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HAL Id: hal-03701053

<https://hal.science/hal-03701053>

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Description of two new species of Turanogryllini crickets (Orthoptera, Gryllidae, Gryllinae) from Cameroon, with identification keys for African species

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Academic editor: Maria-Marta Cigliano | Received 23 August 2021 | Accepted 25 November 2021 | Published 1 June 2022

<http://zoobank.org/4A9BAEB1-2BDB-48DC-9F54-34210B51FE57>

Citation: Um Nyobe PCA, Robillard T, Kekeunou S, Ma L, Mbadjoun Nzike M, Bilong Bilong CF (2022) Description of two new species of Turanogryllini crickets (Orthoptera, Gryllidae, Gryllinae) from Cameroon, with identification keys for African species. Journal of Orthoptera Research 31(1): 83–89. <https://doi.org/10.3897/jor.31.73389>

Abstract

During a Gryllidae survey in the Southern Cameroonian Plateau, two new species of the tribe Turanogryllini Otte, 1987 were discovered and described, namely *Turanogryllus zamakoensis* Um Nyobe, Kekeunou & Bilong Bilong **sp. nov.** and *Neogryllopsis gorochovi* Um Nyobe, Kekeunou & Ma **sp. nov.** This finding extends the known distribution of the genera *Turanogryllus* Tarbinsky, 1940 and *Neogryllopsis* Otte, 1983. New environments are also recorded for these crickets, and an identification key for African species is proposed for these two genera.

Résumé

Au cours d'une étude des Gryllidae dans le Plateau Sud Camerounais, deux nouvelles espèces de la tribu Turanogryllini Otte, 1987 ont été découvertes et décrites, à savoir *Turanogryllus zamakoensis* Um Nyobe, Kekeunou & Bilong Bilong **sp. nov.** et *Neogryllopsis gorochovi* Um Nyobe, Kekeunou & Ma **sp. nov.** Cette découverte élargie l'aire de répartition connue des genres *Turanogryllus* Tarbinsky, 1940 et *Neogryllopsis* Otte, 1983. De nouveaux environnements ont été également signalés pour ces grillons et une clé de détermination est proposée pour les espèces africaines de ces deux genres.

Keywords

bioecology, Central Africa, taxonomy, Turanogryllini

Mots clés

bioécologie, Afrique Centrale, taxonomie, Turanogryllini

Introduction

Despite its central role in ecosystem functioning, biological diversity remains poorly known in some regions, especially for non-emblematic species such as orthoptera. In Cameroon, no detailed taxonomic study of crickets has been performed. Yet, crickets play

several ecosystemic roles and are suitable bioindicators of the assessment of habitat quality and environmental change (Anso 2016). They form a major component of food webs (Capinera 2011, Wellstein et al. 2011), and some crickets are food for humans and some pets (Lavalette 2013, Rumpold and Schlüter 2013). Crickets can also be harmful to the environment (Bellmann and Luquet 2006). They attack most plants, but they are mostly seen on young plants that are not resistant to their injuries (Valdeyron 1955, Sikirou et al. 2018).

Crickets from the tribe Turanogryllini Otte, 1987 belong to the field cricket subfamily Gryllinae Laicharting, 1781 (Chopard 1967, Tae-Woo 2012). This tribe includes four genera: *Podogryllus* Karsch, 1893; *Turanogryllus* Tarbinsky, 1940; *Afrogyrlopsis* Randell, 1964; and *Neogryllopsis* Otte, 1983. Its monophyly, however, has not been confirmed by the recent phylogenetic study of Chintauan-Marquier et al. (2016). Their taxonomy and distribution have yet to be clearly established, and several new species remain undescribed.

The genus *Podogryllus* is known from Africa (16 spp.) and Saudi Arabia (3 spp.) (Cigliano et al. 2021). According to Otte (1987), *Afrogyrlopsis* is a synonym of *Podogryllus*; a taxonomic revision is required for these two genera. The genus *Turanogryllus* is mainly characterized by the presence of styli on the external apical corners of the epiphallus (*sensu* Randell 1964). According to Cigliano (2021), 36 species have been described from Eurasia (Afghanistan, Arabia, China, Iran, Israel, and Russia), Indo-Malaysia (India, Laos, Nepal, and Pakistan), and Africa (Angola, Egypt, Guinea, Kenya, Sierra Leone, Zaire, and Zambia). Currently, 10 species in this genus are known from Africa: *T. niloticus* (Saussure, 1877); *T. scenicus* (Gerstaecker, 1869); *T. machadoi* Chopard, 1961; *T. flavolateralis* (Chopard, 1934); *T. microlyra* (Chopard, 1938); *T. vicinus* (Chopard, 1967); *T. nimba* Otte, 1987; *T. kitale* Otte, 1987; *T. sombo* Otte, 1987, and *T. mau* Otte, 1987 (Cigliano et al. 2021). The last genus of the tribe, *Neogryllopsis*, is mainly characterized by a sharp virga (*sensu* Randell 1964) without spines along edges

(Otte 1983). It is known from southern Malawi, Zimbabwe, and South Africa. It currently includes 20 species (Otte et al. 1988, Gorochoy 1988), all from Africa. Otte et al. (1988) provided a key for males and defined five species groups of Southern African species: *Jordani*, *Pundae*, *Sabianus*, *Kuhlgatzi*, and *Ohopohoi*.

