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New Zealand**
Ko te Aitanga Pepeke
o Aotearoa

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Fauna of New Zealand
Ko te Aitanga Pepeke o Aotearoa
Number / Nama 25

Cercopidae

(Insecta: Homoptera)

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**DSIR Plant Protection / Te Wāhanga Manaaki Tupu
Auckland, New Zealand
1992**

EDITOR'S PREFACE

Co-author Clare Morales (née Butcher) died on 6 August 1991, before the contribution to this work that she was uniquely able to provide was completed. The lack of Clare's New Zealand perspective, especially on areas of the introductory text, is deeply regretted by the senior author and the series editor.

Rather than seek a new collaborator in the final stages of the work, it was agreed to expedite publication by drawing on the relevant subject matter published in Hamilton (1982), 'The spittlebugs of Canada'. This material has been reworked as a general overview of the morphology, biology, and collecting of spittlebugs, applicable in an indicative sense to the New Zealand situation. If any aspect of it should prove inaccurate, or unhelpful to the student of New Zealand's spittlebugs, please inform the senior author or the series editor so that other users of this guide may be notified.

The publication of this work stands of itself as a tribute to Clare's willingness to undertake collaborative projects in support of fellow workers around the world. I believe that Clare would be happy to be remembered in the words used by Andy Hamilton in a letter to me after I informed him of her death: "... a valued and co-operative colleague ...".

—Cleveland Duval
12 December 1991

Cataloguing-in-publication citation / Whakatoopu taa kua perehia - oona maarama tika

HAMILTON, K.G.A.

Cercopidae (Insecta: Homoptera). – Auckland : DSIR Plant Protection = Te Wāhanga Manaaki Tupu, 1992.

(Fauna of New Zealand = Ko te Aitanga Pepeke o Aotearoa, ISSN 0111-5383 ; no. 25)

ISBN 0-477-02636-2

I. Morales, C.F. II. Title III. Series

UDC 595.753(931)

Date of publication / Waa taa ki te perehi

See 'Titles in Print' notice in subsequent numbers / Tirohia te paanui 'Ingoa Taitara' kua perehia me oona nama

Suggested form of citation / Tohu maarama aahua tika

Hamilton, K.G.A.; Morales, C.F. 1992: Cercopidae (Insecta: Homoptera). *Fauna of New Zealand / Ko te Aitanga Pepeke o Aotearoa* 25.

Front cover / Aro mua

The insect depicted is / Ko te ngaarara nei a *Carystoterpa minima*, female / hinc.

Artist / Toihanga: K.G.A. Hamilton

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Prepared for publication by the Series Editor using computer-based text processing, layout, and printing

Maori text by UniServices Translation Centre, Auckland • Printed by GP Print, Wellington

Published by DSIR Plant Protection / Te Wāhanga Manaaki Tupu

Mt Albert Research Centre, Private Bag, Auckland, New Zealand

Class / Karaaihe **Insecta**
Order / Oota **Homoptera**

Family / Whaamere
Cercopidae

The Cercopidae are one of the most distinctive families of plant-sucking insects. Adults have a streamlined body with a large, shieldlike plate extending between the wing bases, thus resembling leafhoppers (Cicadellidae). However, their hind legs resemble those of planthoppers (Fulgoroidea), with prominent spurs on the sides and tip of the tibia. Their squat, rather frog-like appearance and ability to jump have given rise to the common name 'froghoppers'.

Cercopid nymphs live inside a foamy, spittle-like mass which they secrete on to the stems, leaves, or root crown of their host plant, and hence lead an essentially aquatic existence. You may be familiar with these spittle masses, which in western Europe have long been known as 'cuckoo spit'. The nymphs generally resemble the adults but lack wings and are paler in colour; both life stages are known as 'spittlebugs'.

Spittlebug nymphs have special adaptations for producing the frothy bubbles within which they are concealed and protected. Part of their intake of plant sap is diverted from the oesophagus to the hind gut, and exudes from the anus. The nymphs breathe by means of a tubelike canal below the abdomen, and air is replenished by thrusting the tip of the abdomen outside the spittle mass. Strong contractions of the abdomen inside the spittle mass eject air from the tubular canal and result in bubble formation.

Spittlebugs have no close relatives, but are distantly related to both leafhoppers and cicadas. They feed on a wide variety of plants, including grasses, herbs, and trees. The meadow spittlebug of the Northern Hemisphere has nearly 400 recorded hosts, although it prefers a much

(continued overleaf)

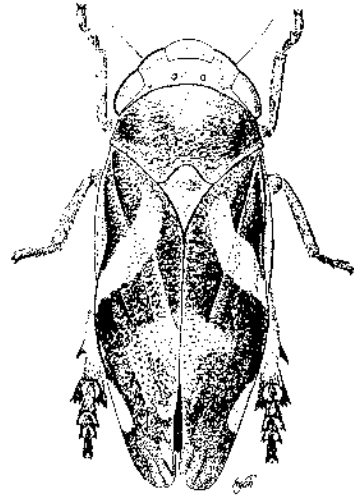


Illustration A native New Zealand spittlebug, *Carystoterpa minima*, adult female. Artist: Andrew Hamilton.

Whakaahua He ngaarara-huare no Aotearoa, *Carystoterpa minima*, he uha pakeke. Toihanga: Andrew Hamilton.

He whaamere tino rerekee nga Cercopidae i waenga nui i nga whaamere o nga aitanga-a-pepeke ngote-raakau. He toohihi nga tinana; he penci penci me te hiira i waenganui i nga puutake parirau; no reira e peenei ana me te ropuu pekepeke-raurakau (Cicadellidae) te aahua. Engari, ko te aahua o nga waewae muri e peenei ana me oo nga pekepeke-raakau (Fulgoroidea); he kipa to nga taha me to te matamata o te 'tibia'. Na te hakahakame te aahua poroka ka tapaina ai ko 'pekepeke poroka'.

Ka noho nga peepi kei roto i te hukana raatou ano o tiko mai ki nga paka me nga rau me te puutake o te tarutaru e nohoia ana e raatou; no reira raatou e noho ana i roo wai. Kua kitea pea e koe eenei putunga hukana; kei Ooropi e tapaina ana ko 'huare piipiwharau'. E penci ana te aahua o nga peepi me nga pakeke engari kaahore he parirau, he aahua maa hoki te kara. Kua tapaina nga peepi me nga pakeke ko ngaarara-huare.

He rawe nga peepi ki te whakaputa mai i te hukana huna ai, e tiakina ai raatou. Ko teetahi waahi o te wai-raakau ka kawca keetia i te korokoro ki te terotero, aa, ka tahc mai i te tou. E whakangaa ana raatou ma teetahi ngongo i raro i te puku, aa, ma te weronga atu o te matamata o te puku ki waho o te putunga huare ka whakahaa mai te hau. Na te nanati o te puku i roto i te putunga huare ka hiirere ai te hau i roto i te ngongo, aa, na reira e koropupuu mai ana te hukana.

(ara haere tonu)

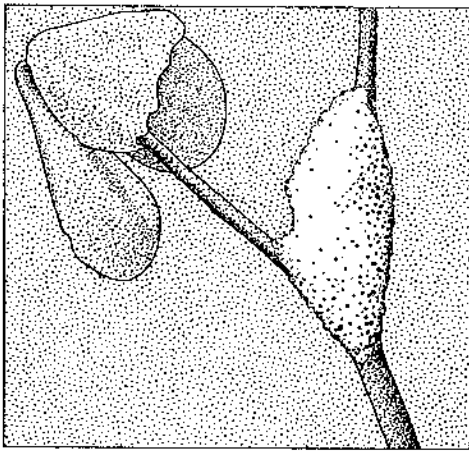


Illustration Spittle mass of the meadow spittlebug *Philaenus spumarius*. Artist: Des Helmore.

Whakaahua Ko te putunga huare o te ngaarara-huare taiapa *Philaenus spumarius*. *Whakaahua: Des Helmore.*

smaller range of mostly herbaceous plants; it is now established and apparently spreading in New Zealand. Native spittlebugs in New Zealand seem to favour woody plants, notably manuka, rata, and *Coprosma*.

Fifteen species in four genera are recognised from New Zealand, most of them confined to the North Island. Four species on island groups to the north and west (New Caledonia, Norfolk Island, Lord Howe Island) are closely related to New Zealand forms.

The largest of the New Zealand spittlebugs is related to a species from Chile. Their ancestors probably existed before the New Zealand and South American land masses lost their connection over 100 million years ago. Other spittlebug species seem to have been carried here by the strong winds of tropical storms, or more recently through human commerce.

Contributor K.G. Andrew Hamilton was born in Britain but moved to Canada at an early age, and was educated in Canada and the U.S.A. After graduating PhD from the University of Georgia under Dr H.H. Ross he joined the (then) Biosystematics Research Unit of Agriculture Canada in 1972 as a specialist in Cicadellidae. He has produced faunal contributions on the spittlebugs, cicadas, and tree-living leafhoppers of Canada, plus over 40 papers on the systematics of leafhoppers, spittlebugs, and fossil Homoptera.

Contributor Clare F. Morales was born and educated in Hawkes Bay, New Zealand. She joined the (then) Entomology Division of DSIR in 1975, and after graduating MSc (Hons) from Auckland University in 1979 became a member of Systematics Group, with responsibility for work on hemipterous insects. In 1990 Clare was awarded a PhD by Imperial College, University of London, for research on the margarodid scale insects of New Zealand (published in 1991 as 'Fauna of New Zealand' no. 21).

Kaahore kau nga whanaunga tata o nga ngaarara-huare, engari he huaanga raatou no te aitanga pepeke-rau me nga taatarakihi. He nui nga raakau e kainga ana, tae atu ki nga karaaihe, nga tarutaru me nga raakau o te ngahere. E whaa rau nga raakau e kainga ana e te ngaarara-huare taiapa no te Haawhe-o-te-ao ki te Raki, engari ko tana kai e tino hiahia ai he tarutaru; kua noho taaturu ia i Niu Tiireni nei, aa, kei te horahora hacre. Ko nga kai e paingia ana i konei ko te maanuka, me te raataa, me te karamuu.

Kotahi tekau maa rima nga tuumomo (species), e whaa hoki nga hapuu (genera) e moohiotia ana i Aotearoa nei; kei Te Ika-a-Maui anoo te nuinga. He whanaunga tata ki nga Cercopidae o Aotearoa nga tuumomo e whaa i runga i nga moutere kei te raki me te hauaauru (New Caledonia, Norfolk Island, Lord Howe Island).

Kei Chile he whanaunga no te mea nui o nga ngaarara-huare o Niu Tiireni. Ko oo raaua tuupuna pea no te waa i mua atu i te wehewehenga o Aotearoa me Amerika-ki-te-tonga, kotahi rau miriona tau i mua atu i to taatou waa. Ko eetahi ngaarara-huare i mauria mai pea e nga aawhaa o nga takiwaa maahanahana; no muri mai pea na te tangata i mau mai eetahi.

No Ingarangi te kai-tuhi, a K.G. Andrew Hamilton; i a ia e tamariki ana i haere ki Kanata, i kurangia ai i reira, i Amerikahoki. No tana whiwhinga i te tohu PhD o te Whare Waananga o Georgia (ko Takua H.H. Ross tana kai-whakaako) i haere ia i 1972 ki te Biosystematics Research Unit of Agriculture Canada hei tohunga mo nga taatarakihi (Cicadellidae). Ko ana pukapuka e paa ana ki nga ngaarara-huare, ki nga taatarakihi, ki nga pepeke-rau-noho-raakau o Kanata, aapiti atu ki nga pepa-tuhituhi e neke atu i te whaa tekau mo nga aahua o ngaa pepeke-rau, me nga ngaarara-huare, me nga Homoptera o nehera kua koohatutia.

No Haaki Pei a Clare F. Morales, aa, i kurangia hoki i reira. Ka kuhu ia ki te Waahanga mo te aitanga-a-pepeke o te DSIR i te tau 1975 i muri i tana whiwhinga i te tohu MSc (Hons) i te Whare Waananga o Aakarana ka tuu ia hei mema o te Roopuu Whakapapa (Systematics Group); ko nga Hemiptera tana waahanga tohungatanga. I te tau 1990 ka whiwhi a Clare i te tohu PhD no te Kaareti Imperial o te Whare Waananga o Raanana mo tana kimi maatauranga e pa ana ki nga Margarodidae unahi o Aotearoa (i perehiti ai te tau 1991 i raro i te ingoa 'Ko te Aitanga Pepeke o Aotearoa' no. 21.)

ABSTRACT

Fifteen species of spittlebug in four genera are recorded from New Zealand, including the following new taxa: *Basilioterpa bullata* n.gen. & sp. from the Three Kings Islands, *Carystoterpa aurata* n.sp., *C. chelyon* n.sp., *C. ikana* n.sp., *C. maori* n.sp., *C. minima* n.sp., *C. minor* n.sp., and *C. vagans* n.sp. from mainland localities. All but the recently introduced *Philaenus spumarius* (Linnaeus) are endemic. Four related species on more distant islands are known: *Basilioterpa fasciata* (Evans) n.comb. and *B. pallida* (Evans) n.comb. from Lord Howe Island, *Carystoterpa xenobilis* Hamilton from New Caledonia, and *C. fusiformis* n.sp. from Norfolk Island. The last-named species, although extralimital, is described here for convenience in view of its close relationship to New Zealand taxa. The text includes notes on distribution and biology. A key to taxa is given, collection localities are mapped, and the descriptions are supported by 57 illustrations.

CHECKLIST OF TAXA

<i>Basilioterpa</i> new genus	12
<i>bullata</i> new species	12
<i>Carystoterpa</i> Lallemand, 1936	13
<i>aurata</i> new species	13
<i>chelyon</i> new species	13
<i>fingens</i> (Walker, 1851)	13
[<i>fusiformis</i> new species]	14
<i>ikana</i> new species	14
<i>maori</i> new species	15
<i>minima</i> new species	15
<i>minor</i> new species	15
<i>subtacta</i> (Walker) new combination	16
<i>subvirescens</i> (Butler, 1874)	16
<i>trimaculata</i> (Butler, 1874)	16
<i>tristis</i> (Alfken, 1904)	17
<i>laeta</i> Alfken, 1904	
<i>vagans</i> new species	17
<i>Philaenus</i> Stål, 1866	18
<i>spumarius</i> (Linnaeus, 1758)	19
<i>Pseudaphronella</i> Evans, 1966	19
<i>jactator</i> (White, 1879)	20

CONTENTS

Acknowledgments	7
Introduction	7
Morphology	8
Biology	8
Distribution and faunal relationships	9
Methods and conventions	10
Key to New Zealand Cercopidae	11
Descriptions	12
References	20
Appendix: list of host-plants	22

Illustrations	23
Distribution maps	28
Taxonomic index	32

ACKNOWLEDGMENTS

For the loan of type material we are indebted to M.D. Webb, British Museum (Natural History), London and to B.J. Day, Australian Museum, Sydney. Dr Webb also kindly brought to our attention one species hitherto incorrectly recorded from Africa. For additional specimens examined we are grateful to curators at the BMNH; the New Zealand Arthropod Collection, DSIR Plant Protection, Auckland; the Auckland Museum; the National Museum of New Zealand, Wellington; the B.P. Bishop Museum, Honolulu, Hawaii; and the Canadian National Collection of Insects, Ottawa, Ontario.

INTRODUCTION

Adult spittlebugs, or froghoppers, are distinguished from other insects by their hind tibiae, which are armed on the outer edge with two stout, thornlike spurs, and end in a broadly flared double row of black-tipped spines. They are superficially similar to leafhoppers (family Cicadellidae), but the latter have slender hind tibiae armed with numerous fine, hair-like spines in several rows on both the inner and outer edges, and lack the black-tipped spines at the end of the tibiae.

Immature spittlebugs are the only insects to create and inhabit spittle masses, in which they are completely screened from view. The nymphal stages generally resemble the adults, but lack wings and are generally paler in colour. The systematics of Cercopidae is based entirely on the adults.

Spittlebugs are represented in New Zealand only by the subfamily Aphrophorinae. Archibald *et al.* (1979) described the fauna as being depauperate, with only two native species, *Carystoterpa fingens* (Walker) and *Pseudaphronella jactator* (F.B. White) (Evans 1966), and the recently introduced meadow spittlebug, *Philaenus spumarius* (L.). The present study, based on more than 1000 specimens, reports fifteen species in four genera from New Zealand proper. Four species on adjacent island groups are closely related to New Zealand taxa.

