

Calling Songs of *Neduba macneilli* and *N. sierranus* (Orthoptera: Tettigoniidae: Decticinae)

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Abstract: The calling songs of decticines remain largely undescribed. Songs of *Neduba macneilli* and *N. sierranus* were recorded and analysed. These species have mirror-image tegmina and individual specimens exhibit reversed wing overlap. Wing symmetry and the elaborate pronotum characteristic of this genus are discussed as adaptations which increase the efficiency of sound radiation.

INTRODUCTION

The calling songs of many shield-backed katydids (Decticinae) remain undescribed. Rentz and Birchim (1968), in a comprehensive revision of nearctic decticines, indicate the potential value of such calls in the resolution of the still confused taxonomy of Decticinae. The songs are also of interest in their own right as elements of communicative behaviour. Rentz and Birchim provide sonograms of eight decticine species, including *Neduba macneilli* Rentz and Birchim. The present paper contains a detailed description of calling song in *N. macneilli* and *N. sierranus* Rehn and Hebard, together with comments on the tegminal structure of these insects.

MATERIALS AND METHODS

Male specimens of *N. macneilli* were collected on 24 July 1972, 1 mile west of Tom's Place, California, the type locality of this species. They were located by their stridulation just after dusk (2200 hr) on pinyon pines, 1-2 m above the ground (temperature 15-16°C).

Males of *N. sierranus* were taken during the early part of the night (16-18°C) in Yosemite National Park, California, on 28 July 1972. Singers of this second species were perched near ground level in an open cedar forest dominated by sugar pine (*Pinus lambertiana*) and incense cedar (*Libocedrus decurrens*). The collection site was at an elevation of 4000 ft.

Songs were collected in the field with a Uher 4000 Report-L tape recorder and, subsequently, living males of both species were transported to Toronto.

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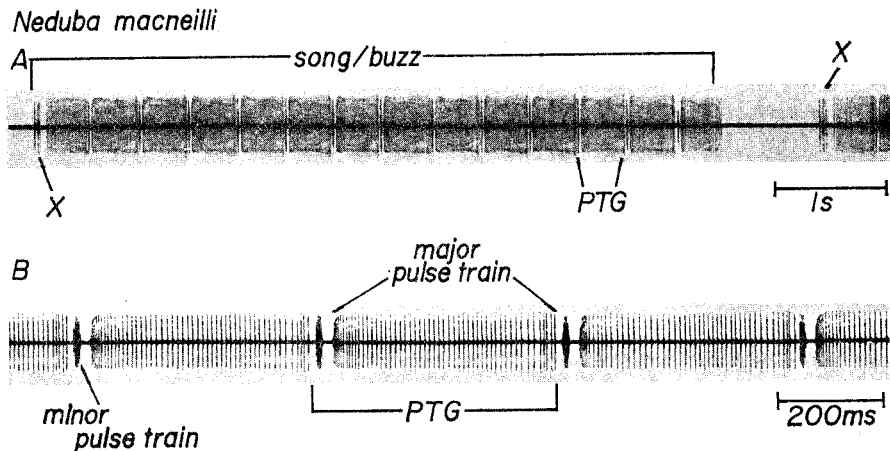


FIG. 1. Oscillographs of *N. macneilli* calling song, laboratory recorded at 22°C with the microphone positioned 4.5 cm dorsal to the insect.

Stridulations were recorded in the laboratory using a Bruel and Kjaer quarter-inch condenser microphone (4135) and power supply (2801): during the laboratory recording, the insects were caged as described by Pipher and Morris (1974). The signal from the microphone was amplified (Keithley 102B) and then recorded at 76.2 cm/sec on an instrumentation recorder (Philips ANA-LOG 7). Oscillograms were obtained with a Tektronix oscilloscope (564) and Nihon Kohden oscillograph camera; carrier frequency spectra were determined with a Tektronix 3L5 spectrum analyser. Specimens of both species were examined periodically for changes in tegminal overlap.

RESULTS

N. macneilli calling song is a buzz (Fig. 1A) made up of identical pulse train groups (PTGs), each group comprised of a minor (short-duration) and major (long-duration) pulse train (Fig. 1B). The major pulse train of a specimen with 72 file teeth contained 52 pulses (based on an average of 10 successive major trains from a single song). At 16°C, the PTGs are easily resolved by the human ear, each PTG lasting about 0.5 sec.

One individual, recorded in the field at this temperature, produced buzzes of 5–12 PTGs at a rate slightly above 1 PTG/sec, with brief pauses of 3–4 sec between the buzzes. In the laboratory, at temperatures near 23°C, buzzes were often of much longer duration. The buzz ends abruptly with the completion of a major pulse train and maintains a uniform level throughout. Slightly in advance of the beginning of the buzz, there occurs a distinctive pulse pattern (X of Fig. 1A) which appears to be a minor pulse train together with an initial few pulses from the subsequent major pulse train.