In the current study, we update the taxonomic information on *Turanogryllus* and *Neogryllopsis* genera by describing two new species from Cameroon and providing identification keys to males of both genera.

Materials and methods

This study was conducted in closed (forests) and open (fields and/or fallows) environments of three localities in the southern Cameroonian plateau: Zamakoe, Ongot, and Ngutadjap (Fig. 1). The characteristics of each study locality can be found in the publication of Um Nyobe et al. (2021). In these habitats, crickets were captured from March 2014 to September 2015 using pitfalls and quadrats, according to the methodology described in Um Nyobe et al. (2021).

The captured specimens were stored in 70% ethanol and transported to the zoology laboratory of the University of Yaoundé I for further studies.

Observations of morphological characters were performed using a binocular magnifier (Leica) connected to an Amscope camera (Heerbrugg brand). Pictures of the external morphology of specimens immersed in 70% ethanol were taken using an LCD Digital Microscope connected to a computer. Measurements were taken using a NEIKO electronic caliper. Male genitalia were dissected and then cleaned with 5% KOH and ethanoic acid for 8 hours and 30 minutes, respectively (Vasanth 1993, Um Nyobe et al. 2021). Imaging of male genitalia was made using an AmScope MU1000 digital camera or a Canon EOS 40D Digital SLR camera. To highlight the structural components of male genitalia, a water solution containing a drop of JBL Punktol was used. To fix

orientations and stabilization of genitalia for photography, a clear and viscous hand sanitizer was used, following Su (2016).

Abbreviations used in morphological identification.—General morphology: FI, FII, FIII, fore, mid, hind femora, respectively; FW, forewing; TI, TII, TIII, fore, mid, hind tibia, respectively. Terminology of forewing venation follows Desutter-Grandcolas et al. (2017) and Schubnel et al. (2019): cubital vein, *cu.v.*; anal vein, *a. v.* (= postcubital vein, *Pcu*); median vein, *m.v.*; radial vein, *r.v.*; subcostal vein and its branches, *sc.v.*; oblique vein, *o.v.*; diagonal vein, *d.v.*; anal node, *a.n.*; mirror, *m.*; harp, *h.*; cord, *c.*; anal field, *a.f.*; apical field, *ap.f.*; lateral field, *l.f.*

Abbreviations used for the measurements.—Measurements were recorded in millimeters (mm) following Otte (1985): BL, body length; FL, hind femora length; TL, hind tibia length; FWL, forewing length; PL, pronotal length; ML, mirror length; MW, width of the mirror; OL, ovipositor length; CL, cercal length.

Abbreviations used in genitalia identification.—Desutter (1987), Randell (1964), and Otte et al. (1988) used different terms for the same genital structures. Although we realize that there is a need to have a unified terminology system that does not currently exist, we chose to use the terminology for male genitalia adapted from Randell (1964) and Otte et al. (1988) because they explicitly described the structure of the male genitalia of the type species of the genera *Turanogryllus* and *Neogryllopsis*, which allows direct comparisons between the new species and the other species previously described in these genera. We indicate the terms corresponding to the terminology from Desutter (1987) in brackets, as presented in the following list of abbreviations for male genitalia: epiphallus, *epi.*; ectoparameres, *ect.*; endoparameres, *end.*; ramus, *r.*; virga, *v.* (ectophallic fold *sensu* Desutter); posterior emargination of epiphallus, *p.e.e.*; stylus, *sty.*; lateral lobe of epiphallus, *l.l.e.* (median lophi of pseudepiphallus

