Zootaxa 5125 (5): 536–546
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5125.5.4
http://zoobank.org/urn:lsid:zoobank.org:pub:BD0FBE8E-2086-40F2-9C46-B6015E771F90

Leptophyes axeli sp. nov. a new bush-cricket from Crete, Greece (Orthoptera: Tettigoniidae: Phaneropterinae)

LUC WILLEMSE[1], BAUDEWIJN ODÉ[2] & JOS TILMANS[3]
[1]*Naturalis, P.O.Box 9517, 2300 RA Leiden, the Netherlands*
luc.willemse@naturalis.nl; https://orcid.org/0000-0003-0517-9778
[2]*Riethorsterweg 12, 6586 AC Plasmolen, the Netherlands*
baudewijn.ode@gmail.com; https://orcid.org/0000-0002-4925-9289
[3]*Herkenboscher Strasse 33, 41849 Wassenberg-Rothenbach, Germany*
jos.tilmans@adactio.nl; https://orcid.org/0000-0003-0127-6191

Abstract

Leptophyes axeli **sp. nov.** is described and illustrated. Tables are presented with character states and song characteristics differing between *Leptophyes* species.

Key words: taxonomy, new species, Barbitistini, *Leptophyes*, Chania

Introduction

Leptophyes is a genus with delicate short-winged bush-crickets including 20 species distributed across Europe, Turkey and the Middle East (Israel, Lebanon) reaching eastward to Iran, Caucasus into Pakistan and Kashmir. Most species prefer habitats with sufficient shadow and lush vegetation like open forests, forest edges, forest meadows or more open vegetation in canyons and gorges, living on tall herbs, shrubs and in trees. There are exceptions like *L. albovitatta* which is found in more open and sunny habitats with lush vegetation. Because they are night active, the male calling song is very soft and they blend in very well in the vegetation, *Leptophyes* can be easily overlooked.

While looking for *Eupholidoptera* species in the southwestern corner of the regional unit of Chania on the island of Crete in June 2019 (Willemse *et al.* in prep), juvenile *Leptophyes* were discovered at several sites. As *Leptophyes* was not yet known from Crete (Willemse & Kruseman 1976; Willemse 1984; Willemse & Willemse 2008; Willemse *et al.* 2018) some juveniles were collected and reared to adult. Once adult it appeared these populations in Crete were quite distinct from any other *Leptophyes* species known and belonged to a yet undescribed species.

Material and methods

Specimens were collected as nymphs on 17–18 June 2019 and reared in captivity, reaching adulthood toward the end of June and the first half of July. Material has been deposited in Naturalis Biodiversity Center, Leiden, the Netherlands (RMNH) and the Collection of Jos Tilmans (CT).

Bioacoustics

The calling song of two males, the holotype (RMNH.5106294) and a paratype (RMNH.5106293) was recorded. During recording, animals were kept in a metal gauze casing within an anechoic chamber. Temperature of all recordings has been between 22.2°C and 22.6°C. All primary recordings have been performed with an Olympus LS-100 (96kHz at 24bits) audio recorder with Sennheiser K6-module with ME62 condenser microphone (between 5–10 cm away from the animal), yielding a frequency response up to about 45kHz. Secondary recordings have been made with a smartphone (iPhone 8s plus) with Echo Meter Touch 2 Pro (sampling rate 256kHz or 384kHz) microphone unit, about 20 cm away from the animal, yielding a frequency response up to about respectively 128

 Accepted by D. Rentz: 7 Mar. 2022; published: 13 Apr. 2022

kHz and 192 kHz. Recordings of the other species of *Leptophyes* and *Andreiniimon nuptialis* have been made with different equipment and under different conditions.

Song analysis has been performed using Wavelab software (Steinberg.net) and oscillograms have been made using Praat software (Praat.org).

Terminology

Calling song: song produced by an isolated male.

Impulse: a simple, undivided, transient train of sound waves. In *Leptophyes*, individual impulses are associated with the impact of one tooth of the stridulatory file.

Syllable: the sound produced by one complete opening and closing movement of the tegmina. In *Leptophyes*, individual impulses can be seen within the closing movement, whereas the opening movement is silent. In some species the closing movement is divided in several parts, resulting in an interrupted structure of an individual syllable. In many species the song only consists of loosely repeated syllables.

Echeme: a first-order assemblage of syllables. In *Leptophyes*, some species produces more fixed series of syllables, divided by intervals. In these cases, we refer to those series as echemes.

***Leptophyes axeli* Willemse, Odé & Tilmans sp. nov.**

Figs 1–24

Material examined (5♂, 5♀). Holotype ♂ (RMNH.5106294), 1♂ (RMNH.5106263), 2♀ (RMNH.5106264, RMNH.5106295) paratypes (RMNH): Greece—Crete (Chania): Psariana-Aligi; on *Rubus* next to road; 420m; 17.VI.2019–loc 4 leg. L.Willemse & J.Tilmans; N 35.351833°; E 23.694208° (RMNH); allotype ♀ (RMNH.5106283), 1♀ (RMNH.5106284) paratype (RMNH), 2♂ (2019.025.01, 2019.025.02), 1♀ (2019.025.03) paratypes (CT): Greece—Crete (Chania): 0.4 km NE Vamvakades; open oak forest; 750m; 17.VI.2019–loc 6 leg. L.Willemse & J.Tilmans; N 35.316483°; E 23.756119° (RMNH); Greece—Crete (Chania): 0.5 km W of Kamaria; on *Rubus* and herbs; 345m; 18.VI.2019–loc 2 leg. L.Willemse & J.Tilmans; N 35.282516°; E 23.778568° 1♂ (RMNH.5106293) paratype (RMNH).

(Primary) Sound recordings in sound library B. Odé: Holotype (RMNH5106294): GR19 Olympus: 1098, 1107, 1108; paratype (RMNH5106293): GR19 Olympus: 1100, 1109.

