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**Systematics and biogeography of the New Zealand  
endemic genus *Zorion* Pascoe 1867 (Coleoptera:  
Cerambycidae: Cerambycinae), with descriptions of  
six new species**

A thesis presented in partial fulfilment  
of the requirements for the degree of

**Masters of Science**

in

**Zoology**

at

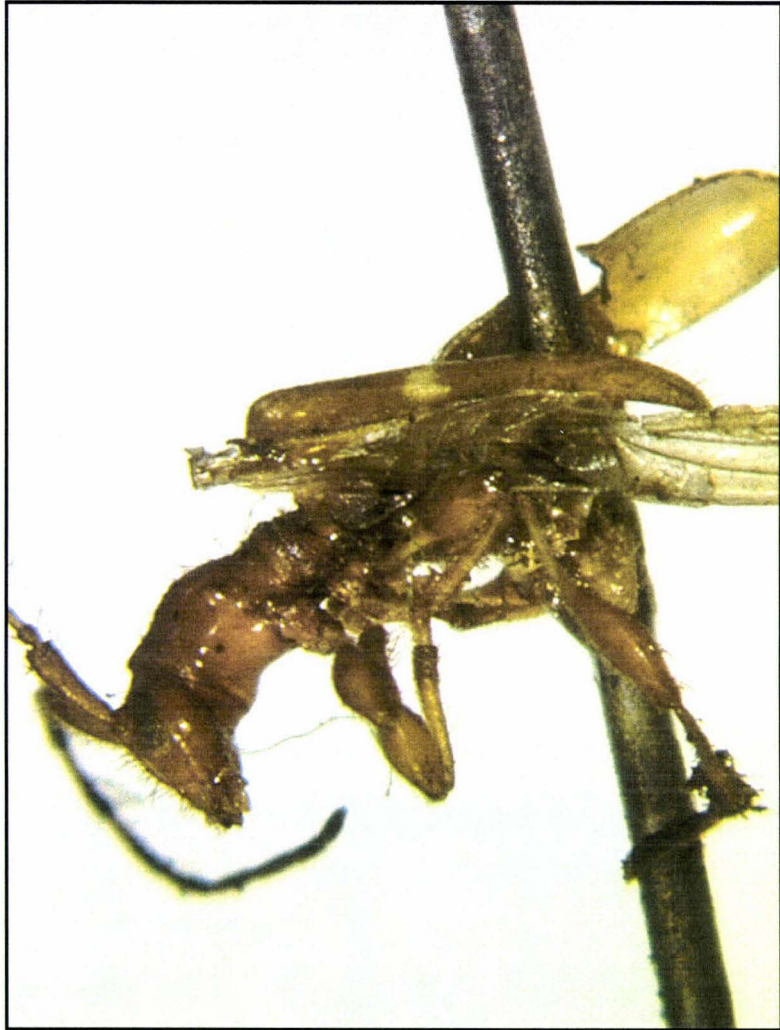
**Massey University**

**Institute of Natural Resources**

Palmerston North, New Zealand

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**2001**



The holotype of *Zorion minutum* Fabricius 1775 collected by Joseph Banks during the first voyage of Captain Cook to New Zealand, 1769-1771, held at the Natural History Museum, London

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## Abstract

The genus *Zorion* (Coleoptera: Cerambycidae: Cerambycinae) commonly known as longhorn flower beetle is endemic to New Zealand and its species are distributed widely on the main and on some offshore islands. A taxonomic revision of *Zorion* is given, including thorough description including illustration of the genus. The previously known species *Z. minutum*, *Z. guttigerum*, *Z. opacum*, and *Z. batesi* are redescribed, *Z. castum* is synonymised with *Z. guttigerum*, and *Z. angustifasciatum*, *Z. australe*, *Z. dugdalei*, *Z. kaikouraiensis*, *Z. nonmaculatum* and *Z. taranakiensis* are described as new species. A key to all ten species is provided. *Z. exiguum* has been excluded from the study because the original description and the holotype could not be located. The beetles are pollen feeders and visit a variety of plant species for feeding, mating and oviposition. The phylogenetic relationship of all ten species was analysed cladistically using PAUP. Results show that *Z. taranakiensis* is the sister taxon to the unresolved clade of *Z. batesi*, *Z. angustifasciatum* and *Z. dugdalei*. *Z. australe* and *Z. nonmaculatum*, whose relationship remains unresolved form a sister group to the *Z. taranakiensis* group. *Z. guttigerum* and *Z. kaikouraiensis* are sister taxa forming a sister group to the *Z. australe* group. *Z. minutum* is the sister taxon to the latter eight species and *Z. opacum* the sister taxon to all species in this study. The relationships between *Zorion* species reflect their distribution patterns, which are discussed in relation to New Zealand's biogeographical history.



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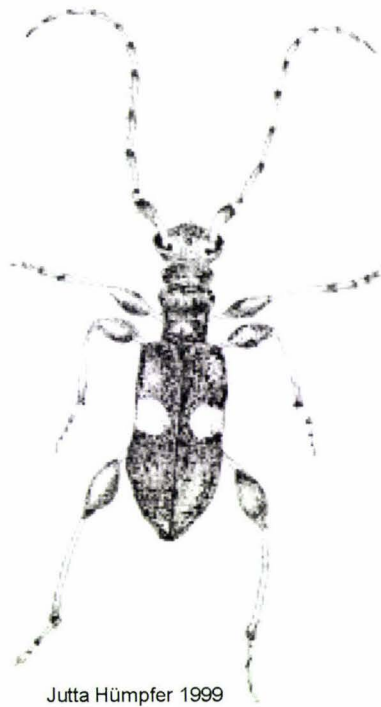
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Jutta Hühnfer 1999

*Zorion guttigerum*

# GENERAL INTRODUCTION

“The greater the abundance of natural objects assembled together, the more do we discover proofs that everything passes by insensible shades into something else: that even the more remarkable differences are evanescent, and that nature has for the most part, left us nothing at our disposal for establishing distinctions, save trifling and, in some respects, puerile particularities.”

Charles Lyell, 1830 – 1833 quoting Lamarck

## 1.1 Preface

The influence of humans on biodiversity has been of concern for some time and many species have been lost worldwide due to human activities such as urbanisation, agriculture and forestry (Jeffries 1997, Reaka-Kudla *et al.* 1997). Studies in biodiversity often ignore insects, which are one of the largest groups of organisms on this planet (Solis 1996). The maintenance of biodiversity is essential to all living organisms due to their interdependency in foodwebs and the cycling of nutrients within ecosystems (Patrick 1997). A high proportion of the world's plant and invertebrate species is unknown and awaits discovery and description (Myers 1997). Many of those unknown species could serve as potential sources for clothing, food and medicine. The economic value of biodiversity is being realised and biodiversity prospecting has become a major investment for many industrial companies (Reid *et al.* 1993).

It is almost impossible to pick up any book on biodiversity or conservation that does not cite the predicament we find ourselves in. For example, agricultural practices and the mobility of humans encourage the spread of pests, which need to be controlled. Biocontrol is becoming more and more in demand with insects increasingly developing resistance to pesticides. It has been shown many times in the past that introduced biological control agents have failed to establish or to effectively suppress the pest populations and millions of dollars have been wasted. In addition, key fundamental questions for conservationists are what species need to be managed and, which are the key species in the ecosystem.

The science of systematics plays a major role in biodiversity assessment as well as in conservation and pest control. The importance of systematics, which embodies taxonomy,

the establishment of phylogenetic relationships and distributions of organisms, has been greatly overlooked in recent decades (Eldredge 1992). It has been through systematic studies that the species involved (pests as well as predators and parasites) have been correctly identified and successful control achieved (e.g. Watt 1979a, New 1993, Emberson 1994, Samways 1994, Crozier 1997, Mitter 1999). In short, systematics is able to establish areas of endemism, determine species and their distributions. These are essential facts for setting up management plans for conservation and pest management. At present a demand for biodiversity assessment is recognised internationally but systematists are lacking (Daly 1995).

I therefore decided to contribute to a better understanding of New Zealand's fauna and chose to carry out a systematic study on the New Zealand endemic beetle genus *Zorion* Pascoe 1867. This genus belongs to the Coleoptera family Cerambycidae, subfamily Cerambycinae, tribe Aphneopini. The majority of New Zealand's cerambycid beetles are found in the subfamily Cerambycinae, which contain many wood-boring and flower-visiting species (Lawrence & Britton 1991). The genus *Zorion* is commonly known as "flower longhorn beetle" (Grant 1999, Scott & Emberson 1999) and the Fauna of New Zealand (Klimaszewski & Watt 1997) describes the genus to be perhaps the most strikingly colourful beetles in the New Zealand fauna. Adults are 3-7 mm in size and are often found in great numbers in association with flowers. They may be important pollinators for some New Zealand native plants. Larvae feed internally on bark or woody material of trees and shrubs and adults were found to lay their eggs in freshly cut or broken branches of *Corynocarpus laevigatus*, suggesting that *Zorion* seek out dead wood in which to lay their eggs (Early *et al.* 1991). The genus therefore could also play an important role in the nutrient cycle by breaking down plant material. The genus *Zorion* comprises a very diverse group and the systematics of the genus is very confused as outlined below in the historical background of the genus. Also the ecological relationships of the genus are unknown and a revision of the genus is needed.



## 1.2 Historical Background to the Taxonomy of the Genus *Zorion* Pascoe 1867.

The first record of the genus *Zorion* is a specimen collected by Banks during the first voyage of Captain Cook from 1769-1771. Fabricius (1775) named this species *minutum* and placed it in the genus *Callidium*. Later, Fabricius (1801) placed the species into the genus *Clytus*. Westwood (1845) described a new species *guttigerum* from Port Nicholson and placed it in the genus *Obrium* together with *minutus*, which he renamed *fabricianum*.

The genus *Zorion* was determined by Pascoe (1867) for the species *fabricianum* and *guttigerum*. Bates (1874, 1875) synonymised *fabricianum* with *minutum* and added a brief description based on specimens from Auckland. Broun (1880) re-described *Z. minutum* based on specimens collected from Auckland, Tairua and Whangarei. Some additional descriptions on *guttigerum* were based on specimens collected from Auckland (Bates 1874, 1875, Broun 1880) and Canterbury (Broun 1880). Hudson (1934) stated that *Z. guttigerum* occurred in the Wellington, Auckland and Marlborough districts and *Z. minutum* was common in South Island and the far North but was extremely rare in the Wellington District. Bates (1874, 1875) and Broun (1880), however, expressed doubts as to whether *Z. guttigerum* and *Z. minutum* were separate species. Nevertheless, at this point in history, 1875, the genus *Zorion* contained only two species *minutum* and *guttigerum*.

Hutton (1898) recorded a specimen of *Z. minutum* collected from the Chatham Islands, which might be the first record of *Z. opacum* (Emberson 1998). *Z. opacum* was later described by Sharp (1903) from a specimen collected by Prof. Schauinsland from the Chatham Islands. Sharp (1875) also described the species *Z. batesi* based on two specimens from Auckland, but later thought this species could be *Z. guttigerum* (Sharp 1877). Blair (1937) did not see the type of *Z. batesi* in the British Museum and he listed *batesi* as a synonym of *Z. guttigerum*. The species *Z. castum* was described by Broun (1893) based on a specimen from the Mt Egmont area and Hudson (1934) listed records of this species from Waiouru (central North Island) and Lyttelton. Therefore at this stage, 1935, there were four species recognised within the genus *Zorion*: *minutum*, *guttigerum*, *opacum* and *castum* and probably one synonym *batesi*.

*Callidium exiguus* Gmelin was mentioned by Linné (1788, p. 1852) with a very brief description and a Fabrician reference, but none of the specimens amongst the Fabrician material could be this species. Blair (1937) must have seen the holotype in the Natural History Museum London but no type material or any specimens can be located, and I was unable to find the original publication for *Z. exiguus* Gmelin (1788). Research on Gmelin Butterflies found some material in Dublin and other material too has been destroyed (S. Shute, BMNH, pers. comm.). The holotype may have been with this collection. *Z. exiguus* Gmelin is therefore excluded from the study.

The species of *Zorion* recognized by Blair (1937) are listed in Table 1.1. Dumbleton (1957), who gave a key to larvae of the subfamilies of the Cerambycidae and to some Cerambycinae species, described the mature larval and pupal stages of *Z. minutum*, and could not separate the larvae of this species from those of *Z. guttigerum*.

Table 1.1 Taxonomic history of the genus *Zorion*  
indicating three species and four synonyms (Blair 1937)

Genus	Species
<i>Zorion</i> Pascoe, 1867	<i>minutum</i> Fab., 1775
	<i>exiguum</i> Gmelin, 1788
	<i>fabricianum</i> Westwood, 1845
	var. <i>guttigerum</i> Westwood, 1845
	<i>batesi</i> Sharp, 1875
	<i>castum</i> Broun 1893
	<i>opacum</i> Sharp 1903

Until now no studies have been conducted on the taxonomic revision and the phylogenetic relationships and of the genus *Zorion*. The species distributions also are unclear, with the exception of *Z. opacum*, which is restricted to the Chatham Islands. This



is not surprising given that a significant proportion (25%) of the Chatham Islands beetle fauna is endemic at the species level (Emberson 1995).

Sorting of museum specimens, which were available for this research, showed that the genus is widespread within New Zealand and its offshore islands, and some type localities were apparently very broadly interpreted by Broun, Pascoe, Sharp and White. 'Auckland' for example may have referred to the provinces rather the city (Watt 1977). There are many colour variations within *Zorion* and it was not clear at the beginning of this study whether these colour variations were different species or colour morphs within one species. The specimens collected on Three Kings Islands, for example, can be distinguished in colour from other New Zealand specimens. Emberson (1995) stated that the endemism on the Three Kings Islands is comparable to that of the Chatham Islands. However, other surveys such as those on Great Barrier Island, Mayor Island (Watt 1956a), the Noises Islands (Hauraki Golf) (Watt 1956b) and Auckland (Watt 1983) failed to mention the presence of *Zorion* specimens.

The available descriptions from the various authors mentioned above are not very clear, and this is reflected in the identification of the museum specimens by previous workers. Specimens identified as *Z. minutum*, for example, are identified as *Z. guttigerum* in some instances and vice versa. Also the figure in Klimaszewski & Watt (1997, p. 161, Fig. 235) of a *Zorion* species is most likely a different genus. Though the exact number of *Zorion* species was not known, Klimaszewski & Watt (1997) thought there could be six or more species. The number of species could, therefore, range from three, as proposed by Blair (1938, Table 1), to seven, as the number of available names. It is clearly evident that further research is required and the main aims for this study are to make a thorough taxonomic revision of the genus *Zorion*, including an evaluation of taxonomically useful characters; provide a key for species identification; and describe the species thoroughly. I will also summarise the distribution, biological and ecological aspects of the genus; and conduct a phylogenetic analysis of the revised genus using cladistic methods.

# TAXONOMY OF THE GENUS *ZORION* Pascoe 1867

## 2.1 Introduction

As I discussed in the previous chapter, a thorough taxonomic revision of the genus *Zorion* is needed. In this chapter I will concentrate on the taxonomic treatment of this genus, providing descriptions and illustrations of the genus and of new and previously known species along with a key to all species.

In the present study ten species are recognized within the genus *Zorion*. This includes four former recognized species: *Z. minutum* Fabricius, *Z. guttigerum* Westwood, *Z. batesi* Sharp, *Z. opacum* Sharp, and six new species: *Z. angustifasciatum* sp. nov., *Z. dugdalei* sp. nov., *Z. taranakiensis* sp. nov., *Z. australe* sp. nov., *Z. nonmaculatum* sp. nov. and *Z. kaikouraiensis* sp. nov. The species *Z. castum* Broun is synonymised with *Z. guttigerum*. Sharp (1877) incorrectly thought *Z. batesi* to be *Z. guttigerum* and thus Blair (1937) listed *Z. batesi* mistakenly as a synonym of *Z. minutum*. The recognition of *Zorion* species in this study is based on the examination of more than 1000 specimens and the evaluation of their taxonomic characters.

## 2.2 Materials and Methods

### 2.2.1 Specimens examined

Specimens were borrowed from the following institutions, abbreviations are as proposed by Watt (1979b).

AMNZ	Auckland Museum, Auckland
CMNZ	Canterbury Museum, Christchurch
FRNZ	Forest Research Institute, Rotorua
JNNZ	John Nunn Collection, Dunedin
LUNZ	Lincoln University, Lincoln
MONZ	Museum of New Zealand, Wellington (Te Papa Tongarewa)
NZAC	New Zealand Arthropod Collection, Auckland
OMNZ	Otago Museum, Dunedin

WMNZ Whangarei Museum, Whangarei

BPBM Bishop Museum, Honolulu, Hawaii

BMNH The Natural History Museum, London

I collected additional specimens from Palmerston North, Akaroa (Banks Peninsula), Mt. Terako (Kaikoura Ranges), Nelson, Picton, Napier and Hastings and deposited some in institutions as indicated in the material examined lists. Those remaining in my own collection I specified as “author’s. coll”. The combined collections comprise over 1,000 specimens and cover all geographic areas of New Zealand and its subregions as proposed by Crosby et al. (1998) (Figs 2.1-2.2). According to this system, New Zealand mainland and offshore islands are divided into 37 areas and are allocated a two-letter code. Type specimens and synonyms were examined except for those that could not be located or are thought to be lost. The naming of new species, determination of types and placement of voucher specimens as well as the publication of the new species follows the rules of the International Code of Zoological Nomenclature (ICNZ 1999).



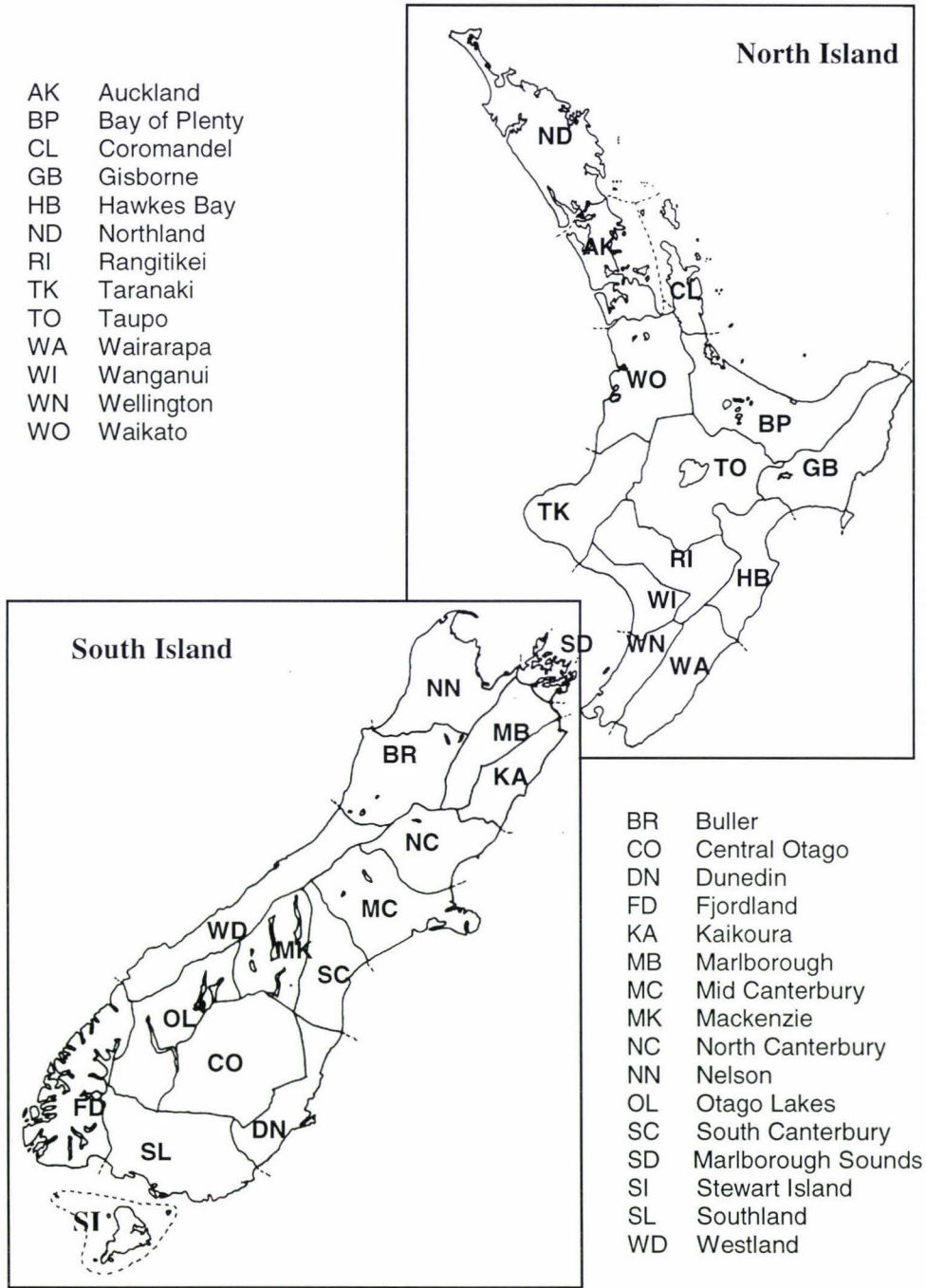
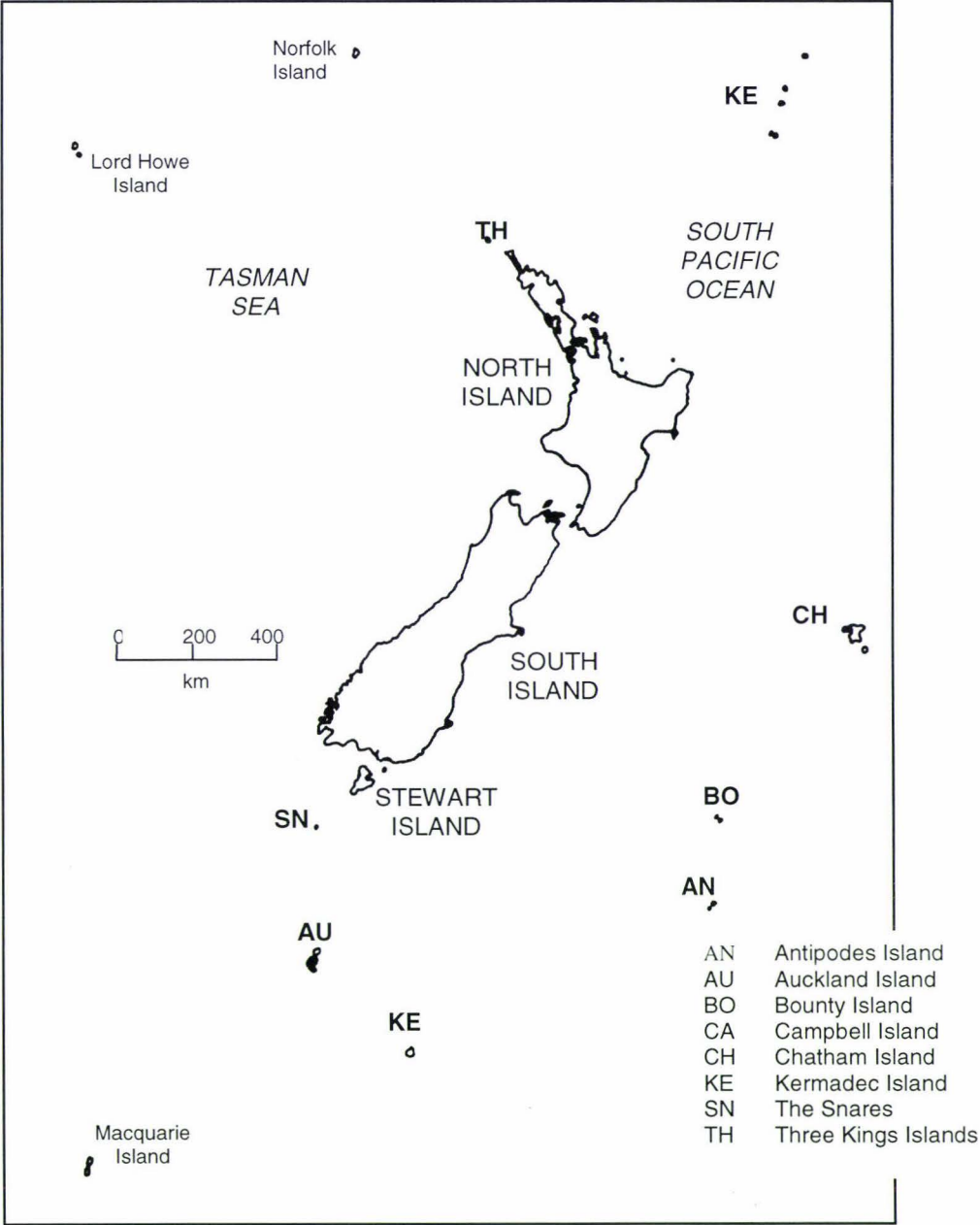


Figure 2.1 Specimen localities for mainland New Zealand and their area codes after Crosby et al. (1998) (Map adapted from Crosby et al. 1976)



**Figure 2.2** Map showing specimen localities and their area codes in the New Zealand subregion adapted from Crosby et al (1998)



### 2.2.2 Measurements and illustrations

Measurements of body parts were carried out under a stereo-microscope (Leica MZ 12) and measurements of terminalia under a compound microscope (Olympus CHA) fitted with an ocular micrometer. Colour descriptions are based on observations under the stereo microscope using a fibre optic continuous ring-light source. Perception of the overall body colour under natural light without a microscope may differ from colour descriptions given in the species descriptions. I used the terms light, dark and medium to differentiate different brightness and saturation of colours. Relevant characters were drawn with the aid of a camera lucida.

Interpretation of images depicting spines in the internal sac of the aedeagus is extremely difficult with the compound microscope used in this study, but could be confirmed using Scanning Electron Microscope (SEM) images which were taken using a Cambridge 250 MKIII Stereoscan. The internal sac for SEM was prepared in 70% ethanol and passed in 15-minute interval graded series at 75%, 95% and  $2 \times 100\%$  ethanol, air-dried and then critical point dried with a Polaron E3000 Series II critical point drier and gold coated with a Baltec SCD 050. After initial images were taken from the specimen, the internal sac was split open using a fine needle and the interior was sputter coated for further images.

### 2.2.3 Dissections of terminalia

To reduce handling of valuable museum specimens, I used specimens collected personally to gain experience in measuring body parts and to experiment with different methods in terminalia dissection. The preparation of the beetles partially follows the procedure described by Upton (1991). Card mounted specimens that needed examination from the ventral side and specimens prepared for dissection of terminalia were soaked in a water bath at  $80^{\circ}\text{C}$  for about 30 minutes. The softened beetles were pinned using entomological pins for permanent storage. To dissect terminalia I removed the abdomen of the softened specimen by inserting fine closed forceps between the thorax and the abdomen from the ventral side and then carefully opening the forceps. I soaked the abdomen for about 30 minutes in 10% potassium hydroxide (KOH) at room temperature to further soften

the tissue so as to remove terminalia easier. The dissected terminalia were cleared of any soft parts in a bath of 10% KOH for 24 hours followed by a bath of distilled water containing a drop of glacial acetic acid to remove the KOH. The remaining abdomen was glued back onto the specimen using clear nail polish. Female terminalia were preserved in glycerine in terminalia vials attached to the specimen. Male terminalia were bathed in absolute isopropyl alcohol for dehydration before being mounted straight onto a microscope slide using Euparal as a mounting medium. Each microscope slide and female terminalia dissection was number-coded (e.g. *Zorion opacum* f-260500-5/8). The species name is followed by the gender (f = female, m = male), the date of dissection (260500 = 26 May 2000) which is followed by the number of dissections made on that day (5/8 = fifth dissection of eight).

#### 2.2.4 Terminology and descriptions

Terminology for body parts and terminalia used in the text is explained in the general description. General terminology follows Sharp & Muir (1912), Snodgrass (1935), Tuxen (1970), Chapman (1971), Matsuda (1976), and Wang (1993 a, b).

Comparison of body measurements revealed no discrete differences so I arranged the specimens according to the geographic collection areas, which allowed to clearly distinguish discrete colour patterns among the specimens. The description of species and the key for identification focus mainly on the colour and the type of spots on the elytra.

Ecological and distribution records were made from collection labels of examined specimens and from literature. Material examined is listed in latitudinal order from north to south. Where spelling is not clear names are marked with ?? marks. “Unknown localities” are specimens without stated locality, or I could not find the place name or it occurred in several areas. To confirm distribution localities of species and compile a distribution map I used the “New Zealand Atlas” (McKenzie 1987) and the “Localities in NZAC gazetteer of collecting sites” (Trevor Crosby, pers. comm.). “Unknown sex” are specimens where fungus or dust obscured sexual characteristics.



### 2.3 Taxonomy of the Genus

#### *Zorion* Pascoe 1867

Pascoe, 1867: 310. - Pascoe, 1869: 423; Broun, 1880: 584; Aurivillius, 1912: 156; Blair, 1937: 265; Kuschel, 1982: 3; Klimaszewski & Watt, 1997: 65, 161, 180; Grant, 1999: 97. The type species is *Callidium minutum* Fabricius 1775.

**Distribution.** Endemic to New Zealand.

#### 2.3.1 External structures

*Head* (Figs 2.3-2.5). Width about as long as height; length almost half as long as width; constricted at base; central and frontal sutures clearly visible. Distance between lower lobes of eyes as long as distance between outer margin of antennal sockets.

*Eyes* (Figs 2.3-2.5). Strongly emarginate, with fine facets. Lower lobe almost round, much larger than the narrow elongate upper lobe which is almost separated from the lower lobe and connected only by a single or double row of ommatidia.

*Antennae* (Fig. 2.6). Eleven segmented, filiform about as long as length between front of head and apex of elytra. Antennal tubercles clearly raised; antennal sockets circular and laterally outward facing. Scape longest forming a club; pedicel as long as wide; flagella linear; segments 1>5>3>4>6>7>8=11>9>10>2. Pedicel, scape and segments 3-6, 7, 8 sparsely covered with erect hairs; segments 6, 7, 8-11 increasingly pubescent.

*Prothorax* (Figs 2.4 & 2.7). Almost 2 × as long as wide and divided into three areas. Anterior area almost cylindrical but restricted, and longer, wider and higher than cylindrical restricted posterior area; middle area with two lateral nodes longer, wider and higher than anterior section, and pronotum with 2-8 dorsal hairs. Prosternum slightly rugose; anterior coxal cavities closed behind and situated in middle and posterior region of prothorax. Prosternal process reduced to a thin ridge between the contiguous coxae; front coxae globose. Anterior and posterior section of pronotum with dark edge.

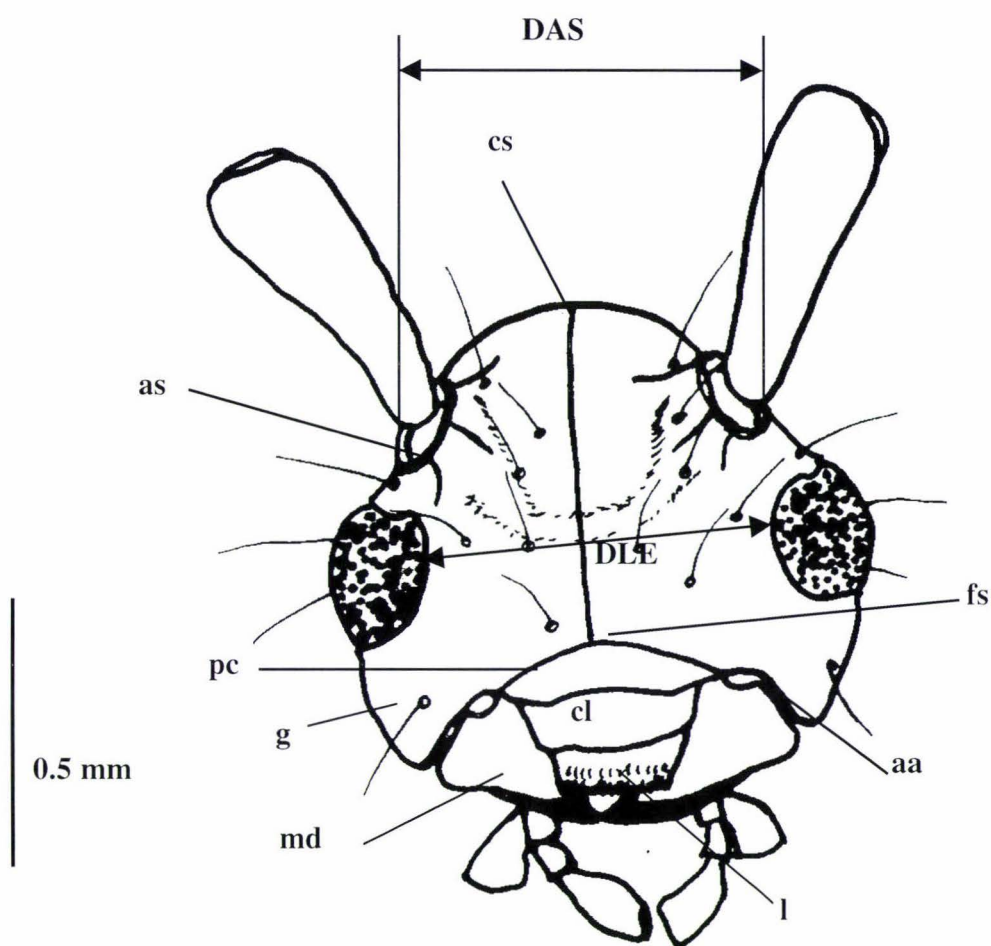
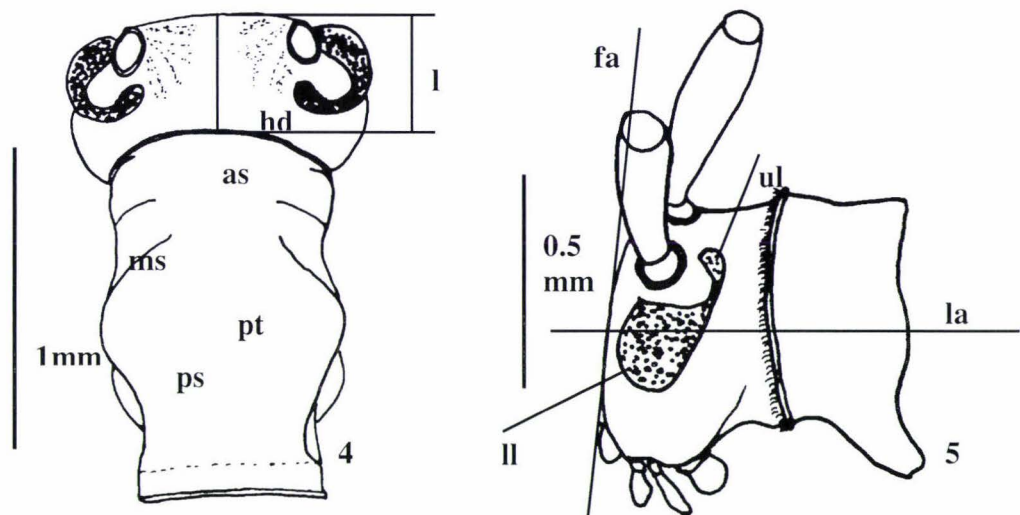


Figure 2.3 Head of *Zorion* front view; aa, anterior articulation; as, antennal socket; cl, clypeus; cs, central suture; fr, postclypeus; fs, frontal suture; g, gena; l, labrum; md, mandible; DLE, distance between lower eye lobes; DAS, distance between outer margin of antennal sockets.