MORPHOLOGY

An elementary knowledge of the structure of adult spittlebugs (Fig. 1, 2) is necessary for identification of species. More detailed accounts of spittlebug morphology can be found in Doering (1922), Snodgrass (1935), and Hamilton (1982).

Spittlebugs, like most insects, have three distinct body sections: head, thorax, and abdomen. The connections between the sections are narrow and the body form is greatly compacted, obscuring these divisions. The sections of the body are most clearly visible from below.

The more or less conical head has an upper part (the crown) and a lower part (the face) visible from directly above and directly below respectively. These are usually separated by a distinct angle, the margin of the crown. The large compound eyes occupy the entire sides of the head. Between them the head is dominated by the frons, which is the greatly inflated outer surface of the sucking pump. This occupies most of the face and extends on to the crown, forming a broadly oval or bean-shaped area just in front of the ocelli, or simple eyes. The antennae are inserted just below the margin of the crown in front of the compound eyes. The mouth with its projecting beak extends backwards between the bases of the front legs.

The boxlike thorax bears the three pairs of legs and two pairs of wings. The two visible parts behind the head are a shieldlike extension of the first thoracic segment, the pronotum, and the folded forewings. Between these is exposed a small triangular part of the second thoracic segment, known as the scutellum.

The front two pairs of legs are similar to each other. The hind legs are somewhat longer and stouter, and bear prominent spines on the sides and near the tips. Each leg is divided into seven articulated joints. The line separating the first two is often difficult to distinguish. These first two joints (coxa and trochanter) are short compared to the rest of the leg; they make up the leg base. The first long joint beyond these is the femur, the second is the tibia. The three terminal joints form the foot, or tarsus,

which is tipped with a pair of claws and a central adhesive pad.

The wings are thin and nearly flat, with thickened struts (the veins) giving structural strength. The forewings are thicker, heavier, and darker than the transparent and membranous hind wings. Only the latter are used in flight, the forewings acting mainly as a protective cover when the insect is at rest.

The globular or tapered abdomen, concave below, is composed of telescoping segments, and the only appendages it bears are the genitalia.

Adult females are readily distinguished by their long, slender ovipositor, which may be up to half as long as the abdomen.

Adult males have a short pair of blunt or tapered processes, the subgenital plates, which serve to protect the copulatory apparatus (Fig. 4). These arise from the ventral margin of pygofer that form the side walls of the genital capsule (Fig. 6). The genital capsule encloses a pair of hooklike styles flanking the penis. The penis is divided into a globular phallobase and a distal, tubular or leaflike aedeagus, which in turn may be composed of a sclerotised theca ending in a membranous, often extensible vesica surrounding the gonopore. Above the aedeagus the slender terminal segments of the abdomen form an anal tube.

BIOLOGY

The biology of only a few species of Cercopidae is known, and the New Zealand fauna has yet to be studied in any detail. The following information, drawn from Northern Hemisphere species, is offered as a guide only, to be qualified by observation.

Gravid females lay relatively few eggs, usually not exceeding 35. The eggs are usually inserted into plant tissue by means of the female's knifelike ovipositor, which cuts a slit into a stem or petiole. Some spittlebugs may simply insert the eggs into crevices, such as leaf sheaths, under bud scales, or under bark. The few eggs that are laid at one time are embedded in a whitish, glue-like substance which tears to expose the egg shortly before the nymph hatches. The egg shell is broken with the aid of a hardened plate, or egg burster, on the outer embryonic cuticle, which the young insect presses against the shell.

Newly hatched spittlebugs wander over the plant on which the eggs were laid until a suitably succulent feeding site is found on the aerial parts of the plant or on the root crowns. They may wander a considerable distance, or even drop from tree branches to the ground before

reaching their host plant. Having selected a feeding site, the young insect inserts its beak and proceeds to draw sap. A filtering chamber in its oesophagus passes much of the excess water and a considerable amount of sugar directly to the posterior part of the gut, and results in less sap being digested than is ingested. The excess flows from the anus and adheres to the plant and the nymph, until sufficient has accumulated to enclose the tiny insect in a shining droplet. The nymph breathes by means of a tubelike canal below its abdomen, which is formed by the large plates fringing the abdomen and almost meeting below the body. The breathing pores, or spiracles, lie within this canal. The air in the canal is replenished by thrusting the tip of the abdomen outside the droplet.

Spittlebug nymphs grow in a series of five stages, or instars, separated by moults which permit a larger cuticle to form around the body. These moults usually occur within the fluid in which the nymphs live; the cast-off skins remain clinging to the plant, or floating in the fluid.

As the insect grows its droplet increases in size, and bubbles begin to appear. The first of these may be due to the breathing activity of the nymph, but by the second instar the nymph begins to actively produce bubbles, permitting a larger liquid mass to accumulate. This remarkable process of bubble production involves vigorous motions of the abdomen: the air canal is filled with air as the abdomen is thrust outside the fluid mass; the abdomen is then strongly contracted within the fluid, forcing a bubble out of the tip. Dipping or rolling motions of the abdomen accompanied by contractions produce several bubbles before the air supply need be replenished. Enough bubbles can be made to cover the body in 15–30 minutes. The bubbles do not immediately collapse, as the fluid is mixed with a sticky secretion exuded from the side of the abdomen.

Spittlebug nymphs may become restless and vagile, especially when disturbed. They will then begin to wander apparently aimlessly over their host and grope in the air at the edge of leaves. There may be a variety of reasons for such wandering behaviour. Nymphs are apparently sensitive to fluctuations in the availability of sap, and will quickly move from a cut or withered plant. The bugs are not content to remain long in one place until the preferred host is found.

Having selected a new feeding site, a nymph takes its position head down, inserts its beak, and begins to exude more fluid. When the fluid begins to fill the air canal it is forced out by contractions of the abdomen, and bubble formation commences. This action is interrupted by irregular resting periods. As the bubbles accumulate around the abdomen, the nymph uses its two front pairs

of legs to kick the bubbles forwards. Bubble formation continues until the insect is again buried in foam. Some nymphs, in wandering, encounter the spittle masses of other nymphs and enter them, anchoring and producing more bubbles. In this way a number of nymphs may come to occupy the same spittle mass.

Nymphs take at least a month to develop fully, and poor weather or unhealthy food-plants may extend the growth period considerably. Under ideal conditions the early instars may moult within 2 days, but later instars take longer to develop. The last nymphal instar differs considerably from the previous instars in appearance. Short wing pads become obvious, and the body changes colour, usually either losing all its dark pigmentation or becoming entirely blackish.

The full-grown nymph may emerge from the fluid and cling to an exposed part of the stem or branch, where the drying spittle fluid on its body cements the shed cuticle to the plant. Others select an open but usually shaded situation on the underside of a leaf or grass blade and construct a new spittle mass. This mass is more gelatinous than the previous ones, and soon dries and hardens around the insect, to form a moulting chamber. The empty chamber with its round exit hole may remain for some time in the field, and numbers of these may occasionally be found.

The adult has quite different behaviour from its immature forms. Usually indolent, it walks slowly and awkwardly, dragging its hind legs, which are used only for powerful leaps. The bugs are agile in jumping but clumsy in landing, seldom recovering their footing quickly.

When feeding, adults may sit for hours in one place, not even changing position. They never form a spittle mass, living instead in exposed situations on leaves or hugging a stem or twig. They apparently rely on their mottled colour pattern and remarkable dodging and jumping abilities for protection against predators.

Feeding by adult spittlebugs can cause severe loss of sap. Ingested sap passes through the filter chamber, as in the nymphs, and is emitted as droplets of a clear, sugary liquid known as honeydew. These droplets are ejected forcibly over the head with a faint cracking sound, often at a considerable rate.

DISTRIBUTION AND FAUNAL RELATIONSHIPS

Although a few species are represented by very few specimens, the overall distribution of the New Zealand spittlebug fauna is clearly defined. With the exception of a single, recently introduced exotic, all species and indeed

all genera are endemic to New Zealand and adjacent islands. The great majority of the species occur on the North Island and most are closely related, suggesting recent speciation events.

The New Zealand cercopid fauna is entirely different from that of Australia at both the specific and generic levels. By contrast, New Zealand Cicadellidae have 7% of the species and 36% of the genera also represented in Australia (Knight 1986). Similarly, there are two Australian leafhopper species on Lord Howe and Norfolk islands, and one of these even on the Kermadec Islands. Both the forementioned islands have six leafhopper species, while the Chatham Islands have four (Knight 1986), as opposed to two spittlebug species on Lord Howe and one each on Norfolk, the Kermadecs, and the Chathams, all endemic. This probably reflects the greater vagility of leafhoppers as opposed to the rather sessile, heavy-bodied spittlebugs.

The genus *Pseudaphronella* Evans (1966), endemic to mainland New Zealand, is represented by one species. It is related to the Chilean species of *Pseudaphrophora* Schmidt (1924) and, more distantly, to the Australian species of *Anyllis* China (1952) and the South African *Napotrephes* Stål (1866). The distribution of these genera is clearly austral circumpolar, and suggests a Gondwana origin for the generic group.

The genus *Carystoterpa* Lallemand (1936) is endemic to Pacific islands east of Australia, with ten of its fourteen known species found on mainland New Zealand and on islands within 100 km of the coast, where they are the most common native spittlebugs. There are single additional species each on the Chatham Islands 670 km to the southeast, Norfolk Island 700 km to the northwest, the Kermadec Islands 800 km to the northeast, and on the southern end of New Caledonia 1500 km to the northwest. Rather distantly related genera are scattered through Polynesia, whence the genus probably came.

A third genus endemic to the South Pacific, here described as *Basilioterpa* n.gen., is represented by a single species on the Three Kings Islands, and there are two species on Lord Howe Island, 1500 km to the northwest of New Zealand. These islands are considered to belong to different biogeographic subregions (Wallace 1876). Related genera are Polynesian, and the exact origin of the genus is obscure, as for *Carystoterpa*.

The Three Kings spittlebug fauna is strikingly different from that of mainland New Zealand. These islands have been separated from the North Island since the late Tertiary (Cranwell 1962) or Miocene (Holloway 1963), and now lie 60 km offshore. A high degree of endemism occurs there in land snails (Climo 1975), arachnids (Forster 1975), and flightless insects (Ramsay 1971). The

known hemipteran fauna includes a pentatomid and a lygaeid that are considered to be relicts from the mainland fauna (Malipatil 1977).

Most of the New Zealand spittlebug species are confined to the North Island, and two are known only from the northern end (ND-AK). One species has its centre of distribution around Cook Strait, and does not reach either extremity of the main islands. Another species is widespread throughout New Zealand including Stewart and Codfish islands in the far south, but does not occur on either the Three Kings or the Poor Knights islands in the far north. None are known from south of Stewart Island.

The exotic genus *Philaenus* is Eurasian. The particular subspecies now found in New Zealand is the same as that which is common in North America, and in the Old World represented mainly in central Europe and southern England (Hamilton 1979). It almost certainly has been introduced to New Zealand on imported plant material. The New Zealand population appears to be genetically rather homogeneous, suggesting a single introduction with subsequent dispersal from one site.

METHODS AND CONVENTIONS

Collecting and preparation

Adult spittlebugs are usually collected by sweeping and beating their host-plants (see Crosby & Walker 1979). This most readily turns up such polyphagous and vagile species as *Philaenus spumarius* (L.) and *Carystoterpa vagans* n.sp., which are disproportionately represented in most collections. Searching and hand-picking from selected plants yields fewer specimens but more biological information. There is a clear need for innovative techniques to sample adults of less abundant species.

Spittlebug nymphs are readily discovered by finding their spittle masses. Rearing nymphs to adulthood is necessary for positive identification. It must be emphasised that nymphal hosts may not be the same as adult hosts; but information of this nature is not yet available for any native New Zealand species.

Adults may be preserved dry or in any of the usual preserving fluids (ethanol, glycerol, etc.). Nymphs are best preserved in fluids, as they may shrink and distort when dried. They should first be washed in a detergent solution to remove the sticky film of spittle that covers their bodies.

Text conventions

Collection localities: the area codes of Crosby *et al.* (1976; see p. 34) are used to categorise records.

Abbreviations for repositories are as follows (after Watt 1979).

- AMNZ Auckland Institute and Museum, Auckland, N.Z.
 BMNH British Museum (Natural History), London, U.K.
 BPBM Bernice P. Bishop Museum, Honolulu, Hawaii
 CMNZ Canterbury Museum, Christchurch, N.Z.
 CNCI Canadian National Collection of Insects, Biosystematics Research Institute, Agriculture Canada, Ottawa, Canada
 NZAC New Zealand Arthropod Collection, Mt Albert Research Centre, Auckland, N.Z.
 USNM National Museum of Natural History, Washington, D.C., U.S.A.

KEY TO SPECIES OF CERCOPIDAE KNOWN FROM NEW ZEALAND

- 1 Tegmen strongly pitted (Fig. 52); beak extending past hind coxae *Pseudaphronella jactator*
 —Tegmen smooth to finely rastrate (Fig. 1); beak not reaching hind coxae 2
- 2(1) Antennal ledge longitudinally sulcate between carinae (Fig. 45) *Philaenus spumarius*
 —Antennal ledge smoothly rounded (Fig. 11, 13) .. 3
- 3(2) Crown declivous; face scarcely inflated (Fig. 11) *Basilioterpa bullata*
 —Crown nearly level; face strongly inflated (Fig. 13) *Carystoterpa* ... 4
- 4(3) General colour dark, or with irregular, bold dark markings 5
 —General colour pale, without obvious dark markings other than longitudinal stripes 12
- 5(4) Corium without oblique pale dashes (Fig. 32, 33) *C. ikana*
 —Corium with at least a trace of oblique pale dashes on basal half 6
- 6(5) Midlength of tegmen midway between pale markings at costa (Fig. 15) *C. vagans*
 —Midlength of tegmen at or near end of oblique pale stripe (Fig. 14) 7
- 7(6) Tegmen blackish (without paler costa) to tawny (Fig. 41–44) 8

- Tegmen blackish-brown with contrastingly pale costa (Fig. 35–40) 11
- 8(7) Head across eyes 2.1 mm or more; length including folded tegmina 7.0 mm or more; theca diamond-shaped (Fig. 21) *C. maori*
 —Head across eyes 2.0 mm or less; length including folded tegmina 6.9 mm or less; theca oval or parallel-margined beyond narrow base (Fig. 19) 9
- 9(8) Tegmina 2.5x as long as broad, pale brown with a bold pale dash on basal half; pale preapical spot indistinct (Fig. 28) *C. chelyon*
 —Tegmina 3.0x as long as broad, dark brown with bold, pale markings on basal half and near apex (as in Fig. 42) 10
- 10(9) Female more than 5.8 mm long and 1.8 mm across eyes; male more than 5.4 mm long and more than 1.6 mm across eyes *C. minor*
 —Female less than 5.8 mm long and 1.8 mm across eyes; [male unknown] *C. minima*
- 11(7) Male with style tip weakly excavated on inside (Fig. 23). Three Kings Is, (?) mainland *C. trimaculata*
 —Male with style tip chelate (as in Fig. 22). Chatham Is *C. tristis*
- 12(4) Tegmina paler than dorsum (Fig. 27), yellow, without pale preapical spot on costa *C. aurata*
 —Tegmina concolorous with dorsum, pallid, or with a pale preapical spot on costa 13
- 13(12) Three Kings Is southward 14
 —Norfolk I., Kermadec Is 15
- 14(13) Male with head across eyes 2.0 mm or narrower; tegminal dark markings, when present, consisting of a continuous dark stripe bordering pale costal area (Fig. 29–31) *C. fagens*
 —Male with head across eyes 2.1 mm or wider; tegminal dark markings, when present, consisting of a V-shaped mark separate from dash at base of costa (Fig. 34). Poor Knights Is *C. subvirescens*
- 15(13) Tegmina beyond claval apex as long as wide. Norfolk I. *C. fusiformis*
 —Tegmina beyond claval apex rounded to subtruncate, 0.6x as long as wide. Kermadec Is *C. subtacta*

DESCRIPTIONS

Basilioterpa new genus

Type-species *Basilioterpa bullata* new species. Etymology: Greek *basileus* (king) + *terphos* (lovely). Gender feminine.

