

## TWO NEW ZEALAND CICADAS COLLECTED ON COOKS' ENDEAVOUR VOYAGE, WITH DESCRIPTION OF A NEW GENUS

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### Summary

The largest and most conspicuous New Zealand cicadas, long known as *Melampsalta cingulata* (Fabricius), are shown to consist of two sibling species differing in song, morphology, average dimensions, ecology, season of emergence, and distribution, one being restricted to the North Island, the other ranging through both North and South Islands. By choice of a lectotype, the name *Tettigonia cingulata* Fabr. is attached to the first, and Bay of Islands chosen as restricted type locality. For the second, the name *Cicada zelandica* Boisduval, 1835, is used, based on a specimen collected by Dumont D'Urville in 1827 (restricted type locality, Tasman Bay).

The new genus *Amphipsalta*, here defined for *C. zelandica* (type species), *T. cingulata*, and *Cicadetta strepitans* Kirkaldy is distinguished from *Cicadetta* (= *Melampsalta*) and related genera by morphology and acoustic behaviour, combining well-developed tymbal song with rhythmic wing-clapping for which its costae are thickened and bowed ("swept back").

### HISTORICAL INTRODUCTION

During the *Endeavour* Voyage of Captain James Cook (1768–71), Joseph Banks and his helpers collected at least nine specimens of cicadas from New Zealand. Surprisingly, no reference to these conspicuous insects can be found in the journals of Cook or of Banks (Beaglehole, Ed., 1955; 1962) or in Banks' rather perfunctory account of New Zealand insects (p. 6 in Beaglehole, 1962, Vol. 2), and it was left to Wm. Anderson, surgeon on the *Resolution* on Cook's Third Voyage (1776–80) to record at Ship Cove, Queen Charlotte Sound, on 13 February, 1777, "a perpetual and universal chirping in the woods which I never heard before in this place . . . , which upon examination I found to be occasion'd by a large kind of flie that rests on the trees in great numbers and flys with much velocity from one to another" (Beaglehole, Ed., 1967, p. 797). He later (p. 808) called them "Scorpion flies which . . . fill the woods with their chirping".

On the *Endeavour* voyage, Cook first landed at Gisborne on October 9 and visited Anaura Bay and Tolaga Bay later in the month. So early in the season it is unlikely that the larger cicadas would have emerged in numbers. The *Endeavour*'s next landings were at Mercury Bay (November

5–14), Thames (November 20–21) and Bay of Islands (November 29–December 4), by which later dates large cicadas would have emerged in considerable numbers in Northland. The *Endeavour* proceeded round North Cape and down the west coast to Queen Charlotte Sound, where she stayed at Ship Cove from January 15 until February 5, 1770, and returned to Admiralty Bay briefly (March 27–30) after circumnavigating the South Island. Judged by modern observations large cicadas must have been abundant during the stay at Queen Charlotte Sound and probably also at Admiralty Bay.

Unlike most of the rich harvest of biological specimens brought back to England by Banks, the insects, which were handed to J. C. Fabricius, were described with reasonable alacrity in the *Systema Entomologiae* which appeared in 1775. According to Zimsen (1964, p. 9) Fabricius spent the summers of 1769–1775 in London, working on Banks's and other collections. At the end of July 1775, Cook returned to Plymouth from his Second Voyage and additional biological material from New Zealand reached the Banks Collection, including a cicada, now in the British Museum, a female of the species later named *Cicada muta* var. *subalpina* Hudson which still bears the label "Forster". Whether or not the Second Voyage insects were sent to Fabricius (who was presumably in London for the summer of 1775) it seems so unlikely that he could have based descriptions on them before the *Systema* was published that we have discarded this possibility and assume that the *Systema* types were all collected on the first (*Endeavour*) voyage.

In the Banks Collection, British Museum (Natural History), two males recognised by Kirby (1896) and Myers (1927) as the type material of *Tettigonia cingulata* were examined briefly by one of us (C.A.F.) in 1967 and 1968 and are illustrated in Fig. 1. Two additional specimens are in the Fabricius collection formerly at Kiel Museum, now deposited in the Zoological Museum at Copenhagen. These are listed in parenthesis by Zimsen (1964, p. 289) indicating a secondary status, and in view of Fabricius' own words ("Mus. Banks") and of Kirby's action (1896) in nominating the British Museum specimens as the types we feel justified in basing nomenclatural decisions on them alone.

In 1835, Boisduval described and figured a large female cicada from New Zealand as *Cicada zelandica*, the specimen having been collected by Dumont d'Urville on the voyage of the *Astrolabe*, which spent a fortnight in Tasman Bay (January 14–28, 1829) before visiting Whangarei and Hauraki Gulf. Other binomina later bestowed on large New Zealand cicadas, according to Metcalf (1963), are *Cicada mendosa* Walker ("Western Africa"), 1858; *C. indivulsa* Walker, 1858; and *C. flexicosta* Stål, 1859 ("Australia"). Hutton (1874) listed some of these names without



FIG. 1—*Tettigonia cingulata* Fabricius. Syntypes collected on Cook's *Endeavour* Voyage, 1769, Banks Collection, British Museum (Natural History);  $\times 1.5$  (approx.).

(a), (b) Syntype No. 2 = *Amphipsalta zelandica* (Boisduval), ♂.

(c), (d) Syntype No. 1, Lectotype, *Amphipsalta cingulata* (Fabr.), ♂.  
(Photographs, British Museum (Natural History)).

evaluating them, but only a single species of "large cicada" was recognised in the lists of New Zealand cicadas by F. B. White (1879), Hudson (1891, 1892, 1893), Kirby (1896), Hutton (1898, 1904), Distant (1906), Kirkaldy (1909) and Myers (1921). Myers (1921) commented that the very varied song distinguishes *Melampsalta cingulata* but later (1929a) stated that there is little variation in *Melampsalta cingulata*. Hudson (1950) noted considerable variation in size.

In February 1966, Professor T. E. Moore, University of Michigan, spent a few hours in Auckland and later reported (to C.A.F.) that he had collected and tape-recorded two species of cicada that accompanied their tymbal song by wing-tapping. Only a single wing-tapping species (*cingulata*) had been recognised in Auckland, but the significance of Professor Moore's observation was not immediately appreciated. In December 1966 one of us (C.A.F.) began recording New Zealand cicada song, and those of "*M. cingulata*" were noted as variable. During the following summer, David and John Lane of Miramar, keen schoolboy observers and collectors of cicadas, pointed out that there are two types of "*cingulata*", differing in song, habitat preference, and morphology, and identified the two songs among the tape recordings then obtained. In February 1968 Dr K. J. Fox, Manaia, collected both species at Whitianga and observed that they sang differently and occupied different habitats. C.A.F. was finally convinced that two distinct species have been confused for more than a century under the name *cingulata* when he visited Professor Moore in October 1968, and their distinct morphology was confirmed by J. S. D. from collections before the summer of 1968-69, when differences in distribution, season, and ecology were established by field work in several parts of New Zealand.

This paper defines *Amphipsalta* nov. and distinguishes the two species that have been so long confused. A more comprehensive revision of New Zealand cicadas is in train; only the main citations are given.

The following abbreviations are used for repositories of specimens: A, Auckland War Memorial Museum; C, Canterbury Museum; D, Dominion Museum, Wellington; E, Entomology Division, D.S.I.R., Nelson; F, Fleming Collection.

#### Family CICADIDAE

#### Subfamily TIBICININAE

#### Tribe CICADETTINI

#### Genus *Amphipsalta* Fleming, nov.

Moderate-sized Tibicinine cicadas with the costae thickened and, in males, angulated at apex of distal cell (swept-back, in aeronautical par-



lance). Tegmina with zig-zag spot of black at distal ends of first and second ulnar areas; a further diffuse black spot at anal margin of hind wing. Venation: characteristic for Cicadettinae as defined by Distant (1906, p. 171) but with the M1-4 stem shorter than the succeeding M1 + 2 stem (Fig. 2a, b).

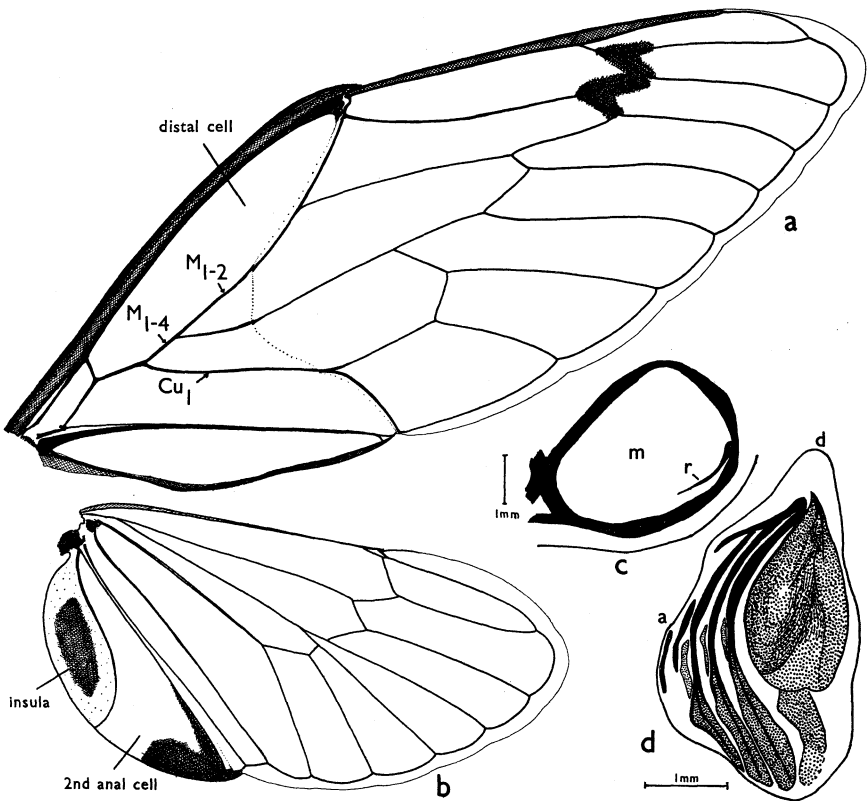


FIG. 2.—*Amphipsalta zelandica* (Boisduval), ♂  
 (a), (b) Venation, right forewing and hindwing.  
 (c) Right tympanum (mirror), showing ventro-lateral position of thickened rod to chordotonal organ (r), m.—membrane.  
 (d) Left tymbal showing rib pattern (a.—anterior; d.—dorsal).

Tymbal (Fig. 2d) with three complete long ribs, two short anterior ribs and three short intercalary ribs, less sclerotised than the rest, across the line of tymbal flexure. Tympanum (Fig. 2c) with narrow sickle-shaped thickened rod-like process to chordotonal organ in ventrolateral position (cf. Myers, 1929b, fig. 26 for position in *Cicadetta sericea* (Walker)).

