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Variability of diagnostic features in *Eumecopoda cyrtoscelis cyrtoscelis* (KARSCH, 1888) from the Raja Ampat Islands (Indonesia) (Tettigoniidae, Mecopodinae)

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Abstract

This paper presents a thorough description of female and for the first time also of male *Eumecopoda cyrtoscelis cyrtoscelis* (KARSCH, 1888), including stridulation and data on the species' biology. Quantitative and qualitative morphological traits as well as life habits – to the extent they are known – may have a potential for discriminating certain Mecopodinae.

Key words: Tettigoniidae, Mecopodinae, *Eumecopoda cytroscelis cytroscelis*, description, stridulation, biology, Raja Ampat Islands, Indonesia.

Summary

In der vorliegenden Arbeit werden Weibchen und – erstmals – auch die Männchen von *Eumecopoda cyrtoscelis cyrtoscelis* (KARSCH, 1888) umfassend beschrieben. Die Beschreibung beinhaltet weiters Angaben zur Stridulation and zur Biologie der Art. Das Potential von quantitativen und qualitativen morphologischen Merkmalen sowie der Lebensweise zur Unterscheidung mancher Mecopodinae Arten wird diskutiert.

Introduction

The genus *Eumecopoda* (HEBARD 1922) currently comprises 5 species known to occur in eastern Indonesia (Irian Jaya, Mollucas, Aru Islands), Papua-New Guinea (New Guinea, Bismarck Archipelago) and the Philippines – the northernmost locality; the occurrence of *Eumecopoda* species in Australia (Queensland) (KIRBY 1891) is questionable (OTTE & NASKRECKI 1997, EADES e. a. 2007, Rentz, pers. communication).

The original descriptions from the late 19th century are understandingly weak in light of current taxonomic standards. They lack crucial morphological data and very often focus on wing colour and patterns as discriminating features. This applies especially to *E. cyrtoscelis cyrtoscelis* (KARSCH, 1888), *E. c. karschi* (KIRBY, 1891) and *E. c. regina* (KIRBY, 1891), which were formerly described as species but have now been downgraded to subspecies (OTTE & NASKRECKI 1997). These insects were originally described based on one sex only, and subsequent workers offered only little information on opposite-sex specimens of the subspecies, mainly concerning measurements and records (GRIFFINI 1907, HEBARD 1922, KARNY 1924, WILLEMSE 1933, RENTZ e. a. 2006).

Here, we present a thorough description of females and – for the first time – also of males, including information on stridulation and the species' biology. Due to lack of relevant information, we compare the life habits with those of *Austromecopoda* RENTZ, SU &

UESHIMA 2006, but we mostly rely on the only hitherto investigated South-East Asian Mecopodinae, "*Mecopoda elongata*"; *M. elongata*, however, is probably not one, but a group of cryptic species (Helfert & Sänger in prep., Römer in prep.).
We primarily assess the variability of diagnostic features in the parental generation, but also refer to those in three filial generations. At the time of collection, the females' abdomens were already swollen by eggs, which they laid immediately after arrival in Vienna; as we kept the adults isolated during transport and for a further two weeks at the insectary, these offspring probably do not stem from the collected males.

Acknowledgments

Our sincere thanks go to: Helmuth Goldammer, Vienna, who spent many weeks taking deep-focus pictures; to Franz Barth (Institute of Zoology, BOKU, Vienna), who persistently experimented on gelatine until it had the necessary consistency; to Heiner Römer and Ismene Fertschai (Institute for Zoology, Neurobiology, Karl-Franzens-University, Graz) for sound recording and sound analysis; to Tom de Jong (Denpasar, Indonesia) for perfect arrangement of our stay at remote areas. We finally thank Michael Ohl and Isolde Dorandt for the opportunity to study the holotype at the Humboldt University Natural History Museum, Berlin (Museum für Naturkunde der Humboldt-Universität Berlin).

Material and methods

Collection sites

We collected the adult specimens in the understorey vegetation of primary tropical evergreen rainforests between 7 and 11 April 1998: 2 ♂♂, 6 ♀♀ in the surroundings of Wai Lima, Batanta Island; 3 ♂♂, 2♀♀ on the northern coast of Salawati Island near Tipin. The distance between these sites and the type locality (Segun Bai, West Papua, Indonesia) is 97 - 105 km beeline.

Rearing and breeding

For breeding, we kept the specimens in 60 x 60 x 100 cm gauze cages with a plexiglas front pane. The containers were illuminated from above (100 W daylight halogen lamps) and richly equipped inside with commercial egg cartons: the rather sluggish animals readily accept these artificial structures for rest and climbing. We fed the leaf-eating katydids with lettuce and carrots, supplemented by a protein-rich diet – Flaked Staple Food for fish (TetraMin) and dogs (Korngold Hundeflocken), which was dispersed in the cardboard depressions. By frequently misting the cages we increased humidity and provided liquid water for drinking.
The females oviposited into large plastic boxes filled with a moist sand-soil mixture. The eggs were then sorted out and placed on moist sand in petri dishes. Daily inspections of the substrate and evaluation of video-tapes (see below) yielded data on egg number/night/specimen and on oviposition sites within the substrate-container (n inspections = 50). This method was not satisfactory with respect to egg number/probing and sometimes did not enable the exact egg number/specimen to be determined. We therefore let the females oviposit in a transparent medium (stiff, non-adhesive gelatine covered with a layer of sand-soil mixture) (n observations = 50); this rendered even the movements of the valves clearly visible. It also allowed us to investigate how egg-laying individuals cope with obstacles in the substrate: glass balls (diameter 1cm) served as artificial obstacles, which were embedded in gelatine at different depths (range 0 - 3 cm, in 3 mm increments) (n observations = 30).

