TWO TYPES OF SOUND PRODUCTION IN *EUPSOPHULUS CASTANEUS* (COLEOPTERA: TENEBRIONIDAE)

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Abstract

Two types of sound are produced by *Eupsophulus castaneus* (Horn): Impact-generated and stridulatory. The impact-generated sounds are produced only by males. These sounds have a characteristic number of taps per burst, burst length, and tap rate. The stridulatory sounds are produced when a plectrum on the inner face of the hind femur is rubbed against a file on a lateral plate that is positioned between the first abdominal sternite and tergite.

Males and females of *E. castaneus* aggregate around UV lights. Males vigorously tap in such aggregations. Since the sex ratio of males to females at such aggregations is approximately 3:1, we speculate that such aggregations may be leks, with the tapping having a spacing or mating-inducement function. The stridulatory sounds are produced only when beetles are immersed in liquid. These sounds may function in startling predators as the predators take a beetle into their mouth.

Introduction

A number of insects are able to stridulate, i.e., mechanically produce sound by rubbing a scraper against a file (Dumortier 1963a, 1963b). Comparatively fewer insects are known to produce impact sounds by tapping on the substrate with their body. Such sounds have been reported for some ants (Markl and Fuchs 1972), hornets (Ishay and Schwartz 1965), termites (Howse 1964), and stoneflies (Rupprecht 1968, 1969). Among the Coleoptera, such sounds have been reported for certain species of woodboring beetles (Cymorek 1969) and several species of *Eusattus* tenebrionids (Tschinkel and Doyen 1976). We report on the sound production of another tenebrionid beetle, *Eupsophulus castaneus* (Horn). We have found that these beetles produce two types of sound: Impact generated, and stridulatory. We present here the characteristics of the two types of sound, and we discuss the possible functions of these sounds.

Methods and Materials

Black lights (15 watt BL fluorescent) were placed against a 2 meter high concrete block wall. Regular collections and observations were made at these sites.

Recordings of beetles tapping were made in the field using a magnetic musical instrument contact microphone and a Uher 4000 L tape recorder. Recordings of stridulation were made using the above recorder, a Bruel and Kjaer 12.7 mm condenser microphone type 3134, and a General Radio 1560-p42 preamplifier inside a sound proof room. Analysis of the stridulation sounds was made using a Kay Electric 7029A spectrum analyzer. The repetition frequency of the taps was determined

both by ear and with a General Radio 1151AP digital time and frequency meter. Since the frequency spectrum of the taps was determined by the substrate, no special analysis of the tapping was made.

The rhythmic activity data were recorded on equipment previously described (Spangler 1972). Individual beetles were placed in 8.7 cm plastic petri dishes, supplied with water in small plastic vials having cotton wicks and placed on a vibration-sensitive platform. Actograms of the beetles' taps and movements were recorded on a logarithmic chart recorder.

A small relay was modified and driven with a pulse generator and audio amplifier to produce a continuous tapping at about the same repetition frequence and intensity as that of the *Eupsophulus* beetles. The relay could be moved about and attached so that it could tap against a variety of surfaces.

Results and Discussion

Eupsophulus castaneus adults are commonly seen at lights around Tucson, Arizona, beginning in the latter half of April. The season appears to extend into the first half of June with a high population level being maintained throughout May. During this period the beetles' nocturnal tapping sounds are noticeable all around dwellings, particularly on window trim and screens.

These beetles produce rhythmic impact sounds by striking the center of the abdomen against a substrate. Only males produce the impact sounds. A sample of 107 *Eupsophulus* was collected while they were tapping. All of these were males. The same situation is apparently found in 3 species of *Eusattus,* closely related tenebrionids which produce sounds in a similar manner (Tschinkel and Doyen 1976). The sounds occur in bursts. As in *Eusattus,* there is a characteristic number of taps per burst, burst length, and tap rate (Table 1). Compared to *Eusattus, Eupsophulus* has fewer taps per burst, a long burst length, and a much lower tap rate.

Table 1. Characteristics of impact-generated sounds produced by *Eupsophulus castaneus.* Sounds recorded at 25°C.

	N	Mean + S. D.
Taps/burst	38	26.79 + 8.85
Burst length (sec)	38	5.15 + 1.83
Tap rate (taps/sec)	38	5.35 + 1.05

Males could readily be stimulated to tap by tapping the substrate they were on rhythmically, at about 5 taps per second, with a pair of forceps or similar object. Males receiving these signals would often become agitated and move rapidly about while frequently pausing to tap. Although we doubt that these beetles have the ability to detect airborne sound, they appear to be quite sensitive to substrate vibration. Beetles standing on large, drum-like surfaces such as a wood panel or a cardboard box could be induced to tap in response to artificial tapping against the side of an automobile up to 6 meters away.