MALE GENITALIA (Figs 3, 4). Phallus trifid. Endotheca sclerotised, shorter than parameres, separate from ventral support; parameres dorsal, apices diverging, simple; ventral support acuminate, shorter than endotheca.

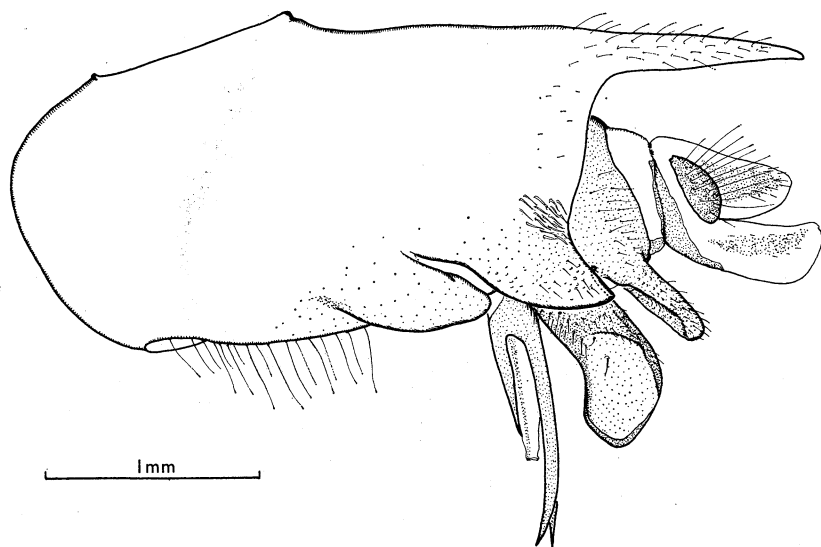


FIG. 3—*Amphisalta zelandica* (Boisd.), ♂, Kenepuru Sound, Marlborough. Complete pygofer in left profile.

FEMALE GENITALIA (Fig. 5). Vulva and ovipore separated by fused lamellae vulvae. Genital scale bearing vulva, tubular, straight to decurved. Vagina sinuous to angulated; genital carrefours extending anteriorly over vagina; lamellae vulvae sclerotised at least below vagina.

ACOUSTIC BEHAVIOUR: Male tymbal song accompanied by rhythmic percussive clicks due to rapid clapping of the wings. Female producing similar rhythmic clicks, thus permitting a two-way communication between the sexes during courtship.

Oviposition in egg-nests forming distinctive herringbone pattern on twigs (Myers, 1929b, Pl. 6, fig. 1).

DISTRIBUTION: New Zealand.

The name *Amphisalta* indicates the combination of two methods of sound production, characteristic of the genus. For convenience of citation the genus is attributed to a single author who is responsible for the name and indication.

TYPE SPECIES: *Cicada zelandica* Boisdual. *Voy. Astrolabe*, Hemiptera: 611; Atlas, Pl. 10, fig. 6.

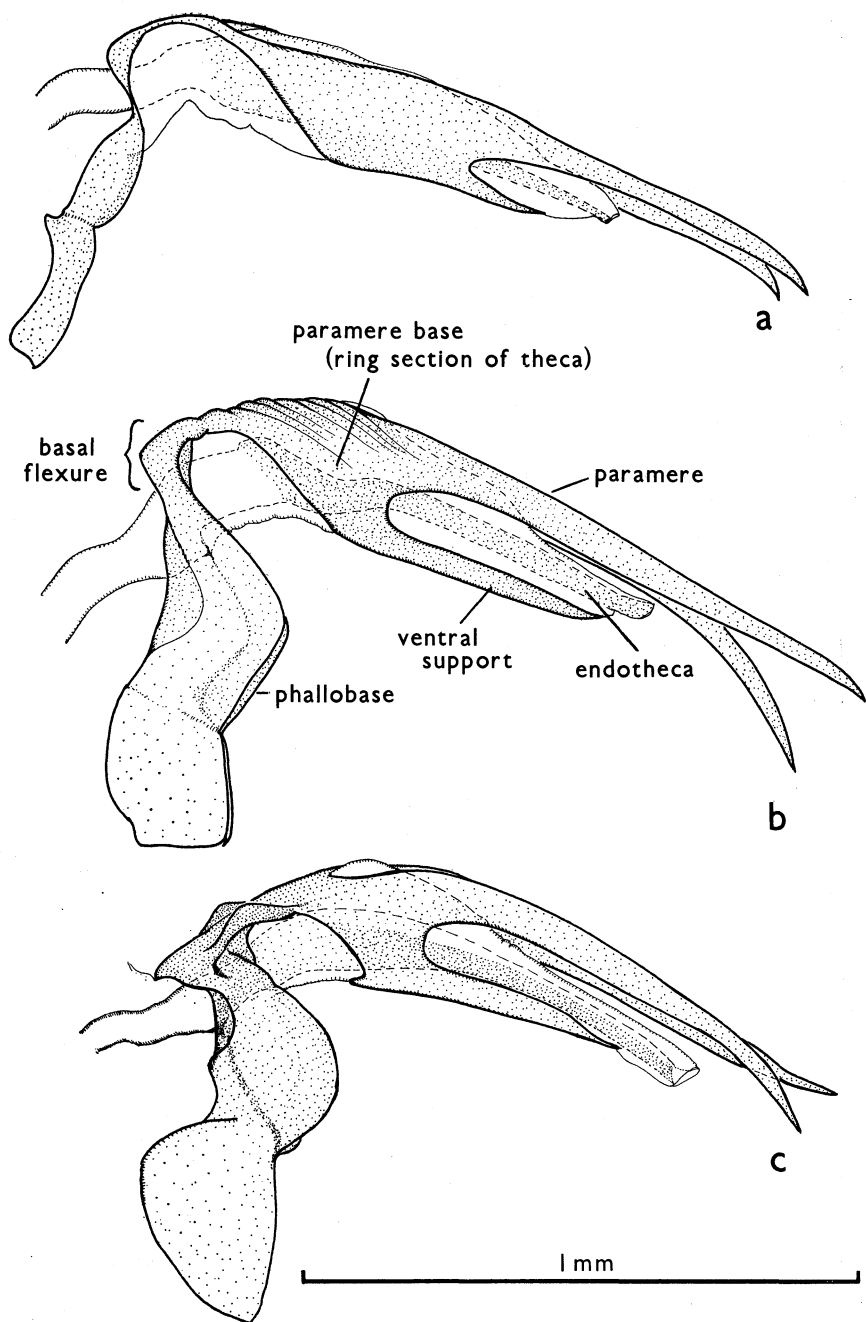


FIG. 4—Male genitalia of *Amphipsalta*  
 (a) Phallus, *A. cingulata* (Fabr.), Rotorua.  
 (b) Phallus, *A. zelandica* (Boisd.), Rotorua.  
 (c) Phallus, *A. strepitans* (Kirk.), Puhipuhi Reserve.

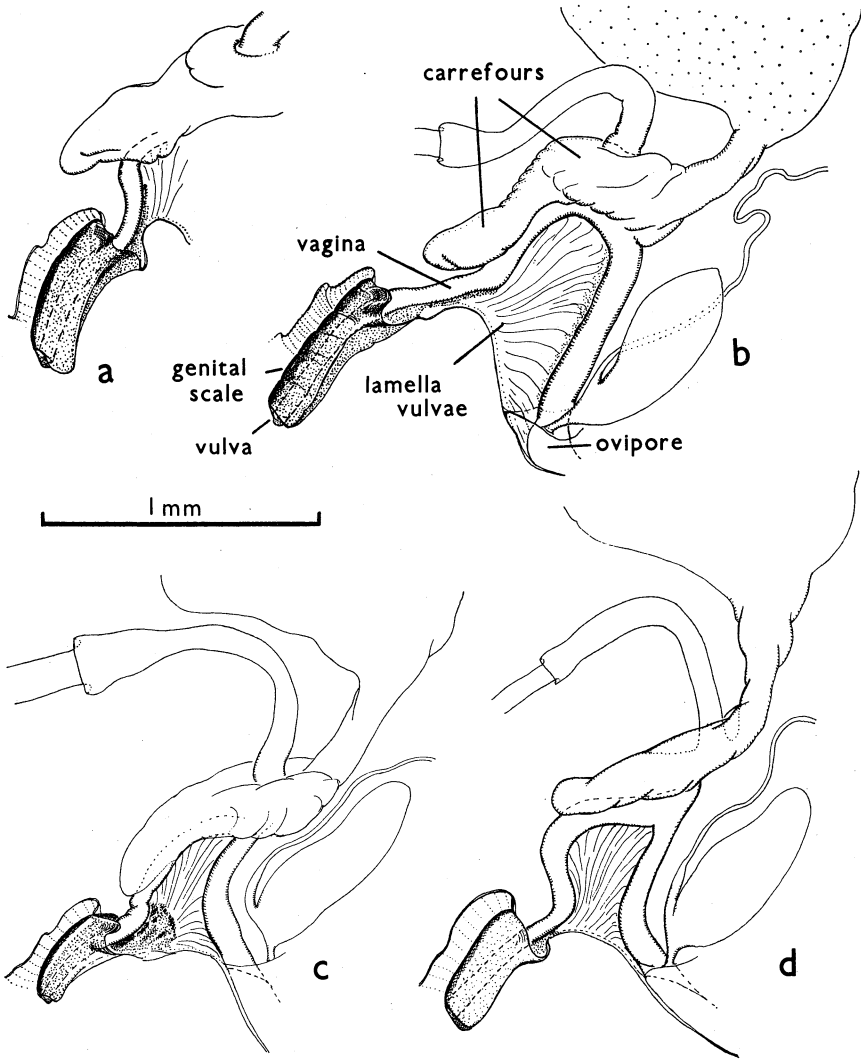


FIG. 5—Female genitalia of *Amphipsalta*

- (a) *A. zelandica* (Boisd.), Opouri Valley, Marlborough.
- (b) *A. zelandica*, Rotorua.
- (c) *A. cingulata* (Fabr.), Takapuna, Auckland.
- (d) *A. strepitans* (Kirk.), Mt Somers, Canterbury.

INCLUDED SPECIES: *Tettigonia cingulata* Fabricius, *Cicadetta strepitans* Kirkaldy.

