

Redescription and diagnosis of the African genus *Gemeneta* Karsch, 1892 (Orthoptera: Acrididae: Catantopinae)

CHARLY OUMAROU NGOUTE¹, SÉVILOR KEKEUNOU¹

¹ Laboratory of Zoology, Faculty of Science, University of Yaoundé 1, Yaoundé, Cameroon.

Corresponding author: Charly Oumarou Ngoute (coumaroungoute@yahoo.fr)

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Abstract

The subfamily Catantopinae is a poorly defined subfamily of the Acrididae, having many genera that require taxonomic clarification. The genus *Gemeneta* from this subfamily is found in African forests and has only two described species, *Gemeneta terrea* and *Gemeneta opilionoides*. However, the original descriptions of the genus relied heavily on external female morphology, and a description of male *G. opilionoides* was completely lacking. The present work provides the first description of the male of *G. opilionoides*, a morphological description of both species, including internal genitalia, and clarifies the generic diagnosis. This study is a contribution to a better understanding of the taxonomy of Catantopinae in the tropical forests of Africa.

Key words

Caelifera, Cameroon, forest, genitalia, male description, taxonomy, Uganda

Introduction

The grasshopper subfamily Catantopinae is a rather large taxon with many genera and a great variety of forms, including around 16 tribes, about 382 genera and 52 species distributed over the Old World (Cigliano et al. 2017). The Catantopinae are a somewhat poorly defined subfamily of the Acrididae that is in need of a major revision because it includes species requiring further study (Dirsh 1961). Many genera within Catantopinae still require clarification of their taxonomic positions and cumulative work over many years may be required (Cigliano et al. 2017) especially in African forest areas where relatively little scientific research has been carried out. In tropical Africa, this taxon includes genera that occupy all terrestrial environments from arid savannah to humid forests (Dirsh 1956a, 1965, 1966, 1970, Jago 1984, Mestre 1988). The genus *Gemeneta* Karsch, 1892 is a forest genus of Catantopinae in Africa that has only two described species, *Gemeneta terrea* Karsch, 1892 and *Gemeneta opilionoides* (Bolivar 1905). *G. terrea* is widely-distributed, from East to West Africa while *G. opilionoides* is endemic to the Congo Basin forests, including Cameroon and Equatorial Guinea.

The distributions of the two species overlap in the Congo Basin forests (Fig. 1), but *G. opilionoides* is very rare and difficult to find there, suggesting that it has a specialized ecological niche in the forests. Deforestation poses a high risk of extinction for this already scarce species, especially in Cameroon where almost all forests are being rapidly destroyed through human activities. Hence, there is an urgent need to ascertain the taxonomy, biology and ecology of this species. The original descriptions of the genus *Gemeneta* relied heavily on external female morphology, and a description of male of *G. opilionoides* is lacking. Although Dirsh (1965, 1970) listed both species of the genus, his work mostly refers to the more common *G. terrea*, and simply indicates the presence of *G. opilionoides* in the forests of central Africa but does not clearly characterize or distinguish it from *G. terrea*. The description of Bolívar (1905) is only based on the female (in MNCN Madrid Museum). The description of Kevan (1956) is also based on coloration and external morphology of a female specimen (in the Copenhagen Museum). The present study provides the first description of the male of *G. opilionoides*, an identification key to species, and clarifies the generic diagnosis of the genus.

Materials and methods

Field sites.—The specimens used in this study were collected in the forest margin benchmark area of the Southern Cameroon plateau and in the Mpanga forest in the south of Uganda. The Southern Cameroonian plateau (between 3°27'N, 11°32'E and 4°10'N, 11°49'E), with an average altitude of 650–700 m, is a part of the plateau which forms the northern and western edge of the Congo basin (Westphal et al. 1981). It has a Guinean climate of 4 seasons: a long dry season (mid-November to mid-March), a small rainy season (mid-March to June), a short dry season (July to mid-September) and a long rainy season (mid-September to mid-November). The range of rainfall is 1500 to 2000 mm per year (Amou'ou et al. 1985, Santoir and Bopda 1995). These forests are dominated by Sterculiaceae and Ulmaceae, and their undergrowth is made up of herbaceous plants such as Maranthaceae and Acanthaceae (Westphal et al. 1981). Mpanga forest is a forest reserve, 30 km west of Kampala (pers. comm. C.H.F. Rowell).