The females generally showed little response to tapping although at times they extruded their genitalia.

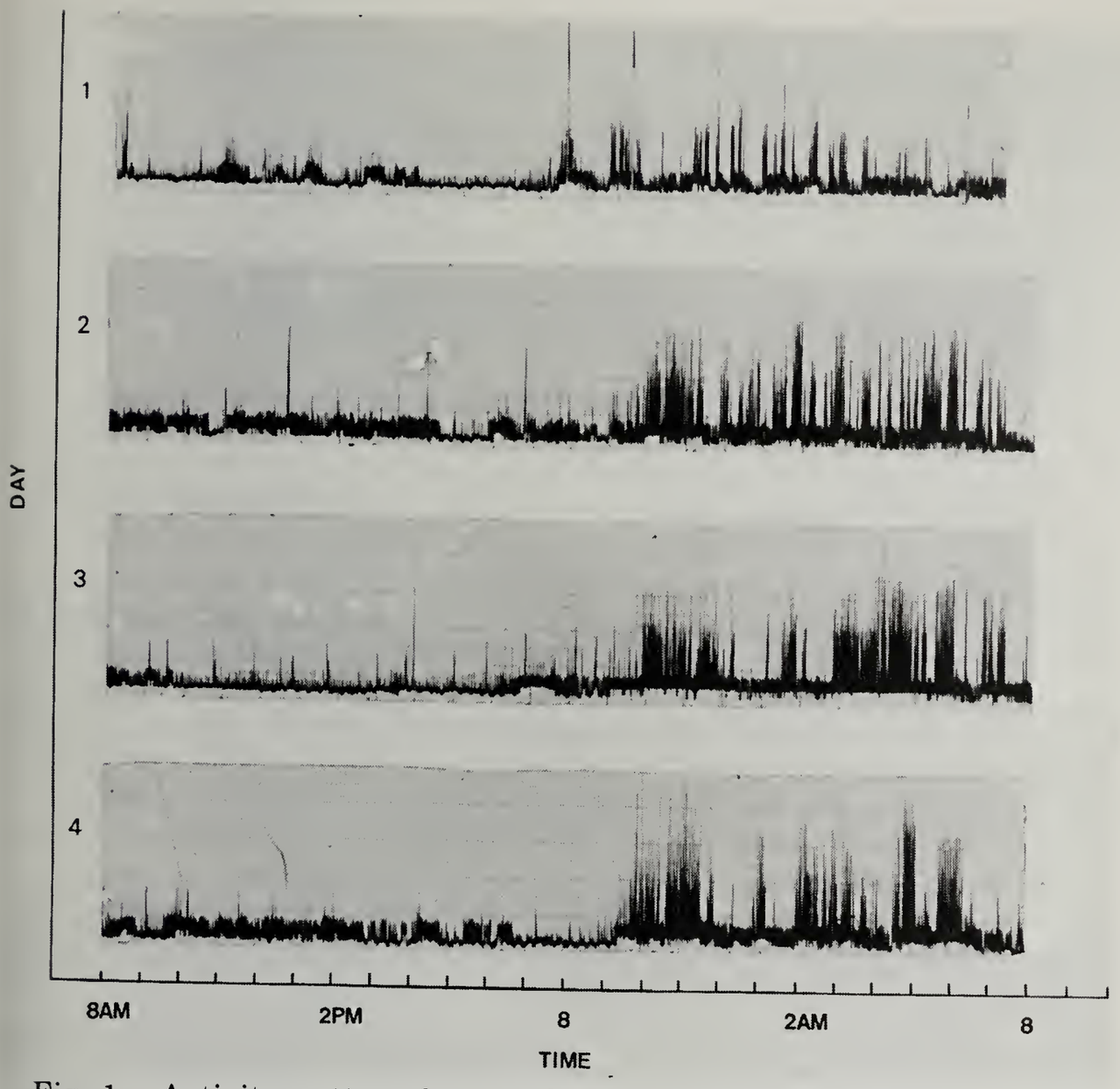

Fig. 1. Activity pattern for a male *Eupsophulus castaneus* over a four day time period. Height of vertical lines indicates intensity of activity.