*Amphipsalta* is related to *Pauropsalta* and some other genera of the tibicinine tribe Cicadettini, differing in its tymbal ridging, thickened and

swept-back male fore-wing costae and in the unique combination of tymbal song with wing-clapping similar to the wing-banging that characterises the American sub-family Platypediinae, which lack tymbals. Other New Zealand cicadas (listed in *Cicadetta* by Metcalf, 1963, and previously classed in *Melampsalta*) flap their wings softly during courtship but rarely produce a conspicuously audible sound. The *Amphipsalta*-type phallus is shared by *Diemeniana tillyardi* Hardy (Australia), *Pinheya* (S. Africa), *Pauropsalta* (Australia), *Ueana* (New Caledonia) and some other Australian and New Zealand species currently classed in *Cicadetta*. *Diemeniana* is at present classed in the Parnisini (Metcalf, 1963).

Post-abdominal structures (for terminology see Dugdale & Fleming, 1967) are best examined when cut off and macerated in 10% KOH in a waterbath, neutralised in 45% acetic acid and then placed in a dish of 70% alcohol. They can be stored in a minivial on the same pin as the rest of the specimen. For more detailed descriptions of the various types of female genitalia in Cicadidae, see Boulard (1965). We have latinised Boulard's term "lèvres vulvaires" to "*lamellae vulvae*", and retained his term "carrefours" (literally "crossroads") for the chamber in which meet the common oviduct, vagina, duct of the dorso-vaginal pouch and the ovipore tube.

The drawings of the male genitalia (except Fig. 3) show only the phallus with the phallobase, cut away from the integument. The drawings of the female genitalia exclude valvifers and valvulae.

#### Key to Species of *Amphipsalta*

- (1) Wing span under 60 mm, axillary membrane orange; anterior angle of pronotum massive, sharp, point distinct, reclinate . . . . . *streptans*  
 Wing span over 60 mm, axillary membrane grey or malachite green; anterior angle of pronotum rounded or with point obscure . . . . . 2
- (2) Axillary membrane malachite green; frons with obscure short median groove; ♂: sternites black, opercula fawn, lacking erect setulae on disc; ♀: second valvula with 16-17 teeth . . . . . *zelandica*  
 Axillary membrane dull grey; frons with distinct long median groove; ♂: sternites patterned in testaceous and black; opercula variably darkened, with many erect discal setulae; ♀: second valvula with 14 teeth . . . . . *cingulata*

#### *Amphipsalta zelandica* (Boisduval) sp. val.

1835. *Cicada zelandica* Boisduval, Hémiptères. *Voy. Astrolabe*: 611, Atlas, Pl. 10, fig. 6.  
 1921. *Melampsalta cingulata*: Myers, Trans. N.Z. Inst. 53: 241 (partim), Pl. 45, fig. 5, 6.

HOLOTYPE: Boisduval's coloured illustration shows a female with a body length of 28.5 mm, forewings of 34.5 to 36.0 mm, and wing spread of 78.6 mm. These dimensions are not accurate, but they indicate a large

insect, beyond the observed range of *A. cingulata* as here restricted. Moreover, the illustration shows the typical bright coloration, pronotal margin, and tapering abdomen of the species to which the name is here attributed.

Myers (1927) reported that the type could not be found at the Musée d'Histoire Naturelle, Paris; fortunately the illustration, together with the type locality as here restricted, are an adequate indication, allowing this eminently suitable name to be used for New Zealand's largest and most conspicuous cicada.

**TYPE LOCALITY:** The locality was stated as "Nouvelle-Zélande"; as the *Astrolabe's* main work was in Tasman Bay, in January 1829, the type locality is here restricted to Tasman Bay.

**DESCRIPTION:** For general description of this species and *A. cingulata* see Myers (1921) and Hudson (1950, p. 128). Closely similar to *A. cingulata*, but on the average larger and with relatively longer wings, though with considerable overlap in dimensions. Frons swollen, smooth and shining mesially, with median groove obscure and restricted (Fig. 6). Pronotal margin with anterior angle rounded, scarcely produced; margin between anterior and posterior angles straight or scarcely excised (Fig. 7). Background colour of pronotum and mesonotum green, generally brighter than in *A. cingulata*. Axillary membrane with central area of turquoise or malachite green (ephemeral), margined with black, and proximal veins of hindwing also green. Male opercula generally uniformly fawn, black at base, but sometimes with narrow black posterior margins, with sparse decumbent silver pile; rarely dark. Abdominal sternites uniformly black

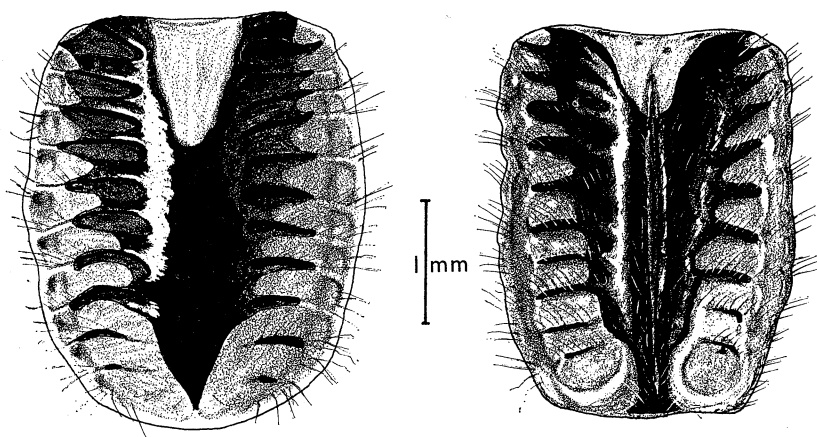


Fig. 6—Frons of *A. zelandica* (Boisd.), left, and of *A. cingulata* (Fabr.), right, showing diagnostic differences in shape; median groove only in latter.

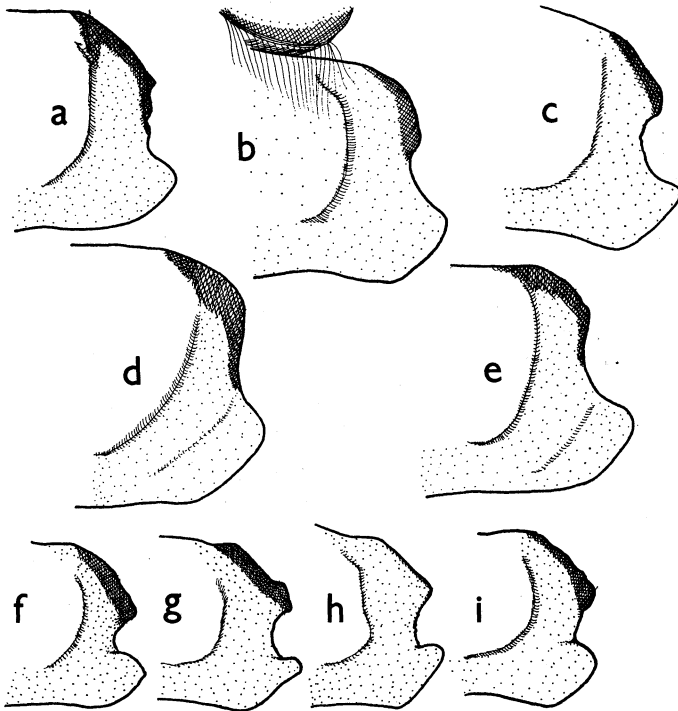


FIG. 7.—Pronotal margins in *Amphipsalta*

*A. cingulata* (Fabr.): (a) Whangarei; (b) Wainuiomata; (c) Rotorua.  
*A. zelandica* (Boisd.): (d) Tutaekuri R.; (e) Nelson.  
*A. strepitans* (Kirk.): (f) Wainuiomata; (g) Kaikoura;  
 (h) Upper Clarence R.; (i) Red Rocks, Wellington.

in most males and females, others with orange-fawn patch on each sternite (Fig. 8). Female abdomen more narrowly tapering than in *cingulata* (Fig. 9).

**MALE GENITALIA** (Figs 3, 4b): Paramere base ("ring" section of theca) corrugated dorsally, shorter than wide, ventral support longer than ventral part of ring section; phallobase deeply indented, left and right portions of phallobase steeply convex; theca angulated at basal flexure.

**FEMALE GENITALIA** (Fig. 5a, b): Genital scale transversely ridged, straight to decurved; anterior prolongation of genital carrefours free of vagina; lamellae vulvae unsclerotised except for a narrow zone by vaginal tube. 1st valvifer with 16–17 "teeth" (Fig. 10a).

**DIMENSIONS:** Length of body, 48 ♂♂, 21.5–29.0 mm, mean 25.4 mm; 30 ♀♀, 22–30 mm, mean 26.2 mm. Length of forewing, 48 ♂♂, 31.5–38.5

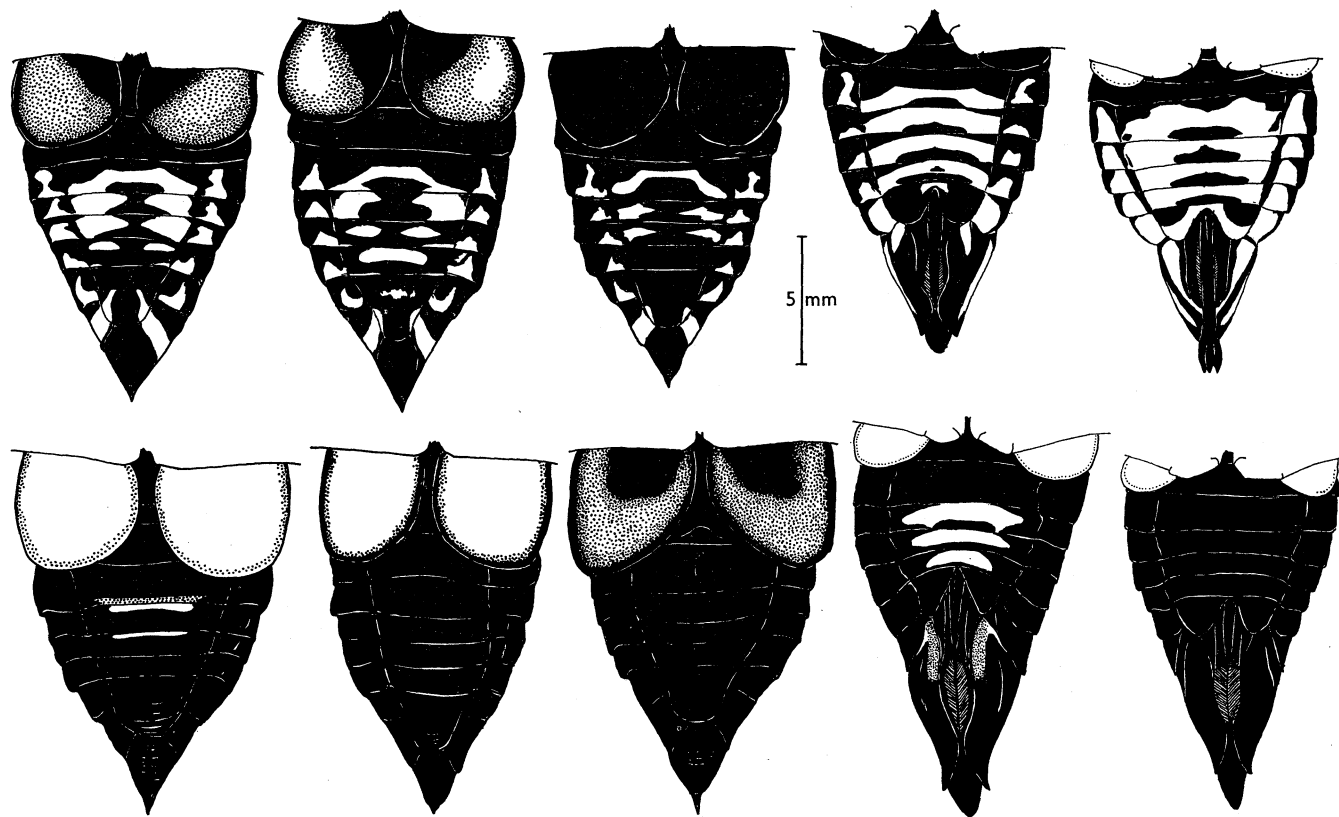


FIG. 8—Diagrams showing pigmentation of abdominal sternites.