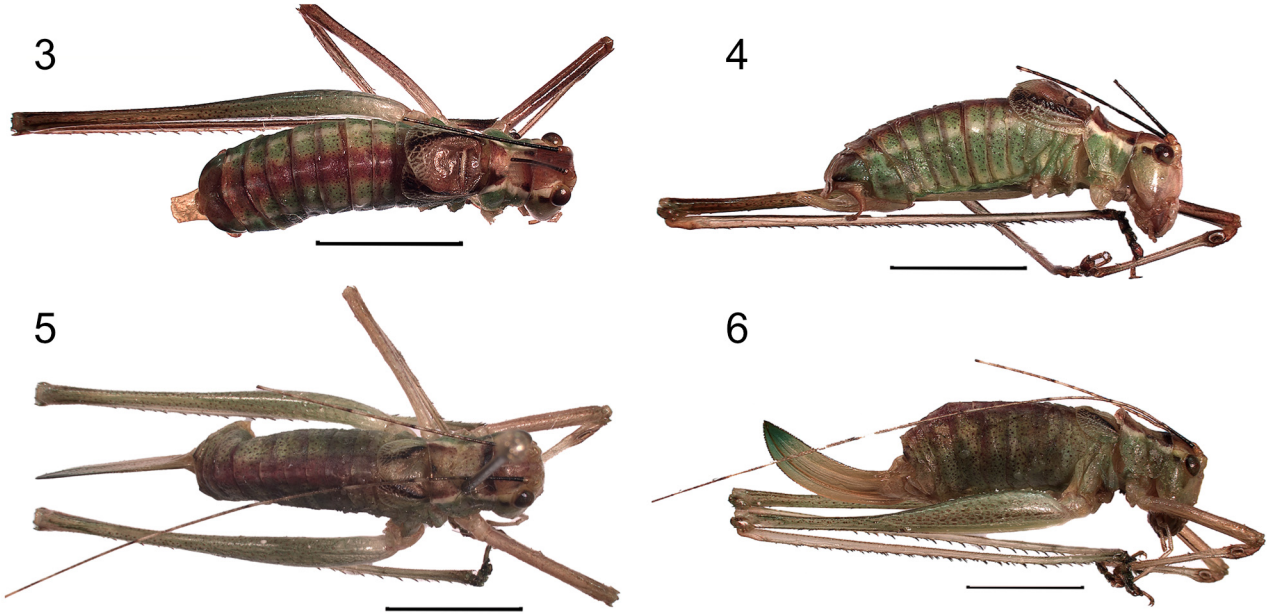
FIGURES 1–2. *Leptophyes axeli* **sp. nov.**, 1. male reared from nymph. Psariana, paratype (RMNH5106263), 2. Female reared from nymph. Vamvakades, allotype (RMNH5106283). Photos R. Kleukers

Description. Male (figs 1, 3–4) as type species, *L. punctatissima*, integument somewhat shiny.

Head broad; eyes prominent; fastigium (fig. 7) short, narrow, blunt not protruding anteriorly beyond the antennal sockets, one third to half as wide as scapus, sulcate; third antennal segment nearly as wide as the distance between antennal sockets, slightly wider than fastigium.

Pronotum (figs 8, 11) short, weakly saddle shaped, not protruding posteriorly beyond the mesonotum, equally widened in prozona and metazoan; anterior margin very weakly concave, posterior margin straight to weakly convex, in lateral view toward front and back gradually raised; sulcus between halfway and two thirds of its length; lateral lobe slightly wider than deep, lower margin short, covering epimeron, anteriorly sinuate, anterior corner hollow,

in dorsal view clearly protruding, fore margin in lateral view slight convex, hind margin straight, in posterior view weakly convex; prothoracic spiracle large.



FIGURES 3–6. *Leptophyes axeli* **sp. nov.** habitus, 3. male holotype dorsal, 4. lateral; 5. female allotype dorsal, 6. lateral.

Fore wings (figs 8, 11) not covered by pronotum except base laterally, about 1.5 times longer than pronotum, apical margin reaching hind margin of second tergite, with veins, archedictyon and bulging of distal end of Cu2 on hind margin rather pronounced (fig. 9), at rest distal part of fore margin convex to truncate; stridulatory file (fig. 13) file weakly arcuate, not reaching hind margin of fore wing, in profile weakly depressed in the middle, with 84–89 teeth, spacing hardly decreasing from the proximal tip to the distal tip, in proximal half hardly widening, almost equally broad, narrowing in the distal half; shortest distance between proximal and distal most tooth 1.25–1.64 mm.

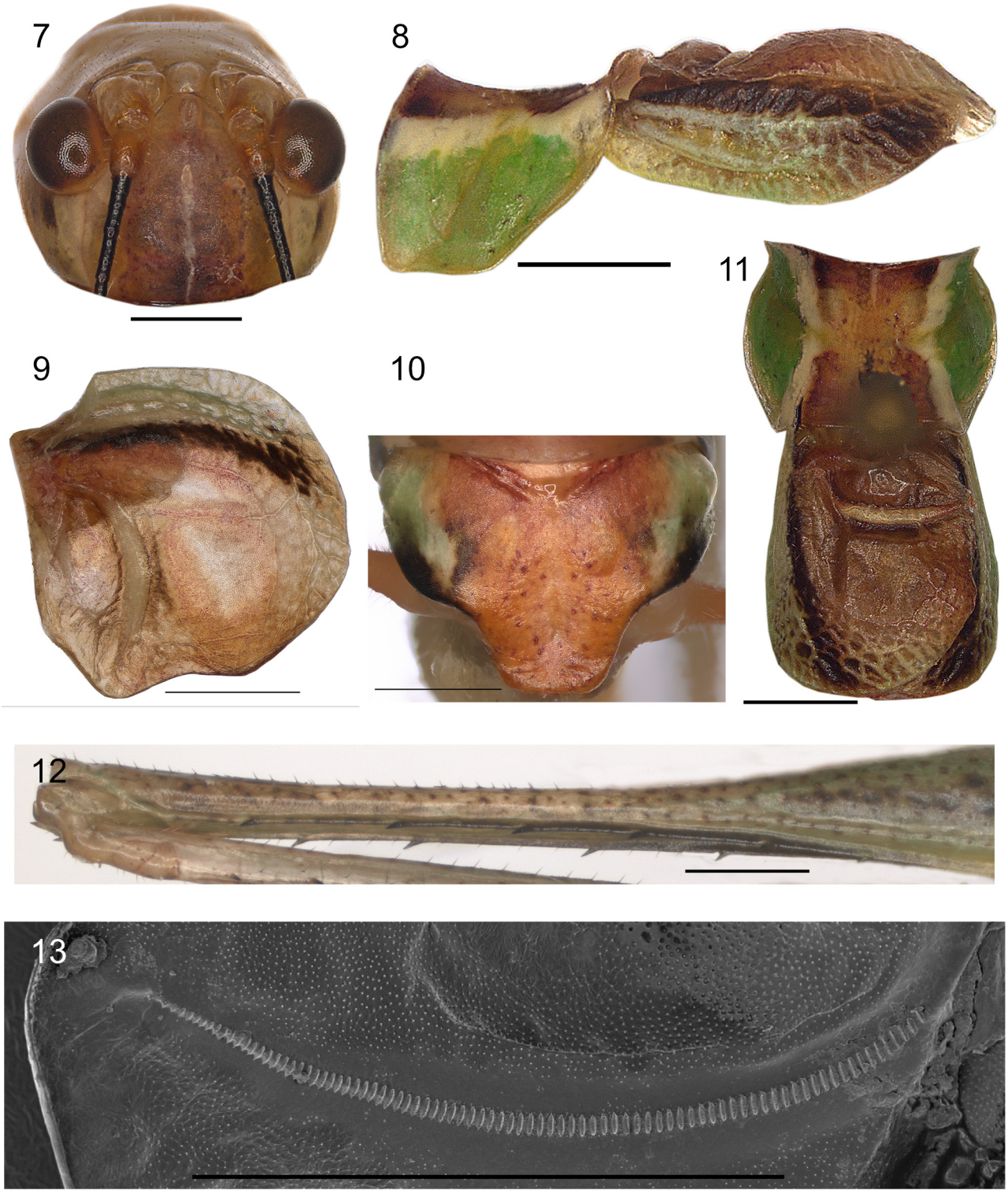
Legs with hind femur 5.6–7.2 times longer than pronotum; outer and inner ventral margin hind femur with 2–6 and 1–3 spines respectively (fig. 12), fore and mid femur spineless.

