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Rhacocleis andikithirensis a new bush-cricket from Greece (Orthoptera: Tettigoniidae: Tettigoniinae)

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Abstract

A new species of the genus *Rhacocleis*, *R. andikithirensis* sp. nov., is described from Greece. It was first discovered on the islet of Andikithira but its distribution area also includes the western Cyclades. Its relation with other members of the genus based on morphological and bioacoustical traits is discussed.

Key words

katydid, new species, species description, systematics, bioacoustics, island

Introduction

In a 1982 survey of the Greek species of *Rhacocleis* (Orthoptera: Tettigoniidae: Tettigoniinae), eleven species were recorded including *R. werneri* and *R. edentata* which were then described as new species (Willemse 1982). Since then another four species have been described from Greece: *R. derrai* (Harz 1983) from Crete, *R. ferdinandi* (Willemse & Tilmans 1987), *R. lithoscirtetes* and *R. crypta* (Willemse & Willemse 2005a) from the Greek mainland.

In May 2002 the first author and his wife collected a male nymph on the islet of Andikithira. When it became adult in June it proved to belong to *Rhacocleis*, but clearly differed from any of the species described under *Rhacocleis* so far.

When submitting the manuscript with the description of the new species in 2004, one of the reviewers advised to collect more material. This advice has been followed and during a second trip to Andikithira in the spring of 2008, 20 more specimens (male and female) from the very same locality were collected. Meanwhile, a female collected in 2005 on the Cycladic island of Milos proved identical with the species from Andikithira. In 2010 the species from Andikithira was also found on the Cycladic islands of Sifnos, Serifos and Kythnos. Based on the more extensive material at hand, in the current paper the new species is finally described, including its morphology and bioacoustics.

Material and methods

Material.—All specimens were collected as nymphs by the use of an insect net. They were reared indoors in cylindrical plastic containers with small twigs of *Sarcopoterium spinosum* or *Cistus* spp. and fed with oat flakes.

Generic placement and classification.—The species clearly fits in with *Rhacocleis* based on its pronotum (no keel), shape of pro-, meso- and meta-sternum, the (number of) spurs on the fore and hind tibia and the long plantulae. Regarding the discussion on the validity of a separate generic status for *Pterolepis* and *Rhacocleis*, we follow the proposal of Willemse & Willemse (2005b, p.264) to consider them as separate genera based on the consistent difference in the armature of the fore tibia. This classification is also followed in the Orthoptera Species File (Eades *et al.* 2015). Because of the close relationship of both genera however, the new species was also compared with all known taxa of the genus *Pterolepis*.

Recordings and acoustic analysis.—For song recordings an Edirol 4 channel portable recorder and wave editor R-4 (10-40,000 Hz freq. resp.) was used combined with a Sennheiser K6 module and ME66 microphone (50-20,000 Hz freq. resp.). In one instance a Sony DAT recorder (TCD-D10, 10-20,000 Hz freq. resp.) was used. Although the song of *Rhacocleis* species shows a wide range of frequencies, including frequencies well above 20 kHz, frequencies below 20kHz are sufficient to describe the relevant parameters of the song.

All recordings were done indoors, at night (mostly around midnight) without artificial light and at temperatures between 21.3 and 24.8 °C. The specimens were kept alone in cylindrical plastic containers with a height of 12 cm and a diameter of 5.5 cm, the open tops of the containers covered with mosquito netting. Distance from specimen to microphone during recording varied from 3 to 15 cm.

Song analysis was performed with Bias Peak software and oscillograms were assembled using Praat software.

Song terminology used was adopted from Ragge & Reynolds (1998) who describe the main functional types of song and the structural elements of the song.

Calling song: the song produced by an isolated male
Syllable: The sound produced by one to-and-fro movement of the stridulatory apparatus. May be devided in two hemisyllables, one for the opening of the wing and one for the closing.
Echeme: A first-order assemblage of syllables.

Photographs.—For the stack photographs a Zeiss SteREO Discovery. V20 stereomicroscope was used, combined with a Zeiss AxioCam MRc5 microscope camera. For photographs taken immediately post mortem, a Canon EOS 5D digital camera was used mounted on a Zeiss Stemi SV8 stereomicroscope. The habitus photographs were taken with a Canon EOS 5D digital camera using a Canon zoom lens EF 28-90 mm F 4-5.6 with three combined Hama Close-Up lenses 1, 2 + 4×.

Abbreviations of depositories

JTCG: Jos Tilmans collection, Gouda, The Netherlands.
RMNH: Naturalis Biodiversity Center (formerly Rijksmuseum van Natuurlijke Historie) Leiden, The Netherlands.

Results

Rhacocleis andikithirensis sp.nov.
(Figs 1-31a, 32)

urn:lsid:Orthoptera.speciesfile.org:TaxonName:478934

Rhacocleis andikithiriensis sp. in litt. (Tilmans, in press/forthcoming): Willemse & Willemse 2005a, p.168; 2005b, pp.265, 266, Table 1, Table 2; 2008, pp.32, 85.

Holotype:♂, labeled: "HELLAS, Andikithira, 50 m , 27.V.2008 / 0,6 km S.E.S. Potamos / WGS84 N. 35°52.600′ E. 023°17.426′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid". With additional labels: "EX LARVA / imago: 15.VII.2008" and "SPECIMEN NR 2008.023.03". (JTCG)

Allotype: ♀, labeled: "HELLAS, Andikithira, 50 m , 27.V.2008 / 0,6 km S.E.S. Potamos / WGS84 N. 35°52.600′ E. 023°17.426′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid". With additional labels: "EX LARVA / imago: 9.VIII.2008" and "SPECIMEN NR 2008.023.16". (JTCG)

Paratypes: 23 ♂♂ and 21 ♀♀, labeled:

Andikithira: 1 ♂: "HELLAS, Andikithira, 50 m, 8/9.V.2002 / 0,6 km S.E.S. Potamos / WGS84 N. 35°52.600′ E. 023°17.426′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2002.003.15"; 8 ♂♂ and 8 ♀♀: "HELLAS, Andikithira, 50 m, 27.V.2008 / 0,6 km S.E.S. Potamos / WGS84 N. 35°52.600′ E. 023°17.426′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2008.023.03".

Milos: 1 ♀: "HELLAS, Milos, 150 m, 7.VI.2005 / Korakia, 2,2 km S.W.S. Pollonia / WGS84 N. 36°44.774′ E. 024°31.445′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2005.020.02".

Sifnos: 4 ♂♂ and 5 ♀♀: "HELLAS, Sifnos, 250 m, 14-16.V.2010 / 0,6 km N.W.N. Troulaki / WGS84 N. 37°00.892′ E. 024°40.330′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2010.017.03" up to "2010.010.11"; 1 ♂: "HELLAS, Sifnos, 50 m, 14.V.2010 / 0,2 km E.S.E. Cherronisos / WGS84 N. 37°02.128′ E. 024°39.261′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2010.018.01".

Serifos: 1 ♂: "HELLAS, Serifos, 350 m, 10.V.2010 / 4,9 km N.E. Megalo Chorio / WGS84 N. 37°09.494′ E. 024°27.761′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2010.007.01".

