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Hepialidae
(Insecta: Lepidoptera)

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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...
He is currently a scientist with the Native Plants and Animals Division of Manaaki Whenua - Landcare Research, 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. In 1979, he was appointed as a senior entomologist with the Entomology Division of DSIR. He specialises 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.

Contribution 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.

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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.

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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 (Double-day), 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 alpine 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. Feredy; 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 ‘Nova’. 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. Eayrs. A.G. Butler described species of Hepialidae from both collections.

Meanwhile, back in the colony, local expertise was developing. Sir Walter Butler described and illustrated a large (“5 in, 11 lines”) hepialid adult found by him in the Ruahine Ranges (HB). Butler’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 gracefully 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 Nelson (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 + Mnesarchaeoidae – Nielsen 1989). Formally, within Hepialo-
dea, five families are recognised in the literature: Palacosetidae, Neoteoreidae, 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, Gazoryla Hübner, Afrotheora Nielsen & Scoble, and Antithepialus Janse, and (2) the Hepialidae s.s., comprising other hepialid genera, including all New Zealand genera and all Australian genera except Fraus (Nielsen & Kriestensn 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 (Heloxyccanus 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 Diocoxycanus, 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 Endothesia group, an allopatric assemblage (Grehan 1987b) in S.E. Asia, as the Aenetus and Endothesia 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 ‘pseudoteignon’ (segments 7–10) structure, male valval structure, and male anogenital configuration. The elevate 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_3 and R_4 arising separately from a combined R_2+3 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 bursas 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_1 stalk shorter than free part of R_2.

(viii) Female anogenital field higher than wide, with ovispore 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 Paroxycanus Viette, and the Bornean-Oriental genera (Ueda 1988, fig. 6, 7), the New Zealand genera lack paramal sclerites in the male (cf. Fig. 300, 303, Dumbletonius, and Ueda 1988, fig. 6, as “subanal” sclerites). Lack of the paramal 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 Diocoxycanus 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) Aorilium 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, 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 *Antichepialus* 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 (R5 stem relatively short in *Antichepialus*; cf. Janse 1942, pl. xlix fig. 6, and Fig. 75, *Aoraia*). The form of the trulleum in *Antichepialus* – with a long, docurve, 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 subantennule tuft extending over the eyes (diffuse in some *Aoraia* species).

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

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

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

Australian *Abanliades* 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 *Antichepialus*, *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 *Antichepialus* (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, 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 (ven- tral) 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) collateral 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, Trichophasus 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 or less vertical rows and the antennal base bounded anteriorly by the pound eye, which is more or less shallowly emarginate in depth of the head capsule. The nomenclature of these zones, which 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 anten- nal 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: bicincturate 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 inter-antennal 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 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.

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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 \emph{Aenetus} reduced to a longitudinal ribbon) bears a pair of nipples (most genera) or is smooth \emph{(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 \emph{(e.g., Heloxycanus, Fig. 103)} the concave area is dorsal to the occipital condyles, where the concavity is deep \emph{(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 \emph{(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 \emph{Aoraia} \emph{(Fig. 88)} the arms arise on a basal flexure of the corporotentorium.

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

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

The galea \emph{(or proboscis rudiment: Nielsen & Kristensen 1989)} is usually reduced to a short, thumb-like process often with apical scales or setae \emph{(most genera)} or to a minute tubercle \emph{(e.g., Aenetus, Dumbletonius, Wiseana)} or to a transverse low ridge \emph{(Dioxycanus)}. Behind the posterior post-labial wart is a large zone between the orbits, somewhat sclerotised anteriorly \emph{(ventrally)} and membranous towards the foramen. The sclerotised area, reminiscent of the larval hypostoma, is either broadly emarginate mesally \emph{(Cladoxycanus, Dioxycanus, Heloxycanus)} or has a straight posterior margin \emph{(Aenetus, Aoraia, Dumbletonius, Wiseana)}.

**Antennae** \emph{(Fig. M1-22)}. Quail (1903b) discussed aspects of hepialid antennal structure, and illustrated \emph{Aenetus} \emph{(as Charagia)} and \emph{Wiseana} \emph{(as Porina)} antennae. Flower \& Helson (1976) described and illustrated the various sensilla on flagellar segments of \emph{Aenetus, Wiseana, and Dumbletonius} \emph{(as Trioxycanus)}, noting sexual dimorphism of sensilla arrays. The scape \emph{(basal segment)} and pedicel \emph{(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 \emph{Fraus} \emph{(Nielsen & Kristensen 1989, p. 5, fig. 14, 15)}. The flagellum is less than 0.45× forewing length (less than 0.20× in \emph{Aenetus} and female \emph{Dumbletonius}), and in all New Zealand genera except \emph{Aoraia} has fewer than 50 segments, usually 30–45 \emph{(e.g., Dioxycanus, with about 35)}. The flagellar segments are unscaled in \emph{Dioxycanus, Heloxycanus, and Wiseana}; in \emph{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 \emph{(Aoraia, Heloxycanus)}, spine-like \emph{(Cladoxycanus)}, broadly or narrowly ovate \emph{(Dioxycanus, Dumbletonius, Wiseana)}, or knife-like \emph{(Aenetus)}. The segments are covered in a dense pile of longer or shorter conical cuticular processes \emph{(Flower \& Helson 1976; a possible hepialid apomorphy--Nielsen \& Kristensen 1989, p. 9)}. Interspersed among these are various kinds of sensilla \emph{(pl. sensillae)}. 
- Sensilla chaetica: dorsally and apically on each rami 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: sunk 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 obscuresly 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 rami, 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 laterocervicals 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 laterocervical is either evenly curved (Dioxyccanus, 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 scutellar 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, Dioxyccanus). Irrespective of this condition there is a triangular mesal extension posteriorly, large in Heloxycanus, Dumbletonius, Dioxyccanus, 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 laterocervicals, 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 laterocervical (Dioxyccanus, Heloxycanus, Dumbletonius) or close or appressed to it (Aoraia, Wiseana).

The katepisternal basal margin is distinctly sclerotised and conical in Dioxyccanus, 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 cell 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.

