

**Fauna of  
New Zealand**  
Ko te Aitanga Pepeke  
o Aotearoa

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**Ko te Aitanga Pepeke o Aotearoa**  
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**Sphecidae**  
**(Insecta: Hymenoptera)**

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**Front cover** The insect depicted is *Podalonia tydei suspiciosa*.

**Aromua** Ko te kararehe nei ko *Podalonia tydei suspiciosa*.

Class / Karaaihe **Insecta**  
Order / Oota **Hymenoptera**

Family / Whaamere

## Sphecidae

### Sphecid wasps

**Illustration:** *Pison spinolae*, female (artist A.C. Harris).

**Whakaahua:** *Pison spinolae*, he uwaha (kaitaa A.C. Harris).



On arriving at a holiday home in December, or on returning home after an extended absence, families often find mud adhering to the curtains. When the curtain is pulled, a shower of mud fragments and – good gracious! – limpbodied spiders descends to the floor.

This is the work of the female of the mason wasp, *Pison spinolae*, a typical sphecid wasp which builds a nest of mud cells in a sheltered place, often on man-made structures. She provisions the cells with small spiders which she has stung to paralysis, and lays an egg on each one. The tiny larva which hatches from the egg has a ready supply of fresh meat on which to feed and grow.

Other sphecids nest in the ground, forming burrows and nest chambers in sandy or clay soils, according to species. Yet others nest in holes made by wood-boring insects. Tiny sphecids in the genus *Spilomena* fill borer beetle holes with thrips, and can sometimes be observed resting on the outside of houses.

On the beaches and dunes of northern New Zealand a large red and black sphecid, *Podalonia tydei suspiciosa*, catches fully grown noctuid moth caterpillars. Having stung one to paralysis, the wasp then straddles it and hauls it to its subterranean nest in the sand.

Throughout the country the shining black *Tachysphex nigerrimus* is often seen digging holes in sand and fine shingle beside streams, and less often may be observed dragging its cockroach prey across the ground.

Ka tae teena meaa te whaanau ki nga whare hororei i Tiihema ka hokimai raanei ki o raatou kaainga i te waa i a raatou engaro ana moo teetahi waa, ka kitea te paru oneone e raparapa haere ana i runga i nga aarai wini. Ka kuumea te aarai wini ka paateretere mai te kongakonga paru – auehc! – ka heke iho mai nga pungaawerewere tinana ngorengore nei ki te papa.

Ko ia teenei te mahi a te uwaha o te katipoo 'mason,' *Pison spinolae*, he momo peenei anoo teenei o te 'sphecid' whaanau katipoo, e hanga peenei i tana ohonga ki te paruparu, ki te waahi ruruha o te meai mahia e te taangata. Ko ia anoo i whaanga i roto i aua waahi paruparu ki te pungaawerewere iti, naana anoo i wero kia keckerewai, aa, ka noho i runga ka whaanautia e heeki kotahi (i ia waahi paruparu). Ko te huhu iti ka puta i te heeki ka whai kaimata miiti, kaikai noa kia tupu ai.

Ko eetahi atu o nga momo 'sphecids' (o te katipoo) ka mahi i o raatou ohongo ki te whenua, hei a kerikeri haere he apu i raro i te whenua i roto i te paru onepuu, uku raanei whakanoho haere ai i o raatou ohonga. Ko eetahi anoo momo ka hanga ohonga ki roto i nga koohao kua hangaa kectia a nga ngaarara wiri whakakoohao raakau. Ko nga 'sphecids' heke iho mai o te whaanau *Spilomena*, ka huri iho ka whakakiiia (e raatou) nga koohao a te ngaarara huhu wiri, ki nga momo ngaarara ko taraatou nei mahi he kaikino i nga tamariki a Taane a Rongo. E kitea ana aua ngaarara (kaikino nei) i eetahi waa e whakataa haere ana i waho o nga whare.

Ki nga waahi o nga utauta moana, me nga pukepuke onepuu i nga takiwaa o te ika a Maau i Niutireni/Aotea-roa nei, kei reira teetahi 'sphecid,' tino rahi he whero me te mangu te kara, ko *Podalonia tydei suspiciosa* te ingoa, e hopuhopu te mahi i nga anuhe nunui o te puurerehua o 'noctuid.' Ka mutu te katipoo nei i te wero (i te anuhe) kia keckerewai, kua ekeina a runga kua tooia ki tana ohonga ki raro i te onepuu.

(continued overleaf)

(ara haere tonu)

The Crabroninae, typically thread-waisted wasps, often prey on flies. The New Zealand species, however, have diverged quite considerably in their prey preferences. One preys exclusively on beetles, another takes only moths, and yet another captures mayflies, caddisflies, and stoneflies in addition to true flies.

For instance, along the Blue Stream at the foot of the Tasman Glacier in Mount Cook National Park, this latter species in January preys exclusively on emerging adult aquatic insects, rejecting seemingly suitable flies even when these would be easy to capture.

This may be an example of the way in which sphecoid wasps first come to prey on new orders of insects, and suggests an adaptive capability that would be significant in the evolution of these insects. It also shows that field study of New Zealand's sphecoid wasps can yield surprising results, as well as fascinating insights into the behaviour of these dedicated hunters.

New Zealand has eighteen species of Sphecidae in seven genera. Nests and adults of a further five species are regularly encountered as importations, but none has so far become established.

Sphecids are solitary or subsocial wasps. The adults are usually active only in sunlight (not on overcast days), and feed largely on plant nectar. Although rather diverse in appearance, resembling variously bees, vespid wasps, or pompilid wasps, the Sphecidae comprise a natural group.

*Contributor Anthony Harris has been Curator of Invertebrate Zoology at the Otago Museum, Dunedin, New Zealand since his appointment to the position in 1974. He has had an abiding interest in insects (especially beetles) since the age of three, the attraction stemming initially from the fact that insects are often very beautiful. Only later did it become apparent to Tony that insect behaviour is "more fascinating than anything else." However, his interests do include tramping, watercolour painting, listening to baroque music, and playing classical music on the piano. Tony contributes a regular column on natural history to the 'Otago Daily Times.' His masterate study on pompilid wasps formed the basis for 'Fauna of New Zealand' no. 12.*

*Ko te kaituhi nei a Anthony Harris he Kaitiaki, he curator mo nga Invertebrate Zoology i te Whare Puriti Taaonga o Otepoti i Niutiireni / Aotearoa nei mai anoo i tana tuunga ki teenei mahi i te tau 1974. Ana mahi pai ka whaiaa e ia ko nga aahuatanga o te ngaarara, (Te huhu rawa atu) mai anoo i te waa e toru oona tau, i runga anoo hoki i te titiro i te aataahua o teenei mea te ngaarara. No muri rawa mai anoo ka kitea e Tony ko nga "aahuatanga o nga ngaarara nei pai atu i eetahi atu mea." Heoi, engari, ko eetahi atu*

*I nga waahi katoa o te motu ko te katipoo mangu kaanapanapa nei ko Tachysphex nigerrimus te ingoa, ka kitea ia waa e kerikeri koohao haere ana i te onepuu, aa, i roto raanei i nga waahi kirikiri i nga tahataha awaawa, engari tata kore e kitea e too papata haere ana i te whenua i muri i te patunga.*

*Ko te katipoo 'Crabroninae,' he momo katipoo - tinana taarete ko ta raatou tino kai patu he ngaro. Ko te momo e noho ana ki Niutiireni / Aotearoa nei, kua tino tihoihoi nga tuumomo kai e patupatua ana e raatou. Ko teetahi ko tana tino kai e patu ana he huhu, teetahi atu ka patu kai puurerehua anahc, aa teetahi anoo ka patu, haaunga anoo te ngaro noa iho nei hei kai, engari ko eenei tuumomo ngaro hei a hopuhopu hei kai, he 'mayflies,' 'caddisflies,' me nga 'stoneflies.'*

*Na, ko taua ngaarara i koorero mutunga ake nei ka (kai nei i nga aahua momo ngaro), ka kitea i te awaawa 'Blue Stream' te wai e rere ana i te rekereke o te maunga haupapa nei te 'Tasman Glacier,' i te marama o Haanuere heoi anoo te kai e patu ana i teenei waa ko nga ngaarara pakeke ka puta i te wai, e kore kai i nga ngaro e rere haere ana ahakoa e taeaa noa i te hopu.*

*Koia puuono teenei te aahua o te 'sphecoid' nei a katipoo i te waa tuatahi, ina ka huri i te patu i eetahi atu ngaarara hei kai hou maana, aa, he tohu anoo hoki i te aahua o teenei tuumomo ngaarara e taeaa noa te orange i te ao hurihuri. Teetahi atu ka kitea i nga tauiratanga aahuatanga o nga 'sphecoid' katipoo o Niutiireni / Aotearoa nei ka puta anoo nga tikanga rerekee, aa, me eetahi anoo momo aahua ka puta i teenei ngaarara kaha i te whaiwhai kai maana. I Niutiireni nei tekau maa waru nga momo atu o 'Sphecidae' i heke iho inga taatai e whitu. Konga ohonga ka kitea haere mo eenai kua pakari, e rima momo, no taawaahi, engari kiihai anoo kia uu rawa (ki konei).*

*Ko te momo katipoo nei a 'sphecoid' ka noho mokemoke, tata kore e huihui, choahoa raanei ki eetahi atu. Konga mea kua pakeke/kaumaatua raanei kanui te kamakama engari i te waa e whiti ana te raa (ehara i nga raa pouuri), ka kai te nuinga i te wai raakau reka. Ahakoa he maha nga aahua rerekeenga, akuanei ko eetahi ka rite ki nga aahua momo pii nga hanga, anoo he katipoo 'vespid,' 'pompilid' raanei, akuanei ko 'Sphecidae' he momo rangapuu tuuturu kotahi.*

---

*tino mea ki a ia he takahi i te whenua e hiikoi haere, he mahi taa i te taawai, whakarongo ki nga waiata baroque aa, ki te puurei hoki i nga waiata tawhito i te piiana. Ko Tony anoo e tuhi tuhinga hiitoria tuuturu (mo nga ngaarara) ki te niupepa o te 'Otago Daily Times.' Ko tana rangahau tohungatanga tuarua ka puta i te whare waananga mo nga katipoo nei a 'pompilid' maa, ipuutake ai te pukapuka nei 'Fauna of New Zealand' no. 12.*

## ABSTRACT

Eighteen species of Sphecidae in the genera *Podalonia* Fernald, *Spilomena* Shuckard, *Tachysphex* Kohl, *Pison* Jurine, *Rhopalum* Stephens, *Podagritys* Spinola, and *Argogorytes* Ashmead are recognised from New Zealand. Three new species are described: *Spilomena earlyi*, *Podagritys digyalos*, and *Podagritys chambersi*. Nests and adults of five species of *Sceliphron* Klug are repeatedly encountered in New Zealand but are not established. Descriptions of larvae are given for some species, revealing distinctive characters in the genera *Argogorytes* and *Spilomena*. Keys are provided for all established species, and details (mostly new) are provided on life history and nesting behaviour for all species. The Crabroninae include species that prey on Lepidoptera, Psocoptera, Hemiptera, Trichoptera, Plecoptera, Ephemeroptera, and Coleoptera (exclusively, one species) in addition to Diptera, their most frequently recorded prey. Extensive prey records are given.

### CHECKLIST OF TAXA

Subfamily SPHECINAE .....	18	Tribe Trypoxylonini	
Tribe Ammophilini		Genus <i>Pison</i> Jurine, 1808 .....	30
Genus <i>Podalonia</i> Fernald, 1927 .....	18	<i>mososum</i> Smith, 1856 .....	31
<i>tydei</i> (Le Guillou, 1841) .....	18	<i>tuberculatum</i> Smith, 1856 new synonymy	
ssp. <i>suspiciosa</i> (Smith, 1856) .....	18	<i>spinolae</i> Shuckard, 1838 .....	33
Tribe Sceliphronini		<i>australis</i> Saussure, 1853	
Genus <i>Sceliphron</i> Klug, 1801 .....	21	<i>tasmanicus</i> Smith, 1856	
Subgenus <i>Sceliphron</i> Klug, 1801		<i>dubia</i> Kirby, 1883	
<i>assimile</i> (Dahlbom, 1843)*		<i>pruinusosus</i> Cameron, 1898	
<i>caementarium</i> (Drury, 1770)*			
<i>laetum</i> (Smith, 1856)*		Subfamily CRABRONINAE .....	35
<i>spirifex</i> (Linnaeus, 1758)*		Tribe Crabronini	
Subgenus <i>Prosceliphron</i> Van der Vecht, 1968		Genus <i>Podagritys</i> Spinola, 1851 .....	36
<i>formosum</i> (Smith, 1856)*		Subgenus <i>Parechuca</i> Leclercq, 1970 .....	36
		<i>digyalos</i> species-group .....	37
Subfamily PEMPHREDONINAE .....	21	<i>albipes</i> (Smith, 1878) .....	38
Tribe Pemphredonini, subtribe Stigmia		<i>carbonicolor</i> (Dalla Torre, 1897) n.comb. ....	41
Genus <i>Spilomena</i> Shuckard, 1838 .....	22	<i>carbonarius</i> Smith, 1856	
<i>earlyi</i> new species .....	22	<i>swalei</i> Leclercq, 1955 new synonymy	
<i>elegantula</i> Turner, 1916 .....	24	<i>chambersi</i> new species .....	43
<i>emarginata</i> Vardy, 1987 .....	25	<i>cora</i> (Cameron, 1888) .....	43
<i>nozela</i> Vardy, 1987 .....	26	<i>jocosum</i> Cameron, 1898	
		<i>digyalos</i> new species .....	46
Subfamily LARRINAE .....	28	<i>parrotti</i> Leclercq, 1955 .....	48
Tribe Larrini, subtribe Tachytina		Genus <i>Rhopalum</i> Stephens, 1829 .....	50
Genus <i>Tachysphex</i> Kohl, 1883 .....	28	Subgenus <i>Aporhopalum</i> Leclercq, 1955 .....	51
<i>nigerrimus</i> (Smith, 1856) .....	28	<i>perforator</i> Smith, 1876 .....	51
<i>sericops</i> Smith, 1856		Subgenus <i>Zelorhopalum</i> Leclercq, 1955 .....	54
<i>depressus</i> Saussure, 1867		<i>aucklandi</i> Leclercq, 1955 .....	54
<i>nigerrimus</i> "White", Butler, 1874		<i>zelandum</i> Leclercq, 1955 .....	55
<i>helmsi</i> Cameron, 1888			
		Subfamily NYSSONINAE .....	57
		Tribe Gorytini	
		Genus <i>Argogorytes</i> Ashmead, 1899 .....	57
		<i>carbonarius</i> (Smith, 1856) .....	58
		<i>trichiosoma</i> Cameron, 1888	

\**Sceliphron* species frequently intercepted, sometimes encountered as temporary colonists, but not established.

## CONTENTS

Acknowledgments .....	8
Introduction .....	8
Diagnosis .....	9
Morphology .....	9
Life cycle .....	12
Nesting behaviour .....	13
Faunal relationships .....	14
Key to taxa .....	15
Descriptions (see Checklist of Taxa) .....	18
References .....	60
Appendix 1: prey species .....	66
Illustrations .....	68
Taxonomic index .....	105

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## INTRODUCTION

The family Sphecidae consists of solitary or subsocial wasps most of which dig nest holes in the ground, nest in abandoned larval galleries or pupal chambers of wood-boring insects, or make nests of moulded mud above ground. Adults are characteristically active only in sunlight, and are not usually active on overcast days. Adults feed mostly on nectar, or from fluid exuding from the mouthparts of paralysed prey (females), but larvae are provided by the female with a store of paralysed insects or spiders. Adult sphecids often resemble bees, vespids, or pompilids. Although they are very diverse, sphecids comprise a natural group.

### Sphecid wasps, bees, and the superfamily name

It is generally accepted that bees arose from a sphecid-like ancestor. Bees are sphecoid wasps whose larvae feed almost exclusively on nectar and pollen rather than insect or spider prey. (Some South American bees forage on carrion, whereas most 'normal' bees provision with pollen and nectar.) Bees are the closest relatives of sphecids, and certain primitive, unspecialised species in the two groups are sometimes difficult to tell apart. It is therefore not surprising that many authors have included them in a superfamily consisting of only two families, Apidae and Sphecidae.

Throughout most of the twentieth century sphecid wasps were either divided into a number of families or were treated as a single family. The latter approach was adopted by Bradley (1958), Evans (1964), Brothers (1975), Lomholdt (1975), and Bohart & Menke (1976). Because the last work, the definitive world treatment of the Sphecidae, has established that the group is best treated as one family with a number of subfamilies, this system has been adopted by almost all subsequent workers.

Although Michener (1944) suggested that bees "should be placed as a division of the Sphecoidea" he nevertheless divided them into a number of families, as have most subsequent students of bees (in a superfamily Apoidea that excluded the sphecoids). Contemporaneously, many workers on sphecid wasps continued to group all bees in one family, the Apidae (e.g., Lomholdt 1975, Bohart & Menke 1976). Lomholdt (1975) stated that an autapomorphy for the Sphecidae was not expected to exist, because the most primitive elements of the sphecid/bee assemblage occur in the Sphecidae. He proposed that the two families Sphecidae and Apidae (s.l.) constituted the superfamily Sphecoidea. Gauld & Bolton (1988), noting that sphecoids are now almost universally treated as a single family, stated that the bees should in consequence be allotted comparable

rank, viz. the family Apidae, and that the Sphecidae and Apidae should be grouped together in a superfamily Apoidea. In the 1991 edition of 'The Insects of Australia' Naumann treated the spheccids as a single family in a superfamily Sphecoidea, which included no other family, while Michener & Houston (in the same work) divided the bees into ten families, grouped into a superfamily Apoidea.

The first modern classification of the Sphecidae was that of Kohl (1896). Since then, a large number of valuable works have appeared, perhaps the most notable being those of E. Arnold, J. de Beaumont, R.M. Bohart, H.E. Evans, V.V. Gussakovskij, K.V. Krombein, J. Leclercq, O. Lomholt, A.S. Menke, V.S.L. Pate, W.J. Pulawski, K. Tsuneki, R.E. Turner, and A. Willink. In 1976 Bohart & Menke's monumental 'Sphecid Wasps of the World: a generic revision' was published, and all subsequent work on the family has started with that book as its basis.

## DIAGNOSIS

Head orthognathous; eyes large; females with 12 antennal articles, males with 13. Pronotum immovably joined to mesothorax (unlike Pompilidae, in which the pronotum has a thin posterior margin that can ride over the scutum); posterior margin of prothorax squarely truncate, often lower than scutum and usually separated from it by a constriction associated with a raised collar. Posterior margin of notum laterally with a rounded extension, the pronotal lobe, which covers the spiracle. Pronotal lobe almost always well separated from tegulae. Scutum usually continuous with dorsal part of mesopleuron. Hind leg with cleaning pecten or brush in a depression basally on inner side of basitarsus (absent in bees); pecten opposed by a complementary pectinate inner tibial spur. Body hairs straight, unbranched.

Spheccids can be distinguished from bees as follows.

**Spheccids** • Body hairs all simple (Fig. 18a).

• Forewing pleat crossing 2nd abscissa of M between 2nd discoidal cell and 2nd or 3rd submarginal cell, usually via a fenestra, and joined to radial pleat in submarginal cells.

• Basitarsi unmodified; hind basitarsus of females not much wider than the following tarsi.

**Bees** • At least some body hairs branched or plumose (Fig. 18b).\*

\* Often, a high-powered microscope is necessary to recognise this character. At low power it can be detected by the way light is reflected off the axillae of the branches. This character is useful when sorting sphecid-like primitive bees in which the basitarsus is not obviously broader than succeeding tarsomeres and not flattened on the side.

• Forewing pleat crossing 1m-cu between 1st and 2nd discoidal cells, usually via a fenestra, and separate from radial pleat in submarginal cells.

• (In many groups) basitarsi enlarged, those of hind leg expanded and flattened in anterior view; hind basitarsus of female often wider than following tarsi.

## MORPHOLOGY

**Adult.** The general structure of Sphecidae differs little from that of other aculeate Hymenoptera. Good descriptions of the morphology of adult Sphecidae are given in Lomholdt (1975) and Bohart & Menke (1976). The following account is given to elucidate the terms used in the keys and descriptions of this work. The sphecid body comprises three tagmata: the head, the mesosoma bearing the legs and wings, and the metasoma.

**Head** (Fig. 10a). The head is orthognathous in all New Zealand species. The mouthparts are generally retracted and largely concealed behind the mandibles. The standard palpal formula in wasps is 6-4 (six maxillary palp segments and four labial palp segments), but this has become reduced throughout the Sphecidae in a variety of ways, especially in more derived or specialised genera (e.g., it is 5-3 in the New Zealand Crabroninae). The mandibles, strongly developed for biting, grasping, and digging, present useful taxonomic characters. Where there are two subequal teeth at the apex, one is here called the upper tooth (= superior or anterior tooth in some works) and the other is the lower tooth (= inferior or posterior). In addition, the mesal (inner) edge may have molar (more proximal) and incisor (more distal) teeth, while there is a notch or step on the external (outer) edge in some Larrinae and Crabroninae. All these teeth are specifically distinct, and of considerable taxonomic use in the New Zealand species. The labrum is articulated distally on the clypeus, behind which it is normally partly or completely concealed. The clypeus is a large plate on the lower face. Its apical edge is very variable, and is of great use taxonomically at the species level. The frons is a large area extending from the epistomal (or fronto-clypeal) suture to the anterior (median) ocellus. The antennae (Fig. 11) are normally inserted low on the frons. The large first article is termed the scape, the small second article is the pedicel, and the remaining articles, termed flagellomeres, collectively comprise the flagellum. (The antenna of higher insects is composed of three true segments, the scape, pedicel, and flagellum. The flagellum subsequently becomes subdivided into units, the flagellomeres, which are morphologically not true segments. Because of this, the units comprising sphecid antennae are called articles rather than segments.) In all New Zealand

species, females have 12 antennal articles while males have 13. The relative size of flagellomeres—especially the first four—is very useful for distinguishing between species. Male Crabroninae often have unusual enlargements of certain antennal articles which are specifically distinct. The compound eyes are very large, and their shape (e.g., the apparent maximum width of the eye, in median frontal view, relative to the maximum width of the clypeus) is useful for distinguishing between some species, especially of New Zealand *Podagritys*. The extent to which the eyes converge above and below is useful in some groups. The top of the head, termed the vertex, extends from the ocellar triangle to the top of the occipital carina. Three ocelli are present in New Zealand species, the median anterior ocellus and the two outer hind (or posterior) ocelli, which are reduced to comma-like ocellar scars in *Tachysphex nigerimus*. The shape and extent of distinct oval or elongate shallow depressions between the compound eye and the hind ocellus, here termed orbital foveae and sometimes called facial or supraorbital foveae or fossae, are of considerable taxonomic use for distinguishing between New Zealand species of *Podagritys*. The back of the head between the mandibular bases, outer orbits, and occipital carina is termed the gena (= temples or cheeks). The occiput is bounded by the foramen magnum and the occipital carina.

**Head ratios.** Several ratios between parts of the head have been used in this work (Fig. 10b). POL:OOL is the ratio of the distance between the posterior ocelli (post-ocellar line) and the distance between one posterior ocellus and the nearest point on the compound eye (ocello-ocular line). The distance between the compound eyes can be measured in three places: UID is the upper interocular distance, MID the middle interocular distance, and LID the lower interocular distance. SFD is the shortest frontal distance, i.e., the greatest frontal convergence of the eyes. The maximum breadth of the head is termed the transfacial distance (TFD), and the height from clypeus to vertex is the facial distance (FD). MID represents the distance between the eyes at their greatest emargination. The ratio SFD:TFD is a useful character for distinguishing between females of *Podagritys carbonicolor* and *P. cora*, for example. FD:TFD is also a useful ratio.

**Mesosoma** (Fig. 12–14). The mesosoma consists of the fused prothorax, mesothorax, and metathorax plus the first true abdominal segment, the propodeum, which is separated from the rest of the abdomen and functions as part of the thorax. For this reason the thorax and propodeum are usually described as a unit, for which at least ten names have been given, many of them still in use. It was termed thorax by Bohart & Menke (1976), thorax and propodeum

by Lomholdt (1975), holmus by Gauld & Bolton (1988), and mesosoma by Naumann (1991).

The prothorax consists of two elements, the pronotum (dorsal and lateral) and the propleuron (lateral and lateroventral). The prothorax is ventrally somewhat loosely connected to the mesothorax. The pronotum has a dorsal posterior collar and a rounded posterolateral lobe which covers the mesothoracic spiracle. The collar often bears a dorsal transverse carina which may be sharp, and may be produced dorsolaterally into spines or tooth-like processes (e.g., in *Podagritys carbonicolor*). The shape of these spine-like humeral angles is of considerable taxonomic use for distinguishing between New Zealand species of *Podagritys*. In all sphecids the posterior margin of the collar is a straight line. The propleuron is somewhat loosely connected with the pronotum and is suggestive of a segment belonging to the foreleg.

The mesothorax is divided dorsally into two sclerites, the anterior scutum (mesoscutum) and the scutellum. On the scutum several paired furrows or carinae occur: the medially situated admedian line, and lateral to this the notaulus and the short parapsidal line. An ovoid plate above the base of the forewing is called the tegula. Because Sphecidae lack a separate mesosternum, the entire lateral and ventral part of the mesothorax is termed the mesopleuron. Below the forewing base is the mesopleural flange, which forms the upper limit of the subalar area. Below the subalar area is a transverse depression, the subalar fossa. Below the subalar fossa is the hypopimeral area, bounded ventrally by the scrobe, a pit somewhat above and behind the middle of the mesopleuron, and the scrobal sulcus, which is a horizontal groove that passes through the scrobe. A roughly vertical groove, the episternal sulcus, originates in the subalar fossa and extends ventrally, separating off the prepectus (or epicnemium), which is the anterior part of the mesopleuron. Near the pronotal lobe the curved post-spiracular carina, when present, is anterodorsal of the episternal sulcus. The omaleus, when present, is a ridge or carina originating below the pronotal lobe and extending posteroventrally. Three horizontal grooves, sulci, or lines may occur ventrad of the scrobe, namely the mesopleuraulus (a groove), the hypersternaulus (a sulcus), and the signum (a short line situated ventrolaterally). In some *Spilomena* species a vertical sulcus originates at the apex of the pronotal lobe (Fig. 14). Bohart & Menke (1976) stated that its position indicates that it could either be a displaced, weak omaleus or a displaced episternal sulcus, and chose the latter interpretation. Vardy (1987) interpreted it anterodorsally as an episternal sulcus and anteroventrally as an omaleus, meeting at the anterior boundary of the hypersternaulus. The

mesopleuron is delineated posteriorly by the mesopleural suture, which ends below at the mesocoxal cavity. A precoxal sulcus curves around in front of the coxa, separating a section of mesopleuron, the precoxal lobe.

The metathorax bears the hind wings. It is represented dorsally by the metanotum, of which the central part, the dorsellum, is often raised and bounded laterally by depressions. The metapostnotum in Apocrita tends to be invaginated or fused to adjacent sclerites. In Sphecoidea the metapostnotum is greatly enlarged, for a posterior expansion of it forms the dorsal 'triangular area' of the propodeum. (This was formerly regarded as morphologically part of the propodeum.) A functional metathoracic spiracle occurs behind the hind wing. Laterally the metathorax consists of the metapleuron, which is often divided by a transverse pleural line into upper and lower areas.

The propodeum, the first abdominal segment of Apocrita, is bounded by the metapleuron sulcus. There is a conspicuous propodeal spiracle. The propodeum bears various ridges and grooves which are useful taxonomically.

**Wings** (Fig. 15a, b). The terminology for the wings used here mostly follows that of Gauld & Bolton (1988), which was based on that of Richards (1956). Note that the submarginal cells have been called 'cubital cells' by some authors, and that the *rs-m* cross-veins are often called the 'transverse cubital veins.' The basal and sub-basal cells are often termed the 'medial cell' and 'submedial cell' (e.g., by Bohart & Menke (1976)). The *m-cu* cross-veins are called the 'recurrent veins.' Some workers term the hindwing vein *rs-m* the 'transverse median vein,' the media has been called the 'cubital vein,' and the cubitus the 'discoidal vein.' The anal area is often called the 'vannal' area and the anal lobe the 'vannal' lobe. Reduction of venation in the forewing has occurred mostly through the loss of one or more submarginal and discoidal cells and by a shortening of the marginal cell.

**Legs.** The legs are little different from those of most aculeate Hymenoptera. The forelegs of females are often modified for digging, consequently the tarsi may bear on the outer side a row of stout, usually deflexed spines (the tarsal pecten, or rake). Proximally on the foreleg basitarsus there is a deep emargination which together with the apical spur on the tibia forms an antennal cleaner. A similar, weaker device occurs on the hind leg. The number of middle tibial spurs differs in various sphecoid groups, and is usually constant within a subfamily, but exceptions occur.

**Metasoma.** The remaining abdominal segments are separated from the propodeum (morphologically the first segment) by a very pronounced constriction, and are very mobile, especially in the vertical plane, functioning to-

gether as an abdomen. Because they are only part of the abdomen, these segments together are termed the metasoma. The anterior part of the metasoma is frequently produced into a distinct petiole. Naumann (1991) used the term 'gaster' for the region posterior to the petiole, and 'metasoma' for gaster plus petiole. Some authors use 'gaster' for the entire region, as a synonym of 'metasoma.' In this work, 'gaster' is used in the sense of Naumann (1991). The metasoma in Sphecidae usually consists of six visible segments in the female and seven in the male. Segments 8 and 9 are highly modified to form the sting apparatus (and associated structures) in females, and terminal segments are modified to form the genitalia in males. When the anterior part of the metasoma is produced into a petiole, it is made up either of the first sternum alone or of the first sternum and tergum. In the latter case it bears spiracles. In many forms, and particularly in females, the last visible tergum – the pygidium (or epipygium) – may bear a pygidial plate. This is usually a flattened area defined by lateral carinae, grooves, or sharp angles. These usually converge apically to form a triangular or U-shaped plate, the pygidial plate. It may be smooth, punctate or rugose-punctate, hairy or hairless, and a median longitudinal keel may be present or absent. The pygidium is of great taxonomic importance at the species level.

**Male genitalia** (Fig. 16, 17). In Sphecidae the male genitalia show considerable variation. Primitively the median aedeagus is surrounded by the volsella, which has an inner articulating part, the cuspis (cuspis volsellaris) and an outer, stationary, apical extension termed the digitus (digitus volsellaris). External to these is the paramere (or gonostyle), the outer paired appendage of male genitalia. The paramere is sometimes divided into proximal and distal areas (e.g., *Podalonia tydei suspiciosa*: Fig. 16). A more derived condition is present in many sphecoids in which the volsella is not differentiated into digitus and cuspis, the cuspis having fused with the digitus or one or the other having been lost. In the New Zealand Crabroninae the digitus volsellaris is often vestigial, almost absent (Fig. 17). In many *Pison* species the volsella is greatly enlarged and partly fused with the paramere (the volsella is notably large in *P. spinolae*, less so in *P. morosum*).

#### Adult variation

**COLOUR.** A degree of parallel ecophenotypical colour variation occurs in *Rhopalum*, *Podagrirus*, and *Spilomena*, in which the species are paler in northern, warmer areas and darker in southern, cooler regions. Such variation can be pronounced, but is not as striking as in the New Zealand Pompilidae (e.g., Harris 1974, 1987). In all the above three sphecoid genera, yellow areas become smaller southwards.

In *Rhopalum* the gaster is mostly fulvous-brown north of latitude 37°S and mostly black south of latitude 45°S.

**STRUCTURE.** Structural variation is only occasionally sufficient to cause difficulties with identification. Wing venation is sometimes variable: for example, *Pison spinolae* generally has three submarginal cells in the forewing, but sometimes two, while occasional individuals have two submarginal cells in one wing and three in the other. *Spilomena* species show considerable variation. In *S. nozela* the lower frontal median longitudinal carina is very variable. Allometric variation sometimes results in small individuals being different to large individuals of the same population. In *Podagrinus albipes*, *P. cora*, and *P. carbonicolor* females the apical margin of the clypeus and the two apical mandibular teeth show confusing variation (see p. 36), but fortunately identifications can be made on the basis of less variable characters such as the shape of the orbital fovea, the spines on the humeral angle of the pronotal collar, and the lateral carinae of the pygidium (and other characters listed in the specific diagnoses).

**Surface microsculpture** (adult). Terms used in this work are defined and illustrated in Harris (1979).

#### **Final-instar larva** (Fig. 79–82)

The final-instar larva is similar to that of most Apocrita. Unlike those of Pompilidae, spiracles on the second segment are not reduced. The most important works on the morphology and taxonomy of sphecoid larvae are those of Evans & Lin (1956a, 1956b), Evans (1957, 1958, 1959), and Grandi (1961). Lomholdt (1976) provided a very good overview with keys to genera of Sphecidae occurring in Fennoscandia and Denmark. Cowley (1962) described the immature stages of *Pison spinolae* in New Zealand.

**Head.** The head capsule (Fig. 90) is strong, sclerotised, lightly pigmented, and subcircular in frontal view. A pair of oblique pigmented parietal bands are sometimes present on the upper part of the head. The antennae are either very short, one-segmented with three small apical sensillae, or the antennal papillae may be absent so that the sensillae arise directly from the antennal orbits. The anterior tentorial arms are visible as thick, pigmented lines on either side of the clypeus, and are continuous with thickenings of the integument above each mandibular base, the pleurostomal thickenings. The latter are contiguous with the hypostomal thickenings, which extend back from the posterior articulation of the mandible to the posterior tentorial arms. The labrum is well developed, mobile, usually bilobed, and has a weak median longitudinal furrow. It bears a number of sensillae, the number and disposition of which are often species-specific and of great taxonomic value. The underside of the labrum, the epipharynx, is usually spinulose.

The mandibles are toothed on the inner side and are useful taxonomically. The maxillae are large and distally support two papillae, of which the outer papilla, usually the largest, bears three or four sensillae. This papilla is the maxillary palp. The inner papilla, which is the galea, has two apical sensillae. The body of the maxilla is made up of the stipes. The median part, the lacinial area, is usually strongly spinulose. The labium is made up of a large postmentum and a small prementum. The prementum bears the unisegmental labial palps, which generally carry three apical sensillae and closely resemble the maxillary palps. The prementum also bears, medially, the spinneret (Fig. 108).

**Body.** The body is fusiform, somewhat depressed ventrally, with convex sides. There are ten abdominal segments. Laterally there is a row of pleural lobes. The tracheal system is provided with two pairs of thoracic spiracles and eight pairs of abdominal spiracles. The spiracle is a complex structure (Fig. 86a). The primary tracheal opening lies between the bowl-shaped atrium and the subatrium, an expanded region which extends proximally to a constriction in the trachea. The basal region of the atrium surrounding the primary tracheal opening is termed the collar, and ridges on the atrium in this region frequently bear large collar spines. Spines also protrude from the internal walls of the distal part of the subatrium. The walls of the atrium project slightly above the general body surface to form a rim, from which a narrow, transparent annulus, the peritreme, slightly constricts the atrial opening. The spiracles vary specifically, and provide good taxonomic characters.

## LIFE CYCLE

The sphecoid egg is white, elongate-ovoid, sausage-shaped, and slightly curved. Larvae are white, almost fusiform, hymenopteriform (eucephalous), with whitish-cream translucent cuticle. The final-instar larval stage is usually attained in less than 3 weeks, and cocoon-spinning commences less than a month after the egg was laid. The larva often incorporates into the surface of the cocoon material from the floor of the cell, such as fragmentary food remains and sand grains (Fig. 110–114). Cocoons of species of *Podagrinus* are of this type, whereas *Rhopalum* cocoons are smooth. Cocoons of New Zealand species of *Pison* are cylindrical, matt, greyish-buff, and rounded at either end, whereas those of *Sceliphron* are brown and shining. Cocoons of *Spilomena* are very thin, white, and sac-shaped.

Although *Pison spinolae* is bivoltine, most New Zealand sphecids are univoltine or variable. For instance, *Podagrinus albipes* is univoltine in some places (e.g., Blue

Stream MK), bivoltine in others, and possibly multivoltine in yet others, but it has a winter prepupal diapause. All New Zealand sphecids spend at least the winter in a prepupal diapause. The following spring the prepupa moults into an exarate pupa which has stout, spined processes on the abdomen. Pupal development takes about 14 days, ending in adult emergence.

## NESTING BEHAVIOUR

The two New Zealand *Pison* species prey mostly on orbweb spiders. *P. spinolae* makes mud cells in crevices in bark, rock overhangs, and man-made structures, including folds in fabric. *P. morosum* nests in beetle holes in wood.

*Podagritys* species nest in the ground. *P. albipes*, *P. cora*, and *P. carbonicolor* nest mostly in sand, where *albipes* preys on flies and adult aquatic insects, the other two taking only Diptera. *P. digyalos*, *P. chambersi*, and *P. parrotti* nest in clay, where the first two provision cells with Diptera and *parrotti* provisions exclusively with Coleoptera.

New Zealand species of *Rhopalum* nest in hollow twigs and in beetle holes in wood. *Argogorytes carbonarius* makes both simple 1- or 2-celled nests and compound, 5-10-celled nests in relatively damp clay or humus banks which it fills with spittlebug nymphs (Cercopidae). *Tachysphex nigerrimus* places a range of native cockroaches in nest burrows dug in sand. *Podalonia tydei suspiciosa* places paralysed final-instar armyworm caterpillars in shallow nests in sand. *Sceliphron* species make mud nests which they fill with spiders when they are periodically introduced into New Zealand (no *Sceliphron* species is currently established here). *Spilomena* species are minute, and place paralysed thrips in holes of wood-boring insects, e.g., *Anobium punctatum* (Coleoptera: Anobiidae).

Prey categories for New Zealand Sphecidae are listed in Table 1; prey species are listed in Appendix 1.

### Behavioural sequences

Female solitary wasps exhibit a set sequence of hunting behaviour peculiar to each species. Malyshev (1966) devised the following formula for denoting these hunting sequences.

- A **hunting**
  - ai seeking the victim
  - aii attacking and paralysing it
  - aiii transporting it to a particular place for temporary keeping
- B **preparation of the nest**
  - bi seeking a place for the nest
  - bii digging the nest, repairing, etc., usually combined with visiting the prey
- C **transporting the prey to the nest and installing it**
  - ci dragging the prey to the nest
  - cii inspecting the nest
  - ciii dragging the prey into the nest
- D **oviposition**
- E **closing the nest**
  - ei closing the cell
  - eii closing the nest

Evans & Eberhard (1970, pp. 114-119) arranged hunting sequences in an evolutionary sequence leading from simple to derived in the direction of social behaviour, as follows:

- (1) **Prey-egg**  
No nest made; egg laid directly on host.
- (2) **Prey-niche-egg-(closure)**  
Prey caught outside prey's own burrow and dragged back into its burrow.
- (3) **Prey-nest-egg-closure**  
Prey caught before nest is made. Prey dragged into pre-existing hole which may be subsequently modified by wasp.
- (4a) **Nest-prey-egg-closure**  
Nest made before prey caught.
- (4b) **Nest-prey-egg-[cell closed and new cell prepared-prey-egg]-closure**

**Table 1** Orders of arthropods used as prey by Sphecidae in New Zealand

#### CLASS ARACHNIDA

Order ARANEAE: *Pison morosum*, *P. spinolae*

#### CLASS INSECTA

Order BLATTODEA: *Tachysphex nigerrimus*

Order COLEOPTERA: *Podagritys parrotti*

Order DIPTERA: *Podagritys albipes*, *P. carbonicolor*, *P. chambersi*, *P. cora*, *P. digyalos*, *Rhopalum perforator*, *R. zelandum*

Order EPHEMEROPTERA: *Podagritys albipes*, *P. cora*

Order HEMIPTERA: *Argogorytes carbonarius*

Order LEPIDOPTERA: *Podalonia suspiciosa*, *Rhopalum aucklandi*

Order PLECOPTERA: *Podagritys albipes*

Order PSYCOPTERA: *Rhopalum zelandum*

Order THYSANOPTERA: *Spilomena earlyi*, *S. elegantula*, *S. emarginata*, *S. nozela*

Order TRICHOPTERA: *Podagritys albipes*, *P. cora*

## FAUNAL RELATIONSHIPS

Nest made before prey caught. Multi-celled nest in ground, and a series of cells in a hollow twig or a beetle hole, or a cluster of mud cells.

(5a) **Nest-prey-egg-(prey)<sup>n</sup>-closure**

An egg is laid on a small prey item and the nest is subsequently filled with additional prey before being sealed.

(5b) **Nest-prey-egg-(prey)<sup>n</sup>-[cell closed and new cell prepared-prey-egg-(prey)<sup>n</sup>]-closure**

The female makes not one but a series of separate cells. Nests may be single or multi-celled. The wasp oviposits on the first prey item but more commonly on the last one.

(5c) **Nest-(prey)<sup>n</sup>-egg-[cell closed and new cell prepared-(prey)<sup>n</sup>]-closure**

This method enables the wasp, in a period of scarcity, to fill a cell over a period of several days before laying an egg.

(6a) **Nest-prey-egg-(prey)<sup>n</sup>-closure**

In addition to bringing in prey over several days, the prey is graded according to the size of the larva, via 'inspection trips.'

(6b) **Nest-prey-egg-(prey)<sup>n</sup>-[cell closed and new cell dug-prey-egg-(prey)<sup>n</sup>]-closure**

Progressive provisioning of this sort involves considerable contact between adult and larva. Some progressive provisioners actually clean the cells of debris at frequent intervals. This helps eliminate parasites and predators of the sphecid larva.

(7a) **Nest-egg-(prey)<sup>n</sup>-closure**

A few sphecids lay an egg not on the first prey, but in an empty cell. This frees the female from the necessity of hunting for prey before ovipositing and from the danger of introducing parasites at the time prey is deposited.

No New Zealand sphecid occupies positions 1 and 2, *Podalonia tydei suspiciosa* occupies positions 3 and 4a, while the other species mostly occupy position 4b. *Spilomena* differs from other New Zealand sphecids in that *S. nozela* and *S. elegantula*, at least, often nest communally, several females sharing a common burrow.

New Zealand species of *Tachysphex*, *Rhopalum*, *Podagritus*, *Argogorytes*, and *Spilomena* nest gregariously, a bank or sand patch containing many closely grouped burrows of the same species, which are not shared with other females. The main burrow is always left open during provisioning, an unusual feature because it is closed between visits by many Eurasian and American species.

The New Zealand sphecid fauna consists of an idiosyncratic mix of recently arrived species and a core Gondwanan element represented by the Crabroninae.

*Podalonia* occurs in all major temperate and tropical land areas of the world except South America. *P. tydei* in its various subspecies is widespread (southern Palaearctic to New Zealand, not the Americas); ssp. *suspiciosa* occurs only in Australia and New Zealand. *Spilomena* is represented in every zoogeographical region. Less than 25% of the species in collections from Australia and South America are described. Of the four New Zealand species, *S. earlyi* and *S. emarginata* occur only in New Zealand, while *S. nozela* and *S. elegantula* are found also in Australia. *Tachysphex* is the largest genus in the Larrini with over 350 described, valid species. It occurs on all continents and even on small oceanic islands, where it is represented by single species. *T. nigerrimus* is the only New Zealand species. Although *Pison* ranges world-wide, most of the species occur in the Southern Hemisphere, and a third of them are found in Australia. Many endemic forms have evolved on islands in the Pacific Ocean. Of the two species present in New Zealand, *P. spinolae* occurs also in Australia (including Tasmania) while *P. morosum* occurs nowhere else. *Rhopalum* has a cosmopolitan distribution, yet the subgenera *Aporhopalum* (one species) and *Zelorhopalum* (two species) occur only in New Zealand. *Podagritus* is known only from South America, Australia, and New Zealand, the six New Zealand species comprising the endemic subgenus *Parechuca*. *Argogorytes* is represented in all faunal regions except the Ethiopian. Species are known from many of the islands of the western Pacific, but *A. carbonarius* is the only *Argogorytes* in New Zealand.

### Repository abbreviations

The following abbreviations are used for repositories:

- BMNH Natural History Museum, London, U.K.  
CMNZ Canterbury Museum, Christchurch, N.Z.  
FCNZ F.D. Chambers Collection, Te Namu Road, Opunaki, N.Z.  
LCNZ Lincoln University, Lincoln, Canterbury, N.Z.  
NZAC New Zealand Arthropod Collection, Mt Albert Research Centre, Auckland, N.Z.  
OMNZ Otago Museum, Great King Street, Dunedin, N.Z.  
USNM United States National Museum of Natural History, Washington D.C., U.S.A.

**KEY TO SPHECIDAE  
KNOWN FROM NEW ZEALAND**

- 1 *Metasoma* strongly petiolate, with 1st segment long and thin (Fig. 1, 2, 6-8) ... 2  
 —*Metasoma* not strongly petiolate, with 1st segment not long and thin (Fig. 3-5, 9) ... 5
- 2(1) Forewing with 2 or 3 submarginal cells (e.g., Fig. 1, 2, 54, 55); antennae long, more than twice width of head ... SPHECIDAE .. 3  
 —Forewing with 1 submarginal cell (e.g., Fig. 6-8); antennae short, less than twice width of head ... CRABRONINAE .. 4
- 3(2) Integument black and orange; forewing marginal cell separated from wing apex by more than its length (Fig. 54); female foretarsus with a row of setae longer than width of segment ... (p. 18) .. *Podalonia*  
 —Integument black and yellow; forewing marginal cell separated from wing apex by less than its own length (Fig. 55); female foretarsus without a row of setae longer than width of segment ... (p. 21) .. *Sceliphron*
- 4(2) Tibiae (e.g., hind tibia) with bristles of normal length (Fig. 19a); apical margin of clypeus with a median lobe not clearly projecting well forward of lateral lobes (only a little in *P. carbonicolor*) (Fig. 33-36); clypeus not greatly modified. FEMALES: pygidium without a median carina (Fig. 49, 50) ... (p. 36) .. *Podagritys*  
 —Tibiae (e.g., hind tibia) with reduced short bristles (Fig. 19b); anterior margin of clypeus nasute, clearly projecting forwards, without lateral lobes (Fig. 38, 39); if lateral lobes present, then clypeus greatly modified and turned outwards, with a marked longitudinal median ridge, the median and lateral lobes anteriorly separated by a very small, deep incision, the whole constituting an ornately embellished median lobe, with true lateral lobes rudimentary (Fig. 37c). FEMALES: pygidium bisected by a longitudinal median carina (Fig. 51-53), this sometimes incomplete and present as a basal tubercle ... (p. 50) .. *Rhopalum*
- 5(1) Eye notched (e.g., Fig. 27) ... (p. 30) .. *Pison*  
 —Eye not notched (e.g., Fig. 28) ... 6
- 6(5) Body under 3.6 mm long ... (p. 22) .. *Spilomena*  
 —Body over 3.6 mm long ... 7
- 7(6) Middle tibia with 1 apical spur; vertex small; eyes distinctly converging above; hind ocelli vestigial, shaped like commas (Fig. 26)... (p. 28) .. *Tachysphex*  
 —Middle tibia with 2 apical spurs; vertex large and smoothly rounded; eyes distinctly diverging above; hind ocelli normal (Fig. 28) ... (p. 57) .. *Argogorytes*

**Spilomena**

- 1 Antenna with 12 articles, the flagellomeres bearing fine pubescence; metasoma with 6 visible segments ... Females .. 2  
 —Antenna with 13 articles, the flagellomeres bearing short, obliquely forward-directed bristles; metasoma with 7 visible segments ... Males .. 5
- 2(1) Mesopleuron without an episternal sulcus; head longer than wide; pygidium short, wide, and flat, dorsoventrally compressed ... (p. 24) .. *elegantula*  
 —Mesopleuron with an episternal sulcus (Fig. 14); head wider than long; pygidium laterally compressed ... 3
- 3(2) Frons widening clypead, UFD clearly shorter than LID; apical margin of clypeus with a median incision one-third of its total width ... (p. 25) .. *emarginata*  
 —Frons not obviously widening clypead, laterally more or less subparallel; apical margin of clypeus with a short median incision, clearly much less than one-third of its total width ... 4
- 4(3) Epipygium with 2 low, very short, approximated longitudinal carinae at apex only, not enclosing a median dorsal longitudinal flat area... (p. 22) .. *earlyi*  
 —Epipygium with raised, sharp-edged lateral carinae extending from base to apex and enclosing a median dorsal longitudinal flat area ... (p. 26) .. *nozela*
- 5(1) Mesopleuron without an episternal sulcus; lower frons clearly with a yellow, triangular spot bounded by eye, clypeus, and antennal sclerite, the 'hypotenuse' facing inwards ... (p. 24) .. *elegantula*  
 —Mesopleuron with an episternal sulcus; lower frons without an obvious, clearly demarcated, yellow triangular spot bounded by eye, clypeus, and antennal sclerite ... 6
- 6(5) Transverse anterior sulcus of scutellum divided into foveae by a series of strong, high cross-ridges; apical margin of clypeus with a broad, deep median incision wider than one-quarter total width of clypeus ... (p. 25) .. *emarginata*  
 —Transverse anterior sulcus of scutellum entire, not divided into foveae by strong cross-ridges, with weak, low cross-ridges only; clypeus medially with a small, short

incision clearly much shorter than one-quarter its total width ... 7

- 7(6) Clypeus fulvous to brown, usually brown, never appearing intensely whitish ... (p. 22) .. *earlyi*  
—Clypeus pale fulvous yellow, usually appearing intensely whitish ... (p. 26) .. *nozela*

## Pison

- 1 Clypeus with a large, protruding median lobe, its apex gently rounded, never acute; antenna with 12 articles; metasoma with 6 visible segments ... Females .. 2  
—Clypeus with a large, protruding median lobe, its apex sharply pointed, acute; antenna with 13 articles; metasoma with 7 visible segments ... Males .. 3

2(1) Body with very short hair, generally shorter than width of thickest antennal article; flagellomere 1 subequal in length to flagellomeres 2 and 3; forewing submarginal cell 2 relatively large, on vein M about 0.35× length of cell 3 ... (p. 31) .. *morosum*

—Body with very long, pale, wispy hair, longer than width of any antennal article; flagellomere 1 very much longer than any other antennal article; forewing submarginal cell 2 very small, variably reduced, on vein M usually about 0.2× length of cell 3, sometimes smaller or absent ... (p. 33) .. *spinolae*

3(1) Metasoma with sternum 2 bearing a large, blunt tubercle on either side of midline; body with very short hair, generally shorter than width of thickest antennal article; flagellomere 1 subequal in length to flagellomeres 2 and 3; forewing submarginal cell 1 relatively large, on vein M about 0.35× length of cell 3 ... (p. 31) .. *morosum*

—Metasoma with ventral surface relatively smooth, lacking large raised structures basad of hypopygium; body with very long, pale, wispy hair, longer than width of thickest antennal article; flagellomere I longer than any other antennal article; forewing submarginal cell II very small, variably reduced, on vein M usually about 0.2× length of cell III, sometimes smaller or absent ... (p. 33) .. *spinolae*

## Podagrirus (Parechuca)

- 1 Metasoma with 6 visible segments; antenna with 12 articles ... Females .. 2  
—Metasoma with 7 visible segments; antenna with 13 articles ... Males .. 7

2(1) Antenna with 1st flagellomere clearly much longer than any other (Fig. 24a); epipygium with sparse, fine, very short bristles (*digyalos* group) ... 3

—Antenna with 1st flagellomere not obviously much longer than any other; epipygium with relatively dense, moderately long, coarse bristles (except *parrotti*, where hairs are sparse and fine, but long) ... 4

3(2) Petiole elongate, slender, a little longer than hind femur (Fig. 47); median lobe of clypeus emarginate (curved inwards); metanotum yellow; antenna yellow / orange ... (p. 43) .. *chambersi*

—Petiole abbreviated, relatively short and thick, a little shorter than hind femur (Fig. 48); median lobe of clypeus rectilinear; metanotum and antenna black ... (p. 46) .. *digyalos*

4(2) First segment of metasoma short, stout, very thick, L/W about 2.3 (Fig. 7); apical margin of clypeus with spine-like lateral projections extending well beyond median lobe (Fig. 36a) ... (p. 48) .. *parrotti*

—First segment of metasoma long, thin, petiolate, L/W about 3.0 (e.g., Fig. 6); apical margin of clypeus with lateral projections not extending well beyond median lobe (e.g., Fig. 33) ... 5

5(3) Tergum 7 with pygidial dorsal area incompletely demarcated by lateral carinae, these little raised above surface, extending from apex to only a little beyond midway on segment, from which point dorsolateral area of tergum 7 very rounded (Fig. 49); pronotum in dorsal view with lateral humeral carinula rising into a sharp, bilobed ridge, with anterior and posterior tubercles separated by a saddle, the anterior tubercle larger and less acute (Fig. 44); usually of moderate size (length 8.0–11.5 mm) ... (p. 38) .. *albipes*

—Tergum 7 with epipygial dorsal area completely demarcated by large, acute, raised lateral carinae extending almost full length of epipygium; pronotum in dorsal view with lateral humeral carinula either blunt, hardly raised, and not higher than median area or rising steeply to a high, sharp, knife-edged keel, without blunt anterior and posterior tubercles and clearly higher than median pronotal area; usually of moderate to large size (length 8.5–16.0 mm) ... 6

6(5) Head in frontal view with frons usually appearing almost as wide as visible (anterior) part of compound eye (TFD/SFD less than 4.0, usually about 3.3) (Fig. 40); median apical margin of clypeus projecting well beyond lateral lobes (Fig. 34); mandibles with apical

teeth well separated, their axes forked or diverging, and lower tooth usually shorter than upper tooth (Fig. 29); pronotum in dorsal view with lateral carinula rising steeply to a high, sharp, knife-edged keel, without blunt anterior or posterior tubercles (Fig. 45)

... (p. 41) .. *carbonicolor*

—Head in frontal view with frons usually appearing little more than half width of visible (anterior) part of either compound eye (TFD/SFD greater than 4.0, usually about 4.8) (Fig. 41); median apical margin of clypeus not projecting markedly beyond lateral lobes (Fig. 35); mandibles with apical teeth parallel, relatively weakly separated and subequal (lower tooth shorter and narrower in *albipes*) (Fig. 30); mesal molar tooth far from base of mandible (Fig. 32); pronotum with dorsolateral carinula blunt in dorsal view (cf. sharp and raised in *albipes*)

... (p. 43) .. *cora*

7(1) Antenna with 1st flagellomere scooped out below, resembling pedicel, and other flagellomeres relatively unmodified (Fig. 24b)

... *digyalos* group .. 8

—Antenna not as above ... 9

8(7) Metanotum yellow; mandible whitish-yellow; antenna yellow/orange; petiole of metasoma long and slender (Fig. 47)

... (p. 43) .. *chambersi*

—Metanotum, mandible, and antenna black; petiole of metasoma abbreviated, relatively short and thick (Fig. 48)

... (p. 46) .. *digyalos*

9(7) First segment of metasoma short, stout, relatively very thick, its apex not nodular (Fig. 7); humeral angles of pronotal collar smoothly rounded, without eroded or tooth-like carinulae

... (p. 48) .. *parrotti*

—First segment of metasoma long, thin, petiolate, the apex nodular (Fig. 6); humeral angles of pronotal collar produced into eroded carinulae (Fig. 44–46)

... 10

10(9) Antenna with basal flagellomeres unmodified, similar to apical ones; all flagellomeres short, more or less cylindrical, and relatively very broad (Fig. 21)

... (p. 38) .. *albipes*

—Antenna with basal flagellomeres modified, scooped out or projecting (Fig. 22, 23)

... 11

11(10) Antenna with pedicel greatly expanded; 3rd flagellomere apically with a large, lobular expansion (Fig. 22)

... (p. 41) .. *carbonicolor*

—Antenna with pedicel unmodified; 2nd flagellomere in dorsolateral view greatly enlarged, its apical half projecting (Fig. 23)

... (p. 43) .. *cora*

## Rhopalum

1 Metasoma with 6 visible segments; antenna with 12 articles

... Females .. 2

—Metasoma with 7 visible segments; antenna with 13 articles

... Males .. 4

2(1) Antennal flagellomere 1 almost twice as long as any other

... (p. 51) .. *perforator*

—Antennal flagellomere 1 much less than twice as long as any other, the flagellomeres almost subequal

... 3

3(2) Propodeum with a lateral carina extending from near spiracle to posterior margin as a thin, high ridge, blade-like and almost transparent over all but its anterior 0.2; epipygium with median longitudinal carina entire, well defined from base to apex as a steep, high ridge; pygidial shield relatively flat, not excavated (Fig. 52)

... (p. 54) .. *aucklandi*

—Propodeum without a lateral carina from near spiracle to posterior margin; epipygium with median longitudinal carina not attaining apex, present only as a basal tubercle; pygidial shield apically excavated, hairless, very shining (Fig. 53)

... (p. 55) .. *zelandum*

4(1) Antenna with flagellomere 1 over twice as long as pedicel and any other flagellomere (Fig. 25); clypeus greatly modified, with median lobe large, protuberant, isolated, apically raised outwards, the apical border with a small incision on either side separating narrow, upturned projections slightly shorter than central part (Fig. 37b, c)

... (p. 51) .. *perforator*

—Antenna with flagellomere 1 little longer than any other; clypeus with median lobe simple, lacking a small apical parallel incision on either side separating projections (e.g., Fig. 39b)

... 5

5(4) Propodeum with a lateral carina on posterior half, as a thin, high, almost transparent blade; epipygium usually with an indistinct median longitudinal carina reaching apex; metasoma very attenuated, in dorsal view with sides of 1st and 2nd segments appearing subparallel; metanotum usually yellow

... (p. 54) .. *aucklandi*

—Propodeum without a lateral carina on posterior half; epipygium without a median longitudinal carina at apex, concave in all directions and bounded by raised lateral carinae; 1st segment of metasoma relatively short and broad; metanotum not yellow

... (p. 55) .. *zelandum*

## DESCRIPTIONS

### Subfamily SPHECINAE

**Adult.** Antennae long, filiform, usually inserted near middle of face, with 12 articles in females and 13 in males. Mandible without a notch or angle on exteroventral margin. Clypeus large. Pronotum usually elongate, with pronotal lobe broadly separated from tegula; no oblique scutal carina. Episternal sulcus usually present, extending to anteroventral region of pleuron; omaulus absent. Propodeum usually very long, with propodeal sternite present. Tarsi usually with large arolia. Forewing usually with 3 submarginal cells and 2 recurrent veins; jugal lobe large, occupying most of anal area; hindwing without subcostal vein but with 3rd anal vein. Gaster with cylindrical petiole usually composed of sternum 1, but displaced tergum 1 forming part of petiole in some *Ammophilini*; tergum 1 without a lateral carina; pygidial plate absent. Male genitalia with volsella having a cuspis and (usually) a movable digitus. Sexual dimorphism pronounced. Males generally with a narrower face than females, and with orbits often converging below, cf. in females often parallel. Clypeus in females modified in accordance with prey-capture and nesting mode, in males adapted for holding female during copulation.

