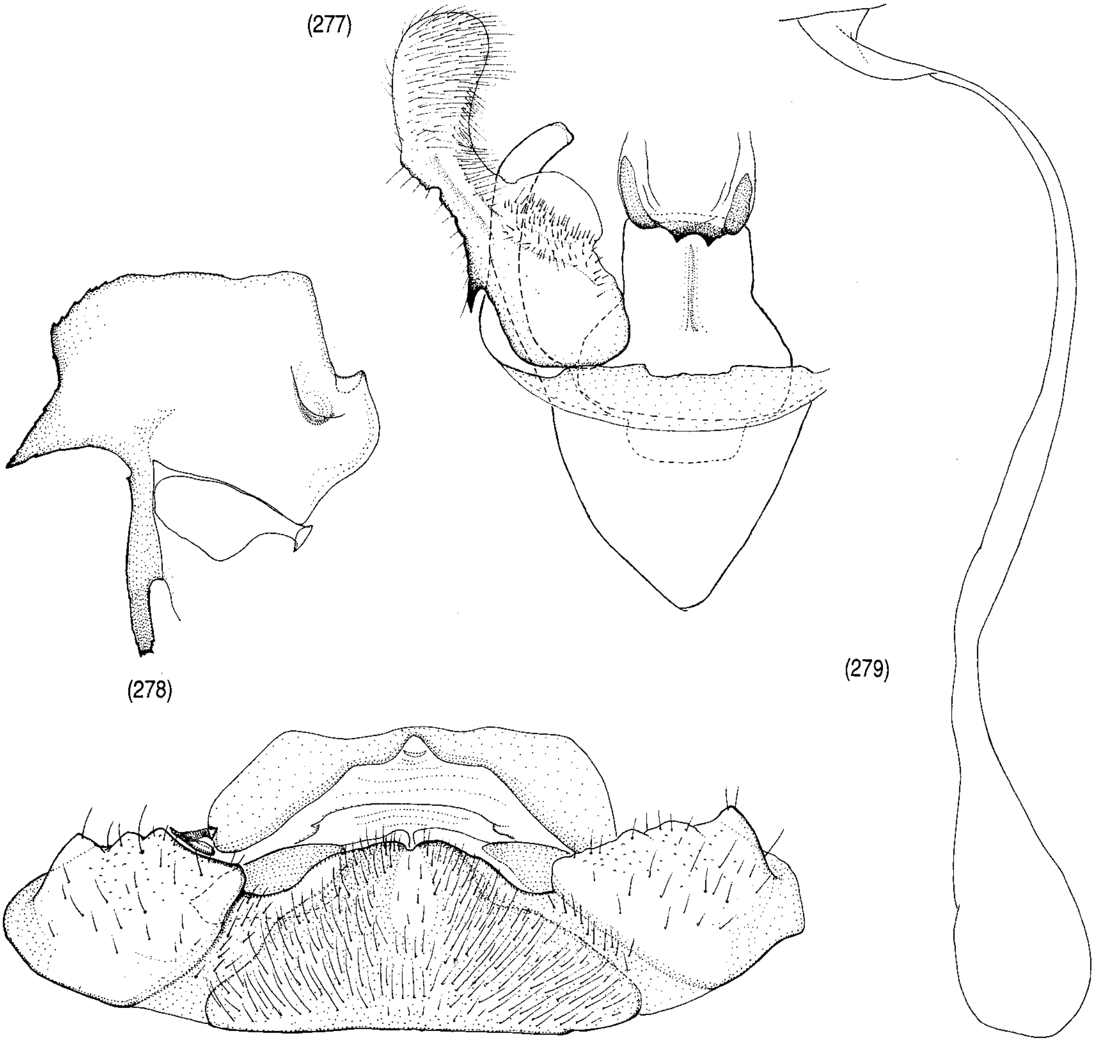


Fig. 277–280 *Aoraia rufivena:* male – (277) valva, trulleum, vinculum/saccus; (278) pseudotegumen, lateral; female – (279) corpus bursae; (280) anogenital field, posterior.

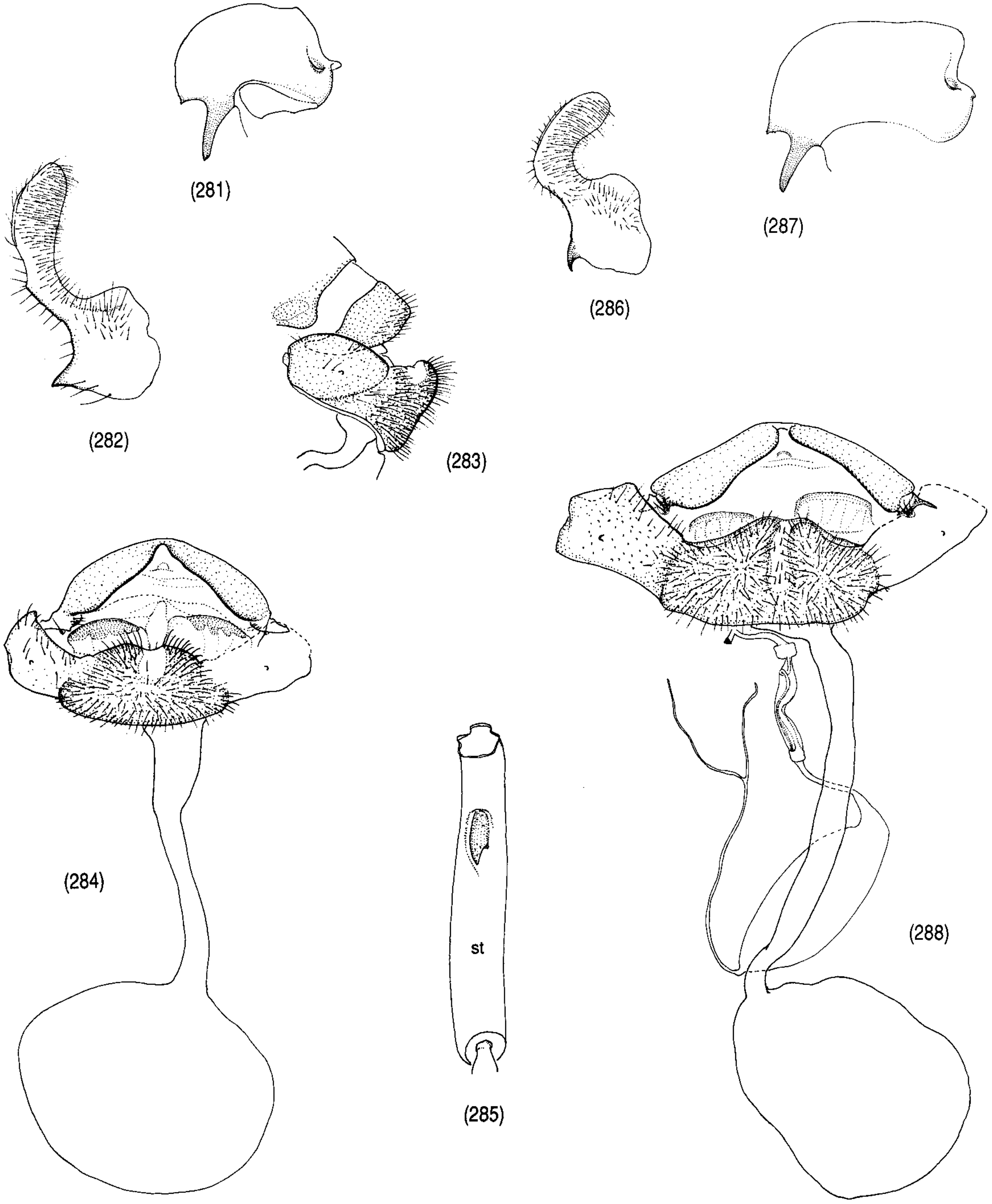
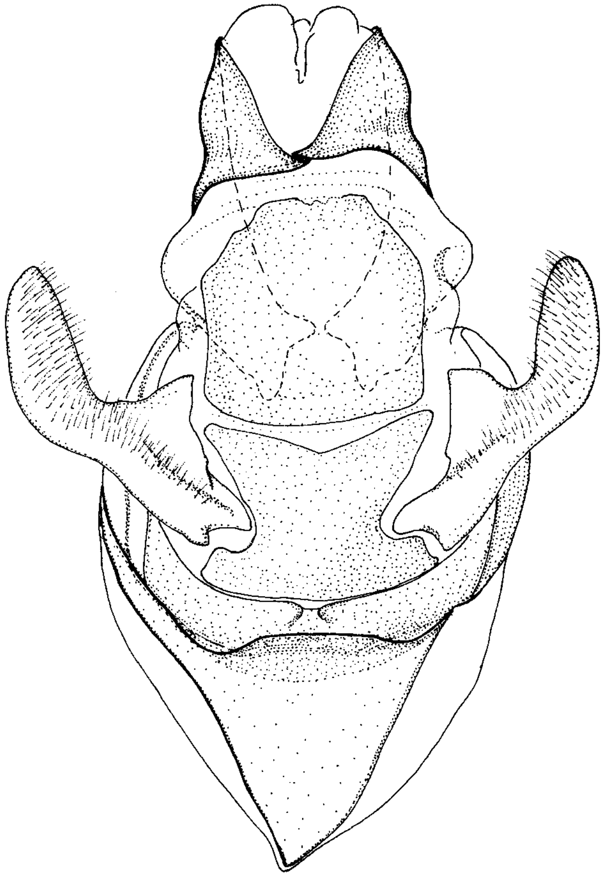
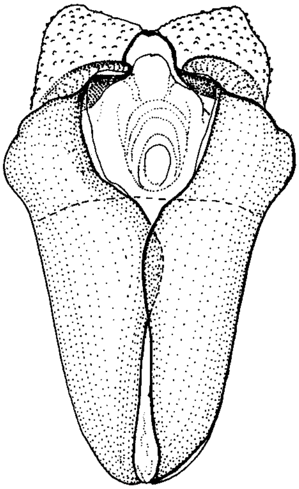


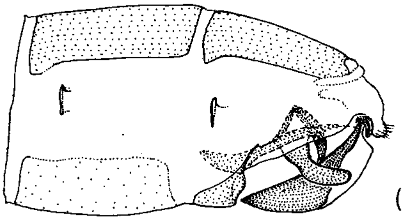
Fig. 281–285 *Aoraia senex:* male – (281) pseudotegumen, lateral, Old Man Ra CO; (282) valva; female – (283) dorsal plate and S9, lateral; (284) anogenital field and bursa copulatrix; (285) foretibia, with reduced epiphysis. **286–288** *A. orientalis:* male – (286) valva; (287) pseudotegumen, lateral; female – (288) anogenital field and bursa copulatrix.



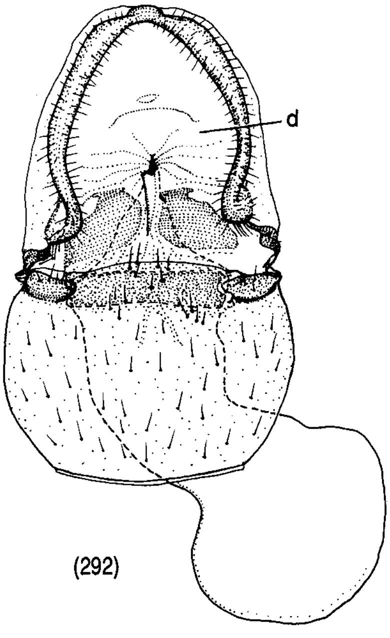
(289)



(290)



(291)



(292)

Fig. 289–292 *Cladoxycanus minos:* male – (289) genitalia, posterior, Paiaka WN; (290) pseudotegumen, dorsal, Invermay DN; (291) posterior abdomen, showing genitalia position; female – (293) anogenital field and bursa copulatrix, Invermay DN.

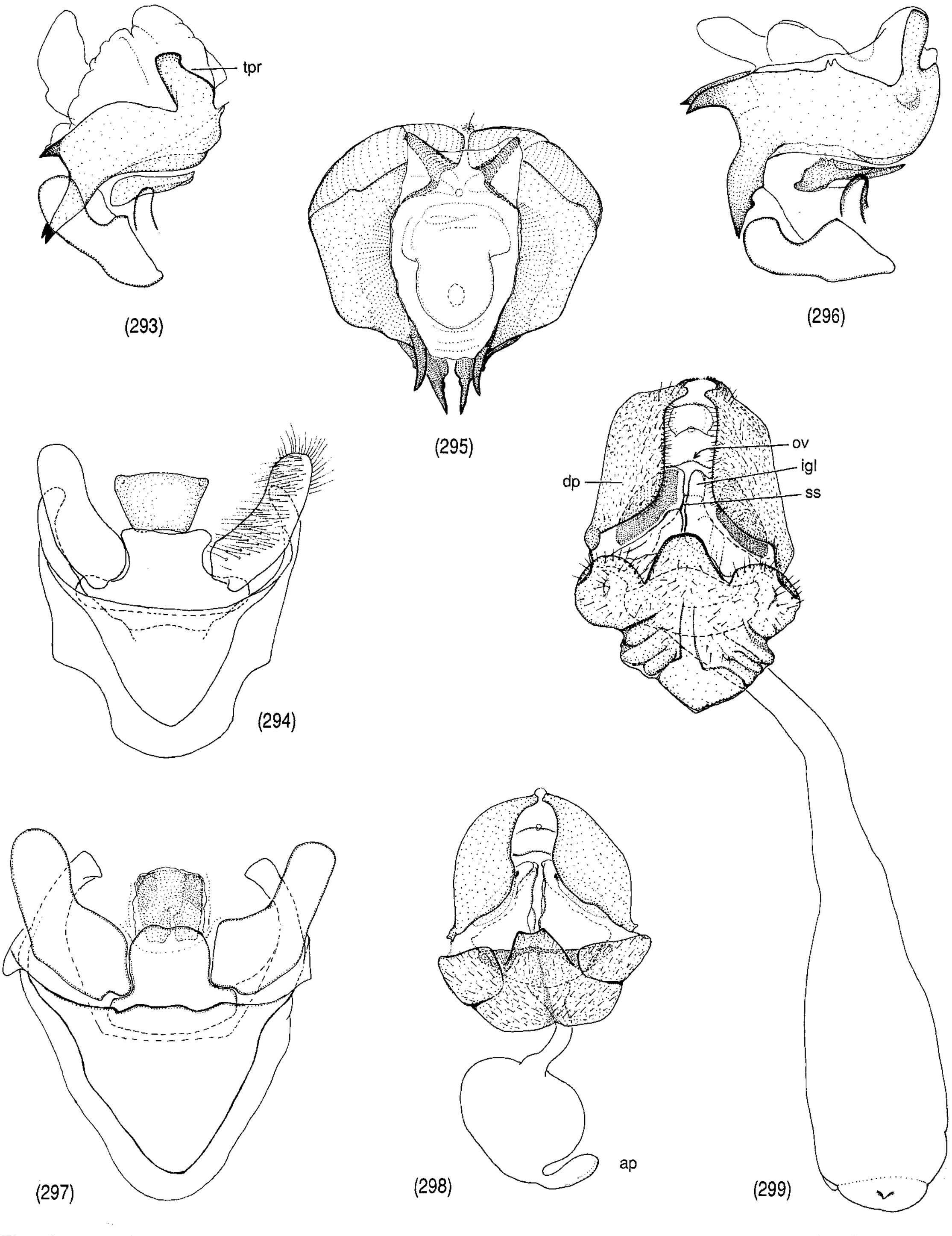


Fig. 293, 294 *Dioxycanus fuscus*, male – (293) pseudotegumen, lateral; (294) valva, trulleum, juxta, vinculum/saccus. **295–297** *D. oreas*, male – (295) pseudotegumen and phallocrypt, dorsal; (296) pseudotegumen, lateral; (297) valva, trulleum, juxta, vinculum/saccus. **298** *D. fuscus*, female, anogenital field and bursa copulatrix, Routeburn OL. **299** *D. oreas*, female, anogenital field and bursa copulatrix, Tararua Ra. WN.

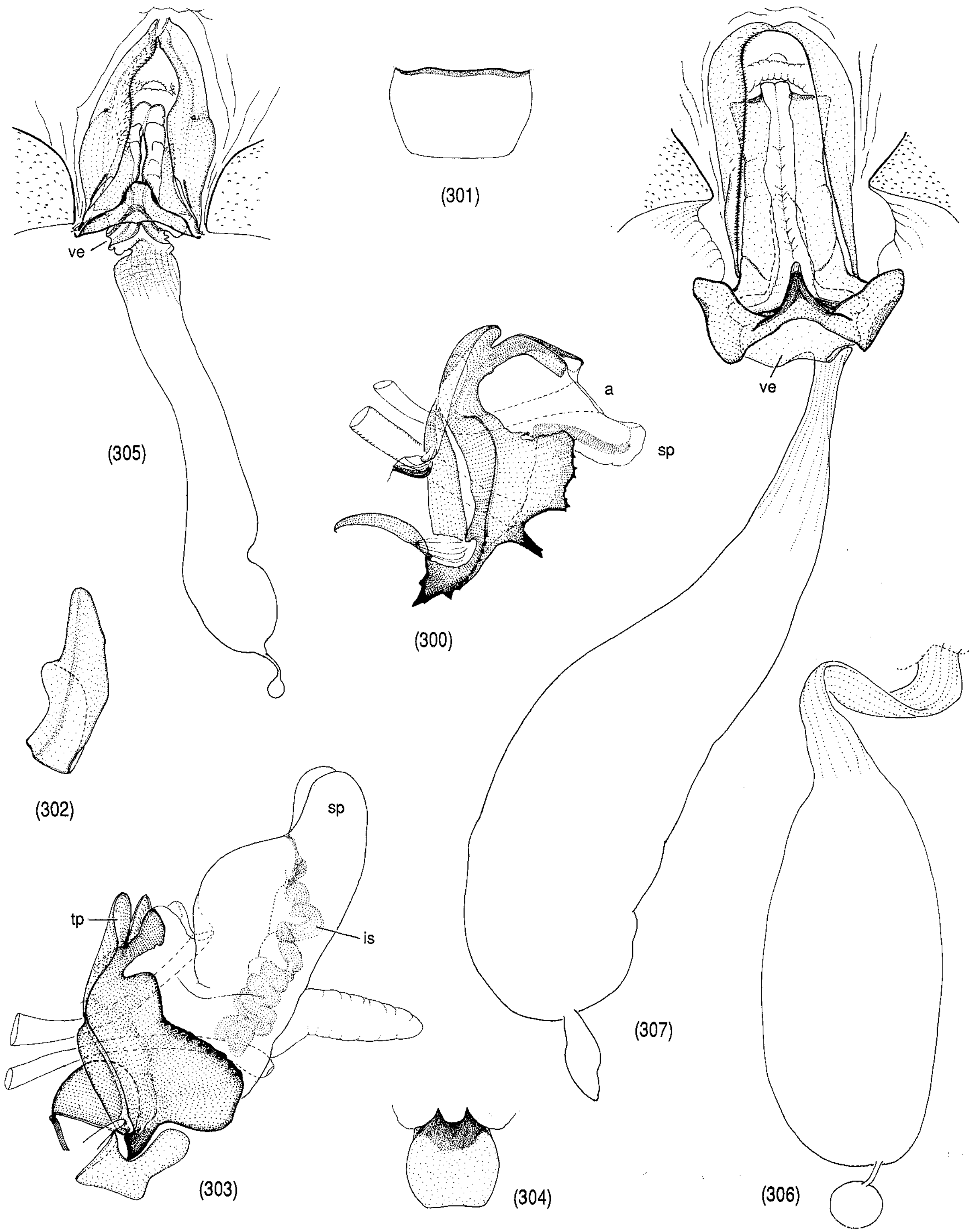


Fig. 300–302 *Dumbletonius characterifer*, male – (300) pseudotegumen and trulleum, lateral; (301) S8; (302) valva. **303, 304** *D. unimaculatus*, male – (303) pseudotegumen, valva, and trulleum, lateral; (304) S8. **305, 306** *D. characterifer*, female: anogenital field and bursa copulatrix, St Arnaud NN; expanded bursa copulatrix. **307** *D. unimaculatus*, female, anogenital field and bursa copulatrix.