Katepistemite 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 katepistemite
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 katepistemite and extending ventrally
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paracoxal suture is a wide, smooth, unscaled flange
(marked with horizontal lines in Fig. 118–125) sometimes
nearly as large as the katepistemite 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 Ciadoxycanus, and in Aenetus it returns on its
length at the ventral apex of katepistemite 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, Di-
oxycanus, 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 mesepistemum 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 polyptila Meyrick) but also
in the course of the anterodorsal arm of the paracoxal
suture. Dorsally this is sharply bent posteriorly so that it
makes katepistemite 2 rhomboidal or polygonal (or apical
truncate), and it joins the mesopleural suture well
below and distant from the apex of the anepipleural cleft.
In all other genera the anepipleural 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 posteroverentral margin of
katepistemite 2.

Metathorax. The only structure compared was the degree
of reduction of the mesal part of the metascutum (meta-
scutal bridge). In Aoraia the metascutum halves meet
broadly at the dorsal midline, at which point the meta-
scutum length is about 0.20× metascutellum length. In
Dioxycanus and Aenetus the metascutum midline length is
about 0.12× metascutellum length. In all other New Zea-
land genera the metascutal bridge is extremely narrow, and
in Ciadoxycanus 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 foretibia 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 sibia (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 char-
acteristic facies (e.g., Fig. 1–72). There is sexual dimor-
phism 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 M3 and CuA2.
Only in male Aenetus is there a distinct tornus, between
the apices of veins M3 and M4; also in Aenetus the male
forewing apex is subfalcate (i.e., the termen is concave).
Male forewing width varies from about 0.40× wing length
(Aoraia, Cladoxycanus, Dioxycanus, Dumbletoniuss char-
acterifer, Heloxycanus) to about 0.45× (Aenetus, Dumble-
tonius unimaculatus, Wiseana). Aenetus males have the
broader forewings, measured as a perpendicular from the
costa (C) to the apex of vein CuA1.

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 R1 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 acu-
leae 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_{3} 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_{5} and R_{6} arise on a common stem which splits off from R_{2+3} (Fig. 73, 75). In the remaining genera R_{5} and R_{6} each arise separately from the R_{2+3} stem (Fig. 76–80). The branches R_{5} and R_{6} 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* hind wing (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_{4} are fused apically in *Dioxycanus, Dumbletonius, Heloxycanus, and Wiseana* (and also in the New Guinea genus *Paraoxycanus Viette*), but not in *Cladoxycanus, Aenetus*, 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’ (stcal 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 apodermal 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 vincular 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 vincular 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 Birkett-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 intermediate 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.

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

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 extended 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 specialisation. The Heloxycanus pseudotegumen has some features shared with the otherwise unrelated (and extraliminal) Oxycanus sirpus Tindale.

Anus and phallo crypt. These are borne on the membrane surrounded by the pseudotegumen halves. In all New Zealand genera except Aenetus the anus and phallo crypt 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 / phallo crypt 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. 200, 203). The paired sclerotised paranal sclerites (see above) are very reduced or absent in other genera — and posteriorly the supraphallic papilla (Fig. 220), which at rest appears to cover the phallic 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 D2 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 unscerotised 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; D1, D3, and SD, are present in Dumbletonius and Wiseana, and D2 and SD, in Dioxycanus; in Cladoxycanus D2 or SD 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.

**Sternum 7 and 8.** These are fused in *Aenetus, Cladoxycanus, Dioxyce anus,* 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 sternum 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. copulatrix,* 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 vental floor of the antrum, flanked by side-pieces which extend to just under the ends of the downward apices of the dorsal plate. In *Cladoxyce anus, Dioxyce anus,* 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, Dioxyce anus,* 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 *Dixoxyce anus* 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 emmeshed 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 Diurysia.

**Diaphragma.** The membranous field enclosing the anus is unspecialised in all genera except *Dumbletonius, Heloxyc anus,* 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 oppose 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* characteriser it is obliquely and convergently plicate (Fig. 307).

In *Aoraia* and *Wiseana* the antrum 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 spines; 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 lagen.

**Larva (Fig. 156–187)**


The terms and chaetotaxic nomenclature followed here are those used by Nielsen & Kristensen (1989, pp. 86–98), with one exception. Concerning setae D₂ and SD₂, SD₃ on the prothorax, I regard the coarse seta as D₂ and the two fine setae, each arising from a felted, primarily circular ring-base, as SD₁, SD₂, 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 Dityriza: 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. 26.31), 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 Mesarchaeoidea). 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 larva 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 stemmatinal (ocellar) arrangement, head capsule structure and chaetotaxy, proleg crochet conformation, prothoracic sclerotisation, structures associated with prothoracic setae D₂, SD₁, and SD₂, 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 *Antiehepiallis* 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
The “oral frame” – that thickened and strongly sclerotised margin between the lateral edge of the clypeus and the ventral mesal margin of each epicanthal 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 larva 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, 1s) 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.

(And *Mnesarchaea* the oral ‘slit’ – here a discontinuity in the oral frame – is directly beside seta SO. In New Zealand Hepialidae this seta is well medial 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 epicanthal 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 sublaterial 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 labium, which are bifid in *Cladoxycanus* (Fig. 165) but unifid in other genera; the presence of sculpturing on the inner face of the dististipes (in *Ditrysia*, 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 F₁, C₁, C₂, only late-instar
Aenetus virescens and Cladoxycanus the prothorax is broadly fused with the post-sternum (Boudriot 1991, fig. 21, shows them separate in *A. cohici*). A small prosternum is present on the mesothorax in all genera except *Cladoxycanus*, *Heloxycanus*, and *Wiseana*. The mesothoracic and metathoracic post-ster nal sclerite (or *V₁* 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 *V₁* pinaculum in *Aenetus* and *Aoraia*. Posterior to the seta *L₁* pinaculum on abdominal segments 1–7 is an elongate, equally large sclerite in *Aoraia*; in *Dioxycanus*, and often in *Wiseana*, there is a small sclerite in this position on A1 and A2, but it is not as large as the *L₁* pinaculum.