All members of the filial generations were marked.
For selective monitoring after sunset, we used a custom-made night vision device (Fa. Optronic), which can be fitted with all customary photo lenses: macro lens for close-ups, 35-70 mm lens for overview. Activities during the night hours (7 p.m.-7 a.m.) were continuously video-taped with a Sony digital camcorder in combination with a JVC video cassette recorder, which allowed 12 h recordings.

Measuring the specimens and recording colour and pattern
Depending on size, morphological structures were measured employing a Wild-Censor in combination with a Wild M8 stereo microscope or a calliper rule.
Beyond using conventional morphological traits, which allow comparison with data from the early literature, we also introduced new traits focussed on wing shape (fig. 1a, b, c). The measurements are:
1) body length (frons to posterior margin of ultimate tergite); 2) head length (fastigium verticis to clypeal suture); 3) head width; 4) eye distance frontal; 5) eye distance occipital; 6) vertex width; 7) vertex height (highest point to frontal suture); 8) pronotum length; 9) pronotum width, 10) pronotum depth (discus to lowermost point of margin); 11) elytra length (le); 12) length section 1 (le 1); 13) length section 2 (le 2); 14) length section 3 (le 3); 15) elytra width 1; 16) width 1 dorsal section (w1d); 17) width 1ventral section (w1v); 18) elytra width 2; 19) width 2 dorsal section (w2d); 20) width 2 ventral section (w2v); 21) stridulatory area length; 22) stridulatory area width; 23) metafemur length; 24) metatibia length; 25) ovipositor length (posterior margin of ultimate tergite to tip). In egg length, the spongy hook is not considered.

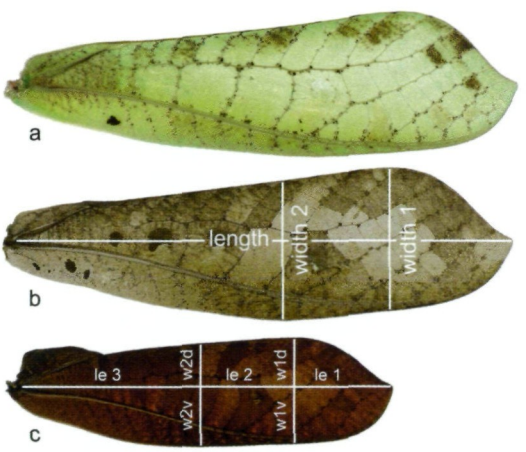


Fig. 1a, b, c Measured sections and colours in left elytra (bright-field illumination); female (a, b), male (c).

Pictures and drawings
The phallic complex was recorded with a video camera (Sony CCD-Iris) in combination with a Nikon SMZ-U stereo microscope and processed by Pinnacle PCTV Vision. All deep-focus photographs (figs. 1, 2 - 16, 18 - 26) were taken with a Nikon SMZ 1500 ste-

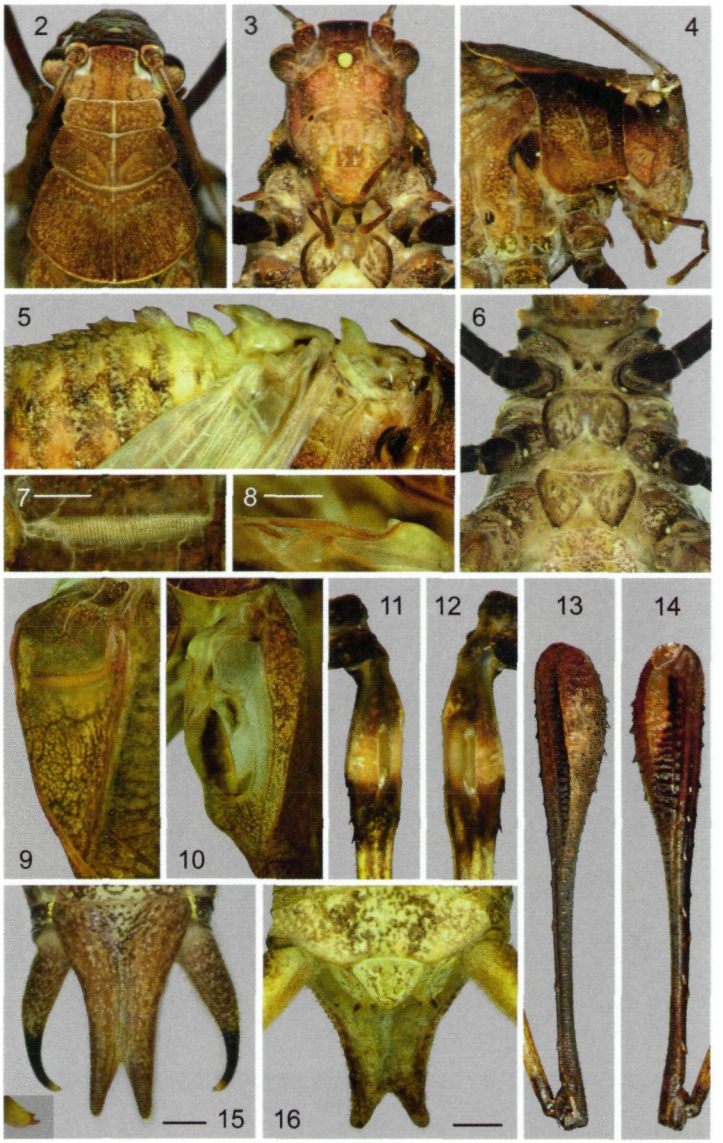
reo microscope in bright- or darkfield illumination or with a Nikon 105 mm macro lens by Helmuth Goldammer.
Several days after the final moulting, we scanned the living specimens with a digital photocopier, recording pattern and colour.

