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A review of the genus *Obelostreptus* Attems, 1909 (Diplopoda, Spirostreptida, Spirostreptidae) with the description of a new species from Kenya

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ABSTRACT

The east African millipede genus *Obelostreptus* Attems, 1909 is revised to include four species, new distribution records are given, and a new combination is established. In addition, the genus is removed from the family Harpagophoridae and placed in the Spirostreptidae. A new species, *O. bilamellatus* VandenSpiegel sp. n. from Kenya is described, and *Mardonius nakitawa* (Silvestri 1907) is removed from the genus *Mardonius* Attems, 1914 to become the fourth known species, *O. nakitawa* comb. n., in *Obelostreptus*. An identification key to the species of *Obelostreptus* based on male gonopod structure is also presented.

KEY WORDS: Diplopoda, Harpagophoridae, Spirostreptidae, *Obelostreptus*, taxonomy, new species, new synonymy.

INTRODUCTION

The small east African genus *Obelostreptus* Attems, 1909, has hitherto been known to comprise only two species. One of these is the type species *O. acifer* Attems, 1909 from Ethiopia, and the other *O. proximospinosus* Krabbe, 1982 from Tanzania.

The taxonomic position of *Obelostreptus* has been contentious for several decades. Although it has traditionally been placed in the Spirostreptidae, Hoffman (1979) pointed out the unsatisfactory position of the genus and suggested that the form of the gonopods of *Obelostreptus* could be intermediate between the Spirostreptidae and the Harpagophoridae. Following Hoffman (1979), Krabbe (1982) placed *Obelostreptus* in the Harpagophoridae based on the position of the antetorsal process on the telopodite, which arises before the major curvature of the knee bend, as the main character to place *Obelostreptus* in the Harpagophoridae. In their revision of the Harpagophoridae of southern Africa, Redman *et al.* (2003) also refer to the genus as a harpagophorid. Furthermore, Redman *et al.* (2003) mention that *Obelostreptus* is taxonomically quite disjunct, with no closely related groups in Africa. However, in the same paper — after looking at unpublished illustrations by VandenSpiegel — they acknowledge the close similarity between the gonopods of *Obelostreptus* and the Spirostreptidae.

Unlike southern African harpagophorids, species of *Obelostreptus* lack a distinct, upturned caudal spine on the preanal ring, which is one of the main distinguishing characters of the Harpagophoridae in Africa (Redman *et al.* 2003). In addition, the gonopods of *Obelostreptus*, particularly the structure of the telopodites, do not resemble those of the Harpagophoridae or *Camaricoproctus*, another genus in the Spirostreptidae that Hoffman (1979) inferred should be reassigned. The species of *Obelostreptus* also differ radically from harpagophorids in the structure of the apical part of the telopodite.

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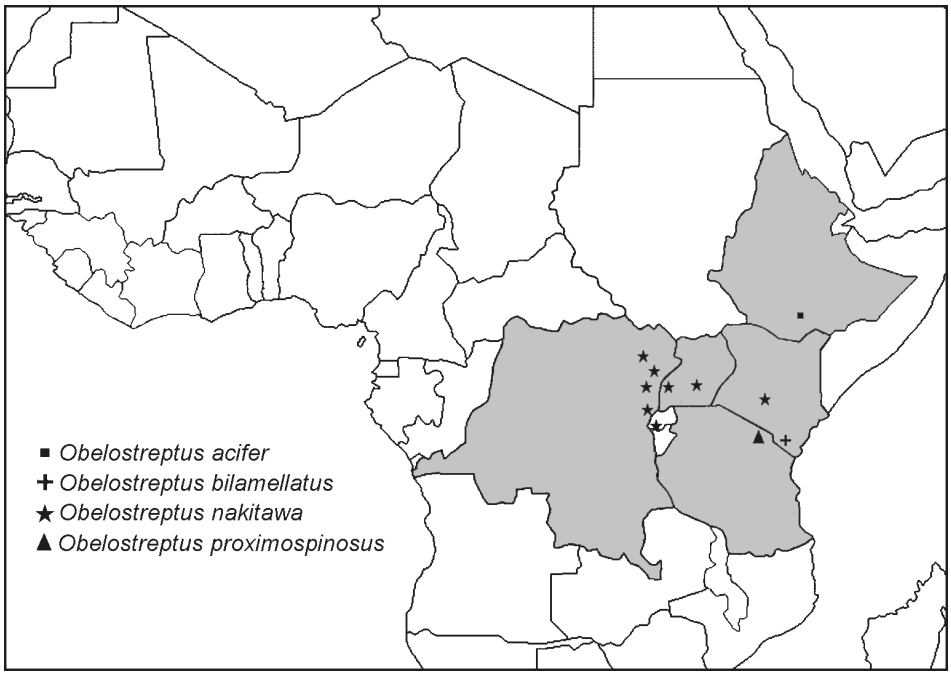


Fig. 1. Distribution of the genus *Obelostreptus*.