*Mesothorax* (Fig. 2.8). Scutellum triangular with a longitudinal black central suture at base. Meso-coxal cavities open laterally, separated by a narrow mesosternal process; coxae protruding, conical and almost contiguous.

*Metasternum* (Fig. 2.8). Width about 0.8 of length of meso- and metathorax combined. Metacoxae separated, slightly transversely, and slightly protruding.

*Abdomen*. Five visible segments, ovate, longer than wide, entirely covered by elytra, sparsely covered in fine hairs on ventral side. Females with micro spines on their 5<sup>th</sup> tergite forming two iridescent eye spots (Fig. 2.41).



Figures 2.4-2.5 Head and prothorax. 4, dorsal view of head (hd) and prothorax (pt): l, head length; as, anterior section of prothorax; ms, middle section; ps, posterior section. 5, lateral view of head: ll, lower eye lobe; ul, upper eye lobe; la, latitudinal axis; fa, frontal axis along frons

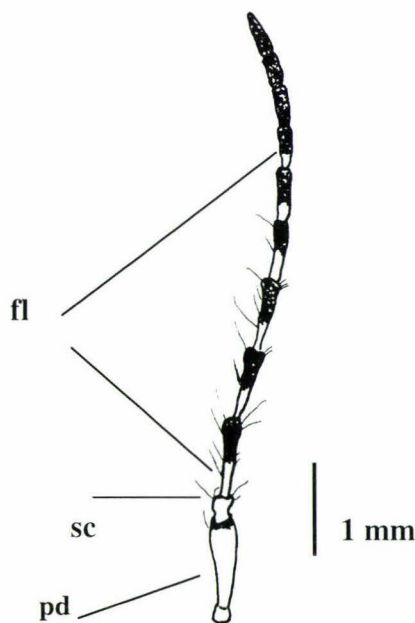
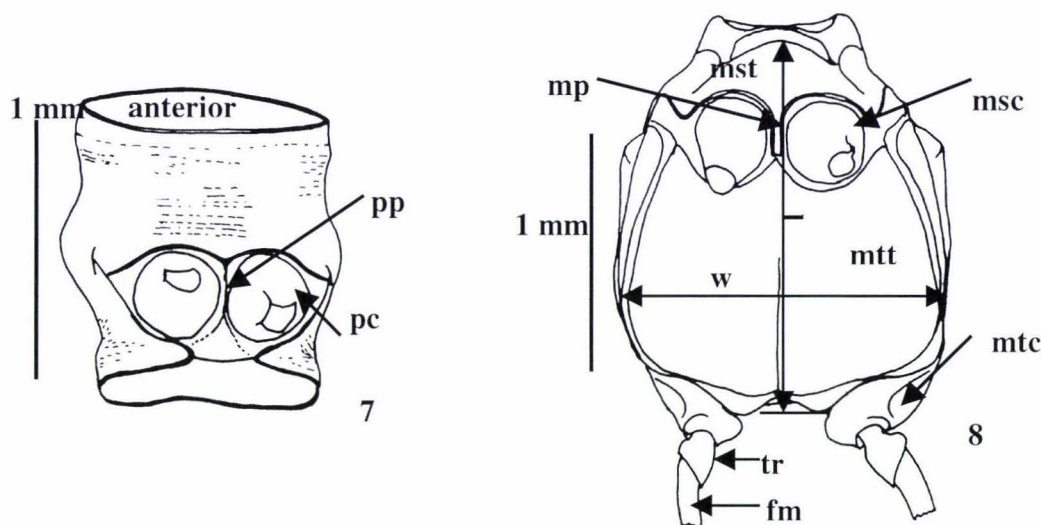


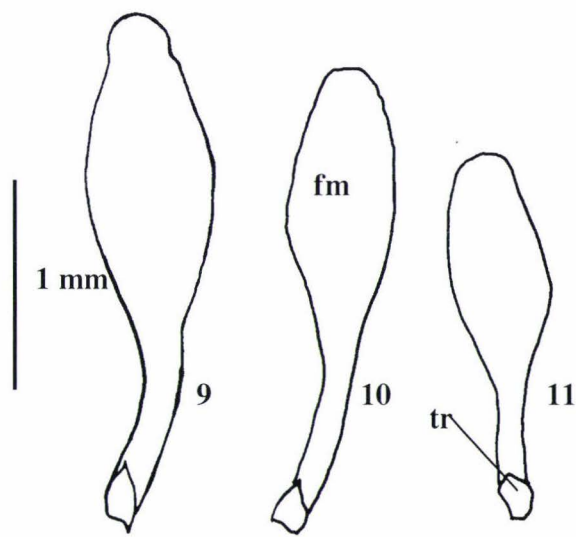
Figure 2.6 Antennae of *Zorion*: pd, pedicel; sc, scape; fl, flagella



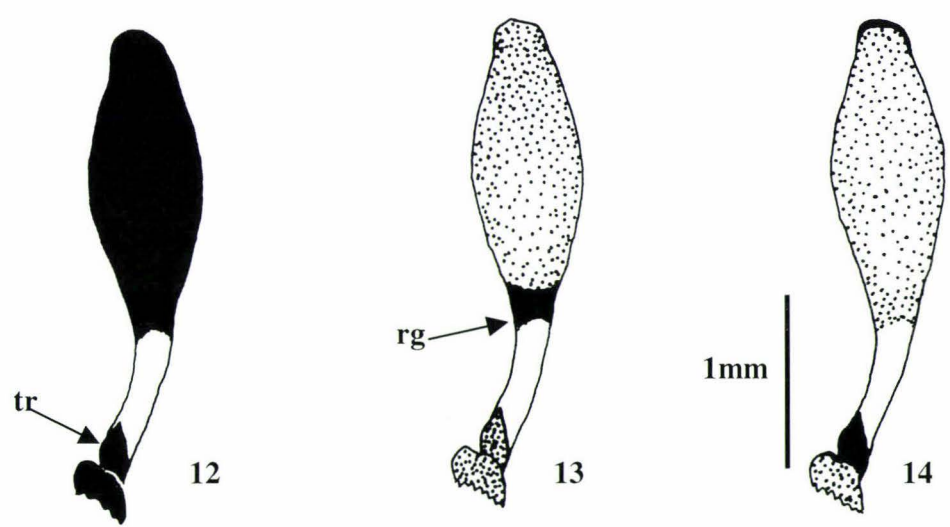
Figures 2.7-2.8 Ventral view of thorax. 7, prosternum: pp, prosternal process; pc, procoxa. 8, meso- and metasternum: l, length of meso- plus metasternum; w, width; mp, mesosternal process; msc, mesocoxa; mst, mesosternum; mtc, metacoxa; mtt, metasternum

*Legs.* Overall length (femur, tibia and tarsal segments) increases posteriorly, length of mesoleg  $1.25 \times$  length of proleg; length of metaleg  $1.5 \times$  length of proleg; length of proleg  $0.58 \times$  of total body length. Femur (Figs 2.9-2.14) club shaped; narrow part of profemur  $0.2$  of total femur length; narrow part of meso- and profemur about  $0.33$  of total femur length; dorsal to ventral width wider than lateral width, increasing from pro- to metafemur; metafemur laterally wider than meso- and profemur. Tibia elongate, as long as corresponding femur, with two spurs at apex of equal length at pro tibia, inner meso- and metatibia spurs longer than outer ones. Femur covered with sparse short hairs; tibia covered dorsally with short hairs, becoming more pubescent ventrally.



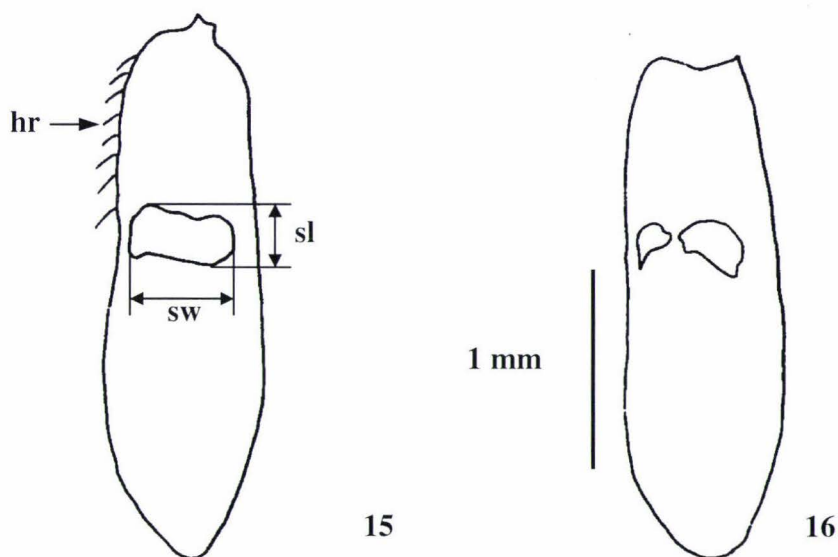


Figures 2.9-2.11 Ventral view of femora in relation to each other: fm, femur; tr, trochanter. 9, metafemur; 10, mesofemur; 11, profemur



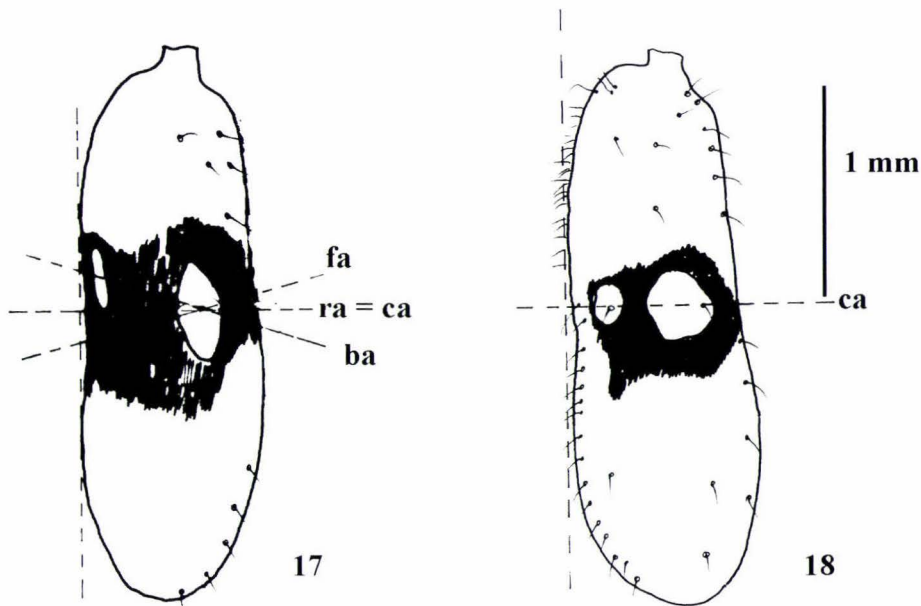
Figures 2.12-2.14 Hind femora, ventral view. 12, dark coloured femur, tr, trochanter; 13, light coloured femur with dark ring (rg); 14, light coloured femur without ring



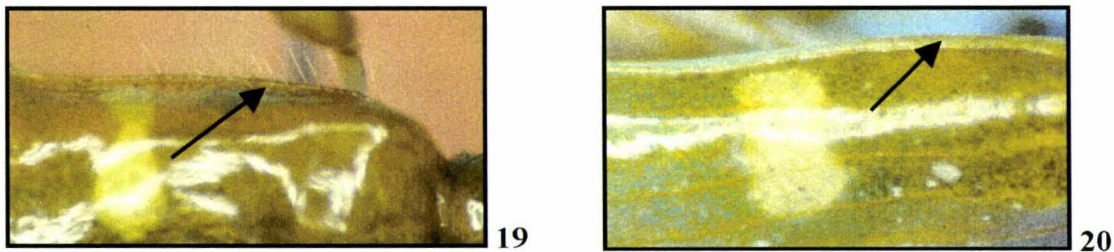


Figures 2.15-2.16 Outline of left elytra, dorso-lateral view: 15, *Z. angustifasciatum* ♀, pointed apex, hr, hair along epipleural fold; sw, spot width; sl, spot length. 16, *Z. minutum* ♂, rounded apex without hair along epipleural fold

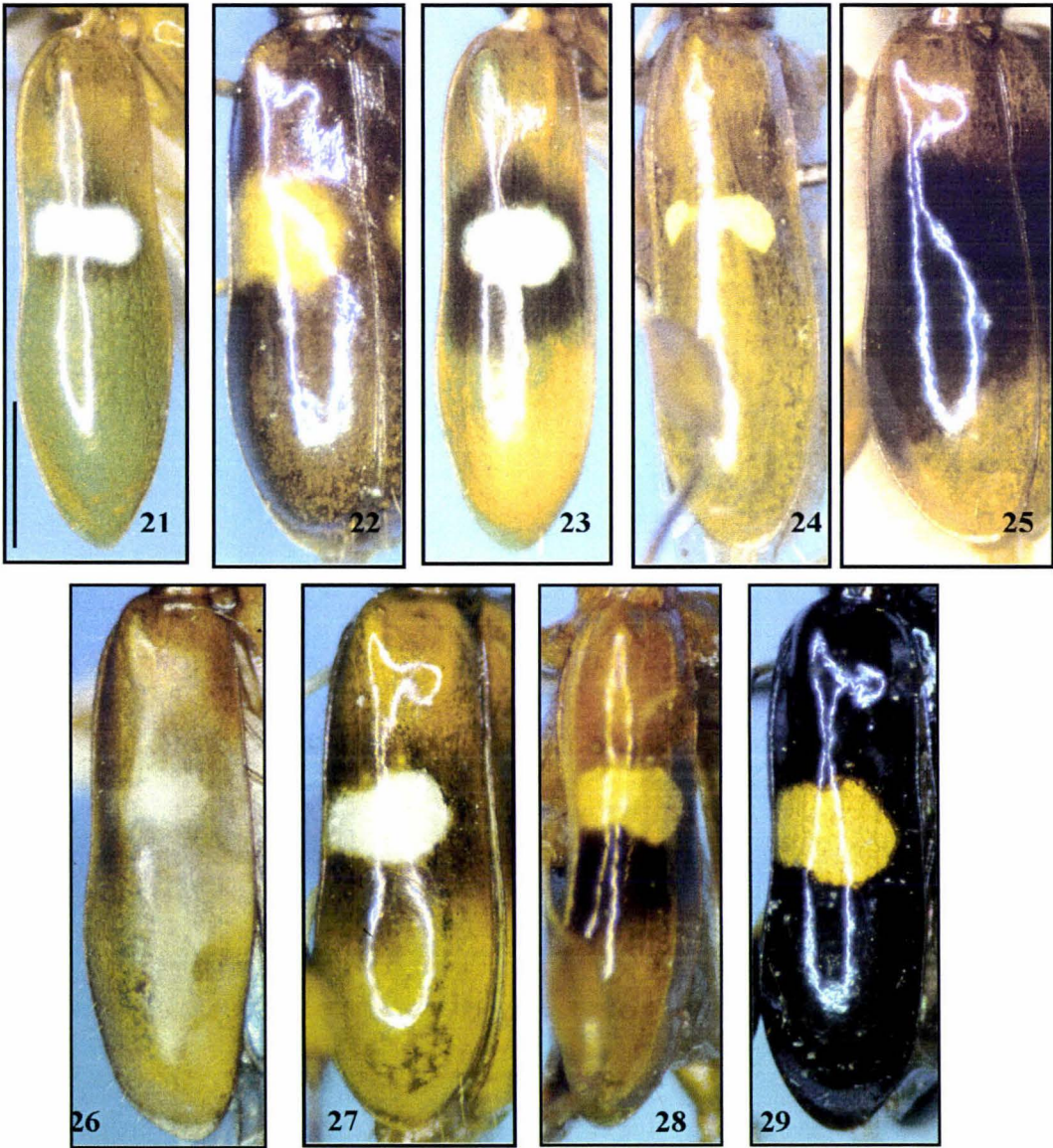
*Elytra* (Figs 2.15-2.30). Elongate with a pointed (Fig. 2.15) to rounded apex (Fig. 2.16), usually covering all abdominal segments. Shoulders raised into a higher point dorsally and laterally covering side of body. Elytral length almost 0.66 of body length and about  $2 \times$  body width. Central axis through spot at forward, right or backward angle in relation to axis along elytral margin (Figs 2.17-2.18). Female with hairs (Fig. 2.19) on anterior epipleural fold not reaching beyond spots on elytra, male without such hairs (Fig. 2.20). Colour and spot pattern on elytra variable (Figs 2.21-2.30).



Figures 2.17-2.18 The major elytra axis and the relationship of the spots to the outline of the elytra (both elytra *Z. batesi*); ca, central axis of spot. 17, ba, backward angle of spots; ra, right angle of spots; fa, forward angle of spots; 18, right angled spots



Figures 2.19-2.20 Sexual dimorphism in the genus *Zorion* at the epipleural fold. 19, female elytron of *Z. minutum* with hairs; 20, male elytron of *Z. minutum* without hairs



Figures 2.21-2.29 Elytral colour patterns of *Zorion*: 21, *Z. angustifasciatum*; 22, *Z. kaikouraiensis*; 23, *Z. dugdalei*; 24, *Z. minutum*; 25, *Z. nonmaculatum*; 26, *Z. opacum*; 27, *Z. taranakiensis*; 28, *Z. australe*; 29, *Z. guttigerum*. Scale bar 1 mm.



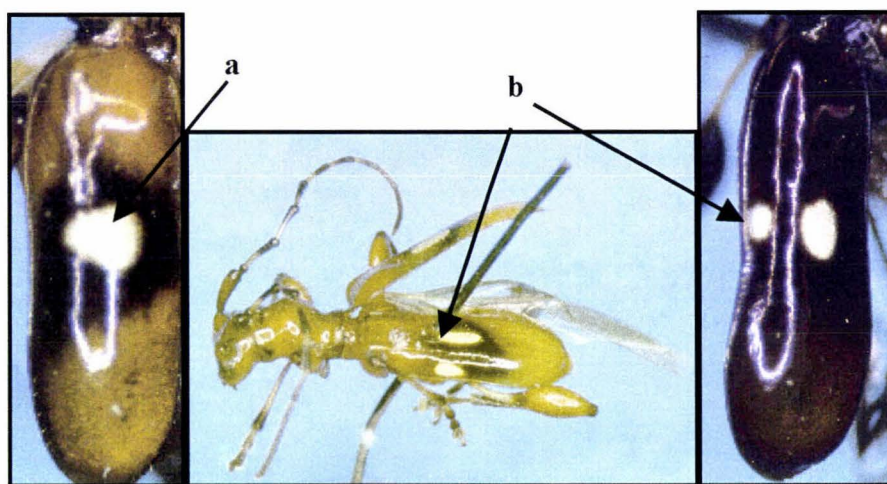


Figure 2.30 Elytral colour patterns for *Z. batesi*. Pear shaped spot (a); split spot (b)

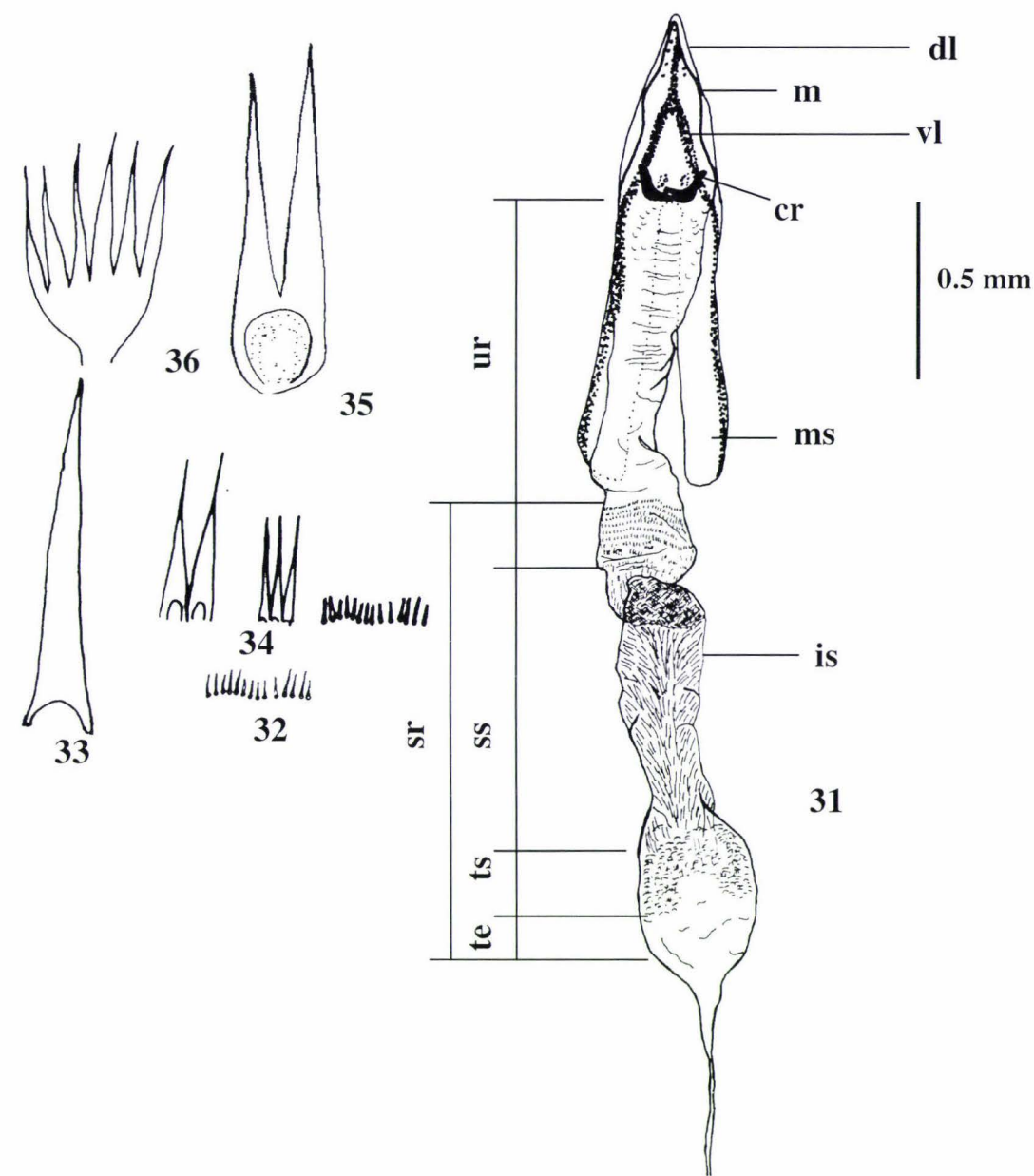
### 2.3.2 Terminalia

#### Male

Male terminalia includes the aedeagus, tegmen, eighth tergite and sternite. I could not find significant differences in male terminalia between *Zorion* species. A SEM image of an interior section of the aedeagus is depicted in Fig. 2.37 showing the different spines present in the aedeagus.

*Aedeagus* (Figs 2.31-2.36). Apex of median lobe pointed, widening into a bulbous base, narrower behind bulb and widening again towards median struts. Internal sac divided into basal spineless region and terminal spinose region. Spineless region transparent and appearing with a scale like surface around area of chitinous rods half way down median struts. Spinose region longer than spineless region. Spinose region divided into 3 sections, first section short starting at end of median struts, with fine thin short hair-like spines arranged in grouped rows (Fig. 2.32); second section 4 × as long as third, with dense long thin single spines (Fig. 2.33) in median area, and sparse paired spines in lateral area (Fig. 2.35), becoming smaller turning into paired spines and even smaller multiple spines (Fig. 2.34); third section with scale like spines with multiple points (Fig. 2.36) ending terminally in a short transparent section.





Figures 2.31-2.36 Aedeagus and its spines of *Z. batesi*. 31, ventral view of aedeagus: m, median lobe; dl, dorsal lobe; vl, ventral lobe; ms, median strut; is, internal sac; fs, first section; ss, second section; ts, third section; te, terminal end; 32, fine spines in rows; 33, long single spines; 34 - 35, paired spines; 36, scale like digitate spines

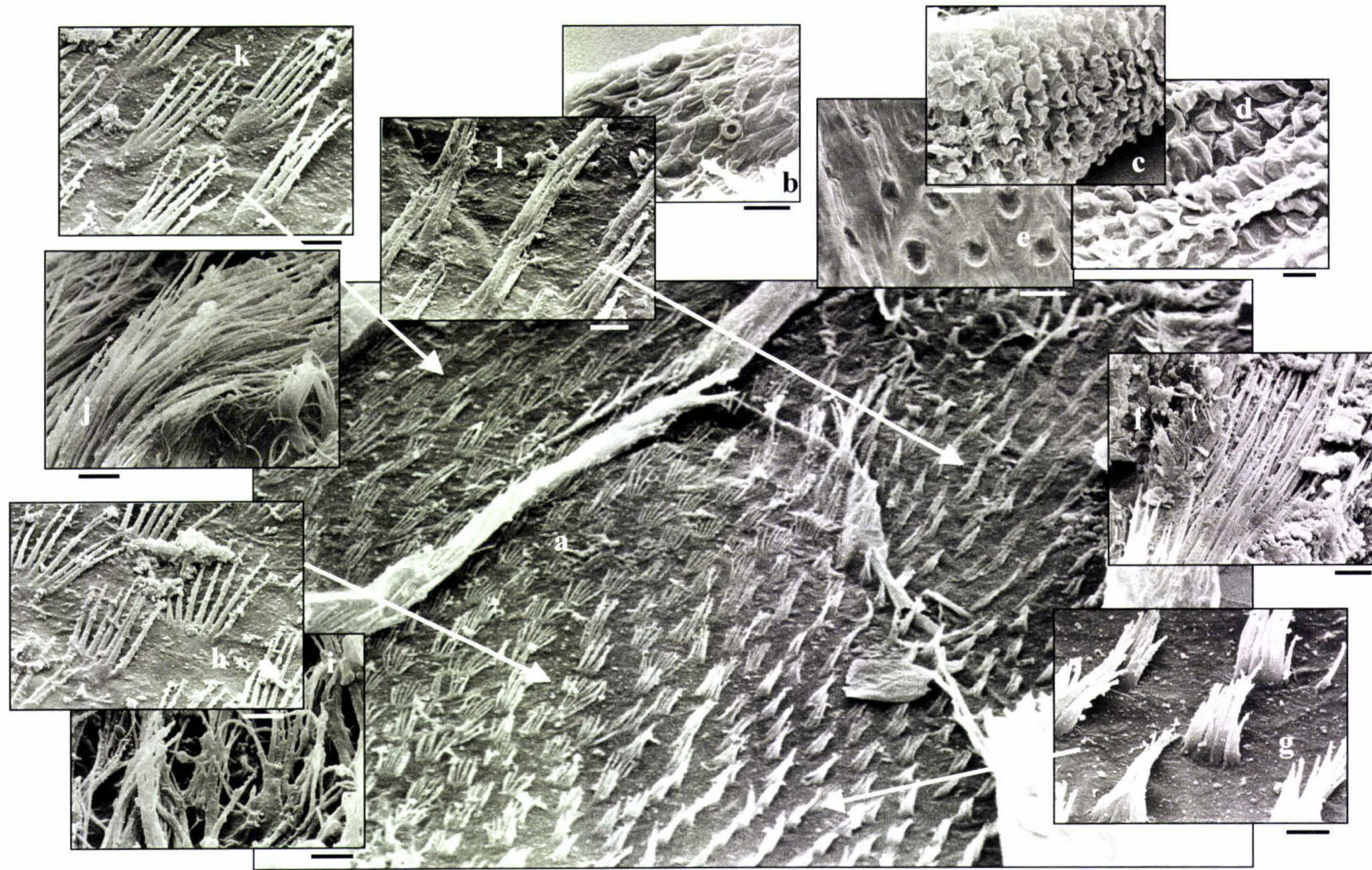
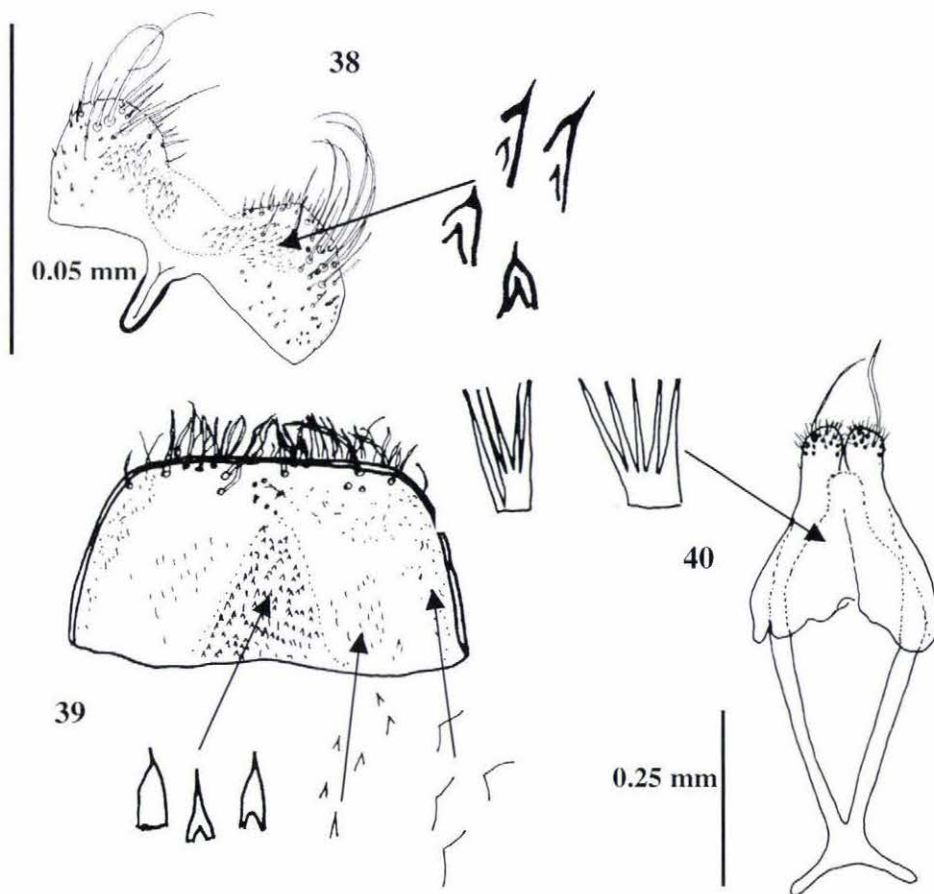


Figure 2.37 SEM images of internal sac from a *Z. guttigerum* specimen. a, internal surface of spined region (scale line 40 µm); b – e, external surface of internal sac (scale line 10 µm); f – l, different spine forms from different regions (scale bar for f & j 10 µm, scale line for g, h, i, k & l 4 µm).





Figures 2.38-2.40 Male terminalia of *Zorion*. 38, 8<sup>th</sup> sternite with single pointed spines; 39, 8<sup>th</sup> tergite with single pointed spines gradually turning into scale like spines; 40, tegmen with digitate spines

*Eighth sternite* (Fig. 2.38). Apex emarginate, forming two lobes with microspines and long hairs.

*Eighth tergite* (Fig. 2.39). Apex rounded or truncate and almost rectangular shaped, with fine hairs at apical edge and single pointed microspines in mid area turning gradually into scale like spines towards lateral margins.

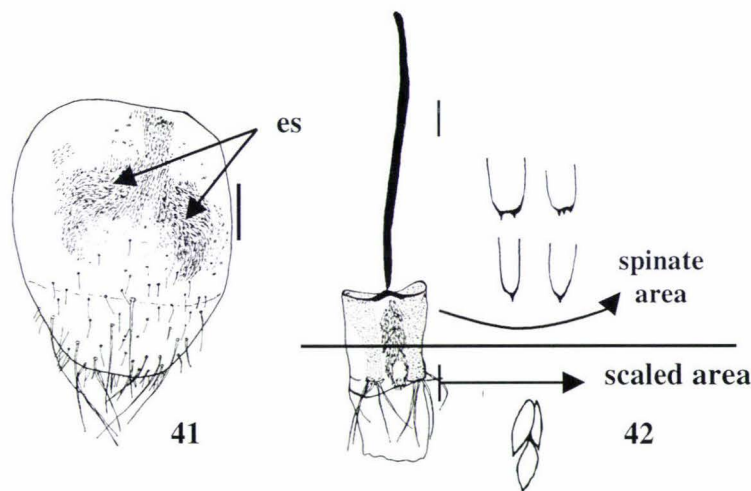
*Tegmen* (Fig. 2.40). Composed of parameres that are two lobed, a spinate, transparent roof and a ringed part; spines multi-pointed.

### Female

Female terminalia includes the fifth tergite, eighth sternite, ovipositor, bursa copulatrix and spermatheca.

*Fifth tergite* (Fig2.41). Obovate, truncate at base, covered with microspines forming two iridescent eyes, apex with short and long hairs

*Eighth sternite* (Fig. 2.42). Scattered with multi-pointed spines strongly sclerotised at point; spines gradually changing into less sclerotised and scale-shaped towards apex.



**Figures 2.41-2.42 Female fifth tergite and eighth sternite. 41, scales on 5<sup>th</sup> tergite forming two iridescent eyespots in females (es). 42, spinate and scaled section on 8<sup>th</sup> sternite. Scale bar 0.25 mm**

*Ovipositor* (Fig 2.43). Divided into two sections, first section scaled with broad scales, becoming slimmer towards the second section; second section with very fine hair like spines or scales. Dorsal baculi shorter than ventral baculi but ratio variable between species; dorsal baculi arising from base of coxite, ventral baculi 0.16 to 0.12 up from base of dorsal baculi. Coxite with stronger sclerotisation on inner sides. Base of coxite with small baculi. Styli sclerotised, flattened at apex with three simple large and long spines; styli slightly pointing outwards.



*Spermatheca* (Fig. 2.43) Sclerotised semi transparent, hook shaped, strongly tapering into pointed apex; attached by a short duct at base of bursa copulatrix at a point above lateral oviduct joining uterine canal. Spermatheca shape slightly different between species.