Sound recording and analysis
The songs of six similar-aged males (F3) were recorded in a sound-poor chamber at 24°C with a 1/4" microphone (Bruel & Kjær type 4136, Odense, Denmark), preamplified through a sound level meter (Bruel & Kjær, type 2209) and digitised at a sampling rate of 250 kHz on a PC with a custom-made AD/DA audio hardware. Sound analysis was performed using Batsound. The records were taken by Heiner Römer and Ismene Fertschai. Additionally, we investigated stridulation of caged specimens in our insectary (for details see section "rearing and breeding").

Statistics
Statistical analysis was conducted with the Statgraphics plus Vers. 5.0 package. We tested the data for normal distribution and equal variances and compared data columns with a t-test or the Mann-Whitney U test.

Results and discussion

Description
Rather medium-sized Mecopodinae. Vertex straightly truncate, narrowed towards the sulcus between vertex and frons (figs. 2, 3). Ocelli conspicuous (figs. 2, 3, 4). Scapus of antennae nearly three times longer and broader than pedicellus, flagellum thin, distinctly longer than the body. Pronotum moderately long, anterior margin straight, posterior margin broadly obtuse. Discus flat, lateral margins strongly carinate with deep incisions at the transverse sulci; the two transverse sulci on discus deep, the anterior one nearly straight, the posterior one considerably concave, extending on paranota (= lateral lobes of pronotum) to the ventral third (figs. 3, 4). Median longitudinal sulcus feeble, but mostly distinct. In the mesozona a V-like depression. Ventro-anterior angle of paranota produced in a distinct projection (figs. 4, 18). Discus and paranota minutely sculptered and punctate. Foramen prothoracicum completely concealed by paranota, behind the foramen on mesopleura a characteristically shaped black spot; dorsal of the foramen a finger-like projection (figs. 4, 5). Prosternum distinctly bidentate, meso- and metasternum of the same length, conchate, apically acute (fig. 6). Meso- and metathoracic tergites with conspicuous median projections; median projections of abdominal tergites shorter, depress, distinctly flattening towards end of abdomen (fig. 5). Elytra extending behind the hind knees, apices pointed (fig. 1a, b, c). Stridulatory area well differentiated (figs. 9, 10); file with 70 - 80 teeth (figs. 7, 8). Alae slightly longer than elytra. Procoxal spur long (figs. 3, 4). Pro- and mesofemora nearly rectangular in cross-section, ventrally with 3 - 4 minute spines, dorsally warty (fig. 21). Metafemora ventrally angular, dorsally broadly rounded, with spines (dorsal 5 - 10, ventral 5 - 9 outer and 4 - 7 inner spines) (figs. 13, 14). Knee lobes of pro- and mesofemora unarmed to rudimentarily armed, inner and outer knee lobes of metafemora with one distinct spur. Tibiae with variable number of spines on both dorsal and ventral inner and outer sides, pro- and mesotibia with 1 pair of ventral and 1 pair of dorsal, metatibia with 2 pairs of ventral and 1 pair of dorsal apical spurs. Tympana subconchate on both sides (figs. 11, 12).
Genital segments: Male: Last abdominal tergite strongly bent downwards, distal margin medially slightly sinuous, with inconspicuous median depression. Supraanal plate triangularly rounded, with small median depression (fig. 16). Cerci basally stout, apical-



Figs. 2 - 16 *E. c. cyrtoscelis* male – 2) Pronotum and head in dorsal view. 3) Head in frontal view. 4) Head and pronotum in lateral view. 5) Tergites of thorax and abdomen in lateral view. 6) Sternites of thorax in ventral view. 7) Stridulatory file (detail of left elytra). 8) Scraper (detail of right elytra; in situ vertically positioned). 9) Stridulatory area of left elytra (underside). 10) Stridulatory area of right elytra (upper side). 11) Tympanal organ (outer side). 12) Tympanal organ (inner side). 13) Hind femur (outer side). 14) Hind femur (inner side). 15) Subgenital plate and cerci in ventral view; tip of cercus (insert). 16) Last abdominal segments in dorsal view (slightly tilted upwards). All scale bars = 1 mm; for other measurements see tab. 1.