Therefore, based on the gonopods, having *Obelostreptus* in the Harpagophoridae is an inappropriate taxonomic assignment because the gonopod structure is not consistent with the family.

During a large Diplopoda survey done in Kenya between 1999 and 2000, the Taita Hills forest fragments and the Gatamaiyo Forest Nature Reserve were visited. The material collected contained several new species, one of them belonging to the genus *Obelostreptus*. All specimens were found in decaying wood. In this paper, we revise the genus *Obelostreptus*, describe a new species and propose a new combination.

MATERIAL AND METHODS

All the millipedes were collected by hand and preserved in 70% ethanol. The description of species and comparisons among species were mainly based on the structure of the male gonopods. To ascertain their validity and taxonomic assignment, all the specimens were compared with the original descriptions of the species. Samples were studied using a Leica MZ95 dissecting microscope. Specimens for scanning electron microscopy (SEM) were air-dried, mounted on aluminium stubs, coated with gold and studied in a JEOL JSM-6480LV scanning electron microscope. Where original species descriptions are adequate, we refer to the appropriate publications. However, in the case of *Obelostreptus nakitawa*, which prior to this study had been placed in three different genera, and given that the original description by Silvestri in 1907 does not have drawings of the gonopods, we have provided a description of the

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specimens from Gatamaiyo forest, including the description of the female.

In this paper, the terminology used to describe gonopods follows that of Hoffman (2008).

Institutions are abbreviated as follows:

MRAC – Musée Royal de l'Afrique Centrale, Tervuren, Belgium;
MV – Museum Vienna, Austria;
MNHN – Muséum national d'Histoire naturelle, Paris, France;
ZMUC – Natural History Museum (Zoological Museum), University of Copenhagen, Copenhagen, Denmark.

TAXONOMY

Order Spirostreptida
Family Spirostreptidae
Genus *Obelostreptus* Attems, 1909

Diagnosis: A genus of moderate-sized millipedes (up to 48 body rings, 50 mm in length and maximum diameter 4 mm) in which the gonopod has a characteristic antetorsal process just before the major curvature of the telopodite, a coxite without lateral cone, and a reduced or absent sternum.

Distribution: The genus *Obelostreptus* is restricted to Central and East Africa; most of the species have been described from East Africa and northern Tanzania to southern Ethiopia (Fig. 1).

Species included: The genus now includes four species: *O. acifer*, *O. proximospinosus*, *O. bilamellatus* and *O. nakitawa*.

Identification key to males of *Obelostreptus*

1 Gonopod coxite tapering apically, not elongate, convex laterally (Fig. 3B, E).....2
– Gonopod coxite not tapering, elongate, not convex laterally (Figs 4B, 4E, 2B).....3

2 Coxite not hook-shaped apically; telopodite with one thin and one enlarged postfemoral process ..... ***O. acifer***
– Coxite hook-shaped apically (Fig. 3B, E); telopodite with two lamellated postfemoral processes (Fig. 3D, F)..... ***O. bilamellatus*** sp. n.

3 Telopodite with one enlarged cone-shaped postfemoral process (Fig. 4C, D)..... ..... ***O. nakitawa***
– Telopodite with two enlarged postfemoral processes (Fig. 2C) .... ***O. proximospinosus***

Obelostreptus acifer Attems, 1909

Obelostreptus acifer Attems, 1909*b*: 412, Taf. 18. Abb. 14–16 (D); 1914: 125 (+D); Manfredi 1936: 257 (C); Krabbe 1982: 417.

Material examined: Syntype ♂: ETHIOPIA: Abera (Djam-Djam), leg. Neumann, 20.xii.1900 (MV 2476).

Remarks: No new material of *O. acifer* was available at the time of the study. However, based on material studied, the description of the species and illustrations of the gonopods are accurate.