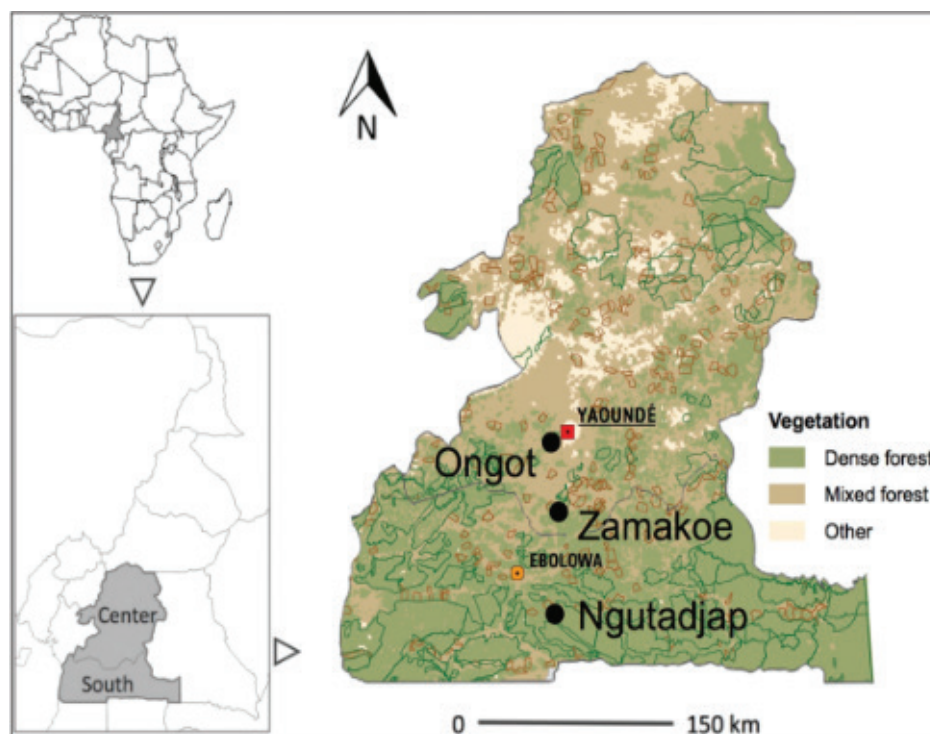


Fig. 1. Study localities in relation to vegetation types in Cameroon (see Oumarou et al. 2020).

sensu Desutter); dorsal lobe of ectoparamere, *d.l.ect.* (lateral lophi of pseudepiphallus *sensu* Desutter); ventral lobe of ectoparamere, *v.l.ect.* (pseudepiphallallic parameres *sensu* Desutter).

Results

Taxonomy

Order Orthoptera Olivier, 1789

Family Gryllidae Laicharting, 1781

Subfamily Gryllinae Laicharting, 1781

Tribe Turanogryllini Otte, 1987

Diagnosis of tribe Turanogryllini Otte (1987)

Inner tympanum small, present, or absent on TI. Outer tympanum present, large. TIII 0.68–0.86 times as long as FIII. Male stridulum with small, short setae arranged in ventral view. Harp with three or more oblique veins connected indirectly to the stridulatory file through small veins. Mirror with one dividing vein. Male genitalia large, epiphallus relatively short, and the entire structure is dominated by huge and sometimes elaborate ectoparameres that form spikes and may present prominent serrations. Virga usually stout, narrowing at point; endoparamers joining posteriorly to form a large muscle attachment plate.

Genus *Turanogryllus* Tarbinsky, 1940

Type species.—*Gryllus lateralis* Fieber, 1853

Diagnosis.—Head globose, body cylindrical. Male tegmina well developed. Male subgenital plate concave or deeply notched; dorsal lobes of ectoparameres externally visible; styli present on the posterolateral corners of epiphallus. Female tegmina reduced to small pads; ovipositor straight, slender, needle-shaped.

Turanogryllus zamakoensis Um Nyobe, Kekeunou & Bilong
Bilong, sp. nov.

<http://zoobank.org/DFD1267F-4E26-47D6-8C38-DADE761156E1>

Material examined.—**Holotype:** CAMEROON • ♂; Center Region, Zamakoe; 3°33'816"N, 11°31'913"E; 14 February 2015; in crops field, quadrat trap; P. Um Nyobe & team leg.; MNHN-EO-ENSIF1749. **Allotype:**—CAMEROON • ♀; Center Region, Zamakoe; 3°33'816"N, 11°31'913"E; 21 March 2015; in crops field, quadrat trap; P. Um Nyobe & team leg.; MNHN-EO-ENSIF1713.

Etymology.—The species epithet *zamakoensis* refers to the type locality.

Diagnosis.—*Turanogryllus zamakoensis* sp. nov. is distinguished from congeners by light brown coloration, male genitalia provided with a large dorsal lobe of ectoparamere, and with microptereous FWs; the other species are either brachyptereous or macroptereous. In addition, it has only one outer tympanum while the other species have tympana on external and internal side.

Description.—(Figs 2, 3) **Male.** Size average, brown, lighter than other species. Head dark brown with four pale stripes on occiput, not extending over vertex (Fig. 2A); cheeks pale (Fig. 2B); ocelli

large; face entirely pale below median ocellus and below level of antennae (Fig. 2C). Pronotum covered with very fine pubescence, without bristles; dorsum dark brown, muscle attachment plates pale brown (Fig. 2A); lateral lobes ivory, becoming dark brown at upper margin (Fig. 2B). TI and TII ivory-colored; TI with a large outer tympanum. Hindlegs: f FIII pale brown with faintly darker oblique stripes on outer surface; darker around knees, especially on inner surface; TIII pale brown with 6 inner and 7 outer subapical spurs. FWs with square base, reaching abdomen mid-length; its length to pronotal length ratio ca. 2.5; dorsum brown; lateral field pale, dark brown between upper three veins. Stridulatory file with 156 teeth; harp with 3 oblique veins; mirror oval, with one dividing vein (Fig. 2E). Hind wings short, hidden by FWs. Abdomen dorsum dark brown; venter pale; cerci pale. Male genitalia (Fig. 3): lateral lobes of epiphallus with styli at their posterior extremities, and these styli are provided with bristles;

