GENITALIA, CLASSIFICATION AND ZOOGEOGRAPHY OF THE NEW ZEALAND HEPIALIDAE (LEPIDOPTERA)

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Summary

Some morphological characters of taxonomic importance in the Hepialidae are briefly reviewed. The male genitalia of all existing New Zealand species are described, and the female genitalia of all except one species. The New Zealand species, with the exception of one species of *Aenetus* Herrich-Schaeffer (= *Charagia* Walker) and the species transferred to *Wiseana* Viette, were previously placed in *Oxycanus* Walker (= *Porina* Walker, preoccupied). The subfamily Hepialinae in New Zealand includes the non-endemic genus *Aenetus* and the endemic genus *Aoraia* gen. n. which has four species. Oxycaninae subfam. n., with *Oxycanus* as type genus, is defined on venational characters. It includes the endemic genera *Wiseana* (5 spp.), *Trioxycanus* gen. n. (3 spp.), *Dioxycanus* gen. n. (2 spp.), and *Cladoxycanus* gen. n. (1 sp.). The New Zealand hepialid fauna has its strongest affinities with that of Australia. The present distributions of the species are largely explicable as modification of late-Tertiary distributions resulting from oscillations of climate in the Pleistocene.

INTRODUCTION

The identification of the species of Hepialidae in New Zealand, except for the work of Philpott (1927a), has been based largely on the colour pattern of the scales of the fore wing. This is extremely variable and for most species there is no satisfactory evidence as to the range of intraspecific variation in this chaarcter and the possible overlapping of the ranges of variation of closely related species. It is therefore difficult to define the species and to identify individual specimens with certainty solely by their wing patterns, especially when the distributions of the species overlap and their flight-periods coincide. The present paper attempts to provide a morphological basis for the classification and identification of the existing species of New Zealand Hepialidae. It is desirable that diagnostic morphological characters for the species should be based on authentic specimens such as types, or at least on topotypic material. In general the scarcity of such material precludes an objective knowledge of the range of variation of any given morphological character. The significance of a difference in the character therefore becomes a matter of subjective judgment as to the reality of its discreteness. The absence of morphological distinguishing characters is no guarantee that specimens with similar wing markings belong to the same species. Differing distributions or flight-periods may indicate that they are biologically distinct species. The separation and definition of such species, or of the local races or populations of a single species, will necessitate the intensive study of the wing markings of extensive collections of moths made during the spring and summer in many localities throughout New Zealand.

The information presented here relates mainly to the genitalia of both sexes, and to such other morphological characters as have been found useful in classification. The scale patterns of the fore wings of the species are mentioned only incidentally. The original descriptions, and others such as those of Meyrick (1890), are readily available and most of the species have been described and illustrated by Hudson (1928, 1939, 1950). The type specimens, however, are illustrated by photographs wherever possible. The relative size of the specimens photographed is indicated in the title by the measurement of the wing spread—wing tip to wing tip of the extended fore wings in a horizontal plane—though this may be a slight underestimate if the wings have not been set in the same horizontal plane.

The opportunity is also taken to publish the selection of lectotypes of several species, and the location of the type specimens for all species for which this is known. Details of the type locality, the distribution and the flight-period are given for each species, since these have a bearing on the identification of the species and their biological distinctness.

The following abbreviations are employed in indicating the location of types and other specimens to which reference is made:

A.M.—Auckland Museum, Auckland.
B.M.—British Museum (Natural History), London.
C.M.—Canterbury Museum, Christchurch.
D.M.—Dominion Museum, Wellington.
E.D.—Entomology Division, D.S.I.R., Nelson.
O.M.—Otago Museum, Dunedin.
P.M.—Paris Museum, Paris.
S.A.M.—South Australian Museum, Adelaide.

MORPHOLOGICAL CHARACTERS OF THE HEPIALIDAE IN RELATION TO TAXONOMY

ANTENNAE: The antennal segments or flagellomeres are laterally compressed in some species, the dorsoventral axis being longer than the lateral axis. The segments of antennae which are described as filiform have no lateral expansions and are not widened distally. If the lateral expansions are shorter than the width of the segment the antennae are described as bidentate, and if longer, as bipectinate. The pectinations may be cylindrical (Fig. 1) or lamellar (apicobasally flattened) (Figs 2 & 3) and may be haired around the margins or only on the ventral surface. The margins of lamellar pectinations may be continuous across the ventral surface of the segment, or produced there into a prominence or lobe. The pectinations may be transverse or inclined both distad and ventrad. In *Aoraia* gen. n. they arise from the base of the segment (Fig. 1). In New Zealand oxycanine genera they arise from the apex (Figs 2 & 3) and there is a small transverse haired ventral ridge at $\frac{1}{3}$ length from the base in the male, or a line of hairs in this position in the female. In the females of bipectinate species the pectinations are usually smaller (bidentate) or else the mesal ones are shorter than the lateral ones. The antennae provide useful generic characters but are less often useful for the differentiation of species.

LABIAL PALPI: The labial palpi are usually moderately long and 3-segmented, with the 2nd segment longest (Fig. 4). In *Cladoxycanus* gen. n. they are unusually long and project beyond the head and a process from the apex of the 1st segment extends far beyond the articulation of the 2nd segment (Fig. 5). In *Dioxycanus* gen. n. the palpi are short and 2-segmented (Fig. 6).

WING VENATION: The wing venation of the family was studied by Philpott (1926). The venation of the hind wings is, in general, very similar to that of the fore wings. A primary subdivision of the genera into two groups of subfamily rank can be made on the origin of wing vein R_4, In the first group R_4 and R_5 arise from a common stem, R_{4+5} (Fig. 7). In the second group R_4 arises basad of the fork of R_2 and R_3, from the common stem R_{2+3+4} (Fig. 8). In both groups there are generic differences in the relative lengths of R_2 and R_3, and their common stem. In most genera of the first group the *r–m* cross vein is distad of the fork of R_4 and R_5 and connects R_5 and M_1, but in the Australian genus *Fraus* Walker, the Oriental genus *Palpifer* Hampson, and the South African genera *Eudalaca* Viette and *Gorgopis* Hübner *r–m* is basad of the fork and connects R_{4+5} and M_1.

LEGS: In *Aenetus* Herrich-Schaeffer (= *Charagia*) the tibial strigil is small, flap-like, appressed to the fore tibia, and concealed by scales. In other New Zealand genera it is large and separated from the tibia by a rounded concavity. *Aenetus* alone has a basodorsal tuft of long hair-like scales of contrasting colour on the hind tibia.

EIGHTH ABDOMINAL STERNITE OF MALE: The 8th sternite varies in both size and shape. The posterolateral angles are usually slightly produced in relation to the posterior margin. In 2 species of *Trioxycanus* gen. n. which

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FIGS 1–12—Morphology of Hepialidae

1—Antennal segment of *Aoraia leonina,* dorsal (U) and end (L) views

2—ditto *Oxycanus australis*

3—ditto *Wiseana umbraculata*

4—Labial palpi, *Wiseana*

5—ditto *Cladoxycanus*

6—ditto *Dioxycanus*

7—Fore (U) and hind (L) wings, *Aoraia leonina*

8—Fore wing, *Wiseana umbraculata*

9—Male genitalia, *Oxycanus australis,* caudal view: legend; A, anus; AS, accessory sclerite of tegumen; C, clasper; DP, dorsal process of tegumen; G, gonopore; IP, inner process of tegumen; J, juxta; S, saccus; SA, subanal sclerites; TG, tegumen; TR, trulleum; VA vinculum arm; VB, vinculum base; 8S, 8th sternite; 8T, 8th tergite.

10—Right half of tegumen, *O. australis,* lateral view.

11—Eighth tergite of female, *Wiseana signata,* and cuticular processes enlarged.

12—Female genitalia, *Oxycanus australis,* caudal view. Legend: IL, intergenital lobe; LA, lateral arm of prevulvar sclerite; MP, median piece of prevulvar sclerite; PA, preanal sclerite; PV, prevulvar sclerite; SP, seminal passage; VU, vulva.

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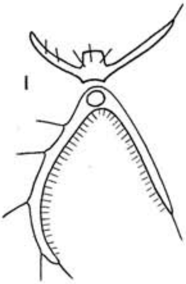

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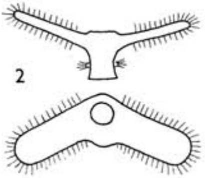

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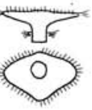

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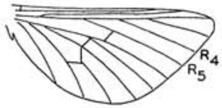

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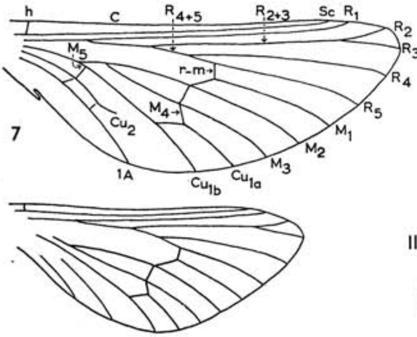

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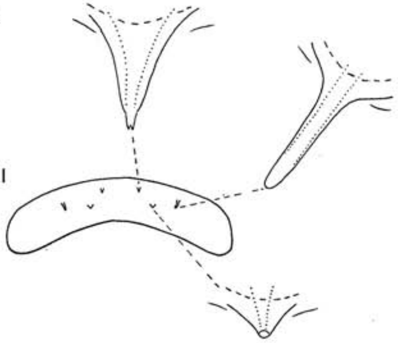

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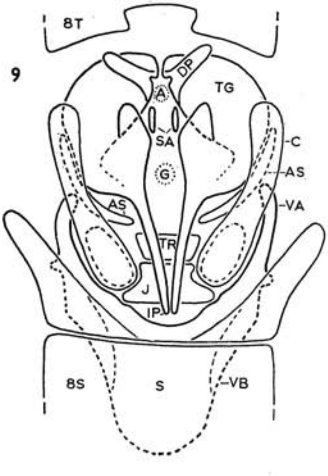

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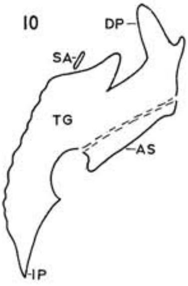

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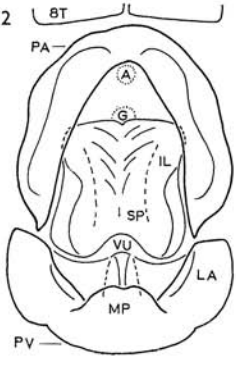


have small or narrow sternites, the processes are prominent, close together, and paramedian in position. No New Zealand species has processes on the disc of the sclerite such as are described in some Chilean species of *Calliepielus* Viette and *Dalaca* Walker (Viette, 1949c).

MALE GENITALIA (Figs 9 & 10): The male genitalia of the family have been studied by Philpott (1927a). The anogenital field, which is bounded by the two halves of the tegumen, is wholly membranous in most species. In some species of *Oxycanus* and *Paraoxycanus* Viette paired subanal sclerites (plaques laterales of Viette, 1950a) are present. The Y-shaped sclerites described by Viette (1950b) as being on the sides of the penis of *Parahepialiscus baluensis* Viette appear to be subanal sclerites. Species of *Trioxycanus* have a median subanal structure (Figs 51 & 55) which has not been previously reported in the family. It consists of a pseudosegmented internal body which is sclerotised and pigmented where it is attached posteriorly to the integument. It may represent the gnathos or be associated with the phallosome, but clarification of its identity and function will necessitate the examination of living or fresh specimens. The anus, dorsal in position, is open, but functions only for the discharge of the meconium. The genital orifice is situated ventrally, The aedeagus is completely membranous, as is the penis, which is not differentiated from the ductus ejaculatorius. A small transverse median dorsal sclerite may be present anterior to the tegumen. The tegumen (9th tergite) consists of two arcuate halves, narrowly joined by membrane in the mid-dorsal line, and connected to the truellum ventrally. At about mid-length on the anterior margin of each tegumen half is an imperfectly separated accessory sclerite. Dorsad of this the anterodorsal portion of the tegumen may be much widened in a transverse plane, or the anterior margin may be reflexed to form a trough or a hood over the dorsum of the tegumen. A dorsal process (apical process of Philpott) of varying size and form on the caudal margin of the tegumen supports the perianal membrane. A concavity may separate the dorsal process from the remainder of the caudal margin, which varies in shape and may be smooth or denticulate. An acute or rounded outer process may be present at ⅔ length. The ventral extremity forms the inner process, which varies in its shape, degree of fusion with the other inner process and in the length of its projection beyond the attachment to the trulleum. The trulleum may be flat or have a central concavity. Its posterior margin is attached to the ventral margin of the inner processes and the accessory sclerites of the tegumen, its sides meet the inner margin of the base of the claspers, and its base is attached to the distal margin of the juxta. The juxta varies in shape. Its sides join the base of the clasper and its base is attached to the distal margin of the sclerite apposed to the vinculum base which encloses a cavity open to the exterior—the saccus. The area between the margin of the saccus and that of the vinculum base is a double-layered invagination of the integument and functions as an apodeme. It is perhaps for this reason that there is much intra-specific variation in the shape of both the saccus and the vinculum base, especially when these are separated by a wide area as in *Wiseana* and *Cladoxycanus* gen. n. The arms of the vinculum (9th sternite) join the outer side of the base of the claspers, and their ends join the accessory sclerite of the tegumen. The base of the vinculum lies above the 8th sternite and is connected to its posterior margin between the bases of the arms by a vertical extension which may also be produced laterally as linear sclerites (Fig. 32) on the membrane below the vinculum arms. The structural plan of the male genitalia is very constant in the family. Generic differences in the male genitalia are slight, though usually definable, but specific differences provide perhaps the most useful taxonomic character for the discrimination of species.

EIGHTH ABDOMINAL TERGITE OF FEMALE: This tergite is usually entire (Fig. 11) but in species of *Trioxycanus* (Figs 56 & 60) and in *Oxycanus australis* Walker (Fig. 12) it is divided into two halves by a median longitudinal membranous area.

ABDOMINAL CUTICULAR PROCESSES: Small projecting structures are present on the 8th tergite of the females of New Zealand oxycanine genera (Fig. 11). In the hepialine genera examined they are either absent or reduced. They vary in placement and may consist of two or three pairs (2/2 or 3/3). They are hollow and either open or membranous at the tip and appear to contain the duct of a gland. It is not certain that these secrete sex attractants since smaller but apparently homologous structures are present in some males. In *Dioxycanus* one pair of these structures is present on the posterior margin of the 7th tergite. There is some variation in the number and development of these processes and it has not been determined how reliable they are as specific characters. These organs may be homologous with those occurring in the primitive lepidopterous families Micropterygidae and Eriocraniidae (Philpott, 1925), though these are paired (1/1) structures on the 5th sternite (occasionally on the 4th also) and, at least in *Sabatinca* Walker, equally well developed in both sexes. They were not present in all the genera examined by Philpott and though relatively uniform within a genus exhibited greater differences between genera.

FEMALE GENITALIA (Figs 12 & 17): The female genitalia of the Hepialidae were discussed by Viette (1948). Females of this family were considered to have only one genital opening until Oiticica (1948) demonstrated that two genital openings were present in *Trichophassus giganteus* Le Cerf, both of them being situated on the 9th abdominal segment. He also found that there was an enclosed seminal passage between the vulva and the gonopore. The condition in the female genitalia of the Hepialidae thus differs from that in the Lepidoptera Ditrysia in which the vulva is on the 8th segment and a true seminal canal, distant from the integument, connects the bursa copulatrix and the oviduct and allows the passage of the sperms to the receptaculum seminis. Bourgogne (1949a, 1949b) confirmed Oiticica's findings but showed that in many other Hepialidae the seminal passage was an open external cleft. He regarded the open and closed passages as variants of an "exoporien" type of genitalia.

The female anogenital field is enclosed dorsally, or dorsally and laterally, by the two halves of the preanal sclerite (9th tergite; anal papillae of Bourgogne) and ventrally by the prevulvar sclerite (9th sternite; antevaginal sclerite of Bourgogne). The two halves of the preanal sclerite may be separate or fused in the median dorsal line. The prevulvar sclerite consists of a median piece, whose posterior margin bounds the lower lip of the transverse vulva, and a lateral arm (anterior gonapophysis of Tindale, 1941) on each side. The distal end of each lateral arm connects with the lateral (ventral) end of the preanal sclerite. Both the preanal and the prevulvar sclerite are setose. The anus is dorsad of the more or less central gonopore and the vulva is ventral in position. The intergenital area consists of two intergenital lobes which are separated in the median line by an open intergenital cleft, or fused in this line to enclose the seminal passage. In either case both lobes are produced posteriorly in the median line and are thus enabled to cover the gonopore. In those species in which the intergenital cleft is open the sclerotisation on each lobe takes the form of a relatively small non-setose intergenital sclerite (subanal sclerite of Bourgogne; posterior gonapophysis of Tindale, 1941) which extends laterally towards the point of lateral junction of the preanal and prevulvar sclerites. When the intergenital lobes are fused they are more extensively sclerotised.

Bourgogne (1949a) recognised three types of female genitalia in the Hepialidae: type A: open intergenital cleft as in *Korscheltellus* Borner, etc.; type B: enclosed seminal passage, as in *Elhamma* Walk. and *Oxycanus*; type C: enclosed seminal passage, as in *Trichophassus* Le Cerf, but difficult to differentiate from B. The present investigation confirms the existence of types A and B in Australian and New Zealand genera. It indicates, however, that there are wider differences, in the proportions and orientation of their components, between the genitalia of these two types.

A primary characteristic of genitalia of type A is the open intergenital cleft. The preanal and prevulvar sclerites are subequal in length, or with the latter longer, and form dorsal and ventral arcs. The lateral ends of these two sclerites are connected and since the two sclerites are either completely apposed and in the same plane (*Aenetus*), or partially apposed, they form a convex structure which cannot be mounted flat without disarticulation of the sclerites. The long axis of the intergenital field enclosed by these sclerites is transverse. In *Aenetus* the anogenital field is completely invaginated and concealed when the sclerites are apposed. The lobed structure of the sclerites in other genera prevents complete apposition and the anal field remains exposed. The separate intergenital lobes are largely membranous. The relatively small intergenital sclerites appear to stiffen the lobes when they are apposed in the median line to convert the intergenital cleft into a temporary seminal passage.

A primary characteristic of genitalia of type B is the permanently enclosed seminal passage which is lined by invaginated integument. The halves of the preanal sclerite tend to be lengthened, and their ends closer together and more ventral, thus forming an inverted U-shape. The prevulvar sclerite tends to be shortened and transverse and closes, or is partially included within, the open end of the U. The lateral arms of the prevulvar sclerite tend to be shortened and may be fused with the median piece or absent. The long axis of the intergenital field is vertical and the preanal and prevulvar sclerites are not apposable. The genitalia can be readily mounted flat without disarticulation. The fused intergenital lobes are extensively sclerotised posteriorly and laterally, instead of having isolated intergenital sclerites. The posterior margin of the fused lobes is usually transverse and at right angles to the sides.