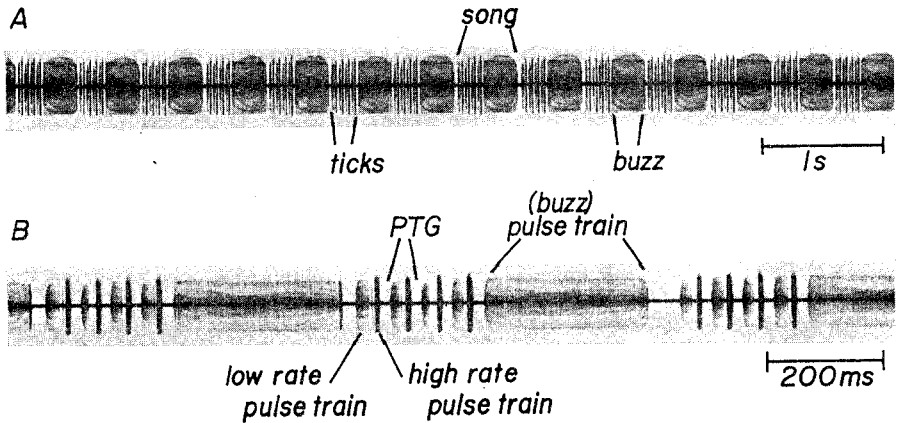
Neduba sierranus

FIG. 2. Oscillographs of *N. sierranus* calling song, laboratory recorded at 23°C with the microphone 4.5 cm dorsal to the insect.

N. sierranus has a bimodal (two-part) song. A specimen recorded in the field at 16°C repeated its song at a rate of about one song per second. The human ear resolves the song as a few brief stuttering ticks, leading without pause into a buzz (Fig. 2A). The buzz is a single pulse train (Fig. 2B). A specimen with 170 file teeth produced 107 pulses in each buzz pulse train (averaged over 10 consecutive songs). The tick mode consists of a PTG repeated (usually) 3 or 4 times as the song is initiated. Each group is comprised of a low-rate pulse train preceding a sharp-fronted, more intense, high-rate pulse train (Fig. 2B).

The most intense carrier frequencies of both species lie near 20 kHz (Fig. 3A, B). *N. macneilli* has a main intensity peak between 15 and 22 kHz with a lesser peak centred on 35 kHz. The dominant peak of *N. sierranus* occurs within the range of 16–23 kHz and is particularly pronounced at 19 kHz. These frequencies exceed the response capability of most tape recorders and microphones; thus sonograms, such as that given by Rentz and Birchim (1968) for *N. macneilli*, may present only a small fraction of the sound energy actually produced by the animal.

In both species the tegmina are mirror images of each other. Swollen lateral and mesal veins diverge from the wing base (A and B of Fig. 4) and subtend a plateau of transparent cells, comprised of relatively stiff, thin cuticle. A membranous (flexible) skirt (C) hangs ventrally from the lateral vein. The medial margin of each tegmen functions as a scraper (D). The file (E) lies toward the midline between the massive veins and is only weakly attached to them. This stridulatory apparatus encloses a chamber of air on the dorsum