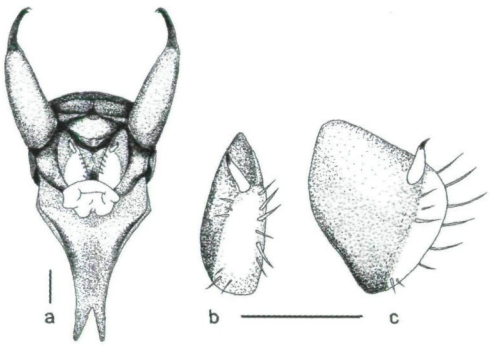
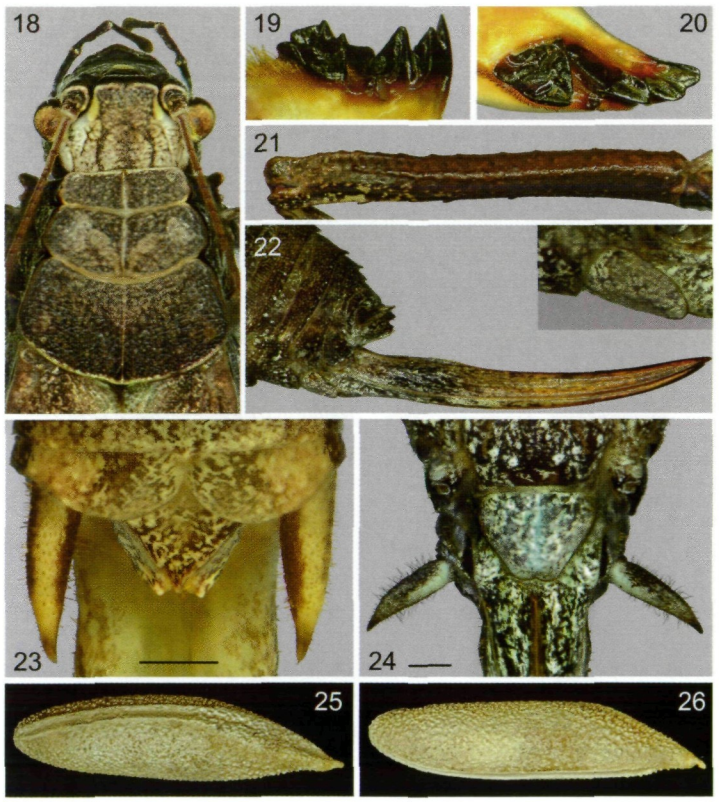


Fig. 17 a, b, c Phallic complex in male *E. c. cyrtoscelis*. a) overview (subgenital plate completely bent downwards, cerci upwards); b) titillator in straight view; c) titillator in lateral view. All scale bars = 1 mm.



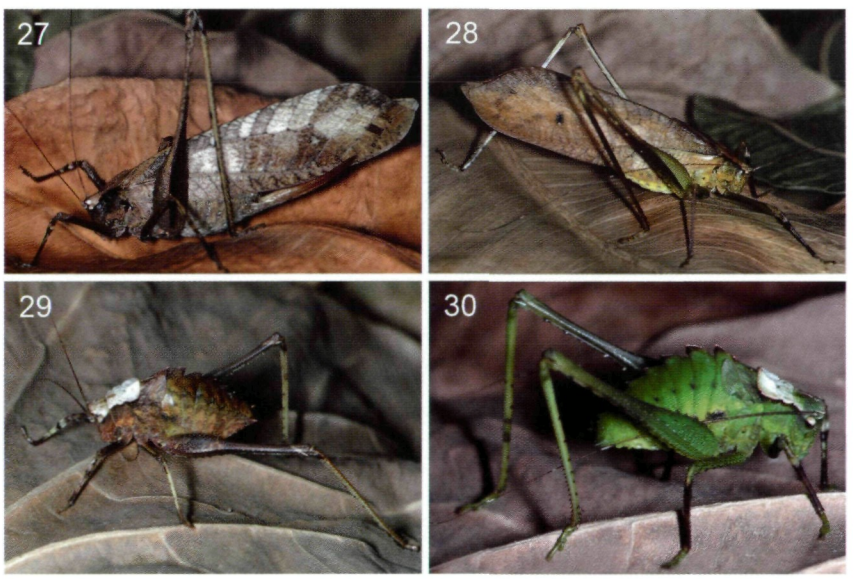
Figs. 18 - 26 *E. c. cyrtoscelis* female – 18) Pronotum and head in dorsal view. 19) Right mandible in lateral view. 20) Right mandible in top view. 21) Fore femur. 22) Ovipositor and subgenital plate in lateral view (insert). 23) Last abdominal segments in dorsal view (slightly tilted upwards). 24) Subgenital plate and cerci in ventral view. 25, 26) Egg with a longitudinal groove on opposite sides. All scale bars = 1 mm; for other measurements see tab. 1.

ly tapering and incurved, with 2 small apical teeth of different length (fig. 15). Phallic complex with titillators as shown in fig. 17a, b, c. Subgenital plate basally broad, distally elongate produced and with two longitudinal ridges, apically deeply forked (fig. 15).