Bourgogne (1949a) found that one or more species of the following genera have female genitalia of type A: *Abantiades* Herrich-Schaeffer, *Aenetus, Triodia* Hübner, *Eudalaca Gorgopis, Hepialus* Fabricius, *Korscheltellus, Leto* Hübner. To these can now be added *Aoraia* and *Dioxycanus*. All of these genera, except *Dioxycanus,* have wing vein R_4 arising from R_{4+5}.

Female genitalia of type B occurred in species of *Oxycanus, Elhamma* Walker, and *Trichophassus,* and to these can now be added *Wiseana* Viette, *Trioxycanus,* and *Cladoxycanus*. All of these genera have wing vein R_4 arising from R_{2+3+4}.

There is thus a strong correlation between the type of wing venation and the type of female genitalia in these two groups of genera. It is not, however, complete since the open intergenital cleft in *Dioxycanus* is anomalous, though its genitalia as a whole resemble those of type B.

Marked differences in the plan of the female genitalia are taken as evidence of generic difference, but within a genus the specific differences are usually small.

GENITALIA AND CLASSIFICATION OF NEW ZEALAND HEPIALIDAE

Family **HEPIALIDAE**

Subfamily HEPIALINAE

Wing veins R_4 and R_5 with a common stem, R_{4+5}.

TYPE GENUS: *Hepialus* Fabr.

DISTRIBUTION: cosmopolitan.

Issiki and Stringer (1932) considered that the common-stemmed condition of wing veins R_4 and R_5 was the primitive one. The hepialine genera studied by Philpott (1927b) exhibit less reduction of the maxillary palpi and galea (haustellum) than the oxycanine genera. The abdomen of the female has less modification of the generalised condition of the sclerites of the 9th segment than that of the Oxycaninae and the intergenital cleft is open. The subfamily Hepialinae, is for the above reasons, considered to be more primitive than the Oxycaninae.

KEY TO THE GENERA OF HEPIALINAE IN NEW ZEALAND AND ADJACENT AREAS

(1) Antennae filiform, adults with green coloration; vinculum of male with short base, arms as wide as length of base; halves of female preanal sclerite fused dorsally, without median caudal emargination, not widened caudally at midlength; median piece and lateral arms of prevulvar sclerite scarcely differentiated; pre-anal and prevulvar sclerites semicircular, completely apposable. Larvae lignivorous, boring in trunks of trees .... (2)

Antennae various, adults without green coloration; vinculum of male with long base, arms narrower than length of base; halves of female preanal sclerite fused dorsally, with median caudal emargination, widened caudally at mid-length; prevulvar sclerite with prominent median piece and distinct lateral arms; preanal and prevulvar sclerites arcuate, not completely apposable. Larvae soil-dwelling, usually herbivorous, if lignivorous feeding on or in roots .... (3)

(2) Wing veins R_2 and R_3 as long as R_{2+3}; claspers of male without basoventral spur or teeth .... (Australia) .... ***Zelotypia*** Scott

R_2 and R_3 one third as long as R_{2+3}; clasper with basoventral spur or teeth .... (New Guinea, Australia, New Caledonia, New Zealand) .... ***Aenetus*** Herrich-Schaeffer

(3) Scent gland present in swollen base of male fore wing .... (Fiji, Samoa) .... ***Phassodes*** Bethune-Baker

Scent gland absent .... (4)

(4) Antennae filiform or subclavate. .... (Australia) .... ***Oncopera*** Walker

Not so .... (5)

(5) Antennae tripectinate .... (Australia) .... ***Trictena*** Meyrick

Not so .... (6)

(6) Antennae unipectinate .... (Australia) .... ***Abantiades*** Herrich-Schaeffer

Antennae bipectinate .... (7)

(7) Labial palpi 2-segmented; cross-vein *r–m* connecting R_{4+5} and M_1 .... (Australia) .... ***Fraus*** Walker

Labial palpi 3-segmented; *r–m* connecting R_5 and M_1 .... (8)

(8) Antennal pectinations very long, cylindrical; 2nd palpal segment longest; humeral vein not continued along costa .... (New Zealand) .... ***Aoraia*** gen. n.

Not so .... (9)

(9) Antennal pectinations skewed; 1st palpal segment as long as 2nd; 2 anal veins present in hind wing .... (Rarotonga) .... ***Toenga*** Tindale

Antennal pectinations opposed; 1 anal vein in hind wing .... (Australia) .... ***Bordaia*** Tindale

Genus *Aenetus* Herrich-Schaeffer

Herrich-Schaefer 1855, Samml. Aussereurop. Schmett. Heteroc., 1 : 5; type-species *Hepialus lignivorus* Lewin (Australia).

Charagia Walker 1856, List Lep. Ins. Brit. Mus., 7 : 1569; type-species *Hepialus virescens* Doubleday (New Zealand).

Oenetus Kirby 1892. Syn. Cat. Lep. Het., 1 : 891 (emend.)

Antennae filiform in both sexes. Labial palpi 3-segmented; 1st and 2nd subequal in length, 3rd shorter, clubbed. Cross vein *r–m* distad of fork of R_4 and R_5, connecting R_5 and M_1. Anterior tibia with small flap-like strigil, obscured by scales; posterior tibia of male with basodorsal tuft of long brown hair-like scales.

♂ GENITALIA: Tegumen halves large, caudal margin smooth rounded, outer process absent, ventral extremity rounded or with short pointed inner process. Vinculum base short and wide, a deep U-shaped median emargination on posterior margin, apex truncate or with a median concavity; vinculum arms as wide as length of vinculum base. Saccus short and wide, half as long as vinculum base. Clasper strongly narrowed from base to apex, laterally compressed, with a large basoventral spur and one or more teeth distad of this. Paired subanal sclerites and median subanal structure absent.

♀ GENITALIA: Eighth tergite entire, without cuticular processes or pores. Preanal and prevulvar sclerites slender, semicircular, completely apposable concealing anogenital field. Intergenital sclerites small, separated in median line. Intergenital cleft open.

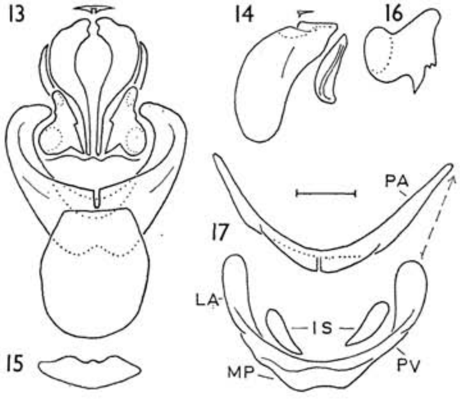
DISTRIBUTION: New Guinea, Australia, New Caledonia, New Zealand.

The species included are large moths, usually with green colouration, but occasionally yellowish or reddish. The larvae tunnel in the trunks of living trees. Species of the Oriental genera *Endoclita* Felder and *Sahyadrassus* Tindale, whose larvae also are lignivorus, have 1- or 2-segmented labial palpi and differ in the structure of the female genitalia (Tindale, 1941, 1942).

Aenetus virescens (Doubleday)

Doubleday 1843, Dieffenbach Travels in N.Z., 2 : 284 (*Hepialus*).

♂ GENITALIA (Fig. 13): Described and figured by Philpott (1927a, fig. 5). Specimen: Te Whaiti, T. C. Askins; E.D. Eighth sternite elongate, widest



FIGS 13–17—*Aenetus virescens* (Scale line for all figs = 1·0 mm)
13—Male genitalia and 8th sternite, Te Whaiti, caudal view
14—Right half of tegumen, Te Whaiti, lateral view
15—Juxta, Te Whaiti
16—Clasper, Te Whaiti
17—Female genitalia. Legend: IS, intergenital sclerite; PA, preanal sclerite; PV, prevulvar sclerite.

slightly before mid-length. A narrow transverse dorsal sclerite anterior to each tegumen half, joined in the median line anteriorly, each produced posteriorly into a paramedian process. Tegumen half (Fig. 14) with smooth evenly-convex caudal margin and short broadly-rounded ventral extremity. Posterior margin of vinculum base with deep U-shaped median emargination, apex with median concavity. Juxta (Fig. 15) transverse, narrowed laterally, convex basally, distal margin with bilobed concavity. Trulleum without strong sclerotisation or pigmentation. Clasper (Fig. 16) stout basally, tapering to narrower rounded apex, ventral margin with a long stout sub-basal spur and a smaller tooth at mid-length.

♀ GENITALIA (Fig. 17): Specimen: unlabelled; C.M. Halves of preanal sclerite widest dorsally but slender and narrowing evenly to the ventral extremity, together semicircular. Prevulvar sclerite similarly arcuate; median piece transverse, slightly concave medially; lateral arms stouter, continuous with and poorly delimited from sides of median piece.

TYPE: holotype, sex unstated; Waitemata, E. Dieffenbach: B.M.

Mr P. E. S. Whalley informs me that the type cannot be located in the British Museum.

DISTRIBUTION: North Island, throughout. Up to 4,000 ft (J. S. Dugdale, pers. comm.).

FLIGHT PERIOD: September to November.

This species, with a wing spread in excess of 100 mm is the largest New Zealand moth. The wing pattern is variable and the colour varies from green to bluish or yellowish-green.

Genus *Aoraia* Dumbleton, gen. n.

(From Polynesian geographical name *Aorai* : feminine)

Antennae bipectinate in both sexes; pectinations long, cylindrical, arising from base of segment, mesal pectination shorter than lateral especially in female. Labial palpi of moderate length, 3-segmented, 2nd segment longest. Humeral vein joining costal vein at right angles; R_2 and R_3 about half as long as their common stem; cross-vein *r–m* distad of fork of R_4 and R_5 and connecting R_5 and M_1; M_5 shorter than transverse part (cross-vein) of Cu_1; Cu_2 short, inclined distally towards fork of Cu_{1a} and Cu_{1b} and ending halfway to it; 1A with complete or partial cross vein to fork of Cu_1 and Cu_2 and another more distad joining Cu_2 at about half-length. Hindwing with both Cu_2 and the single anal vein obsolete basally. Fore-tibia with large prominent strigil.

♂ GENITALIA: Eighth sternite sometimes with long linear sclerite arising from posterolateral angle, or with 2 or 3 small isolated sclerites on membrane adjoining anterior margin. Caudal margin of tegumen half smooth or dentate; outer process obtuse or acute; sometimes a prominent shoulder dorsad of outer process; inner process usually narrowed at half length, distal half sub-parallel-sided, apically dentate. Vinculum base convex, apex rounded or truncate, arms slender. Saccus convex, cavity both long and deep, apex usually coinciding with or only narrowly separated from that of vinculum base. Juxta subparallel-sided and widest basally, sides converging distally, apex truncate. Sclerotised area of trulleum U-shaped or short-stemmed Y-shape, the arms enclosing a median depression which receives the tips of the inner processes of the tegumen, the base with a transverse ridge or median prominence. Clasper nearly as long as tegumen, ventral margin with a sub-basal hook or spur at mid-length of base, sometimes narrowed at mid-length or compressed and serrate or dentate in middle third. Paired subanal sclerites and median subanal structure absent.

♀ GENITALIA: Eighth tergite entire; cuticular processes usually 2/2, sublateral, small, circular, not projecting. Halves of preanal sclerite joined dorsally. Median piece of prevulvar sclerite transverse, posterior margin semicircular, usually with median emargination, disc setose except for anterolateral margins; lateral arms shorter than width of median piece. Both sclerites forming wide shallow transverse arcs, largely concealing anogenital field when apposed but not completely apposable. Intergenital sclerites small, separated medially. Intergenital cleft open.

TYPE SPECIES: *Porina dinodes* Meyrick.

DISTRIBUTION: North, South, and Stewart Islands.

The genus is erected for four New Zealand species previously placed in the preoccupied *Porina* Walker and then in *Oxycanus* Walker. The generic name is derived from a Polynesian variant of the Maori name for Mt. Cook and connotes the montane habitat of most of the species. *Aoraia* resembles the Australian genus *Bordaia* Tindale. The form of the antennal pectinations is not uniform in *Bordaia*. Those of the type species *B. pica* Tindale and *B. karnka* Tindale are similar to those of *Aoraia,* but the other three species of *Bordaia* have wide lamellar pectinations (Tindale, 1932). The female of *Bordaia* is unknown and the male genitalia has not been described in detail. *Aoraia* differs from *Bordaia* in wing venation: the humeral vein does not turn along the costa, M_5 is short, and there are 2 cross-veins between 1A and Cu_2.

KEYS TO GENITALIA OF *Aoraia* SPECIES

♂♂

(1) Vinculum base (Fig. 20) subtrapezoidal, side compressed, apex truncate, margin distant from and contouring both sides and apex of saccus. Outer process of tegumen (Fig. 19) obtuse. Clasper (Fig. 21) not flattened or ventrally dentate. Eighth sternite without linear sclerites from posterolateral angles. (Caudal margin of tegumen without concavity ventrad of dorsal process, slightly convex to subangulate shoulder, thence denticulate and straight to outer process, concave between outer process and elongate triangular inner process) .... ***senex*** (Hudson)

Vinculum base subtriangular or U-shaped, margin of apex coinciding with or only narrowly separated from that of saccus. Outer process of tegument acute. Clasper sometimes compressed and ventrally dentate. Eighth sternite with or without linear sclerites from posterolateral angles .... (2)

FIGS 18–47—*Aoraia* spp. (Scale lines = 1·0 mm)

FIGS 18–22—*A. senex*

18—Male genitalia, Ben Lomond, caudal view
19—Right half of tegumen, Ben Lomond, lateral view
20—Vinculum, Ben Lomond
21—Juxta, trulleum, and clasper, Ben Lomond
22—Female genitalia, Ben Lomond, caudal view

FIGS 23–26—*A. dinodes*

23—Right half of tegumen, syntype, lateral view
24—Vinculum, Philpott's specimen
25—Juxta, trulleum, and clasper, syntype
26—Female genitalia, Ben Lomond, caudal view

FIGS 27–31—*A. aurimaculata*

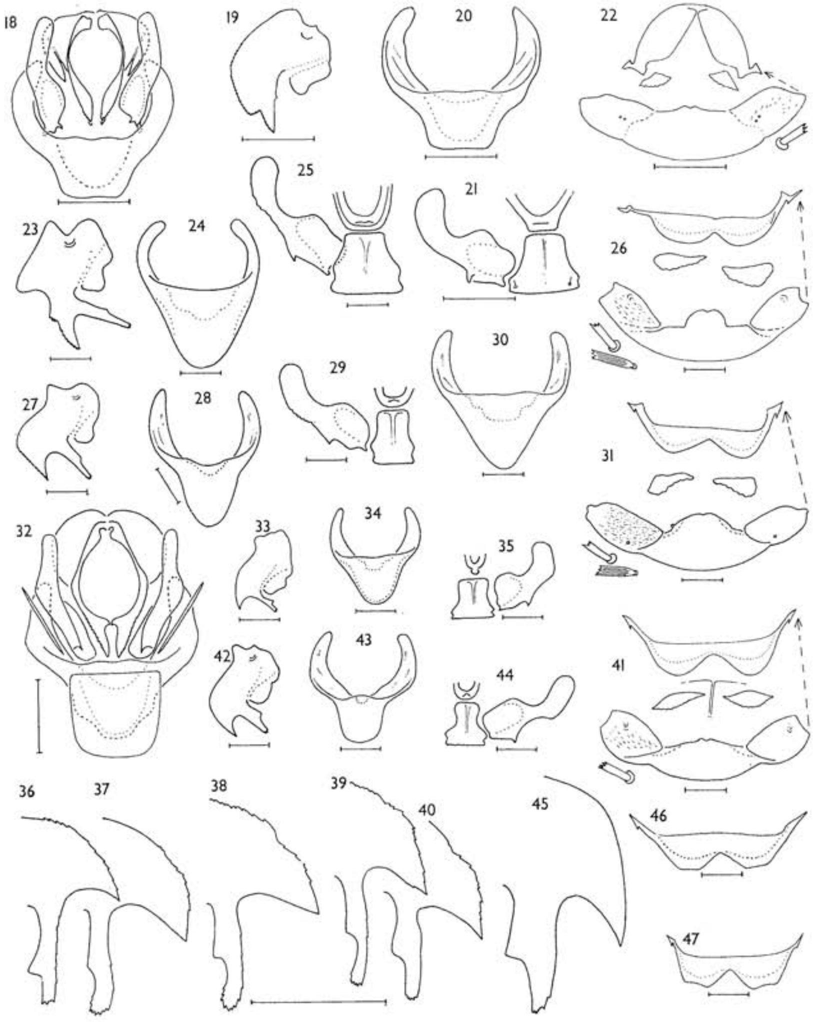
27—Right half of tegumen, L. Ohau
28—Vinculum, L. Ohau
29—Juxta, trulleum and clasper, L. Ohau
30—Vinculum, Dunedin
31—Female genitalia, Landsborough, caudal view

FIGS 32–41—*A. leonina*

32—Male genitalia and 8th sternite, Mt Ruapehu, caudal view
33—Right half of tegumen, type, lateral view
34—Vinculum, type
35—Juxta, trulleum, and clasper, type
36—Outer and inner processes of tegumen, type, lateral view
37—ditto, Waiho
38—ditto, Denniston
39—ditto, Mt. Egmont
40—ditto, Mt Ruapehu
41—Female genitalia, Mt. Arthur, caudal view

FIGS 42–47—*Aoraia* sp.