Between the anal prolegs there is a fused or weakly divided *V₁* pinaculum in *Aoraia*, *Dioxycanus*, *Dumbletonius*, and *Wiseana*: the pinaculum 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 pinacalar fusion and size vary between instars, usually with earlier (e.g., antepenultimate, penultimate) instars having larger or more distinct or less eroded pinacular. At least one character—metathoracic seta *L₁* on or separate from the usually rhomboidal SD₁, SD₂ pinaculum—distinquishes *Aoraia* and *Aenetus* from other New Zealand genera. Some elements do not change: in all New Zealand genera except *Aoraia*, abdominal segment 1 setae *L₁*, *L₂* are on a fused pinaculum, and on succeeding segments they are on separate pinaculum. In all New Zealand genera except *Aenetus*, abdominal proleg seta *SV₂* is on a separate pinaculum and *SV₁*, *SV₃* 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 hepialid genera examined possess black, felted (pirole) 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*, *Zeolotryia*, and *Endoclita* all three setae are enclosed by an elongate felted pit or melanised depression. On the *Mnesarchaea* (*Mnesarchaeoidea*) mesothoracic setae are long, fine, and curved (*SD₁, SD₂*) and lie on a pilose mound; *SD₁* 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 *D₁* is the most dorsal, *SD₂* the intermediate, and *SD₁* the ventral. Wagner (1987) reversed the notation for *D₂* and *SD₁*, 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 *SD₁* setal group tends to be setulose, elongate, and in at least one genus (*Sariseta* Fletcher, as *Gargaphia*) capable of movement.

(b) The relative proportions of the proprioceptor setae *MD₁, MS₁*, and *MSD₁* 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 *MD₁* longer and darker on the metathorax. In *Aenetus* *MD₁* is longer and darker on both mesothorax and metathorax. (*Endoclita excrescens* Butler has the same state.) Seta *MD₁* in particular is prone to damage in preserved specimens, and the *MD₁-MS₁-MSD₁* 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 rest of the pupal integument is pallid, almost flimsily sclerotised (Aenetus—e.g., Boudinot 1991, fig. 23, Endoclita, Zelotypia).

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 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 maxilla is either planeconvex (Aoraia, Aenetus, Cladoxycanus, 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 except Aenetus 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 D₁ and SD₁ 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 quadri-furcate 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 naked 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 hindwing base of the frons is plane in all New Zealand genera except Aenetus, where it is sunken; in Aenetus the frons may be plane, convex, 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 quadri-furcate 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).

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prominent ventral (anterior) row on A7, which is often prominent, particularly in reduced chaetotaxy in all genera, with ventrally a pair of short transverse carinae, posteriorly on A1 and A2 (not connected with the dorsal anterior row in front of the A7 spiracle). *Aenetus*, *Zeolypa*, 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 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 D1 and D2, and the other genera only D1.

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 sinusous. 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, entyiß*, *dinodes* groups) are contemporaneous (NZAC records), as are some members of the penelpine 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.

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(Porina mairi)  "Summer" 1867
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) rear ing 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 pesticides 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 Cladocoxycanus, Dioxyycanus, 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-shafmakin (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 (Lisson 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, ifnot 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), intertusssock swards (A. lenis), and cushion bogs with Oreobolus (A. ruifera, A. oreobolae), with obvious browse damage to live vascular plants (Grehan & Patrick 1984). Dioxyycanus and Wiseana, at least beyond the third instar, browse on live vascular plants, and Cladocoxycanus 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)

<table>
<thead>
<tr>
<th></th>
<th>Mycophagy</th>
<th>Phytophagy</th>
<th>Development time (years)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Fungi, rottent wood</td>
<td>Callus tissue on trunks</td>
<td>Vascular plant turf</td>
</tr>
<tr>
<td>Aenetus</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aoraia</td>
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<td>+</td>
<td></td>
</tr>
<tr>
<td>Cladoxycanus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxycanus</td>
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<td></td>
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<tr>
<td>Dumbletonius</td>
<td>+</td>
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<td></td>
</tr>
<tr>
<td>Heloxycanus</td>
<td>(+)</td>
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<tr>
<td>Wiseana</td>
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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 brachyphylia 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 substrat 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 unbraculata. I have collected W. unbraculata from shafts constructed in the raised heads of Carex secta (niggerhead) in the middle of a swamp, suggesting that W. unbraculata 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 Korscheltelius 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 wets’ — 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 aresia, 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 flourish — 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, Parapieius Vierte) 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.

<table>
<thead>
<tr>
<th>Vegetation zone</th>
<th>Forest</th>
<th>Shrub-grassland</th>
<th>Bogs / seepages</th>
<th>Urban</th>
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<tr>
<td></td>
<td>WT</td>
<td>CT</td>
<td>SA</td>
<td>WT</td>
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<tr>
<td><strong>Aenetus virescens</strong></td>
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<td><strong>Aoraia aspina</strong></td>
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<tr>
<td><em>aurimaculata</em></td>
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<tr>
<td><em>dinodes</em></td>
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<td><em>enysii</em></td>
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<td><em>flavida</em></td>
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<td><em>hespera</em></td>
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<td><em>insulae</em></td>
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<td><em>lentis</em></td>
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<td><em>macropis</em></td>
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<td><em>oreobolae</em></td>
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<td><em>rufivena</em></td>
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<td><em>senex</em></td>
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<tr>
<td><strong>Cladoxycanus minos</strong></td>
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<td><strong>Dioxycanus fuscus</strong></td>
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<td><em>oreas</em></td>
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<td><strong>Dumbletonius characterifer</strong></td>
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<tr>
<td><em>unimaculatus</em></td>
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<tr>
<td><strong>Heloxycanus patricki</strong></td>
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<td><em>cervinata</em></td>
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<td><em>copularis</em></td>
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<tr>
<td><em>fuliginea</em></td>
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<td>+</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td><em>signata</em></td>
<td>(+)</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>umbracluta</em></td>
<td>(+)</td>
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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. umbracluta*) 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 alpine biotopes, except possibly where these are altitudinally depressed, as at Arthur’s 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 other references), including at least seven fungi, a bacterium, an 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 & Kaín 1983) and the baculovirus Borrelinaviruses sp. (Kalmakov 1980). The record of Cordyceps sp. (as Sphaeria) in Aenetus virensensis (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 ichneumonoid 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, Cladoxyccanus, or Heloxycanus. A puparium associated with a dead Diaspycatus 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**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Institution</th>
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<tbody>
<tr>
<td>AMNZ</td>
<td>Auckland Institute and War Memorial Museum, Auckland, New Zealand</td>
</tr>
<tr>
<td>ANIC</td>
<td>Australian National Insect Collection, CSIRO Division of Entomology, Canberra, Australia</td>
</tr>
<tr>
<td>BLNZ</td>
<td>B. Lyford private collection, Queentown, New Zealand</td>
</tr>
<tr>
<td>BMNH</td>
<td>British Museum (Natural History), now The Natural History Museum, London, England</td>
</tr>
<tr>
<td>BPNZ</td>
<td>B.H. Patrick private collection, Dunedin, New Zealand</td>
</tr>
<tr>
<td>CMNZ</td>
<td>Canterbury Museum, Christchurch, New Zealand</td>
</tr>
<tr>
<td>FRNZ</td>
<td>Forest Research Institute, N.Z. Forest Service, Rotorua, New Zealand</td>
</tr>
<tr>
<td>HCOE</td>
<td>Hope Collection, Oxford University, England</td>
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<tr>
<td>LUNZ</td>
<td>Dept of Entomology, Lincoln University, Lincoln, New Zealand</td>
</tr>
<tr>
<td>MNHN</td>
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</tr>
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<td>NMNZ</td>
<td>National Museum of New Zealand, Wellington, New Zealand</td>
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<tr>
<td>NZAC</td>
<td>New Zealand Arthropod Collection, Manaaki whenu - Landcare Research, Mount Albert Research Centre, Auckland, New Zealand</td>
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<tr>
<td>RMVA</td>
<td>Royal Imperial Museum, Vienna, Austria</td>
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<tr>
<td>SAMA</td>
<td>South Australian Museum, Adelaide, Australia</td>
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</table>

