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Acoustic burrow structures of European mole crickets, *Gryllotalpa gryllotalpa* (Orth.: Gryllotalpidae) in Northwestern Iran

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Abstract. The acoustic chambers of the European mole cricket *Gryllotalpa gryllotalpa* (L., 1758) were studied in the north-west of Iran. Observations showed that all the calling burrows in this area had one horn shape entrance and branching tunnels beyond the bulb (the site of the head and thorax of insect in calling position). The patterns of these burrows were alike; however, the sizes of different parts of tunnels were dependent on the dimension of males. This is the first report of a single entrance calling chamber for European mole cricket.

Key words: acoustic chambers, calling song, horn shape, European Mole Cricket.

Introduction

The Gryllotalpidae (Orthoptera) includes seven recent genera with over 100 species in the world (Eades et al. 2014, Walker & Moore 2014). The genus *Gryllotalpa* was once thought to be distributed exclusively in the Old World (Townsend 1983), but the genus is also known from North America (Walker & Figg 1990, Eades et al. 2014). *Gryllotalpa* includes about 50 species and occurs throughout Europe, from Britain to Turkey and Iran, as well as Asia, Australia, Africa and North America (Eades et al. 2014).

The European mole cricket, *G. gryllotalpa* (L., 1758) is one of the most important pests in turf and field crops of Iran and its damage in some areas is economically significant (Kazemi et al. 2011). This pest recently has been studied in Iran (Kazemi et al. 2011, 2012, 2013). In the northwest of Iran, it has seasonal wing dimorphism with eight nymphal instars. The long-winged (LW) morph appears in early-mid spring, when the vegetation density is low, so that they need to fly to rummage for food. Study of the fore-tibia showed that of the LW morph are elongated and longer than the short-winged (SW) morph's tibial dactyls, so that they are suitable for excavating the hard soil in this time. The SW adults with short and broad dactyls emerged from May to July; thus this type of dactyl is more suitable for tunneling in light soils in the middle of spring (Kazemi et al. 2013). Males of the European mole cricket stridulate via rubbing the scraper on the posterior margin of forewing to the CuP (cubitus posterior) vein placed on the under-surface bearing approximately 87 teeth. The males call from burrows for about half an hour (15-46 min) (Kazemi et al. 2012).

Mole crickets are burrowing insects and excavate different types of tunnels during their lifetimes. Endo (2007) divided the tunnels of mole crickets in to horizontal and vertical ones. He believes that vertical tunnels are used for overwintering, hiding from predators, resting and molting, whereas the functions of horizontal burrows are for the mating process and escaping from predators.

The acoustic system of orthopterans has an important role in intra and interspecific communication; especially as it has a major role in reproductive behavior (Alexander 1967, Robinson & Hall 2002). Many males of mole crickets produce calling songs for mating. They construct an acoustic chamber (with an opening to the soil surface) that is used for producing the calling song (Hill 1999). The males of different sizes within the same species show variation in frequency and syllables of their calls (Howard & Hill 2006). Females are attracted to the love song and go to the special chamber of selected males (Morris 1979, Hill 1999, Howard & Hill 2006).

The function of the calling songs and chambers of several species of mole crickets have already been studied extensively. The males of *G. gryllotalpa* and *G. vineae* (Bennet-Clark, 1970) produce calling songs with long trills and build their calling chamber with two openings (Bennet-Clark 1970, Brandenburg et al. 2002). The investigations of mole cricket tunnel structures have been largely for behavioral and ecological studies (Brandenburg et al. 2001). Several factors, including the moisture and hardness of soil, environmental conditions, density of other individuals and especially food resource distribution affect the structure of burrows (Le Comber et al. 2006).

Because the presence of the first acoustic chambers can indicate the beginning of mating time of these insects, thus this research might assist for decisions making control this pest. Observations made over a long period of time and under different ecological conditions, however, reveal that acoustic burrow structures do not completely match every-where and require further investigation. Although mole crickets are well known for the communication function of their burrows (Hansell 2005), this study aimed in clarifies excavating the calling chamber of this species.