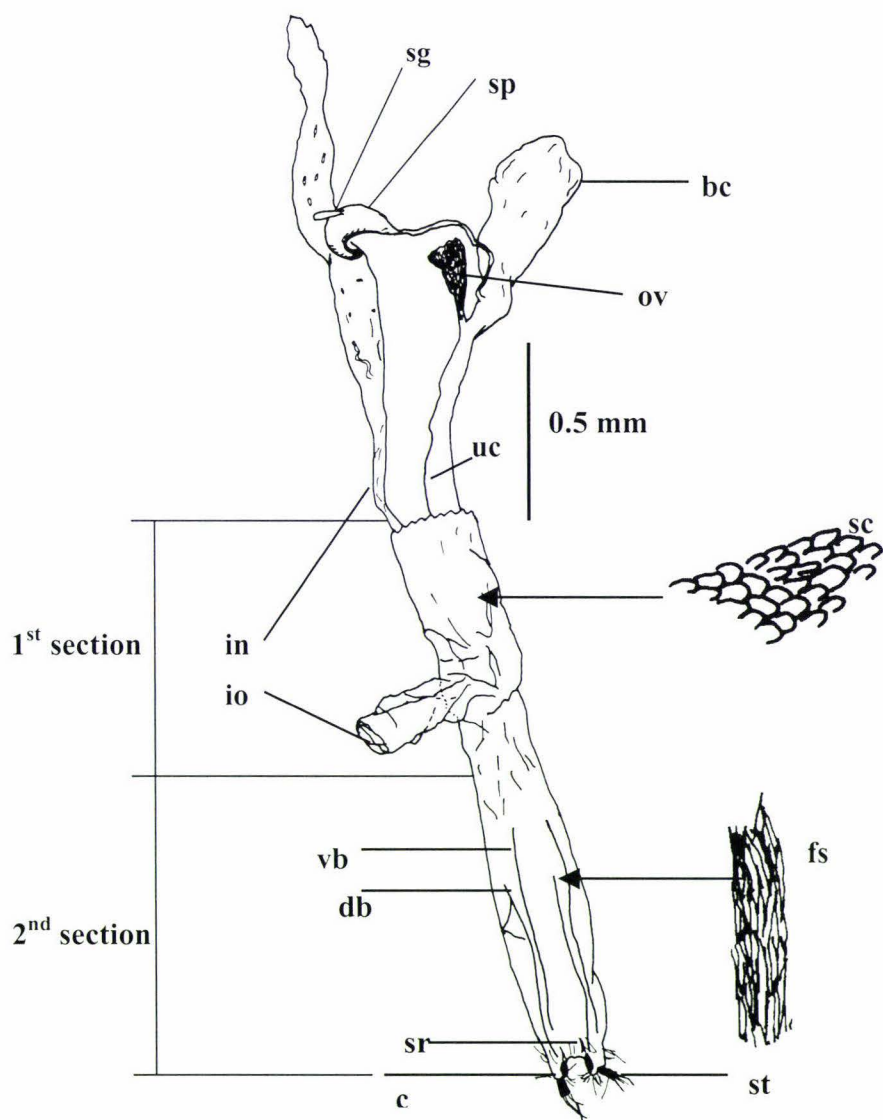


Figure 2. 43 Ovipositor and efferent system of *Z. australe*. bc, bursa copulatrix; cx, coxite; db, dorsal baculi; fs, second finely scaled section; in, intestine; io, intestine opening; ov, oviduct; sc, first scaled section; sb, small baculi; sg, spermathecal gland; sp, spermatheca; sr, sclerotized rod; st, stylus; uc, uterine canal; vb, ventral baculi.

2.3.3 Key to species of the genus *Zorion* Pascoe

- 1 Elytra with ivory or golden yellow spots at or near the middle; if
  - elytra without spots elytra unicoloured.....2
  - Elytra without above spots but central area of elytra much darker
    - coloured than anterior and posterior of elytra.....*Z. nonmaculatum*
- 2 Pronotum (Fig. 2.53b) glossy, shiny.....3
  - Pronotum (Fig. 2.53a) silky-dull.....9
- 3 Spots on elytra forming a band at a right angle to elytral suture,
  - and not reaching elytral margin (Fig. 2.24); width of spot at
  - least 1.5 × greater than its length (Fig. 2.15); femur ringed (Fig.
  - 2.13).....*Z. angustifasciatum*
  - Spots on elytra not forming a band at right angle to suture; spots
  - round or pear shaped; if spots forming a band, beetle dark in
  - colour or band reaching elytral margin (Fig. 2.21); or no spots.. ....4
- 4 Body light orange; no dark field around spots; femur not ringed.....*Z. minutum*
  - Body dark or if orange; spots with dark field; or femur ringed.....5
- 5 Spots on elytra not reaching elytral margin; or split into two.....*Z. batesi*
  - Spots on elytra reaching elytral margin; spots on elytra entire; large
  - round or forming a band; or no spots on elytra .....6
- 6 Body orange to orange-brown; spots with dark field.....7
  - Body dark brown, or purple; or almost black in colour .....8
- 7 Femur with dark ring .....*Z. taranakiensis*
  - Femur without dark ring .....*Z. australe*
- 8 Enlarged part of femur orange-brown and much lighter than
  - pronotum .....*Z. kaikouraiensis*
  - Enlarged part of femur dark as pronotum .....*Z. guttigerum*
- 9 Elytra glossy, shiny compared to silky dull pronotum.....*Z. dugdalei*
  - Elytra silky dull .....*Z. opacum*

### 2.3.4 Descriptions of *Zorion* species

#### *Zorion minutum* (Fabricius)

(Figs 2.24, 2.44, 2.45, 4.1)

*Callidium minutum* Fabricius, 1775: 192. - Fabricius, 1781: 241, 1787: 155, 1792: 332; Olivier, 1795: 57.

*Clytus minutus* Fabricius, 1801: 346. - Dumont d'Urville, 1832: 592; Dieffenbach, 1843 (1974 reprint): 279.

*Obrium fabricianum* Westwood, 1845: 28. - White, 1846: 20, 1855: 240; Hutton, 1873: 164.

*Zorion minutum* Bates, 1874: 22. - Bates 1875: 319; Broun 1880: 584, 1909: 147; Hutton, 1898: 158, 1904: 193; Aurivillius, 1912: 156; Tillyard, 1926: 231, 237; Hudson, 1934: 114; Dumbleton, 1957: 614; Blair, 1937: 265; Milligan, 1975: 1636; Taylor, 1957: 10; Manson, 1960: 27; Duffy, 1963: 126; Kuschel, 1990: 35, 67; Emberson, 1998: 46; Scott & Emberson, 1999: 17, 59, 80.

#### Description

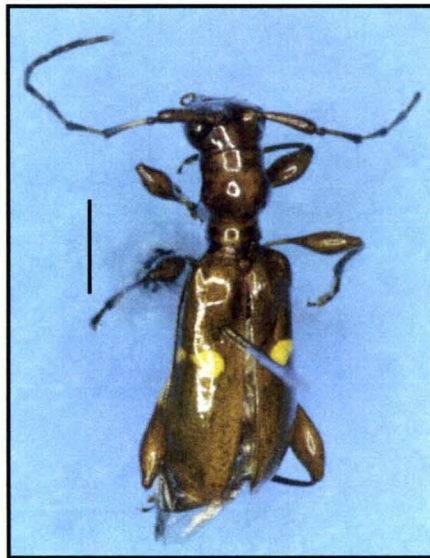
*Body length*: Male 4.84-5.30 mm, female 3.48-6.36 mm.

*Colour*: Body medium orange-brown throughout, with two yellowish white spots on each elytron, not surrounded by dark area (Figs 2.24 & 2.44). Inner elytral spot larger than outer one and  $1.4-1.9 \times$  wider than long, transversely located, not touching elytral suture and margin, central axis through spot at right angle in relation to suture; distance between inner spot and suture  $3-4 \times$  distance between outer spot and margin; distance between central axis of spot and elytral shoulder  $0.4 \times$  elytral length. Central and frontoclypeal suture of head and tip of mandibles black, palps medium orange-brown. Eyes black. Scape medium orange-brown with darker apex; pedicel dark brown; antennal segments 3-11 whitish at base but gradually becoming dark brown towards apex. Pro- and mesocoxal cavity bounded by dark edge; trochanter dark brown; coxa medium orange-brown; base of femur whitish without dark ring at beginning of clubbed, medium orange-brown femur (Fig.



2.14); tibia and tarsi medium orange-brown throughout. Abdominal segments medium orange-brown like remainder.

*Structure:* Body surface glabrous, glossy. Apex of elytra rounded (Fig. 2.16). Females with a row of hairs on epipleural fold not reaching beyond anterior edge of spots; males without such hairs.



**Figure 2.44** Dorsal view of *Z. minutum*. Scale bar 1 mm

*Ovipositor & spermatheca:* Ratio between dorsal to ventral baculi being 1:1.3. Spermatheca sclerotised, more so at apex, strongly curved, bean shaped, wider at base and gradually tapering into a point towards apex, no sclerotised structure within. Spermathecal gland arising at around 0.33 of spermatheca length from base (Fig. 2.45).

*Variation:* Spot on elytral disc golden yellow, may form a fascia whose axis is at a forward angle (Fig. 2.17) and may be partially surrounded by darker area; tibia may be medium orange-brown in middle and dark brown at base and apex.

### Biology

Females were collected between 16 Oct. and 20 Dec., and males between 16 Oct. and 25 Jan. Adult hosts include *Rubus* flower.



### Distribution

North Island in Hawkes Bay and along east coast in the Gisborne geographical region (Fig. 4.1).

### Comments

The holotype is badly damaged; the colour is clearly visible but the specimen is covered in dust. The right elytron is damaged, the wings are separated from the body and the abdomen is missing. Segments 4-11 of left antennae are missing, and the hind legs and body are attached to the pin by glue. The species name *fabricianum* is given by Westwood (1845) as a replacement name for *minutus* Fabricius, which he regarded as a name preoccupied by *O. minutum* Auct. hodiern. However, it is not known what this *O. minutum* is (S. Shute, pers. comm.).

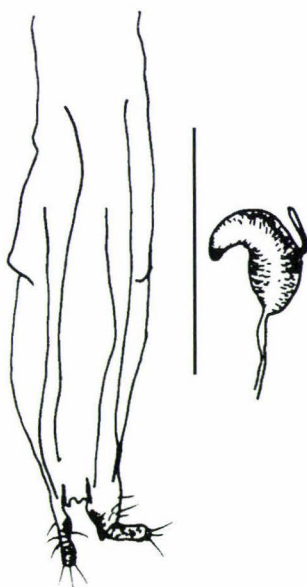


Figure 2.45 Ovipositor and spermatheca of *Z. minutum*. Scale bar 0.5 mm

### Material examined

*Holotype*: 1♀, *Callidium minutum*, Banks collection, (BMNH).

*Other material examined*: 11♀, 2♂. **GB**: 2♀, 1♂, Anaura Bay, *Rubus* blossom, 16 Oct. 1985, G. W. Gibbs (NZAC). 1♀, Waikohu Valley, Northwest of Te Taraka, (x17 256 957), 20 Dec. 1973, J. Dugdale & D. King (NZAC). 1♂, Esk Valley, 25 Jan. 1981, J. E.

Manley, (location confirmed by Manley, pers. comm.) (author's coll.). **HB**: 1♀, Napier, no date, Colenso (BMNH). 1♀, no locality, no date, Colenso (BMNH). 1♀, New Zealand, no data, No.: 26579 (BMNH). 1♀, no data, 1905 313 Sharp coll. (BMNH). **Unknown localities**: 4♀, 15 Nov. 1982, G. Laudon (NZAC).

### *Zorion guttigerum* (Westwood)

(Figs 2.29, 2.46, 2.47, 4.1)

*Obrium guttigerum* Westwood, 1845: 28. - White, 1846: 20, 1855: 240; Redtenbacher, 1868: 199; Hutton, 1873: 164.

*Zorion castum* Broun, 1893: 1281. - Hutton, 1904: 193; Aurivillius, 1912: 156; Hudson, 1934: 114; Blair, 1937: 265.

*Zorion guttigerum* Bates, 1874: 22. - Bates, 1875: 319; Waterhouse, 1876: 14; Broun, 1880: 585; Hutton, 1904: 193; Aurivillius, 1912: 156; Hudson, 1934: 114; Blair, 1937: 265; Dumbleton, 1957: 611; Manson, 1960: 27; Duffy, 1963: 127.

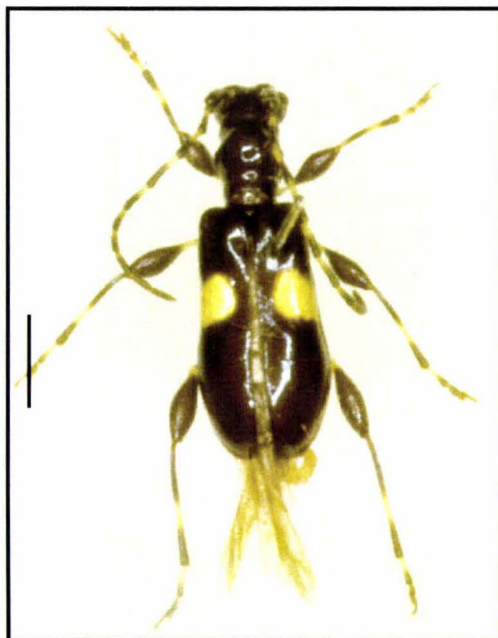
#### Description

*Body length*: Male 3.78-6.36 mm, female 3.78-7.57 mm.

*Colour*: Body dark purple brown all over with a white spot on each elytron. Elytral spot  $1.4 \times$  wider than long and transversely located, not touching elytral suture but reaching elytral margin (Figs 2.29 & 2.46); central axis through spot at right angle in relation to suture; distance between central axis of spot and elytral shoulder  $0.37-0.58 \times$  elytral length. Palps, eyes, scape and pedicel dark purple brown; antennal segments 3-7 or 3-8 whitish at base but gradually becoming dark brown towards apex; antennal segments 8-11 or 9-11 dark brown. Pro- and mesocoxal cavity bounded by dark edge; trochanter and apex of coxa dark; base of femur whitish and without dark ring at beginning of clubbed, dark purple brown femur; tibia and tarsi light brown throughout. Abdominal segments dark purple brown as remainder of the body.

*Structure*: Body surface glabrous, glossy. Apex of elytra rounded (Fig.2.16). Females with two or more hairs on epipleural fold, males without such hairs.

*Ovipositor & spermatheca*: Ratio of dorsal to ventral baculi being 1:1.3. Spermatheca sclerotised, more so at apex, strongly curved bean-shaped, wider at the base and gradually tapering into a point towards apex, no sclerotised structure within. Spermathecal gland arising at around 0.33 of spermatheca length from the base (Fig. 2.47).



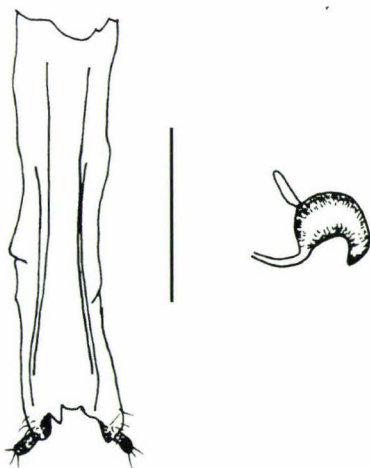
**Figure 2.46** Dorsal view of *Z. guttigerum*. Scale bar 1 mm

*Variation*: Overall body colour may vary from dark orange to dark orange-brown or almost black purple with metallic appearance. Spot may be up to  $1.2 \times$  longer than wide and may be golden yellow in colour; positioned on a forward or backward angle in relation to elytral suture (Fig. 2.17); may almost reach elytral margin and the distance between spot and suture is not less than  $4 \times$  the distance to margin. Scape may be creamy golden brown sometimes with darker apex, pedicel dark brown; antennal segments 3-11 whitish at base but gradually becoming dark brown towards apex. Coxa and trochanter may be light orange-brown. Tibia and tarsi may be dark purple or orange-brown and tibia sometimes light brown in the middle section.



## Biology

Males were collected between 20 Oct. and 25 Mar., and females between 10 Oct. and 23 Jan. Specimens were collected by Malaise trap, in flight intercept trap, beating at night; and found indoors at window or on veranda post, in litter, and at a height of up to 1372 m. Adults were found on flowers of wild carrot, ♂ kiwi fruit vine, yarrow, spindle-berry bush flowers, *Brachyclottis repanda*, *Eucalyptus gregsoniana*, *Hebe* sp., *Hoheria*, *Largunaria pattersonii*, ♂ *Pennantia corymbosa*, *Physocarpus opulifolius*, *Pomaderris*, *Schefflera digitata*; *Senecio petasitis*, *Spiraea* sp., and found on foliage or branches of tussock, lucerne tree, peppertree, on grass, raspberry, runner beans, *Cretaeus*, *Galium palustae*, *Gaultheria*, *Muehlenbeckia*, *Nothofagus menziesii*, *Olearia virgata*, *Phormium*, *Sophora microphylla*. Adults were reared from *Nothofagus menziesii* of up to 900m (coll. Oct. –em. 14 Nov., em. 2 Dec.); *Discaria toumatou* (coll. 11 Nov.-em. 1 Dec.); matagouri (*Discaria toumatou*) stems and from *Nothofagus fusca* (em. 29 & 7 Nov.). In addition I dissected larvae and pupae from dead *Alnus cordata* twigs. One larva was found parasitized by a braconid (Hymenoptera), Mt. Misery, 600m, emerged from *Zorion*, 7 Nov. 1977, J. S. Dugdale (NZAC).



**Figure 2.47** Ovipositor and spermatheca of *Z. guttigerum*. Scale bar 0.5 mm

## Distribution

This species is widely distributed from central North Island to South Island (Fig.4.1). On North Island few specimens were found in the Auckland, Waikato, Bay of Plenty



regions and the south west Gisborne region. The species' distribution extents southwards throughout the Taupo region, central Hawkes Bay, the eastern side of Mt Taranaki, the Rangitikei, Wanganui, Wairarapa and the Wellington region. On South Island the distribution ranges from the Marlborough Sounds, the Nelson region through to the Marlborough region with some specimens found in the Buller and Kaikoura region. The distribution then is restricted to the eastern part of the South island extending through North Canterbury, Mid Canterbury inclusive Banks Peninsula, South Canterbury and the Mackenzie region. One specimen was recorded from southern part of the Central Otago region.

### Comments

No specimen had been designated as holotype in Westwood's original description of *O. guttigerum*. There are four syntypes in the BMNH collection, which came to the BMNH from the Parry collection via Fry. One specimen bears a red type label, which is thought to have been added at some later stage (S. Shute, BMNH, pers. comm.). The right middle and hind leg of the lectotype are missing. The paralectotypes are not in a very well preserved state, with antennae and some legs missing. The label of the *Z. castum* holotype states the specimen as male, however the specimen is female. The original description states the locality of the specimen to be near Stratford collected by A.T. Urquhart. The common name "Blue longhorn" is given by Manson (1960).

### Material examined

*Lectotype*: *Obrium guttigerum*, designated here. 1♂, Port Nicholson, ex Mus. Parry, via Fry coll. 1905-100 (BMNH).

*Paralectotypes*: *Obrium guttigerum*, designated here. 1♂, ex Mus. Parry, via Fry coll. 1905-100 (BMNH). 2♀, ex Mus. Parry, via Fry coll. 1905-100 (BMNH).

*Holotype*: *Zorion castum* **syn. Nov.**: 1♀, Mt Egmont, No.2256, Broun coll. 1922-482 (BMNH).

*Other material examined*: 214♂, 187♀. **AK**: 1♂, 2♀, Waionui, North Hills, 30 Nov. 1908, A. O'Connor (MONZ). **SC**: 1♂, Waihi Gorge, 28 Dec. 1943, S. Lindsay (CMNZ). **WO**: 4♀, Mt. Pirongia, 29 Dec. 1931, E. Fairburn, terminalia vial No. *Z. guttigerum* f-

030800-3/10, terminalia vial No. *Z. guttigerum* f-030800-4/10 (WMNZ). 1♂, 3♀, Waitomo, 16 Nov. 1941, terminalia vial No. *Z. guttigerum* f-030800-5/10, terminalia vial No. *Z. guttigerum* f-030800-6/10 (AMNZ 18811 & AMNZ 18813, 18814, 18815). 1♂, Waitomo (AMNZ 18817). **BP**: 3♂, 1♀, Roaring Meg, Kawerau Gorge, beating at night, 19 Nov. 1974 & 8 Mar. 1979, J. C. Watt (NZAC). 1♀, 1♂, Roaring Meg, Kawerau Gorge, beating *Olearia virgata*, 23 Nov. 1974, J. S. Dugdale (NZAC). 1♂, Roaring Meg, 490m, beating *Nothofagus menziesii*, 26 Nov. 1974, J. C. Watt (NZAC). 1♀, White Pine Bush, Dec. 1970, litter, T. H. Davies, terminalia vial No. *Z. guttigerum* f-030800-2/10 (NZAC). 1♀, Rotorua, Andrewes Bequest. B. M. 1922-221 (BMNH). **GB**: 1♂, 1♀, Waikaremoana, *Hoheria* flowers, 1 Jan., 1958, J. C. Watt (NZAC). **TK**: 1♂, Mt. Egmont, NP Potaema picnic area in tent, 650 m, 24 Dec. 1985, R. M. Emberson, P. Syrett (LUNZ). 1♀, Makahu, 914m, sweeping tussock and *Dracophyllum* scrub, 13 Mar. 1980, C. F. Butcher (NZAC). 2♂, 2♀, Okoke, Urenui, 29 Nov. 1945, D. Weeks (MONZ). 1♂, 1♀, Manaia, Nov. 1976, G. Fox (NZAC). **RI**: 2♀, Ohakune, 1 Jan. 1917 (NZAC). 1♀, Ohakune, 1 Jan. 1917, Broun coll. 1922-482 (BMNH). 1♂, Ohakune, large carrot park, *Hebe* flowers, 28 Feb. 1999, A. Marrison (author's coll.). 2♂, 4♀, Ohakune, 16 Dec. 1961, G. Kuschel, terminalia vial No. *Z. guttigerum* f-030800-9/10 (NZAC). 1♂, L. Colenso, 19 Jan. 1998 C. Briggs (author's collection). **TO**: 1♂, Desert Road, swept, 17 Feb. 1973. S. A. Timms (LUNZ). 3♂, 1♀, Raurimu, ex *Gaultheria*, 23 Nov. 1977, J. S. Dugdale, terminalia slide No. *Z. guttigerum* m-030800-7/10, terminalia vial No. *Z. guttigerum* f-030800-8/10 (NZAC). 1♀, WaiMarino, Jan. 1909 (BMNH). 1♂, Waihohonu Track, 9 Jan. 1965, J. S. Armstrong (NZAC). 1♂, Waipakihi, 900m, Oct. 1979, em. from *Nothofagus menziesii* 14 Nov. 1979, J. S. Dugdale (NZAC). 1♂, Waipakihi, 900m, reared from *Nothofagus menziesii*, em. 2 Dec. 1979, J. S. Dugdale (NZAC). 2♂, Oio, 20, Nov. 1936, F. Gardener, E. S. Gourlay (NZAC). 1♀, Erua, 1 Jan. 1941 (AMNZ18818). 1♀, Kaimanawa, F P N entrance, on *Hebe* flowers, 20 Feb. 1986, J. C. Clearwater (NZAC). 1♂, Kaimanawa SFP, Waikato Falls, beating *Hebe* flower, 26 Nov. 1985, C. J. Lyal (BMNH). 1♀, Ruapehu, 14 Dec. 1961, G. Kuschel, terminalia vial No. *Z. guttigerum* f-030800-10/10 (NZAC). **HB**: 1♀, Kaweka Ra 950m, Ngahere Basin, beating at night, 22 Dec. 1983, J. C. Watt, terminalia



vial No. f-190400-2/4 (NZAC). 1♂, 2♀, Napier, on wild carrot, 19 Dec. 1996, Q. Wang (Q. Wang collection). 1♂, Napier, on wild carrot, 19 Dec. 1996, Q. Wang, terminalia slide No. *Z. guttigerum* m-110400-2/2 (NZAC). 2♀, Clifton, 7 Nov. 1943, J. S. Armstrong, terminalia vial No. *Z. guttigerum* f-100400-2/2 (NZAC). 1♀, Hastings, 28 Dec. 1964, G. Ramsay, terminalia vial No. *Z. guttigerum* f-060400-2/2 (NZAC). 2♂, 1♀, Hastings, ex. chinese gooseberry flowers, 19 Nov. 1953, terminalia slide No. *Z. guttigerum* m-170400-1/2, terminalia vial No. *Z. guttigerum* f-190400-4/4 (NZAC). 5♂, 5♀, Hastings, 18 Nov. 1941, D. Spiller, terminalia slide No. *Z. guttigerum* m-120400-1/2, *Z. guttigerum* m-120400-2/2 (NZAC). 3♀, Hastings, Cromwell Park, beating *Hebe* & *Spirea* flowers, 10 Jan. 2000, F. R. Schnitzler, terminalia vial No. *Z. guttigerum* f-050400-1/2, *Z. guttigerum* f-100400-1/2, *Z. guttigerum* f-190400-1/4 (NZAC). 1♂, Hastings, 18 Nov. 1941, D. Spiller, terminalia slide No. *Z. guttigerum* m-180400-1/2 (NZAC). 3♂, Hastings, Cromwell Park, beating *Hebe* & *Spirea* flowers, 10 Jan. 2000, F. R. Schnitzler (author's coll.). 1♀, 4♂, Hastings, Frimley park, beating *Largunaria pattersonii* & *Spirea* sp, 9 Jan. 2000, F. R. Schnitzler (author's coll.). 12♂, 2♀, Haveloch North (should be Havelock North), about tree lucerne, fruit store, 7 Nov. 1952, D. McKenzie, terminalia slide No. *Z. guttigerum* m-110400-1/2, *Z. guttigerum* m-130400-1/2, *Z. guttigerum* m-130400-2/2, *Z. guttigerum* m-170400-2/2, terminalia vial No. *Z. guttigerum* f-060400-1/2, *Z. guttigerum* f-190400-3/4 (NZAC). 1♂, 2♀, Wimbeldon, 26 Nov. 1957, J. I. Townsend (NZAC). **WI**: 2♂, 1♀, Kitchener Park, Fielding, beating *Muehlenbeckia*, 18 Dec. 1956, R. M. Bull (NZAC). 1♂, Ruahine Rd, Triplex Creek, 610m, *Schefflera digitata* flowers, 9 Feb. 1980 (NZAC). 1♀, Manawatu Gorge, Balance Reserve, 16 Jan. 1957, Tit. (NZAC). 6♂, Ashurst, on *Cretaeagus*, 20 Oct. 1983, J. S. Dugdale (NZAC). 1♂, Palmerston North, Oct. 1962 (NZAC). 1♀, Palmerston North, Dec. 1956, R. M. Bull (NZAC). 5♂, 2♀, Palmerston North, Esplanade, ex *Eucalyptus gregsoniana* & ♂ *Pennantia corymbosa* flowers, 4 Dec. 1999, F. R. Schnitzler (author's coll.). 1♂, Palmerston North, Churchill Ave, on ♂ Kiwi vine flower, 17 Jan. 2000, F. R. Schnitzler (author's coll.). 5♂, 3♀, Palmerston North, Esplanade, ex *Senecio petasitis* flowers, 5 Jan. 2000, F. R. Schnitzler (author's coll.). 7♂, 1♀, Palmerston North, Massey, ex *Physocarpus opulifolius* flowers, 17 Nov. 1999, F. R.



Schnitzler (author's coll.). 2♀, Palmerston North, Massey, ex *Physocarpus opulifolius* flowers, 17 Nov. 1999, F. R. Schnitzler, terminalia vial No. *Z. guttigerum* f-210600-3/4, *Z. guttigerum* f-210600-4/4 (NZAC). 1♂, Palmerston North, Massey, *Pomaderris* flowers, 21 Nov. 1999, F. R. Schnitzler (author's coll.). 1♀, Palmerston North, Massey, sweep wild carrot, 22 Nov. 1999, F. R. Schnitzler (author's coll.). 2♀, Rangitane, 17 Nov. 1916 (NZAC). 1♀, 1♂, Rangitane, Lagoon Bush, 4 Dec. 1916 (NZAC). 3♂, Grasslands, beaten out of *Muehlenbeckia*, 9 Jan. 1957, R. M. Bull Collection (NZAC). 2♀, Manawatu, Tiritea Road, 15 Jan. 1957 (NZAC). 1♀, 3♂, Paiaka, *Phormium* survey, 1 Nov. 1941, R. A. Cumber (NZAC). 4♀, 2♂, Paiaka, 5 Jan. 1950, R. A. Cumber (NZAC). 1♂, Paiaka, 1 Nov. 1944, R. A. Cumber (NZAC). 2♂, 1♀, Paiaka, Monton Estate, clover Mar.sh, *Galium palustre*, J. T. Salmon (MONZ). WN: 1♀, Balance, on *Cretaceous*, 20 Oct. 1983, J. S. Dugdale, terminalia vial No. *Z. guttigerum* f-090800 -3/9 (NZAC). 1♀, 1♂, Levin, on grass, 22-24 Nov. 1990, C. A. Stewart (LUNZ). 1♀, Levin, Prouse's bush, landed on leg, 11 Dec. 1998, S. J. Bennett (author's coll.). 2♀, 2♂, Weraroa, 2 Dec. 1917, terminalia slide No. *Z. guttigerum* m-090800 -2/9, terminalia vial No. *Z. guttigerum* f-090800 -1/9 (NZAC). 1♀, Waikanae beach, 3 Nov. 1990, A. Tennyson, terminalia vial No. *Z. guttigerum* f-090800-8/9 (MONZ). 3♀, 1♂, Hutt Valley, 2 Jan. 1928, E. Fairburn, terminalia vial No. *Z. guttigerum* f-090800-5/9, terminalia vial No. *Z. guttigerum* f-090800-4/9 (WMNZ). 1♂, Hutt Valley, 2 Jan. 1928, E. Fairburn (AMNZ 18816). 1♀, Wellington, G. V. Hudson B. M. 1925-23 (BMNH). 1♀, Wellington, 1880, C. M. Wakefield, Hudson coll. (BMNH). 1♀, Wellington, Whakatiki, 21 Oct. 1923, T. Colkerof (AMNZ 18819). 1♂, Wellington, 1889, E. Huglson (BPBM). 1♀, Wellington, Silverstream, 16 Dec. 1923, T. Colkerof (AMNZ 18808). 1♂, Korotoro, Wellington, 29 Dec. 1923, T. Colkerof (AMNZ 18810). 1♂, Karori Reservoir, on flowering *Brachyglottis repanda*, 3 Nov. 1993 (JNNZ). 2♂, Tinakori Hill, Wellington, general beating, 17 Oct. 1991, J. Nunn, terminalia slide No. *Z. guttigerum* m-090800 7a/9, *Z. guttigerum* m-090800 7b/9 (JNNZ). 1♀, Wellington, 1980, C. M. Wakefield (Hudson BMNH). 1♀, Wellington, Mar. 1903, J. J. Walker, G. C. Champion collection B. M. 1927-409 (BMNH). 1♂, Port Nicholson, Pascoe coll. 93-60 (BMNH). WA: 1♂, Masterton, landed on neck, 9 Jan. 1999, A. Atkinson,

terminalia slide No. *Z. guttigerum* m-090800-9/9 (author's collection). 1♂, 1♀, Castlecliff, Jan. 1993, E. Harris, terminalia SEM stub No. 332 (Hort Research Palmerston North), terminalia vial No. *Z. guttigerum* f-090800-6b/9 (OMNZ). 1♂, Castlecliff, 22 Nov. 1996, E. C. Harris (OMNZ). 1♀, Castlecliff, 10 Oct. 1996, E. C. Harris (OMNZ). 1♂, Putangirua Stm., Palliser, general beating, 29 Oct. 1995, J. Nunn (JNNZ). 1♂, Pakuratahi Forks, 9 Jan. 1993, J. Nunn (JNNZ). **SD**: 2♂, 2♀, Stephen's Island, 14-28 Jan. 1933, E. S. Gourlay, terminalia slide No. *Z. guttigerum* m-110800-1/10 (NZAC). 4♂, 1♀, Stephen's Island, Cook Strait, 10 Jan. 1931, E. Fairburn, terminalia slide No. *Z. guttigerum* m-110800-6/10, terminalia vial No. *Z. guttigerum* f-110800-5/10 (WMNZ). 1♀, Ship Cove, 27-30 Jan. 1972, G. Kuschel (NZAC). 1♀, 2♂, Queen Charlotte Sound, Maud Island, 6 Nov. 1949, E. S. Gourlay, terminalia slide No. *Z. guttigerum* m-110800-4/10 (NZAC). 1♀, Maud Island, found on veranda post early sunny morning, 15thFeb. 1961, D. R. Notman (NZAC). 1♂, Te Iro Bay, Tory Channel, Malaise trap in coastal scrub and broadleaved forest, 1-6 Jan. 1993, J. W. M. Marris, J. B. Mander (LUNZ). 1♂, Arapawa Island, Te Iro Bay, on yarrow flower, 21 Dec. 1985, J. W. M. Marris terminalia slide No. *Z. guttigerum* m-110800- 2/10 (LUNZ). 3♀, Queen Charlotte Sound, Te Iro Bay, on yarrow flower, 24 Dec. 1985 & 10 Jan. 1987, J. W. M. Marris, terminalia vial No. *Z. guttigerum* f-110800-3/10 (LUNZ). 1♂, Queen Charlotte Sound, Te Iro Bay, on yarrow flower, 10 Jan. 1987, J. W. M. Marris (LUNZ). **NN**: 1♀, Takaka Hill, 28 Dec. 1953, E. S. Gourlay (NZAC). 1♂, Nelson, 21 Feb. 1935, E. S. Gourlay, terminalia slide No. *Z. guttigerum* m-110800-7/10 (NZAC). 1♂, Canaan, 17-26 Jan. 1949 (NZAC). 2♂, 1♀, Canaan, Nelson, 17 Feb., 1965, J. I. Townsend, terminalia vial No. *Z. guttigerum* f-110800-8/10 (NZAC). 2♂, Mt Misery, 600m, em. 7 Nov. 1977 from *Nothofagus fusca*, J. S. Dugdale (NZAC). 4♀, Mt Misery, 600m, em. 29 Sept. & 7 Nov. 1977 from *Nothofagus fusca*, J. S. Dugdale (NZAC). 3♀, Mt Robert 823m, near Lake Rotoiti, beating *Nothofagus menziesii* with parasitic fungus, 16 Jan. 1976, A. K. Walker (NZAC). **MB**: 1♀, Blenheim (BPBM). 1♀, Blenheim, 151 (NZAC). 1♂, Blenheim, kiwifruit flowers, 19 Nov. 1985 (NZAC). 1♂, Mt. McCabe 1372m, sweeping tussock, 21 Jan. 1976, A. R. Ferguson, terminalia slide No. *Z. guttigerum* m-110800-10/10 (NZAC). 1♀, Lake Tennyson, 1220m, Malaise Trap, 21 Jan. 1976, A. K.