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 R₅ and R₆ on a common stem separate from the R₆ 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 R₅, R₆, and R₇ on a common stem separate from R₈ (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 red-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 arculum; 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 arculum; 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 sternum 7 and 8 fused (Fig. 152). Emerging in summer (Nov–Jan) ... (p. 53) .. Dioxyxanus (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 tegumen 8 split mesally from posterior margin ... (p. 55) .. 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 tegumen 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 pro-anteral bar, an oral frame slit, similar chaetotaxy (abdominal seta L₃ anterocentral 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 D₂, SD₁, SD₂ 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 L1 close to seta L3; proleg crotchets biserial (Fig. 181); SV2 setae on proleg on a common pinaculum; anal proleg crotchets 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 L1 displaced posteriorly to beside epicranial lateral notch (Fig. 162); proleg crotchets multiserial; proleg SV2 setae on 2 pinacula; anal proleg crotchets 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 L4, pinaculum (Fig. 185) on abdominal segments 1 and 2; either para- or procoxal sclerites tumid and strongly sclerotised or pro- or thoracic shield setae SD1, SD2 in a common, kidney-shaped felled pit (Fig. 185, see caption). Larvae in forest or montane tall shrubland, not alpine or subalpine ... (p. 56) .. *Dumbletonius*

---No sclerite posterior to L4, pinaculum (e.g., Fig. 183, 184); prothoracic setae SD1, SD2 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 / moss 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 setae SD2 far longer than greatest width of SD3–SD2 pinaculum; abdomen lacking sternal plates. Larvae in sphagnum moss cushion bogs ... (p. 51) .. *Cladoxycanus*

---Abdominal seta SD2 length not exceeding greatest width of SD1–SD2 pinaculum, or SD1, SD2 on separate or greatly reduced pinaculum (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 (*Dioryctria 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, discarded, 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 SD1, SD2 (Fig. 191) ... (p. 40) .. *Aoraia*

---Abdomen with A8 bearing a subventral carina, sometimes very short, posteroverentral 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

---Vertex raised, conical or thorn-like, 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, Ip), 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, horizontal, 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 foretibial 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 sub-terminal patches of yellow scales, veins Sc and R, 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, 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 blunty 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 forctibial 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; forctibial epiphysis very small to obsolete ... 12

12(11) Male with trulicum 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 trulicum 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

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(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(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(5) Twin processes large (length over 0.4x, usually about 0.5x posterior process length); pseudotegmnal 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); pseudotegmnal 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 secundifurc, not obliterating or narrowing subantennal cleft. Larvae known from MK, OL, CO, DN, SL, FD

—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 SD₁, SD₂ in separate felted pits; upper surface of mandibles creased or furrowed. Pupa: A3 with anterior dorsal crest straight

—Larva: prothoracic shield with setae SD₁, SD₂ 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

**Wiseana** (penultimate and final instars)

1 A1+2 setae SD₁ and SD₂ pinacula narrowly fused or, if separate, then SD₂ pinacula excavate ... 2
—A1+2 setae SD₁ and SD₂ pinacula broadly fused or, if separate, then pinacula entire

2(1) Mesal (inner) paraproct setae further apart than posterior setae on anal proleg base; A2–8 with SD₁ and SD₂ pinacula narrowly fused. Larva in bogs and swamps, associated with large monocotyledonous plants (e.g., *Carex, Juncus*). North I., South I., Stewart I.

—Mesal paraproct setae and posterior seta on anal proleg base equally far apart; if SD₁ and SD₂ pinacula on A2–8 narrowly fused then SD₂ 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

3(1) SD₁, SD₂ on a common pinaculum on all abdominal segments ... (p. 64) .. *copularis*
—SD₁, SD₂ pinacula fused on A1 and A2, sometimes A1–3, and SD₂ separate from, or at margin of, SD₁ 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.


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 0.2× 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; metasomum half with a narrow bridge of depth approx. 0.12× metasomatum length. Forewing venation with R₄+R₅ stem separate from R₂–R₃ 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 suture, with and 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 paired segments 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): sternum 7 and 8 separate or fused; saccus biolated; valva with 1–3 decayed, 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). Male genitalia (Fig. 211, 214–217): sternum 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; spermatecal duct sinus; ductus bursae long, slender, sparsely spinulate apically; corpus bursae ovoid, 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; frontal-ocular setae P₁ distinctly dorsal to clypeal seta (C₂); hypostoma half with a narrow bridge in all instars. Pronotum with setae D₁, D₂, D₃, D₄ in line and included in a blackened, micropilose pit; setae L₁, L₂ 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 scrobinate, 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 A4–5, 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, Zeolotypia, 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 SD₁, SD₃, SD₄ 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 crotchets 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, Bouddi not 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 (D2, SD, S3) in the prothoracic felted pit and with biseral 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.


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 (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): stemmata 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; truleum un sclerotised.

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 B1, A2 and setae A2, A3. 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, Ilidghe Colln.

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

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., *Echinocloa russica* (fungi on wood).