42—Right half of tegumen, Gordon's Knob, lateral view
43—Vinculum, Gordon's Knob
44—Juxta, trulleum, and clasper, Gordon's Knob
45—Outer and inner processes of tegumen, Gordon's Knob, lateral view
46—Female preanal sclerite, Dun Mt.
47—Female preanal sclerite, Rotoiti.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(2) Caudal margin of tegumen (Fig. 33) with concavity immediately ventrad of subtriangular dorsal process, thence broadly convex, without obvious shoulder, narrowed evenly to apex of outer process. Eighth sternite elongate, with linear sclerites (Fig. 32) from posterolateral angles .... ***leonina*** (Philpott)

Caudal margin of tegumen with or without triangular dorsal process, shoulder shortly rounded, no concavity between shoulder angles to margin between shoulder and outer process, shoulder shortly rounded, with or without pronounced concavity ventrad of shoulder. Eighth sternite transverse without linear posterolateral sclerites .... (3)

(3) Caudal margin of tegumen (Fig. 23) straight between apex of dorsal process and shoulder, a deep concavity between shoulder and outer process .... ***dinodes*** (Meyrick)

Caudal margin of tegumen (Fig. 27) with triangular dorsal process, shoulder shortly rounded, no concavity between shoulder and outer process .... ***aurimaculata*** (Philpott)

♀ ♀

(1) Lateral arms of prevulvar sclerite bearing sparse setae, without narrow scales (Figs 22, 41) .... (2)

Lateral arms of prevulvar sclerite bearing both sparse setae and narrow scales (Figs 26, 31) .... (3)

(2) Lateral arms of prevulvar sclerite (Fig. 22) poorly differentiated from median piece, postero-mesal angle not free, without tubercles on posterior submargin, 2 pores or processes near middle; lateral submarginal area of median piece non-spinulose. Halves of preanal sclerites (Fig. 22) subrectangular, caudal margins not meeting in a median dorsal V .... ***senex*** (Hudson)

Lateral arms (Fig. 41) clearly differentiated from median piece, postero-mesal angles free, with or without tubercles on posterior submargin, with not more than 1 pore or process, lateral submarginal area of median piece spinulose. Halves of preanal sclerite subtriangular, caudal margins meeting in a median dorsal V .... ***leonina*** (Philpott)

(3) Lateral arm (Fig. 26) posteriorly with a prominent longitudinal submarginal ridge with a distinct tubercle at ⅔ length, scales confined to ridge .... ***dinodes*** (Meyrick)

Lateral arm (Fig. 31) without prominent ridge, without tubercles, completely clothed with dense narrow scales .... ***aurimaculata*** (Philpott)

Aoraia senex (Hudson), n. comb.

Hudson 1908, Trans. Proc. N.Z. Inst., 40 : 107 (*Porina*).
annulata Hamilton 1909, *ibid*, 41 : 48 (*Porina*).

♂ GENITALIA (Fig. 18): Specimen: Ben Lomond, E. Fairburn, —.III.38; C.M. Caudal margin of tegumen half (Fig. 19) with low rounded dorsal process defined ventrally only by shallow concavity, finely dentate and straight or slightly convex to angulate shoulder of 130°; more strongly dentate and straight or slightly convex to short outer process which is dentate and apically rounded or obtuse; margin between outer and inner process dentate, with angular or rounded concavity; inner process tapering elongate-triangular with small denticles on caudal margin. Vinculum base (Fig. 20) wider than long, sides slightly converging, apex truncate, apical angles rounded. Saccus wider than long, margin distant from that of vinculum base, especially at apical angles. Clasper (Fig 21) nearly as long as tegumen, 2 × as long as basal width of juxta, base 2 × as wide as distal portion which is scarcely narrowed at mid-length, ventral margin neither serrate nor dentate. Juxta (Fig. 21) with a sublateral seta on each side of posterior margin. Trulleum (Fig. 21) Y-shaped, the base short and wide with a transverse ridge.

♀ GENITALIA (Fig. 22): Specimen: Ben Lomond, E. Fairburn, —.III.38; C.M. Eighth tergite with cuticular processes 2/2; submedian elongate, projecting, sublateral small pore-like. Halves of preanal sclerite subtrapezoidal or subrectangular; the caudal margins long and straight, not meeting in a median dorsal V, gradually narrowing at 2/3 width to short angulate lateral extremity. Median piece of prevulvar sclerite weakly sclerotised, posterior margin transverse; lateral arms poorly delimited from median piece, without posterior submarginal ridge or tubercles, sparsely setose, without scales, with 2 pores sub-basally.

TYPE: holotype ♂ (Fig. 95); Old Man Range, 4,000 ft, J. H. Lewis, —.II.06; 730a, D.M.

The original description was based on this specimen which was "bred from a pupa found under stones". It has therefore been labelled as the holotype.

DISTRIBUTION: South Island—Central Otago; 4,500–5,000 ft.

FLIGHT PERIOD: December–February.

This is apparently a day-flying species. Both the fore and hind-wings are sparsely scaled and those of the female are narrowed and apically pointed. The other 3 species of *Aoraia* are closely interrelated but *senex* is more distantly related to them.

Aoraia dinodes (Meyrick), n. comb.

Meyrick 1890, Trans. Proc. N.Z. Inst., 22: 206 (*Porina*).

♂ GENITALIA: Described and figured by Philpott (1927a, fig. 29) and figured by Viette (1950a, fig. 11). Specimens: syntype, Invercargill, C.M.; Philpott's specimen, no data, E.D.

Eighth sternite transverse, posterolateral angles acute, without linear sclerites. Dorsal process of tegumen (Fig. 23) not differentiated from the straight caudal margin which ends at a shortly-rounded dentate shoulder; outer process long, acute, caudal margin strongly dentate, separated from shoulder by large non-dentate semicircular concavity; inner process nearly 2 × as long as outer, slender, narrowed past ½ length, subparallel-sided and apically dentate. Vinculum base (Fig. 24) subtriangular, apex rounded. Saccus U-shaped, margin of apex coincident with that of vinculum. Juxta as in Fig. 25. Trulleum (Fig. 25) U-shaped, with transverse basal ridge.

Clasper (Fig. 25) 2× as long as basal width of juxta, narrowed at mid-length, base 2 × as wide as apex, ventrally with acute spur at ½ length of base and margin serrate or dentate.

♀ GENITALIA (Fig. 26): Specimen: West Plains, Invercargill, A. Philpott; E.D.

Eighth tergite cuticular processes 2/2, both sublateral, anterior larger and more projecting. Halves of preanal sclerite fused dorsally, caudal margins meeting in a median V, each broadly rounded, abruptly narrowed to distal ⅓ which is slender and angled distally. Posterior margin of median piece of prevulvar sclerite rounded with slight median emargination, setose, setae stout. Lateral arms wider distally, separated from base of median piece by oblique groove, posterobasal angle free, about 45°; a prominent submarginal ridge from basal angle to large tubercle at 2/3 length, sparse stout setae on ridge and anterior to it, narrow scales on basal portion of ridge, scale sockets ½ diameter of seta sockets.

TYPE: lectotype ♂ (Fig. 97); Invercargill, F. W. Hutton; C.M. A specimen bearing two written labels, "*Porina dinodes* Meyr." and "Invercargill from Hutton", and two printed labels, "Fereday Collection" and "5", is here designated as the lectotype and has been so labelled. A second male specimen, also in the Canterbury Museum and similarly labelled, is apparently the second of Meyrick's two syntypes and has been so labelled.

DISTRIBUTION: South Island—Southland, Stewart Is., and islands in Foveaux Strait; at or near sea level. The male genitalia of the species are distinctive and specimens have been seen only from the above area. Hudson's (1928, 1939, 1950) records of this species from elsewhere have not been confirmed. His records from Chateau Tongariro and Waiho are based on specimens of *A. leonina*, that from Dunedin on *A. aurimaculata* or a species near it, and that from Dun Mountain on *Aoraria* sp.

FLIGHT PERIOD: February–April.

Aoraia aurimaculata (Philpott), n. comb.

Philpott 1914, Trans. Proc. N.Z. Inst., 46: 121 (*Porina*).

♂ GENITALIA: Specimens. Lake Ohau, R. L. Wigley, —.IV.32; C.M.: Hunter R., —.IV.23; CM.

Eighth sternite transverse, semicircular, without linear sclerites from posterolateral angles, without 3 small isolated sclerites anteriorly. Caudal margin of tegumen (Fig. 27) with triangular dorsal process, without concavity ventrad of this, margin straight to shortly-rounded shoulder, thence straight and at right angles to acute outer process; a U-shaped rounded concavity between outer process and inner process, sometimes dentate below outer process; inner process slender, long, gradually narrowed at half length, distal half half as wide, slightly narrowed to dentate apex. Vinculum base (Fig. 28) U-shaped with slightly convex sides which coincide with those of saccus. Juxta (Fig. 29) of usual type 6-sided narrower distally. Trulleum (Fig. 29) a U-shaped sclerotisation with transverse median prominence on base.

Clasper (Fig. 29) twice as long as basal width of juxta, slightly narrowed at mid-length, ventral margin serrate to sub dentate at mid-length.

The Ohau specimen has a shorter outer process, dentate on the ventral margin, and a wider concavity between inner and outer processes, than that from Hunter R.

A specimen from Homer (Mrs D. Sutherland, —.IV.42; D.M.) and 2 from Dunedin (12.III.41; D.M.; 16.III.11, Fenwick; D.M.) closely resemble *aurimaculata* but differ in the more triangular base of the vinculum (Fig. 30). Female specimens are not available from these two localities and the identity of these males, which are not those of *dinodes,* is uncertain.

♀ GENITALIA (Fig. 31): Specimens. Franz Josef Glacier, J. Ure, 26.V.65; C.M.: Landsborough Valley, R. A. Wilson, 18.IV.25; D.M.

Eighth tergite with small, circular, sublateral pores, 2/2, anterior larger. Caudal margin of each half of the pre-anal sclerite rounded, fused dorsally forming a median caudal V. Median piece of pre-vulvar sclerite transverse, setose except posteriorly in the median line and the non-spinulose lateral submarginal area; lateral arms well defined, elongate, slightly more convex on posterior half, uniformly clothed with dense narrow scales in addition to sparse setae, and with a single cuticular process at about 1/3 length and nearer anterior margin.

TYPE: Holotype ♂ (Fig. 96); Hermitage, Mt. Cook, F. S. Oliver, 28.III.—; location unknown. Apparently returned by Philpott to Oliver, since it was later borrowed by Hudson (1928) for figuring.

DISTRIBUTION: South Island—both sides of the Alps in the vicinity of Mt. Cook; 1,000–2,500 ft.

FLIGHT PERIOD: March–April.

In the absence of the type the species cannot be defined with certainty. The descriptions above of the presumed male and female genitalia are based on specimens which are distinguishable from other existing species, and from the vicinity of the type locality. The species is most nearly related to *dinodes* in the form of the tegumen and the scaling of the lateral arms of the prevulvar sclerite. It occurs at higher altitudes than *dinodes* and the two species have not been taken in the same localities.

Aoraia leonina (Philpott), n. comb.

Philpott (1927, Trans. Proc. N.Z. Inst., 57 : 709 (*Porina*).

♂ GENITALIA (Fig. 32): Specimen: holotype.

Eighth sternite of type not examined; in other specimens subquadrate or slightly elongate, with linear sclerite from each posterolateral angle, without isolated small sclerites anteriorly. Caudal margin of each half of tegumen (Figs 33, 36) with a prominent subtriangular dorsal process with rounded apex and a shallow concavity below; thence broadly convex, without shoulder; dentate, teeth small, dorsal group inclined dorsad, ventral group at base of outer process inclined ventrad. Outer process acute, a wide rounded concavity with some denticles between outer and inner processes. Inner process long, widening on the anterior margin to 2/3 length where it is abruptly narrowed, caudal margin with a few obscure denticles, distal third subparallel-sided to subtruncate apex with 3 denticles. Vinculum base (Fig. 34) subtriangular, sides slightly concave and distant from those of saccus basally, apex rounded and narrowly contouring saccus. Saccus U-shaped, posterior margin with a wide median concavity, apex rounded. Clasper (Fig. 35) nearly as long as tegumen, twice as long as basal width of juxta, narrowed at mid-length; ventral margin non-serrate, slightly shouldered at mid-length. Juxta (Fig. 35) as wide as long, trapezoidal, widest basally. Trulleum (Fig. 35) with a U-shaped sclerotisation with a transverse basal ridge and median prominence.

The specimens listed below are considered to be conspecific with the type but differ in the characters mentioned:

Waiho Gorge (G. L. Richardson, —.IV.27; D.M.): resembles Denniston specimen but without concavity in caudal margin of tegumen (Fig. 37) apical teeth of inner process smaller and less acute.

Denniston (J. E. Kelly, —.IV.44; C.M.) resembles Ruapehu specimen but apex of inner process (Fig. 38) widened, with 6 or 7 large teeth.

Mt. Egmont (21.III.17; D.M.): similar to Ruapehu specimen but concavity of tegumen (Fig. 39) absent, apex of inner process with 6 teeth.

Mt. Ruapehu (C. Lindsay, —.IV.39; C.M.): caudal margin of tegumen (Fig. 40) strongly dentate, with slight concavity at base of outer process, inner process less widened at 2/3, apical teeth more obtuse. This specimen was considered by Hudson (1939) to be *dinodes* or, with later specimens from this locality (Hudson, 1950), a variety of *dinodes*.

♀ GENITALIA (Fig. 41); Specimen. Mt. Arthur, E. S. Gourlay; 31.I.32, E.D.

Eighth tergite without projecting cuticular processes but with 2/2 small, circular, sclerotised, sublateral pores at mid-length.

Caudal margin of each half of preanal sclerite rounded, meeting dorsally in a median rounded concavity. Median piece of prevulvar sclerite transverse, anteriorly arcuate, posteriorly with sides converging to 2 small paramedian lobes separated by a median emargination, disc setose and also bearing narrow scales posteriorly and laterally, posterolateral submarginal areas spinulose, non-setose, non-pigmented. Lateral arms pear-shaped, longer than wide, widest in distal half, posteromesal angle free, disc slightly convex on posterior submargin, without evident ridge from posterobasal angle to apex but setose area ending in this position, and a small setigerous prominence at 2/3 length, scales absent.

The specimens listed below are considered to be conspecific with the above but differ in the characters mentioned:

Mt. Egmont (21.III.17; D.M.): lateral arms wider basally, with setigerous tubercles at 1/4, 1/2, and 3/4 length, the basal 2 larger.

Denniston (J. E. Kelly, —.IV.44; C.M.): lateral arm with setigerous tubercle at 3/4 length, one cuticular pore at 1/2 length.

TYPE: holotype ♂ (Fig. 98): Salisbury's Opening, Mt. Arthur Tableland, 4,000 ft, A Philpott, 4.IV.—; E.D.

DISTRIBUTION: North Island—Mt. Ruapehu, Mt. Egmont; South Island—Nelson, Westland. The distribution area meets that of *aurimaculata* at Franz Josef Glacier and this latter species may extend further up the eastern side of the divide. The record of *leonina* from Homer by Howes (1947) appears to be an error since specimens from there in the Dominion Museum are near *aurimaculata*.

FLIGHT PERIOD: March–April.

The North Island population of *leonina* could perhaps be considered to be a subspecies but it cannot be separated by reliable morphological characters. The species has some affinities with *aurimaculata* but is separable by characters of the eighth sternite and tegumen of the male, and the lateral arms of the prevulvar sclerite in the female.

Aoraia sp.

♂ GENITALIA: Specimen: Gordon's Knob, S. Hudson, I.IV.44; 373k, D.M. The deep strongly-shouldered tegumen (Figs 42 & 45) resembles that of *aurimaculata,* though its caudal margin is non-dentate. The basal portion of the inner process of the tegumen is 2× as wide as in *leonina* and *aurimaculata* and the distal portion is strongly tapered. The vinculum (Fig. 43) and the juxta, trulleum and clasper (Fig. 44) are similar to those of *leonina*.

♀ GENITALIA: Specimen: Dun Mt., O'Connor, 15.IV.17; 373h, D.M. This specimen was considered by Hudson (1950) to be *dinodes*. Caudal margin of each half of the preanal sclerite (Fig. 46) is truncate medially but not concave; lateral arm of the prevulvar sclerite without setigerous tubercles or narrow scales.

Specimen: Rotoiti, A. Philpott, —.IV.28; E.D. Caudal margin of each half of the preanal sclerite (Fig. 47) truncate and slightly concave medially; lateral arm of the prevulvar sclerite with a setigerous tubercle at 2/3 and a smaller one at ½, without narrow scales.

Both sexes differ from those of existing species and they are tentatively associated. The male tegumen resembles that of *aurimaculata,* rather than *leonina,* in its depth but the female differs from both *dinodes* and *aurimaculata* in the absence of narrow scales on the lateral arms of the prevulvar sclerite and from all existing species in the form of the caudal margin of the halves of the preanal sclerite. Rotoiti is at the southern end of the Richmond Range—a continuation of the main Divide—and Gordon's Knob and Dun Mt. are on branches of this range, the whole forming a massif which is topographically isolated from the distribution area of *leonina* in north-west Nelson. The morphological features of the specimens and their distribution suggest that a distinct species may have survived, or segregated, in this massif. Additional specimens are desirable before describing the species and only the diagnostic features of existing specimens are mentioned here.

Subfamily OXYCANINAE subfam. n.

Wing vein R_4 branching from common stem R_{2+3+4} (R_1 included also in *Elhamma*).

TYPE GENUS: Oxycanus Walker 1856.

DISTRIBUTION: Palaearctic region—*Neohepialiscus* Viette 1948 (Algeria); Oriental region—*Hepialiscus* Hampson 1892 (Nepal), *Xhoaphryx* Viette 1953 (Indo-China), *Parahepialiscus* Viette 1950 (Borneo); Australian region—*Paraoxycanus* Viette 1950, *Zauxieus* Viette 1952, *Theaxieus* Viette 1952 (New Guinea), *Oxycanus* Walker 1856, *Elhamma* Walker 1856. *Jeana* Tindale 1935 (Australia), *Wiseana* Viette 1952, *Dioxycanus* gen. n., *Trioxycanus* gen. n., *Cladoxycanus* gen. n. (New Zealand); Neotropical Region—*Trichophassus* Le Cerf 1919 (Brazil and Paraguay).

The following morphological features indicate that this subfamily is more specialised than the Hepialinae: wing vein R_4 arising from R_{2+3+4}; greater reduction of maxillary palpi and galea; greater modification of the sclerites of the 9th abdominal segment of the female and (except in *Dioxycanus* gen. n.) permanent fusion of the intergenital lobes. The antennae are diverse in form but in *Oxycanus* and in New Zealand oxycanine genera other than *Trioxycanus* the pectinations arise from the distal part of the antennal segments and a haired transverse ridge, or a line of hairs, is present basoventrally.

Genus *Oxycanus* Walker

Walker 1856, List Lep. Ins. Brit. Mus. 7: 1573; type-species *O. australis* Walker (Australia).

Porina Walker 1856, *ibid.* 7: 1572 (preocc.).

"Antennae moderate, strongly bipectinate, or feebly bidentate; when strongly bipectinate there is sometimes also a pair of short dentations at the base of each segment, pectinations and dentations terminating in tufts of cilia. Labial palpi moderate, porrected, with basal segment twice as long as wide, second at least three times as long as wide, apical one slightly swollen at apex, and nearly twice as long as wide, clothed with short flattened hairs. Maxillary palpi either present as a single rudimentary subspherical segment, or obsolete. Hind tibiae densely hairy. Forewings with R_1 and R_2 separately from near base, R_3, R_4 and R_5 out of R_2; R_2 and R_3 branching nearer to R_4 than to termen; R_5 from about two-fifths. Hindwings with R_2 and R_3 branching nearer to R_4 junction than to termen; 1A well developed; 2A present as rudiment near base." (Tindale, 1935).

DISTRIBUTION: Australia alone if *Paraoxycanus* Viette is regarded as a genus; Australia and New Guinea if *Paraoxycanus* is regarded as a subgenus of *Oxycanus*.