Walker, terminalia vial No. *Z. guttigerum* f-110800-9/10 (NZAC). **BR**: 1♂, Inangahua, 25 Nov. 1961, G. Kuschel (NZAC). 1♀, L. Rotoroa, 10 Nov. 1928, A. Philpott (NZAC). 3♂, 2♀, Greymouth, 1881, Helms, Sharp Coll. 1905-313 (BMNH). **KA**: 1♂, Pudding Hill, 1 Feb. 1912 Broun coll. 1922-482 (BMNH). 12♂, 6♀, Mt. Terako, Cunningham Stream, beating *Hebe* sp., 17 Dec. 1999, F. R. Schnitzler (author's coll.). 1♀, Mt. Terako, Mason River, beating *Hebe* sp., 18 Dec. 1999, F. R. Schnitzler (author's coll.). 2♂, 2♀, SH 70, Mt. Lyford, beating flowering *Pomaderris* sp., 16 Dec. 1999, F. R. Schnitzler (author's coll.). **NC**: 1♂, Hope River, Glynn Wye, 2 Dec. 1962, O. N. Briar (LUNZ). 1♂, Lewis Pass, 18-24 Nov. 1961, G. Kuschel (NZAC). 1♂, Lewis Pass, 8-12 Dec. 1957, M. J. Esson (NZAC). 1♀, 1♂, 18 km W Springfield, Lake Lyndon, 14 Jan. 1960, C. W. O'Brien (BPBM). 2♀, 8 km NW Springfield, Waimakariri River, 15 Jan. 1960, C. W. O'Brien (BPBM). 3♂, Waimakariri Basin, bred ex Matagouri stems, 1967, R. A. Harrison (LUNZ). 1♀, Amberley Beach, 12-14 Nov. 1937, S. Lindsay (CMNZ). **MC**: 1♀, 2♂, Canterbury, C. M. Wakefield, B. M. 1946-280 (BMNH). 2♀, Mt. Hutt, McClemans, *Sophora microphylla*, 11 Dec. 1973, J. S. Dugdale (NZAC). 1♂, Cass, beaten ex Matagouri (*Discaria toumatou*) 25 Oct. 1993, J. W. M. Marris (LUNZ). 2♀, 3♂, Lake Georgina near Lake Coleridge, 11 Nov. 1977, em. from *Discaria toumatou*, 1 Dec. 1977, J. S. Dugdale (NZAC). 1♂, Christchurch, Dec. 1920, T. R. Harris (BMNH). 2♀, 2♂, Christchurch, Sharp coll. 1905-313 (BMNH). 1♀, 64 km NW Christchurch, Ashley Gorge, 21 Jan. 1960, C. W. O'Brien (BPBM). 1♀, Highbank, 6 Aug. 1966, C. Lackner (CMNZ). 2♀, Riccarton bush, 31 Oct. 1986, C. A. Muir (LUNZ). 1♀, Riccarton, 15 Jan. 1968, C. D. Hoyt (LUNZ). 1♀, Southbridge, ex. spindle-berry bush flowers, 4 Dec. 1976, K. McEvedy (LUNZ). 2♂, 1♀, Christchurch, Suter (BMNH). 1♂, 3♀, Christchurch, Suter, Sharp Coll. 1905-303 (BMNH). 4♂, 2♀, Christchurch, Suter, Sharp Coll. 1905-313 (BMNH). 2♂, 1♀, Christchurch, Sharp Coll. 1905-313 (BMNH). 1♂, 1♀, Christchurch, 1939 (LUNZ). 1♂, Christchurch, swept long grass, 10 Nov. 1981, N. Hancox (LUNZ). 1♀, Christchurch Addington, ex runner beans, 22 Dec. 1968, M. G. McPherson (LUNZ). 1♀, Christchurch, Travis Swamp, swept from grass and sedge around swamp, 13 Dec. 1989, J. W. Early (LUNZ). 1♂, Christchurch, St. Albans, ex Raspberry, 14 Dec. 1969, W. D. Pearson



(LUNZ). 1♂, Christchurch, *Hebe*, 15 Dec. 1984, D. A. J. Teulon (LUNZ). 1♂, Christchurch, 20 Nov. 1964, E. S. Gourlay (NZAC). 1♂, Christchurch, 26 Dec. 1970, D. S. Horning (NZAC). 1♀, Christchurch, 14 Oct. 1924, A. Tonnoir (NZAC). 1♀, Mc.Lennan's Bush, 9-10 Dec. 1941, E. S. Gourlay (NZAC). 1♂, Mc. Lennon's, 27 Jan. 1964, M. J. Esson & J. I. Townsend (NZAC). 1♀, Banks Peninsula, Pigeon Bay, 16 Jan. 1960, C. W. O'Brien (BPBM). 2♀, 1♂, Banks Peninsula, Kaituna scenic reserve, native forest, 9 Dec. 1962, J. L. Gressitt (BPBM). 1♀, Kaituna Valley, 28 Dec. 1969, M. G. & R. J. McPherson (LUNZ). 1♀, 2♂, Akaroa, Oct. 1902, J. J. Walker, Champion Coll. 1927-409 (BMNH). 1♂, 1♀, Akaroa, H. Swale, 1913-117 (BMNH). 2♂, 3♀, Akaroa, Woodilltrack, beating *Pennantia corymbosa* flowers, 12 Dec. 1999, F. R. Schnitzler (author's coll.). 2♂, Akaroa, 16 Nov. 1941 & 11 Nov. 1938, S. Lindsay (CMNZ). 3♀, Akaroa, 14 & 16 Nov. 1941 & 14 Nov. 1939, S. Lindsay (CMNZ). 1♀, Sleepy Bay, Banks Peninsula, 27 Nov. 1939, S. Lindsay (CMNZ). 1♂, Sleepy Bay, Banks Peninsula, Jan. 1941, S. Lindsay (CMNZ). 1♂, 1♀, Banks Peninsula, Governors Bay, J. F. Tapley (CMNZ). 1♀, Governors Bay, Dec. 1935, G. V. Hudson (BMNH). 1♀, Banks Peninsula, Mt. Evans, 30 Nov. 1963, M. J. (LUNZ). 1♀, Banks Peninsula, Hinewai Reserve, Quiet Stream, Malaise trap, 2-17 Nov. 1993, J. B. Ward (LUNZ). 1♀, Banks Peninsula, Hinewai Reserve, Shewards Boundary, Malaise trap, 29 Dec. 1993-1 Feb. 1994, J. B. Ward (LUNZ). 4♂, Mt. Hutt, McClemans, *Sophora microphylla*, 11 Dec. 1973, J. S. Dugdale (NZAC). 2♂, Mt Algidus, beating peppertree, 29 Nov. 1977, T. Jackson (LUNZ). 1♂, Cashmere, ex window, 28 Oct. 1972, R. Welsh (LUNZ). 1♀, Hilltop, 22 Jan. 1958, E. S. Gourlay (NZAC). 1♀, Trentham, 5 Nov. 1916, Broun coll. 1922-482 (BMNH). **MK**: 1♀, Mt. Cook, Bush Stream, 23 Jan. 1964, J. I. Townsend (NZAC). **SC**: 1♂, Coopers Creek, 23 Oct. 1961, R. A. Marrison (LUNZ). 1♂, Peel Forest, 25, Oct. 1973, S. A. Timms (LUNZ). 1♂, Peel Forest 1 Jan. 1974, A. C. Harris (MONZ). **CO**: 1♂, Roxburgh, 27 Dec. 1997, B. H. Patrick (JNNZ). **Unknown localities**: 1♀, Manhera State Forest, 11 Nov. 1971, G. Kuschel (NZAC). 2♂, Wainuiomata, South Island, Nov. 1960, G. & C. Laurie (NZAC). 1♂, ? MacClells ?, 25 Mar. 1913, Broun Dup. Coll. (NZAC). 1♂, Moehau, 18. Mar. 1980, reared em. 28 Jan. 1981, B. M. May, terminalia slide No. *Z. guttigerum* m-030800-1/10 (NZAC). 6♀, 2♂, no

data (BPBM). 3♀, 3♂, no data (BMNH). 1♀, G. V. Hudson, B. M. 1930-355 (BMNH). 1♀, 1880, C. M. Wakefield (BMNH). 3♀, C. M. Wakefield (BMNH). 1♀, ??? Bush, 1941, G. V. Hudson (BMNH). 1♀, J.H. Lewis, G. C. Champion coll. B. M. 1927-409 (BMNH). 2♂, ex. Simson, G. C. Champion coll. B. M. 1927-409 (BMNH).

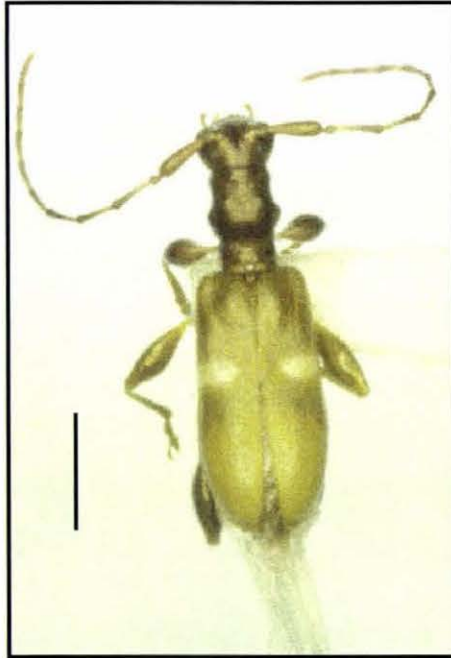
### *Zorion opacum* (Sharp)

(Figs 2.26, 2.48, 2.49, 4.1)

*Zorion opacum* Sharp, 1903: 109. - Broun, 1909: 147; Aurivillius, 1912: 156; Blair, 1937: 265; Macfarlane, 1979: 64–70; Early et al., 1991: 10-24; Emberson, 1998:46.

#### Description

*Body length:* Male 3.18-6.96 mm, female 3.78-7.12 mm.



**Figure 2.48** Dorsal view of *Z. opacum*. Scale bar 1 mm

*Colour:* Body golden brown throughout, with a white spot on each elytron. Elytral spot transversely located, not touching suture and margin, and central axis through spot at right angle in relation to suture (Figs 2.26 & 2.48); distance between central axis of spot

and elytral shoulder  $0.37 \times$  of elytron length. Head and pronotum dark brown, base of elytra dark brown about half way towards apex elytra becoming light brown. Tip of mandibles black, palps golden brown. Eyes brown. Scape and pedicel golden brown; antennal segments 3-7 or 3-8 pale brown at base but gradually becoming dark brown towards apex; antennal segments 8-11 or 9-11 dark brown or pale brown. Pro- and mesocoxal cavity bounded by dark edge; trochanter and apex of coxa creamy golden brown; base of femur whitish or pale brown, not bearing a dark ring at beginning of clubbed femur; tibia and tarsi golden brown throughout. Abdominal segments dark brown but often the last two visible segments light brown.

*Structure:* Head, prothorax and elytra silky dull, matt surface dorsally, body shiny ventrally. Pronotum with slightly wrinkly surface. Elytral apex rounded.

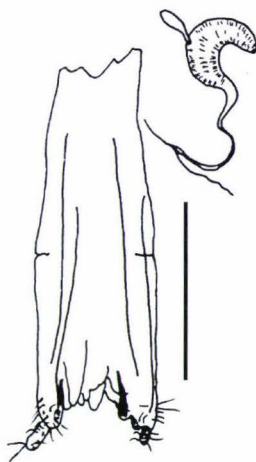
*Ovipositor & spermatheca:* Ratio of dorsal to ventral baculi being 1:1. Spermatheca sclerotised without sclerotised inner structure, strongly curved, bean-shaped widest towards middle and gradually tapering into a point towards apex. Spermathecal gland arising at around  $1/3$  of spermatheca length from base (Fig. 2.49).

*Variation:* Elytral spot is from a very small round spot to pear shaped, split into two, or a small transversely located band reaching or not reaching elytral margin; or no spot at all. Scape and pedicel may be dark brown.

## Biology

*Z. opacum* adults were found under a log, ex rotten log, on a leaf at night, in litter, beating broadleaf vegetation and bush, mixed shrub or forest. Plants swept or beaten were blackberry flowers and leaves, flax, of *Apium*, *Brachyclottis huntii*, *Coprosma*, *Muehlenbeckia australis*, *Myoporum laetum*, *Plagianthus*, *Plagianthus regius*, *Pseudopanax*. Others were collected on *Melicytus chathamicus* branch trap and by Malaise trap at bush edge in grass/*Muehlenbeckia* flat. Adults were reared from the following hosts: *Hebe barkeri*, *Myrsine* bark, *Myrsine chathamica* bole, *Myrsine coxii* boles and *Plagianthus*. Females were collected between 9 Nov. and 6 Mar., and males between 2 Nov. and 2 Mar. Development of collected non-adult stages ranges for females from 216-245 days and for males from 216-316 days.





**Figure 2.49** Ovipositor and spermatheca of *Z. opacum*. Scale bar 0.5 mm

#### Distribution

Main Island, Rekohu, and Wharekauri, Pitt Island (Rangiauria) and South East Island (Rangatira) of the Chathams Islands (Fig. 4.1).

#### Comments

Hind tarsi, right middle tibia, left antenna segments 9-11 are missing on lectotype. The locality of the specimen collected by Pascoe from Otago (93-60 BMNH) is questioned by Sharp (1903) in the original species description.

#### Material examined

*Lectotype*: *Z. opacum*, designated here. 1♀, Chatham Islands, collected by Prof. Schauinsland, labelled type by D. Sharp, Sharp coll. 1905-313. (BMNH).

*Paralectotype*: *Z. opacum*, designated here. 1♀, Chatham Islands, Sharp coll. 1905-313. (BMNH).

*Other material examined*: 67♀, 113♂. **Chatham Island**: 1♀, *Z. opacum*, Pascoe coll. 93-60, Otago, (BMNH). 1♀, Chatham Island, no date, Broun coll., A. E. Brookes Collection (NZAC). 1♂, 1♀, Chatham Island, Nov. 1959, L. J. Dumbleton (NZAC). 2♀, Chatham Islands, reared from *Hebe barkeri*, coll. 22 Feb. 1967, em. 24 Oct. 1967, G. Kuschel (NZAC). 2♀, 6♂, Chatham Island, Limestone Quarry, 11 Feb. 1967, G. W. Ramsay (NZAC). 1♀, 1♂, Chatham Island, Limestone Quarry, on bush, 11 Feb. 1967, G. Kuschel (NZAC). 2♂, Chatham Islands, ex *Myrsine coxii*, coll. 22 Feb. 1967, em. 19 & 24

Oct. 1967 & 3 Jan. 1968, G. Kuschel (NZAC). 1♀, Chatham Islands, Rotoparaoa, beating, 12 Feb. 1967 (NZAC). 1♀, 1♂, Chatham Island, Awatotara, beating, 16 Feb. 1967, J. S. Dugdale (NZAC). 8♂, Chatham Islands, Awatotara, beating bush & forest, 6-23 Feb. 1967, G. Kuschel (NZAC). 3♀, 3♂, Chatham Islands, Awatotara Valley, reared from *Myrsine coxii*, coll. 22 Feb. 1967, em. 25 & 28 Sept. 1967, J. S. Dugdale (NZAC). 2♀, Chatham Islands, Awatotara Valley, reared from dead boles *Myrsine coxii*, coll. 22 Feb. 1967, em. Oct., & 16 Oct. 1967, (W67/46) (NZAC). 2♀, Chatham Islands, Awatotara Valley, reared from dead boles *Myrsine coxii*, 1967, em. 27 Nov. 1967, (W67/46) (NZAC). 2♂, Chatham Islands, Awatotara, beating, 6-19 & 12 Feb. 1967, no collector (NZAC). 2♂, Chatham Islands, Awatotara, 22 Feb. 1967, no collector (NZAC). 1♂, Chatham Islands, Awatotara, no collector (NZAC). 2♂, Chatham Islands, Awatotara, ex dead *Myrsine chathamica* 21 Feb. 1967, no collector (NZAC). 1♂, 1♀, Chatham Islands, Awatotara Tableland, reared ex *Myrsine coxii*, em. 14 Nov. 1967, no collector, w67/46, one terminalia slide No. *Z. opacum* m-270700-7/8 (NZAC). 1♀, Chatham Islands, Waitangi, 6 Mar. 1967, G. W. Ramsay (NZAC). 1♂, Chatham Islands, Waitangi, Jan. 1946, J. Ardley (MONZ). 2♀, Chatham Islands, Wharekauri, swept ex blackberry flowers and leaves, 20 Jan. 1976, R. P. Macfarlane (NZAC). 1♀, Chatham Islands, Tuku Valley, coll. 22 Feb. 1967, em. 24 Oct. 1967, (W67/40) (NZAC). 1♂, Chatham Islands, Tuku Valley, reared from *Myrsine chathamica* bole, coll. 22 Feb. 1967, em. 25 Sept. 1967, J. S. Dugdale (NZAC). 2♂, Chatham Islands, Pt. Munning, Eastern Beach & Kaingaroa, litter, 28 Feb. 1967, A. K. Walker (NZAC). 1♂, Chatham Islands, Waipaua Scenic Reserve, Half Chain, beating *Brachyclottis huntii*, 16 Jan. 1990, R. M. Emberson, terminalia slide No. *Z. opacum* m-270700-4/8 (LUNZ). 3♂, Chatham Islands, Rangatira, beaten from vegetation, 28 Nov. 1992, P. Syratt (LUNZ). 1♂, Chatham Islands, Rangatira, beaten from *Myoporum laetum*, 30 Nov. 1992, J. W. Early, J. W. M. Marris (LUNZ). 2♂, Chatham Islands, Rangatira, one beaten from *Plagianthus regius* & one in forest, 28-29 Nov. 1992, R. M. Emberson, one terminalia slide No. *Z. opacum* m-270700-1/8 (LUNZ). 2♂, Chatham Islands, Rangatira, Malaise trap at bush edge in grass/*Muehlenbeckia* flat, 27-29 Nov. 1992, J. W. Early, R. M. Emberson, J. W. M. Marris, P. Syratt (LUNZ). 1♂, Chatham Islands, Kiawhata, 19 Jan.



1976, R. P. Macfarlane (NZAC). 2♂, Chatham Islands, Orchard Bluff Station, reared, em. 24 Oct. 1967, no collector, w67/49 (NZAC). **Pitt Island:** 1♀, 2♂, Chatham Island, Pitt 33., Broun coll., A. E. Brookes Collection (NZAC). 1♀, Chatham Islands, Pitt Island, 16-26 Jan. 1944, E. S. Gourlay, A. E. Brookes Collection (NZAC). 1♀, Chatham Islands, Pitt Island, 16-26 Jan. 1944, E. S. Gourlay (AMNZ 18847). 4♀, 15♂, Chatham Islands, Pitt Island, 16-26 Jan. 1944, E. S. Gourlay (NZAC). 1♀, Chatham Islands, Pitt Island, North Head, Orchard block, 30m, under log, 23 Nov. 1992, J. W. Early (AMNZ 1123). 1♀, 2♂, Chatham Islands, Pitt Island, Glory Reserve, beating broadleaf vegetation, 22 Jan. 1997, J. W. Marris (LUNZ). 1♀, Chatham Islands, Pitt Islands, Preece Covenant Bush, around caravan, 21 Jan. 1997, R. M. Emberson, one terminalia vial No. *Z. opacum* f-270700-5/8 (LUNZ). 1♀, Chatham Islands, Pitt Island, South End, 2 Mar. 1967, G. W. Ramsay (NZAC). 1♀, Chatham Islands, Pitt Island, on leaf at night, 27 Nov. 1992, J. W. W. Marris (LUNZ). 1♀, Chatham Islands, Pitt Island, beaten from mixed shrub, 28 Nov. 1992, R. M. Emberson (LUNZ). 1♀, Chatham Islands, Pitt Island, beaten from *Melicytus chathamicus* branch trap, 30 Nov. 1992, J. W. W. Marris & J. W. Early, terminalia vial No. *Z. opacum* f-270700-2/8 (LUNZ). 1♀, Chatham Islands, Pitt Island, ex rotten log, 16 Jan. 1997, R. M. Emberson & J. W. W. Marris (LUNZ). 2♀, 1♂, Chatham Islands, Pitt Island, reared from *Plagianthus* and *Myrsine* bark, coll. 26 Feb. 1967, em. 19 Oct., 6 & 30 Nov. 1967, G. Kuschel (NZAC). 1♀, Chatham Islands, Pitt Island, Tupuangi Creek, reared from *Myrsine* & *Plagianthus*, em. 5 Oct. 1967 (NZAC). 2♂, 1♀, Chatham Islands, Pitt Island, 33., G. Hall, Broun collection BM1922-482 (BMNH). 3♂, Chatham Islands, Pitt Island, 2 Mar. 1967, G. W. Ramsay Entomological Division DSIR (NZAC). 1♂, Chatham Islands, Pitt Island, Cannister Cove, beaten from flax and *Apium*, 26 Nov. 1992, P. Syrratt (LUNZ). 9♂, Chatham Islands, Pitt Island, Tupuangi Creek, reared from *Plagianthus* branch and *Myrsine* bark, coll. 24 & 26 Feb. 1967, em. 11, 18 & 21 Sept. 1967, J. S. Dugdale (NZAC). **South East Island:** 1♂, Chatham Islands, South East Island, 2 Nov. 1970, J. I. Townsend (NZAC). 15♀, 16♂, Chatham Islands, South East Island, 3 Nov. 1970, J. I. Townsend, terminalia vial No. *Z. opacum* f-270700-3/8 (NZAC). 3♀, 6♂, Chatham Islands, South East Island, beating & on *Pseudopanax*, 9 Nov. 1970, J. I. Townsend (NZAC). 1♀,



Chatham Islands, South East Island, *Muehlenbeckia australis*, 9 Nov. 1970, J. I. Townsend (NZAC). 1♀, 1♂, Chatham Islands, South East Island, 10 Nov. 1970, J. I. Townsend, terminalia vial No. *Z. opacum* f-270700-8/8 (NZAC). 4♀, 7♂, Chatham Islands, South East Island, 10-20m, beating *Coprosma*, 28 29 Nov. 1992, J. W. Early (AMNZ 11223, 11226, 11227, 11229, 11228, 11230, 11231, 11236, 11234, 11237, 11238). 2♀, 1♂, Chatham Islands, South East Island, 10-20m, beaten from *Muehlenbeckia* and *Plagianthus* 29 Nov. 1992, J. W. Early (AMNZ 11240, 11241, 11242).

*Zorion angustifasciatum*, new species

(Figs 2.21, 2.50, 2.51, 2.53b, 4.1)

Description

*Body length:* Male 3.8-5.45 mm, female 3.6-6.8 mm.

*Colour:* Body creamy golden brown throughout, translucent, with a white spot on each elytron. Elytral spot at least  $1.5 \times$  wider than long and transversely located, not touching suture and margin, and central axis through spot at right angle in relation to suture

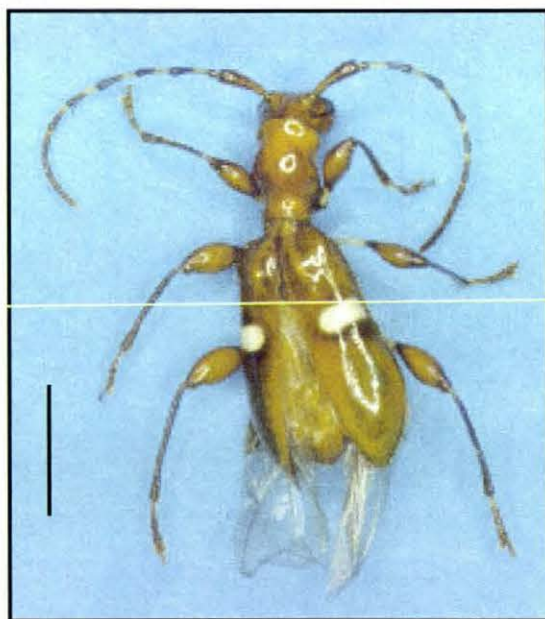
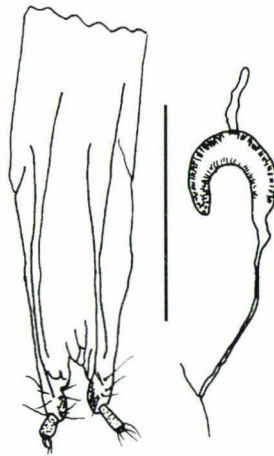


Figure 2.50 Dorsal view of *Z. angustifasciatum*. Scale bar 1 mm

(Figs 2.21 & 2.50); distance between spot and suture  $1.5-2 \times$  distance between spot and margin; distance between central axis of spot and elytral shoulder  $0.37-0.5 \times$  elytron length. Palps creamy golden brown. Eyes black. Scape creamy golden brown sometimes with darker apex; pedicel dark brown; antennal segments 3-7 or 3-8 whitish at base but gradually becoming dark brown towards apex; antennal segments 8-11 or 9-11 dark brown. Pro- and mesocoxal cavity bounded by dark edge; trochanter and apex of coxa dark; base of femur whitish with dark ring at beginning of creamy golden brown club; tibia dark brown throughout; tarsi creamy golden brown at base, darkening towards apex. Abdominal segments creamy golden brown.

*Structure:* Body surface glabrous, glossy. Elytral apex pointed. Females with a row of hairs on epipleural fold not reaching beyond anterior edge of spots, males without such hairs on epipleural fold.

*Ovipositor & spermatheca:* Ratio between dorsal to ventral baculi being 1:1.1. Spermatheca sclerotised but transparent, U-shaped widest halfway between base and apex gradually tapering towards apex. Spermathecal gland arising halfway between base and apex (Fig. 2.51).



**Figure 2.51** Ovipositor and spermatheca of *Z. angustifasciatum*. Scale bar 0.5 mm

*Variation:* Body darkens gradually towards head, translucent cuticle sometimes appears interspersed with dark grain in particular in the pronotum. Palps may appear dark

golden brown. Spot on elytral disc may be with or without or partially surrounded by darker area. Tibia may have creamy golden brown base and section in the middle.

### Biology

Adults were collected from *Cordyline* flowers and from *litsea*. Adults were raised from of *Myoporum laetum*. Specimens were collected throughout November.

### Distribution

Great and South West Island approx. 4 km south west of Great Island of the Three Kings Islands (*Manawa Tawhi*), which are approx. 80 km north west of Cape Reinga (*Te Rerengawairua*). I could find no record for any specimens collected from Princess Islands, West Island and North East Island of the Three Kings Islands (Fig. 4.1).

### Etymology

Latin for narrow band referring to the narrow elongate spots on the elytra.

### Material examined

*Holotype*: *Zorion angustifasciatum*. 1♀, Great Island, Three Kings Islands, on *Cordyline kaspar* flowers, 27 Nov. 1997, R. E. Beever (NZAC).

*Paratypes*: *Zorion angustifasciatum*. 22♀, 26♂. **TH**: 14♂, 11♀, Tasman Valley, Great Island, Three Kings Islands, *Cordyline* flowers, 1 Nov. 1970, J. C. Watt, terminalia slide No. *Z. angustifasciatum* m-270600-2/2, terminalia slide No. *Z. angustifasciatum* m-240500-6/8, terminalia vial No. *Z. angustifasciatum* f-230500-5/8, terminalia vial No. *Z. angustifasciatum* f-230500-6/8 (NZAC). 2♀, 1♂, Tasman Valley, Great Island, Three Kings Islands, 1 Nov. 1970, J. C. Watt, terminalia vial No. *Z. angustifasciatum* f-260600-1/2 (NZAC). 2♀, 4♂, Tasman Valley, Great Island, Three Kings Islands, 1 Nov. 1970, terminalia vial No. *Z. angustifasciatum* f-260600-2/2, terminalia slide No. *Z. angustifasciatum* m-240500-5/8 (NZAC). 1♂, Tasman Valley, Great Island, Three Kings Islands, *Coprosma macrocarpa*, 1 Nov. 1970, J. C. Watt (NZAC). 1♂, Tasman Valley, Great Island, Three Kings Islands, on *Cordyline*, 30 Nov. 1983, C. F. Butcher (NZAC). 1♂, Great Island, Three Kings Islands, beating, 30 Nov. 1983, C. F. Butcher (NZAC). 2♂, Great Island, Three Kings Islands, on *Cordyline kaspar* flowers, 29 Nov. 1997, R. E.



Beever (NZAC). 1♀, Great Island, Three Kings Islands, 3 Jan. 1963, E. S. Gourlay, terminalia vial No. *Z. angustifasciatum* f-230500-4/8 (NZAC). 1♀, Great Island, Three Kings Islands, beating, 28-29 Nov. 1983, J. C. Watt (NZAC). 2♀, Great Island, Three Kings Islands, on *Cordyline kaspar* flowers, 27 & 29 Nov. 1997, R. E. Beever (NZAC). 1♀, Castaway Camp, Great Island, Three Kings Islands, 1 Nov. 1970, G. Ramsay (NZAC). 2♀, 1♂, Castaway Camp, Great Island, Three Kings Islands, ex. *Myoporum laetum*, & on *Litsea*, 1 Nov. 1970, G. Kuschel, terminalia slide No. *Z. angustifasciatum* m-270600-1/2 (NZAC). 1, Great Island, 6 Oct., L. C. Bell (18834 AMNZ). 1♂, South West Island, Three Kings Islands, 1 Nov. 1970, J. C. Watt (NZAC).

### *Zorion dugdalei*, new species

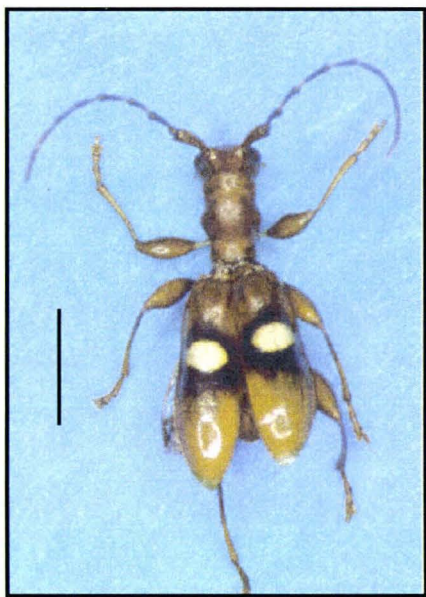
(Figs 2.23, 2.52, 2.53a, 2.54, 4.1)

#### Description

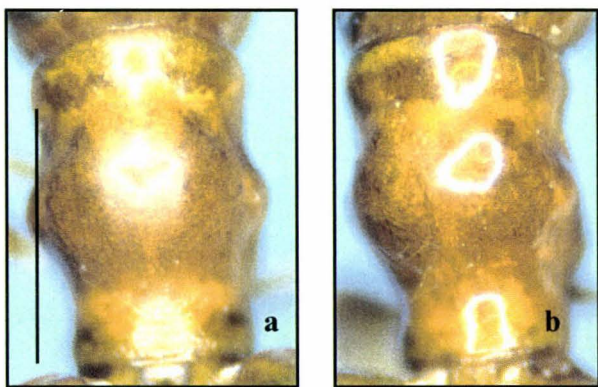
*Body length*: Male 4.24-5.15 mm, female 5 mm.

*Colour*: Body orange-brown, with a white spot on each elytron. Elytral spot large, egg-shaped, between 1.2 and 1.4 × wider than long and transversely located, not touching suture and margin; central axis through spot at right angle in relation to suture (Fig. 2.23 & 2.52); spot surrounded by dark brown area; distance between spot and suture 1-1.5 × the distance between spot and margin; distance between central axis of spot and elytral shoulder 0.38-0.41 × of elytron length. Palps orange-brown. Eyes black. Scape, pedicel orange-brown; antennal segments 3-7 orange-brown at base but gradually becoming dark brown towards apex; antennal segments 8-11 dark brown. Elytra orange-brown, becoming slightly darker anteriorly. Pronotum and head orange-brown. Ventral side of meso-, metathorax, as well as coxa and trochanter slightly darker than remainder of body. Base of femur whitish, club orange-brown with a faint dark ring; tibia and tarsi orange-brown throughout. First two abdominal segments dark brown, remaining visible three abdominal segments orange-brown.

*Structure:* Dorsal surface at base of head and pronotum (Fig. 2.53a) glabrous and silky dull, remainder of body shiny. Anterior surface of elytra slightly wrinkled, glabrousing out centrally and posteriorly. Apex of elytra pointed. Females with hairs on anterior epipleural fold, males without such hairs.



**Figure 2.52** Dorsal view of *Z. dugdalei*. Scale bar 1 mm



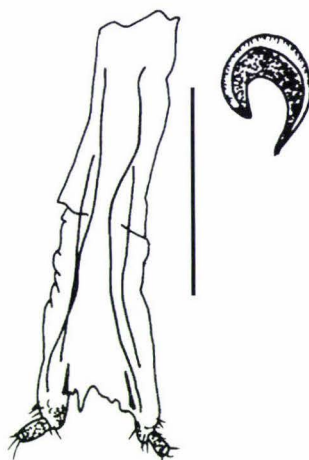
**Figure 2.53** Dorsal view of Pronotum. a) *Z. dugdalei* in comparison to b) *Z. angustifasciatum*. Scale bar 1 mm

*Ovipositor & spermatheca*: Ratio of dorsal to ventral baculi being 1:1.75. Spermatheca sclerotised, strongly curved, widest at middle section tapering into a stronger sclerotised point apex, with a second, similar shaped sclerotised structure inside. Spermathecal gland arising at about 1/3 of spermathecal length from base (Fig. 2.54).

*Variation*: Overall appearance of body may vary from darker orange-brown to brown.

### Biology

Adults were collected from an unspecified flower and from a Malaise trap in a *Beilschmiedia tarairi* site. One specimen was attracted to light. All specimens were collected between 10 and 16 Nov.



**Figure 2.54** Ovipositor and spermatheca of *Z. dugdalei*. Scale bar 0.5 mm

### Distribution

Aorangi Island, Poor Knights Islands (Fig. 4.1).

### Comments

This species needs further investigation to establish flowers visited and host plants on Poor Knights Island. The period of occurrence could not be established due to a lack of available specimen. One male was attracted to light, which could suggest some night activity or the specimen was resting close by and the light disturbed the beetle.



## Etymology

This new species is named in honour of Dr. J. S. Dugdale, who collected the types.

## Material examined

*Holotype*: *Z. dugdalei* designated here. 1♂, Aorangi Island, Poor Knights Islands, attracted to light, 10 Nov. 1981, J. S. Dugdale (NZAC).