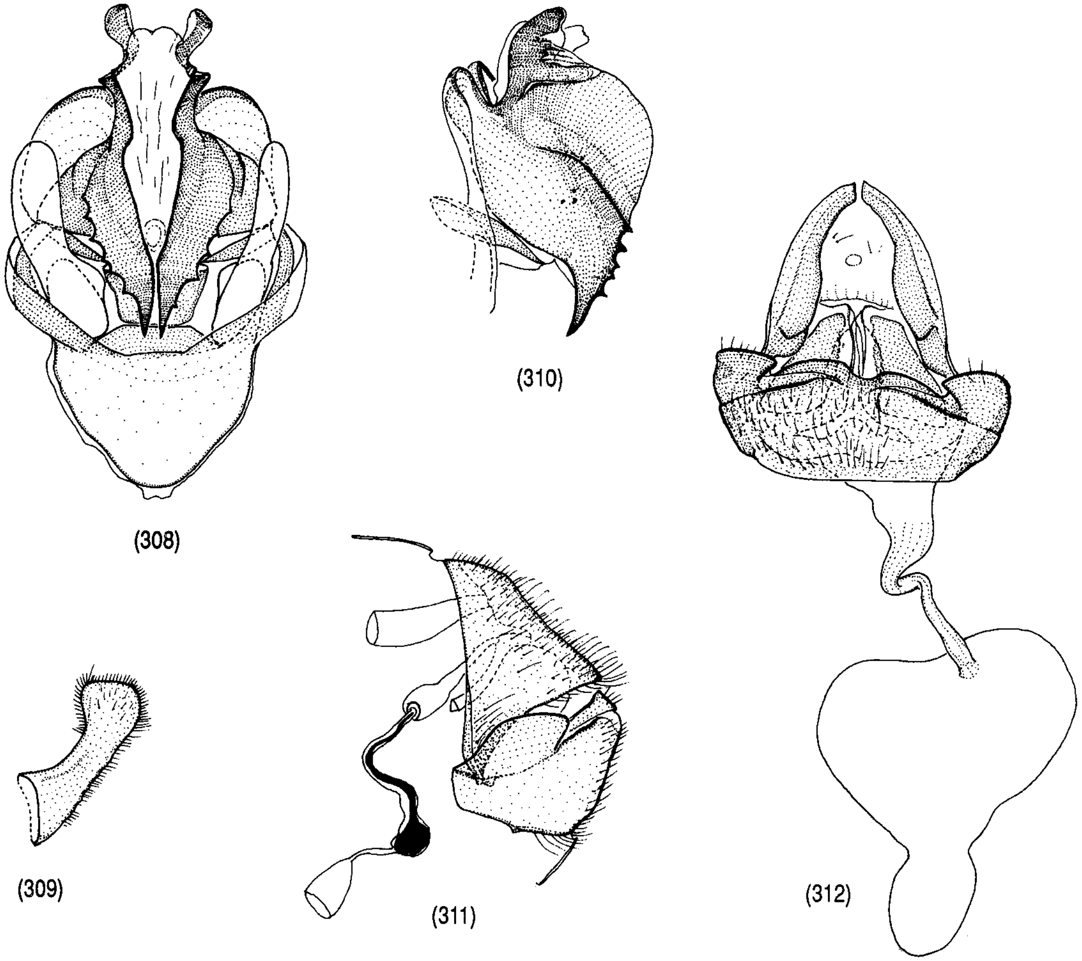


Fig. 308–312 *Heloxycanus patricki:* male – (308) genitalia, posterior, Old Man Ra. CO; (309) valva; (310) pseudotegumen, lateral; female – (311) dorsal plate and S9, lateral; (312) anogenital field and bursa copulatrix.

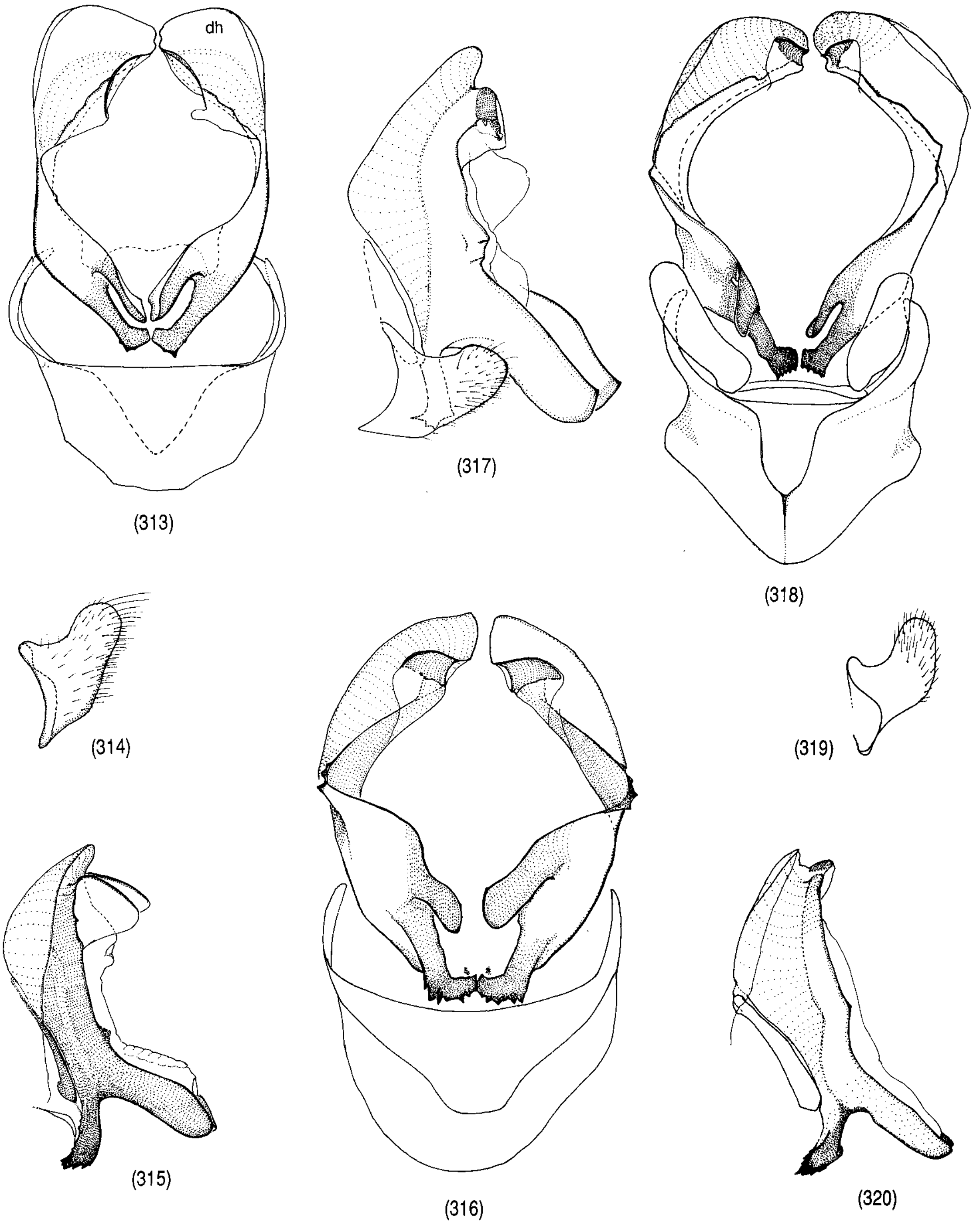


Fig. 313–315 *Wiseana cervinata*, male genitalia: (313) posterior view (valvae omitted), Nelson NN; (314) valva; (315) pseudotegumen, lateral. **316, 317** *W. copularis*, male genitalia: (316) posterior view (valvae omitted); (317) pseudotegumen and valva, lateral. **318–320** *W. fuliginea*, male genitalia: (318) posterior view; (319) valva; (320) pseudotegumen, lateral.

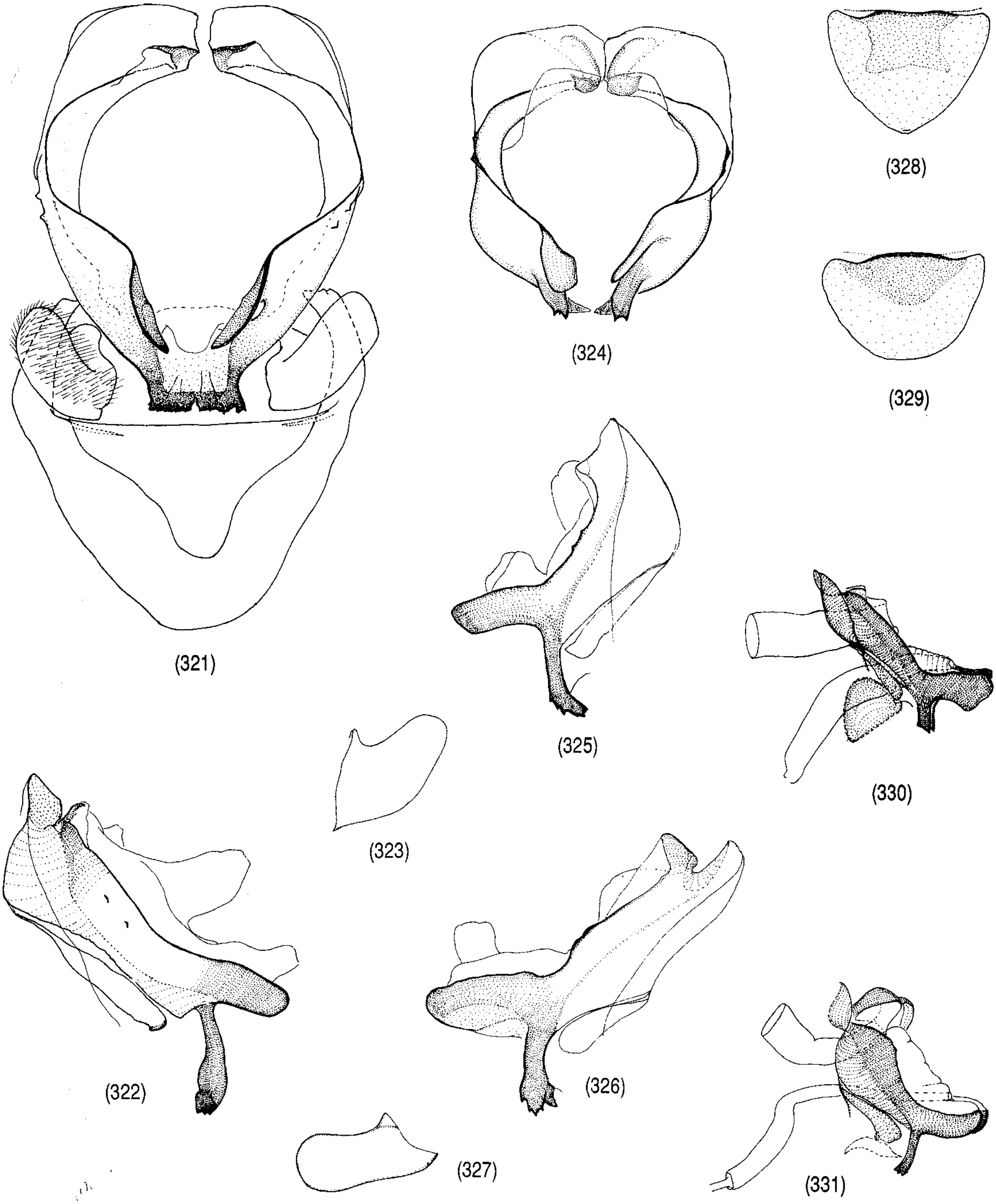


Fig. 321–323 *Wiseana jocosa*, male genitalia: (321) posterior view; (322) valva; (323) pseudotegumen, lateral. **324–329** *W. mimica*, male genitalia: (324–326) pseudotegumen, dorsal, lateral, Invercargill SL, and lateral, Craigieburn MC; (327) valva; (328, 329) S8, Invercargill and Craigieburn. **330, 331** *W. signata* and *W. umbraculata*, pseudotegumen and trulleum, lateral.

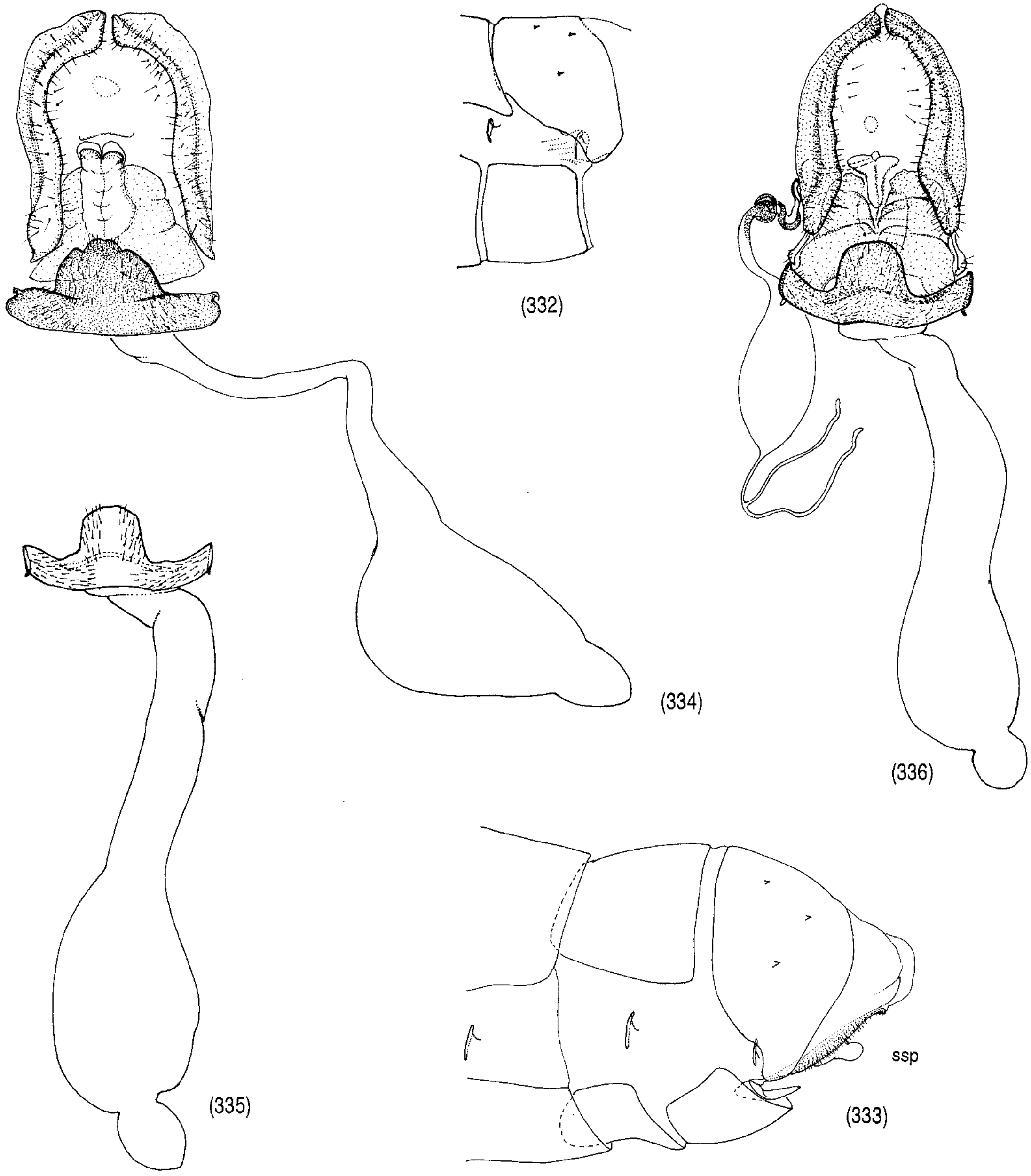


Fig. 332–336 *Wiseana* spp., female postabdomen and genitalia: (332) *cervinata*, A7 and A8; (333) *umbraculata*, A7, A8, and external genitalia; (334) *copularis*, anogenital field and bursa copulatrix, Otatara SL; (335) *cervinata*, S9 and bursa copulatrix, Upper Moutere NN, dark form; (336) *cervinata*, anogenital field and bursa copulatrix, Upper Moutere, pale form.