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Obelostreptus proximospinosus Krabbe, 1982

Fig. 2A–D

Obelostreptus proximospinosus Krabbe, 1982: 419. Abb. 267.

Material examined: Holotype ♂: TANZANIA: Usambara Mts. Amani, at Dodwe River, in rotten wood, *c.* 1000 m, 31.vii.1974, I. Bødker-Enghoff & H. Enghoff (ZMUC). Additional material: numerous further specimens from Amani (ZMUC).

Remarks: Examination of many specimens (including the holotype) housed in the ZMUC revealed that the drawing of the gonopod coxite made by Krabbe (1982) is slightly erroneous. According to Krabbe, the distal part of the coxite forms a unique lobe, but our observations clearly show that this part of the coxite is bilobed (Fig. 2B). Other than that, the description and drawings are adequate. SEM illustrations of first leg and gonopod are given in Fig. 2.

Females slightly longer and wider than males; vulva poorly sclerotized, located in a pouch behind coxosternite of second legs. Valves smooth with an elongated apical appendix (Fig. 2D).

Obelostreptus bilamellatus VandenSpiegel, sp. n.

Fig. 3A–G

Etymology: Referring to the two lamellate processes occurring on the distal half of the telopodite.

Diagnosis: Lateral margins of coxites convex, tapering and hook-shaped apically (Fig. 3B, E). Distal half (post-knee) of telopodite with two adjacent and different sized lamellated processes (Fig. 3B, D).

Description (holotype):

Adult male with 46 body rings, length ± 50 mm, maximum diameter *c.* 3 mm.

Body colour dominantly brownish, prozonite yellowish brown, metazonite dark brown. Head surface smooth, *c.* 30 ocelli disposed in five rows (4, 5, 7, 9, 5), length of antenna approximately half of the body diameter, four sensory cones on last article. Pre-mandible rounded ventrally with no projection. Collum rounded laterally, surface virtually smooth and polished.

Body rings with low longitudinal ridges on metazonite, metazonite slightly greater in diameter than the prozonite, with a distinct suture, ozopores rather discreet but distinct.

Paraprocts convex, distal margins set off by submarginal groove. Hypoproct not fused with preceding segment.

First pair of legs of males with prominent prefemoral processes (Fig. 3A). Walking legs elongated (length greater than body diameter) with large ventral tibial pads extending up to the proximal half of the tarsus.

Gonopods with a small, medially divided sternum, distal parts with an extending lateral cone projecting outside the body when at rest. Gonocoxa oblong, with a hook-shaped distal part, a small anterolateral metaplical process and a well-developed median metaplica lobe (Fig. 3B, E). Form of the telopodite highly characteristic as shown in Fig. 3B, C and F. Just after its emergence from the gonoschima, the telopodite gives rise to an elongated antetorsal process and, beyond this, are two different sized post-knee lamella-shaped processes (Fig. 3B, C, F).