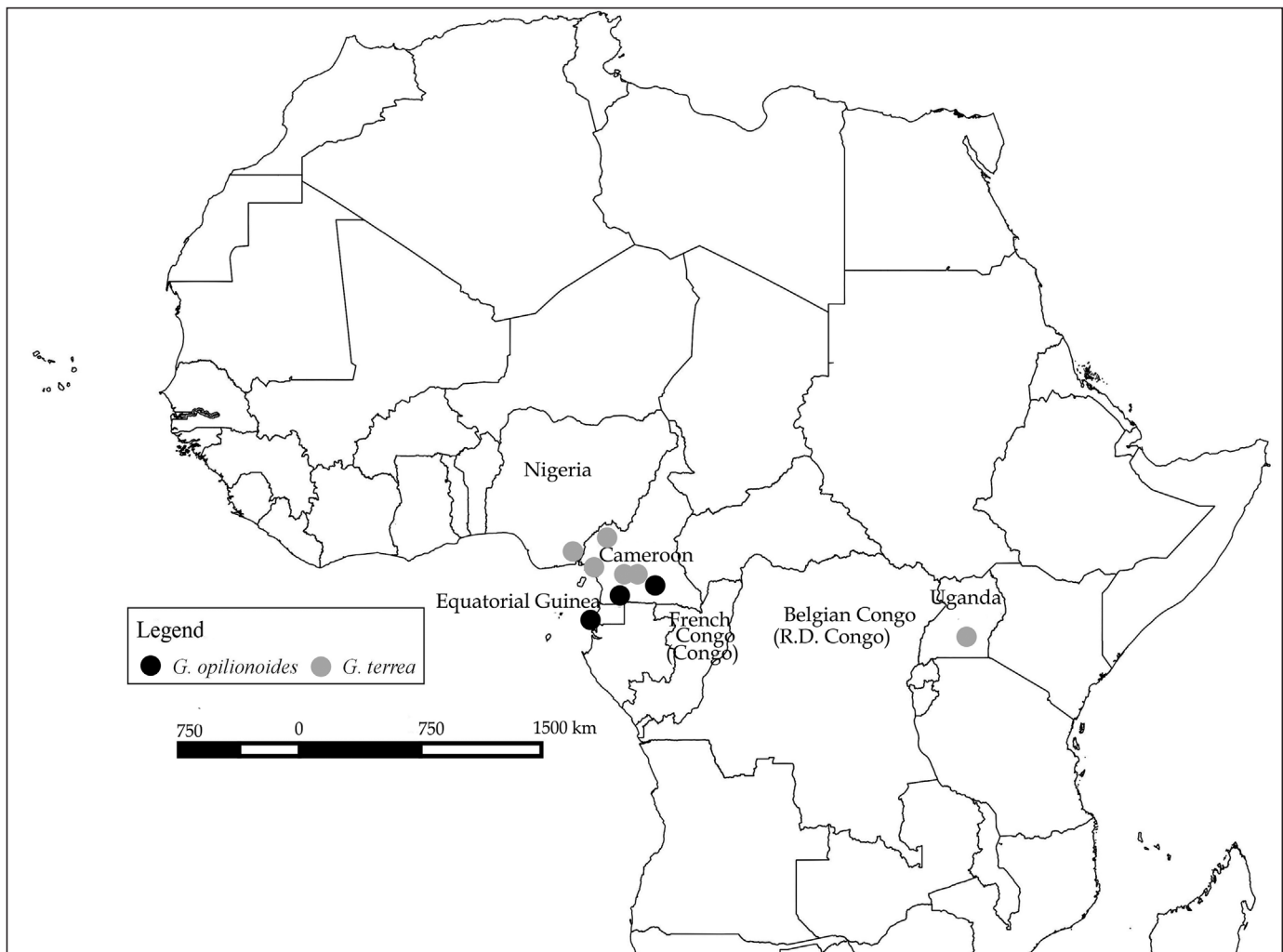


Fig. 1. Distribution map for *Gemeneta* spp.

Morphological study.—The morphology of all the specimens was described and measured using a Wild microscope under 25-50 \times magnification with a digital stage and a graticule eyepiece. Drawings were made using the same microscope with drawing tube attachment and edited in Photoshop CS6 (Adobe Systems Inc., San José, California, USA).

Measurements.—The following measurements were made (Table 1, Supplementary material 1): L: Overall length from the tip of the fastigium to the most posterior part of the genitalia, measured in lateral view; FL: Length of fastigium, measured from a line joining the most anterior part of the profile of the eyes in dorsal view to the tip of the fastigium; CV: Height of the head from clypeal suture to vertex, measured in lateral view from the clypeal suture to the highest point on the vertex posterior to the eyes; P: Length of the pronotum in the midline; F: Maximum length of the hind femur; FD: Depth of femur, measured as the distance between the two parallel lines running through the dorsal and ventral extremities of the femur, drawn parallel to the long axis of the femur; Ta1, Ta2, Ta3: Lengths of each of the three hind tarsal segments.

The mean and standard error of each measurement was calculated by the software PAST version 3.12.

Genitalia.—Standard methods for the extraction and preparation of the internal genitalia were used to extract the male and female genitalia studied. The internal genitalia were extracted, macerated in 8% KOH solution, neutralized in 5% dilute acetic acid, then stained in acid fuchsin and stored in glycerine before examination and drawing. The terminology of phallic complex used is derived from Dirsh (1956b, 1970) and Rowell (2013); that of the female subgenital plate and spermatheca is derived from Randell (1963) and Thomas (1965).

General terms: Ectophallus: external part of the phallus organ consisting mainly of the ectophallic membrane plus the cingulum and its rami; Endophallus: internal part of the phallic organ, consisting of the aedeagus and its appendices, ejaculatory and spermatophore sac, and the ventral valves of the aedeagus; Epiphallus: strongly sclerotized sclerite located on the dorsal part of the phallic organ; Spermatheca (S): a vesicle or a blind-ending duct, the part of the female genitalia that receives and stores the ejaculatory product from the male.

Specific terms: Ancorae (A), Ventral aedeagal valves (Vv), Apodemes of cingulum (Apd), Bridge (B), Columella (C), Valves of cingulum (Cv), Ectophallic sheath (Es), Egg-guide (Eg), Floor pouches (Fp), Gonopore processes (Gpr), Lophi (L), Preapical appendix (Pa), Posterior edge (Pe), Zygoma (Zyg) (see Figs 7–8).

Results

Gemeneta Karsch, 1892

= *Escalera* Bolívar, 1905 (syn. Dirsh 1958).

Type species.—*G. terrea* Karsch 1892.

