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ENTOMOLOGY

Vibro-Acoustical Signals of the Locust *Trilophidia annulata* (Thunb.) (Orthoptera, Acrididae, Oedipodinae)

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Abstract—Vibrational and acoustical signals of *Trilophidia annulata* (Thunb.) are described for the first time. Oscillogramms are presented.

Keywords: Orthoptera, Acrididae, Oedipodinae, *Trilophidia*, acoustical signals, tremulation, stridulation.
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INTRODUCTION

The genus *Trilophidia* Stål, 1873, belongs to the tribe Trilophidiini Shumakov, 1963, out of the subfamily Oedipodinae (Acrididae). Currently, it comprises ten species. *T. annulata* (Thunberg, 1815) is the only species that occurs on the territory of Primorskii krai, Russia (Fig. 1). It is widespread in Japan, Southeastern Asia, Korea, China, Sri Lanka, India, and Pakistan. No previous study has investigated the acoustical communication and signals of *Trilophidia* spp.

It is known that locusts of the subfamily Oedipodinae are capable of generating audible and loud ale-tegminal, tegmino-femoral, and tibio-tegminal acoustical signals on land, wing sounds during flying, low-frequency buzzing (1–3 kHz) by kicking one of their hind legs next to the elytron (without direct contact), and drumming on the surface of the substrate [1–22]. Besides, these insects often perform demonstrative movements using their hind legs, wings, and elytra.

Vibrational and acoustical signals of *T. annulata* form Laos are described below. A complex vibro-acoustical communication of this species has been studied for the first time.

MATERIALS AND METHODS

Vibrational and acoustical signals were studied in two males and a female of *T. annulata* form Laos: Vang-Vieng, II 2010 (V. Gromenko).

Sounds and vibrations were digitized simultaneously on two different channels of a Sony MZ-RH910 Hi-MD Walkman Minidisc Recorder (20–20000 Hz). The sound was recorded with a Creative MC-1000 electret condenser microphone (100–16000 Hz). Vibrational signals were registered with the help of a GZP-308 piezoceramic adapter (50–12500 Hz) attached to a cardboard plate (75 × 90 mm) with the insects sitting on it. During the process of recording, the temperature was +27–29°C. All signals were processed using a computer.

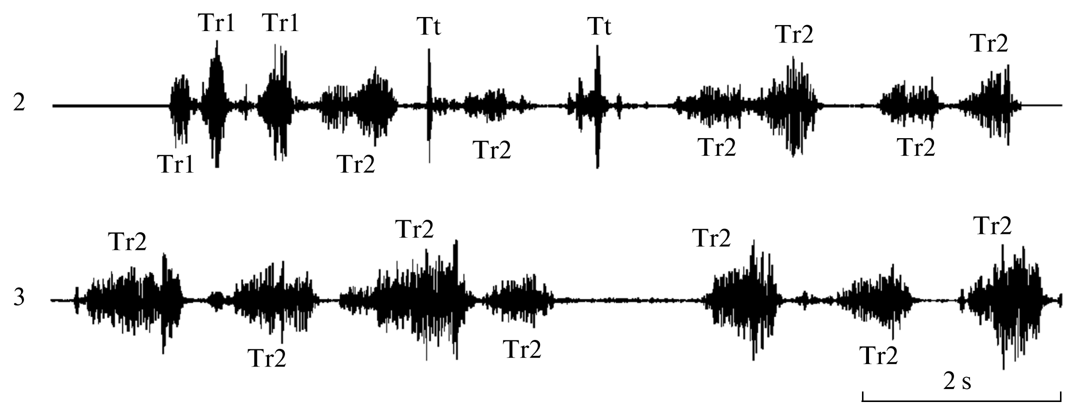
Oscillogramms were described by the standard terms according to R.D. Zhantiev [23].