Nymphs unknown; presumed to resemble those of the related genus *Carystoterpa*.

Adults not dorsoventrally flattened, but crown declivous. Face not inflated, so apex of head lies halfway between planes of dorsum and venter (Fig. 3, 11). Head slightly wider than pronotum (Lord Howe I. species) to slightly narrower (Three Kings Is species); crown shorter than pronotum on midline (0.7–0.8), its apex bluntly pointed; antennal ledges carinate; beak reaching trochanter of middle legs. Fore femur moderately long, 1.5X as long as hind femur; hind tibial pecten with 9–11 black-tipped spines; hind basitarsal pecten with 5–7 spines, of 2nd joint with 7–12 spines. Tegmen (Fig. 4) 2.5X as long as broad, with costal margin evenly convex and apices bluntly pointed; venation weakly carinate at apices, obscure elsewhere, defining 6–8 apical cells and 1 closed anteapical cell, the inner antepical cell broadest.

Genitalia. Female: ovipositor (Fig. 5) nearly straight, lanceolate, toothless, bluntly pointed at tip. Male (Fig. 6, 7): pygofer short, narrow; subgenital plates short or narrow, exposing styles; styles broad, their apex a large, curved spine; aedeagal shaft laterally compressed, strongly reflexed cephalad; anal tube with basal segment as long as other segments combined.

Remarks. The short hind femora, narrow pygofer, and anteriorly directed aedeagal shaft place *Basilioterpa* with other cloviiine genera from the Pacific archipelago fauna: *Carystoterpa* Lallemand, *Cloviana* Lallemand, *Costacloviana* Hamilton, *Euryercopsis* Kirkaldy, *Fusiptyelus* Hamilton, *Handschinia* Lallemand, *Interocrea* Walker, *Iophosa* Jacobi, *Irlandiana* Lallemand, *Izzardana* Lallemand, *Lallemandana* China & Myers, *Lemoultana* Lallemand, *Liorhina* Stål, *Nesaphrestes* Kirkaldy, *Novophilaenus* Lallemand, *Pareuryercopsis* Lallemand & Synave, *Perinoia* Walker, *Salomia* Lallemand, and *Strandiana* Lallemand. The short male pygofers and stout styles with broadly curved, exposed apical spines are distinctive.

Included species. *Basilioterpa bullata* new species from the Three Kings Islands; *B. fasciata* (Evans) and *B. pallida* (Evans), both new combinations from *Carystoterpa*, from Lord Howe Island (extralimital).

Basilioterpa bullata new species

Figures 3–8

Adults. Head slightly narrower than pronotum. Tegmen with a bulla at base of central anteapical cell. Pecten of 2nd tarsomere with 7 black-tipped spines. Black to tawny, marked with an ivory band on crown between eyes, and usually an ivory stripe across middle and base of pronotum; white scutellum and white tegminal markings forming a square patch across clavi, 2 patches on costa, a diamond-shaped mark across commissure, and 3 or 4 irregular, small spots near apex (Fig. 4, 8); face and pleura of first 2 thoracic segments ivory, marked with 5–8 pairs of brown stripes across frons; legs tan to black.

Subgenital plates narrow, exposing styles laterally. Style bulbous basally; distal quarter strongly hooked and tapering to a pointed tip directed mesad. Aedeagal shaft narrow at base, abruptly widened to midlength; distal half narrowed and curved dorsad, shaped like a gondola prow, with preapical hook directed posteriad and with an expanded, triangular tip (Fig. 7).

Length: male 4.9–5.4 mm, female 5.9–6.2 mm. Width across eyes: male 1.4–1.6 mm, female 1.7–1.8 mm.

Type data. Holotype (NZAC): male, Three Kings Islands, West Island, 29 February 1983, ex *Entelea*, C. Butcher.

Paratypes (25 NZAC, 4 CNCI, 2 BMNH): 6 males, 4 females, same data as holotype; 8 males, 9 females, Three Kings Islands, Southwest Island, ex *Meryta sinclairii*, *Myrsine*, and *Pittosporum*.

Material examined. Type series only.

Remarks. The narrow head, prominent tegminal bulla, narrow subgenital plates, and aedeagal shaft shaped like a gondola prow are all distinctive. A similar aedeagal shape is otherwise known only from Neotropical members of *Sphodroscarta* Stål, a member of a different tribe characterised by double pectina on the basal tarsomere.

B. fasciata (Evans, 1966) (Fig. 9, 10) and *B. pallida* (Evans, 1966) (Fig. 11, 12) differ from the type species as follows: head slightly wider than pronotum; tegmina with faint bulla or none at base of central anteapical cell; pecten of 2nd tarsomere with 11 or 12 black-tipped spines; subgenital plates short and broad, exposing styles distally (Fig. 9); style stout basally, furcate; aedeagal shaft nearly parallel-margined, straight or weakly curved from just beyond narrow base to tapered and pointed or bluntly acute tip (Fig. 10, 12); length of male 6.1–7.1 mm, width across eyes 2.0–2.2 mm.

Etymology: Latin *bullatus* (blistered).

Genus *Carystoterpa* Lallemand

Carystoterpa Lallemand, 1936: 264. Type species *Ptyelus trimaculatus* Butler (1874); original designation.

Nymphs robust. Head as wide as pronotum to distinctly narrower (0.8), as long as pronotum on midline; ventral air channel well developed. Colour pale green to deep tan, unmarked or with brown spots at bases of wing buds. Feeding and producing 'spittle' on tips of branches on woody plants, including *Cineraria* and *Coprosma robusta*.

Adults (Fig. 1) not dorsoventrally flattened. Crown scarcely declivous; face inflated; apex of head closer to plane of dorsum than that of venter (Fig. 13). Head as wide as pronotum; crown shorter than pronotum at midline (0.60–0.75), its apex bluntly pointed; antennal ledges carinate; beak reaching trochanter of middle legs. Legs similar; fore femur 1.25x as long as hind femur; hind tibial pecten with 12–14 black-tipped spines; hind basitarsal pecten with 6 or 7 spines, that of 2nd tarsomere with 8–11 spines. Tegmen (Fig. 14, 15) as in *Basilitoterpa*, but usually narrower, 2.5–3.0x as long as broad; antecapical cells similar in width.

Genitalia. Female: ovipositor (Fig. 16) distinctly bent near midlength, lanceolate, bluntly pointed at tip; dorsal margin with fine teeth. Male (Fig. 17, 18): pygofer low, narrow; subgenital plates large, spoon-shaped; styles slender, with an upturned sharp tip; aedeagal theca directed cephalad from strongly curved base, apically large, longitudinally folded; membranous underside with invaginated vesica bearing indefinite circular plates; anal tube with basal segment as long as distal segments.

Included species. *Carystoterpa xenobilis* Hamilton (1981) from New Caledonia, and the following 12 species from New Zealand (plus a new species from Norfolk Island – extralimital).

Carystoterpa aurata new species

Figure 27

Adult female yellow, unmarked; crown and notum deeper tawny. Tegmen 3x as long as broad, with an obscure dark bar obliquely across basal half of corium (Fig. 27).

Male unknown.

Length 8.5 mm; width across eyes 2.5 mm.

Type data. Holotype (BMNH): female, [North I., WN], Silverstream, December 1902, G.V. Hudson "41b". The type locality is in the Hutt Valley, where Hudson did most of his collecting.

Material examined. Holotype only.

Biology. Host unknown.

Remarks. This specimen is similar to that of *C. vagans* n.sp. in size and body colour. Its lack of any pale tegminal markings is unique in the genus.

Etymology: Latin *auratus* (golden).

Carystoterpa chelyon new species

Figure 28

Adults yellow to tawny; crown and notum darker. Tegmen 2.5x as long as broad, with a broad, oblique, pale stripe on basal half of corium ending at or just before midlength of tegmen; lacking a distinct preapical pale spot on costa (Fig. 28).

Male genitalia as in *C. fingsens*, but with style more abruptly angled dorsad.

Length: males 5.5–6.0 mm, females 5.5–6.5 mm. Width across eyes: males 1.7–1.9 mm, females 1.7–2.0 mm.

Type data. Holotype (NZAC, ex BMNH): male, ND, Kaitaia, 1 March 1923, J.G. Myers.

Paratypes: 3 males, 5 females, same locality as holotype; 8 males, 17 females from ND – Houhora, Kaitaia, Kohukohu, Te Kao, Te Pahi (25 BMNH, 4 each NZAC and CNCI).

Material examined. Type series only.

Biology. Paratypic adults recorded 24 November to 6 December, ex *Leptospermum scoparium* (manuka).

Remarks. Colour pattern is distinctive in *C. chelyon*.

Etymology: Greek *chelyon* (tortoise-shell).

Carystoterpa fingsens (Walker)

Figures 29–31

fingsens Walker, 1851: 718 (*Ptyelus*). Evans, 1966: 323 (*Carystoterpa*).

Adults yellow to pale green; crown and notum concolorous. Tegmen 2.5–3.0x as long as broad, unmarked or (males) with a brown band on inner half of corium throughout length of tegmen (Fig. 29–31); a pale preapical spot on costa.

Theca nearly parallel-margined beyond curved base; style tip upturned and minutely chelate (Fig. 22).

Length: males 6.2–7.7 mm, females 6.7–8.4 mm.
Width across eyes: males 1.8–2.0 mm, females 2.0–2.3 mm.

Type data. Lectotype of *fingens* (BMNH), here designated: male (Fig. 30), no data, [W.] Colenso. Presumably this specimen is from the North Island, Auckland vicinity, as *fingens* is not known from Hawkes Bay, where Colenso did most of his collecting.

Material examined. Lectotype, plus 742 non-type examples (1 nymph, 123 males, 120 females; 181 NZAC, 20 AMNZ, 19 CNCI, 12 BMNH, 10 NMNZ) from the following localities.

Three Kings Islands: Great I., Castaway Camp, Tasman Valley.

North Island: ND – Hen and Chickens Is (Whatupuke I.), Kohukohu, Maunganui Bluff, Tutukaka Harbour, Whangarei. AK – Auckland, Greenlane, The Noises Is (Maria I., Motuhoropapa I., Otata I.), Rangitoto I. CL – The Aldermen Is (Ruamahua I.), Cuvier I., Great Barrier I., Little Barrier I., Mayor I., Mercury Is (Stanley I.), Ohena Is (Koruenga I.). BP – Karewa I. WI – Wanganui. WN – Days Bay, Kapiti I. (Wharekoho Bay), Makara, Makara Bush, Paekakariki, Sinclair Head, Wellington, York Bay.

South Island: SD – Stephens I. NN – Nelson.

Also three unassociated females, probably this species, from TK – New Plymouth; KA – Oaro.

Biology. Adults recorded 20 September to 20 March, in coastal areas ex *Astelia*, “cabbage” [tree? *Cordyline*], coastal shrubs, *Coprosma lucida*, *C. macrocarpa*, *C. repens* (taupata), *Geniostoma*, *Hebe*, hollyhock, *Hymenanthera*, *Leptospermum scoparium* (manuka), *Meliclytus*, *Metrosideros excelsa* (pohutukawa), *Muehlenbeckia*, *Myoporum laetum* (ngaio), *Olearia*, *Pseudopanax*, *Solanum nodiflorum*, *Tecoma*.

Remarks. *C. fingens* apparently is confined to coastal localities and has a disjunct distribution manifesting local variants. Specimens from the Three Kings Islands are shorter and more yellow-green than those from further south, and males may have a dusky streak on the tips of the tegmina. All specimens from islands in BP are entirely unmarked, while those from islands in CL are usually unmarked. Males from Auckland and vicinity (including the lectotype) usually have a sinuous brown band running down the middle of the corium. All males from the south coast of the North Island and some from Stephens Island in Cook Strait have the corium brown except for the pale costal margin and preapical spot.

Carystoterpa fusiformis new species [extralimital]

Not figured

Adult female with body and tegmina pallid. Head strongly produced, with crown 0.75x as long as pronotum on midline. Tegmen 3x as long as broad, parabolically produced to apex, extending beyond clavi by a distance equal to their width at this point.

Male unknown.

Length 8.8 mm; width across eyes 2.4 mm.

Type data. Holotype: female, Norfolk Island, Mt Pitt, 800' [250 m], 7 November 1967, G. Kuschel (NZAC).

Material examined. Holotype only.

Biology. Host unknown.

Remarks. This specimen is similar to *C. fingens* females in body colour, but is larger. Its produced head and tegminal tips are unique in the genus. In its congeners the crown is not more than 0.7x pronotal length at the midline, and the rounded to subtruncate tegminal tips are two-thirds as long as wide.

Etymology: Latin *fusus* (spindle) + *formis* (shaped).

Carystoterpa ikana new species

Figures 32, 33

Adults with body and tegmina brownish. Tegmen 3x as long as broad, darkest along costa, except for a pale preapical spot on costa (Fig. 32). Male sometimes tawny with broad, dark brown tegminal stripes across corium and 1st claval cell, interrupted only by large, pale costal spots (Fig. 33).

Theca nearly parallel-margined beyond curved base (as in *fingens*, Fig. 18); style tip upturned, minutely excavated preapically on inner surface (as in *vagens*, Fig. 24).

Length: males 8.2–8.3 mm, females 7.7–8.8 mm.
Width across eyes: 2.3–2.5 mm.

Type data. Holotype (AMNZ): male (Fig. 33), ND, Mangonui County, Mangamuka hills forest summit [882 m], 19 December 1966, K.A.J. Wise.

Paratypes (2 each BMNH, NZAC, CNCI, 1 each AMNZ, NMNZ): 1 male, 7 females from the following North Island localities: ND – Bay of Islands, Kaeo, Kaitaia, Whangarei Heads; WO – Matamata; WN – Wellington.

A female paratype in the BMNH taken by J.G. Myers bears the label “*Philaenus ikanus* Chirotype”.

Material examined. Type series only.

Biology. Adults recorded 4 October to 23 March; host unknown.

Remarks. *C. ikana* is apparently rather rare. Most specimens were taken from 1921 to 1923, though a female paratype was taken in 1982.

Etymology: Greek *hikanos* (sufficient), in reference to the colour pattern; Myers's original transliteration is retained.

Carystoterpa maori new species

Figures 14, 20, 21, 23

Adults yellow to tawny; crown and notum usually darker. Tegmen (Fig. 14) 2.5x as long as broad, with a broad, oblique, pale stripe on basal half of corium ending at or just before midlength of tegmen, usually separated by less than its own width from a pale preapical spot on costa.

Theca (Fig. 20, 21) with strongly produced angles at midlength, in dorsal aspect nearly diamond-shaped; style apex (Fig. 23) broad, truncate, with a preapical dorsal tooth.

Length – males 7.0–8.2 mm, females 7.4–8.8 mm; width across eyes – males 2.1–2.3 mm, females 2.3–2.5 mm.

Type data. Holotype (NZAC): male, BR, Lake Rotoiti, E camping area, sphagnum sedge, 30 December 1976, L.L. Deitz.

Paratypes (54 NZAC, 15 each NMNZ, BMNH, 4 each AMNZ, CNCI, 2 BPBM): 4 males, 3 females, same data as holotype; 28 males, 59 females from the following localities.

North Island: AK – Titirangi; WN – Akatarawa, Days Bay, Kapiti I., Karori, Keith George [Park], Wellington, Weraroa, Wilton Bush, York Bay; WA – Tauherenikau.

South Island: SD – Chetwode I., Croisilles, Port Underwood, Stephens I.; NN – Abel Tasman N.P. (Totaranui), Aniseed Valley, Belgrove, Dun Mtn, Maungatapu Saddle, Nelson, Upper Maitai, Wainui State Forest, Whangamoā Saddle; BR – L. Rotoiti, St Arnaud; NC–WD – Arthurs Pass.

A paralectotype of *C. trimaculata* without data (probably from Auckland) and a series of specimens labeled "97-166" in the BMNH are included in the type series of *C. maori*.

Material examined. Type series, plus a vial with unassembled male genitalia (BMNH).

Biology. Adults recorded 23 October to 9 March, up to 720 m a.s.l., ex *Coprosma*, long grass, *Nothofagus*, sphagnum.