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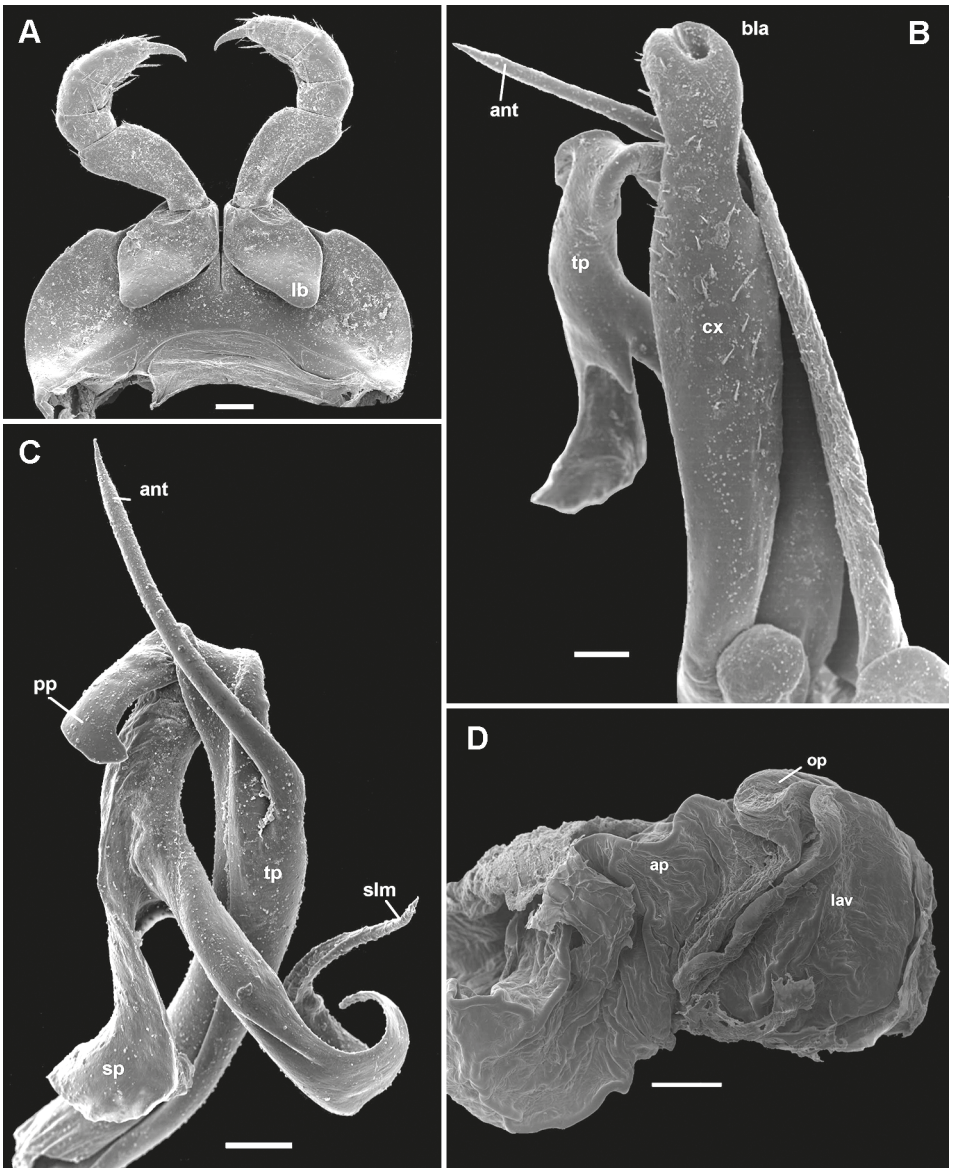


Fig. 2. *Obelostreptus proximospinosus*: (A) first pair of legs of male, anterior view; (B) posterior aspect of right gonopod; (C) posterior aspect of left telopodite; (D) right vulva, posterio-lateral view. Scale bars = 100µm. Abbreviations: ant – antetorsal process, ap – apical appendix, bla – bilobed apex, cx – coxite, lav – lobe of aboral valve, lb – lobe, op – opercule, pp – primary posttarsal process, slm – solenomerite, sp – secondary postarsal process, tp – telopodite.

The male paratypes agree precisely with the holotype in coloration and structural detail; they are nearly the same size and also have 46 segments.

The females are longer and wider than males; first pair of legs not modified; vulva poorly sclerotized, valves equal in size, smooth without setae (Fig. 3G).

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Holotype ♂: KENYA: Taita Hills, Ngangao Forest (03°22'S 38°21'E), 1820 m, 19.vi.1999, D. VandenSpiegel (MRAC 22541).

Paratypes: 2♂ 2♀ same data as holotype (MRAC 22540); 2♂ 2♀ same data as holotype (MRAC 22542); 1♂ 1♀ same data as holotype (ZMUC); 1♂ 1♀, same data as holotype (MNHN); 1♂ 1♀ same data as holotype (MRAC 22539); 2♂ same data as holotype (MRAC 22543).

Other material examined: KENYA: 2♂ 1♀: Taita Hills, Mbololo forest (03°19'S 38°27'E), 1800–1900 m, 21.vi.1999, D. VandenSpiegel (MRAC 17.972); 2♂ 2♀ Taita Hills, Mbololo forest (03°19'S 38°27'E), 1800–1900 m, 22.vi.1999, D. VandenSpiegel (MRAC 17.986); 100 specimens Taita Hills, Ngangao Forest (03°22'S 38°21'E), 1820 m, 19.vi.1999, D. VandenSpiegel (MRAC 18.005); 1♂ 3♀ Taita Hills, Mbololo forest (03°19'S 38°27'E), 8.xii.1999, D. VandenSpiegel & J. P. Michiels (MRAC 18.411); 1♂ 2♀ Taita Hills, Chawia forest (03°29'S 38°20'E), 7.xii.1999, D. VandenSpiegel & J. P. Michiels (MRAC 18.428); 1♂ 3♀ Taita Hills, Fururu forest (03°26'S 38°20'E), 9.xii.1999, D. VandenSpiegel & J. P. Michiels (MRAC 18.448); 20 specimens Taita Hills, Ngangao Forest (03°22'S 38°21'E), 4.xii.1999, D. VandenSpiegel & J. P. Michiels (MRAC 18.477); 54 specimens Taita Hills, Ngangao Forest (03°22'S 38°21'E), 1820 m, 19.vi.1999, D. VandenSpiegel (MRAC 22538).