Revised diagnosis of genus, compared to Dirsh's (1965) generic description.—The generic description presented in this work differs somewhat from the description of Dirsh (1965). Dirsh describes the integument as being strongly tuberculate, and his diagnosis emphasizes the presence of a fastigial furrow and a short epiphallus. Unlike Dirsh (1965), we find that only *G. opilionoides* has a strongly tuberculate integument and *G. terrea* has a less tuberculate and granulated integument; *G. opilionoides* lacks a fastigial furrow – this character is specific to *G. terrea*; the epiphallal lophi of both species are lobiform but *G. opilionoides* have wide lophi while those of *G. terrea* are narrow or short like those described by Dirsh (1965).

Diagnosis.—Body with integument slightly or strongly tuberculate and granulated; antenna longer than head and pronotum together; head conical, frons incurved; fastigium of vertex elongate-angular and sloping forwards; frontal ridge weak, strongly constricted below lateral ocelli; eyes convex; ocelli small. Pronotum cylindrical, with median and lateral carinae substituted by granulae; dorsum crossed by three sulci; prosternal process conical; external apical spine of the hind tibia absent; elytra and wings absent; the third segment of foot longer than the first, and the first longer than the second. Male supra-anal plate elongated, angular, with deep transverse furrow. Subgenital plate conical, with acute apex. Valves of ovipositor long, straight, with slightly curved apices; cercus conical. Epiphallus with wide bridge, small ancorae and incurved lobiform lophi; ventral aedeagal valves and valves of cingulum elongated, enclosed in a wide ectophallic sheath; anterior apodemes of aedeagus divergent with rounded apices; gonopore process pointed; zygoma wide, apodemes of cingulum parallel with acute apices.

Gemeneta terrea Karsch, 1892

Tables 1–2; Figs 2–3, 6–8

Syntypes.—Africa, West-Central Tropical Africa Cameroon: Buea; 2 ♂♂, 1 ♀; MfN.

Recorded localities.—Buea, Cameroon (4°15'27"N, 9°24'1"E) by Karsch (1892); Oban District, Nigeria (5°18'868"N, 8°34'827"E) by Ramme (1929); French and Belgian Congo by Dirsh (1965) without precision on localities; Western and Southern Uganda (2°97'78"N, 32°64'22"E) by Rowell (pers. comm.); Zamakoe (3°33'816"N, 11°31'913"E), Ongot (3°85'786"N, 11°38'333"E) and Bamenda (5°95'971"N, 10°14'597"E), Cameroon by Oumarou Ngoute (Fig. 1).

Material examined.—Uganda, Mpanga forests, 4 ♂♂, 3 ♀♀, in the collection of Dr. Rowell, Switzerland; Cameroon, Zamakoe forests, 1 ♂, 1 ♀; Ongot forests, 1 ♀, in the Laboratory of Zoology, University of Yaoundé 1, Cameroon.

Diagnosis.—Body slightly elongated, 5 to 6 times the length of the pronotum; integument rugose. Head conical, the maximum

Table 1. Measurements (mm) of *G. terrea* and *G. opilionoides*. The values in the table represent: mean ± standard error (min–max). All measurements for *G. terrea* repeated for five specimens, except tarsal measurements which were repeated for four specimens. Only one male and one female of *G. opilionoides* were available for study so no range of values could be provided for this species.

Species	<i>G. terrea</i>		<i>G. opilionoides</i>		
	Sex	Male	Female	Male	Female
L		20.02±0.36 (18.87–20.97)	29.89±0.93 (27.52–32.02)	21.94	29.43
FL		0.99±0.04 (0.86–1.13)	1.26±0.03 (1.15–1.33)	1.52	2.15
CV		4.51±0.09 (4.16–4.7)	5.97±0.25 (5.54–6.7)	4.8	5.81
P		3.37±0.06 (3.24–3.58)	4.97±0.14 (4.49–5.35)	3.83	4.73
F		12.31±0.15 (12.06–12.92)	16.48±0.18 (15.99–17.07)	14.66	19.33
FD		2.67±0.03 (2.61–2.79)	3.44±0.11 (3.07–3.67)	2.56	3.48
Ta1		1.34±0.09 (1.11–1.54)	1.65±0.05 (1.53–1.79)	1.67	1.86
Ta2		0.51±0.04 (0.44–0.62)	0.58±0.04 (0.45–0.66)	0.48	0.63
Ta3		1.60±0.07 (1.43–1.77)	2.01±0.06 (1.83–2.13)	2.08	2.50