The mechanical relay tapper was attached to a 25 × 40 cm piece of 6 mm plywood and run for 5 nights. Although numerous males in the vicinity appeared to respond by tapping, some from as far away as 5 meters, periodic observations revealed no significant congregation of either male or female beetles on or near the tapped plywood. The mechanical tapper was attached to the block wall, a cardboard box, and the top of an automobile with similar negative results.

The tapping sounds do appear, however, to be related to some form of mating behavior. *Eupsophulus castaneus* has a relatively short adult stage, lasting 3-5 weeks from the end of April to the beginning of June. During this time, adults generally have brief spurts of activity during the nocturnal hours, beginning around 8:30 PM (MST) and ending around 7:30 AM (MST) (Fig. 1). Often the adults are found around lights. We found that in the vicinity of UV lamps the mean sex ratio of males: females was 3.55 (s = 3.48, N = 16 days). Thus, the males out-number the females by more than 3 to 1. At such assemblages vigorous tapping behavior occurs among the males.

Although male *E. castaneus* adults can be quite easily located when they tap, females are rarely seen away from lights. Therefore the actual sex ratio of the adults in a more natural situation, i.e., away from lights, is not

known. However, among sexual organisms, it is unusual to find sex ratios different from 1:1 (Fischer 1930; Hamilton 1967). If the sex ratios of *Eupsophulus castaneus* are normally 1:1 away from light, then the males may be setting up leks, to which the females are attracted. The tapping sounds may have the function of: 1) ensuring that a certain minimum space is kept between the males; 2) inducing the female to mate, perhaps with a male that has an optimum configuration of tapping bursts. We observed different females extruding their genitalia upon their approach to a tapping male; however, once a pair is in contact, mating appears to proceed without the stimulus of further tapping.

As we mentioned previously, *Eupsophulus castaneus* stridulate in addition to tapping. The stridulatory apparatus consists of a plectrum (fig. 2), located on the inner face of the hind femur, and a file (fig. 3), located on a lateral plate between the tergite and sternite of the first abdominal segment. Sound is produced by rubbing the hind femora over the abdominal stridulatory plates.

A sonagram of the sounds produced by the stridulatory apparatus is shown in Figure 4. The chirps are fairly rhythmic, and appear to have maximum intensity at 4 kHz and 9.3 kHz. The behavioral significance of this type of sound is not entirely clear. The stridulatory sounds generally could not be induced by manipulation of the beetles with forceps. They could only be elicited when we dropped the beetles into dishes filled with alcohol. The mouth chemistry of some predators may elicit stridulation in these