The diagnosis of the genus reproduced here is a very wide one. The number and variety of the Australian species at present referred to *Oxycanus* suggest that more detailed study will result in the definition and segregation of subgenera, and perhaps genera, from within it. Viette (1950a) erected the genus *Paraoxycanus* Viette for a number of species of *Oxycanus* from New Guinea, and the genus *Wiseana* Viette for a group of New Zealand species. *Paraoxycanus* was considered by Tindale (1955), who described 15 new species of *Oxycanus* from New Guinea (and also by Paclt, 1953), to be not more than a subgenus of *Oxycanus*. The New Guinea species described by Viette have subanal sclerites (plaques laterales) in the male but these are also present in *O. australis* and in some other Australian species of *Oxycanus*. Before considering the status of the segregates which were apparent in the New Zealand *"Oxycanus"* fauna, a tentative definition of the nominate subgenus of *Oxycanus* was formulated. This was based on existing descriptions and on a study of the genitalia of *Oxycanus australis* (Walker). Specimens: ♂, Whitemark, T., J. J. Ick, 10.V.39; S.A.M.: ♀, F—— [illegible]; S.A.M.) and the closely related *O. diremptus* (Walker) (Specimens: ♂ and ♀, Moe, Vict., 17.IV.38; S.A.M.).

Subgenus *Oxycanus* Walker

Antennae bipectinate in male, pectinations lamellar, wide, parallel-sided, rounded apically, length $2\frac{1}{2}\times$ width of shaft; female bidentate. Labial palpi 3-segmented, 2nd segment longest. Vein R_2 in fore wing $2\times$ to $3\times$ as long as R_{2+3}.

♂ GENITALIA (Fig. 9): Eighth abdominal sternite elongate. Paired subanal sclerites present. Tegumen half with the anterodorsal portion large and in a plane at right angles to the caudal portion; caudal margin deeply excavate and undercut ventrad of the large dorsal process, serrate or dentate; outer process absent; inner process triangular, acute, free beyond trulleum; ventral extremity of accessory sclerite strongly produced above the trulleum towards the median line. Vinculum margin coinciding with that of saccus; both convex, the cavity large; vertical connection to 8th sternite large sclerotised and with large posterolateral extensions. Claspers slender nearly $2\times$ as long as basal width of juxta. Juxta quadrilobate, wider basally. Trulleum, flat, Y-shaped.

♀ GENITALIA (Fig. 12): Eighth abdominal tergite divided, without evident cuticular processes. Halves of preanal sclerite together forming an inverted U. Prevulvar sclerite arcuate; transverse median piece with a sclerotised median dorsal structure; lateral arms directed laterodorsad, their posterior margins free. Intergenital lobes large, elongate, sclerotised laterally and posteriorly, fused in the median line and transversely striate posteriorly. Seminal passage sclerotised, broad, wider posteriorly, transversely striate.

TYPE SPECIES: *Oxycanus australis* Walker.

DISTRIBUTION: Australia.

A third species, *Oxycanus fuscomaculatus* Walker, was examined (specimens: ♂, Mt Gambier, F. Pearson, 15.V.52; E.D.; ♀, Mt. Gambier, 20.V.96, det. Tindale; E.D.). It differed from the other two species in antennal characters, in the entire condition of the female 8th tergite and in the large size of the subanal sclerites of the male. The female genitalia of these three Australian species is similar to that described and figured by Bourgogne (1949a) for *Perissectis australasiae* (Walker) (= *Elhamma*).

Four segregates are recognisable within the New Zealand "*Oxycanus*" fauna. They are clearly defined by characters of the antennae, the palpi, and the genitalia of both males and females and none of them conform with *Oxycanus (Oxycanus)*. *Wiseana* has been accorded generic status by Viette and in recognising this as justified and in proposing generic status for the other three segregates particular weight has been given to the differences in the more conservative female genitalia, which are usually markedly uniform within a genus.

The oxycanine genera now recognised in Australia and New Zealand can be separated by the key given below. Minor deficiencies in the key are due to the absence of detailed descriptions of the wing venation and female of *Paraoxycanus,* and the male genitalia of *Jeana* Tindale.

KEY TO AUSTRALIAN AND NEW ZEALAND GENERA OF OXYCANINAE

(1) Labial palpi 2-segmented .... (2)

Labial palpi 3-segmented .... (3)

(2) Labial palpi with 2nd segment longest. Male antennal segments with a longitudinal flange or lamella on one side only. Fore wing of female with R_1 branching from R_{2+3} distad of R_4; male hind wing with M_1 and M_2 fused and R_1 branching from fork of R_2 and R_3 .... (Australia) .... ***Elhamma*** Walker

Labial palpi with 1st segment longest. Male antennae with transverse lamellar bipectination. Vein R_1 branching from R_s basad of R_5; venation of fore and hind wings similar in both sexes .... (N.Z.) .... ***Dioxycanus*** gen. n.

(3) Labial palpi long, projecting beyond head, 1st segment longest or with apical extension .... (4)

Not so .... (5)

(4) First segment of labial palpi with apical extension. Antennae with lamellar bipectination. Veins R_2 and R_3 twice as long as R_{2+3}. Caudal margin of tegumen smooth, without outer process .... (N.Z. .... ***Cladoxycanus*** gen. n.

First segment of labial palpi longest, without apical extension. Antennal pectinations long. Veins R_2 and R_3 half length of R_{2+3} .... (Australia) .... ***Jeana*** Tindale

(5) Male with filiform or bidentate antennae; median subanal structure present. Female 8th tergite divided .... (N.Z.) .... ***Trioxycanus*** gen. n.

Male with bipectinate or bidentate antennae, no median subanal structure. Female 8th tergite divided or entire .... (6)

(6) Caudal margin of tegumen dentate, without outer process, inner process long slender without mesal arms. Paired subanal sclerites present. (Eighth tergite of female divided. Wing vein R_2 2× or 3× as long as R_{2+3}) .... (Australia) .... ***Oxycanus (Oxycanus)*** *Walker*

Caudal margin of tegumen dentate or smooth, outer process usually present, inner process short and wide, the mesal arms fusing medially. Subanal sclerites present or absent .... (7)

(7) Caudal margin of tegumen dentate, outer process truncate-conical or acute, seldom parallel-sided and apically rounded. Paired subanal sclerites present. Male antennae bidentate .... (New Guinea) .... ***Paraoxycanus*** Viette

Caudal margin of tegumen smooth, outer process always sub-parallel-sided and rounded apically. Subanal sclerites absent. Male antennae bipectinate (Eighth tergite of female entire. Vein R_2 1× to 1½× length of R_{2+3}) .... (N.Z.) .... ***Wiseana*** Viette

Genus ***Trioxycanus*** Dumbleton gen. n.

(From Greek *Tri* (= three) and generic name *Oxycanus*: masculine)

Antennae filiform, feebly unidentate or bidentate, basoventral ridge absent. Labial palpi 3-segmented, of moderate length, as long as eye-margin, not projecting beyond head. Wing veins R_2 and R_3 slightly longer than R_{2+3} which is twice as long as R_{2+3+4}.

♂ GENITALIA: Eighth abdominal sternite small or narrow with 2 triangular paramedian posterior processes (except in *characterifer*). Anterior dorsal portion of tegumen forming a hood-like structure overhanging the dorsal processes. Tegumen half with long dorsal process, separated from rest of caudal margin by a deep concavity; dorsal half of caudal margin with fairly regular teeth; outer process present or absent; inner process short, acute. Juxta tranverse, slightly wider basally, with sub-basal lateral concavity, quadrilobate. Trulleum subquadrate, slightly or strongly dished. Clasper length 1½× basal width of juxta; base variable in length and width, without basoventral hook or teeth; distal part digitiform, sub-parallel-sided or slightly tapering, apex rounded. Paired subanal sclerites absent. Median subanal structure present.

♀ GENITALIA: Eighth abdominal tergite divided in median line; cuticular processes 2/2. Halves of preanal sclerite long, separated or fused dorsally. Median piece of prevulvar sclerite large, with strongly sclerotised structure on ental surface; lateral arms poorly developed or continuous with sides of median piece. Intergenital lobes long, together subrectangular, with transverse distal margin. Intergenital cleft closed.

TYPE SPECIES: *Porina enysii* Butler.

DISTRIBUTION: Three Kings Is.; North Is.; South Island—northern half.

The prefix in the generic name refers to to the 3-segmented labial palpi. The divided 8th tergite of the female occurs also in some species of *Oxycanus,* but these have bipectinate antennae. The median subanal structure of the male has not previously been reported in the family. The female genitalia is similar to that of *Elhamma australasiae* except in the reduction of the lateral arms of the prevulvar sclerite.

KEYS TO GENITALIA OF *Trioxycanus* SPECIES

♂♂

(1) Eighth sternite (Fig. 57) without posterior paramedian processes; tegumen (Fig. 58) concave above and below outer process vinculum base apically emarginate; saccus subconical; median subanal structure without pseudosegmented internal body .... ***characterifer*** (Walker)

Eighth sternite with posterior paramedian processes; tegumen without outer process, convex, rounded; vinculum base apically rounded; saccus U-shaped; median subanal structure with pseudosegmented internal body .... (2)

(2) Dorsal half of caudal margin of tegumen (Fig. 53) with 8 teeth; vinculum narrower at base .... ***enysii*** (Butler)

Dorsal half of caudal margin of tegumen (Fig. 49) with 4–5 teeth; vinculum wider at base .... ***unimaculatus*** (Salmon)

♀♀

(1) Halves of preanal sclerite (Fig. 56) slender, fused dorsally; intergenital lobes nearly as long as the preanal sclerite; median piece of prevulvar sclerite long and narrow, sides concave and diverging anteriorly; lateral arms weak, ovoid .... ***enysii*** (Butler)

Halves of preanal sclerite (Fig. 60) stout, separated dorsally; intergenital lobes half as long as anal sclerite; median piece of prevulvar sclerite broadly rounded with rounded median prominence; lateral arms continuous with sides of median piece .... ***characterifer*** (Walker)

(Female of ***unimaculatus*** unknown)

Trioxycanus unimaculatus (Salmon), n. comb.

Salmon, 1948, Rec. Auckland Inst. Mus., 3: 309 (*Porina*).

♂ GENITALIA (Fig. 48): Specimen: holotype.

Eighth sternite $1\frac{1}{2} \times$ as long as wide, concave anteriorly, sides slightly convex and widening posteriorly, narrowing obliquely on each side to 2 acute

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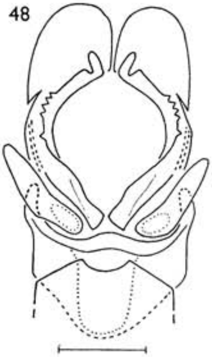
FIGS 48–60—*Trioxycanus* spp. (Scale lines = 1·0 mm)

FIGS 48–51—*T. unimaculatus,* type
48—Male genitalia and 8th sternite, caudal view
49—Right half of tegumen, lateral view
50—Juxta, trulleum, and clasper
51—Male anogenital field and subanal structure, caudal (L) and lateral (R) views

FIGS 52–56—*T. enysii*
52—Male genitalia and 8th sternite, caudal view
53—Right half of tegumen, lateral view
54—Juxta, trulleum, and clasper
55—Subanal structure
56—Female genitalia, Wellington, caudal view

FIGS 57–60—*T. characterifer*
57—Male genitalia and 8th sternite, Kumara, caudal view
58—Right half of tegumen, Kumara, lateral view
59—Juxta, trulleum, and clasper, Kumara
60—Female genitalia, Pokaka, caudal view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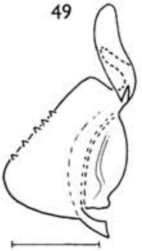
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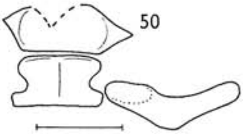
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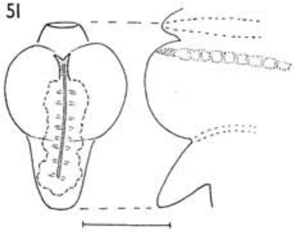
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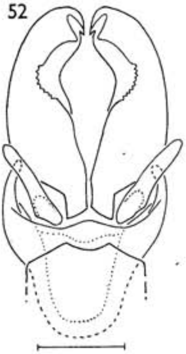
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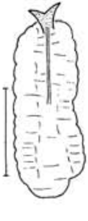
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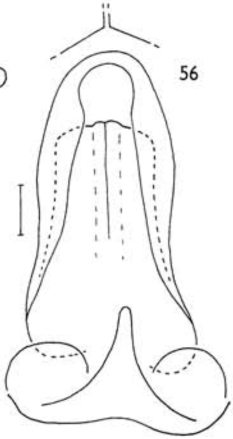
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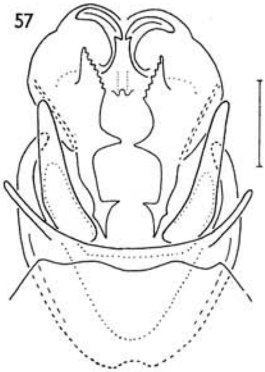
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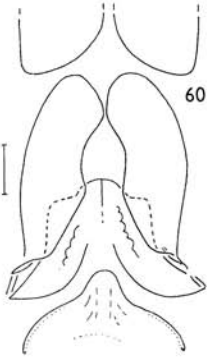
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paramedian processes separated by a semicircular median concavity. Caudal margin of tegumen half (Fig. 49) slightly convex from cleft below dorsal process to position of outer process, bearing 4–5 small, equal, conical teeth; outer process absent, the margin strongly rounded and turning at 90° towards the short acute inner process. Posterior margin of vinculum base with prominent median convexity; sides subparallel basally, shouldered at $\frac{1}{3}$, narrowing evenly to rounded apex. Saccus U-shaped, sides distant basally from sides of vinculum, apex closely approaching that of vinculum. Juxta (Fig. 50) with rounded distal angles. Trulleum (Fig. 50) strongly dished. Clasper (Fig. 50) base not widened, about $\frac{1}{3}$ total length; ventral margin of distal part angled at mid-length. A median subanal structure (Fig. 51) present, consisting of a small bifid sclerite in a concavity of the integument formed by the dorsal junction of 2 large hemispherical membranous lobes; internally and attached to this sclerite by 2 long slender paramedian rods is a large elongate less-densely-sclerotised body consisting of 8 or 9 transverse pseudosegments.

♀ : unknown.

TYPE: Holotype ♂ (Fig. 108); Great Is., Three Kings, E. G. Turbott, 24.IV.46; A.M.

DISTRIBUTION: Three Kings Is.

FLIGHT PERIOD: April.

The species, known only from the holotype, is closely related to *T. enysii.*

Trioxycanus enysii (Butler) n. comb.

Butler, 1877, Proc. zool. Soc. Lond., 381 (*Porina*).

♂ GENITALIA (Fig. 52): Described and figured by Philpott (1927a, fig. 19). Specimen: Fereday; C. M. Philpott's specimen also examined.

Eighth sternite as long as wide, posterior margin strongly sclerotised, with median concavity between 2 triangular paramedian processes. Caudal margin of tegumen half (Fig. 53) below dorsal process and deep concavity straight and bearing 8 teeth, thereafter rounded convex; outer processes absent; inner process short acute, the apices of the two processes close together. Vinculum base with a median convexity on posterior margin, sides not constricted, apex rounded. Saccus long, U-shaped, apex rounded, sides slightly diverging and more distant from sides of vinculum basally. Juxta (Fig. 54) with rounded distal angles. Trulleum (Fig. 54) strongly dished. Clasper base (Fig. 54) not widened, about $\frac{1}{3}$ length; distal part subparallel-sided, slightly angled at mid-length of ventral margin. A median subanal structure present (Fig. 55), very similar to that in *T. unimaculatus.*

♀ GENITALIA (Fig. 56): Specimen: Wellington, A. Philpott, 24.XI.09; E.D.

Cuticular processes of 8th tergite 2/2, anterior and posterior submedian in position. Halves of preanal sclerite fused dorsally, long, slender, tapering, flared outward ventrally. Median piece of prevulvar sclerite long, apically narrow and acuminate, sides concave basally, ental surface with a sclerotised structure of similar form; lateral arms reduced to weakly sclerotised subcircular lobes. Intergenital lobes together twice as long as wide occupying 4/5 of anogenital field, each largely sclerotised but not obviously so in the median line of fusion.

TYPE: holotype ♂ (Fig. 106); North Island, New Zealand, J. D. Enys; B.M.

DISTRIBUTION: North Island—throughout. At low levels, usually coastal.

FLIGHT PERIOD: December–January.

Closely related to *T. unimaculatus*.

Trioxycanus characterifer (Walker), n. comb.

Walker, 1865, List Lep. Ins. Brit. Mus., Part 32, Supp. pt. 2: 594. (*Hepialus.*)

♂ GENITALIA (Fig. 57): Described and figured by Philpott (1927a, fig. 18), and figured by Viette (1950a, fig. 9). Specimen: Kumara, J. W. Campbell; C.M.

Eighth sternite semicircular, posterior margin wide, postero-lateral angles slightly produced. Dorsal part of caudal margin of tegumen half (Fig. 58) straight, raised above the deep cleft below the dorsal process and concavity above the outer process, bearing about 6 rather regular teeth; outer process directed posteromesad, long, tapered, apex laterally bifid; a subapical tooth before the apex of the acute inner process. Vinculum base wider than long, shortly produced laterally below vinculum arms, posterior margin broadly concave, sides broadly convex with submarginal groove on basal 2/3, apex with a median concavity and a median groove to apex of saccus. Saccus wider than long, subtriangular, sides distant from and contouring those of vinculum base, apex rounded. Juxta (Fig. 59) with distal angles acute. Trulleum (Fig. 59) weakly dished. Clasper (Fig. 59) not angled ventrally at mid-length; base wide, more than half length. A median subanal structure (Fig. 57) present but lacking the internal body and pigmentation of those in *enysii* and *unimaculatus*.

♀ GENITALIA (Fig. 60); Specimen: Pokaka, G. R. Crowley, 10.XII.24; E.D. Anterior submedian and lateral cuticular processes of 8th tergite elongate, tapered; posterior submedian represented by a pore. Halves of preanal sclerite separated dorsally, long, massive, ventral extremity flared outward. Median piece of prevulvar sclerite semicircular, wide, with blunt rounded median prominence, ental surface sclerotised with transverse anterior margin; lateral arms absent or fused indistinguishably with median piece. Intergenital lobes with parallel sides and transverse posterior margin, almost completely sclerotised and fusing in the median line posteriorly.

TYPE: holotype (*? lectotype*) ♂ (Fig. 107); Auckland, New Zealand, Oxley; B.M.

The male and female, mentioned in the original description were presumably syntypes but the former now carries a "type" label.