*Paratype*: *Z. dugdalei* designated here. 1♂, 1♀. **ND**: 1♀ Aorangi Island, Crater Bay, Poor Knights Islands, of flowers, 16 Nov. 1981, J. S. Dugdale, terminalia vial No. *Z. dugdalei* f-130301-1/2 (NZAC). 1♂, Aorangi Island, Puweto V. 80 m, Poor Knight Islands, Malaise trap in *Beilschmiedia tarairi* site, 11-16 Nov. 1981, J. S. Dugdale, terminalia slide No. *Z. dugdalei* m-130301-2/2 (NZAC).

*Zorion taranakiensis*, new species

(Figs 2.27, 2.55, 2.56, 4.1)

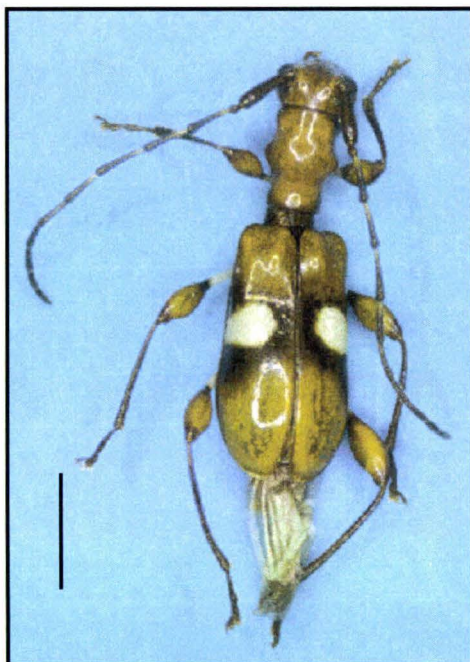
## Description

*Body length*: Male 3.8-5 mm, female 3.9-5.8 mm.

*Colour*: Body light golden brown throughout, with a white spot on each elytron. Elytral spot as long as wide, pear-shaped, not touching elytral suture but almost reaching margin, and central axis through spot at right angle in relation to midline (Figs 2.27 & 2.55); distance between spot and suture  $2.25-2.5 \times$  the distance between spot and margin; distance between central axis of spot and elytral shoulder  $0.40-0.45 \times$  elytral length. Palps golden brown. Eyes black. Scape red golden brown with dark brown apex, pedicel dark brown, antennal segments 3-6 whitish at base but gradually becoming dark brown towards apex; antennal segments 7-11 dark brown. Pro- and mesocoxal cavity bounded by dark edge; trochanter and apex of coxa dark; base of femur whitish, with dark ring at beginning of golden brown club; tibia dark brown throughout; tarsi red golden brown. First two abdominal segments dark brown and remainder light golden brown.

*Structure*: Surface of body glabrous, glossy. Elytral apex rounded. Female with a few hairs on epipleural fold, male without such hair.

*Ovipositor & spermatheca* (Fig. 2.56): Ratio of dorsal to ventral baculi being 1:1.1. Spermatheca sclerotised, bean-shaped, widest at about 1/3 of spermathecal length from base, gradually tapering towards stronger sclerotised apex. Spermathecal gland arising at 0.33 of spermathecal length from base



**Figure 2.55 Dorsal view of *Z. taranakiensis*. Scale bar 1 mm**

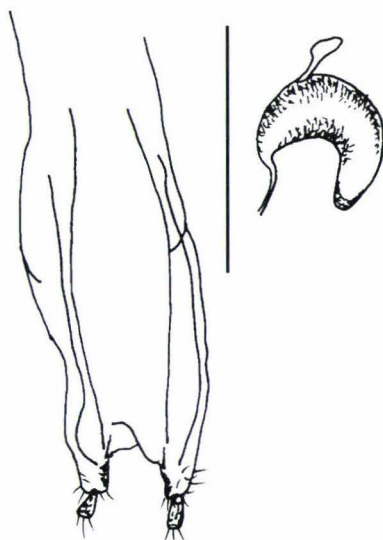
*Variation:* The elytral spot is up to  $1.35 \times$  wider than long, not reaching elytral margin; spot may be almost of circular shape or eight-shaped or central axis may be on a forward angle; the spot may be surrounded with or without dark field. The scape may be golden brown at base, gradually turning red golden brown towards apex; the pedicel may be red golden brown; the antennal segments 3-8 may be whitish at base and the remaining segments dark brown or the antennal segments 3-10 maybe whitish at base and segment 11 dark brown through out. The femur may be dark orange-brown and the dark ring therefore not visible or the dark ring is fading on light golden brown femur. The trochanter may be golden brown like the coxa. The tibia and the tarsal segments maybe whitish at base darkening towards apex. The first three abdominal segments maybe dark brown compared to the last two visible golden brown abdominal segments.

## Biology

Adults were collected from *Weinmannia racemosa* flowers. All specimens collected on 29 Nov.

## Distribution

Western slopes of Mt. Taranaki of North Island(Fig. 4.1).



**Figure 2.56** Ovipositor and spermatheca of *Z. taranakiensis*. Scale bar 0.5 mm

## Etymology

Referring to the species' distribution at Mt Taranaki.

## Material examined

*Holotype*: *Z. taranakiensis*. 1♀, Mt Taranaki, Western slopes, 400m, *Weinmannia racemosa* flowers, bush remnant, 29 Nov. 1981, K. J. Fox (NZAC).

*Paratypes*: *Z. taranakiensis*. **TK**: 12♂, 6♀, Mt Taranaki, Western slopes, 400m, *Weinmannia racemosa* flowers, bush remnant, 29 Nov. 1981, K. J. Fox, terminalia slide No's *Z. taranakiensis* m-240500-7/8 & *Z. taranakiensis* m-240500-8/8, terminalia vial No's *Z. taranakiensis* f-230500-7/8 and *Z. taranakiensis* f-230500-8/8, wing slide number *Z. taranakiensis* f-230500-8/8w (NZAC).



*Zorion kaikouraiensis* new species

(Figs 2.22, 2.57, 2.58, 4.1)

## Description

*Body length:* Male 3.78-5.45 mm, female 3.93-5.45 mm.

*Colour:* Head, thorax, elytra and abdomen dark orange purple, with a yellow golden spot on each elytron. Coxa, trochanter, femur, tibia and tarsal segments light orange-brown; femur without dark ring (Fig. 2.57). Elytral spot (Figs 2.22 & 2.57) as wide as long and pear-shaped, not reaching elytral suture but reaching margin; spot not surrounded by distinct darker area. Central axis of spot at a slight backward angle in relation to suture. Mandibles, labrum and palps light orange-brown. Eyes orange-brown. Scape and pedicel light orange-brown; at least antennal segments 3-10 light orange-brown at base but gradually becoming dark brown towards apex. Pro- and mesocoxal cavity bounded by dark edge.

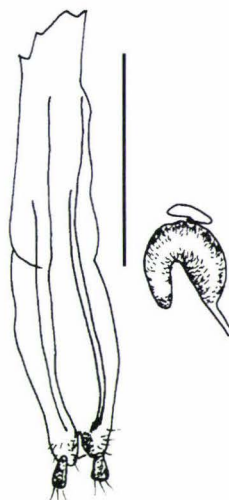


**Figure 2.57** Dorsal view of *Z. kaikouraiensis*. Scale bar 1 mm

*Structure:* Surface of body glabrous, glossy. Elytra with rounded apex. Female with few hairs above epipleural fold and a row of hairs on anterior epipleural fold not reaching beyond centre line of spots, male without such hairs.

*Ovipositor & spermatheca*: Ratio of dorsal to ventral baculi being 1:1.4. Spermatheca sclerotised, hook-shaped widest near base and gradually narrowing into a point at the apex, apex more sclerotised. Spermathecal gland arising between 0.33 to 0.5 spermathecal length from base (Fig. 2.58).

*Variation*: Body may appear purple-brown. Elytra may be light orange-brown posteriorly, medium orange-brown anteriorly with dark orange-brown pronotum, or elytra may be same colour as pronotum throughout. Sometimes only antennal segments 3-8 are light orange-brown at base and segments 9-11 dark brown, pedicel may be dark purple brown. Central axis through spot may be at right angle in relation to midline, spot may appear almost round or square-shaped.



**Figure 2.58** Ovipositor and spermatheca of *Z. kaikouraiensis*. Scale bar 0.5 mm

#### Biology

Specimens were collected between 12 Nov. and 11 Apr., and were found on rhubarb flowers, on *Himalayan buddlia*, in a Malaise trap, and at light.

#### Distribution

Restricted to the Kaikoura region along the east coast on South Island(Fig.4.1).

#### Etymology

Referring to the species' restricted distribution in the Kaikoura region.

## Material examined

*Holotype*: *Zorion kaikouraiensis*. 1♀, Puhi Puhi Res., South Island, 3-6 Dec. 1957, M. J. Essen (NZAC).

*Paratypes*: *Z. kaikouraiensis*. 19♂, 17♀. **KA**: 1♂, Clarence River, 15 Nov. 1932, G. V. Hudson, 19448-525 (BMNH). 2♀, Half Moon Bay, Ohau Stream Walk, at light, RL495, 41°15' S, 173°50'E, 17 Nov. 1999, R. Leschen & R. Hoare (NZAC). 9♂, 8♀, Puhi Puhi Res., South Island, 3-6 Dec. 1957, M. J. Essen (NZAC). 1♂, 1♀, Puhi Puhi Res., South Island, 3-6 Dec. 1957, E. S. Gourlay, terminalia slide number *Z. kaikouraiensis* m-140800-5/6, terminalia vial number *Z. kaikouraiensis* f-140800-6/6 (NZAC). 5♂, 2♀, Kaikoura, Marlborough, South Island, 11 Jan. 1953, E. Fairburn terminalia slide number *Z. kaikouraiensis* m-140800-4/6 (WMNZ). 1♂, Oaro, Malaise trap, 21-27 Mar. 1983, J. W. Early (LUNZ). 1♀, Oaro, 11-13 Nov. 1968, Entom. Staff Field Trip (LUNZ). 1♀, Oaro, 10 Mar. 1984, P. Darragh (LUNZ). 1♀, Oaro, 11 Apr. 1984, P. Elliott (LUNZ). 2♂, Conway Flats, South Island, rhubarb flowers, 12 Nov. 1969, R. Macfarlane (NZAC). 1♀, Ngaroma, Parnassus, Nth. Canterbury, ex Himalayan buddlia, Nov. 1966, R. Macfarlane (NZAC).

*Zorion australe*, new species

(Figs 2.28, 2.59, 2.60, 4.1)

## Description

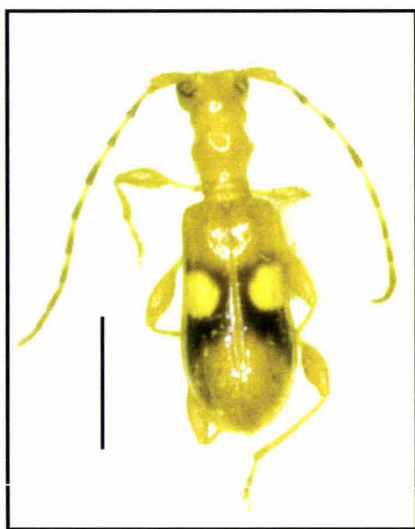
*Body length*: Male 3.93-6.96 mm, female 3.93-7.12 mm.

*Colour*: Body orange-brown throughout with a yellowish golden spot surrounded by dark brown area on each elytron (Fig. 2.59). Elytral spot at most  $1.8 \times$  wider than long, transversely located and not touching elytral suture but reaching margin, central axis through spot at right angle in relation to suture (Figs 2.28 & 2.59). Distance between central axis of spot and elytral shoulder  $0.31\text{--}0.61 \times$  elytral length. Palps orange-brown. Eyes black. Scape and pedicel orange-brown; at least antennal segments 3-10 orange-brown at base but gradually becoming dark brown towards apex. Pro- and mesocoxal cavity anteriorly bounded by dark edge; coxa and trochanter orange-brown; femur whitish



at base, club orange-brown without dark ring; tibia and tarsi orange-brown. First 3 abdominal segments almost black.

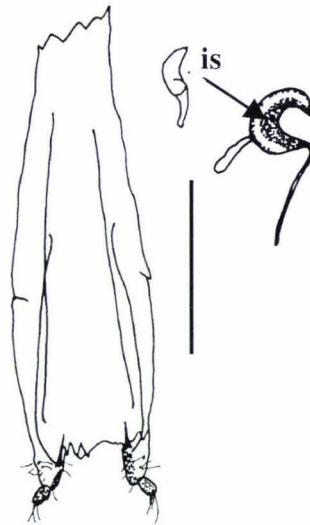
*Structure:* Body surface glabrous, glossy. Elytral apex rounded. Female with 2 or more hairs on epipleural fold and none to very few hairs above epipleural fold, male without such hairs.



**Figure 2.59** Dorsal view of *Z. australe*. Scale bar 1mm.

*Ovipositor & spermatheca:* Ratio between dorsal to ventral baculi being 1:1.2. Spermatheca sclerotised, hook-shaped, widest at base tapering into point towards more sclerotised apex with an inner sclerotised structure (Fig. 2.60). Spermathecal gland arising about 0.33 of spermathecal length from base.

*Variation:* Body may be light yellow-brown, brown, or dark brown throughout; scape and pedicel may be light brown or dark brown; antennal segments 3-11 may be light brown or 3-8 light yellow-brown at base but gradually darkening towards apex sometimes with segment 11 light brown at base and apex but being darker in the middle, or segments 9-11 may be light yellow-brown. Trochanter may be darker brown than clubbed part of femur; tibia may light brown or dark brown or dark brown at base and apex gradually lightening towards middle. Elytral spot may be more whitish yellow; spot maybe pear-shaped or almost round, and spots maybe at a forward or backward angle in relation to suture. Eyes may be orange-brown. Only first two abdominal segments almost black. Male at most two hairs on epipleural fold.



**Figure 2.60** Ovipositor and spermatheca of *Z. australe*; is, inner sclerotised structure removed. Scale bar 0.5 mm.

### Biology

*Z. australe* ♂ adults were collected between 9 Oct. and 30 Mar. and ♀ adults between 4 Oct. and 30 Mar. However, the 30 March was the last date of a Malaise trap catch that lasted from 9-30 Mar. Specimens were trapped by Malaise trap in kanuka coastal forest and in coastal forest *Kunzia*. Adults were also found by beating the following plants: *Carpodetus*, *Coprosma*, *Fuschia excorticata*, *Hebe* spp., *Hebe elliptica*, *Hebe stricta*, *Leptospermum*, *Muehlenbeckia* flowers, *Myrsine montana*, *Neopanax arboreum*, *Nothofagus menziesii*, dead *Nothofagus truncata* branches, *Olearia colensoigrandis*, *Pseudopanax edgerleyi*, *Rubus*, *Schefflera*, *Senecio* flower, *Stilbocarpa*, *Weinmannia*, broadleaved vegetation, at a forest edge, in second growth bush & at night. Sweeping vegetation resulted in specimens collected from long grass, native bush, fir tree in coastal bush, scrub/undergrowth in kanuka forest, *Blechnum*, *Olearia rani* flower, *Podocarpus*. Further specimens were collected from *Cordyline*, *Crataegus* flower, fennel, *Nothofagus* forest, *Persea americana* flower, ragwort, scotch thistles, flower heads of wild carrot, rotten wood, shopping bag.

Adults emerged from *Dracophyllum*, *Olearia arborescens*, *Pittosporum*, *Pittosporum eugenoides* & *Pseudopanax*. Adults also emerged on 22 Oct. from small *Hedycarya* branches collected on 6 May and other adults were removed on 7 July the following year, it

is not stated whether removed adults were dead or alive. Adults emerged from small rimu branches collected 6 May on 18 Oct. & 28 Oct. the year after and emerged on 26 Oct. from dead *Cassinia* stems collected on 21 Oct.. Adults emerged on 4 & 22 Jan. from *Rubus australe* collected on 21 Oct. the previous year, from unknown material collected on 21 Oct. adults emerged in Nov./Dec. and from dead *Nothofagus solandri* branches collected on 22 Oct. adults emerged the same year 25, 27, 30 Oct. & 2 Nov. the following year. Adults also emerged from *Dacrydium cupressinum* on 26 Nov. The records do not state under which light phase the adults were reared.

### Distribution

This species' distribution (Fig. 4.1) ranges with very few specimen collected from the Wairarapa and Wellington region on North Island through the Marlborough Sounds, Marlborough and Nelson regions on South Island. The distribution then extents southwards along the west coast of South Island through the Buller, Mackenzie, Westland and Otago Lakes regions. The species' distribution in the southern part of South Island ranges from west to east through the Central Otago, Dunedin, Fordland, Southland and Stewart Island regions.

### Etymology

Latin referring to the species' distribution on South Island.

### Material examined

*Holotype*: *Zorion australe*. 1♂, Momorangi Bay, Okiwa Bay (SD), beating *Pomaderris* sp., 19 Dec. 1999, F. R. Schnitzler (NZAC).

*Paratypes*: *Zorion australe*. 1♀, 1♂, Picton, Marlborough, 12 Jan. 1953, E. Fairburn (WMNZ). 1♂, Moeraki, 1 Feb. 1983, J. S. Dugdale (NZAC). 1♀, Nelson, Aniseed Valley, coll. on 22 Oct. 1972, reared from dead branches *Nothofagus solandri*, emerged 2 Nov. 1973, G. Kuschel (NZAC). 4♂, Anakiwa, Okiwa Bay, beating *Pomaderris*, 20 Dec. 1999, F. R. Schnitzler, terminalia slide No. *Z. australe* m-280200-2/5(AMNZ), *Z. australe* m-290200-1/2 (BPBM), (FRNZ, NZAC). 2♂, Momorangi Bay within Okiwa Bay, beating *Pomaderris*, 19 Dec. 1999, F. R. Schnitzler (LUNZ, MONZ). 1♂, Hira, Tealsaddle, coll.



21 Oct. 1972, em. Nov./Dec. 1972, J. S. Dugdale (NZAC). 1♀, Queen Charlotte Sound, Bay of Mary Coves, ex flight intercept trap in *Kunzia* / coastal forest, 26 Dec. 1992-6 Jan. 1993, J. W. M. Marris (LUNZ). 1♀, Cobb R., 914m, *Hebe* flowers, 10 Feb. 1985, M. H. Bowle (LUNZ). 1♂, Nelson, Lee Valley, on scotch thistles, 17 Nov. 1967, C. Lackner (CMNZ). 1, Dun Mt. Track, 2 Jan. 1947, G. Ramsay (MONZ). 2♀, 2♂, Lake Rotoiti, 18 Jan. 1976, W. J. Knight, B. M. 1976-572 (BMNH). 1♂, 1♀, Dunedin, 1 Jan. 1953, E. Fairburn (WMNZ). 1♂, Dunedin, Woodhaugh, 17 Dec. 1996, H. & B. & H. Patrick (JNNZ). 1♀, Dunedin, Broadleaf F, 23 Feb. 1976, A. C. Harris (OMNZ). 1♂, Otago, Feb. 1984 (OMNZ). 1♀, Cape Farewell, 2 Nov. 1996, B. H. Patrick (JNNZ). 1♀, Mistletoe Bay, beaten from bush, 13 Feb. 1985, D. R. Penman (LUNZ). 1♀, Stewart Island, Rakeahua Valley, 19 Feb. 1968, G. Kuschel (NZAC).

*Other material examined:* 232♂, 225♀, 8 unknown sex (covered in mould and dust).  
**WA:** 1♀, 2♂, Balance Reserve, on *Brachyclottis*, 20 Oct. 1983, J. S. Dugdale (NZAC).  
**WN:** 1♂, 2 km south of Paekakariki, rest area hill side, 13 Nov. 1977, E. Schlinger (NZAC). **NN:** 1♂, Kaihoka Lakes Rd., 22 Nov. 1977, *Nothofagus fusca*, E. Schlinger (NZAC). 1♂, Cape Farewell, 2 Nov. 1996, B. H. Patrick (JNNZ). 2♂, Kaituna, Collingwood, *Hedycarya* small branches & dead twigs, 6 May 1965, removed 7 Jul. 1966, J. I. Townsend (NZAC). 3♀, Kaituna, Collingwood, 6 May 1965 collected small branches of Rimu, emerged 18 Oct. 1966 & 28 Oct. 1966 J. I. Townsend (NZAC). 1♂, Kaituna, Collingwood, *Hedycarya* small branches & twigs, 6 May 1965, emerged 22 Oct. 1965, J. I. Townsend (NZAC). 1♂, Collingwood, Ft. of Mt. Barnett, *Podocarpus*, 26 Oct. 1965, J. I. Townsend (NZAC). 1♀, Nelson, Collingwood, on fennel, 23 Oct. 1965, G. J. H. (NZAC). 2♀, Nelson, 6 Jan. 1921, R. J. Tillyard (NZAC). 1♀, Takaka, Pigeon Saddle, 1 Feb. 1945 (NZAC). 1♂, near Puponga, 2 Nov. 1996, B. H. Patrick (JNNZ). 1♂, Parkers Farm, 88 Valley, 19 Dec. 1972, N. A. Martin (NZAC). 1♀, 1♂, Cobb Valley, 840m, Cobb R. track, 11 Feb. 1985, J. S. Ensor (LUNZ). 1♂, 1♀, Cobb R., 914m, *Hebe* flowers, 10 Feb. 1985, M. H. Bowle (LUNZ). 1♀, Nelson, Riwaka Valley, 28-31 Jan. 1949, A. E. Brookes (NZAC). 1♀, Riwaka Valley, 13 Nov. 1962, A. K. Walker (NZAC). 2♂, Riwaka V., Moss's Bush 20 Nov. 1969, J. S. Dugdale (NZAC). 1♂, Hira, Tealsaddle, 21 Oct. 1972, ex

*Rubus australis*, emerged 22 Jan. 1973, J. S. Dugdale (NZAC). 1 unknown sex, 1♀, Hira, Tealsaddle, coll. 21 Oct. 1972 *Rubus australis*, em. 4 Jan. 1973, J. S. Dugdale (NZAC). 11♀, 15♂, Hira, Tealsaddle, coll. 21 Oct. 1972, em. Nov./Dec. 1972, J. S. Dugdale (NZAC). 1♂, flanks of the Doubles Hira SF, reared, 24 Oct. 1972 J. S. Dugdale (NZAC). 1♀, Appleby Road, ex tree, 1 Nov. 1968, A. Ferguson (NZAC). 2♂, West Nelson, Canan, Dec. 1949, O'Connor (NZAC). 1♂, Nelson City, 21 Oct. 1968 in dead *Cassinia* stems, emerged 26 Oct. 1968, G. Kuschel (NZAC). 19♂, 11♀, 2 unknown sex, Nelson, Aniseed Valley, coll. on 22 Oct. 1972, reared from dead branches *Nothofagus solandri*, emerged 25, 27, 30 Oct. 1972, 2 Nov. 1973, G. Kuschel (NZAC). 3♂, 2♀, Nelson, Aniseed Valley, beating *Nothofagus menziesii*, 14 Jan. 1976, A. K. Walker (NZAC). 1♀, 1♂, Aniseed Valley, sweeping long grass, 24 Nov. 1949, A. W. Parrot (NZAC). 1♀, 2♂, Aniseed Valley, sweeping long grass, 24 Nov. 1949, A. Carson (NZAC). 1♀, Nelson, Wakapuaka, on Horthorn hedge, 10 Oct. 1949, Anirs. (NZAC). 1♀, Aniseed Valley, sweeping native bush, 24 Oct. 1949, A. Carson (NZAC). 1♀, 1♂, Nelson, 12 Nov. 1922, R. Mayson (NZAC). 2♀, Nelson, 4 Oct. 1922, E. S. Gourlay (NZAC). 4♀, Nelson, 13 Dec. 1951, E. S. Gourlay (NZAC). 1♂, Nelson, 12 Dec. 1951, E. S. Gourlay (NZAC). 4♂, Nelson, 10, 12, 13 Dec. 1951, E. S. Gourlay (NZAC). 1♀, Nelson, Maitai Valley, sweeping grass, 15 Jan. 1976, A. K. Walker (NZAC). 1♀, Nelson, 4 Nov. 1920, A. Philpott (NZAC). 1♀, Nelson, 4 Nov. 1922, A. Philpott (NZAC). 2♀, 1♂, Nelson, Lee Valley, on scotch thistles, 17 Nov. 1967, C. Lackner (CMNZ). 2♂, Graham V., Nelson, *Olearia rani* flowers, 21 Nov. 1969, J. I. Townsend, B. M. May & J. N. Jolly (NZAC). 2♂, Nelson, Track to Boulderslake, *Nothofagus*, 27 Nov. 1965, J. I. Townsend (NZAC). 1♂, Nelson, Paturau, 11 Jan. 1966, A. K. Walker (NZAC). 3♂ Nelson, Cawthron Pk., Matai, *Blechnum*, 14 Feb. 1943 (NZAC). 1♂, Nelson, Wakapuaka, Atawhai, 7 Dec. 1966, J. B. Walker (NZAC). 1♂, 1♀, Dun mountains, 600m, R. A. Cumber Collection, 6 Feb. 1973, B. A. Holloway (NZAC). 1♀, Dun Mt., 600m, 14 Dec. 1921, A. Philpott (NZAC). 1♀, Dun Mt., 15. 12. 1962, G. Kuschel & B. A. Holloway (NZAC). 3♂, Dun Mt., 600m, 2 Nov. 1920, 9 Feb. 1921, 23 Feb. 1921, A. Philpott (NZAC). 1♂, (?)Dunn (?)Mt., 24 Feb. 1962, G. Kuschel (NZAC). 4♂, 3♀, Richmond, long grass, cabbage field, A. W. Parrot (NZAC). 1♀, nr



Richmond, *Persea americana* flower, Nov. 1981, R. P. Macfarlane (NZAC). 1♂, Maitai Valley, *Schefflera*, 17 Feb. 1965 J. I. Townsend (NZAC). 1♂, Lake Rotoiti, 7 Feb. 1965, A. K. Walker (NZAC). 6♂, 7♀, Lake Rotoiti, 600m, sweeping *Nothofagus* forest, 27 Dec. 1984, A. K. Walker (NZAC). 7♀, 12♂, Lake Rotoiti, 610m, sweeping *Hebe* flowers, beating, *Pittosporum eugenioides* & *Pseudopanax*, 18 Jan. 1976, A. K. Walker (NZAC). 1♂, Westport, Nelson 9 Oct. 1969, J. I. Townsend (NZAC). 1♀, Westport, Island creek area, swept Fir tree, 28 Oct. 1970 (LUNZ). **SD**: 2♀, D'Urville Island, Kapowai, *Muehlenbeckia australis*, 17 Feb. 1971, G. Kuschel (NZAC). 1♀, 6♂, D'Urville Island, Mt. Attempt, 520 m, *Hebe* sp., 27 Feb. 2000, J. S. Dugdale, terminalia slide No. *Z. australe* m-140300-7/7, terminalia vial No. f-220300-1/2 (NZAC). 1♀, Opouri, beating flowering scrub, 14 Jan. 1968, J. C. Watt (NZAC). 1♀, Marlborough Sounds, 12 Nov. 1959, C. & G. Laurie (NZAC). 2♀, Rarangi, Whites Bay, RL 466, 41°24', 174°03'E, 14 Nov. 1999, R. Leschen, R. Hoare (NZAC). 2♀, 3♂, Anakiwa, Okiwa Bay, beating *Pomaderris*, 20 Dec. 1999, F. R. Schnitzler, terminalia slide No. *Z. australe* m-280200-1/5, *Z. australe* m-280200-3/5, *Z. australe* m-280200-4/5, terminalia vial No. *Z. australe* f-290200-2/2, *Z. australe* f-280200-5/5 (NZAC). 5♀, 2♂, Momorangi Bay within Okiwa Bay, beating *Pomaderris*, 19 Dec. 1999, F. R. Schnitzler, terminalia slide No. *Z. australe* m-130300-1/2, terminalia vial No. *Z. australe* f-150300-1/2, *Z. australe* f-200300-1/2, *Z. australe* f-200300-2/2, *Z. australe* f-210300-1/2, *Z. australe* f-210300-2/2 (NZAC). 6♂, 8♀, Okiwi Bay, Malaise trap second growth bush, Nov. 1983, G. Simpson, terminalia slide No. *Z. australe* m-130300-2/2, *Z. australe* m-140300-1/7, *Z. australe* m-140300-2/7, *Z. australe* m-140300-3/7, terminalia vial No. *Z. australe* f-150300-2/2, *Z. australe* f-140300-4/7, *Z. australe* f-230300-1/2, *Z. australe* f-300300-1/2, *Z. australe* f-300300-2/2, (NZAC). 2♂, Whangamoia, *Pseudopanax* & *Neopanax arboreum*, 13 Dec. 1963, G. Kuschel (NZAC). 3♀, Queen Charlotte Sound, Whatamango Bay, sweeping *Clematis* sp., 6 Feb. 1976, J. S. Dugdale, terminalia vial No. *Z. australe* f-140300-6/7, *Z. australe* f-220300-2/2, *Z. australe* f-230300-2/2 (NZAC). 1♂, Queen Charlotte Sound, Bay of Mary Coves, Malaise trap kanuka coastal forest, 4-31 Jan. 1992, J. W. M. & W. A. Marris (LUNZ). 2♀, Queen Charlotte Sound, Bay of Mary Coves, beaten from dead *Nothofagus truncata* branch, 6 Jan.



1983, J. W. M. Marris (LUNZ). 1♀, Queen Charlotte Sound, Bay of Mary Coves, swept from scrub/undergrowth in kanuka forest, 29 Dec. 1991, J. W. M. Marris (LUNZ). **MB**: 7♂, 2♀, Picton, Helms (BMNH). 1♂, Picton, Queen Charlotte Drive, swept along roadside, 3 Jan. 1971, M. G. McPherson, terminalia slide No. *Z. australe* m-140300-5/7 (LUNZ). 2♀, 2♂, Picton, Marlborough, 2 Jan. 1929, E. Fairburn (WMNZ). 2♀, 4♂, Picton, Marlborough, 12 Jan. 1953, E. Fairburn (WMNZ). 2♂, 3♀, Upper Maitai, 29 Jan. 1945, B. Given (NZAC). 1♂, 2♀, Upper Maitai Valley, Maungatapu Tr., 360m, *Hebe stricta*, 15 Feb. 1967, J. I. Townsend (NZAC). 2♀, Maitai Valley, 22 Nov. 1957, J. I. Townsend (NZAC). 1♀, Upper Maitai, Cawthron Park, 22 Nov., 1950, E. S. Gourlay (NZAC). 1♂, Jollies Pass, *Myrsine montana*, 29 Oct. 1962, J. I. Townsend & A. C. Eyles (NZAC). **BR**: 1♀, Greymouth (AMNZ 188827). 3♀, 4♂, Greymouth, 1980, 1981, 1985, Helms, Sharp coll 1905-313 (BMNH). 1♀, Moana, 1932 (CMNZ). 1♀, Punakaiki, 30 Oct. 1970 (LUNZ). **MC**: 3♂, Moa Hill, Broun coll. 1922-182 (BMNH). 1♂, Mt Oakden Paradise (comment this might be Mt. Oaken) (NZAC). 2♀, Mt Oakden Paradise (this might be Mt. Oaken) (NZAC). **WD**: 1♂, 2♀, South Westland, Lake Paringa, 6-10 Dec. 1960, J. I. Townsend & P. R. Kettle (NZAC). **OL**: 1♂, 1♀, West Wanaka, 600m, 10 Feb. 1997, B. & H. Patrick (JNNZ). 1♀, E. Matukituki V, 400m, Malaise trap at forest edge, 31 Jan.-4 Feb. 1987, J. W. Early (LUNZ). 1♂, Mt. Dick (AMNZ 18828). 1♀, Mt. Dicks (NZAC). 1 unknown sex, Mt. Dicks (NZAC). **DN**: 2♀, Oamaru, 1 Dec. 1990, B. Patrick (JNNZ). 4♀, Moeraki, on *Muehlenbeckia* flowers, 1 Feb. 1983, J. S. Dugdale (NZAC). 1♂, Waipori Tuapeka, 15 Jan. 1928, A. Richardson (AMNZ 18830). 1 unknown sex, Mt. Maungatua (AMNZ 18824). 1♀, Maungatua, Broun coll. 1922-482 (BMNH). 1♂, Maungatua, C. E. Clarke Collection, 19 Nov. 1922 (AMNZ 18820). 1♀, Woodhaugh, 6 Jan. 1920 (AMZ 18825). 2♂, Dunedin, 1878, Hutton (BMNH). 4♀, 1♂, Dunedin, Leith Saddle, Malaise trap, 9-30 Mar. 1977, A. C. Harris (NZAC). 1♀, 1♂, Dunedin, Leith Saddle, Malaise trap, 6-14 Mar. 1976, A. C. Harris (NZAC). 1♂, Dunedin, Leith Saddle, Malaise trap, 19-29 Dec. 1975, A. C. Harris (NZAC). 1♀, 1♂, Dunedin, Leith Saddle, Broadleaf F, Jan. 1976, A. C. Harris (OMNZ). 1♂, Dunedin, Broadleaf F, 23 Feb. 1976, A. C. Harris (OMNZ). 1♂, Dunedin, Woodhaugh, 17 Dec. 1996, H. & B. & H. Patrick