Female: Last abdominal tergite bent downwards, distal margin rounded with median incision. Supraanal plate triangularly acute (fig. 23). Cerci moderately long, apically tapering, without teeth. Subgenital plate basally broad, distally much narrower, distal margin slightly concave (figs. 24, 22 insert). Ovipositor ensiform, slightly bent upwards, smooth, distinctly shorter than length of hind femur (fig. 22).

Colouration in vivo

General colour in adult males always dark-brown (figs. 28, 1c), in adult females variable, mostly brownish, occasionally greenish (fig. 27). Flagellae in both sexes light-brown, sparsely dark-brown annulated. Lateral ocelli white, the median one whitish to yellowish. Vertex with light line, normally median a small dark point inside the line (figs. 2, 18). Sulci on discus light, anterior and posterior margins of pronotum lightly lined. In most specimens black stripes occur behind the eyes and on the paranota below the lateral carina of the discus (fig. 4); the legs are dark speckled. On the mesopleura behind the foramen prothoracicum always a characteristically shaped dark-brown to black marking. In males, cerci and subgenital plate apically dark-brown, in females only the outermost point of the cerci dark-brown, the ovipositor is basally of general colour, distally light-brown to chestnut.



Figs. 27 - 30 Colouration in larval and adult *E. c. cyrtoscelis* – 27) Female. 28) Male (just moulted and not yet dark-brown). 29) Brown larva with vertex and discus of pronotum whitish; on the leaf a drop which just oozed out from the mouth (see section "biology"). 30) Green larva with only discus of pronotum whitish.

The elytra of the males are always dark-brown (fig. 1c), rarely with few isolated darker spots. In females, however, colour and pattern of the forewings vary considerably: though usually mottled greyish brownish of various shades, some specimens have olive to light-green forewings, which gradually turn brown with age. The greyish wing areas are poorly pigmented to unpigmented and the alae shine through. In most females, dark-brown to black spots and/or dark patches of various size and numbers occur at the base or the whole elytra (figs. 1a, b); such marks can differ between right and left forewing.
A great variability of colour and pattern has also been demonstrated for members of the *M. elongata*-group and *Austromecopoda* species (RENTZ e. a. 2006).
In laboratory-reared *E. c. cyrtoscelis*, early larvae of both sexes are green. This colour either persists until the final moult, or the later instars undergo spectacular colour changes during moulting from green to dark-brown and vice versa without any intermediate phase. The number of colour changes varies (1-3), but the reasons are unknown: this phenomenon is not triggered by density, because it can also be observed in solitary-kept larvae. Independent of general colour, vertex and discus of pronotum are partly or entirely whitish in the middle and late instars (figs. 29, 30). No information is available on the appearance of larval *E. c. cyrtoscelis* in the field; in the studied "*M. elongata*", the larvae are without exception green from egg to last instar at both field and laboratory conditions. Field-caught larvae of *Austromecopoda* species also seem to be green only.

Colouration ex alcohol
Both males and females are uniformly brown with lighter brown undersides; black markings persist.