**Final-instar larva.** Integument with spinules present. Head with parietal bands well developed, antennal papilla absent; labrum bilobed, biconvex; mandibles short, stout, with 4 teeth; galea as long as maxillary palps or longer; spinneret a transverse slit with prominent raised lips.

**Remarks.** The subfamily Sphecinae is mostly subtropical, only four of the nineteen genera occurring in Europe. The one taxon established in New Zealand, *Podalonia tydei suspiciosa* (tribe *Ammophilini*), is of Australian origin. Five species of Sceliphri are frequently intercepted as casual visitors.

### Genus *Podalonia* Fernald

*Podalonia* Fernald, 1927, p. 11. Type species *Ammophila violaceipennis* Lepeletier, 1845, designated by ICZN Opinion 857 (Melville 1968).

*Podalonia* Spinola, 1851, suppressed in same Opinion.

*Psammophila* Dahlbom, 1842, p. 2. Type species *Ammophila affinis* W. Kirby, 1798, designated by Fernald (1927, p. 11, as *Psammophila affinis*). Not *Psammophila* Brown, 1827.

**Diagnosis.** Large, red and black wasps.

Head. Face short and broad. Frons subparallel in female, the eyes not converging below, but converging below in male. Mandibles in female large and very long, with up to 3 mesal molar teeth, in male shorter and strongly curved, with only a single mesal molar tooth.

Thorax. Scutum with admedian lines contiguous. Labium, maxillae, and their palps very long in both sexes. Forewing with 3 submarginal cells, the 2nd joined by both recurrent veins. Middle and hind legs very long; foretarsus of female with a very large rake; middle tibia with 2 spurs.

Metasoma with petiole cylindrical, composed only of 1st sternum; petiole socket broadly bounded ventrally by propodeal sternite; 1st sternum (petiole) reaching base of 2nd sternum. Tergum 1 in dorsal view high and short, in lateral view with spiracle located basad of sternum I apex.

**Remarks.** Genus *Podalonia* occurs in most parts of the world except South America. All species are confined to sandy soils exposed to sunlight. The single-celled underground nests are stocked with soil-living lepidopterous larvae. Only one species occurs in New Zealand.

### *Podalonia tydei* (Le Guillou)

*tydei* Le Guillou, 1841, p. 319 (*Ammophila*); Canary Is, Madeira.

*madeirae* Dahlbom, 1843 (*Psammophila*).

*Podalonia tydei* occurs in southern Europe, Asia, North Africa, Australia, and New Zealand. Bohart & Menke (1976) recognised four subspecies, viz. *senilis* (Dahlbom, 1843), *argentata* (Lepeletier, 1845), *suspiciosa* (F. Smith, 1856), and *apakensis* (Tsuneki, 1971b). The single subspecies present in Australia and New Zealand, *suspiciosa*, occurs nowhere else. A full synonymy for *P. tydei* is given in Bohart & Menke (1976).

### *Podalonia tydei suspiciosa* (Smith)

Fig. 1

*suspiciosa* Smith, 1856, p. 241 (*Ammophila*); Australia, New Zealand. McCarthy, 1917, pp. 195–200. Chandler, 1925, pp. 107–114. Riek, 1970, p. 940 (*Podalonia*). Bristowe, 1971, pp. 42–44. Bohart & Menke, 1976, p. 145 (as ssp. of *tydei*). Callan, 1979, p. 32. Cardale, 1985, p. 228. Valentine & Walker, 1991, p. 41.

**Diagnosis. Female.** (1) Head, metasoma, legs, and distal half of metasoma (terga 4–6) black; proximal half of metasoma (except petiole) fulvous-red; head, metasoma, and

coxae with long, silver-white hairs. (2) Mandible large and very long, with 3 mesal molar teeth; apex unidentate, acute. (3) Pronotum costate anterodorsally and on all lateral aspects. (4) Propodeum without an enclosure. (5) Metasoma with petiole long, thin, cylindrical, much longer than hind coxa, composed only of 1st sternum, bent up at base of tergum 1, reaching to base of sternum 2. (6) Epipygium without carinae or sulci and with only a few, very small hairs laterally.

**Male.** As for female except as follows. (2) Mandible with 1 large, acute, mesal molar tooth; apex unidentate, acute, strongly curved inwards to parallel mesal tooth. (5) Metasoma with petiole very long, cylindrical, longer than hind femur. (6) Genitalia as in Fig. 72.

**Description. Female** (Fig. 1). Body length 15.8–22.2 mm; forewing length 8.5–13.5 mm.

**Colour.** Head black except for mandibles (dark red, with apex black); mesosoma and legs black; forewing amber-tinted, apically with a dusky cloud; all wing veins amber; metasoma with petiole and segments posterior to III black, remainder (i.e., most of proximal half) fulvous red.

**Vestiture.** Head covered with short, decumbent silver pubescence and long, erect silver-white hairs, especially between antennal socket and eye on frons, proximal half of clypeus, occiput, and gena. Thorax dorsally with scattered fine, short, erect white hairs; pleura and propodeum with long, fine, wispy silver-white hairs. Legs with long, erect silver hairs and decumbent silver pubescence. Metasoma mostly with little vestiture, but base of petiole with long, erect silver hairs.

**Structure.** Head. Surface shagreened and unevenly punctured; hind ocelli smaller than anterior ocellus, widely spaced – POL:OOL about 7:10; median frontal line entire; frons very wide, almost parallel-sided; inner margins of eyes straight, not converging below. Antennal sclerites separated by a very short space, situated lower on face than in male, below maximum diameter of face. Antenna with scape roughly oblong-ovate, curved, somewhat dilated apically; flagellomere I clearly longer than any other antennal article. Clypeus large, with disc gibbous and median lobe very broad, truncate, its apical margin evenly rectilinear. Mandible with 3 mesal molar teeth, the 1st acute, the 2nd very large, obtuse, the 3rd a mere swelling; apex unidentate, acute.

**Mesosoma.** Pronotum rounded, costate anterodorsally and laterally, dorsolaterally and lateroventrally. Collar punctate dorsally. Scutum areolate-rugose to rugose-punctate; admedian lines contiguous, prominent; notaulus indistinct; parapsidal line fine. Scutellum longitudinally carinate, rugose-punctate. Metanotum areolate-rugose.

Mesopleuron and propodeum heavily rugose-punctate; propodeal enclosure absent.

**Legs.** Foretarsus with a large rake composed of very long, stiff, black bristles; outer apices of fore tarsomeres prolonged. Middle leg long, slender. Hind leg very long and slender.

**Wings.** Stigma small. Apex of marginal cell bluntly rounded. Venation as in Fig. 54.

**Metasoma.** Petiole much longer than hind coxa, sinuous, bent upwards at base of tergum 1, reaching base of sternum 2. Spiracle of tergum 1 basad of middle. Tergum 6 evenly curved, without ridges or grooves, minutely colliculate, with only a few scattered, very shallow punctures. Gastral venter smooth. Hypopygium laterally with 5 or 6 long black hairs.

**Male.** Body length 10.2–17.5 mm, forewing length 5.4–11.4 mm.

**Colour.** Similar to female.

**Vestiture.** Similar to female, but thoracic dorsum as well as pleura and propodeum covered with long, erect silver hair.

**Head.** Vestiture, surface sculpture, and ocelli similar to female. Eyes converging below; inner margins straight. Frons cuneiform, constricting evenly ventrad, together with clypeus appearing very long and narrow – UID 44, MID 38, LID 29. Antenna with scape oblong-ovate; flagellomere I the longest antennal article. Clypeus large, simple; apical margin uniformly curved, very shallowly concave at centre. Mandible with only 1 large, acute mesal molar tooth, unidentate; apical tooth acute, curved inwards and subparallel with molar tooth.

**Mesosoma** with pronotal sides costate.

**Metasoma** with long, erect silver hair on proximal half of petiole, otherwise almost without vestiture. Petiole longer than in female, exceeding length of hind femur. Genitalia as in Fig. 72.

**Type data.** Holotype (BMNH; not seen): adult female, from "North West Coast, Swan River, Hunter River" (Western Australia).

**Material examined.** 560 adults (318 females, 252 males), 27 larvae, and 11 pupae from coastal sand dunes at Spirits Bay, Ninety Mile Beach, Waiti Beach, Papamoa Beach, Kaituna Spit, Maketu, Little Waiti Beach, and Piripai.

ND, CL, BP / —.

**Biology** (in New Zealand). Habitat. *Podalonia tydei suspiciosa* frequents areas of exposed sand, especially coastal dunes.

**Activity.** Adults are mostly active in strong sunlight, disappearing when conditions become overcast.

**Mating.** Mating occurs in early March, when mating couples are frequently seen on the foredune between Papamoa Beach and Little Waihi Beach (BP). Couples often remain together for 15–20 minutes. A male alights on a receptive female and grips her with his mandibles around her neck. His body is directly above hers. On the ground, the male attempts to engage her genitalia, twisting the apex of his abdomen over the side of the female's. The ends of their abdomens twist about, often without copulation taking place. At times they engage briefly, then disengage. They walk about, the male all the time attempting to mate. This is sometimes difficult, because the apex of the abdomen of the shorter male ends short of that of the female. The couples frequently fly briefly then alight, when the male again attempts to copulate. Males sometimes alight fleetingly on non-receptive females, flying away a second or two later.

**Adult feeding.** Adults of both sexes take nectar from flowers of *Hypochoeris radicata* (Compositae) (16 observations: Papamoa Beach, Kaituna River mouth spit at Maketu, and Little Waihi foredune, BP).

**Hunting.** *P. t. suspiciosa* females fly close to the ground, and walk over the sand searching for likely places to begin digging for larvae of *Agrotis* (Lepidoptera: Noctuidae); they often use antennal tactile chemoreception to find a larva's diurnal retreat. Typically a large hole about 90 × 40 mm is dug near dune plants growing in loose sand. The female wasp digs from several sides of the hole. It sometimes breaks off digging at 5–10-minute intervals to run 2 to 3 m away to dig a 'false' burrow (see below). Two or three such burrows are dug. At other times it uncovers the *Agrotis* larva without breaking off to make a side burrow.

**Prey capture.** The *Agrotis* larva, active on the surface at night, spends the day curled up in the sand. When *P. t. suspiciosa* finds a larva it is dragged to the surface and stung about seven times, starting in the thoracic venter and ending in the first three abdominal segments.

**Paralysis.** Paralysis is strong, and the prey does not recover. When taken from the cell the prey makes occasional small twitching movements.

**Prey carriage.** Females straddle the prey and carry it forwards over the ground, head first and venter up. The prey is grasped by the wasp's mandibles in usually the first or second abdominal segment, occasionally the third or fourth, and is supported by the wasp's forelegs, which pass beneath the caterpillar and cradle it. The large caterpillar extends a considerable distance both in front of the wasp and behind (Fig. 115a). The wasp runs a few centimetres to 5 m then hangs the caterpillar over a leaf (12 observations)

or under a leaf (five observations), and digs a shallow nest. It then returns for the caterpillar and walks with it to the nest, plunging inside without stopping at the entrance. Sometimes it digs the nest before finding prey. Then, when it finds a caterpillar, it rapidly stings it to paralysis and walks with it to the nest, which it enters without stopping at the entrance, walks to the end, positions the caterpillar, and lays an egg on it.

**Nidification formula.** (3) Prey-nest-egg-closure and (4a) Nest-prey-egg-closure.

**Digging.** The fore tarsi rake dry sand particles backwards, the legs moving rapidly and in unison, so that showers of sand (rather than a constant stream) shoot out behind the wasp. Facing the burrow, the wasp digs steadily forwards until after a few minutes, and still facing forwards, it reverses to remove accumulated sand.

Nests (Fig. 115b) are dug only in sand. The nest is shallow, single-celled, and slopes at a low angle of 15–20°. It is 35–65 mm long, 10–12 mm wide at the entrance, and occasionally expanded at the end if the caterpillar is stored curled, although usually the caterpillar is straight. It is made in almost dry sand, the burrow's shape seemingly being maintained by the presence of fibrous plant roots.

The burrow entrance is a round hole 10–12 mm wide. From this a low, elliptical mound about 100 mm long and 50 mm wide extends out. After the wasp has laid its egg on the caterpillar, it immediately begins filling in the burrow, raking in sand from within the burrow entrance. It begins filling in the burrow 14–20 seconds after taking in the caterpillar. It digs in the burrow entrance, just behind the caterpillar, facing out. After the burrow is filled the wasp sends sand showering over the burrow entrance from several different directions, seemingly to camouflage the entrance, which is thus well disguised.

Nests are always single-celled, and are provisioned with a single prey item. The nest is left open during provisioning. Nests are dug before prey capture (six observations), but more usually after prey capture (14 observations).

One individual at Kaituna River mouth spit, at 1700 h NZDT on 12 March 1991, dug a hole 12 mm wide, 60 mm long, sloping at 15° in almost dry sand containing fibrous roots of *Hypochoeris radicata*, *Calytstegia saldanella*, and *Muehlenbeckia* sp. It then dug a huge, irregular hole of 90 × 40 mm. In the course of digging this crater the wasp went away on three occasions, at 5–10-minute intervals, to dig three small burrows 2.3, 3.0, and 1.3 m from the very large hole. It eventually uncovered an *Agrotis inominata* caterpillar under one side of the crater. This it immediately stung to paralysis, then transported it directly without pausing into an open, previously dug burrow in a different direction to the false burrows.

The large craters made by females when they search for caterpillars are a conspicuous feature of sand inhabited by *P. t. suspiciosa*.

Life history. The white egg, 2.0 mm long by 0.9 mm wide, usually is laid low on the side of the fourth abdominal segment (Fig. 115c). Sometimes it is laid on the side of the third abdominal segment. The egg is cemented to the caterpillar at its upper end, and the lower half hangs free slightly away from the caterpillar near the second proleg. The egg hatches in 2–3 days, and the larva finishes feeding in 10 days.

### Genus *Sceliphron* Klug

*Sceliphron* Klug, 1801, p. 561. Type species *Sphex spirifex* Linnaeus, 1758, designated by Bingham (1897, p. 235).

*Pelopoëus* Latreille, 1802–03, p. 334. Type species *Sphex spirifex* Linnaeus, 1758, designated by Latreille (1810, p. 438, as *Pelopoëus spirifex* Fab[ricius, 1804]).

*Pelopaëus* Latreille, 1804, p. 180. Lapsus, or unnecessary emendation of *Pelopoëus* Latreille.

*Sceliphrum* Schulz, 1906, p. 192. Unnecessary emendation of *Sceliphron* Klug.

**Diagnosis.** Head with relatively thick vestiture including much erect hair; postocular area not elongate. Antenna inserted relatively high on face, usually dorsal of midway; antennal sockets separated from clypeus by at least half their diameter; flagellomere 1 usually longer than 2; male flagellum without placoids. Clypeus relatively large, 0.5–0.8× as long as wide, with disc convex; apical margin in females sharp-edged, with pair of broad, flat, obtusely rounded lobes separated by a V-shaped median excision; male clypeus bilobed or with a median lobe, its apical margin sometimes rectilinear or gently concave. Mandible simple, but with an inner subapical tooth in some females. Mouthparts short, with 3rd maxillary palpomere swollen asymmetrically. Hypostomal carina ending near mandibular socket in subg. *Sceliphron*, evanescent about halfway to mandibular socket in *Prosceliphron*; occipital carina ending just short of hypostomal carina. Pronotum short; propodeum moderately long, with a U-shaped dorsal enclosure defined at least apically by a broad furrow; propodeal spiracular groove absent. Wings with marginal and 3rd submarginal cells relatively close to apex, 2nd submarginal cell broader than long and receiving both recurrent veins (Fig. 55); hind wing anal veins long, the 3rd well separated from wing margin. Middle coxae practically contiguous; tibiae not spinose, but middle tibia with 2 apical spurs; intersegmental membrane of tarsi with lamel-

late oval pads ventrally; front tarsal claws with only 1 tooth; female fore tarsus without a comb (rake). Petiole length 2.5–3.6× hind coxal length, 1.5–2.2× length of hind basitarsus. Male tergum 8 with cerci (only) in subg. *Prosceliphron*; sternum 8 broadly triangular; aedeagus ventrally with apical teeth.

**Remarks.** These wasps are distinctive, with the body typically marked in black and yellow and the petiole (sternum I of the metasoma) very thin, long, and parallel-sided (Fig. 2). Females make mud cells which they fill with spiders. The genus is cosmopolitan, and several species have been widely distributed by man.

Two subgenera are recognised: the nominate subgenus, and subgenus *Prosceliphron* van der Vecht, 1968, p. 192 (type species *Pelopaëus coromandelicus* Lepelletier, 1845, by original designation, as *Sceliphron coromandelicum*).

Although no *Sceliphron* is currently established in New Zealand, at least seven species have been recorded as imported, of which five—*S. (S.) assimile* (Dahlbom), *S. (S.) caementarium* (Drury), *S. (S.) spirifex* (Linnaeus), *S. (S.) laetum* (Smith), and *S. (P.) formosum* (Smith)—have been intercepted repeatedly, sometimes as temporary colonists (Harris 1987, 1992; Early & Townsend 1993). Harris (1992) recorded occasions in which live, diapausing prepupae of *laetum* and *formosum*, imported into New Zealand in mud nests on second-hand cars that had been stored outside, were able to develop into adult wasps in an unheated room in Dunedin. Since then additional prepupae of *laetum*, introduced into Dunedin on second-hand cars from Australia, have developed into adult wasps (A.C. Harris, unpubl. data). Early & Townsend (1993) recorded adult *assimile* flying in widely separated parts of New Zealand. *S. assimile* is now widely established in the Pacific (Early & Townsend 1993), while *formosum*, *laetum*, and *caementarium* are established in Australia, the first two as endemics. It therefore seems likely that species of *Sceliphron* will continue to be encountered in New Zealand, and that one or other of them will eventually become established here.

Van der Vecht & van Breugel (1968) provided a good key to the species of subgenus *Sceliphron*. The basic biology is summarised in Bohart & Menke (1976), and Naumann (1983) described the biology of *laetum*, *formosum*, and *caementarium* in Australia.

### Subfamily PEMPHREDONINAE

**Adult.** Medium-sized to tiny species with a greatly enlarged forewing stigma and a somewhat square or cuboid head. Frons usually broad; eyes generally widely sepa-

rated; inner orbits usually subparallel. Antennae low on face or near middle; females with 12 antennal articles and males with 13. Clypeus often very short. Mandible without a notch or step on exteroventral margin; apex with 2-5 teeth. Mouthparts short, the maxillary palpi with 6 articles and the labial palpi with 4 articles. Pronotal collar short, usually high, often transversely carinate; admedian lines separated. Middle tibia with 1 apical spur. Gaster sessile or petiolate, the petiole, when present, composed only of sternum 1. Pygidial plate present or absent.

**Final-instar larva.** Body integument usually with spinules. Spinneret distinctly paired, although the openings, occurring at the ends of 2 prolongations, may be connected by a narrow slit. Maxilla directed medially; galea smaller than maxillary palp, sometimes vestigial. Mandibles short and broad, with 4-6 teeth (fewer in small species). Antennal papilla usually absent (although in New Zealand *Spilomena* species it is unusually large).

**Remarks.** Females provision nests with Homoptera, Thysanoptera, or Collembola.

Evans (1958a, p. 127) gave as a subfamily character "antennal orbits relatively large, the three sensillae arising directly from the membrane of the orbit, which may be slightly elevated." This does not apply to the New Zealand species of *Spilomena*, in which the antennal papilla is unusually large.

The subfamily is divided into tribes Psenini and Pemphredonini, of which only the latter is represented in New Zealand, by genus *Spilomena* (subtribe Stigmina).

### Genus *Spilomena* Shuckard

*Celia* Shuckard, 1837, p. 182. Type species *Stigmatroglydites* van der Linden, 1829, by original designation.

*Spilomena* Shuckard, 1838, p. 79. New name for *Celia* Shuckard (preoccupied by *Celia* Zimmerman, 1832).

*Microglossa* Rayment, 1930, p. 212. Type species *Microglossa longifrons* Rayment, 1930, by original designation.

*Microglossella* Rayment, 1935, p. 634. New name for *Microglossa* Rayment (preoccupied by *Microglossa* Voigt, 1831).

*Taialia* Tsuneki, 1971, p. 10. Type species *Taialia formosana* Tsuneki, 1971, by original designation.

(Above synonymy proposed by Bohart & Menke 1976.)

**Diagnosis (partial).** **Adult.** Very small species, not exceeding 3.5 mm in maximum length. Antennae inserted

very low on frons, and lower frons with a short ridge. Clypeus without silver vestiture, narrow, strongly convex medially; anterior border projecting only a little. Occipital carina absent. Malar space short to moderate. Mandible bidentate. Pronotum with a transverse carina; notauli indistinct; episternal sulcus present or absent, when present with the (apparent) episternal sulcus displaced forwards, originating at upper end beneath posterior apex of pronotal lobe; omaulus, hyposternaulus, and signum present, acetabular carina and scrobal sulcus absent. Female foretarsus without a rake (or pecten). Hind tibia without posterior spines. Stigma large, half size of submarginal cell;  $R_1$  extending to end of marginal cell; 2 submarginal cells present; hindwing M diverging at cu-a (not segregated from Cu), its posterior margin fringed with relatively long hairs. Petiole absent or short, i.e., no longer than broad when viewed dorsally.

**Final-instar larva.** Body cylindrical, with posterior end narrow and attenuated; anus terminal, central; supra-anal and subanal lobes subequal. Spiracles with subatrium narrow. Head without coronal suture parietal bands, and almost without setae. Antennal papilla unusually large. Mandibles crowded with 5 large teeth.

Cocoon pure white, very thin, bag-like, completely filling the cell and lining it.

**Remarks.** *Spilomena* is represented in most faunal regions. When nesting these species excavate pith in twigs and also remove frass in abandoned galleries of wood-boring insects. Females provision their nests with coccids, psyllids, aphids, and thrips. Some species are subsocial.

Mr J. Vercoe (pers. comm.) reports that *Spilomena* species are familiar to him and to other house painters because they "fly out of their burrows into one's face when one is painting a weatherboard house with borer in it."

The New Zealand species were revised by Vardy (1987).

### *Spilomena earlyi* new species

**Diagnosis. Female.** (1) Mesopleuron with an episternal sulcus. (2) Pygidium laterally compressed. (3) Epipygium with 2 low, very short, approximate longitudinal carinae at apex only. (4) Head rotundly subquadrate, with inner orbits subparallel. (5) Clypeus with a short, median incision on apical boundary. (6) Scutellum with transverse anterior sulcus entire, with only low cross-carinae, not broken up into distinct foveae by high cross-carinae. (Note: character 3 is decisive.)

**Male.** (1) Mesopleuron with an episternal sulcus. (2) Head in front view rotundly subquadrate. (3) Inner orbits subparallel. (4) Clypeus with a small incision centrally, on

apical border. (5) Frons without distinct yellow markings; clypeus brown, not fulvous yellow, never appearing intensely whitish. (6) Transverse anterior sulcus of scutellum entire, with very low cross-carinae only, never broken up into series of foveae. (Note: character 5 is decisive.)

**Description. Female.** Body length 2.3–3.1 mm; forewing length 1.5–2.3 mm.

**Colour.** *Warm localities north of latitude 38°S:* head, thorax, and propodeum largely dark brown; clypeus, mandibles, scape, pronotal lobe posteriorly, tegulae, and legs pale fulvous yellow; antennal pedicel, flagellum, and gaster castaneous. *Cooler localities, especially South Island south of latitude 43°S:* head (including clypeus and scape), thorax (including entire pronotal lobe, tegulae, forewing stigma, and wing veins), propodeum, and gaster very dark brown; mandibles, coxae, posterolateral aspects of trochanters, femora, tibiae, and tarsomeres 4 and 5 dark brown; tarsomeres 1–3 and sometimes anterolateral aspects of trochanters and tibiae variably infuscated fulvous-brown.

**Vestiture sparse.**

**Structure.** Head in frontal view rotundly subquadrate, nitid, minutely colliculate; POL:OOL as 4.5:7.2. Inner orbits subparallel. Lower frons with a weak, low, median longitudinal carina extending onto upper part (only) of subtriangulate median raised area between antennal sclerites. Clypeus narrow, its apical boundary with a short median incision similar to that of *nozela*. Mandible bidentate, with anterior (upper) tooth obtuse, rounded and posterior (lower) tooth acute, longer. Antennae with pale pubescence. FD 35.8, TFD 40.0, UID 22.0, MID 23.5, LID 23.0, SFD 22.0, FD/TFD 0.9, SFD/TFD 0.5, POL/OOL 0.6.

**Thorax.** Dorsum mostly minutely colliculate; transverse carina of pronotal dorsum strong, the area behind it relatively smooth, with low longitudinal carinules. Pronotal sides with a relatively deep, nitid, horizontal groove. Scutum with a series of very short, small, parallel longitudinal carinae on posterior boundary. Scutellum with transverse anterior sulcus entire, with only low cross-carinae. Metanotum laterally scrobiculate. Mesopleuron with episternal sulcus, omaulus, anterior part of hyposternaulus, and signum.

**Propodeum.** Dorsum rugose, bearing 2 irregular trunk carinae with low dendritic carinae; dorsal area not separated from sides and declivity by carinae. Pronotal sides posteriorly substrigulate; declivity with only low, indistinct carinae.

**Wings.** Forewing with abscissa 1 of radial vein 0.25× length of abscissa 2 (Fig. 56).

Metasoma smooth, highly nitid; pygidium laterally compressed; epipygium with 2 low, very short, approximate longitudinal carinae at apex only.

**Male.** Body length 2.1–2.9 mm; forewing length 1.4–2.0 mm.

**Colour.** *Warm localities north of latitude 38°S:* head, thorax, and abdomen largely very dark brown; mandibles whitish-fulvous yellow; clypeus, scape, pedicel, posterior edge of pronotal lobe, tegula, subalar area, and legs pale fulvous yellow; antennal flagellum and gaster castaneous to dark brown. *Cooler localities, especially south of latitude 43°S:* head, thorax, and propodeum very dark brown; mandible, antenna, pronotal lobe, tegula, legs, and gaster brown to dark brown; clypeus never intensely whitish.

**Vestiture sparse.**

**Structure.** Head in frontal view rotundly subquadrate, nitid, minutely colliculate; POL:OOL as about 1:2. Inner orbits subparallel. Lower frons with a low median longitudinal carina, this not extending onto disc of subtriangulate raised area between antennal sclerites. Clypeus narrow, its apical border medially with a small incision. Mandible bidentate, with upper tooth obtusely rounded and lower tooth of similar width but a little longer, acute. Antennal flagellomeres with numerous short, oblique, forward-directed bristles. FD 27.5, TFD 32.5, UID 18.0, MID 19.0, LID 17.5, SFD 17.5, FD/TFD 0.8, SFD/TFD 0.5, POL/OOL 0.5.

Mesosoma and metasoma similar to female; pygidium conoid; epipygium without a median flat area and without carinae.

**Type data.** Holotype (LCNZ): female, MC, Lincoln College, 2–4 December 1987, J.W. Early. Paratypes: 238 adults (219 females, 165 males; 1 NZAC, 1 FCNZ, 17 LCNZ, 401 OMNZ) from Whangarei; Auckland; Te Kuiti; Taumarunui; Ohakune; Dawson Falls, Mt Taranaki [Mt Egmont]; Maxwell, Wanganui; Upper Hutt; Iwirua Bay, Picton; Prices Valley, Banks Peninsula; Lincoln University campus; Mt Cook, Hermitage; North East Valley, Dunedin; Hokonui Hills, Gore.

ND, AK, WO, TO, RI, TK, WI, WN/SD, MC, MK, DN, SL.

**Material examined.** Type series only.

**Biology.** Similar to that described below for *S. nozela*. Mr J. Early found this new species at Lincoln MC, and observed it in 1987, 1988, and 1989 at flowers similar to the ones described for *S. nozela* and *S. elegantiula*. It took prey to *Anobium punctatum* holes.

## *Spilomena elegantula* Turner

*elegantula* Turner, 1916a, pp. 211–220, pl. 21 (*Spilomena*); Australia, New Zealand. Cardale, 1985, p. 232. Vardy, 1987, pp. 254–255, fig. 4, 8, 11, 15. Valentine & Walker, 1991, p. 41.

**Diagnosis. Female.** (1) Mesopleuron without an episternal sulcus. (2) Pygidium short, wide, dorsoventrally compressed, almost flat, shelf-like. (3) Head elongate, oblong, in frontal view with sides above eyes rising vertically before curving to mid vertex.

**Male.** (1) Mesopleuron without an episternal sulcus. (2) Frons with a yellow triangular spot bounded by eye, clypeus, and antennal sclerite (or antennal socket), the 'hypotenuse' facing mesad. (3) Lower frons, clypeus, mandible, gena, and hypostoma bright yellow. (4) Metasoma with 7th tergum mid-dorsally flat, very broad, its apical outline broadly convex (cf. dorsally curved and conoid).

**Description. Female.** Body length 2.3–3.0 mm; forewing length 1.8–2.3 mm.

Colour. Black to dark brown except for the yellow to yellow-fulvous clypeal apex, mandible, trochanters, fore and middle tibiae, and tarsi.

Vestiture very sparse.

Structure. Head markedly elongate, in frontal view vertically rectangular, oblong; sides above eyes rising almost vertically before curving to mid vertex; surface nitid, punctulate, minutely colliculate; POL:OOL as about 5:8. Eyes very long and narrow. Lower frons between antennae triangular, raised, without a median longitudinal carina. Clypeus with submedian obtuse longitudinal carinae continuous with obsolete ridges on apical part of median raised area of lower frons; apical margin medially with a broad, very shallow concavity (or emargination). Mandible lacking a mesal molar tooth, bidentate, with upper tooth broad, obtuse and posterior tooth slightly narrower, longer, acute. FD 41, TFD 39, UID 23, MID 26, LID 21, SFD 21, FD/TFD about 1.05, SFD/TFD about 0.5, POL/OOL about 0.6.

Thorax. Surface nitid, minutely colliculate. Pronotum anterodorsally with a transverse scrobiculate line; posterodorsal transverse carina gently arcuate, directed forwards laterally; posterior side scrobiculate. Mesothorax and metathorax smooth. Mesopleuron lacking all carinae and sulci except signum (e.g., episternal sulcus absent). Transverse anterior sulcus of scutellum not bisected by strong cross-carinae. Metapostnotum with longitudinal carinae very weak or absent.

Propodeum dorsally strigulate, the sides with a narrow

horizontal groove.

Wings. Abscissa 1 of forewing radial vein 0.2–0.3× as long as abscissa 2 (Fig. 57).

Metasoma highly nitid; surface smooth; pygidium very broad, short, almost flat, with disc slightly concave.

**Male.** Body length 2.2–2.9 mm; forewing 1.4–2.2 mm.

Colour largely dark brown to black; tegulae, wing veins, apical flagellomeres, and 5th tarsomeres pale brown to fulvous. The following yellow: lower frons, including lateral triangular spot bounded by eye, antennal sclerite, and clypeus; subantennal sclerite, plus entire median raised area between antennal sclerites; clypeus; mandible; maxilla; labium; molar area; gena; hypostoma; antennal scape, pedicel, and flagellum except last 2 flagellomeres; prosternum and pronotal lobe; fore and middle legs; left hind tibia, tarsomeres 1–4, and femur apically. In cooler areas, antennal flagellomeres darken basad.

Vestiture very sparse.

Structure as for female, except as follows. Head very much less elongate, in frontal view not appearing vertically oblong (or rectangular), not extending vertically above eyes before curving to mid vertex, wider than high; FD/TFD about 0.9, SFD/TFD about 0.6. Frons widening clypead. Apical margin of clypeus convex, broad but very shallowly emarginate, medially arcuate, with obtuse submedian longitudinal ridges continuous with those on apex of raised median part of frons. Antennal flagellomeres with numerous short, oblique, forward-directed bristles. FD 31.8, TFD 33.8, UID 19.3, MID 21.8, LID 20.3, SFD 19.3.

Mesosoma and metasoma similar to female.

**Type data.** Holotype (BMNH; not seen): female, Kuranda, Queensland, Australia.

**Material examined.** 190 adults (113 females, 77 males), 5 larvae, and 5 pupae.

ND, AK, CL, TO, TK, RI, WI, WN/NN, MC, WD, DN, SL.

**Biology.** Similar to that described below for *S. nozela*.

Vardy (1987) recorded *S. elegantula* removing *Thrips obscuratus* (Thysanoptera: Thripidae) from lemon flowers and nesting in vacated burrows of the beetles *Anobium punctatum* and *Euophryum confine*. Mr J. Early (pers. comm.) found this species at the flowers listed under *S. nozela* (below). He noted that *S. nozela* sometimes nests in *Hadrobregmus magnus* holes when the smaller *S. elegantula* is nesting in holes of *A. punctatum*, which are of a slightly smaller diameter. In my own (less comprehensive) observations abandoned galleries of both anobiid species were nested in by either *Spilomena* species.

## *Spilomena emarginata* Vardy

*emarginata* Vardy, 1987, pp. 255–256, fig. 5, 6, 9, 12, 15 (*Spilomena*); New Zealand. Valentine & Walker, 1991, p. 41.

**Diagnosis. Female.** (1) Head clearly transverse, much wider than long. (2) Clypeus with a broad, deep, central incision (emargination) occupying a little over 0.3× its width. (3) Mesopleuron with an episternal sulcus. (4) Pygidium laterally compressed. (5) Epipygium with raised, longitudinal carinae on distal 0.7 very close together, almost (but not quite) appressed, not enclosing a 'pygidial shield.' (6) Transverse anterior groove of scutellum bisected by strong cross-carinae. (7) Mandible bidentate, with upper tooth straight-sided, acute (not rounded). (8) Median carina on lower frons large, occupying most of subtriangular median raised area between antennal sclerites as a steep-sided, acute ridge.

**Male.** (1) Mesopleuron with an episternal sulcus. (2) Head rotund but transverse (wider than long), the frons gradually widening clypead. (3) Clypeus with a broad, deep central incision (emargination) on apical boundary. (4) Transverse anterior sulcus of scutellum scrobiculate, divided into foveae by strong cross-carinae.

**Description. Female.** Body length 2.7–3.0 mm; forewing length 2.3–2.6 mm.

Colour. *North Island, warmer localities:* head, thorax, and propodeum largely dark brown; mandible, clypeal margin, antenna, wing veins, tegulae, and apical part of pronotal lobe fulvous yellow; gaster fulvous brown. *South Island, cooler areas, and south of latitude 45°S:* as above, but pronotal lobe posteriorly, tegula, and legs (except some parts of femora) fulvous and clypeus, antennae, and parts of femora fulvous brown to brown.

Vestiture very light.

Structure. Head in front view clearly broader than long, markedly transverse, nitid, minutely colliculate; POL: OOL as 1:2. Frons widening uniformly clypead (inner orbits divergent clypead); median carina on lower frons large, occupying most of subtriangular median raised area between antennal sclerites as an acute, high, steep-sided ridge. Clypeus narrow, with lateral lobes resulting from a large, deep, median concavity (or emargination) occupying slightly over 0.3× its width. Mandible bidentate, with upper tooth acute, straight-sided and lower tooth narrower, a little longer. Antennae finely pubescent. FD 38.5, TFD 47.7, UID 26.0, MID 29.4, LID 32.0, SFD 26.0, FD/TFD 0.8, SFD/TFD 0.5, POL/OOL 0.5.

Thorax. Dorsum mostly minutely colliculate; prosternum, pronotum laterally, and episternum longitudinally

substrigulate. Transverse carina of pronotal dorsum high, steep-sided, weakly inclined forwards laterally, bounded posteriorly by a scabriculous area; pronotal sides with a distinct, narrow, horizontal groove. Scutum with a row of short, weak, more or less longitudinal carinae on posterior boundary. Scutellum with transverse anterior sulcus scrobiculate, bisected by a series of strong cross-carinae. Metanotum laterally substrigulate. Mesopleuron with episternal sulcus, omaulus, anterior part of hypersternaulus, and signum.

Propodeum with dorsal 'enclosure' area demarcated by an irregular carina, sometimes 2 carinae; dorsum and declivity with transverse striae (sometimes a little rugose); sides transversely substrigulate (occasionally rugose).

Wings. Abscissa 1 of forewing radial vein 0.70–0.75× length of abscissa 2 (Fig. 58).

Metasoma with pygidium laterally compressed; epipygium with raised longitudinal carinae on distal 0.7 very close together, almost appressed, not enclosing a 'pygidial shield.'

**Male.** Body length 2.6–3.0 mm; forewing length 2.2–2.6 mm.

Colour. Head, thorax, and propodeum largely black; most of clypeus, mandible, antennal scape and pedicel, tegula, pronotal lobe, and legs pale fulvous; antennal flagellum and forewing stigma brown; gaster dark brown.

Vestiture sparse.

Structure. Head wider than long, less transverse than in female. Apical margin of clypeus with median incision large, wide and deep, but shorter than in female, less than 0.35× clypeal width. Antennal flagellum with short, obliquely forward-directed bristles.

Mesosoma and metasoma similar to female, but epipygium without longitudinal carinae.

**Type data.** Holotype (NZAC; seen): male, NN, Nelson, Cawthron Institute, 30 November 1963, working at *Anobium* exit holes.

**Material examined.** Holotype, plus 245 non-type adults (163 females, 82 males), 6 larvae, and 4 pupae.

ND, AK, CL, TK, TO, WI, WN/NN, WD, MC, DN, SL.

**Biology.** Much as described for *S. nozela*. Vardy (1987) noted *S. emarginata* "Working at *Anobium* exit holes", and Mr J. Early (pers. comm.) has found it in similar situations.

## *Spilomena nozela* Vardy

Fig. 3

*nozela* Vardy, 1987, pp. 250–254, fig. 1, 2, 7, 10, 13–15 (*Spilomena*); Australia, New Zealand. Valentine & Walker, 1991, p. 41.

**Diagnosis. Female.** (1) Mesopleuron with an episternal sulcus (Fig. 14). (2) Pygidium laterally depressed. (3) Epipygium with a narrow pygidial shield delineated by parallel, raised, sharp-edged carinae extending from base to apex. (4) Head in frontal view rotundly subquadrate. (5) Frons broad, with sides subparallel, not widening clypead (inner orbits subparallel).

**Male.** (1) Mesopleuron with an episternal sulcus. (2) Frons uniformly dark brown, without a large frontolateral yellow spot extending along orbit between eye and antennal sclerite. (3) Head wider than long, with frons subparallel, not widening clypead (inner orbits subparallel). (4) Transverse anterior sulcus of scutellum with only small, low cross-carinae, not bisected by cross-carinae of similar height to surrounding dorsum. (5) Clypeus usually appearing intensely whitish.

**Description. Female** (Fig. 3). Body length 2.2–3.1 mm; forewing length 2.2–2.8 mm.

**Colour.** *Warmer North Island localities:* head, thorax, and propodeum largely castaneous to fulvous-brown; mandible white and fulvous-yellow; antenna fulvous to brown; palpi, legs, tegula, subalar area, and pronotal lobe fulvous; gaster fulvous-brown. *Cooler South Island localities:* head, thorax, and propodeum black; gaster dark brown; mandible fulvous-white; clypeus, scape, legs (except middle and hind femora), tegula, and apex of pronotal lobe fulvous; middle femur with dark brown areas; hind femur dark brown. Appendages even darker in cooler areas.

**Vestiture** sparse.

**Structure.** Head. Outline in frontal view rotundly subquadrate; surface minutely colliculate; POL:OOL as about 2:5. Frons broad, with sides roughly subparallel; median raised area between antennal sclerites without a median carina (sometimes with lower frontal median carina extending onto upper end only). Clypeus very narrow; apical margin with a narrow, notched, median incision bearing 3 long apical setae on either side. Mandible lacking mesal teeth, bidentate, with upper tooth large, very obtusely rounded and lower tooth narrower, longer, acute. Antennal flagellomeres finely pubescent. FD 42.8, TFD 47.5, UID 29.0, MID 32.9, LID 27.0, SFD 27.9, FD/TFD 0.9, SFD/TFD 0.59, POL/OOL 0.4.

**Thorax.** Surface minutely colliculate. Pronotal sides with a broad, shallow, weakly scrobiculate groove; pro-

notal collar with dorsal transverse carina strong, high, sharp-edged. Scutellum with anterior transverse sulcus bisected only by fine, low, transverse carinae. Mesopleuron with an episternal sulcus, omaulus, and signum; hypersternaulus present only anteriorly.

**Propodeum.** Sculpture variable, usually with dorsum substrigulate; sides and declivity rugose-carinate, sometimes with paired dorsal longitudinal carinae, a transverse carina at dorsolateral boundary, and another at dorsal boundary of declivity.

**Wings.** Abscissa 1 of forewing radial cell 0.25–0.50× length of abscissa 2 (as in male, Fig. 59).

**Metasoma** smooth, highly nitid. Pygidium laterally compressed. Epipygium with a narrow pygidial shield bounded by parallel, raised, sharp-edged carinae extending from base to apex.

**Male.** Body length 2.0–2.9 mm; forewing length 1.8–2.7 mm.

**Colour.** Similar to female, but often a little darker; frons uniformly dark brown; clypeus, mandible, and scape white to pale fulvous. Individuals from cooler and southern regions darker. Clypeus usually appearing intensely whitish.

**Vestiture** very sparse.

**Structure.** Head. Outline in frontal view rotund, wider than long; surface minutely colliculate; POL:OOL as 1:2. Frons broad, with sides subparallel. Clypeus with median apical incision smaller than in female. Antennal flagellomeres robust, bearing short, obliquely forward-directed bristles. FD 35, TFD 41, UID 24.2, MID 25.5, LID 24.0, SFD 24.0, FD/TFD 0.9, SFD/TFD 0.6, POL/OOL 0.5.

**Thorax** and propodeum similar to female.

**Metasoma** similar to female; 7th tergum conoid; dorsum evenly rounded, not flattened.

**Final-instar larva.** Description based on six specimens from North East Valley, Dunedin.

**Body** (Fig. 79) 3.8 mm long, 0.8 mm in maximum width; pleural lobes small; last segment long, with anus terminal and central; supra-anal and subanal lobes subequal. Integument without spicules. Spiracles circular, transparent. First thoracic spiracle (Fig. 84): peritreme circular; atrium 33.3 µm in diameter, lined with anastomosing ridges which (at ×400) lack spines; collar (i.e., opening into subatrium) circular, without spines. Subatrium narrow, its greatest diameter less than half that of atrium, apparently without spines.

**Head** (Fig. 88) higher than wide, 440 µm long (vertex to labrum), 366 µm wide, without either a coronal suture or parietal bands and almost without setae. Antennal papilla

(Fig. 92) very large, 33  $\mu\text{m}$  long, surmounted by 3 sensillae. Antennal orbits circular. Labrum 73  $\mu\text{m}$  high, 120  $\mu\text{m}$  wide; disc with scattered campaniform sensillae and setae; apical border smooth, without spinules but with 6–8 setae set in depressions, similar to pigmented sensory cones. Epipharynx without spinules but with 4 large and 2 smaller sensory cones in sensory areas on either side.

Mandible (Fig. 102) 145  $\mu\text{m}$  long, 100  $\mu\text{m}$  wide at base, with a single basolateral seta and with 5 teeth.

Labium and maxilla (Fig. 106): labial palp 22  $\mu\text{m}$  long, stout, shorter than spinnerets. Spinnerets 35  $\mu\text{m}$  long, connected at base by a membrane. Maxilla without apical spinules; lacinial area smooth; palp large, stout, 29  $\mu\text{m}$  long; galea vestigial, 6.5  $\mu\text{m}$  long, with beside it an even smaller sensilla-like peg 5.5  $\mu\text{m}$  long.

**Cocoon** (Fig. 110). Very thin, pure white, matt, papery, flexible, responding to pressure like a plastic bag, sac-like, completely filling the *Anobium* gallery and lining it, 2.8–5.4 mm long by 1.3–1.5 mm wide.

**Type data.** Holotype (NZAC; scen): male, ND, Poor Knights Islands, Tawhiti Rahi, 4–10 December 1980, R. Kleinpaste.

**Material examined.** 539 adults (288 females, 251 males), 47 larvae, and 42 pupae.

ND, AK, CL, TO, TK, BP, WI, WN/NN, SD, MC, DN, SL.

**Biology.** Emergence. Males and females emerge at the same time (unlike most solitary wasps, in which males emerge a few days before females).

**Mating.** The male climbs onto the female from behind, repeatedly tapping his antennae on her head and holding her with his fore and middle legs. Copulation lasts less than a minute, but the male holds the female for about 5 minutes.

**Activity around nest holes.** Both sexes fly in and out of emergence galleries of wood-boring insects. Up to 15 females were observed to fly out of one hole in the frame of a window in a suburban house.

**Hunting.** Females run over flowers from many families, both native and introduced, where thrips are caught. At times leaf-eating thrips are taken as well. Both larval and adult thrips are taken, adults usually making up about 6% of the prey.

**Paralysis.** Prey is stung to permanent paralysis.

**Nests** (Fig. 117) are made in abandoned pupal and larval galleries of small xylophagous beetles, primarily *Anobium punctatum* and *Hadrobregmus magnus* (Anobiidae), *Euophryum confine* (Curculionidae), and some small species

of Cerambycidae. In *Anobium* holes *S. nozela* first removes from some of the galleries frass, which accumulates in a large mound at the entrance. Compacted frass is used for cell closures and divisions. Cells are made right to the very end of tunnels of wood-boring insects, and can occur up to 37 cm from the nearest *Anobium* exit hole. The species nests communally, several females using the same hole. The nests are made in long rows in the galleries, where male and female cells occur together.

Nest cells averaged 1.46 mm wide and 3–6 mm long, a typical cell being about 1.45 mm wide by 5 mm long. Partitions, made of compacted frass, varied from 0.7 mm to 1.4 mm thick. Prey were packed tightly into the cells, sometimes facing the end of the cell and sometimes facing the floor, depending on the orientation of the gallery. Fully provisioned cells contained from 28 to 72 thrips per cell (mean, 52 per cell), from first instars to adults. In one gallery a line of cells had the following numbers of prey: cell 1, 42; cell 2, 33; cell 3, 52; cell 4, 70; cell 5, 49; cell 6, 58. Some of the cells contained thrips lying entirely on their sides, all facing away from the exit, and others contained thrips facing the cell floor. The prey comprised *Thrips obscuratus* adult females (6%), first instars (41%), and second instars (53%).

No seal is placed at the external entrance to the nest; there are inner cell closures only.

**Life history.** The white, oblong-ovate egg, 0.8 mm long, is laid longitudinally on the venter of the last prey item. The cell is then sealed with a plug of compacted frass. The egg hatches after 2–3 days, and the larva completes feeding in about 3 weeks. It remains chewing the residue of the last thrips on its posterior thorax and anterior abdominal venter for a few hours, then spins its peculiar white, sac-like cocoon. It makes a cap extending across the cell at either end, the caps being connected to sides that closely line the cell throughout its length. The cocoon thus resembles a cell lining. After it has spun its cocoon, in about 18 hours, the larva waits a further 3 hours, then voids the meconium and changes into a prepupa, with somewhat more acute pleural lobes and less distinction between the thoracic segments, which become a more uniform, cylindrical unit.

*Spilomena nozela* is univoltine, with an 8-month prepupal diapause in winter.

**Prey.** First- and second-instar nymphs and adults of *Thrips obscuratus* (Thripinae) and *Heliothrips haemorrhoidalis* (Panchaetothripinae).

**Other observations.** Gourlay (1964) reported a *Spilomena* species preying on *Heliothrips haemorrhoidalis*, which it stored in *Anobium punctatum* holes. Vardy (1987) stated that this was likely to have been *S. nozela*, because there were no specimens of *elegantula* or *emarginata* in the

collections of Entomology Division, DSIR older than 1957 (a reasonable conclusion, because E.S. Gourlay's private collection was bought by the DSIR, and material examined by him should have been examined by Vardy as well). Mr J. Early made important observations of this species on opened flowers of *Astilbe* sp., *Aruncus* sp., *Lilium reglae*, *Clematis* sp., and *Kolkomitzia* sp. He noted a preference for white flowers, and stated that the wasps were not present on coloured flowers nearby such as *Geum chiloense* (red), *Fuchsia* (red/purple), African marigolds (yellow/orange), *Dianthus* (pink), *Heimerocallis* (yellow), and *Delphinium*. The prey (*Thrips obscuratus*) were stored in *Anobium punctatum* holes (J.W. Early, pers. comm.).

### Subfamily LARRINAE

**Adult.** Eyes usually converging above. Antennae usually low on face; female with 12 antennal articles and males almost always with 13. Mandibles with a large ventral emargination limited proximally by a stout tooth. Pronotal lobe separated from tegula. Mesopleuron usually with an episternal sulcus; sternaulus absent. Male with 7 visible terga. Sternum VII similar to preceding sterna. Male genitalia with volsella simple, lacking a digitus. Cerci absent.

**Final-instar larva.** Body integument with spinules. Last abdominal segment forming a rounded, terminal lobe; anus ventral. Opening into spiracular subatrium with or without spines. Parietal bands usually absent. Antennal papilla absent. Labrum broad, bearing sensillae over much of its surface, but often without specific subapical, pigmented sensory cones. Mandible stout, its inner margin with 4 or 5 teeth. Lacinal area of maxilla prominent, well developed, often projecting apically as a lobe. Galea smaller than maxillary palps, sometimes vestigial. Spinneret paired, much longer than labial palps.