Kythnos: 1 ♀: "HELLAS (N. Kythnos) Apokrisi / beach, 5 m, L. Willemse, 18-06-2005 / N 37°24′47.4″ E 024°23′52.0″, with additional label "Ex juvenile, died 2.VIII.2005"; 7 ♂♂ and 6 ♀♀: "HELLAS, Kythnos, 50 m, 12/13.V.2010 / 2 km E.S.E. Merichas / WGS84 N. 37°22.950′ E. 024°25.040′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2010.010.04" up to "2010.010.16"; 1 ♂ and 1 ♀: "HELLAS, Kythnos, 25 m, 13.V.2010 / 2 km S.W.S. Liotrivi / WGS84 N. 37°21.829′ E. 024°26.799′ / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid", with additional label "SPECIMEN NR 2010.016.01" and "SPECIMEN NR 2010.016.02".
(RMNH: 1 ♂ (spec.nr 2008.023.08) and 1 ♀ (spec.nr 2008.023.17) from Andikithira 1 ♂ (spec.nr 2010.010.15) + 1 ♀ (spec.nr 2010.010.14) from Kythnos; JTCG: all other paratypes).

Sound recordings.—

1. Recording 081005010321; specimen 2008.023.05, paratype Andikithira; recorded with Edirol R-4; recording date and time 05.10.2008 01.03; temperature unknown.

2. Recording 100828010228; specimen 2010.016.01, paratype Kythnos; recorded with Edirol R-4; recording date and time 28.08.2010 01.02; temperature 22.2 °C.

3. Recording 100830004801; specimen 2010.018.01, paratype Sifnos; recorded with Edirol R-4; recording date and time 30.08.2010 00.48; temperature 21.3 °C.

4. Recording 100904001658; specimen 2010.017.09, paratype Sifnos; recorded with Edirol R-4; recording date and time 04.09.2010 00.16; temperature 22.2 °C.

5. Recording 100905004525; specimen 2010.010.10, paratype Kythnos; recorded with Edirol R-4; recording date and time 05.09.2010 00.45; temperature 21.9 °C.

6. Recording 100913000127; specimen 2010.010.08, paratype Kythnos; recorded with Edirol R-4; recording date and time 13.09.2010 00.01; temperature 22.4 °C.

7. Recording tape 2002-4-18; specimen 2002.003.15, paratype Andikithira; recorded with Sony TCD-D10; recording date and time 12.08.2002 23.55; temperature 22.7 °C.

8. Recording tape 2002-4-19; specimen 2002.003.15, paratype Andikithira; recorded with Sony TCD-D10; recording date and time 24.08.2002 01.35; temperature 22.8 °C.

9. Recording tape 2002-4-20; specimen 2002.003.15, paratype Andikithira; recorded with Sony TCD-D10; recording date and time 27.08.2002 23.45; temperature 24.8 °C.

10. Recording tape 2002-4-15/16; specimen 2002.003.15, paratype Andikithira; recorded with Sony TCD-D10; recording date and time 08.08.2002 00.50; temperature 24.4 °C.

All recordings are in the collection of Jos Tilmans and copy conform Baudewijn Odé.

Male: Medium sized (Figs 1-2 and Table 1). General appearance and characters as in *Rhacocleis germanica* (Herrich-Schäffer, 1840). Integument glossy.

Head: Sides of fastigium of vertex slightly diverging to the tip.
Thorax: Pronotum (Figs 3-4) shiny with front margin slightly concave medially; metazona short, dorsally flattened; hind margin obtuse, almost straight; lateral lobes along fore and lower edges distinctly impressed; hind margins of paranota clearly raised.

Forewing (Figs 5-6) reaching or slightly surpassing hind margin of first abdominal tergite; apex of left elytron rounded, that of right elytron very broadly rounded, nearly transverse. Stridulatory file of left elytron (Figs 6-7) slightly sinuate consists of 95 to 110 teeth; shortest distance between proximal and distal end 2.3 mm, in mid greatest width of teeth 0.025 mm, spacing of teeth in mid two third part of the stridulatory file about 35 per mm.
Legs: Fore femur a little shorter than pronotum; hind femur nearly three times as long as pronotal length. Free plantulae slightly longer than first tarsal segment. Important traits in the armature of the legs: fore tibia with an upper outer margin presenting an apical spur and inner margin armed with 1 to 3 spurs; hind tibia ventrally with a single pair of large apical outer spurs but no inner spurs.
Abdomen: Abdominal tergites with weak median keel. Last abdominal tergite apically with a shallow dorsomedian depression furnished with some long hairs; hind margin medially slightly

Fig. 1. *Rhacocleis andikithirensis*, holotype male, habitus, dorsal.

Fig. 2. *Rhacocleis andikithirensis*, holotype male, habitus, lateral.

Fig. 3. *Rhacocleis andikithirensis*, pronotum, dorsal, paratype male Andikithira 2002 (immediately *post mortem*).

Fig. 4. *Rhacocleis andikithirensis*, pronotum, lateral, paratype male Andikithira 2002 (immediately *post mortem*).

Fig. 5. *Rhacocleis andikithirensis*, forewings *in situ*, holotype male.

Table 1. Minimum and maximum measures (mm) in *Rhacocleis andikithirensis*. Fore wings: only visible part surpassing margin pronotum measured. Subgenital plate: length / width. Distance teeth cercus: distance between inner and subapical tooth.

	Andikithira	Milos	Sifnos	Serifos	Kythnos
Males	n = 10	n = 0	n = 5	n = 1	n = 8
body	18.8-27.6		22.2-24.4	20.0	17.6-24.6
pronotum	6.5-7.9		6.2-6.8	6.4	5.9-6.8
fore wing	1.0-3.2		1.4-1.7	1.2	1.2-2.0
hind femur	18.6-22.9		19.0-21.3	18.2	17.5-20.7
subgenital plate	2.4/1.5-3.2/1.8		2.9/1.7-3.4/1.9	2.1/1.4	2.7/1.6-3.2/1.8
distance teeth cercus	0.6-0.7		0.5-0.6	0.6	0.5-0.6
Females	n = 8	n = 1	n = 5	n = 0	n = 7
body	18.8-23.7	25.4	21.3-23.9		20.0-22.9
pronotum	7.0-8.2	8.5	6.8-7.6		6.7-7.9
fore wing	0.0-1.6	1.2	0.0-1.3		0.3-1.4
hind femur	19.2-25.5	23.1	21.5-22.6		20.0-22.8
subgenital plate	2.0/1.9-2.6/1.9	2.5/2.2	2.4/2.1-3.3/2.3		2.4/1.9-2.8/1.8
ovipositor	15.5-17.5	17.5	15.2-16.1		13.8-15.9

to clearly emarginate, variably delimited by two weakly rounded (arrowed in Fig. 8) or more pronounced subtriangular lobes (arrowed in Fig. 9).

Cercus (Figs 8-9) short, granular, stocky with golden coloured short hairs, from dorsal view incurved with a well developed and sclerotized upwards angled single inner tooth (arrowed with abbreviation IT in Figs 10-11) inserted in median third part of cercus; apex of cercus broad, margin sometimes slightly concave, outer side obtuse-angled, inner side slightly curved downwards and armed with a single medially directed strong well-sclerotised subapical tooth (arrowed with abbreviation ST in Figs 10-11).