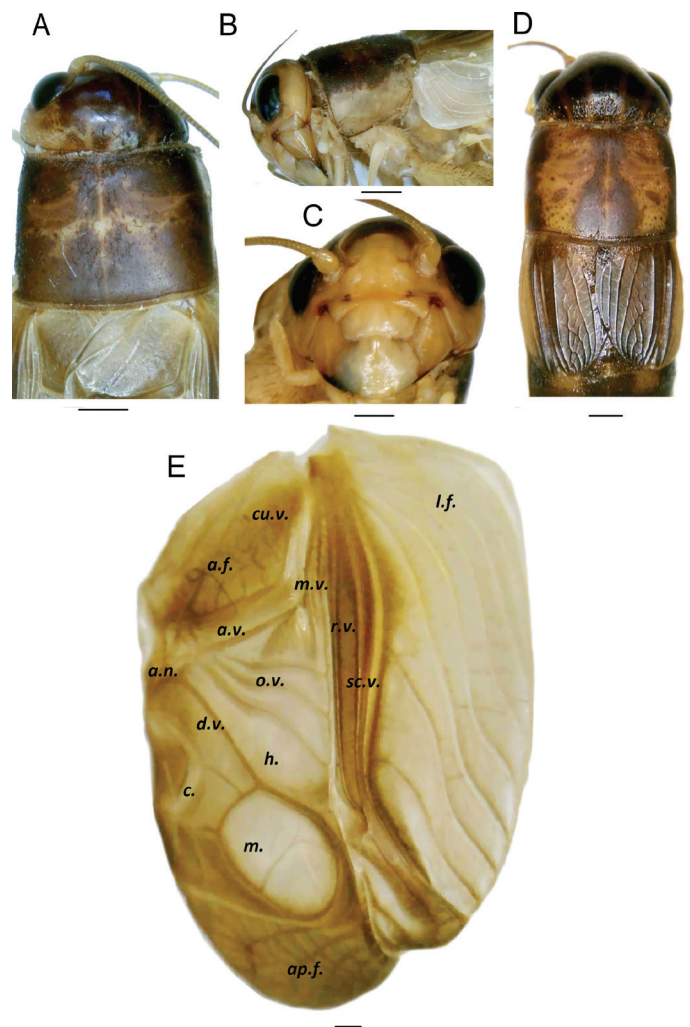


Fig. 2. Morphology of *Turanogryllus zamakoensis* sp. nov. A. Male head and pronotum; B. Male lateral view of head and pronotum; C. Male face; D. Female head, pronotum, and FWs; E. Male FW. Scale bars: 10 mm (A); 8 mm (B, C); 7 mm (D); 5 mm (E). Abbreviations: cubital vein, *cu.v.*; anal vein, *a.v.* (postcubital vein, *Pcu*); median vein, *m.v.*; radial vein, *r.v.*; subcostal vein and its branches, *sc.v.*; oblique vein, *o.v.*; diagonal vein, *d.v.*; anal node, *a.n.*; mirror, *m.*; harp, *h.*; cord, *c.*; anal field, *a.f.*; apical field, *ap.f.*; lateral field, *l.f.*