**Remarks.** This subfamily of over 3000 species, the most diverse group of Sphecidae, is represented world-wide. Evans (1959, 1964) and Lornholdt (1976), unlike Bohart & Menke (1976), included the crabronine sphecids in this subfamily because not only can they not be separated from it on the basis of larval characters, but also there are genera of which the adults form a bridge between the two groups.

### Genus *Tachysphex* Kohl

*Tachysphex* Kohl, 1883, p. 166. Type species *Tachytes fugax* Radoszkowski, 1877, designated by Bingham (1897, p. 192, as *Tachysphex filicornis* Kohl).

*Schistosphex* Arnold, 1922, p. 137. Type species *Schistosphex breijeri* Arnold, 1922, by original designation. *Atelosphex* Arnold, 1923, p. 177. Type species *Atelosphex miscophoides* Arnold, 1923, by original designation.

**Description.** Head short, wide, flat. Inner orbits very strongly converging above, relatively narrowly separated at vertex. Compound eyes strongly divergent below (UID very short, LID very long). Anterior ocellus circular; hind ocelli vestigial, as flat, opaque 'ocellar scars,' with very narrow curved, clear area elliptic, crescentic, or C-shaped, their long axes oblique. Frons with an elliptic, shining tubercle above each antennal socket, the tubercles convergent above. Clypeus relatively large. Malar space usually absent. Flagellomeres usually longer than wide.

Thorax usually stout, flat dorsally, wide in the middle. Dorsum of collar usually thin, usually much lower than scutum, to which it is appressed. Scutum with admedian lines well separated.

Legs. Male forefemur notched in most species. Female foretarsus with a pecten of flexible setae.

Wings. Forewing with 3 cubital cells, the 2nd joined by both transverse discoidal veins. Apex of radial cell strongly truncate. Stigma very narrow. Marginal cell not foreshortened, its apex narrowly truncate.

Metasoma. Tergum 1 with a lateral carina. Female with pygidial plate flat, triangular, delimited by lateral carinae. Apex of male sternum 8 bispinose. Volsella long, slender, often bearing a mediodorsal lobe. Apex of aedeagus nearly always with ventral teeth.

**Remarks.** Genus *Tachysphex* (Tribe Larrini, Subtribe Tachytina) occurs world-wide. The females dig underground nests, and prey exclusively on Orthoptera. There is only one species in New Zealand.

### *Tachysphex nigerrimus* (Smith)

Fig. 4

*nigerrimus* Smith, 1856, p. 302 (*Tachytes*) (name attributed to White; authorship attributed to Smith by all subsequent authors); New Zealand. White & Butler, 1874, pl. 7 fig. 14 (*Astata*). Hutton, 1881, p. 102 (*Tachytes*). Dalla Torre, 1897, p. 692. Hutton, 1904, p. 98. Turner, 1908, p. 491 (*Tachysphex*). Hudson, 1950, p. 57. Wilkinson, 1952, p. 166 (*Tachytes*). Miller, 1955, p. 35. Valentine, 1967, p. 1146 (as *nigerimus*; lapsus calami). Miller, 1971, p. 26. Pulawski, 1975, p. 311 (*Tachysphex*). Bohart & Menke, 1976, p. 231 (fig. 61J-M), p. 254 (fig. 70E), p. 275. Pulawski, 1977, p. 308. Callan, 1979, p. 34. Miller, 1984, p. 26. Valentine & Walker, 1991, p. 40.

*sericops* Smith "White", 1856, p. 302 (*Tachytes*). Hutton, 1881, p. 103. Dalla Torre, 1897, p. 694 (*Tachysphex*).\* Hutton, 1904, p. 98 (*Tachytes*).\*  
*depressus* Saussure, 1867, p. 69 (*Tachytes*). Hutton, 1881, p. 103. Kohl, 1884, p. 401 (*Tachysphex*). Dalla Torre, 1897, p. 679. Hutton, 1904, p. 98 (*Tachytes*).\*  
*helmsi* Cameron, 1888, p. 182 (*Tachysphex*). Dalla Torre, 1897, p. 680. Hutton, 1904, p. 98 (*Tachytes*).\*

**Diagnosis. Female.** Recognisable in New Zealand by the following characters. (1) Eyes very strongly convergent above, very strongly divergent below (UID/TFD 0.3, LID/TFD 0.6); vertex small (Fig. 26). (2) Hind ocelli vestigial, reduced to C-shaped scars (Fig. 26). (3) Ocelli appearing on face, well below level of greatest convergence of eyes (Fig. 26). (4) Frons with shining tubercles above antennal sockets. (5) Mandible unidentate. (6) Body shining, intense black; abdomen conical, tapered, its apex pointed; eyes black, even in alcohol.

**Male.** Recognisable in New Zealand by characters 1-5 as for female, plus (6) Body dull grey; wings hyaline; gaster with grey chevrons caused by differently directed hairs; eyes olive green, immediately becoming bright yellow-olive green in alcohol.

**Description. Female** (Fig. 4). Body length 8.0-15.2 mm; forewing length 6.0-9.9 mm.

**Colour.** Appearing intensely black, mostly very shining; compound eyes black in live and fresh specimens. Wings clear hyaline.

**Vestiture.** Vertex and upper frons with scattered erect bronze hairs; lower frons and clypeus laterally with decumbent silver hairs. Mesosoma with short, sparse, fine, griseous to bronze hairs and with very fine, decumbent, bronze pubescence; erect hair sparse, even on apex of head, where there are a few such hairs, mostly on sides. Pygidium with scattered fine hairs.

**Structure.** Head (Fig. 26). Surface intensely black, nitid; punctures irregular and of varying sizes. Vertex with a median depression posterior to ocelli. Eyes very strongly convergent above, very strongly divergent below (UID/TFD 0.3, LID/TFD 0.6). Hind ocelli well below and anterior to point of maximum convergence of eyes, vestigial, the scars elliptic, with long axis oblique, the narrow, clear area almost C-shaped. Anterior ocellus small, round, well forward of hind ocelli. Ocellar triangle less than 30°. Median frontal sulcus present, ending at median carina just above level of antennal socket; a shining tubercle above each antennal socket. Face broad; FD/TFD 0.6. Clypeus

with a large, wide median lobe, its apical margin simple, medially concave. Mandible with a rounded, basal, exteroventral tooth and a tooth-like inner mesal molar lobe with a small incision anterior to it; apex of mandible unidentate, acute. Antennal flagellomeres subequal, relatively long.

Thorax with sparse, short, griseous to bronze hairs. Surface intensely black, nitid. Pronotum very short, much below level of scutum, to which collar is appressed. Scutum and scutellum flat; scutum wide medially.

Propodeal enclosure flat, planar, horizontal, closely and minutely rugose-punctate, causing it to appear dull; sides abruptly declivous through 90°; propodeal declivity also steep, rendering propodeum box-shaped. Pleura obliquely rugose, the rugae from either side curving onto the declivity and meeting in the narrow, deep median fovea.

Legs. Tibiae with 2 apical spurs. Foretarsus on outer side with a row of very long, bronze, flexible setae, 7 on 1st segment, 4 on 2nd, 3 on 3rd, 2 on 4th; 5th segment slightly asymmetrical.

Wings as in Fig. 60.

Metasoma sessile, smooth, black, very nitid, obovate-conoid though dorsoventrally depressed, apically acute, widest slightly before middle of 2nd tergum; sides smoothly rounded. Pygidial area subtriangular, apically truncate, delimited from base to apex by raised lateral carinae; surface with a few scattered coarse punctures and associated fine hairs.

**Male.** Body length 5.5-10.0 mm, forewing length 4.0-8.0 mm.

**Colour.** Appearing dull grey, with wings clear hyaline; eyes olive-green, unlike female becoming vivid yellow-olive when placed in alcohol.

**Vestiture.** Head with silvery decumbent hairs and pubescence. Thorax thickly covered with decumbent griseous pubescence. Propodeal enclosure relatively densely covered with erect, silver hairs. Metasoma relatively densely covered with decumbent griseous pubescence. Terga 1-4 with sinuous, transverse indentations caudad of midway, the pubescence basal to these lines directed posteriorly and that apical of the lines directed laterally, parted in mid-dorsum, giving the appearance of transverse grey bands. Tergum 7 with few hairs.

**Structure.** Essentially similar to female, otherwise as follows.

Head densely punctate to punctulate. Frons between anterior ocellus and antennal sclerites slightly more gibbous. Clypeus with apical boundary convex. Antenna with flagellomere 1 very short, 0.6× length of flagellomeres 2-4, which are subequal.

\*Synonymy proposed by Bohart & Menke (1976).

Mesosoma similar to female, but surface densely punctate, dull. Scutum narrower at level of tegulae.

Legs. Foretarsus with a rake of long, bronze setae on outer lateral margin, 5 on 1st segment, 2 on 2nd segment, and 1 each on 3rd and 4th segments.

Metasoma sessile, obovate, laterally smoothly rounded, but much more squat and broader than in female, with surface minutely shagreened. Terga 1-4 with a sinuous, transverse indentation posterior of midway; tergum 7 without lateral carinae, densely punctate/punctulate.

**Type data.** Holotype *nigerrimus* (BMNH; not seen): female, "New Zealand."

Holotype *sericops* (BMNH; not seen): male (originally incorrectly described as a female), "New Zealand."

Syntypes of *depressus* (repository unknown): females, "New Zealand."

Holotype *helmsi* (BMNH; not seen): female, Grey-mouth (BR), New Zealand.

**Material examined.** 668 adults (451 females, 217 males), 16 larvae, and 14 pupae.

From all coded collection areas between North Cape (latitude 34°25'S) and Stewart Island (47°00'S).

**Biology.** Emergence and copulation. Protandrous, males emerging a few days before females. In stable banks with large populations, 7-11 males congregate in areas where a female will emerge and walk about excitedly in a roughly 60 mm<sup>2</sup> area. Some males begin digging down to the female before she breaks through the surface. After the female's head and thorax have appeared, a male sometimes succeeds in digging the apex of his abdomen through the soil to that of the female. As the mating pair climb out, 7-10 other males jump onto the pair, forming a ball of wasps that roll down the bank. Only one male succeeds in mating under these circumstances. Copulation lasts from 39 to 48 seconds, and all wasps have separated within 40-50 seconds.

Hunting. *T. nigerrimus* females hunt native cockroaches in grass, scrub, dead plants, and low vegetation and under logs and stones, usually not far from areas of shingle and sand.

Paralysis. The prey is stung to paralysis. Prey items in cells are often capable of considerable movement in the legs and antennae, but cannot right themselves or walk. Their antennae move back and forth, the mouthparts move, and the palps quiver and shake.

Prey carriage. Prey is held prone (dorsum uppermost) facing forwards, and is usually flown to the nest. However, a large prey insect is usually dragged across the ground by

a leg or an antenna. It is positioned in the cell supine.

Nests (Fig. 117a). Completed nests have from one to five cells, but most that I have observed were single-celled. The nest is typically a simple burrow dug in sand, coarser sand among shingle, silt, or loam and in areas of sand in river scrolls, beaches, moraines, gravel pits, and similar places. The entrance is characteristically an obovate burrow wider than high, usually about 6 x 4 mm. There is generally a mound of spoil at the entrance, typically oval, 5 mm deep, 40 mm long, and 23 mm at its widest. However, some nests are concealed: for example, a single-celled nest dug 15 mm deep in sand beside the Blue Stream, Mt Cook National Park, in January 1989 was constructed beneath a clump of lichen only 40 mm long by 35 mm wide, leaving no external sign of the nest.

In single-celled nests the main burrow is usually short, gently sloping, 4 x 6 mm to 5 x 5 mm in diameter, 14-75 mm long, and often expanded a little terminally into the cell. A cell typically contains three prey items, usually *Celatoblatta* or *Parellipsoidion* nymphs, and both cell and nest are closed after oviposition. (In multi-celled nests the cell is closed after oviposition but the main burrow entrance is left open.) Inner cell closures, made of compacted sand/loam, averaged 6 mm long.

Life history. The whitish egg, 3.5 mm long and 0.7 mm wide, is curved and relatively very long and narrow. One end is cemented to the middle of the prosternum of the prey, between the fore coxae. The egg rises outward and projecting to one side over the middle coxa, which it does not touch (Fig. 117b).

The egg is often laid on the largest of the three nymphs. It hatches in about 3 days, and the final-instar larva spins its cocoon about 28 days later. This species has a facultative prepupal winter diapause.

### Genus *Pison* Jurine

*Pison* Jurine in Spinola, 1808, p. 255. Type species *Pison jurini* Spinola, 1808, (properly *jurinei*, = *Alyson ater* Spinola, 1808); monotypic.

*Tachybulus* Latreille, 1809, p. 75. Type species *Tachybulus niger* Latreille, 1809 (= *Alyson ater* Spinola, 1808); monotypic.

*Nephridia* Brullé, 1833, p. 408. Type species *Nephridia xanthopus* Brullé, 1833; monotypic.

*Pisonitus* Shuckard, 1838, p. 79. Type species *Pison argentatum* Shuckard 1838, designated by Pate (1937, p. 51).

*Pisum* Agassiz, 1847, p. 293. Emendation of *Pison* Jurine, 1808. Not *Pisum* McGerle, 1811.

*Pseudonysson* Radoszkowski, 1876, p. 104. Type species *Pseudonysson fasciatus* Radoszkowski, 1876; monotypic.

*Taranga* W.F. Kirby, 1883, p. 201. Type species *Taranga dubia* W.F. Kirby, 1883 (= *Pison spinolae* Shuckard, 1838); monotypic.

*Pisum* Schultz, 1906, p. 212. Emendation of *Pison* Jurine, 1808. Not *Pisum* Megerle, 1811.

*Pisonoides* F. Smith, 1858, p. 104. Type species *Pison oblitteratum* F. Smith, 1858; monotypic.

*Paraceramius* Radoszkowski, 1887, p. 432.

*Krombeiniellum* Richards, 1962, p. 118. New name for *Paraceramius* Radoszkowski.

*Entomopison* Menke, 1968, p. 5. Type species *Pison pilosum* F. Smith, 1873, by original designation.

**Diagnosis. Adult.** Inner orbits usually converging above. Frons simple or with a short median longitudinal carina or line. Clypeus variable, but usually about twice as wide as high; apical margin usually with a truncate or V-shaped median lobe. Labrum quadrangular, its apex sometimes lobed. Mandible usually simple but with an inner subapical or mesal tooth in some species. Pronotum usually with an anteromedian depression (usually obscured by head). Propodeum short to moderately long, often with a lateral carina or areolate sulcus running between spiracle and petiole socket; dorsum with a median longitudinal sulcus and/or carina but no enclosure. Metasoma sessile (rarely pedunculate). Terga 1 and 2 with a lateral carina; sterna without graduli, in male sometimes with a central tubercle or transverse welts. Female tergum 6 conical, without a pygidial plate. Middle coxae widely separated to subcontiguous, hind coxae contiguous. Fore and middle tibiae with 1 apical spur, hind tibia with 2 apical spurs. Arolia moderate and equal. Forewing usually with 3 submarginal cells; cell 2 petiolate, sometimes greatly reduced or absent, when cell 3 (not petiolate) becomes the definitive submarginal cell; marginal cell usually acuminate distally, with apex usually well beyond outer veinlet of last submarginal cell. Hindwing hamuli sometimes divided into 2 groups. Male genitalia with gonostyle simple or biramous; volsella often greatly enlarged and partially fused with gonostyle.

**Final-instar larva** stout, cylindrical, with posterior end blunt and anus ventral; spiracles lacking atrial spines. Head in anterior view subcircular, a little flattened on top, with neither coronal suture nor parietal bands, with relatively long setae, especially on genae. Antennal orbits without a papilla. Mandible with 2 apical teeth and, on inner margin, 3 further teeth surrounding a concavity. Maxilla with apex

evenly rounded, papillose; lacinial arca with an angular, spinulose lobe. Spinnerets discrete, not much longer than labial palpus.

**Biology.** At least one species (*chilense*, from Chile) excavates burrows in the ground, with cells separated by mud partitions. Most other species nest above ground, in sheltered situations such as rock overhangs, birds' nests, the underside of leaves, hollow objects, crevices, insect burrows in wood, and in and on man-made structures. The two species present in New Zealand nest in insect burrows in wood (*morosum*) and on rock overhangs, tree trunks, and man-made objects (*spinolae*).

**Remarks.** *Pison* (Tribe Trypoxylonini) is a genus of about 180 species occurring world-wide, but most of the species are restricted to the Southern Hemisphere, and a third of them are confined to Australia. A large number of endemic forms have evolved on islands in the Pacific.

The four subgenera recognised by Bohart & Menke (1976) were abandoned by Menke (1988), and none are currently recognised in *Pison*.

#### *Pison morosum* Smith

*morosus* "White" Smith, 1856, p. 317 (*Pison*); New Zealand. Hutton, 1881, p. 103. Dalla Torre, 1897, p. 712 (*morosum*). Hutton, 1904, p. 98 (*morosus*). Turner, 1916, p. 627 (*morosum*). Bohart & Menke, 1976, p. 336. Callan, 1979, p. 36. Laing, 1988, p. 37. Valentine & Walker, 1991, p. 40.

*tuberculatus* Smith, 1869, p. 296 (*Pison*). Hutton, 1881, p. 103. Dalla Torre, 1897, p. 713 (*tuberculatum*). Hutton, 1904, p. 98 (*tuberculatus*). Turner, 1916, p. 626 (*tuberculatum*). Bohart & Menke, 1976, p. 336. Callan, 1979, p. 36. Valentine & Walker, 1991, p. 40. New synonymy.

**Diagnosis. Female.** (1) Antennal flagellomeres 1-3 subequal. (2) Body and appendages clothed with very short hair, the body hairs generally shorter than width of thickest antennal segment. (3) Hind ocelli large, each closer to eye than half its own width. (4) POL:OOL as 7:3 (almost 2:1). (5) Forewing submarginal cell 2 relatively large, on vein M about 0.35× length of cell 3. (6) Forefemur swollen. (These characters serve to separate *morosum* females from *P. spinolae*, the only other *Pison* species present in New Zealand.)

**Male.** (1) Metasoma with sternum 3 bearing a large, blunt tubercle on either side of midline. (2) Forewing submarginal cell 2 relatively large, on vein M about 0.35×

length of cell 3. (3) Antennal flagellomeres 1–3 subequal. (4) Body and appendages clothed with very short hair, the body hairs generally shorter than width of thickest antennal segment. (5) POL:OOL almost as 2:1. (6) Forefemur swollen.

**Description. Female.** Body length 7.5–11.5 mm; forewing 5.1–8.0 mm.

**Colour.** Body and appendages black; wings clear hyaline, tinged with pale fuscous (darker apically); metasoma not banded.

**Vestiture.** Head with short, decumbent hairs dorsolaterally. Vertex and upper frons with little vestiture; frons between antennal sockets, paraoccipital area below eye notch, and clypeus with short, decumbent pubescence. Mesosoma dorsally almost without pubescence. Metasoma: tergum 1 with very short, decumbent, griseous pubescence; epipygium sparsely hairy; hypopygium with a few long, apically curved, infusate hairs.

**Head.** Hind ocelli large, each closer to compound eye than half its width; POL:OOL as 7:3 (almost 1:2). Clypeus relatively long; disc evenly gibbous, with a large, crescentic, semicircular median lobe; apical border convex, simple, evenly rounded, without lateral lobes. Mandible with a small mesal molar tooth, without a basal, exteroventral tooth, unidentate; apex obtuse. Antennae filiform; flagellomeres 1–3 subequal.

**Mesosoma.** Surface of rounded thorax dull, contiguously punctulate. Scutum with admedian lines well separated; notauli and parapsidal lines present. Propodeal enclosure with obsolete longitudinal rugae posterolaterally, discontinuous before declivity, which bears strong transverse rugae; propodeum laterally with vertical (perpendicular) rugae. Forefemur somewhat swollen.

Forewing submarginal cell 2 relatively large, on vein M about 0.35× length of cell 3 (Fig. 61).

Metasoma piceous, smoothly ovate. Epipygium hemiconoid.

**Male.** Body length 5.5–8.0 mm; forewing length 4.5–7.1 mm.

Colour and vestiture very similar to female.

**Structure.** Size, overall shape, and most characters very similar to female.

**Head.** Similar to female, but clypeus with a large, protruding, apically pointed median lobe, its sides subapically concave, and mandible without a mesal molar lobe.

Mesosoma and wings virtually as for female. Forefemur swollen, similar to female.

Metasoma. Very similar to female in general shape, but

sternum 3 apically with a pair of large, obtuse mesolateral tubercles, highest mesally, and sterna 2 and 4 with smaller, depressed mesolateral tubercles.

**Type data.** Holotype *morosum* (BMNH; not seen): female, "New Zealand."

Holotype *tuberculatum* (BMNH; not seen): male, "New Zealand."

**Material examined.** 478 adults (316 females, 162 males), 7 larvae, and 3 pupae.

From all coded collection areas.

**Biology.** *P. morosum* usually nests in abandoned galleries of wood-boring insects, which are filled with spiders.

Hunting. The wasp flies around and about stones, shrubs, tree trunks, leaves, and flowers searching for prey. When a suitable spider is located it is stung to permanent paralysis and then flown to the nest.

Nest (Fig. 118a). Typical nests comprised abandoned pupal galleries of *Sirex noctilio* (Hymenoptera: Siricidae) in *Pinus radiata* plantations, *Psepholax coronatus*, *Ps. barbifrons*, and other *Psepholax* species (Coleoptera: Curculionidae), and burrows of *Hybolasius cristatus* (Coleoptera: Cerambycidae) and other longhorns in living trees such as *Fuchsia excorticata*, *Melicetus ramiflorus*, and *Alectryon excelsus*. These typically have a burrow diameter of 2.9–4.0 mm. If the inner end of the cell is not smoothly concave, a mud partition is sometimes made in the insect gallery, moulded to give it a smooth, concave inner surface. The cell is then provisioned with 5–25 spiders, often Araneidae but also of other families (juveniles and adults of smaller species). When the cell was stocked, an outer seal with a rough, convex inner surface and a smooth, concave outer surface was added. Nests had 1–3 cells, but most naturally occurring nests (90%) were single-celled. Cells were 2.9–4.0 mm in diameter and 15–56 mm long.

*P. morosum* readily makes serial nests in artificial trap-nests. Four such nests at Alexandra (CO) made in trap-nests 5 mm wide by 70 mm long had cells on average 9.4 mm long with mud partitions 1.0 mm thick, except for the outer seals, which were 4.7 mm thick on average. Three nests were 5-celled and one was 6-celled. All contained cocoons when the nests were opened, these frequently occupying the cells fully, touching seals at either end. Two nests had outer vestibular cells. No nest had a mud seal against the inner boundary of the trap-nest, which was concave (Fig. 118b).

Life history. The oblong-ovate egg, 2.1 mm long by 0.4 mm wide, is laid on the opisthosoma of the last provisioned

prey item. Incubation takes 3–6 days, and larval development until cocoon spinning takes a further 14–24 days. The oblong-ovate, matt greyish-brown cocoon is 7–11 mm long. This species is bivoltine, with a facultative prepupal winter diapause.

Other observations. Laing (1988), Miller (1971, 1984).

**Remarks.** *Pison morosum* is confined to New Zealand. Some confusion was caused when Smith (1864) gave the same name to a species restricted to New Guinea. That species was subsequently renamed, so that *P. morosum* Smith, 1864 is a synonym of *P. papuanum* Schulz, 1904.

### *Pison spinolae* Shuckard

Fig. 5

*spinolae* Shuckard, 1837, p. 76 (*Pison*); Australia (incl. Tasmania), New Zealand. Saussure, 1867, p. 66. Roth, 1885, p. 321. Radoszkowski, 1891, p. 594. Dalla Torre, 1897, p. 713. Turner, 1916, p. 607. Miller, 1955, p. 36. Cowley, 1962, p. 355. Valentine, 1967, p. 1146. Miller, 1971 (and 1984), p. 25. Sharell, 1971, pp. 179–182. Bohart & Menke, 1976, p. 336. Callan, 1979, p. 34. Cardale, 1985, p. 262. Valentine & Walker, 1991, p. 40.

*australis* Saussure, 1855, p. 11 (*Pison*). Dalla Torre, 1897, p. 713. Bohart & Menke, 1976, p. 336 (*australe*). Callan, 1979, p. 34. Cardale, 1985, p. 262 (*australis*). Synonymised by F. Smith (1869).

*tasmanicus* Smith, 1856, p. 316 (*Pison*). Bohart & Menke, 1976, p. 336 (*tasmanicum*). Callan, 1979, p. 34. Cardale, 1985, p. 262 (*tasmanicus*). Synonymised by F. Smith, 1869.

*dubia* Kirby, 1883, p. 201 (*Taranga*). Dalla Torre, 1897, p. 711 (*Pison dubium*). Hutton, 1904, p. 98 (*dubius*). Bohart & Menke, 1976, p. 336 (*dubium*). Callan, 1979, p. 34. Valentine & Walker, 1991, p. 40 (*dubia*). Synonymised by Bohart & Menke (1976).

*pruinus* Cameron, 1898, p. 44 (*Pison*). Bohart & Menke, 1976, p. 336 (*pruinus*). Callan, 1979, p. 34. Valentine & Walker, 1991, p. 40 (*pruinus*).

Not *hirtipes* Smith, 1878 (= *Leioproctus* (*Nesocolletes*) *hirtipes* (Smith)). Misidentification of *P. spinolae* by Hudson (1892), Bonham (1904), and others following Hudson.

**Diagnosis. Female.** (1) Flagellomere 1 very much longer than any other antennal article. (2) Body and venter of trochanters and femora with very long, pale, wispy hair, longer than width of any antennal article. (3) Hind ocellus separated from eye by more than half its width; POL:OOL as 10:9 (almost 1:1). (4) Clypeus with a large, linguiform

median lobe, its apical margin convex, a little flattened at midpoint, without lateral lobes. (5) Forewing submarginal cell 2 very small, on vein M, usually about 0.2× length of cell 3, sometimes smaller or (in about 1% of individuals) absent; sometimes fully developed in one wing and absent from the opposite wing. (6) Forefemur not swollen.

**Male.** (1) Flagellomere I very much longer than any other antennal article. (2) Body with very long, pale, wispy hair, longer than width of any antennal article. (3) Hind ocellus separated from eye by more than half its width; POL:OOL as 10:9 (almost 1:1). (4) Clypeus with median lobe rostriform in outline, apex acute. (5) Forewing submarginal cell 2 very small, variably reduced, on vein M usually about 0.2× length of cell 3, sometimes smaller, absent in up to 20% of males in some areas throughout New Zealand. (6) Forefemur not swollen.

**Description. Female** (Fig. 5). Body length 11.0–16.0 mm; forewing length 9.0–12.0 mm.

**Colour.** Body and appendages black; metasoma with pale transverse bands; wings clear hyaline, tinged with pale fuscous brown, apically dusky.

**Vestiture.** Head, mesosoma, trochanters, and femora with very long, pale, wispy hairs, much longer than width of thickest antennal segment. Tergum 1 with long, erect silver hair on declivous basal part. Terga 1–3 with shallow, somewhat sinuous preapical sulci lined with decumbent, laterally directed, silver-white pubescence, causing metasoma to appear banded. Tergum 4 densely clothed with short, decumbent pubescence, thicker and whiter at apex. Epipygium laterally with long, curved black hairs. Hypopygium encircled with very long, stiff, erect, apically curved black hairs.

**Structure.** Head. Hind ocellus separated from eye by more than half its width; POL:OOL 10:9 (almost 1:1). Clypeus relatively large, with disc evenly gibbous; apical margin produced into a large, linguiform median lobe, its anterior margin convex, a little flattened at midpoint, without lateral lobes. Malar space absent. Mandible with a minute mesal molar tooth, without a basal, exteroventral tooth, unidentate; apex obtuse. Flagellomere 1 clearly longer than any other antennal article.

**Mesosoma.** Thorax dull, minutely closely punctulate. Scutum with lateral margin reflexed upwards. Admedian lines small, well separated. Notauli present; parapsidal line clearly defined. Propodeal enclosure and declivity usually costulate, punctate, with ridges on enclosure arranged concentrically around shallow median sulcus, occasionally with costae obsolete or rugose; costae larger, transverse on declivity. Propodeal pleura usually without ridges, shagreened, punctate.

Legs. Forefemur not swollen.

Forewing (Fig. 62a) with submarginal cell 2 variable, usually very small, on vein M about 0.2× length of cell 3, very occasionally larger, occasionally absent (Fig. 62b), in some individuals (rarely) absent on one side and fully developed on the other.

Metasoma sessile, dully shining; surface punctulate. Pygidium hemiconoid.

**Male.** Body length 9–12 mm; forewing 6.8–9.9 mm.

Colour similar to female.

Vestiture similar to female, but metasoma with short, decumbent silver pubescence in addition to long wispy hairs on base of tergum 1, and terga 1–4 with apical 0.2 depressed from the shallow, sinuous, transverse preapical sulcus; this area clothed with dense, decumbent, laterally inclined silver pubescence, causing the gaster to appear banded, though bands less apparent mid-dorsally. Terga 5–7 with fine, decumbent pubescence. Sternum 7 with sparse, long wispy hairs and scattered bronze, decumbent pubescence.

Structure. Head. Resembling female, but clypeus with median lobe rostriform in outline, and apex acutely pointed. Mandible with vestigial mesal molar lobe often smaller than in female, otherwise similar. Flagellomere 1 clearly longer than any other antennal article.

Wings virtually as for female, but forewing submarginal cell 2 absent in 20% of individuals in some areas throughout New Zealand (about 95× more prevalent in the male).

Metasoma similar to female, but base of tergum 1 a little less steep. Tergum 7 evenly curved except for a small, mid-dorsal flat area; apex arcuate-truncate; venter minutely coriaceous-punctate, somewhat shining, without obvious raised structures.

**Final-instar larva** (Dunedin DN, March 1972) (Fig. 80).

Body length 16.5 mm, maximum width (abdominal segments 6 and 7) 4.6 mm; very stout, cylindrical, with posterior end bluntly rounded and anus ventral. Thoracic pleural lobes sharply projecting; abdominal pleural lobes very distinct but less elevated. Spiracles circular, colourless.

First thoracic spiracle (Fig. 85a) colourless, circular. Atrium: maximum diameter 93.3 µm; peritreme wide, difficult to see; inner diameter 31.3 µm; atrium lined with regularly anastomosing ridges bearing no spines (Fig. 85b). Collar (opening between atrium and subatrium) circular, 31.3 µm in diameter, without spines. Subatrium circular in section, without spines, its distal part consisting of 8 annuli which widen proximally, the most proximal annulus 80.0 µm in diameter, itself bounded proximally by

an expanded area 86.7 µm in maximum diameter.

Head (Fig. 89) in anterior view subcircular, somewhat flattened on top, with face relatively flat, without either coronal suture or parietal bands; width 1.9 mm, height (from vertex to apical margin of clypeus) 1.7 mm. Setae relatively long, especially on genae, where longest head seta (55.3 µm) occurs.

Antennal orbits (Fig. 93) vertically ovoid, asymmetrical, 103 µm in maximum diameter, with 3 small sensillae rising directly from orbital floor; papilla absent.

Labrum (Fig. 96) 684 µm wide by 253 µm high at lateral lobe, 120 µm high at midline, bearing 18 large setae and 12 small, apical to subapical sensory cones; apical and lateral margins minutely crenate-serrate.

Epipharynx (Fig. 99) with 4 small sensory cones in sensory areas on either side, 2 others of a different type basal to those, and 4 large, uneven pegs subapically near middle.

Mandible (Fig. 103) robust, 667 µm long by 432 µm wide at base, with 2 large apical teeth and, basal and internal to those (on inner margin), a further 3 stout grinding teeth surrounding a concavity, and with 1 long laterobasal seta.

Labium and maxilla (Fig. 107). Maxilla with apex evenly rounded, papillose; lacinial area with an angular spinulose lobe; maxillary palp stout, 110 µm long by 55 µm in maximum width; galea more slender, 99 µm long by 35 µm in maximum width. Spinnerets 125 µm long, discrete, well separated, ending bluntly, with openings as relatively wide cylindrical tubes projecting a little beyond labial palpi. Labial palpi 110 µm long.

**Cocoon** (Nelson NN) (Fig. 111). Length 15.2 mm, maximum width 6.0 mm. Oblong-oval, matt grey; outer surface smooth except for small, moulded irregularities of low relief.

**Type data.** Holotype *spinolae* (BMNH; not seen): female, Sydney, N.S.W., Australia.

Syntypes of *australis* (repository unknown: Cardale 1985): Australia (as "New Holland").

Holotype *tasmanicus* (BMNH; not seen): male, Tasmania.

Holotype *dubia* (BMNH; not seen): female, New Zealand.

Holotype *pruinosis* (BMNH; not seen): female, Grey-mouth (BR), New Zealand.

**Material examined.** 802 adults (477 females, 325 males), 46 larvae, and 32 pupae.

From all coded collection areas.

**Biology.** Hunting. *P. spinolae* females fly around buildings, walls, stones, long grass, bushes, branches, and tree trunks searching for spiders, mostly Araneidae. Suitable prey is stung to paralysis and flown to the nest cell.

**Nest** (Fig. 119a, b). Nests of moulded mud are made on tree trunks, rocks, banks, and man-made objects such as outside corners of buildings, in equipment, on fabric indoors, in hollow bamboo containers, and similar places. The irregular mud walls can consist of one or two layers of cells. Sometimes there is a row of cells in a cylindrical container, in which case the cell wall closest to the entrance has a rough inside surface, whereas the inner wall has a smooth inside surface. Two oblong cells in a group of 13 contiguous cells measured  $26 \times 17$  mm and  $19 \times 14$  mm. Nests contained 4–16 prey items (fewer large prey, more small prey).

**Life history.** The white, oblong-ovate egg, 2.5 mm long by 0.5 mm wide, is laid on the opisthosoma of the last prey item (Fig. 119c). Incubation takes 4–8 days, and larval development from eclosion to cocoon-spinning takes 11–26 days. This species is bivoltine, with a facultative prepupal winter diapause.

**Other records.** Buller (1877) described and figured a *Pison spinolae* nest which he attributed to *Priocnemis* (*Trichocurgus*) *monachus* (Pompilidae), a mistake which was repeated by Andersen (1953). Hudson (1892) described the nest as consisting of about ten mud cells, made "between the boards of outhouses" and "in crevices in the bark of trees" by the female which made a "loud buzzing noise," but he incorrectly identified it as a colletine bee, *Dasycolletes hirtipes* (= *Leioproctus* (*Nesocolletes*) *hirtipes*), and went on to describe its provisioning the cells with honey and pollen. His plate 3 fig. 1 is clearly *P. spinolae*. Subsequent authors, evidently using this book as a guide, made the same mistake (e.g., Benham in Bathgate 1904, p. 74). Seemingly for that reason, *P. spinolae* became known in New Zealand as the 'mason bee.'

Cowley (1962) gave a good account of the life history of this species, and Laing (1988) recorded further information.

### Subfamily CRABRONINAE

**Adult.** Antennae short, with scape nearly to fully as long as flagellum; antennal sockets close to frontoclypeal suture; male with 11–13 antennal articles (13 in New Zealand species), female with 12. Clypeus transverse. Pronotal collar short; pronotal lobe and tegula separated. Notauli short, usually indistinct; admedian lines very narrowly separated. Scutum without an oblique carina, but with a

lateral flange partly overlapping tegula. Episternal sulcus usually present; scrobal sulcus usually absent. Metapleuron usually consisting of upper area only. Middle tibia usually with 1 apical spur; middle coxae without a dorsolateral carina; precoxal sulcus and lobes present; plantulae absent. Forewing with 1 submarginal cell, this sometimes fused with 1st discoidal cell; 3rd discoidal cell absent; stigma extending distally well beyond base of marginal cell. Hindwing jugal lobe small; 2nd anal vein and subcosta absent. Metasoma sessile to pedunculate, the peduncle clearly consisting of tergum and sternum; a lateral carina on tergum I, usually also on tergum 2, and rarely on following terga. Pygidial plate present in females and some males. Volsella simple; cerci absent.

**Final-instar larva.** Body integument with spinules. Anus ventral and preapical; 10th segment either truncated or produced beyond anus. Spiracle with opening into subatrium either surrounded with spines or without spines. Head with parietal bands small or more usually absent, the 3 (sometimes only 2) sensillae arising from membrane of orbit. Antennal papilla absent. Labrum broad, bearing sensillae over much of its surface but usually without subapical pigmented sensory cones ('barrel-shaped sensillae'). Mandibles stout; inner margin with 4 or 5 teeth. Lacinial area of maxilla prominent, well developed, often projecting apically as a lobe; galea smaller than maxillary palpus, sometimes vestigial. Spinneret paired, much longer than labial palpus.

**Remarks.** Adult crabronines are characterised by the cuboidal head and the single, well defined submarginal cell of the forewing. The silvery transverse clypeus is also characteristic.

Final-instar larvae cannot be distinguished from those of Larrinae. In a classification of the Sphecidae based on larvae, Evans (1959, 1964) suggested that the crabronines should be included in the family Larrinae; this suggestion was adopted by Lomholdt (1976). Bohart & Menke (1976, p. 30) noted that such a move was also supported by adult morphology, because the crabronines are closely related on adult characters to the larrines through the Bothynostethini and Scaphentini, but retained the subfamily name Crabroninae on account of its convenience.

Crabroninae occur in most parts of the world. Bohart & Menke (1976) noted that most crabronines prey on Diptera, but the New Zealand species (in Crabronini) depart from this general pattern. In New Zealand *Podagritys* species prey on the orders Coleoptera, Ephemeroptera, Plecoptera, and Trichoptera in addition to Diptera, and one species (*P. parrotti*) preys exclusively on Coleoptera.

## Genus *Podagritys* Spinola

*Podagritys* Spinola, 1851, p. 353. Type species *Podagritys gayi* Spinola, 1851, by monotypy.

Medium-sized, elongate species in most features very similar to *Rhopalum* (q.v.). Clypeus very short (relatively shorter than in *Rhopalum* in New Zealand species). Antennae with 12 articles in females, 13 in males; flagellum of male simple or modified; basal flagellomeres often with pronounced secondary sexual characteristics comprising dilations and concavities, all New Zealand species except *P. albipes* and *P. parrotii* being modified thus. Mandible of New Zealand species with 2 apical teeth. Mesopleuron lacking a postspiracular carina. Metasoma pedunculate, of variable size and shape in New Zealand species, with a pygidial plate in both sexes (usually), that of female clearly defined, nearly flat, triangular and punctate, without a clearly defined, raised median longitudinal carina.

**Remarks.** In most New Zealand species the humeral angles of the pronotal collar are produced into a tooth-like carinula, the shape of which is very useful for distinguishing between females of *P. albipes*, *P. carbonicolor*, and *P. cora*. (The pronotal humeral carinule is obsolete in *P. chambersi* and *P. digyalos* and absent in *P. parrotii*.) The shape of the orbital fovea is specifically distinct in New Zealand *Podagritys* species, and is useful for distinguishing between females of *carbonicolor* and *cora*, although the latter is usually immediately recognisable by its very wide face.

*Podagritys* is confined to the Southern Hemisphere, with 51 known species in South America, Australia, and New Zealand. These nest in the ground, often in sand.

Throughout their range, species of *Podagritys* are recorded as preying on Diptera. Although most New Zealand species prey only on adult Diptera, one (*P. parrotii*) preys entirely on soft-bodied adult Coleoptera and two others (*P. albipes*, *P. cora*) prey not infrequently on subimaginal Ephemeroptera and adult Trichoptera and Plecoptera. Some populations of *P. albipes*, in at least one locality, prey almost exclusively on Ephemeroptera and Trichoptera.

Females of *Podagritys* have characteristic morphological adaptations associated with ground nesting, such as a row of relatively long bristles on the first segment of the fore tarsus, relatively long spines on the hind tibia, and the absence of a distinct, sharply raised median longitudinal carina on the epipygium. (New Zealand *Rhopalum* females, which all nest above ground in confined places such as beetle holes in wood, have very short spines on the hind tibia and possess a median longitudinal carina on the epipygium.) When these morphological features are taken

together with the clypeal characteristics (clypeus very narrow and short medially in *Podagritys*, relatively wide and medially long in *Rhopalum*), the New Zealand crabronines can be assigned to either genus, but this distinction does not apply outside New Zealand.

It is sometimes difficult to distinguish between females of *P. albipes*, *P. carbonicolor*, and *P. cora*. *P. albipes* is usually easily recognisable by the incomplete lateral pygidial carinae, the shape of the spines on the humeral angle of the pronotal collar, and the shape of the orbital fovea. *P. cora* can be distinguished by the rather gently rounded top of the spines on the humeral angle of the pronotal collar when viewed dorsally, the narrow orbital fovea, and the relatively narrow frons, in addition to the subequal, rounded apical teeth of the mandible. *P. carbonicolor* can be distinguished on the basis of the wide orbital fovea, the high, keel-like spine on the humeral angle of the pronotal collar in dorsal view, the fact that the upper apical mandibular tooth is larger and protrudes further than the lower one, and that there is a notch between the two teeth, and also by the fact that the frons is very broad, so that the face is very much more rectangular and much wider than in *P. albipes* and *P. cora*. Unfortunately this last character is not always reliable, because it is subject to allometry. The best single character for distinguishing between *carbonicolor* and *cora* females is the position on the mandible of the mesal molar tooth, which is much more basal in *carbonicolor* than in *cora* (Fig. 31, 32).

### Subgenus *Parechuca* Leclercq

*Parechuca* Leclercq, 1970a, p. 91. Type species *Podagritys neuqueni* Leclercq, 1957.

**Diagnosis.** Metapleuron smooth above or with sculpture very superficial, not gibbous; prepectus convex, ocellus absent or incomplete below; area behind episternal sulcus not completely flat.

**Remarks.** Restricted to South America and New Zealand. All New Zealand *Podagritys* species are included in this subgenus.

### *digyalos* species-group

The two members of this species-group, *chambersi* and *digyalos*, are readily distinguished by the distinctively modified first antennal flagellomere in the male and the elongated first flagellomere in the female, the absence of sharp spines dorsolaterally on the humeral angles of the pronotal collar, the distinctive pygidial plate (which is

smooth-surfaced with small, well separated punctures and fine hairs bounded by lateral carinae which are entire and enclose the plate), as well as the other characters listed in the species-group diagnosis.

By their different colour patterns and shapes, given that both are normally active only in direct sunlight, *chambersi* and *digyalos* are respectively adapted to warmer and cooler climates.

Silver hairs on the posterior of the propodeum would reflect heat from the middle of the body, and the long, thin petiole of the metasoma would present a larger surface area relative to volume from which heat would be lost. The pale and non-black areas of the body would not absorb as much heat from the sun as black. These characteristics would adapt *chambersi* to warmer, northern, lower altitude areas. Conversely, in *P. digyalos* the absence of silver hairs on the posterior of the petiole would enable the black dermis there to absorb heat, while the thick, short, stocky petiole would present a smaller surface area relative to volume, enabling heat to be retained. The general bodily melanism would permit heat to be absorbed.

Unlike the other New Zealand species of *Podagritys*, *digyalos* and *chambersi* have not evolved distinctively shaped flagellomeres in the male antennae. This is possibly so because these two species seldom, if ever, occur in sympatry, unlike the others, which are often found together.

*Podagritys digyalos* and *P. chambersi* are very closely related. They are probably derived from a single species that occupied a north-south cline in which adult colour and surface area relative to volume were directly related to contemporary climate, becoming fixed in the pupal stage. Individuals in the northern parts of the cline would have had paler-coloured bodies, silver hairs on the posterior of the propodeum, and a long, slender, petiole. Conversely those at higher altitudes and latitudes would have had a shorter petiole and darker pigmentation.

During a severe glacial period colour and form may have become genetically fixed. In the following interglacial, rising sea levels would have produced a Cook Strait separation. In the next glacial period lower sea levels would have permitted the black form to extend into the North Island across the former strait while the paler form would have retreated further north, into the northern lowlands. During the following interglacial, Cook Strait would have reappeared, preventing the pale form from reaching the South Island as it extended back further south in the North Island, while the higher temperatures would have resulted in the melanic form, *digyalos*, retreating to and occupying an increasingly higher altitudinal band on the North Island mountains. This would have resulted in *digyalos* occurring

throughout the South Island and on North Island mountains and *chambersi* occurring in the north and on lowlands throughout the North Island, but not in the South Island – the current distribution of these two species.

**Diagnosis. Female.** (1) First flagellomere much longer than any antennal article except scape, about twice as long as flagellomeres 2, 3, and 4 (e.g., Fig. 24a). (2) Mandible without a distinct mesal tooth. (3) Pronotum in dorsal view with lateral carinulae very flat, subdepressed, without anterior and posterior tubercles. (4) Metasoma widest near apex of segment 4, near its boundary with segment 5. (5) Pygidial plate with only a few scattered, sparse punctures and appearing almost without bristles. (6) First segment of foretarsus without a psammophore (a row of setae along its length such as occurs in *albipes*, *carbonicolor*, and *cora*).

Note. The relatively large spines on the hind tibia enable females of this species-group to be distinguished from those of *Rhopalum zelandum* and *R. aucklandi*, with which they are sometimes confused. *R. zelandum* is most often confused with the *P. digyalos* species-group, but can be easily distinguished on clypeal characters, in addition to hind tibial bristles, etc. (see Diagnosis). *P. digyalos* group females are sometimes mistaken for those of *P. albipes*, but can at once be distinguished by the long first article of the antennal funicle (cf. short in *albipes*) and by characters 1–5 in the diagnosis above.

**Male.** (1) First flagellomere expanded apically, ventrally excavated, resembling pedicel (Fig. 24b). (2) Pygidial plate short, broad, with well raised lateral carinae, its surface having very few, well separated punctures and sparse, scattered long hairs. (3) Pronotum in dorsal view without a spinose lateral humeral carinula. (4) Head in dorsal view with supraorbital sulcus obsolete, present only as a lateral indentation behind ocellus and obliquely opposite it beside compound eye. (5) Propodeum without a lateral carina.

**Remarks.** *P. digyalos* species-group females sometimes have an obsolete median carina on the pygidial shield, and fewer punctures and hairs than in other *Podagritys* species, thus resembling a *Rhopalum*. The male genitalia are very similar to those of *Rhopalum zelandum*. Notwithstanding this, in most respects this species-group is typical of *Podagritys* as here conceived.

Males of this species-group are sometimes mistaken for those of *Rhopalum aucklandi*, which however have a high, blade-like lateral propodeal carina. Males are also mistaken for *R. zelandum*, but note that the greatly excavated first flagellomere in *digyalos* and *chambersi* contrasts with that of *R. zelandum*, which is not excavated.

**Note.** The *digyalos* species-group members are described in the alphabetical sequence of species under *Podagritys* (*Parechuca*).

***Podagritys (Parechuca) albipes* (Smith)**

Fig. 6

*albipes* Smith, 1878, p. 7 (*Rhopalum*); New Zealand. Hutton, 1881, p. 106. Dalla Torre, 1897, p. 582 (*Crabro*). Hutton, 1904, p. 98 (*Rhopalum*). Leclercq, 1955b, p. 9, fig. 1, 5, 9 (*Rhopalum (Rhopalum)*); —1970a, p. 87 (*Podagritys (Parechuca)*). Miller, 1971 (and 1984), p. 27 (*Rhopalum*). Callan, 1979, p. 38 (*Podagritys (Parechuca)*). Valentine & Walker, 1991, p. 39.

**Diagnosis. Female.** (1) Head in dorsal view with anterior outline of frons, beyond ocelli, appearing subrectilinear, only a little concave but indented at midline. (2) Apical margin of clypeus with median lobe rectilinear (typically) or concave, and lateral erosions shallow, so lateral lobes not produced into sharp tubercles (Fig. 33). (3) Epipygial area incompletely demarcated by lateral carinae, these more or less straight but evanescent and obtuse, little raised above surface and extending only from apex to a little beyond mid segment in most specimens, occasionally continuing as a faint line to base. In these specimens the rounded dorsolateral area distinguishes *albipes* from *P. cora* and *P. carbonicolor*, in which the dorsolateral area is angular and the carina protrudes more (Fig. 49a,b). (4) Epipygium relatively densely covered with bristles. (5) Pronotum in dorsal view with lateral carina (on humeral angle) rising into a sharp, bituberculate, bilobed ridge, with anterior and posterior tubercles separated by a saddle; anterior tubercle larger and less acute than posterior one (Fig. 44). (6) Frons steeply declivous below horizontal frontovertex; area in front of ocelli with only a shallow erosion, and area between top of compound eyes not deeply excavated. (7) Mandible with lower tooth much shorter than upper tooth. (8) First 5 flagellomeres roughly subequal. (9) Epipygium usually with densely grouped punctures and closely arranged, moderately long bristles. (10) Ocelli widely spaced; POL:OOL 0.7–0.8. (11) Mandible with mesal molar tooth well basad of midway.

**Male.** (1) Antennae not greatly modified; flagellum very robust, its segments short and fat, about as wide as long; flagellomeres 1–5 with obtuse, fulvous yellow carinules on outer lateroventral aspect (Fig. 21). (2) Hind tibia very clavate (distal 0.3 very swollen relative to proximal 0.4). (3) Metasoma with 1st segment very long and thin, slightly exceeding length of hind trochanter and femur. (4) Hind tibia basally with a yellow ring.

**Description. Female** (Fig. 6). Body length 5.5–11.0 mm; forewing length 4.0–8.0 mm.

**Colour.** Body black with the following yellow. *Latitude 48–32°S*: ventral scape, apices of femora, anterolateral aspect of fore tibia, fore tarsus, base of middle tibia, middle tarsal segments 1–4, posterodorsal aspect of hind tibia, hind tarsal segments 1–4, pronotal lobe, and anterior spot on tegula. *Latitude 44–45°S*: extreme base of scape, anterolateral aspect of foretibia, spot on fore femur, base of middle tibia, rim of pronotal lobe, and anterior spot on tegula. Darker and paler individuals occur in both areas.

**Vestiture.** Head with scattered erect, fusco-aeuous hairs and decumbent silvery pubescence on genae, lower frons, clypeus, and between vertex and lower occiput. Metasoma with small, decumbent, aeneous hairs dorsally and laterally on segments 4–6 and with scattered long, erect fusco-aeuous hairs ventrolaterally on apical boundaries of segments 2–5. Epipygium with dense, regularly spaced bristles. Hypopygium with densely grouped bristles at apex.

**Structure.** Head (Fig. 10). Surface minutely punctulate. Median ocellus 0.7× width of lateral ocelli; POL:OOL usually about 2:3 to 3:4 (0.7–0.8). Orbital fovea curved, extending from lateral ocellus to compound eye. Area in front of ocelli only a little concave, but deeply indented at midline; SFD/TFD about 0.3; TFD/FD 1.5. Clypeus short, with apical boundary shallowly indented; lateral lobe forming a small spine; outline as in Fig. 33. Mandible usually with lower apical tooth much shorter and often narrower than upper tooth but occasionally almost equal in length; mesal molar tooth prominent, situated basad of midway. Antennal flagellomeres short and approximately equal; flagellomeres 1–5 varying in relative length as about 5.5 : 5.4 : 5.6 : 5.0 : 5.0 to 8.0 : 10.0 : 10.0 : 8.8 : 8.0.

**Thorax and propodeum.** Surface minutely punctulate. Pronotum in dorsal view with lateral carinula (on humeral angle) gently raised, eroded sharply on its dorsolateral face, forming anterior and posterior tubercles; ridge top nevertheless appearing sharp throughout (Fig. 44). Scutum with notaulus, admedian line, and parapsidal line distinct. Propodeum with a deep median sulcus; longitudinal median fovea on declivity with posterior boundary V-shaped.

**Legs.** Foretarsus 1 with a psammophore of 5 setae; hind femur notably claviform, its dorsal outline smooth in lateral view.

Wings as for male (Fig. 63).

**Metasoma nitid.** First segment long, thin, a little bowed, slightly dilated at midway about spiracle, very nodular apically; 1.0–1.2× length of hind femur, with proximal 0.8 much narrower than middle of hind femur. Gaster widest between segments 3 and 4. Sixth segment very rounded;

epipygial area incompletely demarcated by lateral carinae, these evanescent and obtuse, little raised above surface and extending only from apex to a little beyond mid segment (Fig. 49).

**Variation.** Epipygium: lateral carinae always obsolete basad of midway (but somewhat variable), never raised much above surface; sides of epipygium always gently rounded in vicinity of carinae. Surface of epipygium usually coriaceous-punctate, sometimes imbricate-punctate or areolate-rugulose-punctate, occasionally with integument between punctures nitid throughout, often with a dense covering of hairs, but these sometimes moderately sparse.

**Mandible:** lower tooth usually shorter and narrower than upper tooth, but teeth sometimes appearing of roughly equal length, almost subequal; occasionally mandible apically truncate and lacking a lower tooth.

The female of *P. chambersi* is sometimes mistaken for that of *P. albipes*, but can at once be distinguished by the long first article of the antennal flagellum (cf. short in *albipes*).

**Male.** Body length 4.2–10.0 mm; forewing length 3.2–6.2 mm.

Colour relatively constant, black except for the following, which are yellow. *Latitudes 36–42°S*: pronotal lobe; anterior spot on tegulae; wing axillary sclerites; antennal scape; outer lateral surface of antennal scrobc and flagellomeres 1–5 (especially carinules on 2–5, which are fulvous yellow); distal half of fore femur and entire tibia and tarsus; apical 0.1 of middle femur, dorsal and lateral aspects of tibia, and tarsal segments 1–4; apical 0.3 of hind tibia and tarsal segments 2 and 3, and proximal half of segment 4. *South of latitude 45°S*, and in colder microhabitats north of that, black occurs on upper surface of antennal scape and ventral surface of fore tibia. *North of latitude 36°S*, and in warmer microhabitats south of that, the yellow areas may be only slightly more extensive.

Vestiture similar to female.