Distribution: Only known from Taita Hills, Kenya.

Remarks: The coxites of the gonopods resemble those of *O. acifer* by being convex laterally and tapering apically. However, unlike in *O. bilamellatus* the coxites in *O. acifer* are not hooked apically. The telopodite is typical of the genus, having a characteristic antetorsal process just before the major curvature of the telopodite.

Obelostreptus nakitawa (Silvestri, 1907) **comb. n.**

Fig. 4A–F

Archispirostreptus nakitawa Silvestri, 1907: 4–5 (D); 1909: 26, Abb. 55–60 (+D).
Mardonius nakitawa: Attems 1914: 138 (C); Brölemann 1920: 105, Taf. 7, Abb. 32 (N); Attems 1950: 210 (C); Attems 1953: 117 (C); Krabbe 1982: 156.
Obelostreptus oligozonus Attems, 1927: 78, Abb. 43, 44 (D); Attems 1937: 15 (C).
Globanus leviceps Attems, 1934: 189, Abb. 37–39 (D).
Archispirostreptus nakitawa: Demange 1970: 367 (C).

Description (Gatamaiyo specimens):

Adult male with 41 body rings, length ±37 mm, maximum diameter *c.* 4 mm.
Body colour dominantly brownish, slightly lighter ventrally; prozonite yellowish brown, metazonite with an anterior part brownish and a posterior part dark brown. Antennae and legs yellowish brown. Ozopores visible as blackish spots through cuticle and the succession of these spots gives an impression of a continuous line.
Eyes with *c.* 24 ocelli in five rows. No frontal setae, four supralabral setae in a transverse row, a row of labral setae, labrum tridentate. Stipes of the mandible with a small ventral lobe. Gnathochilarial stipites with one medio-apical tuberculate of four apico-lateral setae.
Length of antennae 66 % of the diameter of midbody rings. Antennomeres 5 and 6 with an apical sensory pit, four apical sensory cones.
Collum large and smooth. Body roughly cylindrical, diameter decreasing slightly towards posterior; body rings circular to slightly compressed (height/width ratio 106% of midbody ring). Prozonites smooth. Suture between prozonite and metazonite discrete. Lower side of metazonites with metazonital striae extending up to the level of ozopore. No metazonital setae. Ozopore up to ½ metazonite length, behind suture on midbody rings.
First pair of male legs as shown in Fig. 4A, coxae broadly in contact medially; prefemora with small basal projection on anterior side and a few apical setae.