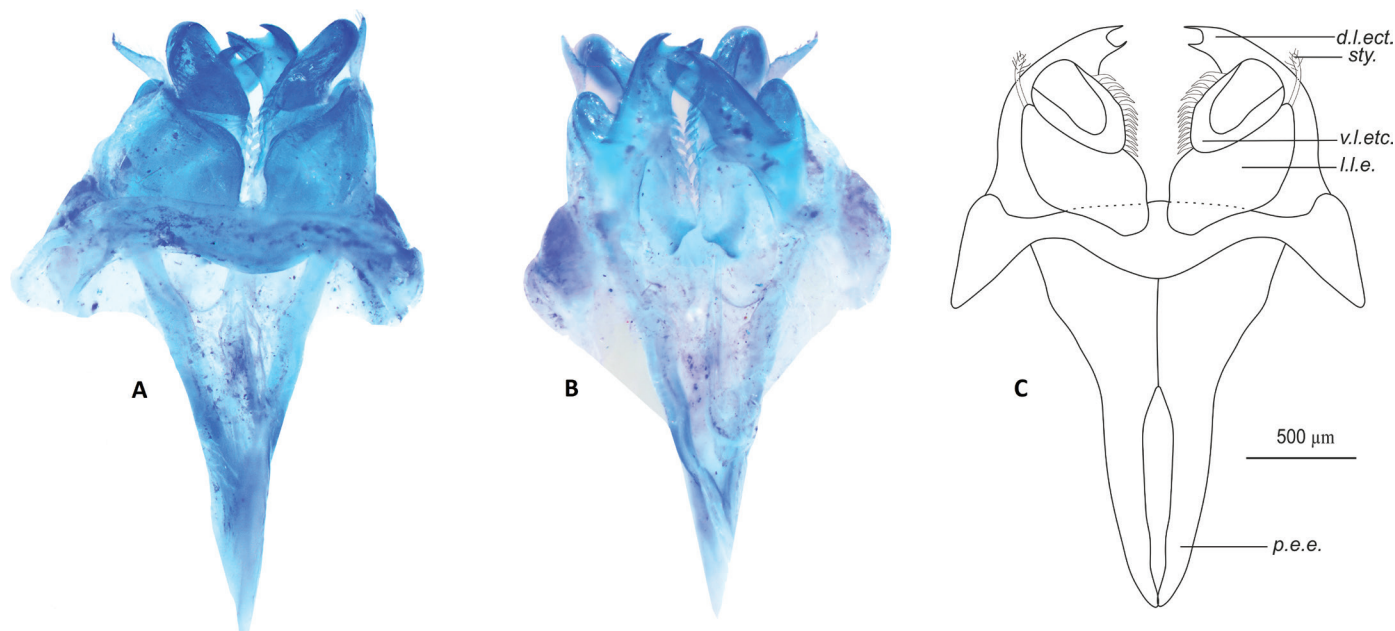


Fig. 3. Male genitalia of *Turanogryllus zamakoensis* sp. nov. **A.** Dorsal view; **B.** Ventral view; **C.** Drawing. Scale bar: 500 µm. Abbreviations: posterior emargination of epiphallus, *p.e.e.*; stylus, *sty.*; lateral lobe of epiphallus, *l.l.e.*; dorsal lobe of ectoparamere, *d.l.ect.*; ventral lobe of ectoparamere, *v.l.ect.*

dorsal lobes of ectoparameres lamelliform, curved dorsally in its posterior half; ventral lobes of ectoparameres digitiform, sigmoidally curved; dorsal lobes of ectoparameres enlarged above ventral lobes of ectoparameres.

Female. Similar to male but occiput with 6 fine, well-individualized brown stripes; FWs short, overlapping slightly and with rounded ends (Fig. 2D).

Male measurements (holotype, in mm).—BL, 18.37; PL, 3.83; PW, 4.07; FWL, 9.41; CL, 9.00; FL, 12.18; FW, 4.25; TL, 8.61. Stridulatory file with 156 teeth.

Key to males of African species of *Turanogryllus*

- 1 Pronotum dark brown or black 2
- Pronotum light brown 10
- 2 Vertex unbanded *Turanogryllus flavolateralis* (Chopard, 1934)
- Vertex banded 3
- 3 Occiput without stripe *Turanogryllus kitale* Otte, 1987
- Occiput with stripe 4
- 4 Occiput with one thin medium pale stripe 5
- Occiput with four distinct longitudinal stripes 5
- 5 FWs with a small mirror and long apical field 6
- FWs with a large mirror and short apical field 6
- 6 TIII armed with 5:5 subapical spurs 7
- TIII armed with more than 5:5 subapical spurs 8
- 7 FWs covering the abdomen; 4 oblique veins; the first cord sending one venule to the anterior inner edge of the mirror; dorsal lobes of ectoparameres located below the ventral ones *Turanogryllus niloticus* (Saussure, 1877)
- FWs covering less than half of the abdomen; 3 oblique veins; the first cord sending two venules to the anterior inner edge of the

mirror; dorsal lobes of ectoparameres located above the ventral ones *Turanogryllus zamakoensis* sp. nov.

- 8 Dorsal lobe of ectoparameres lamelliform, curved dorsally in its posterior part like claws with more than two fingers *Turanogryllus scenicus* (Gerstaecker, 1869)
- Dorsal lobe of ectoparameres lamelliform, curved dorsally in its posterior part like claws with one or two fingers 9
- 9 Dorsal lobe of ectoparameres with one finger *Turanogryllus mau* Otte, 1987
- Dorsal lobe of ectoparameres with two fingers *Turanogryllus sombo* Otte, 1987
- 10 Short diagonal vein and large apical field *Turanogryllus vicinus* (Chopard, 1967)
- Long diagonal vein and short apical field *Turanogryllus machadoi* Chopard, 1961

Genus *Neogryllopsis* Otte, 1983

Type species.—*Neogryllopsis zomba* Otte, 1983.