**Structure.** Head in dorsal view similar to female; POL: OOL as about 5:6. Orbital fovea similar to female. Apical outline of clypeus with median lobe concave; lateral lobes not spine-like nor with apices directed forwards; lateral indentations shallow. Mandible with a greatly reduced basal, mesal molar tooth; upper apical tooth usually longer and wider than lower tooth; lower tooth sometimes very small, but occasionally teeth subequal or even equally developed; teeth generally acute and separated by a deep incision. Antennal flagellum very robust, the articles short, fat, about as long as wide, almost unmodified; flagellomeres 1–5 with obtuse carinules on outer lateroventral aspect (basal only on flagellomere 5) (Fig. 21).

Thorax and propodeum similar to female. Foretarsus segment 1 with 3 large spines in a row on posterior lateral surface. Hind tibia notably very clavate. Wings, Fig. 63.

Metasoma notably narrow and elongate (much more so than in female). First segment very elongate, slightly exceeding length of hind trochanter and femur, dilated medially about spiracle, not greatly expanded apically, although nodular. Gaster widest between segments 4 and 5. Tergum 7 apically rounded; dorsal surface with lateral pygidial carinae anteriorly obsolete, and with large, close punctures.

**Genitalia.** Parameres with a fringe of hairs on inner side only (outer side hairless), more than twice length of aedeagus. Digitus volsellaris vestigial, acicular, apically very narrow and attenuated, seta-shaped, reaching to about distal quarter of aedeagus (Fig. 73).

**Cocoon.** No. 1 (Fig. 112): Wanaka OL, in lake beach sand, 8 March 1975. Length 9.5 mm, maximum width 4.0 mm. Oblong-oval, with outer surface composed entirely of cemented sand grains, i.e., without fragments of hosts. No. 2: Earnsclough Station CO, 9 March 1975. Length 9.6 mm, maximum width 4.5 mm. Composed of welded clay fragments, partly fused, with recognisable fragments of host's integument incorporated throughout outer surface.

**Type data.** Holotype *albipes* (BMNH; not seen); female, ?Otago.

**Material examined.** 1442 adults (783 females, 659 males), 17 larvae, and 20 pupae.

From all coded collection areas.

**Biology.** Hunting. *P. albipes* females capture Diptera from flowers of low herbs, grasses, and occasionally shrubs, including *Selliera radicans*, *Lepidium desvauxii*, *Achillea millefolium*, *Rumex acetosella*, *Gnaphalium* spp., *Brachyglottis* spp., *Senecio* spp., *Helichrysum* spp., *Muehlenbeckia complexa*, *Phormium tenax*, *Hebe* sp., *Aciphylla* sp., *Gingidium* spp., *Anisotome* spp., and others. Diptera flying about plants (e.g., flowering *Muehlenbeckia complexa*, *Cirsium vulgare*) or above low plants (e.g., flowering *Rumex acetosella*) are captured in the air. Diptera are also captured on leaves and stems of plants, on stones and on the ground. When nesting occurs in sand of riverbeds (e.g., Hutt River WN) and streams a combination of adult aquatic insects (usually Ephemeroptera) and Diptera is captured and stored in the same nest-cells. Such prey is often hunted on sedges and low vegetation near water.

At Blue Stream, below the Tasman Glacier, Mt Cook National Park MK, in every year between 1975 and 1991 a population during January preyed almost exclusively on Ephemeroptera and Trichoptera (Harris 1990). The Blue Stream is lined with large boulders, which also protrude above the water in mid-stream. Its banks are lined with sedges and grasses, beyond which are areas of shingle and sand in which the crabronines nest. Every January the boulders in and lining the Blue Stream were regularly occupied by from 3 to 24 *P. albipes* and *P. cora*. The wasps waited for *Deleatidium myzobranchia* and *D. hillii* (Ephemeroptera) to crawl out of the water onto the stones. As the back of the mayflies split and the subimago attempted to struggle out, the crabronines would pounce, pull the subimago from its exuviae, sting it to paralysis, and take it to a nest. Syrphidae, their normal prey in other parts of New Zealand, were sometimes investigated but rejected. Lesser numbers of *Pycnocentodes aureola* were captured on the stones as well, and similarly were stung to paralysis and taken to nests. It would seem that the population at Blue Stream is locally adapted to predation on adult aquatic insects, and this may indicate how species of groups normally host-specific at the ordinal level come to prey on entirely new orders of insects.

**Paralysis.** Prey is stung to permanent paralysis on being captured.

**Prey carriage.** Prey is held supine, head forwards, by the wasp's middle legs. The apex of the prey's abdominal venter and wings project beyond the wasp's pygidium.

**Nest sites.** This species nests in sand, sandy loam, silt, silt/loam, glacial till, and sand among gravel in sand dunes, beaches, scrolls in rivers and streams, glacial moraines, silty river banks, roadsides, and similar places. It is often common on the banks and in the bed of rivers and streams. It occurs as well on exposed soil above forest and in tussock country.

**Nests.** Nests are made vertically into horizontal soil and horizontally into vertical banks, the latter usually curving and continuing downwards steeply, or at an angle. There is usually a mound at the entrance, and all nests examined had either one or two cells. A spur was usually present in the main burrow just before the cell. The burrow is left open during provisioning. Main burrows were 20–68 (mean 50.3) mm long by 2.3–4.0 (mean 3.2) mm wide. Cells were 8.8–17 mm long by 4.7 mm wide, and cell burrows were 4–18 mm long. When present, the entrance mound varied from 15 mm to 46 mm across (it was often absent).

Typical nests are shown in Fig. 120a–c. Nest 1: at Outram Bridge, on the Taieri River, in silt. Main burrow vertical, 3.1 mm wide by 40 mm long; cell burrow 4 mm long; cell 14 mm long by 4.6 mm wide; inner closure 4 mm

long, of compacted clay; spur 5 mm long. Cell contents: 16 Dolichopodidae.

Nest 2: in sand, Silver Stream, Taieri. Main burrow inclined at 70°, 3 mm wide by 50 mm long; cell burrow 6 mm long; inner closure of compacted sand 4 mm long; cell 15 mm long by 4.7 mm wide; spur 6 mm long. Cell contents: Empodidae (Diptera), sp. indet, 2 prey items; *Deleatidium myzobranchia* subimago (Ephemeroptera), 5 prey items.

Nest 3: in silt, Outram, Taieri River. Main burrow vertical, 3.1 mm wide by 4 mm long. First cell 40 mm below surface; cell burrow 8.5 mm long; cell 12.3 mm long; cell contents Tephritidae (3), Simuliidae (5), Lauxaniidae (2), Drosophilidae (1), Dolichopodidae (3), Culicidae (2). Second cell 49 mm below surface, 12 mm long by 4.9 mm wide; cell contents 6 *Melangyna novae-zelandiae* (Syrphidae).

Male burrows (Fig. 120d) are shorter and narrower than female nests, varying in width from 1.5 to 3.5 mm and in length from 20 to 28 mm. One to five individuals occupy such nests (which are never closed) at night and during inclement weather.

**Life history.** The white, oblong-ovate egg, 2.5 mm long by 0.7 mm wide, is sometimes laid across the ventral neck region of prey items (Fig. 120e) and at other times oblique-transversely on the abdominal venter (Fig. 120f). The larva makes its cocoon after about 30 days. A typical cocoon made in sand was oblong-ovate, pale buff-brown, matt, 9 mm long by 4 mm in maximum width, with a very rough, granular exterior composed of cemented sand grains. The walls throughout consisted of cemented sand grains lined on the inside with a very thin, shining, pale brown 'varnish' secreted by the larva. Nests in clay/loam are made of earth and have a granular, earthy appearance, with small fragments of chitin from uneaten prey remains built into the outer cocoon walls.

**Remarks.** Although preying extensively on Diptera, *P. albipes* occasionally includes Ephemeroptera, Plecoptera, and Trichoptera in its nests. On Otago riverbanks it sometimes includes Plecoptera with Diptera.

Ms Diane Dunstan (pers. comm.) has observed this species filling nests with a mixture of dolichopodids, stratiomyids, lauxaniids, drosophilids, and Ephemeroptera on the banks of the Hutt River at Silverstream WN. I have made similar observations in both the North and South Islands. The situation at Blue Stream MK is unusual in that, during January at least, *P. albipes* populations prey exclusively on aquatic insects (mostly Ephemeroptera and Trichoptera) and reject seemingly suitable Diptera (Harris 1990).

### *Podagritys (Parechuca) carbonicolor* (Dalla Torre)

*carbonarius* Smith, 1856, p. 424 (*Crabro*), not Dahlbom, 1838; New Zealand. —1876, p. 484 (*Rhopalum carbonarium*). Hutton, 1881, p. 105 (as *carbonaria*); —1904, p. 98. Miller, 1971 (and 1984), p. 27, pl. 4 fig. 3. Davies, 1986, p. 61.

*carbonicolor* Dalla Torre, 1897, p. 586 (*Crabro*) (replacement name for *carbonarius* Smith).

*swalei* Leclercq, 1955b, p. 12 (*Rhopalum (Rhopalum)*); —1970a, p. 87 (*Podagritys (Parechuca)*). Bohart & Menke, 1976, p. 393. Callan, 1979, p. 39. Valentine & Walker, 1991, p. 40. New synonymy.

**Diagnosis. Female.** (1) Mandible with mesal margin bearing a large molar tooth well basad of midway (cf. much nearer midway in *cora*) (Fig. 31). (2) Mandible with axes of upper and lower apical teeth divergent; teeth well separated by a deep incision, pointed; lower tooth usually smaller and shorter than upper tooth (Fig. 29). (Occasional individuals with rounded, subequal apical teeth similar to those of *cora* should be checked for characters 1–9.) (3) Pronotum in dorsal view with a lateral (humeral) carinula rising steeply to a high, sharp, knife-edged keel, without blunt anterior and posterior tubercles, clearly higher than median discoidal area (Fig. 45). (4) Head in frontal view unusually wide, with frons usually appearing as wide as compound eye (TFD/SFD usually less than 4.0, generally about 3.3) (Fig. 40). (5) Anteromedian margin of clypeus projecting well beyond lateral lobes. (6) Area in front of ocelli very concave. (7) Orbital fovea shallow, very broad, its outline somewhat indistinct (cf. distinctly impressed and narrow in *cora*) (Fig. 42). (8) POL:OOL as about 1:2; hind ocelli very well separated from compound eyes. (9) Lateral epipygial carina prominent, entire. (10) Usually large (10.6–18.0 mm) — the largest species in New Zealand.

**Male.** (1) Antennal pedicel greatly expanded (Fig. 22). (2) POL:OOL as about 1:2. (3) Orbital fovea short, very wide. (4) Pronotum with lateral (humeral) carinula in dorsal view appearing high and sharp-sided.

**Description. Female.** Body length 10.6–18.0 mm; forewing length 7.8–12.3 mm.

Colour. Throughout its range, body and appendages black except for a yellow, elongate-oval spot on inner anterolateral aspect of fore tibia.

Vestiture on head and mesosoma similar to *cora*. Metasoma much as for *cora*, but hairs on hypopygium covering middle of distal 0.4 (cf. bare in *cora*, where the hairs form a lateral fringe).

Structure. Head. Microsculpture similar to *cora*. Vertex very wide. Orbital fovea shallow, the outline somewhat

indistinct, relatively short and very broad (Fig. 42). Ocelli appearing well separated from compound eyes; POL:OOL as about 1:2 (0.52). Area in front of ocelli very concave. Head unusually transverse, in frontal view appearing rectangular and very wide (Fig. 40); FD/TFD about 0.6; SFD/TFD about 0.3. Anterior border of clypeus as in Fig. 34, with median lobe clearly extending well beyond lateral lobes. Mandible with molar tooth well basad of midway (Fig. 31); axes of upper and lower apical teeth divergent; teeth pointed, well separated by a distinct incision; upper tooth larger and longer than lower tooth (Fig. 29). First 4 flagellomeres as about 5.5:5:4.5.

Mesosoma. Microsculpture similar to *cora*. Pronotum in dorsal view with lateral (humeral) carinula clearly raised as a knife-edged ridge with a single median point, rising well above height of central discoidal area (Fig. 45). Scutum, metanotum, and propodeum much as for *cora*.

Legs as for *cora*, but psammophore on 1st foretarsal segment generally with 7 or 8 bristles.

Forewing similar to male.

Metasoma much as for *cora*. Epipygium as for *cora*, but surface between punctures nitid, usually without microsculpture; lateral carina extending from apex to base, well raised above surface.

**Male.** Body length 7.8–14.0 mm; forewing 5.4–11.7 mm.

Colour relatively constant, darker in cooler areas (e.g., at higher latitudes and altitudes), black with the following yellow. *North of latitude 36°S*: dorsal and posterior margin of prothoracic tubercle; anterior spot on tegula; antennal scape except for dorsal and ventral oblong-oval black spots, ventral surface of pedicel, and outer lateral aspect of flagellomeres 1–4 on apex of carinules (last 5 parts fulvous yellow); dorsal and anterolateral surfaces and entire base and apex of fore tibia, and foretarsal segments 1–4; distal 0.2 of middle femur, base, apex, and inner anterolateral aspect of tibia, and tarsal segments 2–4. *South of latitude 44°S*: anterior spot on tegula; base and outer lateral aspect of scape, and outer lateral aspect of pedicel and flagellomeres 1–4 on carinules (last 5 parts fulvous yellow); distal 0.1 of fore femur, anterior dorsolateral aspect of tibia, tarsal segments 1–3, and distal half of segment 5; apical, posterolateral spot on middle femur, anterolateral aspect of tibia, and tarsal segments 1–3; hind tarsal segments 2 and 3.

Vestiture similar to female.

Structure. Head. Dorsal surface similar to female. POL:OOL as about 1:2 (0.5). Shallow supra-orbital sulcus as for female. Anterior margin of clypeus with median lobe extending well beyond lateral lobes, its outline deeply incised (similar to female, Fig. 34). Mandible with mesal margin bearing a distinct, basal molar tooth; upper apical

tooth almost always much larger and longer than lower tooth, similar to female. Antenna highly modified, with pedicel greatly expanded, notably wider than subsequent articles; flagellomeres 1-4 bearing carinules on outer dorsolateral faces, with 1 and 2 very rounded, 3 excavated basally, and 4 expanded apically on outer lateroventral half (Fig. 22).

Mesosoma similar to female.

Legs. Foretarsal segment 1 with a row of 5 setae. Hind tibia proportionately less expanded than in *albipes*.

Forewing as in Fig. 64.

Metasoma widest between segments 3 and 4. First segment long, thin, nodular, as long as hind trochanter plus femur; remainder robust. Segment 7 long, narrow, very heavily punctured, well covered with setae.

Genitalia very similar to *albipes*, but digitus volsellaris even more sharply attenuated.

**Type data.** Holotype *carbonarius* (BMNH; seen): female, bearing 8 labels - "TYPE" (circular, red-margined), "New Zealand / 49 13" (circular, grey), "Type, Fixed by J. Leclercq.", "J. Leclercq. det. 1955 CRABRO CARBONARIUS Smith.", "J. Leclercq. det. 1955. Rhopalum cora CAM.", "/ TYPE" (pink), "SYNTYPE" (circular, blue-margined), "SYNTYPE. Crabro carbonarius Sm. det. C.R. Vardy, 1981."

Holotype *swalei* (BMNH; not seen): male, Putavuru [sic; = Putaruru] (WO).

**Material examined.** 427 adults (271 females, 156 males), 10 larvae, and 9 pupae representing all coded collection areas.

**Biology.** Hunting. *P. carbonicolor* females sometimes patrol gaps and paths in sand dunes, where they hawk for large Diptera which use the passages as fly-ways. As well they take Diptera in the lee of sand banks, at flowers, and on and about foliage. In a pasture surrounding a blow-out sand dune in partially cleared forest near Haast WD in January 1974, *P. carbonicolor* females were hawking *Calliphora quadrimaculata* (Calliphoridae) around fresh cow droppings, and on 26 November 1989 females were capturing a large species of *Anabarrhynchus* above flowering *Rumex acetosella*. Paralysis is permanent.

Prey carriage. Prey is held supine, head forward, by the wasp's middle legs, with the apex of the fly's abdominal venter and wings projecting beneath the wasp's pygidium. The wasp flies into its nest carrying the prey without pausing at the entrance. The fly is dropped inside the entrance, at the narrow end of the entrance cone (when present), with its pygidium just visible, but the wasp

remains invisible under the fly while it goes down the burrow. Fifteen seconds later the fly disappears as it is taken into the burrow, without the wasp reappearing at the surface. The main burrow is left open during provisioning.

Nests (Fig. 121a-c) are made in sand or sandy-loam soil, often in dunes, moraines, or sand scrolls in rivers and streams. The main burrow varies from almost horizontal to vertical, and the number of cells varies from one to five. Vertical burrows with radiating nest cells are the most common. The wasp digs much of the main burrow with the apex of the abdomen, bent under the mesosoma. There is often a mound of spoil at the burrow entrance, up to 10.5 mm deep and 95 mm wide.

In some nests the main burrow was preceded by a short funnel (Fig. 121b), which opened to the surface as an oval entrance measuring 7 x 6 mm to 12 x 10.8 mm, narrowing over a 7-20 mm distance to a perfectly round hole 5.0-7.2 (mean 5.4) mm in diameter. A spur at the base of the first cell is subsequently enlarged into a cell burrow, leading to the second (or subsequent) cell. Cell burrows were 5.0-5.5 (mean 5.2) mm wide by 20-180 mm long, the longest in coastal sand. Cells were 17.8-19.9 mm long and 6.5-6.9 (mean 6.8) mm high.

Prey items represented a great diversity of species (though only Diptera), and were positioned supine, heads facing away from the cell entrance. An inner closure of compacted sand 3-5 mm long is made after oviposition. The egg is laid on the last prey item.

Life history. The long, thin, curved egg (Fig. 121d), 3.4-3.6 mm long by 0.9 mm wide, is positioned ventrally on the neck, curving around the head of the fly. Eclosion occurs 3 days after the egg is laid, and cocoon construction takes place about a month later.

Male burrows, like those of the females, are not closed at night or during inclement weather, when they are occupied. Such burrows, made in sand, varied from 40 to 75 mm deep and from 5 to 7 mm wide.

Prey. *P. carbonicolor* preys exclusively on Diptera, so far as is known. It takes large calliphorids, therevids, tabanids, tachinids, muscids, and stratiomyids, as well as very much smaller flies. Three or four very large flies are placed in each cell, but 16 or more smaller prey items may occupy a single cell.

**Remarks.** In 1838 Dahlbom described a European species as *Crabro carbonarius* (now recognised as a synonym of *Crossocerus* (*Blepharipus*) *leucostomus* - e.g., Lomholdt 1976, p. 400). When Smith (1856) described his New Zealand species as *Crabro carbonarius* the name was therefore preoccupied; Dalla Torre (1897) accordingly provided the replacement name *carbonicolor*.

The two conflicting determination labels on the holotype indicate that Leclercq had been unable to distinguish between females of *carbonarius* (i.e., *carbonicolor*) and *cora*. These are indeed very similar, but the large, high spine on the humeral angles of the pronotum is distinctive of *carbonicolor* (in *cora* the spine is flattened). Leclercq's *swalei* proves to be a male of *carbonicolor*, which is the largest New Zealand *Podagritys*.

### *Podagritys (Parechuca) chambersi* new species

**Diagnosis. Female.** Petiole of gaster elongate, slender, exceeding length of hind femur. Median lobe of clypeus apically emarginate, with a pronounced rounded incision. Metanotum and mandibles yellow. Antennae yellow-orange or fulvous orange, occasionally black.

**Male.** Metanotum and mandibles yellow. Antennae yellow-orange or fulvous, occasionally black. (Plus characters in diagnosis of *digyalos* species-group.)

**Description. Female.** Body length 5.0–8.5 mm; forewing length 4.0–6.6 mm.

Colour less dark than in *P. digyalos*. In warmer areas black or dark brown with the following yellow: mandibles, except apex (red); antennal scape (pedicel and flagellum fulvous yellow-orange); pronotal lobe; spot on tegula; basalar area; metanotum; wing axillary sclerites; foreleg except proximal 0.2 of femur; middle leg except proximal 0.15 of femur and 5th tarsomere; distal 0.3 of hind coxa, proximal 0.2 of trochanter and tibia, and tarsomeres 2–4. Palpi fulvous, and metasoma (particularly on venter) often partly fulvous. In cooler areas: yellow areas whitish-yellow with some dark pigment showing through; antennal pedicel and flagellum fulvous brown; wing axillary sclerites brown; more than 50% of fore and middle femora black; otherwise much as above.

Vestiture very similar to *digyalos*, but propodeal declivity with sagittal sulcus bounded very closely on either side with dense silvery pubescence, obscuring the underlying dermis (cf. almost nude in *digyalos*).

Structure very similar to *digyalos*, but orbital fovea often clearly outlined, pyriform, and more deeply incised, though very variable. Frons narrow; SFD/TFD 0.13–0.19. Propodeal declivity with a deep sagittal sulcus closing above and below with an attenuated V, bounded very closely on either side with dense silvery pubescence. (In *digyalos* this sulcus is usually broader and shallower, and is usually not attenuated into a narrow V above, but ends broadly; nor is it bounded closely on either side by long silvery pubescence.)

Metasoma with 1st segment very long and narrow in

lateral view, its apex less nodular than in *digyalos*, longer than hind femur; in direct dorsal view with area surrounding spiracle not appearing raised (Fig. 47; cf. raised in *digyalos*, Fig. 48). Remainder of abdomen very similar to *digyalos*.

**Male.** Body length 5.0–7.6 mm; forewing length 4.0–6.0 mm.

Colour black to dark brown, with the following yellow: antenna (pedicel and flagellum fulvous yellow); mandible (teeth red); anterior spot on tegula; wing axillary sclerites; metanotum; foreleg except base of femur; middle leg except extreme base of femur; apex of hind coxa, base and apex of trochanter, apex of femur, proximal 0.4 of tibia, and tarsomeres 2–4. Only a little darker in cooler North Island localities.

Structure in most respects similar to female, but metasoma with 1st segment much longer and slenderer than in *digyalos*, generally of similar length to hind femur; remainder of metasoma similar to *digyalos*. Genitalia (Fig. 74) similar to *digyalos*, but paramere broader.

**Type data.** Holotype (NZAC; seen): male, Taupo TO, 10 January 1932, J.S. Armstrong.

Paratypes: 257 adults (57 females, 216 males; 13 NZAC, 14 FCNZ, 230 OMNZ) from Kaiwaka; Whangarei; Auckland; Thames; Hicks Bay; Mt Pirongia; Piriaka; Manunui; Ohura; Taupo; Waiotapu; Waimangu; Mamaku Range, Rotorua; Summerlee Stream, Clifton; Huiarau Range; Mt Taranaki [Egmont]; Patea Dam; Hunterville; Feilding; Pohangina Valley; Palmerston North; Munro's Bush, Palmerston North; Upper Hutt; Wainuiomata; and Te Wharau.

**Material examined.** Type series only.

ND, AK, CL, WO, BP, TO, HB, GB, TK, RI, WN, WA /—.

Confined to the North Island, in warmer or lower areas.

**Biology.** Hunting, prey capture, and nesting very similar to *P. digyalos*. Nest as in Fig. 122.

### *Podagritys (Parechuca) cora* (Cameron)

*cora* Cameron, 1888, p. 181 (*Crabro*); New Zealand. Dalla Torre, 1897, p. 592 (locality incorrect: "India"). Hutton, 1904, p. 98 (*Rhopalum*). Leclercq, 1954, p. 185; — 1955b, p. 11, fig. 7, 11 (*Rhopalum (Rhopalum)*); — 1970a, p. 87 (*Podagritys (Parechuca)*); — 1970b, p. 276. Bohart & Menke, 1976, p. 393. Callan, 1979, p. 37. Valentine & Walker, 1991, p. 40.

*jocosus* Cameron, 1898, p. 3 (*Crabro* (*Rhopalum*)). Bohart & Menke, 1976, p. 393 (*Podagrirus jocosus*). Callan, 1979, p. 37. Valentine & Walker, 1991, p. 40.

**Diagnosis. Female.** (1) Mandibular apex with upper and lower teeth relatively weakly separated, subequal, with axes parallel and apices gently rounded (Fig. 30). (2) Mandibular mesal margin with a large tooth a little basad of midway (Fig. 32). (3) Humeral angle of pronotum with lateral carinula blunt in dorsal view, hardly raised, often with blunt anterior and posterior tubercles separated by a saddle (Fig. 46). (4) Head with area in front of ocelli very concave. (5) Frons in facial view appearing little more than half width of compound eye (Fig. 41). (6) POL:OOL about 3:5 to 1:2. (7) Epipygium completely bounded by lateral carinae, these entire, large, and well raised above surface; pilosity relatively fine; smooth integument showing between punctures (Fig. 50). (8) Orbital fovea narrow (cf. wide in *carbonicolor*) (Fig. 43).

**Male.** (1) Antenna with pedicel not expanded, less swollen than flagellomere 2; flagellomere 1 excavated basally, swollen apically; flagellomere 2 very greatly enlarged, produced laterally into a large, oblong expansion; flagellomere 3 greatly expanded (Fig. 23). (2) Pronotum in dorsal view with lateral carina little raised (as in Fig. 46). (3) Gaster with 1st segment much shorter than hind trochanter plus femur.

**Description. Female.** Body length 9.8–15.6 mm; forewing length 7.1–11.4 mm.

Colour black, with the following yellow. *Latitudes* 38–42°S: elongate-ovate spot on inner anterolateral aspect of foretibia; small round spot dorsoapically on fore femur; dorsal margin of pronotal tubercle. *Latitudes* 44–45°S: oblong-ovate spot on foretibia.

**Vestiture.** Vertex nude except for numerous long, erect, fusco-aeuous hairs which occur elsewhere on head, including mandibles. Dense, decumbent silvery pubescence on genae and lower frons between antennal sockets and frontal margins of compound eyes. Pronotum laterally and on declivity with long, erect, fusco-aeuous hairs. Metasoma with fine, decumbent, fusco-aeuous hairs, especially dorsally and laterally on segments 4–6; widely spaced erect hairs in a transverse line near posterior margin on sterna 2–5. Distal 0.7 of hypopygium with a fringe of erect bristles; sagittal part bare. Epipygium with hairs decumbent, relatively fine; much integument visible between hairs and punctures.

**Structure.** Head. Surface minutely punctulate; POL:OOL as 3:5 to 1:2 (0.6–0.5). Orbital fovea narrow (Fig. 43). Area in front of ocelli where dorsal part of head curves

sharply into perpendicular face very concave, sloping evenly inwards from compound eyes to midline. FD/TFD about 0.6; SFD/TFD about 0.2. Clypeus with anterior margin as in Fig. 35, its median lobe extending little beyond lateral lobes, these projecting forwards as tubercles. Mandible with molar lobe midway on mesal surface (Fig. 32); upper and lower apical teeth subequal, little separated, with apices gently rounded; sometimes the 2 teeth equally developed, with little or no indentation between; sometimes lower tooth slightly the shorter (Fig. 30). First 4 flagellomeres as about 7:9:8:8.

**Thorax and propodeum.** Surface minutely punctulate. Pronotum in dorsal view with lateral carinula (on humeral angle) subdepressed, relatively very flattened, no higher than central disc (Fig. 46). Scutum with admedian lines long and conspicuous, notauli faint, parapsidal lines very distinct. Scutellum and metanotum nitid; pronotum minutely colliculate. Median longitudinal sulcus deep, continuous; declivity with a deep median fovea.

**Legs.** Foretarsus with 1st segment bearing a psammophore of 5 or 6 long bristles. Hind tibia clavate, but a little less so than in *albipes*.

Forewing as in Fig. 65.

**Metasoma nitid.** First segment pedunculate; apex nodular, rather spherical; proximal 0.7 thin, not much dilated near spiracle. Epipygium with hairs decumbent, relatively fine; much integument visible between hairs and punctures (Fig. 50); lateral carinae large, entire, raised well above surface from apex to base, the segment not appearing rounded (Fig. 50).

**Male.** Body length 6.0–13.8 mm; forewing length 4.0–8.5 mm.

Colour relatively constant, black with the following yellow. *Latitudes* 38–43°S: pronotal lobe (except base); anterior spot on tegula; wing axillary sclerites; base and outer lateral aspects of antennal scape (as a narrow band), outer lateral aspects of pedicel, and expansions on flagellomeres 1–4 (last 5 parts fulvous yellow); distal 0.4 of fore femur, tibia except for dorsal and ventral oblong-oval black spots, and tarsus; distal 0.2 of middle tibia except for dorsal and ventral narrow oblong-oval black spots, and tarsal segments 1–4; hind tarsal segments 2–4. *North of latitude* 43°S yellow occurs on distal 0.1, base, and inner face of hind femur, and on entire middle tarsus. *South of latitude* 45°S black occurs on distal half (at least) of all hind tarsal segments, pronotal lobe, and base of antennal scape. Notwithstanding this, individuals from particularly warmer microhabitats in those latitudes will be more yellow than indicated, and those from cooler microhabitats will be darker.

Vestiture similar to female, but with notably long hair on lateral and posterior faces of propodeum.

Structure. Head in dorsal view similar to female. POL: OOL as about 6:9 (0.6). Anterior border of clypeus with median lobe projecting well forward of lateral lobes (as in Fig. 35). Mandible with a vestigial mesal molar tooth; upper tooth larger and longer than lower tooth. Antenna greatly modified; pedicel not expanded; flagellomere 1 expanded apically, excavated basally below; flagellomere 2 greatly expanded, its distal 0.6 below as an almost oblong projection, larger than pedicel; flagellomere 3 greatly expanded (Fig. 23).

Thorax and propodeum. Pronotum in dorsal view with lateral (humeral) carinula relatively little raised, produced into anterior and posterior tubercles. Propodeum similar to female.

Legs. Foretarsal segment 1 with a row of 4 spines on posterior ventrolateral surface. Hind tibia notably less clavate (distal 0.4 proportionately much less expanded) than in *albipes*.

Metasoma similar to female, widest between segments 3 and 4, where it is notably broad. First segment nodular, expanded in region of spiracle, much shorter than hind trochanter plus femur. Seventh segment with obsolete dorsolateral carinules, densely punctate, proportionately larger and more angular than in *albipes*.

Genitalia very similar to *albipes*, but parameres relatively slightly longer and a little less hairy.

**Type data.** Holotype *cora* ("repository unknown" Leclercq 1955b): male, Greymouth (BR), J. Helms.

Holotype *jocosus* ("repository unknown" Leclercq 1955b): male, Greymouth (BR). Leclercq (1955b) stated that he would designate a neotype, but did not publish further details.

In 1994 I examined 2 female syntypes of *Crabro cora* Cameron, designating one as lectotype, and a male and a female syntype of *Crabro jocosus* Cameron.

Lectotype *cora*: female, bearing 5 labels - "N. Zealand /49 13" (circular, grey), "J. Leclercq det, 1955. Rhopalum cora [female] CAM", "SYNTYPE" (circular, blue-margined), "SYNTYPE *Crabro carbonarius* Sm. det. C.R. Vardy, 1981", "Lectotype, *Crabro cora*, designated A.C. Harris, 1994". Syntype female (head missing) with 6 labels - "New Zealand" (circular, grey), "/ Smith coll. pres. by Mrs. Farren White. 99-303", "J. LECLERCQ DT. PODAGRITUS CORA [female] ? (Cameron)", "SYNTYPE" (circular, blue-margined), "SYNTYPE, *Crabro carbonarius* Sm. det. C.R. Vardy, 1981", "LECTOTYPE, *Crabro cora* Cameron, designated A.C. Harris, 1994".

Syntype *jocosus*: (1) male, bearing 6 labels - "TYPE"

(circular, red-margined), "Cameron coll. 98 - 124.", "Rhopalum jocosum Cam. type. N. Zealand", "B.M. TYPE HYM. 21.907b", "SYNTYPE" (circular, blue-margined), "SYNTYPE *Rhopalum jocosum* Cam. det. C.R. Vardy, 1981"; (2) female, bearing 7 labels - "TYPE" (circular, red-margined), "Cameron, 99-30.", "/N. Zeal.", "Rhopalum jocosum Cam type New Zealand.", "B.M. TYPE HYM. 21.907a", "SYNTYPE" (circular, blue-margined), "SYNTYPE *Rhopalum jocosum* Cam. det. C.R. Vardy, 1981". The right mandible of the female pierces the pronotal disc of a melolonthid beetle, probably *Pyronota festiva*.

**Material examined.** Type series, plus 702 non-type adults (412 females, 285 males), 5 larvae, and 3 pupae.

From all coded collection areas.

**Biology.** Hunting. *P. cora* females sometimes take flies (Diptera) as they suck nectar from flowers, and sometimes capture them in the air as they approach the flowers. Flies are also removed from leaves and from grass flower heads and stalks. In November 1989 among dunes near Haast WD, *P. cora* females were hawking above *Rumex acetosella*, catching Syrphidae and Stratiomyidae. Along Blue Stream, Mt Cook MK in January, *P. cora* females joined *P. albipes* waiting on stones in the stream for subimaginal mayflies (e.g., *Deleatidium myzobranchia*) to climb out of the water and up the stones, when the crabronines would pounce and remove them from their exuviae as soon as the back of the subimago split. As well, both crabronines captured emerging adult Trichoptera such as *Pycnocentrotodes aureola*. Elsewhere this species, unlike *P. albipes*, appears to prey on Diptera only. Paralysis is permanent.

Prey carriage. Prey is held supine, head forward, by the wasp's middle legs, with the apex of the abdominal venter and wings projecting beneath and beyond the wasp's pygidium. The wasp flies its prey into the nest without pausing at the entrance. Sometimes the prey is dropped a few millimetres inside the entrance, where the pygidium is just visible. The wasp examines the cell at the end of the burrow, then (without appearing at the surface) returns for the prey, which disappears underground.

Nest sites consist of sand, silt loam, and shingle and sand in coastal and inland dunes, stream and river scrolls, moraines, and gravel pits. Where *P. cora* appears to nest in shingly soil, the burrows usually penetrate to an area of buried sand in which the cells are made. *P. cora* often nests in the same general area as *P. albipes* and *P. carbonicolor*, e.g., in a sand dune exposed by logging and farming in cut-over forest on the banks of the Turnbull River near Okuru WD in summer 1972-89.

Nests (Fig. 123) are dug in sandy soils. The cylindrical main burrow may be dug vertically into horizontal surfaces (when there may be a roughly circular mound surrounding the entrance, up to 10 mm deep and 90 mm in diameter), horizontally in a vertical bank (when the main burrow will turn and proceed at a steep angle), sloping at an angle, or curved. There may be from one to five cells, though most nests have one or two cells. (At Haast WD in 1974 and 1989, in stabilised inland sand, most nests had from three to five cells.) Cells are connected to the main burrow by cell burrows of varied length. When each cell is completed, a spur is dug in front of the cell burrow, at the bottom of the main burrow. This is often subsequently enlarged as the next cell burrow. Length of cell burrow and number of cells appear to depend on soil type, climate, prey available, and various other characteristics of the microhabitat. Cell burrows near Haast were very long, while some at the foot of the Tasman Glacier MK were notably short. Prey items are positioned in cells supine, head away from the entrance. Main burrows were 60–180 (mean 106) mm long and 3.0–5.6 (mean 4.8) mm in diameter. Cell burrows were 30–180 (mean 67) mm long, cells varied from 14 to 25 (mean 19) mm long by 4.6–10 (mean 9) mm wide, and the spur was 5–6 mm long. Individual cells were closed at the entrance in the cell burrow by a 3–5-mm plug of compacted sand, and the spur was 5–6 mm long.

Individual nests at Blue Stream MK in horizontal sand had entrances 3.5–3.9 mm wide in the centre of mounds 30–50 mm wide. As elsewhere, some nests were dug beside stones. The main burrow was 3.5–3.9 mm wide, and the first cell was 65–80 mm below the surface. Of 15 nests excavated, nine were single-celled and six had two cells. The cells contained seven or eight mayflies (*Deleatidium myzobranchia* group and *D. hilli* group), or seven mayflies and one caddisfly (*Pycnocentroides aureola*). At Kidd's Bush OL a single-celled nest 3 mm wide in a vertical sand-till bank went in horizontally for 40 mm then turned and continued vertically for 50 mm, ending in a single terminal cell.

The following nest in a dune in coastal forest near the Turnbull River, Okuru, is typical of many *P. cora* nests in the area. The entrance was a round hole 5 mm in diameter in the centre of a mound 90 mm wide and 10 mm deep in horizontal sand covered with a ryegrass/clover sward. The main burrow consisted of a vertical, parallel-sided round hole 5 mm wide by 80 mm long. There were five cells, as follows.

Cell 1: 60 mm from surface, 80 mm from main burrow; contents 1 *Stomoxys calcitrans* (Muscidae), 12 Stratiomyidae, 3rd-instar *P. cora* larva.

Cell 2: 63 mm from surface, 80 mm from main burrow;

contents 1 *Stomoxys calcitrans*, remains of 2 others, 4th-instar *P. cora* larva.

Cell 3: 66 mm below surface, 30 mm from main burrow; contents 5 *Stomoxys calcitrans*, 4th-instar *P. cora* larva.

Cell 4: 75 mm below surface, 90 mm from main burrow; contents 12 *Dilophus nigro stigma* males (Bibionidae), *P. cora* egg.

Cell 5: 80 mm below surface, 95 mm from main burrow; contents 6 small Stratiomyidae, 1 *Stomoxys calcitrans*, *P. cora* egg.

The cells, 14–19 mm long by 6.8 mm wide, were closed at the entrance with 3–5 mm of compacted clay.

Male burrows. Males spend nights and inclement weather in short burrows that they dig with the apex of the abdomen.

Life history. The white, oblong-ovate, curved egg, 2.8–3.1 mm long by 0.8–0.9 mm wide, is laid ventrally on the host's neck, curved around the head. Eclosion occurs after 3 days, and the final-instar larva makes its cocoon a month later. There is an 8-month prepupal diapause. Cell contents are sometimes destroyed by larvae of *Anabarrhynchus* species (Diptera: Therevidae).

**Remarks.** Females of *cora* and *carbonicolor* were confused in the past (see Remarks under *carbonicolor*, p. 43).

### *Podagritys (Parechuca) digyalos* new species

**Diagnosis. Female.** Petiole of gaster abbreviated, relatively short and thick, a little shorter than hind femur (Fig. 48). Median lobe of clypeus rectilinear. Metanotum, mandible, and antenna black (plus characters in *digyalos* species-group diagnosis).

**Male.** Metanotum, mandible, and antenna black. Petiole of gaster relatively short and thick (plus characters listed in *digyalos* species-group diagnosis).

**Description. Female.** Body length 5.0–9.3 mm; forewing length 4.0–7.0 mm.

Colour black, except for inner dorsolateral aspect of foretibia, base of middle and hind tibiae, and axillary sclerites of wing, which are yellow (latitudes 38–45°S).

Vestiture. Head with scattered erect, fusco-aeuous hairs in front of ocelli, and decumbent silvery pubescence on lower frons near compound eyes, malar area, and clypeus. Propodeal declivity with sagittal sulcus not bounded on either side by silvery pubescence sufficiently dense to obscure underlying epidermis, which is always clearly visible. Metasomal segments 2–5 with small, decumbent, fusco-aeuous hairs laterally as well as apically

on tergum 4 and over most of tergum 5, except base; a few long, erect, fusco-aeuous hairs in a sparse apical row on sterna 2-5. Hypopygium with only a few sparse hairs apically. Epipygium almost without vestiture.

Structure. Head minutely punctulate. POL:OOL as 5.5:9.0 (0.6). Orbital fovea very short, obsolete posteriorly. Area in front of compound eyes not much excavated, similar to that of *albipes*; FD/TFD 0.76. Frons narrow; SFD/TFD about 0.2. Clypeus with apical border similar to that of *albipes*, median lobe rectilinear. Mandible without a mesal molar tooth; upper and lower teeth subequal, often equally developed, frequently without an incision between them. First article of flagellum clearly very much longer than any antennal article except scape; flagellomeres 1-4 in a ratio of about 14:7:7:7 (Fig. 24a).

Thorax and propodeum. Surface of thorax minutely punctulate. Pronotum with lateral (humeral) carinula very blunt, appearing as a single tumescence without anterior and posterior lobes. Scutum with notaulus and parapsidal lines present; admedian lines short, distinct, relatively well separated. Propodeum with finely coriaceous-strigulate microsculpture arranged in whorls; sagittal sulcus shallow on disc; fovea on declivity often with an obsolete longitudinal carina on either side of sagittal sulcus.

Legs. Foretarsus segment 1 with scattered small spines not arranged in a row, without a psammophore. Hind tibia clavate, its dorsal outline smooth in lateral profile.

Forewing as in Fig. 66.

Metasoma widest on segment 4, near boundary with segment 5. Segment 1 nodular, relatively short and thick, a little shorter than hind femur; in dorsal view area surrounding spiracle distinctly protuberant (not so in *chambersi*) (Fig. 48).

Epipygium. Epipygial plate with only a few scattered, sparse punctures and appearing almost without bristles; surface nitid, highly polished; distal 0.4 concave; central disc gibbous; lateral epipygial carina strongly developed, spanning the segment.

Variation (female). Hypopygium (pygidial plate) sometimes with disc gibbous, apex concave, and no median longitudinal subdepressed carina, sometimes (e.g., some specimens from Lake Rototoi NN) with a complete, sub-depressed median longitudinal carina extending from apex to base. Mandible with teeth subequal, or one tooth a little larger than the other, or sometimes teeth truncated or rounded together, without an incision between them. A female specimen from Queenstown OL had the upper frons excavated, similar to that of *P. cora*.

Male. Body length 5.0-8.0 mm; forewing length 4.0-6.2 mm.

Colour. A dark species. North of latitude 44°S: mostly black to dark brown, but yellow on narrow outer lateral band of antennal scape; anterior dorsolateral aspect of foretibia; fore tarsus (fulvous); proximal 0.3 of middle tibia; middle tarsomeres 1-4; proximal 0.3 of hind tibia; hind tarsomeres 2 and 3 (bases fulvous); and wing axillary sclerites. In warmer areas (e.g., Picton SD) metasoma and dark parts of legs (but not antennae) sometimes fulvous rather than black. South of latitude 45°S: black, but yellow on extreme base of antennal scape; anterior dorsolateral aspect of foretibia; proximal 0.2 of middle tibia and proximal 0.8 of tarsomeres 1 and 2; and proximal 0.3 of hind tibia (occasionally base of hind tarsomeres 2 and 3, and usually also wing axillary sclerites).

Vestiture on head and mesosoma similar to female. Metasoma with fine, moderately long hairs on epipygium.

Structure. Head in dorsal view similar to female. Orbital fovea obsolete, perceptible only as an oblique depression laterally abutting hind ocellus and another, shallower depression obliquely opposite it beside compound eye. Area in front of ocelli barely excavated (apart from deep median sulcus). Frons narrow; SFD/TFD 0.17-0.20. Apical boundary of clypeus with median lobe subrectilinear, gently arcuate, and lateral lobes as blunt spines. Mandible without a mesal molar tooth; apical teeth separated by a distinct incision, with upper tooth larger and slightly longer than lower tooth. Flagellomeres: 1st enlarged, ventrally excavated and shaped like pedicel; remainder short, fat, as wide as they are long (or wider), except the last (Fig. 24b).

Mesosoma similar to female. Pronotum in dorsal view without a lateral (humeral) carinula other than an obsolete tumescence, with a shallow sagittal sulcus. Fore tarsus segment 1 with 3 small postcrolateral bristles. Hind tibia clavate, but distal 0.4 less swollen than in *albipes*.

Metasoma widest between segments 4 and 5. First segment nodular, shorter than length of hind femur. Segments 2 and 3 long, narrow. Segments 4 and 5 distinctly more dilated than others. Epipygium with pygidial plate complete, rounded, broad, bounded laterally by well raised carinae and basally by a sulcus; surface of epipygium with relatively few scattered punctures.

Genitalia (Fig. 75) similar to those of *P. albipes* and *P. parrotti*, but paramere bearing long hairs on both inner and outer faces, as in *Rhopalum zelandum*. Paramere long, slender, narrow basally, gradually dilating towards apex, a little narrower than in *P. chambersi*, which it otherwise resembles.

Type data. Holotype (OMNZ; seen): male, Obelisk Range CO, on clay ridge near upper part of Fraser's Dam Creek (45°17'S, 169°14'E), 15 January 1974, A.C. Harris.

Paratypes: 396 adults (259 females, 137 males; 15 NZAC, 8 LUNZ, 19 FCNZ, 408 OMNZ) from Waitakere Range; Tongariro; Ngauruhoe; Ngamatea, Taihape; Dawson Falls, Curtis Ridge, West Egmont, and above Stratford Plateau, Mt Taranaki [Egmont]; Picton; Mt Arthur; Lake Rotoiti; Venus Hut, Karamea River; St Arnaud Range; Inland Kaikoura Range; Spenser Mountains; Arthur's Pass; Bcaley River; Harper's Pass; Mt Hutt; Craigieburn Range; Mt Algidus; Kaituna Valley Rd, Banks Peninsula; Lake Tekapo; Mt Cook National Park; Blue Stream, Tasman Valley; Wanaka; Queenstown; Ben Lomond; Obelisk Range; Carrick Range; Old Man Range; Homer; Haast Pass; and Takitimu Mountains.

**Material examined.** Type series only.

AK, TO, RI, TK/SD, NN, MB, KA, NC, MC, MK, OL, CO, FD, SL.

Only in higher, cooler places in the North Island. In the South Island from subalpine to below 200 m in the Marlborough Sounds. On heavy clay soils frequently, and sometimes on humic soils.

**Biology.** Hunting and prey capture. Females typically capture small Diptera flying near plants on relatively bare clay soils. On 23 March 1972 in the Obelisk Range CO at 1280 m females were hawking back and forth over *Rumex acetosella* growing on a dry clay bank. The wasps settled on earth or pebbles when the sun was obscured temporarily by clouds, and resumed hawking whenever it became sunny. Small acalyprate Diptera were captured in flight. After being stung to paralysis the prey item, held by the wasp's middle legs, was flown venter up and facing forwards to the nest, which the wasp entered without alighting. Nest cells were left open during provisioning.

Nests (Fig. 124) have either one or two cells, with a main burrow about 2.4 mm wide by 31–65 mm deep (to the first cell) and inclined at roughly 85°. A typical cell contained 14–16 small acalyprate Diptera positioned venter up, facing the end of the cell. The egg is laid on the neck region of the prey. Entrances to nests are frequently partly concealed by small stones a few centimetres in diameter.

**Remarks.** *P. digyalos* differs from *P. albipes*, *P. carbonicolor*, and *P. cora* in that it does not nest in sand.

**Podagritys (Parechuca) parrotti (Leclercq)** Fig. 7  
*parrotti* Leclercq, 1955b, p. 13 (*Rhopalum (Rhopalum)*); New Zealand. —1970a, p. 87 (*Podagritys (Parechuca)*). Bohart & Menke, 1976, p. 393. Callan, 1979, p. 39. Valentine & Walker, 1991, p. 40.

**Diagnosis. Female.** (1) Anterior border of clypeus with lateral lobes as long projections extending well forward of median lobe (Fig. 36). (2) Humeral angle of pronotal collar not produced into tooth-like carinulae. (3) Metasoma with 1st segment short and broad, without a long, spindly basal section. (4) Hind tibia with dorsal surface carinate-rugose, its dorsal profile in lateral view appearing very uneven.

**Male.** (1) Metasoma with 1st segment very short and broad, much shorter than hind femur. (2) Antennal flagellomeres little modified, the 1st not excavated ventrally, the last 7 articles narrow. (3) Pronotal collar with a pronounced transverse dorsal ridge; humeral angles not produced into tooth-like carinulae. (4) Epipygium with a complete pygidial plate; lateral carinae extending from apex to base.

**Description. Female** (Fig. 7). Body length 8–11 mm; forewing length 6–8 mm.

Colour variable, black with the following yellow. *Latitude 36–43°S*: pronotal lobe; antennal scape; distal 0.3–0.5 of fore femur, entire tibia, and 5th segment of tarsus; distal 0.2–0.4 of middle femur, proximal 0.6–0.9 of ventral surface and entire dorsal surface of tibia, and proximal 0.8 of 1st tarsal segment and most of segments 2 and 3; distal 0.2–0.4 of hind femur and segments 2 and 3 of tarsus. *South of latitude 45°S*: pronotal lobe; ventral basal area of antennal scape; outer dorsolateral aspect of fore tibia. Some individuals are entirely black, e.g., 12 of 17 individuals from Mt Luxmore FD, 1000 m (OMNZ). Throughout New Zealand the yellowest specimens were taken from lower latitudes and warmer microclimates.

Vestiture sparse; epipygium with very few setae, similar to *digyalos*.

**Structure.** Head. POL:OOL as 5:8 (0.62). Orbital fovea touching both hind ocellus and compound eye. Area in front of ocelli relatively shallowly concave, similar to *digyalos*. FD/TFD 0.7; SFD/TFD about 0.2. Anterior border of clypeus with median lobe concave, lateral lobes as thorns extending forwards well beyond median lobe (Fig. 36). Antennal flagellomeres 1–4 in a ratio of about 7.7:5.5:5.5. Mandible with a blunt mesal molar tooth at about midway; apical teeth subequal, sometimes bluntly truncated, usually with an incision between them; upper tooth usually the larger.

Thorax and propodeum. Pronotum without an eroded dorsolateral (humeral) carinula, rising to a transverse ridge interrupted medially by an incision. Scutum with admedian lines (these short and relatively separated), notaulus, and parapsidal lines. Propodeum with median sulcus on declivity more shallow than in *cora*, *albipes*, *carbonicolor*, or *digyalos*.

**Legs.** First segment of foretarsus with a row of 4 bristles in position of psammophore, but bristles surrounded by many fine hairs. Hind tibia clavate, with dorsal surface carinate-rugose, and dorsal profile in lateral view very uneven.

Wings as in Fig. 67.

Metasoma widest on segment 3, near boundary with segment 4. First segment short, broad, not nodular, without a long, thin, spindly base, much shorter than hind femur (0.7× its length). Epipygium with only a few sparse, scattered punctures and very few setae, similar to that of *digyalos*; lateral carina prominent, well raised above surface, extending from apex to base.

**Male.** Body length 5.5–9.0 mm; forewing length 4.0–6.0 mm.

Colour variable, black with the following yellow. *North of latitude 42°S*: pronotal lobe; antennal scape; outer lateral band on scrobes and flagellomeres 1–4 (last 5 flagellomeres fulvous yellow); dorsolateral aspects of pronotum (in occasional individuals fulvous yellow); distal 0.6 of fore femur, tibia, and tarsus; distal 0.4 of middle femur, tibia except for a variable spot medially, and tarsus; base of hind tibia, tarsal segments 3 and 4, and apical and basal parts of segment. *South of latitude 44°S*: pronotal lobe; anterior spot on tegula; antennae as above, but scape black dorsally; apex of fore femur, dorsal and anterolateral aspects of tibia, and tarsus; base and apex of middle tibia, and tarsus; base of hind tarsal segments 2–4. *South of latitude 46°S and west of longitude 168°E*: very variable, ranging from coloration typical of that at latitude 44°S to entirely black, including pronotal lobe and outer ventrolateral aspect of pedicel and flagellomeres 1–4 (7 of 41 specimens from Mt Luxmore FD completely black, remainder with greatly varying amounts of yellow).

Vestiture sparse; epipygium with sparse, fine, long hairs.

**Structure.** Head dorsally similar to female. Anterior border of clypeus with frontal lobe rectilinear, lateral lobes as angular projections not extending as far forwards as median lobe. Mandible without a mesal molar tooth; apical teeth subequal, clearly separated by an incision, the upper usually slightly larger and longer than the lower. Antennae little modified, with obtuse carinulae on outer lateral surface of flagellomeres 1–4; flagellomeres 2 and 4 apically slightly more dilated than other articles; last 7 articles narrow.

Thorax and propodeum similar to female. Pronotum similarly rising to a narrow longitudinal ridge, without dorsolateral humeral carinulae. Fore tarsus with 1st segment bearing a double row of about 11 bristles set among

fine hairs. Hind tibia clavate, but less so than in *albipes* male.

Metasoma widest at base of segment 4. First segment very short and broad, much shorter than hind femur. Epipygium short and broad, with completely defined pygidial plate bounded laterally by carinae extending from apex to base, its surface with only a few scattered punctures.

**Genitalia.** Overall form and proportions similar to *albipes*, but parameres hairless, and digitus volsellaris proportionately much larger and blunt (not apically attenuated as a thin, needle-like process) (Fig. 76).

**Type data.** Holotype *parrotti* (NMNZ; seen): female, Wiltons Bush (WN).

**Material examined.** 387 adults (213 females, 174 males), 5 larvae, and 4 pupae.

ND, AK, WO, TO, TK, RI, HB, WI, WN/NN, MB, KA, BR, WD, MC, SC, MK, CO, OL, FD, SL / SI.

**Biology.** Nests are made in heavy clay soils in exposed situations.

Hunting. During October–November, below 840 m, throughout Wellington City (incl. Makara Hills, Karori), Gisborne–Hawkes Bay, Bay of Plenty, and around Greater Auckland *P. parrotti* females fly principally to *Brachyglottis repanda* flowers, capture and sting to paralysis adult *Adoxia vulgaris* (Chrysomelidae), and take them to their nests. Most North Island nests I have examined contained only that species.

In the South Island other *Adoxia* species as well as small soft-bodied beetles belonging to other families are taken. On Mt Luxmore FD at 1080 m females nesting during January in an exposed clay bank behind the former Mt Luxmore Hut crawled over *Cassinia vauvilliersii* and captured an *Adoxia* species, *Asilis tumidus* (Cantharidae), and a *Cyphon* species (Helodidae). On the Old Man Range CO at about 1100 m *Adoxia* species were taken from grasses, herbs, and shrubs. Only Coleoptera are taken.

Prey carriage (Fig. 125a). *Adoxia vulgaris* is held venter up, facing forwards, appressed against the wasp's venter by the middle tarsi, which are wrapped around the posterior part of the beetle's pronotum. Carriage of other beetle species was substantially the same.