RESULTS AND DISCUSSION

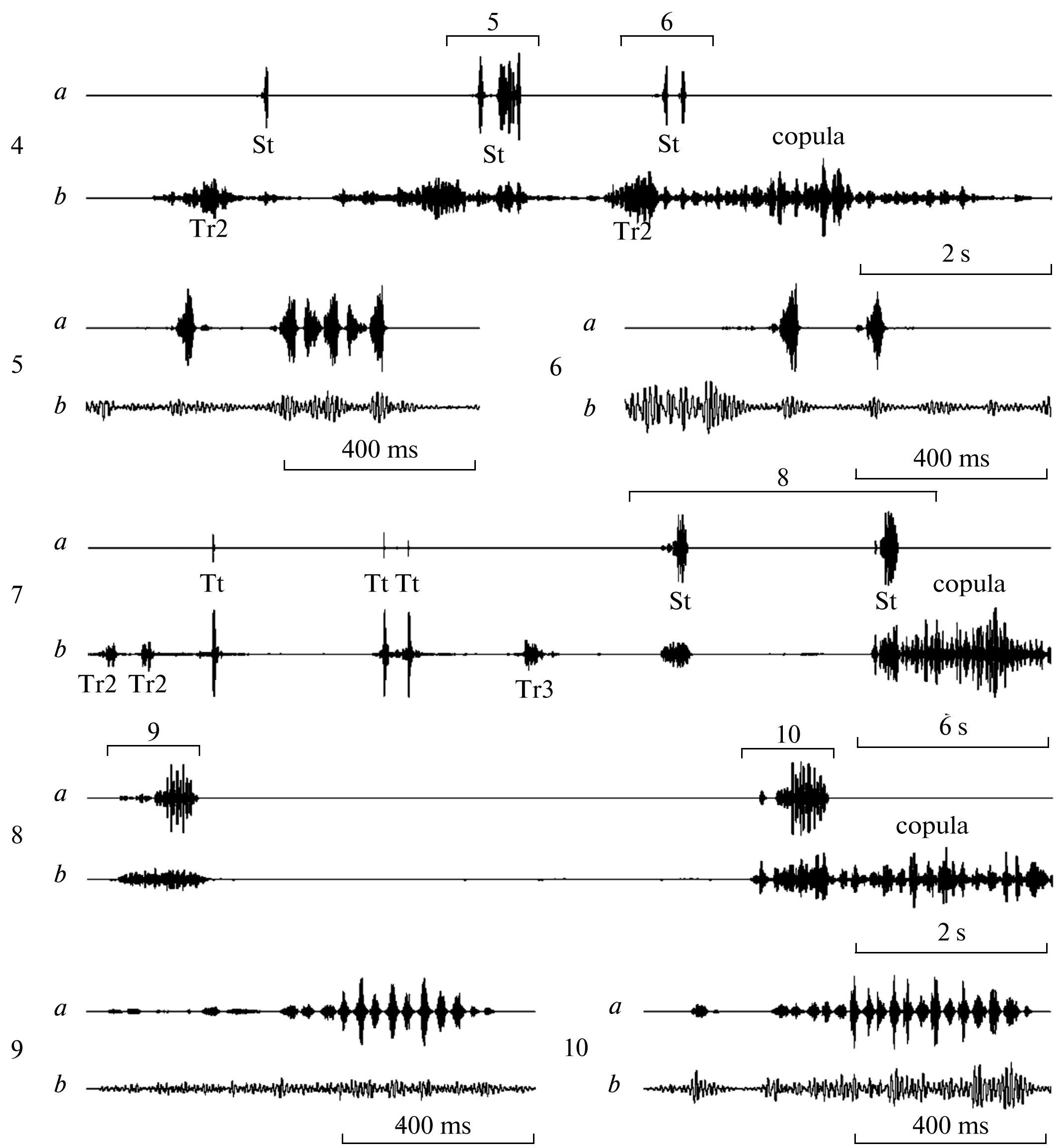
Trilophidia annulata (Thunb.)

Tremulation of Hind Legs. Tremulation of hind legs with raising them next to the head was observed in the male groups communicating with each other, as well as next to a female in sight, possibly to identify its sex. At this moment, their hind tibiae could remain pressed to the thighs. Thus, such movements were rapid tremulous flappings, as those during stridulation but without touching the elytra. The vibrational signal was short (250–420 ms) with the frequency ranging from 50 to 200 Hz (Fig. 2, Tr1). A similar vibrational signal was produced by the female (Fig. 7, Tr3), which meant

Fig. 1. External appearance of *T. annulata* male from Laos: there is a clear intercalary vien on the elytron bearing tubercles. When an insect rubbing its hind thigh over it, a sound is produced. Photo: A. Benediktov.



Figs. 2, 3. Oscillogramms of vibrational signals from a calling between two *T. annulata* males (signals of different males are given at different sides of oscillogramms): (2) alternation using short tremulation series without moving tibia from thigh (Tr1), with tibio-tegminal clicks (Tt), as well as prolonged tremulation series with moving tibia from thigh (Tr2); (3) alternation with only two long tremulation series (Tr2).



Figs. 4–10. Oscillogramms of acoustical (*a*) and vibrational (*b*) signals produced by *T. annulata* at different sweep speed. Designations: Tr2—tremulation of a male; Tr3—tremulation of a female; Tt—tibio-tegminal clicks of a male; St—tegmino-femoral stridulation of a male, copula—vibrations from movements of a male at the beginning of copulation with a female.

that she is ready for mating, because it was followed by copulating.

In other cases, tremulation of both hind legs occurred when the thighs were raised simultaneously, often (but not always) with extension of the tibiae. During this movement, there was a long vibrational series (600–1500 ms) with the same frequency. Two males could take turns (alternation) generating from 1–2 to 10–12 and more such series (Fig. 3, Tr2). The sound recorded with a microphone at a distance of 3 cm from an insect was not clear in all these cases.

From time to time, the males and females kicked silently and gently one or both legs at varying amplitude without tremulation. Vibrations from such demonstrative movements were not registered.

Tibio-tegminal cicks (= ticking). Males and Females are capable of generating high-frequency sounds (ticking) by hitting the tibia apex of a hind leg against the apex of elytra, often touching the apex of the abdomen. This process was commonly accompanied by a clear vibrational replica. Emission of such sounds occurred in various situations: in same-sex groups, before copulation, sometimes between single specimens (Fig. 2, 7—Tt). A similar way of sound production has been described in the large marsh grasshopper (*Stethophyma grossum* (L.)) from the same subfamily, in both males and females.

Femoral stridulation. Acoustical stridulation signals of *T. annulata* males were produced with their tegmino-femoral frictional apparatus. This apparatus, common in the majority of locusts out of the subfamily Oedipodinae, consists of the intercalary vien with numerous tubercles, which is located in the central elytral field, and a smooth keel from the inner side of the hind thigh rubbing against these tubercles. Tegmino-femoral signals were generated only with one hind leg. The sounds came from a male sitting next to a female before copulation (Fig. 4–10, St). Nevertheless, copulation could begin without acoustical signals. Similar acoustical signals were generated by single specimens, as well as males in close contact. Stridulation was faint; the signals were either discrete pulses (Fig. 4–6), from 1 to 6, 35–45 ms long, or series (Fig. 7–10) up to 1 s long consisting of 15–20 pulses repeated every 20–40 ms. In all cases, the frequency ranged from 5 to 6 kHz. Vibrational replica from stridulation were easily registered.

Summing up, let us note that stridulation in *T. annulata* was less frequently observed than tremulation. In addition, it was uncommon for legs to be raised without vibrational signals. Therefore, our observations show that vibrational communication is typical for the studied species.

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