(JNNZ). 2♂, 3♀, Dunedin, 1 Jan. 1953, E. Fairburn (WMNZ). 1♀, Dunedin, Leith Saddle, Malaise trap in second growth bush, 26 Feb.-6 Mar. 1977 (NZAC). 1♀, Dunedin, 25 Nov. 1997, A. C. Harris (OMNZ). 1♀, Dunedin, Saddle Hill, 10 Dec. 1950, E. S. Gourlay (NZAC). 1♀, Dunedin, Ana Bay, 10 Nov. 1922 (AMNZ 18832). 1♀, Dunedin, Woodhaugh, 20 Jan. 1914 (AMNZ 18822). 4♀, Dunedin, Woodhaugh, 17 Dec. 1996, H. & B. & H. Patrick (JNNZ). 2♀, Dunedin, Bradford, 17 Nov. 1996, H. & B. & H. Patrick (JNNZ, OMNZ). 1♀, Dunedin, Chisholm Park, 16 Dec. 1996, H. & B. & H. Patrick (JNNZ). 1♀, Dunedin, Whisky Gully, 14 Dec. 1995, H. & B. & H. Patrick (JNNZ). 1♀, 5 km north of Dunedin, Waitatai V Rd. Leith Hill, sweeping, 19 Feb. 1976, L. L. Deitz (NZAC). 2♀, 1♂, Port Chalmers, Oct. 1901, J. J. Walker (BMNH). **CO**: 1♂, Otago, T. Broun Dup. Coll. (NZAC). 1♀, Otago, Feb. 1984 (OMNZ). 5♂, Otago, 1877, Hutton, Sharp coll. 1905-313 (BMNH). 1♀, Otago, Broun coll. 1922-482 (BMNH). 13♂, 10♀, Earnsclough Orchard, on *Crataegus*, Nov. 1991, G. Maclaren (NZAC). **FD**: 1♂, Secretary Island, Grono Bay, sweeping, 28 Nov. 1981, C. F. Butcher (NZAC). 1♂, Secretary Island, Gut Hut, Malaise trap 22 -28 Nov. 1981, C. F. Butcher (NZAC). 1♀, Dusky Sound, Feb. 1987, A. Frampton (NZAC). 1♀, Fjordland Nat. Pk, Eglington V., 1, Jan. 1979, M. R. Butcher (LUNZ). **SL**: 2♂, Beaumont SF, *Nothofagus* forest, 30 Jan. 1984, J. S. Dugdale (NZAC). 1♀, Gore, Hokonui Hills, Dolamore Park, 27 Jan. 1976, L. L. Deitz (NZAC). 3♂, 2♀, Tautuku Outdoor Education Centre, Malaise trap, 3-10 Jan. 1994, J. B. & G. M. Ward (LUNZ). 2♀, 3♂, Tautuku Forest, 10 km East Mokoreta, beating *Rubus*, *Muehlenbeckia*, *Hebe*, *Carpodetus*, *Leptospermum* and *Coprosma*, 11 Feb. 1976, G. W. Ramsay (NZAC). 1♂, 1♀, Wyndham Station, Tautuku Forest, sweeping, 11 Feb. 1976, L. L. Deitz (NZAC). 1♂, 5♀, Birch I, on *Cordyline*, 12 Dec. 1984, J. S. Dugdale & P. N. Johnson (NZAC). 7♂, Otautau, 25 Jan. 1962, J. I. Townsend (NZAC). 1♀, Otautau Station, 25 Jan. 1962, J. I. Townsend (NZAC). 1♀, Longwood Pa, *Weinmannia*, 25 Nov. 1962, J. I. Townsend & A. C. Eyles (NZAC). 2 unknown sex, Otara Southland (AMNZ 18823, 188829). 1♀, six miles south of Riverton, 12 Nov. 1958, M. J. Esson (NZAC). 1♀, Purakaunui Falls, 15km SW of Owaka, on rotten wood, 16 Jan. 1978, G. Kuschel (NZAC). 1♀, 2♂, Pounaweia, East of Owaka 18th Jan. 1978, G. Kuschel



(NZAC). 1♀, Catlins, Southland, 15 Nov. 1980, E. Cook (OMNZ). 1♀, Wyndham Station, Tautuku Forest, sweeping, 11 Feb. 1976, L. L. Deitz (NZAC). 1♂, Invercargill, on shopping bag, Oct. 1991, D. Baird (LUNZ). 1♀, Invercargill, Thomsons Bush, 27 Dec. 1996, B. Patrick (JNNZ). 1♂, Invercargill, Thompson Bush, beating *Nothofagus*, 16 Mar 1977, A. K. Walker (NZAC). 1♀, Greenhills, 17 Jan. 1959, J. I. Townsend (NZAC). 1♂, Bluff, ragwort, 3 Feb. 1969, A. C. Eyles (NZAC). 1♀, Bluff Point, sweeping, 26 Jan. 1976, L. L. Deitz (NZAC). 4♀, Bluff, 25 Jan. 1962, J. I. Townsend (NZAC). 1♀, Bluff, 14 Dec. 1972, D. S. & C. J. Horning (NZAC). 1♂, Bluff, coastal, 20 Dec. 1996, B. & H. Patrick (JNNZ). 1♂, Kohuamarua Bluff, sweeping scrub and ferns, 15 Jan. 1982, J. W. Early (LUNZ). **SI:** 1♀, Codfish Island, Camp Sealers Bay, 8 Dec. 1966, J. I. Townsend (NZAC). 1♂, 1♀, Stewart Island, Christmas Village, 26 Jan. 1962, J. I. Townsend (NZAC). 1♀, Stewart Island, Lee Bay, 23-27 Dec. 1975, A. C. Harris (JNNZ). 1♀, Stewart Island, Lee Bay, 6-9 Jan. 1976, A. C. Harris (JNNZ). 1♀, Stewart Island, Lee Bay, 22-29 Jan. 1976, A. C. Harris (NZAC). 1♀, Stewart Island, Feb. 1943, A. E. Brookes (NZAC). 1♀, Stewart Island, Port William, swept from coastal bush, 9 Nov. 1991, J. W. Early (LUNZ). 2♂, 12♀, Stewart Island, Rakeahua Valley, 19 Feb. 1968, G. Kuschel (NZAC). 1♀, Stewart Island, Halfmoon Bay, 12 Jan. 1996 (JNNZ). 1♀, Stewart Island, Rakeahua Valley, 21-25th Feb. 1968, G. Kuschel (NZAC). 1♀, Stewart Island, Rakeahua Valley, south bank bush, 12 Feb. 1968, J. S. Dugdale (NZAC). 1♀, Stewart Island, Mt. Rakeahua, reared from *Dacrydium cupressinum*, emerged 26 Nov. 1968, J. S. Dugdale (NZAC). 3♂, Stewart Island, Mason Bay, Malaise trap, coastal bush, 2-8 Feb. 1991, C. J. Vink, J. W. Early, R. M. Emberson (LUNZ). 2♂, Stewart Island, Mason Bay, beating *Fuschia excorticata*, 7 Feb. 1991, J. B. Walker (LUNZ). 1♂, Stewart Island, Pegasus, 21-25 Feb. 1968, G. Kuschel (NZAC). 1♀, campsites, Islet Cove, P. Pegasus, Dec. 1974, R. M. Emberson (LUNZ). 2♂, Stewart Island, SW, Big South Cape Island, 11 Feb. 1969, J. McBurney (NZAC). 1♂, Stewart Island, SW, Big South Cape Island, Sealers Bay, 13th Dec. 1966, J. I. Townsend (NZAC). 4♂, Stewart Island, SW, Big South Cape Island, *Hebe elliptica*, *Senecio* flowers & at night, J. I. Townsend (NZAC). 1♂, 3♀, Stewart Island, SW, Big South Cape Island, *Stilbocarpa*, Nov. 1968, G. Kuschel (NZAC). 4♂, Stewart Island,



SW, Big South Cape Island, *Pseudopanax edgerleyi*, *Olearia colensoigrandis*, beating *Senecio* branches & general beating, Feb. 1969, G. Kuschel (NZAC). 2♂, 2♀, Stewart Island, Big South Cape Island, Moor. N. E., 16 Feb. 1969, J. McBurney (NZAC). 5♀, Stewart Island, Big South Cape Island, S. W., *Olearia arborescens*, *Senecio* flowers, *Hebe elliptica*, and general beating, J. I. Townsend (NZAC). 6♀, Stewart Island, Big South Cape Island, sweeping *Leptospermum*, *Senecio*, *Dracophyllum*, in forest & general beating, Feb. 1969, G. Kuschel (NZAC). **Unknown location:** 3♂, 3♀, no location, flower head wild carrot, 8 Dec. 1939, Instr. in Agric. (NZAC). 1♂, Mistletoe Bay, Peninsula track, sweeping vegetation, 13 Feb. 1985, J. S. Ensor (LUNZ). 1♂, (NZAC). 2♀, 1♂, 1884, Grey (BPBM). 1♀, no data (BPBM). 1♂, ? Jill. Tai. 1882 ? (BPBM). 1♀, 1♂, data not readable (BMNH). 1♀, Auckland, purchased from Stevens 1880, location doubtful (BMNH).

### *Zorion nonmaculatum*, new species

(Figs 2.25, 2.61, 2.62, 4.1)

#### Description

*Body length:* Female 2.8-5.15 mm.

*Colour:* Body reddish brown throughout, elytra purple brown with reddish brown shoulders and apex and no spot (Figs 2.25 & 2.61). Head and pronotum dark reddish brown; palps, labrum, mandibles, eyes, scape, pedicel, coxae, trochanter, femur, tibia and tarsi reddish brown. Antennal segments 3-8 whitish brown at base gradually darkening towards apex; antennal segments 9-11 dark brown. Femur whitish brown at base, club without dark ring,. Pro- and mesocoxal cavity bounded by dark edge. First two abdominal segments dark red brown, gradually becoming reddish brown from third to fifth abdominal segment.

*Structure:* Body surface glabrous, glossy. Elytra rounded at apex. Female with a row of hairs on epipleural fold.



Figure 2.61 Dorsal view of *Z. nonmaculatum*. Scale bar 1 mm.

*Ovipositor & spermatheca*: Ratio of dorsal to ventral baculi being 1:1.25. Spermatheca sclerotised, hook-shaped, widest at base, more sclerotised at apex, spermathecal gland arising 0.33 of spermathecal length from base (Fig. 2.62).

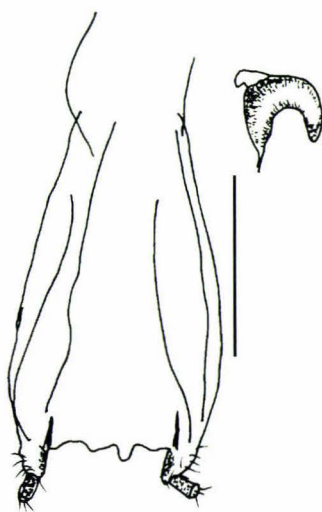


Figure 2.62 Ovipositor and spermatheca of *Z. nonmaculatum*. Scale bar 0.5 mm

### Biology

Adults were collected in mid January and no further information is available. John S. Dugdale in Feb. 2000 was not able to detect any specimens of this species during a visit to the D'Urville Islands.

### Distribution

D'Urville Island (Fig. 4.1).

### Etymology

Latin referring to the spot less elytra.

### Material examined

*Holotype*: *Zorion nonmaculatum*. 1♀. D'Urville Island, 20-24 Jan. 1946, E. S. Gourlay (NZAC).

*Paratype*: *Zorion nonmaculatum*. **SD**: 1♀. D'Urville Island, 20-24 Jan. 1946, E. S. Gourlay (NZAC).

## *Zorion batesi* (Sharp)

(Figs 2.30, 2.63, 2.64, 4.1)

*Zorion batesi* Sharp 1875: 57. - Sharp 1877: 194.-Waterhouse, 1876: 14; Aurivillius, 1912: 156; Blair 1938: 265.

### Description

*Body length*: Male 3.8-6.7 mm, female 3.6-6.8 mm.

*Colour*: Body dark brown throughout, with a white spot on each elytron. Elytral spot white, small and round, not touching elytral suture and margin, (Fig. 2.30 & 2.63), distance between spot and suture  $1.5-2 \times$  distance between spot and margin, distance between central axis of spot and elytral shoulder  $0.37-0.5 \times$  elytron length. Palps dark brown. Eyes black. Scape and pedicel dark brown; antennal segments 3-6 whitish at base but gradually becoming dark brown towards apex; antennal segments 7-11 dark brown. Trochanter and



coxa dark; base of femur whitish; femur club, tibia and tarsal segments dark brown throughout. Abdominal segments dark brown.

*Structure*: Surface of body glabrous, glossy. Elytral apex round. Female with a row of hairs on epipleural fold not reaching beyond anterior edge of spot, male without such hairs.



Figure 2.63 Dorsal view of *Z. batesi*. Scale bar 1 mm

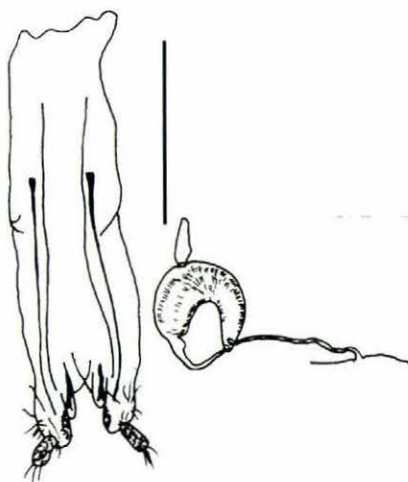


Figure 2.64 Ovipositor and spermatheca of *Z. batesi*. Scale bar 0.5 mm.

*Ovipositor & spermatheca* (Fig. 2.64): Ratio of dorsal to ventral baculi being 1:1.2. Spermatheca sclerotised, widest at base, apex more sclerotised and spermathecal gland arising 0.33 of spermathecal length from base.

*Variation*: Body may be creamy golden brown, orange-brown, honey brown to beer brown throughout, and sometimes may be gradually darkening from posterior to anterior, central axis of the elytral spot may be at a forward or backward angle in relation to suture (Figs 2.17 & 2.18), spot not touching suture and margins; distance between spot and suture in relation to the distance between spot and margin variable; spot may be pear-shaped, wider than long or almost small round or split into two; if the elytron has two white spots than the sutural spot is longer than wide or pear-shaped or small and round, not reaching suture; the marginal spot may be situated anterior or posterior in relation, but parallel to sutural spot and may be longer than wide or as long as wide, very small or almost disappearing and/or almost joining with sutural spot or highly reduced in size not touching or joining margin, or spot may form a band almost reaching margin. Scape may be creamy golden brown or orange-brown sometimes with darker apex, pedicel, orange-brown or creamy golden brown. Trochanter, coxa or only apex of coxa may be dark brown or light brown; femora with a dark ring at beginning of club, dark ring disguised if overall body colour dark brown; tarsi creamy may be golden brown at base, darkening towards apex. Abdominal segments may have the same colour as remainder of the body or at least the first two abdominal segments and at the most segments 1-4 dark brown. Apex of elytra may be semi pointed to pointed.

### Biology

Specimens of this species were beaten from *Crataegus*, *Coprosma* from edge of swamp, *Hebe* and *Metrosideros carminea* flowers. Adults were found in cabbage tree swamp, *Coriaria sarmentosa*, mahoe, *Melictus*, under wood in *Melictus* swamp, monstera, pigeon wood, *Phebalium nudum*, *Solanum aviculare*, and at night. Adults also were collected from *Alectryon excelsum*, *Dacrycarpus dacrydioides* and *Nothofagus truncata* branch traps, adults were Malaise trapped, swept from shrubbery, wild carrot by roadside,

grasses, and out of flowers from a Bon Chretien pear tree. Kuschel (1990) found specimen in large numbers on *Ligustrum sinense* and a female ovipositing in *Eucalyptus*.

### Distribution

This species' is distributed throughout the northern parts of New Zealand (Fig. 4.1). One specimen has been found on Kermadec Island. In the Northland region the species' distribution ranges from Waipoua forest through the Whangarei area to the Auckland, Coromandel and Bay of Plenty. The distribution includes Great Barrier Island, Little Barrier Island, Cuvier Island. The southern distribution boundary includes the Waikato and Taupo region from where only one specimen each was collected.

### Comments

According to the original description there were two type specimens, one in the Bates collection and the other in the Lawson collection. There is no information on the Lawson material. The Bates specimens should be in Paris in the Oberthur or Lawson collection (S. Shute, pers. comm.). I contacted the Muséum National d'Histoire Naturelle in Paris several times and unfortunately received no reply. This species was therefore determined on the basis of Sharp's original description.

### Material examined

60♂, 74♀. **KE:** 1♀, Kermadec Islands, Raoul Island, Fleetwood Bluff area, in building, 7 Sept. 1998, M. K. Eagle (AMNZ 36272). **ND:** 1♀, Kaitaia, 29 Dec. 1962, E. S. Gourlay, terminalia vial No. *Z. batesi* f-240700-6/12 (NZAC). 2♂, 1♀, Maungakaramaea, 22 Oct. 1927, E. Fairburn, terminalia slide No. *Z. batesi* m-240700-10/12 & *Z. batesi* m-240700-12/12, terminalia vial No. *Z. batesi* f-240700-11/12 (WMNZ). 1♂, Waipu, 1/14, no collector, lost body of pin except right elytra and abdomen in vial, terminalia slide No. *Z. batesi* m-240700-8/12 (NZAC). 1♂, Waipoua State Forest, Waipoua river, on *Phebalium nudum*, 31 Oct. 1985, R. C. Craw, terminalia slide No. *Z. batesi* m-240700-4/12 (NZAC). 3♀, 5♂, Waipoua State Forest, 26 Nov. 1980, G. Kuschel, terminalia vial No. *Z. batesi* f-240700-5/12, *Z. batesi* f-290500-1/4, *Z. batesi* f-2905002/4, terminalia slide NO. *Z. batesi* m-290500-3/4, *Z. batesi* m-290500-4/4 (NZAC). 1♂, Omāpere, Hunoke, 30 Oct.



1985, R. C. Craw (NZAC). 1♂, Whangarei, Maungakarama, 22.Oct. 1924, no collector, terminalia slide No. *Z. batesi* m-240700-9/12 (MONZ). 2♀, Whangarei heads, 7. Dec. 1961, G. Kuschel, terminalia vial No. *Z. batesi* f-240700-7/12, *Z. batesi* f-120600-3/6 (NZAC). 1♂, Hen Island, 2 Jan. 1963, E. S. Gourlay, terminalia slide No. m-240500-4/8 (NZAC). 1♂, Paparoa, 1022, no further data, Broun coll. 1922-482 (BMNH). **AK**: 1♀, Auckland, Takapuna, on monstera in garden, 7 Oct. 1980, J. M. Gurr, terminalia vial No. *Z. batesi* f-010800-6/9 (AMNZ 18821). 1♀, Auckland, no data, 1905. 353 Sharp coll. (BMNH). 1♀, Auckland, Broun, no data, Fry coll. 1905.100 (BMNH). 3♀, Auckland, 498 & 499, H. Swale, 1913-117 (BMNH). 1♀, Auckland, 1021, Broun coll. 1922-482 (BMNH). 1♀, Auckland, Sharp coll. 1905-313 (BMNH). 1♂, Auckland, H. Swale, 1913-117 (BMNH). 1♂, Auckland, 496, H. Swale, 1913-117 (BMNH). 1♀, Auckland, Swanson, 22 Nov. 1917, no collector, (1022) (NZAC). 1♀, Howick, 1022, Broun coll. 1922-482 (BMNH). 1♂, Waitakere Ranges, Matuku Reserve, on leave at night, 15 Nov. 1985, C. & J. Lyal, 1986-274 (BMNH). 1♂, Spragg's Bush, 18 Nov. 1957, J. S. Armstrong, terminalia slide No. *Z. batesi* m-240500-3/8 (NZAC). 1♂, Piha, resting on mahoe, 20 Oct. 1979, C. F. Butcher, terminalia slide No. *Z. batesi* m-300500-3/4 (NZAC). 1♀, Titirangi, 24 Oct. 1916 (NZAC). 1♂, Titirangi, 23 Nov. 1918, 1022, Broun coll. 1922-482 (BMNH). 1♂, Auckland, Green Bay, no collector, 2 Jan. 1915, (1022) (NZAC). 3♂, 6♀, Parau, on Parsley, 2 Jan. 1990, no collector, , terminalia slide No. *Z. batesi* m-300500-2/4, terminalia vial No. *Z. batesi* f-300500-4/4 (NZAC). 1♀, 1♂, Auckland Titirangi, ex light trap, 10 Dec. 1952, C. R. Thomas (NZAC). 1♀, Waitakere Ranges, beaten ex Rimu Cascades FK, 14 Feb. 1960, B. M. May, terminalia vial No. *Z. batesi* f-010800-7/9 (NZAC). 1♀, Huia, Malaise trap in bush, Jan. 1981, B. M. May, terminalia vial No. *Z. batesi* f-010800-9/9 (NZAC). 1♂, Pukekohe, ex *Solanum aviculare*, 29 Nov. 1977, N. A. Matin, terminalia slide No. *Z. batesi* m-010800-8/9 (NZAC). 1♂, 2♀, Mangatawhiri, beaten of *Crataegus*, 2 Nov. 1977, J. S. Dugdale, terminalia vial No. *Z. batesi* f-010800-5/9 (NZAC).

**CL**: 3♂, 6♀, Kopu, beaten of *Crataegus*, 2 Nov. 1977, J. S. Dugdale, terminalia slide No.: *Z. batesi* m010800-3/9, terminalia vial No. *Z. batesi* f-010800-1/9 (NZAC). 1♀,

Fletchers Bay, Coromandel, Grass, 13 Nov. 1956, J. C. Watt, terminalia vial No.: *Z. batesi* f120600-6/6 (NZAC). 1♂, Tairua, no further data, 1021, Broun coll. 1922-482 (BMNH). 1♀, Tairua, Sharp coll. 1905-313 (BMNH). 1♀, Tairua, Pascoe coll. 93-60 (BMNH).

**Little Barrier Island.** 1♂, Little Barrier, 363, H. Swale, 1913-117 (BMNH). 1♂, Little Barrier, H. E. Andrews, Bequest, B. M. 1922-221 (BMNH). 1♀, Te Titoki Point, Little Barrier Island, 28. Nov. 1954, R. A. Harrison (NZAC). 1♀, Little Barrier Island, 29 Dec. 1931-10 Jan. 1932, A. E. Brookes, terminalia vial No. *Z. batesi* f-120600-5/6 (MONZ). 1♀, Little Barrier Island, 29 Dec. 1931-10 Jan. 1932, A. E. Brookes, terminalia vial No. *Z. batesi* f-170700-1/1 (NZAC).

**Great Barrier Island.** 1♀, Okiwi, Great Barrier Island, ex pigeon wood, 24. Nov. 1957, J. C. Watt, terminalia vial No. *Z. batesi* f-310500-1/4 (NZAC).

**Cuvier Island.** 2♀, 3♂, Main Ridge, Cuvier Island, feeding on *Hebe* sp. flowers, 18 Jan. 1972, K. A. J. Wise, terminalia vial No. *Z. batesi* f-220500-3/4, egg slide No. *Z. batesi* f-220500-3/4, terminalia slide No. *Z. batesi* m-220500-2/4 (AMNZ 18837, 18838, 18839, 18840, 18841). 2♀, 1♂, Summit 250 m, Cuvier Island, beaten *Hebe* sp. flowers, 20 Jan. 1972, B. M. May (AMNZ). 1♂, Summit, Cuvier Island, on *Hebe* sp. flowers, 20 Jan. 1972, K. A. J. Wise (AMNZ 18846). 2♀, 3♂, Main Ridge, Cuvier Island, swept *Hebe* sp. flowers, 21 Jan. 1972, K. A. J. Wise, terminalia vial No. *Z. batesi* f-220500-4/4, terminalia slide No. *Z. batesi* f-220500-4/4 terminalia No. *Z. batesi* m-220500-1/4 (AMNZ 18835, 18836, 18842, 18843, 18844).

**BP:.** 1♂, 2♀, Tui Ck, 122m, Mt Te Aroha, beaten off *Metrosideros carminea*, 2 Nov. 1977, B. M. May, terminalia slide No. m010800-2/9, terminalia slide No. *Z. batesi* f-010800-4/9 (NZAC). 1♂, Tokata, NZMS260 Z14 808 844, beaten from *Coprosma* from edge of swamp, 26 Oct. 1992, J. W. M. Marris, terminalia slide No. *Z. batesi* m240400-3/12 (LUNZ). 2♂, Rereauira Swamp, ex. *Alectryon* branch trap, 24 Nov. 1992, G. Hall (NZAC). 1♂, Rereauira Swamp, ex. *Nothofagus truncata* branch trap, 24 Nov. 1992, G. Hall (NZAC). 1♂, Rereauira, ex. *Melicytus*, 24 Nov. 1992, M-C. Lariviere (NZAC). 2♂, Rereauira, NZMS260 Y14 584 906, ex *Nothofagus truncata* branch trap, 23 Oct. 1992, J. W. M. Marris, terminalia slide No. *Z. batesi* m250500-1/1 & *Z. batesi* m-240500-1/8 (LUNZ). 2♂, Rereauira, NZMS260 Y14 584 906, ex *Alectryon excelsum* branch trap, 30 Oct. 1992, J. W. M. Marris (LUNZ). 1♂, Te Rereauira,



NZMS260 Y14 584 906, Malaise trap *Nothofagus truncata* forest, 24 Nov. 1992-26 Jan. 1993, J. W. M. Marris, R. M. Emberson, terminalia slide No. *Z. batesi* m240500-2/8 (LUNZ). 1♂, Te Rereauira, NZMS260 Y14 584 906, Malaise trap *Nothofagus truncata* forest, 26 Jan.-9 Mar. 1993, J. W. M. Marris (LUNZ). 1♀, Rereauira swamp, Malaise trap, 20 Oct.-24 Nov. 1992, G. Hall (NZAC). 1♀, Rereauira swamp, ex sedges & *Hebe* flowers, 9 Mar. 1993, J. S. Dugdale (NZAC). 2♀, Te Rereauira, NZMS260 Y14 584 906, Malaise trap *Nothofagus truncata* forest, 20-24 Nov. 1992, G. Hall (LUNZ). 2♀, Te Rereauira, NZMS260 Y14 584 906, Malaise trap *Nothofagus truncata* forest, 24 Nov. 1992-26 Feb. 1993, J. W. Marris, R. M. Emberson, terminalia vial No. *Z. batesi* f230500-1/8 (LUNZ). 2♀, Rereauira, NZMS260 Y14 582 904, ex *Alectryon excelsum* branch trap, 23 Oct. 1992, J. S. Dugdale, J. W. M. Marris, terminalia vial No.: *Z. batesi* f-240700-2/12 (LUNZ). 1♀, Lottin Point Road, Waenga, ex *Dacrycarpus dacrydioides* branch trap, 27 Jan. 1993, J. S. Dugdale (NZAC). 1♀, Lottin Point Road, Waenga bush, sweeping grasses between pasture and native bush, 24 Nov. 1992, M. C. Lariviere (NZAC). 1♀, Lottin Point Road, Waenga bush, Malaise trap, 24 Nov. 1992-27 Jan. 1993, R. C. Henderson (NZAC). 1♀, Waiaroho, Malaise trap, 25 Nov. 1992-26 Jan. 1993, J. S. Dugdale (NZAC). 1♀, Papatea, 22 Oct. 1992, J. S. Dugdale, D. King (NZAC). 1♀, Hicks Bay, Malaise trap, 26 Nov. 1992-3 Feb. 1993, R. C. Henderson (NZAC).. 1♀, Hicks Bay, roadside near sea grasses and clover, 26 Nov. 1992, M. C. Lariviere (NZAC). 1♂, 1♀, road to Blue Lake, Rotorua, 8 Dec. 1956, no collector (FRNZ). 1♂, 1♀, Rotorua Lake side, H. Swale, 1913-117 (BMNH). 1♂, 2♀, Rotorua, H. Swale, 1913-117 (BMNH). **GB**: 1♀, Te Araroa, Awatere River, *Melictus* swamp under chunks of wood, no date, A. Larochelle (NZAC). 1♂, Awatere River, sweeping roadside, 2, Dec. 1982, G. Hall (NZAC). 1♂, Tolaga Bay, 30 Oct. 1991, J. S. Dugdale & G. Hall (NZAC). **TO**: 1♀, Desert Road, Outere Stream, 26 Nov. 1985, R. C. Craw, terminalia vial No. *Z. batesi* f-120600-2/6 (NZAC). **WO**: 1♂, Owairaka, 14 Nov. 1940, D. Spiller (NZAC). **Unknown localities**: 1♂, no data, Pascoe coll. 93-60 (BMNH). 1♂, no data, ex Simson, G. C. Champion coll. B. M. 1927-409 (BMNH). 1♂, no further data, H. Swale, 1913-117 (BMNH). 1♀, 881, no further data, H. Swale, 1913-117 (BMNH). 1♀, Colenso, no further data (BMNH).



## 2.4 General Biology and Behaviour

*Feeding:* The beetles are pollen feeders as pollen can be found in their digestive tract. They feed on a variety of flowers, preferably on small flowers (Fig. 2.65) that are arranged into a inflorescence such as *Hebe* or wild carrot. Host use does not seem to be species specific. When feeding, the labia and labial palps act as a guide and are held almost steady against the stamen. The maxillary are constantly in motion and the brushes on the maxillae brush the pollen into the mouth. Pollen may be gathered in this way from the pollen sac, its stem, the carpel and from the leaf. The whole body of the beetle may be covered in pollen (Fig. 2.66) and while the beetle is feeding, its body repeatedly comes into contact with the carpel and thus contributes to the pollination. It needs to be investigated whether the beetles visit flowers in the canopy and hence may be important pollinators to New Zealand trees. When disturbed the beetles instantly fall from the flowers into the shrubbery and thereafter take to flight during their fall. Drinking is also an important part of feeding and beetles held in captivity readily drank water from moistened filter paper in petri dishes (diameter 85 mm) or from water drops that formed on flowers after mist spraying. Beetles might take water as dew or through nectar in nature.

Even though beetles are mainly found on shrubby plants such as *Hebe* and *Pomaderris*, which are found predominantly in edge communities or open landscape (Fig. 2.67-2.72), females might venture further into the forest to find host plants for oviposition. For example, specimens were collected in pitfall traps set in mature forest at Lake Papaitonga (Levin) (Melissa Hutchison, pers. comm.). Kuschel (1990) lists *Zorion* habitat to be in canopy as well as in bush but gives no Records on canopy flowers.



Figure 2.65 *Z. guttigerum* feeding on *Physocarpus opulifolius* flowers



Figure 2.66 *Z. guttigerum* covered with fine pollen.

The morphological appearance of the *Zorion* species suggests that they may be mimicking ants (Dugdale, Kuschel, pers. comm.). However, while collecting *Zorion* in the Mt. Terako region where a large number of small native bees were present on the flowering shrubs it was very difficult to distinguish *Zorion* from the native bees. The yellow spots on the elytra resembled the yellow pollen sacs of the native bees.





Figure 2.67      *Hebe* bush  
from which a number of *Z.  
guttigerum* were collected.  
Mason River, South Island



Figure 2.68      Open vegetation at Mason river, South Island

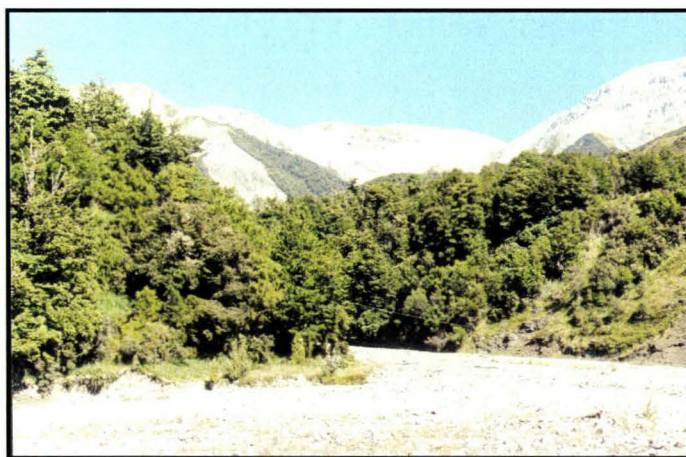


Figure 2.69      Forest remnant below Mt. Terako, South Island along  
Cunningham stream from where *Z. guttigerum* was collected along the stream side

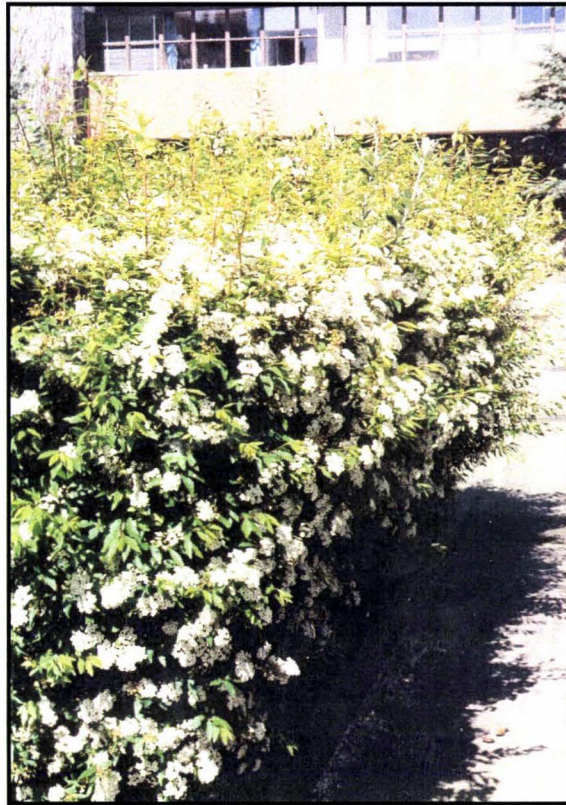




Figure 2.70      Camp site at Cunningham Stream, South Island



Figure 2.71      Collecting *Z. australe* by beating *Pomaderis* in the Marlborough Sounds

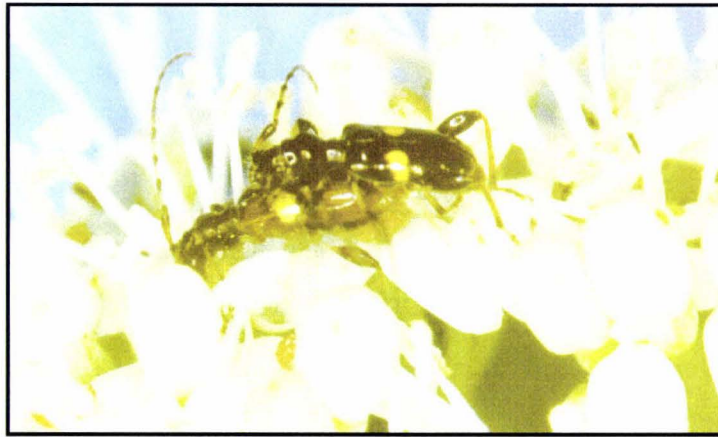


**Figure 2.72**     *Physocarpus opulifolius* bush on which *Z. guttigerum* was found and from which flowers were used to feed captured specimens at Massey University, Palmerston North

*Mating:* *Zorion guttigerum* and *Z. australe* beetles that I collected in December 1999 cross-mated with the opposite sex between species when brought into a petri dish (diameter 85 mm) or plastic cylinder containers (65mm diameter by 83mm high). All beetles that I collected in late September 2000 and early October 2000 were found as single individuals on florescence. The number of beetles collected later in mid November through to December 2000 varied between 2-5 individuals on one florescence and readily mated when placed into a petri dish (diameter 85 mm). Beetles collected earlier in the season and found singly did not mate for several days. Sexually mature males will mount females instantly (Fig. 2.73) when brought into contact. The female everts the ovipositor and places it on the genital opening of the male, which inserts its aedeagus into the female. The male maintains its position on the female for some time while a pumping motion of the body occurs.



Under the microscope I could observe that part of the aedeagus slid forward and backward within the female genital tract. Individuals of the species *Z. guttigerum* and *Z. australe* mated readily when brought into the lab but oviposition did not occur.



