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Source: Journal of Orthoptera Research, 15(1) : 99-103

Published By: Orthopterists' Society

URL: [https://doi.org/10.1665/1082-6467\(2006\)15\[99:ASANSO\]2.0.CO;2](https://doi.org/10.1665/1082-6467(2006)15[99:ASANSO]2.0.CO;2)

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# *Aerotegmina shengena*, a new species of Listroscelidinae (Orthoptera: Tettigoniidae) from the Eastern Arc Mountains of East Africa

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## Abstract

*Aerotegmina shengena* is described from the montane forests of the South Pare Mts of Tanzania. A habitat description is given and co-occurring *Saltatoria* registered. By the morphology of the acoustical chamber, *A. shengena* is more primitive than *A. kilimandjarica*. Speciation processes are discussed for *Aerotegmina* species.

## Key words

Orthoptera, Listroscelidinae, *Aerotegmina*, *Euryastes*, South Pare Mountains, West Usambara Mountains, new species

## Introduction

The genus *Aerotegmina* was erected on *A. kilimandjarica* Hemp, 2001, from Mt. Kilimanjaro, Tanzania (Hemp 2001a). As is *A. kilimandjarica*, *A. shengena* is a canopy dweller in montane forests of the South Pare Mts. Individuals are well camouflaged in daylight, probably hiding under leaves high up in the canopy. After sunset they descend from the canopy to lower levels to attract partners with their songs. The song is very conspicuous to human ears and that of *A. kilimandjarica* (Hemp 2001a) easily audible at several hundred meters.

The genus *Aerotegmina* is characterized by highly modified wings and the shape of the pronotum. The tegmina are strongly inflated to form an acoustical chamber, closed by the flap-like alae completing the chamber ventrally. The pronotum is saddle-shaped. *Aerotegmina* probably evolved from Hexcentrini ancestors (Hemp 2001a).

## Material and Methods

**Collection plots.**—Permanent plots were laid in clearings, swamps and closed montane forest around Mt. Shengena, the highest of the South Pare mountains.

**Measurements.**—Total body length refers to the body length of the insect, disregarding tegmina but not genitalia: in females the ovipositor is included in body length. Tegminal length is determined as viewed from above.

**Song.**—The field recording of the songs were made with a Canon 3CCD Digital Video Camcorder XM1 Pal (16 Bit, 48 kHz). The songs of both *Aerotegmina* species were recorded from captive specimens on the same night under the same temperature conditions (22 °C). When recording the songs the video camera was positioned about 2 to 3 m distant from the singing *Aerotegmina* males. A heterodyning bat

detector (Laar PX 1, 15-130 kHz) aided in searching for tettigoniids. Using this device, it was apparent that *Aerotegmina* has no frequency output in the ultrasonic range; thus the song was fully recorded by the Canon Video Camcorder.

**Depositories.**—MNB: Museum für Naturkunde, Zentralinstitut der Humboldt-Universität zu Berlin. NHML: Natural History Museum London, UK. EDNMK: Entomological Department National Museums of Kenya, Nairobi.

## Results

### *Aerotegmina shengena* n. sp.

Figs 1-7

**Holotype.**—Male: Tanzania, South Pare Mts., Mt. Shengena, 2100 m, UTM zone 37M, 03.80.822E 95.30.035S, canopy of undergrowth tree, March 2001, C. Hemp coll.; depository, NMB.

**Paratypes.**—All Tanzania; 1 male, same collection data as holotype; depository, NHML. 1 male, same collection data as holotype; depository, EDNMK.

**Additional material examined.**— all Tanzania, all C. Hemp coll. 4 males, 1 female, 2 nymphs, same data as holotype.

**Description.**— Color light green.

Head and antennae: Antenna more than twice as long as length of body, whitish with annulate dark markings (Fig. 6). Cuticle of head smooth. Conical and laterally compressed fastigium of vertex situated slightly before antennal sockets (Figs 1, 2). Space between eyes 2.6 × as wide as diameter of eye. Eyes almost circular, prominent, of whitish color (Figs 1, 6).

Thorax: Light green in the preserved insect, rugulose callosities marked darker green in the living insect. Pronotum narrowly emarginate, the margin anteriorly and posteriorly yellow.

Abdomen: Abdomen ventrally milky white.

Tegmina and wings: Acoustical chamber imperfectly closed by blunt alae, leaving a gap posteriorly (Fig. 5). Tympanum (mirror of right tegmen) about 3.5 mm in diameter.