Measurements

Morphological trait	Parental generation						Filial generations 1 - 3					
	male			female			male			female		
	mean	sd	range	mean	sd	range	mean	sd	range	mean	sd	range
Body length	**30.8**	1.4	28.7 - 32.7	**40.0**	3.6	35.0 - 46.9	**30.9**	1.5	27.9 - 34.0	**40.4**	3.1	32.8 - 46.8
Head length	**6.2**	0.4	5.5 - 6.7	**7.1**	0.3	6.6 - 7.6	**5.9**	0.3	5.3 - 6.8	**6.9**	0.3	6.0 - 7.6
Head width	**5.0**	0.1	4.8 - 5.2	**6.1**	0.2	5.9 - 6.4	**4.9**	0.2	4.5 - 5.6	**5.9**	0.2	5.2 - 6.4
Eye distance front.	**4.1**	0.2	3.9 - 4.4	**4.9**	0.1	4.8 - 5.1	**4.1**	0.2	3.7 - 4.4	**4.9**	0.2	4.2 - 5.1
Eye distance occ.	**4.9**	0.2	4.6 - 5.1	**5.7**	0.3	5.4 - 6.0	**4.7**	0.3	3.9 - 5.3	**5.6**	0.3	5.0 - 6.1
Vertex width	**1.9**	0.1	1.9 - 2.0	**2.5**	0.2	2.1 - 2.8	**2.0**	0.1	1.8 - 2.3	**2.6**	0.2	2.1 - 3.0
Verex. height	**0.9**	0.1	0.8 - 1.1	**1.2**	0.1	1.1 - 1.3	**0.9**	0.1	0.8 - 1.3	**1.2**	0.1	1.0 - 1.4
Pronotum length	**7.9**	0.2	7.6 - 8.1	**9.3**	0.3	8.8 - 9.6	**7.8**	0.3	7.0 - 8.5	**9.1**	0.4	8.2 - 10.2
Pronotum width	**7.2**	0.4	6.5 - 7.8	**8.2**	0.2	8.0 - 8.5	**7.2**	0.3	6.5 - 7.8	**8.2**	0.3	7.6 - 8.9
Pronotum height	**5.6**	0.3	5.1 - 6.0	**6.5**	0.3	6.0 - 6.7	**5.5**	0.3	4.9 - 6.0	**6.4**	0.3	5.5 - 7.3
Elytra length	**56.2**	3.1	52.0 - 61.0	**66.9**	4.0	61.0 - 72.3	**55.3**	2.1	50.0 - 61.0	**67.1**	2.9	60.7 - 73.7
section 1	**15.1**	0.6	14.3 - 16.0	**17.2**	1.7	14.3 - 19.3	**15.2**	1.2	12.0 - 19.7	**17.0**	1.4	12.3 - 19.3
section 2	**14.5**	2.1	11.3 - 16.7	**13.9**	1.4	11.7 - 15.3	**13.7**	2.2	8.7 - 24.0	**13.3**	2.4	7.0 - 18.7
section 3	**26.7**	3.2	22.3 - 30.7	**35.8**	3.2	31.3 - 39.7	**26.4**	2.2	18.7 - 34.0	**36.8**	2.5	31.3 - 44.3
Elytra width 1	**16.3**	0.7	15.7 - 17.0	**19.1**	1.0	17.7 - 20.7	**16.4**	0.7	14.0 - 18.0	**19.1**	0.8	17.0 - 20.7
dorsal section	**8.5**	0.5	8.0 - 9.3	**10.0**	0.7	9.0 - 10.7	**8.5**	0.5	7.3 - 10.3	**9.9**	0.9	7.0 - 11.3
ventral section	**7.7**	0.6	7.0 - 8.7	**9.1**	0.5	8.7 - 10.0	**7.8**	0.6	6.0 - 9.3	**9.1**	0.7	7.7 - 12.3
Elytra width 2	**15.6**	0.6	14.7 - 16.3	**18.3**	0.8	17.0 - 19.3	**15.7**	0.7	13.0 - 17.3	**18.5**	0.8	16.0 - 19.7
dorsal section	**7.2**	0.3	7.0 - 7.7	**8.4**	0.8	7.0 - 9.0	**7.2**	0.6	5.3 - 9.0	**8.6**	0.9	6.0 - 10.3
ventral section	**8.4**	0.6	7.7 - 9.3	**9.8**	0.3	9.3 - 10.3	**8.5**	0.6	7.0 - 10.0	**9.9**	0.8	8.0 - 12.3
Strid. area length	**11.6**	0.3	11.3 - 12.0	**19.3**	2.1	15.9 - 22.2	**11.6**	0.4	10.4 - 12.5	**18.1**	1.5	15.5 - 22.2
Strid. area width	**8.1**	0.3	7.6 - 8.5	**9.1**	0.2	8.9 - 9.4	**8.1**	0.3	7.5 - 8.6	**9.1**	0.3	8.3 - 9.8
Metafemur length	**39.4**	2.3	36.5 - 41.8	**49.5**	1.5	47.6 - 51.3	**39.9**	1.4	36.3 - 42.7	**49.4**	1.7	45.6 - 52.5
Metatibia length	**40.1**	2.2	37.1 - 42.1	**49.8**	1.1	48.6 - 51.7	**40.1**	1.5	36.7 - 42.9	**49.4**	1.5	46.4 - 51.8
Ovipositor				**29.4**	1.2	27.7 - 30.8				**29.2**	1.2	26.9 - 31.8

Tab. 1 Measurements of parental generation (field-caught) and succeeding three filial generations (laboratory-reared) in mm; mean, standard deviation, range; n (parental generation) = 5 ♂♂, 8 ♀♀; n (filial generations) = 40 ♂♂, 40 ♀♀ each.

The few measurements in the early literature correspond with the data presented here. Neither the means nor medians differ between the evaluated generations. Cultured specimens showed a greater variability of wing measurements, but this was independent of the filial generation and probably not due to laboratory effects like crowding, which may cause wing elongation in tettigoniids (ANDO & HARTLEY 1982). In the Mecopodinae we have studied, elytra length and width – the most common measurements – are extremely variable: we occasionally recorded even greater differences in field-caught "*M. elongata*" than afterwards in cultured specimens. Nevertheless, *E. c. cyrtoscelis* and similar-sized "*M. elongata*" can easily be distinguished by elytra shape and proportions: in *E. c. cyrtoscelis* the females have considerably broader wings than the males, which resembles the male elytra of "*M. elongata*"; in females of the latter, the forewings are distinctly narrower than in males.