Abdomen with second tergite bristle-like hairy mediodorsally, remaining tergites hairless; 10th tergite medially produced backwards into trapezoid protuberance (fig. 10), depressed in the center, hind margin swollen, straight, covering the epiproct, weakly downcurved; cerci (fig. 14–15,17), strongly narrowed from the base, conical and straight in basal third, conical, somewhat flattened and strongly curved inward in upper two thirds, the apical third spiral-like turned downward, terminating in stout and sharp apical denticle; subgenital plate (fig. 16, 18) in ventral view oval, widening from base, halfway widest, in apical half narrowing, folded and strongly upcurved, chute formed, reaching up to the epiproct, margins swollen, posterior margin straight between the slightly protruding tips formed by the side margins.

Coloration (fig. 1) General color green to pale green, abdomen and less so thorax finely rusty brown spotted.

Head with frons, clypeus and labrum yellowish to creamy white, genae yellowish to green; vertex and first two antennal segments rusty brown with a narrow median and a wider postocular yellow or creamy white stripe often bordered with black markings. Flagellum of antennae from blackish to pale brown, sparsely annulated with yellow. Pronotum with dorsum rusty brown with or without pale central line, lighter in mesozona, darker brown along fore margin bordered on the sides by yellow or creamy white lateral band; lateral lobe green or pale yellowish green. Fore wings with stridulatory apparatus rusty brown, stridulatory vein yellowish white, with a black lateral streak along longitudinal folding of the wing widening apically, downfolded anterior areas and in some specimen's apex of elytron greenish to yellowish white. Legs of general color, lower outer and inner keel of fore and mid femora blackish, upper side of fore and mid femora and fore and mid tibiae usually with blackish streaks. Abdomen green with a wide rusty brown median band and with or without a distinct white band along the side, last tergite with hind margin toward the middle more or less distinctly blackish, protuberance epiproct and cerci chestnut brown; subgenital plate pale yellowish, darkening somewhat apically; sternite green, with central white square.

Bioacoustics. The song of *L. axeli* **sp. nov.** consists of a repetition of very short syllables (fig 19). Syllables last 50–70ms and are repeated at a rate of about 1/s at maximum, but frequently at a lower rate. In our sound recordings frequently only short series of about 4–10 syllables are produced, followed by longer intervals. Each syllable consists of 27–40 impulses that show a marked crescendo, with the first impulses weak and the loudest impulses in the second half of the syllable. The final few impulses are weaker again. The frequency spectrum of the song shows frequencies between 15kHz and 90kHz, with a peak between 30–40kHz.



FIGURES 7–13. *Leptophyes axeli* **sp. nov.** male, 7. head dorsal, 8. pronotum and elytron, lateral, 9. left elytron, ventral, 10. anal tergite, dorsal, 11. pronotum and elytron, dorsal, 12. ventral side hind femur, ventro-lateral, 13. stridulatory file. Bar: 1 mm.

FIGURES 14–18. *Leptophyes axeli* **sp. nov.** male, 14. cercus dorsal, 15. cercus lateral, 16. subgenital plate ventral, 17. cercus caudal, 18. subgenital plate lateral. Bar: 1 mm.

Female (figs 2, 5–6): as male. Pronotum (figs 20–21) only raised toward the back. Fore wings (figs 20–21) short, broadly overlapping, reaching or surpassing posterior margin of the first tergite, 0.75–0.85 as long as pronotum. Legs with hind femur 5.9–6.4 times longer than pronotum, outer and inner ventral margin with 2–6 and 1–2 spines respectively. Basal fold of lower ovipositor valve (fig. 23) somewhat swollen, extending laterally with the gonangulum forming a large pit that opens anterolaterally. 10th abdominal tergite (fig. 22) in the middle with bow-shaped extension, more or less folded downward. Cerci (fig. 22) conical, stout, 2.2 times longer than greatest width, apical third strongly narrowed, slightly bend inward, apex pointed. Ovipositor (fig. 23) slightly widening toward the middle, widest around the middle, margins subparallel in basal half, upper margin extremely weak concave, edge in apical half obtusely serrate, lower margin straight in basal half, convex in apical half edge finely dentate. Subgenital plate small, triangular, apex slightly pulled out, sides inflated.

Coloration (fig. 2) as in male, less pronounced; ovipositor green.