DISTRIBUTION: North Is.—throughout; South Is.—northern half. Lowland—montane.

FLIGHT PERIOD: Late October–January.

The species is very distinct and not closely related to the other 2 species in the genus. It is the only species of the genus which extends into the South Island the only New Zealand hepialid in which the individual wing scales are bicoloured, i.e., with a sharp line between the white basal half and the black apical half.

Genus *Cladoxycanus* Dumbleton gen. n.

(From Greek *Klados* (= branch) and generic name *Oxycanus* : masculine)

Antennal segments of ♂ laterally compressed, bipectinate; pectinations short, lamellar, triangular, not continuous across venter of segment; basoventral ridge present; ♀ bidentate. Labial palpi $\frac{1}{2}$ as long as antennae, projecting beyond head, 3-segmented, 1st segment with apicoventral extension reaching $\frac{1}{2}$ length of 2nd. Wing veins R_2 and R_3 as long as R_{2+3}. ♂ GENITALIA: Eighth sternite transverse, posterior angles produced laterocaudad; posterior margin deeply concave, rolled or thickened. Tegumen half with moderately long dorsal process, narrowest in dorsal third, widest at midlength; caudal margin smooth, convex; outer process absent; inner process without projection at point of articulation with trulleum, apex rather bluntly pointed and extending well beyond trulleum. Accessory sclerite anterior to dorsal third of tegumen half. Vinculum arms slender, longer than base; sides of base not compressed, apex rounded or truncate. Sides and apex of saccus distant from and contouring those of vinculum base, apex acute or rounded. Juxta transverse, quadrilobate, with median and/or sublateral longitudinal thickened ribs. Trulleum with a median depression, continued as a membrane joining anterior margins of inner processes to their apices. Clasper digitiform, slightly longer than basal width of juxta, not con-

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FIGS 61–66—*Cladoxycanus minos* (Scale line = 1·0 mm)
61—Male genitalia, Lower Hutt, caudal view
62—8th sternite, Lower Hutt
63—Right half of tegumen, Lower Hutt, lateral view
64—Juxta, trulleum, and clasper, Lower Hutt
65—Vinculum, Haast Pass
66—Female genitalia, Masterton, caudal view

FIGS 67–77—*Dioxycanus* spp. (Scale line = 1·0 mm)

FIGS 67–72—*D. oreas*
67—Male genitalia, Mt. Egmont, caudal view
68—Right half of tegumen, Mt. Egmont, lateral view
69—Juxta and clasper, Mt. Egmont
70—Female genitalia, Arthur's Pass (*descendens*), caudal view
71—Outer and inner processes of tegumen, Mt. Arthur (*gourlayi*) lateral view
72—ditto, Arthur's Pass (*descendens*)

FIGS 73–77—*D. fuscus*
73—Male genitalia, Bold Pk., caudal view
74—Right half of tegumen, Bold Pk., lateral view
75—Juxta and clasper, Bold Pk.
76—Right half of tegumen, Hunter Mts, lateral view
77—Female genitalia, Homer, caudal view

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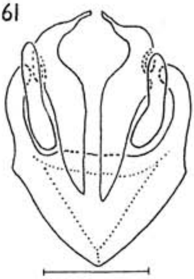

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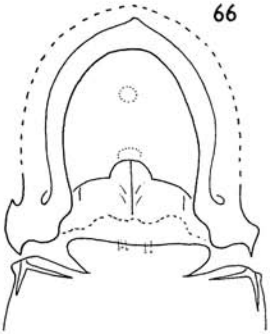

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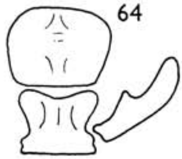

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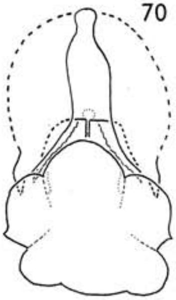

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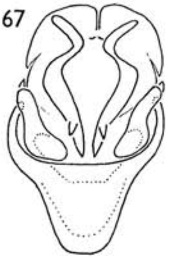

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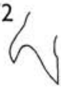

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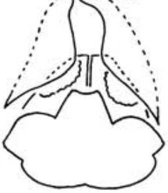

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stricted at mid-length, base weakly sclerotised, without ventral dentation or basoventral hook.

♀ GENITALIA: Eighth abdominal tergite entire; cuticular processes 2/2. Halves of preanal sclerite fused dorsally, subparallel-sided, much widened at ventral extremities, together horseshoe-shaped. Prevulvar sclerite reduced, fused with or withdrawn above the 8th sternite; median piece transverse, weakly sclerotised; lateral arms poorly differentiated from median piece, represented by a T-shaped thickening above posterolateral angle of 8th sternite, articulating with lateral extremity of preanal sclerite. Intergenital lobes short, sclerotised posteriorly and fused in median line, posterior margin transverse. Intergenital cleft closed.

TYPE SPECIES: *Porina minos* Hudson.

DISTRIBUTION: North and South Islands.

The prefix in the generic name refers to the apparently-branched labial palpi. A very distinct genus on the characters of the palpi and the genitalia of both sexes.

Cladoxycanus minos (Hudson), n. comb.

Hudson 1905, Trans. Proc. N.Z. Inst., 37: 357 (*Porina*).
autumnata Hudson 1920, Ent. mon. Mag., 56: 277 (*Porina*).

♂ GENITALIA (Fig. 61): Described and figured by Philpott (1927a, fig. 17) apparently from a specimen from Paradise, 10.V.06; E. D. Philpott was in error in stating that the inner process of the tegumen was absent. It is the outer process which is lacking.

Specimen: Haast Pass, C. Hodgkinson, —.V.35; 575f, D.M. Eighth sternite (Fig. 62) and tegumen (Fig. 63) as in genus. Sides of vinculum base (Fig. 65) straight or slightly concave, apex narrowly truncate. Sides of saccus slightly concave, apex rounded, a wide process extending halfway between apices of saccus and vinculum base. Juxta (Fig. 64) with median and sublateral longitudinal thickenings. Trulleum (Fig. 64) a shield-shaped shallow trough, as long as wide, posterior margin of sclerotised area with median concavity. Clasper as in Fig. 64. The specimen coincides with Philpott's figures except in the presence of a process at the apex of the saccus and a median thickening in the juxta.

The holotype male of *autumnata* (Lower Hutt, F. de J. Clere, —.V.16; 575c, D.M.) (Fig. 105) differs mainly in the strongly convex sides and broadly rounded apex of the vinculum base and the wider saccus with a more broadly rounded apex and a narrow process extending from it to that of the vinculum base. The distal margin of the trulleum is straight.

A second specimen from the type locality of *autumnata* (Lower Hutt, P. Field, —.VI.18; 575d, D.M.) has a more triangular vinculum base with less convex sides and more pointed apex. The saccus is narrower and triangular with a subacute apex but has a similar narrow apical process. The juxta is without the median thickening. The posterior margin of the sclerotised area of the trulleum is triangular medially.

♀ GENITALIA (Fig. 66): Specimen: unlabelled; associated with male and female, Paradise, 10.V.06; E.D. Posterior sublateral cuticular processes of 8th tergite larger and projecting more than the anterior submedian. Posterior median area of 8th sternite, which conceals median piece of prevulvar sclerite, with setae continuous to posterior margin.

A specimen of *autumnata* (Masterton, 19.VI.45; D.M.) (Fig. 66) differs only in that the 8th tergite has two posterior paramedian groups of 2 or 3 setae separated from the rest of the setose area.

TYPE: holotype ♂ (Fig. 104); Ophir, J. H. Lewis, —.I.02; 575a, D.M.

The collection data, the small size of the specimen, and Hudson's number, indicate that the original description was based on this specimen alone and it has accordingly been labelled as the holotype.

DISTRIBUTION: North Island—Wellington, Hutt Valley, Masterton, Foxton (Cumber, 1951). South Island—Central and Western Otago, Southland.

FLIGHT PERIOD: The holotype was collected in January but its small size suggests that it may have been an out-of-season straggler. All other specimens have been taken in May–July.

Hudson (1928) synonymised the North Island *autumnata* with *minos* but was later (1950) uncertain as to the correctness of this. Specimens of the North Island population are darker in the ground colour of the fore wing—dark chocolate-brown to blackish-brown—and the wing-markings are fewer in number, smaller in size, and without the elongate white streaks of South Island specimens. The morphological differences in the genitalia are minor and probably within the range of individual variation. The disjunct distribution areas are widely separated but the species has an unusually late flight-period and more intensive collecting may disclose its presence in intervening localities.

Genus ***Dioxycanus*** Dumbleton, gen. n.

(From Greek *Dis* (= twice) and generic name *Oxycanus* : masculine)

Antennal segments of ♂ laterally compressed, shortly bipectinate, pectinations subtriangular lamellae, not continuous across venter, transverse basoventral ridge present; ♀ feebly bidentate. Labial palpi 2-segmented, short, not projecting beyond head, half as long as ventral eye-margin, 1st segment slightly longer than wide, 2nd longer than wide slightly shorter and much narrower than 1st. Wing vein R_2 shorter than R_3, ending on costa; R_3 longer than R_{2+3}.

♂ GENITALIA: Eighth sternite transverse semicircular, posterior margin slightly concave, without posterolateral processes. Tegumen half with long dorsal process; caudal margin usually smooth, if irregular without definite teeth; outer process large and acute or a group of 1 to 3 small teeth in this position; inner process elongate triangular, at least twice as long as outer, acute apex freely projecting beyond trulleum. Sides of vinculum base usually not compressed, apex rounded. Saccus contouring apex and sides of vinculum base, or sides of saccus and vinculum converging basally, apex rounded. Juxta quadrilobate, widest basally. Trulleum flat. Clasper digitiform, length subequal to basal width of juxta. Subanal sclerites and median subanal structure absent.

♀ GENITALIA: Posterior margin of seventh abdominal tergite with a long, wide-based, tapering, unpigmented, cuticular process at $\frac{1}{4}$ width on each side. Eighth tergite with 2/2 smaller, subparallel-sided, pigmented cuticular processes, 1 submedian, 1 (occasionally 2) sublateral. Halves of preanal sclerite biconvex or triangular, not fused dorsally. Prevulvar sclerite long, compact, lobate; median piece semicircular or truncate, as long as wide; lateral arms reflexed cephalad, anterior margins fused with the large base of median piece. Intergenital lobes short, separated, together subconical, each sclerotised laterally and posteriorly, overhanging the seminal passage in the median line. Intergenital cleft open.

TYPE SPECIES: *Porina fusca* Philpott.

DISTRIBUTION: North Island—Mt. Egmont; South Island—throughout. At 3,000 ft.

The prefix in the generic name refers to the 2-segmented palpi. The antennal characters are similar to those of *Wiseana* Viette and *Cladoxycanus* gen. n. The genus is distinct in the form of the tegumen and especially in the form of the prevulvar sclerite. The open intergenital cleft is anomalous in an oxycanine genus but the structural plan of the female genitalia is of the oxycanine type.

KEYS TO GENITALIA OF *Dioxycanus* SPECIES

♂♂

Tegumen (Fig. 74) with outer process represented by 1 to 3 small triangular teeth; without concavity between outer and inner processes, or if present shallow and angulated .... ***fuscus*** (Philpott)

Tegumen (Fig. 68) with outer process large, acute, slightly falcate; a deep rounded concavity between outer and inner processes .... ***oreas*** (Hudson)

♀♀

Median piece (Fig. 77) of prevulvar sclerite with sides nearly straight, converging distally; apex truncate-concave .... ***fuscus*** (Philpott)

Median piece (Fig. 70) rounded, sides and apex both convex .... ***oreas*** (Hudson)

Dioxycanus oreas (Hudson), n. comb.

Hudson 1920, Ent. mon. Mag., 56: 277 (*Porina*).
ascendens Meyrick 1921, Trans. Proc. N.Z. Inst., 53: 336 (*Porina*). NEW SYNONYMY.
descendens Hudson 1923, Ent. mon. Mag., 9: 180 (*Porina*). NEW SYNONYMY.
gourlayi Philpott, 1932, Trans. Proc. N.Z. Inst., 62: 36 (*Porina*). NEW SYNONYMY.

♂ GENITALIA (Fig. 67): Specimen: Mt. Egmont, 3,100 ft, A. Castle, 8.XII.27; D.M. Caudal margin of tegumen half (Fig. 68) smooth; outer process large, stout, $\frac{1}{2}$ as long as inner, outer margin convex, inner margin slightly concave, apex acute; a deep rounded concavity between outer and inner processes, the submargin of its apex unpigmented or membranous; inner process wide at base, elongate-triangular, apically acute, ventral margin without prominence at articulation with trulleum. Vinculum base as long as wide, sides not compressed before broadly-rounded to subtruncate apex. Posterior margin of saccus with a wide subrectangular excavation, sides converging with those of vinculum basally, apically distant from and contouring those of vinculum base, apex flattened subtruncate. Juxta and clasper as in Fig. 69.

♀ GENITALIA (Fig. 70): Specimen: syntype; Mt. Egmont, A. Lysaght, —.XII.19; 376b, D.M.

Median piece of prevulvar sclerite semicircular, slightly wider than long, with a small posterior median emargination; an elongated submarginal sclerotised plaque on each side of ental surface, the two separated in the median line.

TYPE: lectotype ♂ (Fig. 99); Mt. Egmont, A. Lysaght, —.XII.19; 376a, D.M.

The lectotype selected and designated here is one of 2 syntypes.

DISTRIBUTION: North Island, Mt. Egmont; South Island, Mt. Arthur (*ascendens* and *gourlayi*), Arthurs Pass (*descendens*).

The specimens on which were based the records of *oreas* and *ascendens* from Lake Manapouri by Clarke (1933) and Hudson (1939) are considered to be *fuscus*.

FLIGHT PERIOD: December–January.

This is the only species of the genus which extends into the North Island.

NOTES ON SPECIES SYNONYMISED WITH *D. oreas*

Five species assignable to *Dioxycanus* have been described, but investigation of the genitalia, and those of the male in particular, indicates that there are, at most, two taxa of specific rank. The minor and inconstant variation which occurs within these two taxa is regarded as intra-specific. Exclusive reliance on the wing markings as criteria of specific identity has resulted, in the past, in identifications which are either inconsistent with the evidence of the genitalia (e.g., the synonymising of *descendens* with *fuscus*), or anomalous in relation to the authenticated distributions of the species recognised as distinct (e.g., records of *oreas* and *ascendens* from the Lake Manapouri area).

(a) ***ascendens*** Meyrick.

♂ unknown.

♀ GENITALIA: Specimen: Balloon Hill, 4,100 ft, Mt. Arthur Tableland, E. S. Gourlay; 8.I.30; E.D. Differs from *oreas* only in the absence of the posterior median emargination of the median piece of the prevulvar sclerite and in the submarginal sclerotised plaques on its ental surface being slightly longer and narrower and more clearly continuous across the median line.

TYPE: lectotype ♀ (Fig. 101) (selected by Mr W. H. T. Tams and lesignated here); Mt. Arthur Tableland, 3,600 ft, G. V. Hudson; —.I.89; B.M.

Hudson's (1939) record of *ascendens* from Flat Top Mts., Manapouri, ippears to have been based on specimens of *fuscus*.

(b) ***descendens*** (Hudson)

♂ GENITALIA (Fig. 72): Specimen: lectotype. The posterior margin of the 8th sternite has a slight median convexity which is unusual but is perhaps due to the preparation and mounting of the specimen. The small irregular prominences on the caudal margin of the tegumen half, are similar to those in the specimen of *gourlayi*.

♀ GENITALIA: Specimen: Arthurs Pass, S. Lindsay, 25.XII.40; C.M. There is a slight posterior median emargination of the median piece. On its ental surface the submarginal plaques are interrupted in the median line and there are two weakly sclerotised areas posteriorly. The lateral arm has a median pore at ⅓ length. A second specimen (Arthurs Pass, C. Lindsay, —.—.41; C.M.) differs in that the posterior median emargination of the median piece is absent and there is no pore on the lateral arm.

TYPE: lectotype ♂ (Fig. 100) selected and designated here; Arthurs Pass, H. Hamilton, —.XII.22; 847n, D.M.

The species (*descendens*) was considered by Salmon (1946) and Hudson (1950) to be a synonym of *fuscus* but the genitalia show clearly that it belongs to the *oreas* complex and is in fact indistinguishable from *oreas*.

(c) ***gourlayi*** Philpott.

♂ GENITALIA (Fig. 71): Specimen: Flora Camp, Mt. Arthur, E. S. Gourlay, 5.I.30; E.D. Differs from *oreas* only in the presence of small irregular prominences on the caudal margin of the tegumen half and a prominence on the inner margin of the inner process where it joins the trulleum.

♀ GENITALIA: Specimen: Flora Camp, Mt. Arthur, E. S. Gourlay, 5.I.30; E.D. Resembles *ascendens* in the absence of the posterior median emargination of the median piece and in the weaker sclerotisation of the submarginal plaques on its ental surface. There are on the posterior ental surface two transverse sclerotised areas separated in the median line.

TYPE: holotype ♂ (Fig. 102); Flora Camp, 3,000 ft, Mt. Arthur, E. S. Gourlay, 5.I.30; E.D. Occurs in the same general locality as *ascendens*.

No specimens of *Dioxycanus* have so far been taken between Mt. Arthur and Arthurs Pass which are separated by 150 miles but the populations in these two localities are not separable from one another or from the North Island population of *oreas* by consistent differences in genitalia.

Dioxycanus fuscus (Philpott) n. comb.

Philpott 1914, Trans. Proc. N.Z. Inst., 46: 121 (*Porina*).

♂ GENITALIA (Fig. 73); Figured and described by Philpott (1927a, Fig. 16). Specimen: Bold Peak, C. Fenwick, 27.XII.12; D.M.

Outer process of tegumen (Fig. 74) represented by short triangular teeth—2 on one side, 3 on other in specimen—length about $1/_{10}$ of inner process. Tapering evenly from base of outer tooth to acute apex of inner process, without obvious concavity between. Vinculum base wider than long, sides slightly concave in middle third, apex broadly rounded. Saccus subtriangular apex narrowly rounded, posterior margin with wide non-angulate emargination, sides distant from and contouring those of vinculum base. Juxta (Fig. 75) 2× as wide as long. Trulleum shield-shaped, widest posteriorly. Clasper (Fig. 75) subparallel-sided, apex rounded, base extending to ½ length.

An otherwise typical specimen (Homer, G. Howes, —.I.43; O.M.) has the vinculum sides subparallel basally, the apices of both vinculum and saccus acute and the apical halves of the sides of vinculum and saccus scarcely separated.

Two specimens examined (Flat Top Mts., Hope Arm, C. E. Clarke, 27.XII.28; A.M.: Hunter Mts., L. Manapouri, C. E. Clarke, 5.I.23; A.M.) have an outer process (Fig. 76) consisting of a single small tooth, sometimes with an accessory tooth, and the concavity between outer tooth and inner process angulated at the bases of both. Hudson's (1939) records of *oreas* and *ascendens* from Manapouri are presumably based on those of Clarke (1933), but the specimens concerned are considered to be not more than a possible subspecies of *fuscus*.