Remarks. *C. maori* has the most distinctive genitalia in its genus. In colouring it is similar to *C. minima*, but in body size it is much larger. This species occurs mainly near Cook Strait, and sparingly as far south as Arthurs Pass. The Auckland specimens stand in isolation.

Etymology: *Maori*, the indigenous people of New Zealand.

Carystoterpa minima new species

Fig. 1

Adult female with abdominal venter tawny, pleura black, head and notum brown. Tegmen 3x as long as broad, dark brown with an oblique pale stripe on basal half of corium edged with black, ending before midlength of tegmen (as in Fig. 34), but closer to midlength than pale preapical spot on costa.

Male unknown.

Length 5.5 mm; width across eyes 1.7 mm.

Type data. Holotype (AMNZ): female, ND, Mangonui Co., Kerr Point (North Cape), clifftops, 6 December 1967, K.A.J. Wise.

Material examined. Holotype only.

Remarks. *C. minima* is the smallest species in its genus.

Etymology: Latin *minimus* (smallest).

Carystoterpa minor new species

Figure 24

Adults with venter yellow, crown and notum red-brown. Tegmen 3x as long as broad, red-brown with an oblique, pale stripe on basal half of corium ending well before midlength of tegmen (as in *C. vagans*, Fig. 42), but closer to midlength than pale preapical spot on costa.

Male genitalia as in *C. fingenis*, but style apex (Fig. 24) more abruptly angled dorsad.

Length: males 5.9–6.3 mm, females 6.5–6.9 mm. Width across eyes: males 1.7–1.9 mm, females 1.9–2.1 mm.

Type data. Holotype (NZAC): male, BP, Rotorua, Blue Lake, 23 January 1960, J.J. Townsend & R. Zondag.

Paratypes (3 each NZAC, BMNH, 1 each CNCI, AMNZ): 2 females, same data as holotype; 2 males, 4 females from the following North Island localities. ND – Kohukohu; CL – Coromandel, Great Barrier I. (Okiwi, Te Maraeroa); WI – Longacre (Wanganui).

Material examined. Type series only.

Biology. Adults recorded 21 November to 23 March, up to 350 m a.s.l.; host unknown.

Remarks. Adults of *C. minor* are distinctly larger and paler than those of *C. minima*. They closely resemble those of *C. vagans* n.sp., but have the midlength of the tegmen slightly closer to the oblique pale stripe than to the preapical spot. Specimens of *vagans* collected with the holotype showed character displacement, being larger and paler than specimens from adjacent sites (see Remarks under *C. vagans*).

Etymology: Latin *minor* (smaller).

Caryototera subtacta (Walker) new combination

Not figured

subtactus Walker, 1858: 718 (*Ptyelus*).

Adult female unmarked, tawny. Tegmen 2.5x as long as broad.

Male unknown.

Length 7.7–7.9 mm; width across eyes 2.3 mm.

Type data. Lectotype of *subtacta* (BMNH), here designated: female, no data.

Material examined. Lectotype, plus 1 non-type female (NZAC) from Kermadec Islands, Macauley I.

Remarks. *Ptyelus subtactus* was described from an unspecified number of individuals, without accession numbers, recorded as coming from West Africa. This is believed to be erroneous, as the genus is unknown outside New Zealand and adjacent islands. The lectotype is the only known extant specimen from the type series. It is almost identical to the only known female from the Kermadec Islands, being merely slightly smaller, and is most probably conspecific.

The females examined are almost indistinguishable from those of *C. fingens*, yet the populations are so widely separated geographically that they are unlikely to represent the same species. The following weak characters distinguish them from most specimens of *fingens*. (1) The

third apical tegminal cell is wider distally than both adjacent cells, and at midlength at least as wide as either. In *fingens* the third apical cell of the tegmen is usually of similar width to adjacent cells distally, and narrower at midlength, unless it has expanded at the expense of the fourth apical cell. (2) The second hind tarsomere is distinctly asymmetrical, with two pecten spines on the inner side projecting beyond those on the outer.

It is likely that males, when discovered, will show specific distinguishing characters.

Caryototera subvirescens (Butler)

Figure 34

subvirescens Butler, 1874: 26 (*Ptyelus*). Evans, 1966: 323 (*Caryototera*; as synonym of *fingens*).

Adult form, colour, and male genitalia as in *C. fingens*, but males usually with a V-shaped brown mark separate from dash at base of costa (Fig. 34).

Length: males 6.3–7.7 mm, females 6.8–8.0 mm. Width across eyes: males 2.1–2.3 mm, females 2.0–2.4 mm.

Type data. Lectotype (BMNH), here designated: male, "54.4" [North I., AK, Auckland].

Paralectotype (BMNH): male, no data.

Material examined. Type specimens, plus 96 non-type examples (55 males, 41 females; 88 NZAC, 8 CNCI) from the North Island, ND, Poor Knights Is (Aorangi, Tawhiti Rahi).

Biology. Adults recorded 12 November to 10 December, ex *Cassinia*, coastal vegetation, *Coprosma*, *Cyathodes juniperina*, ferns, grasses, *Hebe*, *Pseudopanax lessonii*.

Remarks. Both syntypes of *subvirescens* are unmarked males. The wider head distinguishes this species from *C. fingens*.

Now known only from the Poor Knights Islands, this species apparently once had a more extensive range along the coast as far as Auckland.

Caryototera trimaculata (Butler)

Figures 25, 35, 36

trimaculatus Butler, 1874: 26 (*Ptyelus*). Lallemand, 1936: 264 (*Caryototera*). Evans, 1966: 323 (as synonym of *fingens*).

Adult form and colour as in *C. maori*, but darker, usually with tegminal oblique stripe exceeding midlength of tegmen at costa, and costal margin contrastingly pale (Fig. 35, 36).

Male genitalia as in *C. ikana*.

Length – males 6.7–7.5 mm, females 7.5–8.7 mm; width across eyes – males 2.7–2.3 mm, females 2.3–2.6 mm.

Type data. Lectotype (BMNH), here designated: male (Fig. 36), “N[ew] Zeal[and]”.

Paralectotype male (BMNH; damaged) with same data as lectotype.

Material examined. Type specimens, plus 50 non-type examples (29 males, 21 females; 43 NZAC, 6 CNCI, 1 BMNH) from Three Kings Islands, Southwest I. and Great I. (Castaway Camp).

Biology. Adults recorded 1 November to 3 January, to 200 m a.s.l., ex *Meryta [sinclairii]*, *Vitex lucens*.

Remarks. The type series consists of eight specimens, of which the four males represent three species. Males here referred to *C. maori* n.sp. and *C. vagans* n.sp. do not agree with the original description, which states “hemelytra pitchy, becoming paler at the margins; an oblique subbasal *semicircular* streak (curving from near base to middle of costal area)” [italics ours]. The lectotype agrees well with Butler’s original figure.

The males from the Three Kings have the style apex more regularly tapered in posterior aspect (Fig. 25) than in the type specimens (as in *C. vagans*, Fig. 26). Evidently the type specimens came from a mainland site, and the insular population has been subject to genetic drift.

Carystoterpa tristis (Alfken)

Figures 37–40

trimaculatus var. *tristis* Alfken, 1904: 598 (*Ptyelus*).

Lallemand, 1937: 253 (*Carystoterpa*).

trimaculatus var. *laetus* Alfken, 1904: 598 (*Ptyelus*).

Lallemand, 1937: 253 (*Carystoterpa*).

Adult form and male genitalia as in *C. fingsens*. Colour as in *C. trimaculata*, but with oblique pale stripes seldom exactly attaining midlength of tegmen, often fused to a diamond-shaped pale patch across clavi (Fig. 37–40).

Length: males 6.7–7.8 mm, females 7.5–8.5 mm. Width across eyes: males 2.0–2.2 mm, females 2.2–2.4 mm.

Type data. Twelve possible syntypes in the Alfken Collection, Ubersee Museum, Germany were examined. One of these bears a label “Chatham Islds 2 [or possibly L].” Two other labels state “compared with type [of *trimaculata*?] in the Brit. Mus.” and “*Philaenus trimaculatus* (Walker). det. Kirk [aldy 18]99.” Varieties *tristis* and *laeta* are each represented by a pair of specimens, but there are no identification labels with Alfken’s names on them. There is thus insufficient evidence that they are in fact type material, and accordingly we have not designated lectotypes.

Material examined. Seventy-one non-type examples (43 males, 28 females; 54 NZAC, 8 CNCI, 4 AMNZ, 3 BMNH, 2 NMNZ) from the following Chatham Islands localities: Chatham I. (Awatotara, limestone quarry, Mangahou Creek, Maunganui, Waitangi), Pitt I. (Tupurangi), Southeast I.

Biology. Adults recorded 7 November to 24 February; host unknown.

Remarks. *C. tristis*, the only spittlebug on the Chatham Islands, has the most variable markings in the genus.

Carystoterpa vagans new species

Figures 13, 15, 26, 41–44

Adults yellow; dorsum pale orange to brown or tawny. Tegmen 2.5–3.0x as long as broad, with an oblique pale stripe on basal half of corium ending well before midlength of tegmen, and usually separated by more than its own width from a pale preapical spot on costa; midlength of tegmen halfway between apex of oblique stripe and preapical spot (Fig. 15), or closer to preapical spot.

Male genitalia as in *C. ikana*, except for specimens from Hawkes Bay, which have chclate styles as in *C. fingsens* (Fig. 26).

Length – males 6.8–8.2 mm, females 7.0–9.4 mm; width across eyes – males 2.0–2.4 mm (usually 2.1–2.2 mm), females 2.1–2.6 mm (usually 2.3–2.4 mm).

Type data. Holotype (NZAC): male (Fig. 42), BP, Mt Te Aroha, 1000' [300 m], 24 October 1967, at night / swept fern, J.C. Watt.

Paratypes (11 NZAC, 6 BPBM, 2 BMNH): 11 males, 8 females from BP – type locality, Mt Ngongotaha 750 m, Rotorua 500 m, Te Wairoa, Tui Valley 275 m.

Material examined. Type series, plus 417 non-type

examples (4 nymphs, 197 males, 216 females; 278 NZAC, 76 BMNH, 19 each CNCI, NMNZ, 18 AMNZ, 7 BPBM) from the following localities.

North Island: ND – Coopers Beach, Helena Bay, Kaihu Bush, Oakura Bay [or CL?], Ohaeawai, Paihia, Tutukaka Harbour, Waiotemarama Walkway (Hokianga Co.); AK – Auckland, Beacon Point (Piha), Bethells, Titirangi, Waitakere; CL – Coromandel, Cuvier I., Kauaeranga Valley (Thames), Little Barrier I., Whitianga; WO – Mt Pirongia; BP – Blue Lake (Rotorua), Okere; GB – Mt Arowhata; TO – Makatote, Ohakuri, Ruapehu, Tarawera, Taupo, Tihoi; TK – Egmont, North Egmont; RI – Pohangina Valley; HB – Little Bush (Pukititiri) Tangoio (White Pine Bush); WI – Feilding, Longacre; WN – Eastbourne, Haywards, Johnsonville, Korokoro, Makara Bush, Red Rocks, Wainuiomata, Wellington, Weraroa; WA – Mt Bruce.

South Island: NN – Dun Mtn, Goulard Downs, Granity, Mapua, Nelson; KA – Clarence Bridge, Puhi Puhi Reserve; BR – Maruia; NC – Arthurs Pass; WD – Kaihinu, L. Paringa, Open Bay Is (Taumaka I.), Woodstock; MC – Banks Peninsula, Christchurch, Deans Bush (Riccarton Bush), Glentui, Kaituna Bush, Kowhai Bush (near Springfield); SC – Waihao Gorge; DN – Dunedin, Leith Hill (5 km N of Dunedin), Opoho, Ross Ck Reservoir; FD – Bauza I., Hollyford Rd, Milford [Sound], Stillwater R.; SL – Bluff Hill, Colac Bay, Dolamore Park (Hokonui Hills), 10 km NW of Fortrose, Gore, Green Hills, Invercargill, Orepuki, Tisbury.

SI – Big South Cape I., Codfish I., Halfmoon Bay, Port Adventure, Port William, Rakeahua Valley, Small Craft Retreat.

Also (locality unknown): "Whitanui".

Biology. Adults recorded 2 October to 22 April, up to 1370 m a.s.l., ex broad bean, coastal shrubs, *Coprosoma parviflora*, *Elatostema rugosum* (parataniwha), *Geniostoma*, *Griselinia*, *Hebe elliptica*, *Leptocarpus*, *Leptospermum scoparium* (manuka), *Meliccytus ramiflorus*, *Metrosideros excelsa* (pohutukawa), *Nothofagus fusca*, *Olearia arborescens*, *Populus alba*, *Pseudopanax edgerleyi*, *Senecio minima*, *Syringa vulgaris*.

Remarks. Specimens from HB, as mentioned above, have the chelate style of *fingens* but show no other evidence of character introgression. A short series from Blue Lake, Rotorua (BP) taken on 23 January 1960 by J.I. Townsend and R. Zondag also contains the rather similar *C. minor*. The four females of *vagans* are paler (Fig. 44) and larger than usual, and the two males are similar in colour and proportionate in size: males 7.7–8.0 mm (width of head 2.2–2.3 mm), females 8.5–9.0 mm (width

of head 7.4–2.6 mm). This probably represents character displacement, demonstrating that these very similar species are reproductively isolated from each other. Similar instances of character displacement are known in sibling species of leafhoppers (e.g., Hamilton 1986).

Most other specimens conform to a narrow range of variability of size and colour pattern (Fig. 42), but occasional specimens or short series show unusual variants. The most striking instances of this are shown by geographical races. Several series from Dunedin (DN) are mainly unusually dark specimens (Fig. 41), although a few specimens with the typical colour pattern are also present. A single series from Banks Peninsula (MC) has every specimen with the colour effaced between the oblique stripe and the preapical pale spot. A single female without collection data has a contrasting yellow diamond-shaped dorsal mark (Fig. 43). A short series from Waiotemarama (ND) have the body colour green rather than yellow and orange-brown. Specimens from SI and FD tend to be large and pale, with obscurely defined markings. The presence of similar individuals on Little Barrier Island (CL) suggests that this last form is an ecophenotypic variety from coastal localities.

Owing to the unexplained variability of this species the type series is limited to specimens taken in BP outside the range of *C. minor*.

Etymology: Latin *vagans* (roaming).

Genus *Philaenus* Stål

Philaenus Stål, 1864: 66. Type species *Cicada spumaria* Linnaeus (1758), by designation of Van Duzee (1917).

Nymphs robust. Head as wide as pronotum; crown as long as pronotum on midline; ventral air channel well developed. Colour pale green, without markings. Polyphagous, producing spittle.

Adults not dorsoventrally flattened. Crown scarcely declivous; face inflated; apex of head closer to plane of dorsum than that of venter. Head (Fig. 45) as wide as pronotum; crown shorter than pronotum on midline (0.7), with apex bluntly pointed; antennal ledges sulcate between parallel carinae; beak reaching trochanters of middle legs. Legs similar; fore femur less than 1.25x as long as hind femur; hind tibial pecten with 8–10 black-tipped spines; hind tarsal pecten of basomere with 6–8 spines, of 2nd joint with 8–11 spines. Tegmen (Fig. 46) as in *Basiliotherpa*, but costal margin straight on basal half.

Genitalia. Female: ovipositor (Fig. 47) straight, preapically slightly enlarged; dorsal margin minutely toothed, curved downwards to slightly deflexed tip. Male

(Fig. 48–50): pygofer short, broad; subgenital plates slender, tapered to rounded tips; styles strongly curved upwards, digitate on apical half; aedeagal theca directed dorsad from base, broad, parallel-margined, bearing 3 pairs of short spines; vesica small, not invaginated; anal tube short, its basal segment widest, bearing recurved hooks on outer angles.

Included species. Three Eurasian species are known (Drosopoulos & Asche 1991), one of them established in New Zealand; other species are doubtfully assigned to this genus.

Philaenus spumarius (Linnaeus)

Figures 45–50

spumaria Linnaeus, 1758: 437 (*Cicada*).

Sixty synonyms are listed by Hamilton (1979).

See generic description, above. Adults dull brown with indistinct markings.

Length: males 5.4–6.2 mm, females 5.9–6.8 mm in New Zealand (males 5.2–6.4 mm, females 5.4–6.8 mm from Holarctic sites). Width across eyes: males 1.9–2.1 mm, females 2.0–2.3 mm.