Subgenital plate (Fig. 12) in ventral view slightly longer than wide, tapering with median keel, triangular apical incision; basal area of the subgenital plate V-shaped, membraneous and sharply deepened in most dried specimens; styli slender, normal shape and size.

Titillators (Figs 11, 13-18): robust, well-sclerotised, smooth, shiny; first section of the basal part strongly diverging, transverse, the second section at a more or less right-angle to the first; apical part towards the apex downcurved, twisted inwards and slightly flattened, dorsally and ventrally with a longitudinal ridge; tip of the apex hook-shaped. To distinguish between basal and apical sections, Galvagni's (1981, fig. 12) method was followed.

Coloration.—General coloration in living material greyish to brown, with darker brown marbling (Figs 19-21); becoming more reddish in dried material. Clypeus and frons whitish to yellowish, brown marbled, respectively with 2 and 4 symmetrical arranged brown to black spots (Fig. 22); frons in the area below the eyes also with brown to black spots and in many specimens a curved black line from under the eye to the lateral margin of the frons. Vertex whitish to purplish brown, its lateral margins black; fastigium in most specimens medially with a meandering yellow dark-bordered line. Head (Fig. 3) in most specimens with a dark brown to black band behind the eye with a yellow white stripe dorsally that is again dark bordered dorsally. Pronotal lateral lobe with a whitish band along hind and lower margin, sharply black-bordered dorso-posteriorly. Forewing light brown transparent to whitish with dark anterior and whitish posterior veins. Tergites medially with a black spot on the hind margin which together form a longitudinal row. Sternites and subgenital plate creamy white. Cercus pale brown with tip of inner and apical tooth darker brown. Basal part of titillator and hook-shaped tip dark brown, apical part lighter brown. Femora yellowish, grey and brown marbled. Fore and mid femora dorsally on inner margin with brown marks forming an untidy parallel stripe along the length of the femora; basis of fore and mid femora with a dark brown band; the creamy white knees are bordered by a dark brown band on fore and mid femora and tibiae. Basal half of dorsum and first half of outside of hind femur with dark brown transverse stripes forming longitudinal stripes. The ventral spines of the femora dark brown. Fore and mid tibiae and underside of hind tibiae yellowish brown with blackish brown spots at base of the yellowish tibial spines with blackish brown tips; upper side of hind tibiae pale brown with a dark brown band near basis, dorsal spines with brown tips.

Female: Medium sized. General appearance (Figs 23-24) as in male. Forewings lateral, nearly completely covered by pronotum, just reaching the fore margin of the 1st tergite (arrowed in Fig. 25). The 6th abdominal sternite gibbous, the 7th abdominal sternite with a triangular ridge at its front margin pointing to the subgenital plate (Figs 26-27).

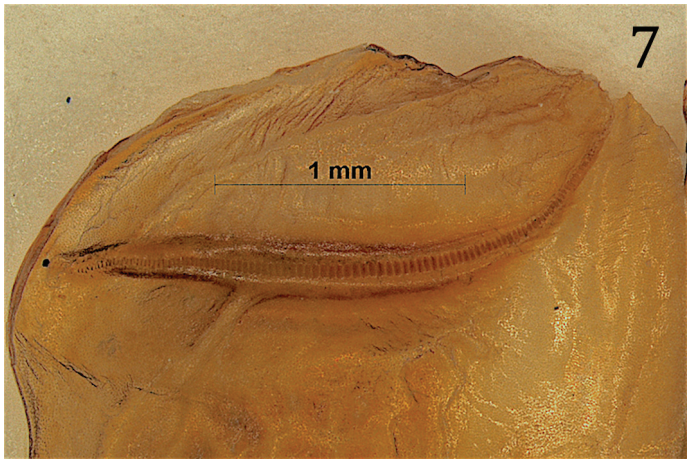
Cercus conical. Ovipositor (Fig. 24) 0.7 times as long as hind femur; nearly straight in profile, weakly curved up near apex. Subgenital plate (Figs 26-28) subelliptical with a transverse fold; apical sclerite semi-circular with a U- or V-shaped incision, posterior part convex, lateral margins swollen, anterior part inflated with clear median keel; basal sclerite inflated with median keel and its lateral margins slightly converging towards the 7th abdominal sternite.

Coloration paler as male with less marking and spots on body and legs (Figs 29-30). Tegmina light brown to whitish. Apex of ovipositor dark brown.

Measurements.— (in mm) See Table 1.

Acoustics.— (Fig. 31a) The song consists of an echeme, with usually quite evenly spaced syllables, repeated at the rate of about 25-35/s. Syllable repetition rate is largely temperature-dependent and has been measured between 21 and 25 °C. Syllables consist clearly of a closing and opening hemisyllable, one of which is loud and one is weak. In *Rhacocleis*, usually the opening hemisyllable is weak and the closing hemisyllable loud. However we were not able to confirm this in *Rhacocleis andikithirensis*.

The song shows a large amount of variation, especially in the length of the echeme, varying between about 200ms and 30s. Usually every echeme shows a crescendo in the course of the first few syllables and stays constantly loud thoughout the echeme. In prolonged echemes, however, it seems that in the course of an echeme



Figs 6-7. *Rhacocleis andikithirensis*, stridulatory file, paratype male Andikithira 2002.

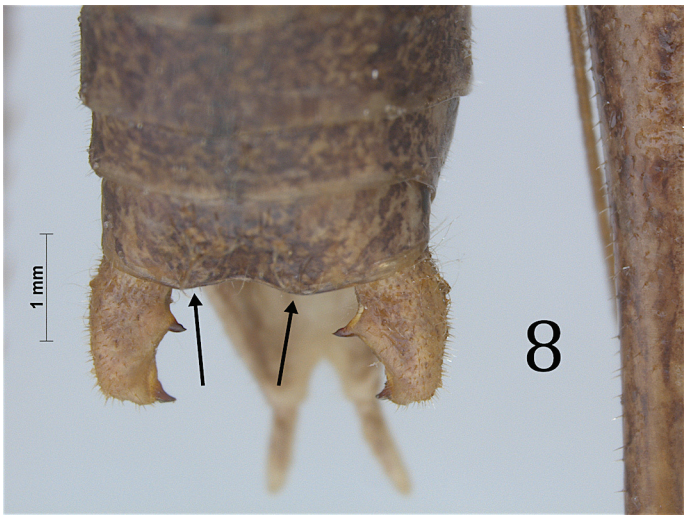


Fig. 8. *Rhacocleis andikithirensis*, last abdominal tergite and cerci, dorsal, holotype male.