Diagnosis.—**Males.** Head and pronotum orange-brown on dorsum, ivory-colored on sides and venter, abdomen banded with dark brown and ivory on dorsum. Dorsum of head without longitudinal stripes, sometimes with transverse light and dark bands. Face and cheeks ivory colored. FWs: Dorsum brown to gray-brown, lateral field pale; vein 1A strongly raised above level of stridulum; harp with 5 or 6 veins (rarely 4); harp veins attached indirectly to the distal half of the stridulum through a series of small veinlets; stridulum with small short setae arranged along both sides of the file; diagonal vein bent close to chords. Hind wings absent in males. Abdomen medium to dark brown, with pale segmental margins, and tergites becoming pale on sides of body. Inner tympanum absent on TI; outer tympanum present, large. FIII with distinct or indistinct oblique rows of medium

brown spots in middle of inner and outer surfaces. TIII 0.63–0.68 times as long as FIII; with 4 or 5 inner and 4 to 6 outer subapical spurs. Cerci very pale.

Females. Similar in coloration to males. Apterous. Ovipositor as long as or longer than FIII.

Neogryllopsis gorochovi Um Nyobe,
Kekeunou & Ma, sp. nov.

<http://zoobank.org/50C1C458-BB47-4C8B-A7D6-BA3583D1D599>

Material examined.—**Holotype:** CAMEROON • ♂; Center Region, Ongot; 3°33'816"N, 11°31'913"E; 23 November 2014; secondary forest, pitfall trap; P. Um Nyobe & team leg.; MNHN-EO-ENSIF1727. **Paratypes:** CAMEROON • 1♀; same information as holotype; MNHN-EO-ENSIF1751 • 5♂, 12♀; Center Region, Zamakoe; 3°33'816"N, 11°31'913"E; 19 October 2014; 16 November 2014; 13 December 2014; crops field and forest, pitfall and quadrat traps; MNHN • 4♂, 9♀; Ongot; 3°85'786"N, 11°38'333"E; 27 September 2014; 26 October 2014; 28 March 2015; 21 April 2015; 23 August 2015; secondary forest, pitfall traps; P. Um Nyobe & team leg.; MNHN • 2♂, 7♀; Ngutadjap; 02°42'N, 011°03'E; 07 December 2014; 14 February 2015, 14 March 2015, 11 June 2015, 09 May 2015, 12 June 2015; secondary forest, pitfall traps; P. Um Nyobe & team leg.; MNHN.

Etymology.—The species is dedicated to Dr. Andrej V. Gorochov for his background work on the taxonomy of crickets in general and of *Neogryllopsis* species in particular.

Diagnosis.—Characters of the male genitalia of *Neogryllopsis gorochovi* Um Nyobe, Kekeunou & Ma sp. nov. grouped it in the **Sabianus group** made up of two species, namely *Neogryllopsis sabianus* Otte, Toms & Cade, 1988 and *Neogryllopsis limpopensis* Otte, Toms & Cade, 1988. *Neogryllopsis gorochovi* can be differentiated from these species by its male genitalia with ectoparamere without setae, short epiphallus, and FW with an undivided round mirror.

Description.—(Figs 4, 5, Table 1) **Male.** Medium size, pale orange-brown. Dorsum of head without a transverse pale band across vertex (Fig. 4A); top of head without dark markings along inner margins of eyes; forehead dark brown, without white stripe between lateral ocelli; cheeks pale brown (Fig. 4B) and face brown before epistomal suture and pale after this suture (Fig. 4C). Pronotum red-brown without ivory-colored band along margins (Fig. 4A). TI and TII pale, somewhat orange. Hindlegs: FIII with distinct oblique brown stripes on outer surface; TIII pale brown with 5 inner and 5 outer subapical spurs. FWs: dorsum grayish brown, lighter on lateral field; FW length to pronotal length ratio c. 2.3 mm; stridulatory file with 86 teeth; harp with 4 oblique veins; mirror round without a dividing vein; apical field very small (Fig. 4E). Hind wings absent. Abdomen: Tergites dark brown, with pale posterior margins; venter light brown; cerci dark brown. Male genitalia (Fig. 5): Epiphallus well developed but short; lobes of epiphallus in posterior view long, tapering, two points closely apposed, separated by a deep cleft; lateral lobe of epiphallus with long setae near base and without spines; ectoparamere without setae.

Female. Similar to male in color. Size range extends considerably above that of male (Table 1). FWs very short, sometimes just visible under edge of pronotum (Fig. 4D).