**Figure 2.73** *Z. guttigerum* male above and female below about to mate

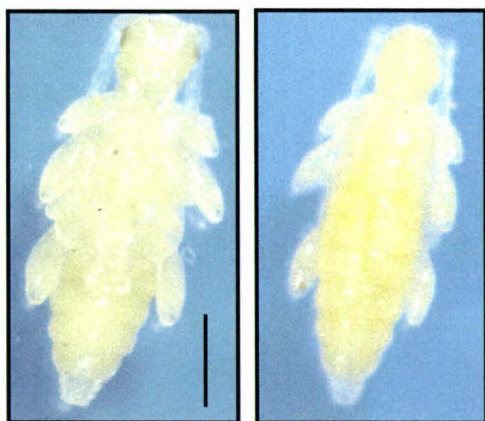
*Lab breeding:* Pupae (Fig. 2.74) and larvae (Fig. 2.79) of *Z. guttigerum* were dissected out from *Alnus cordata* twigs collected in mid-September and placed in small glass vials (50×15/16) with punctured lids to allow for airflow. Larvae were supplied with a diet for Cerambycid wood boring larvae (Rogers et al. 2001). Vials were kept in controlled rooms with a photoperiod of 16L:8D and room temperature of 20°C. The larvae soon pupated and all pupae eclosed in mid-October.

Adults were brought into the lab and kept in plastic cylinder containers (65mm diameter by 83mm high) lined with filter paper on the bottom, to hold moisture, and multipore plastic film (Wicket bag plain 15µm, Cryovac™, W. R. Grace Ltd.) on the side walls. The container was covered with a plastic sheet secured with a rubber band, and drinking water was provided in a plastic tube (40mm by 10mm diameter) dispensed with a 3.75cm cotton wick (Richmond, USA) inserted through the plastic sheet. In addition, the container was supplied with *Physocarpus opulifolius* flowers that were changed daily and an *Alnus cordata* twig about 1cm diameter and 5cm length that had notches cut at regular intervals into the bark (Fig. 2.76). Mating took place within the container, and eggs (Fig. 2.77) were deposited in the cut notches of the twigs. Larvae hatched after 1 to 2 weeks (Fig. 2.78). Newly hatched larvae that were transferred into glass vials (50×15/16) with a

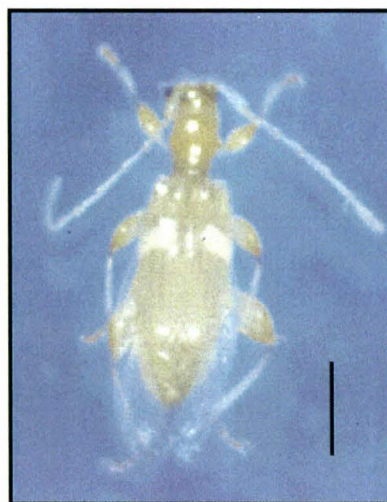


Cerambycid diet did not survive. Larvae that were kept on the twig (2.79) soon started tunnelling under the bark and rapid growth could be observed. To keep the twig moist, I placed the twig on fine bark mulch in a plant pot which was standing in water. The twig was further covered with a cloth to keep the surface from drying out. This might have become too wet and the larvae died after several weeks.

In addition to the information gathered from collection labels, Dumbleton (1957) reared adults from larvae found in hawthorn, *Sequoia gigantea* and flax (*Phormium tenax*) and Kuschel (1990) found *Z. minutum* (which he thought to be *Z. batesi*) ovipositing in *Eucalyptus*. Host plants for *Zorion* species oviposition also do not seem to be species specific and a wide variety of exotic and native plants are used for hosts. Milligan (1975) names *Zorion* amongst several other Cerambycinae species, which feed between the bark and the sapwood or occupy small branches or lianes soon after death of the host. They share this habitat with a number of Cerambycinae, Lamiinae and other species of woodborers belonging to other families. Dumbleton (1957) provides a key to the larvae of Cerambycinae including *Zorion* and gives a description of *Z. minutum* larvae from the Nelson area, which I believe were possibly *Z. australe*. He could not distinguish between the larvae of *Z. guttigerum* and *Z. minutum*.



**Figure 2.74** *Z. guttigerum* larvae.  
Ventral view left; dorsal view right.  
Scale bar 1 mm



**Figure 2.75** Newly emerged  
*Z. guttigerum*. Scale bar 1 mm

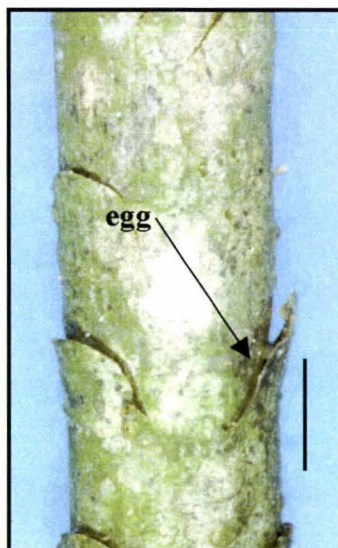


Figure 2.76 *Alnus cordata* twig showing notches and deposited egg of *Zorion*. Scale bar 5 mm

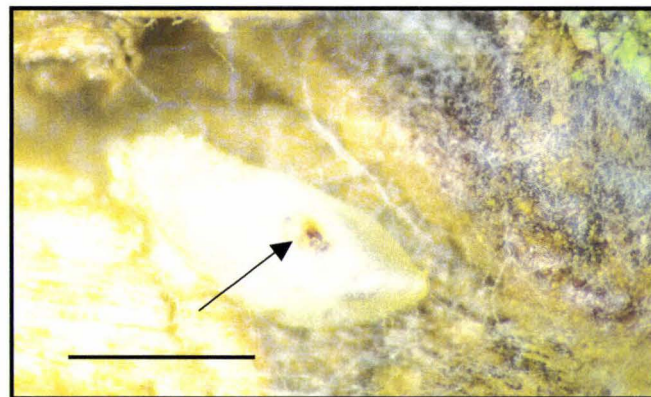


Figure 2.77 Hatching *Zorion* larva, arrow indicating whole in egg exposing darker coloured mandibles. Scale bar 0.5 mm

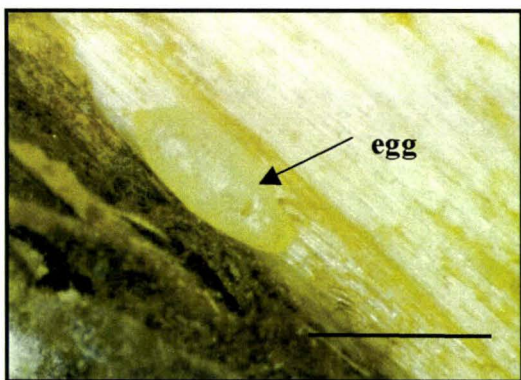


Figure 2.78 *Zorion* egg against *Alnus cordata* twig. Scale bar 0.5 mm



Figure 2.78 Figure 2.79 *Z. guttigerum* larvae on an *Alnus cordata* twig. Scale bar 0.5 mm

# PHYLOGENETIC ANALYSIS OF THE GENUS *ZORION*

## 3.1 Introduction

Ten species of the genus *Zorion* were recognised based predominantly on the morphological colour and elytral spot characters in the previous chapter. The occurrence of the colour ring on the femur of some North Island species, the appearance of the elytral spot as well as the overall dominant body colour might give some indications of the phylogenetic relationship amongst the species of the genus. Phylogenetic relationships amongst species are determined by the presence or absence of apomorphic (derived) characters. Thus, systematics attempts to establish the status of a given character and group (Maddison *et al.* 1984). If individuals of populations or taxonomic groups share apomorphic character states then this group is monophyletic (Hennig 1965, Wiley 1981).

Based on the characters used to describe the *Zorion* species in the previous chapter this section aims to confirm the monophyly of the genus *Zorion* and establish the phylogenetic relationships amongst the species within the genus.

## 3.2 Terminal Taxa

Members of a monophyletic group share one or several unique derived characters (synapomorphies) and each character of a taxon needs to be evaluated to see whether it is a derived or an ancestral (plesiomorphic) character. A character or a combination of characters clearly is derived when it is restricted to a particular taxon (Mayr & Ashlock 1991). Having examined a high number of Cerambycid specimens of various genera from New Zealand I concluded that the morphological character combination described below is unique to the genus *Zorion*. The genus *Astetholea* is thought to be very closely related to *Zorion* because the subcortical larvae of *A. pauper* are very similar (Kuschel 1990, Kuschel, pers. comm.). The combination of character states that I suggest are restricted to *Zorion* and can be compared with character states in *Astetholea*. These are as follows: the width of the clubbed femur is wider in *Zorion* compared to a narrow clubbed femur in *Astetholea*; the shape of the prothorax narrows from the middle area and widens again towards the anterior and posterior areas forming a restricted waist in *Zorion*, in *Astetholea*



the prothorax is gradually tapering from a wider middle and narrowing anteriorly and posteriorly; frontal coxal cavities are divided by a long narrow sternal process in *Zorion*, and are not so divided in *Astetholea*; the central longitudinal basal suture on the scutellum in *Zorion* is absent in *Astetholea*; the elytral length in *Zorion* is  $< 3 \times$  the thoracic length compared to a elytral length  $> 5 \times$  the thoracic length in *Astetholea*. When compared with the outgroup *Astetholea*, the apomorphic states of these characters occur only in *Zorion*, suggesting that it is a monophyletic group and the phylogenetic analysis of this study all the species of *Zorion* were treated as ingroup taxa.

An outgroup is a taxon that is outside the monophyletic group and is used to determine which of two homologous character states that are found in the ingroup may be apomorphic and where to root trees in cladistic analysis (Wiley 1981). In cladistic studies, homologous characters that are variable and are found in some portion of the ingroup, the characters are placed into a transformation series and selection of an outgroup (outgroup comparison) is one way to determine character polarity (Hennig 1950, 1965, 1966) of a series of character states. Therefore, a character state occurring in a group outside the group of study is assumed to be the plesiomorphic character state if found in both groups and a character state that is found only in the ingroup or a portion of it is assumed to be apomorphic (Watrous & Wheeler 1981, Wiley 1981).

Outgroup analysis and outgroup selection have been subject to many debates and relevant literature have been summarised by Nixon & Carpenter (1993). They concluded that an outgroup need not be a direct sister taxon to the ingroup nor need be monophyletic or ancestral relative to the ingroup and the outgroup/ingroup relationship should not be constrained in the analysis to establish monophyly of, and phylogenetic relationships within the taxa under study. They further pointed out that it was not necessary to have more than one outgroup. When using one outgroup in an analysis this group becomes equivalent to the outgroup node in an analysis that uses two outgroups. Further assuming polarity *a priori* is not essential, and simultaneous (unconstrained) analysis of both the ingroup and outgroup allows to search for informative character distributions of the observed

similarities. Polarity then can be established *a posterior* using the outgroup as a root for the ingroup giving direction to the character transformations along a tree.

As an outgroup I chose the genus *Astetholea* Bates 1874 (Cerambycidae, Cerambycinae), which has three species *A. aubreyi* Broun 1880, *A. lepturoides* Bates 1876 and *A. pauper* Bates 1874 in New Zealand and three further species in New Caledonia.

### 3.3 Characters and Character State Coding

The terms character and character states as well as other terminologies often appear confusing. The terms used for characters and their states in this study are therefore based on the definitions given by Platnick (1979). According to him a state is an attribute of a group of organisms such as species, whereby a character is an entity that entails a group of states, which are modifications of the same thing.

To infer species relationships of *Zorion*, fourteen characters were chosen Table 3.1. Characters were coded as binary or multistate and their numbers (0, 1, or 2) did not imply character state polarity, which was decided *a posterior* on the most parsimonious trees. The data matrix of the eleven terminal taxa (1 outgroup and 10 *Zorion* species) and 14 characters is shown in Table 3.2. Missing characters were coded with a question mark (?) in the matrix.

**Table 3.1** Characters and character states used in the phylogenetic analysis of the genus *Zorion* (character states are in square brackets)

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<b>Femur</b>	
1	coloured ring on femur: absent [0]; present [1].
<b>Prothorax</b>	
2	Pronotal surface: Pronotum glossy [0]; pronotum dull [1].
<b>Elytra</b>	
3	Spot shape: Large spot [0]; reduced spot [1]; no spot [2].
4	Spot width: < 1.4 × length [0]; > 1.4 × length [1]; no spot [2].
5	Distance between spot and elytral suture in relation to distance between spot and elytral margin: > 2 × marginal distance [0]; < 2 × marginal distance [1]; no spot [2].
6	Spot position to elytral margin: spot not reaching margin [0]; Spot reaching margin [1]; no spot [2].
7	Spot axis angle: Transverse [0]; variable [1]; no spot [2].
8	Spot colour: Yellow [0]; whitish [1]; no spot [2].
9	Elytra apex: Rounded [0]; pointed [1].
10	Surface: Dull [0]; glossy [1].
11	Dark field Present [0]; absent [1].
<b>Body Colour</b>	
12	Colour: Brown [0]; purple [1]; orange [2]; variable [3].
<b>Ovipositor</b>	
13	Ratio of dorsal to ventral baculi: < 1 : 1.4 [0]; > 1 : 1.4 [1].
<b>Spermatheca</b>	
14	Secondary structure in spermatheca absent [0]; present [1].

---



**Table 3.2** Data matrix for cladistic analysis of the genus *Zorion*.  
Multistate characters are unordered

Taxa	Characters													
	0	0	0	0	0	0	0	0	0	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	0	1	2	3	4
<i>Z. minutum</i>	0	0	1	0	1	1	0	1	0	1	1	2	0	0
<i>Z. guttigerum</i>	0	0	0	1	0	0	0	0	0	1	1	1	0	0
<i>Z. batesi</i>	1	0	1	1	0	0	1	1	0	1	0	3	0	0
<i>Z. opacum</i>	0	1	1	0	0	0	0	1	0	0	1	0	0	0
<i>Z. angustifasciatum</i>	1	0	1	0	0	0	1	1	1	1	0	2	0	0
<i>Z. dugdalei</i>	1	1	1	1	0	0	1	1	0	1	0	2	1	1
<i>Z. taranakiensis</i>	1	0	0	1	1	1	1	1	0	1	0	2	0	0
<i>Z. nonmaculatum</i>	0	0	2	2	2	2	2	2	0	1	0	2	0	0
<i>Z. australe</i>	0	0	0	1	1	1	1	0	0	1	0	2	0	1
<i>Z. kaikouraiensis</i>	0	0	0	1	1	1	1	0	0	1	1	1	1	0
<i>Astetholea</i>	0	1	2	2	2	2	2	2	1	0	1	0	?	?

### 3.4 Cladistic Method

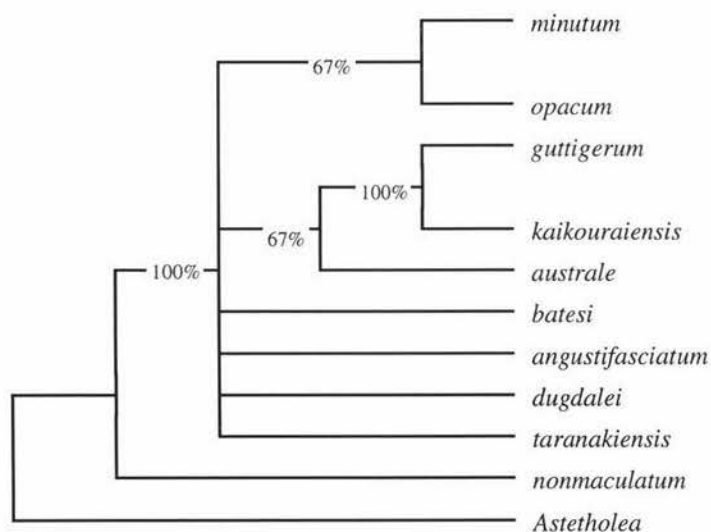
The computer program PAUP\*4.0b8 (Swofford 2001) was used for the phylogenetic analysis. Character state changes were treated as unordered and topological constraints were not enforced. In Cladistics characters might be assigned different weights (Carpenter 1988, Farris 1979) and for this study two analyses were conducted as follows: (1) characters were given equal weight followed by successive character weighting by the maximum value of rescaled consistency indices; (2) all characters were given equal weight except characters three to eight, which were given a weight of 0.1667. The character state 'no spot [2]' occurs six times, each time with a weight of 1 dominating the search for optimal trees. To give this character state an overall weight of 1, I divided 1 by 6 (the number of times the state occurs), which gives it a weight of 0.1667. The taxon *Astetholea* was transferred to the outgroup under the 'define outgroup' option. The PAUP\* program provides the options of a heuristic (approximate) and a Branch and Bound method. The heuristic setting allows the program to search stepwise for optimal trees from very complex data sets but there is no guarantee that the trees found are the most parsimonious ones. Since my data set is relatively small I applied the Branch and Bound algorithm which is guaranteed to find all minimum length trees (Swofford 2001). To find the most optimal tree that requires the least number of evolutionary character changes needed to explain the

variation in a given data set (Mayr & Ashlock 1991) the maximum parsimony criterion was applied. When a single data set contains two or more equally parsimonious trees a consensus tree can be built (Minelli 1993). In this case I provide 50% majority rule consensus (Margush & McMorris 1981), which constructs a combined tree that includes those groups that appear in a majority (>50%) of the individual trees.

### 3.5 Results and Discussion

#### 3.5.1 Cladograms obtained

The first Branch and Bound search (all characters equal weight) retained six equally parsimonious cladograms (Length = 37, Consistency Index (CI) = 0.5946, Retention index (RI) = 0.5833). Successive character reweighting resulted in six equally parsimonious cladograms (Length = 12, CI = 0.7928, RI = 0.8422). Cladograms retained before and after character reweighting were the same. The six cladograms differed in the arrangement of some species in the terminal clades. The 50 % majority rule consensus cladogram (Fig. 3.1) of these six cladograms is presented as the preferred hypothesis of the relationships between the taxa because it shows these areas of cladogram conflict as polytomies.



**Figure 3.1** 50% Majority-rule consensus derived from six most parsimonious cladograms

**Table 3.3** Frequency and % of bipartitions for 11 taxa occurring in 50% majority rule consensus of six cladograms

Bipartitions Freq	%	Taxa										
		0 1	0 2	0 3	0 4	0 5	0 6	0 7	0 8	0 8	1 0	1 1
6	100.0%	-	*	-	-	-	-	-	-	-	*	-
6	100.0%	-	-	-	-	-	-	-	*	-	-	*
4	66.7%	-	*	*	-	*	*	*	*	*	*	*
4	66.7%	-	*	-	-	-	-	-	-	*	*	-
3	50.0%	-	*	*	-	*	*	*	-	*	*	-
3	50.0%	-	*	*	-	-	*	*	*	*	*	*
3	50.0%	-	*	-	-	-	-	*	*	*	*	*
3	50.0%	-	*	-	-	-	-	-	*	*	*	*
3	50.0%	-	*	*	-	-	*	*	-	*	*	-
3	50.0%	-	*	-	-	-	-	*	-	*	*	-
1	16.7%	-	*	-	-	-	-	-	*	-	*	*
1	16.7%	-	*	*	*	*	*	*	-	*	*	-
1	16.7%	-	-	-	*	-	-	-	*	-	-	*

Bipartitions found in one or more cladograms and frequency of occurrence are listed in Table 3.3.

The similarity between all cladograms is that *Z. nonmaculatum* is outside the clade of the remaining *Zorion* species and *Z. guttigerum* and *Z. kaikouraiensis* always occur as sister species while *Z. minutum* and *Z. opacum* are sister species only in four cladograms and *Z. australe* forms a clade with the sister group *Z. guttigerum* and *Z. kaikouraiensis* in four cladograms. The polytomy of *Z. batesi*, *Z. angustifasciatum*, *Z. dugdalei*, *Z. taranakiensis* with the sister group of *Z. minutum* and *Z. opacum* and the *Z. australe* clade is not resolved. Islands of cladograms Maddison (1991) within the six retrieved cladograms could not be established. An island consists of at least two cladograms, which are connected in that they differ by the arrangement of one branch. The six cladograms found by PAUP\* all were connected in that they differ by the arrangement of one branch.

The second Branch and Bound search with characters 3-8 given a weight of 0.1667 retained three equally parsimonious cladograms (Length = 18.3342, CI = 0.6545, RI = 0.6576). These three cladograms differ at their nodes 15 and 16 as shown in the sub cladograms in Figs 3.2-3.4. The remaining nodes in all three cladograms are corresponding



to the resulting consensus cladogram shown in Fig. 3.5 where the branch for the taxa *nonmaculatum* and *australe* is unresolved and the bipartitions found at node 12, 14, 17, 18 & 19 occur in each of the three cladograms (see also Table 3.4).

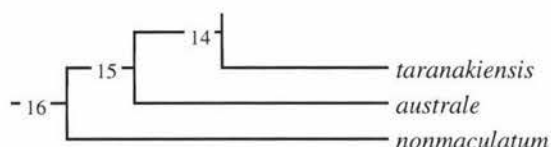


Figure 3.2 Partition of cladogram 1 of 3

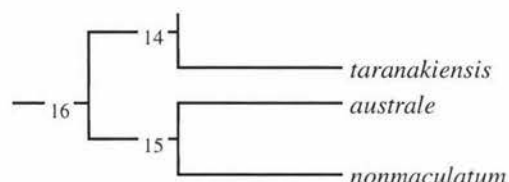


Figure 3.3 Partition of cladogram 2 of 3

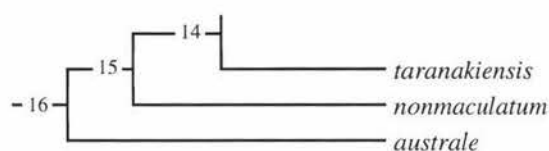


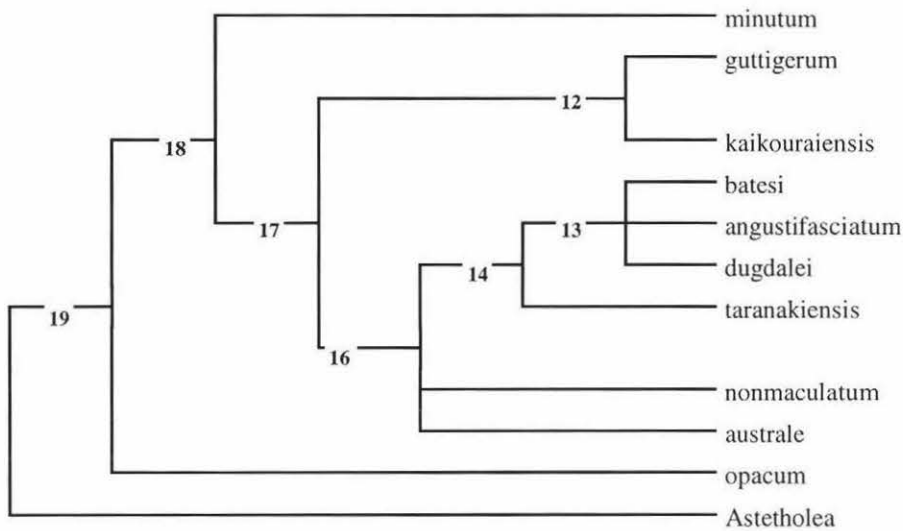
Figure 3.4 Partition of cladogram 3 of 3

The 50% majority rule consensus “cladogram 2” as shown in Fig. 3.5 has the following implications:

- 1 *Z. opacum* is at the base of the ingroup connected to the root and forming its own clade.
- 2 *Z. minutum* forms its own clade arising at node 18 from which the remaining *Zorion* species arise.
- 3 *Z. guttigerum* is the sister species of *Z. kaikouraiensis* forming a clade at node 12.
- 4 *Z. batesi*, *Z. angustifasciatum* and *Z. dugdalei* are combined in one clade at node 13 and their polytomy is not resolved.
- 5 *Z. taranakiensis* forms the sister group to clade 13.
- 6 The polytomy of *Z. nonmaculatum* and *Z. australe* remains unresolved.

To further discuss the implications of the cladistic analysis I will concentrate on the consensus cladogram shown in Fig. 3.5 since this is derived from only three trees and has a higher resolution in comparison to the cladogram in Fig. 3.1. Also the cladogram Fig. 3.5

seems not to be influenced by the equal weight given to the characters as in the cladogram Fig. 3.1. In addition, having examined the specimens available for this study I believe that *Z. nonmaculatum* should be closer to *Z. australe* as is found in the cladogram from Fig. 3.5.



**Figure 3.5 50% Majority rule consensus of three most parsimonious cladograms**

### 3.5.2 Determination of character state polarity

According to Watrous and Wheeler (1981) character polarisation not only determines synapomorphies for the taxonomic ingroup but also for groupings within the ingroup. The cladogram (Fig. 3.5) is rooted at its base using the outgroup as the root and character polarity determination is based on the character states present at each node of the ingroup (Watrous and Wheeler 1981). Therefore, the characters 1, 2, 4, 7, 9, 12, 13 and 14 at node 19 (Fig. 3.5, Table 3.5) have state 0 and the remaining characters state 1. This indicates that for characters 1, 2, 4, 7, 9, 12, 13 and 14, state 0 is plesiomorphic and state 1 or 2 is apomorphic and for the remaining characters state 1 is plesiomorphic and state 0 or 2 is apomorphic. A summary of the reconstructed states for the internal nodes given by PAUP\* is shown in Table 3.5.

Table 3.4 Frequency and % of bipartitions for 11 taxa occurring in 50% majority rule consensus of three cladograms

Bipartitions		Taxa										
		0	0	0	0	0	0	0	0	0	1	1
Freq	%	1	2	3	4	5	6	7	8	8	0	1
3	100.0%	-	*	*	-	*	*	*	*	*	*	-
3	100.0%	-	*	-	-	-	-	-	-	-	*	-
3	100.0%	-	-	*	-	*	*	*	*	*	-	-
3	100.0%	-	-	*	-	*	*	*	-	-	-	-
3	100.0%	-	-	*	-	*	*	-	-	-	-	-
3	100.0%	-	-	-	*	-	-	-	-	-	-	*
1	33.3%	-	-	*	-	*	*	*	-	*	-	-
1	33.3%	-	-	-	-	-	-	-	*	*	-	-
1	33.3%	-	-	*	-	*	*	*	*	-	-	-

Table 3.5 List of reconstructed states of *Zorion* for internal nodes from Figs 3.2-3.5

Nodes	Characters														
	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
12	0	0	0	1	1	1	1	0	0	1	1	1	0	0	
13	1	0	1	1	0	0	1	1	0	1	0	2	0	0	
14	1	0	0	1	1	1	1	1	0	1	0	2	0	0	
15	0	0	0	1	1	1	1	0	0	1	0	2	0	0	
16	0	0	0	1	1	1	1	0	0	1	0	2	0	0	
17	0	0	0	1	1	1	1	0	0	1	1	2	0	0	
18	0	0	1	0	1	1	0	1	0	1	1	0	0	0	
19	0	1	1	0	0	0	0	1	0	0	1	0	0	0	

3.5.3 Synapomorphies and clades of *Zorion*.

Synapomorphies (Table 3.6) for the clades in Fig. 3.5 are derived from the lists of apomorphies produced by PAUP\* for the three cladograms from which the consensus cladogram in Fig. 3.5 was derived . The implications for each clade are discussed below.

Synapomorphies

Seven synapomorphies (Table 3.6) at node 19 are in support of the genus *Zorion* (character numbers given in parentheses): reduced spot (3); spot width < 1.4 × length (4);



distance spot and elytral suture  $> 2 \times$  distance between spot and margin (5); spot reaching margin (6); spot axis transverse (7); spot colour whitish (8); and rounded elytra apex (9).

**Table 3.6 Characters and their state transformations  
that are synapomorphies for each clade in Fig. 3.5**

Clade	No. of synapomorphies	Characters and their state transformations
12	1	12, 2→1.
13	3	3, 0→1; 5, 1→0; 6, 1→0.
14	2	1, 0→1; 8, 0→1.
16	1	11, 1→0.
17	4	3, 1→0; 4, 0→1; 7, 0→1; 8, 1→0.
18	5	2, 1→0; 5, 0→1; 6, 0→1; 10, 0→1; 12, 0→2.
19	7	3, 2→1; 4, 2→0; 5, 2→0; 6, 2→0; 7, 2→0; 8, 2→1; 9, 1→0.

**Clade 18.**

This clade is supported by five synapomorphies (Table 3.6): glossy pronotum (2); spot distance to suture  $< 2 \times$  distance to margin (5); spot not reaching margin (6); elytra glossy (10); main body colour orange (12).

**Clade 17.**

Four synapomorphies (Table 3.6) support this clade: large spot on elytra (3); spot width  $> 1.4 \times$  wider than long (4); spot axis angle variable (7); spot colour yellow (8).

**Clade 12.**

One synapomorphy (Table 3.6) supports the sister species relationship between *Z. guttigerum* and *Z. kaikouraiensis*: overall purple body colour (12).

## Clade 16.

One synapomorphy (Table 3.6) supports this clade: dark field on elytra present (11).

## Clade 14.

This clade is supported by 2 synapomorphies (Table 3.6): coloured ring on femur present (1); spot colour whitish (8).

## Clade 13.

Three synapomorphies (Table 3.6) support the unresolved clade *Z. batesi*, *Z. dugdalei* and *Z. angustifasciatum*: reduced spot (3); spot distance to suture  $> 2 \times$  distance to margin (5); spot not reaching margin (6).

**3.5.4 Character diagnostics for the genus *Zorion*.**

Diagnostics of each character in terms of its steps, consistency index (CI) and retention index (RI) are discussed here and support for the clades is based on the information from Tables 3.1-3.2 & 3.5-3.7. Characters with little or no homoplasy (character derived not from nearest common ancestor but through convergence, parallelism, or reversal) have high CI values whereas characters that show considerable homoplasy have low CI values (Kluge & Farris 1969). The CI value and RI value, the latter measuring the fraction of apparent synapomorphy to actual synapomorphy (Farris 1989), and the minimum number of steps needed to explain the evolution of character states are given in the PAUP\* output and are listed in Table 3.7.

Binary characters 9, 13 and 14 (each 1 step) and multistate characters 3, 4, 5, 6, 7, and 8 (each 2 steps) have lowest CI and RI value suggesting they have highest homoplasy. This is in contrast to binary characters 1, 10 and 11 (1 step each) and multistate character 12 (3 steps) having the highest CI and RI value, suggesting that they are good synapomorphic characters. The binary character 2 and multistate character 3 both have values in between these two extremes and they may act as synapomorphies but both have reversals.

The seven characters 3, 4, 5, 6, 7, 8, and 9 at node 19 do not seem to support the clades of the genus *Zorion* but may be synapomorphies subject to missing taxa, character

reversals or convergence. The apomorphic states of characters 10 and 12 appear to be good synapomorphies without reversals or convergence supporting the monophyly of the clade 18 containing *Z. minutum* and its sister clade 17 whereas characters 2, 5, and 6 have reversals along the cladogram. Consequentially characters 3, 4, 7 and 8 may be synapomorphies for the clade 17, which contains two main groups but may be subject to convergence, reversals or missing taxa.

**Table 3.7 Character diagnostics for the 50% majority rule consensus cladogram (Fig. 3.5) for the genus *Zorion***

Character	Steps	CI	RI
1	1	1.000	1.000
2	1	0.500	0.500
3	2	0.500	0.500
4	2	0.500	0.333
5	2	0.400	0.250
6	2	0.400	0.250
7	2	0.500	0.333
8	2	0.500	0.333
9	1	0.500	0.000
10	1	1.000	1.000
11	1	1.000	1.000
12	3	1.000	1.000
13	1	0.500	0.000
14	1	0.500	0.000

The apomorphic state of character 11 for clade 16 is synapomorphic without reversals or convergence. Clade 14 contains *Z. taranakiensis* and the clade 13 and is supported by the apomorphic character state of character 1 acting as good synapomorphy while again character 8 does not support this clade. Characters 3, 5 and 6 at clade 13 are reversed characters. The clade of the sister group *Z. guttigerum* and *Z. kaikouraiensis* is supported by the synapomorphy of character 12.



### 3.6 Summary

In this chapter I discussed the monophyly of the revised genus *Zorion* and used cladistic analysis to test the phylogenetic relationships between its species. Two different search methods were applied (1) with all characters given an initial equal weight, and (2) with characters 3 – 8 given a weight of 0.1667 each. The retrieved cladogram for the second search method had a higher resolution and was analysed in detail. Characters available to solve species relationships in this study are very limited and are dominated by the appearance of the spots on the elytra and other colour characters. The available characters have many reversals occurring throughout the character distributions on the tree obtained from the computerized analysis. *Z. opacum* is at the root of the cladogram followed by the confirmed monophyletic clade 19 containing *Z. minutum* and clade 17 whose monophyly could not be confirmed and contains clades 12 and 16. *Z. guttigerum* and *Z. kaikouraiensis* are confirmed sister species in the monophyletic clade 12, which forms a sister group to clade 16 whose monophyly was confirmed by one character and contains the unresolved polytomy of *Z. nonmaculatum* and *Z. australe* and clade 14. The latter again is recognised as a monophyletic group by one character and contains the species clade *Z. taranakiensis* and clade 13 consisting of *Z. batesi*, *Z. angustifasciatum* and *Z. dugdalei* whose polytomy remains unresolved. Comparing the two retrieved consensus trees it becomes apparent that the sister group *Z. guttigerum* and *Z. kaikouraiensis* is found in both cladograms (Figs 3.1 & 3.5) and the polytomy of *Z. batesi*, *Z. angustifasciatum*, *Z. dugdalei*, *Z. taranakiensis* (Fig. 3.1) has been resolved to the two groups connected at clade 14 in Fig. 3.5.

# BIOGEOGRAPHY AND DISTRIBUTION

### 4.1 Introduction

Biogeography is the study of geographic distribution patterns of organisms and their ecological and historical evolution. The distribution of taxa may be studied in terms of their history or in terms of their interactions with their biotic or abiotic environment (Cox & Moore 2000).

Since its break-up from Gondwana 180 million years ago, New Zealand's geology together with its flora and fauna have been subject to many changes. New Zealand shares many common aspects with Australia, New Caledonia and South America (Williams 1973, Kuschel 1975, Stevens 1980, Stevens *et al.* 1995). There is disagreement on how New Zealand's flora and fauna has been established and which method might best establish past events. For example, have species established as a result of long distance dispersal or are they ancient Gondwana remnants left through vicariant events (Rosen 1978, Page 1988, Craw 1989, Pole 1994, Morrone & Crisci 1995, Heads 1998, Craw *et al.* 1999, Cox & Moore 2000, Grehan 2001). However, New Zealand's flora and fauna are unique and endemism is high in comparison to even some of its closest neighbours. Watt (1975), for example, suggests that the beetle fauna of the New Zealand region is 96% endemic at the species level. Dugdale (1975) stated that monophagous plant-insect relationships (insects that are host specific to a particular plant species) were likely to be those that withstood the cold Pleistocene glacial regimes, whereas polyphagous insect-plant relationships were confined to warm-temperate climates such as in the larger Pacific, including New Zealand. New Zealand is unusually poor in monophagous insects and a typical example of a highly successful polyphagous genera is *Zorion*, which is studied in this thesis.