Nests (Fig. 125b–d). All observed nests were single-celled. At Makara Bush WN nests were made in a vertical clay bank. The entrance was a round hole 4.8 mm in diameter. The main burrow, 4.8 mm wide, curved through a right angle then proceeded near-vertically for 10–30 mm, after which it opened out into a cell 8 mm wide by 13–15

mm long. Nests contained 8–14 beetles, and completed nests had an inner closure 3–4 mm long of compacted clay at the cell entrance. The main burrow lacked an outer closure. At Karori WN burrows were made in almost horizontal clay, opening as a round hole 3.8–4.5 mm wide. The main burrow, 4.5 mm wide, descended at a 74° angle for 30–50 (mean 32) mm before expanding into a single terminal cell 13–18 mm long and 4.5–7.5 mm wide. The cells were packed with 8–16 beetles, all *Adoxia vulgaris*, as at Makara. Cells were blocked with an inner closure of compacted clay 3.0–4.8 mm long. Older nests sometimes also had an outer closure 2.5 mm wide, 4.0 mm from the entrance. A few nests had a spur before the cell, suggesting that nests with more than one cell are sometimes made, although none were seen. Nests were left open during provisioning.

**Life history.** The egg is laid on the ventral metathorax and abdomen of the last prey item provisioned, lateral of the midline, and hatches after 3 days. The larva begins feeding from the pleural region of the beetles, exhausting its store 2–3 weeks later. This species is univoltine.

**Remarks.** It is probable that the progenitors of *P. parrotti* preyed on Diptera feeding from nectar of native flowers. Some individuals may have occasionally taken, in addition to flies, the soft-bodied beetle *Adoxia vulgaris* (or its progenitors) which, then as now, would often have been more abundant than Diptera. Eventually beetles only came to be taken, a prey substitution similar to that of the populations of *P. albipes* and *P. cora* at Blue Stream, Mt Cook, which prey exclusively on Ephemeroptera and Trichoptera and reject seemingly appropriate species of Diptera that constitute their only prey in most other localities (see p. 40, and Harris 1990).

### Genus *Rhopalum* Stephens

*Euplilis* Risso, 1826, p. 227. Type species *Crabro rufiventris* Panzer, 1799 (= *Sphex clavipes* Linnaeus, 1758), designated by Pate (1935, p. 246).

*Rhopalum* Stephens, 1829a, p. 34. Type species *Crabro rufiventris* Panzer, 1799 (= *Sphex clavipes* Linnaeus, 1758), designated by J. Curtis (1837, text accompanying pl. 656). See also Stephens (1829b, p. 366) and J. Curtis (1829, p. 123).

*Physoscelus* Lapeletier & Brullé, 1834, p. 804. Type species *Crabro rufiventris* Panzer, 1799 (= *Sphex clavipes* Linnaeus, 1758), designated by Westwood (1839, p. 80, as *Physoscelus*; lapsus, or correction of *Physoscelus* Lapeletier & Brullé).

(*Euplilis* Risso has priority over *Rhopalum* and had been used by North American authors, while Europeans – who published most of the major works on the genus – continued to use *Rhopalum*. For this reason Menke *et al.* (1974) asked the International Commission on Zoological Nomenclature to suppress *Euplilis* in favour of *Rhopalum*, resulting in ICZN Opinion 1106 (Melville 1978).)

**Diagnosis. Adult.** Small to medium-sized elongate species. Head large, in dorsal outline rectangular. Gena with ridged lower border. Clypeus wide and long (relative to *Podagritys* – New Zealand species). Antenna of female with 12 articles, of male with 13 articles; male flagellum simple (New Zealand species) or modified. Labial palp with 3 segments, maxillary palp with 5. Mandible apically with 2 teeth. Mesopleuron with postspiracular carina and ornaulus absent in New Zealand species; ornaular area usually rounded. Scutum with admedian lines long, or close, but well separated. Middle tibia with 1 apical spur; hind tibia moderately swollen in New Zealand species, bearing short, straight spines. Metasoma usually pedunculate, slender; 1st segment often nodose. Female pygidial plate variable, concave and shining to flat and dull, with a median longitudinal carina of variable expression in the 3 New Zealand species.

**Final-instar larva.** Clavate; abdomen greatly expanded posteriorly, with anus ventral and preapical; spiracles with small spines on atrial ridges. Head with neither coronal suture nor parietal bands, sparsely setose. Mandibles with 3 teeth (including apical one) in almost the same plane and of similar size. Spinnerets joined by a horizontal membrane, much longer than labial palp.

**Biology.** The three New Zealand *Rhopalum* species nest above ground, usually in abandoned larval galleries and pupal chambers of wood-boring insects such as Curculionidae and Cerambycidae (Colcoptera), but sometimes Siricidae (Hymenoptera), in standing tree trunks and dead twigs. Prey items are generally Diptera (*R. perforator*, *R. zealandum*) and adult Lepidoptera (*R. aucklandi*), although unusual items (see p. 55) are sometimes taken.

Many New Zealand *Rhopalum* of both sexes are covered with phoretic mites, acquired in old tunnels of xylophagous insects.

**Remarks.** *Rhopalum* has a cosmopolitan distribution. Most species nest in twigs, hollow reeds, or abandoned beetle holes in tree trunks. In New Zealand *Rhopalum* is distinguishable from *Podagritys* by the clypeus (wide, long in middle; apical boundary with a prominent, long,

isolated median lobe), by the humeral angles of the pronotal collar being smoothly rounded and never spined or toothed, and by the female having short, straight spines on the hind tibia and a longitudinal median carina on the epipygium.

### Subgenus *Aporhopalum* Leclercq

*Aporhopalum* Leclercq, 1955a, p. 3. Type species *Rhopalum perforator* F. Smith, 1876, by original designation.

**Diagnosis (partial).** Male genitalia with parameres short and relatively massive, not thin and flattened as in other New Zealand *Rhopalum* species; parameres little longer than aedeagus. Aedeagus very large, complex, with each valve produced dorsally into a large, laminar expansion curving over laterally and partly surrounding distal half of valve.

**Remarks.** The male genitalia of *R. perforator* are so different in the appearance and structure of their constituent lobes that if one were to rely on genitalia alone *perforator* would appear to be only distantly related to the other New Zealand Crabronini. This species should certainly be separated from other New Zealand *Rhopalum* through its inclusion in a separate subgenus.

Bohart & Menke (1976, p. 388) provided a key to the five subgenera of *Rhopalum* in which *Zelorhopalum* is separated on the basis of the pygidial area of the female being dull and punctate (shiny in *Aporhopalum*). However, this distinction does not work, because the pygidial area is relatively shiny in all New Zealand *Rhopalum* species, that of *R. zelandum* being the shiniest.

Subgenus *Aporhopalum* is monotypic, and is restricted to New Zealand.

### *Rhopalum* (*Aporhopalum*) *perforator* Smith

*perforator* Smith, 1876, p. 483 (*Rhopalum*); New Zealand.

Hutton, 1881, p. 105 (*Crabro*); —1904, p. 98 (*Rhopalum*). Dalla Torre, 1897, p. 618 (*Crabro*). Leclercq, 1954, p. 184 (*Rhopalum*); —1955b, p. 16, fig. 4 (*Rhopalum* (*Aporhopalum*)). Miller, 1971 (and 1984), p. 27 (*Rhopalum*). Bohart & Menke, 1976, p. 390 (*Rhopalum* (*Aporhopalum*)). Callan, 1979, p. 36. Valentine & Walker, 1991, p. 40. Davies, 1986, p. 61 (*Podagrityus*).

**Diagnosis. Female.** (1) Flagellomere 1 very much longer than any antennal article except scape, almost twice as long

as any other flagellomere. (2) Epipygium with median longitudinal carina obsolete posteriorly, not reaching apex (Fig. 51). (3) Propodeum without a long lateral carina. (4) Vertex with shallow supraorbital fossa narrow, abutting compound eye throughout its length. (5) Metanotum seldom yellow.

**Male.** (1) Flagellomere 1 over twice as long as pedicel and as any other flagellomere. (2) Clypeus greatly modified, with a median longitudinal carina, the median lobe very large, protuberant, isolated, raised markedly outwards apically, the apical border with a small incision on either side separating narrow, obtuse, upturned projections slightly shorter than the central part (Fig. 37b,c). (3) Propodeum without a long lateral carina. (4) Metanotum seldom yellow. (5) Metasoma in dorsal view appearing similar to that of female, with sides of 1st and 2nd segments not appearing subparallel (cf. other New Zealand species, in which this character is greatly attenuated in males only).

**Description. Female.** Body length 7.2–14.0 mm; forewing length 6.0–11.0 mm.

Colour variable, as follows. *North of latitude 37°S*: head black, with mandible yellow, apically red; antennal scape with venter yellow, dorsum black; pedicel and flagellum fulvous brown, sometimes infuscated dorsally. Thorax and propodeum black; pronotal lobe yellow. Fore trochanter basally red and black, apically yellow; forefemur with proximal 0.8 black on outside and red on inside, apically yellow; foretibia with proximal half red, a black spot on outer side, and distal half yellow; foretarsus yellow. Middle trochanter basally black and red, apically yellow; middle femur black; middle tibia with proximal 0.3 yellow, remainder blackish-brown; middle tarsal segments 1–4 fulvous brown, segment 5 fulvous, claws yellow. Hind leg black, but hind tibial base yellow. Metasoma bright fulvous orange-red. *Latitudes 38–44°S*: as above, but antennal pedicel and flagellum often mostly black, metasoma black with reddish black on terga 2 and 3, and venter mostly fulvous. *South of latitude 45°S*: head, thorax, and propodeum black; mandibles with proximal 0.8 yellow, apically black; antennal scape yellow ventrally; pronotal tubercle yellow; distal 0.4 of forefemur yellow to fulvous; inner surface of foretibia yellow; fore and middle tarsus 5 fulvous yellow. Metasoma mostly black; venter of segments 1–3 fulvous brown.

Within the above latitude bands individuals from warmer microclimates are more lightly coloured while those from cooler ones are darker, and melanism correlates positively with increasing latitude and altitude. Notwithstanding this, yellow areas occasionally occur on the scutellum and metanotum of specimens from mid Canter-

bury. Two females from Pricess Valley, Banks Peninsula had the metanotum wholly yellow. One had the scutellum with two large yellow spots, the other with two small yellowish-black crescentic areas. A syntype from Canterbury (BMNH) had the scutellum black but the metanotum yellow. In all other specimens examined the scutellum and metanotum were entirely black.

**Vestiture.** Upper parts of head with little hair or pubescence; genae with fine decumbent hairs; clypeus with dense decumbent silver hair. Mesosoma with vestiture mostly sparse; long griseous hairs on propodeal sides and declivity. Metasoma relatively sparsely clothed; tergum 1 with long griseous hair on proximal 0.7; segments 2-5 with groups of 2-4 hairs ventrolaterally; epipygium almost without hairs; hypopygium relatively sparsely hairy.

**Structure.** Head minutely, closely, and relatively deeply punctate. Orbital fovea narrow, abutting compound eye throughout is length. POL:OOL as about 10.5:17 (0.6). Frontal concavity relatively shallow; lower frons narrow; SFD/TFD 0.12, FD/TFD 0.8. Clypeus with median lobe large, protruding, isolated, with a very small indentation on either side (Fig. 37a). Mandible robust, its main axis little curved (cf. curved in *aucklandi* and *zelandum*), without a mesal molar tooth; upper and lower apical teeth acute, equally developed. Flagellomere 1 very much longer than any antennal article except scape, almost twice as long as flagellomeres 2-10.

**Mesosoma.** Pronotum smoothly rounded, without a dorsal median furrow. Scutum with admedian lines close but well separated, notauli and parapsidal line present. Propodeum with either side of disc bisected by a diagonal sulcus, meeting in middle at declivity, enclosing a right-angled triangle; longitudinal median sulcus shallow on disc, narrow and deep on declivity; lateral carina absent.

**Legs.** Fore and middle femora greatly expanded, much wider than hind femur; hind tibia moderately claviform, little expanded, the spines short, straight, but much larger than in *aucklandi*, apically with a row of short spines.

Wings similar to male.

**Metasoma** smooth; segment 1 petiolate, apically nodular. Gaster widest at middle of segment 4. Epipygial area bounded laterally by a well developed carina, bisected by median carina, which becomes obsolete before apex; surface very highly polished, nitid (Fig. 51).

**Male.** Body length 6.6-13.9 mm; forewing 6.0-10.8 mm.

Colour variable, similar to female but antennal flagellum sometimes wholly fulvous, tarsi somewhat darker, and apex of mandible black, even in ND males.

The metanotum of an exceptional individual from Pricess Valley, Banks Peninsula, bears two large yellow areas. In

every other specimen examined the metanotum is entirely black.

Vestiture similar to female, but hair on propodeum longer and more dense; epipygium bearing many fine hairs.

**Structure.** Head with vertex, frons, and genae mostly similar to female. Clypeus relative long, greatly modified, with a median longitudinal carina; median lobe large, protuberant, isolated, with a small apical incision on either side separating off a raised, upturned obtuse spine, this projecting forwards almost as far as central part (Fig. 37b, c). Mandible robust, without a mesal molar tooth but with a large, projecting basal area; apical teeth acute, of equal length, but upper tooth slightly larger. Antennae with flagellomere 1 very long, over twice as long as pedicel and as any other flagellomere, without characteristic male modifications.

**Mesosoma** similar to female, but anterior dorsolateral angles of pronotum produced into a subdepressed tubercle.

Legs mostly similar to female.

Wings as in Fig. 68.

**Metasoma** with 1st segment long, almost parallel-sided (i.e., apex not greatly expanded), widest at apex of segment 4. Epipygium without a pygidial shield, without lateral carinae, its surface rugose-punctate.

**Genitalia** very distinctive, unlike those of other New Zealand *Rhopalum* or *Podagrītus* species. Parameres hairless, very short and relatively massive, not thin, flattened blades as in the other New Zealand Crabroninae. Digitus volsellaris very small, not visible in dorsal view. Aedeagus very large, complex, each valve produced dorsally into a very large, laminar, plate-like expansion curving laterally around distal half of valve (Fig. 77).

**Final-instar larva** (description based on a specimen from Moore's Bush, Dunedin, 21 November 1975).

Length 9.0 mm, maximum width 2.5 mm. Overall shape clavate; prothorax slender, somewhat attenuated; abdomen broad, greatly expanded posteriorly, widest at segment 7; pleural lobes small but distinct. Spiracles small but readily visible, ochre. Ultimate segment truncate, with subanal lobe ill defined, very small; supra-anal lobe large and greatly protruding; anus ventral and preapical (Fig. 81). Integument with numerous minute spicules about 7  $\mu$ m long (Fig. 83).

First thoracic spiracle (Fig. 86) with both rim and primary tracheal opening circular; rim 44.4  $\mu$ m in diameter. Internal walls of atrium lined with anastomosing ridges bearing small spines, those near rim larger than spines on ridges closer to collar. Collar (internal opening into subatrium) without spines. Subatrium thrown into irregular

pockets and folds, some of them bearing small spines internally.

Head (Fig. 90) longer than wide (maximum width 1.2 mm, maximum height 1.12 mm), sparsely setose, with groups of short setae on vertex, on genae lateral to antennal orbits, on frons between antennal orbits, and a transverse row of 12 setae on clypeus. Longest head seta (on gena) 43  $\mu$ m long. Parietal bands vestigial or absent.

Antennal orbits (Fig. 94) ovoid, asymmetrical, 60  $\mu$ m in maximum diameter, without a papilla; base a little raised into a low dome supporting 3 unequal sensillae arranged in a row, the two sides different. Left antennal orbit with a large sensilla in middle of row, a slightly smaller sensilla above it, and a very small sensilla below, on inner margin of rim of orbit. Right antennal orbit with a large sensilla at bottom end of row, close to rim of orbit, and 2 very much smaller subequal sensillae close together above it.

Labrum 346  $\mu$ m wide; apical margin fringed with very long acicular spines, especially laterally; disc with numerous long setae arranged as in Fig. 97.

Epipharynx with abundant spicules and papillae laterally and long acicular spines medially and apically. Discal sensory areas on either side consisting of 5 small sensillae and 5 larger cones basad of these (Fig. 100).

Mandible 518  $\mu$ m long, with 3 teeth (including the apical one) which are in almost the same plane and are of similar size (Fig. 104a); in lateral view only the penultimate tooth prominent (Fig. 104b), and apex therefore somewhat bifid; 1 mandibular seta present.

Maxillae with lacinal area bearing dense, long, acicular spines on inner mesal boundary grading laterally into short spicules; maxillary palp conical, 66.5  $\mu$ m long; palpa small and slender, 44.0  $\mu$ m long. Apex of labium with dense, long, aciculate spicules; labial palpus conical, 66.5  $\mu$ m long; spinnerets 126  $\mu$ m long, greatly exceeding palpus (Fig. 108).

**Cocoon** 11.0 mm long by 3.6 mm in maximum diameter, parallel-sided, rounded at one end and a little cone-shaped at the other, where there is a small, sharp-pointed, beak-shaped projection. Cocoon thin-walled, pale brown, with frass and dipterous chitin adhering to exterior (Fig. 113).

**Type data.** Holotype (BMNH; seen): female, bearing 5 labels - "TYPE" (circular, red-margined), "Rhopalum perforator Sm. Type", "14.30", [female symbol], "B.M. TYPE HYM 21.908." Syntypes: 2 males labelled (1) [male], "N. Zealand / 76..20", "J. Leclercq det., 1955 Rhopalum perforator Smith [male]" and (2) "New Zealand / 49.13" (circular, grey), "J. Leclercq det., 1955 Rhopalum perforator Smith [male]."

The holotype, typical of the Canterbury form of *R. perforator*, has the scutellum black and the entire metanotum yellow. It was probably collected in MC by C.M. Wakefield, and examined by Smith in 1876. Syntype 1 is the typical form, with scutellum and metanotum black; syntype 2 also has the scutellum and metanotum black, but the metasoma is missing.

**Material examined.** Type series, plus 487 non-type adults (318 females, 169 males), 11 larvae, and 2 pupae.

From all coded collection areas.

**Biology.** Hunting *R. perforator* hunts in sunshine, sometimes capturing prey at blossoms of flowering vegetation (e.g., *Griselinia littoralis*).

**Paralysis.** Prey is stung to permanent paralysis, although prey may sometimes make feeble movements in the provisioned cells.

**Prey carriage.** Prey is clasped underneath the wasp, head forwards, sternum uppermost, the wasp's middle legs gripping the prey item with tarsi wrapped around it. The wasp usually flies directly into the nest without pausing at the entrance.

**Nests** (Fig. 126a). Completed nests have 7-11 cells (occasionally more than 11) and are made in the galleries of wood-boring insects, e.g., *Sirex noctilio* (Hymenoptera: Siricidae) in *Pinus radiata*, and in burrows of *Ambeodontus tristis* (Coleoptera: Cerambycidae) in dead trunks of *Cupressus macrocarpa*. Three nests in a dead *C. macrocarpa* trunk in Moore's Bush, Dunedin in November had 11, 5, and 7 cells; these were 14.0-22.5 mm long and 10.0-11.5 mm wide. Cell inner closures were made of compacted frass and averaged 5.0 mm thick. Nests had no outer closures, but were left open during provisioning. The entrances were oval holes 4.0 mm deep by 6.6 mm wide, outside which were large mounds of frass removed by the wasp, 140 mm long by 26 mm wide. The first cell was 50 mm below the surface and the deepest was 75 mm below the surface. Cells contained 23-32 prey items, all Diptera of the families Syrphidae, Stratiomyidae, Drosophilidae, and Tachinidae. Prey items were positioned in a pile venter up, with the heads facing away from the nest entrance. The egg was laid on the last prey item, after which the cell was closed with compacted frass. In fine weather one female took 4-6 hours to fill each cell; usually only one cell was provisioned in a day.

**Life history.** The curved, creamy-white egg, 1.9 mm long by 0.9 mm wide, is positioned around the neck of the fly (Fig. 126b). The egg hatches after 3 days, and the final instar larva spins its cocoon 18 days later.

### Subgenus *Zelorhopalum* Leclercq

*Zelorhopalum* Leclercq, 1955b, p. 3. Type species *Rhopalum aucklandi* Leclercq, 1955b, by original designation.

**Diagnosis (partial).** Male genitalia in overall appearance similar to those of New Zealand *Podagritys*; parameres about twice length of aedeagus, dorsoventrally flattened, thin and flat. Aedeagus small, simple, without plate-like expansions.

**Remarks.** This subgenus comprises two species, and is endemic to New Zealand. Male genitalia of *aucklandi* and *zelandum* are very similar to those of the New Zealand *Podagritys* species, forming a continuum via those of *P. digyalos*, which somewhat resemble those of *R. aucklandi* and similarly lack a dorsally visible digitus volsellaris.

### *Rhopalum* (*Zelorhopalum*) *aucklandi* Leclercq Fig. 8

*aucklandi* Leclercq, 1955b, p. 14 (*Rhopalum* (*Zelorhopalum*)); New Zealand. Bohart & Menke, 1976, p. 389. Callan, 1979, p. 37. Valentine & Walker, 1991, p. 40.

**Diagnosis. Female.** (1) Flagellomere 1 short, only a little longer than other flagellomeres (Fig. 11). (2) Epipygium with median longitudinal carina entire, well defined, steep and high from base to apex (Fig. 52). (3) Lateral propodeal carina a thin, high ridge from near spiracle to apex, blade-like and almost transparent in its posterior 0.8. (4) Vertex with a shallow, wide supraorbital fossa abutting compound eye throughout its length. (5) Metanotum yellow.

**Male.** (1) Flagellomere 1 a little longer than any other. (2) Clypeus with median lobe protuberant, its apical margin rectilinear and simple, without small lateral incisions and without associated narrow, lateral, spine-like projections (Fig. 38b). (3) Lateral propodeal carina present, on posterior half as a thin, high, almost transparent blade. (4) Vertex with a very small, narrow supra-orbital fossa abutting compound eye throughout its length. (5) Metanotum usually yellow (sometimes with a median black spot of variable expression). (6) Metasoma very long and spindly, in dorsal view with sides of 1st and 2nd segments appearing subparallel. (7) Epipygium usually with an indistinct median longitudinal carina reaching apex.

**Description. Female** (Fig. 8). Body length 8.0–12.6 mm; forewing length 6.0–8.8 mm.

Colour variable, as follows. *North of latitude 37°S*: head black; mandible yellow, apically red; antennal scape yellow; pedicel fulvous, basally infuscated; flagellum fulvous

red. Thorax and propodeum black, but pronotal lobe, tegula, hypoepimeral area, and metanotum yellow. Foreleg yellow, but proximal half of femur and most of trochanter and coxa bright fulvous red; middle leg yellow, but proximal half of femur and parts of trochanter and coxa bright fulvous red; hind leg with tarsal segments 3–5, base of tibia, and apices of femur and trochanter yellow, remainder bright fulvous red. Metasoma bright fulvous red, but proximal half of segment 1 and terga 6 and 7 bright fulvous red. *Latitudes 37–44°S*: as above, but pedicel and flagellum reddish infuscated; tegula fulvous, with hypoepimeral area black; legs with fulvous red replaced by black; metasoma with dorsum very dark mahogany brown, and sterna 1–4 at least partly fulvous. *South of latitude 46°S*: darker than above, but colour pattern essentially the same; mandibles yellow with apex red; antennal scape yellow except for an apicodorsal black spot; pronotal tubercle yellow; metanotum yellow except for central black mark; entire fore-tibia and tarsus, middle tibia and tarsus, apices of fore and middle femora, base of hind tibia, hind tarsal segments 3 and 4, and apex of segment 5 yellow.

Darker coloration is positively associated with increasing latitude, altitude, and coldness. Individuals from unusually warm microclimates are more lightly coloured than usual for any given latitude and altitude.

Vestiture similar to *R. perforator*, but epipygium with many fine hairs.

**Structure.** Head minutely, shallowly punctate. POL; OOL roughly as 9:16 (0.6). Orbital fovea small, wide, abutting compound eye. Frons relatively shallowly excavated; lower frons narrow; SFD/TFD 0.16; FD/TFD 0.8. Clypeus relatively wide, its apical border almost without lateral lobes; median lobe long, protruding, isolated, curved forwards (Fig. 38a). Mandibles robust, with long axis curved; mesal molar tooth absent; apical teeth approximately equal in development. Antennal flagellum with successive flagellomeres becoming shorter, except the last; 1st flagellomere only a little longer than 2nd (Fig. 11).

Thorax and propodeum. Pronotum in dorsal view evenly rounded, with a central furrow. Scutum with admedian line, notaulus, and parapsidal line. Propodeum with either side of disc bisected by an obsolete diagonal sulcus, meeting in middle at declivity and enclosing a right-angled triangle (sometimes absent, almost always weaker than in *R. perforator*); median longitudinal sulcus shallow basally, deep and narrow on declivity; lateral carina entire, from near propodeal spiracle to apex, its distal 0.8 as a high, very thin, almost transparent blade.

Legs. Hind tibia very claviform, with spines minute. Wings as in Fig. 69.

**Metasoma.** First segment long, of similar length to hind femur, moderately nodular. Gaster widest at apex of segment 4. Epipygium with surface rough, not shining, indistinctly granular, punctate; lateral carinae little raised; median longitudinal carina as a distinct, steeply raised ridge from base to apex (Fig. 52).

**Male.** Body length 7.9–11.1 mm; forewing length 5.3–7.4 mm.

Colour variable. Similar to female, but apex of mandible black, and metanotum with a central black spot in specimens from cooler areas throughout, but especially in South Island and Stewart Island specimens where, with increasing latitude and altitude especially, the spot can widen until yellow occurs only on the lateral extremities of the metanotum; yellow areas otherwise as in female.

Vestiture sparse, similar to female.

**Structure.** Head. Mostly similar to female, but orbital fovea very small and narrow, abutting compound eye. Clypeus with anterior margin lacking lateral lobes; median lobe protuberant, bent forwards; apical margin rectilinear, without incisions or spines, only slightly shorter than in female. Mandible robust, without mesal molar lobe; teeth subequal; anterior lobe slightly longer. No antennal segment greatly enlarged or excavated; 1st flagellomere only slightly longer than 2nd, with a narrow longitudinal carina on outer lateral surface.

Thorax similar to female. Propodeum usually without a diagonal sulcus on disc, this sometimes replaced by an asymmetrical series of shallow impressions, occasionally aligned outwards so as not to enclose a triangle; raised lateral propodeal carina and median longitudinal carina similar to female.

Metasoma very long and spindly, almost without erect hairs; 1st segment a little longer than hind femur, not very nodular, with sides subparallel in dorsal view; 2nd segment with sides subparallel, only a little wider than 1st segment. Gaster attaining its maximum width near middle of segment 5. Epipygium with pygidial shield delineated by obsolete lateral carinae and with a faint median longitudinal carina attaining apex; surface finely punctured.

**Genitalia.** Similar to *Podagritys albipes*, but parameres broader and shorter, less than twice length of aedeagus, with lateral fringes of hairs on outer as well as inner sides; digitus volsellaris very small, dorsally indistinct.

**Type data.** Holotype (BMNH; seen): female, bearing 5 labels – "TYPE" (circular, red-margined), "Auckland, N. Zeal. / 60.73" (circular, grey), "J. Leclercq det., 1955, *Rhopalum aucklandi* Mihi [female]", "/ TYPE" (pink), "B.M. TYPE HYM. 21. 1, 764."

**Material examined.** Holotype, plus 537 non-type adults (296 females, 241 males), 5 larvae, and 4 pupae.

From all coded collection areas.

**Biology.** *R. aucklandi* nests in tree trunks in burrows of xylophagous Coleoptera such as *Oemona hirta* (Cerambycidae), *Psepholax coronatus*, and *Ps. barbifrons* (Curculionidae) (Fig. 127). At Peel Forest (MC) and Trotters Gorge (DN) it nested in *Psepholax barbifrons* emergence burrows in *Fuchsia excorticata*. In February females fly to grass in small forest clearings and, with the legs extending directly downwards, fly about 23 cm above the ground slowly around tall grass stems and leaves, examining them closely and occasionally pouncing with a rapid dart. Small adult Lepidoptera were pounced on and stung to paralysis, but were sometimes abandoned in leaf axillae. Brownish discolorations of a size and shape resembling a small insect on otherwise green stems were also pounced on. One nest at Trotters Gorge contained two moth species, *Glyphipterix neoptera* and *Epichorista siriana*. At Peel Forest *R. aucklandi* sometimes takes relatively large moths, with which it can hardly fly. *R. aucklandi* also captures small Hemiptera, but these may be 'mistakes.' Prey is stung to paralysis and flown to the nest, where it is positioned venter up, facing away from the entrance. *Dusona stramineipes* (Ichneumonidae: Campopleginae) is a Müllcrian mimic of *R. aucklandi*.

**Remarks.** I expect that Diptera too are taken as prey. However, all nests examined contained only Lepidoptera.

### *Rhopalum (Zelorhopalum) zelandum* Leclercq

*zelandum* Leclercq, 1955b, p. 16 (*Rhopalum (Zelorhopalum)*); New Zealand. Bohart & Menke, 1976, p. 390. Callan, 1979, p. 37. Valentine & Walker, 1991, p. 39.

**Diagnosis. Female.** (1) Antennal flagellomeres subequal. (2) Epipygium with median longitudinal carina not attaining apex, present as a basal tubercle; pygidial shield apically very excavated, the surface without punctures or hairs and very shining (Fig. 53). (3) Orbital fovea very long and narrow, bowed, extending from compound eye to hind ocellus and abutting both, crossing vertex as a thin line. (4) First segment of gaster short and fat. (5) Propodeum without a long lateral carina.

**Male.** (1) Basal flagellomeres subequal. (2) Pygidial plate concave in all directions, bounded by raised lateral carinae, without a median carina at apex. (3) Orbital fovea similar to that of female, but fainter and in some specimens difficult to see. (4) First segment of gaster short and

relatively broad. (5) Clypeus wide, without lateral lobes, with a relatively long and protuberant median lobe, slightly shorter than in female (Fig. 39b). (6) Pronotum very rounded. (7) Genitalia as in Fig. 78.

**Description. Female.** Body length 5.8–10.0 mm; forewing length 4.8–8.0 mm.

Colour variable. *North of latitude 38°S*: head black; palps yellow; antennal scape yellow, pedicel and flagellum fulvous red; mandible uniformly reddish brown. Thorax and propodeum black; pronotal lobe yellow. Foreleg and middle leg yellow, but middle leg with tarsus fulvous; hind leg with coxa, trochanter, apex of tarsal segment 1, tarsal segments 2–4, parts of 5, and claws yellow, remainder fulvous red. Metasoma bright fulvous to fulvous red. *Latitudes 38–43°S*: as above, but forefemur and middle trochanter, femur, and tarsus fulvous red or reddish black infuscate. Metasoma dark mahogany red. *South of latitude 44°S*: antennal scape with base dorsally and entire apex brown-black; fore coxa, trochanter, and femur with large areas brownish black; tarsal segments 2 and 3 brown, segments 1, 4, and 5 fulvous yellow; middle trochanter, femur, apex of tibia, and tarsus reddish brown; hind leg reddish brown. Individuals from cooler areas are darker, and melanism is positively correlated with increasing latitude and altitude. Note that the mandible and epinotum always lack yellow.

**Vestiture.** Upper head with much decumbent bronze pubescence but lacking long, erect hairs; clypeus with decumbent silver pubescence. Vestiture sparse on metasoma, absent from epipygium.

**Structure.** Head minutely and shallowly punctate. POL/OOL about 8:9. Supra-orbital fossa shallow, very long, narrow, recurved, with anterior end abutting compound eye, middle region crossing vertex as a narrow line, and posterior end abutting lateral ocellus. Frons moderately excavated; lower frons relatively wide; SFD/TFD 0.26; FD/TFD 0.89. Clypeus relatively large; apical margin without projecting lateral lobes; median lobe large, protruding, curved forwards, similar to *aucklandi* but narrower (Fig. 39a). Mandible robust, with long axis curved; mesal molar tooth absent; apical teeth subequal. Antenna with flagellomeres subequal.

Thorax and propodeum. Pronotum very rounded, without a dorsolateral spine, with a small, mid-dorsal longitudinal impression. Scutum with admedian line deeply impressed; notaulus and parapsidal line faint. Propodeum with disc rounded, median longitudinal sulcus obsolete basally, relatively very shallow and wide on declivity, and without a lateral carina.

Legs. Fore and middle femora only moderately expanded; hind tibia not very expanded and hardly clavate, with very short spines.

Forewing as in Fig. 70.

Metasoma widest in middle of segment 4; 1st segment relatively short and robust, with apex not very nodular. Epipygium nitid, very shining, without punctures or hairs; lateral carinae steeply raised, the area between them deeply excavated; median longitudinal carina as a prominent tubercle basal to an obsolete, obtuse ridge which does not reach apex. Pygidial shield surrounded by very long, recurved hairs originating beneath lateral carinae (Fig. 56).

**Male.** Body length 5.5–7.8 mm; forewing length 4.0–6.2 mm.

Colour variable, similar to female.

Vestiture similar to female, but epipygium with short fine hairs.

**Structure.** Head. Vertex similar to female; orbital fovea with section bisecting vertex from compound eye to hind ocellus very narrow and faint. Clypeus large, its apical border without lateral lobes but with a large, protuberant median lobe, very similar to female. Mandible similar to female. Antenna without enlarged or excavated articles; basal articles of flagellum subequal.

Thorax and propodeum similar to female. Propodeum with median longitudinal sulcus obsolete or entirely absent from disc, very shallow on declivity, where fovea is shallow and very wide.

Legs similar to female. Forefemur expanded, middle and hind femora much less so; hind tibia little expanded, not clavate.

Metasoma similar to female but a little thinner, widest just before apex of 4th segment; 1st segment robust, in dorsal view with sides subparallel. Epipygium with a pygidial plate; lateral carinae raised, the enclosed dorsal area excavated, concave in all directions, its surface somewhat shining, with punctures and short fine hairs.

Genitalia similar to those of *Podagritys digyalos* (see Remarks, below), except basal part less bent in dorsoventral plane. Parameres fringed with hairs on both inner and outer sides, about twice length of aedeagus. Digitus volsellaris very small, not visible in dorsal view (Fig. 78).

**Type data.** Holotype *zelandum* (USNM; not seen); female, "Kumara" (WD).

**Material examined.** 421 adults (257 females, 164 males), 5 larvae, and 3 pupae.

ND, AK, CL, WO, TK, TO, RI, HB, WI, WN/MB, BR, NC, MC, SC, MK, WD, FD, CO, DN, SL/SI.

**Biology.** *R. zelandum* frequently nests in hollow dead twigs of living bushes in native forest margins. Such nests are often made in vacated galleries of larval burrows of various native Cerambycidae (Fig. 128). At Peel Forest (MC) in December 1973 a three-celled nest in a hollow dead twig of otherwise living *Coriaria arborea* had cells 9, 6, and 10 mm long, 1.4 mm wide, with partitions 2.6 mm wide made of compacted pith, frass, and wood scrapings. Prey comprised: cell a, Diptera and *Zelandopsocus formosellus* (Psocoptera); cell b, *Beris* spp. (Diptera); and cell c, various small Diptera.

**Remarks.** *Rhopalum zelandum* males and females have been confused with *Podagrītus albipes* males and with *Podagrītus digyalos*. In *P. albipes* the pronotum bears a spined dorsolateral projection on the humeral angle; the projection is absent in *R. zelandum*. *P. digyalos* males have the first flagellomere and the pedicel basally scooped out below; this character state is absent in *R. zelandum*. The *P. digyalos* female has flagellomere 1 twice as long as flagellomeres 2-4, whereas in *R. zelandum* males and females flagellomeres 1-4 are all of equal length.

*R. zelandum* has also been confused with *R. aucklandi*, from which it can immediately be distinguished by the absence of a long, high lateral propodeal carina.

### Subfamily NYSSONINAE

**Adult.** Mostly medium-sized to large species. Face wider than high. Eyes strongly convex, with inner orbits parallel or converging ventrally. Clypeus large, its anterior margin without teeth, points, or emargination. Mandibles without notches or exteroventral teeth; mandibular socket open. Antennae filiform. Pronotum without a transverse carina. Scutum with notauli incomplete, often with an oblique carina, anterolaterally with mesonotal lamellae (strongly delimited dilations covering wing bases). Propodeum without a sternite. Middle tibia usually with 2 apical spurs. Forewing with 2 or 3 submarginal cells, the 2nd usually receiving at least 1 recurrent vein, and with 3 discoidal cells. Metasoma usually sessile, its 1st segment always with both tergum and sternum. Male genitalia usually with volsella differentiated into cuspis and digitus.

**Final-instar larva.** Integument smooth (i.e., without spinules). Spiracle with opening into subatrium armed with a circle of spines; peritreme usually well developed. Head with parietal bands absent or very short. Antennal papilla present. Labrum retractable below clypeus, its apical margin with at least some subapical, pigmented

sensory cones (sometimes termed 'barrel-shaped sensillae'). Mandibles acuminate, about twice as long as their maximum width, with apex acute; inner margin with from 1 to 3 teeth. Maxillary palpus larger than galea or only slightly shorter; spinneret paired, each opening at end of a process about as long as a labial palpus.

**Remarks.** This subfamily occurs in most parts of the world, and its constituent species are all ground-nesting. Five tribes are usually recognised; the single New Zealand species belongs to the tribe Gorytini.

### Genus *Argogorytes* Ashmead

*Argogorytes* Ashmead, 1899, p. 324. Type species *Gorytes carbonarius* Smith, 1856, by original designation.

*Archarpactus* Patc, 1937, p. 10. Proposed new name for *Arpactus* Jurine, 1801, which has no nomenclatural standing (ICZN Opinion 135; Hemming 1939).

**Diagnosis.** Antennae relatively thick and long; basal flagellomeres subequal in length; male antennae simple. Face without a sharply impressed median line. Frons broad; upper interocular distance relatively very long. Clypeus large, with middle region transversely gibbous, protruding. Pronotal collar elevated. Female scutellum with a postero-medial pubescent depression. Ommaulus entire, strongly developed. Episternal sulcus scrobiculate, ending ventrad on ommaulus; scrobal sulcus ending on episternal sulcus at a right angle; acetabular carina present; sternaulus absent. Propodeum with spiracular groove absent or weakly defined; propodeal enclosure with a deep, scrobiculate sulcus. Metasoma sessile; sternum 2 basad with a median swelling. Male with 7 visible terga, and with sternum 8 slender apically, acinaciform, upturned.

**Final-instar larva.** Body fusiform, with anus central; supra-anal lobe larger than subanal lobe. Spiracles with very large collar spines. Head relatively long and deep, with frons especially projecting forwards. Frons bearing a pair of large, rounded, pigmented, vertical ridges, each bearing about 8 prominent, cone-shaped sensillae. Most of head capsule without setae, but with numerous small sensillae. Coronal suture large; parietal bands absent. Antennal orbits with a short, stout papilla. Spinnerets small, discrete, not projecting as far as labial palpi.

**Remarks.** *Argogorytes* consists of 24 known species distributed in all faunal regions except the Ethiopian, many of them on islands in the western Pacific Ocean. The species are very uniform in structure. All prey on nymphal spittle-

bugs, which they pluck from the surrounding foam. The single New Zealand species (type species of the genus) always, in my experience, digs its nest in relatively moist clay, humus, or loam, never in sand. This is undoubtedly related to its lacking a rake on the foretarsus, as this structure in solitary wasps is positively correlated with sand-nesting.

### *Argogorytes carbonarius* (Smith)

Fig. 9

*carbonarius* Smith, 1856, p. 366 (*Gorytes*); New Zealand.

Hutton, 1881, p. 104. Handlirsch, 1888a, p. 539; — 1895, p. 870. Dalla Torre, 1897, p. 539. Ashmead, 1899, p. 324. Hutton, 1904, p. 98. Tillyard, 1926, p. 299 (*Arpactus*). Bohart & Menke, 1976, p. 492, fig. 159B (*Argogorytes*). Callan, 1979, p. 33. Valentine & Walker, 1991, p. 40.

*trichosoma* Cameron, 1888, p. 180 (*Gorytes*). Hutton, 1904, p. 98. Bohart & Menke, 1976, p. 492 (*Argogorytes*; synonym of *carbonarius*).

**Diagnosis. Female.** (1) Eyes widely separated above (Fig. 28). (2) Frons uniformly very wide. (3) Scutellum with a wide, scrobiculate groove along entire lateral border, between tegula and parapsidal line. (4) Scutellum with an ovate, pubescent depression posteromedially. (5) Propodeum sessile; sternum 2 produced anteromedially into a dome-like tubercle. (6) Head, thorax, and propodeum covered with long, erect, black hair.

**Male.** (1) Eyes widely separated above. (2) Frons uniformly very wide. (3) Propodeum sessile; sternum 2 produced anteromedially into a subdepressed tubercle. (4) Head, thorax, and propodeum covered with long, erect, black hair.

**Description. Female** (Fig. 9). Body length 7.5–10.3 mm; forewing length 6.0–9.0 mm.

Colour. Body and appendages black, nitid. Wings clear hyaline at base, tinted elsewhere with fuscous, and with mauve iridescence in certain lights, appearing steel-blue in active, living individuals.

Vestiture. Head (including scape and pedicel), mesosoma (including coxae and ventral femora), and 1st tergum of metasoma with long, erect, fuscous black hairs. Apex of metasoma with relatively few bristles.

Structure. Head (Fig. 28). POL:OOL as about 5:4 (1.25), in frontal view broad (FD/TFD 0.77). Frons uniformly very broad, its sides subparallel; SFD/TFD 0.5. Clypeus large, with an apical flange-like emargination. Apical border vaulted, but otherwise simple and rectilinear. Mandible without a mesal molar tooth, apically with 3 teeth; posterior

tooth the longest and very much the largest. Antenna relatively long and thick, about as long as mesosoma; flagellomeres subequal in thickness and length.

Thorax and propodeum. Scutum with a wide, scrobiculate groove along entire lateral margin, posteromedially with an ovate, pubescent depression; admedian lines very well separated; parapsidal lines conspicuous. Propodeum with discal enclosure outlined by scrobiculate sulci; declivity areolate-rugose. Foretarsus with a row of long setae posterolaterally on segments 1–4.

Legs. Middle and hind legs with 2 apical spurs.

Wings as in Fig. 71.

Metasoma sessile, widest at middle of 2nd segment. First tergum with proximal 0.7 steeply inclined, distal 0.3 horizontal, with a preapical transverse groove. Second tergum basally with a curved, scrobiculate transverse groove; surface otherwise strongly nitid, with widely spaced, deep punctures. Third tergum with a shallow basal transverse groove. Epipygium with pygidial plate ligulate, beset with scattered coarse, setiferous punctures. Venter of metasoma nitid, with small, shallow punctures and large, well spaced, deep punctures. Sternum 1 with a sharply raised median longitudinal carina, its sides carinate-rugose. Sternum 2 produced anteromedially as a dome-like tubercle, the 'hump' unusually well developed.

**Male.** Body length 7.8–8.4 mm; forewing length 6.0–7.8 mm.

Colour and vestiture as for female.

Structure very similar to female. Head in frontal view more rounded; FD/TFD 0.7. Frons narrower, especially below level of antennal sclerites, cuneate, narrowing ventrad; SFD/TFD 0.4. Mandibles apically with only 2 teeth, the lower tooth much larger. Antennae simple, relatively thick and long; flagellomeres subequal.

Mesosoma similar to female. Scutellum without a posteromedian pubescent depression.

Fore tarsus without a row of long bristles.

Metasoma very similar to female, but punctures on tergum 2 larger, and terga 5–7 with long, inclined setae. Sternum 1 with a sharply raised median longitudinal carina; sternum 2 produced anteromedially as a large, subdepressed tubercle.

**Final-instar larva** (Outram Bridge, Taieri River, March 1975).

Specimen 1: length 15 mm, maximum width (abdominal segments 3–4) 4 mm.

Specimen 2 (Fig. 82): length 11.5 mm, maximum width (abdominal segments 5–6) 3.3 mm.

Specimen 3: length 13 mm, maximum width (abdominal

segment 4) 4 mm. The following measurements apply to specimen 3.

Body fusiform, with prothorax somewhat produced, anus central, supra-anal lobe longer than subanal lobe, and spiracles relatively large and conspicuous. First thoracic spiracle the largest. Integument without small spicules. (In life the head is often retracted into the mesosoma, causing it to appear different, in photographs of living individuals, to the head of preserved specimens.)

Spiracles with peritreme, atrium, and collar circular. First thoracic spiracle visibly larger than the 2nd and the anterior abdominal spiracles.

First thoracic spiracle (Fig. 87a): peritreme 53.3  $\mu\text{m}$  in diameter; atrium 92  $\mu\text{m}$  in maximum diameter; collar 36.7  $\mu\text{m}$  in diameter; subatrium 112  $\mu\text{m}$  in maximum diameter. Internal walls of atrium lined with anastomosing ridges which (at  $\times 400$ ) appear to be without spines. Collar lined with very large, simple spines, sloping out towards centre at about  $15^\circ$ , forming a dome. Subatrium much wider than atrium, thrown into folds and pockets which lack internal teeth.

Second thoracic spiracle (Fig. 87b) similar to first but smaller; atrium 63.3  $\mu\text{m}$  in diameter; collar 26.7  $\mu\text{m}$  in diameter; subatrium 86.7  $\mu\text{m}$  in maximum diameter.

First abdominal spiracle (Fig. 87c) similar to thoracic spiracles; peritreme 56.7  $\mu\text{m}$  in diameter; atrium 74.7  $\mu\text{m}$  in diameter; collar 26.7  $\mu\text{m}$  in diameter; subatrium 98.0  $\mu\text{m}$  in maximum diameter. (There was the suggestion of a wide peritreme with an inner diameter of 26.7  $\mu\text{m}$ , but this may have been an artifact caused by the preserving methods.)

Second abdominal spiracle similar to the first, but without the suggestion of a wide peritreme.

Head (Fig. 91). Height (vertex to labrum) 0.96 mm; maximum frontal width 0.90 mm. Head relatively long, or deep, the frons especially projecting forwards, hence in lateral profile side of head appearing unusually large. A pair of very large, rounded, pigmented, vertical ridge-like elevations on frons between antennal orbits and immediately above them, each bearing about 8 prominent cone-shaped sensillae and about 9 clustered spots of fulvous pigment. Most of head capsule almost without true setae, but bearing numerous small sensillae, many of them cone-shaped. Coronal suture large, conspicuous. Parietal bands absent.

Antennal orbits (Fig. 95) circular, 60  $\mu\text{m}$  in diameter. Papilla short, stout, 19.4  $\mu\text{m}$  long by 13.3  $\mu\text{m}$  wide, surmounted by 3 sensillae.

Labrum (Fig. 98) 366.6  $\mu\text{m}$  wide by 160  $\mu\text{m}$  high, bearing 12 setae and 12 campaniform sensillae on disc and 19 pigmented sensory cones (or 'barrel-shaped sensillae') on apical margin (left lobe with 9, right lobe with 10).

Apical border with numerous small acicular spicules.

Epipharynx (Fig. 101) densely papillose and spinose, the spinules becoming increasingly sharp-pointed apically and laterally. Disc bearing on either side 2 very large, cone-shaped sensillae and, basal to these, 4 somewhat smaller sensory cones. In addition, various much smaller cone-shaped sensillae occur individually among the spinules, outside the main sensory areas.

Mandibles (Fig. 105) relatively long, 420  $\mu\text{m}$  by 212  $\mu\text{m}$  wide at base, with 2 teeth (including apical one); base laterally with a group of 3 small setae.

Labium and maxilla (Fig. 109). Lacinal area of maxilla angular, bearing regularly arranged aciculate spicules. Maxillary palp large, conical, 79.3  $\mu\text{m}$  long by 40  $\mu\text{m}$  wide at base. Galca small, narrow, 50  $\mu\text{m}$  long by 16.7  $\mu\text{m}$  wide. Labial palp conical, 60  $\mu\text{m}$  long by 37  $\mu\text{m}$  wide at base. Spinnerets very small, adjacent, gently rounded tubercles 33.3  $\mu\text{m}$  long, not projecting as far as labial palp.

**Cocoon** (Fig. 114) (Outram Bridge, Taieri River DN). Length 11.5 mm, maximum width 6.5 mm. Regularly ovoid, grey-brown; surface matt, irregular, with fine silt particles incorporated into outer layers. Cocoon itself vandyke brown, with inside surface matt.

**Type data.** Holotype *carbonarius* (BMNH; not seen); adult, "New Zealand".

Holotype *trichiosoma* (BMNH; not seen); adult, Grey-mouth (BR).

**Material examined.** 739 adults (382 females, 357 males), 5 larvae, and 5 pupae representing all coded collection areas.

**Biology.** Hunting. In November and December female *A. carbonarius* hunt nymphs of *Carystoterpa fingens*, *C. vagans*, and *Philaenus spumarius* on a wide variety of native and introduced annuals, herbs, and shrubs.

Prey capture and paralysis. A female plunges into the mass of froth and plucks out the nymph, which is stung to permanent paralysis.

Prey carriage (Fig. 129a). Aphrophorid nymphs are transported venter up, facing forwards, with the sternum appressed to that of the wasp; the prey's head reaches the wasp's metathorax, while its ultimate abdominal segment reaches that of the wasp. Prey is held by the wasp's middle legs, the tarsi of which are wrapped around the prey's forewing bases and scutellum. The wasp flies the prey to the burrow.

Nests (Fig. 129b-e). Between 1972 and 1990 I excavated 65 nests, which had from 1 to 10 cells. Nests were

sometimes made in sloping soil, but usually they were constructed in slightly moist, vertical clay and clay/sand/loam banks. The main burrow varied from almost horizontal to almost vertical (5–80°). In some banks the entrance was an obovate, funnel-shaped hole about 7 × 10 mm, narrowing to a round main burrow 4.5–5.2 (mean 5.0) mm in diameter and 45–180 (mean 76) mm long to the first cell. At Haast WD, Wilton Bush WN, and in a small, narrow, isolated bank at Outram DN nests were either 1-celled or 2-celled. In a large, gregarious nesting area at Outram occupied by 62 females, nests had 6–10 (mean 7) cells. These nests had circular entrances of almost the same diameter as the main burrow, outside which were large mounds 60–135 mm long by 35–65 mm wide. Cells were 8.0–14.8 (mean 12.2) mm long and 6.9–8.4 (mean 7.5) mm wide, connected to the main burrow by cell burrows 4.6 mm wide and 5–25 mm long, and fitted with inner seals composed of compacted clay 5 mm thick. Nests were always left open during provisioning. Until nests were completed, only inner (cell) closures were made. Cells were provisioned with 14–26 prey items from the second to the penultimate instar, which were introduced into cells often at a rate of one every 7–20 minutes, the wasp spending 1.5–2.0 minutes in the cell per visit. One individual took 4 hours to fill a cell with its complement of 17 prey items. When after 9–15 days the nest was completed (with 6–9 cells), an outer (nest) closure was often made with a plug of compacted clay in the entrance, and a new nest was then dug. At Outram an individual female made from 3 to 5 nests per season.

**Male activity.** After the females have dug their nests, the protandrous males fly from nest to nest, spending on average less than a minute inside each burrow. Copulation lasts about 40 seconds.

**Life history.** The white, oblong-ovate egg (Fig. 129f), 2.0–2.1 mm long by 0.65–0.90 mm wide, was laid on the prey's abdomen slightly to one side of mid-ventral. Development from oviposition until cocoon-spinning took 2–3 weeks. There was a 9-month prepupal diapause.

**Other studies.** Gourlay (1964) reported this species nesting in the soil of garden beds at Nelson, and preying on *Carystoterpa fingens*.

**Remarks.** The banks in which this species nests are often more moist than those selected by other New Zealand Sphecidae. It is likely that this reflects the requirements of the paralysed but still living hosts, which in normal life are surrounded by an aerosol foam, and may be susceptible to desiccation. The introduction from Northern Europe in the 1960s of *Philaenus spumarius* has provided an extremely abundant new prey item, which may result in *A. carbonarius* becoming more common.

*P. spumarius* was first recorded in 1960 at Palmerston North (Archibald *et al.* 1979), and has since spread to central and southern areas of the North Island and to several centres along the eastern coast of the South Island (Hamilton & Morales 1992). In the Dunedin area it first became abundant in 1986–87, and has since been by far the most common cercopid in eastern Otago. Before 1986 *A. carbonarius* made mostly two-celled nests in the area, but when prey became more abundant eight- or nine-celled nests were more characteristic. The wasp appears to be limited by suitable nesting sites, and has not yet increased its range very much to exploit this new prey item.

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## APPENDIX 1: HOST RECORDS FOR SPHECIDAE IN NEW ZEALAND

### *Argogorytes carbonarius*

#### HEMIPTERA

APHROPHORIDAE: *Carystoterpa fingens* (nymphs), *C. vagans* (nymphs); *Philaenus spumarius* (nymphs)

### *Pison morosum*

#### ARACHNIDA

ARANEIDAE: *Cryptaranea albolineata*, *C. subcompta*; *Eriophora pustulosa*; *Eolaranea viridatas*; *Novaranea laevigata*; *Zealaranea crassa*; *Z. trinotata*

SALTICIDAE: *Trite* sp. (Laing 1988)

STIPHIDIDAE: *Cambridgea* sp.

THERIDIIDAE: *Achaearanea* sp.

THOMISIDAE: *Diaea ambara* sp.

### *Pison spinolae*

#### ARACHNIDA

ARANEIDAE: *Arachnura feredayi*; *Argiope protensa*, *A. trifasciata*; *Colaranea viriditas*, *C. brunnea*; *Cryptaranea albolineata*, *C. subcompta*; *Cyclosa trilobata*; *Eriophora pustulosa*, *E. heroine*; *Leucauge dromedaria*; *Novaranea laevigata*; *Zealaranea trinotata*, *Z. crassa*

### *Podagritys albipes*

#### DIPTERA

ANISOPODIDAE: *Anisopus notatus*

BIBIONIDAE: *Dilophus segnis*

CERATOPOGONIDAE: *Forcipomyia antipodum*

CHIRONOMIDAE: *Polypedilium luteum*, *P. opimus*

CULICIDAE: *Aedes antipodeus*

DIXIDAE: *Paradixa fuscineris*

DOLICHOPODIDAE: *Parentia restricta*

DROSOPHILIDAE: *Drosophila hydei*

EMPIDIDAE: *Homalocnemis adelensis*, *Homalocnemis* sp., unid. empidid

LAUXANIIDAE: *Poecilohetaerus* sp. nr *punctatifacies*, *P. dubiosa*; *Sapromyza neozelandica*; *Trypaneoides* sp.