width of head across the eyes almost as long as the pronotum in the males, slightly shorter in females; fastigium of vertex clearly projecting forward with a deep furrow which merges with frontal ridge sulcus, apex of fastigium rounded, fastigium 1/4 the length of pronotum and about 1/2 the length of the fastigium of *G. opilionoides* (Table 1: FL); width of fastigium 1/3 the length of pronotum; frontal ridge low and discontinuous; frons incurved; eye large and oval; antenna fine, filiform, longer than the head and pronotum together. Pronotum dorsally cylindrical, slightly convex between sulci 2 to 4 in dorsal view and rugose; laterally, and in the anterior part of the prozona and posterior part of metazona more rugose, slightly tuberculate; anterior and posterior margins of pronotum rounded; prosternal process conical with acute apex; mesosternal space open with rounded lobes; hind femur 4 to 5 times longer than wide, 4 times longer than the foot and about 2/3 the length of the hind femur of *G. opilionoides* (Table 1: F); the third segment of foot longer than the first, and the first longer than the second (Table 1: Ta1, Ta2, Ta3). Epiproct triangular with deep transverse furrow and rounded apex; valves of ovipositor long, straight, with slightly curved apices; cercus in both sexes straight, conical, usually shorter than the paraproct in female and slightly exceeding paraproct in the male; male subgenital plate conical. Endophallus slender; ventral aedeagal valves slender and strongly elongated; valves of cingulum slender and elongated, ventral aedeagal valves and valves of cingulum enclosed in a wide ectophallic sheath; anterior apodemes of aedeagus divergent with rounded apices; gonopore process pointed; zygoma wide, apodemes of cingulum parallel with acute apices. Epiphallus with wide bridge, strongly concave in the anterior margin, ancorae curved; lophi curved forward, narrow and lobiform. Spermatheca with a long tubular duct and vermiform preapical appendix, without distinct terminal ampullae; egg-guide of subgenital plate dorsally conical, laterally with pointed apex, columella present and wide, floor pouches and posterior edge rounded, median longitudinal groove absent.



Fig. 2. *G. terrea*, female from Mpanga forest, Uganda (2°97'78"N, 32°64'22"E).



Fig. 3. *G. terrea*, male from Mpanga forest, Uganda (2°97'78"N, 32°64'22"E).

Table 2. Tabular key to species.

Characters	<i>G. terrea</i>	<i>G. opilionoides</i>
Body coloration	Body generally entirely brownish; median inner area of hind femur blackish (Figs 2–3)	Body greenish mottled with brown dark; median inner area of hind femur greenish (Figs 4–5)
Integument	Integument less granulated and less tuberculate in pronotum (Figs 2, 6C)	Integument granulated and strongly tuberculate in pronotum (Figs 4, 6D)
Fastigium of vertex	Fastigium of vertex with a deep apical furrow (Fig. 6A)	Fastigium of vertex without apical furrow (Fig. 6B)
Length of cercus	Cercus shorter than the paraproct in female (Fig. 6E)	Cercus almost as long as the paraproct in female (Fig. 6F)
Apical valves of penis	Ventral aedeagal valves slender and strongly elongated (Figs 7E, G, I)	Ventral aedeagal valves dorsally flattened and curved outwards (Figs 7E, H, J)
Lophi	Lophi lobiform and narrow (Figs 8C, G)	Lophi lobiform and wide (Figs 8D, H)

Coloration.—Body generally brownish. Antenna brown; eyes black with a characteristic brown band in the upper half; prothoracic and mesothoracic legs brown mottled with light green in life; internal face of hind femur blackish, external upper area brown, median external area green drying black, lower inner area of hind femur and tibia slightly greenish to blueish in life.

***Gemeneta opilionoides* (I. Bolívar, 1905)**

Tables 1–2; Figs 4–8

= *Escalera opilionoides* Bolívar, 1905 (syn. Dirsh 1958).

= *Gemeneta rostratuberculata* Kevan, 1956 (syn. Dirsh 1958).

Holotype.—*E. opilionoides*: Africa, West-Central Tropical Africa, Equatorial Guinea, Cabo San Juan, Biafra; 1 ♀; MNCN Madrid Mus.

Recorded localities.—Biafra, Equatorial Guinea (1°18'284"N, 9°36'336"E) By Bolívar 1905; Makak, Cameroon (3°43'333"N,

12°78'333"E) by Kevan 1956; former holotype of *G. rostratuberculata*, ZMUC Copenhagen; Ngutadjap, Cameroon (2°42'N, 11°03'E) by Oumarou Ngoute (Fig. 1).

Material examined.—Cameroon, Ngutadjap forests, 1 ♂, 1 ♀, in the Laboratory of Zoology, University of Yaoundé 1, Cameroon.

Diagnosis.—The species differs from *G. terrea* in having the integument strongly granulated and tuberculate, body greenish mottled with dark brown; median inner area of hind femur greenish, fastigium of vertex without apical furrow, cercus almost as long as the paraproct in female, ventral aedeagal valves dorsally flattened and curved outwards, lophi lobiform but wide.

Description.—Body slightly elongated, 5 to 6 times the length of the pronotum; integument granulated and strongly tuberculate in pronotum. Head strongly conical, the maximum width of head across the eyes almost as long as the pronotum; fastigium about