Upper figures: *A. cingulata* (Fabr.), ♂♂: Titirangi, Wainuiomata, and Hen Island; ♀♀: Wellington and Hen Island.

Lower figures: *A. zelandica* (Boisd.), ♂♂: Taupo, Eastbourne, and Mt Hercules track (Westland); ♀♀: Waikanae and Stafford.



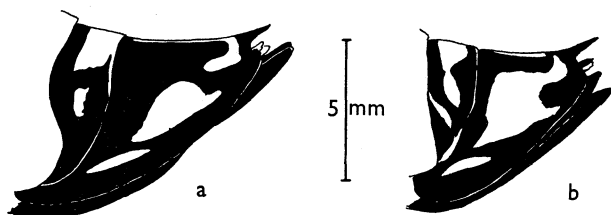


FIG. 9—Lateral views of terminal segments of females of  
(a) *A. zelandica* (Boisd.) (Wairarapa) and  
(b) *A. cingulata* (Fabr.) (Point Howard)  
showing differences in proportions and pigmentation.

mm, mean 35.3 mm; 30 ♀♀ 33–41 mm; mean 36.5 mm. Wingspan, 35 ♂♂, 65–82 mm, mean 75.3 mm; 16 ♀♀, 70–85 mm, mean 78.1 mm. Forewing/body length ratio, 48 ♂♂, 1.31–1.53, mean 1.40; 30 ♀♀, 1.26–1.54, mean 1.39.

**DISTRIBUTION:** North, South, and Stewart Islands, and closer outlying islands. Specimens have been examined from Great Island, Three Kings (A), Unawhao (A), Bay of Islands (Lane Coll.), Waipoua (E), Mt Tamatua (D), Whangarei (F), Hen Island (E, F), Mahurangi (A), Henderson (A), Huia (A), Waitakere Ranges (F), Karamatura Stream (A), Whakatane (Lane Coll.), Whakarewarewa (Rotorua) (F), Waimangu (F), Aratiatia (D), Taupo (F), Waikaremoana (Lane Coll.), Mt Messenger (F), Taurewa (F), Moawhango (F), Tutaekuri River (E), Hatuma (F), Okehu Stream (Wanganui) (F), Waikanae (F), Glenlean Station (Wairarapa) (F), Kapiti (T. L. Grant-Taylor), Kaitoke (Lane Coll.), Rimutaka Range (D, F.), Hutt Valley (F), Wellington and suburbs (D, E, F), Days Bay (D, F), Eastbourne (F), Catchpole Stream (F), Gollans Valley (E), Orongorongo Coast (F), Pelorus Bridge (F), Opouri Valley (E), Kenepuru Sound (E), Camp Bay and Endeavour Inlet (Queen Charlotte Sound) (F), Pepin Island (E), Miner and Roding rivers (F), Dun Mountain (E), Nelson (E, F), Onekaka (F), Black Birch Range (F), L. Rotorua (D), Fletcher's Creek (Reefton) (E), Greymouth (F), Stafford (F), Big Wanganui R. (F), Franz Josef Glacier (A), Waiho (D), Mt Hercules (F), Martin's Bay (F), Hollyford Valley (F), Clarence Valley (E), Conway Coast (F), Akaroa (F), Greenhills (E).

Additional song records, plotted in Fig. 11, include Wairau, Awatere, Haast, Makarora and Eglinton valleys, Peel Forest, L. Monowai and Halfmoon Bay (Stewart Island). Catlins, Leith Saddle, etc. (R. R. Forster).

*A. zelandica* is absent from some bush areas on the Canterbury side of the Southern Alps, from most of the Canterbury plains and lowlands, and from central Otago; more data are needed to define this area of absence,



of *c* 26 per second, each note generally lasting *c* 18 millisecs. Often, but not invariably, the phrase opens with a group of up to 16 shorter notes, each less than 3 millisecs in duration (Fig. 14b, c), and in rapid song in high temperatures such notes may dominate the phrase (Fig. 14a). The second phrase, (b) ("zúrþ") lasts 0.12 to 0.2 seconds, has a characteristic rise and final fall in frequency (Fig. 13a–c), and is immediately followed, in full song, by a wing-clap (click), or by a series of up to 5 wing-claps at 0.8 second intervals, separated by short bursts of tymbal pulses. With the approach to optimal conditions (i.e. rising temperature) the length of phrase (a) becomes shorter and the number of clicks increases. Apparently multiple clicks are characteristic of this species; they have not been observed in *A. cingulata*.

Further work is necessary to determine whether *A. zelandica*, singing in chorus, attains some degree of synchronisation, such as occurs with *Magiccicada cassinii* (Fisher) (U.S.A.) and *Oncotympana maculaticollis* (Motschulsky) (Japan).

### *Amphipsalta cingulata* (Fabricius)

1775. *Tettigonia cingulata* Fabr., Syst. Ent.: 680.

1921. *Melampsalta cingulata*: Myers, Trans. N.Z. Inst. 53: 241 (partim).

1963. *Cicadetta cingulata*: Metcalf, Gen. Cat. Homopt., fasc. 8(2): 302–5 (partim; with references).

LECTOTYPE ♂, here chosen, syntype 1 in Banks Collection, British Museum (Natural History). Length of body 22.0 mm; length of tegmina 28.0 mm; width of mesonotum 7.5 mm.

Fabricius wrote "Habitat in Nova Zelandia. Mus. Banks". He apparently had at least four specimens, two that remained in the Banks Collection, now in the British Museum, and two that were in his own collection of Kiel, now deposited in the Zoological Museum of Copenhagen for an indefinite period (Zimsen, 1964: 7, 189). The phrase "Mus. Banks" may be taken as restricting the choice of lectotype to the London specimens, which were examined by C.A.F. (April 1967, November 1968); Dr P. S. Broomfield has supplied further details and the photographs reproduced in Fig. 1.

One of the specimens (syntype 1, Fig. 1c, d) is *A. cingulata* as here restricted, the other *A. zelandica* Boisduval. Syntype 1 bears the label "New Zealand", has a pale fawn axillary membrane, dirty fawn opercula, black at base, black abdominal sternites with paler markings, and a frons with a distinct median groove. In Fabricius' description the words "Abdomen atrum . . . , subtus lineis quatuor punctorum flavorum",

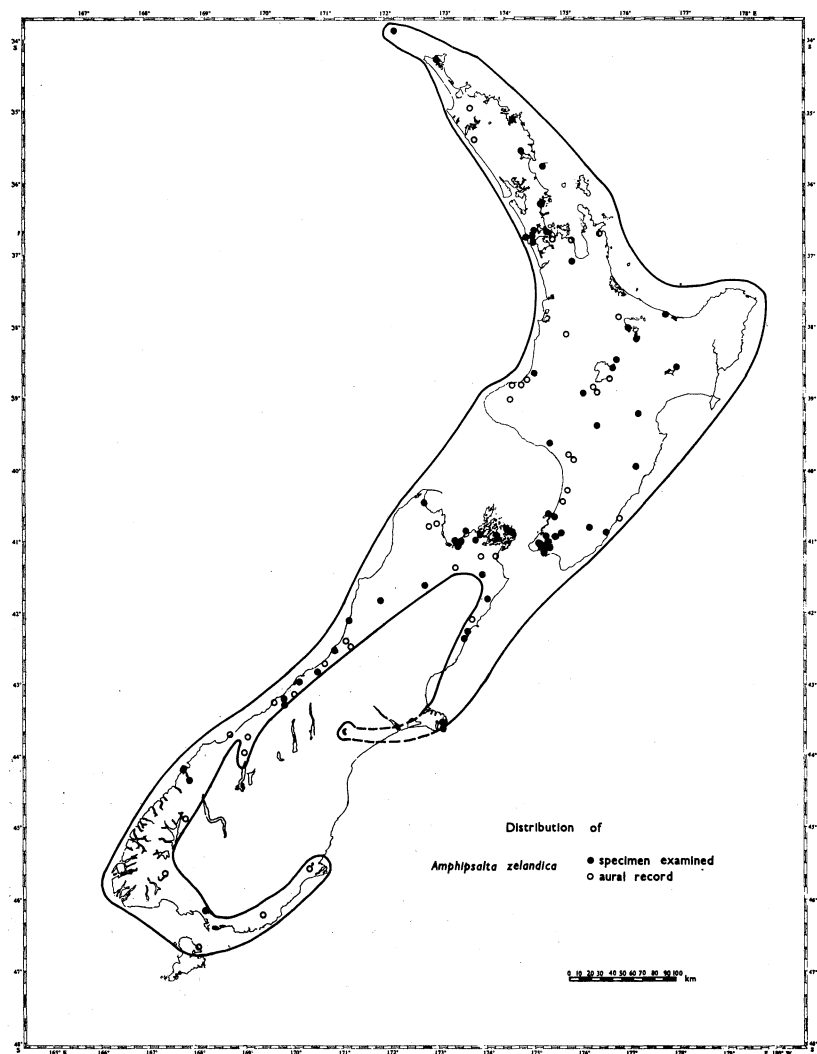


FIG. 11—Distribution of *Amphipsalta zelandica* (Boisd.).

indicating patterned sternites, support the restriction of his name to syntype 1.

Syntype 2 (Fig. 1a, b), a male of *A. zelandica*, was probably collected at Queen Charlotte Sound in January–February 1770.