Remarks. *A. virescens* is distinguished from Australian species and from New Caledonian *A. cohici* by its clavate (club-shaped) labial papil lary 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 *putapatuweta* ('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 show 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 in temperate forest sites (Te Rereauira Swamp BP, Otanga BP, Waioreko BP, and Te Koau BP) during spring and summer 1992–93 (n > 300) wore 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, 0.3–0.45× 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 long, hair-like scales ventrally; maxillary palpi reduced to a pair of stumps. Metathorax with setal punctures La displaced posteriorly to bends lateral epicranial notches; abdominal segments 1–6 (at least) with 2 longitudinal pinacula at the level of seta L, one anterior (bearing L2), the other (Fig. 182, p) posterior to it.

**Larva.** Stemmata arranged in 2 vertical rows, diverging ventrally; hypostomal plates fused in midline; head capsule with setal punctuation displaced posteriorly to bends lateral epicranial notches; abdominal segments 1–6 (at least) with 2 longitudinal pinacula at the level of seta L, one anterior (bearing L2), 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 SD1, SD2.

**Remarks.** *Aoraia*, with thirteen species, is the largest hepaliald 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. oreoidae*).

Larvae and pupae have so far yielded no consistent characters diagnostic of species or species-groups. Imma-
ture 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 fororhiza is of use in species with fully winged females; in species with brachypterous females epiphysis state, wing scale shape, and confirmation 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 trullar 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 Ia displaced posteriorly and most abdominal segments with a posterior pinaculum at the seta I 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, pen-alpine 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 0.35× 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 Mins, 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 antero-dorsally directed median piece. Males also differ in having the apex of the supraphallic papilla strongly sclerotised and setose. In other species the papilla may or may not be sclerotised apically, and nude. Males (the commoner sex so far collected) externally papilla may or may not be sclerotised apically, and nude. Females were found crawling in the same plant community at Gem Lake (Patrick 1988).

**Aorala aurimaculata (Philpott)**

Fig. 7-9, 225-229; Map 3

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

Male (Fig. 7-9) large, 62-67 mm in wingspan, with forewing length 29-32 mm; antenatal length 0.3× forewing length; forewing often with 1 or more small patches of yellow scales subterminally between veins R₅ and M₁₋₃; 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 *Aorala aurimaculata* (Philpott)" (red card), "Mt Cook Nat. Pk, Gov. Bush 810 m, 18 Apr. 1977, light, W.J. Swenney" (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, Landsborough Vly, Mt Cook Nat. Park, Governors Bush, L. Ohau, headwaters of Hunter R., L. Hawea, Queenstown, Snowy R. / Dart Vly junction, Homer, Hollyford/Elginnt Divida, 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 reduced to a short, elongate stump. 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. ensisii* from Mt Te Aroha BP and Mt Piariuch 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 mountain shrubland. The two males recorded from Dunedin DN by Dumbleton (1966, p. 937) are assigned to *A. rufivena*.

**Aorala 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 *(Aorala).*
Male large, 62–70 mm in wingspan, with forewing length 27–32 mm; anten nal length approx. 0.35 x 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 unisclerotised.

Female genitalia (Fig. 256–239): 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 lacking a flange; supraphallic papilla unisclerotised.

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) Otara, Mr B.H. Patrick did not collect any, nor observed any pupal exuviae. Occasional trapping at Thomson 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).


Male large, 60–74 mm in wingspan, with forewing length 26–32 mm; anten nal length approx. 0.33 x 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 that 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; 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.


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, Dermiston, 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 Aorala 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 Aorala 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.

Aorala 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 0.45× 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 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 nar-
rowed to acuminate apex; valva (Fig. 253) 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. 258) with process unifid, base narrow, arms straight; saccus with a marginal flange; suprachallic 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, enlarged caudally, with side-pieces wider than long, dorsal margin carinate, irregularly toothed; trulleum lyre-shaped (Fig. 259), with dorsal margin convex, apically toothed; valva strongly curved, apically acute, relatively stout, 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; suprachallic papilla unsclerotised.

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.

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

Distribution: — / CO, SL.

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 seta on the suprachallic sclerite, the palillip 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 lobo, 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; suprachallic papilla unsclerotised.

Type data. Holotype male labelled “New Zealand FD Mt George 2 km N 25 March 1977, D.R. Given” (white card), “HOLOTYPE 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; antennal length 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 sclerolised 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


Male large, 62–73 mm in wingspan, with forewing length 26–32 mm; antenna 0.3 x 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 veins 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 plano-convex in lateral view (Fig. 264), with no dorsal process or lobe; posterior process smooth apically, irregularly serrate or roughened dorsally on margin, ventral process subspinose apically, irregularly serrate 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 scutulose 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 (M26742091), 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, Alimurock, 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.
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 *Aoraria* species by pseudotegumen shape (Fig. 264, and Dumbleton 1966, p. 939, fig. 42–45) and the conspicuous white basal streak or stripes 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 males are brachypterous. The females tentatively associated with this species by pseudotegumen shape (Fig. 264, and Dumbleton 1966, p. 939, fig. 42–45) and the conspicuous white basal streak or stripes 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 that is apically broadly rounded, not narrowed or vestigial as in similarly large females of other species.

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

*Aoraria 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*); forewings 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); trullum lyre-shaped (arms sinu-ous), with base narrow rectangular and basal cone small, unifid; valva strongly geniculate (slidowed), 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 clongate-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] *Aoraria macropis* Dugdale", NZAC.

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

Material examined. Type series, plus the following nontype 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 Whitcombe Creek, 1100 m, 19 Mar 1986, B. Patrick & 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 *Aoralaia* 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, in which lateral view hide the genital 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 rotted 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 or the compound eyes, in contrast to their reduced state in the sympatric *A. senex*.

**Aoralaia 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 (0.45×) 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); supravaginal papillae, un sclerotised.

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 1.5× 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), "Aoralaia sp. [male] det. B.H. Patrick 4/4/1987" (white card), "Holotype *Aoralaia 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 trappic 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 *Aoralaia* 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 forcibital epiphysis. The slender and strongly carinate valva in the male, and the prominent setose tubercle outward from the subanal selerites 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
Grennan (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 spectinatus).

Aoria 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 0.33–0.35× 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, 0.1–0.25× 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 Aoria 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 (perpendicularly, 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.

Aoria 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 0.31–0.33× 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, 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, Rs); hind wings narrow, apically subacute; foretibial epiphysis variable, 0.25–0.33 × foretibial length, apically acute.