Legs: Fore and middle femora with four pairs of stout spines on the inner and outer side. Apically with a pair of short spurs. Hind femur with six stout outer and three smaller inner spines; distally one spur on each side. Fore and mid tibiae with five pairs of light green predatory spines on each side, apically with a pair of spurs. Base of each spine with small black dot dorsally. Hind tibiae with four rows of minute spines. With well developed tarsal arolium.

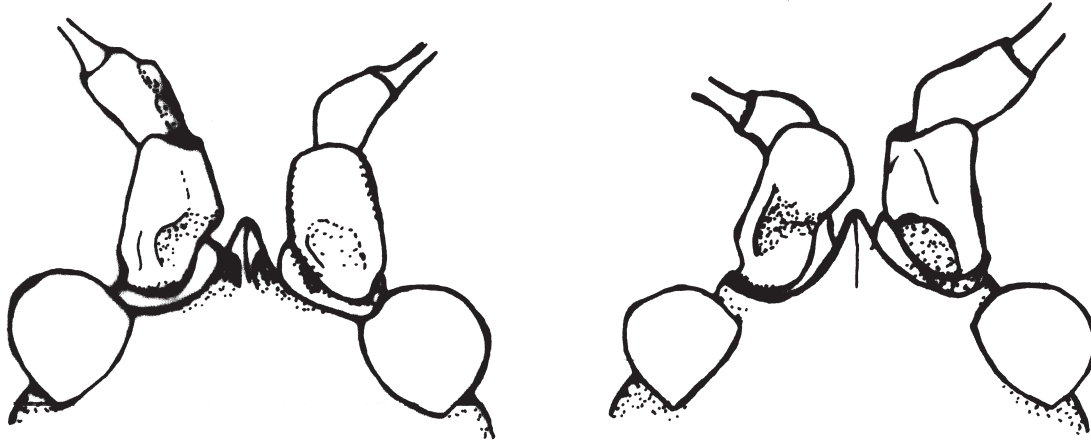


Fig. 1. Dorsal view of male head of *Aerotegmina shengenaе* (left) and *A. kilimandjarica* (right).



Fig. 2. Fastigium verticis of *A. shengenaе* (left) and *A. kilimandjarica* (right).

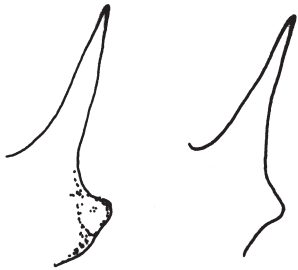


Fig. 3. Procoxal spine of *A. shengenaе* (left) and *A. kilimandjarica* (right).

Genitalia: Subgenital plate symmetrical (Fig. 4), of same milky white color as venter of abdomen, with smooth surface, flattened ventrally, lobes with scattered hairs. Cerci robust with rugose surface, on inner basal side a bulge (Fig. 4); in the living specimen stretched out from the body.

Measurements.— (mm).

	males (n = 7)
Total length of body	13.0 to 15.0 (mean 14.3)
Length of pronotum	3.5 to 4.0 (mean 3.7)
Length of hind femur	10.0 to 11.0 (mean 10)
Length of tegmina (as seen from above)	12.0 to 13.0 (mean 12.7)

Only a little general data can be given on the female. It was only possible to collect one female, this in the last instar, which in captivity moulted incompletely to an adult. Therefore some characters could not be determined such as body, femur and wing lengths. But it is obvious from the specimen, that it is very similar to the female of *A. kilimandjarica* and thus typical for the genus *Aerotegmina*.

Female.—

General characters: Color pattern similar to the male, of predominantly greenish color.