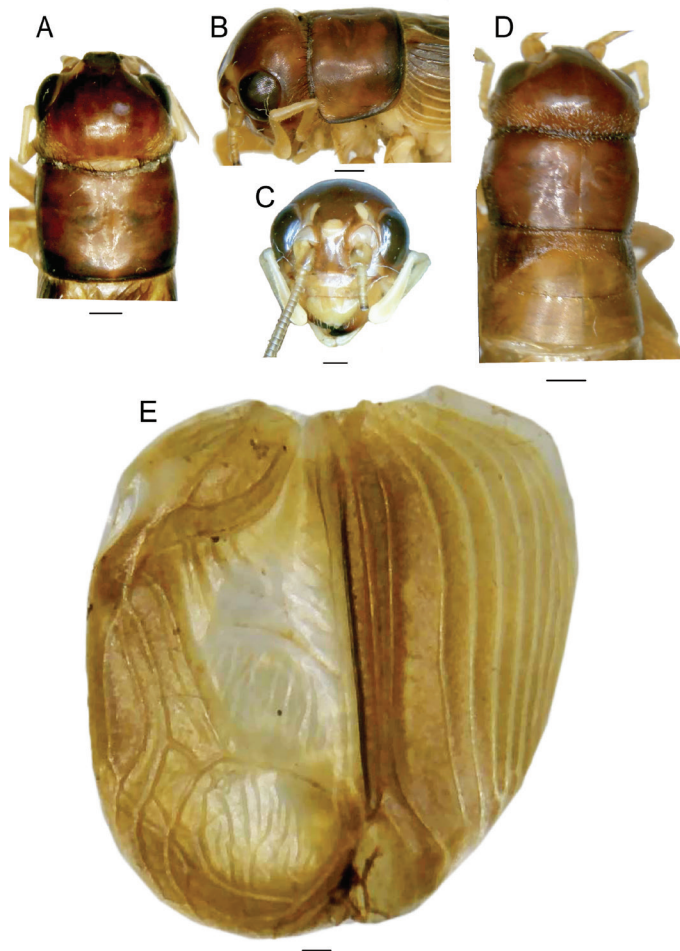


Fig. 4. Morphology of *Neogryllopsis gorochovi* sp. nov. A. Male head and pronotum; B. Male lateral view of head and pronotum; C. Male face; D. Female head, pronotum, and FWs; E. Male FW. Scale bars: 7 mm (A); 6 mm (B, E); 5 mm (C); 8 mm (D).

Male measurements (holotype, in mm).—BL, 15.03; PL, 2.60; PW, 4.12; FWL, 6.02; CL, 10.33; FL, 11.82; FW, 3.83; TL, 9.49. Stridulatory file with 86 teeth.

Key to males of African *Neogryllopsis* species of *Sabianus* group

- 1 FWs without a dividing vein in mirror; harp with 4 oblique veins; less than 200 stridulatory file teeth; ectoparamere without setae *Neogryllopsis gorochovi* sp. nov.
- FWs with a dividing vein in mirror; harp with 5 oblique veins; more than 200 stridulatory file teeth; ectoparamere with setae 2
- 2 Stridulatory file with 200 to less than 270 teeth; presence of white stripe between lateral ocelli and pale band across vertex; pronotum reddish brown, unbanded *Neogryllopsis sabianus* Otte, Toms & Cade, 1988
- Stridulatory file with more than 270 teeth; absence of white stripe between lateral ocelli and pale band across vertex; pronotum reddish brown but with a distinct ivory-colored band along all margins *Neogryllopsis limpopensis* Otte, Toms & Cade, 1988