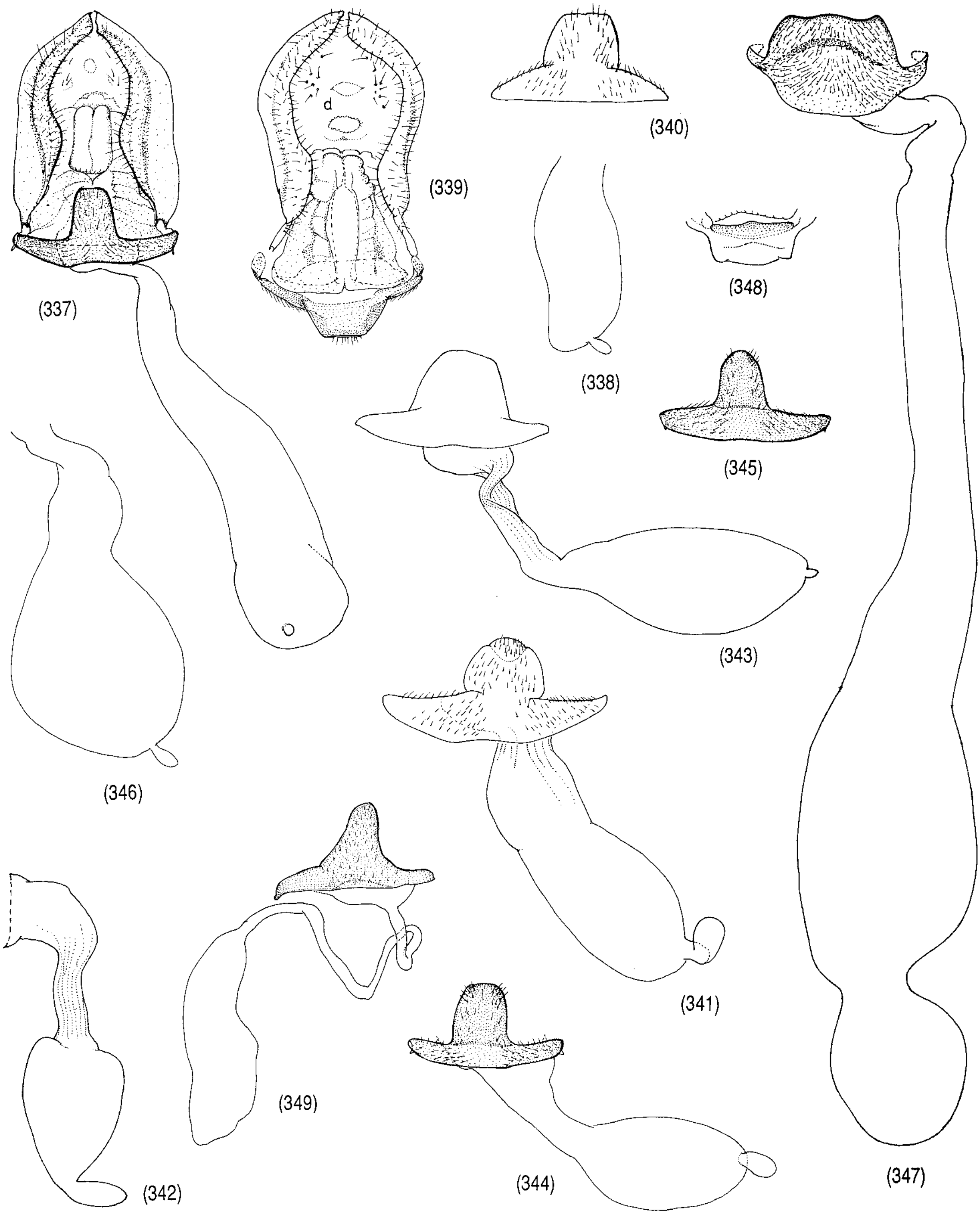
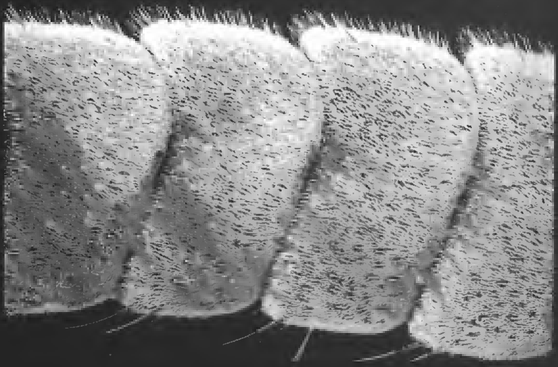
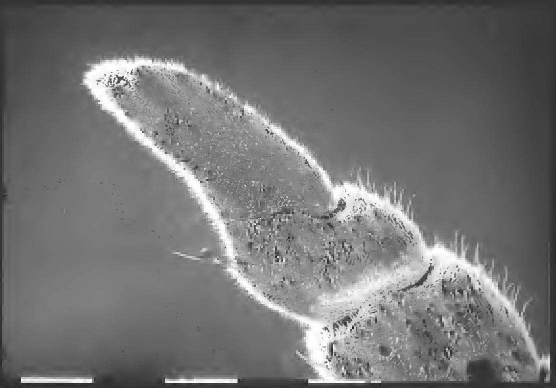


Fig. 337–349 *Wiseana* spp., female genitalia. **337, 338** *fuliginea:* (337) anogenital field and bursa copulatrix, Invermay DN; (338) corpus bursae and appendix, Banks Peninsula MC. **339–343** *jocosa:* (339) anogenital field; (340) S9; (341) S9 and bursa copulatrix, Cobb Dam NN; (342) bursa copulatrix, Gore SL; (343) S9 and bursa copulatrix, Owaka SL. **344–346** *mimica:* (344) S9 and bursa copulatrix; (345) S9, Craigieburn MC; (346) bursa copulatrix. **347, 348** *signata*: (347) S9 and bursa copulatrix; (348) S9, internal, with sclerotised inner lip. **349** *umbraculata*, S9 and bursa copulatrix.



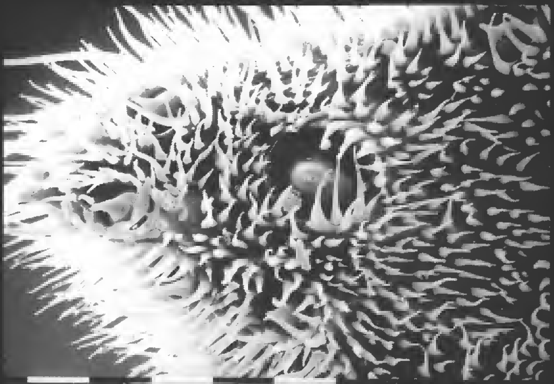
(M1)



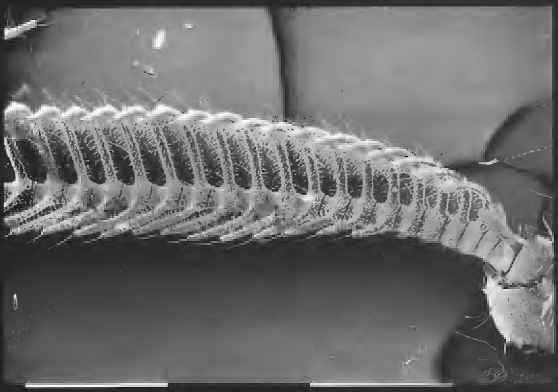
(M2)

Fig. M1–3 *Aenetus virescens:* M1, male, middle antennal flagellomeres, lateral; M2, apical antennal flagellomeres; M3, sensillae on apical flagellomere.

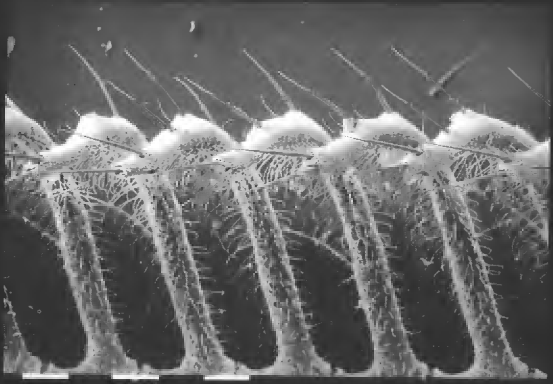
M4, 5 *Aoraia insularis*, male: M4, antennae; M5, detail of flagellomere rami.



(M3)

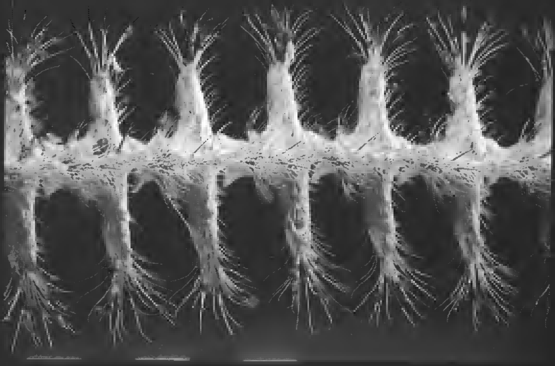


(M4)



(M5)


(M6)

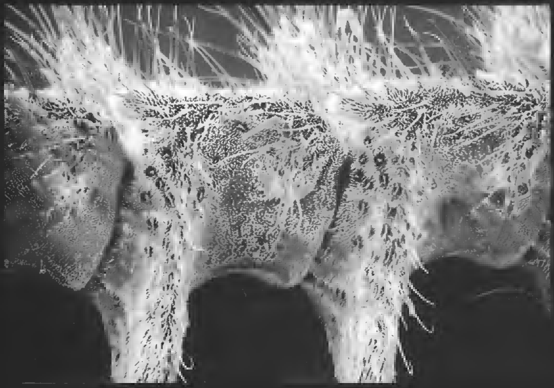

(M7)

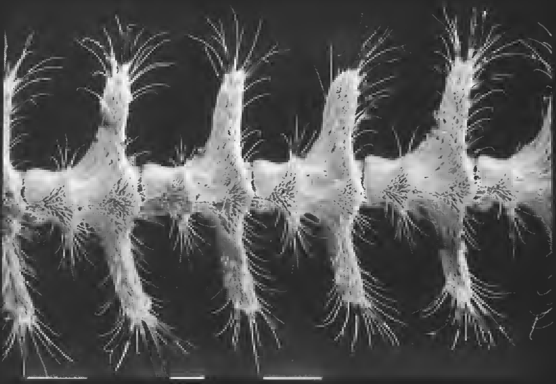

(M8)

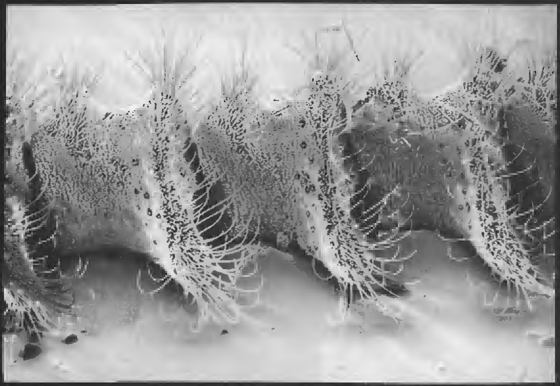
Fig. M6 *Aoraia insularis*, male, apical flagellomeres.

M7–9 *Cladoxycanus minos*, male: M7, middle antennal flagellomeres, ventral; M8, 9, same, oblique, showing apical lateral rami and central process.

M10 *Dioxycanus oreas*, male, middle antennal flagellomeres, ventral, showing apical rami and central process.


(M9)


(M10)



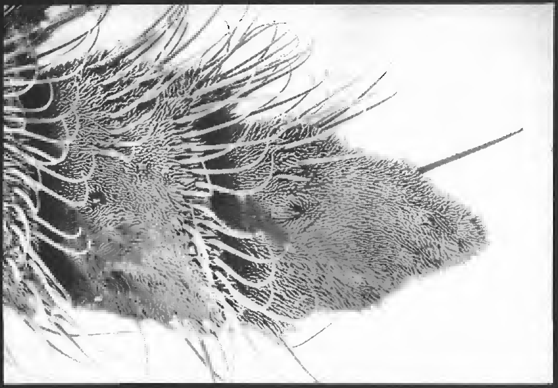
(M11)

(M12)

Fig. M11, 12 *Dioxycanus oreas*, male: M11, middle antennal flagellomeres, lateral; M12, apical flagellomeres.

M13–15 *Dumbletonius unimaculatus*, male: M13, middle antennal flagellomeres, showing reduced rami; M14, apical flagellomeres; M15, sensillae on apical flagellomere.

(M13)



(M14)

(M15)


(M16)


(M17)

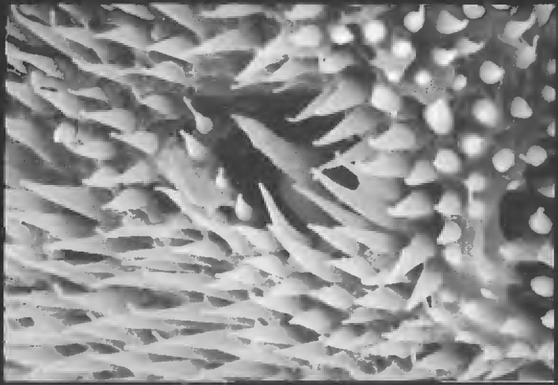
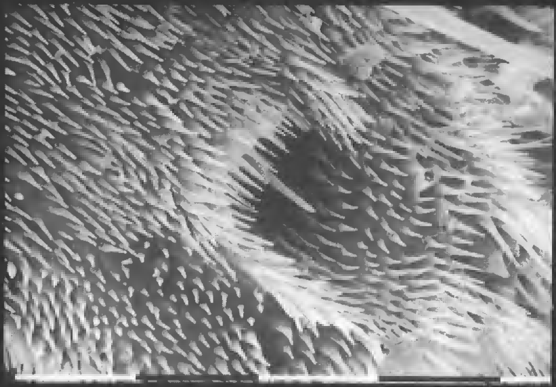
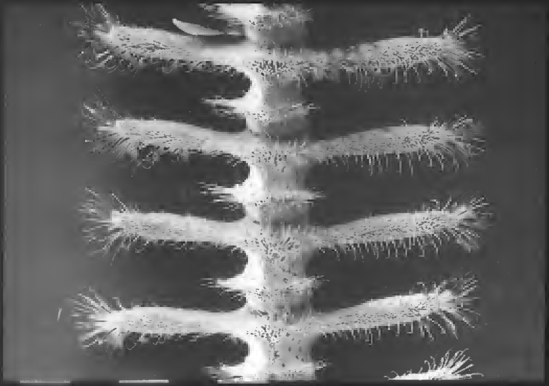
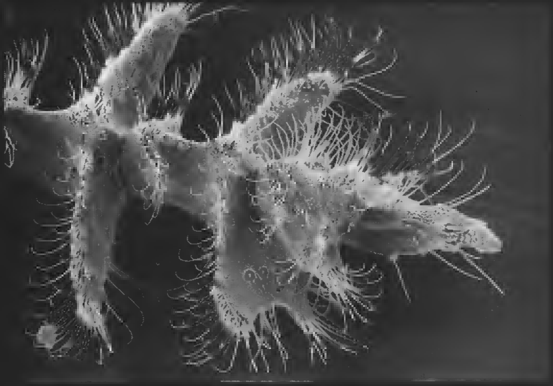

(M18)

Fig. M16–18 *Heloxycanus patricki*, male: M16, middle antennal flagellomeres, ventral, showing apical lateral rami and central process; M17, apical flagellomere; M18, short sensilla on apical flagellomere.

M19, 20 *Wiseana copularis*, male: M19, short sensilla on flagellomere; M20, middle antennal flagellomeres, showing apical rami and basal central process.


(M19)


(M20)

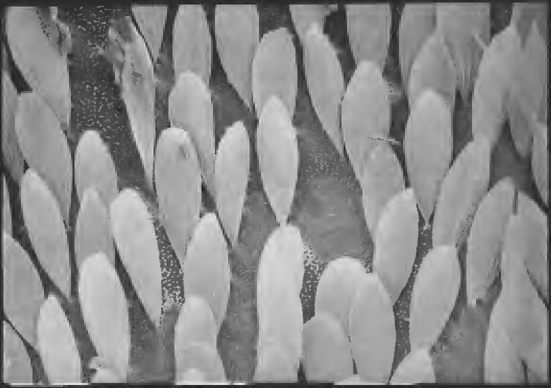


(M21)

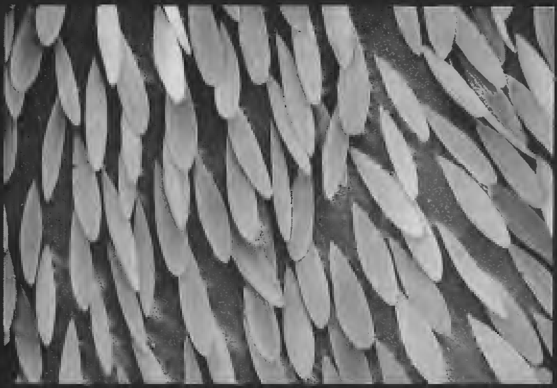
(M22)

Fig. M21, 22 *Wiseana copularis*, male: M21, apical flagellomeres; M22, middle antennal flagellomeres, lateral, showing distribution of short sensillae.

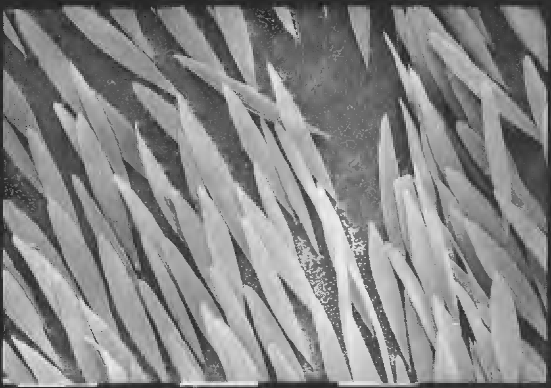
M23–25 *Wiseana* species, male forewing scale shapes (dorsal): M23, *jocosa*, Otatara SL; M24, *cervinata*, Nelson NN; M25, *mimica*, Otatara SL.