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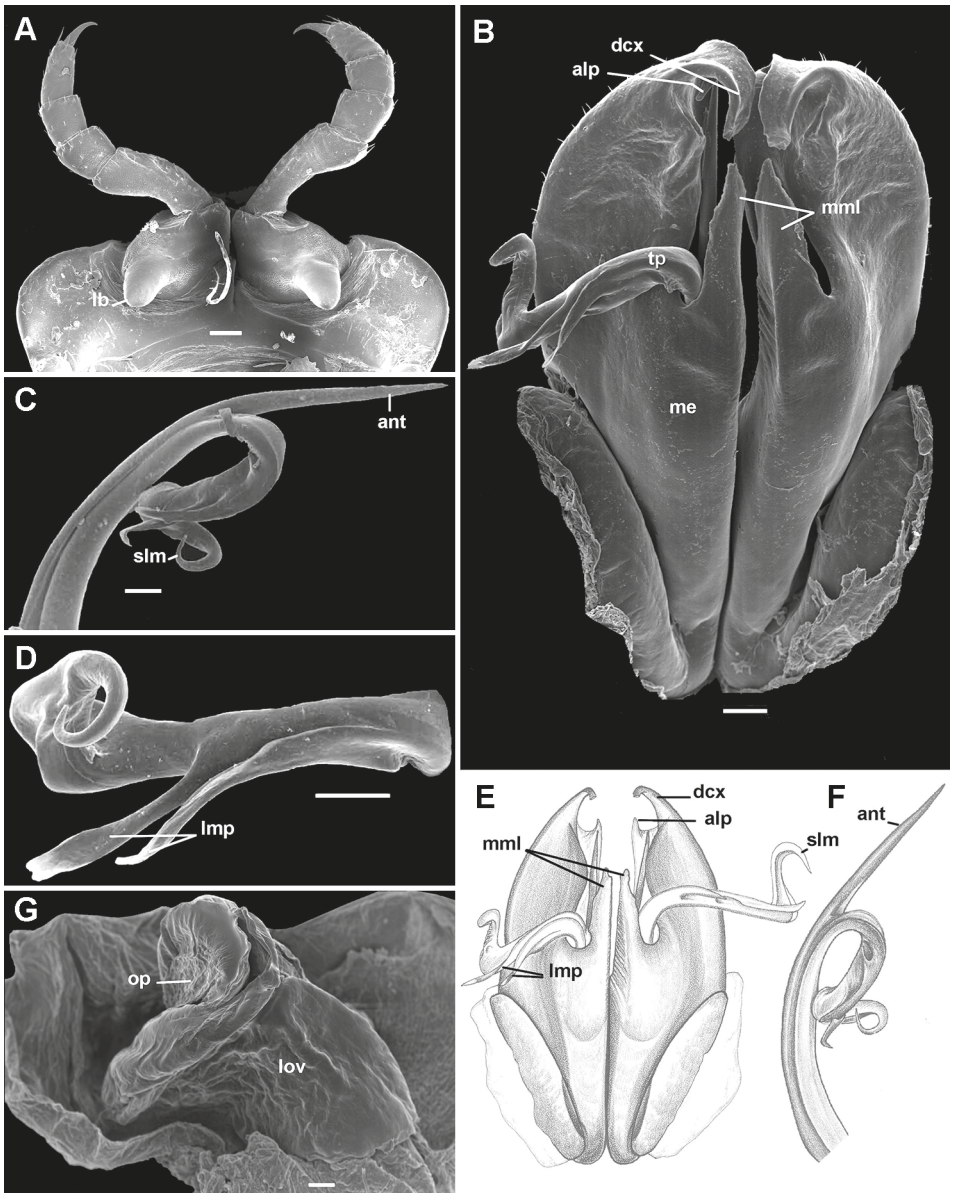


Fig. 3. *Obelostreptus bilamellatus*: (A) first pair of legs of male, anterior view; (B) posterior aspect of gonopods; (C) left telopodite, sublateral aspect; (D) apical part of telopodite; (E) drawing of gonopods, posterior view; (F) drawing of telopodite; (G) right vulva, posterio-lateral view. Scale bars = 100μm. Abbreviations: alp – anterolateral process, ant – antetorsal process, dcx – distal part of coxite, lb – lobe, lmp – lamellate processes, lov – lobe of oral valve, me – metaplica, mml – median metaplica lobe, op – opercule, slm – solenomerite, tp – telopodite.

Gonopod coxite rounded distally (Fig. 4B), telopodite with an antetorsal process arising just before the major curvature, a laminated postfemoral lobe arising just after the major curvature and a small tarsal process (Fig. 4C).