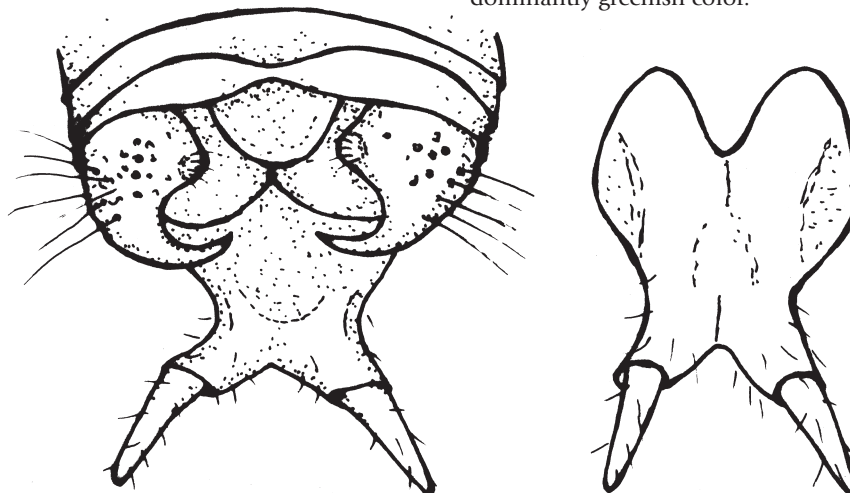


Fig. 4. Dorsal view of genitalia (left) and ventral view of subgenital plate (right) of male *A. shengenaе*.

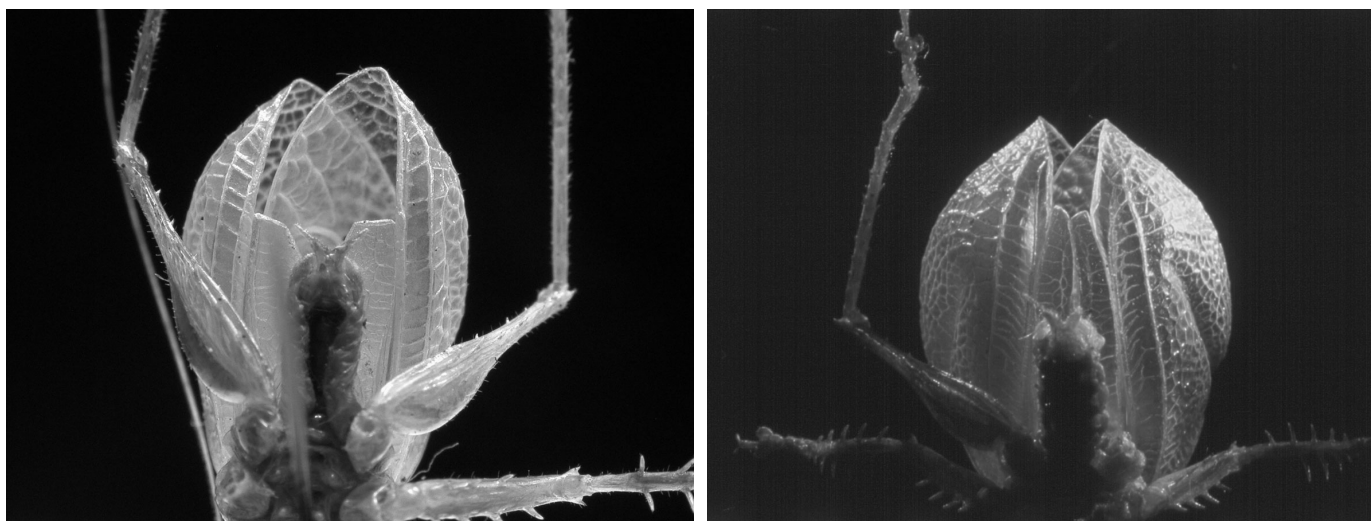


Fig. 5. Ventral view of acoustical chamber of *A. shengenaе* (left) and *A. kilimandjarica* (right).

Abdomen: Ventrally milky white.

Thorax: Median length of pronotum 3.5 mm.

Tegmina: Shortened reticulate lobes with reduced venation, of greenish color; alae lobular with reduced venation, covered by tegmina.

Legs: As in male.

Genitalia: Ovipositor 8.5 mm, of brownish color in the inflated part, proximally greenish.

*Nymphs.*— Nymphs similar to adults.

*Distribution.*—*A. shengenaе* n. sp. was collected in montane forest in the South Pare Mts. Here extensive forest cover still exists, starting at about 1900 m on the southern slopes and at about 1700-1800 m on the northern side. Huge areas below this have been burnt and are either partly under cultivation by the local population, or in a regeneration stage with *Erica* species. *A. shengenaе* was detected only in intact, closed *Ocotea* forest (see below). It did not occur in smaller forest remnants (e.g., along small rivers where fires could not completely destroy forest cover) or in *Erica* bushland. Its presence was indicated by its conspicuous song, from the lower borders (south and north slopes) of montane forest, almost to the top of Mt. Shengena. Near its summit at 2400 m, Mt. Shengena is covered by *Erica* forest, which does not seem to serve as acceptable habitat for *A. shengenaе*. On the northern slopes *A. shengenaе* was noted at about 1600 m.