(M23)

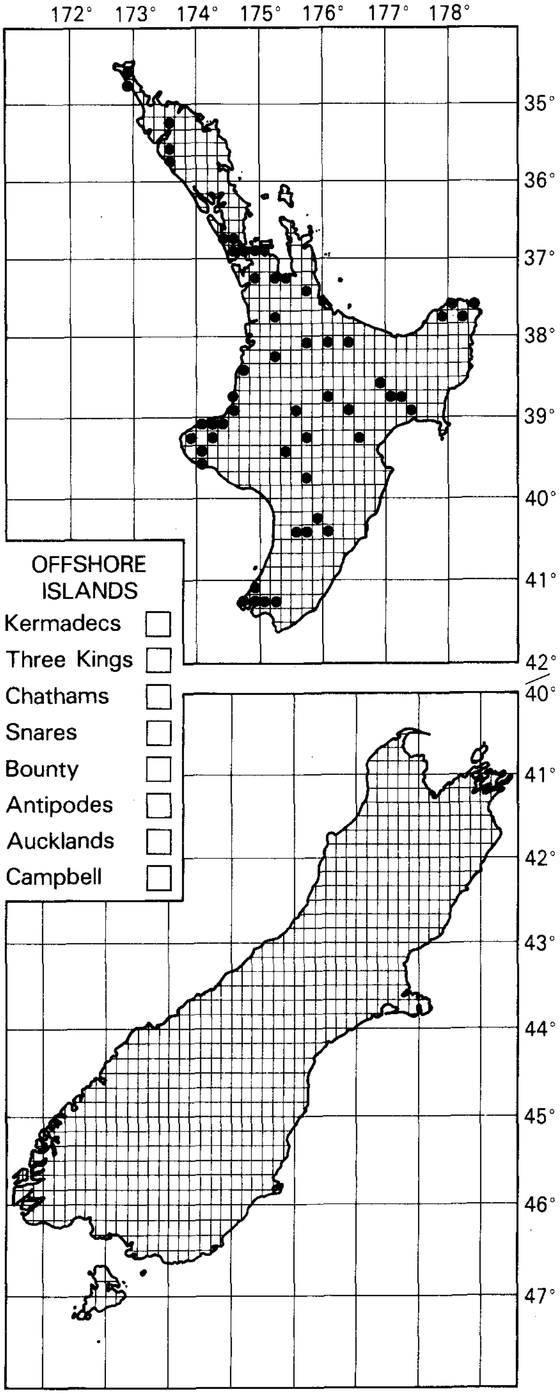


(M24)

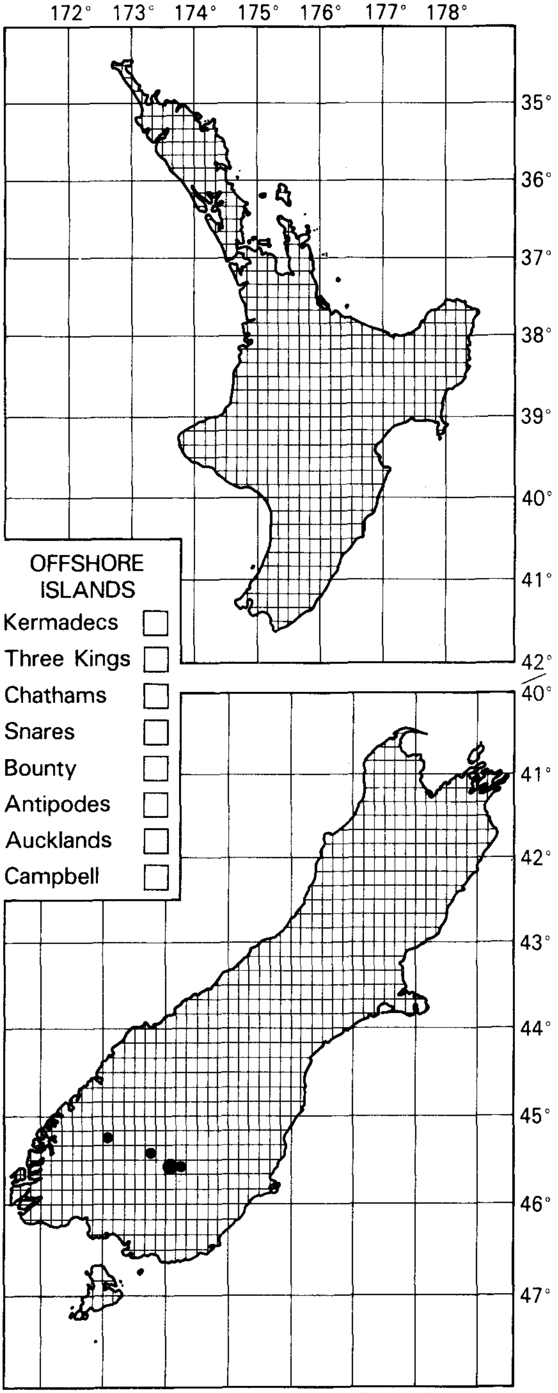


(M25)

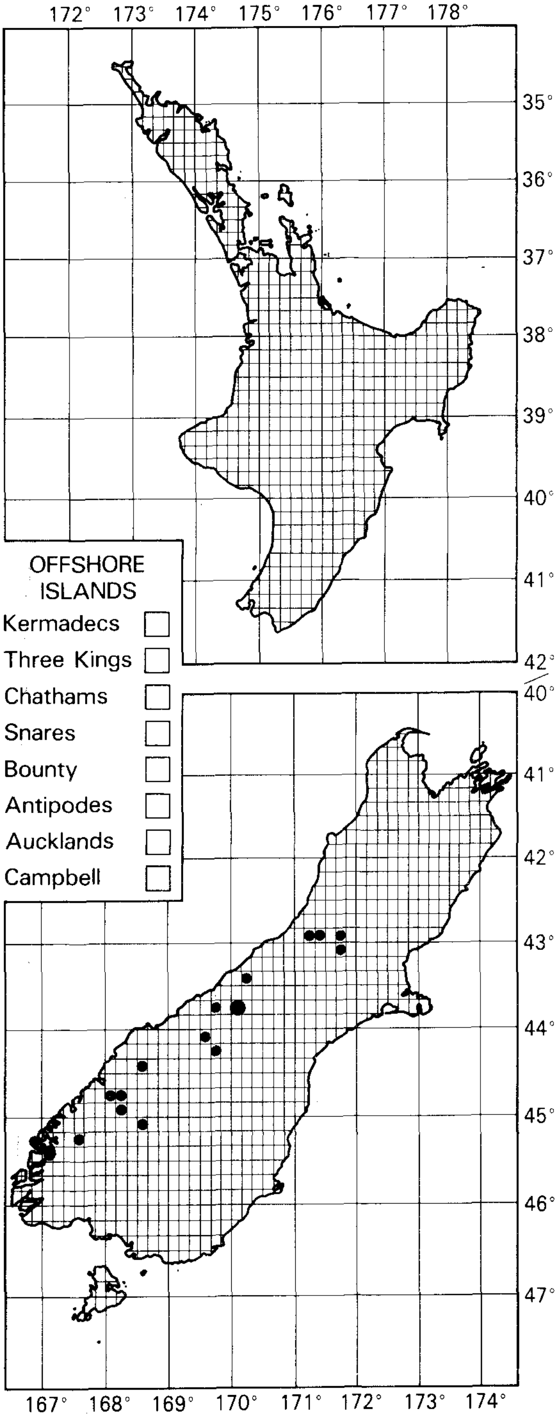
DISTRIBUTION MAPS



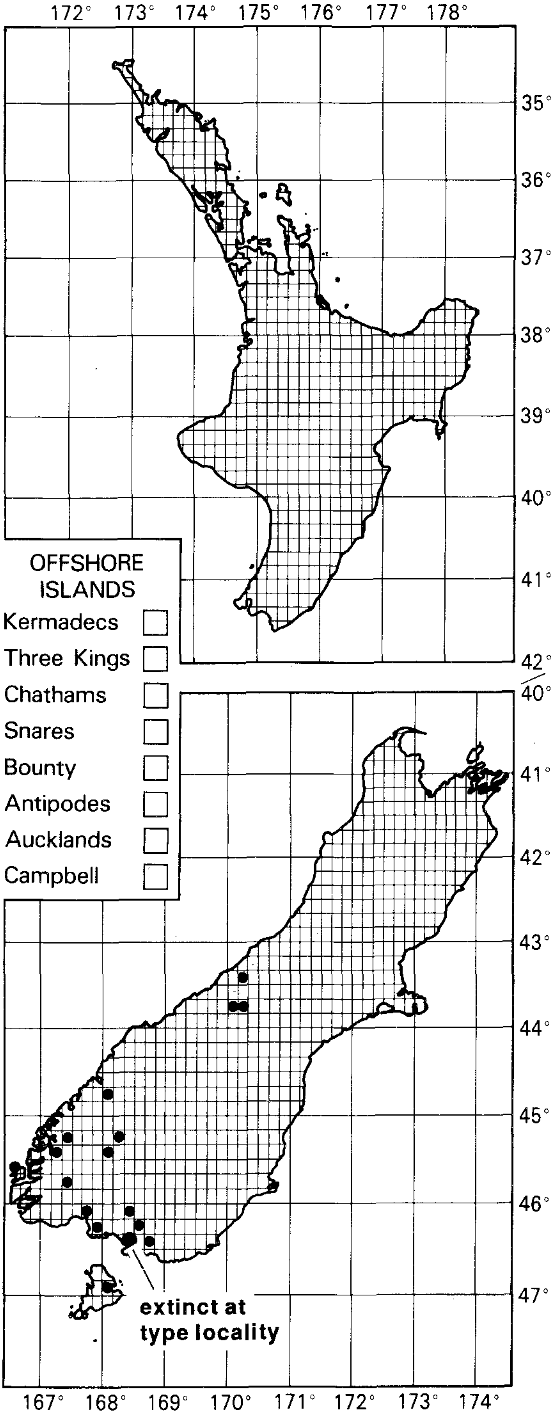
• **Map 1** Collection localities, *Aenetus virescens* •



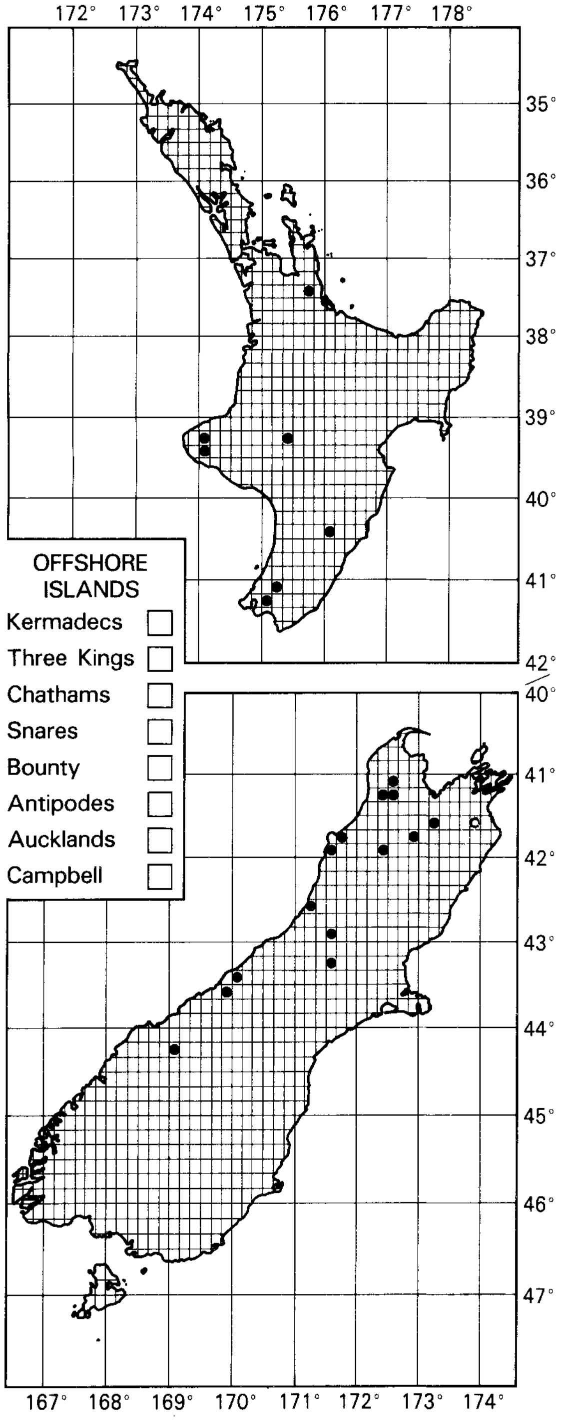
• **Map 2** Collection localities, *Aoraia aspina* •



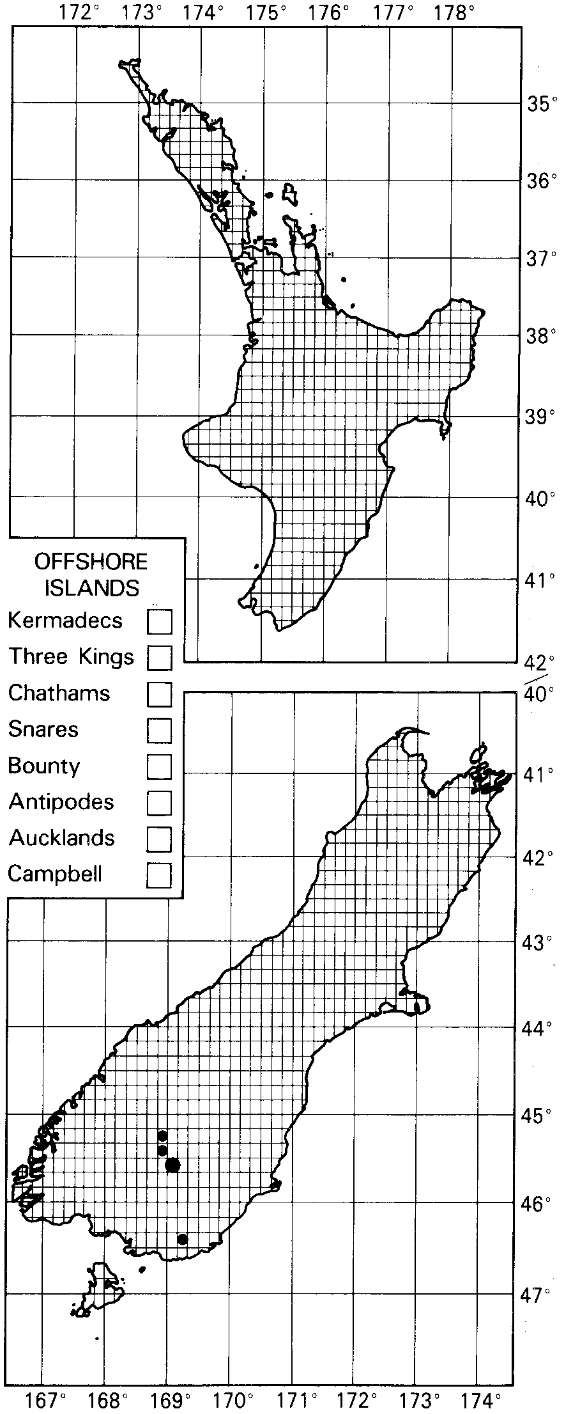
• **Map 3** Collection localities, *Aoraia aurimaculata* •



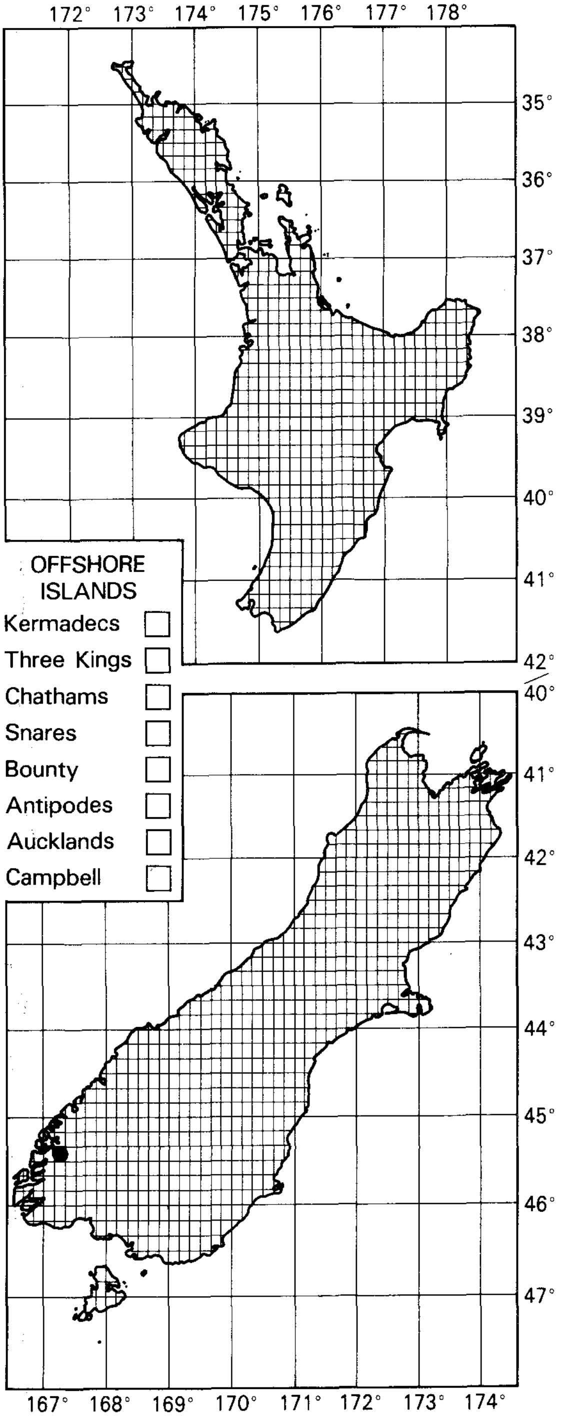
• **Map 4** Collection localities, *Aoraia dinodes* •