♀ GENITALIA (Fig. 77): Specimen: Homer, J. T. Salmon, 16.XII.44; D.M. Median piece of prevulvar sclerite wider than long, sides only slightly convex, converging distally, apex concave-truncate.

TYPE: location unknown. The species was described from specimens from Bold Peak (4,500 ft, C. Fenwick, —.XII.—) and Ben Lomond (M. O. Pasco, —.XII.—) and the type may have been returned to the collector. A paratype male (Fig. 103) exists (Bold Pk., A. Philpott, 27.XII.12; E.D.).

DISTRIBUTION: South Island—Western Southland and Otago; ca. 3,000 ft.

Records of *fuscus* from Mt. Grey, North Canterbury (Hudson, 1928) and Mt. Cook (Hudson, 1939) require verification. Records from Arthurs Pass, based on the supposed synonymy of *fuscus* and *descendens,* are in error, since specimens of the latter clearly belong to the *oreas* complex.

FLIGHT PERIOD: December–January.

The species is distinguishable from *oreas* on characters of the male tegumen and the median piece of the female prevulvar sclerite.

Genus ***Wiseana*** Viette

Viette 1961, Entomologist, 94: 38–9.

Philpottia Viette, 1950, Zool. Med. Leiden, 31: 72–3; type-species *Pielus umbraculatus* Guénée. (Preoccupied.)

Antennae of ♂ shortly bipectinate, pectinations lamellar, triangular; ♀ bidentate. Labial palpi of moderate length, as long as ventral eye-margin, not projecting beyond head, 3-segmented, 2nd segment longest. Wing veins R_2 and R_3 twice as long as R_{2+3}.

♂ GENITALIA. Eighth sternite usually transverse, widest posteriorly, posterior margin slightly concave sometimes with slight posterolateral processes, anterior margin rounded. Anterodorsal portion of tegumen half reflexed to form dorsal hood and a lateral trough; dorsal process variable in length; caudal margin of tegumen smooth; outer process large, in lateral view subparallel-sided, rounded or truncate apically; inner process extending little beyond articulation with trulleum, dentate on outer margin of apex, a prominent dentate arm extending mesad and separated by a ventromedian cleft from the opposite arm. Vinculum variable in shape, margin widely separated from and contouring saccus margin. Saccus variable in shape, cavity shallow. Juxta quadrilobate, widest basally. Trulleum subquadrate, strongly dished. Clasper digitiform, subparallel-sided, rounded apically, as long as basal width of juxta, half as long as tegumen. Paired subanal sclerites and median subanal structure absent.

♀ GENITALIA: Eighth tergite entire, cuticular processes 2/2 or 3/3. Halves of preanal sclerite separated dorsally, together bell-shaped. Prevulvar sclerite short, without large base; median piece rounded or transverse posteriorly, sclerotisation on ental surface with transverse anterior margin; lateral arms elongate, transverse, anterior margin continuous with anterior margin of base of median piece. Intergenital lobes largely sclerotised, fused in median line, together subrectangular, posterior margin transverse. Intergenital cleft closed to form seminal passage.

DISTRIBUTION: North and South Islands, throughout.

Viette (1950) stated that *Wiseana* was represented in Australia but he cited no species and none of the described Australian species of *Oxycanus* would fall in the genus.

Wiseana was considered by Paclt (1953) to be a synonym of *Oxycanus* Walker. The species included, however, form a well defined group, and this and other New Zealand segregates previously included in *Oxycanus*

FIGS 78–93—*Wiseana* spp. (Scale lines = 1·0 mm)
FIGS 78–83—*W. cervinata*
78—Male genitalia, Lincoln, caudal view
79—Eighth sternite, Opotiki
80—Right half of tegumen, Opotiki, lateral view
81—Vinculum, Opotiki
82—Juxta, trulleum, clasper and apices of inner processes of tegumen, Opotiki
83—Female genitalia, Seddon, caudal view
FIGS 84–86—*W. copularis*
84—Right half of tegumen, syntype, caudal view
85—Outer process of tegumen, syntype, lateral view
86—Female genitalia, West Plains, caudal view
87—*W. despecta,* female genitalia, Rockville, caudal view
FIGS 88–90—*W. signata*
88—Eighth sternite, Nelson
89—Vinculum, Nelson
90—Female genitalia, Picton, caudal view
FIGS 91–93—*W. umbraculata*
91—Eighth sternite, Lincoln
92—Vinculum, Lincoln
93—Female genitalia, Murchison, caudal view.

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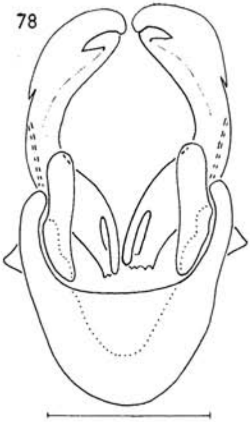

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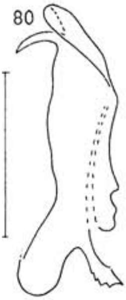

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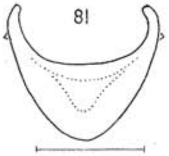

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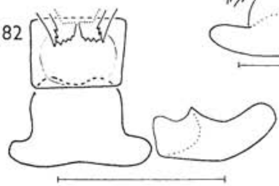

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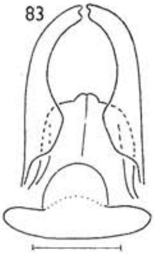

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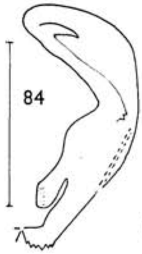

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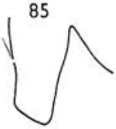

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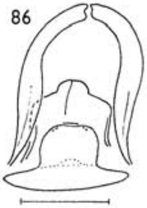

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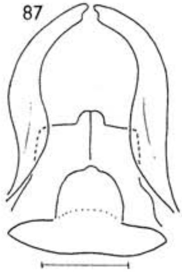

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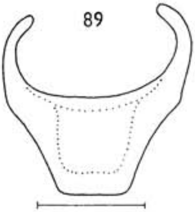

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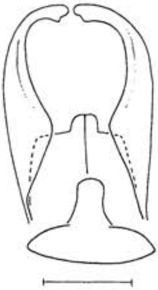

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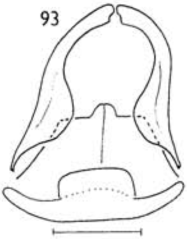

merit generic rank. *Wiseana* resembles *Dioxycanus* and *Cladoxycanus* in antennal characters. The New Guinea species included in *Paraoxycanus* by Viette and the New Guinea species of *Oxycanus* described by Tindale (1955) resemble those of *Wiseana* in the partial fusion of the short dentate inner processes of the tegumen.

Philpott (1927a) described and figured the male genitalia of the 7 New Zealand species later placed by Viette in *Wiseana* but the apparent definiteness of his key to the species is misleading. The date and locality of collection of his specimens is not given and these supplementary aids cannot be used to check his specific identifications. In most instances his descriptions were apparently based on single specimens and no allowance could be made for intra-specific variation in the taxonomic characters which he employed. The male genitalia in *Wiseana* are very uniform in type and in the present investigation it has been found that there is considerable intra-specific variation, and overlapping between species, in such characters as the form of the vinculum vase and saccus and the shape of the apex of the outer process of the tegumen. The female genitalia are also very uniform within the genus and variable within the species. The morphological differences between the species are therefore small and difficult of definition and the keys to the genitalia given below are indications of the modal condition for each species of the character employed and are probably inadequate for the identification of all individuals. Considerable reliance must still be placed on wing markings, which are themselves very variable (Gaskin, 1964) and on corroboratory evidence from time of flight and locality.

KEYS TO GENITALIA OF *Wiseana* SPP.

♂♂

1. Dorsal half of caudal margin of tegumen thickened, frequently with 1 or 2 small submarginal teeth or prominences at ½ length of tegumen (Fig. 84); apex of outer process conspicuously bent mesad, usually obliquely truncate in lateral view (Fig. 85); caudal margin of tegumen and outer process sinuate in caudal view (Fig. 84) .... {***despecta*** (Walker)
{***copularis*** (Meyrick)

Caudal margin of tegumen without thickening or submarginal teeth (Fig. 78); apex of outer process rounded (Fig. 80), neither bent mesad nor thickened; tegumen and outer process non-sinuate, evenly curved to apex (Fig. 78) .... (2)

2. Sides of saccus strongly diverging and wide apart at base, apex rounded (Fig. 78); vinculum base usually with rounded apex and convex sides; 8th sternite (Fig. 79) transverse, subsemicircular .... ***cervinata*** (Walker)

Sides of saccus slightly diverging (Figs 89, 92), sub-parallel .... (3)

3. Sides of vinculum base (Fig. 92) slightly concave, not compressed, apex rounded, width of saccus at ½ length less than distance between margins of saccus and vinculum base; 8th sternite (Fig. 91) transverse, sub-quadrate .... ***umbraculata*** (Guénée)

Sides of vinculum base (Fig. 89) compressed, apex truncate, width of saccus at ½ length greater than distance between margins of saccus and vinculum base; 8th sternite (Fig. 88) sub-trapezoidal .... ***signata*** (Walker)

♀ ♀

1. Median piece (Fig. 93) of prevulvar sclerite transverse, half as long as basal width, posterior margin straight .... ***umbraculata*** (Guénée)

Median piece not twice as wide as long, posterior margin rounded, medially emarginate or with median lobe .... (2)

2. Median piece (Fig. 90) as long as basal width, apex rounded; basal half of side concave, turning laterad .... ***signata*** (Walker)

Median piece shorter than basal width, apex various; sides slightly concave, not markedly directed laterad .... (3)

3. Halves of preanal sclerite (Fig. 83) markedly widened at mid-length; the caudal margin subangulate, angulate, or lobed; cuticular processes of 8th tergite 3/3 .... ***cervinata*** (Walker)

Halves of preanal sclerite not markedly widened at mid-length; caudal margin not angulate or lobed; cuticular processes of 8th tergite 2/2 .... (4)

4. Median piece (Fig. 86) of prevulvar sclerite with a sclerotised median lobe, separate from and dorsad of posterior margin .... ***copularis*** (Meyrick)

Median piece (Fig. 87) with or without median lobe, if present forming part of posterior margin .... ***despecta*** (Walker)

*Wiseana cervinat*a (Walker)

Walker, 1865, List. Lep. Ins. Brit. Mus., 32 supp. 2: 595 (*Elhamma*).
vexata Walker, *ibid.* 597 (*Porina*).
variolaris Guénée, 1868, Ent. mon. Mag., 5: 1 (*Pielus*).
fuliginea Butler, 1879, Cist. Ent. 2: 488 (*Porina*).
jocosa Meyrick 1912, Trans. Proc. N.Z. Inst., 44: 124 (*Porina*). NEW SYNONYMY.
mimica Philpott 1923, *ibid.* 54: 153 (*Porina*). NEW SYNONYMY.

♂ GENITALIA (Fig. 78): Described and figured by Philpott (1927a, Fig. 22). Specimens: Philpott's specimen; Lincoln (15), L. J. Dumbleton, 20.X.64; E.D. Eighth sternite (Fig. 79) transverse, subsemicircular. Tegumen half (Fig. 80) with dorsal process of moderate length; outer process as long as inner, parallel-sided, rounded apically; apex of inner process and ventral margin of mesal arm variably dentate, the two mesal arms divided posteromedially by a deep narrow cleft. Vinculum base (Fig. 81) wide, sides not compressed or markedly concave, apex broad and rounded. Saccus wide at base, about 2/3 length of vinculum base, sides of variable concavity, apex usually rounded. Juxta, trulleum and clasper as in Fig. 82.

The margin of the vinculum base may be irregular and its shape variable. The saccus also is variable in shape and in some specimens one or more thickened ribs may extend perpendicularly between the margin of the saccus and that of the vinculum base. The median distal concavity of the juxta varies from semicircular to a wide V-shape.

♀ GENITALIA (Fig. 83): Specimens: Seddon, L. J. Dumbleton, 26.X.40; E.D.: Lincoln, L. J. Dumbleton, 20.X.64; E. D. Cuticular processes of 8th tergite 3/3, sides tapered to truncate apex, as long as basal width.

Caudal margin of each half of preanal sclerite concave in dorsal half, rounded or subangulate and widest at mid length, strongly narrowed at $\frac{3}{4}$ length, the area between forming a lobe. Median piece of prevulvar sclerite semicircular, posterior margin rounded, with or without median emargination, length $\frac{2}{3}$ basal width; lateral arms as long as median piece.

TYPE: holotype ♂ (Fig. 110); Auckland, Oxley; B.M.

DISTRIBUTION: North and South Islands, throughout.

FLIGHT PERIOD: September–November. Peak in late October in Canterbury, earlier further north.

Few specimens are available from the type locality (Auckland). As recognised here *cervinata* is separable from the 4 other species whose flight period is later, but not from *jocosa* and *mimica* which are here synonymised with it. There is some evidence of regional differences in colouration and wing markings, such as the dark form from Grasmere (Cass), which suggest the incipient segregation of subspecies.

The species builds up larger populations than any other of the genus and is a major defoliator of improved pastures, especially in the lower-rainfall eastern districts.

NOTES ON SPECIES SYNONYMISED WITH *cervinata*

(a) *jocosa* Meyrick

♂ GENITALIA: Described and figured by Philpott (1927a, Fig. 20). Specimen: lectotype. Differs from *cervinata* mainly in the shorter dorsal process of the tegumen half. There are 6 or 7 teeth on the apex of the inner process and mesal arm. Another specimen from the type locality (West Plains, —.—.94; 202f, D.M.) has a longer dorsal process, the vinculum with compressed sides and subtruncate apex, and the sides of the saccus concave. The juxta of Philpott's specimen (also examined) is wider basally and not as shown in his figure, and he does not show the teeth which are present on the inner process of the lectotype.

♀ GENITALIA: Specimen: West Plains; 202d, D.M.

Differs from *cervinata* in the 2/2 short bluntly-conical cuticular processes of the 8th tergite. Another specimen (Nelson, A. Philpott, 23.XI.22; E.D.) has cuticular processes which are similar but 3/3.

TYPE: lectotype ♂ (Fig. 115) (here designated); Invercargill, A. Philpott, —.X.—; B.M. Selected from 5 syntypes in the British Museum. The original description localises the type locality as West Plains.

The species is recorded from the South Island only. The flight-period coincides with that of *cervinata*. It if were recorded only from Southland it could perhaps be regarded as a subspecies of *cervinata*, but if the specimens from Nelson were correctly identified it might be a distinct species. There is however no reliable morphological evidence that the latter is the case and it is considered to be not more than a form of *cervinata*.

(b) ***mimica*** Philpott

♂ GENITALIA: As described and figured by Philpott (1927a, Fig. 21) differs from *cervinata* in the small size of the dorsal process of the tegumen half, the non-dentate mesal arm of the inner process the relatively flat trulleum, and the short juxta. These are considered to fall within the range of variability of *cervinata* or to be attributable to the orientation of the specimen studied.

♀ GENITALIA: Specimen: allotype, Kapuka, A. Philpott, 9.X.11; E.D. Differs from *cervinata* in that the cuticular processes of the 8th tergite though 3/3 are very small and rounded and the lateral arms of the prevulvar sclerite are rather short and weakly-developed.

TYPE: holotype ♂ (Fig. 109) A. Philpott, —.X.—; E.D.

The species is recorded only from Southland with the exception of specimens, which have not been seen, from Anderson's Bay (Dunedin) and Waipukurau (North Is.). The flight period coincides with those of *cervinata* and *jocosa*. The species was stated by Philpott to be much smaller and less ochreous than *jocosa*. Hudson (1928) described it as an obscure species, and there are no reliable morphological characters to suggest that it is more than a form of *cervinata*.

Wiseana copularis (Meyrick)

Mayrick, 1912, Trans. Proc. N.Z. Inst., 44: 123 (*Porina*).

♂ GENITALIA: Described and figured by Philpott (1927, Fig. 23). Specimen: syntype, Invercargill, —.—.10, A. Philpott; B.M. Eighth sternite transverse sub-semicircular. Caudal margin of each tegumen half (Fig. 84) bounding the anogenital field subangulate at mid-length; dorsal process long, pointed; dorsal half of caudal margin contoured by submarginal thickening ending at mid length where it is obscurely dentate; outer process long parallel-sided, apex bent mesad and obliquely truncate (Fig. 85); inner process with 5 or 6 teeth on ventral margin of mesal arm; ventro median cleft between mesal arms narrow V-shaped. Vinculum base wide, sides concave (the two asymmetrical) apex broadly rounded. Saccus wide short, half as long as vinculum base, sides slightly convex, apex rounded. Juxta wider basally.

Philpott's description and figures, presumably of a specimen from the type locality, differ in the following respects: dorsal process represented by rounded prominence; apex of inner process non-dentate; sides of both vinculum base and saccus strongly compressed and apices subtruncate; juxta as wide distally as basally. The vinculum and saccus in particular appear to be variable.

Other specimens (3) (Kaiwera, 1.XII.40, Tripp; E.D.) from a locality 30 miles distant from the type locality conform with the wing colour and markings described for the species and with the genitalia of the syntype.

♀ GENITALIA (Fig. 86): Specimen: West Plains, A. Philpott; E.D. Cuticular processes of 8th tergite 2/2, anterior and posterior submedian both short. Halves of preanal sclerite without pronounced widening, angulation or lobe at mid length of caudal margin. Median piece of prevulvar sclerite

4/5 as long as basal width, sides diverging slightly at base, posterior margin rounded with slight median emargination, dorsad of the margin and partly concealed by it a median lobe strongly slerotised except in the median line; lateral arms slightly shorter than length of median piece.

Another specimen (Tisbury, 25.I.13, A. Philpott; E.D.) has the sides of the median piece more diverging, the posterior margin more emarginate and two dorsal lobes with a median concavity between.

TYPE: lectotype ♂ (Fig. 111); Invercargill, N.Z., —.—.10, A. Philpott; B.M.

The lectotype designated here was selected and labelled by Mr W. H. T. Tams of the British Museum from the 5 syntypes, which included both males and females. In the original description the type locality was given as "West Plains, Invercargill".

DISTRIBUTION: South Island—Southland.

FLIGHT PERIOD: December–January.

The species is morphologically very similar to *despecta* in both male and female genitalia. It differs in the ochreous ground colour of the fore-wing, the restricted distribution and slightly earlier flight period.

Wiseana despecta (Walker)

Walker, 1865, List Lep. Ins. Brit. Mus., Pt 32, Supp. Pt. 2: 594 (*Hepialus*).