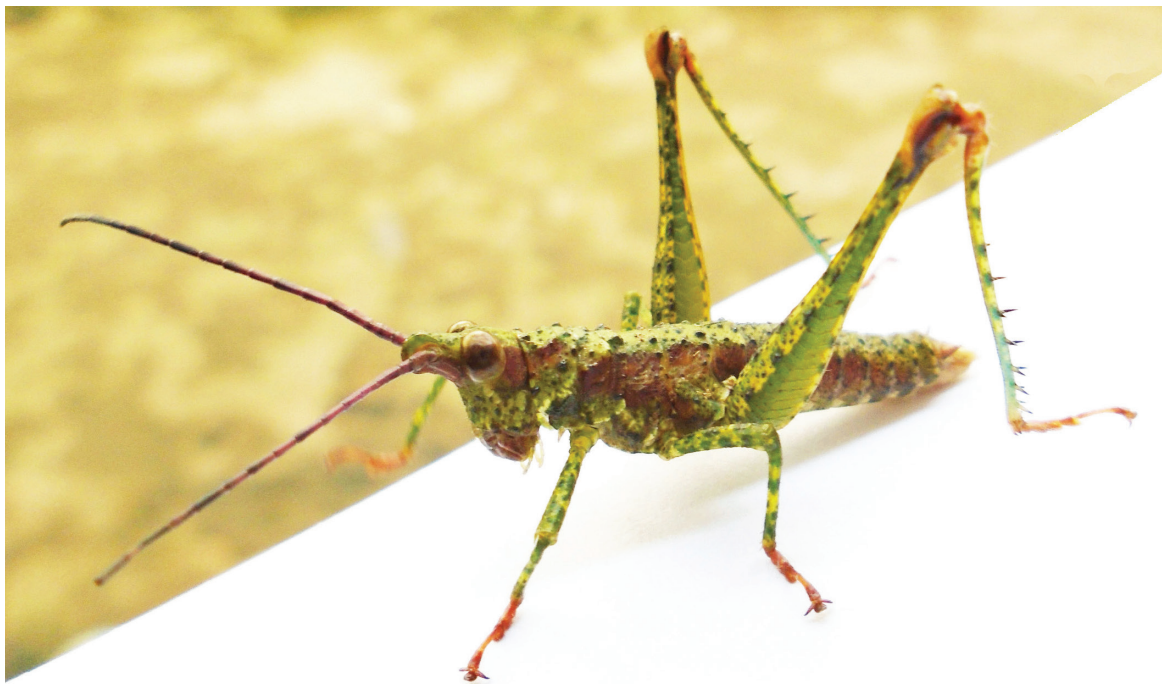


Fig. 4. *G. opilionoides*, female from Ngutadjap, Cameroon (2°42'N, 11°03'E).



Fig. 5. *G. opilionoides*, male from Ngutadjap, Cameroon (2°42'N, 11°03'E).

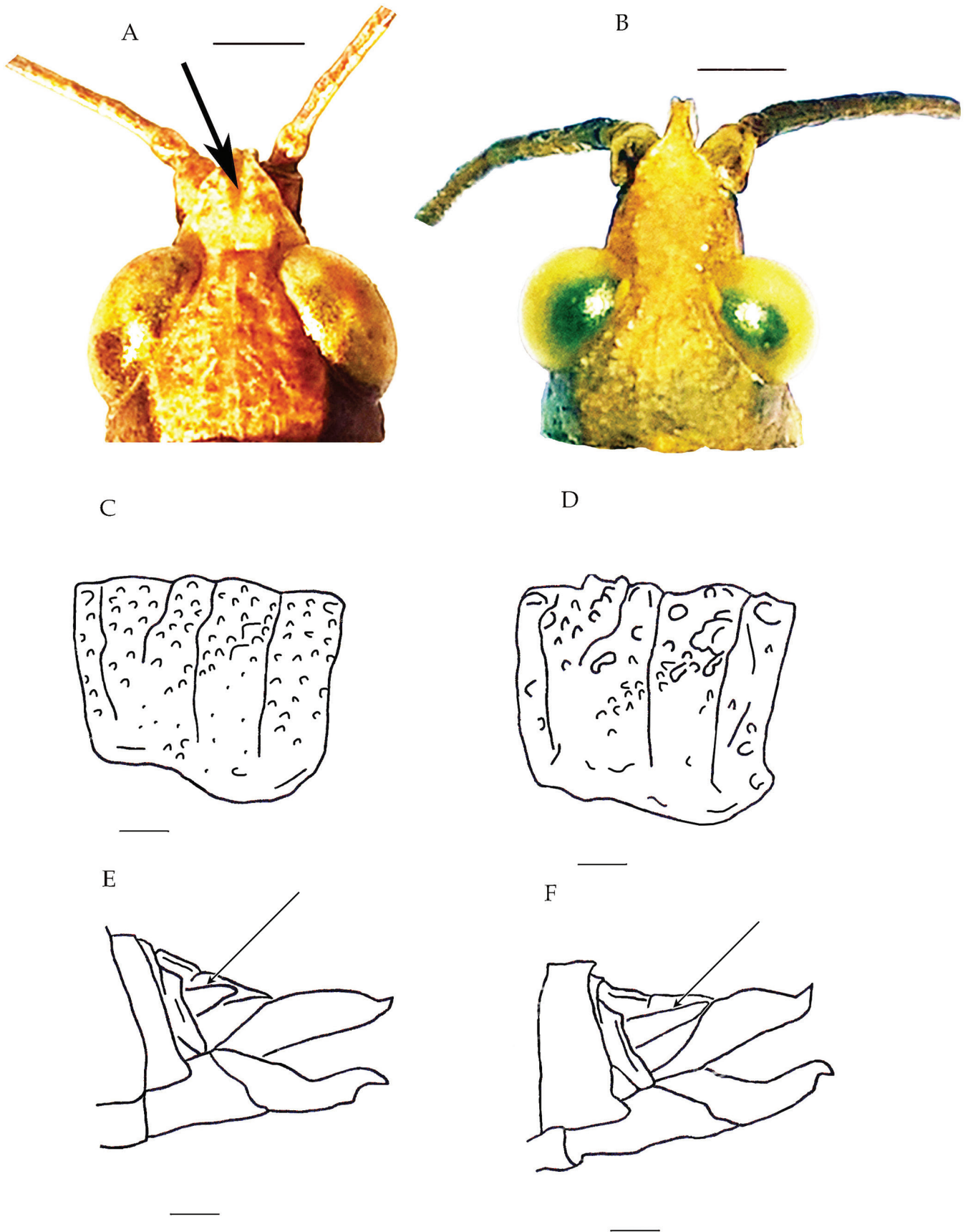


Fig. 6. External diagnostic characters of *Gemeneta* spp. A, B. Fastigium of vertex; C-D. Pronotum lateral view; E-F. External genitalia female; A, C, E. *G. terrea* and B, D, F. *G. opilionoides*. Scale bars = 1 mm.