Measurements (length in mm) and ratios. Body ♂ 11.4–13.9, ♀ 11.7–12.9; pronotum ♂ 2.3–2.6, ♀ 2.6–2.8; elytron ♂ 3.0–3.6, ♀ 2.0–2.3; hind femur ♂ 13.4–15.5, ♀ 16.1–17.9; ovipositor 8.0–8.6. Ratio fore tibia/pronotum ♂ 2.9–3.5, ♀ 2.8–3.2, hind femur/pronotum ♂ 5.6–7.2, ♀ 5.9–6.4, ovipositor/pronotum 2.9–3.2 and hind femur/ovipositor 1.9–2.1.

Generic assignment. *L. axeli* **sp. nov.** has been assigned to *Leptophyes* based on the following characteristics: fore tibiae in the male and female respectively 2.9–3.5 and 2.8–3.2 times longer than the pronotum, anterior margin of the lateral lobe of the pronotum vertical, not protruding, the flat ovipositor slightly widening from the base with finely serrated apex and the male cercus lacking a basal tubercle. *L. axeli* shares the distinct median protuberance on

the last abdominal tergite with *Andreiniimon*. In *L. axe*li the protuberance is much smaller than in *Andreiniimon*, the female subgenital plate is triangular and not transverse as in *Andreiniimon* and the high peak frequency in the male calling song in *L. axeli* is lower (30–40kHz) than in *Andreiniimon* (60kHz).

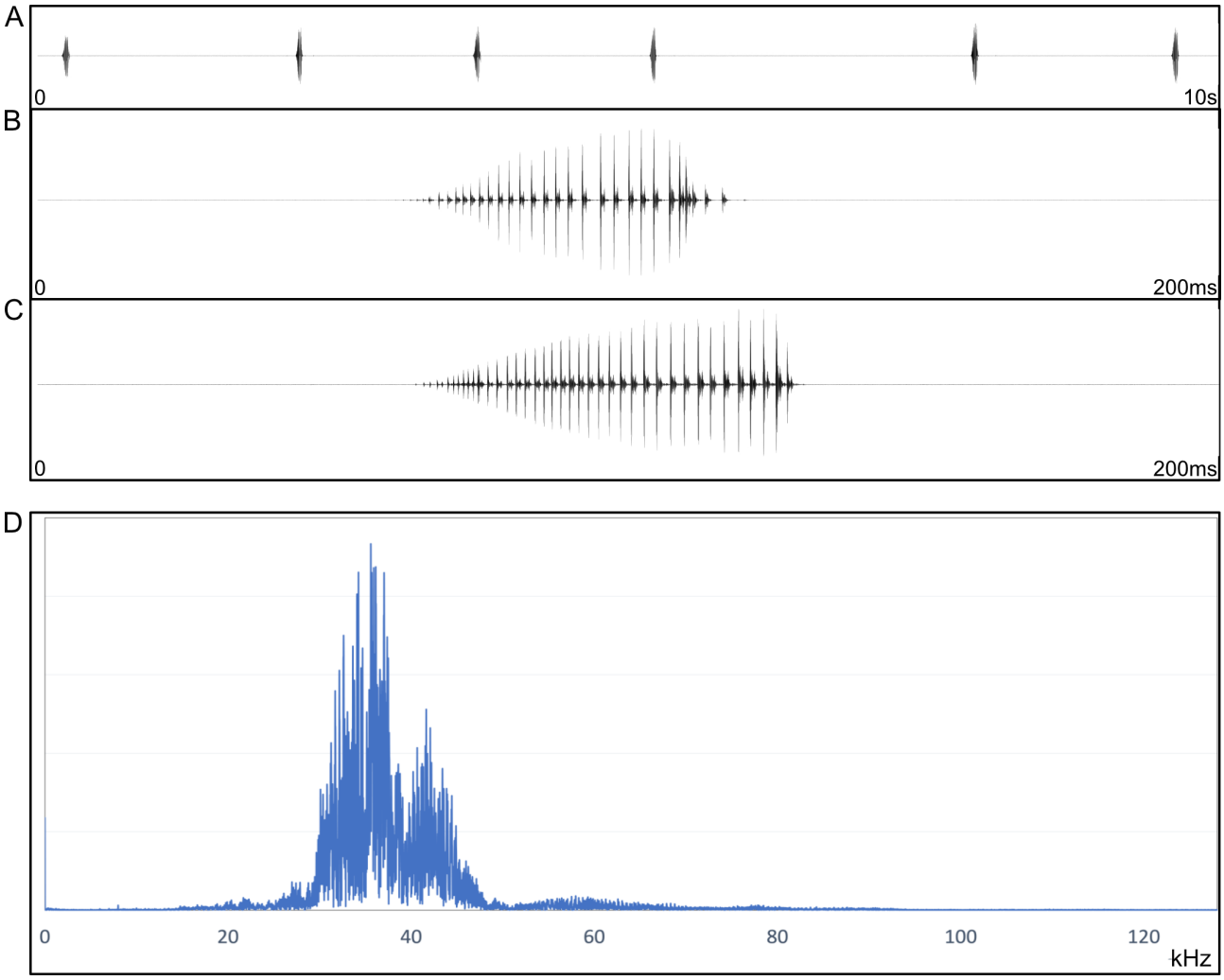
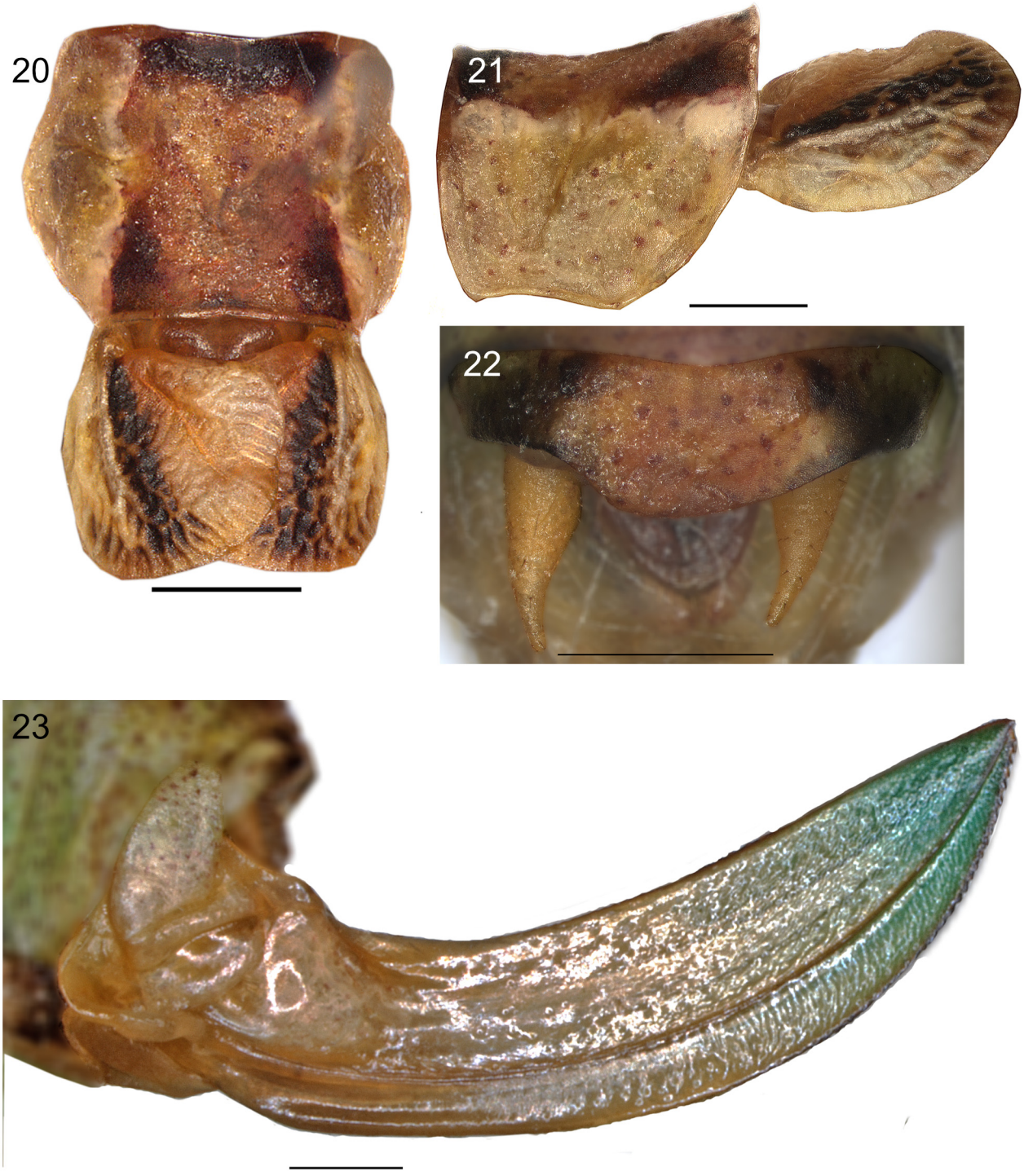