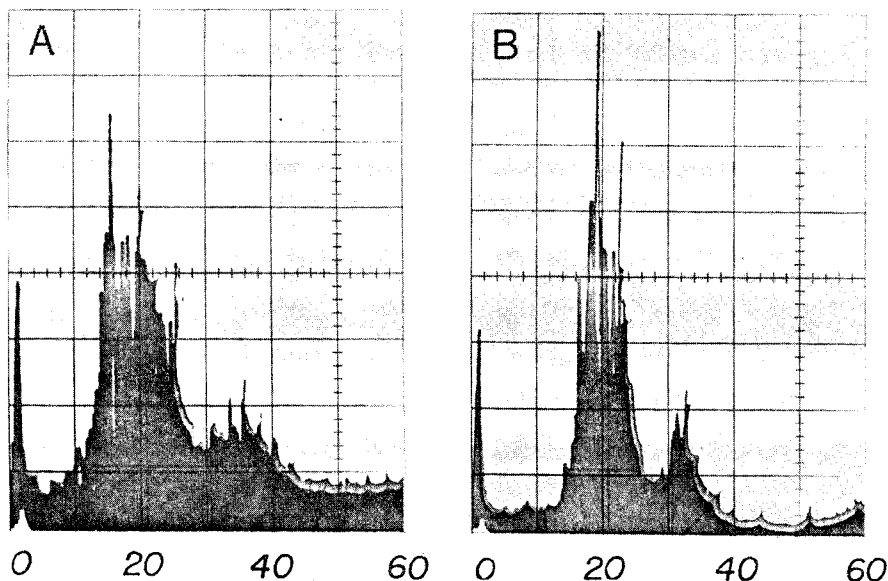
*Neduba macneilli**Neduba sierranus*

FIG. 3. Spectrograms of carrier frequencies in the calling songs of *N. macneilli* (A) and *N. sierranus* (B); each record is a series of traces superimposed on the screen of a storage oscilloscope during a 10 second sample of the insect's song at a sweep rate of 20 ms/division; horizontal scale in kHz; a 0 kHz marker appears at the extreme left.

of the insect. The floor of this chamber is the terga of the meso- and metathorax and the first few abdominal segments. Each tegmen contributes the region bounded by the two large veins as half of the chamber roof. The skirt reaches and trails out upon the insect's back, delimiting the sides of the chamber and closing it off posteriorly. Tegminal structure is essentially the same in both species; they differ only in the far greater number of teeth occurring on the file of *N. sierranus*.

Tegminal overlap was found to be variable in these insects. Of five specimens of *N. sierranus*, three exhibited the left over right tegminal orientation typical of most katydids, but two males had reversed overlap—right over left. Of four specimens of *N. macneilli*, two exhibited 'normal' overlap and two the reverse. Over a one week period, none of these animals were observed to alter their original overlap. Manual manipulation of the tegmina of freshly killed specimens resulted in sound production of an identical nature with either orientation.

DISCUSSION

Left on right overlap of dimorphic tegmina has been considered universal in Tettigoniidae (Ragge 1955). *N. macneilli* and *N. sierranus* are exceptions to

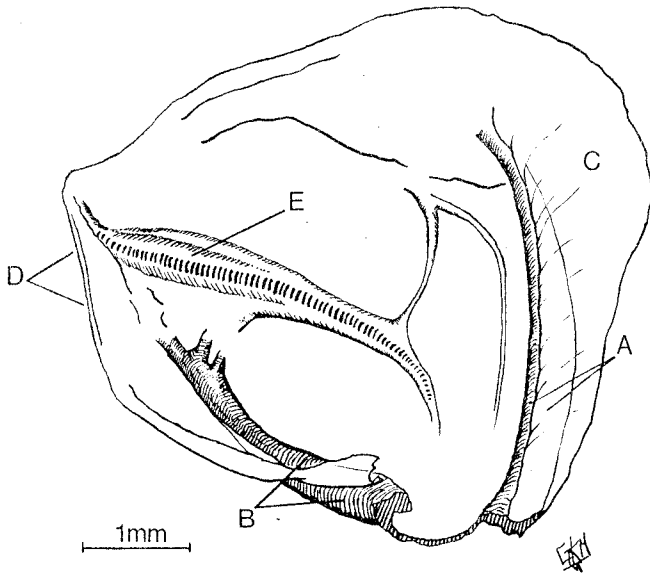


FIG. 4. Ventral view of excised right tegmen of *N. macneilli*; lateral vein (A), mesal vein (B), skirt (C), scraper (D), file (E).

this rule, but they are not alone in varying overlap of identical forewings. They share this distinction with *Cyphoderris monstrosa* Uhler and *C. buckelli* Hebard, survivors of a largely extinct family of primitive katydids (Prophalangopsidae) (Spooner 1973).

Neduba species have a remarkably enlarged pronotum which projects rearward above the tegmina. When singing the animal adopts a characteristic posture with the abdomen dorsally concave and lowered and the pronotum elevated, forming an acoustic horn. The plateaux of the tegmina may be considered collectively as the driver or diaphragm. Wing symmetry may then be seen as an adaptation promoting synchronous displacement of the tegmina, allowing them to function as a single diaphragm. The air chamber enclosed by the tegmina is very small relative to the wavelength involved (λ 20 kHz \approx 172 mm; chamber dimensions approximately $1 \times 4 \times 5$ mm) which means that the chamber will act as a pure acoustic compliance (Beranek 1954), and not as a resonating tube, although its presence will affect the resonance frequency of the diaphragm.

The horn is too irregular to be considered an exponential horn so calculation of its throat inductance is not possible. However, as in the case of the mole cricket (Bennet-Clark 1970) a properly chosen compliance behind the driver will improve its efficiency. Since the diaphragm is small relative to the wavelength ($kr \approx .01$) even without the horn the presence of a closed box behind

(beneath) the diaphragm will greatly increase the efficiency of sound radiation by preventing acoustic short-circuiting between the front and back of the diaphragm (Michelsen and Nocke 1974).

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