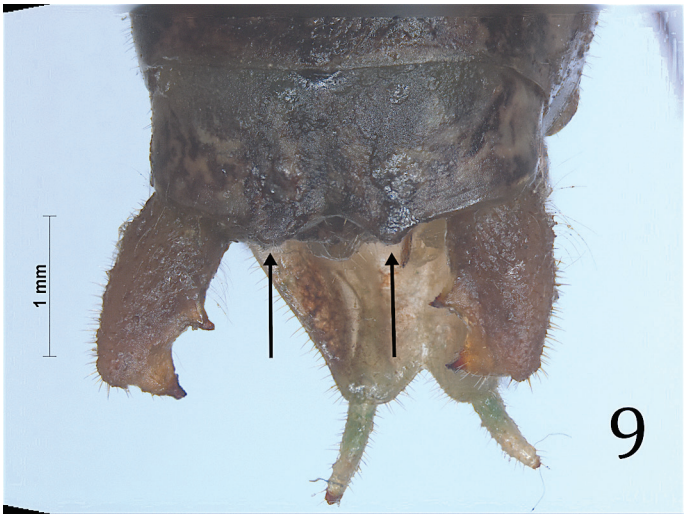


Fig. 9. *Rhacocleis andikithirensis*, last abdominal tergite and cerci, dorsal, paratype male Kythnos.

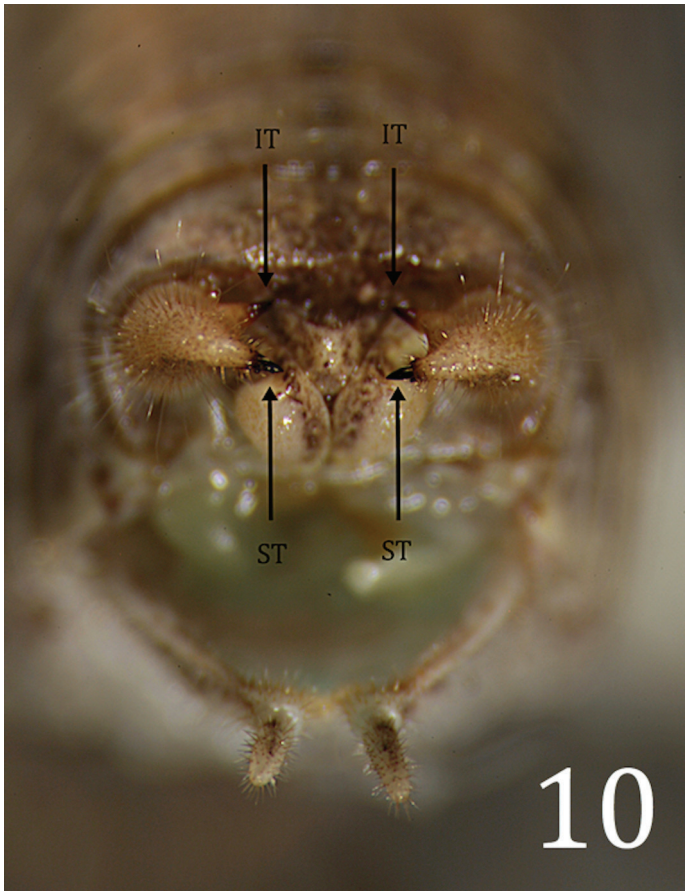


Fig. 10. *Rhacocleis andikithirensis*, cerci *in situ* (IT= inner tooth, ST= subapical tooth), dorsoposterior, holotype male (immediately *post mortem*).

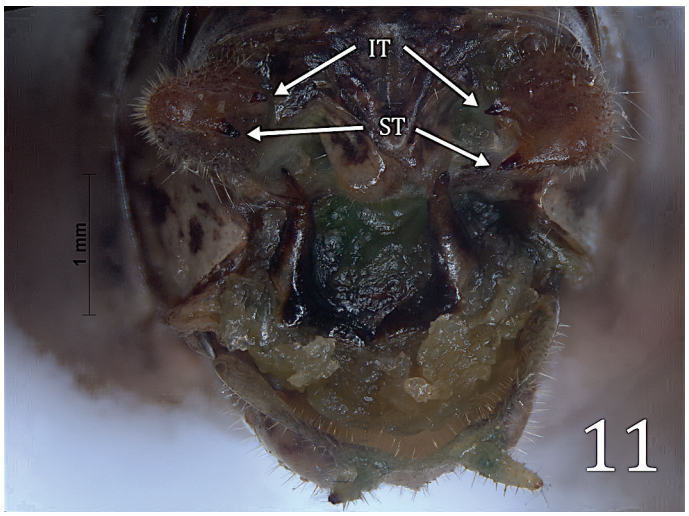


Fig. 11. *Rhacocleis andikithirensis*, cerci *in situ* (IT= inner tooth, ST= subapical tooth), dorsoposterior; titillators pulled outwards and bent over for ventral view, paratype male Kythnos.

Fig. 12. *Rhacocleis andikithirensis*, subgenital plate and cerci, ventral, holotype male.

Fig. 13. *Rhacocleis andikithirensis*, titillators, ventral (slightly from right), holotype male.

Fig. 14. *Rhacocleis andikithirensis*, titillators, ventral, (slightly from right and a bit more dorsal), holotype male.

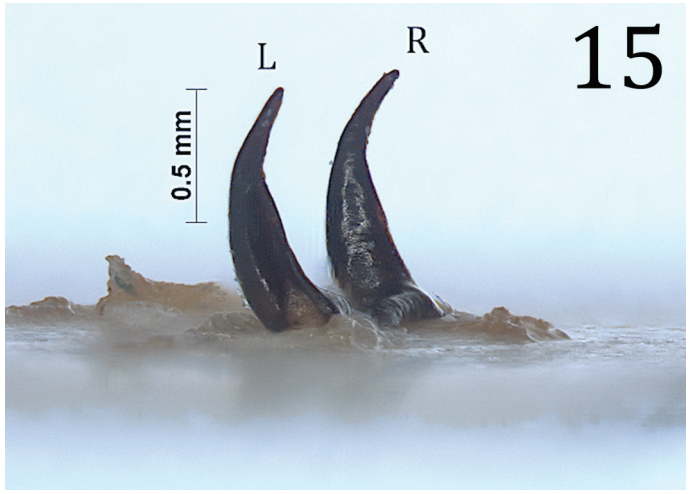


Fig. 15. *Rhacocleis andikithirensis*, titillators, lateral, slightly posterior), holotype male.

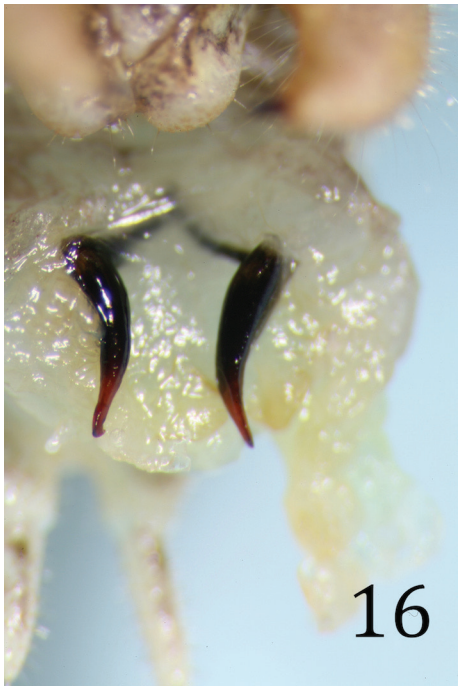


Fig. 16. *Rhacocleis andikithirensis*, titillators *in situ*, dorsal, holotype male (immediately *post mortem*).