FIGURE 19. *Leptophyes axeli* **sp. nov.** Bioacoustics: A. Oscillogram (10s) of calling song; B. Oscillogram (200ms) of one syllable of Holotype (RMNH5106294); C. Oscillogram (200ms) of one syllable of paratype (RMNH5106293): D. Frequency spectrum of the song.

Differential diagnosis. Within *Leptophyes*, male *L. axeli* **sp. nov.** is clearly differentiated from all other species by the supra-anal plate being extended into a protuberance, somewhat reminiscent of *Andreiniimon nuptialis* and by the slender, strongly inward and slightly spirally down curved cerci in the male. With the third antennal segment being relatively narrow, the short pronotum with vertical side flaps, the fore wings not covered by the pronotum and the ovipositor from the base slightly widening distally, *L. axeli* **sp. nov.** belongs to the 'punctatissima' group of species in *Leptophyes* sensu Bey-Bienko (1954). From species of the 'punctatissima' group occurring in Turkey and the Middle-East (*L. festae, L. karanae, L. peneri, L. helleri*) male *L. axeli* **sp. nov.** differ by the tip of the male cercus not being spine-like but simply pointed. Male *L. nigrovittata*, a species from the 'puntatissima' group found in the Caucasus, is characterised by a slender, almost straight cercus, the tip being blunt with a small inward pointing denticle, resembling cerci found in species of the 'Iranica' Group and very different from the cercus in *L. axeli* **sp. nov.** From the European species of the 'punctatissima' group, male L. axeli **sp. nov.** differ from *L. laticauda* and *L. intermedia* in the cercus not being slender but rather compact, the tip not being pointed but blunt with a small denticle or tooth and in the ventral side of the hind femur lacking spinules. Overall *L. axeli* **sp. nov.** most closely resembles *L. punctatissima, L. asamo, L. calabra, L. sicula* and *L. lisae*, but differs from these species except for the cercus and the protuberance on the anal tergite also in the relatively long wings. *L. axeli* shares with *L. sicula* and *L. lisae* the cerci being bent from halfway up whereas in *L. punctatissima* and *L. asamo* the cercus is bent more apically.



FIGURES 20–23. *Leptophyes axeli* **sp. nov.** female, 20. pronotum and elytron, dorsal, 21. pronotum and elytron, lateral, 22. anal tergite and cerci, dorsal, 23. ovipositor, lateral. Bar: 1 mm.

Within the 'punctatissima' group of species in *Leptophyes* females are less easy to distinguish. Female *L. axeli* **sp. nov.** differ from *L. calabra*, *L. intermedia* and *L. sicula* in the distinctly larger length of the visible part of the fore wings and length of ovipositor compared to the pronotum. In *L. axeli* **sp. nov.** the inner and outer keel on the ventral side of the hind femur carry spines whereas in *L. laticauda* they are bare. Differences with other species in the 'punctatissima' group are less distinct. The very large lateral pit of the ovipositor in *L. axeli* **sp. nov.** combined with its relatively long ovipositor and visible part of the fore wing can be used to quite clearly differentiate it from for instance *L. punctatissima*, but less so from other species

Based on material at hand and taxonomic treatments provided in published papers, male and female character states, useful to differentiate species within *Leptophyes*, are summarized in Table 1. An illustrated key to the European species of *Leptophyes* is provided by Kleukers *et al*. (2010).