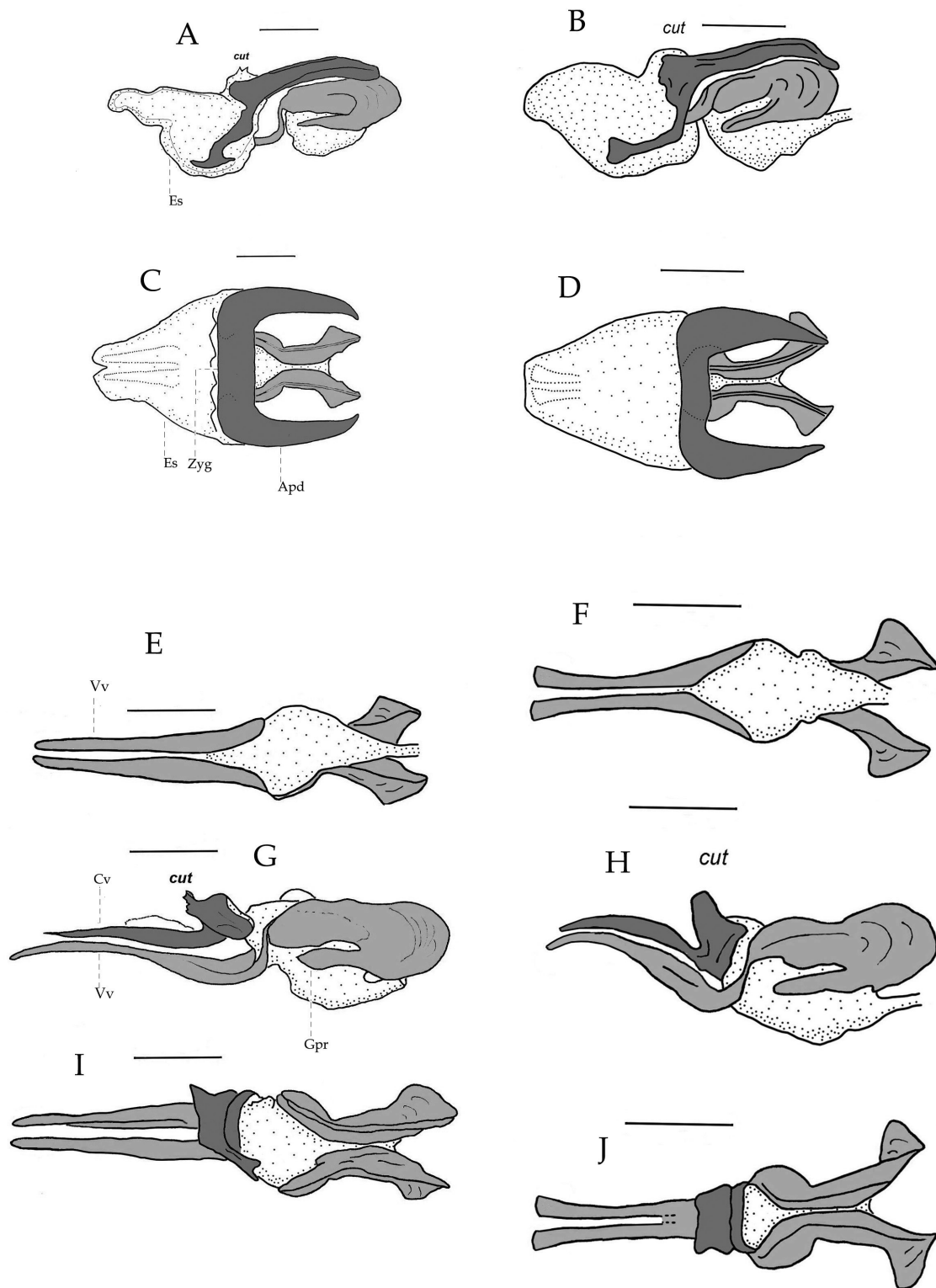


Fig. 7. Ectophallus and endophallus of *Gemeneta* spp. A, B. Entire phallic complex without epiphallus in lateral view; C, D. Entire phallic complex without epiphallus in dorsal view; E, F. Endophallus in ventral view; G, H. Endophallus in lateral view; I, J. Endophallus in dorsal view; A, C, E, G, I. *G. terrea* and B, D, F, H, J. *G. opilionoides*; Apodemes of cingulum (Apd): pair of ectophallic sclerotized structures situated dorsally to endophallus; Valves of cingulum (Cv): pair of valves projecting from the posterior end of the cingulum from the arch of cingulum; they form the upper valves of the aedeagus; Ectophallic sheath (Es): the membrane part of ectophallus covering the ventral aedeagal valves and valves of cingulum, often partially sclerotized; Gonopore processes (Gpr): pair of ventral processes from the aedeagal valves, functioning as a pinch valve between the ejaculatory and spermatophore sacs; Ventral aedeagal valves (Vv): endophallic valves, divided in two parts; Zygoma (Zyg): transverse dorsal part of cingulum, connecting the apodemes. Scale bars = 0.5 mm.