Type data. The name of this economically important species was fixed by action of the International Commission on Zoological Nomenclature (1961).

Material examined. Many specimens from Europe and North America, and 35 New Zealand specimens (20 males, 15 females; NZAC) from the following localities.

North Island: TO – Ohakune, Papakai, Ruapehu, Waipunga Falls; TK – Mt Egmont; HB – Kaweka Ra., Porangahau, Puketitiri; WI – Hunterville, Palmerston North, Wanganui; WN – Keith George Park.

South Island: NC – Loburn, Rangiora; SC – Ikawai; DN – Dalmore. Also reported by Archibald *et al.* (1979) from NC – Amberley, Sefton, Waipara, Weka Pass; MC – Burwood, Christchurch, Kirwee, Leeston, Lincoln, Marshland, New Brighton, Papanui, Riccarton, Southbridge, West Melton; DN – Dunedin.

Biology. Adults recorded 10 October to 30 March, up to 1220 m a.s.l., ex carrots (Archibald *et al.* 1979), *Cirsium arvense* (thistle), *Coriaria*, introduced grasses, lavender, lucerne, *Sonchus*.

Remarks. *P. spumarius* is a recent introduction by man; most likely it was carried on nursery stock from England.

First recorded in 1960 at Palmerston North (Archibald *et al.* 1979), it has since spread to central and southern areas of the North Island and to several centres along the eastern coast of the South Island.

Only a few of the many colour phases of *P. spumarius* are known from New Zealand, suggesting low genetic diversity, possibly as the result of a very small founding colony. All males examined had the thecal form of the central European race (subspecies *quadrimaculatus* in the sense of Hamilton 1979).

Genus *Pseudaphronella* Evans

Pseudaphronella Evans, 196b: 374. Type species *Aphrophora jactator* White (1879), by original designation.

Nymphs robust. Head 0.9X as wide as pronotum; crown 0.8X as long as pronotum on midline; ventral air channel well developed. Colour brown, without markings. Producing spittle masses on roots of *Nothofagus* seedlings in a hollow log (J.S. Dugdale, pers. comm.).

Adults not dorsoventrally flattened. Crown scarcely declivous; face strongly inflated; apex of head closer to plane of dorsum than that of venter. Head (Fig. 51) much narrower (0.8) than pronotum; crown as long as pronotum on midline, with apex bluntly rounded; antennal ledges bulbous; beak attaining trochanters of hind legs. Legs similar; fore femur less than 1.25X as long as hind femur; hind tibial pecten with 11 or 12 black-tipped spines; hind basi tarsal pecten with 7 or 8 spines, of 2nd tarsomere with 11 spines. Tegmen (Fig. 52) 3X as long as broad; costal margin convex on basal half, tapered to narrow, rounded apices; membrane strongly pitted; venation carinate, forming a reticulate plexus across small antepical and apical cells.

Genitalia. Female: ovipositor (Fig. 53) weakly curved upwards; dorsal margin straight and minutely toothed; apex pointed. Male (Fig. 54–57): pygofer short, broad; subgenital plates broad, obliquely truncate, basally separated by a rounded notch exposing phallobase; styles short, directed caudad, bluntly pointed, bearing a small tuft of setae on inner edge before tip; aedeagal theca strongly curved cephalad, tubular to round gonopore, with tip beyond gonopore half as long as shaft, bearing a vesica-like membranous sac on dorsal surface which extends caudally as furcate processes; anal tube with basal segment as long as other segments together.

Included species. *Pseudaphronella jactator* on the North I., and a possible second species on the South I.

Pseudaphronella jactator (White)

Figures 51–57

jactator White, 1879: 214 (*Aphrophora*). Evans, 1966: 324 (*Pseudaphronella*).

See generic description, above. Adults mottled brown; specimens with an orange overtone are probably chemically altered since death.

Length: males 9.3–11.4 mm, females 11.0–12.6 mm. Width across eyes: males 2.4–2.7 mm, females 2.7–2.9 mm.

Type data. Described from "many" specimens of both sexes without collection data, collected by Captain Broun (BMNH).

Material examined. Syntype male, plus 40 non-type examples (4 nymphs, 15 males, 21 females; 17 NZAC, 15 NMNZ, 6 CNCI, 2 BMNH) from North Island localities: CL – Little Barrier I.; WO – Mt Pirongia; BP – Mt Te Aroha; TO – Hauhungaroa Ra., Mt Ruapahu, National Park, Ohakune, Turangakumu Saddle, Waikato–Waipakihi Junction, Whakapapa; GB – Huiarau Ra., [Lake] Waikaremoana; HB – Kaweka Ra., Puketitiri; TK – Mt Egmont; RI – Ohakune, Rangataua, Wharite; WN – Gollans Valley, Tararua Ra., Wainuiomata, Wellington.

A female from the South Island, "west coast" (NZAC) may belong to a related species, but until males are found this remains problematical.

Biology. Adults recorded 12 November to 29 March, up to 1280 m a.s.l., ex *Dracophyllum*, *Nothofagus*, *Olearia ilicifolia*, subalpine scrub.

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APPENDIX List of host-plants and their associated Cercopidae

<i>Astelia</i>	<i>Carystoterpa fingsens</i>	lavender	<i>Philaenus spumarius</i>
broad bean	<i>Carystoterpa vagans</i>	<i>Leptocarpus</i>	<i>Carystoterpa vagans</i>
cabbage [?tree, <i>Cordyline</i>]	<i>Carystoterpa fingsens</i>	<i>Leptospermum scoparium</i>	<i>Carystoterpa chelyon</i> , <i>C. fingsens</i> , <i>C. vagans</i>
carrots	<i>Philaenus spumarius</i>	lucerne	<i>Philaenus spumarius</i>
<i>Cassinia</i>	<i>Carystoterpa subvirescens</i>	<i>Melicytus</i>	<i>Carystoterpa fingsens</i>
<i>Cineraria</i>	<i>Carystoterpa</i> sp. (nymphs)	<i>M. ramiflorus</i>	<i>Carystoterpa vagans</i>
<i>Cirsium arvense</i>	<i>Philaenus spumarius</i>	<i>Meryta sinclairii</i>	<i>Basilioterpa bullata</i> , <i>Carystoterpa trimaculata</i>
<i>Coprosma</i>	<i>Carystoterpa maori</i> , <i>C. subvirescens</i>	<i>Metrosideros excelsa</i>	<i>Carystoterpa fingsens</i> , <i>C. vagans</i>
<i>Coprosma lucida</i>	<i>Carystoterpa fingsens</i>	<i>Muehlenbeckia</i>	<i>Carystoterpa fingsens</i>
<i>C. macrocarpa</i>	<i>Carystoterpa fingsens</i>	<i>Myoporum laetum</i>	<i>Carystoterpa fingsens</i>
<i>C. parviflora</i>	<i>Carystoterpa vagans</i>	<i>Myrsine</i>	<i>Basilioterpa bullata</i>
<i>C. repens</i>	<i>Carystoterpa fingsens</i>	<i>Nothofagus</i>	<i>Carystoterpa maori</i> , <i>Pseudaphronella jactator</i>
<i>C. robusta</i>	<i>Carystoterpa</i> sp. (nymphs)	<i>N. fusca</i>	<i>Carystoterpa vagans</i>
<i>Coriaria</i>	<i>Philaenus spumarius</i>	<i>Olearia</i>	<i>Carystoterpa fingsens</i>
<i>Cyathodes juniperina</i>	<i>Carystoterpa subvirescens</i>	<i>O. arborescens</i>	<i>Carystoterpa vagans</i>
<i>Dracophyllum</i>	<i>Pseudaphronella jactator</i>	<i>O. ilicifolia</i>	<i>Pseudaphronella jactator</i>
<i>Elatostema rugosum</i>	<i>Carystoterpa vagans</i>	<i>Pitiosporum</i>	<i>Basilioterpa bullata</i>
<i>Entelea</i>	<i>Basilioterpa bullata</i>	<i>Populus alba</i>	<i>Carystoterpa vagans</i>
ferns	<i>Carystoterpa subvirescens</i>	<i>Pseudopanax</i>	<i>Carystoterpa fingsens</i>
<i>Geniostoma</i>	<i>Carystoterpa fingsens</i> , <i>C. vagans</i>	<i>P. edgerleyi</i>	<i>Carystoterpa vagans</i>
grasses	<i>Carystoterpa maori</i> , <i>C. subvirescens</i> , <i>Philaenus spumarius</i>	<i>P. lessonii</i>	<i>Carystoterpa subvirescens</i>
<i>Griselinia</i>	<i>Carystoterpa vagans</i>	<i>Senecio minima</i>	<i>Carystoterpa vagans</i>
<i>Hebe</i>	<i>Carystoterpa fingsens</i> , <i>C. subvirescens</i>	<i>Solanum nodiflorum</i>	<i>Carystoterpa fingsens</i>
<i>H. elliptica</i>	<i>Carystoterpa vagans</i>	<i>Sonchus</i>	<i>Philaenus spumarius</i>
hollyhock	<i>Carystoterpa fingsens</i>	sphagnum	<i>Carystoterpa maori</i>
<i>Hymenanthera</i>	<i>Carystoterpa fingsens</i>	<i>Syringa vulgaris</i>	<i>Carystoterpa vagans</i>
		<i>Tecoma</i>	<i>Carystoterpa fingsens</i>
		<i>Vitex lucens</i>	<i>Carystoterpa trimaculata</i>

ILLUSTRATIONS

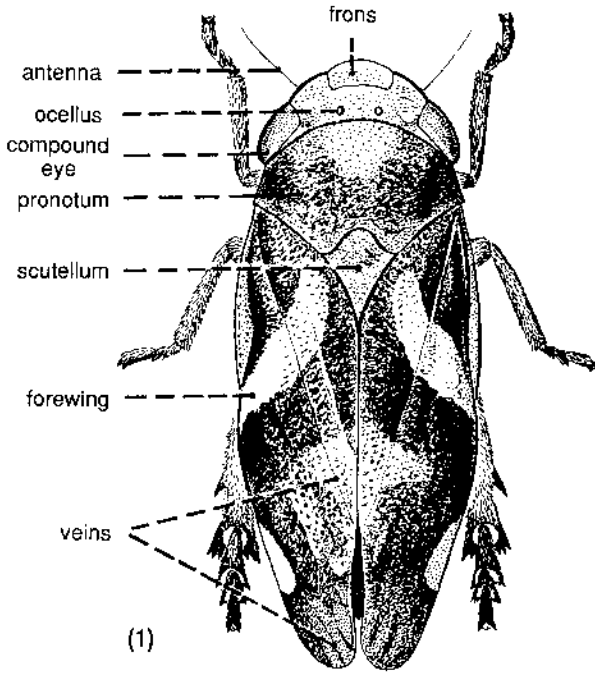
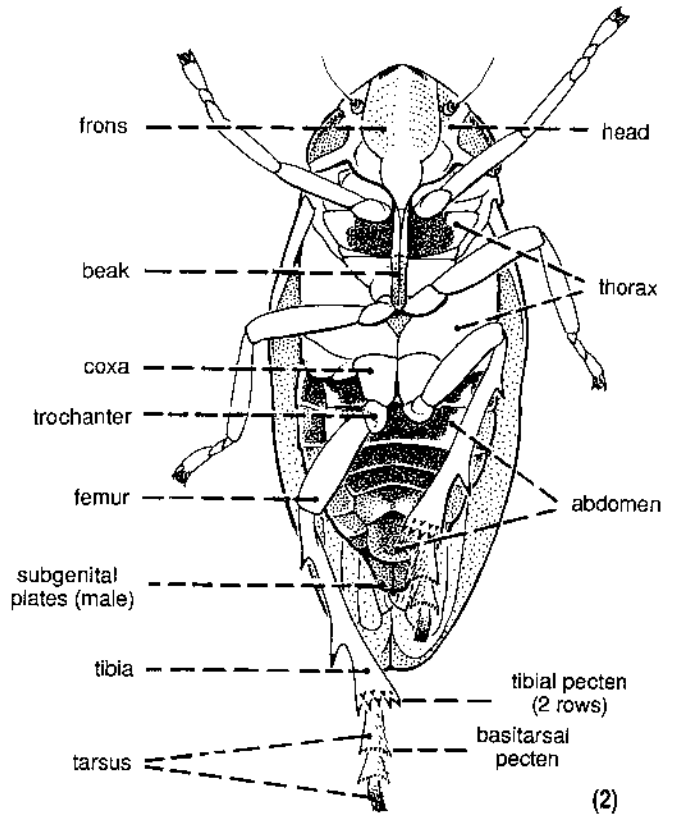


Fig. 1 Morphological features of *Carystoterpa minima*, female, dorsal.

Fig. 2 Morphological features of *Philaenus spumarius*, male, ventral.



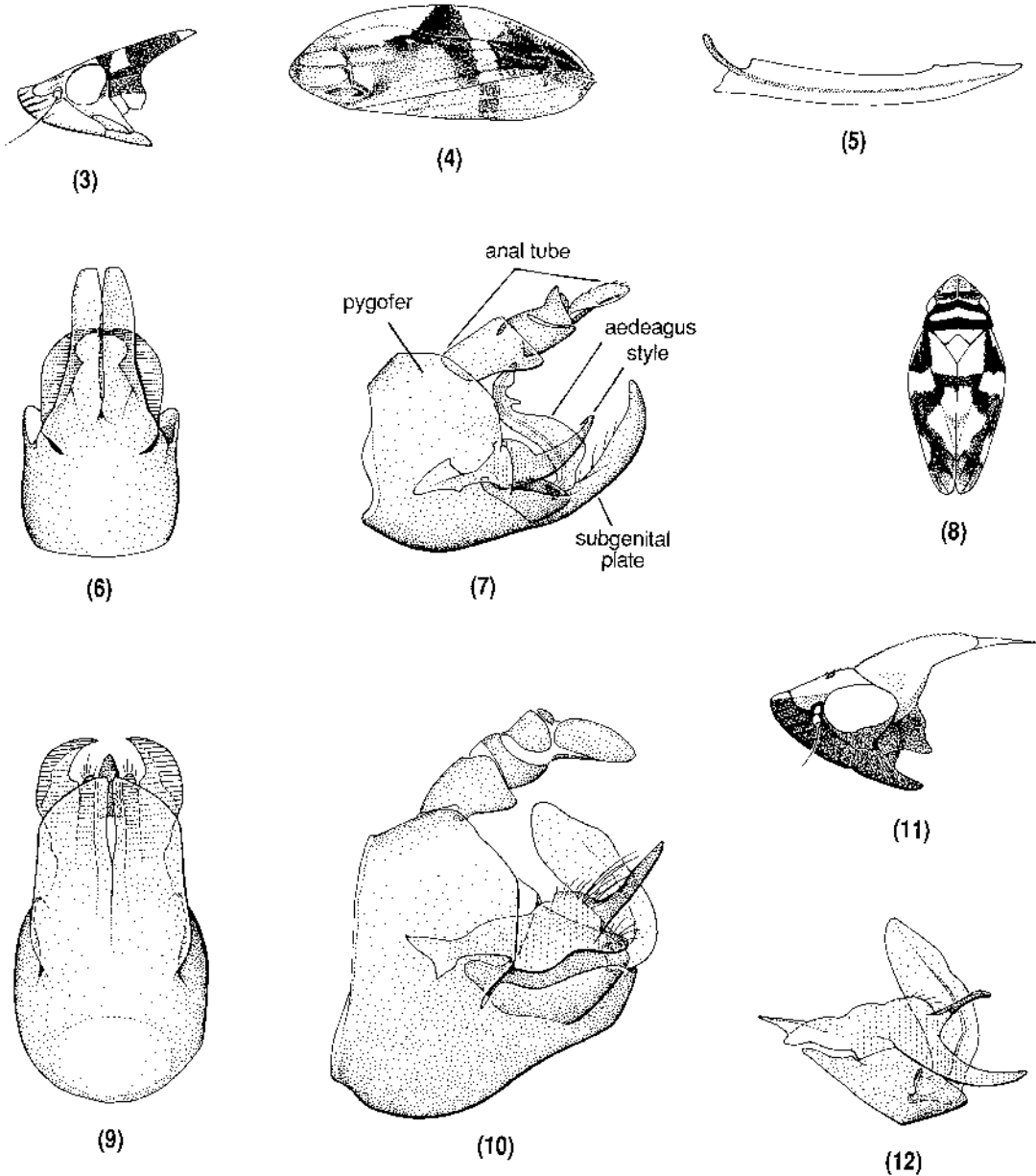


Fig. 3-8 *Basilioterpa bullata*: (3) head and thorax, lateral; (4) tegmen, palest form; (5) ovipositor; (6,7) male genital capsule, ventral and lateral; (8) colour pattern, typical form. 9, 10 *B. fasciata*, male genital capsule, ventral and lateral. 11, 12 *B. pallida*: (11) head and thorax, lateral; (12) aedeagus and style, widest aspect.