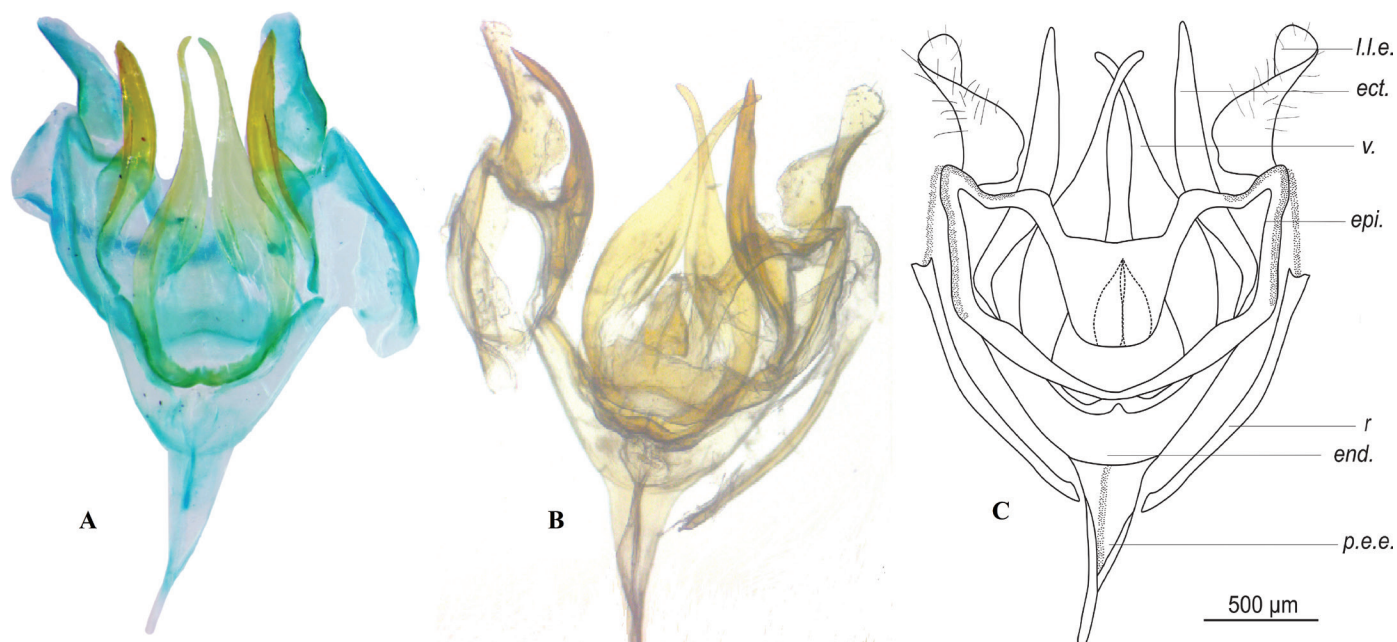


Fig. 5. Male genitalia of *Neogryllopsis gorochovi* sp. nov.; A. Dorsal view; B. Ventral view; C. Drawing. Scale bar: 500 µm. Abbreviations: epiphallus, *epi.*; ectoparameres, *ect.*; endoparameres, *end.*; ramus, *r.*; virga, *v.*; posterior emargination of epiphallus, *p.e.e.*

Table 1. Measurements in mm: average $\pm$ standard error (minimum–maximum) total abundance.

Feature	Male	Female	t Value	P Value
BL	15.77 $\pm$ 0.48 (14.10–19.84) 12	17.43 $\pm$ 0.34 (14.64–21.10) 29	2.70	0.01
PL	2.93 $\pm$ 0.08 (2.40–3.23) 12	3.26 $\pm$ 0.06 (2.62–4.45) 29	3.25	0.002
PW	3.95 $\pm$ 0.03 (3.77–4.12) 12	4.23 $\pm$ 0.06 (3.16–4.68) 29	2.63	0.01
FWL	5.17 $\pm$ 0.22 (3.99–6.10) 12	–	–	–
CL	9.15 $\pm$ 0.87 (8.27–11.58) 11	11.00 $\pm$ 0.32 (6.83–14.24) 29	2.49	0.017
FL	12.32 $\pm$ 0.11 (11.60–12.92) 12	12.73 $\pm$ 0.13 (10.43–13.8) 29	1.85	0.07
FW	3.92 $\pm$ 0.10 (3.43–4.61) 12	4.19 $\pm$ 0.06 (3.33–4.67) 29	2.47	0.018
TL	9.88 $\pm$ 0.23 (7.88–10.62) 12	10.34 $\pm$ 0.16 (8.45–11.48) 29	1.62	0.11
OL	–	9.30 $\pm$ 0.28 (7.52–13.89) 29	–	–
FWL/PL	1.78 $\pm$ 0.09 (1.31–2.32) 12	–	–	–
CL/FL	0.74 $\pm$ 0.07 (0.67–0.93) 11	0.86 $\pm$ 0.02 (0.65–1.24) 29	2.14	0.039
OL	–	0.74 $\pm$ 0.03	–	–
FL	–	(0.59–1.15) 29	–	–

Discussion

We described two new species belonging to the genera *Turanogryllus* and *Neogryllopsis*, respectively. Both are newly recognized for Cameroonian fauna; they increase the number of African species of *Turanogryllus* to 11 and of *Neogryllopsis* to 21.

These species, namely *Turanogryllus zamakoensis* Um Nyobe, Kekeunou & Bilong Bilong sp. nov. and *Neogryllopsis gorochovi* Um Nyobe, Kekeunou & Ma sp. nov., are characterized by comparatively low numbers of teeth on the stridulatory file, i.e., 156 and 86 teeth, respectively, while the other known species belonging to the genera *Turanogryllus* and *Neogryllopsis* have stridulatory files with more than 200 teeth (Otte 1994, Otte et al. 1988).

It is worth noting that all species of the genus *Turanogryllus* have TI with small inner and large outer tympanum (Tarbinsky 1940), while those of the genus *Neogryllopsis* have divided mirrors (Otte 1987). Nevertheless, *T. zamakoensis* sp. nov. has only one outer tympanum, and *N. gorochovi* sp. nov. has an undivided mirror as found in *Neogryllopsis storozhenkoi* Gorochov, 1988 (Otte et al. 1988).

The description of these two new species of *Turanogryllini* from Central Africa (more precisely, from Cameroon), extends the known range for both genera. In addition, they were previously known as field crickets (Randell 1964, Otte 1983, Otte 1987, Otte et al. 1988) but in the current work, *T. zamakoensis* sp. nov. was captured in a forested area, while *N. gorochovi* sp. nov. was found in both open and closed environments. It is possible that *T. zamakoensis* and *N. gorochovi* also occur in open areas near forests. To better characterize the species' living environments, additional studies are needed.

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