Fig. 17. *Rhacocleis andikithirensis*, titillators *in situ*, ventral, holotype male (immediately *post mortem*).

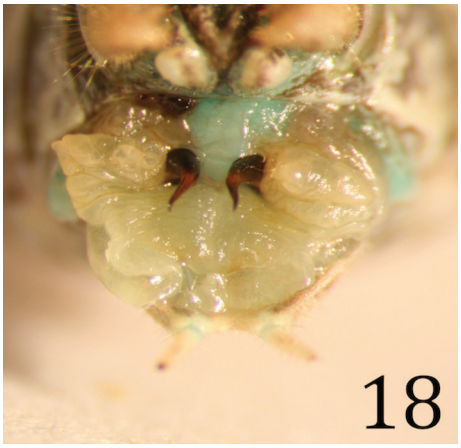


Fig. 18. *Rhacocleis andikithirensis*, titillators *in situ*, posterior, paratype male Kythnos (immediately *post mortem*).

Fig. 19-20. *Rhacocleis andikithirensis*, holotype male, in vivo in studio.

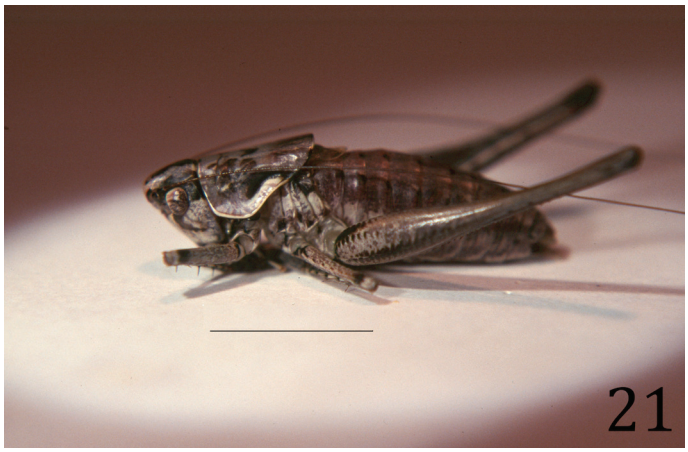


Fig. 21. *Rhacocleis andikithirensis*, paratype male, Andikithira 2002 (immediately *post mortem*) (scale bar 10 mm).

Fig. 22. *Rhacocleis andikithirensis*, clypeus and frons, paratype male Andikithira 2002 (immediately *post mortem*).

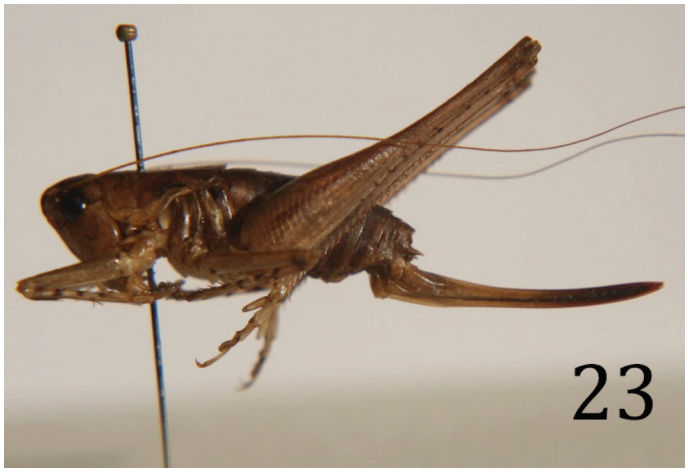


Fig. 23. *Rhacocleis andikithirensis*, allotype female, habitus, lateral.

Fig. 24. *Rhacocleis andikithirensis*, allotype female, habitus, dorsal.

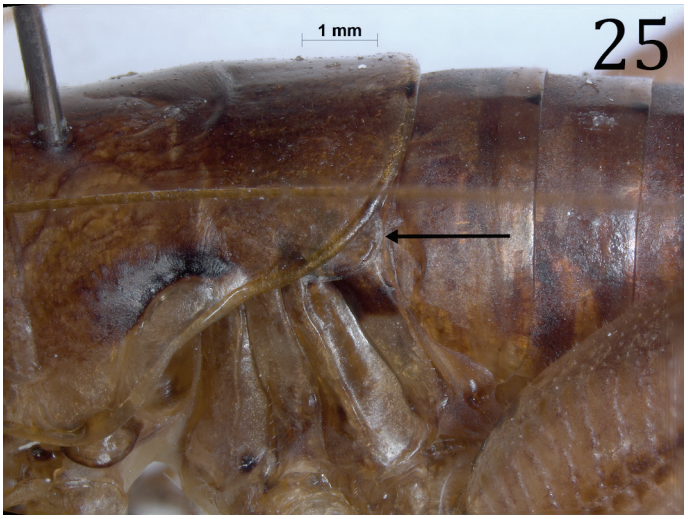


Fig. 25. *Rhacocleis andikithirensis*, left forewing, lateral, allotype female.

Fig. 26. *Rhacocleis andikithirensis*, 6th and 7th abdominal sternites and subgenital plate, ventral, paratype female Andikithira.

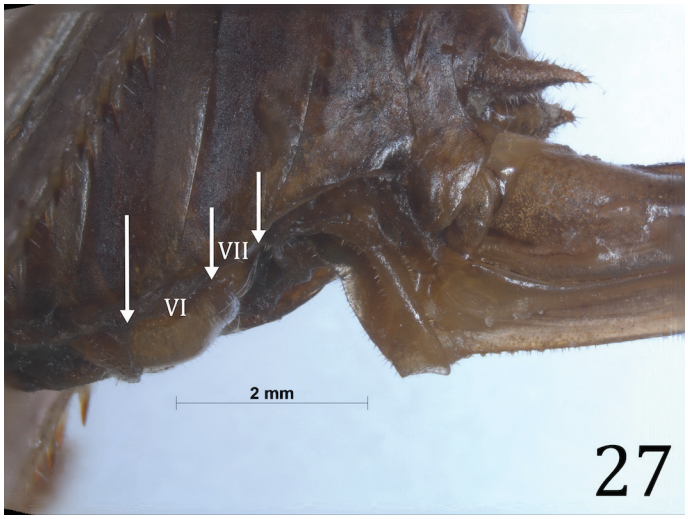


Fig. 27. *Rhacocleis andikithirensis*, 6th and 7th abdominal sternites and subgenital plate, lateral, paratype female Andikithira.

Fig. 28. *Rhacocleis andikithirensis*, subgenital plate, ventral, paratype female Andikithira (immediately *post mortem*).

Figs 29-30. *Rhacocleis andikithirensis*, paratype female Andikithira, in vivo in studio.