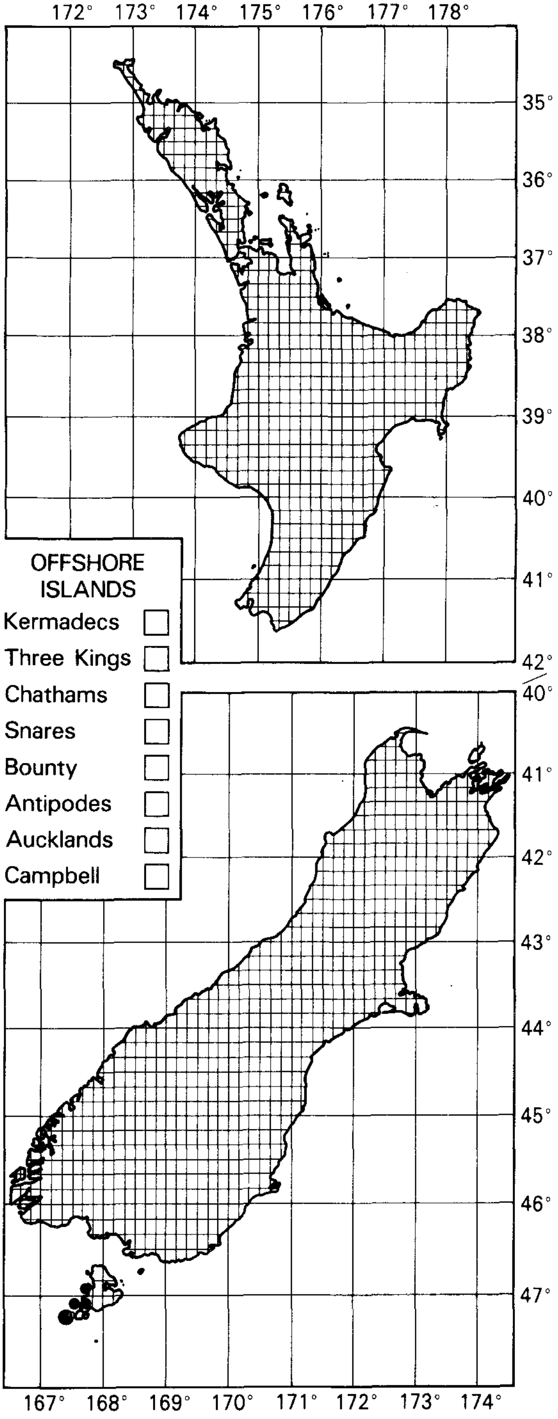
• **Map 5** Collection localities, *Aoraia enysii* •



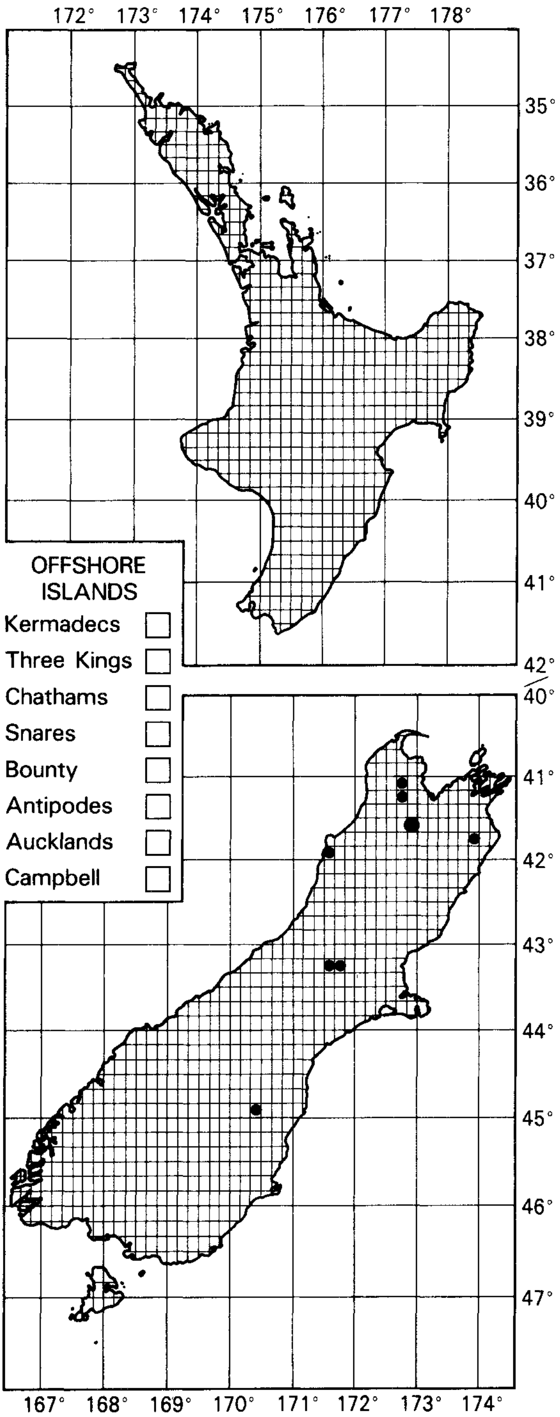
• **Map 6** Collection localities, *Aoraia flavida* •



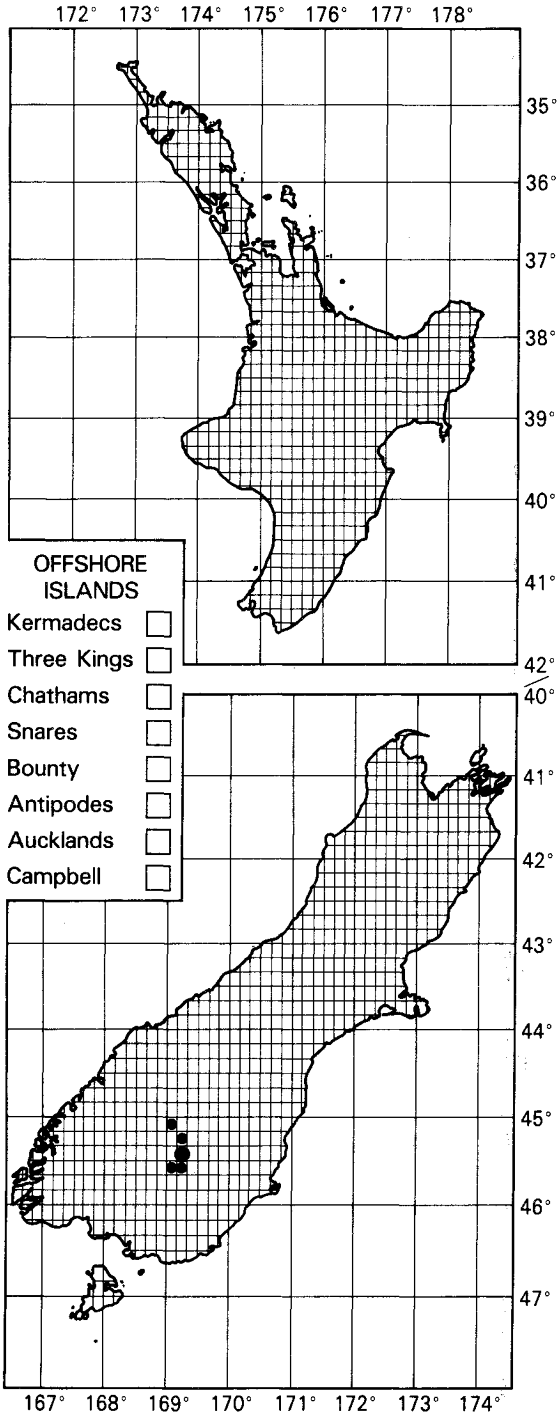
• **Map 7** Collection localities, *Aoraia hespera* •



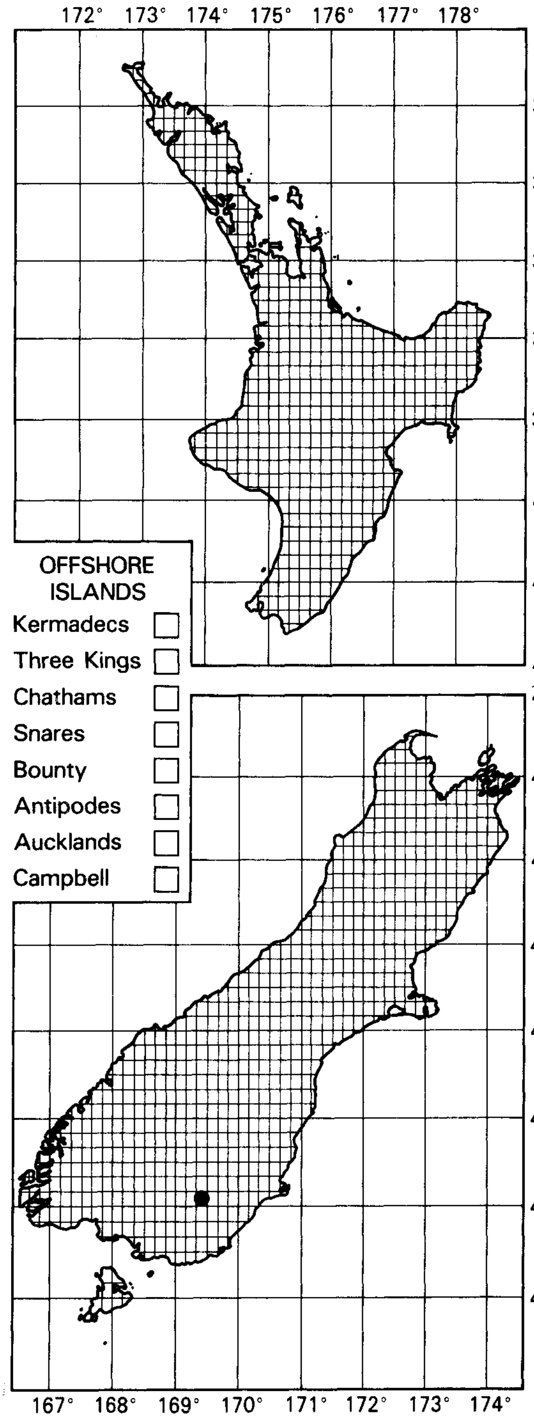
• **Map 8** Collection localities, *Aoraia insularis* •



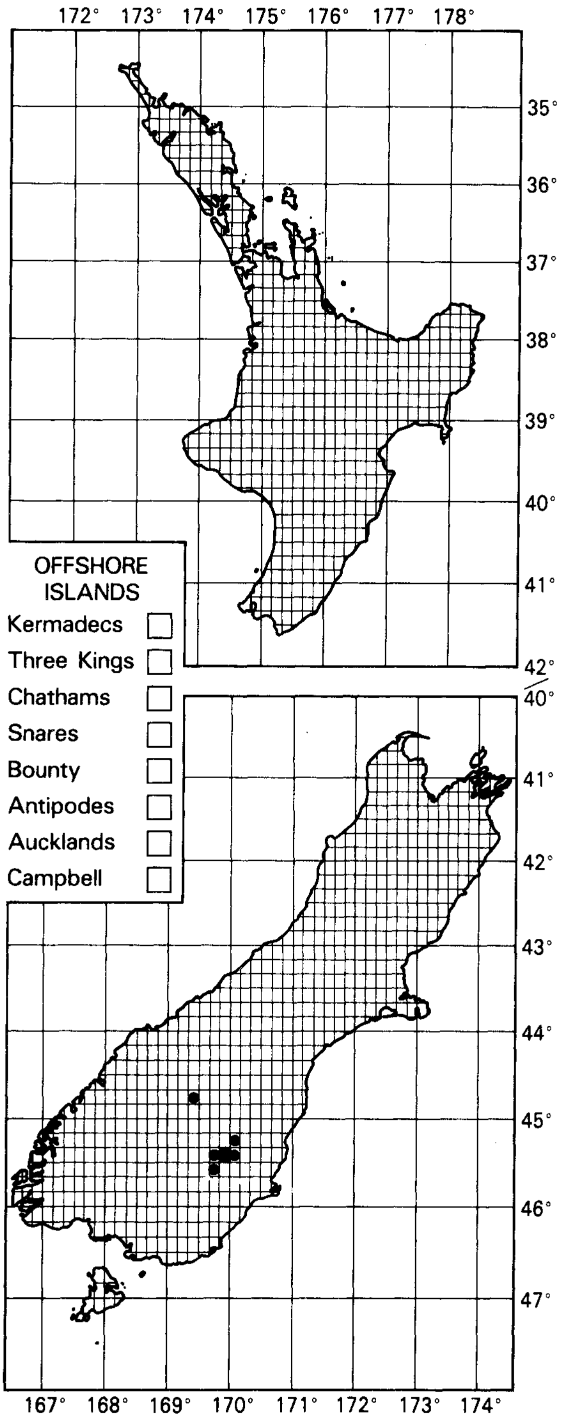
• **Map 9** Collection localities, *Aoraia lenis* •



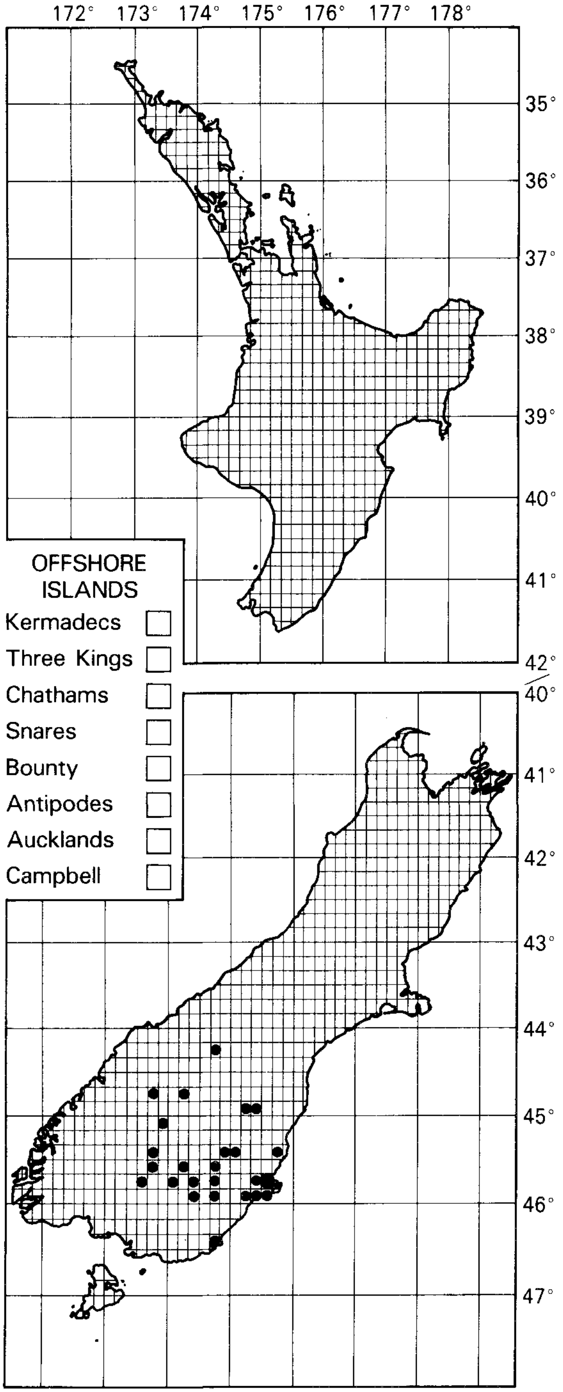
• **Map 10** Collection localities, *Aoraia macropis* •



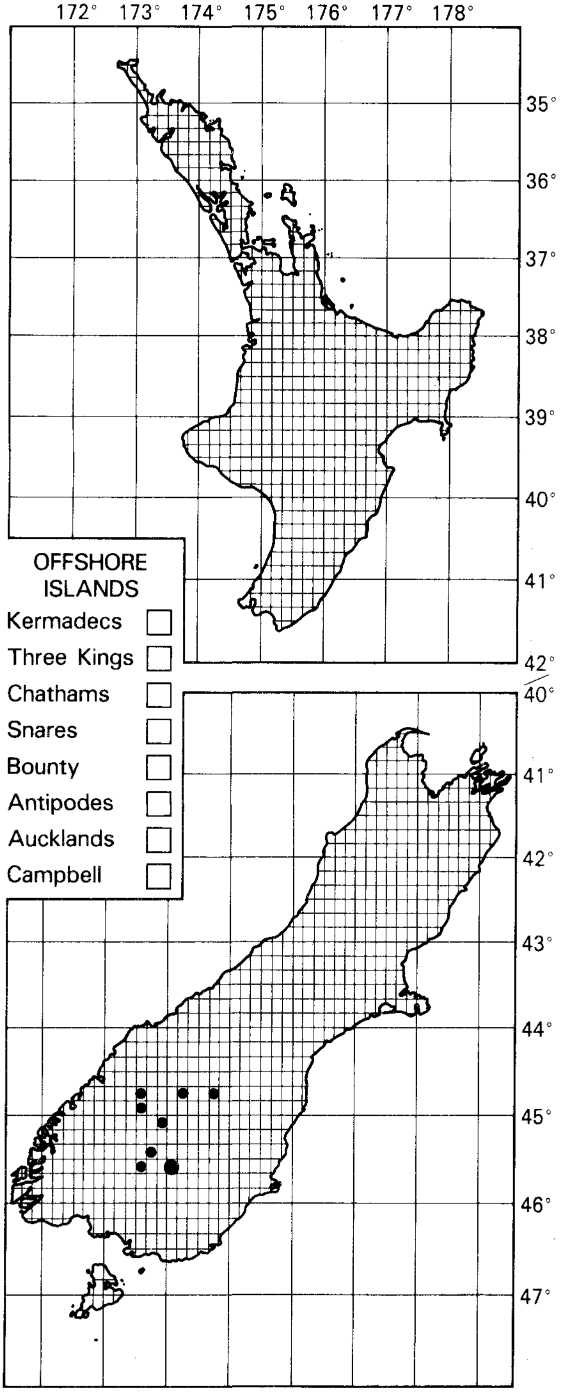
• **Map 11** Collection localities, *Aoraia oreobolae* •