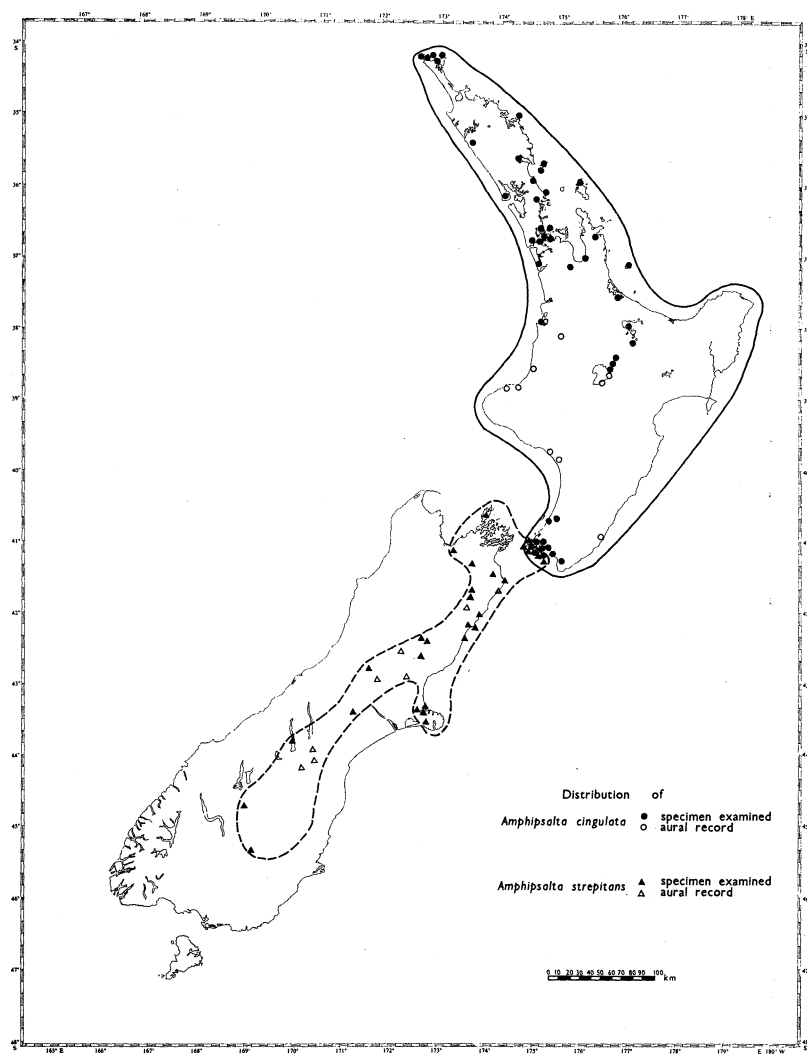


FIG. 12—Distribution of *Amphipsalta cingulata* (Fabr.) and *A. strepitans* (Kirk.).

TYPE LOCALITY: "Nova Zelandia" (Fabricius); here restricted to Bay of Islands, where Banks and his companions collected between November 29 and December 4, 1769.

DESCRIPTION: The following characters differentiate *cingulata* from

*zelandica*: Frons rugose, hirsute, with long, distinct median groove (Fig. 6). Pronotal margin with anterior angle broad, rarely with a minute thorn; margins between anterior and posterior angles moderately excised (Figs 7a-c). Background colour of pronotum and mesonotum olive green to fuscous with silvery pubescence. Axillary membrane of tegmen grey or pale fawn. Venation of hindwing fuscous proximally, not green. Male opercula fuscous fawn to black, generally smoky and hirsute (Fig. 8) and with erect setulae as well as sparse silver pile. Abdominal sternites black and orange-fawn, variably patterned with central dark markings margined by lighter areas (Fig. 8). The general effect is of a smaller, darker, more hirsute insect, with patterned ventral abdomen, darker opercula, and shorter wings. Females are greener than males but seldom so bright as to resemble females of *zelandica*, and their abdominal outline is more obtuse.

**MALE GENITALIA** (Fig. 4a): Paramere base ("ring" section of theca) smooth dorsally, longer than wide, ventral support shorter than ventral part of ring section; phallobase shallowly indented; theca not angulated at basal flexure.

**FEMALE GENITALIA** (Fig. 5c): Genital scale smooth, decurved; anterior prolongation of genital carrefours appressed to vagina; lamellae vulvae heavily sclerotised basally. First valvula with 14 "teeth" (Fig. 10).

**DIMENSIONS**: Length of body 38 ♂♂, 22-27 mm, mean 24.6 mm; 10 ♀♀, 23-26 mm, mean 24.8 mm.

Length of forewing 38 ♂♂, 28.5-34.0 mm, mean 31.5 mm; 10 ♀♀, 31-35, mean 33.2 mm.

Wingspan, 31 ♂♂, 61-73 mm, mean 68 mm; 7 ♀♀, 63.0-75.5 mm, mean 71 mm.

Forewing/body length ratio, 38 ♂♂, 1.19-1.40, mean 1.28, 10 ♀♀, 1.30-1.46, mean 1.35.

**DISTRIBUTION**: North Island and some outlying islands. Specimens have been examined from C. Reinga (E), Pandora (A, D), Kerr Point (F), Tom Bowling Bay (F), Unawhao (A), C. Brett (Lane Coll.), Waipoua (E), Poutu (D), Hen Island (F), Chickens Islands (F), Whangarei (E), Great Barrier (E), Mangawai (A), Warkworth (A), Leigh (D), Titirangi (F), Takapuna (E), Epsom, (F), Remuera (F), Te Papapa (A), Waiuku (D), Mangatarata (F), Whitianga (E), Thames (E), Kawhia (F), Tauranga (F) Mayor Island (D), Rotorua (F), Mokoia Island (E), Waimangu (F), Wairakei (F), Aratiatia (D), Taupo (F), Waikanae (F), Mangakotukutuku Stream (F), Wellington and suburbs (D, F), Wainuiomata (E), C. Tura-kirae (F), Point Howard (F), Days Bay (D), Butterfly Creek (D), Sinclair Head (D), Putangirua Stream (F), Palliser Bay (D). Additional song

records are shown on the distribution map (Fig. 12). Records of this species from White Island have not been checked by specimens or song. *A. cingulata* is absent from the alluvial floor of Hutt Valley.

**HABITAT:** Coastal and lakeside scrub, forest margins, suburban gardens, introduced trees, at altitudes generally less than 350 m. Seldom emerging in such large numbers as *A. zelandica*.

**SEASON OF EMERGENCE:** First song records from October 16, 1966, at Mokoia Island; October 31 to November 16 at Mangatarata, Hauraki Plains (three years' observations, S. Chambers); November 26 near Wellington (two years). Last records: April (Hen and Chickens, 1929, C. J. Lindsay), April 20 (Paekakariki, G. Stevenson, 1969). In experiments that entailed caging of live insects on shrubs in mesh sleeves, individual imagines lived up to nine days; more work is needed, but life span after emergence is unlikely to exceed a month. In 1969 the first Wellington record was 13 Nov.

**SONG:** The song of *A. cingulata* is more leisured and phrased than that of *A. zelandica*. It may be represented as follows: "didididididididid<sup>(a)</sup> . . . eéka<sup>(b)</sup> (click), eéka<sup>(c)</sup> (click), eéka<sup>(d)</sup>". Oscillograph analysis of magnetic tape recordings of the song (Figs 13d, e, 14d, e) shows that the opening phrase consists of 15 to 20 notes each *c* 57 milliseconds long, repeated at the rate of *c* 18 notes a second, but with the first 3 to 20 notes of the phrase shorter and more rapid. Although the speed and frequency of cicada song varies with ambient temperature, observations of *A. cingulata* and *A. zelandica* singing together show that these differences are diagnostic. The individual notes of phrase (a) are made up of about 6 tymbal pulses. Phrase (a) passes directly into the phrase represented by "eéka" (b) which is repeated two to four times, with notable pauses between its syllables and between each phrase. Each phrase except (sometimes) the last (d) (see Fig. 13e), is followed in full song by a wing clap, producing a click. The first syllable ("eek") is 0.2 seconds in duration in (b), but 0.5 sec. in later phrases (c-d), and the second syllable ("a") is much shorter, about 0.1 seconds. Phrases b to d show a regular frequency modulation (Fig. 14d, e).

*A. cingulata* is a solo singer seldom congregating in large numbers and not singing in chorus. Unlike its relative *A. zelandica*, it has not been heard after dark. In many localities its song is drowned by that of *A. zelandica* in late February and March, but it persists widely, and remains dominant in March in some coastal scrub localities where *A. zelandica* is rare, such as the shores of Lake Taupo, Paramata Arm, Porirua Harbour, and Evans Bay, Wellington.