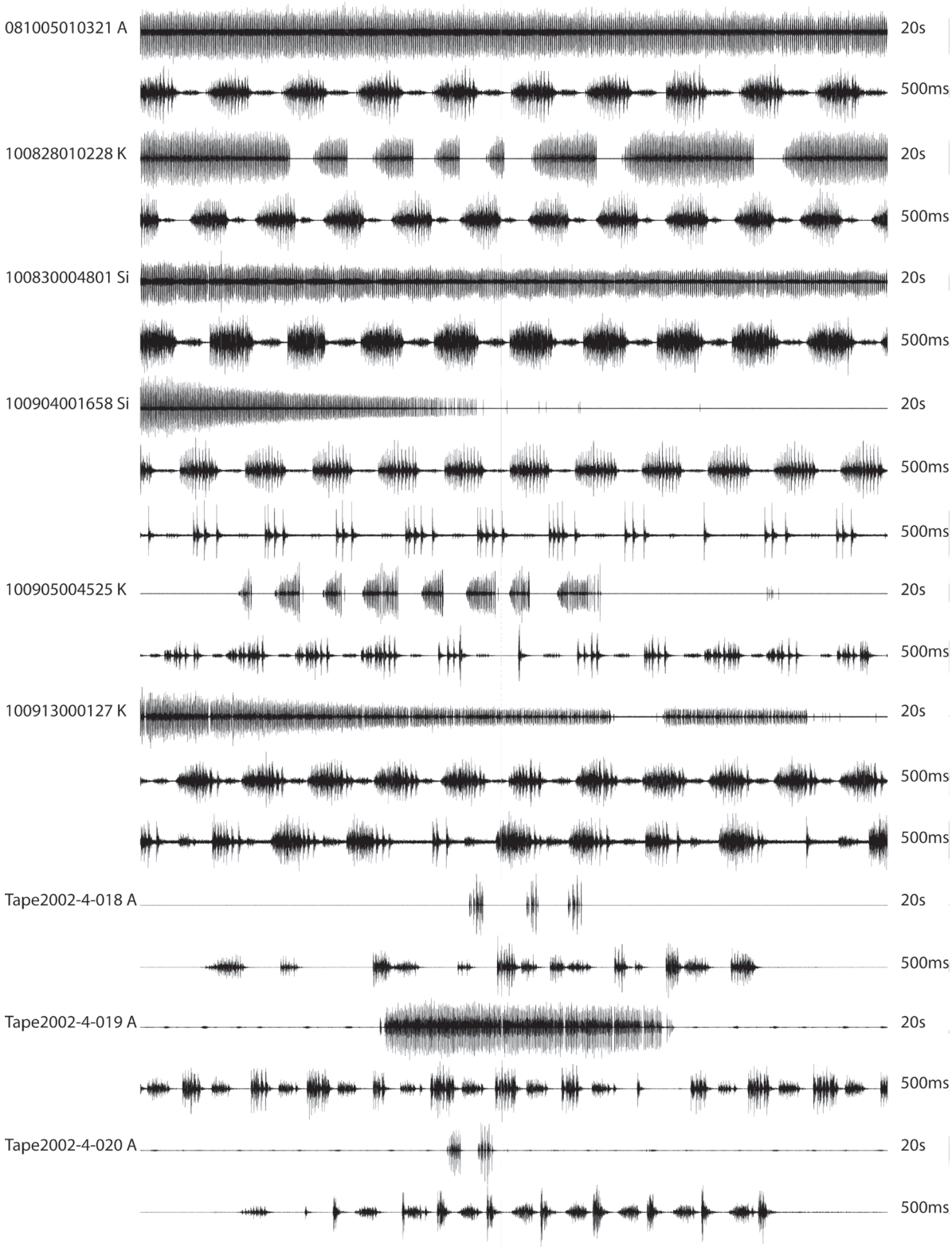


Fig. 31a. Oscillograms of sound recordings from *Rhacocleis andikithirensis*. Each recording (with recording number and abbreviation A, K or Si for Andikithira, Kythnos or Sifnos) is represented by two or three oscillograms, one lasting 20s, and one or two lasting 500ms, taken from the 20s oscillogram above. For recording details, see materials.

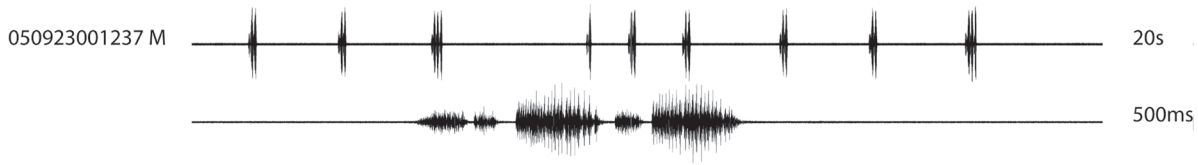


Fig. 31b. Oscillograms of sound recording from *Rhacocleis insularis*. Labeled: "HELLAS, Milos, 150 m, 7.VI.2005 / Korakia, 2,2 km S.W.S. Pollonia / WGS84 N. 36°44.774' E. 024°31.445' / legnt. J.M. Tilmans & J.F.R. Tilmans-Smid". With additional labels: "EX LARVA / imago: 20.VII.2005" and "SPECIMEN NR 2005.020.01". (JTCG). Recording 050923001237; recorded with Edirol R-4; recording date and time 23.09.2005 00.12; temperature 20.0 °C. Two oscillograms, one lasting 20s, the other one lasting 500ms, taken from the 20s oscillogram above. Recording in the collection of Jos Tilmans and copy conform Baudewijn Odé.

syllables become weaker and also less dense, as if fewer stridulatory teeth are being used. In some cases it seems that at the end of an echeme only an irregular ticking remains. It may be argued that this is caused by tiring of the wing muscles.

The variation found does not show any correlation with the geographic provenance. Also the same individual may emit both longer and shorter echemes. It only seems to be a matter of intensity of singing, possibly dependent upon temperature or time after the start of the singing.

One recording shows sounds produced by shaking the body rapidly. This tremulation produces a short rustling sound, which in *Rhacocleis* species usually is emitted in social interaction.

Diagnosis.—The male of *R. andikithirensis* is characterized by the unique shape of the cercus (Figs 8-9) and the titillator (Figs 11, 13-18). Females of *R. andikithirensis* are diagnosed by the shape of the subgenital plate (Figs 26-28).

Distribution.—Known from the island of Andikithira and the western Cycladic islands of Milos, Sifnos, Serifos and Kythnos (Fig. 32).

Andikithira is an island of only 20.4 km^2, geographically isolated about halfway between two islands: in the north the island of Kithira, an offshore island of extreme southeastern Peloponnese, and in the south the most northwestern point of Crete. The shortest distance between Kithira and the NW coast of Andikithira is 32 km and between the S. coast of Andikithira and Crete also 32 km. The islands of Milos (151 km^2), Sifnos (73 km^2), Serifos (73 km^2) and Kythnos (99 km^2) form part of the western arch of the Cyclades roughly in a line from south to north. Kythnos is located nearest to continental Greece at a distance of 38 km to the most southeastern part of Attica. Milos, situated at the greatest distance 102 km east of the Peloponnese, lies nearest to Andikithira at a distance of 124 km.

Habitat.—On all the islands where the new species was collected, it was found in the typical Aegean garrigue and phrygana formations with herbaceous plants and small bushes (Figs 33-34). In many cases the new species was hiding in bushes of *Sarcopoterium spinosum*. This habitat is widespread on the islands where the species has been found.