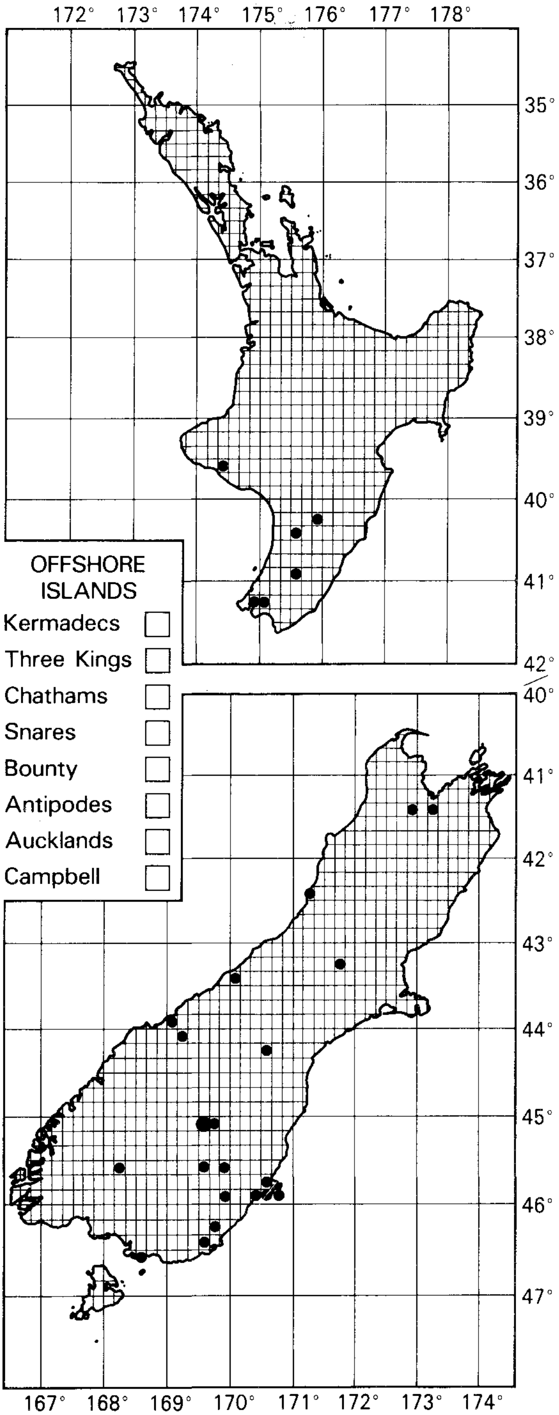
• **Map 12** Collection localities, *Aoraia orientalis* •



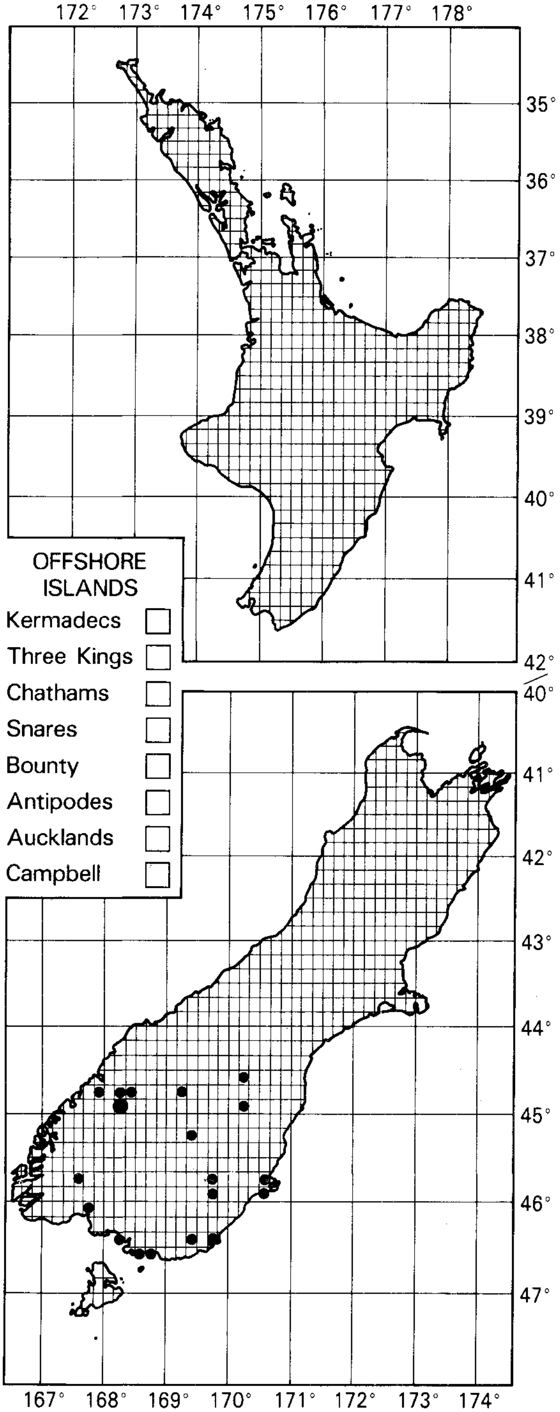
• **Map 13** Collection localities, *Aoraia rufivena* •



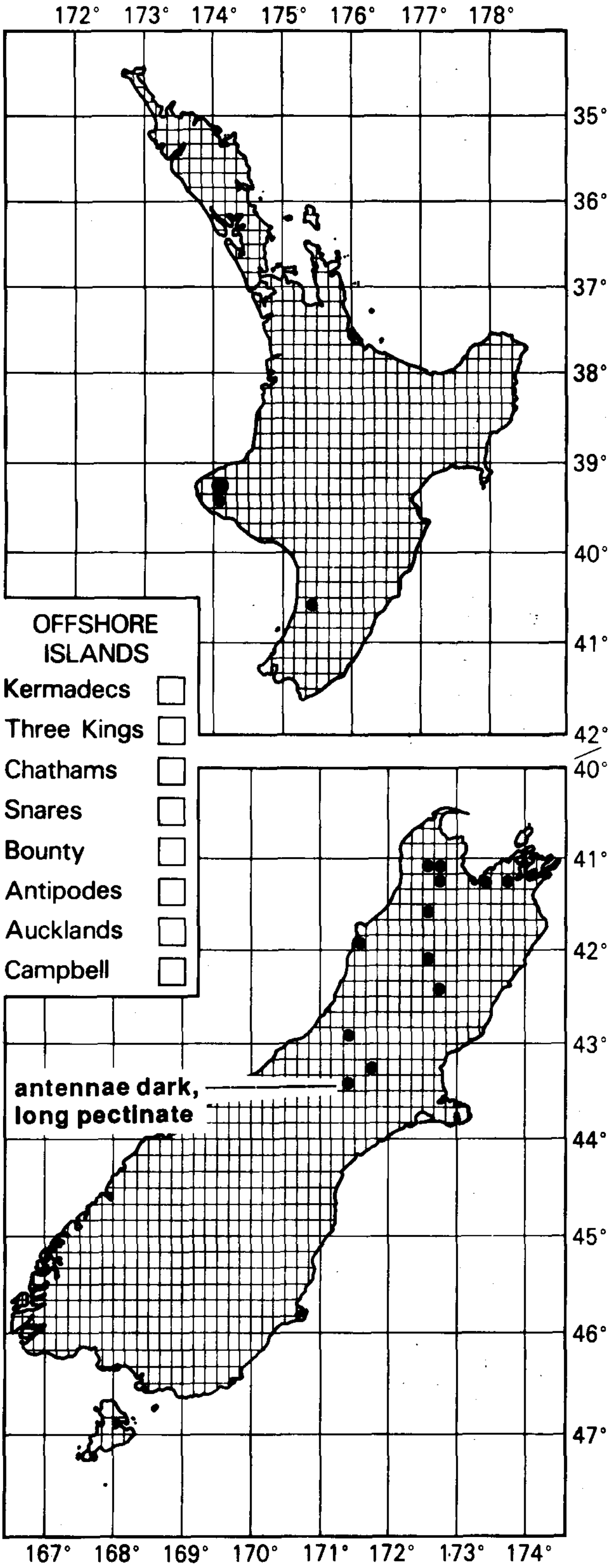
• **Map 14** Collection localities, *Aoraia senex* •



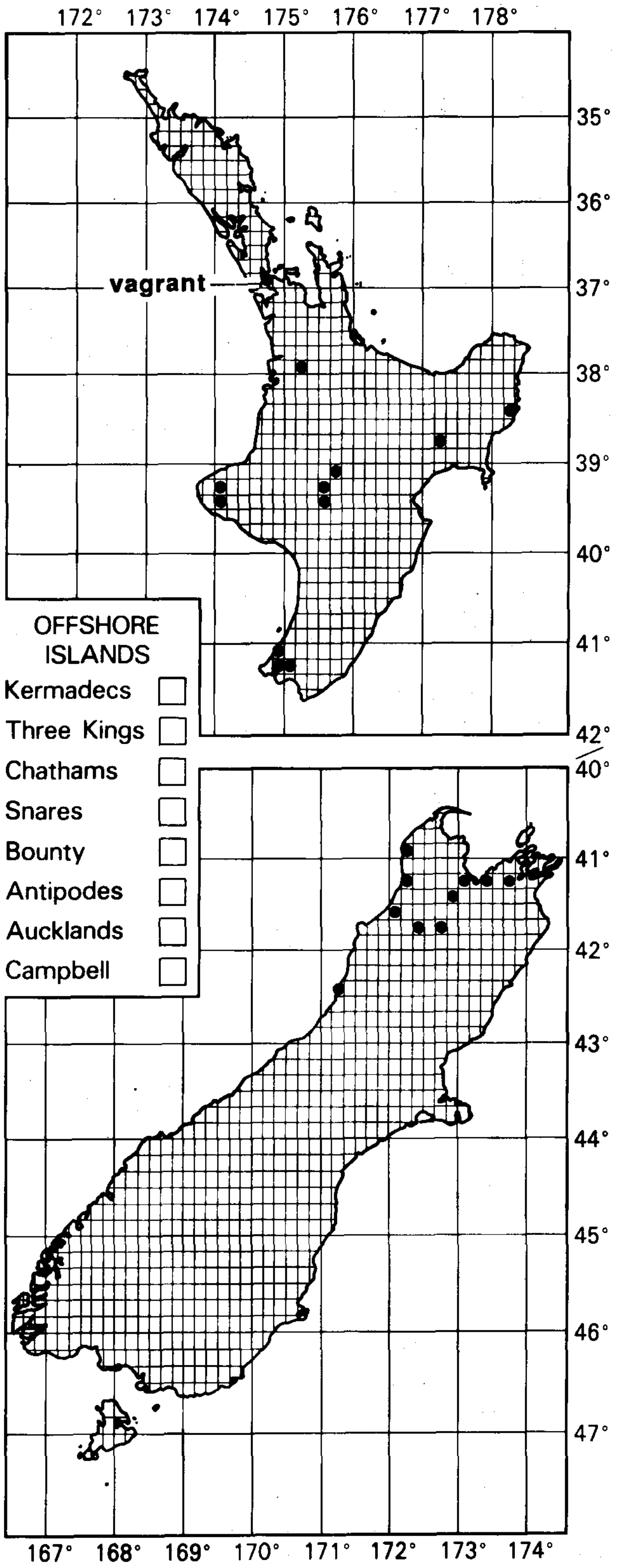
• **Map 15** Collection localities, *Cladoxycanus minos* •



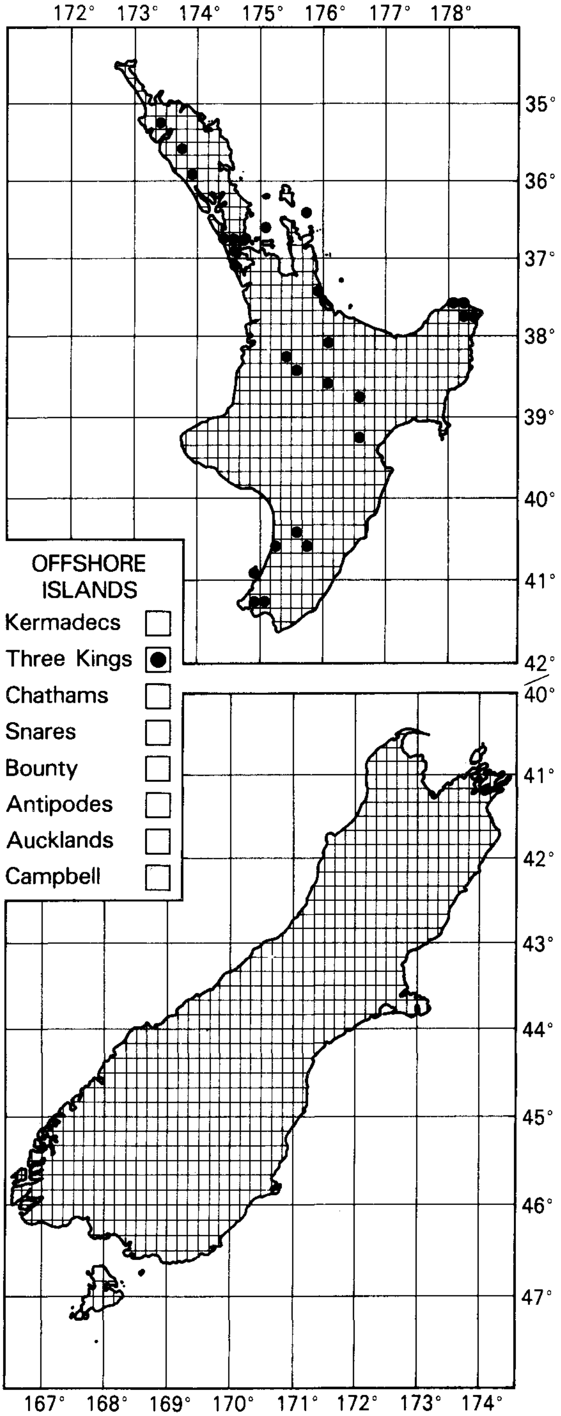
• **Map 16** Collection localities, *Dioxycanus fuscus* •



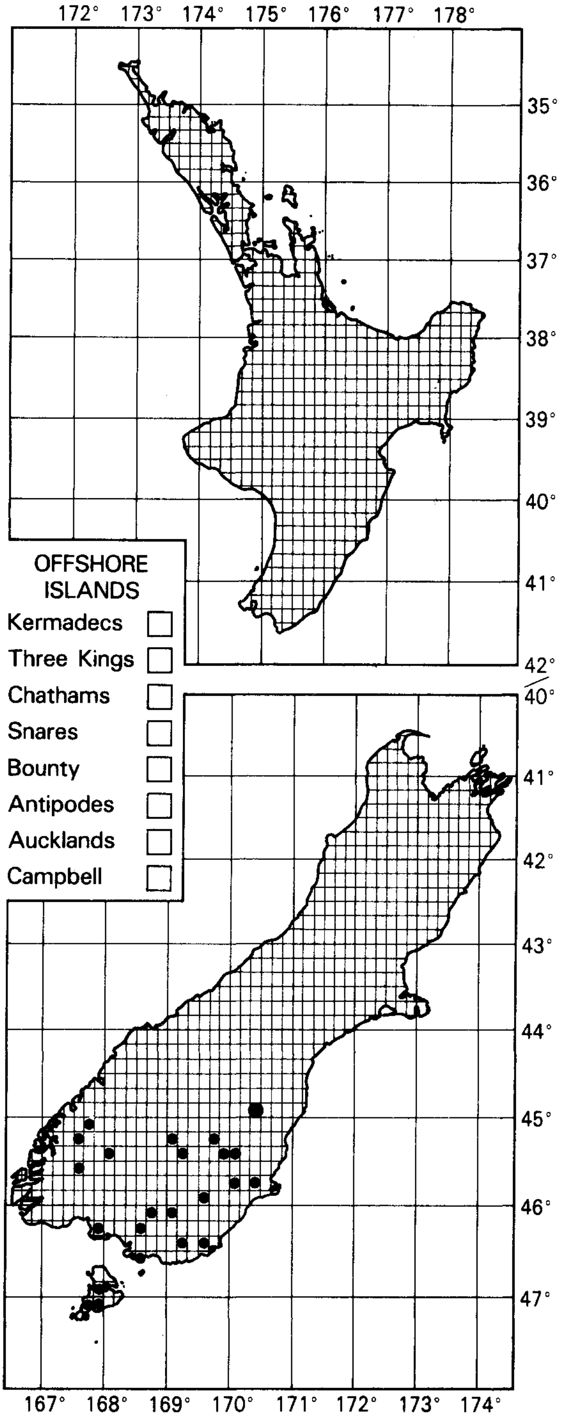
• **Map 17** Collection localities, *Dioxycanus oreas* •



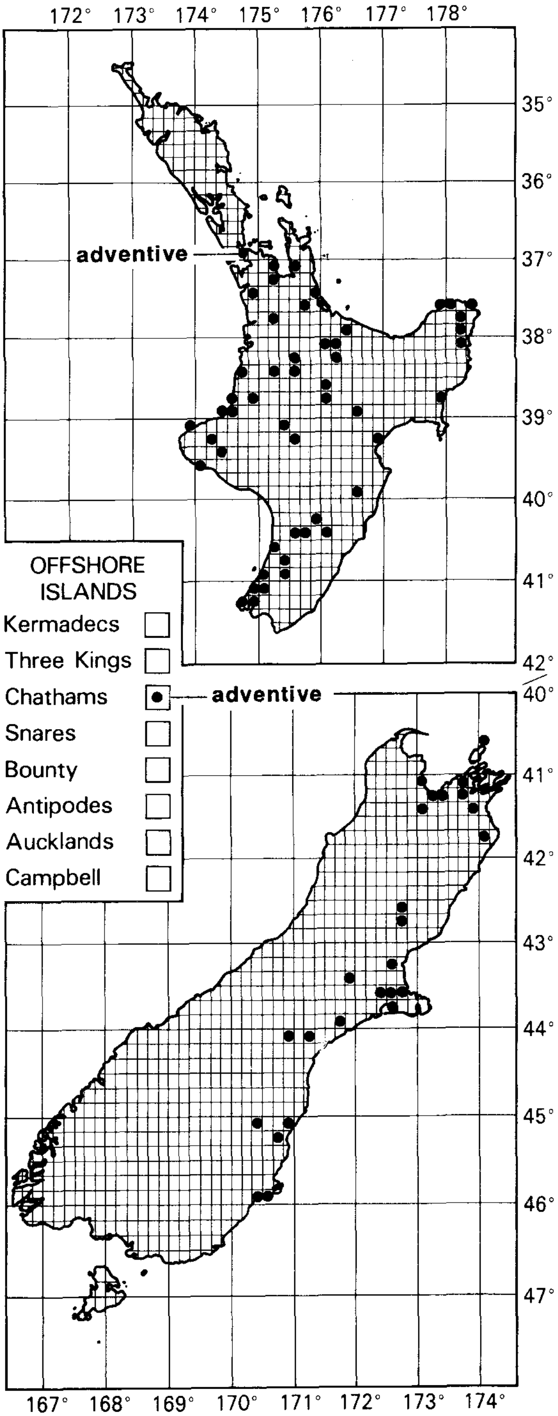
• **Map 18** Collection localities, *Dumbletonius characterifer* •