Song pattern

The males produce successive trills with a short pause in between; Römer (pers. communication) preliminarily classifies *E. c. cyrtoscelis* as a "continuous (short) caller". The frequency spectrum of the song includes a low frequency component between 7 - 9 kHz as well as high and ultrasonic frequency bands ranging up to more than 70 kHz (fig. 31a, b).

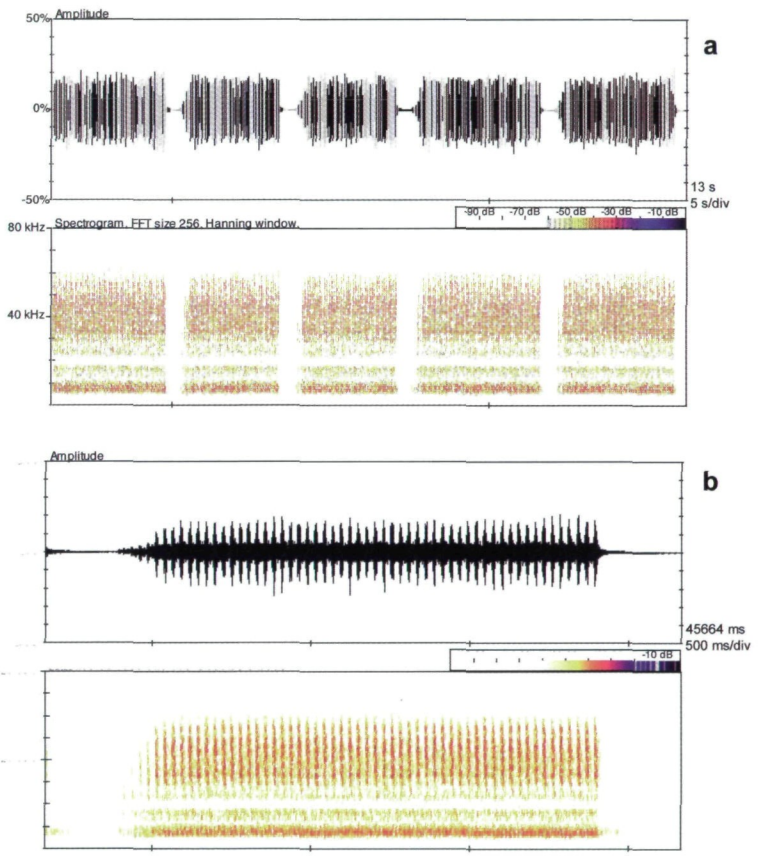


Fig. 31a, b Song pattern and frequency spectrum. a) successive trills; b) one trill.

Song element	Duration, ms			n
	mean	sd	range	
Trill	**1351**	443	433 - 2584	180
Pause	**303**	87	717 - 805	180

Tab. 2 Duration of song elements in milliseconds; mean, standard deviation, range; n = 6 males, 30 trills each.

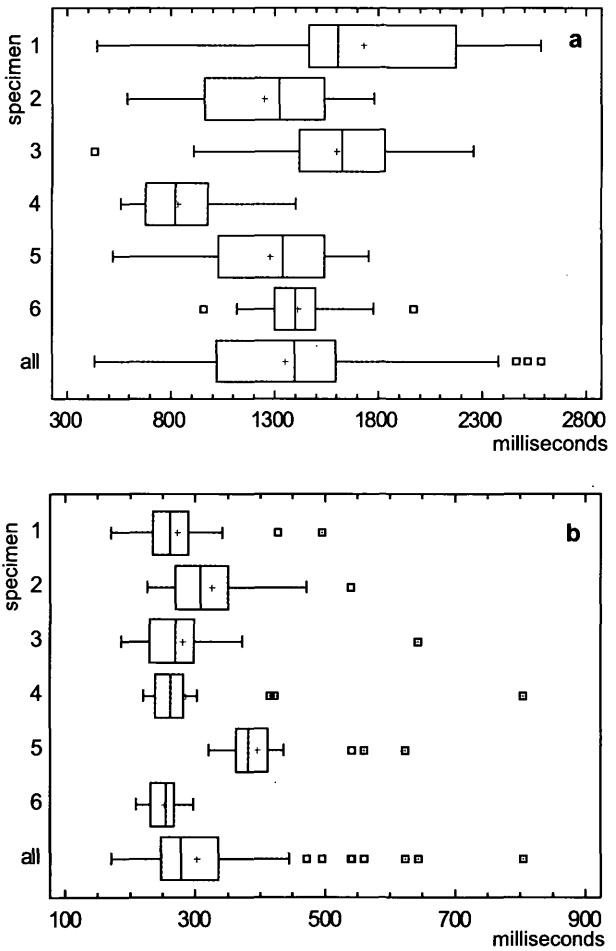


Fig. 32a, b Duration of trill (a) and pause (b) in milliseconds; n specimens = 6, n song elements = 30/specimen. Box edges and bar caps indicate 25/75% and 10/90% percentiles, respectively; inside the boxes the medians are marked by solid lines and the means by crosses. Points outside the whiskers are values lower and higher than 10/90% percentiles.