Population.—Although the species is very difficult to catch, it appears to be not very rare in the typical garrigue and phrygana habitat. The population size is expected to be stable and no major threats are known.

Etymology.—Although during the long period of maturation of the manuscript of this publication it became clear that this new species is not confined to Andikithira but also is present on several of the Western Cyclades, we have chosen the nomen *andikithirensis*. Not only as a salute and tribute to that remote, often forgotten Greek island, but also as a nomen that is unique in Orthoptera and therefore easy to memorize within the order. Furthermore, there has already been referred to the new species under the provisional name of *R. andikithiriensis* in some publications (see the references in the beginning of the Results paragraph).

Discussion

Differential diagnosis.—*R. andikithirensis* differs in the male sex from all other 63 taxa of *Rhacocleis* and *Pterolepis* by the unique shape of cercus and titillator.

The male cercus of most taxa belonging to the genera *Rhacocleis* and *Pterolepis* is longer, slender, armed with a single apical and a (sub)basal tooth. Some taxa within *Rhacocleis* and *Pterolepis* show male cerci that are more robust or possess another armature, however still differing considerably from that of the new species.

The cercus of the male of *R. ayali* Karabağ 1974 (l.c. fig. 2) is also short but shows a more tapering incurved distal half, its apex ending in a blunt tooth and an inner subapical tooth.

In *R. derrai* the cercus of the male possesses in the median part a bi-dentate inner tooth; the apex of the cercus is rounded (Harz 1983, fig. 1; see also Willemse & Willemse 2005a, fig. 4 and the online photograph in Eades *et al*. 2015).

The form of the cercus of the male of *R. edentata* is quite short and thick with the outside of the apex obtuse-angled like in the new species, but the inside of the apex ends in a long tooth and not in a shorter and downcurved subapical tooth. Moreover its cercus misses the inner tooth inserted in the median third; only in some specimens of *R. edentata* a basal inner tooth is present (Willemse & Willemse 2005a, p.168 and figs 1-3).

The male of *Pterolepis lagrecai* (Fontana & Massa 2004, figs 6-10) shares with the new species the inner tooth inserted on the median third. The apex of its cercus however is not broad and blunt like in the new species. Instead, the distal half of its cercus is tapering, strongly incurved, ending in an apical tooth.

The titillators of *R. andikithirensis* are also unique in the first section of the basal part strongly diverging, transverse, and the second section at a more or less right-angle to the first (see Figs 11, 13-14). Within the genus *Rhacocleis* only the titillators of *R. derrai* show some resemblance. But a closer look makes clear that its basal parts are incurved instead of showing a more rectangular form like in the new species. Moreover the apical parts of the titillators of *R. derrai* are far more outcurved than in the new species (Harz 1983, fig. 3; see also the online photograph in Eades *et al*. 2015). The titillators of *P. lagrecai* also show some resemblance but they are more S-shaped than transverse, rugose instead of smooth, and the tip of their apex is flattened and expanded (Fontana & Massa 2004, p.482 and figs 11, 12) instead of hook-shaped as in the new species.

Fig. 32. Map of Aegean area, Greece, with distributions of *Rhacocleis andikithirensis* sp. nov. and *Rhacocleis insularis* Ramme 1928.

Within the genus *Rhacocleis* there is no other taxon that shows in the female sex the combination of a subgenital plate with a transverse fold, the apical sclerite semi-circular with a moderate incision in the hind margin and the basal sclerite nearly unmodified except for a median keel. In the genus *Pterolepis* only the female sex of *P. lagrecai* possesses a subgenital plate with the same combination of traits (Fontana & Massa 2004, p.483 and fig. 19).

The song of *R. andikithirensis* is well-delimited. Despite the large variation recorded in the length of the echeme, it is concluded that the song with its characteristic syllabic structure and the presence of long echemes has to be assigned to one species. Within the genus *Rhacocleis* and *Pterolepis* long echemes are as far as presently known to exist in *R. maculipedes* (Ingrisch, 1983), *R. derrai*, *R. edentata* and *R. thyrrenica* La Greca 1952 (Heller 1988, Odé & F Willemse personal recordings, DORSA/SYSTAX). Those species are morphologically well distinguished from *R. andikithirensis*. We were not able to compare the song of *R. andikithirensis* with the song of *R. ayali* and *P. lagrecai* as the song of these two species is not known.

Combining the characteristic features of cerci and titillators of the male and the subgenital plate of the female of the new species and comparing that combination with all other taxa of *Rhacocleis* and *Pterolepis*, *R. andikithirensis* shows the most similarities with *P. lagrecai* from Libya.

Fig. 33. Overview of type locality on Andikithira, 0,6 km S.E.S. Potamos.

Fig. 34. Type locality on Andikithira, 0,6 km S.E.S. Potamos.

This very interesting finding raises the oft-discussed status of both genera. We think that for the sake of nomenclatural stability it is wiser at this moment not to suggest synonymisation of *Rhacocleis* and *Pterolepis*. Parallel evolution of the internal and external genital structures cannot be excluded. And if the lock-and-key mechanism in Orthoptera genitalia really has any meaning, parallel evolution could then result in quite similar genital male and female structures, like in *P. lagrecai* and *R. andikithirensis*.

In our opinion real clarification of the status of both genera can only be given with an in-depth DNA investigation of the taxa in both genera. We also call to mind that Willemse & Willemse (2005b, pp. 264-265) underlined the importance of a wider and critical review of the generic definitions in the Platycleidini (s.l.), but these much needed investigations are beyond the scope of this paper.

Distributional and biogeographical comments.—With the description of *R. andikithirensis*, the number of described species in the genus rises to 32 and in Greece to 16. The geographical area of the genus *Rhacocleis* is roughly northern and eastern Mediterranean with the exception of the widely distributed *R. germanica* which ranges also more north and eastward, reaching Austria, Moldova and the Caucuses (Harz 1969, p.433, 436; Willemse 1982, p.199; Willemse & Willemse 2005b, Tables 1 and 2).

From the surveys given in Willemse (1982, 1984, 1985) and Willemse & Willemse (2005b) it is clear that most of the Greek species of this genus have a restricted range, particularly those inhabiting islands. The new species *R. andikithirensis* is another example of the high degree of endemism in Greece.

In the neighbouring geographical areas of Andikithira *R. germanica* is present (Peloponnese and the islands of Kithira and Crete). Eastern Crete forms the restricted area of *R. derrai* (Willemse 1985, p.25, map 9). *R. graeca* Uvarov 1942 inhabits the Peloponnese, Kithira, southeastern continental Greece and Euboea. In the Cyclades, the endemic *R. insularis* Ramme 1928 is known from several islands: Andiparos (type locality), Naxos and Serifos (Willemse 1982, p.210; 1984, pp.71, 72, map 79), Thira/Santorini (Baccetti 1992, p.252), Andros (Warchalowska-Sliwa *et al.* 2005, p.171), Tinos, Siros, Tzia/Kea and Kythnos (Willemse & Willemse 2008, p.32) and Milos (present paper).