Materials and methods

Study regions and sampling methods
The study was conducted in turf grass and field crops of Tabriz (N 38º 6', E 46º 26') in the north-west of Iran, based on observations of the damages caused by mole crickets, whose calling songs are heard during the sunset hours. The calling song of the European mole cricket was recorded with a Canon sound recorder near their singing burrows during the mating season (from April to mid-May for long winged morph and from mid-May to July for short winged morph) in 2012 and 2013. Soil temperature was measured at the depth of the calling chamber. The burrows were marked and examined the following day. The calling songs of males were analyzed using computer software, MATLAB.

Tunnel structures
Old singing chambers in *Scapteriscus* might be destroyed when not used (Ulagarag 1976), but it is not the case in *G. gryllotalpa*. Therefore, they can be studied later on. During the reproductive seasons of mole crickets 10 singing burrows were cast. Paraffin wax was used for study of the calling burrow structure of *G. gryllotalpa*. After warming the paraffin each chamber was filled from its entrance opening. The paraffin wax is a rapid and relatively low cost technique for casting. The hardening process takes about half an hour. Excavation of each cast was carefully done and was watchfully rinsed.

Following Walker & Figg (1990), measurements of different parts of acoustic burrows were done by using a pair of calipers (± 0.01). The measurements were made on 10 burrows.

To be sure about identity of the studied species, in addition to morphological identification, we compared song with sound descriptions in available literature (Bennet-Clark 1970, Zhantiev et al. 2003).

Results and discussion

All acoustic chambers that were observed in the field have just one opening to the surface of the soil with branching tunnels beyond the bulb. Based on the present study, the burrows have one opening that is far larger than seen in other tunnels (usually with two entrances and not associated with an acoustic chamber) and distinguished easily from them (Figs 1,b & 2). Bennet-Clark (1970) reported that the calling chambers of European mole crickets have two horns with mouth spanning an area about 100 mm, however, in this study, these structures were never found.

The funnel shapes of the calling burrows have an important role for amplifying the sound but male body size and soil moisture influence the size of tunnels, so that large males excavate larger acoustic chambers and produce louder calling songs than the smaller males (Forrest & Green 1991). Table 1 summarizes the measurements of different parts of the acoustic burrow structures, provided in Fig. 2. Burrow morphology in the studied area varies from a single horizontal tunnel with just one tunnel branch, to a complex composed of several calling chambers that are connected together with several branches.

The bulbs usually connect to short vertical and

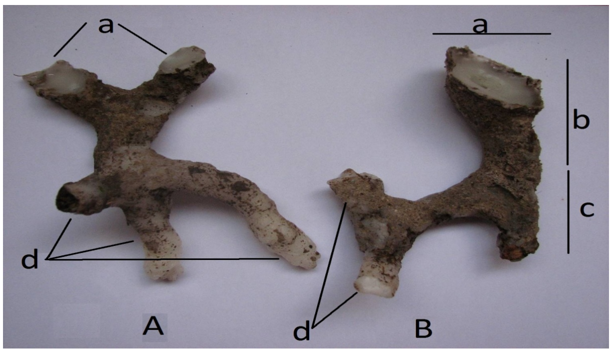

Figure 1. Shape of common tunnel (A) and acoustic burrow (B) of European mole crickets in the north-west Iranian populations. (a, Opening; b, horn; c, bulb; d, branching).