TABLE 1. Character states of some morphological diagnostic characters in male (nos. 1–7), both sexes (8) and female (nos. 9-10) *Leptophyes*[1]

	0	1a	1b	2a	2b	3	4	5	6	7	8	9	10
L. albovittata [2]	A	2	1	2	1	45–50[12]	1	1	1	1	2	1	1
L. angusticauda [2]	I	X	X	X	X	X	X	X	X	X	?	?	3
L. asamo [3]	P	2	3	1	1	57–66	1	3	1	1	1	X	X
L. axeli **sp. nov.**	P	1	2	1	1	84	3	3–4	2	2	1	3	3
L. bosci [2]	A	1	1	2	1	56–60[12]	2	1	1	1	2	1	1
L. calabra [4]	P	1	3	1	1	50–100	1	3	1	1	1	2	2
L. discoidalis [2]	A	1	1	2	1	?	?	1	1	1	1–2	1	1
L. festae [5]	P	X	X	X	X	X	X	X	X	X	?	?	3
L. helleri [6]	P	1	1	1	2	85–100	2	2	1	1	1	2	3
L. intermedia [7]	P	1	3	2	1	≥ 70	2–3	2	1	1	2	2	2
L. iranica [2]	I	2	1	2	1	?	?	4	?	?	?	2	2
L. karanae [8]	P	2	2	1	2	110–120	2	3	1	1	1	3	2
L. laticauda [2]	P	2	3	2	1	72[12]	?	3	1	1	2	2	3
L. lisae [9]	P	1	2	1	1	90–120	1/3	3	2	1	1	3	3
L. nigrovittata [2]	P	2	1	2	1	?	?	3	?	1	?	3	2
L. peneri [10]	P	2	3	1	2	?	?	3	1	1	1	3	3
L. punctatissima [2]	P	2	3	1	1	60–70[4, 12]	1	3	1	1	1	3	2
L. purpureopunctatus [11]	I	X	X	X	X	X	X	X	X	X	?	3	2
L. sicula [4]	P	1	2	1	1	110–125	2	3	2	1	1	2	2
L. trivittata [2]	I	2	1	2	1	?	?	4	2	?	2	3	2

1. excluding *L. bolivari* described by Bolívar (1899), only known after the single male type, which could not be traced back in the Museo Nacional de Ciencias Naturales in Madrid (Paris 1994); 2. Bey-Bienko (1954); 3. Pavićević & Ivković (2014); 4. Kleukers *et al*. (2010), female from type locality in collection RMNH; 5. Giglio-Tos (1893); 6. Sevgili (2004); 7. Ingrisch & Pavićević (2010); 8. Naskrecki & Ünal (1995); 14. Heller & F.Willemse (1989); 10. Harz (1970); 11. Garai (2002); 12. Heller (1988) X: male or female unknown; ?: not evident from description.

0. species group sensu Bey-Benko (1954): A: albovittata; I: iranica; P: punctatissima
1. male cercus shape
a. 1. constricted; 2. not constricted
b. 1. (nearly) straight; 2. bent halfway; 3. bent at 2/3 of the length
2. male cercus tip
a. 1. tapering; 2. blunt
b. 1. short tooth/denticle; 2. long tooth
3. number of stridulatory teeth
4. stridulatory file: 1. largely equally broad; 2. widest in middle part; 3. widest in proximal 2/3
5. male ratio length visible tegmen/pronotum: 1: < 0.6; 2: 0.6–0.9; 3. 0.9–1.2; 4. > 1.3
6. male bulge elytron: 1. weak; 2. strong
7. hind margin last tergite male: 1. straight to weak convex; 2. extended
8. hind femur ventrally: 1. with spinules; 2. bare
9. female ratio length visible tegmen/pronotum: 1. <0.3; 2. 0.4–0.6; 3. > 0.7
10. female ratio length ovipositor/pronotum: 1. < 2.0; 2. 2.0–2.6; 3. > 2.7

The song of *L. axeli* **sp. nov.** has been compared with the other European and Turkish species of the genus *Leptophyes* and also with *Andreiniimon nuptialis*. We combined both data from personal sound recordings, published

data (Ragge & Reynolds 1998; Heller 1988) and published sound recordings (Systax, Cigliano *et al.* 2021, Sardet *et al.* 2021, Sevgili 2004, Ingrisch & Pavicevic 2010) to summarize the song characters in Table 2.

TABLE 2. Sound characters of male calling song in *Leptophyes* and *Andreiniimon*

Species	Syllable duration (ms)	Number of impulses	Peak frequency (kHz)	Note
L.axeli **sp. nov.**	50–70	27–40	35	Crescendo within syllable
L. albovittata	24–38	5–15	50–57	Crescendo within syllable, sometimes followed by isolated impulses
L. boscii	21–36	10–27	40–50	Crescendo within syllable
L. discoidalis	10–22	1–9	32–35	Echeme of 4–36 syllables, each showing a decrescendo in impulses
L. punctatissima	8–31	4–8	40	Decrescendo within syllable
L. helleri	27–50	10–22	Unknown	Echeme of 4–32 syllables (with crescendo in impulses) mixed with isolated impulses
L. laticauda	5–40	1–10 (per part)	20–23	Song in 1–5 parts, consisting of 1–2(–3?) syllables, but wing movement not fully understood
L. intermedia	8–35	3–8	28–30	Song in 4 parts, possibly 4 syllables, but wing movement not fully understood
L.karanae	146–166	5–10	Unknown	Echeme of 5–7 syllables, each showing a crescendo in impulses
L. lisae	150	(19–28)+ (7–8)+(8–11)	27(–30)	Syllable in 3 parts, final part shows a decrescendo in impulses
L. calabra	150–160	(11–18)+ (9–11)+(1–2)	35	Syllable in 3 parts, final part usually only one impulse
L. sicula	40–50	>8–15 (est.)	29	Crescendo within syllable, occasionally broken in 2 parts
Adreiniimon nuptialis	14–18	18–22	61	Crescendo within syllable

The song of *L. axeli* **sp. nov.** proves to be highly characteristic in the high number of impulses showing a crescendo within the unparted syllable. The species in this respect clearly differs from the other European and known Turkish species of *Leptophyes*. Also, the lower maximum of the frequency spectrum presents a clear difference with *Andreiniimon*. Moreover, all the species of *Leptophyes* with the exception of *L. albovittata* show a maximum frequency between 20 and 50kHz, whereas *Andreiniimon* shows a maximum at 60kHz.