♂ GENITALIA: Described and figured by Philpott (1927d, fig. 25). Specimens: Collingwood, 30.XII.40, Rockville, 17.XI.41 and 18.XI.41 L. J. Dumbleton (Bred ex pupae); E.D. Eighth sternite transverse subsemicircular. Caudal margin of tegumen bounding anogenital field rounded, non-angulate. Dorsal process of tegumen short wide; caudal margin with thickened submargin ending at mid length, usually without obscure teeth; outer process in caudal view sinuate, bent mesad, before apex, in lateral view parallel-sided, apex obliquely truncate; inner process with 7 or 8 teeth on ventral margin of mesal arm; mesal arms separated ventromesally by an open V. Vinculum sides not compressed, apex rounded. Saccus twice as wide as long, 3/5 as long as vinculum, sides not compressed, apex rounded.

In two specimens (Rockville, No. 3, bred, L. J. Dumbleton, 17.II.41; E.D. Taylor Str., A. D. Lowe, 3.IV.65; E.D.) the caudal margin of the outer process is bent mesad before the apex but the process itself is slightly tapered and in lateral view the apex is rounded.

♀ GENITALIA (Fig. 87): Specimen: Rockville, —.II.41, F. Tyree; E.D. Cuticular processes of 8th tergite 2/2, anterior submedian long slender, posterior submedian short conical. Halves of preanal sclerite not markedly widened, angulate, or lobed at mid length of caudal margin. Length of median piece of prevulvar sclerite $\frac{3}{4}$ basal width, sides slightly diverging basally, posterior margin with slight deflexed median lobe; lateral arms shorter than length of median piece. Other specimens from the same locality show some variation in the proportions of the median piece, the development of the median lobe and the length of the lateral arm.

TYPE: holotype ♀ (Fig. 112); Auckland, Oxley; B.M.

The original description was based on one specimen, purporting to be a male, though the description of the antennae suggests that it was a female. The photograph also indicates that the holotype is a female and this was confirmed by Mr P. E. S. Whalley of the British Museum.

DISTRIBUTION: North and South Islands, throughout.

FLIGHT PERIOD: not given for the type. Specimens determined as this species have been collected from late October to March but the principal flight period is undoubtedly from December to February.

The holotype of this species has a single short white discal streak. The females figured by Hudson (1928) all have one discal streak at ¼ and another reaching ½ as described by Meyrick (1890). The male genitalia described by Philpott, the locality and date of collection being unstated, coincides with that of a summer-flying species which is recognised here as *despecta*. It could however prove to be not conspecific with the type.

The species is morphologically very similar to *copularis* but differs in the fuscous ground-colour of the fore-wing and in the shape of the anogenital field in the male, as well as the wider distribution and slightly later flight period. It can build up large populations in improved pasture but these occur characteristically in higher rainfall areas than those favoured by *cervinata*.

Wiseana signata (Walker)

Walker 1856, List Lep. Ins. Brit. Mus., Pt. 7: 1563 (*Elhamma*).
novae zelandiae Walker, *ibid.*: 1573 (*Porina*).

♂ GENITALIA: Described and figured by Philpott (1927d, fig. 26). Specimen: Nelson, L. J. Dumbleton, 20.XI.40: E.D. Eighth sternite (Fig. 88) longer than wide, widest posteriorly, subtrapezoidal. Dorsal process of tegumen short and blunt, or apparently absent; outer process narrowed at base, widest subapically, apex rounded but produced and subangulate ventrally, ventral margin straight; inner process with 2 or 3 teeth on outer margin, 4 or 5 teeth on ventral margin of mesal arm; a ventromedian concavity, wider than deep, separating the mesal arms. Sides of vinculum (Fig. 89) compressed, slightly concave, apex broadly truncate. Saccus ⅔ as long as vinculum, its width twice the distance to margin of vinculum base, sides not diverging strongly basad, apex truncate.

♀ GENITALIA (Fig. 90): Specimen: Picton, S. Lindsay, 4.XII.31: C.M. Cuticular processes of 8th tergite 3/3, both submedians bluntly conical, sublateral longer and finger-like. Caudal margin of each half of preanal sclerite strongly concave, increasing in width to subangulate prominence at mid length, thence evenly narrowed to ventral extremity but not flared laterad. Base of median piece of anogenital sclerite wide, sides converging to slight constriction at ⅔ length, distal third slightly knobbed and apically rounded, length equalling basal width, twice as long as width at constriction; lateral arms ogival, posterior margin convex, apex acute, as long as basal width of median piece.

TYPE: lectotype ♂ (Fig. 113); New Zealand; B.M. The species was described from 4 syntypes (2 from Colenso and 2 from Col. Bolton). It is probable that they were from the North Island. No type was designated and the male now bearing a "type" label is presumably a lectotype.

DISTRIBUTION: North Island, throughout; South Island, northern third.

FLIGHT PERIOD: late December to February.

The species, though distinct, is most closely allied to *umbraculata*. The variation in the wing markings has been illustrated by Hudson (1928) and Gaskin (1964). The wing pattern of the female differs from that of the male and it may be difficult to separate from that of *umbraculata*.

Wiseana umbraculata (Guénée)

Guénée 1868, Ent. mon. Mag., 5: 1 (*Pielus*).

♂ GENITALIA: Described and figured by Philpott (1927a, fig. 24) and figured by Viette (1950a, fig. 10).

Specimen: Lincoln, R. D. Dick, —.XI.39; E.D. Eighth sternite (Fig. 91) subquadrate, slightly wider than long. Dorsal process of tegumen long and tapering; outer process widest at mid length, slightly constricted basally, rounded apically; inner process with 2 or 3 teeth on outer margin before apex, ventral margin of mesal arm with 3 teeth; ventromedian cleft between mesal arms deep, narrow, U-shaped. Vinculum (Fig. 92) sides scarcely concave not compressed, apex rounded. Saccus about $\frac{1}{2}$ length of vinculum, width less than distance to margin of vinculum base, apical half parallel-sided, apex rounded.

♀ GENITALIA (Fig. 93): Specimen: Murchison, L. J. Dumbleton, 10.XII.39; E.D. Cuticular processes of 8th tergite 3/3 anterior submedian long tapered, posterior submedian shorter, sublateral asymmetrical curved mesad. Caudal margin of each half of preanal sclerite concave and widened to broad rounded lobe at $\frac{2}{3}$ length, thence narrowed abruptly before ventral extremity. Median piece of prevulvar sclerite twice as wide as long, apex slightly concave, lateral angles rounded, sides diverging slightly to base; lateral arms slightly shorter than basal width of median piece, slender, rounded distally, posterior margin slightly concave.

Another specimen (Takapau, 1.XII.47; E.D.) differs in the wider more truncate median piece, shorter stouter lateral arms, and the absence of cuticular processes on 8th tergite.

TYPE: lectotype ♂ (Fig. 114); New Zealand, R. W. Fereday; P.M.

Guénée did not nominate a type, or state the number of syntypes on which his original description was based, but he had before him more than one male and at least one female. Three specimens, 2 males and one female, labelled as from the Guénée Collection (and later from the Oberthur and Biederman Collections) are in the Paris Museum. A male bearing the label "*Hepialus (Pielus) umbraculatus* Gn., Nouvelle Zélande, M. Fereday" and a "type" label, has been labelled as the lectotype and is here designated as such. The second male and the female (which bears an "allotype" label) are syntypes. The type locality, within New Zealand, was not specified but the title of the original paper by Guénée (1868) states that the insects described were from Canterbury. They were probably from the vicinity of Christchurch where Fereday lived.

DISTRIBUTION: North and South Islands, widespread.

FLIGHT PERIOD: Hudson (1928) gives the flight period as October to January. The peak of flight in Canterbury is in November.

This species is most nearly related to *signata,* which has a more restricted distribution, but the two are distinct on characters of both male and female genitalia. The wing-markings, especially those of the females, closely resemble those of some forms of *signata* (Gaskin, 1964). Some forms of *despecta* with a single white discal streak also resemble *umbraculata* except for the darker ground-colour of the forewing.

Guénée mentioned two forms in the specimens before him and Gaskin (1964) found the Arapawa Island population of *umbraculata* to be distinct in its wing markings. It is possible that more detailed study may disclose the existence of morphologically definable subspecies within *umbraculata* as it is now recognised.

SPECIES INCERTAE SEDIS

Oxycanus mairi (Buller)

Buller 1873, Trans. Proc. N.Z. Inst., 5: 279 (*Porina*).

TYPE: wooded summits of Ruahine Rt., North Island, W. Buller, 1867; lost.

The type was a unique specimen and in its absence neither the species nor the genus to which it belonged is determinable. The size given, "about 5 inches", is very large even for *Aenetus virescens,* of which Hudson (1928) thought it might have been an aberration lacking the usual green coloration. The species of *Aoraia* lack green coloration but are smaller than those of *Aenetus* and none are recorded from the Ruahine Range.

RELATIONSHIPS OF THE NEW ZEALAND HEPIALID FAUNA

The terrestrial invertebrate fauna of New Zealand can be considered as originating from colonisations from faunal sources outside the present area of the country. Large assemblages of taxa, recognisable as from a common source and as constituting a distinct biotic "element" can scarcely have accumulated in the country unless dispersal was either much easier than at present or continuous over long periods. The dispersal of wingless species, or others of poor vagility, might appear to require land connections between the source areas and New Zealand, and considerations of present-day geography might suggest that these were tenuous. New Zealand may, however, have had contacts over a wider front with large land areas which are now submerged. Whether a single land area, such as the western Tasmantis, provided the necessary contacts with external faunal sources and

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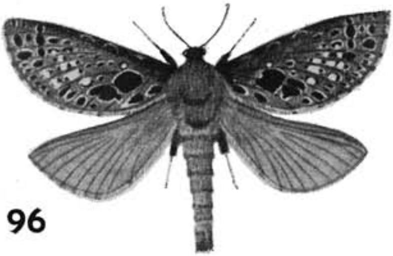

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FIGS 95–103—N.Z. Hepialidae, type specimens (wing spread in brackets)

95—*Aoraia senex* (Huds.): holotype ♂ (39 mm)

96—*Aoraia aurimaculata* (Philp.): holotype ♂ (70 mm) after Hudson

97—*Aoraia dinodes* (Meyr.): lectotype ♂ (57 mm)

98—*Aoraia leonina* (Philp.): holotype ♂ (63 mm)

99—*Dioxycanus oreas* (Huds.): lectotype ♂ (35 mm)

100—*Dioxycanus descendens* (Huds.): lectotype ♂ (40 mm)

101—*Dioxycanus ascendens* (Meyr.): lectotype ♀ (49·5 mm)

102—*Dioxycanus gourlayi* (Philp.): holotype ♂ (23·5 mm)

103—*Dioxycanus fuscus* (Philp.): paratype ♂ (32·5 mm)

FIGS 104–115—N.Z. Hepialidae, type specimens (wing spread in brackets)

104—*Cladoxycanus minos* (Huds.): holotype ♂ (25 mm)

105—*Cladoxycanus autumnata* (Huds.): holotype ♂ (42 mm)

106—*Trioxycanus enysii* (Butl.): holotype ♂ (62 mm)

107—*Trioxycanus characterifer* (Walk.): holotype ♂ (71 mm)

108—*Trioxycanus unimaculatus* (Salm.): holotype ♂ (60 mm)

109—*Wiseana mimica* (Philp.): holotype ♂ (32 mm)

110—*Wiseana cervinata* (Walk.): holotype ♂ (40 mm)

111—*Wiseana copularis* (Meyr.): lectotype ♂ (35 mm)

112—*Wiseana despecta* (Walk.): holotype ♀ (47·5 mm)

113—*Wiseana signata* (Walk.): lectotype ♂ (47 mm)

114—*Wiseana umbraculata* (Guén.): lectotype ♂ (50 mm)

115—*Wiseana jocosa* (Meyr.): lectotype ♂ (41 mm)


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whether continental drift contributed to the present isolattion of New Zealand is not yet clear. Wardle (1963) suggested the possibility of an influx of alpine plant taxa as late as the Pliocene but the evidence for this is not compelling and the probabilities are that palaeogeographical conditions favouring the easy dispersal of terrestrial biota to New Zealand have not existed since the Cretaceous.

The difficulty is to determine the number and identity of the possible faunal sources and to select criteria which will identify the taxa derived from them. It is commonly postulated (Fleming, 1962) that three major biotic "elements" are represented in the existing terrestrial biota. Individual taxa are, in most instances, assigned to one or other of these elements solely on the evidence of their morphological relationships and the extra-limital distributions of related taxa. The Edwardsininae (Dipt. : Blepharoceridae) and the Peloridiidae (Hemipt.) for example, are confined to the Southern Hemisphere and are regarded as belonging to a Palaeaustral element. The first is primitive within its family and the second within its order. It is conceivable, however, that taxa belonging to an old Australian element could be equally or even more primitive. The type of intra-limital distribution of a taxon has also been used as a criterion of origin, Cockayne (1928) identified his northern-biassed and predominantly lowland group of plant taxa with a Palaeotropical (Malayo-Pacific) element, and Mackerras (1950) used southern-biassed distribution as one criterion of taxa belonging to the Torresian (Palaeaustral) element in the Australian Diptera. This appears to be based on the assumption (cf. Ross, 1956), which may be true for some but not for all taxa, that the physiological characteristics of taxa, in respect of temperature requirements, have not changed appreciably in geological time and that their survival is evidence that habitats which met these requirements have been continuously available.

The whole of the Mesozoic era was a warm phase and while cooler boreal provinces developed in the upper Jurassic glaciations and polar icecaps did not develop until the late Tertiary (Schwarzbach, 1963). Dearnley's (1965) synthesis of the earth's evolution involves an expanding earth and the occurrence in the Triassic–Jurassic of continental drift caused by altered convection currents in the earth's mantle. It requires for Australia, New Zealand, and Antarctica a more nearly equatorial position in the Pacific, which is consistent with the palaeobotanical evidence of a vegetated Antarctica in the Mesozoic and Tertiary. This would imply, however, that any adaptation to cold now exhibited by taxa regarded as belonging to a Palaeaustral element arose in the late Tertiary and is not an original characteristic of these taxa.

It is evident that different taxa belonging to the same biotic element must have differed widely in their temperature requirements or in their preadaptation to cooling temperatures. The extinction of the *Nothofagus brassi* group in New Zealand is usually assumed to have been due to unfavourably low temperatures in the Pleistocene, though there is an anomaly in its extinction in Northern Queensland at lower latitudes than those in which it survived in New Caledonia. If its extinction was due wholly to low temperatures it must have been unusually sensitive to them compared with the other species groups of *Nothofagus*.

It is also likely that in other taxa there has been considerable adaptive change in respect of temperature tolerances. The type of distribution of individual taxa may now be inconsistent with the tropical or temperate character of the elements to which they are assumed to belong. The genus *Paryphanta* (Mollusca) which has no Palaeaustral affinities is most strongly represented in the South Island, and if the *Nothofagus brassi* group—a Palaeaustral taxon—had just managed to survive in New Zealand it would now be confined to the north of the North Island. It has been shown (Couper, 1960; Cranwell, 1964; Fleming, 1963a) that some exclusively or predominantly Southern Hemisphere plant taxa have now, or had in the past, a distribution which extends from South America, through Antarctica, to Australia and/or New Zealand, and beyond these to New Guinea, and in some cases to South-East Asia and Japan. These are regarded as belonging to a Palaeaustral element. Some of these now occur in only one or two of the countries mentioned. In the absence of palaeontological evidence of former distributions such Palaeaustral taxa as the *Nothofagus brassi* group, whose present distributions are confined to or centred in tropical areas north of Australia, could be regarded as belonging to a Malayo-Pacific element. Similarly other taxa now occurring only in Australia and New Zealand could be regarded as either Malayo-Pacific or Australian. No palaeontological evidence of former distributions is available for the terrestrial invertebrates of New Zealand. Those which are now confined to New Zealand and/or Australia could belong to any one of the three postulated elements. It is particularly difficult to select criteria for the recognition of taxa belonging to an (old) Australian element.

The adults of the Hepialidae lack functional mouthparts and cannot feed, and the females are heavy-bodied and short-lived. They are therefore poorly adapted for aerial dispersal over wide expanses of water. This is suggested also by their absence from both the Chatham Islands and the Auckland Islands. The occurrence of *Phassodes* in Fiji and *Aenetus* in New Caledonia is not unexpected, since these are older islands, but the occurrence of *Phassodes* in Samoa and of *Toenga* in Rarotonga is more anomalous. *Toenga* in particular might be classed with other distinctive and problematical eastern-Polynesian taxa such as *Simulium oviceps* Edw. (Dipt. : Simuliidae) and *Fitchia* (Compositae) which may have survived in the area since the Cretaceous.

It is possible, of course, that the New Zealand hepialid fauna was derived from more than one source but it provides no internal evidence of this.

The Neotropical region has a large hepialid fauna but the only oxycanine genus recorded there (*Trichophassus*) occurs in Brazil and Paraguay (Viette, 1949b). Since other more credibly Palaeaustral taxa extend further north into southern Brazil (cf. *Araucaria*) the Oxycaninae could be a Palaeaustral taxon but the absence of any oxycanine genus from Chile and Patagonia—the classical distribution area for Palaeaustral taxa in South America—weakens the the case for considering it as such. None of the hepialine genera which occur in Chile and Patagonia occur also in Australia or New Zealand. Viette (1949a) remarked that the Chilean genus *Parapielus* Viette resembled the Australian genus *Bordaia* but there is no evidence that they form a monophyletic group confined to the Southern Hemisphere, as do the genera of the Peloridiidae. There is therefore no evidence that either the New Zealand or the Australian hepialid fauna has affinities with South America sufficient to suggest that it is of Palaeaustral origin.

The evidence, in fact, suggests that the New Zealand hepialid fauna has its closest affinities with that of Australia. The only non-endemic genus (*Aenetus*) is confined to the Australian region. *Aoraia* is closely related to the Australian *Bordaia*. Both these latter genera contain autumn-flying species but *Aoraia* is more distinctly montane in habitat. The four oxycanine genera in New Zealand were previously included in the Australian genus *Oxycanus* and are undoubtedly related to it. The phenological and physiological differences between the Australian and New Zealand faunas presumably result from differing histories and environments. Thus the late-summer to autumn flight of the majority of *Oxycanus* species, which contrasts with the stronger representation of spring–summer flying species of Oxycaninae in New Zealand, may be due to the adverse effect of greater spring–summer aridity in Australia on the incubation of eggs and the survival of larvae in that period. The Australian genera *Jeana* and *Oncopera (Oncopera)* (Tindale, 1933) which show some southern bias in distribution, are not restricted to higher altitudes, and there is no development there of cold-adapted taxa of generic rank such as there is in New Zealand. The Australian examples of adaptation to higher altitudes and colder temperatures, such as *Aenetus paradiseus montanus* Tindale (1935), are at the species level and suggest relatively recent adaptation.