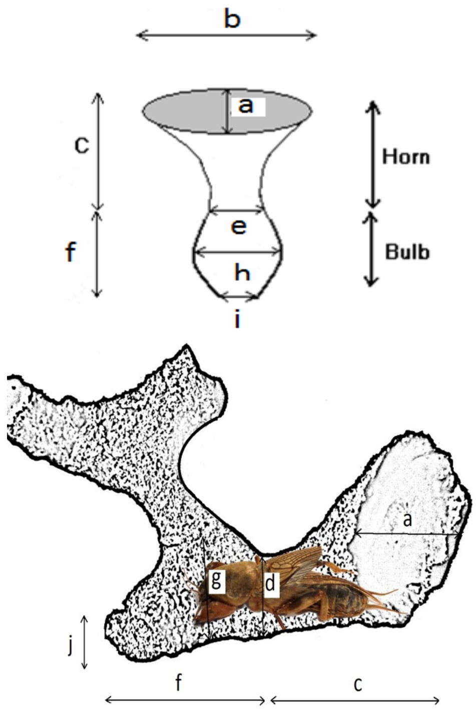

Figure 2. Drawing of European mole cricket acoustic chamber in lateral views in the northwest of Iran with measurements of different parts. (a, Opening width; b, Opening length; c, Length of horn; d, Throat height; e, Throat width; f, Length of bulb; g, Height of bulb; h, Width of bulb; i, Width of exit; j, Height of exit).

Table 1. The mean length (mm) of different parts of acoustic burrow of European mole cricket (n=10).

Parts of acoustic burrow	Mean ± SE	Min	Max
a: Opening width (horn)	32.6 ± 1.86	27	38
b: Opening length (horn)	42.8 ± 1.69	39	49
c: Length of horn	45.2 ± 2.13	38	49
d: Throat height	21.2 ± 0.59	19	24
e: Throat width	20 ± 0.83	18	22
f: Length of bulb	28 ± 2.13	22	34
g: Height of bulb	22.8 ± 2.01	18	28
h: Width of bulb	25 ± 2.03	17	28
i: Width of exit	20 ± 0.04	19	21
j: Height of exit	18 ± 0.07	17	20

at least two horizontal tunnels which link to the egg chamber or other vertical passageways. The other end of the bulb is always closed with soils and it is the site where the head and pronotum of the insect are positioned when calling.

The recorded songs were analyzed (Fig. 3) and compared with sound description in Bennet-Clark (1970) and Zhantiev et al. (2003). The results

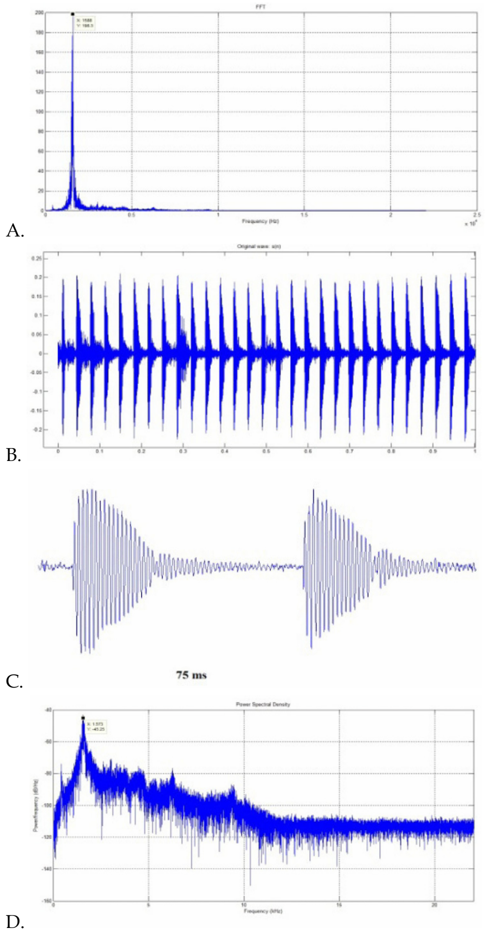

Figure 3. Analysis the calling song of European mole cricket at 22 °C; (A) Fast Fourier Transform with 1.588 kHz frequency (B) waveform in 1 s (C) waveform in 75ms (D) Power spectral density.

showed that waveform and frequency are the same. After Bennet-Clark (1970) fewer studies have focused on the calling chamber of *G. gryllo-talpa* and the present study is the first report that these burrows may only have a single horn.

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