MUSCIDAE, Coenosiniinae, Limnophorini: *Spilogona* sp. A – Outram, Taieri River (DN); *Spilogona* sp. B; unid. limnophorine sp. A – coastal beaches, Christchurch (MC); unid. limnophorine sp. B – old Mt Cargill quarry, Dunedin (DN)

SCIARIDAE: *Sciara rufulenta*

SIMULIIDAE: *Austrosimulium australense*

STRATIOMYIDAE: *Benhamyia alpina*, *B. apicalis*, *B. straznitskii*; *Beris micans*, *Beris* spp. (2); *Neactina* spp. (2); *Oplacantha substituta*

SYRPHIDAE: *Melanostoma fasciatum*, *M. novaezealandiae*, *M. ortas*; *Syrphus* sp.

TACHINIDAE: several medium-sized to small species, throughout New Zealand

TEPHRIDAE: *Tephritis plebeia*, *T. fascigera*

#### EPHEMEROPTERA

LEPTOPHLEBIDAE: *Deleatidium myzobranchia* – Blue Stream (MK), Hutt River (WN); *D. lillii* – Blue Stream (MK), Hutt River (WN)

#### PLECOPTERA

GRIPOPTERYGIDAE: *Zealandobius furcillatus* – Taieri R., Outram (DN); *Z. uniramus* – Taieri R., Outram (DN)

#### TRICHOPTERA

CONGOSUCIDAE: *Pycnocentodes aureola* – Blue Stream (MK)

RHYACOPHILIDAE: *Hydrobiosis parumbripennis* – Nevis River (CO)

### *Podagritys carbonicolor*

#### DIPTERA

CALLIPHORIDAE: *Calliphora hilli*, *C. quadrimaculata*, *C. stygia*, *C. vicina*

MUSCIDAE: several large, undetermined, native species

SARCOPHAGIDAE: several unidentified, large, native species

STRATIOMYIDAE: *Benhamyia alpina*

TABANIDAE: *Dasybasis (Protodasyommia) truncata*, *D. (P.) viridis*; *Saptia (Pseudoscione) milleri*, *S. (Ps.) montana*, *S. (Ps.) adrel*

TACHINIDAE: *Pales nyctemeriana*, plus several large, undetermined species

THREVIDAE: *Anabarhynchus farinosus*, *A. femoralis*, *A. hayakawai*, *A. laterepilosus*, *A. latus*, *A. arenarius*, *A. lacustris*, *A. microphallus*; *Ectinorhynchus castaneus*; *Megatheria bilineata*, *M. albipilosa*

### *Podagritys chambersi*

#### DIPTERA

TEPHRIDAE: *Trypanea* sp.

### *Podagritys cora*

#### DIPTERA

BIBIONIDAE: *Dilophus nigrostigma*

CALLIPHORIDAE: *Calliphora vicina*, *C. hilli*, *C. quadrimaculata*; *Ptilonesia auronotata*

MUSCIDAE: *Stomoxys calcitrans*

SARCOPHAGIDAE: several unidentified species

SIMULIIDAE: *Austrosimulium australense*, *A. tillyardianum*

STRATIOMYIDAE: *Benhamyia alpina*, *B. apicalis*; *Beris* spp. (2); *Odontomyia chloris*, *O. atrovirens*

SYRPHIDAE: *Melangyna novaezealandiae*, *M. fasciatum*

TACHINIDAE: several unidentified species, medium-sized to large

THEREVIDAE: *Anabarhynchus farinosus*, *A. femoralis*, *A. hayakawai*, *A. huttoni*, *A. innotatus*, *A. laterepilosus*, *A. latus*, *A. rufobasalis*, *A. flaviventris*; *Anabarhynchus* sp. A – Haast (WD) (undescribed: L. Lynceborg, pers. comm.); *Anabarhynchus* sp. B – Taranaki (TK) (undescribed: L. Lynceborg, pers. comm.); *Megathereva albobilosa*

#### EPHEMEROPTERA

LEPTOPHELEIIDAE: *Deleatidium myzobranchia* – Blue Stream (MK); *D. lillii* – Blue Stream (MK)

#### TRICHOPTERA

CONOESUCIDAE: *Pycnocentrodus aureola* – Blue Stream (MK)

#### *Podagritys digyalos*

#### DIPTERA

OTIDAE: *Zealandortalis interrupta*

TEPHRIDAE: *Tephritus plebeia*

#### *Podagritys parrotti*

#### COLEOPTERA

CANTHARIDAE: *Asilis tumidus* – Mt Luxmore (FD)

HELODIDAE: *Cyphon* sp. – Mt Luxmore (FD)

CHRYSOMELIDAE: *Adoxia vulgaris* – Karori, Makara, Tara-rua Range (WN); Gisborne/Hawkes Bay area (GB-HB); Bay of Plenty, Rotorua (BP); greater Auckland area (AK). Most prey records are of this species. *Adoxia* spp. – Mt Luxmore (FD); Old Man Range, Central Otago mountains (CO).

#### *Podalonia tydei suspiciosa*

#### LEPIDOPTERA

NOCTUIDAE: *Agrotis innominata* – 43 mature final-instar larvae, Papamoia Beach, Kaituna River mouth sand spit, Little Waihi foredune (BP).

#### *Rhopalum perforator*

#### DIPTERA

DROSOPHILIDAE: *Drosophila* sp.

MUSCIDAE: *Spilogona* spp. (3); unid. muscids (2 spp.)

STRATIOMYIDAE: *Beris saltusans*, *Beris* spp. (3); *Exaireta spinigera*; *Neactina simmondsii*; *Oplacantha substituta*

SYRPHIDAE: *Allograptus* sp.; *Melanostoma novaezealandiae*, *M. fasciatum*; *Syrphus ortas*

TACHINIDAE: unid. tachinids (2 spp.)

(In addition to the above, I have taken several hundreds of dipterous prey items from nests of this species.)

#### *Rhopalum aucklandi*

#### LEPIDOPTERA

CRAMBIDAE: *Orocrambus flexuosellus*

GEOMETRIDAE: *Selidosema* sp. (MC)

GLYPHIPTERIGIDAE: *Glyphipterix neoptera* (DN)

TORTRICIDAE: *Epichorista siriana* (DN)

#### HEMIPTERA

CICADELLIDAE: *Arawa variegata*; *Zygina zealandica* (erroneous records?)

#### *Rhopalum zealandum*

#### DIPTERA

STRATIOMYIDAE: *Beris* spp. (WD)

#### PSOCOPTERA

PHILOTARSIDAE: *Zelandopsocus formosellus*

#### *Spilomena earlyi*

#### THYSANOPTERA

THRIPIDAE: *Thrips obscuratus*

#### *Spilomena elegantula*

#### THYSANOPTERA

THRIPIDAE: *Thrips obscuratus* (nymphs and adults)

#### *Spilomena emarginator*

#### THYSANOPTERA

THRIPIDAE: *Heliothrips haemorrhoidalis*

#### *Spilomena nozela*

#### THYSANOPTERA

THRIPIDAE: *Thrips obscuratus* (1st- and 2nd-instar nymphs and adults); *Heliothrips haemorrhoidalis* (1st- and 2nd-instar nymphs and adults)

#### *Tachysphex nigerrimus*

#### BLATTODEA

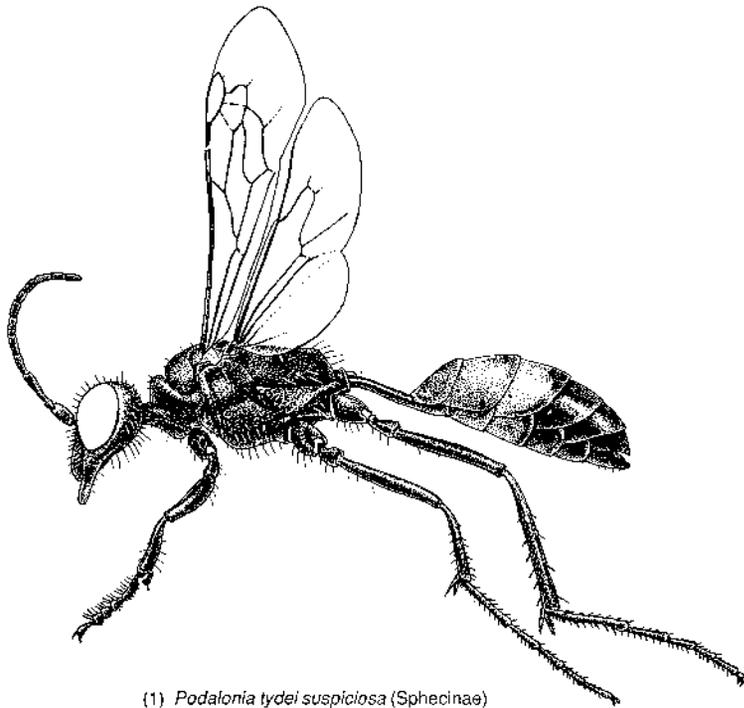
BLATELLIDAE: *Parellipsidion conjunctum*, *P. inaculeatum*, *P. pachycercum*

BLATTIDAE: *Celatoblatta anisoptera*, *C. hesperia*, *C. notialis*, *C. pallidicaudata*, *C. undulivitta*, *C. vulgaris*; *Platyzosteria novaeseelandiae*

CHORISONEURIDAE: *Celeriblattina minor*

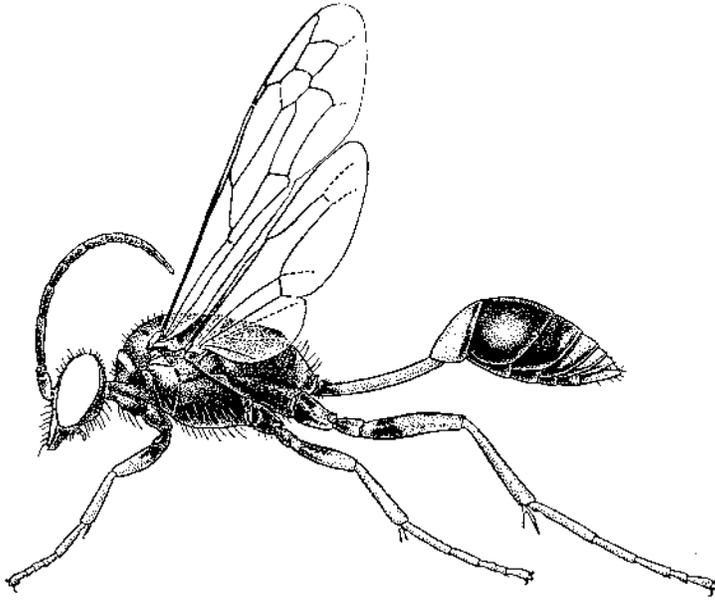
OTHER RECORDS. "Cockroaches" (Hudson 1950); *Celatoblatta undulivitta* (Gourlay 1964); female dragging *C. peninsularis* (P. Johns, unpubl. obs. – Callan 1979).

ILLUSTRATIONS

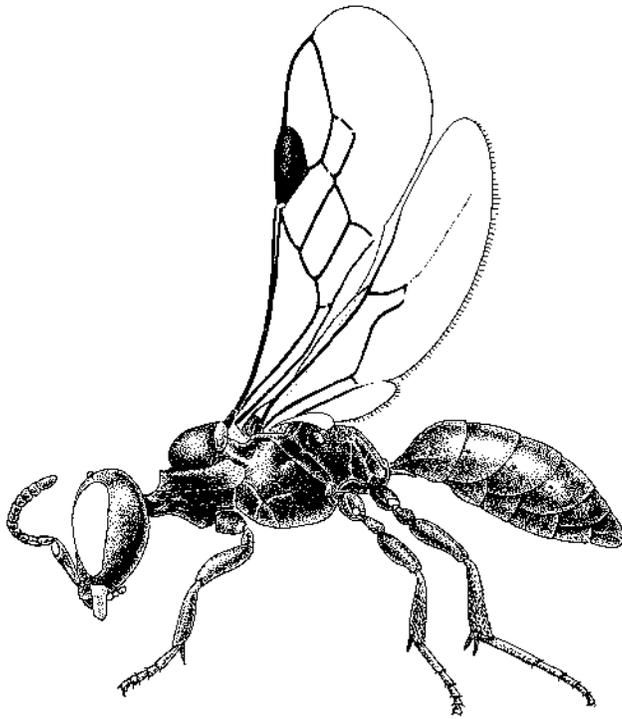


(1) *Podalonia tydei suspiciosa* (Sphecinae)

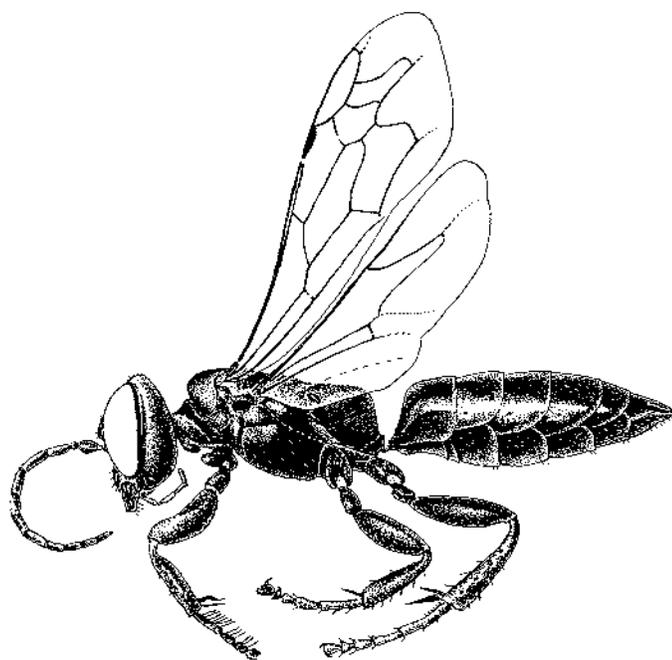
Fig. 1-9 Habitus drawings, in lateral view, of females representing the genera of New Zealand Sphecidae.



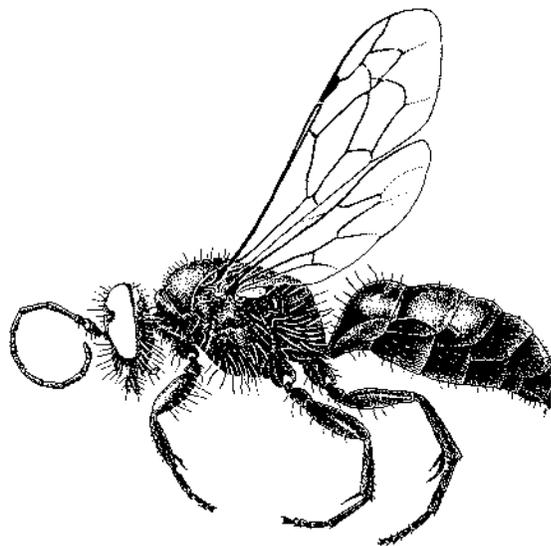
(2) *Sceliphron formosum* (Sphecinæ)



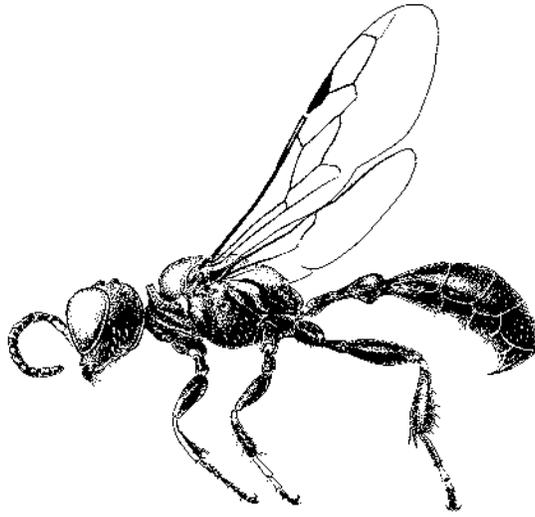
(3) *Spilomena nozola* (Pempredoninae)



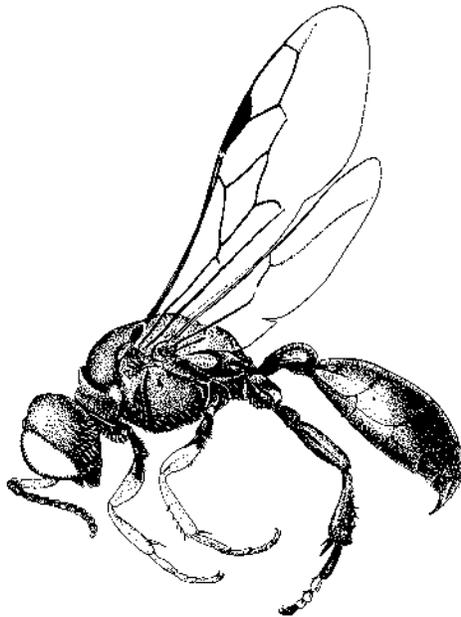
(4) *Tachysphex nigerrimus* (Larriinae)



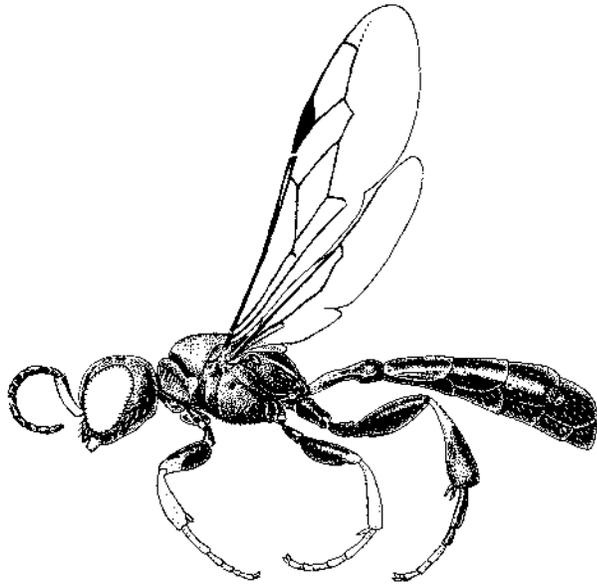
(5) *Pison spinolae* (Larriinae)



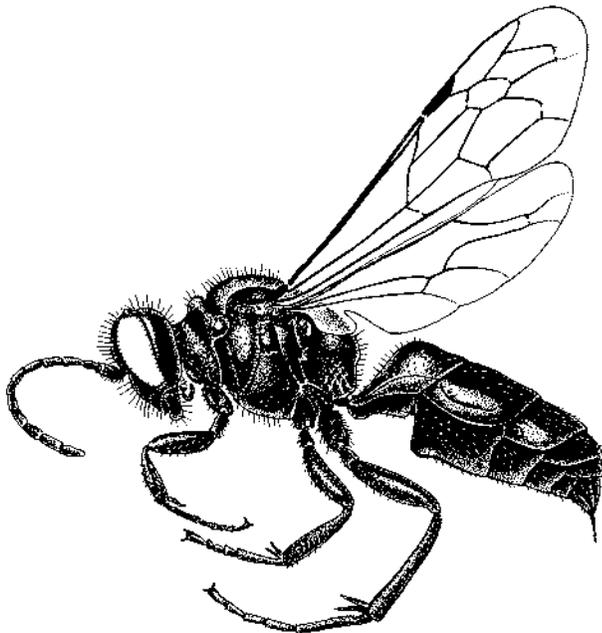
(6) *Podagritus albipes* (Crabroninae)



(7) *Podagritus parrotti* (Crabroninae)

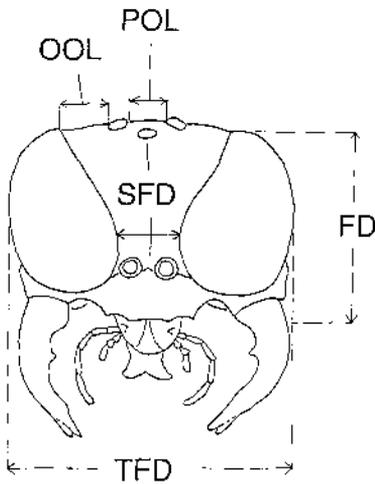
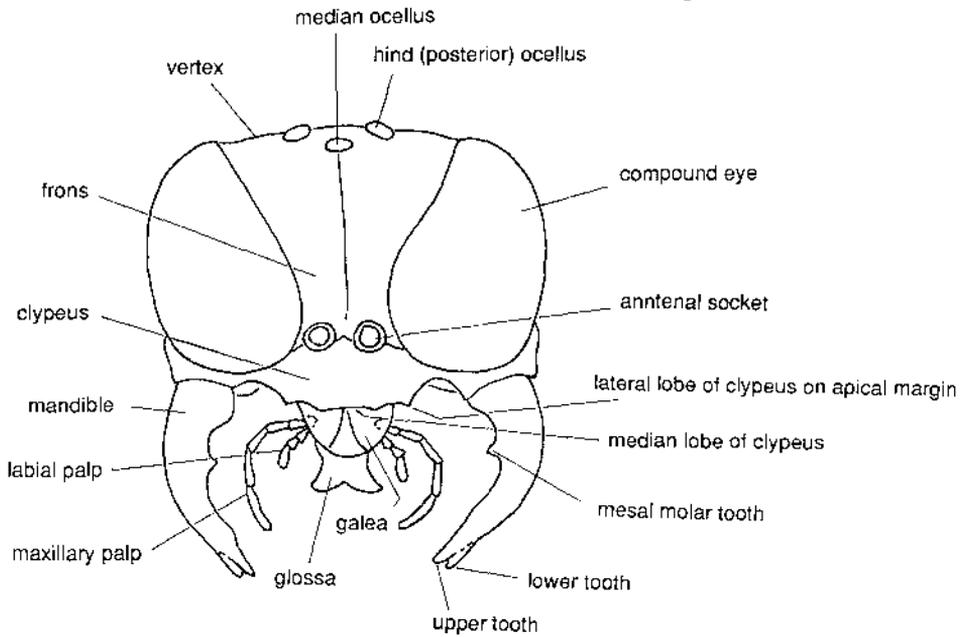


(8) *Rhopalum aucklandi* (Crabroninae)

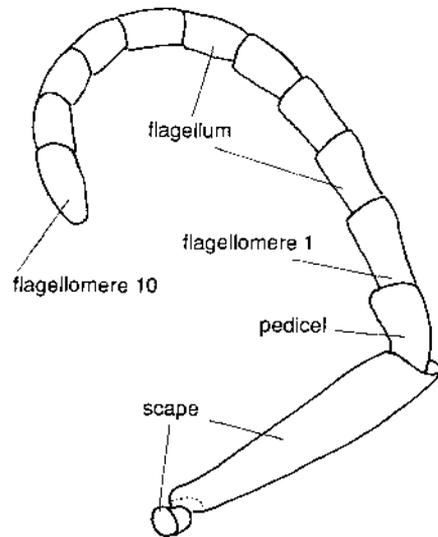


(9) *Argogorytes carbonarius* (Nyssoninae)

(10a) Head structures, frontal view,  
*Podagritys albipes*, female

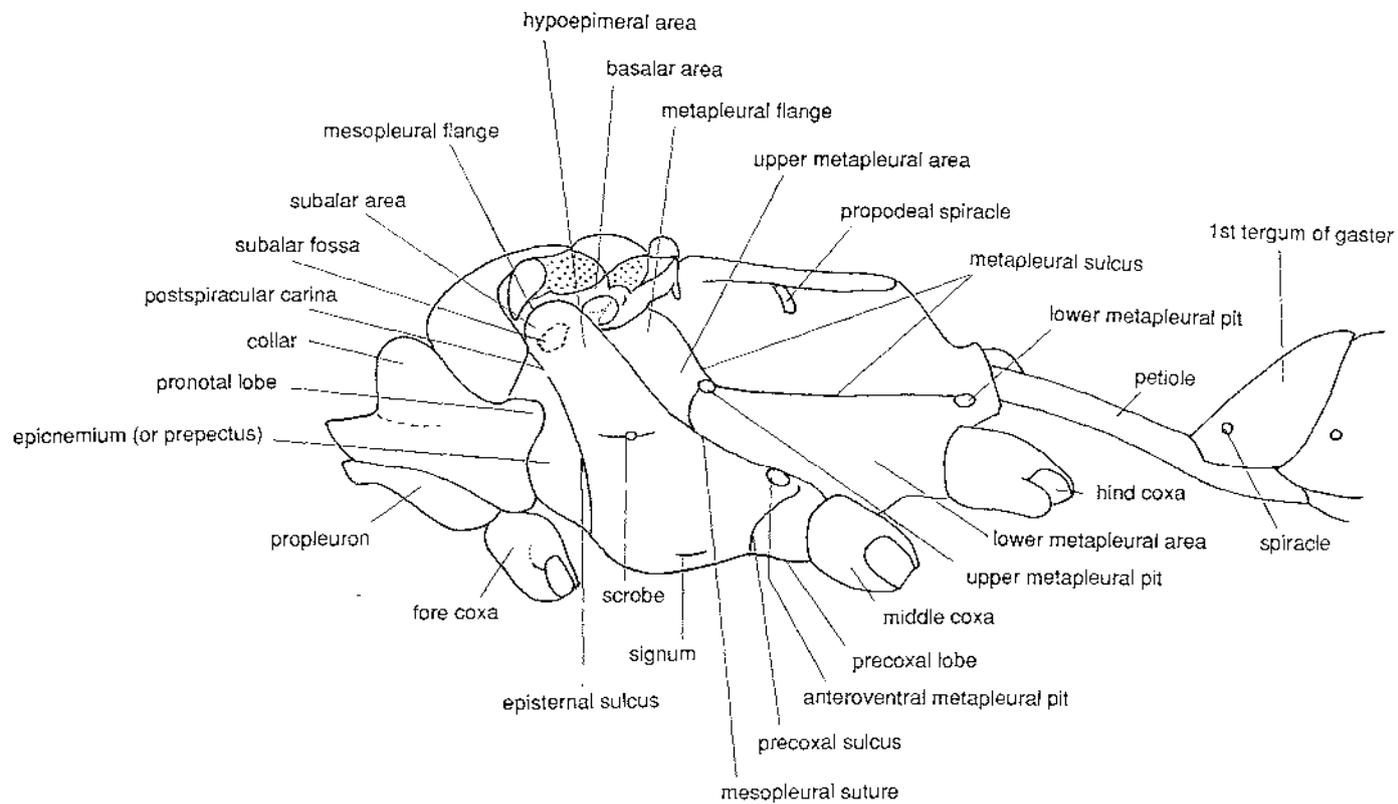


(10b) Head ratios, frontal view,  
*Podagritys albipes*, female

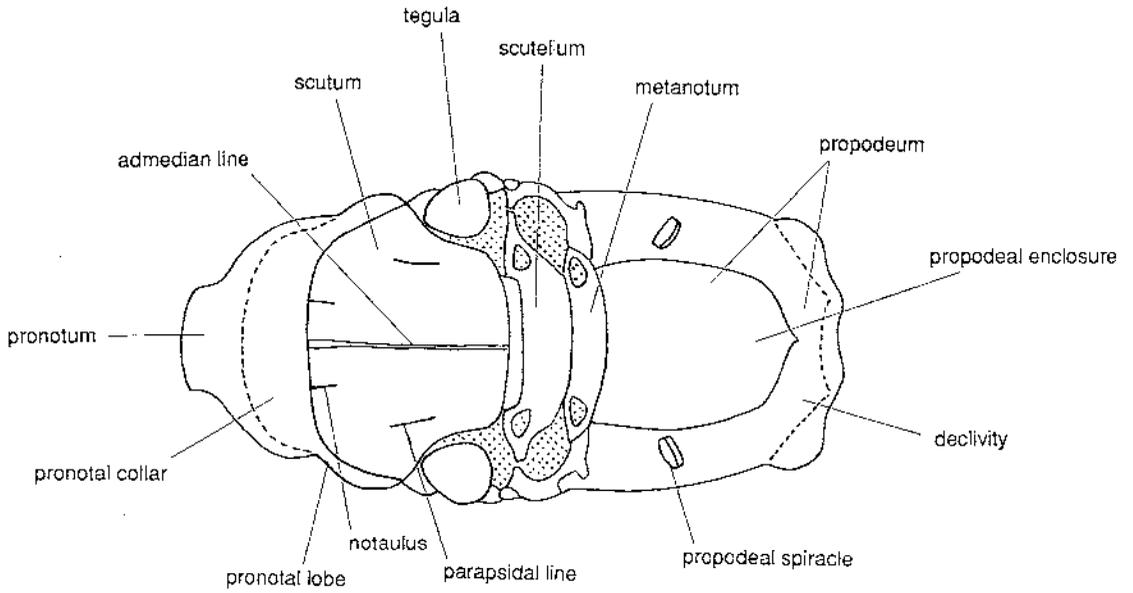


(11) Antenna, *Rhopalum aucklandi*, female

**Fig. 10-19** Morphological features of New Zealand Sphecidae, illustrating terminology used (schematic).

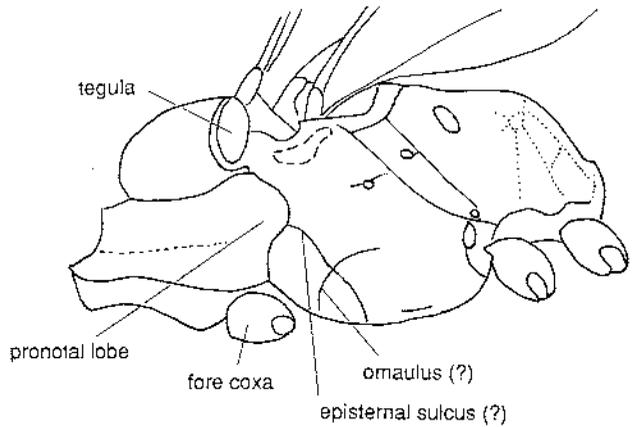


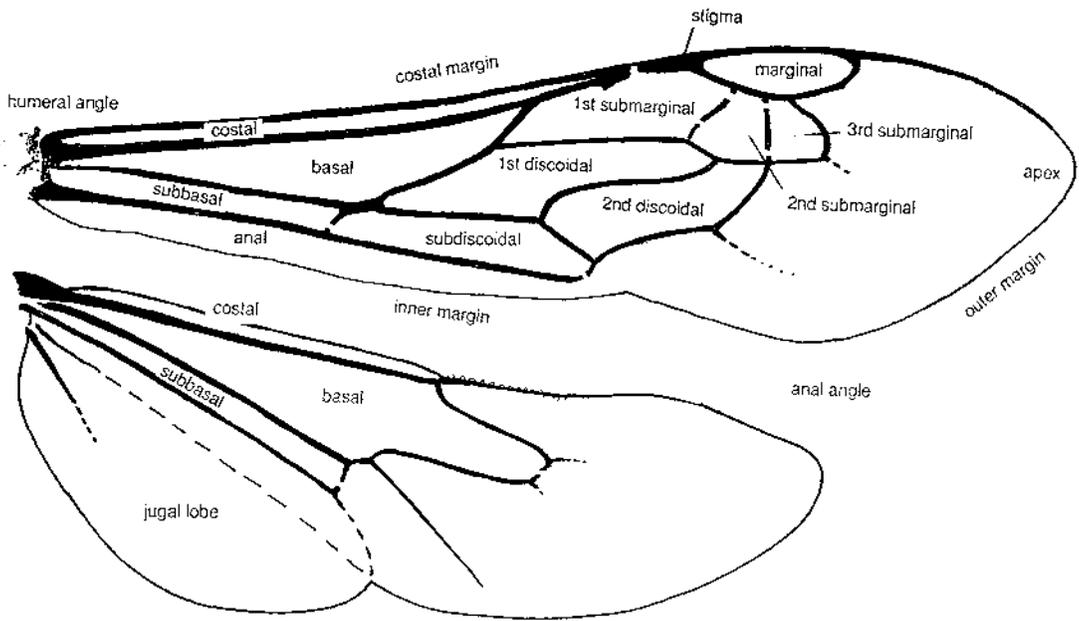
(12) Thorax, propodeum, and base of metasoma, lateral, *Podalonia tydei suspiciosa*, female



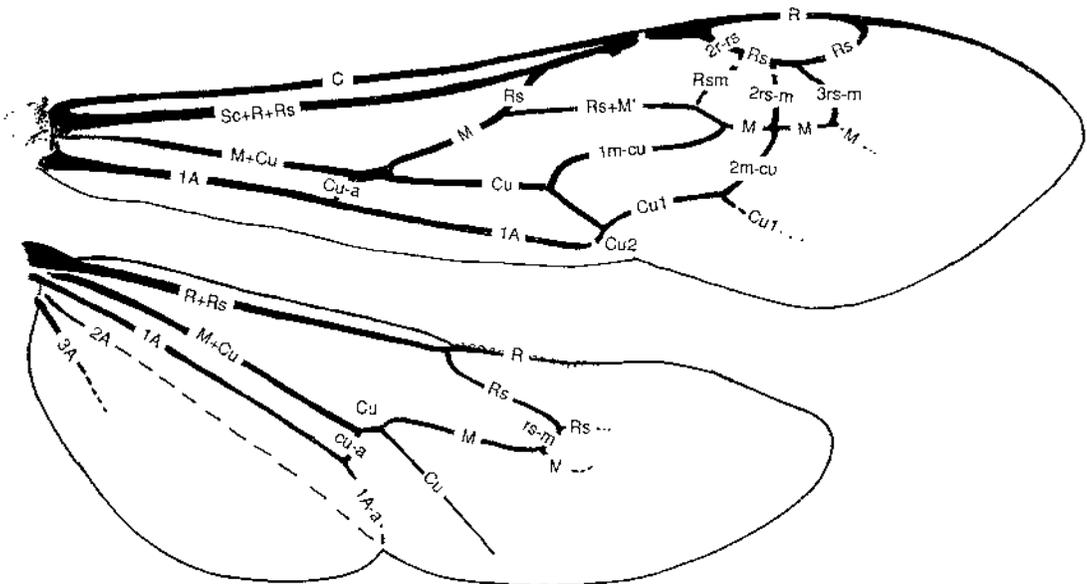
(13) Thorax and propodeum, dorsal, *Podalonia tydei suspiciosa*, female

(14) Presumed episternal sulcus and omaulus, *Spilomena nozela*, female

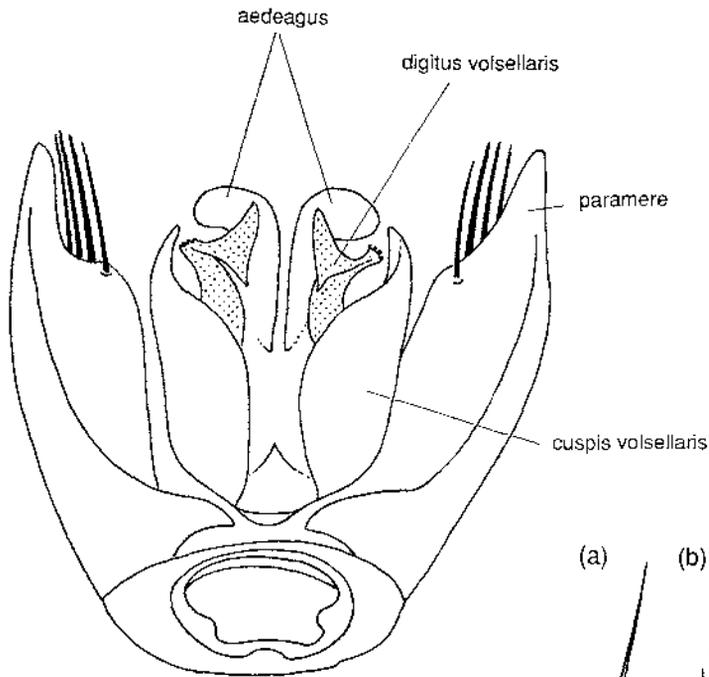




(15a) Wing cells, *Podalonia tydei suspiciosa*, female

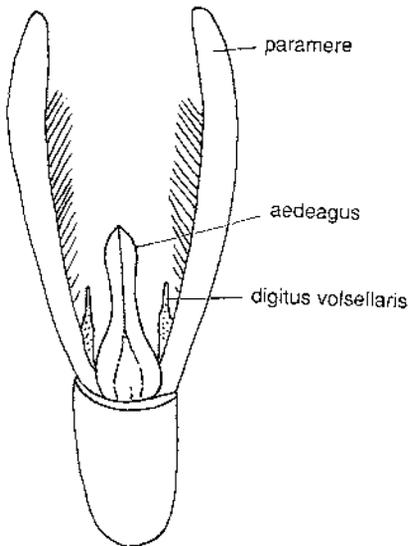


(15b) Wing venation, *Podalonia tydei suspiciosa*, female

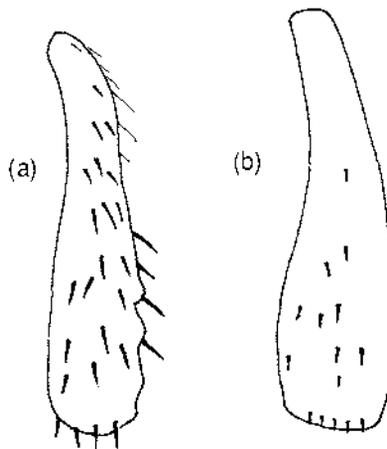


(16) Male genitalia, *Podalonia tydei suspiciosa* (Sphecinae)

(18) Body hairs: (a) unbranched (Sphecidae);  
(b) branched (Hylaeinae).



(17) Male genitalia, *Podagritys albipes* (Crabroninae)



(19) Hind tibiae, showing relative size of spines:  
(a) *Podagritys parrotti*; (b) *Rhopalum perforator*.

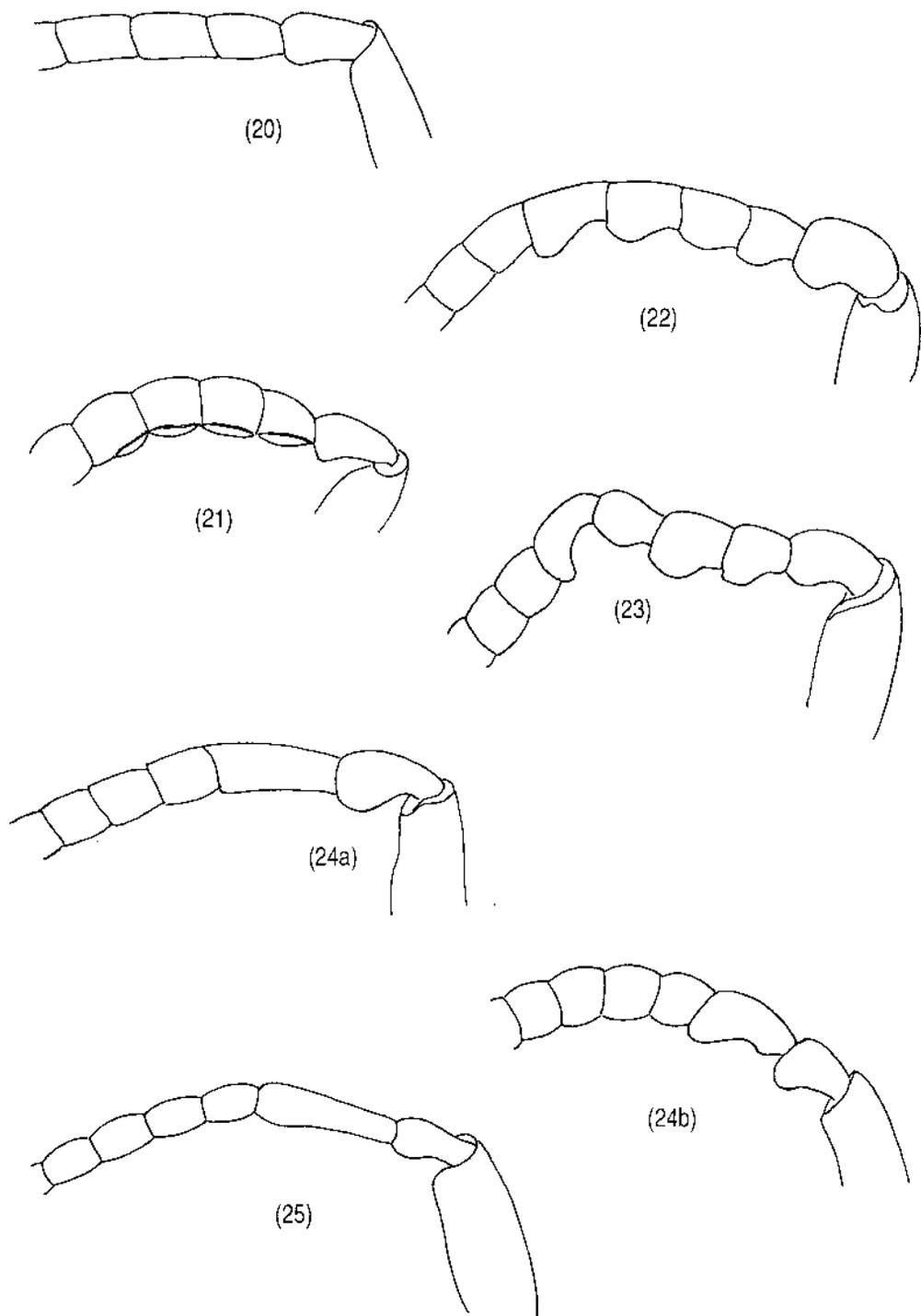


Fig. 20-25 Proximal antennomeres: (20) *Podagrityx albipes*, female; (21) *P. albipes*, male; (22) *P. carbonicolor*, male; (23) *P. cora*, male; (24a, b) *P. digyalos*, female and male; (25) *Rhopalum perforator*, male.

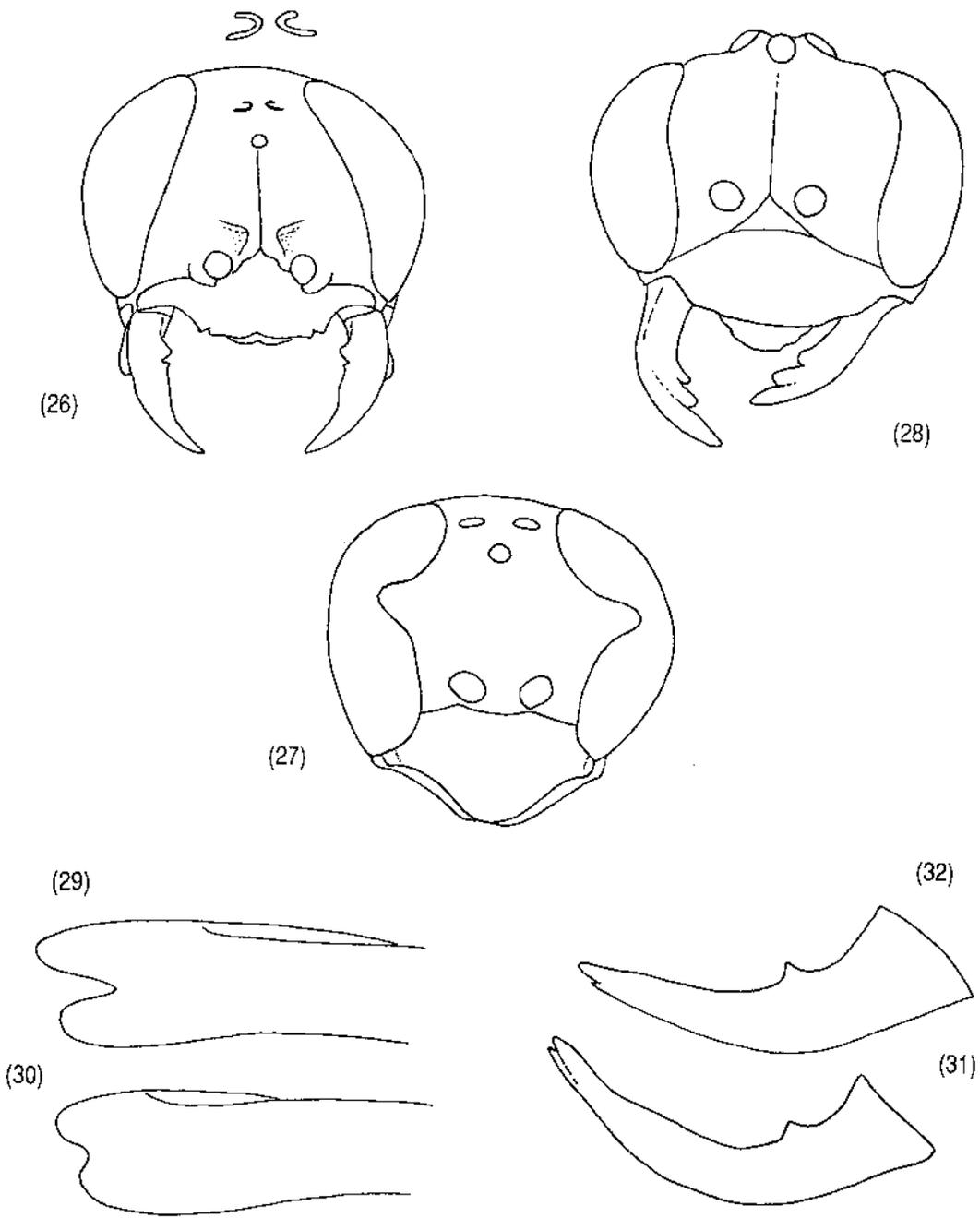


Fig. 26-28 Head, frontal view: (26) *Tachysphex nigerrimus*, female—eyes converging above, diverging below, and hind ocelli reduced to ocellar scars (enlarged, above); (27) *Pison spinolae*, female—note incision in eyes; (28) *Argogorytes carbonarius*, female—eyes well separated above. Fig. 29-32 Left mandible, showing differences between *Podagritus carbonicolor* and *P. cora* females in (29, 30) apical teeth and incision and (31, 32) position of mesal molar tooth.

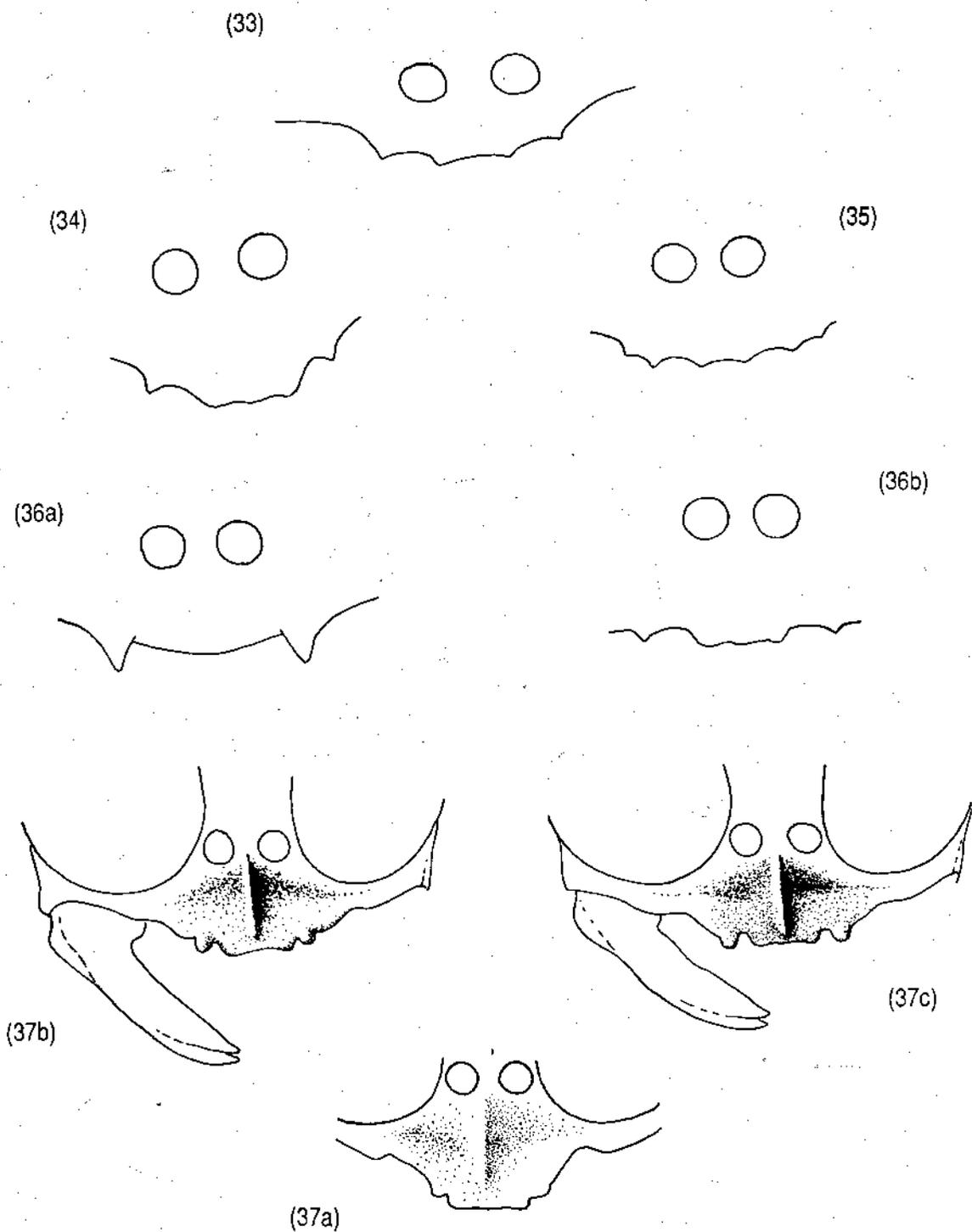
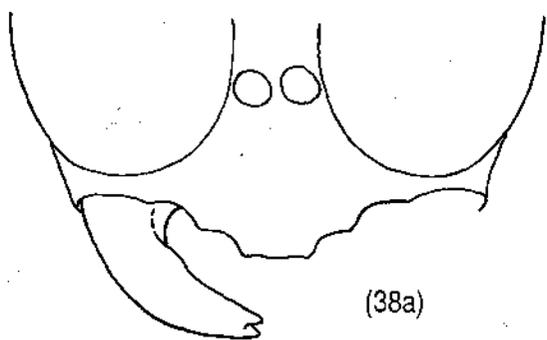
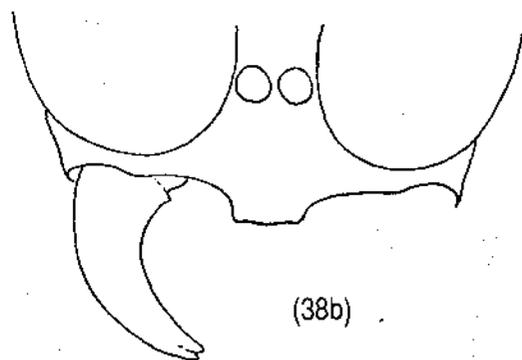


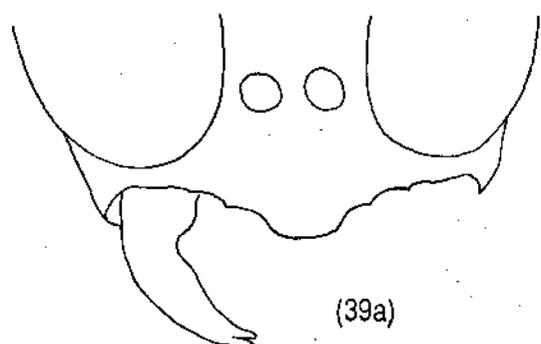
Fig. 33–36 Anterior margin of clypeus, *Podagritys* species: (33) *albipes*, female (Wanaka OL); (34) *carbonicolor*, female; (35) *cora*, female (Dunedin DN); (36a, b) *parrotti*, female and male. Fig. 37 Clypeus, *Rhopalum perforator*: (a) female (Dunedin DN); (b, c) male (Mt Taranaki TK and Banks Peninsula MC).



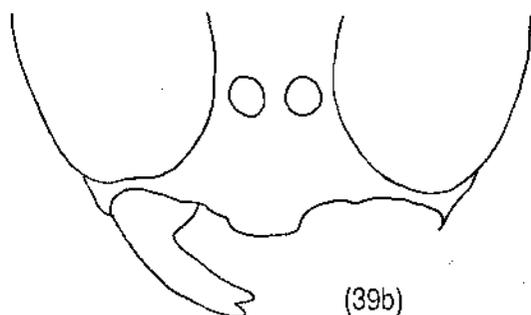
(38a)



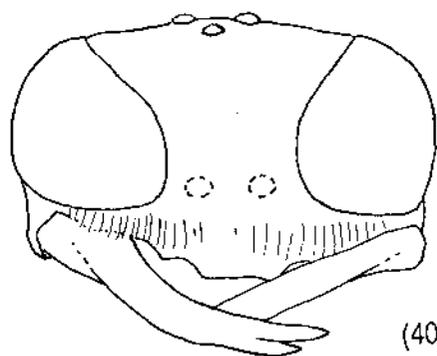
(38b)



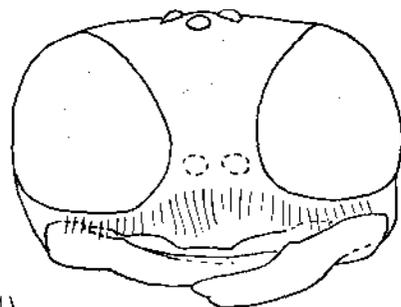
(39a)



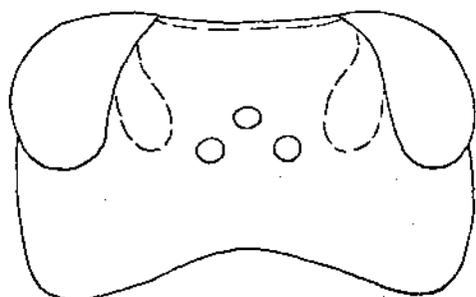
(39b)



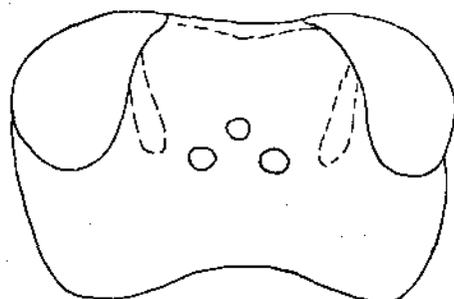
(40)



(41)



(42)



(43)

Fig. 38, 39 Clypeus, *Rhopalum* species: (38a, b) *aucklandi*, female and male (Mt Taranaki TK); (39a, b) *zelandum*, female and male (Mt Taranaki TK). Fig. 40, 41 Head, frontal view, showing difference in width of frons relative to eye in female *Podagrityus carbonicolor* (Canterbury MC) and *P. cora* (Mt Taranaki TK). Fig. 42, 43 Head, dorsal, showing differences in outline of orbital foveae in female *Podagrityus carbonicolor* and *P. cora* (both Mt Taranaki TK).