Interestingly, the new species inhabits the islands of Milos, Serifos and Kythnos with its congeneric *R. insularis* (Fig. 32). On Milos and Kythnos, even syntopic. It is worth mentioning that *R. insularis* has a song very different from *R. andikithirensis*, with short echemes and large intervals (Fig. 31b). One may speculate that the partly sympatric species may have experienced an evolution of their songs to enhance isolation, resulting in the present differences.

The limited and, at first glance, also somewhat peculiar distribution of the new species over Andikithira and several islands of the Cyclades, while lacking on Kithira, the Peloponnese and in neighbouring continental Greece, is also found in a subspecies of the gecko *Cyrtopodion kotschyi* (Steindacher 1870). *Cyrtopodion kotschyi saronicus* (Werner 1937) was found on the islands of Andikithira, Milos, Serifos, Paros and Milos, while *Cyrtopodion kotschyi bibroni* (Beutler & Gruber 1977) inhabits Kithira, the Peloponnese and parts of continental Greece (Kasapidis *et al*. 2005, Table 1).

The geological history of the Aegean and whole eastern Mediterranean area is complex with several changes of sea level, volcanic incidents and tectonic events.

The latest connection over land between Andikithira and the Western Cyclades occurred in the Late Miocene/Messinian (5.5 Mya) (Parmakelis *et al*. 2006, fig. 3). Andikithira became isolated from Crete and Kithira-Peloponnese in the Pliocene /Zanclean (4.5-2.5 Mya) (Tzanoudakis *et al*. 2006, p.285), was again connected for some time to Kithira-Peloponnese during Middle Pleistocene (0.781-0.126 Mya) (Parmakelis *et al*. 2006, fig. 3). The Cyclades, in turn, were islands during the Middle Pleistocene, but it is uncertain whether or not there were land connections between some of these islands (Dermitzakis 1990, p.269). The complex floral and faunal distribution in the Aegean area with numerous endemic elements is the biogeographical outcome of these many geological changes and also the most likely explanation for the distribution pattern of *R. andikithirensis*. However, dispersal of taxa as a result of the several millennia of human activities in this region cannot be completely excluded.

The similarities between *R. andikithirensis* and *P. lagrecai* seem to be a surprise. However in other faunal groups relationship of taxa from Greece with taxa within the same (sub)genus or closely related genera from coastal Libya is not something extraordinary. An example of this biogeographic affinity is found in the endemic landsnail *Sphincterochila insularis* (Boettger 1894) from Andikithira with two related *Sphincterochila* species from Libya (Gittenberger 1993, p.530).

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References

Baccetti B. 1992. Notulae orthopterologicae. 50. Su alcuni ortotteroidei del Mediterraneo orientale. Fragmenta Entomologica, Roma, 23 [1991]: 247-276.

Dermitzakis D.M. 1990. Paleography, geodynamic processes and event stratigraphy during the Late Cenozoic of the Aegean area. International Symposium on Biogeographical Aspects of Insularity. Roma 1987. Accademia Nazionale de Lincei 85: 263-288.

DORSA/SYSTAX. Deutsche Orthopteren Sammlungen – Rheinische Friedrich Wilhelm Universität Bonn / database System for Systematics and Taxonomy – Universität Ulm & Ruhr Universität Bochum. <http://www.biologie.uni-ulm.de/systax/daten/index.html>.

Eades D.C., Otte D., Cigliano M.M., Braun H. 2015. Orthoptera species file. Version 5.0/5.0 (Last retrieved 2 February 2016). <http://Orthoptera.SpeciesFile.org>.

Fontana P., Massa B. 2004. A new species of the Genus *Rhacocleis* from Libya (Orthoptera Tettigoniidae). Memorie della Società entomologiaca italiana 82: 481-492.

Gittenberger E. 1993. On the only Greek *Sphincterochila* species, two Libyan close relatives, *Cerigottella* subgen. nov., and an extended diagnosis of the Sphincterochilidae (Mollusca, Gastropoda Pulmonata). Zoologische Mededelingen Leiden 67: 529-535.

Harz K. 1969. The Orthoptera of Europe I. Series Entomologica 5: I-XX, 1-749. The Hague (Dr. W. Junk N.V.).

Harz K. 1983. Eine neue *Rhacocleis*–Art auf Kreta. Articulata 2: 13-14.

Karabağ T. 1974. A new species of the genus *Rhacocleis* Fieber 1853 (Orthoptera: Tettigoniidae) from Israel. Communications de la faculté des sciences de l'Université d'Ankara, C, 18: 115-118.

Heller K.-G. 1988. Bioakustik der europaischen Laubheuschrecken. Okologie in Forschung und Anwendung. 1: 1-360.

Kasapidis P., Magoulas A., Mylonas M., Zouros E. 2005. The phylogeography of the gecko *Cyrtopodion kotschyi* (Reptilia: Gekkonidae) in the Aegean archipelago. Molecular Phylogenetics and Evolution 35: 612-623.

Parmakelis A., Stathi I., Chatzaki M., Simaiakis S., Spanos L., Louis C., Mylonas M. 2006. Evolution of *Mesobuthus gibbosus* (Brullé, 1832) (Scorpiones: Buthidae) in the northeastern Mediterranean region. Molecular Ecology 15: 2883-2894.

Ragge D.R., Reynolds W.J. 1998. The songs of the grasshoppers and crickets of Western Europe: i-x, 1-591. Colchester, Essex (Harley Books).

Tzanoudakis D., Panitsa M., Trigas P., Iatrou G. 2006. Floristic and phytosociological investigation of the island Antikythera and nearby islets (SW Aegean, Greece). Wildenowia 36 (Special Issue): 285-301.

Warchalowska-Sliwa E., Heller, K-G., Maryanska-Nadachowska, A. 2005. Cytogenetic variability of European Tettigoniinae (Orthoptera, Tettigoniidae): karyotypes, C- and Ag-NOR banding. Folia Biologica (Krakow) 53: 161-171.

Willemse F. 1982. A survey of the Greek species of *Rhacocleis* Fieber (Orthoptera, Ensifera, Decticinae). Annales Musei Goulandris 5: 195-213.

Willemse F. 1984. Catalogue of the Orthoptera of Greece. Fauna Graeciae I: i-xii, 1-275.

Willemse F. 1985. Supplementary notes on the Orthoptera of Greece. Fauna Graeciae Ia: 1-47.

Willemse L., Tilmans J. 1987. *Rhacocleis ferdinandi*, a new species from the Greek mainland (Orthoptera: Tettigoniidae). Entomologische Berichten, Amsterdam 47: 9-11.

Willemse F., Willemse L. 2005a. Two new cryptic aberrant species of *Rhacocleis* Fieber 1853, living under stones in the mountains of Greece (Orthoptera, Tettigoniidae). Journal of Orthoptera Research 14: 161-172.

Willemse F., Willemse L. 2005b. *Rhacocleis* Fieber 1853 and *Pterolepis* Rambur 1838, distinct species groups or not? Journal of Orthoptera Research 14: 261-269.

Willemse F., Willemse L. 2008. An annotated checklist of the Orthoptera-Saltatoria from Greece including an updated bibliography. Articulata, Beiheft 13: 1-91.