Male genitalia (Fig. 277, 278): pseudotegumen with anterior margin perpendicular (cf. dinodes), dorsal margin undulate, suberose to subspinose; dorsal process area perpendicular, with margins straight, not produced mesally undulate, subserrate to subspinose; dorsal process area perpendicular (cf. wings narrow, apically subacute; foretibial epiphysis variable, 0.25–0.33 × foretibial length, apically acute.

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; Larmerrmoor Range, 1100 m; Fisa Range, 1680 m (found dead); The Remarkables, Rastus Burn, 1640 m; Garvie Mtns, 1300 m; Old Man Range, 1500 m (found dead); ridge W of Whitecoomb, 1100 m; Umbrella Mtns; Gem Lake; Whitecoomb, 1550 m; Awatere Stm; Hokonui Stm, 250 m; Damseys 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 Aorala 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 Aorala.

Dumbleton (1966, p. 937) noted that two specimens of Aorala 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, on the forewing.
Remarks. *A. senex* is

Range, in the Roaring Meg headwaters at 1500 m. Dome, 1450 m. Larvae have been collected on the Pisa Burn, 1800 m; Pisa Range, 1890 m; Old Man Range, W

Material examined. *A. senex* holotype male labelled "730a" [Old Man Range CO, 4000 ft, J.H. Lewis] (white card), *P. annulata* Holotype [male]" (pink card), NMIN.

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, NMIN. 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, NMIN, BPNZ) from Coronet Peak, 1500 m; The Remarkables, Rastus Burn, 1800 m; Pisa Range, 1890 m; Old Man Range, W side, 1570 m; Dunstan Mts, summit, 1590 m; Mt Tennyson, 1595 m; Umbrella Mts, 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 *Aoraiia* species (*aspina*, *flavida*, *macropis*, *oreobola*, *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. oreobola*, and *A. orientalis* form a group defined by the globose corpus bursae and the presence of a lateral setose tubercle (oreobola) 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 sensitae chaeticae; basal flagellar segments with sparse dorsal scaling; apical flagellomere spine-like. Labial palpi (Fig. 93) porrect, elongate; basal flagellar segments with many sensillae chaeticae; basal flagellar segments with a long ramus, and prelabium strongly bilobed. Tarsal claws lacking an arolium. Wing venation (Fig. 76) of *Oxycanus* type, i.e., veins R₂ and R₅ each arising separately from a common R₅ stem; discal cell ending before half wing length; hind wing with veins Sc and R₂ 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 supraflhalic papilla absent.
Female genitalia (Fig. 151, 292): tergum and sternum 8 posterior margin clad in long, pallid (yellow-fawn), hairlike 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 intercalary 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 sensilla bifid. Prosternum broadly fused with poststernum; pronotum with SD₁, SD₂ 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. Scapae, 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 metascutum completely dividing the metascutum anteriorly.

*Cladoxycanus* larvae, with their 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. xliv fig. 3–5 (*Porina*). Dumbleton 1966, pp. 950–951, fig. 61–66, 104 (*Cladoxycanus*).


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 0.33× 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. Clerc] (white card), "Genitalia preparation No. 361 Holotype [male]" (yellow card), "Holotype [male] Porina autumn-
**Genus Dioxycanus** Dumbleton

*Dioxycanus* Dumbleton, 1966, pp. 951–952. Type species *Porina fuscus* 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<sub>2</sub> shorter than free R<sub>2</sub> or R<sub>3</sub>; discal cell ending at half wing length; hindwing veins Sc and R, 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; trulum 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 seminatis a gutter; antrum vestibule sclerotised; vestibule / ducus 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 punctuation about equidistant between basistipes setae; inner face of distipes with a patch of asperities; prothorax with SD<sub>1</sub>, SD<sub>2</sub> 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 prominesses; 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 south-
ern, 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


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 subchavate; juxta with basal lateral lobes extended 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 proantennal bar base (Fig. 171) secundiform, i.e., not obliterating or narrowing subantenal cleft. Larva occupying a shaft in the ground.

Pupa as in generic description.

Typedata. 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, RP, NZAC) from ‘Mt Cook’; above Temple Forest, L. Ohau; Bold Peak; Routeburn; Symmetry Peaks, Eyre Mins, 1500 m; Humboldt Range; St Mary’s 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; Mil Cargill; Longwood Range; Slope-downer Range, 715 m; Otatara; Seaward Moss; Waituna Reserve; and Owaka.

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

Flight period: — / MK, OL, CO, FD, DN, SL.

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 (1630h) 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


*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. liii 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 0.3× forewing length, pallid (except for Mt Hutt specimens). Forewing scales broadly ovate, mostly truncate; pattern (Fig. 38, 39) always with a dark sinuous or notched bar on proximal third near dorsum.

Male genitalia (Fig. 295–297): valva with basal saccular margin smoothly rounded, costal (upper) margin angulate; pseudosegment 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 lateral lobes short, not extending beyond level of valvul saccular base.

Female genitalia (Fig. 299): sternum 9 median piece tumid, higher than wide, apically subtriangular; sidepieces 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 “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.

*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 “347 m” [Arthurs Pass NC-WD, 914 m, Dec. 1922, H. Hamilton], “Genitalia preparation No. 120” (yellow card), “Holotype [male] Porina *gourlayi* Hudson, genitalia taken LJD” (pink card), NMNZ.

*gourlayi*: holotype male (wingspan 35 mm) labelled “Flora Camp 3000 ft 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 Huts; Cobb Valley, Cobb Hut, 914 m; Balloon Hut; Mt Owen, 1520 m; St Arnaud Ranges, Rainbow Skifield, 1530 m; Paparoa Range, Buckland Peaks, 1100 m; Island Pass, 1490 m; Craigieburn Range, Camp Sum Basin, 1250 m; and Mt Hutt, 1000 m. Locality in doubt: Homer (FD), J.T. Salmon (CMNZ).

Distribution: TN, 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 Affurine 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 fuscas-like dark antennae with rather long pectinations, and the forewing basal white streak downcurved rather than straight, but on genitalia is undoubtedly areas.