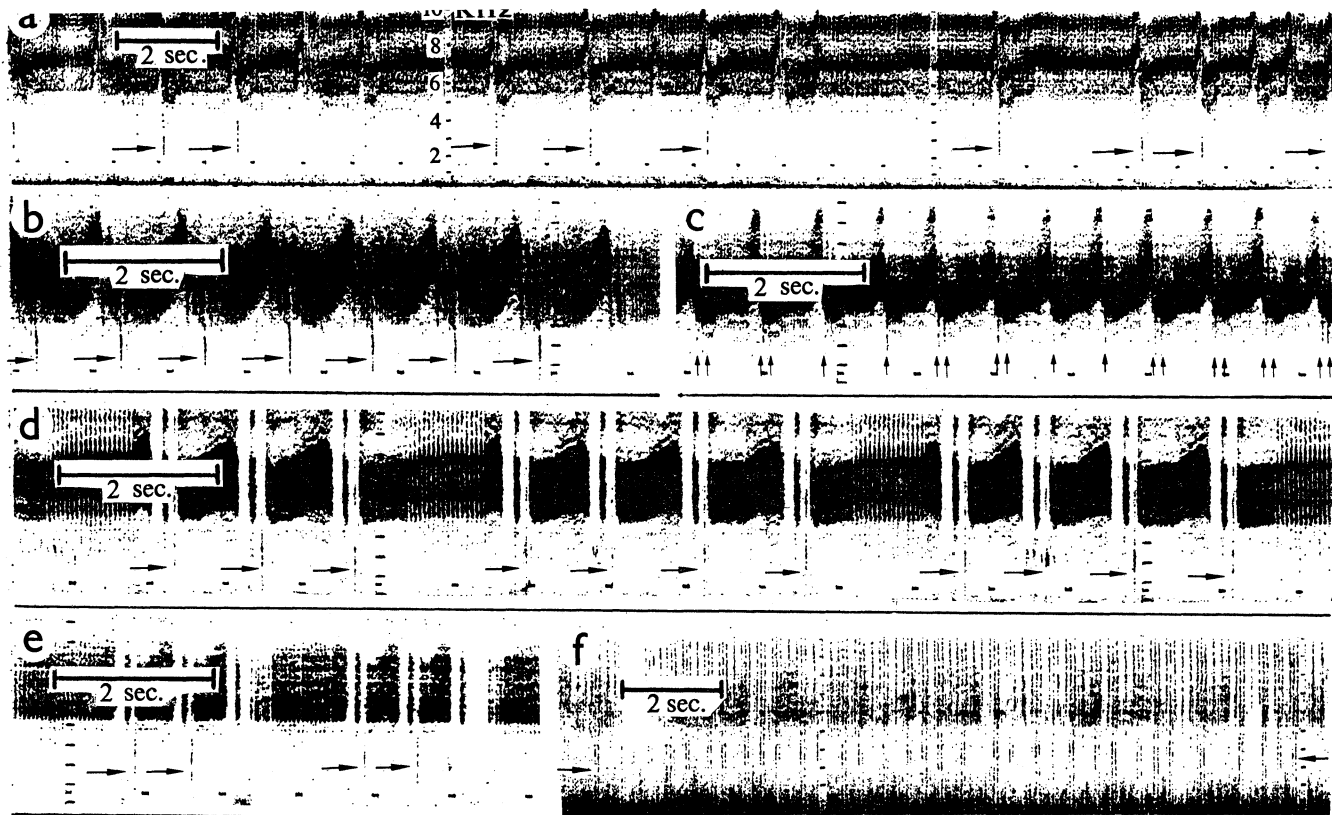


FIG. 13—Oscillograph records of song of *Amphipsalta* species, recorded on magnetic tape and analysed at normal speed. Frequency scale (vertical) on all records 0–10 KHz marked at 1 KHz intervals. Time scale (horizontal) marked at 1 sec. intervals above base line, 6.5 mm per sec. in (a) and (f), 1 cm per sec. in (b) to (e). Arrows mark individual clicks, and band of clicks in (f); click signals in (a) have been retouched and an artificial base-line drawn in (b) to (e).

*A. zelandica*: (a) Waikanae; (b) Okehu; (c) Rough Island, Nelson.

*A. cingulata*: (d) Wainuiomata; (e) Wadestown.

*A. strepitans*: (f) Wainuiomata R. mouth.



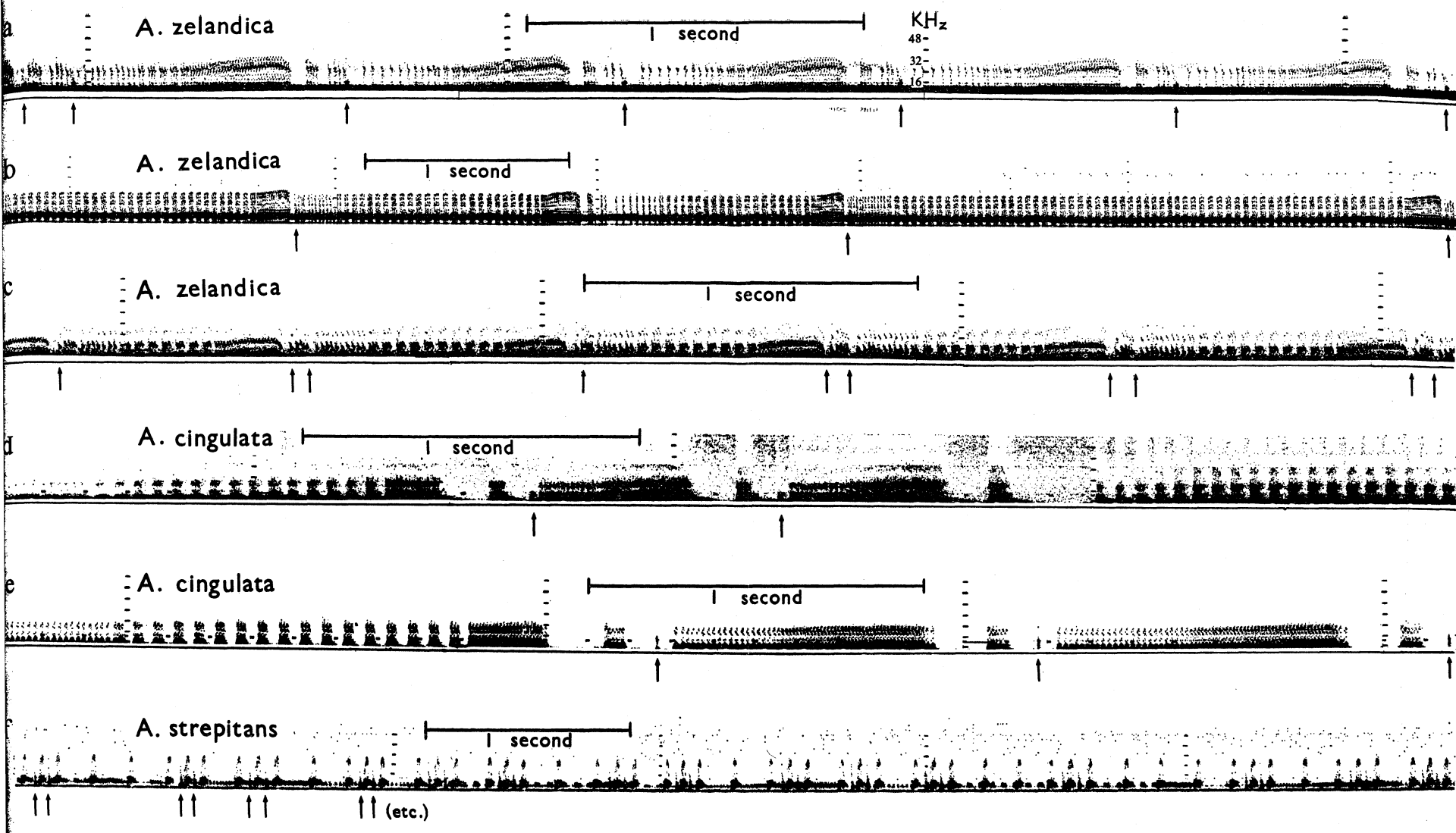


FIG. 14—Oscillograph records of song of *Amphipsalta* species analysed at one eighth normal speed. Vertical frequency scales mark intervals of 8 KHz. Position of clicks (sometimes obscured by "noise") shown by arrows.

*A. zelandica*: (a) Okehu; (b) Waikanae; (c) Rough Island, Nelson.

*A. cingulata*: (d) Wadestown; (e) Wainuiomata.

*A. strepitans*: (f) Wainuiomata R. mouth.

*Amphipsalta strepitans* (Kirkaldy)

1891. *Cicada cingulata* var. *obscura* Hudson, Trans. N.Z. Inst. 23: 51.  
 1904. *Melampsalta obscura* Hudson; Hutton, Index Faunae Novae Zealandiae: 224.  
 1909. *Cicadetta strepitans* Kirkaldy, Trans. N.Z. Inst. 41: 28, nom. nov. for *Cicada cingulata* var. *obscura* Hudson, 1891.  
 1921. *Melampsalta strepitans* (Kirkaldy); Myers, Trans. N.Z. Inst. 53: 241, Pl. 45, fig. 7.  
 1963. *Cicadetta strepitans* Kirkaldy; Metcalf, Gen. Cat. Homoptera, Fasc. 8(2): 382-3, with references.

As the status of some older names applicable to *Amphipsalta* species is still in doubt (e.g. *flexicosta* Stål 1861), and as this paper does not pretend to be a complete systematic account of the genus, we employ Kirkaldy's name *strepitans* for the time being. We have also interpreted Article 23(b) of the Code as being relevant to the situation *obscura* vs *strepitans*. Accordingly, we have applied to the International Commission to place *Cicada cingulata* var. *obscura* on the Official Index of Rejected Specific Names in Zoology.

LECTOTYPE (Fleming & Ordish, 1966, p. 196): A male in the Dominion Museum.

TYPE LOCALITY: Dee River, Kekerangu, February 13, 1890 (Hudson Coll., Dominion Museum).

DISTRIBUTION: Southern tip of North Island and eastern South Island from D'Urville Island south to Central Otago. Specimens have been examined from: Oteranga Bay (F), Waiariki Stream (F), Tongue Point (F), South Karori Stream, 2 miles from coast (F), Sinclair Head (A, D, F), Red Rocks Point (D, E, F), stream west of Owhiro Bay (F), lower Wainuiomata Valley (E, F), Orongorongo coast (F), C. Turakirae (F) (North Island); D'Urville Island (F), Miner R. (F), C. Campbell (F), Wharanui (E), Dee River (Kekerangu) (D), Shin R. (Inland Kaikoura Range) (E), Hodder R. (Awatere) (F), 2 m. NE of Wairau Valley Settlement (F), Awatere Valley, 3 m. S. of Dashwood (F), Clarence Bridge (D), Lower Clarence (F), St James Station, upper Clarence (E), Puhipuhi Reserve (E, F), Kaikoura (E, F), Oaro Valley (F), Oaro Saddle (E), Kowhai Stream (F), Manuka Creek (Waiarau) (F), Marble Point (E, F), Hurunui-Waitohi Junction (F), East Grey R. (C), Mt Grey (E), Sumner (A, C), Governor's Bay (E, F), Lake Forsyth (F), Okain's and Laverick's Bays (B. Helson), Mt Somers (E), Tasman R., Mt Cook (D), Mt Pisa Range (F), 1½ m. S. of Roxburgh Dam, Clutha R. (R. Rowe Coll.). Aural records are added in Fig. 12.