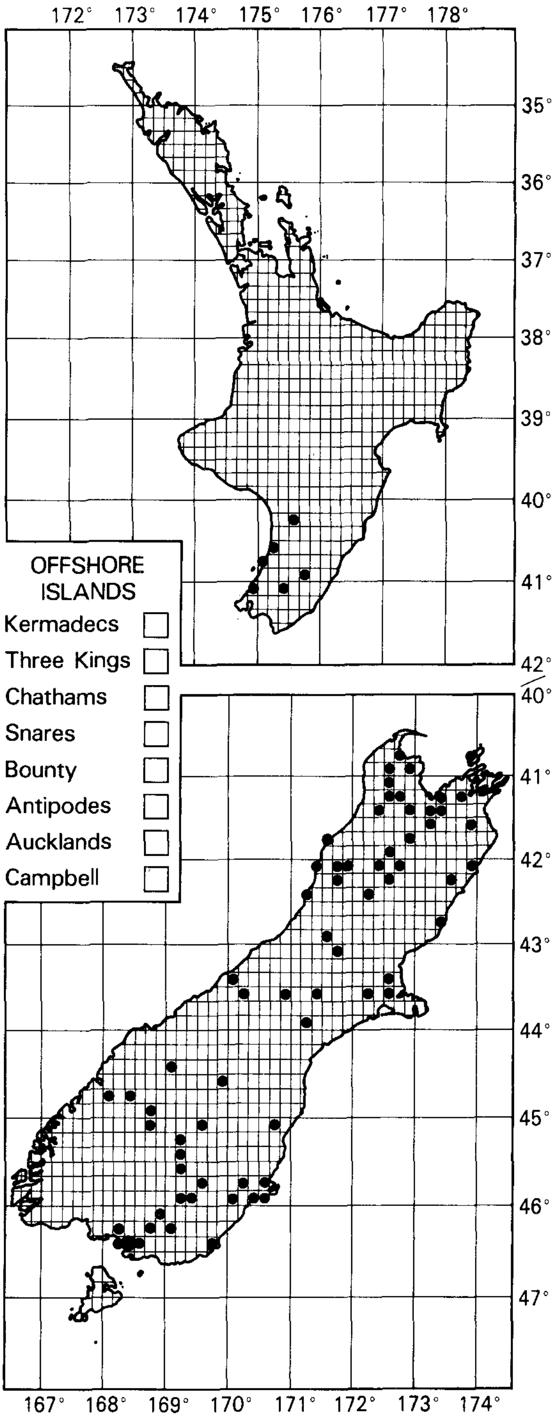
• **Map 19** Collection localities, *Dumbletonius unimaculatus* •



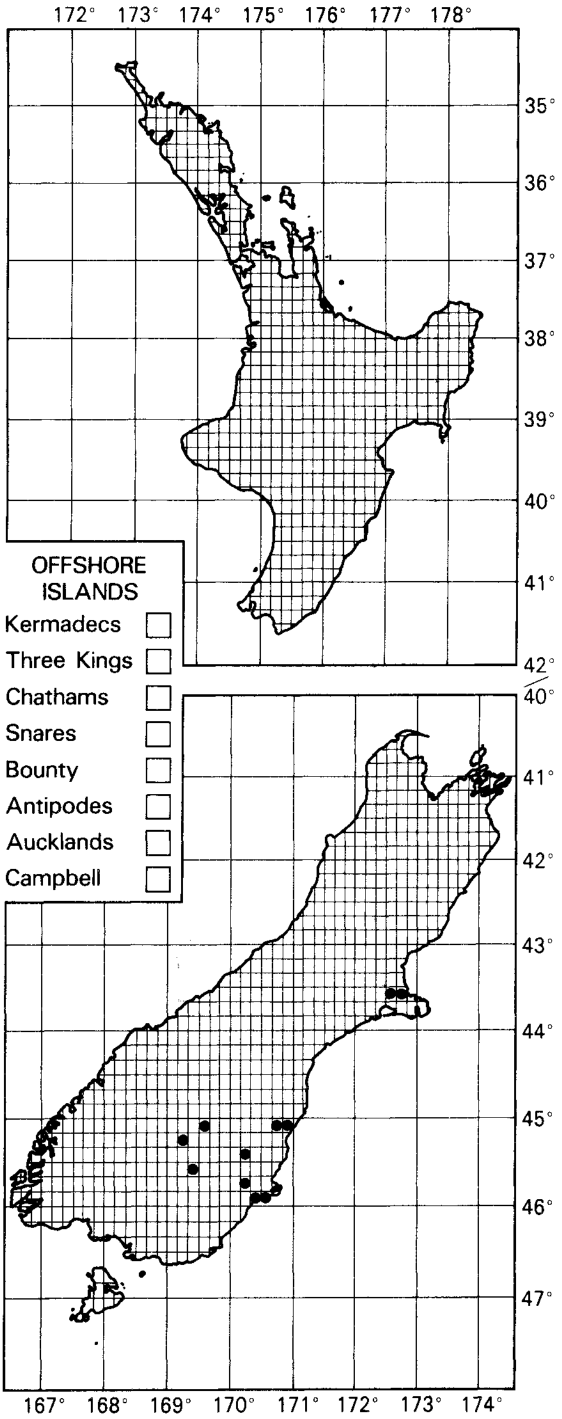
• **Map 20** Collection localities, *Heloxycanus patricki* •



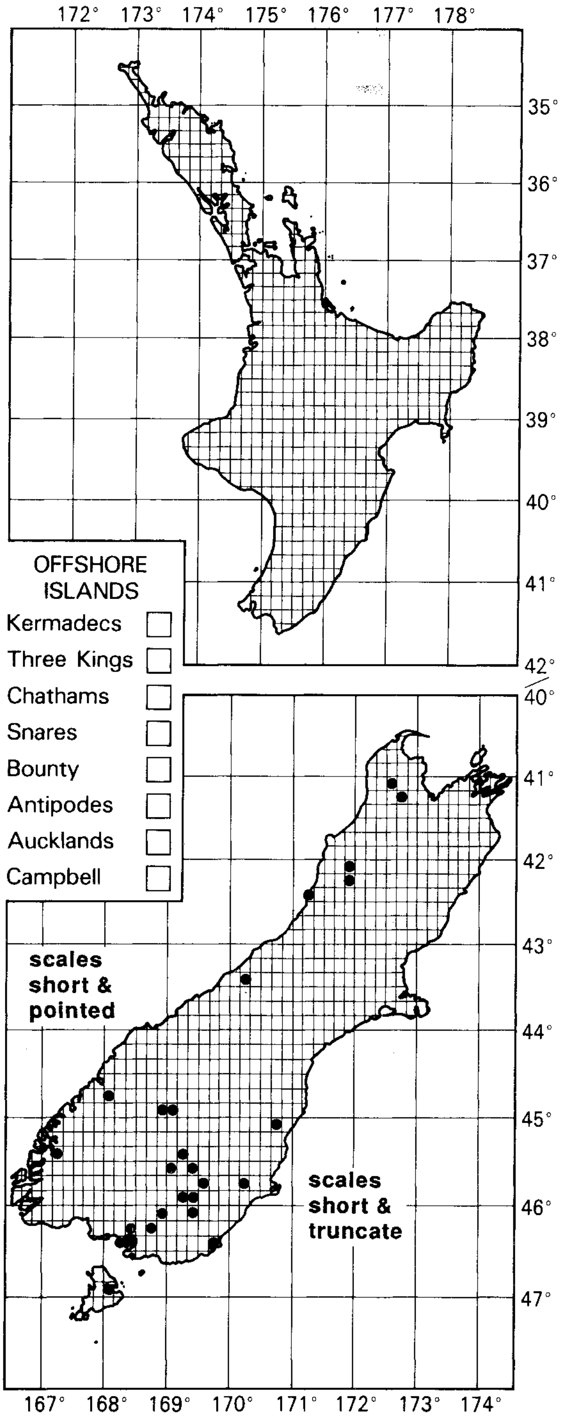
• **Map 21** Collection localities, *Wiseana cervinata* •



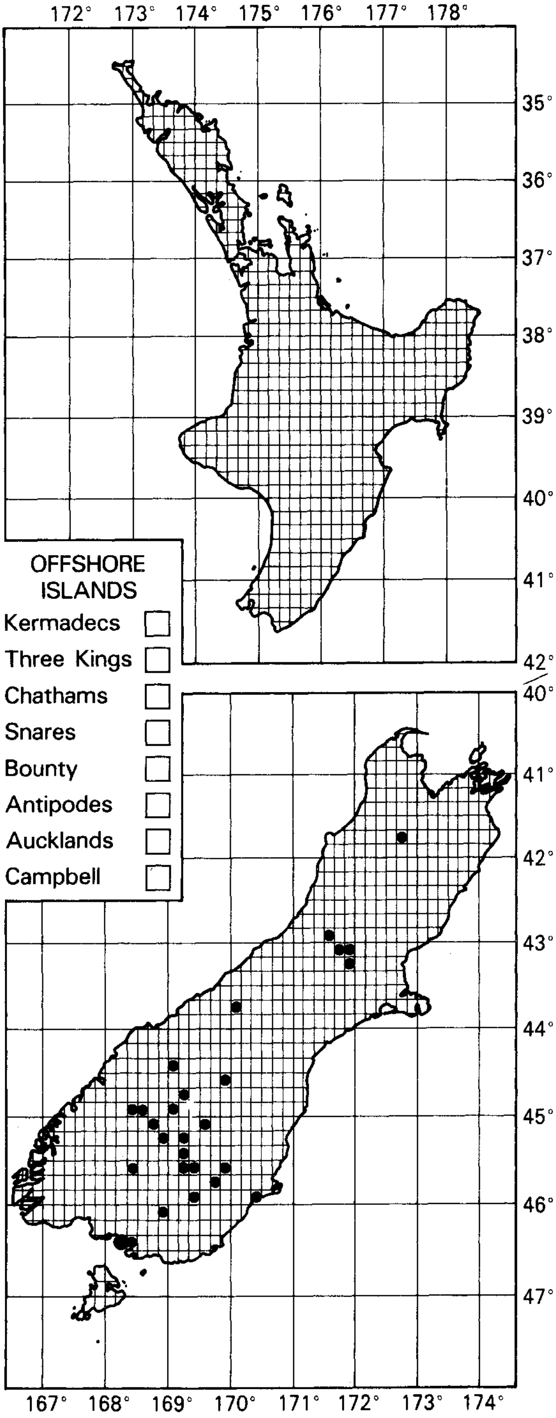
• **Map 22** Collection localities, *Wiseana copularis* •



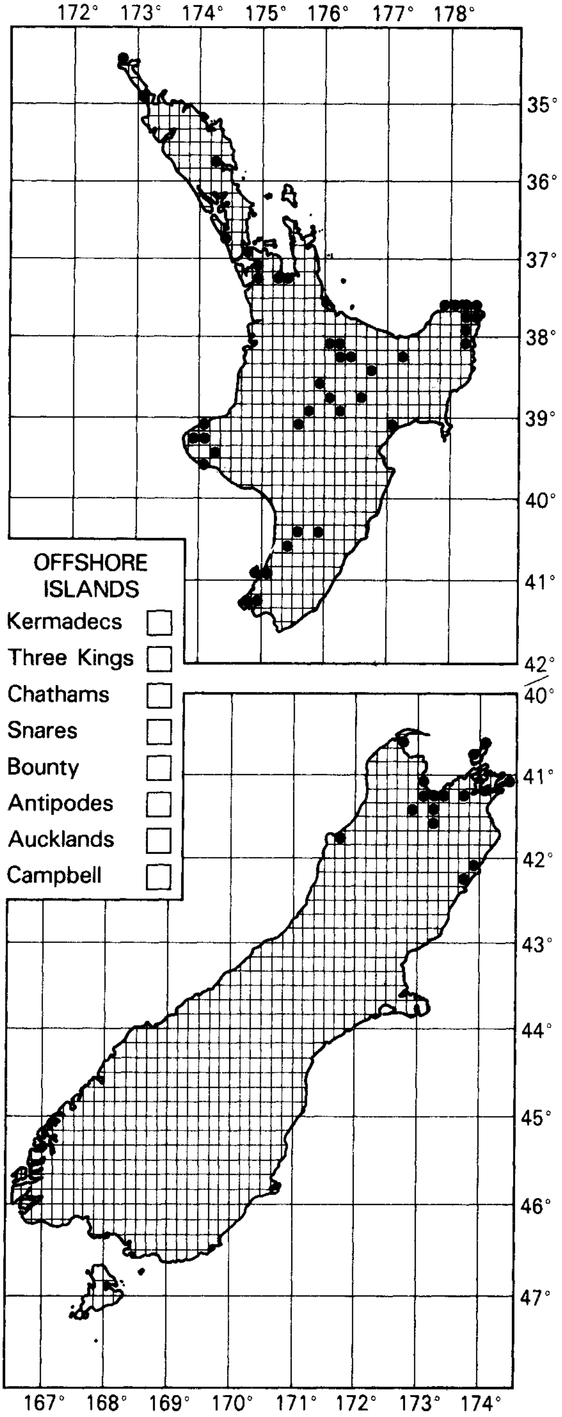
• **Map 23** Collection localities, *Wiseana fuliginea* •



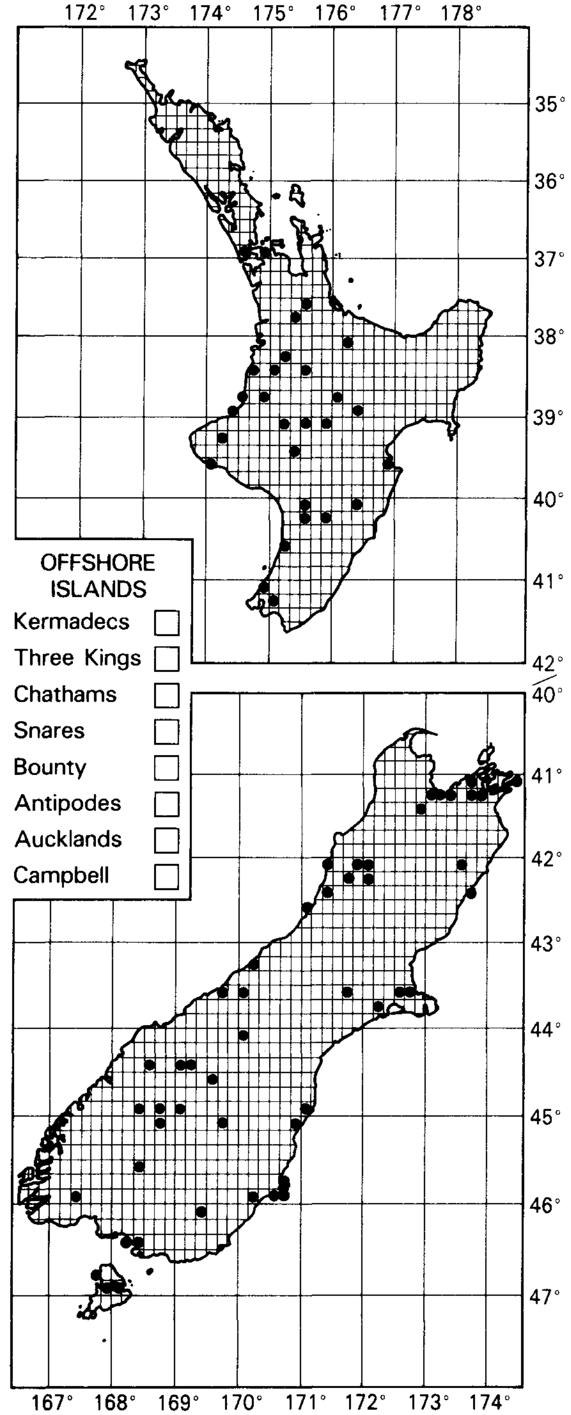
• **Map 24** Collection localities, *Wiseana jocosa* •



• **Map 25** Collection localities, *Wiseana mimica* •



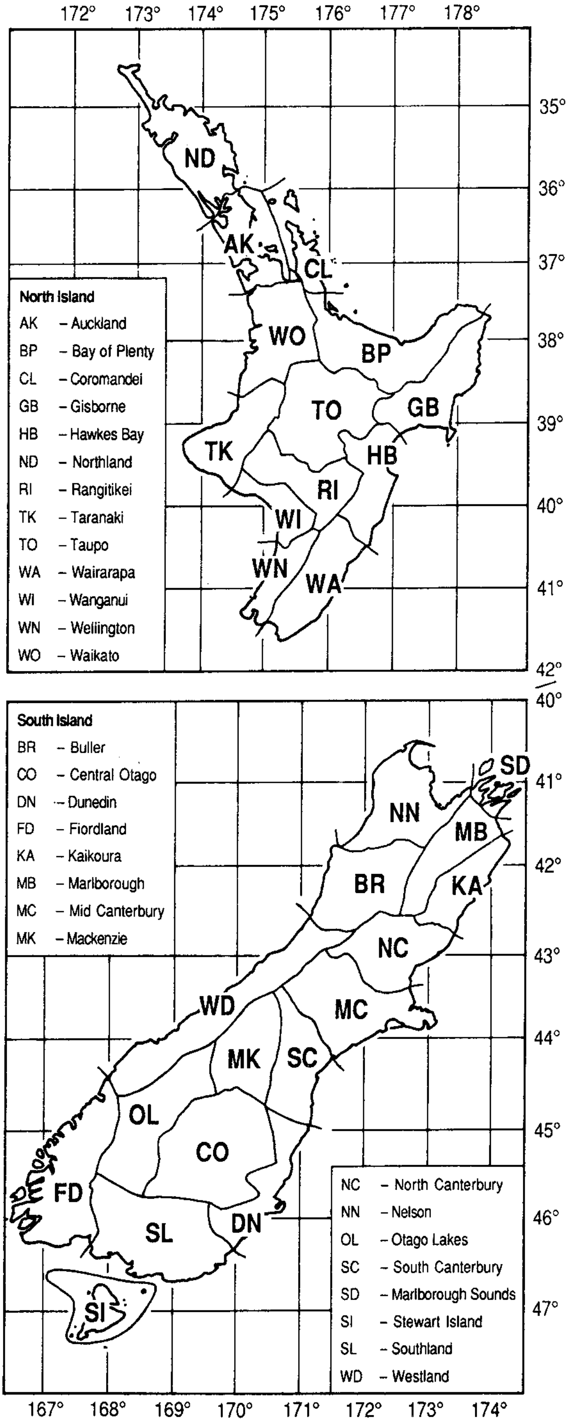
• **Map 26** Collection localities, *Wiseana signata* •