The following discussion is not an attempt to establish relationships of the genus *Zorion* but to discuss patterns of present day distribution of the species in relation to geographical history and to areas of endemism in New Zealand.

## 4.2 New Zealand Moving and Origin of *Zorion*

New Zealand lies between two subduction zones and its origin and formation has been subject to tectonic movements of the neighbouring Indian-Australian and Pacific plate. By Jurassic times, 192-135 million years ago, the Gondwanan climate became warmer due to a shift northwards and due to an expansion of the tropical and subtropical zones. At the same time New Zealand, that had been merely an appendage to Gondwana and mostly covered by sea, was connected to Australia and Antarctica. By the end of late Jurassic earth movements had pushed land above the sea level stretching towards New Caledonia, the Lord Howe Rise, the Chatham Islands and the Campbell Plateau. New Zealand was no longer separated from Gondwana and links had been established for organisms to colonize the new land. New Zealand is thought to have been a larger land mass than it is today. Sea floor spreading during early Cretaceous lead to the development of the Tasman Sea, which was an open seaway about 85 million years ago, in the late Cretaceous and left New Zealand separated from Australia (Stevens *et al.*). About 40 to 25 million years ago approximately 60% of modern New Zealand was below sea level leaving only aerial fragments (Aitken 1996). The earliest land animals that colonized New Zealand by late Jurassic or early Cretaceous would have been insects, amphibians and reptiles. Some of these early land animals are now endemic and only found in New Zealand, an outstanding example are tuatara and weta (Fleming 1979, Stevens *et al.* 1995). The survival and endemism of these organisms coincides with the time when New Zealand started to move away from Gondwana.

Organisms might be either primary endemic and have developed in New Zealand or they are secondary endemic and went extinct elsewhere (Fleming 1979). The genus *Zorion* is endemic to New Zealand and in this study no close relationship to any other Cerambycidae has been established to indicate its place of origin. However, Gressitt was cited by Williams (1973) saying that New Zealand Cerambycidae have strong affinities with New Guinea forms through New Caledonia and there are no evident American relationships. The genus might have its origin during the time when New Zealand was connected to Gondwana. If the genus is a Gondwanan remnant then there might well have



been only one species distributed in Gondwana and the land that had separated it from Gondwana. Species of the genus *Zorion* then might have become extinct in Gondwana and could be secondarily endemic to New Zealand. On the other hand, species described in this study may have evolved after the formation of islands resulting from tectonic movements and sea level changes. *Zorion* species then would be primary endemic to New Zealand, evolved separated from closely related species that remained in Gondwana.

#### 4.3 New Zealand Changing and *Zorion* Species Distributions

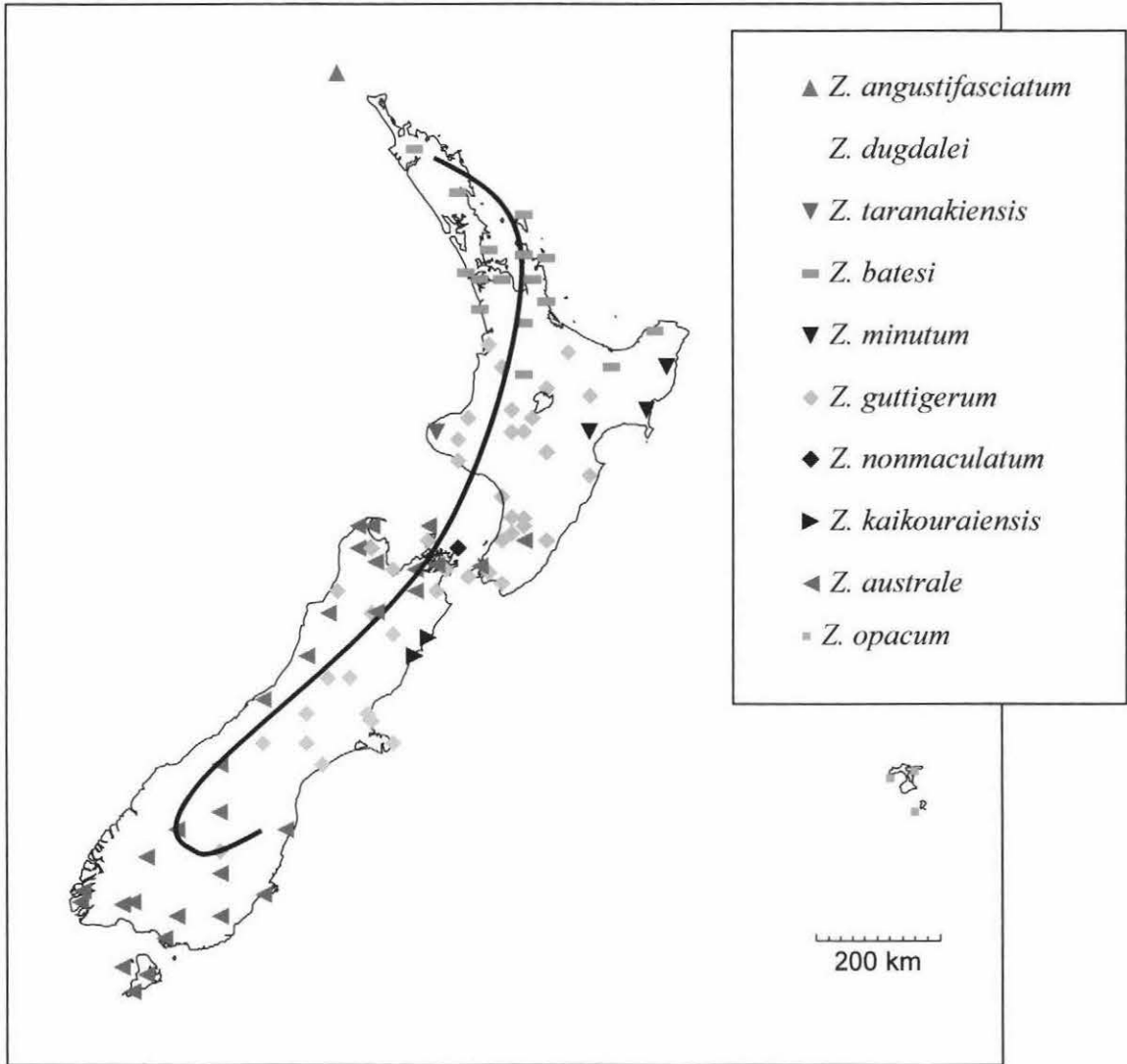
The combination of plate tectonics and resulting volcanic formations as well as sea level changes due to climatic changes all have influenced the formation of New Zealand mainland and off shore islands. In particular, the northern offshore islands and their present landscape are thought to have originated mostly during the last 2 million years (Hayward 1986). However, at the peak of the last glacial event sea levels were only around 100-115 m below present. New Zealand was one landmass, except Three Kings Islands, whose last land connection is thought to be more than 2 million years ago (Hayward 1986). Poor Knights Islands had land connection with New Zealand less than 1 million years ago.

Three Kings Islands are situated 70 km NW of Cape Reinga comprising one large island of 407 ha (Great Island) and three smaller islands (North East Island, West and South West Islands) and several small islets. Poor Knights Islands is thirty-two kilometres from the eastern shoreline of northern North Island and is also comprised of several small islands. A large number of taxa including plants, invertebrates and vertebrates are endemic to the Three Kings Islands in comparison to other New Zealand offshore islands and New Zealand mainland (Simpson 1986, Watt 1986). Three Kings Islands has a very high endemism of Coleoptera (100% in some families) as does the Poor Knights Islands with about 14% endemism (Watt 1986). The beetle endemism of the Three Kings Islands exceeds even that of the Chatham Islands, which are at much greater distance (670 km) from New Zealand. For example the Three Kings *Platysus zelandicus* Marris & Klimaszewski 2001 (Watt et al. 2001) is endemic to the Three Kings Islands and is the only representative of Cucujidae in New Zealand with its next closest relatives found in Australia, while species of the genus *Hadramphus* are restricted to the Chatham Islands,

Poor Knights Islands but also to Fordland, the Snares and the Canterbury plains (Craw 1999).

Emberson (1995, 1998) suggested that since endemism on the Chathams is mainly at the species level a land connection to the mainland of New Zealand must have been more recent. In addition, the panbiogeographical approach by Craw (1988, 1989) connecting the Chatham Islands biota with parts of New Zealand, depended on tectonic movements long before New Zealand's separation from Gondwana. A more recent study (Trewick 2000) using molecular data seems to confirm Emberson's (1995, 1998) suggestion, and Trewick (2000) assumed that elements in the Chatham's biota are the result of dispersal during the Pliocene 2-6 million years ago.

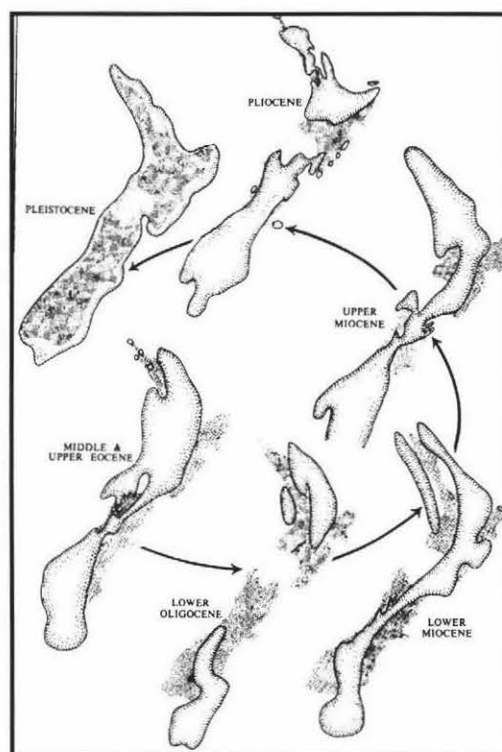
Therefore, it might not be surprising to find the species *Z. angustifasciatum* on Three Kings Islands and *Z. dugdalei* on Poor Knights Islands (Fig. 4.1) as endemic representatives of the genus *Zorion* and forming one clade with the northern species *Z. batesi* in Fig. 3.5. Furthermore, both the Poor Knights Island species *Z. dugdalei* and Chathams Island species *Z. opacum*, (Fig. 4.1) have a dull prothorax in comparison to the other *Zorion* species, suggesting that they are more closely related to each other than to any other *Zorion* species. A connection between Poor Knights Islands and Chatham Islands was also considered by Williams (1973). He assumed there is some floral and faunal association between Poor Knights Islands and the Chatham Islands. Craw (1988, 1989) established a connection with the northern part of New Zealand through track analysis of the Chatham Islands biota. Yet looking at the cladogram at Fig. 3.5 in the previous chapter, *Z. opacum* is the sister group to all other *Zorion*. This again might suggest an ancient relationship between North Island and the Chathams supporting the vicariance model of Craw (1988, 1989). Watt (1986) previously stated that the high level of endemism on Three Kings and Poor Knights Islands is not due to distance but rather due to connectedness followed by a long period of isolation and most beetles even those that are fully winged do not seem to cross substantial sea barriers. This might have allowed the species *Z. angustifasciatum*, *Z. dugdalei* and *Z. opacum* to evolve separately despite the ability to fly.



**Figure 4.1** Distribution of the *Zorion* species as recorded from collection labels. The *Z. batesi* record on Kermadec Island is not shown here. Black line showing distribution trend of *Zorion* species over the North and South Island. (Map with permission from Ian Henderson, Massey University)



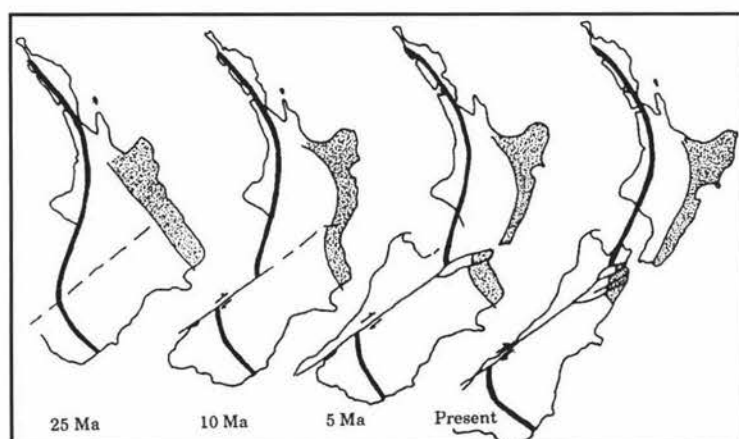
New Zealand underwent some major changes throughout its history. Rising and falling sea levels as well as glacial events and the formation of mountains such as the Kaikoura ranges in the Pliocene all might have contributed to the diversity of disjunct and overlapping distributions of the present day biota (Fleming 1979) (Fig. 4.2).



**Figure 4.2** Changing New Zealand during the Cenozoic (after Fleming 1979)

A recent study by Heads (1998) tries to explain speciation within New Zealand based on the recurved arc model, which shows movements of New Zealand land masses in relation to movement of the Australian-Pacific plate boundary (Fig. 4.3). The model demonstrates disjunct distributions of species along the southern alpine fault. While there is not such a disjunct distribution of *Zorion* species, which Heads (1998) showed existing for some species between northern and southern South Island, one can still draw a line along the alpine fault. This line seems to separate the distribution of *Z. guttigerum* and *Z. australe* (Fig. 4.1) and follows distribution patterns depicted by Heads (1998). These two

species could have evolved through disjunct displacement as suggested by the model shown by Heads (1998). This places *Z. guttigerum* and *Z. kaikouraiensis*, which form a sister group (Fig. 3.5) to the east of New Zealand. *Z. kaikouraiensis* may have evolved while separated from its founder population through the Kaikoura ranges. *Z. guttigerum* may have dispersed back into the lower part of North Island at some latter stage when South and North were connected as it was the case during the last glacial event about 10 thousand years ago. Another hypothesis is that this species might have dispersed into South Island from North Island, since it forms a sister species to *Z. minutum* in the east of North Island. Extending the line in Fig. 4.1 into the North Island, a geographic connection of *Z. australe* and *Z. dugdalei* with *Z. taranakiensis* and the Northland clade may be established, which is reflected in the clade formed by the six species in Fig. 3.5. *Zorion guttigerum* is mainly found to the east of the line as in South Island.



**Figure 4.3** Model of the age and origin of recurved arcs in New Zealand in relation to movement on the Australian-Pacific plate boundary (after Heads 1998)

A recently collected *Z. batesi* specimen from the Kermadec Islands appears to be an exception and is most likely to have been transported by humans. No other records from the Kermadec Islands are known. These islands are of volcanic origin and are situated some 1,000 kilometres NW of Auckland and have been isolated since their formation. The

islands' faunal and floral populations are thought to have arisen entirely by transoceanic dispersal (Fleming 1979, Atkinson & Bell 1973). This specimen on the Kermadec Islands might therefore be an example of a common present day dispersal mechanism, human assisted. This can allow access in a short time frame and across otherwise impassable barriers.

#### **4.4 Conclusion**

In this chapter I briefly discussed some theories about the origin of New Zealand and its developmental changes. These obviously had some influence on past and present day biota. Ecological as well as tectonic events must have contributed to the evolution of species. The distribution and phylogenetic associations established in the previous chapters of the *Zorion* species were discussed. I established comparisons with theories about glacial events and species distribution observations made by previous researchers. Whereas vicariant and climatic events may have had some influence on the distribution of *Zorion* species on New Zealand's main islands, the presence of species on offshore islands might be attributed to dispersal during periods of low sea levels followed by rising sea levels. A future study similar to the one carried out by Trewick (2000) using molecular data to test between vicariance and over-seas dispersal, might confirm the distribution and relationship patterns amongst *Zorion* species.



## **GENERAL DISCUSSION AND SUMMARY**

### **5.1 Introduction**

This study contributes towards the knowledge of New Zealand's biodiversity investigating the systematics and biogeography of the endemic genus *Zorion*. These data were previously unknown and the relationships and distributions of this species have been problematic. This was despite the fact that many entomologists were attracted to the colourful beetles and some species were collected in high numbers.

### **5.2 Taxonomy**

This thesis presents for the first time a thorough taxonomic description of the genus *Zorion* and its species. A key for the identification of ten species of this genus is provided in the taxonomy section. Discrete colour, elytral spot patterns and different exo-skeletal surfaces have confirmed four previously described species, and as a result of the present study six new species and one new synonym have been established. Table 5.1 compares the taxonomy of this study with the previously recognised taxonomy of the genus.

Included in the description are the male terminalia and aedeagus for which no distinct species characteristics were determined. Spines within the aedeagus often show distinct differences between species but I could find no study showing SEM images of the spine of Cerambycid beetles. Andrew Calder (CSIRO, pers. comm.), agreed that useful publications on the endophalic structures of Cerambycidae are lacking and that the main problem to overcome is to evert the aedeagus so that structures are on the surface rather than be obscured inside the internal sac. The method of splitting the internal sac after drying to reveal the internal structures as employed in the present study may destroy too much of the specimen. Skelley (1993) described a method for everting the inflatable internal sac of the aedeagus and examining under the SEM, but his method lends itself best to freshly collected specimens and museum specimens often cannot be inflated (Matthews 1998). Matthews (1998) introduced the CSIRO vesica everter which was used successfully to evert the aedeagus of some Lamiinae (Cerambycidae), but these are much larger specimens than those of *Zorion*. Finding a suitable method to prepare the everted aedeagus of *Zorion*

specimens for SEM images would be useful in establishing structural differences between species. In general structural differences of the body between species could not be found and SEM images might reveal subtle differences not visible under the stereomicroscope.

Table 5.1 Taxonomic history (Blair 1937) and present status of the genus *Zorion*

History	Present
<b><i>Z. minutum</i> (Fab.) 1775</b>	<b><i>Z. minutum</i> (Fab.) 1775</b>
<i>Z. exiguum</i> (Gmelin) 1788	<i>Z. exiguum</i> (Gmelin) 1788 (no specimen seen)
<i>Z. fabricianum</i> (Westwood) 1845	<i>Z. fabricianum</i> (Westwood) 1845
var. <i>Z. guttigerum</i> (Westwood) 1845	<b><i>Z. guttigerum</i> (Westwood) 1845</b>
	<i>Z. castum</i> (Broun) 1893 <b>syn. nov.</b>
<i>Z. batesi</i> (Sharp) 1875	<b><i>Z. batesi</i> (Sharp) 1875</b>
<b><i>Z. castum</i> (Broun) 1893</b>	
<b><i>Z. opacum</i> (Sharp) 1903</b>	<b><i>Z. opacum</i> (Sharp) 1903</b>
	<b><i>Z. angustifasciatum</i> sp. nov.</b>
	<b><i>Z. australe</i> sp. nov.</b>
	<b><i>Z. dugdalei</i> sp. nov.</b>
	<b><i>Z. kaikouraiensis</i> sp. nov.</b>
	<b><i>Z. nonmaculatum</i> sp. nov.</b>
	<b><i>Z. taranakiensis</i> sp. nov.</b>

The taxonomy in this study was based on adults since immature stages of *Zorion* are largely unknown. Dumbleton (1957) and Duffy (1963) described the larvae of *Z. minutum* and these could not be distinguished from the *Z. guttigerum* larvae. Further study is required to describe and illustrate the immature stages of the genus.

5.3 General Biology

Biological records could be made from information on labels attached to the specimens, and from information given by Dumbleton (1957), Milligan (1975) and Kuschel (1990). Adults of *Zorion* emerge from September and October and can be found

throughout the summer period from September till March. The genus *Zorion* is associated with more than 67 host species in 55 genera. A great variety of plants are used both for feeding of the adult and as a host for the larvae, which feed under the bark of freshly cut or dead branches. Some plant species serve both purposes, feeding and hosts for larvae. Polyphagous Cerambycidae are considered to be “primitive” and the range of hosts is, in general, greatest in species which oviposit on freshly cut, slightly injured or decaying wood (Linsley 1959). The genus does not pose a threat as a pest to any plant but could contribute significantly to the cycling of nutrients. This study also shows that *Zorion* may be an important pollinator for some plants as the adults feed on the pollen of flowering plants and gather there for mating. Males mating on flowers tend to stay on the female for some time whereas females kept in the laboratory mated with several males. Feeding and mating behaviour as well as breeding of the beetles has been briefly discussed in this thesis but in general further studies are necessary to further understand the biology of this genus, for example are the females polyandrous or is male guarding behaviour involved? A method needs to be established to raise *Zorion* under laboratory conditions. To extend the information gathered in this thesis to all species of *Zorion* more data is needed on populations and their ecology.

#### 5.4 Phylogeny

A cladistic analysis to resolve relationships within *Zorion* was carried out for the first time. Two analyses retained six and three cladograms from which a consensus was computed. The most resolved consensus cladogram ( Fig. 3.5) was unresolved at clade 13 containing three species and one branch at clade 16 containing two species. However, character states are distributed on the cladograms with many reversals. Reversals of character states on the cladograms might be due to missing taxa, irrespective of whether those have gone extinct or not been collected. Characters chosen for the analysis were mainly based on colour and the appearance of the elytral spot. More characters need to be established to resolve the species relationships further. Neither immature stages of *Zorion* nor DNA sequencing were included in the phylogenetic analysis. As pointed out earlier, Dumbleton (1957) and Duffy (1963) found no differences between the larvae of *Z. minutum*



and *Z. guttigerum* and larvae characters might prove to be uninformative in establishing species relationships. DNA sequences should be included in further phylogenetic analyses and a brief basis for *Zorion* DNA sequencing is given in the appendix. Sequencing a section of the mitochondrial CO1 gene shows nucleotide differences between *Z. guttigerum* and *Z. australe* (Appendix Fig. 6.1).

### 5.5 Biogeography and Distribution

This study shows for the first time a full distribution map for *Zorion* species. The present day distribution is discussed in relation to New Zealand's geographical history along with literature that considered the distribution of some New Zealand endemic beetle species. Dispersal to islands at times of low sea levels followed by vicariant events separating islands from the mainland seem to have been influential in speciation rather than long distance dispersal over the sea. Some collecting sites have been used repeatedly while others have been left out. For example, *Z. dugdalei* was collected on Aorangi Island in the Poor Knights group, and it remains to be determined whether this species distribution includes Tawhiti Rahi Island, Motu Kapiti Island, Aorangaia Island and Archway Island, also in the Poor Knights Islands group. To adequately determine the distribution patterns of *Zorion* species or find new species, collection needs to expand into areas that have previously been left out.

### 5.6 Synopsis

This thesis presented an overview of the taxonomic history and provided descriptions for the genus *Zorion* and its species and a key for their identification. The species relationships, their biology and present day distribution in relation to New Zealand's biogeographical history are also discussed. It is hoped that this research will provide a useful introduction to the genus *Zorion*, as well as an extensive reference resource for those interested. It is intended to be used as a basis on which to build further research about the genus *Zorion*.

## 6.1 PRELIMINARY SEQUENCE DATA

DNA was extracted and mitochondrial sequence obtained by Leon Huynen (Massey University) from the following beetles and their parts: main body of *Z. australe* Momorangi Bay, 19 Dec 1999, delivered in 70% ethanol; leg of *Z. guttigerum* Palmerston North, Esplanade, 5 Jan 2000, delivered dried on pin; head of *Z. guttigerum* Palmerston North, Esplanade, 5 Jan 2000, delivered dried on pin. A section of the mitochondrial CO1 gene was amplified using primers bCOIf (TACCTCAGCAACTATATTATTGC) and bCOIr (TGAATTAATCCTGCTATAATAGC) using oligonucleotide polymerase chain reaction (PCR) reaction. PCR products were then sequenced using the primer bCOIf. Preliminary data show that sequence differences between the beetles do exist, but further analysis may require sequence data from more variable DNA regions.

### *Z. australe*

TAGCTGACTGGCTACCCTTCACGGAAGTCAATTACTCATAAGACCC  
ACAACTCTTTGATCATTAGGCTTTGTGTTTCTGTTTACAGTAGGAG  
GTCTAACAGGAGTAGTTCTTGCAAAGTCAATCCTTAGATATTATACT  
TCACGATACTTACTATGTAGTAGCCCACTTTCCTACGTTTTATCT  
ATAGGAGCAGTCTTT

### *Z. guttigerum* leg

TAGCTGACTAGCTACCCTTCACGGAAGTCAATTACTAATAAGACCC  
ACAACTCTTTGATCATTAGGCTTTGTGTTTCTGTTTACAGTAGGAG  
GTCTAACAGGAGTAGTTCTTGCAAAGTCAATCCTTAGATATTATACT  
TCACGATACTTACTATGTAGTAGCCCACTTTCCTACGTTTTATCT  
ATAGGAGCAGTTTTT

### *Z. guttigerum* head

TAGCTGACTAGCTACCCTTCACGGAAGTCAATTACTAATAAGACCC  
ACAACTCTTTGATCATTAGGCTTTGTGTTTCTGTTTACAGTAGGAG  
GTCTAACAGGAGTAGTTCTTGCAAAGTCAATCCTTAGATATTATACT  
TCACGATACTTACTATGTAGTAGCCCACTTTCCTACGTTTTATCT  
ATAGGAGCAGTTTTT

**Figure 6.1** Partial mitochondrial CO1 gene sequence of *Z. australe* and *Z. guttigerum*, one individual each. The sequences shown exclude primer sequences

6.2 SEQUENCES LINEUP

<i>austr.</i> BCOIf	-----G	-----	-----	-----C---
<i>gutt.</i> leg.BCOIf	-----	-----	-----	-----
<i>gutt.</i> Hd.BCOIf	-----	-----	-----	-----
	.....	.....	.....	.....
	TAGCTGACTA	GCTACCCTTC	ACGGAACTCA	ATTACTAATA
<i>austr.</i> BCOIf	-----	-----	-----	-----
<i>gutt.</i> leg.BCOIf	-----	-----	-----	-----
<i>gutt.</i> Hd.BCOIf	-----	-----	-----	-----
	.....	.....	.....	.....
	AGACCCACAA	CTCTTTGATC	ATTAGGCTTT	GTGTTTCTGT
<i>austr.</i> BCOIf	-----	-----	-----	-----
<i>gutt.</i> leg.BCOIf	-----	-----	-----	-----
<i>gutt.</i> Hd.BCOIf	-----	-----	-----	-----
	.....	.....	.....	.....
	TTACAGTAGG	AGGTCTAACA	GGAGTAGTTC	TTGCAAATC
<i>austr.</i> BCOIf	A-----	-----	-----	-----
<i>gutt.</i> leg.BCOIf	-----	-----	-----	-----
<i>gutt.</i> Hd.BCOIf	-----	-----	-----	-----
	.....	.....	.....	.....
	GTCCTTAGAT	ATTATACTTC	ACGATACTTA	CTATGTAGTA
<i>austr.</i> BCOIf	-----	-----	-----	-----C---
<i>gutt.</i> leg.BCOIf	-----	-----	-----	-----
<i>gutt.</i> Hd.BCOIf	-----	-----	-----	-----
	.....	.....	.....	.....
	GCCCACTTTC	ACTACGTTTT	ATCTATAGGA	GCAGTTTTTT

Figure 6.2 Lineup of partial mitochondrial CO1 sequences of *Z. australe* and *Z. guttigerum*. The consensus sequence is presented below the beetle sequences. Only nucleotides that differ from the consensus sequence are shown



### 6.3 SEQUENCE COMPARISON

The COI sequence of *Z. australe* was compared with sequences in the NCBI Genbank database with following results (Fig. 6.3).

Sequences producing significant alignments:						(bits)	Value
gi	3421446	gb	AF082733.1	AF082733	Charybdis affinis cytochr...	121	2e-25
gi	6707861	gb	AF116830.1	AF116830	Anopheles fluviatilis T c...	119	7e-25
gi	3421454	gb	AF082737.1	AF082737	Charybdis japonica cytoch...	115	1e-23
gi	6118259	gb	AF187111.1	AF187111	Coccotrypes dactyliperda ...	113	4e-23
gi	12054859	emb	AJ248206.1	PBA248206	Pimelia baetica mitoch...	113	4e-23
gi	12054861	emb	AJ248207.1	PVA248207	Pimelia variolosa mito...	111	2e-22
gi	2388830	emb	X97173.1	GRCOIGR	G.roeseli cytochrome oxidas...	111	2e-22
gi	3687372	emb	AJ225884.1	SBJ225884	Sesarmoides borneensis ...	111	2e-22
gi	7230595	gb	AF227647.1	AF227647	Aethina tumida strain SAJ...	109	6e-22
gi	13172514	gb	AF309876.1	AF309876	Alpheus antepenultimus A...	107	3e-21
gi	13172512	gb	AF309875.1	AF309875	Alpheus antepenultimus A...	107	3e-21
gi	6707863	gb	AF116831.1	AF116831	Anopheles fluviatilis S c...	107	3e-21
gi	872243	emb	X88952.1	MTLAGCT01	Lagria sp. mitochondrial C...	107	3e-21
gi	13172480	gb	AF308989.1	AF308989	Alpheus antepenultimus A...	105	1e-20
gi	7920379	gb	AF230793.1	AF230793	Synalpheus paraneptunus c...	105	1e-20
gi	4204538	gb	AF097859.1	AF097859	Alpheus antepenultimus cy...	105	1e-20
gi	6118282	gb	AF187134.1	AF187134	Xyleborinus intersetosus ...	103	4e-20
gi	5835289	ref	NC_001761.1		Albinaria coerulea mitochondrio...	103	4e-20
gi	6019176	gb	AF150922.1	AF150922	Parategeticula sp. countr...	103	4e-20
gi	3115101	emb	AJ008109.1	AJ8109	Oreina cacaliae COI gene, ...	103	4e-20
gi	975668	emb	X83390.1	MIACDNA	Albinaria coerulea complete ...	103	4e-20

**Figure 6.3** Sequences that produced significant alignments with that of *Z. australe*.

The sequences are presented in order of homology with the most homologous sequence (*Charybdis affinis*) presented first. The Genbank and identification number for each organism is also shown

1	11	gctacccttcacggaactcaattactcataagaccacaaactctttgatcattaggcttt	70
6707861	225	.....t..a...	239
7230595	570	.....a...g.....a...	591
13172514	307	.....a...	315
13172512	307	.....a...	315
6707863	180	.....a-.....c...g.t.ta..a.....t..a...	239
		t	
872243	191	.....	199
13172480	308	....a...	315
7920379	334	....a...	341
4204538	308	....a...	315
6019176	995	.....a...	1004
3115101	17	.....a...	27
1	71	gtgtttctgtttacagtaggaggtctaacaggagtagttcttgcaaacatccttagat	130
3421446	247	.....t.....t.a.....t...a.t...	294
6707861	240	..a....a.....at.....t.a.t.t.t...c.t...	299
3421454	247	.....t.....t.a.....t...a.t...	294
6118259	776	.....a.....t.a.....aa.t...	819
12054859	79	.....a.....a...a.t.....ta.t...	126
12054861	76	.....a.....a...a.t.....a.t...	126
2388830	135	.....a.a.....c.....ga.t...	169
3687372	322	.....t.....t.a.t.....a.t...c	372
7230595	592	.....t.a.....c.....t.at.....a.t.....ta.t...	651
13172514	316	.....c.a.....a.....c.a.c.....aa.c.c	375
13172512	316	.....c.a.....a.....c.a.c.....aa.c.c	375
6707863	240	..a...t.a.....c.....at.....t.a.t.t.t...c.t...	299
872243	200	.....t.a.....at.....g..a.t.a.....aa.t...	259
13172480	316	.....c.a.....a.....c.a.c.....aa.c.c	375
7920379	342	.....a.g.....t...t.....a.c.a.t...t...a.c...	401
4204538	316	.....c.a.....a.....c.a.c.....aa.c.c	375
6118282	769	.....a.....a.....t.....a.....	819
5835289	11896	.....t.a.....	11910
6019176	1005	..a....a.....a.....t.....a...a...t.t...aa.t...	1064
3115101	28	..a...t.a.....at.....t...a.t.t.t...aa.t...	87
975668	11896	.....t.a.....	11910
1	131	attatacttcacgatacttactatgtagtagccactttcactacggtttatctatagga	190
3421446	295	....t.....a.....t.t...c.c.a.....	354
6707861	300	....g.t.....t.....t.t...t.t...c.c.a.....	359
3421454	295	....t.....c.a.....g.....t....c.t.....	354
6118259	820	....c...t....c.....t.....t.c....a....t	879
12054859	127	....t.a.....a....c.....t.....t.c.....	186
12054861	127	....g...t....a.t.c.....a.....t.cc.....	186
2388830	170	..g...c.....t.....t.....t.c.g.....	229
3687372	373	....t...t.....t.....t.t.t.c....a....	432
7230595	652	....t.a.t.....c.....t.c.t.t.a.....	711
13172514	376	....tt.a.....t.c.g.....c.....cc.....	435
13172512	376	....tt.a.....t.c.g.....c.....cc.....	435
6707863	300	..g.t.....t.....t.t...t.t...c.c.a.....	359
872243	260	....t.....t.....t.t...t.t...c.t.a.....	319
13172480	376	....tt.a.....t.c.g.....c.....cc.....	435
7920379	402	....c...t.c.g.....t.....t.....c.....	461
4204538	376	....tt.a.....t.c.g.....c.....cc.....	435
6118282	820	..c.t.g.t....a.t.....a.....t.cc.t.....	879
5835289	11911	.....t.....t.g.a.t.....t.....	11970
6019176	1065	..cc...t.....t.....t.....t.a.....	1124
3115101	88	..c.t...t.....a.t.c...t.....	147
975668	11911	.....t.....t.g.a.t.....t.....	11970
1	191	gcagtccttt	199
3421446	355	..t.....	363
6707861	360	.....	364
3421454	355	..	356

6118259	880	.....	884
12054859	187	.....	191
12054861	187	.....	191
2388830	230	.....	238
3687372	433	.....	437
7230595	712	.....	716
13172514	436	.....	440
13172512	436	.....	440
6707863	360	.....	364
872243	320	.....	324
13172480	436	.....	440
7920379	462	.....	466
4204538	436	.....	440
6118282	880	.....	884
5835289	11971	.....	11979
6019176	1125	..	1126
3115101	148	.....	152
975668	11971	.....	11979

**Figure 6.4** Alignment of sequences from Fig. 6.3 with the sequence of *Z. australe*. The *Z. australe* sequence is presented in full with nucleotide identities being shown as dots. Each organism is presented by an identification number (see Fig. 6.3)



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