*Habitat.*—The forests, in which *A. shengenaе* lives, have an upper tree canopy of 30 to 40 m-height and 80 to 90% coverage. Dominant trees are *Ocotea usambarensis*, *Podocarpus latifolius*, *Cassipourea malosana*, *Ochna hostii*, *Aphloia theiformis*, *Xymalos monospora*, *Syzygium guineense*, *Ilex mitis*, *Dasylepis integra*, *Melchiora schliebenii* and *Ficalhoa laurifolia*. In the shrub layer at 4 to 5 m-height, with 40 % coverage, in addition to young trees the shrubs *Psychotria goetzei*, *P. pseudo-platyphylla*, *Lasianthus kilimandscharicus*, *Pauridiantha paucinervis* and *Keetia gueinzii* are of importance. The herb layer, consisting mainly of ferns of the genus *Asplenium* and tree seedlings, covered 30 % of the ground. Epiphytes, mainly bryophytes, covered 10 to 30 % of the stems and branches of the trees and shrubs. These diverse forests (with over 70 vascular plant species per plot) receive approximately 1900 mm of mean annual precipitation; mean annual temperature

is about 14 °C (Hemp, A. unpub. data).

*A. shengenaе* males were located by their singing which starts with nightfall and lasts to the early morning hours. Individuals were collected, perched under broad leaves, at heights from 1.5 to about 2 m. In the montane forest at 2100 m elevation singing males separated themselves from each other by about 20 to 30 m. (Nymphs were obtained by shaking small to medium-height trees.) As occurs for *A. kilimandjarica*, *A. shengenaе* probably execute a diurnal shift within the habitat: during the day short chirps are occasionally heard from single males high up in the canopy.

*A. shengenaе* occurred syntopically with *Anthracites* sp., *Melidia kenyensis* Chopard, 1954, *Amytta* sp., *Horatosphaga parensis* Hemp, 2002, and *Rhainopomma* sp. in the montane forest area around Mt. Shengena at 2100 m elevation.

*Song.*—As appears typical for the genus *Aerotegmina*, one may observe — because the movement is slow enough — one sound pulse per tegminal movement cycle, this sound made only on tegminal opening. This is the reverse of the situation in most tettigoniids, in which principal sound emissions coincide with tegminal closure (e.g., Heller 1988).



Fig. 6. Male of *A. shengenaе*.

Fig. 7 shows the song patterns of two specimens of *A. kilimandjarica* (A, C, E) and *A. shengena* (B, D, F), recorded under identical temperature conditions. A and B compare the songs at the same time scale. While *A. kilimandjarica* makes three syllables (or pulses), *A. shengena* is emitting five, meaning that pulses are generated almost twice as fast in the latter species. Power spectra over the audio range are compared for the two species (Fig. 7 C, D). Both have their sound frequencies confined to the audio range below 10 kHz. *A. shengena* is higher in peak carrier frequency than *A. kilimandjarica*: 5.3 kHz, with a bandwidth (12 dB down from the highest peak) of 4.3 to 7.3 kHz. For *A. shengena* the principal peak is 6.8 kHz with a bandwidth 12 dB down of 6.4–9.4 kHz.

E and F (Fig. 7) are short time samples from the pulses at high resolution, showing their waveforms. For both species there is a virtual absence of any pulse structure within the sound emission that accompanies each opening.

*Phenological Notes.*—The South Pare Mts were visited four times during different months (Dec 2000, March 2001, July and September 2005). The presence of mature *A. shengena* was always made apparent by the hearing of its song. As is the case for *A. kilimandjarica* on Mt. Kilimanjaro, *A. shengena* is probably present throughout the year.

*Diagnosis.*—Only *A. kilimandjarica* from Mt. Kilimanjaro has been described previously, although additional undescribed species of *Aerotegmina* have been detected from at least six other regions in East Africa. *A. shengena* differs from *A. kilimandjarica* in body size, the shape and size of the acoustical chamber, song, shape of the alae and some other minor morphological characters. In the same way as *A. kilimandjarica* is restricted to montane forests on Mt. Kilimanjaro, *A. shengena* only occurs in montane forests of the South Pare Mts.