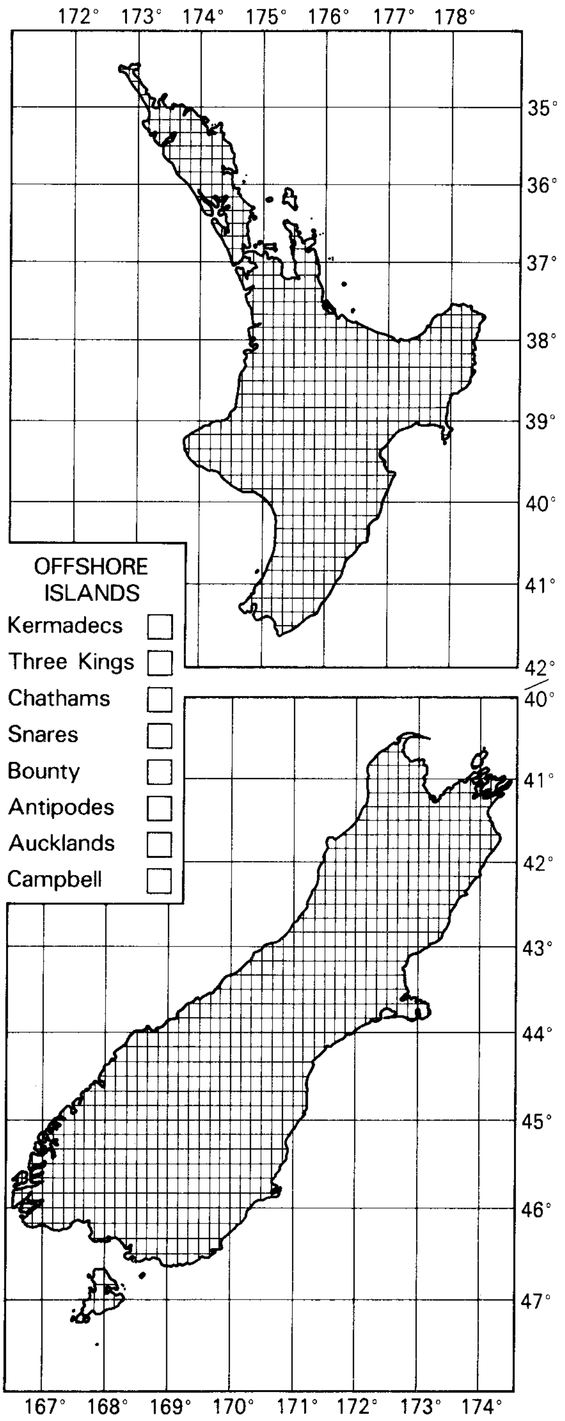
• **Map 27** Collection localities, *Wiseana umbraculata* •

TAXONOMIC INDEX

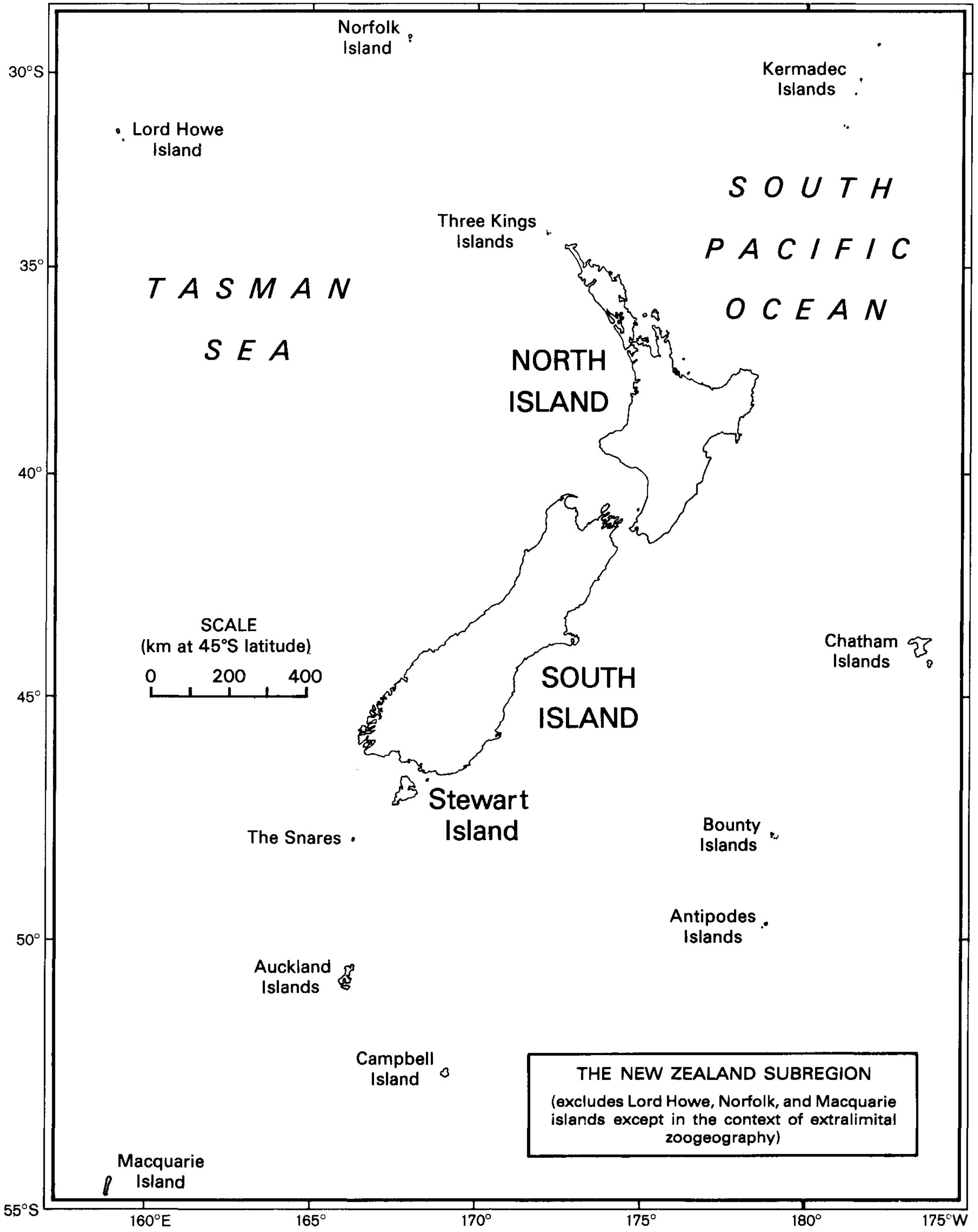
This index covers the nominal taxa mentioned in the text, regardless of their status in taxonomy. Page numbers are in bold type for descriptions of taxa and in italic type for illustrations. Suffixed letters denote keys (k) and distribution maps (m).



Area codes and boundaries used to categorise specimen locality data (after Crosby *et al.* 1976)



Base-map for plotting collection localities; this may be photocopied without copyright release



THE NEW ZEALAND SUBREGION

(excludes Lord Howe, Norfolk, and Macquarie islands except in the context of extralimital zoogeography)

TITLES IN PRINT / PUNA TAITARA TAA

1	**Terebrantia** (Insecta: Thysanoptera) • *Laurence A. Mound & Annette K. Walker* ISBN 0-477-06687-9 • 23 Dec 1982 • 120 pp.	$29.95
2	**Osoriinae** (Insecta: Coleoptera: Staphylinidae) • *H. Pauline McColl* ISBN 0-477-06688-7 • 23 Dec 1982 • 96 pp.	$18.60
3	**Anthribidae** (Insecta: Coleoptera) • *B.A. Holloway* ISBN 0-477-06703-4 • 23 Dec 1982 • 272 pp.	$41.00
4	**Eriophyoidea except Eriophyinae** (Arachnida: Acari) • *D.C.M. Manson* ISBN 0-477-06745-X • 12 Nov 1984 • 144 pp.	$29.95
5	**Eriophyinae** (Arachnida: Acari: Eriophyoidea) • *D.C.M. Manson* ISBN 0-477-06746-8 • 14 Nov 1984 • 128 pp.	$29.95
6	**Hydraenidae** (Insecta: Coleoptera) • *R.G. Ordish* ISBN 0-477-06747-6 • 12 Nov 1984 • 64 pp.	$18.60
7	**Cryptostigmata** (Arachnida: Acari) – a concise review • *M. Luxton* ISBN 0-477-06762-X • 8 Dec 1985 • 112 pp.	$29.95
8	**Calliphoridae** (Insecta: Diptera) • *James P. Dear* ISBN 0-477-06764-6 • 24 Feb 1986 • 88 pp.	$18.60
9	**Protura** (Insecta) • *S.L. Tuxen* ISBN 0-477-06765-4 • 24 Feb 1986 • 52 pp.	$18.60
10	**Tubulifera** (Insecta: Thysanoptera) • *Laurence A. Mound & Annette K. Walker* ISBN 0-477-06784-0 • 22 Sep 1986 • 144 pp.	$34.65
11	**Pseudococcidae** (Insecta: Hemiptera) • *J.M. Cox* ISBN 0-477-06791-3 • 7 Apr 1987 • 232 pp.	$49.95
12	**Pompilidae** (Insecta: Hymenoptera) • *A.C. Harris* ISBN 0-477-02501-3 • 13 Nov 1987 • 160 pp.	$39.95
13	**Encyrtidae** (Insecta: Hymenoptera) • *J.S. Noyes* ISBN 0-477-02517-X • 9 May 1988 • 192 pp.	$44.95
14	**Lepidoptera** – annotated catalogue, and keys to family-group taxa *J. S. Dugdale* • ISBN 0-477-02518-8 • 23 Sep 1988 • 264 pp.	$49.95
15	**Ambositrinae** (Insecta: Hymenoptera: Diapriidae) • *I.D. Naumann* ISBN 0-477-02535-8 • 30 Dec 1988 • 168 pp.	$39.95
16	**Nepticulidae** (Insecta: Lepidoptera) • *Hans Donner & Christopher Wilkinson* ISBN 0-477-02538-2 • 28 Apr 1989 • 92 pp.	$22.95
17	**Mymaridae** (Insecta: Hymenoptera) • *J.S. Noyes & E.W. Valentine* ISBN 0-477-02542-0 • 28 Apr 1989 • 100 pp.	$24.95
18	**Chalcidoidea** (Insecta: Hymenoptera) – introduction, and review of smaller families *J.S. Noyes & E.W. Valentine* • ISBN 0-477-02545-5 • 2 Aug 1989 • 96 pp.	$24.95

19	**Mantodea** (Insecta), with a review of aspects of functional morphology and biology • *G.W. Ramsay* • ISBN 0-477-02581-1 • 13 Jun 1990 • 96 pp....	$24.95
20	**Bibionidae** (Insecta: Diptera) • *Roy A. Harrison* ISBN 0-477-02595-1 • 13 Nov 1990 • 28 pp.	$14.95
21	**Margarodidae** (Insecta: Hemiptera) • *C.F. Morales* ISBN 0-477-02607-9 • 27 May 1991 • 124 pp.	$34.95
22	**Notonemouridae** (Insecta: Plecoptera) • *I.D. McLellan* ISBN 0-477-02518-8 • 27 May 1991 • 64 pp.	$24.95
23	**Sciapodinae, Medeterinae** (Insecta: Diptera) with a generic review of the Dolichopodidae • *D.J. Bickel* • ISBN 0-477-02627-3 • 13 Jan 1992 • 74 pp..	$27.95
24	**Therevidae** (Insecta: Diptera) • *L. Lyneborg* ISBN 0-477-02632-X • 4 Mar 1992 • 140 pp.	$34.95
25	**Cercopidae** (Insecta: Homoptera) • *K.G.A. Hamilton & C.F. Morales* ISBN 0-477-02636-2 • 25 May 1992 • 40 pp.	$17.95
26	**Tenebrionidae** (Insecta: Coleoptera): catalogue of types and keys to taxa *J.C. Watt* • ISBN 0-477-02639-7 • Jul1992 • 70 pp.	$27.95
27	**Antarctoperlinae** (Insecta: Plecoptera) • *I.D. McLellan* ISBN 0-477-01644-8 • 18 Feb 1993 • 70 pp.	$27.95
28	**Larvae of Curculionoidea** (Insecta: Coleoptera): a systematic overview *Brenda M. May* • ISBN 0-478-04505-0 • 14 Jun 1993 • 226 pp.	$55.00
29	**Cryptorhynchinae** (Insecta: Coleoptera: Curculionidae) *C.H.C. Lyal* • ISBN 0-478-04518-2 • 2 Dec 1993 • 308 pp.	$65.00
30	**Hepialidae** (Insecta: Lepidoptera) • *J.S. Dugdale* ISBN 0-478-04524-7 • Feb 1994 • 164 pp.	$P.O.A.

NOTICES

This series of refereed occasional publications has been established to encourage those with expert knowledge to publish concise yet comprehensive accounts of elements in the New Zealand fauna. The series is professional in its conception and presentation, yet every effort is made to provide resources for identification and information that are accessible to the non-specialist.

'Fauna of N.Z.' deals with non-marine invertebrates only, since the vertebrates are well documented, and marine forms are covered by the series 'Marine Fauna of N.Z.'.

Contributions are invited from any person with the requisite specialist skills and resources. Material from the N.Z. Arthropod Collection is available for study.

Contributors should discuss their intentions with an appropriate member of the 'Fauna' Advisory Group or with the Series Editor before commencing work; all necessary guidance will be given.

Subscribers should address inquiries to 'Fauna of N.Z.', Library, Mt Albert Research Centre, Private Bag, Auckland, New Zealand.

Subscription categories: 'A' – standing orders; an invoice will be sent with each new issue, as soon after publication as possible. 'B' – promotional fliers with order forms will be sent from time to time.

Retail prices (see 'Titles in print', page 162) include packaging and surface postage. Subscribers in New Zealand and Australia pay the indicated amount in $NZ; GST is included in the price. Other subscribers pay the listed price in $US, or equivalent.

Back issues of all numbers are available, and new subscribers wishing to obtain a full set or a selection may request a discount. Booksellers and subscription agents are offered a trade discount of 20%.

NGA PAANUI

Kua whakatuuria teenei raarangi pukapuka hei whakahauhau ki nga tohunga whai maatauranga kia whakaatu i nga mea e paa ana ki nga kararehe o Niu Tiireni. He aahua tohunga teenei raarangi pukapuka, engari, ko te hiahia kia maarama ai te tuhituhi, kia moohio ai te maria ki nga tohu o ia ngaarara, o ia ngaarara, aa, kia whakaari i te maatauranga e paa ana ki a ratou.

Ko eenei pukapuka 'Fauna of New Zealand' kaaore e paa ana ki nga kararehe, ki nga ika, ki nga maataitai raanei. E tino moohiotia ana nga kararehe. Kei roto i nga pukapuka e kiia ana 'Marine Fauna of New Zealand' nga tuhituhi e paa ana ki nga ika me nga maataitai.

Tuhituhinga. Ko te tono ki nga tohunga kia tukua mai aa koutou pukapuka. E waatea ana te kohikohinga kararehe e kiia ana ko te New Zealand Arthropod Collection hei maatakitaki maau.

Me whaakii oo koutou whakaaro ki te mema o te kaahui tohutohu o 'Fauna' e tika ana, ki te Etita raanei, i mua i te tiimatanga tuhituhi.

Nga kai-hoko pukapuka. Me tuhi ki te 'Fauna of N.Z.' kei te Library, Mt Albert Research Centre, Private Bag, Auckland, New Zealand.

E rua nga tuumomo kai-hoko: 'A' – Kai-hoko tuumau; ka tukua ia pukapuka, ia pukapuka, me te kaute, i muri tonu i te taanga o taua pukapuka. 'B' – ka tukua nga paanui anake, a toona waa, a toona waa.

Te utu (tirohia te whaarangi 162): Ko te koopakitanga me te pane kuini kei roto i te utu. Me utu koutou e noho ana Niu Tiireni me Aahitereiria ki nga taara o Niu Tiireni. Ko eetahi atu me utu te whakaritenga i nga taara Marikena.

E toe ana nga pukapuka o mua. Mehemea e hiahia ana koe ki te katoa o nga pukapuka, tonoa mai kia heke iho te utu. E rua pai heneti te heke iho o te utu ki nga toa hoko pukapuka.

Fauna of New Zealand

Ko te Aitanga Pepeke o Aotearoa

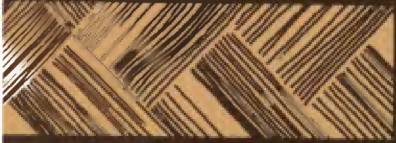
Number 30

Hepialidae

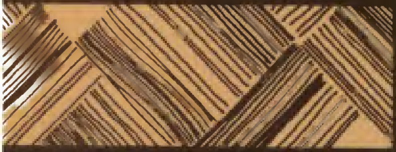
(Insecta :
Lepidoptera)

J. S. Dugdale

POPULAR SUMMARY

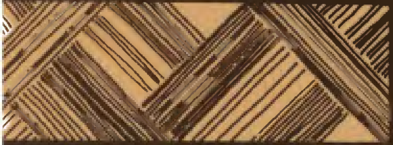


CHECKLIST OF TAXA



KEYS TO TAXA

REFERENCES



TAXONOMIC INDEX

Dugdale, J. S. 1994: Hepialidae (Insecta: Lepidoptera). *Fauna of New Zealand 30,* 164 pp.

Date of publication: 1 March 1994

Fauna of New Zealand, ISSN 0111-5383; 30
ISBN 0-478-04524-7