For comparison with the foregoing species, oscillograph records of the characteristic song of *A. strepitans* are reproduced in Figs 13 and 14. Chirrup-like notes are repeated in a rhythmic sequence of triplets and

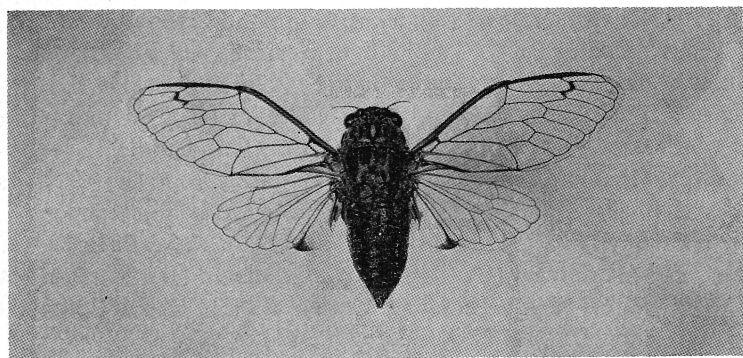
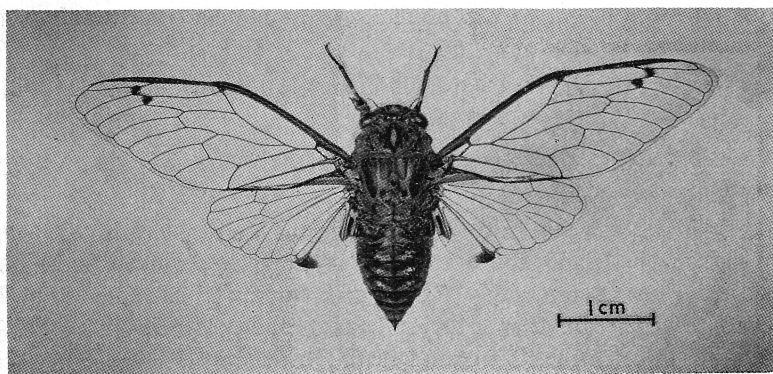
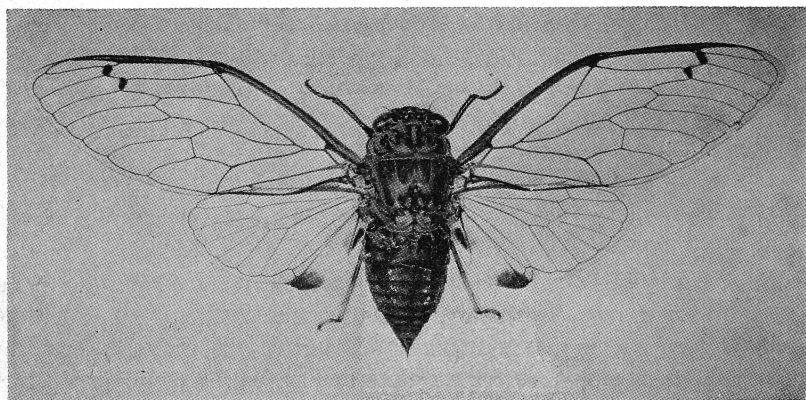


FIG. 15—Dorsal views on same scale (somewhat enlarged) of male *Amphipsalta*:  
*A. zelandica*, upper; *A. cingulata*, middle; *A. strepitans*, lower.  
(Photographs by Entomology Division, D.S.I.R., Nelson.)

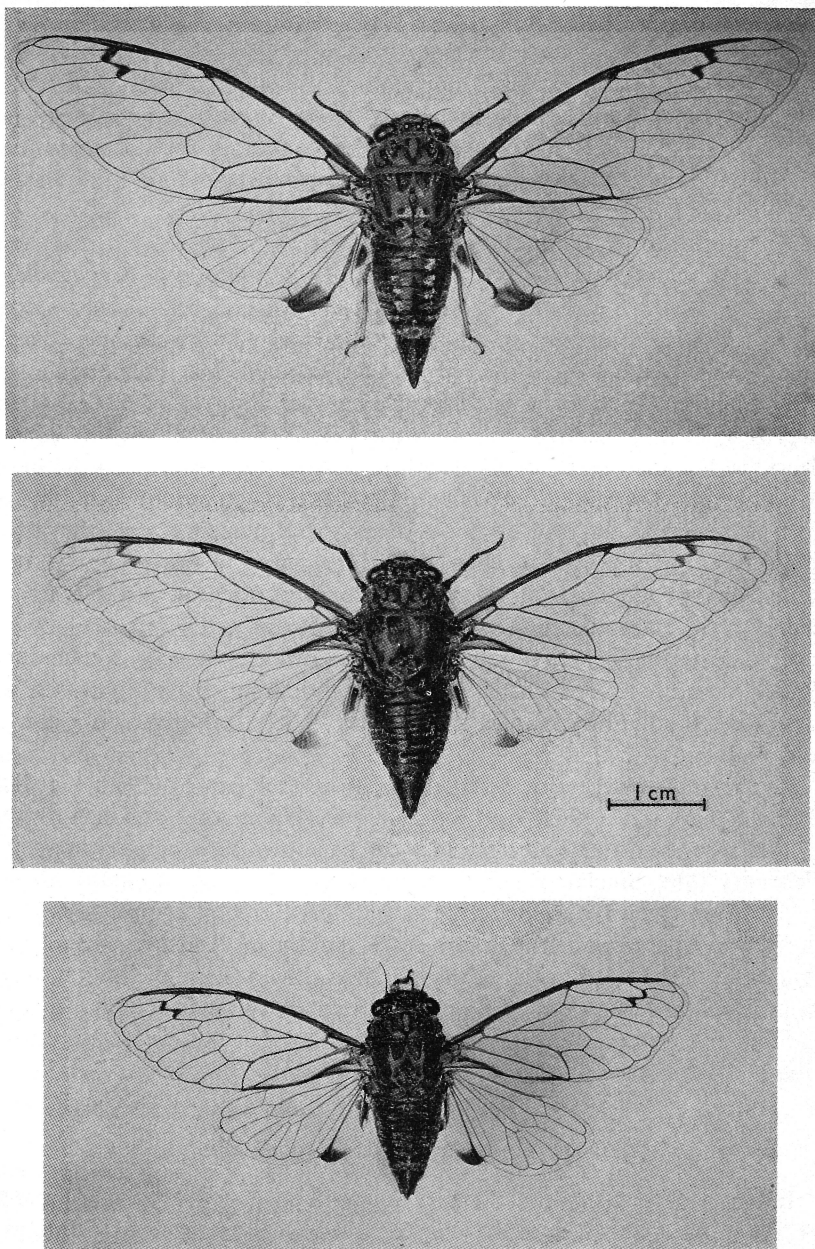


FIG. 16—Dorsal views on same scale as Fig. 15 of female *Amphipsalta*:  
*A. zelandica*, upper; *A. cingulata*, middle; *A. strepitans*, lower.  
(Photographs by Entomology Division, D.S.I.R., Nelson).

single notes, with two clicks spaced between the three notes of a triplet (Fig. 14f).

In its smaller size, external morphology, duller coloration, hairiness, and preference for scrub (*Discaria*, *Cassinia*) rather than forest, *A. strepitans* resembles *A. cingulata* more closely than it does *A. zelandica*. The latter two are more related in song structure, but in genitalia *A. zelandica* and *A. strepitans* are closer than *A. cingulata*.

The genitalia of *A. strepitans* (male: Fig. 4c; female: Fig. 5d) are illustrated for comparison with those of *A. cingulata* and *A. zelandica*. It is clear that *A. strepitans* and *A. zelandica* are closely related—they share a long ventral support and correspondingly short paramere base, angulated thecal base and strongly bi-convex phallobase in the male. In the female genitalia, the only difference between the two species is in the degree of development of the anterior prolongation of the genital carrefours (to less than half vaginal length in *A. strepitans*, almost to the base of the genital scale in *A. zelandica*). Despite this, on external characters such as general wing and body shape, pronotal margin shape, the three *Amphipsalta* species form a cline, from long wings to short stout wings, from slender abdomen to stout, suddenly tapering abdomen, from scarcely excised pronotal margins with anterior angle not extending laterally to level of posterior angle to deeply excised margin with both angles extending equally laterally—and for that matter also in habitat, from high forest to scrub-grassland. Photographs of the three species are given in Figs 15 and 16.

*A. strepitans* emerges in early spring, from October 24 (1962, Kowhai Stream, Kaikoura; 1968, Red Rocks coast, Wellington) and has disappeared by the end of February in most localities (latest observation, 21 February 1969, Sinclair Head, G. Stevenson).

The three species of *Amphipsalta* have different but overlapping seasons, the first to emerge being the first to cease, and the last to emerge persisting longest, and the third bridging the extremes. In southern Wellington (e.g. near mouth of Orongorongo River), all three are sympatric, with different habitat preferences, and are synchronous during a few weeks on either side of 1 February.

#### NOTE ON WING-CLAPPING IN AMPHIPSALTA

In addition to the tymbal method of sound production typical of males of the Cicadidae (Leston & Pringle, 1964), an accessory stridulating apparatus of the strigil and plectrum type occurs in both sexes of the Neotropical Subfamily Tettigadinae (Kato, 1956, p. 64; 1961, p. 2) while in the Western North American Platypediinae sound is produced by wing-

banging (Moore, 1968). *Amphipsalta* is unique in combining tymbal song with wing-clapping similar to the wing-banging of Platypediinae.

New Zealand naturalists (and, in fact, observant laymen) have long recognised the secondary method of sound production in the closely related cicadas here grouped in *Amphipsalta*. It was described by Myers & Myers (1924, pp. 425–6) as “a rhythmical clacking accompaniment to the song . . . caused by sudden outward jerkings of the wing, plainly visible . . . from some distance. . . . There appears on some occasions at least to be a synchronisation of the wing-clicking of all the individuals in a singing group”. The song of *A. strepitans* “is accompanied by rhythmical wing-clickings” at a quicker rate than in *A. cingulata* (in which Myers included *A. zelandica*). The female of *A. strepitans* had “been observed making the noise produced by clicking the wings”. Myers later (1929b, p. 79) recorded in both species “a loud wing-clicking produced in both sexes and additional to the male’s song. It results from a rapid lateral movement of the wings from the roof-like resting-position to one at an acute angle with the body; but the movement is so quick that one cannot be sure whether the noise is produced by friction between tegmina and hind-wings on each side or between one or both pairs and the body”.

In *Amphipsalta*, wing-clapping accompanies full song, but is sometimes absent, for instance in relatively cool temperatures, or when an individual first begins to sing. Wing-clapping by females apparently functions to speed the coming together of the sexes by providing a two-way communication by sound. Thus, to cite but a single observation of many (Tongue Point, Wellington, 21 January, 1968), C.A.F. was photographing a male *A. strepitans* singing and clicking on a fence post, when a female flew from at least 20 ft away, settled about 4 ft from the male and began vigorous rhythmic wing-clicking. Within 30 seconds the male flew from the post and settled 4 inches from the female.

To the human ear, the wing-clapping is a very different sound from the vibrant tymbal song that it accompanies, and resembles the percussive note made by clicking the second finger against the ball of the thumb. The clicks occur regularly (though not inevitably) at exactly the same point in the tymbal song. Tymbal song is made up of a very rapid succession of pulses; each click, on the other hand, is recorded by the oscillograph as a vertical line representing a single pulse of sound, ranging down to about 2 KHz, its upper range merging into the record of tymbal song which it accompanies. As each click is accompanied by a simultaneous flicking of both wings of the insect, sound production on each side of the insect’s body must be precisely synchronised to produce such a linear trace on the oscillograph.