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. fuscas 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 R2 + 3 stem shorter than free part of R3 or R4; discal cell ending slightly before half forewing length; hind wing with veins Sc+R1 fusivated 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; pseudotegegmen 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 D2?) subdorsally; tergum 8 (Fig. 153) ventrally lobate and dorsally split, the split widest posteriorly; apical scale tuft partially hidden in life by tergum 8; sternite 7 and 8 fused; sternite 9 with a triangular median piece and tapering sidepieces fused to form a single sclerite; sidepieces 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 L4 setal pinaculum; pronotum with setae SD1, SD2 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, thor-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 *Aerolia*, 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 hepiolid. 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 robertsi*

**Dumbletonius characterifer** (Walker)

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

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


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 0.25× forewing length (males) to 0.17× (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 palid, 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; phallicrypt 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 SD1, SD2 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" (green-rimmed 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; Makairoa; 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 1988); 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 *Ande-ambatis 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 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


enysii Meyrick, 1890, p. 207, not Butler, 1877 (Porina). Hudson 1898, p. 133, pl. xiii fig. 9, 10 (Porina).


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 0.25–0.27× forewing length in males, 0.19× 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 trilobum; claspers variable, more-or-less geniculate; juxta variable, usually wider than high; phallicrypt 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 posteriad; 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 sculpture; pronotal shield with setae SD₁, SD₂ 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 25.11.10" (white card), "Holotype Dumbletonius sylvicola Dugdale nom nov pro Auraia [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 forest canopy like a pointed wings tightly appressed to the body. The large females 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 0.4× forewing length, tripectinate, with apical segment slender; lateral rami finger-like, at least 2× longer than flagellomere; ventral rami erect, about 0.3–0.5× 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 arrolium. Forewings with *Oxycanus*-type venation; discal cell ending a little beyond half wing length; hind wing with veins Sc and R, 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 subtrangular 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 submarginal 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 $S_1, S_2, S_3$ in a straight line. Prothorax alone with a sternal plate, and with setae $S_D, S_{D1}$ 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 intercostal and spiracular.

**Remarks.** The monotypic new genus *Heloxycanus* is distinguished from other genera by its trispectate antenna; reduced, obscurely two-segmented labial palpi hidden beneath long, hair-like head vestiture; explanate, spinose ridge on the pseudotegumen; lobate sternum 7 and 9 (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.

**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 infusionate basally; antennae pallid to yellow-brown; abdomen concolorous with hind wings. Female (Fig. 47, 48) with forewings 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 A.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 Mins; and Scolloys Flat. Larvae also from Takahoe Vly FD, Table Hill SL, pupa from Mt Luxmore FD.

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

**Flight period:** Mar (2), Apr (122), May (1), early Jun
Remarks. *H. patricki* is a member of the autumn/winter-emerging assemblage of New Zealand Lepidoptera. Populations are confined to bogs and marshes, 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 pseudotegum 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 northwest (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 evidence 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.

*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**


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

Moderate-sized, sleek-bodied moths, 35–65 mm in wing-span, 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 pro-antennal scale tuft. Labium with a central apical spine; 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 epiplum. Forewing venation (Fig. 80) of *Oxycanus* type; discal cell ending beyond half wing length; hind wing with veins Sc and R, 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. Pseudotegum 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 mem branous 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 ovisac, 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 setae than to apical setae and greatly offset; hypostomal halves narrowing and fused mesally; oral frame slit always open; pronotum with setae SD
d, SD, on separate felted pits; abdominal segments 3–8 without a posterior sclerite at level of seta Lb; this sclerite sometimes present on A1 and A2. Final and penultimate instars with integument darkened dorsally, palleid 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 pseudotegumenal processes, and in the hood-like development of the dorsolateral pseudotegumenal 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 basistidal setal puncture relative to the basal and apical basistipes 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 electrophor 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 five 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 color." 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 (Tarratt 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 punicea 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 m² 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).
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, 0.30× 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 1.5× 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**, **SD** narrowly 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 pedicel 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 "Elhamma 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. 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 On 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**, **SD** 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 Huna 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 (Schaumland, J. Fougeré, S. Lindsay) took *W. cervinata*, and none of its tachinid parasites (Diptera) have been collected on *W. cervinata* or other *Wiseana* species.

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


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 ovoid, 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 1.5xn 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 variably; median piece often with apical portion demarcated by a fold from remainder, which is laterally convex.

*Wiseana* in *W. cervinata*; final instar with a tendency for SD1, SD2 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 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


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 type examples (226 males, 297 females; NZAC, BPNZ) and 523 non-reduced.*

bursae; appendix variable - pedicellate, thumb-like, or populations); ductus bursae broad, shorter than corpus piece usually ovate, i.e., sides convex, and apical portion.

processes broadly fused mesally; vinculum bases with a more or less pronounced lateral apophysis; saccus margin demarcated (southern populations) or truncate, with sloping sides, but apical portion differentially setose (northern populations); ductus bursae broad, shorter than corpus bursae; appendix variable - pedicollate, thumb-like, or reduced.

Male genitalia (Fig. 321–323): pseudogena 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 – pedicollate, 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, syn-type” (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; Caplestone; Tauhai; Franz Josef; Weston; Hindon; Clutha Vly, E side, lower gorge; Roxburgh; Kawarau Gorge, Roaring Meg; Arrowtown; Lauder; Waikāia Vly; Piano Flat; Queenstown; L. Howden; Doubtful Sound, Deep Cove; Tisbury, West Plains (6 Philpott specimens, NZAC); Invercargill; Otara; Beaumont Forest; Black Gulley; Tapunui; Owaka; Gore; and Oban, Horseshoe Bay.

**Distribution**. —/NN, BR, WD, OL, CO, DN, SI, 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 contrasting pale yellow.

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

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 flagellomeric shaft. Male forewings scales narrow ovate, acuminate (Fig. M25); female forewings 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 darkfuscate 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; Larnermoor Range, 1080 m, 1100 m; Conroys Gully, 300 m; Roxburgh; Lauder; Mt Tevio, 300 m; Nevis Vly, 800 m; Roaring Meg, powerhouse; Earnscleugh; Pisa Range, 1700 m; Invermay, Mosgiel; West Plains; Otatara; Gore; and Tapamui, 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 antenial 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. Aoraiia 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


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 subacutate; trulleum deeply concave, sometimes globose in lateral view (cf. W. umbraculata).

Female genitalia (Fig. 347, 348): tergum 8 with 2 cuticular processes ('setae' D₁, D₂); 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; ducus 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 SD₁, SD₂ setal pinacula narrowly fused, or SD₂ pinaculum excavae; medial paraproct seta and anal proleg base medial seta equally far apart; final-instar larva approx. 60–65 mm long; integument dorsally darkened, ventrally pallid.