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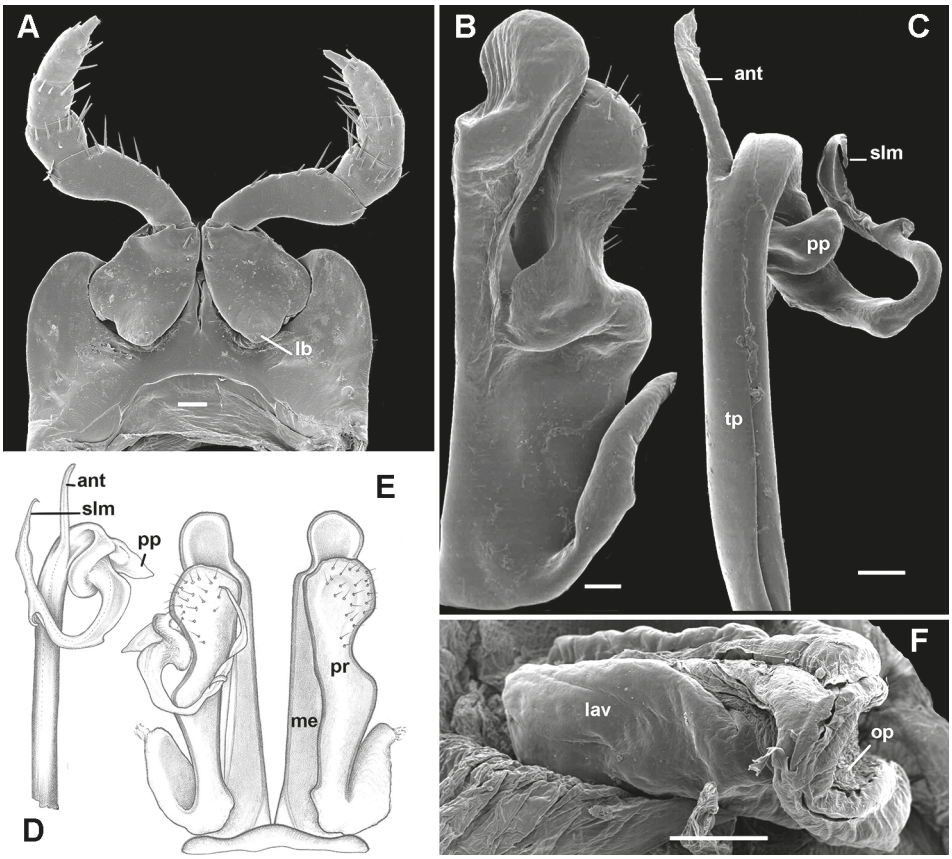


Fig. 4. *Obelostreptus nakitawa*: (A) first pair of legs of male, anterior view; (B) left gonopod without telopodite, posterior view; (C) left telopodite, posterior view; (D) drawing of right telopodite, anterior view; (E) drawing of gonopods, right without telopodite, anterior view; (F) right vulva, lateral view. Scale bars = 100μm. Abbreviations: ant – antetorsal process, lav – lobe of aboral valve, lb – lobe, me – metaplica, op – opercule, pp – primary posttarsal process, pr – proplica, slm – solenomerite, tp – telopodite.

Female longer and wider than male; first pair of legs unmodified; vulva simple, placed vertically in a pouch behind coxosternite of second leg; no vulval setae, aboral valve and oral valve of similar size (Fig. 4F).

Material examined: DEMOCRATIC REPUBLIC OF CONGO: 1♂ Mongbwalu (01°57'N 30°02'E), 1938, Scheitz (MRAC 3.760); 1♂ Mahunga, Ruwenzori (00°20'N 29°50'E), 9.viii.1937, J. Bredo (MRAC 5.623); RWANDA: 1♂ Nyongwe, Rugege forest (02°30'N 29°12'E), 2000 m, 6–10.viii.1949, Laurent (MRAC 5.269); KENYA: 30 specimens Central Province, Mt. Kenya, face W., Naro Moru Track, 2400 m, G. Coulon (MRAC 14.163); 5♂ 9♀ Gatamaiyo Indigenous Forest, in rotten wood, D. VandenSpiegel & Ch. Lange (MRAC 22544); 3 specimens Gatamaiyo Indigenous Forest, in rotten wood, D. VandenSpiegel & Ch. Lange (MRAC 22545); 12 specimens Gatamaiyo Indigenous Forest, in rotten wood, D. VandenSpiegel & Ch. Lange (MRAC 22546); 1♂ 1♀ Gatamaiyo Indigenous Forest, in rotten wood, VandenSpiegel D. & Ch. Lange (MRAC 22547); 1♂ 2♀ Gatamaiyo Indigenous Forest, in rotten wood, D. VandenSpiegel & Ch. Lange (MRAC 22548); 1♀ Gatamaiyo Indigenous Forest, in rotten wood, D. VandenSpiegel & Ch. Lange (MRAC 22549).

Distribution: The holotype was collected from Nakitawa, Bihunga, on the border between Uganda and the Democratic Republic of Congo. This species has a large

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distribution, occurring in the eastern Democratic Republic of Congo, Uganda, Rwanda and now Kenya. Recent records (from Gatamaiyo forest) suggest that the species is more widespread, with the distribution extending eastwards into central Kenya.

Remarks: The telopodite of this species is consistent with the definition of *Obelostreptus* as demonstrated by the position (just before the major curvature of the telopodite), structure and orientation of the antetorsal process.