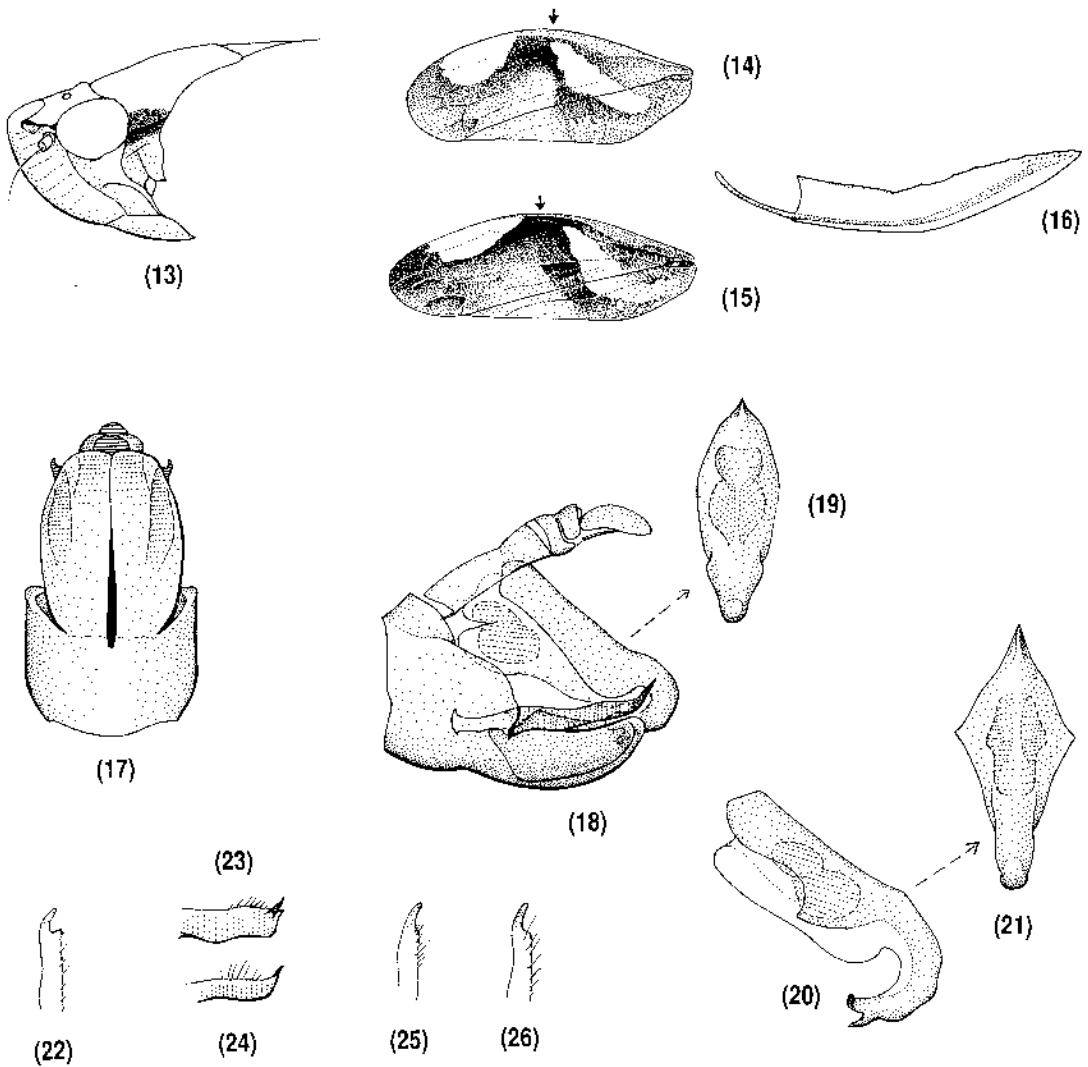


Fig. 13 Head and thorax, lateral, *Carystoterpa vagans*. 14, 15 Tegmen, holotype, *C. maori* and *C. vagans* (arrow: midlength). 16-19 *C. fingens*: (16) ovipositor; (17, 18) male genital capsule, ventral and lateral; (19) theca, dorsal. 20, 21 Theca, *C. maori*, lateral and dorsal. 22-26 Style apex: (22) *C. fingens*, caudal, (23) *C. trimaculata*, caudal, (24) *C. vagans*, caudal, (25) *C. maori*, lateral, (26) *C. minor*, lateral.

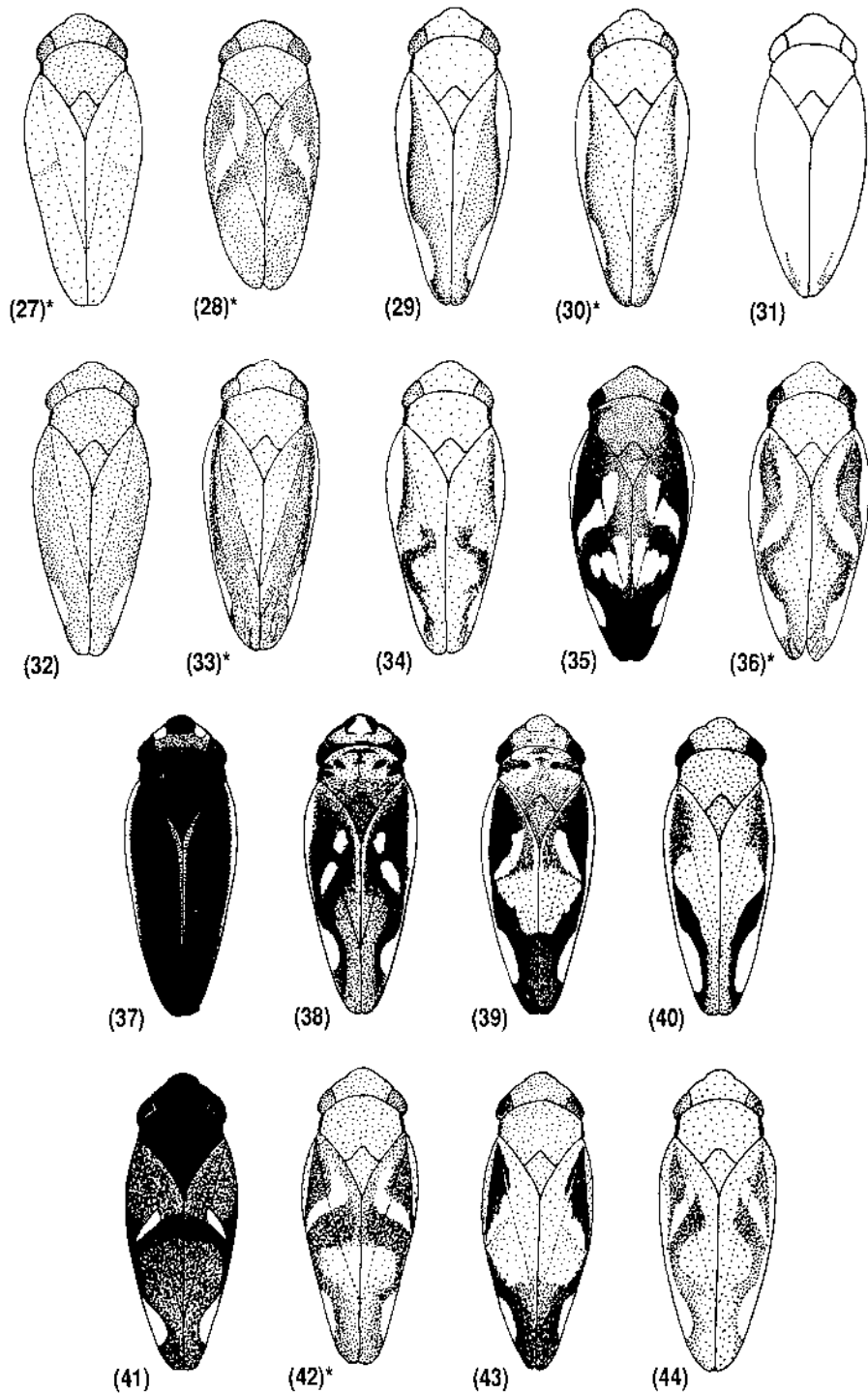


Fig. 27–44 *Carystoterpa* species, colour pattern (*holotypes): (27) *C. aurata*; (28) *C. chelyon*; (29–31) *C. fingens*; (32,33) *C. ikana*; (34) *C. subvirescens*; (35,36) *C. trimaculata*; (37–40) *C. tristis*; (41–44) *C. vagans*.

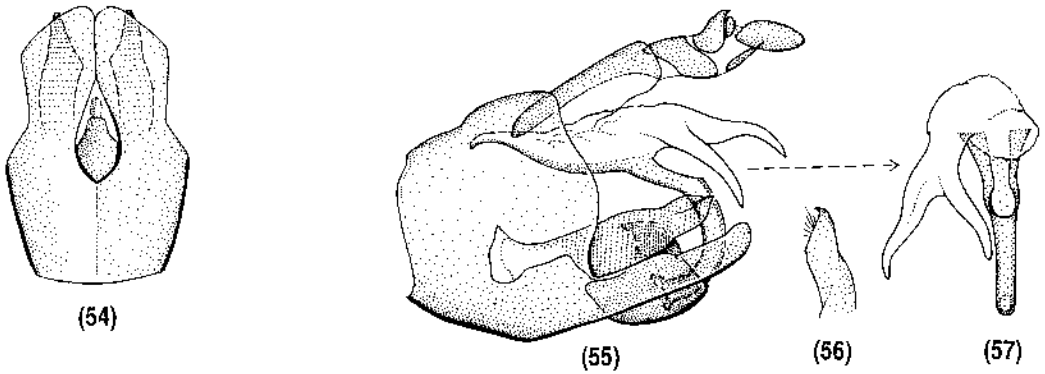
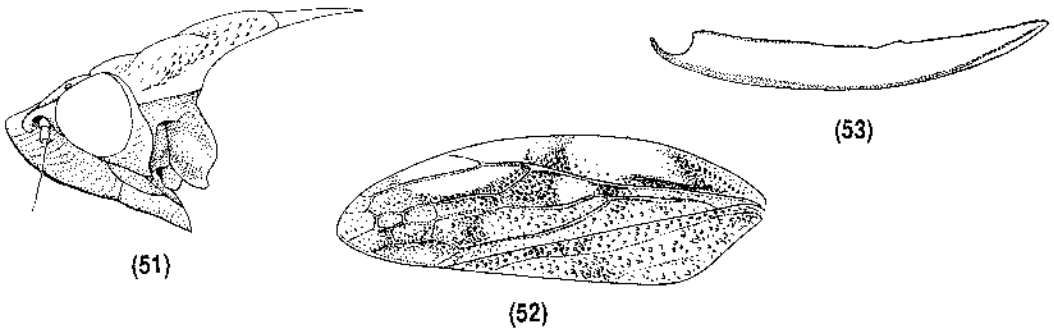
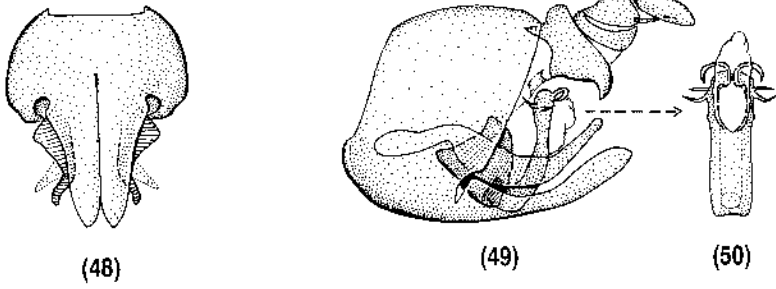
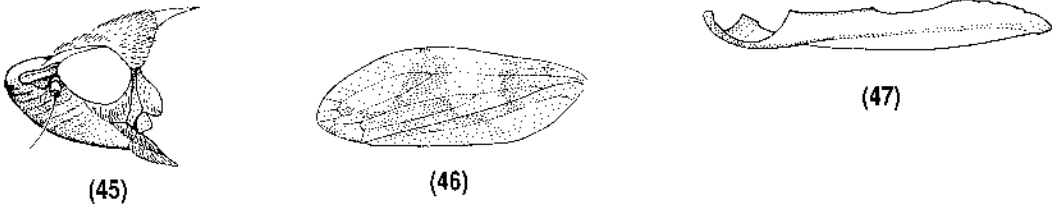
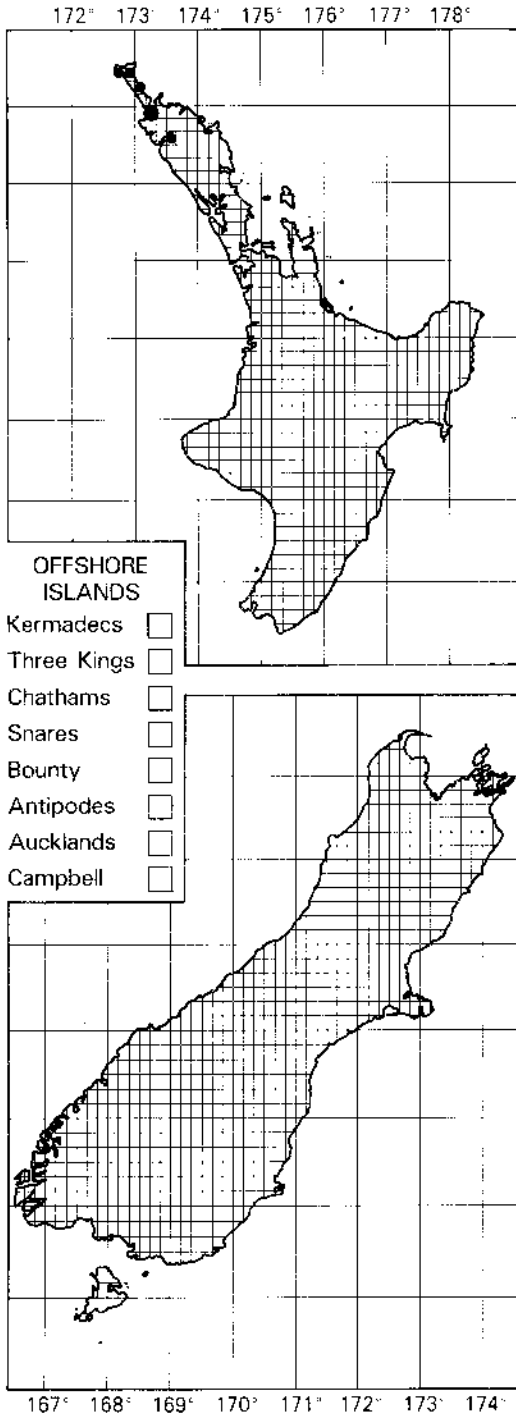


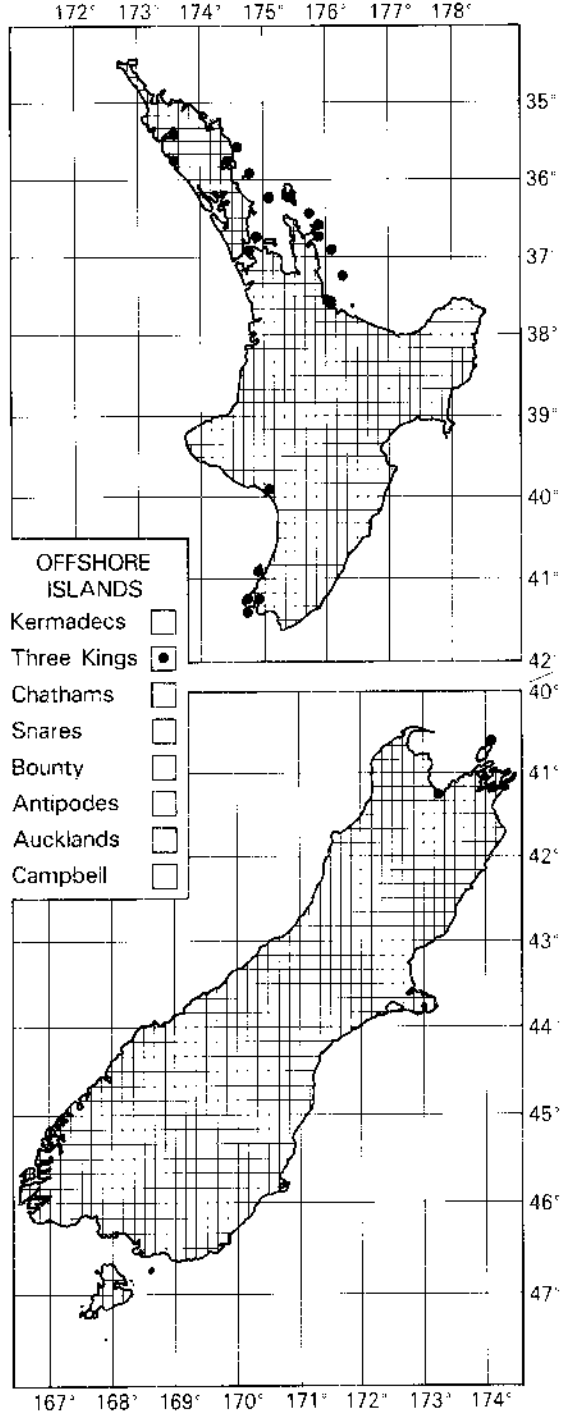
Fig. 45–50 *Philaenus spumarius*: (45) head and thorax, lateral; (46) tegmen; (47) ovipositor; (48,49) male genital capsule, ventral and lateral; (50) aedeagus, posterior.