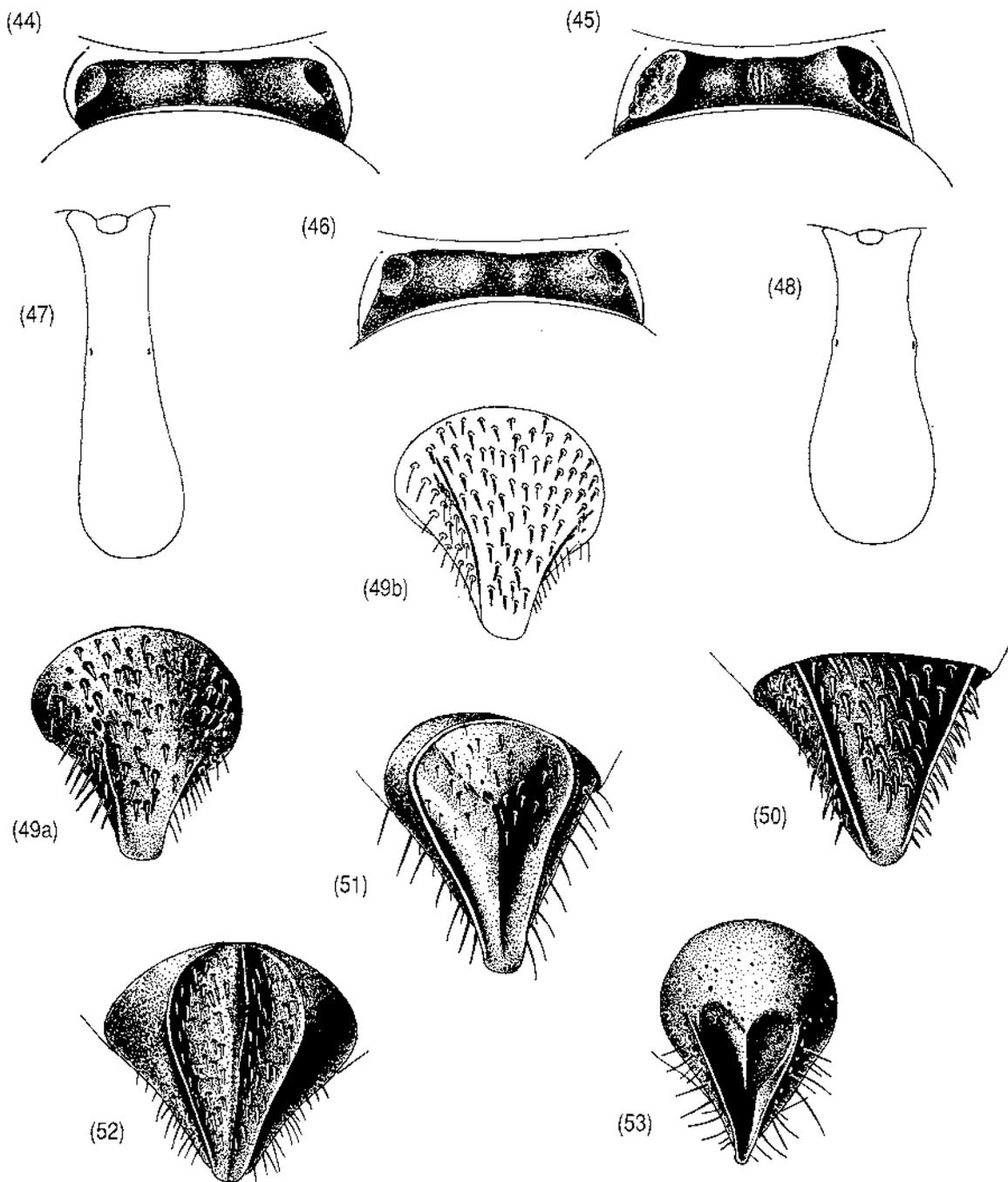


Fig. 44-46 Pronotal collar, dorsal, showing difference in shape of humeral angle of female *Podagritys albipes*, *P. carbonicolor*, and *P. cora* (Mt Taranaki TK). Fig. 47, 48 Petiole of metasoma, dorsal, *Podagritys chambersi* and *P. digyalos*. Fig. 49-53 Apex of metasoma, dorsal, in females of *Podagritys* and *Rhopalum* species: (49a, b) *P. albipes* (Outram DN); (50) *P. cora* (Outram DN); (51) *R. perforator* (Secretary I. FD); (52) *R. aucklandi* (Trotter's Gorge DN); (53) *R. zelandum* (Dunedin DN).

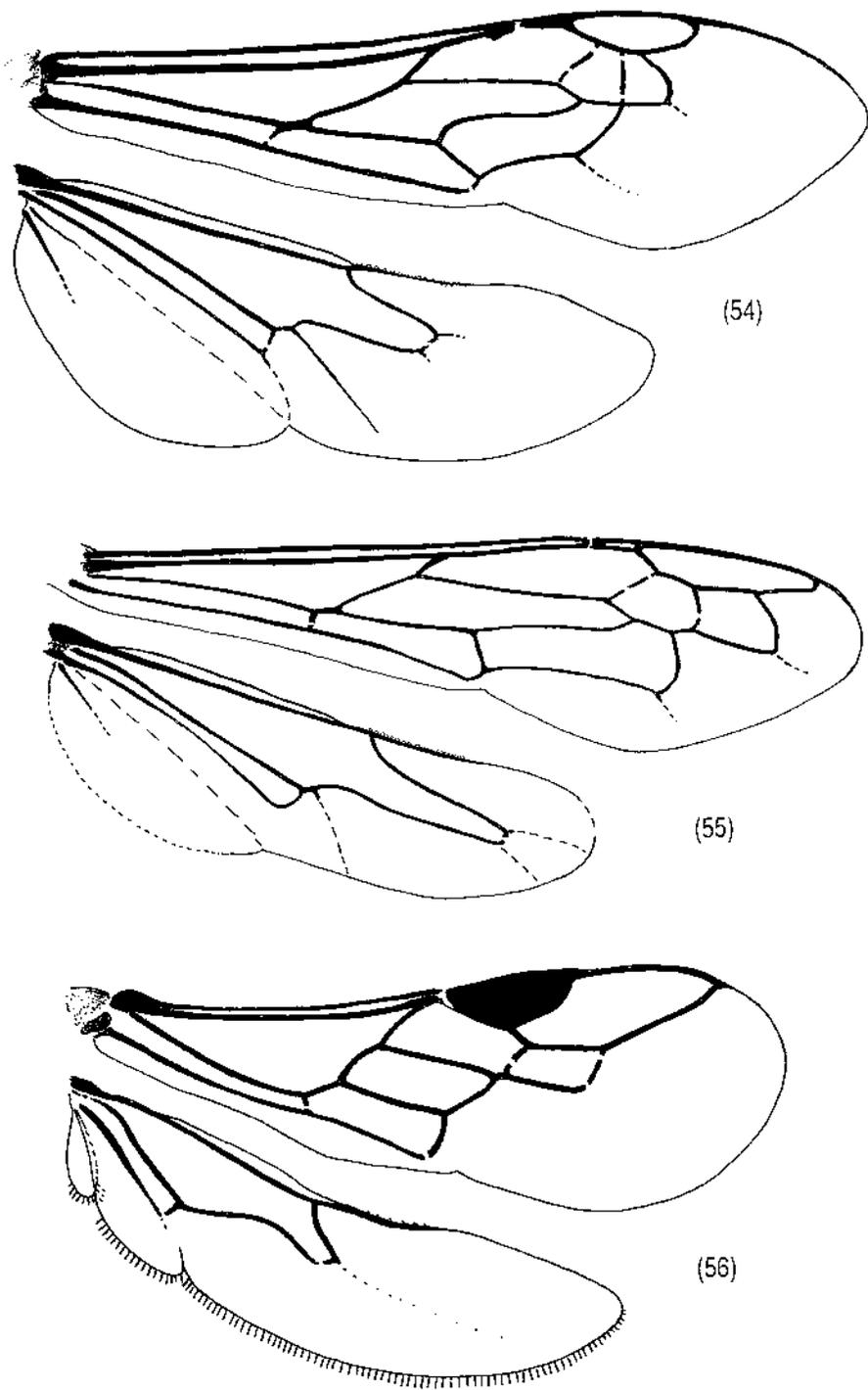


Fig. 54-56 Wings, showing venation: (54) *Podalonia tydei suspiciosa*, female; (55) *Sceliphron formosum*, male; (56) *Spilomena earlyi*, male.

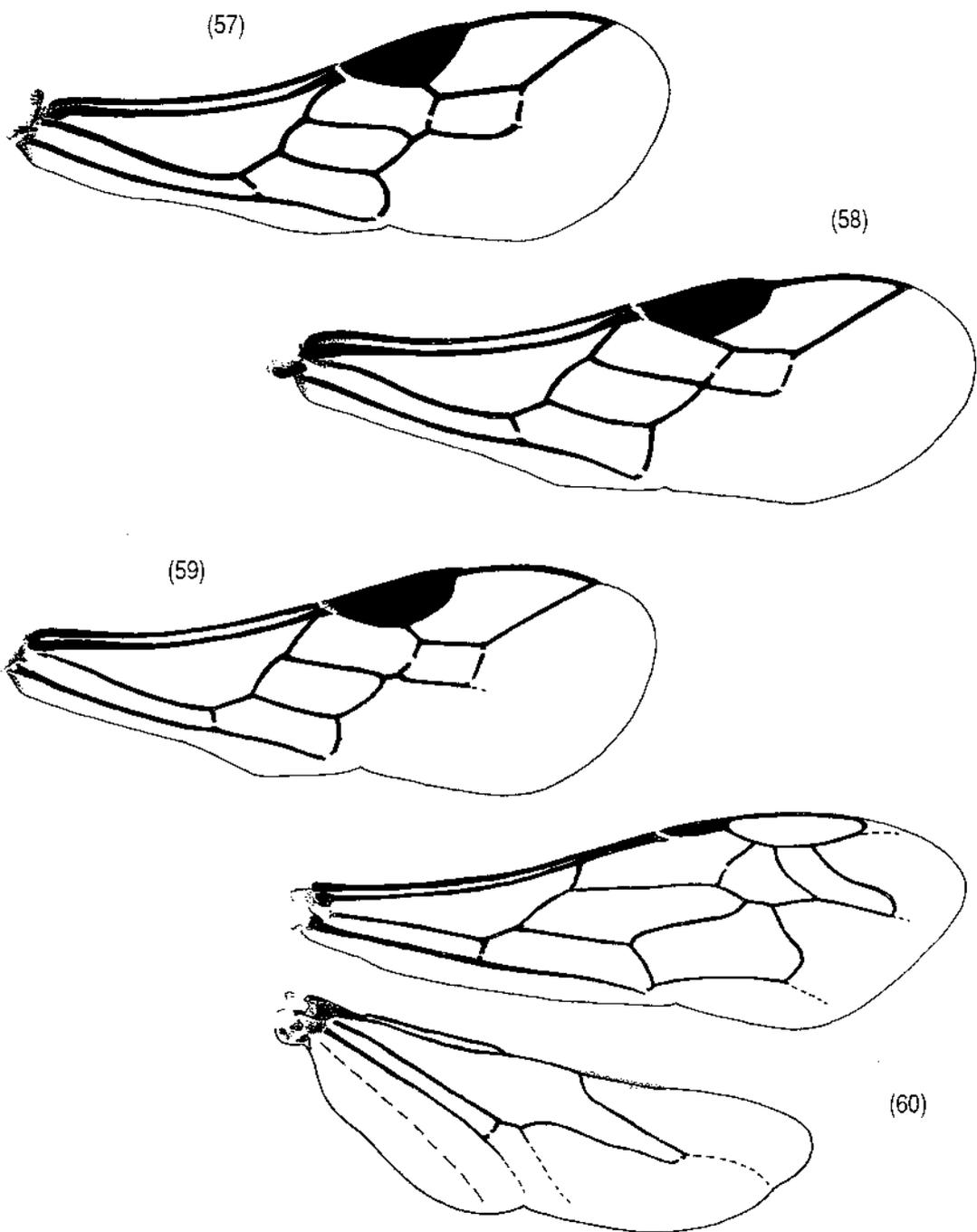


Fig. 57-60 Wings, showing venation: (57) *Spilomena elegantula*, female; (58) *S. emarginata*, female; (59) *S. nozela*, male; (60) *Tachysphex nigerrimus*, female.

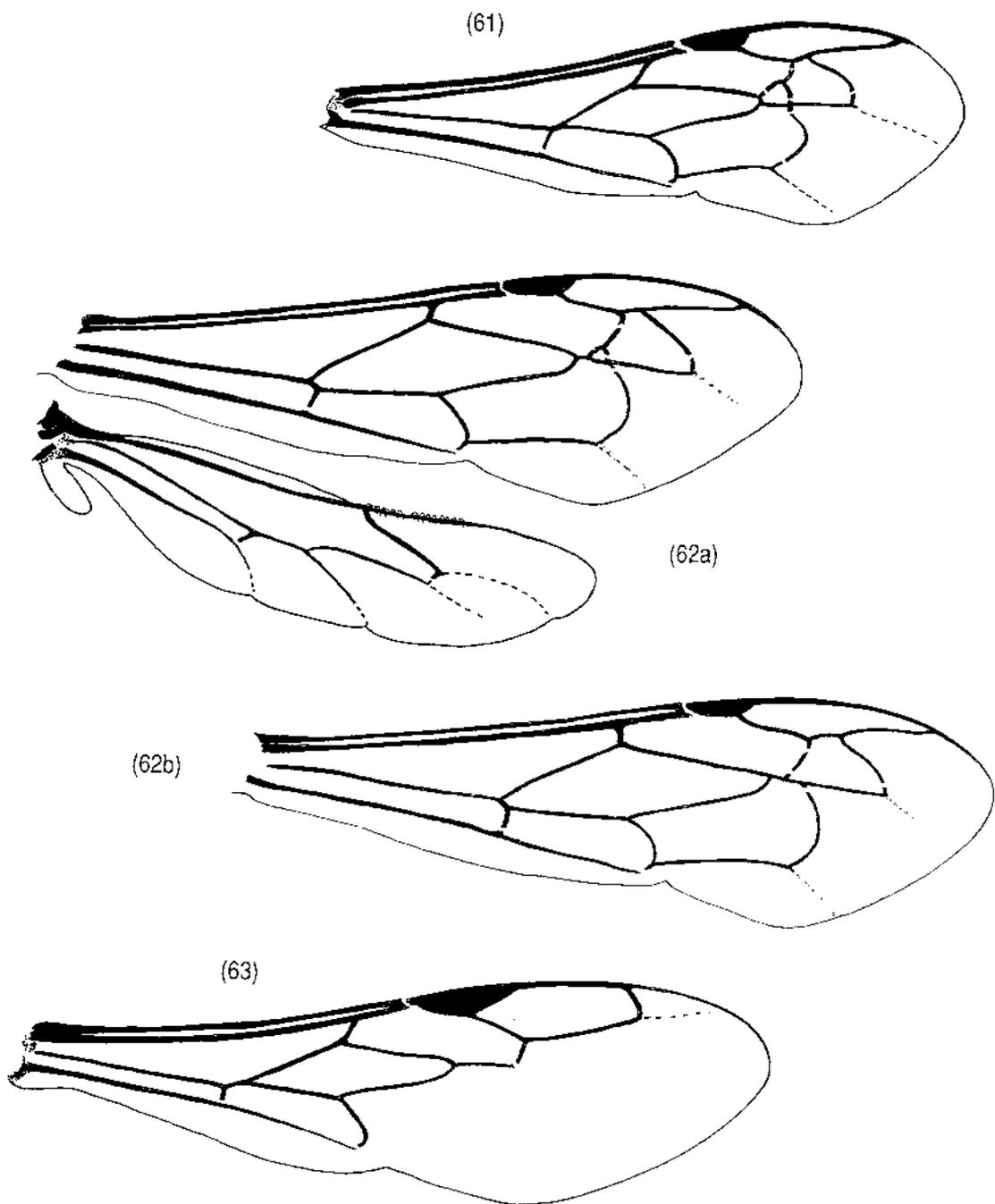


Fig. 61-63 Wings, showing venation: (61) *Pison morosum*, female;  
(62a, b) *P. spinolae*, female; (63) *Podagritys albipes*, male.

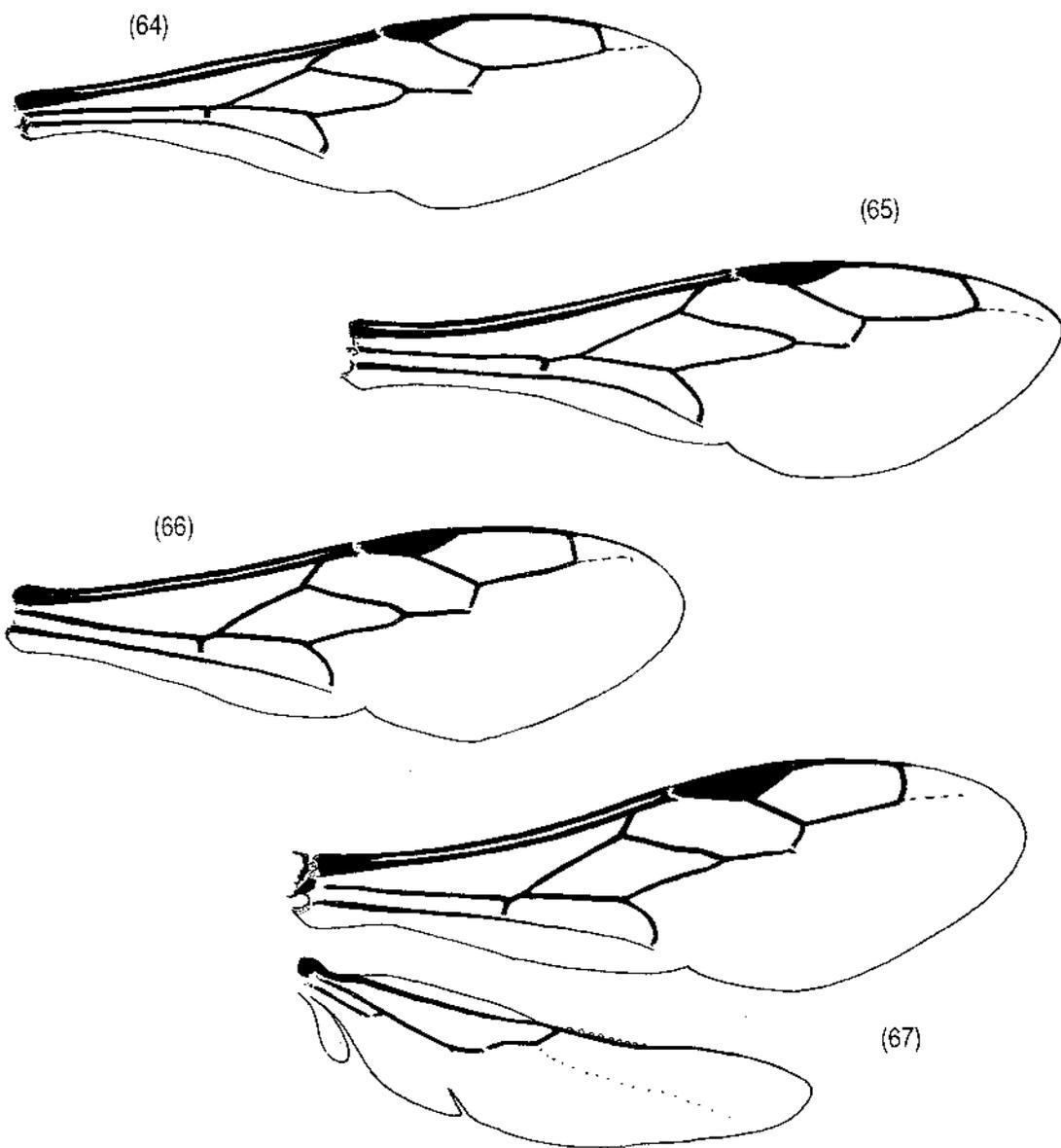


Fig. 64-67 Wings, showing venation: (64) *Podagritys carbonicolor*, male; (65) *P. cora*, male; (66) *P. digyalos*, female; (67) *P. parrotii*, female.

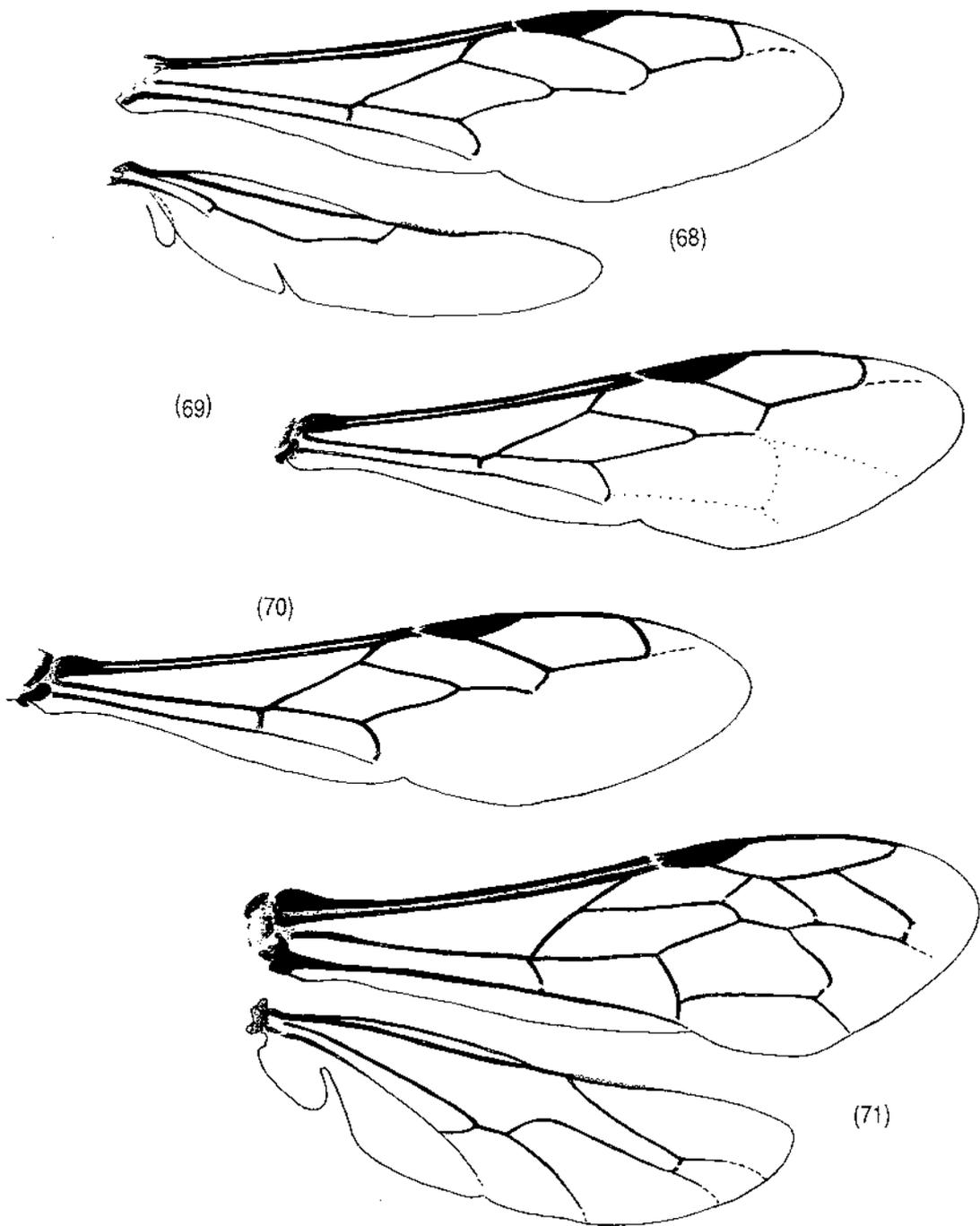


Fig. 68-71 Wings, showing venation: (68) *Rhopalum perforator*, male; (69) *R. aucklandi*, female; (70) *R. zelandum*, female (large individual); (71) *Argogorytes carbonarius*, female.

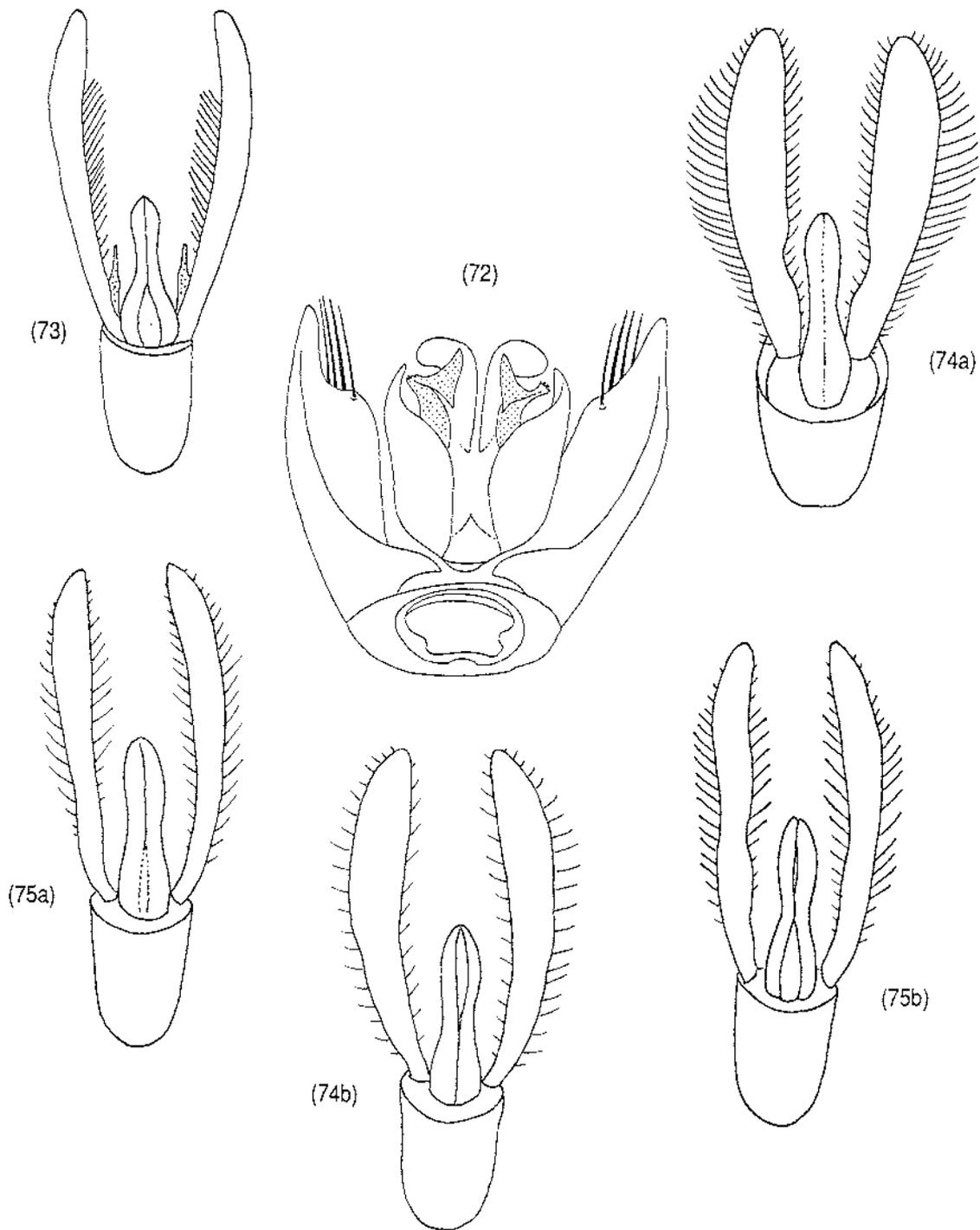
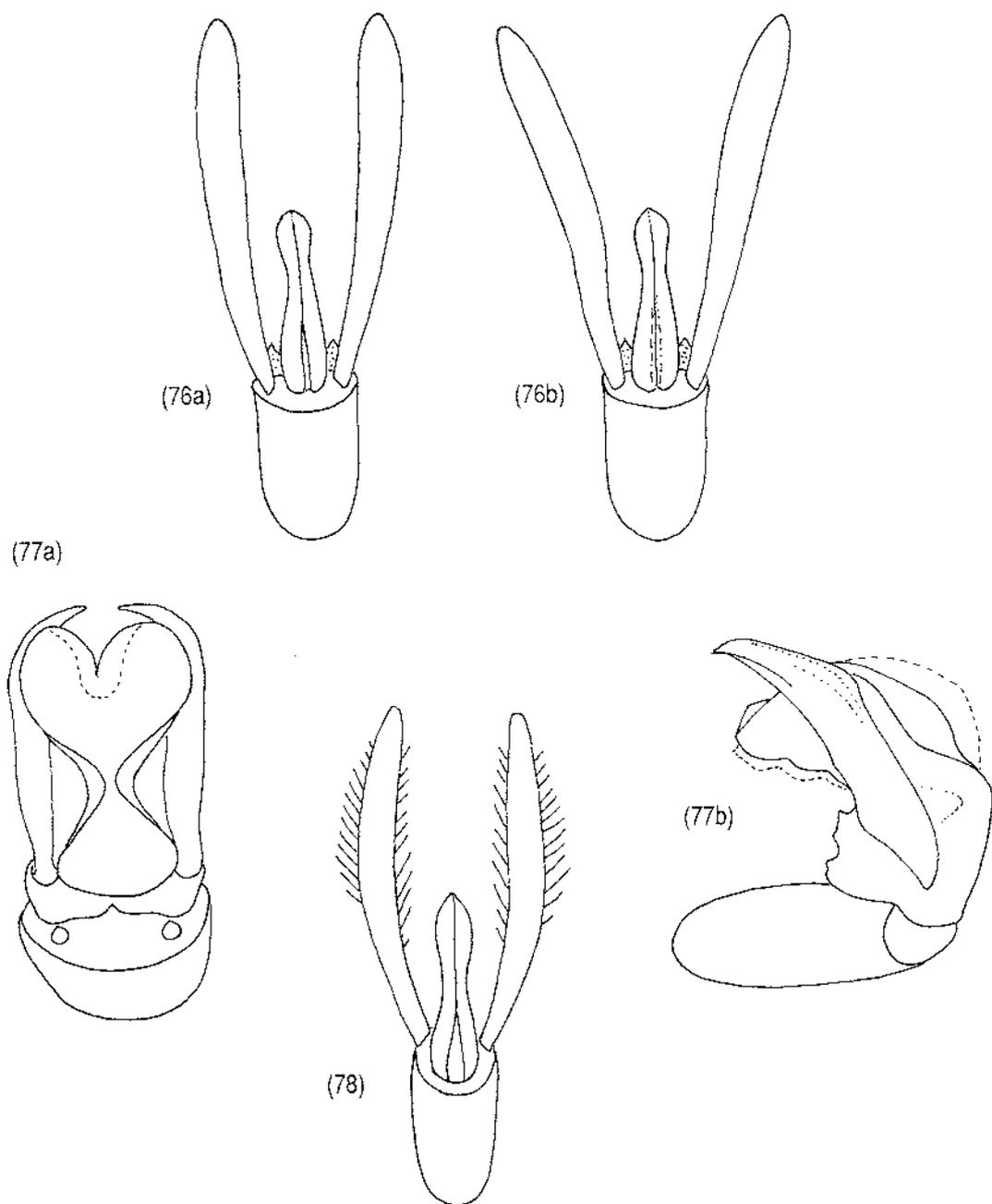


Fig. 72-75 Male genitalia, dorsal (exc. 72): (72) *Podagrityx tydei suspiciosa*, ventral (Maketu BP); (73) *Podagrityx albipes* (Outram DN); (74a, b) *P. chambersi* (Feilding WI, Palmerston North WN); (75a, b) *P. digyalos* (Taihape RI, Obelisk Ra. CO).



**Fig. 76-78** Male genitalia: (76a, b) *Podagrityx parrotti*, dorsal (Makara Hill WN); (77a, b) *Rhopalum perforator*, dorsal and lateral (Banks Peninsula MC); (78) *R. zelandum*, dorsal.

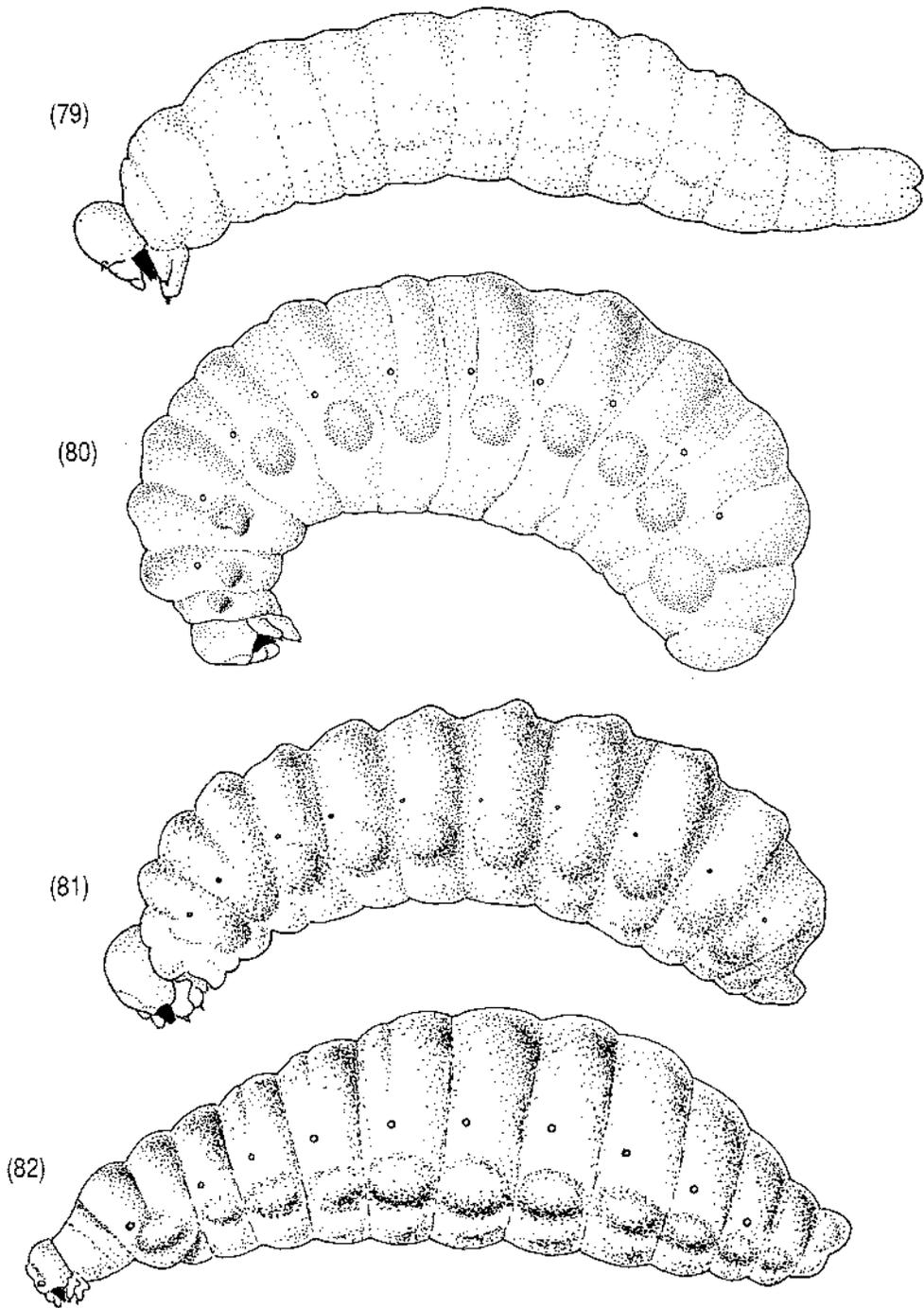


Fig. 79–82 Final-instar larvae: (79) *Spilomena nozeia*; (80) *Pison spinolae*; (81) *Rhopalum perforator*; (82) *Argogorytes carbonarius*.

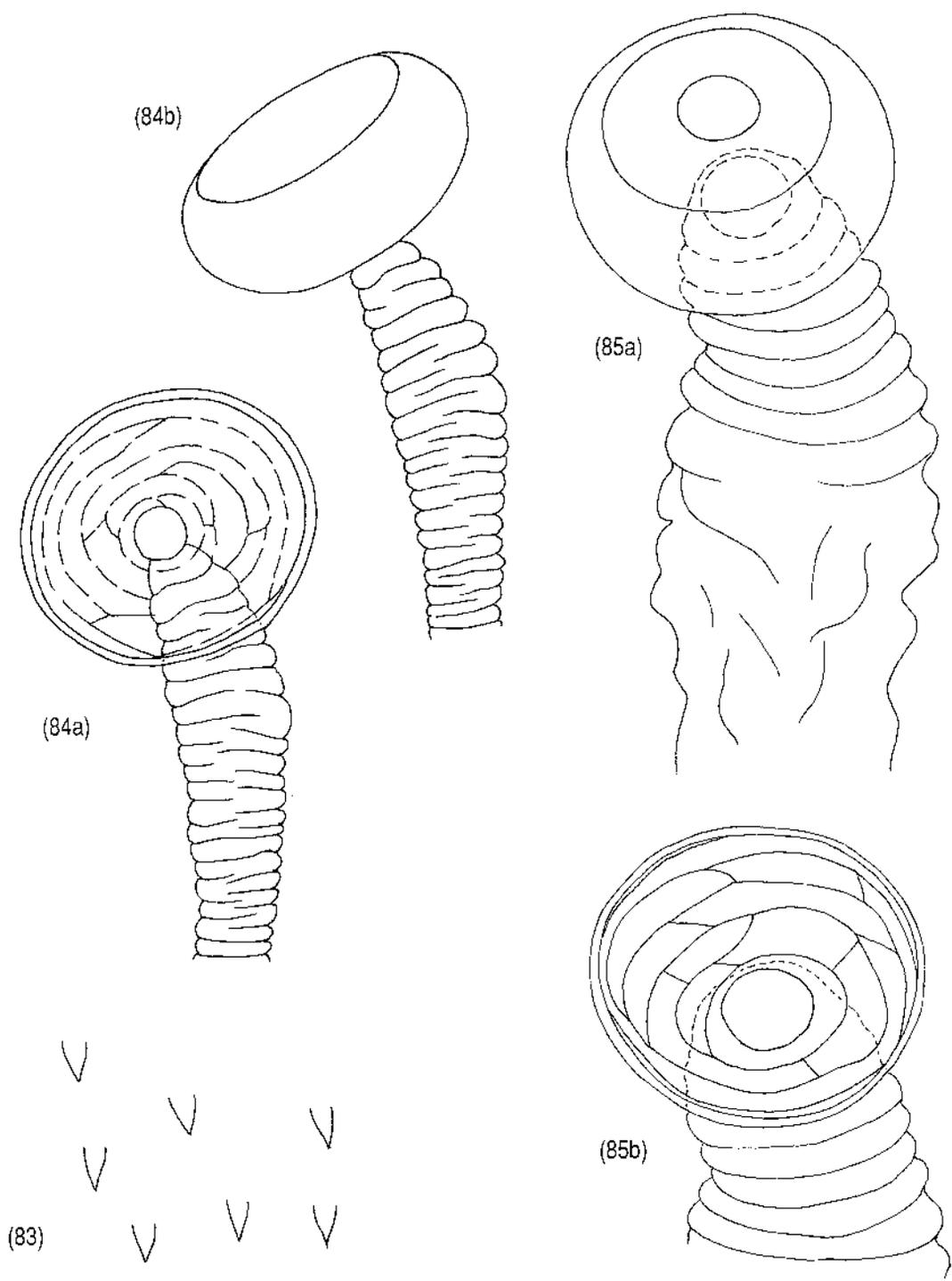
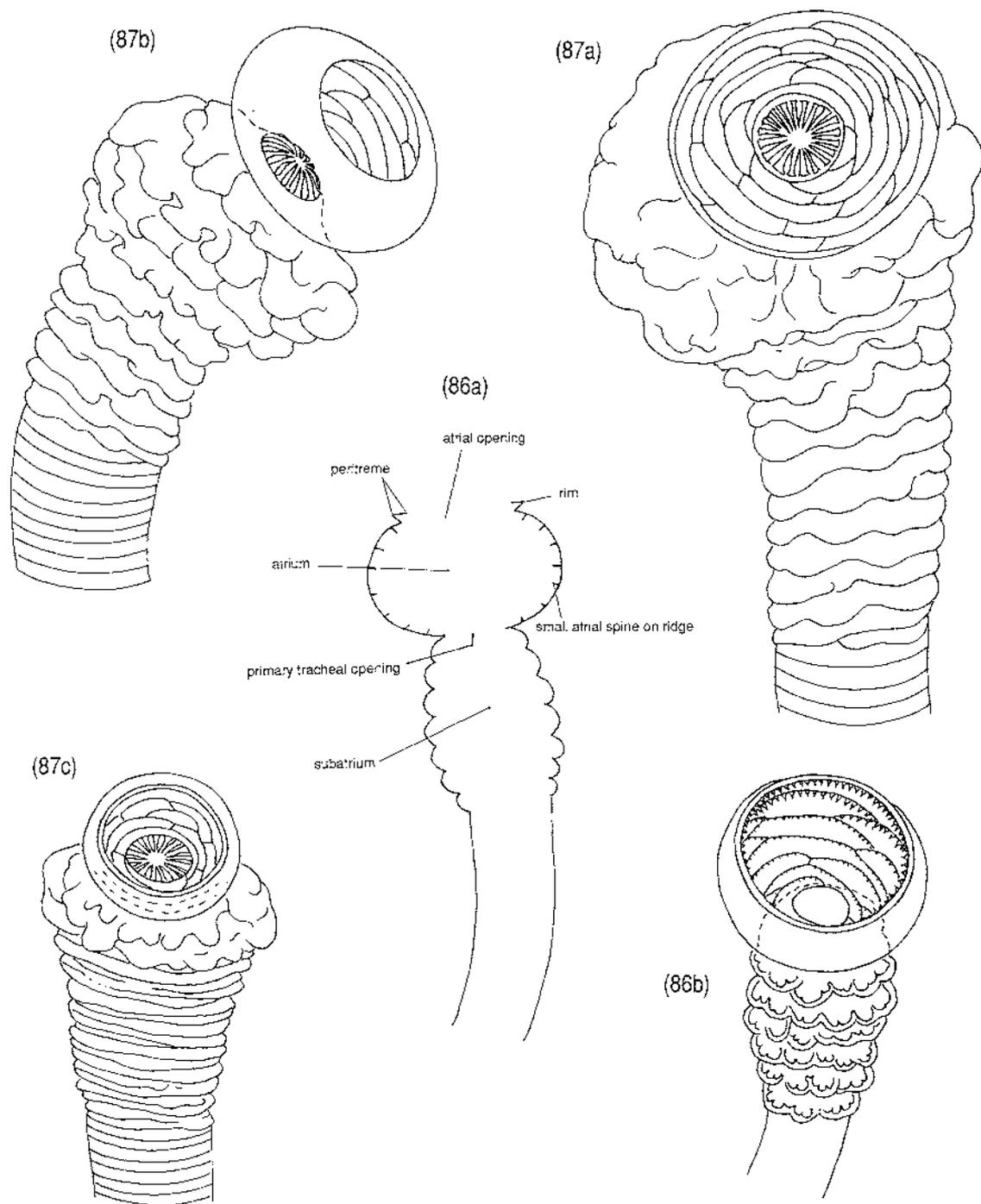


Fig. 83 Spicules on mesopleuron, *Rhopalum perforator* final-instar larva. Fig. 84, 85 Spiracles, final-instar larvae: (84a, b) *Spilomena nozela*, 1st thoracic; (85a, b) *Pison spinolae*, 1st thoracic and atrium, showing internal ridge.



**Fig. 86, 87** Spiracles, final-instar larvae: (86a, b) *Rhopalum perforator*, 1st thoracic (a, schematic section); (87) *Argogorytes carbonarius*: (a) 1st thoracic, plan view showing pattern of internal atrial ridges and arrangement of collar teeth (peritreme omitted); (b) 2nd thoracic; (c) 1st abdominal.

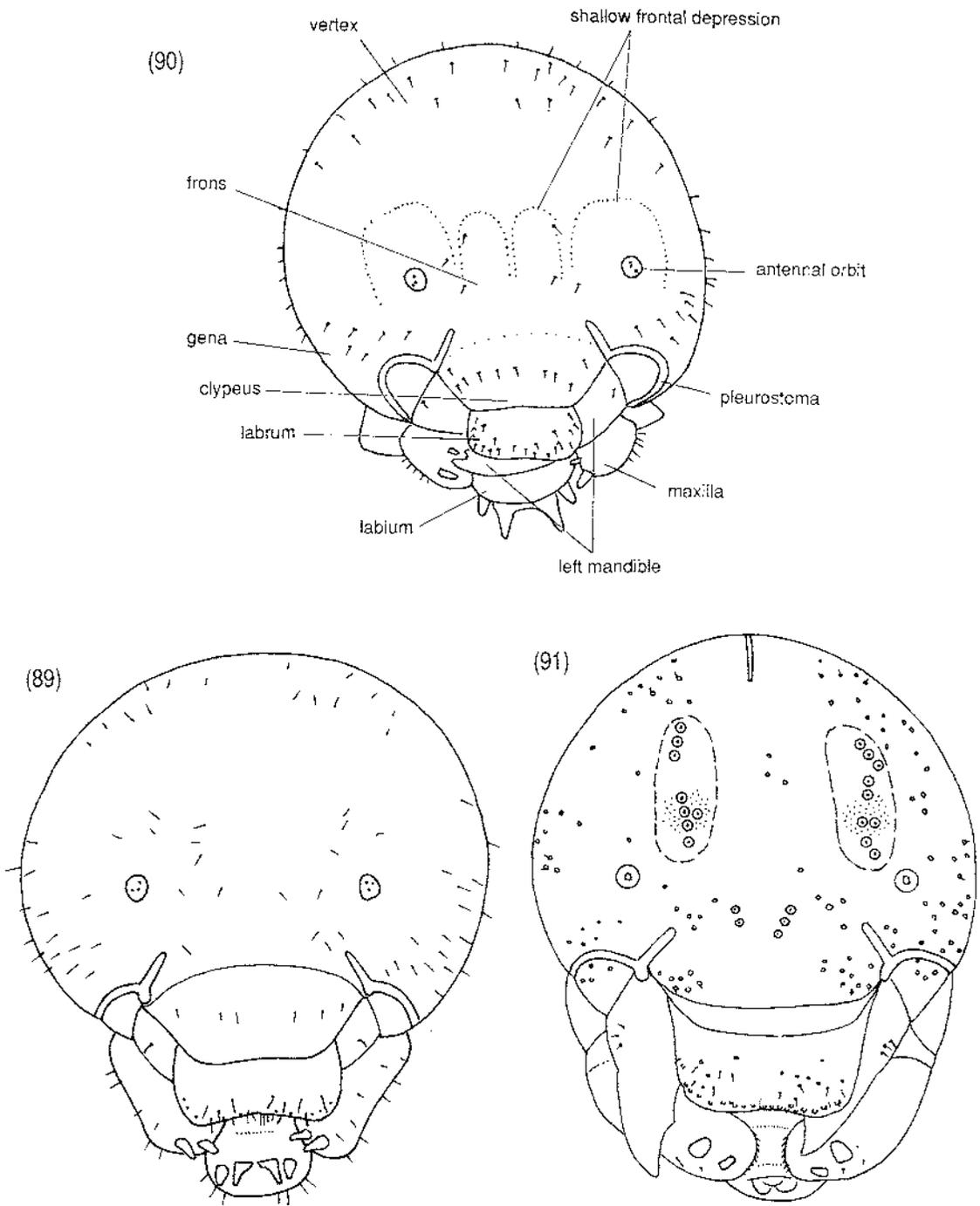
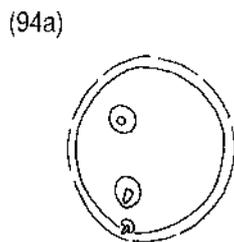
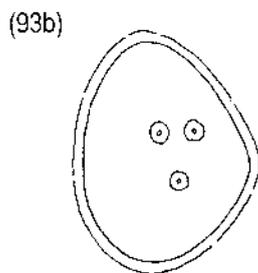
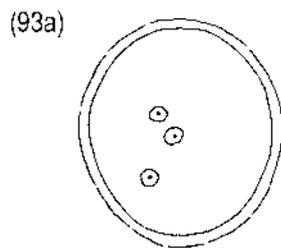
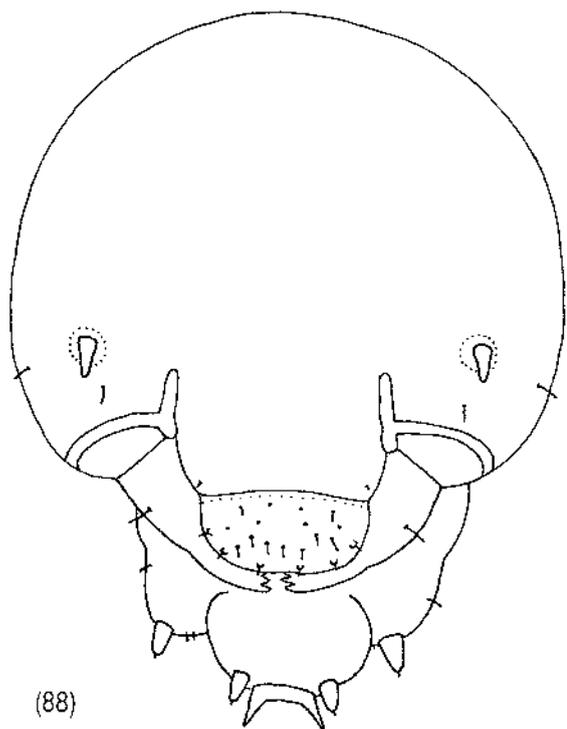
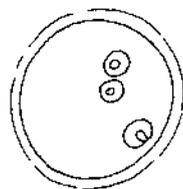


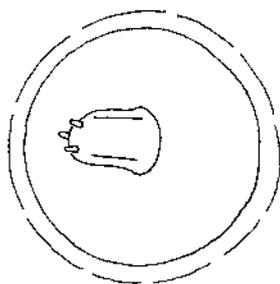
Fig. 88-91 Head capsules, final-instar larvae: (88) *Spilomena nozela* (see p. 94); (89) *Pison spinolae*; (90) *Rhopalum perforator*; (91) *Argogorytes carbonarius*.



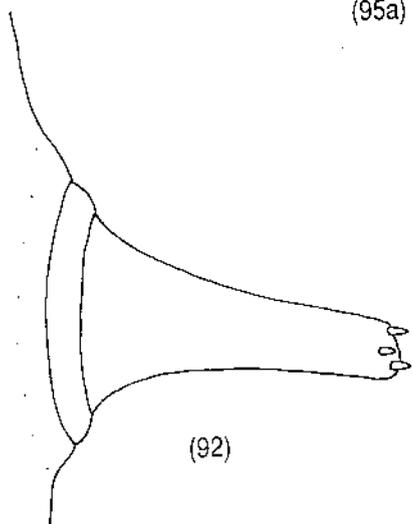
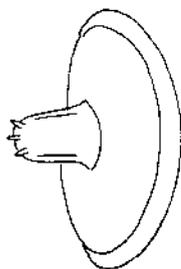
(94b)



(95a)



(95b)



(92)

Fig. 88 Head capsule, final-instar larva, *Spilomena nozela*. Fig. 92-95 Antennal orbits, final-instar larvae: (92) *Spilomena nozela*; (93a, b) *Pison spinolae*, right and left; (94a, b) *Fhopalum perforator*, right and left; (95a, b) *Argogorytes carbonarius*.