Under the standardised recording conditions the duration of trills and pauses is quite variable; consequently, stridulation seems to "stutter". The mean duration of the song elements is significantly different in some of the investigated specimens ($p < 0.001$) (fig. 32a, b). Under more "natural" conditions and in the presence of conspecifics we also recorded songs consisting of prolonged trills (up to 4500 milliseconds). Caged males call for a short time only (singing period < 1 to 6 minutes); longer-lasting songs are rare. Our records and monitoring in the insectary further prove *E. c. cyrtoscelis* to be a solitary singer. All these findings correspond with the field observations, which, however, were made under different climatic conditions (higher temperatures and humidity, short but heavy showers). Unlike in other SE Asian Mecopodinae, we never observed sound production in females.

We cannot assess the potential of the calling song for discriminating *Eumecopoda*-species, but studies on "*M. elongata*" yield distinctly different song patterns between the latter species-group and *E. c. cyrtoscelis*; the frequency spectrum of their songs, however, is very similar (Helfert, Römer, unpublished).

Notes on the biology

The biology of *E. c. cyrtoscelis* is very similar to that of the hitherto investigated SE Asian "*M. elongata*". Field and laboratory studies prove that the kadydids are strictly nocturnal: activity starts immediately after sunset and lasts until the late night hours; towards dawn the animals become torpid and remain motionless if not massively disturbed. The present species can adopt a resting-position that we have never observed in any tettigoniid before: they limply lean against nearby structures or sometimes even slowly glide down deathlike with legs retracted. Such atonic animals can be picked up and even manipulated for several seconds until they suddenly become aware of the situation – mostly when the tarsi contact any ground – and escape. As this remarkable behaviour is not restricted to certain specimens and already occurred in the parental generation, gradual limpness during rest seems to be species-specific.

Like "*M. elongata*", *E. c. cyrtoscelis* inhabits the ground vegetation and rarely climbs up higher than 1.5 m. The katydids do not actively hide during daylight, but their camouflage colour allows them to perfectly blend with the surroundings. Although the animals are normally sluggish, they can perform sudden spectacular jumps and can fly for minutes even at greater heights (e. g. towards and around light-sources). The tettigoniids are phytophagous and feed on foliage; together with leaves they consume sessile or hemi-sessile insects, arthropod eggs and animal litter, which supplement the protein-poor diet. The stout mandibles indicate leafy food: they have three similar-sized incisive dentes and a cup-shaped molar region on the right (figs. 19, 20), and a cusp-shaped one on the left mandible.

As the leaf-eating species are non-selective with respect to food-plants, especially the males often remain at the same place or nearby for days; mobility is higher in those females moving towards a mate or seeking out ground sites for oviposition. Caged specimens also barely move except to feed or lay eggs. Despite lengthy video monitoring, the information on mating behaviour of *E. c. cyrtoscelis* is poor: the only three observed copulations took place without any recognizable foreplay and lasted for only 19 to 25 seconds. The attached spermatophore is tiny compared with the animal´s size and probably lacks a spermatophylax.

Oviposition can last up to one hour: most of the time, however, is spent repeatedly probing into the various substrates, without egg-deposition. The ovipositor works its way down by up-and-down movements, the main thrust generated by abdominal muscles; the legs help push down or the whole body may even twist to support the probing, especially when the ovipositor meets obstacles (e. g. embedded glass balls). Independent of obstacle depth, in most cases (83%) the females successfully directed the valves past them. Impenetrable structures may be used to help guide the ovipositor: the tettigoniids preferably oviposited directly along the wall of the containers (89%). By sliding movements of the valves relative to each other, they deposit one or two eggs per bore; occasionally, up to five eggs are laid at once (10%); the total egg number/female/night ranges between one and nine.

The eggs of *E. c. cyrtoscelis* have a mean length of 8.1 ± 0.2 mm (7.8 - 8.5 mm; n = 60). Their shape closely resembles that of SE Asian Mecopodinae: the tapered egg pole is drawn into a spongy hook, which easily breaks off, sometimes already during oviposition; its loss, however, does not impair embryonic development. On opposite sides, a groove runs longitudinally along the entire length of the egg (figs. 25, 26). These structures do not serve as predetermined hatching sites; the larva escapes the egg well beside the groove near the tapered end, which is directed upwards in the oviposition substrate. As far as known, eggs of *Austromecopoda* species are considerably smaller and grooved on one side only. In some members of that genus, adult females might undergo a reproductive diapause (RENTZ e. a. 2006), which we never observed in the present or other Mecopodinae we have studied.

Like "*M. elongata*", *E. c. cyrtoscelis* regularly releases clear liquid from its gut: large drops ooze out from the mouth or squirt from the anus up to 97 cm. This behaviour is not linked with defence or deterrence, because it also occurs in solitary-kept, undisturbed specimens. As we frequently observed such liquid release in the field too, it might serve to rapidly eliminate excess of water ingested with food; dried liquid is brownish, indicating a mixture of water with fore- and hindgut content.

According to the present state of knowledge, *E. c. cyrtoscelis* has more in common with the "*M. elongata*-group" than with *Austromecopoda* species.

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