*A. shengena* is smaller (mean body size 14.3 mm, mean tegminal length 12.7 mm) than *A. kilimandjarica* (mean body size 15.5 mm, mean tegminal length 14.5). In *A. kilimandjarica* the acoustical chamber is inflated and balloon-like while it is more elongated and smaller in *A. shengena* (Figs 6, 7). In *A. kilimandjarica* the alae are elongated and spatulate, perfectly closing the acoustical chamber ventrally in the living specimen; in *A. shengena* the alae are shorter and the tips are blunt, leaving a posterior ventral opening (Fig. 5).

The consequences of these morphological differences in generator may be perceptible in the field: the calling song of *A. kilimandjarica* is very much louder, audible at several hundred metres when approaching the forest on Mt. Kilimanjaro. Males of *A. shengena* are heard only at maximum distances of 10 to 20 m. This dramatic difference in intensity is probably related to a smaller-volume chamber and its imperfect ventral completion in *A. shengena*.

Further morphological differences between the two species are seen in the shape of the fastigium vertex (Fig. 1, 2). In *A. shengena* it is more elongate, while it is broader in *A. kilimandjarica*. The procoxal spines also differ slightly between species: in *A. shengena* the spine has a very swollen base, while in *A. kilimandjarica* this swelling is much less prominent (Fig. 3). In the male genital complex differences are found in the shape of the cerci, the length of the appendices of the subgenital plates and the penis area. In *A. shengena* at the base of the inner side, the cerci show a bulge which is lacking in *A. kilimandjarica*. In *A. kilimandjarica* the appendices of the subgenital plate are longer (see Hemp 2001a, Fig. 3).

## Discussion

The Eastern Arc mountains of Tanzania and Kenya are well known hotspots of diversity and endemism (*e.g.*, Rodgers and Homewood 1982). Archaeo-endemics (geologically old species) are mostly found in environments evincing long-term stable climatic conditions (*e.g.*, the coastal forests of East Africa). By contrast, mountainous areas of East Africa, including geologically young mountains such as Mt. Kilimanjaro (about 1.5 Mya), harbor many neo-endemics that have evolved (geologically) rather recently (16% endemism in Saltatoria on Mt. Kilimanjaro, Lambrechts *et al.* 2002, Hemp 2005). Speciation processes here may have been governed by changing climatic conditions that sometimes isolated taxa on higher mountains, but at other times enabled taxa to migrate and spread.

The genus *Aerotegmina* is restricted to isolated montane forest and its expansion/dispersal could only have happened under a climatic regime which was colder and more humid than today. The South Pare Mts are in a special geographical position: close enough to the coast to receive enough moisture to maintain montane forest cover, but far enough away from the stable coastal climate to become isolated during drier and warmer climatic conditions. Such factors might provide necessary conditions for speciation.

The generator of *A. shengena* is apparently the most primitive within the genus *Aerotegmina*, with a smaller, less rotund acoustical chamber which is not perfectly closed as in other *Aerotegmina* species (*e.g.*, *A. kilimandjarica*). It seems possible that *Aerotegmina* evolved in the South Pare Mts. since no other *Aerotegmina* has been found with an incompletely closed acoustical chamber (Hemp, unpub. data).

The closest relative from the same area is a member of the genus *Hexacentrus*, a widespread genus distributed throughout Africa, Asia, Indo-Malaysia, and the Pacific islands (Hemp 2001a). As in *Aerotegmina*, tegmina in *Hexacentrus* are often modified into an inflated acoustical chamber in African and Asian *Hexacentrus* species, indicating perhaps a genetic predisposition for such chambers in Listrosclidinae.

Ecological reasons could also have provided pressure for canopy dwellers to develop highly effective acoustical communication. In regard to climate, similar conditions to those in the South Pare prevail in the adjacent West Usambara Mts. Both mountain ranges are isolated from each other today and probably have been so for a long time. From a plant sociological perspective, the montane *Ocotea* forests do not differ much between these mountain ranges (Hemp, A., unpub. data), but in respect to *Saltatoria* species there are hardly any common to both ranges.

*Aerotegmina* is missing from the forests of the West Usambaras. Its niche seems to be occupied there by the phaneropterine *Euryastes jagoi* Ragge (Ragge 1980). *Euryastes* is a monotypic genus unknown elsewhere (Ragge 1980). Like the *Aerotegmina* species, *E. jagoi* starts with its loud calling song at nightfall, singing from medium heights on broadleaf vegetation. Its calling song as heard by human ears, resembles that of *Aerotegmina* astonishingly.