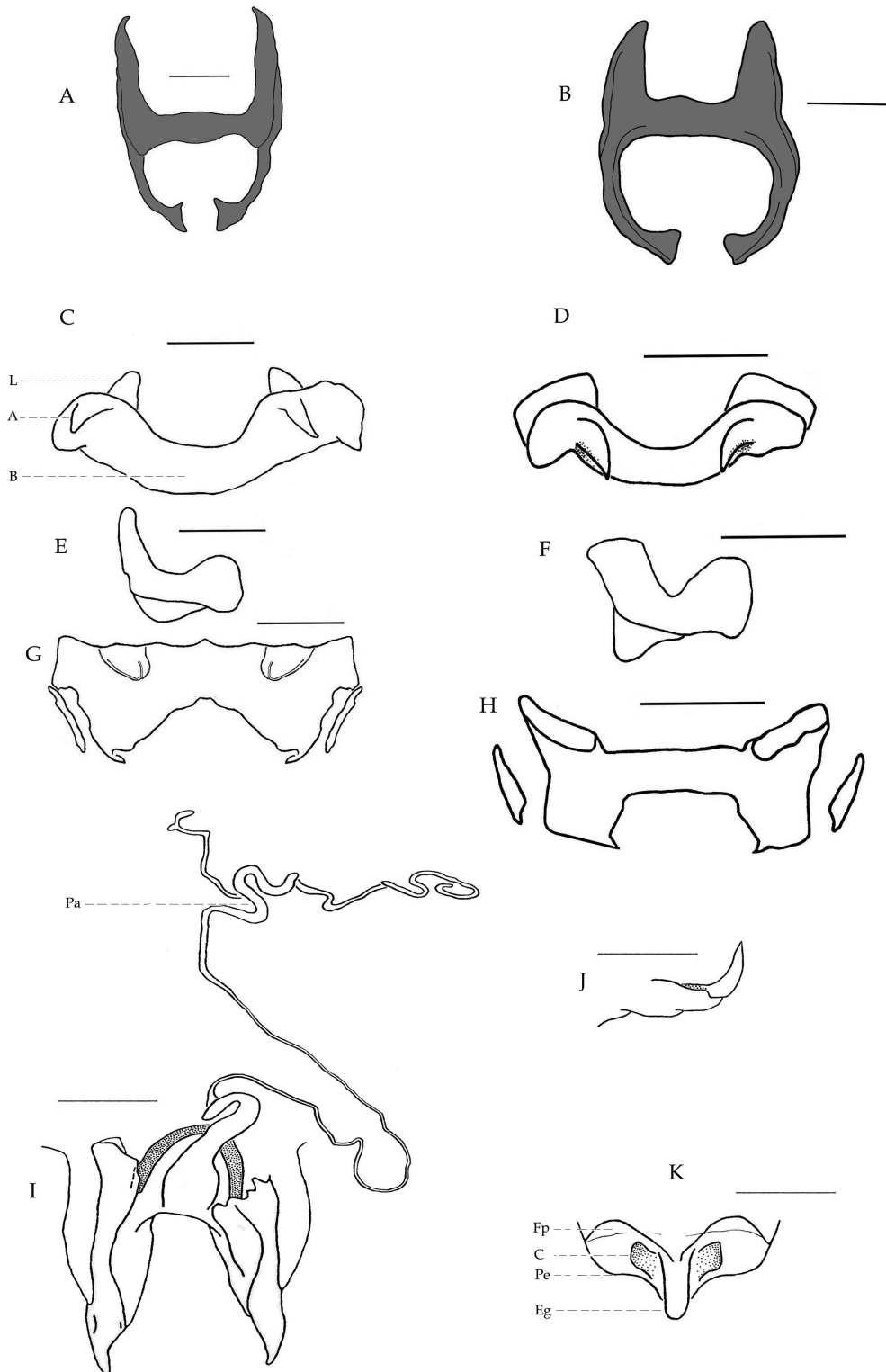


Fig. 8. Ectophallus, epiphallus, spermatheca and subgenital plate of *Gemeneta* spp. **A, B.** Ectophallus in ventral view; **C, D.** Epiphallus in axial view; **E, F.** Epiphallus in lateral view; **G, H.** Epiphallus in dorsal view; **I.** Spermatheca in dorsal view; **J.** Subgenital plate in lateral view; **K.** Subgenital plate in dorsal view; **A, C, E, G, I, J, K.** *G. terrea* and **B, D, F, H.** *G. opilionoides*; **Ancorae (A):** a pair of processes or projections from the anterior margin or the dorsal surface of the epiphallus; **Bridge (B):** transverse part of epiphallus connecting the lateral parts; **Lophi (L):** lobiform processes near the posterior margin of the epiphallus; **Columella (C):** columnar structures on either side of the egg-guide in the subgenital plate; **Egg-guide (Eg):** median, dorsally produced part of the posterior edge in the subgenital plate; **Floor pouches (Fp):** pair of short anterior invaginations in the floor of the subgenital plate; **Preapical appendix (Pa):** preapical dilatation of the spermathecal duct; **Posterior edge (Pe):** pair of short posterior invaginations of the border that meets the floor in the subgenital plate. Scale bars = 0.5 mm.