The female response song has not yet been recorded but may be present in *L. axeli* **sp.n.** as it is known for many of the other species of *Leptophyes* (Heller *et al*. 2018).

Habitat. The species occupies shadowy spaces in open forests with a luxurious undergrowth of ferns, blackberries (*Rubus*) and roses (*Rosa*). This habitat is typical for the area West of the Lefka range which consists of a myriad of hilly ridges running mostly north to south, reaching up to 500–1000m, covered by maquis and smaller and larger patches of open forest especially along the lower parts of the valleys. Similar rugged landscapes with patches of open forest extend further to the north and east along the northern foothills of the Lefka range. The region where this kind of habitat is found is sparsely populated and agricultural activities are predominantly restricted to the valleys, in some places hill slopes being transformed to olive orchards.

Distribution. The three locations where the species has been found (fig. 24) are situated in the southwestern quadrant of Chania in western Crete which is an area in Crete with a relatively high annual rainfall (Varouchakis *et al.* 2018).

Etymology. The species is named in honour of Axel Hochkirch in recognition of his unwavering efforts and contributions in the field of Orthoptera research in general and Orthoptera conservation in particular. He adds to these disciplines by a wide variety of activities including his own research, supervising MSc and PhD students and chairing the IUCN Grasshopper Specialist Group.

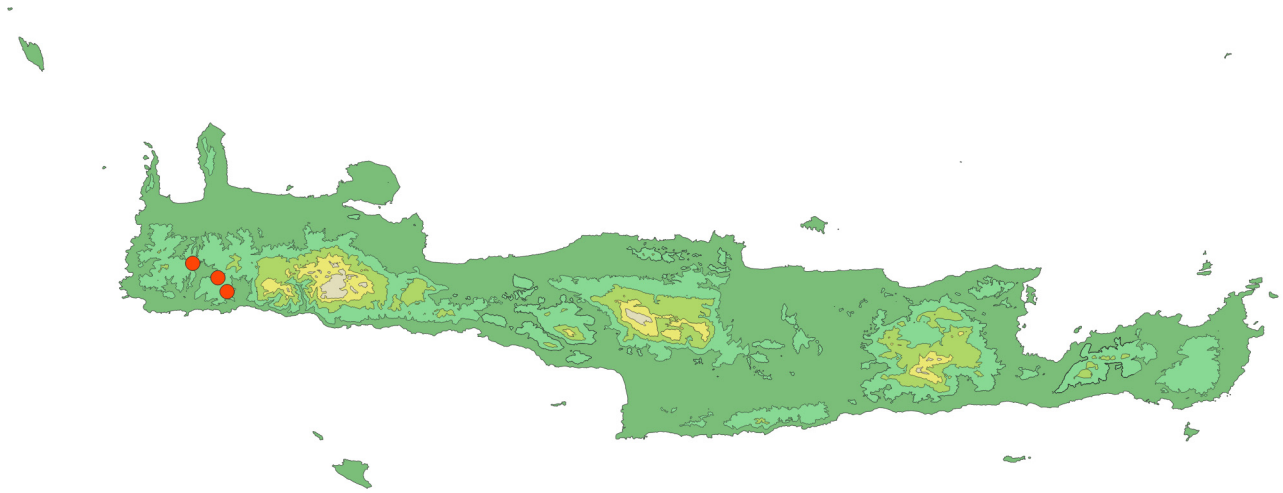


FIGURE 24. Distribution *Leptophyes axeli* **sp. nov.**

Discussion

Leptophyes is a rather heterogenous assembly of species. With the addition of *L. axeli* **sp. nov.**, the genus now includes 21 species (Cigliano *et al.* 2021). The heterogeneity within *Leptophyes* has been discussed by Bey-Bienko (1954) and further elaborated on by Sevgili (2004). Although individual characters like the width of the third antennal segment, shape of pronotum, the extent of fore wings covered by the pronotum, the male cercus or the male calling song allow to group species, the group composition depends largely on the set of characters used and/or the relative importance assigned to them. A phylogenetic analysis of *Leptophyes*, possibly including closely related genera like *Dasycercodes, Euconocercus, Kurdia* and *Orthocercodes* is needed to better assess the clades within *Leptophyes* and their species composition and assess whether the three species groups recognised by Bey-Bienko (1954) and the five *Leptophyes* species found in Turkey and the Middle-East (Sevgili 2004) form separate clades.

As with most sound producing Orthoptera, also in *Leptophyes* acoustic signals are species specific. Even closely related species like *L. karanae* and *L. helleri* can be easily separated based on the male calling song (Sevgili, 2004). Within the 'punctatissima' group alone, songs may consist of single uninterrupted syllables (e.g. *L. punctatissima*, *L. axeli* sp.n.), single interrupted syllables (e.g. *L. lisae*, *L. calabra*) and more complex songs (e.g. *L. intermedia*). Furthermore, it seems puzzling that the syllables of many species in *Leptophyes* only consists of a relatively low number of impulses, in relation to the number of stridulatory teeth, as if only a part of the teeth are used to produce the song. Based on the rather low number of specimens examined, there is as yet no indication that the number of impulses per syllable reflect the number of stridulatory teeth.

Despite the recent increase in number of species quite some species in *Leptophyes* are still poorly known and lack information on bioacoustics which hampers a much-needed re-evaluation of *Leptophyes*. The finding of *L. axeli* **sp. nov.** in Crete, an island visited several times by Orthopterists in the past 50 years came as a surprise. Still its small distribution area in a part of western Crete not yet visited by Orthopterists explains why it has not been found and described earlier. Its finding once more stresses the need for a survey of this genus including bioacoustics, not only in southern Europe as proposed by Kleukers *et al.* (2010) but also across Turkey, the Middle East and the region further East up to Kashmir.

Acknowledgements

We are thankful to the Directorate General for the Protection and Development of Forests and Rural Environments of the Ministry for Environment and Energy in Greece for issuing permits to Luc Willemse and Jos Tilmans in 2019 (178527/93/22-1-2-19) initially restricted to *Eupholidoptera* but kindly extended to also include the *Leptophyes* specimens. We like to thank Roy Kleukers for making the field images and preparing the specimens. Bertie-Joan

van Heuven is gratefully acknowledged for helping us with making an image of the stridulatory file with a scanning electron microscope. Ton de Winter is gratefully acknowledged for his assistance with the habitus photo's.