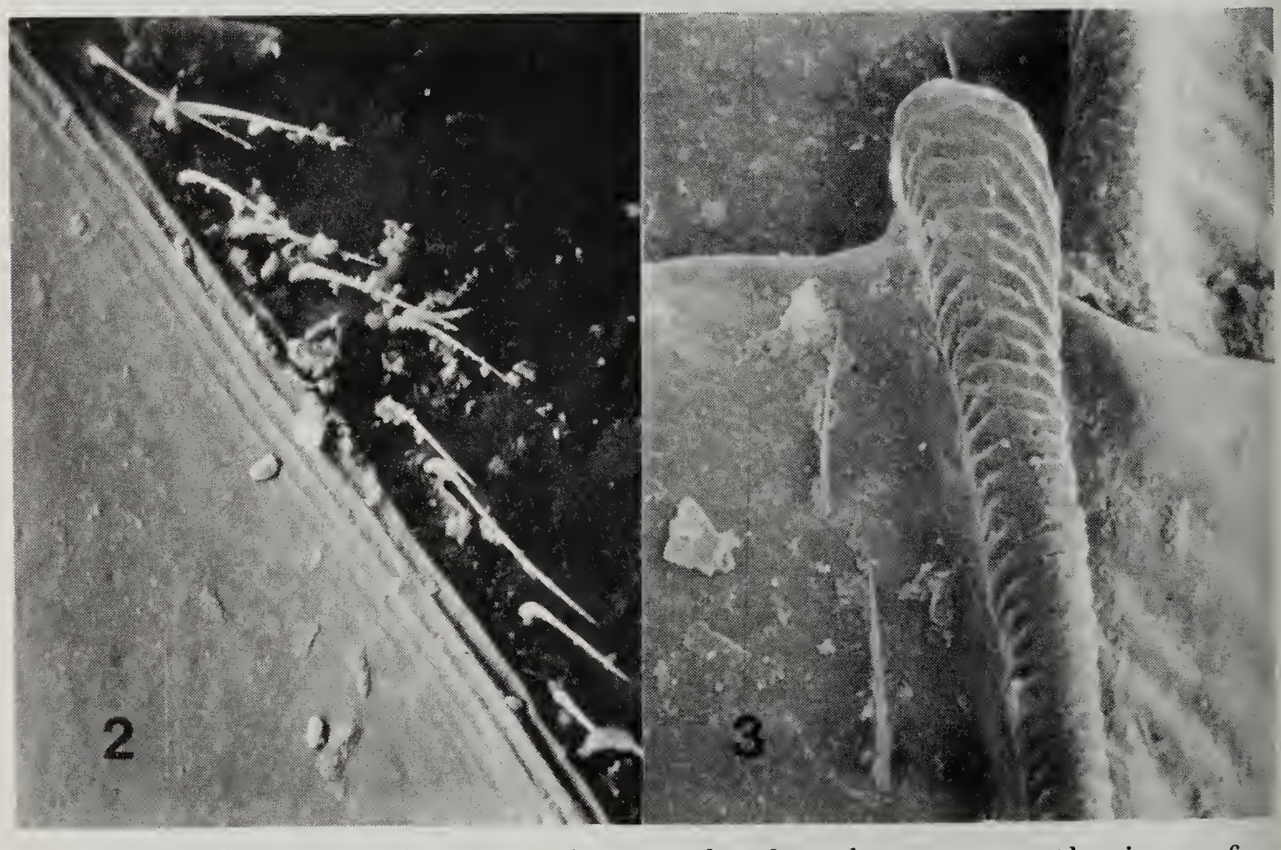

Fig. 2. Scanning electron micrograph of a plectrum on the inner face of the hind femur of *Eupsophulus castaneus*. The plectrum in this species is a series of parallel ridges that are rubbed against an abdominal file. Magnification 235 ×.

Fig. 3. Scanning electron micrograph of the abdominal file of *Eupsophulus castaneus*. The file is located on a plate between the tergite and the sternite of the first abdominal segment. Magnification 235 ×.

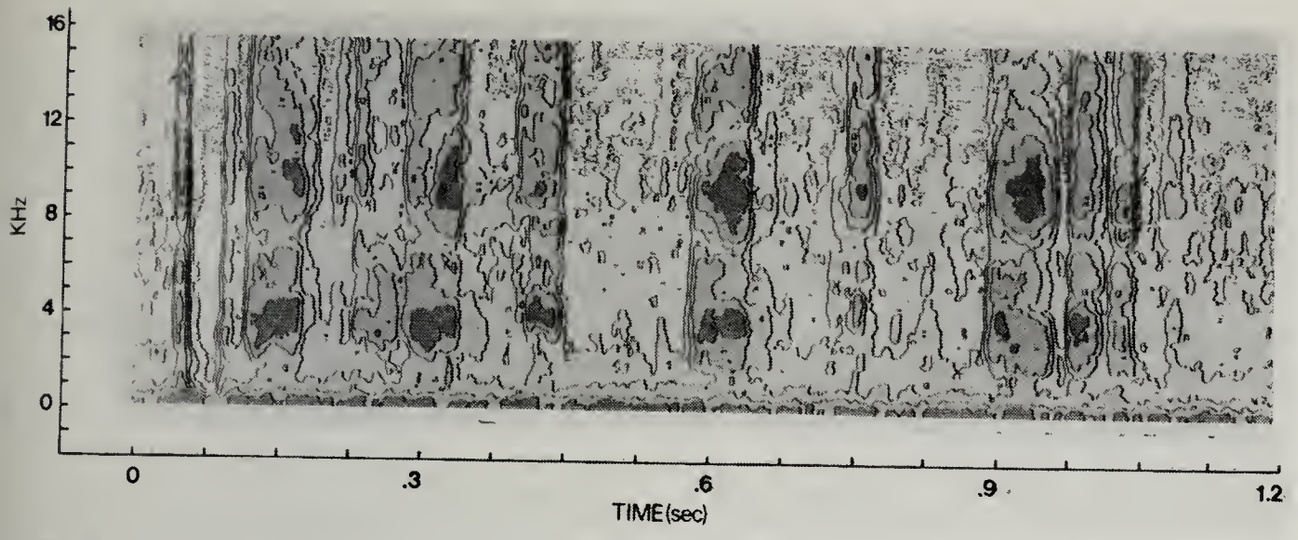

Fig. 4. Sonagram of a stridulating male *Eupsophulus castaneus*.

beetles. Such a stridulatory response might startle a predator into dropping the beetle. Since some stridulatory sounds of beetles are known to be associated with chemical defense systems (Eisner *et al.* 1974), a predator may have learned through trial and error that stridulating beetles are unpalatable.

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