In *Amphipsalta* the costae and the anal margins of the forewing are

relatively more robust than in related species, and in males the costa is strongly bent ("swept back") at the distal end of the radial area. As a result, the basal angle of the forewing is less acute than in most cicadas and when the wing is folded in the resting position of a singing insect, the costa droops further below the edge of the operculum (Fig. 17). The

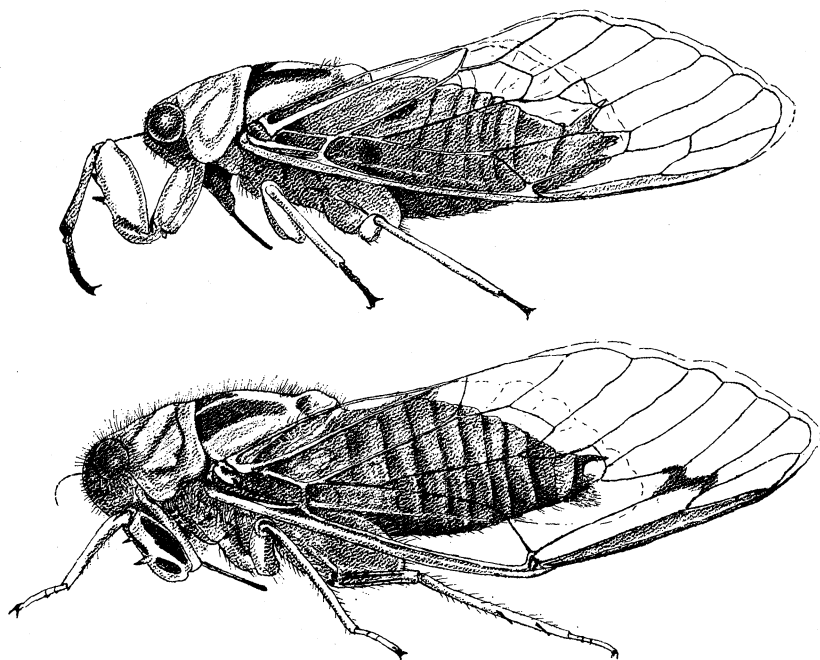


FIG. 17—Lateral view of males of *Cicadetta subalpina* (Hudson), upper, and *Amphipsalta strepitans* (Kirk.), lower, to show lower position of the forewing costa in *Amphipsalta* due to greater basal angle of forewing.

female's costa is not "swept back" in the same way, but is bowed and both it and the anal margin are as robust as in males. In North American *Platypedia*, too, the forewing costa is bowed so that it droops below the abdomen (Kato, 1956, fig. 68). It is difficult to avoid the conclusion that these peculiarities in morphology are in some way connected with production of the "clicks" that characterise *Amphipsalta* song, but their precise mechanism is uncertain, so that we refer to wing-clapping rather than wing-banging (Moore, 1968).

Dr T. E. Moore (pers. comm.), after observing *A. cingulata* and *A. zelandica*, suggested that the clicks are caused by impact of the costa on

the substratum, as in Platypediinae he had studied. Certainly, the costa often strikes the substratum. This was supported by the observation (by C.A.F.) that the quality of the clicks changed as a singing insect (*cingulata*) moved from a half inch stem (full click) to a leaf (subdued click) and to the cheese-cloth wall of its cage (muffled click). On the other hand, in several clear observations of *A. zelandica* in full song the light could be seen between the plane of the vertical substratum and the pulsating costa (T. L. Grant-Taylor, pers. comm.; C.A.F.). Contact of costa with the edge of the operculum has been considered. Against this, the females produce clicks of virtually the same quality as males, but have only rudimentary opercula. Further work is needed to determine the mechanism of clicking in *Amphipsalta*.

The three species of *Amphipsalta* are the only New Zealand cicadas in which the wing-click is a normal and conspicuous element in the song, but both sexes of other New Zealand species at certain times flick their wings in the same way, producing a flapping sound audible only at close range. Thus at Endeavour Inlet (4.3.1967), a female *Cicadetta*\* *muta* (Fabricius) flicked its drooped wings audibly, apparently against the edge of the horizontal grass blade on which it sat. A male flew in, landed in the grass 2 ft away, and sang at intervals as he approached the female by a devious route from which she was mainly out of sight. As the male came closer he too was seen to be flicking his wings. Copulation followed about 90 seconds after his initial flight. The same behaviour pattern in mating was seen at Mangatepopo (24.2.1969). At Wellington (12.3.1967) a pair of *C. ochrina* (Walker) flicked their wings as they approached for copulation. John and David Lane, of Miramar, found that the feeble sound of wing-flicking by females of *C. muta* (Fabr.) can be imitated by gently flapping a jandal on a bare heel, so that male cicadas held in the hand, mesmerised by the sound, did not fly away. Wing-flapping has also been observed in one of the black alpine cicadas of New Zealand, *C. mangu* (White). Unlike species of *Amphipsalta*, the other New Zealand species seldom make a sufficiently audible wing-click for it to be distinguished from background noise on tape. One exception, however, is a tape recording made by Mr W. V. Ward of *C. cutora exulis* (Hudson), the Raoul Island (Kermadec) race of a North Island member of the *muta-ochrina* group. In this recording distinct clicks are audible, occurring at a consistent point in the repeated cycle of tymbal song.

Wing flapping or clicking, of varying intensity, is thus so widespread in New Zealand cicadas that it is to be expected in related Australian species of *Cicadetta* (= *Melampsalta*).

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\* The genus *Cicadetta* is used for New Zealand species following Metcalf, 1963.



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## REFERENCES

- BEAGLEHOLE, J. C. (Ed.) 1955: "The Journals of Captain James Cook on his voyages of Discovery. The Voyage of the *Endeavour*, 1768-1771". Hakluyt Society, C.U.P.
- 1962: "The *Endeavour* Journal of Joseph Banks, 1768-1771". 2 vols. Public Library of N.S.W. and Angus & Robertson.
- 1967: "The Journals of Captain James Cook on his voyages of Discovery. The Voyage of the *Resolution* and *Discovery*, 1776-1780". Part Two. Hakluyt Society, C.U.P.
- BOISDUVAL, J. A. 1835: "Faune entomologique de l'Océan Pacifique avec l'illustration des insectes nouveaux recueillies pendant le voyage. Voy. de . . . l'*Astrolabe* . . . 1826-1829, sous le commandement de M. J. Dumont D'Urville". 2. pp. i-vii, 1-716; Pl. 10 in Atlas.
- BOULARD, M. 1965: L'appareil génital ectodermique des cigales femelles. *Annls Soc. ent. Fr (N.S.)* 1(4): 797-812.
- DISTANT, W. L. 1906: "The Fauna of British India. Rhynchota Vol. 3". 503 pp. Taylor & Francis, London.
- DUGDALE, J. S.; FLEMING, C. A. 1967: A Gynandromorph Cicada. *N.Z. Entomologist* 3(5): 31-5.
- FABRICIUS, J. C. 1775: "Ryngota. Systema entomologiae . . .": pp. 673-89. Leipzig.
- FLEMING, C. A.; ORDISH, R. 1966: Type Specimens of G. V. Hudson's Taxa of New Zealand Cicadas (Genus *Melampsalta*: Hemiptera Homoptera). *Rec. Dom. Mus., Wellington* 5(2): 195-200.
- HUDSON, G. V. 1891: On the New Zealand Cicadae. *Trans. N.Z. Inst.* 23: 49-55.
- 1892: "An Elementary Manual of New Zealand Entomology . . ." 128 pp., plates. London.
- 1893: Synonymical Notes on New Zealand Cicadidae. *Trans. N.Z. Inst.* 25: 162-3.
- 1950: "Fragments of New Zealand Entomology". 188 pp.; 17 plates. Ferguson & Osborn, Wellington.
- HUTTON, F. W. 1874: List of Insects Recorded as Having Been Found in New Zealand Previous to the Year 1870. *Trans. N.Z. Inst.* 6: 158-71.
- 1898: Synopsis of the Hemiptera of New Zealand which have been Described Previous to 1896. *Trans. N.Z. Inst.* 30: 167-87.
- 1904: "Index Faunae Novae Zelandiae". 312 pp. Dulau & Co., London.
- KATO, M. 1956: The Biology of the Cicadas. *Bull. Cicadidae Mus. Iwasaki Shoten*, Tokyo, Japan. 319 pp., 46 plates.
- 1961: Cicadidae. *Fauna Japonica*. 72 pp., 34 plates. Biogeograph. Soc. Japan, Nat. Sci. Mus., Tokyo.
- KIRBY, W. E. 1896: Notes on the Cicadidae of New Zealand. *Trans. N.Z. Inst.* 28: 454-9.

- KIRKALDY, G. W. 1909: A List of the Hemiptera (excluding *Sternorrhyncha*) of the Maorian Subregion, with notes on a few of the species. *Trans. N.Z. Inst.* 41: 22-29.
- LESTON, D.; PRINGLE, J. W. S. 1964: Acoustical Behaviour of Hemiptera. Chapter 14 in "Acoustic Behaviour of Animals" (R. G. Busnel, Ed.). Elsevier Publ. Co., Amsterdam.
- METCALF, Z. P. 1963: General Catalogue of the Homoptera. Fasc. VIII Cicadoidea, Pt. 2, Tibiciniidae. *N. Carolina State College Paper No. 1564*.
- MOLLOY, B. P. J.; BURROWS, C. J.; COX, J. E.; JOHNSTON, J. E.; WARDLE, P. 1963: Distribution of Subfossil Forest Remains, Eastern South Island, New Zealand *N.Z. Jl Bot.* 1: 68-77.
- MOORE, T. E. 1968: The Evolution of Cicadas and Their Acoustical Behavior. *Thirteenth Internat. Congr. Entom. Abstracts of Papers*: 173 (Moscow).
- MYERS, J. G. 1921: A Revision of the New Zealand Cicadidae (Homoptera), with Descriptions of New Species. *Trans. N.Z. Inst.* 53: 283-50, pl. 45-46.
- 1927: On the Nomenclature of New Zealand Homoptera. *Trans. N.Z. Inst.* 57: 685-90.
- 1929a: The Taxonomy, Phylogeny, and Distribution of New Zealand Cicadas (Homoptera). *Trans. R. Ent. Soc. Lond.* 77: 29-60. Pl. 2-4.
- 1929b: "Insect Singers. A Natural History of the Cicadas". G. Routledge & Sons, Ltd., London. xix + 304 pp., 7 pl., 116 text figs.
- MYERS, I.; MYERS, J. G. 1924: The Sound-organs and Songs of New Zealand Cicadidae. *Rep. 16th Meeting Aust. Assoc. Advanc. Sci. (Wellington)*: 420-32.
- WHITE, F. B. 1879: List of the Hemiptera of New Zealand. *Ent. mon. Mag.* 15: 213-20.
- ZIMSEN, E. 1964: "The Type Material of J. C. Fabricius". Munksaard, Copenhagen.