Fig. 51–57 *Pseudaphronella jactator*: (51) head and thorax, lateral; (52) tegmen; (53) ovipositor; (54,55) male genital capsule, ventral and lateral; (56) style tip, widest aspect (57) aedeagus, posterior.

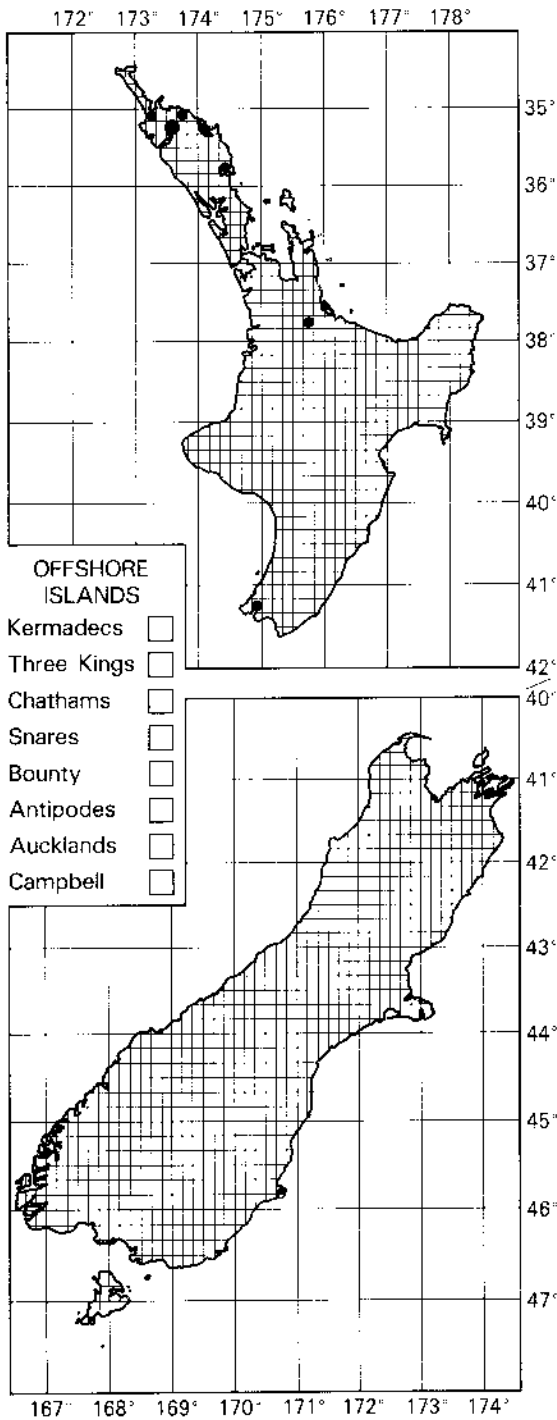
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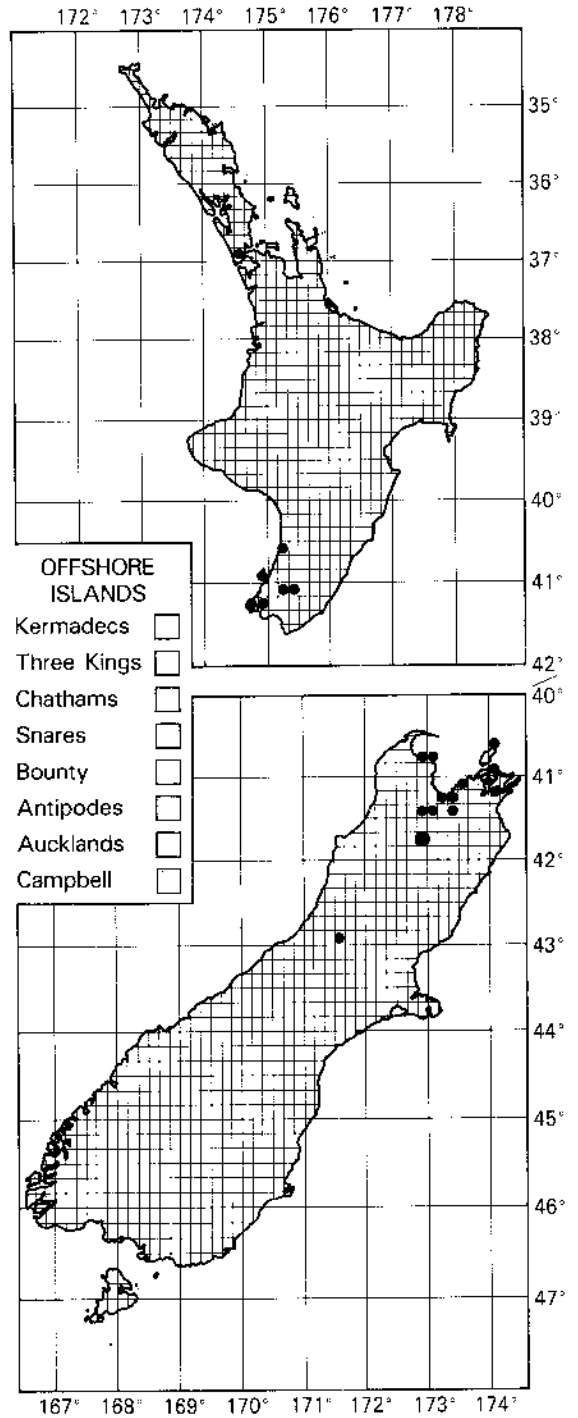
• **Map1** Collection localities, *Carystoterpa chelyon* •



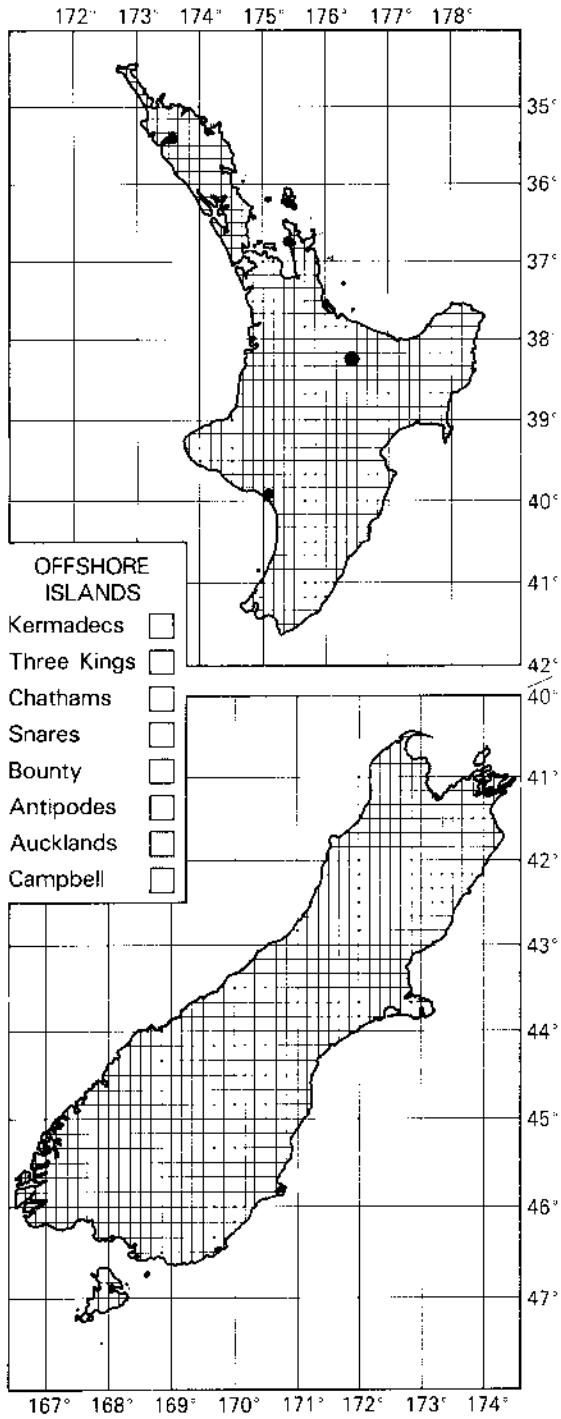
• **Map2** Collection localities, *Carystoterpa fingens* •



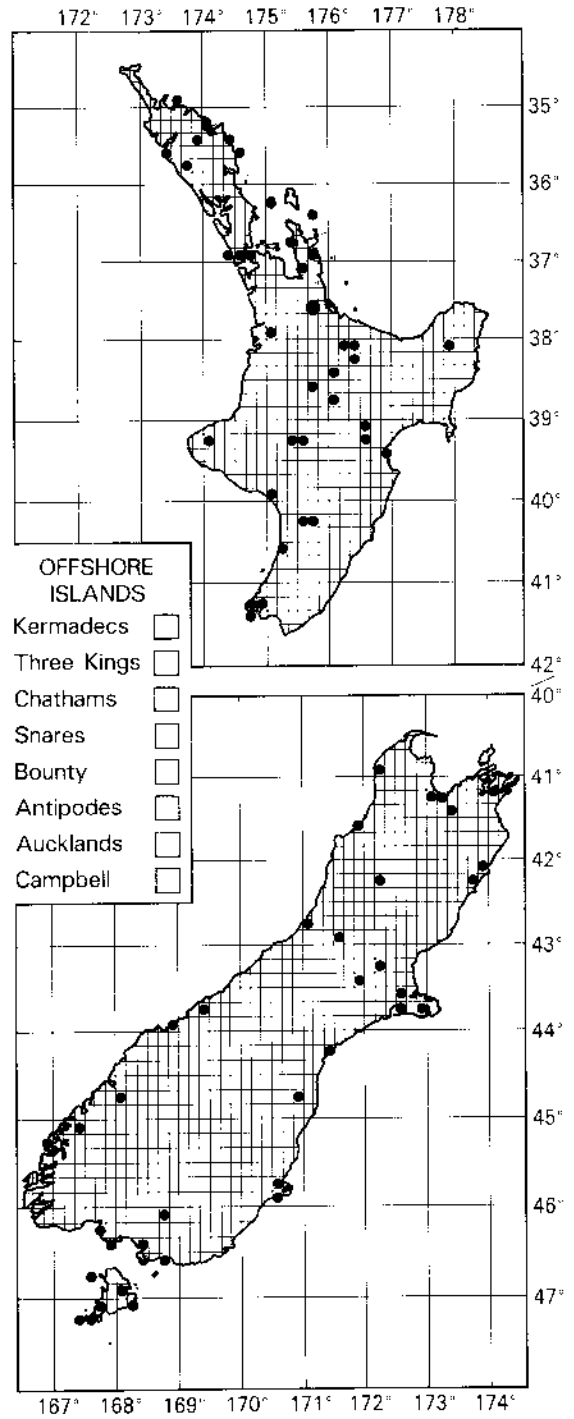
• Map 3 Collection localities, *Carystoterpa ikana* •



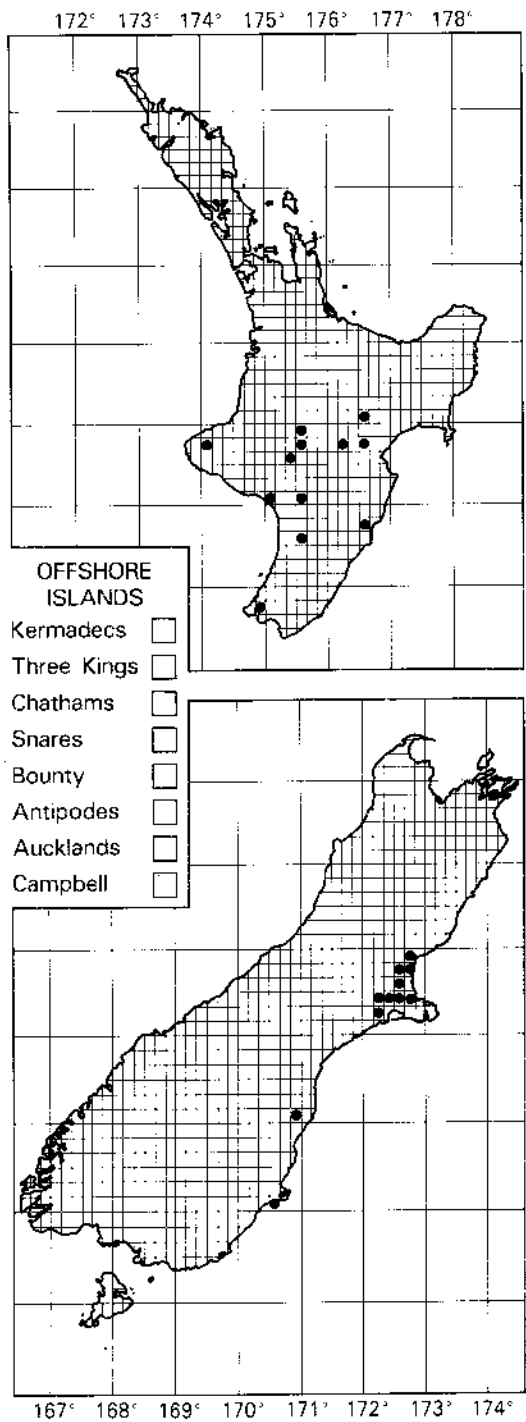
• Map 4 Collection localities, *Carystoterpa maori* •



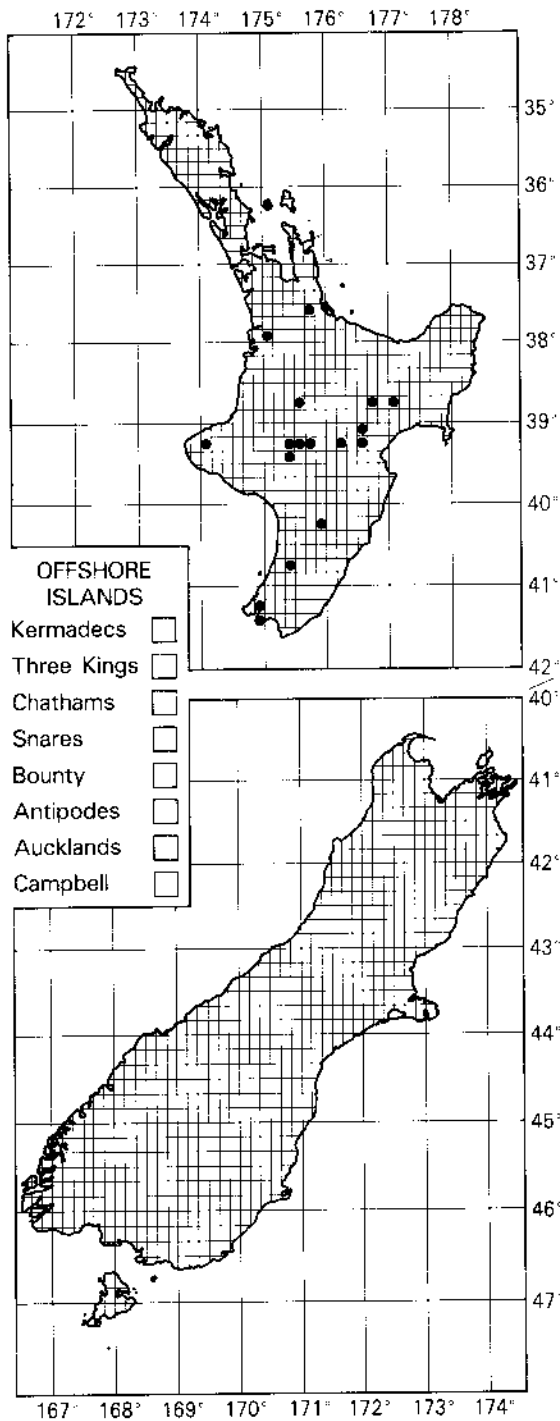
• Map 5 Collection localities, *Carystoterpa minor* •



• Map 6 Collection localities, *Carystoterpa vagans* •



• Map 7 Collection localities, *Philaenus spumarius* •



• Map 8 Collection localities, *Pseudaphronella jactator* •

TAXONOMIC INDEX

This index covers the nominal taxa of Cercopidae and other arthropod groups mentioned in the text, regardless of their status in taxonomy. Page numbers in bold type denote descriptions of taxa, and in italic type illustrations. A suffixed letter 'k' indicates a key, and 'm' a map.