1/2 the length of the pronotum and nearly 2 times longer than the fastigium of *G. terrea* (Table 1: FL); width of fastigium about 1/3 to 1/2 the length of pronotum; fastigium projected forward, flat, horizontal, narrowing toward apex and fusing with the frontal ridge to form a rostrum; frons strongly concave below rostrum; frontal ridge weak, and obsolete below the medial ocellus; eyes globular, slightly longer than wide; antenna fine, filiform, but slightly expanded at the base; antenna longer than the head and pronotum together. Pronotum cylindrical, tuberculate, lateral and median carinae absent; disc of pronotum crossed by three sulci, (2 to 4) (sulcus 1 obsolete on the disc and visible only on the lobes); sulci 3 and 4 deep and extend almost to the ventral margin of the lobes; anterior and posterior margins of pronotum straight but emarginated in the midline; prosternal spine vertical, conical, with acute apex; mesosternal interspace almost as long as wide; mesosternal lobes rounded; tympanum oval, slightly longer than wide. Hind femur 5 to 6 times longer than wide, 3 to 4 times longer than the foot and 1.5 times longer than the hind femur of *G. terrea* (Table 1: F); upper internal and external genicular lobes rounded, lower internal and external lobes pointed with a rounded apex; posterior tibia almost as long as the femur; the third segment of foot longer than the first, and the first longer than the second (Table 1: Ta1, Ta2, Ta3). Epiproct triangular with deep transverse furrow and rounded apex; valves of ovipositor long, straight, with slightly curved apices; cercus conical, almost as long as the paraproct in female and exceeding paraproct in the male; male subgenital plate conical. The male phallic complex of the *G. opilionoides* is in general very similar to that of *G. terrea*, and the differences are very small, especially the tips of the ventral aedeagal valves in endophallus are dorsally flattened and curved outwards; the lophi of epiphallus lobiform but much wider than those of *G. terrea*.

Coloration.—Body greenish with brown color in some parts; vertex, frons and genae green mottled brown; antennae brown basally, blackening distally. Pronotum greenish brown with discontinuous brown bands on the lateral lobes in life; knee light brown; median inner and external areas of femur light green, lower inner and external areas greenish; upper inner and external areas greenish but mottled brown; posterior tibia greenish; tarsus red-brown. Abdomen greenish with discontinuous brown bands in the lateral parts, most pronounced behind the hind femur; external genitalia green-yellowish.

Discussion

The presence of a fastigial furrow in *G. terrea* is a strange character, because the fastigial furrow is not a common morphological structure in the Catantopinae but rather typical for the Pyrgomorphidae. As shown above, this is not in fact a generic character of *Gemeneta*, but only of the species *G. terrea*. Nevertheless, there is a strong resemblance between the different genital parts of *G. terrea* and *G. opilionoides*. Only minimal differences were observed in the width of the lophi as well as the form of the apical valves of the penis. Bolívar's (1905) description of *E. opilionoides* is close to ours but unlike Dirsh (1965), Bolívar (1905) does not present the fastigial furrow as a generic character. This is probably due to the fact that, like Dirsh (1965), this author used only the external characters of a single species (in his case, *E. opilionoides*) to define the characters of the genus *Escalera*. Kevan's (1956) description of *G. rostratuberculata* is also close to ours but as with Bolívar (1905) his work lacks the male description and genitalia structures and, unlike us, Kevan (1956) says the female cercus of *G. terrea* is longer than that of *G. opilionoides*.

Based on these characters, the genus *Gemeneta* can be maintained in the Catantopinae. The structure of the spermatheca in *G. terrea* is typical for the Catantopinae, with a long tubular duct and vermiform preapical appendix, and lacking distinct terminal ampullae. Indeed, when Dirsh (1961, 1965) erected various new subfamilies within the Catantopidae, he maintained the genus *Gemeneta* in the Catantopinae. OSF (Cigliano et al. 2017) also maintains the genus in the Catantopinae. However, Dirsh (1966, 1970) transferred the genera *Gemeneta*, *Mazaeta* Stål, 1876 and *Barombia* Karsch, 1891, all apterous genera from the Catantopinae, to the Hemiacridinae. This confusion probably reflects the inadequacies of the definitions of these two subfamilies rather than any ambivalent morphology of the genus *Gemeneta*.

The distribution of *G. terrea* and *G. opilionoides* in Africa is poorly known and needs to be clarified. However, *G. terrea* is found in the Congo Basin forests, in West Africa (Nigeria, but not in Ghana (Jago 1968)) and extending into East Africa in Uganda, while *G. opilionoides* is restricted to Cameroon and Equatorial Guinea. This likely reflects biological and ecological differences between the two species. These species do indeed show a distinct difference in coloration, which would make one think of differences in the bio-ecology of the two species. We note in our study that *G. opilionoides* is from marshy forests near rivers or streams, while *G. terrea* were collected in a less marshy forest. Kevan (1956) also reported the type specimen of *G. rostratuberculata* (= *G. opilionoides*) in the Nyong River Reserve forest, 16 km from Makak village in Cameroon and suggests that the different coloration of these two species would translate to different habits. Rowell (1978) and Le-Gall (1989) consider that the structure of vegetation and food specialization are fundamental to the grasshopper's biology and ecology. Thus, it is necessary to gain a better understanding of the biology and ecology of these two species in the African forests. This applies especially to *G. opilionoides*, which is very rare, apparently having a very specialized ecological niche in the forests. This implies a high risk of extinction in Central Africa, where almost all the forests and wetlands are being rapidly destroyed due to human activities. This article, which allows the recognition of species of the genus *Gemeneta*, should facilitate other studies on these species.

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Supplementary material 1

Authors: Charly Oumarou Ngoute, Sévilor Kekeunou

Data type: Microsoft Excel 97-2003 Worksheet (.xls)

Explanation note: Table S1. Mensurations of *Gemeneta* spp.

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