DISCUSSION

The origin of the antetorsal process (proximal to the emergence of the telopodite from the coxite) and its orientation (almost parallel or at an acute angle to the median edge of the coxite) are common to all the species of *Obelostreptus*. These characters may have been overlooked previously, probably because less taxonomically useful traits such as the presence or absence of spines were considered more important. This may have led to the incorrect taxonomic assignment of the genus to the family Harpagophoridae. As reported for harpagophorids (Redman *et al.* 2003), at the level of genus the presence or absence of processes or spines may not discriminate spirostreptids. Thus subtle characters such as the shape or orientation could be more taxonomically informative, which is why on close examination the distal elements of the telopodite demonstrate that *Obelostreptus* belongs in the Spirostreptidae. We concluded that the incorrect assignment of *Obelostreptus* and *O. nakitawa* was probably a result of using taxonomically deficient characters. That *Obelostreptus* belongs in the Spirostreptidae is further corroborated by the similar gonopod telopodite found in other East and Central African genera, among them *Anastreptus*.

Having gone through the original descriptions, and closely examined and compared the gonopods, *Obelostreptus* should not be included in the Harpagophoridae. According to Redman *et al.* (2003) the apical elements of the gonopod telopodite, consisting of a plate which may have hooked spines, are considered genus-specific in harpagophorids. The telopodite of *Obelostreptus* species does not have the same apical structure. For example, the lack of a distal crest or row of blepharochaetae excludes the genus from African (see Redman *et al.* 2003) and Asian harpagophorids (see Pimvichai *et al.* 2011*a*, 2011*b*). Instead, the telopodite of *Obelostreptus* tapers and does not have distal spines. Besides lacking the spine on the preanal ring and distal telopodite spines (which characterise some African harpagophorids), the telopodite shape, the orientation and structure of the antetorsal process, and the tapering distal telopodite support our view that *Obelostreptus* belongs in the family Spirostreptidae.

Unlike several other genera in the Spirostreptidae the gonopod coxites of *Obelostreptus* do not have any lateral processes. However, *Obelostreptus* is among the spirostreptid genera with genus-specific telopodite structure. For example, on the telopodite there is an antetorsal (femoral) process and postfemoral processes of various shapes, sizes and orientations that originate from different positions on the telopodite (Figs 2C, 3D, 3F, 4C, 4D). The form of the telopodite of *Obelostreptus* is similar to some genera from East and Central Africa. *Anastreptus*, *Calostreptus* and *Tibiozus* are the genera whose post-knee telopodite structure most resembles *Obelostreptus* by having postfemoral processes and by the distal half of the telopodite being broad and lamellate before tapering apically. These genera also have distributions that overlap with that of *Obelostreptus* species. Records of *Anastreptus* are from East Africa (Kenya, Somalia and Eritrea) and

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the Democratic Republic of Congo; *Calostreptus* has been recorded in Eritrea, Kenya, Rwanda, Tanzania, South Africa and Zimbabwe; and *Tibiozus* occurs in East Africa (Uganda) and some parts of West Africa (Krabbe 1982).

After the description of *O. bilamellatus* and the addition of *O. nakitawa*, the known distribution of the genus *Obelostreptus* extends to Kenya. Previously, the genus was known from Ethiopia, Uganda, Rwanda and Tanzania (Redman *et al.* 2003). Our results follow the observed trend in spirostreptid millipedes, where new species and records are added each time new or unprocessed material from the East Africa highlands is studied. Mwabvu and VandenSpiegel (2009) described three new species from Taita Hills and also reported several new records of spirostreptids. Before that, VandenSpiegel (2001) described a new genus and a new species from the same region. Our observations further support the notion that although the level of species endemism is high, the spirostreptid genera may be widespread. As reported for other spirostreptid genera (see Hamer 2009; Mwabvu & VandenSpiegel 2009; Mwabvu *et al.* 2007, 2009, 2010) taxonomic revisions often result in the discovery of new taxa, taxonomic inflation and addition of new distribution records. The description of *O. bilamellatus* and the addition of new records *of O. nakitawa* suggest that the current known distribution of *Obelostreptus* may be a collecting artifact. Because biodiversity hotspots in the East African highlands are threatened by anthropogenic disturbances (Myers 1988; Burgess *et al.* 2007) and probably climate change, there is much to be gained if taxonomic effort is increased. Our results highlight the importance of revising genera not only to stabilise their taxonomy but also to provide accurate data on diversity and distributions for future comparisons.

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