- Aphrophorinae 8
Anyllis 10
aurata, Carystoterpa 11k, **13**, 26
- Basilioterpa* 10, **12**, 18
bullata, Basilioterpa 11k, **12**, 24
- Carystoterpa* 10, 11k, **12**, **13**
chelyon, Carystoterpa 11k, **13**, 26, 28m
 Cicadellidae 7, 10
Cloviana 12
Costaclovia 12
- Eurycercopis* 12
- fasciata, Basilioterpa* 12, 24
fungens, Carystoterpa 8, 11k, **13**, 14–18, 25, 26, 28m
 Ptyelus 13
fusiformis, Carystoterpa 11k, **14**
Fusiptyelus 12
- Handschinia* 12
- ikana, Carystoterpa* 11k, 14, 17, 26, 29m
Interocrea 12
Iophosa 12
Irlandiana 12
Izzardana 12
- jactor, Aphrophora* 19, 20
 Pseudaphronella 8, 11k, 19, **20**, 27, 31m
- laeta, Carystoterpa* 17
- laetus, Ptyelus trimaculatus* 17
Lallemandana 12
Lemoultana 12
Liorhina 12
- maori, Carystoterpa* 11k, **15**, 17, 25, 29m
minima, Carystoterpa 11k, **15**, 16, 23
minor, Carystoterpa 11k, **15**, 18, 25, 30m
- Napotrepes* 10
Nesaphrestes 12
Novophilaenus 12
- pallida, Basilioterpa* 12, 24
Pareurycercopis 12
Perinoia 12
Philaenus 10, **18**
Pseudaphronella 10, **19**
Pseudaphrophora 10
- quadrinaculatus, Philaenus spumarius* 19
- Salomia* 12
Sphodroscarta 12
spumaria, Cicada 18, 19
spumarius, Philaenus 8, 10, 11k, **19**, 23, 27, 31m
Strandiana 12
subtacta, Carystoterpa 11k, **16**
subtactus, Ptyelus 16
subvirescens, Carystoterpa 11k, **16**, 26
 Ptyelus 16
- trimaculata, Carystoterpa* 11k, 15, **16**, 17, 25, 26
trimaculatus, Ptyelus 16
tristis, Carystoterpa 11k, 17, 26
 Ptyelus trimaculatus 17
- vagans, Carystoterpa* 10, 11k, 15–17, 18, 25, 26, 30m
- xenobilis, Carystoterpa* 13

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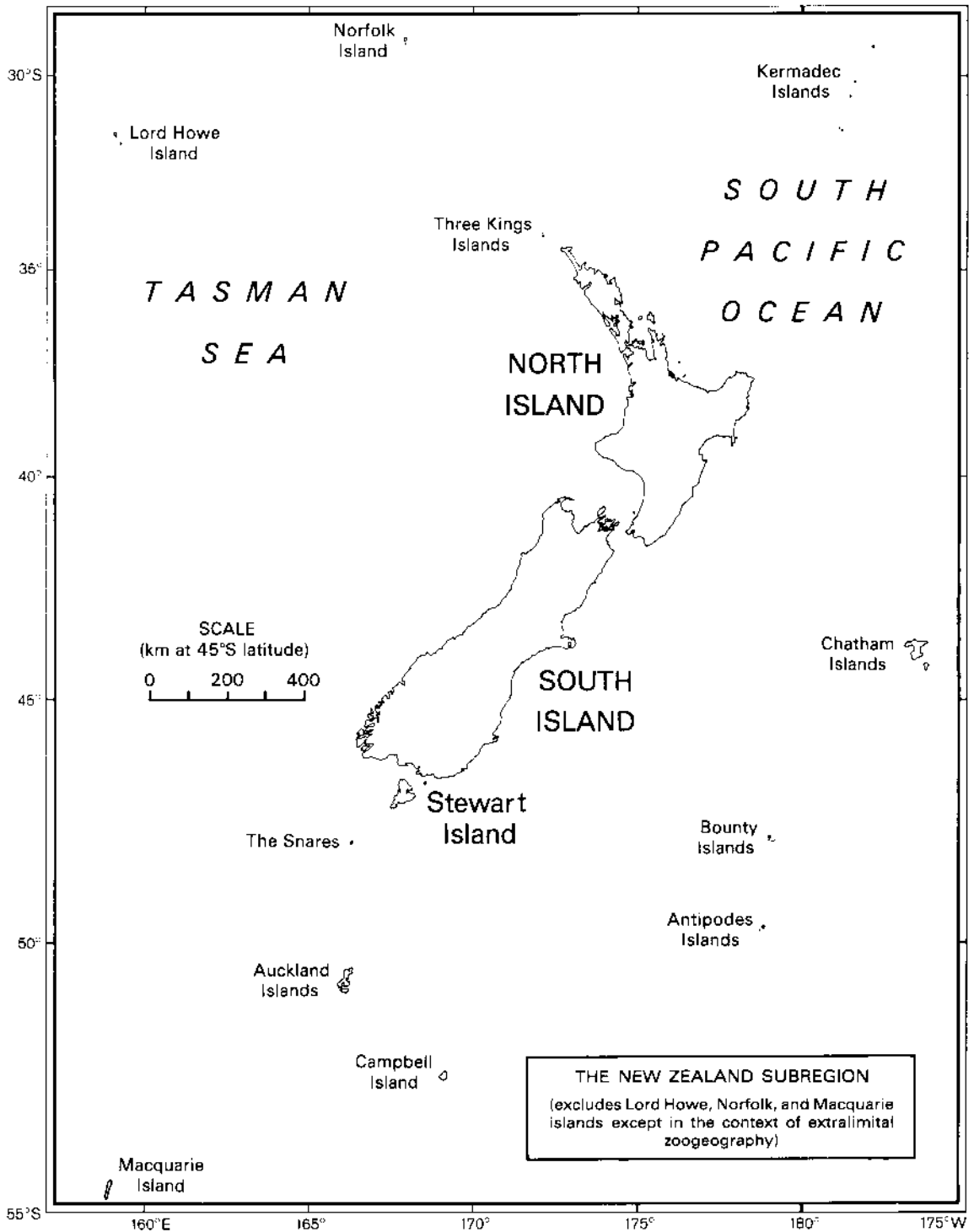
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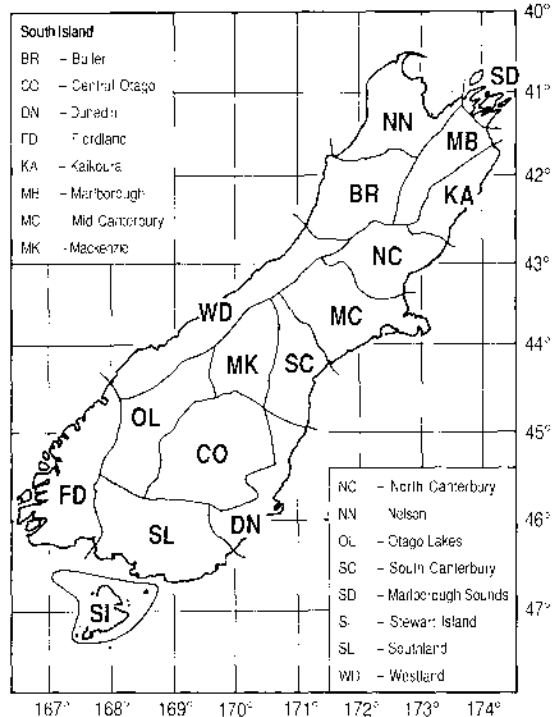
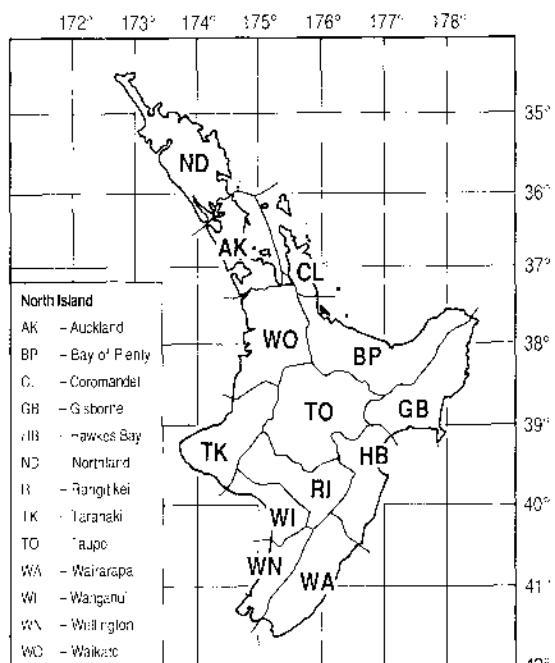
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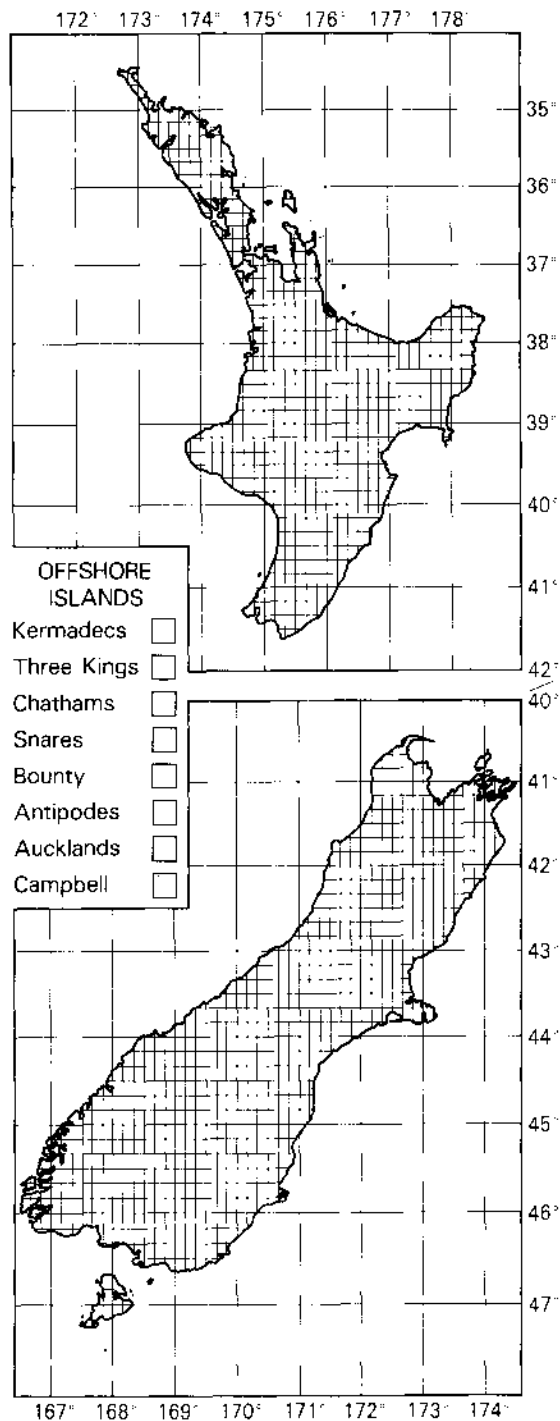
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Area codes and boundaries used to categorise specimen locality data (after Crosby *et al.* 1976)



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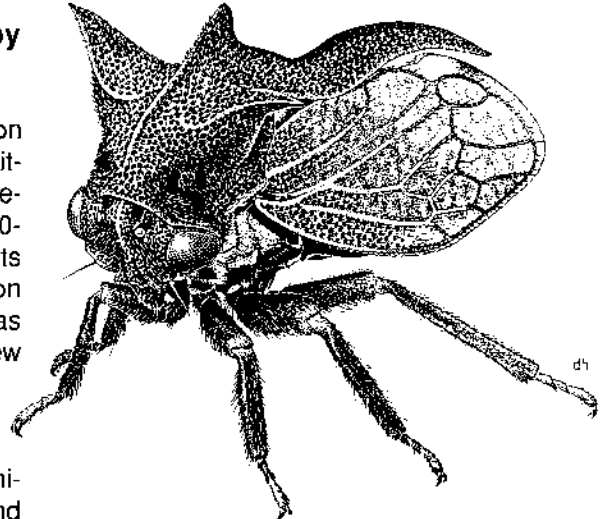
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Graeme W. Ramsay & Trevor K. Crosby

This bibliography and its associated information retrieval database, BUGS, cover all available literature concerned with non-marine invertebrates of the New Zealand subregion for the 210-year period 1775 to 1985. The bibliography lists approximately 14 500 references to information in about 950 periodicals and numerous books, as well as about 750 theses and projects of New Zealand universities. Literature concerning both endemic species and those which are adventive or introduced is included. Many of the introduced species from the Northern Hemisphere and Australia are of agricultural and horticultural significance, and form a significant proportion of New Zealand's economic literature.

The references are arranged in independent sections, each a separate bibliography. The 19 categories are: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, other insect orders, Arachnida, other Arthropoda, Annelida, Mollusca, Nematoda, Platyhelminthes, Protozoa, other invertebrate phyla, Aves, Mammalia, other vertebrates, university theses and research projects, and pesticides.

The introductory section includes a history of the development of the project and a brief review of computerised information retrieval. The criteria used in compiling the bibliography and the BUGS database are set out and fully explained.



A detailed guide is given, with examples of how to search the database. The information content of references was recorded using a thesaurus of 4000 content descriptors. These are listed to demonstrate the depth of indexing of the information and the very wide range of topics and aspects it is possible to search, e.g., vertebrates as hosts or as predators of invertebrates, chemicals and other materials and techniques used in pest control, medical or veterinary topics concerned with invertebrates. Searches may be narrow or wide-ranging, e.g., on a particular pest species or on all members of its family. The bibliography has no detailed subject index for the references, as this function is fulfilled by the BUGS database.

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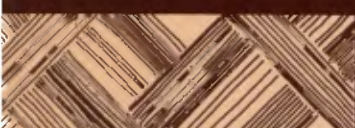
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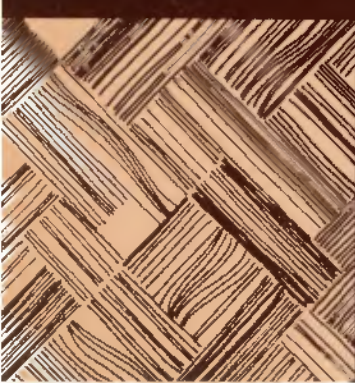
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Date of publication: 25 May 1992
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