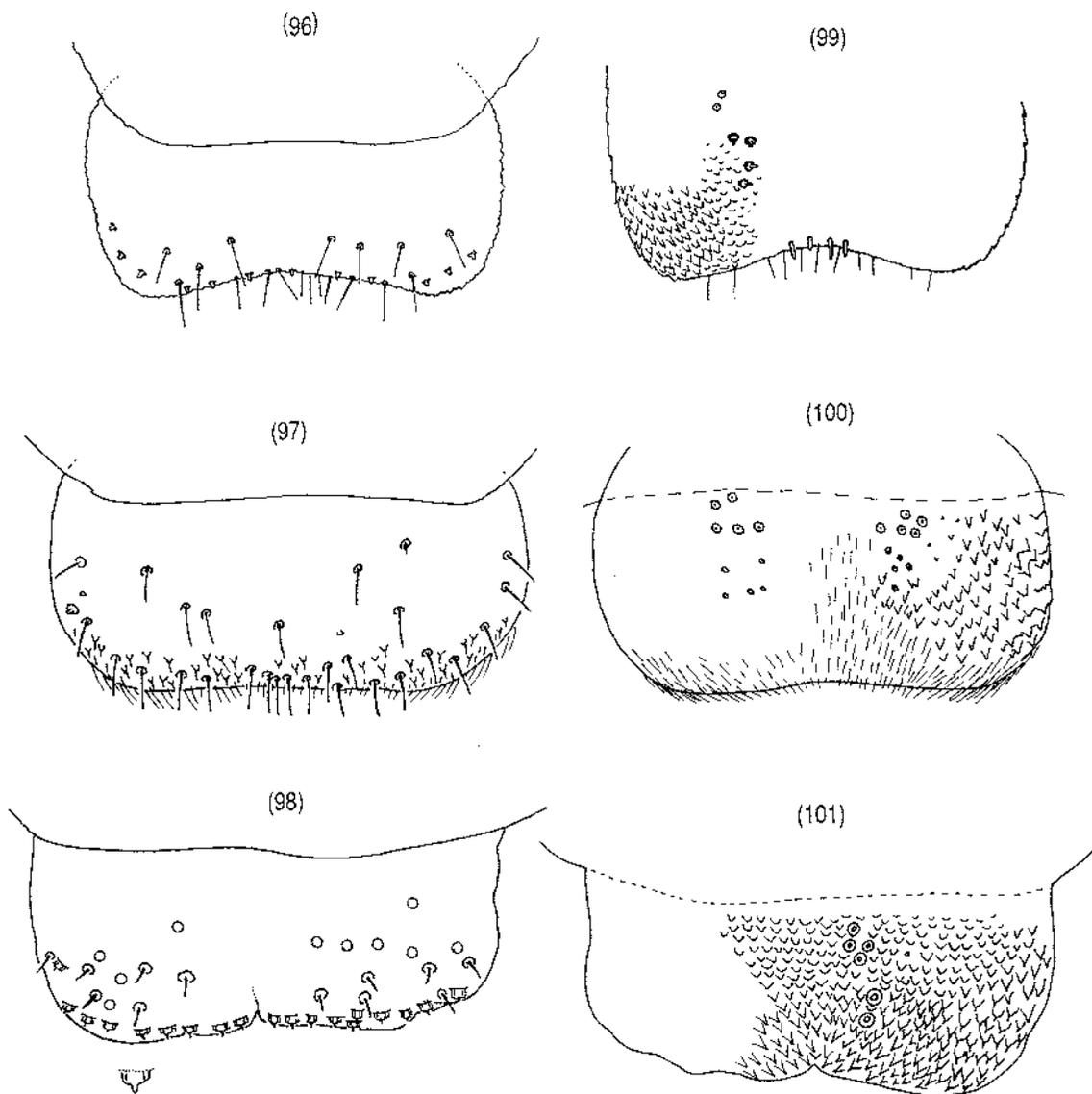
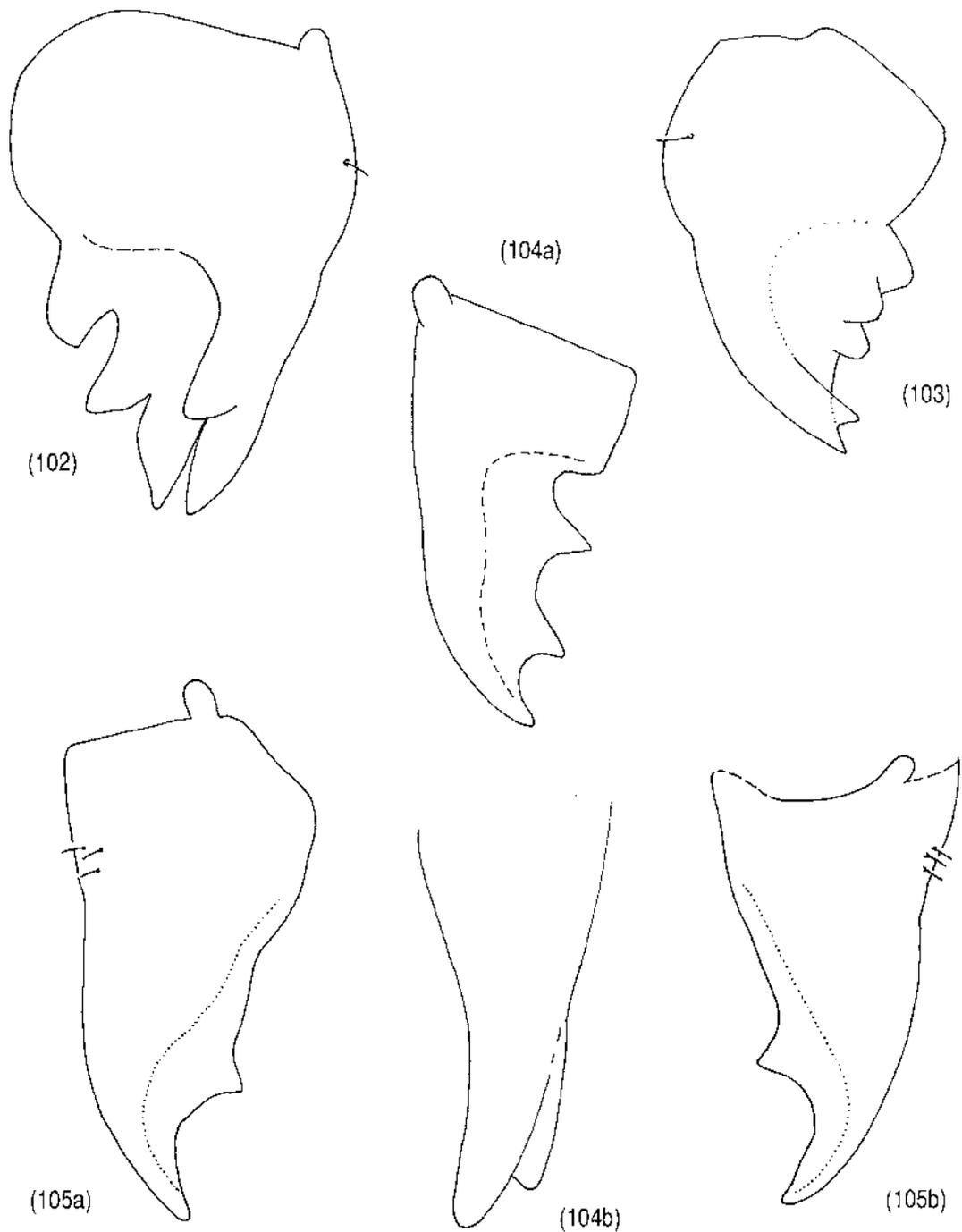


Fig. 96-98 Labrum, and 99-101 epipharynx, final-instar larvae: (96, 99) *Pison spinolae*; (97, 100) *Rhopalum perforator*; (98, 101) *Argogorytes carbonarius*.



**Fig. 102–105** Mandible, final-instar larvae: (102) *Spilomena nozela*; (103) *Pison spinolae*; (104a, b) *Rhopalum perforator* (with lateral profile); (105a, b) *Argogorytes carbonarius*, right and left.

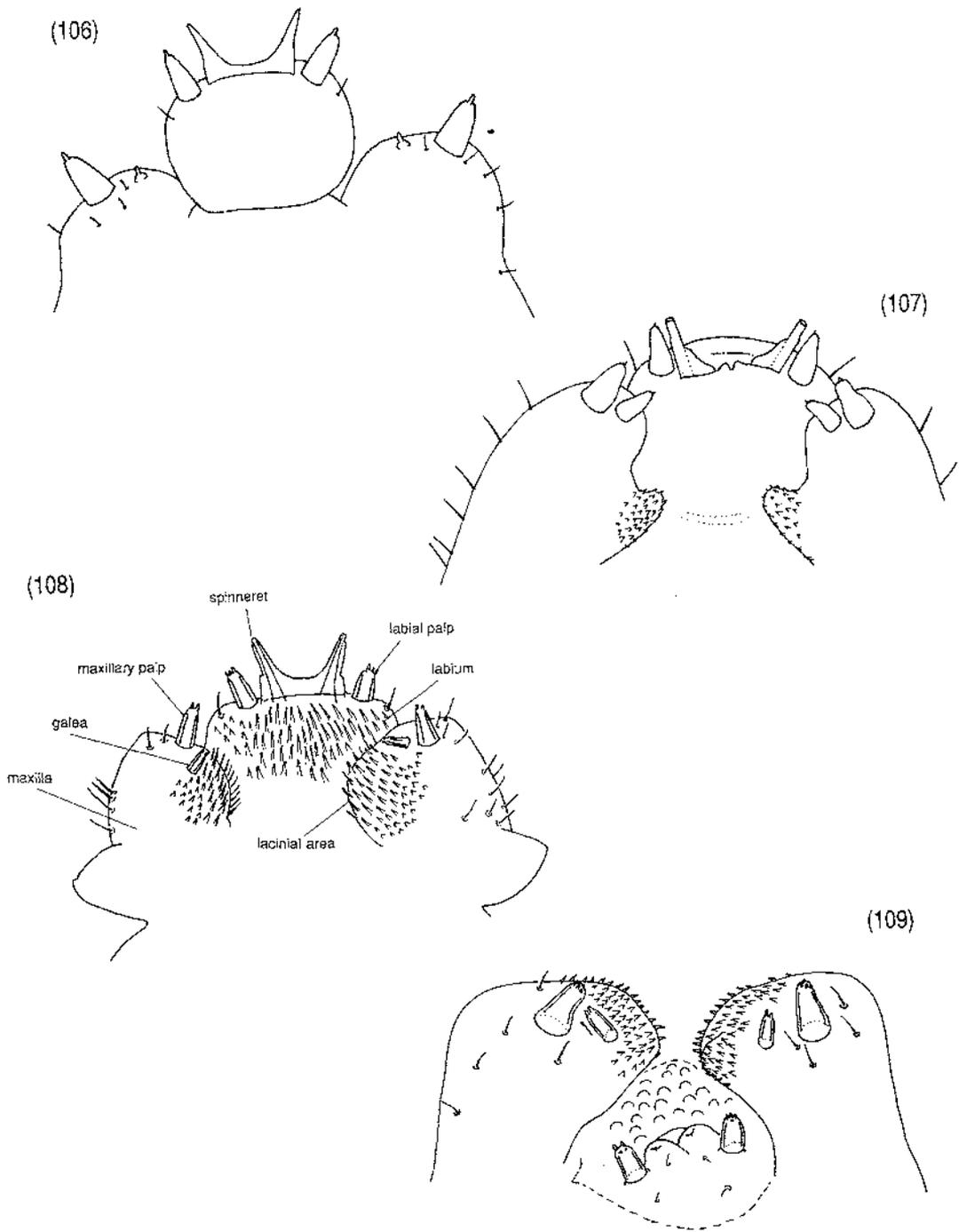
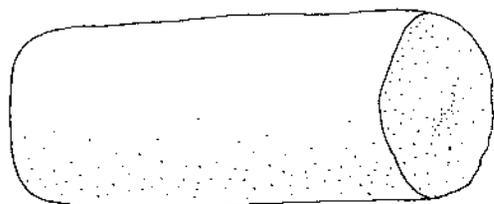
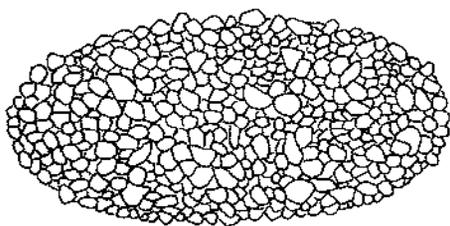
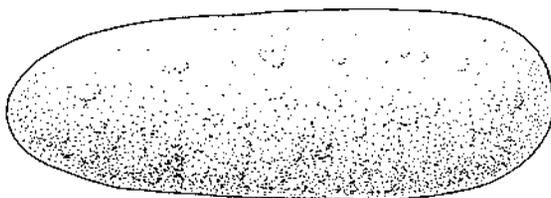


Fig. 106–109 Labium and maxilla, final-instar larva: (106) *Spilomena nozela*; (107) *Pison spinolae*; (108) *Rhopalum perforator*; (109) *Argogorytes carbonarius*.



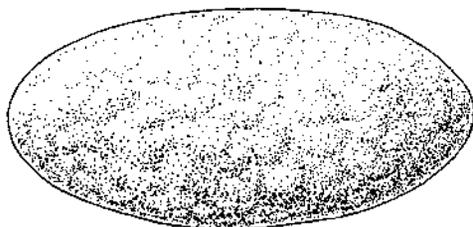
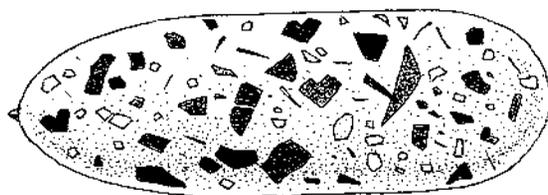
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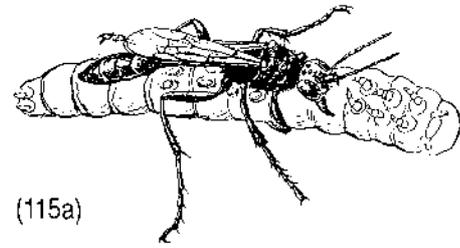
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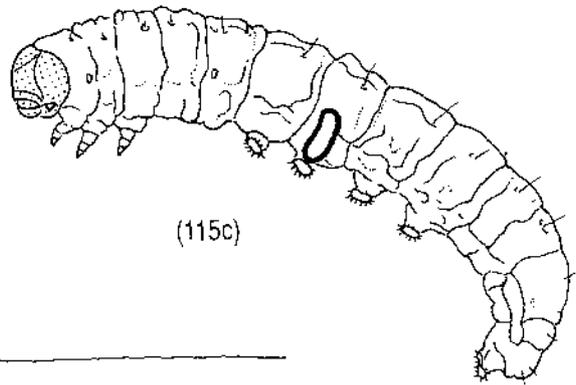


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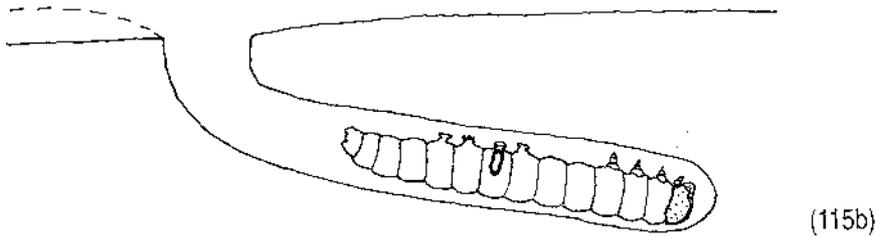
**Fig. 110–114** Cocoons: (110) *Spilomena nozela*; (111) *Pison spinolae*; (112) *Podagritys albipes* (in sand); (113) *Rhopalum perforator*; (114) *Argogorytes carbonarius*.



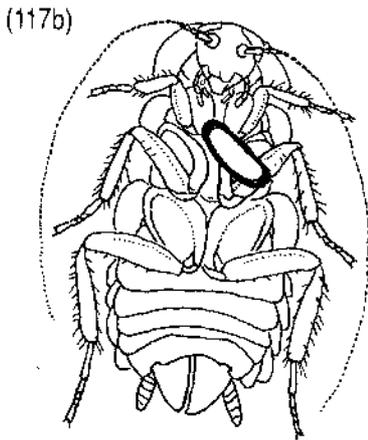
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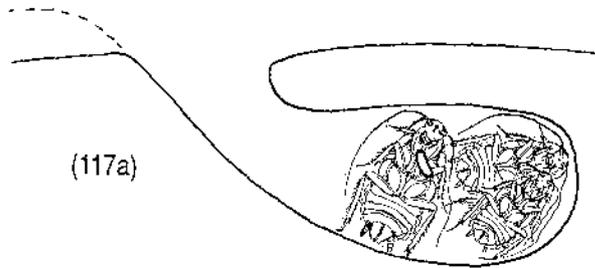
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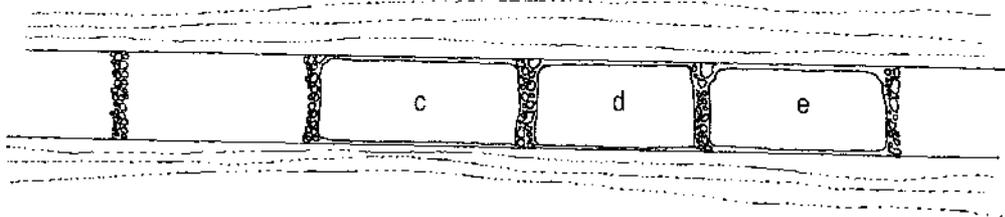
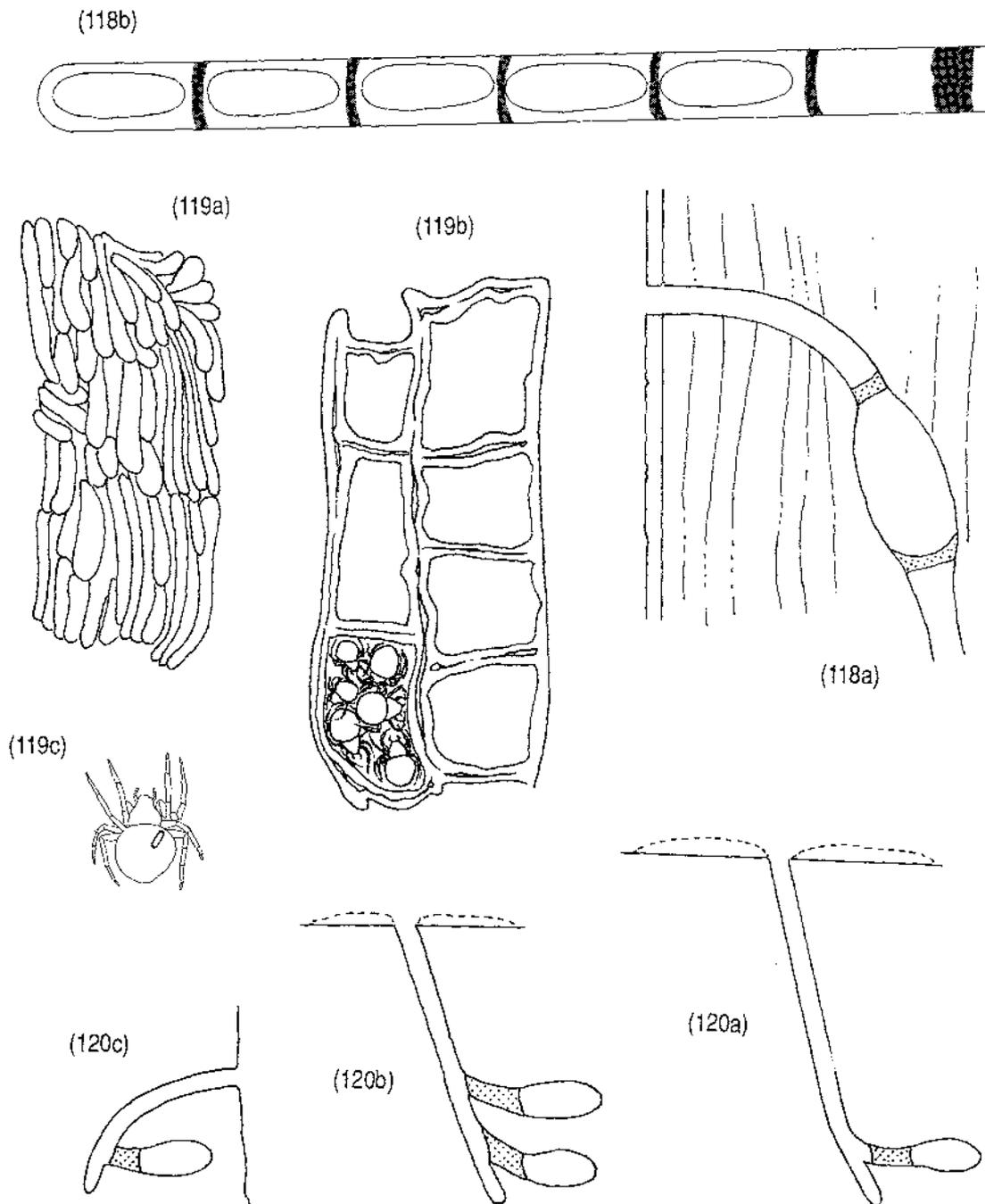
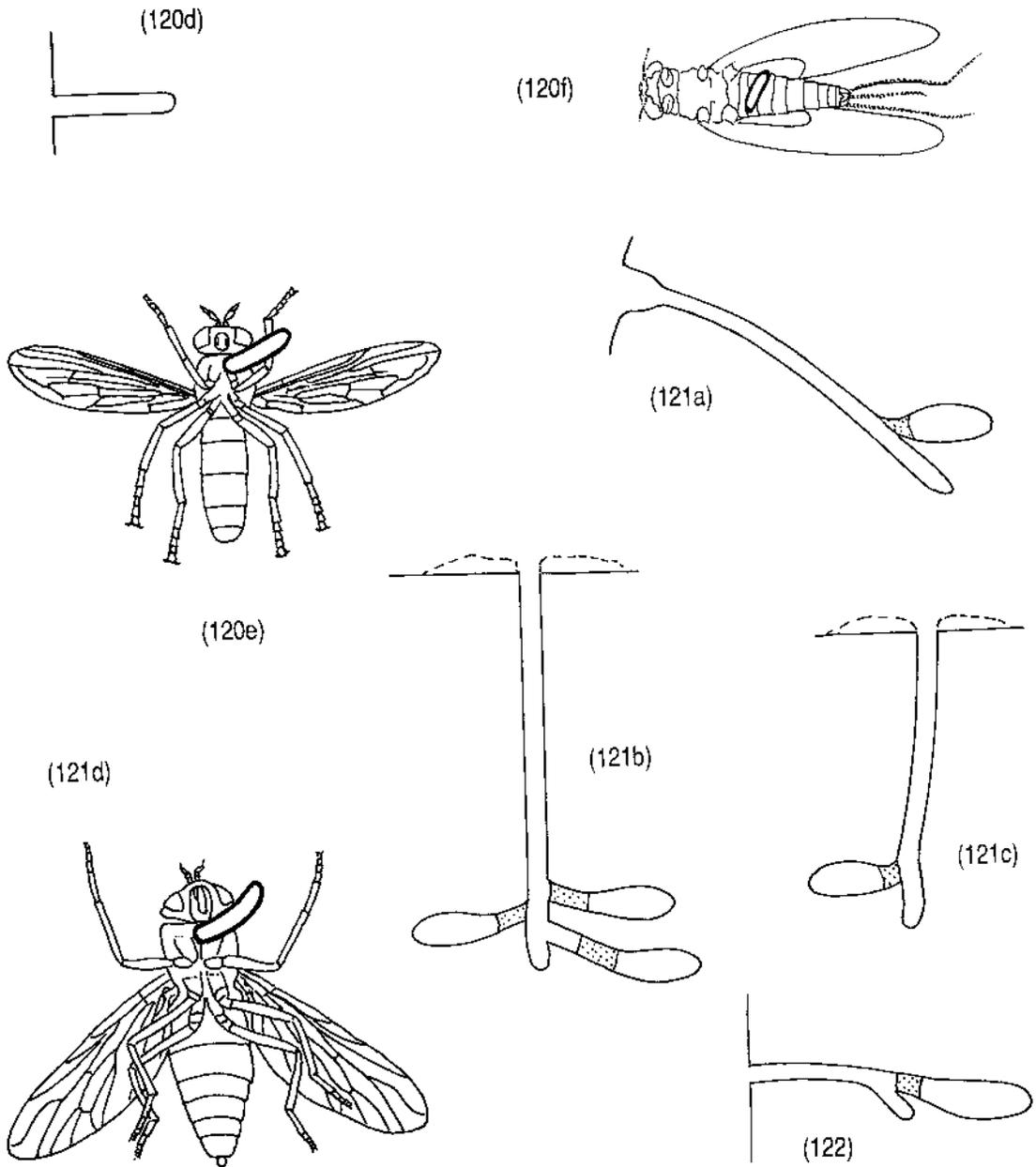


Fig. 115 *Podalonia tydei suspiciosa*: (a) female running with a caterpillar 30 mm long (Mt Maunganui BP); (b) nest (Little Waihi Beach BP); (c) position of egg on *Agrotis innominata* final-instar larva. Fig. 116 Part of *Spilomena nozela* nest in abandoned gallery of *Anobium punctatum*; cells c,d,e contain cocoons. Fig. 117 *Tachysphex nigerrimus*: (a) nest; (b) position of egg on *Celatoblatta* sp.



**Fig. 118** *Pison morosum* nests: (a) in abandoned pupal chamber of *Psepholax barbifrons* in *Fuchsia excorticata* trunk (note presence of both inner and outer mud seals); (b) in artificial trap-nest (note presence of 5 brood-cells with cocoons and a vestibular cell). **Fig. 119** *Pison spinolae* nest: (a) exterior; (b) transverse section; (c) position of egg on *Zealaranea crassa*. **Fig. 120a-c** *Podagrītus albipes* nests.



**Fig. 120** *Podagritys albipes*: (d) male burrow; (e, f) egg in usual 'neck' position on dipterous prey item, and on *Deleatidium* sp. subimago. **Fig. 121** *P. carbonicolor*: (a-c) nests in sand; (d) position of egg on *Anabarhynchus* sp. **Fig. 122** *P. chambersi* nest in clay bank.

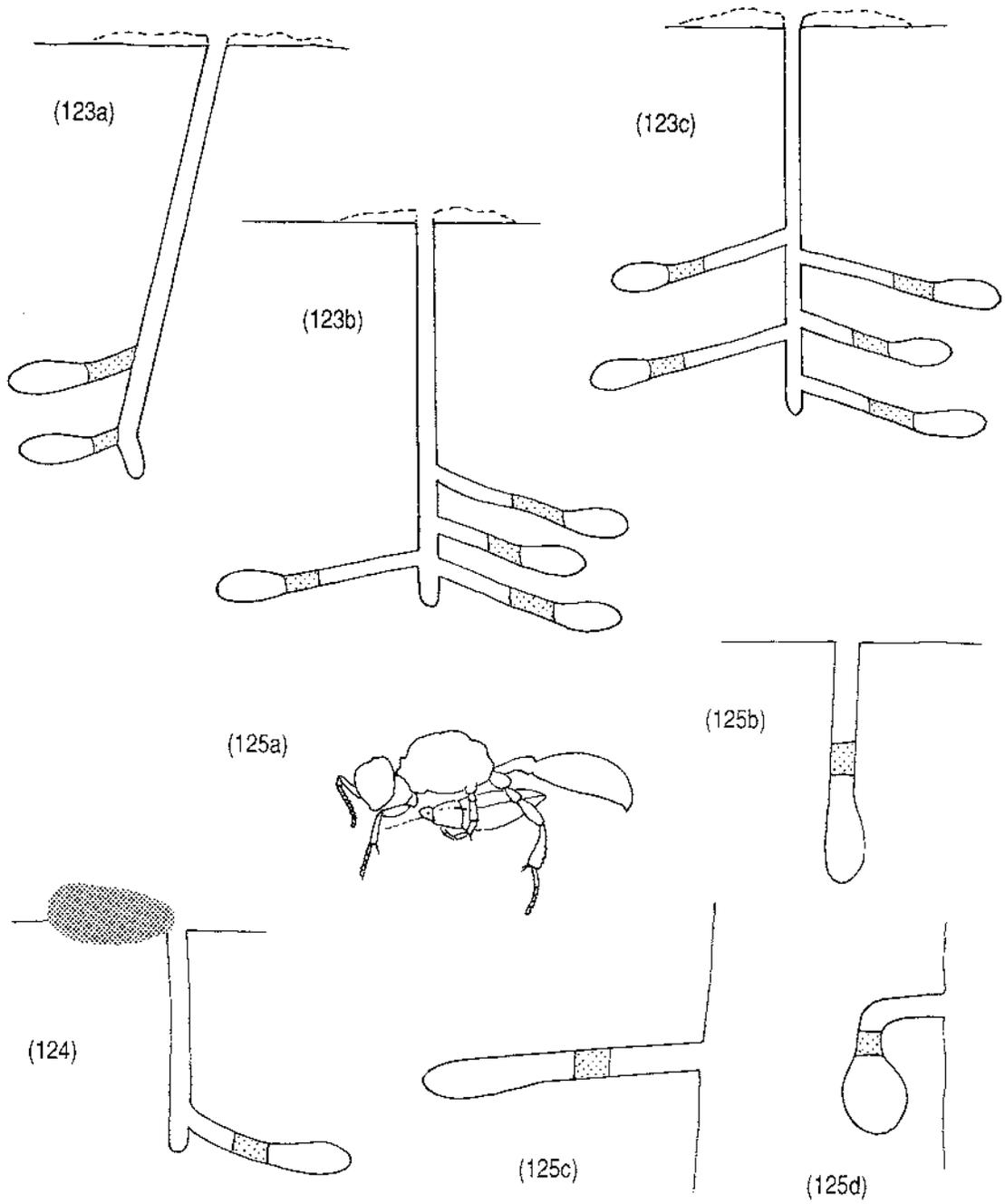
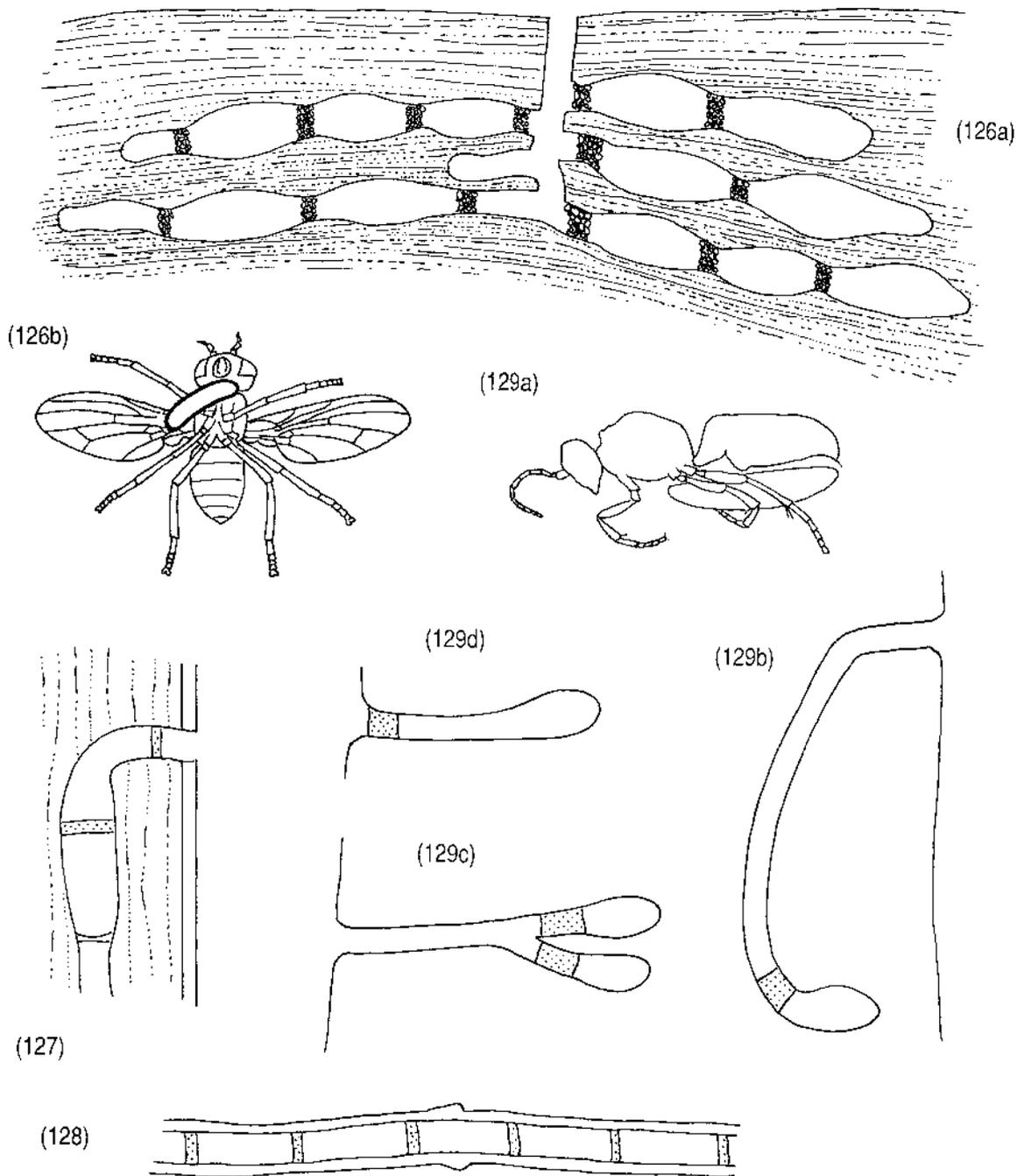


Fig. 123 *Podagritus cora* nests: (a) in sand/silt; (b) 4-celled nest in stabilised dune, and (c) 5-celled nest (both Haast WD). Fig. 124 *Podagritus digyalos* nest beside small stone in almost horizontal clay. Fig. 125 *Podagritus parrotti*: (a) female carrying *Adoxia vulgaris*; (b-d) nests in clay substrates, horizontal and vertical.



**Fig. 126** *Rhopalum perforator*: (a) 12-celled nest in abandoned *Ambeodontus tristis* galleries in *Cupressus macrocarpa*; (b) egg on last provisioned prey item. **Fig. 127** Nest of *Rhopalum aucklandi* in abandoned pupal gallery of *Psepholax barbiifrons* in trunk of *Fuchsia excorticata*. **Fig. 128** Nest of *Rhopalum zelandum* in dead branch of *Coriaria arborea* hollowed out by a cerambycid. **Fig. 129** *Argogorytes carbonarius*: (a) female carrying a cercopid; (b-d) 3 typical nests.

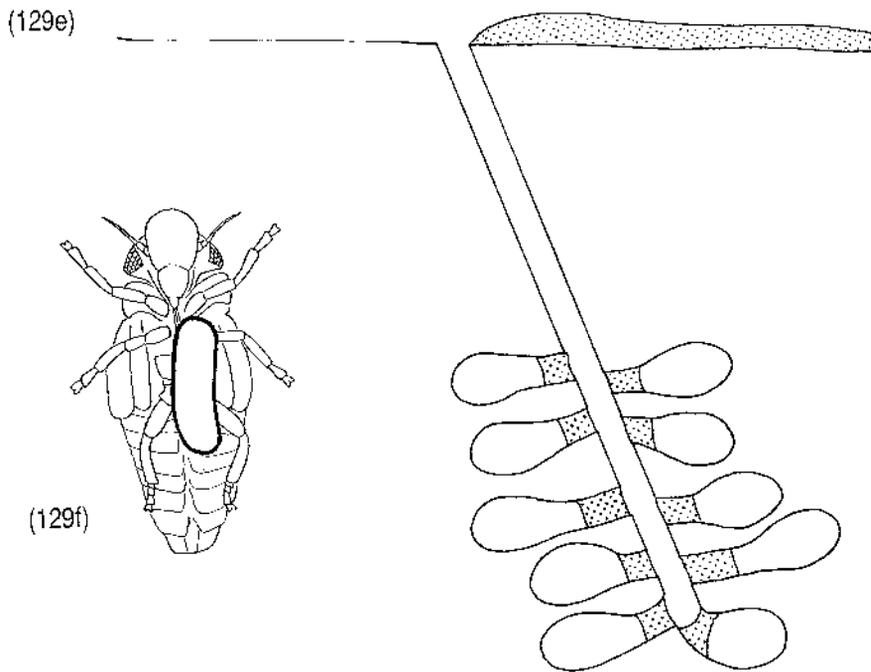


Fig. 129 *Argogorytes carbonarius*: (e) 10-celled nest (Tairi Bridge DN); (f) position of egg on *Carystoterpa vagans* nymph.

## TAXONOMIC INDEX

This index covers the nominal taxa mentioned in the text, regardless of their current status in taxonomy. Page numbers in bold type indicate descriptions of taxa, and in italic type illustrations. A suffixed letter 'k' is used to indicate a key. Prey taxa are listed only as they occur in the text proper; see also Table 1 (p. 13) and Appendix 1 (p. 66). Plants are indexed by genus name only.

- Achillea* 39  
*Aciphylla* 39  
*Adoxia vulgaris* 49, 50, 102  
*affinis*, *Ammophila* 18  
     *Psammophila* 18  
*Agrotis (innominata)* 20, 99  
*albipes*, *Crabro* 38  
     *Podagritys (Parechuca)* 12, 13, 16k, 17k, 36-38, 42, 44, 45, 47-50, 55, 57, 71, 73, 77, 78, 80, 82, 85, 88, 98, 100, 101  
     *Rhopalum* 38  
*Alectryon* 32  
*Ammophilini* 18  
*Anabarhynchus* 42, 46, 101  
*Anisotome* 39  
*Anobium (punctatum)* 13, 23, 24, 27, 28, 99  
**APIDAE** 8, 9  
**APOCRITA** 11, 12  
**APOIDEA** 8, 9  
*apakensis*, *Podalonia tydei* 18  
*Aporhopalum* 14, 51  
*Archarpactus* 57  
*argentata*, *Podalonia tydei* 18  
*argentatum*, *Pison* 30  
*Argogorytes* 14, 15k, 57  
*Arpactus* 57  
*Aruncus* 28  
*Asilistumidus* 49  
*assimile*, *Sceliphron* 21  
*Astilbe* 28  
*Atelosphex* 28  
*ater*, *Alyson* 30  
*aucklandi*, *Rhopalum (Zelorphopalum)* 37, 50, 52, 54, 56, 57, 72, 73, 81, 82, 87, 103  
*australis*, *Pison* 33, 34  
*Beris* sp. 57  
*Bothynostothini* 35  
*Brachyglottis* 39, 49  
*breijeri*, *Schistosphex* 28  
*caementarium*, *Sceliphron* 21  
*Calliphora quadrimaculata* 42  
*Calystegia soldanella* 20  
*carbonarius*, *Arpactus* 58  
     *Argogorytes* 13, 14, 58, 72, 79, 87, 90, 92-98, 103, 104  
     *Crabro* 41, 42  
     *Gorytes* 57, 58  
     *Podagritys* 43  
     *Rhopalum* 41  
*carbonicolor*, *Podagritys (Parechuca)* 10, 12, 13, 15, 17k, 36, 41, 44, 45, 48, 78-82, 86, 101  
     *Crabro* 41, 42  
*Carystoterpafingens* 59, 60  
     *vaganus* 59, 104  
*Cassinia* 49  
*Celatoblatta* 30, 99  
*Celia* 22  
*chambersi*, *Podagritys (Parechuca)* 13, 16k, 17k, 36, 37, 39, 43, 47, 82, 88, 101  
*chilense*, *Pison* 31  
*Cirsium* 39  
*clavipes*, *Sphex* 50  
*Clematis* 28  
*cora*, *Crabro* 43, 45  
     *Podagritys (Parechuca)* 10, 12, 13, 17k, 36, 37, 38, 40, 41, 43, 48, 50, 78, 79, 80, 81, 82, 86, 102  
     *Rhopalum* 43  
*Coriaria* 57, 103  
*coromandelicum*, *Sceliphron* 21  
*coromandelicus*, *Pelopaeus* 21  
**CRABRONINAE** 9, 10, 11, 14, 15k, 35, 71, 72  
*Crabronini* 35, 51  
*depressus*, *Tachysphex* 29  
     *Tachytes* 29, 30  
*Cupressus* 53, 103  
*Cyphon* 49  
*Deleatidium (hillii, myzobranchia)* 40, 45, 46, 101  
*Delphinium* 28  
*Dianthus* 28  
*digyalos* group 16k, 17k, 36  
*digyalos*, *Podagritys (Parechuca)* 13, 16k, 17k, 36, 37, 43, 46, 48, 49, 54, 56, 57, 78, 82, 86, 88, 102  
*Dilophus nigrostigma* 46  
*dubia*, *Taranga* 31, 33, 34  
*dubiwm*, *Pison* 33  
*Dusona stramineipes* 55  
*earlyi*, *Spilomena* 14, 15k, 16k, 22, 83  
*elegantula*, *Spilomena* 14, 15k, 23, 24, 27, 84  
*emarginata*, *Spilomena* 14, 15k, 25, 27, 84  
*Entomopison* 31  
*Epichorista siriana* 55  
*Euophryum confine* 24, 27  
*Euplilis* 50  
*fasciatus*, *Pseudonysson* 31  
*filicornis*, *Tachysphex* 28  
*formosana*, *Taialia* 22  
*formosum*, *Sceliphron (Prosceliphron)* 21, 69, 83  
*Fuchsia* 28, 32, 55, 100, 103  
*fugax*, *Tachytes* 28  
*gayi*, *Podagritys* 36  
*Geum* 28  
*Gingidium* 39  
*Glyphipterix neoptera* 55  
*Gnaphalium* 39  
*Griselinia* 53  
*Gorytini* 57  
*Hadrobregmus magnus* 24, 27  
*Hebe* 39  
*Helichrysum* 39  
*Heliothrips haemorrhoidalis* 27  
*helmsi*, *Tachysphex* 29, 30  
     *Tachytes* 29

- Hemerocallis* 28  
*hirtipes, Dasycolletes* 35  
     *Leioproctus (Nesocolletes)* 35  
     *Pison* 33  
*Hybolasius cristatus* 32  
*Hylaeinae* 77  
*Hypochoeris* 20  
  
*jocosus, Crabro* 44, 45  
     *Podagritus* 44  
*jurinei, Pison* 30  
  
*Kolkomitzia* 28  
*Krombeiniellum* 31  
  
*laetum, Sceliphron* 21  
**LARRINAE** 9, 28, 35, 70  
*Larrini* 14, 28  
*Lepidium* 39  
*leucostomus, Crossocerus (Blepharipus)* 42  
*Lilium* 28  
*longifrons, Microglossa* 22  
  
*madeirae, Psammophila* 18  
*Melangyna novaezealandiae* 40  
*Melicytus* 32  
*Microglossa* 22  
*Microglossella* 22  
*miscophoides, Aelosphegus* 28  
*monachus, Priocnemis (Trichocurgus)* 35  
*morosum, Pison* 11, 13, 14, 16k, 31, 85, 100  
*Muehlenbeckia* 20, 39  
  
*Nephridia* 30  
*neuqueni, Podagritus* 36  
*niger, Tachybulus* 30  
*nigerrima, Astata* 28  
*nigerrimus, Tachysphex* 10, 13, 14, 28, 70, 79, 84, 99  
     *Tachytes* 28, 30  
*nozela, Spilomena* 12, 14, 15k, 16k, 23-26, 69, 75, 84, 90, 91, 94, 96-99  
**NYSSONINAE** 57, 72  
  
*obliteratum, Pison* 31  
  
*Oemona hirta* 55  
  
*papuanum, Pison* 33  
*Paraceramius* 31  
*Parechuca* 14, 36  
*Parellipsidion* 30  
*parrotti, Podagritus (Parechuca)* 13, 16k, 17k, 35, 36, 47, 48, 71, 77, 80, 86, 89, 102  
     *Rhopalum* 48  
*Pelopaues* 21  
*Pelopoeus* 21  
**PEMPHREDONINAE** 21, 69  
*Pemphredonini* 22  
*perforator, Crabro* 51  
     *Podagritus* 51  
     *Rhopalum (Aporhopalum)* 17k, 50, 51, 54, 77, 78, 80, 82, 87, 89-98, 103  
*Philaenus spumarius* 59, 60  
*Phormium* 39  
*Physoscelis* 50  
*Physoscelus* 50  
*pilosum, Pison* 31  
*Pinus* 32, 53  
*Pison* 11-14, 15k, 30  
*Pisonitus* 30  
*Pisonoides* 31  
*Pisum* 30, 31  
*Podagritus* 10-14, 15k, 36, 50, 52, 54  
*Podalonia* 14, 15k, 18  
**POMPILIDAE** 9, 11, 12, 35  
*Prosceliphron* 21  
*pruinus, Pison* 33, 34  
*Psammophila* 18  
*Psepholax (barbifrons, coronatus)* 32, 55, 100, 103  
*Pseudonysson* 31  
*Psenini* 22  
*Pycnocentroides aureola* 40, 45, 46  
*Pyronota festiva* 45  
  
*Rhopalum* 11-14, 15k, 36, 37, 50  
*rufiventris, Crabro* 50  
*Rumex* 39, 42, 45, 48  
  
*Scaphentini* 35  
*Sceliphriini* 18  
*Sceliphron* 12, 13, 15k, 21  
  
*Sceliphrum* 21  
*Schistosphex* 28  
*Selliera* 39  
*Senecio* 39  
*senilis, Podalonia tydei* 18  
*sericops, Tachysphex* 29  
     *Tachytes* 29, 30  
*Sirex noctilio* 32, 53  
**SPHECINAE** 15k, 18, 68, 69  
**SPHECOIDEA** 8, 9, 11  
*Spilomena* 10-14, 15k, 22  
*spinolae, Pison* 11-14, 16k, 31, 33, 70, 79, 85, 90, 91, 93-98, 100  
*spirifex, Sceliphron* 21  
     *Sphex* 21  
*Stigmata* 22  
*Stomoxys calcitrans* 46  
*suspiciosa, Ammophila* 18  
     *Podalonia tydei* 11, 13, 14, 18, 68, 74-77, 83, 88, 99  
*swalei, Rhopalum* 41-43  
  
*Tachybulus* 30  
*Tachysphex* 14, 15k, 28  
*Tachytina* 28  
*Taialia* 22  
*Taranga* 31  
*tasmanicus, Pison* 33  
*Thrips obscuratus* 24, 27, 28  
*trichiosoma, Argogorytes* 58  
     *Gorytes* 58, 59  
*troglodytes, Celia* 22  
     *Stigma* 22  
*Trypoxylonini* 31  
*tuberculatum, Pison* 31, 32  
*tydei, Ammophila* 18  
     *Podalonia* 14, 18  
  
*violaceipennis, Ammophila* 18  
  
*xanthopus, Nephridia* 30  
  
*Zelaraneacrasa* 100  
*Zelandopsocus formosellus* 57  
*zelandum, Rhopalum (Zelorhopalum)* 37, 47, 50, 51, 52, 55, 81, 82, 87, 89, 103  
*Zelorhopalum* 14, 51, 54

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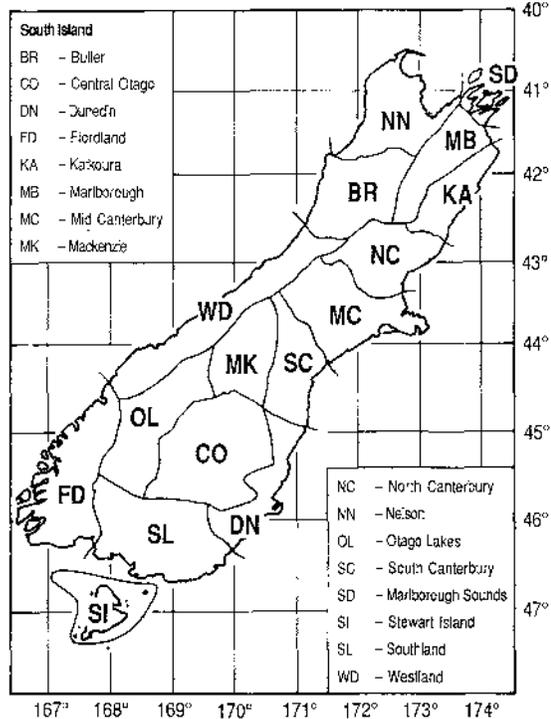
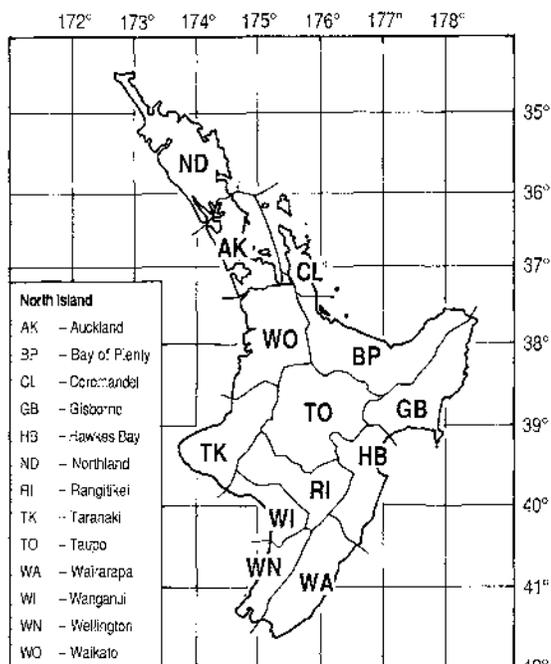
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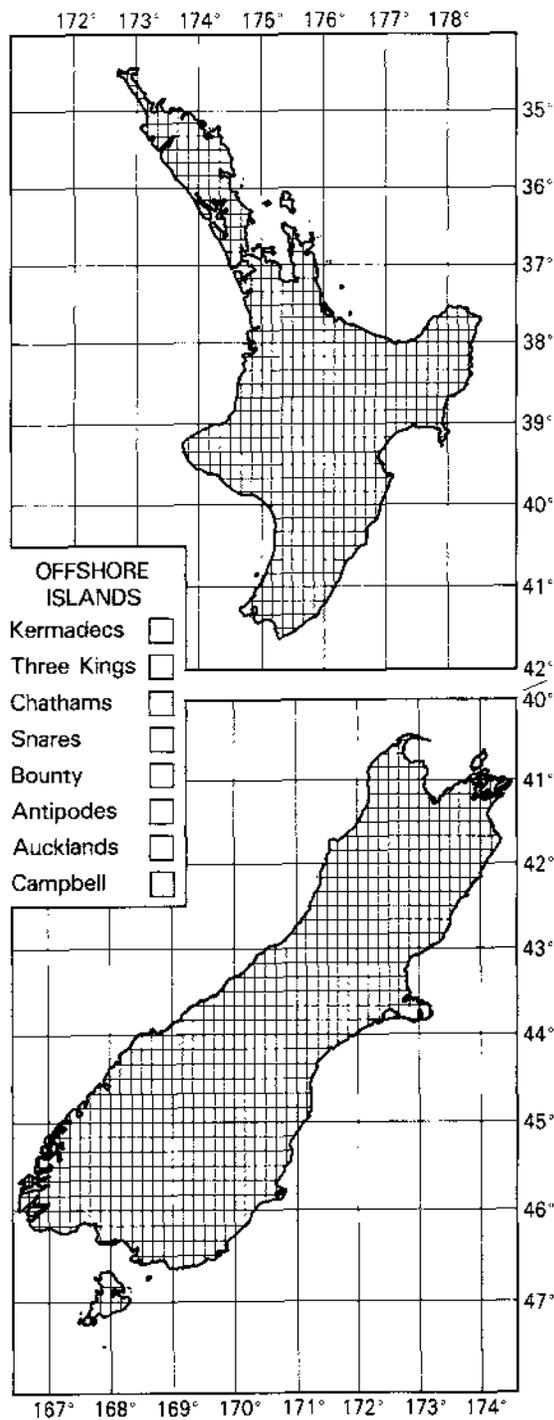
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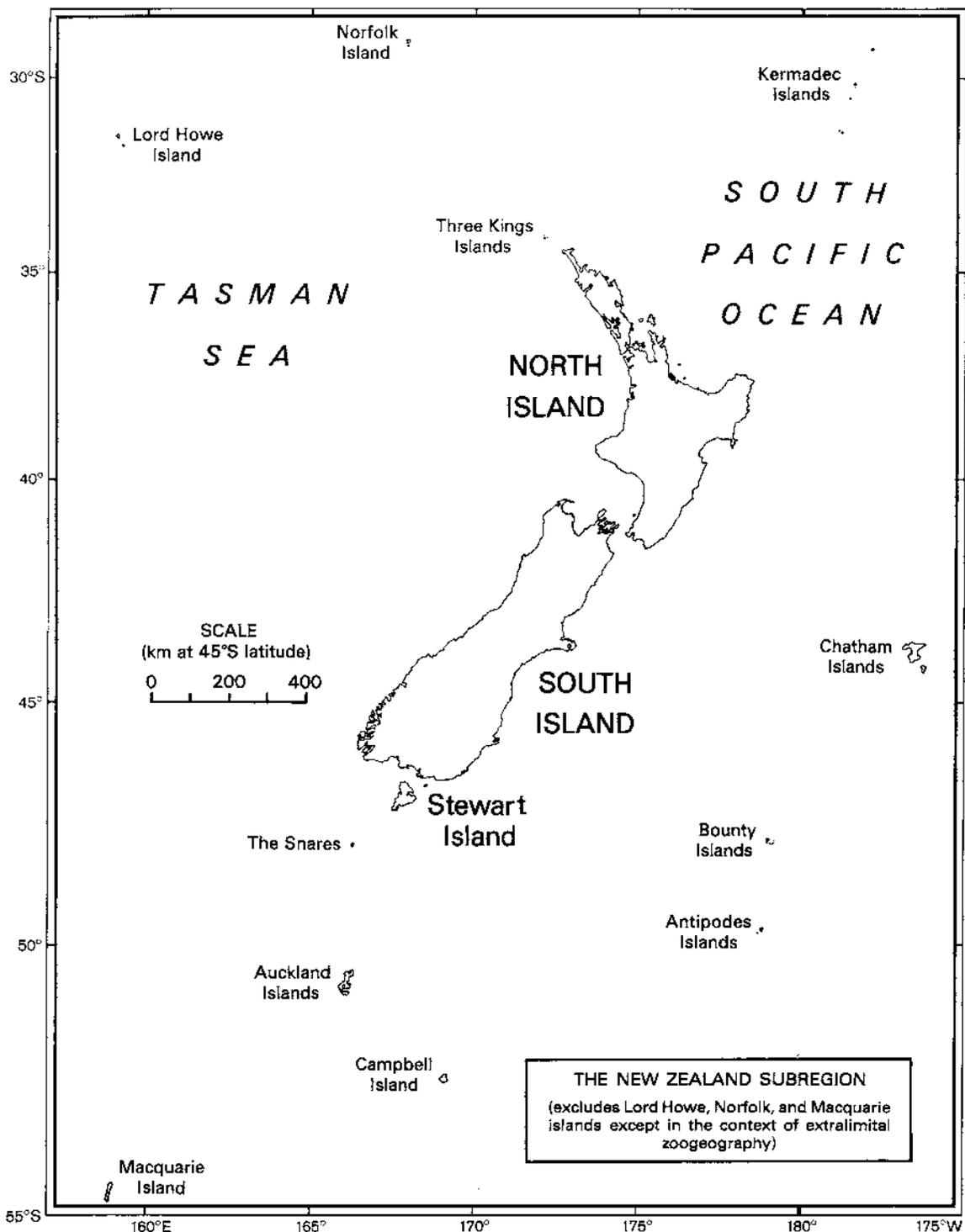
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A. C. Harris



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