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

**novaezealandiae:** lectotype male (selector unknown; wingspan 46.5 mm) labelled "Porina novaezealandiae" (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 collections, 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 ducus 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 (Guénée)

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


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 processes hood-like, broadly sclerotised; posterior processes pinkish-fawn to yellow-fawn; margin with an obscure to high-rainfall (forest) localities (Fig. 70, 71); females usually broken (Gaskin 1964, fig. 1–5), shaded below with a dark white scales tapering to a pointed or rounded apex; forewing length 16–23 mm, females 49–66 mm and 22–29 mm. Proleg base; abdominal segments 2–8 with seta SD paraproct setae further apart than posterior setae on anal bursae slender, about 2× length of corpus; corpus bursae median piece bluntly triangular, higher than wide; ductus bursae signata),Wisena umbraculata

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, SD2 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 paraphyletic types (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/SL. 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. Guénée (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 conspicuous 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. umbracula 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. umbracula 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 R1. 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 the wreck of the barque `Assaye' is wrong. The `Assaye' (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 caracterifer 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. caracterifer 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.

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APPENDIX: non-New Zealand taxa examined
(A, adult; L, larva; P, pupa)

AFRICA
Antihepialus (according to G.W. Gibbs), L; Eudalaca am-
mon (Wallengren), A; Gorgopis auratilis Jansc, 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 deli-
catula Tindale, A; Jeana sp., SW Tasmania, A; Oncopera
mitocera Turner, A; O. rufobrunnea Tindale, A; Oxyccus
spp. indet., L; O. australis (Walker), ALP; 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 fusconebu-
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NEW CALEDONIA
Aenetus cohici Viette, ALP.

NEW GUINEA
Paraoxyccus, 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.

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ORIENTAL
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(6) *Aoraia aspina*, TT female
    Umbrella Ra. CO

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Aoraia aurimaculata
male, Castle Hill MC

Aoraia dinodes,
male, Oban SI

Aoraia aurimaculata,
male fore and hind wings,
Mt Cook Village MK

dh '86

Aoraia dinodes,
dh '84

Aoraia dinodes
male, Invercargill SL

Aoraia dinodes,
forewing, The Divide FD

Aoraia dinodes
male, Bald Hill, Longwood Ra. SL

Aoraia dinodes,
female

Aoraia dinodes, male,
Invercargill SL

Invercargill SL

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Mt Patriarch MB

Aoraia enysii, male
Manuia Camp TO

Aoraia flavida, male HT, Umbrella Ra. CO

Aoraia enysii, female
Taranaki (Mt Egmont) TK

Aoraia flavida, female
Umbrella Ra. CO

Aoraia insularis, male
Craigieburn Ra. MC

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

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Blue Mtns SL

(25) Aoraia orientalis, male
Rock & Pillar Ra. CO

(26) Aoraia orientalis, female
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
Swampy Summit DN

(32) Aoraia senex, female
Old Man Ra. CO
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Male, ocellate wings
Invermay DN

(33) *Cladoxycanus minos*
Male, Glenleith DN

(35) *Cladoxycanus minos*
Male, brown-shaded wings, Invermay DN

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Male, Tararua Ra. WN

(39) *Dioxycanus oreas*
Female, Tararua Ra. WN
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male, Onehunga AK

Dumbletonius characterifer
male, Gouland Downs NN

Dumbletonius characterifer
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Dumbletonius unimaculatus
male, Puketiriri HB

Dumbletonius unimaculatus
male forewing, Onehunga AK

Dumbletonius unimaculatus
female, Waitakere Ra. AK
Heloxycanus patricki
male, Burgan Creek CO

Heloxycanus patricki
male, Seaward Moss SL

Heloxycanus patricki
female, Seaward Moss SL

Heloxycanus patricki
female, Burgan Creek CO

Heloxycanus patricki
female, Seaward Moss SL
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male, Nelson NN

(50) *Wiseana cervinata*
male, Christchurch MC

(51) *Wiseana cervinata*
female, Nelson NN

(52) *Wiseana cervinata*
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male, Gore SL

(54) Wiseana copularis
female, Gore SL

(55) Wiseana fulginea
male

(56) Wiseana fulginea
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(57) Wiseana fulginea
male

(58) Wiseana fulginea
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Wiseana jocosa, female, pale form, Tapanui SL

Wiseana jocosa, female, dark form, Beaumont SL

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Wiseana mimica, female, Kapuka SL
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Wiseana umbraculata male, Balmoral NC

Wiseana signata, male 'umbraculata' pattern

Wiseana signata, male reduced white areas

Wiseana umbraculata male, striped form, Taupo TO

Wiseana umbraculata male wing underside, Mangapehi WO

Wiseana umbraculata female, Kaikoura KA
ABBREVIATIONS USED IN ILLUSTRATIONS

ac  anapleural cleft (adult mesothorax)
adp  anterior dorsal plate (adult prothorax)
ad  adfrontal zone (larva)
ae2  anepisternite (prothorax)
an  anus (male/female terminalia)
ap  appendix bursae (female genitalia)
Aspi '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)
c  clypeus (adult and larval head)
clp  clypeal plate (pupa)
ep  epicranium (larval head capsule)
ep2,3  epimeron 2, 3 (adult thorax)
et  episternal tooth (adult prothorax)
ep2  epimeral margin (adult metathorax)
mep.m  metepimeral margin (adult metathorax)
mp  median piece, sternum IX (female genitalia)
mp2  mid posterior process (male genitalia)
mpa  mesopleural ridge (adult mesothorax)
mpd  mesopleural suture (adult mesothorax)
mpx  maxillary palp (adult, larva), palp plate (pupa)
oc  occiput (adult head)
oco  occipital condyle (adult head)
0v  ovipore (female genitalia)
ap  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  propiugial sclerite (adult prothorax)
pr  tribial process (adult)
prl  prelabium (adult head)
prsp  prothoracic spiracle (adult)
psm  pseudotegumen (male genitalia)
r  rectum (adult)
sa  sacculus (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)
asp  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)
tdp  tuberculate plates (adult abdomen)
tpr  twin processes (male genitalia)
tr  trulium (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)
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Snares
Bounty
Antipodes
Aucklands
Campbell

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Number 30

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(Insecta : Lepidoptera)

J. S. Dugdale
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