The Australian region is regarded as a major geographical centre of the family. Nine of the 43 genera recognised by Paclt (1953) are endemic in Australia and this number is exceeded only by the 11 genera endemic in the Neotropical region. The species described from Australia comprise about one-third of those included in the family. No oxycanine genera are recorded in the Ethiopian region (Janse, 1942) but there are links between the two regional faunas such as the apparent affinity between *Zelotypia* and *Leto* Hubner and the similarity of venation in *Fraus, Eudalaca,* and *Gorgopis*. Australia has, in addition, a more complete representation of primitive families of Lepidoptera than any other region. Two of these (Palaeosetidae and Anomosetidae) are endemic and another (Prototheoridae) is shared with South Africa. One genus (*Sabatinca* Walker) of the Micropterygidae is shared only with New Zealand and another (*Agathiphaga* Dumbleton) belonging to the Eriocraniidae is shared only with Fiji. If Australia was not a centre of evolution for these families the preservation of such a comprehensive range of primitive families indicates at least that the fauna is very ancient. It would be a reasonable hyothesis that the New Zealand hepialid fauna was derived from the Australian one in the Mesozoic, but is not capable of proof.

The extension of the distribution area of the Old World Oxycaninae to Algeria would be exceptional, if not anomalous, in a Palaeaustral taxon. In fact, the distribution of the Oxycaninae closely parallels that of the Apistomyinae (Dipt. : Blepharoceridae) (Dumbleton, 1963a) which are absent from South America, but whether this type of distribution results from dispersal from an Australian, a Malaysian, or a Palaearctic centre is problematical.

Tillyard (1926) considered that New Zealand received its first insects including some Lepidoptera–Homoneura in the Jurassic and regarded them as belonging to an "early Austro-Malayan element". If the Australian and New Zealand Hepialidae derive from a Malaysian centre it is anomalous that no hepialine genera, other than *Aenetus* are so far recorded from New Guinea or New Caledonia.

The only conclusion it is possible to draw is that the Australian and New Zealand Hepialidae derive from a common stock and give no evidence of close affinity with the South American fauna. The New Zealand fauna may derive directly from the Australian one but does not necessarily do so. The strong development of the Oxycaninae in the Australian - New Zealand region might suggest this or the adjoining Palaeotropical area as its centre of origin but at least one genus occurs in central South America. There are indications of relationships between the South African and Australian Hepialinae but the suprageneric classification and phylogeny of this subfamily is as yet too imperfectly known to permit recognition of distinct Southern Hemisphere (?Gondwanan) and Holarctic components.

THE DISTRIBUTION OF THE HEPIALIDAE WITHIN NEW ZEALAND

One feature of the distribution of many New Zealand taxa, the greater number of species in the South Island, is anomalous in relation to the universal trend towards a decrease in species density with increasing latitude. There are about twice as many species of dicotyledonous plants endemic in the South Island as in the North Island and about three times as many endemic species of Lepidoptera (Hudson, 1939). This may be partially explained by the 30% greater area of the South Island and the more extensive or more diversified habitats or ecological niches available in a more mountainous area. The level of generic endemism suggests, however, that the greater species density is in part determined by the palaeogeographical and palaeoclimatic history of the South Island and the stronger representation there of one or more faunal elements. It is not possible, however, to delimit major biotic provinces within New Zealand for the terrestrial biota. Cockayne (1928) recognised two floristic-ecological groups of plant taxa whose distributions overlapped from north to south. The first, to which he attributed a Palaeotropical origin, consists of taxa whose distributions are predominantly northern-biassed or lowland in character. The second, of mixed Palaeozelandic and Antarctic origins, consists of taxa whose distributions are predominantly southern-biassed or at higher altitudes. There is an apparent parallel in the distribution of the marine biota (Knox, 1960), the warmer northern Aupourian Province being separated from the colder southern Forsterian Province by a central zone of overlap which constitutes the Cookian Province.

A similar overlap of two principal groups of terrestrial invertebrate taxa is apparent, but not all the northern-biassed taxa are *ipso facto* of Malayo-Pacific origin, and within the southern-biassed group it is difficult to distinguish between taxa that belong to a Palaeaustral element and those that may belong to an Australian element. If it is accepted that there has been no major overland colonisation of New Zealand since about the Cretaceous and that New Zealand was of low relief and much warmer climate in the mid-Tertiary, then many of the existing taxa, or their ancestors, must have been capable of physiological adaptation in order to survive both the warmer temperatures of the mid-Tertiary and the colder temperatures of the Pleistocene.

The present distributions of the New Zealand genera and species are shown in Fig. 94. Some genera in both subfamilies have a northern-biassed distribution (*Aenetus; Trioxycanus*) and others a southern-biassed distribution (*Aoraia; Dioxycanus, Cladoxycanus*). Some species of the first group extend into the northern part of the South Island at lower altitudes (*T. characterifer*) and some species of the second group extend into the central North Island (*D. oreas; A. leonina*) at higher altitudes or exceptionally, into the southern North Island at low altitudes (*C. minos*). *Wiseana* comprises species with both northern (*W. signata*) and southern (*W. copularis*) types of distribution as well as some which are distributed throughout both Islands.

Sylvester-Bradley (1963) concluded that in the Northern Hemisphere "geographical subspecies or ecological forms have appeared within 7,000 years but for the evolution of full species 100,000 years are normally insufficient while one half to one million years is a reasonable estimate of the time required". The segregation of genera would require proportionately longer periods and there is no evidence that this has occurred during or after the Pleistocene.

The distributions of existing genera, thus suggest that the hepialid fauna of the South Island in the Tertiary was qualitatively different from that of the North Island. The reasons for this are obscure, but they are possibly connected either with the longer continuous history as a land mass of parts of the South Island, especially the Otago-Southland area, or the spatial relationship of the South Island to a particular dispersal route. The present distributions are regarded as based on Tertiary distributions which were modified by northward retreats or advances during Pleistocene glacial, interglacial, and postglacial periods.

It may be inferred from the existence of locally endemic taxa, not only in the major refuge areas but also in the intervening areas, that some of these segregated from populations which survived there throughout the Pleistocene. It is probable that other species with a wide ecological range also survived in these intervening areas, though in the absence of subspeciation or palaeontological evidence there can be no proof that this was so. The paleontological evidence that would be necessary to demonstrate the existence and the extent of recolonisations of the central South Island by invertebrates during interglacials is also lacking.

Willett (1950) estimated that the position of the snowline and the altitudinal limits of the biotic zones in New Zealand were 3,500 ft lower in the Pleistocene than at present, and considered that this indicated that the mean annual temperatures in all biotic zones were 6°C lower at present. Fleming (1963b) indicated a northward latitudinal shift of the southern limits of the biotic zones, at sea level, of about 11° of latitude. Since New Zealand extends over 12° of latitude and has a range of present mean annual temperature of 10°F (5·5°C) between its extremities this is con-

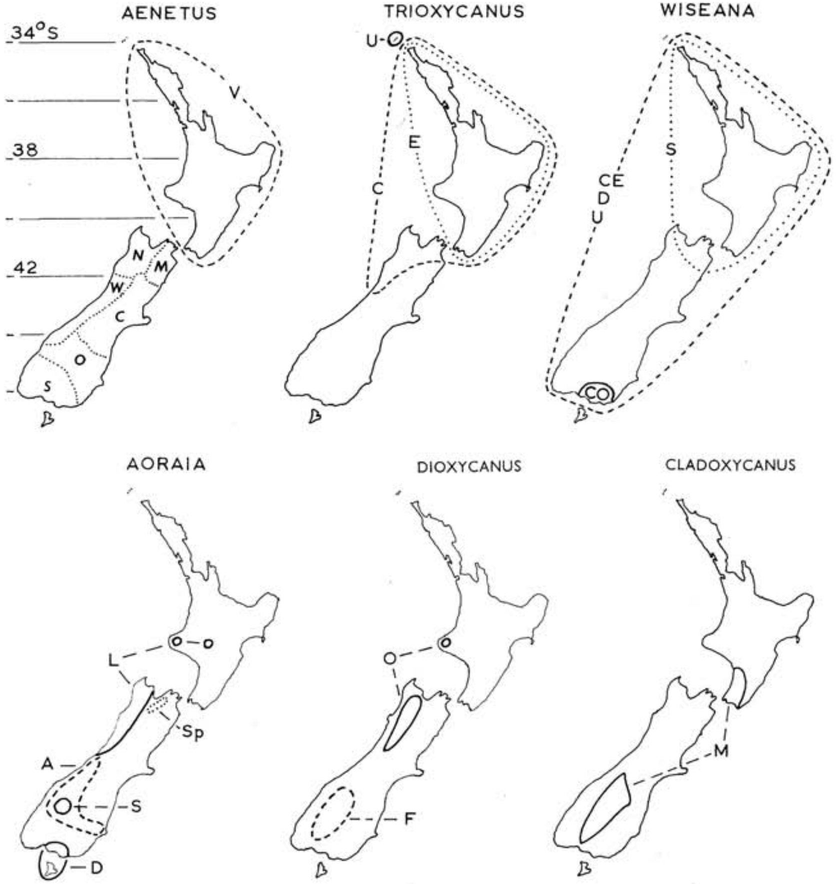

FIG. 94—Distribution of New Zealand Hepialidae, by genera and species, Species distributions identified by initial letter(s) of species names. South Island regions referred to in text indicated in figure for *Aenetus*.

sistent with Willett's estimate. Gage (1965) refers to the moderate degree of refrigeration of the alpine zone in New Zealand and believes that the Pleistocene winter temperatures were not sufficiently low to cause the formation of permafrost in the "periglacial" areas—the winters being broken by spells of above-freezing weather. Geological evidence suggests that the winters were both warmer and wetter than in the glaciated areas of the Northern Hemisphere.

Two biological phenomena which are related to the intensity of winter cold are of remarkably low incidence in the native biota as compared with that of the Northern Hemisphere and might suggest either that the Pleistocene cold climate of New Zealand was not comparable in intensity with that of continental areas of the Northern Hemisphere or that there were important refuge areas with less severe climate; these are winter deciduousness in plants, and winter diapause in insects.

The evidence of the first of these phenomena is not unequivocal, however, since its low incidence may have been partly determined by the lack of necessary genetic preadaptation, as Du Rietz (1960) has suggested for *Nothofagus*. Axelrod (1966) advanced the hypothesis that the present cold-induced deciduousness dates from the Pleistocene but is based on a preadaptation consisting of a much earlier drought-induced deciduousness. In the Southern Hemisphere, however, the Pleistocene cold climates in existing temperate land areas were not so severe as to exert an inescapable selection pressure favouring deciduousness. If they had been so, there seems no reason why winter deciduousness should not have arisen directly in the absence of any preadaptation. The existing deciduous species in New Zealand appear to have arisen directly, but their small number and, in general, the facultative nature of the deciduousness, testify that the cold temperature stimulus was marginal in relation to the greater part of the flora.

Willett thought it possible that some forest might have survived in areas of adequate rainfall in both the northern and southern extremities of the South Island. Wardle (1963) presented evidence of the survival of extensive assemblages of plants, including forest trees in major biotic refuges in Nelson–Marlborough and Otago–Southland, and similar, but less comprehensive, evidence exists for the invertebrates. It appears to be inescapable that after the Pleistocene all the altitudinal biotic zones in the South Island were recolonised from within the island and the inference is that the refuge areas provided habitats which permitted the survival of the biotic nuclei necessary for this. There is no doubt that the low temperature of the Pleistocene had an important influence on the distribution of plants and animals but it is unsafe to assume that it was always predominant or regular in its distribution and effects. It is likely to have been locally modified by edaphic factors or by other climatic factors such as rainfall. The relatively greater Pleistocene extinction of biota in the Canterbury–Westland area may be explicable primarily in terms of greater relief, more extensive glaciation and greater climatic severity, but these were probably accentuated by the unfavourable edaphic conditions on the unstable outwash gravels. The apparent decimation of the biota in the southern half of the North Island (Wardle, 1963) is more difficult to reconcile with the survival of larger and more diverse biotas, not only at approximately the same latitude in Nelson–Marlborough but also 5° further south in Otago–

Southland. This suggests the existence of greater irregularities or anomalies in the regional distribution of temperature than exist at the present time. Gage (1965), for example, has remarked on the absence of solifluxion phenomena in Westland and suggested that a Pleistocene depression of mean annual temperature of 2–3°C may have been sufficient to produce the same results there in terms of glacier expansion as 5–7°C east of the Alps.

The age of the existing adaptations to cold temperatures is a factor which must be considered in any discussion of present distributions. The species of *Dioxycanus,* for example, are exclusively montane-subalpine in habitat, and those of *Aoraia* vary from exclusively subalpine (*A. senex*) to lowland (*A. dinodes*), but neither genus is considered to have a long history in its present type of habitat. The existence of a significant number of genera which were enabled to survive in the alpine habitat only because they were already adapted to it, would imply that lower biotic zones in the South Island were largely recolonised by derivatives of these genera or by recolonisation from the North Island, and there is no evidence that either of these processes was significant. Fleming (1963b) suggested that the alpine biota included both taxa with a long history as alpines in the Antarctic or the Northern Hemisphere, and therefore relatively recently established in New Zealand, and those with a long history in New Zealand but relatively recently adapted to and established in the alpine zone as distinct species. If the Pleistocene period proves to have been much longer than the current estimate of one million years it would increase the probability that such recently adapted species constitute the major part of the alpine biota.

Many subalpine–alpine insects appear to be pioneer species of genera which are much more strongly represented in lower altitudinal zones, e.g., *Melampsalta* (Hemipt. : Cicadidae), *Austrosimulium* (Dipt. : Simuliidae), *Chlorochiton* (Col. : Scarabaeidae). Some genera which are endemic in the subalpine–alpine zone may appear to be relict in this habitat, but with few exceptions they are explicable as recently adapted to it. Several of them are wingless and some, such as the wetas, belong to wholly wingless groups. Perhaps only the black butterfly *Erebia* (Lep. : Nymphalidae) could conceivably be a Pliocene or Pleistocene immigrant already adapted to the alpine habitat. If a species constituting a monotypic genus, or only one species of a larger genus, were successful in adapting to the alpine habitat it would then simulate a relict alpine–endemic genus. If such a species had an originally wide distribution it is likely that there would be geographical or topographical speciation into suites of closely related species. *Dioxycanus* and *Aoraia* approach this condition, and the same may be true of the wingless grasshoppers of the genus *Paprides* (Orth. : Acridiidae).

The wingless stonefly *Apteryoperla* (Plecopt.) occurs up to 6,500 ft and above the glaciers in the South Island and might appear to be relict in this habitat, but its occurrence in the grassland zone of the subantarctic islands suggests that its moisture requirement is more critical and less capable of modification than its temperature requirement. Powell (1930) has implied that the montane habitat of the large native land snail *Paryphanta* (Mollusca) is also determined by the need for adequate moisture, and that the adaptation to cooler temperatures is incidental to this. Other species such as the wingless snow weta *Pharmacus* (Orth. : Rhapidophoridae) whose permanent habitat is on rock outcrops above the snow line, and the chironomid species which breeds in melt-pools on the Franz Josef Glacier must be recently adapted since these habitats were not available to them until the Pleistocene.

The relative importance of the two major South Island faunal refuges was no doubt different for different taxa. Forster (1954) stressed the importance of the Otago–Southland area for the Opiliones and Given (1964) stated that the genus *Prodontria* (Col. : Scarabaeidae) is confined to this area. There are also locally endemic species of Culicidae (Dipt.) and Simuliidae (Dipt.) as well as a disjunct population of a northern species of Simuliidae (Dumbleton, 1963b, 1963c). For the Hepialidae, the Otago–Southland refuge seems to have been at least as important, in respect of the number and diversity of the taxa surviving there, as the Nelson–Marlborough area. It is interesting in view of the higher latitude of the Otago–Southland area that *W. copularis* and *A. dinodes,* like the locally endemic species of Culicidae and Simuliidae, are lowland species.

The importance of the Nelson–Marlborough refuge is well illustrated by the development there of the genus *Paryphanta* (Powell, 1930). Some predominantly North Island taxa such as *Lasiorhynchus barbicornis* Fab. (Col. : Brenthidae), *Teleogryllus commodus* (Walk.) (Orth. : Gryllidae) and *Aedes notoscriptus* (Skuse) (Dipt. : Culicidae) apparently survived there in the lowlands. Montane species of Hepialidae such as *A. leonina* and *D. oreas* also survived there, and so apparently did the predominantly northern species *T. characterifer* and *W. signata,* of which the latter at least is a lowland species.

The cooler temperature of the Pleistocene and the bridging of Cook Strait also appear to have permitted populations of *A. leonina* and *D. oreas* to gain access to the North Island. *A. leonina* is known to occur at elevations of from 1,100 to 3,500 ft apparently being able to descend to the lower altitudes if the warmer temperatures are compensated for by favourable moisture conditions. Under such conditions the dispersal of *A. leonina* across a bridged Cook Strait could be accomplished during a depression of the altitudinal zone limits by much less than the 3,500 ft estimated by Willett. The absence of *Dioxycanus* and *Aoraia* (unless *mairi* was an *Aoraia*) from the Tararua–Ruahine chain is unexplained. Their habitat is not so high as to suggest that it may have been eliminated there during the post-Pleistocene rise in temperature as Wardle (1963) has suggested for some of the alpine plant taxa that show similar distributions. It is also curious that the only Otago–Southland hepialid species (*C. minos*) which extends to the North Island occurs in the Wellington–Wairarapa–Manawatu area, at a surprisingly low altitude.

The North Island populations of *A. leonina* and *D. oreas* were apparently isolated in the montane–subalpine zones of Mts Egmont and Ruapehu by the post-Pleistocene rise in temperature. The distributions of *A. virescens* and *T. ensyii* suggest that Cook Strait, at least in the later Quaternary, has functioned as a barrier to the southward dispersal of northern species. These species may have survived in the northern part of the Norh Island, and it is possible that their southward dispersal was halted by the reopening of Cook Strait. The present southern limit of *A. virescens* is apparently not determined solely by low temperature since it occurs at 3,800 ft to 4,000 ft in the central North Island (Mr J. S. Dugdale, pers. comm.). The existence of a periodic discontinuity at Cook Strait makes it difficult to decide whether certain species survived in the north of the South Island during the Pleistocene, or reached there later from the North Island. The present distributions of hepialid species in the central South Island suggest the meeting or overlap of species which dispersed from the northern and southern refuges after the Pleistocene. There is no evidence in the form of locally endemic species, such as exist in the Simuliidae (Dumbleton, 1963c), that any hepialid species survived the Pleistocene in Canterbury. The presence of distinctive local colour forms suggests that local populations may have survived in widespread species such as *W. cervinata.*

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