## Acknowledgments

For the evaluation of the sound data of *Aerotegmina* species I owe gratitude to Prof. O. von Helvesen, Erlangen and his staff. I am further very grateful to Glenn Morris who analysed the sounds of the *Aerotegmina* species and gave valuable advice on the manuscript and especially improved the acoustical section of the paper. Many thanks also to the second, anonymous reviewer for constructive comments on the manuscript.

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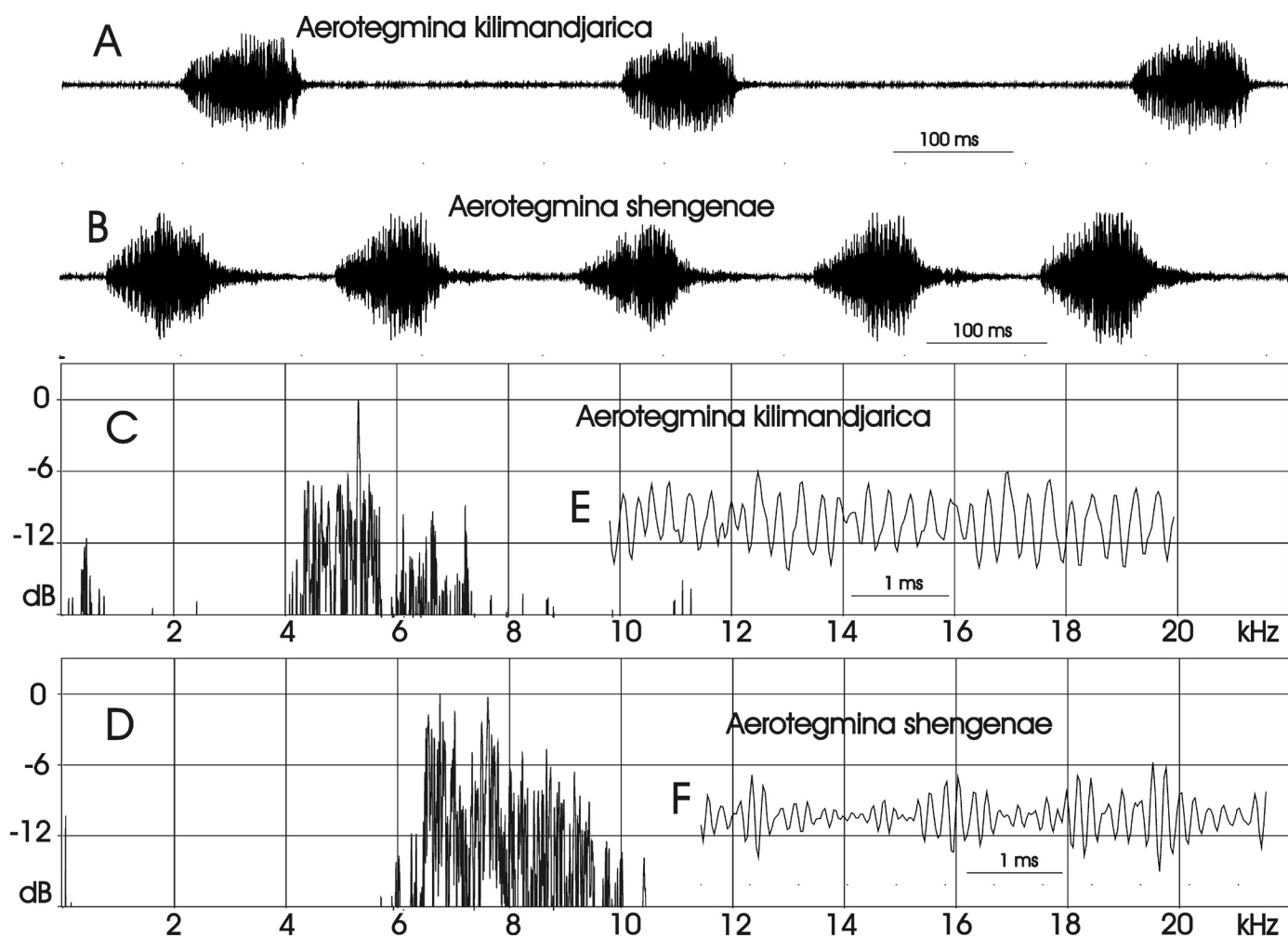


Fig. 7. Oscillograms and spectra of the calling songs of *A. kilimandjarica* and *A. shengeniae*.