References

Bey-Bienko, G.Y. (1951) Studies on the long-horned grasshoppers of the USSR and adjacent countries (Orthoptera, Tettigoniidae). *Trudy Vsesoyeiznogo Entomologischeskojo Obshchestva, Moskva*, 43, 129–170.

Bey-Bienko, G.Y. (1954) Orthoptera Vol. II, Sect. 2. Bush-crickets. Subfam. Leaf Bush-crickets (Phaneropterinae). Fauna U.S.S.R. *Proceedings of the USSR Academy of Sciences*, 59, 1–385.

Bolívar, I. (1899) Orthoptères du voyage de Martinez Escalera dans l'Asi Mineure. *Annales de la Société Entomologique Belge*, 43, 583–607.

Cigliano, M.M., Braun, H., Eades, D.C. & Otte, D. (2022) Orthoptera Species File. Version 5.0/5.0. 27 October 2019. Available from: http://Orthoptera.SpeciesFile.org (accessed 15 March 2022)

Garai, A. (2002) Orthopteroid insects from Pakistan. *Esperiana*, 9, 431–447.

Giglio-Tos, E. (1893) Viaggio del Dott. E. Festa in Palestina, nel Libano e regioni vicine. V. Ortotteri. *Bollettino del Musei di Zoologia ed Anatomia Comparata della R. Universita di Torino*, 8 (164), 1–18. https://doi.org/10.5962/bhl.part.27226

Harz, K. (1970) New and little known Tettigoniidae (Orthoptera) from Israel and Africa. *Israel Journal of Zoology*, 19 (4), 191–201.

Heller, K.-G. (1988) *Bioakustik der europäischen Laubheuschrecken*. Josef Markgraf Verlag, Weikersheim, 358 pp.

Heller, K.-G. & Willemse, F. (1989) Two new bush-crickets from Greece, Leptophyes lisae sp. nov. and Platycleis (Parnassiana) tenuis sp. nov. (Orthoptera: Tettigoniidae). *Entomologische Berichten, Amsterdam*, 49 (10), 144–156.

Heller, K.G., Korsunovskaya, O., Massa, B. & Iorgu, I.S. (2018) High-speed duetting—latency times of the female acoustic response within the bush-cricket genera Leptophyes and Andreiniimon (Orthoptera, Phaneropteridae). *Zookeys*, 750, 45–58. https://doi.org/10.3897/zookeys.750.23874

Ingrisch, S. & Pavicevic, D. (2010) Seven new Tettigoniidae (Orthoptera) and a new Blattellidae (Blattodea) from the Durmitor area of Montenegro with notes on previously known taxa. *Zootaxa*, 2565 (1), 1–41. https://doi.org/10.11646/zootaxa.2565.1.1

Kleukers, R.M.J.C., Odé, B. & Fontana, P. (2010) Two new cryptic *Leptophyes* species from southern Italy (Orthoptera: Tettigoniidae). *Zootaxa*, 2506 (1), 26–42. https://doi.org/10.11646/zootaxa.2506.1.2

Naskrecki, P. & Ünal, M. (1995) The Orthoptera of Hatay province, S. Turkey. *Beiträge zur Entomologie*, 45, 393–419.

Paris, M. (1994) Catálogo de tipos de Ortopteroides (Insecta) de Ignacio Bolívar, I: Blattaria, Mantodea, Phasmoptera y Orthoptera (Stenopelmatoidea, Rhaphidophoroidea, Tettigonioidea, Grylloidea, Tetrigoidea). *EOS Revista española de entomología*, 69, 143–264. [1993]

Pavićević, D. & Ivković, S. (2014) Leptophyes asamo n.sp. (Orthoptera, Phaneropteridae) a new species from Eastern Herzegovina. *Fauna Balkana*, 3, 95–102.

Ragge, D.R. & Reynolds, W.J. (1998) *The songs of the grasshoppers and crickets of western Europe*. Harley Books, Colchester, Essex, x + 591 pp.

Ramme, W. (1939) Beiträge zur Kenntnis der palaearktischen Orthopterenfauna (Tettig. u. Acrid.). *III Mitteilungen aus dem Zoologischen Museum, Berlin*, 24 (1), 41–150.

Sardet, E., Roesti, C. & Braud, Y. (2021) *Grasshoppers of Britain and western Europe. A photographic guide*. Bloomsbury Wildlife, London, 295 pp.

Sevgili, H. (2004) Review of the Genus Leptophyes of Turkey with the description of a new species (Orthoptera, Phaneropterinae). *Transactions of the American Entomological Society*, 130 (1), 95–112.

SysTax. DORSA (2013) German Orthoptera Collections. Occurrence dataset. https://doi.org/10.15468/bdwtd8

Varouchakis, E.A., Corzo, G.A., Karatzas, G.P. & Kotsopoulou, A. (2018) Spatio-temporal analysis of annual rainfall in Crete, Greece. *Acta Geophysica*, 66, 319–329. https://doi.org/10.1007/s11600-018-0128-z

Willemse, F. & Kruseman, G. (1976) Orthopteroidea of Crete. *Tijdschrift voor Entomologie*, 119, 123–164.

Willemse, F. (1984) Catalogue of the Orthoptera of Greece. *Fauna Graeciae*, 1, i–xii + 1–275.

Willemse, F. & Willemse, L.P.M. (2008) An annotated checklist of the Orthoptera-Saltatoria from Greece includig an updated bibliography. *Articulata Beiheft*, 13, 1–91.

Willemse, L., Kleukers, R. & Od, B. (2018) *The Grasshoppers of Greece*. EIS Kenniscentrum Insecten and Naturalis Biodiversity Center, Leiden, 439 pp.

Willemse, L., Tilmans, J., Kotitsa, N., Trichas, A., Heller, K.-G., Chobanov, D. & Odé, B. (2022) New species and data of *Eupholidoptera* (Orthoptera: Tettigoniidae) from Crete, Gavdos, Gavdopoula and Andikithira. [in preparation]