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The fifth element: reconnection of the disjunct distribution of the members of Siphonocryptida (Diplopoda) with the description of a new species from Nepal

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The fifth species of the millipede order Siphonocryptida, *Hirudicryptus quintumelementum* sp. nov., is described from Nepal. With this, the surprisingly disjunct distribution of the order with its four former species from Sumatra, the Macaronesian Islands, Malaya and Taiwan, has become connected through the relatively young mountain chains of the Himalayas. The new species shows the typical morphology of the order, with very little variation in external characters (in lack of male specimens). This may be the result of the conservative evolutionary history of the surviving small, widely separated, remnant populations of a once coherent, ancient range. The female vulva of the new species is described, and illustrated for the first time in the order.

Keywords: *Hirudicryptus quintumelementum* sp. nov.; Siphonocryptida; distribution; female sexual characters

Introduction

When Enghoff and Golovatch (1995) wrote their revisionary paper on the millipede family Siphonocryptidae, they obviously did not think that hardly more than a decade later the number of species in the family would increase by 166% (from three to five, at present)! They provided a detailed overview of the classification history of the group, established the synapomorphies – later used by Shelley (2003) to elevate the family to ordinal status – and gave a good characterization of the species, emphasizing the importance of some morphological characters other than those of the generally very simple, leg-like male gonopods. In addition to the then known species: *Siphonocryptus compactus* Pocock, 1894 from Sumatra and *Hirudicryptus canariensis* (Loksa, 1967) from the Canary Islands and Madeira, they added a new species from Malaya: *Siphonocryptus latior* Enghoff and Golovatch, 1995. They separated the three species into two genera (one of them, *Hirudicryptus* as new), distinguishing between them by the body length–width proportions and the shape of the collum.

Ten years later, as a part of a long-term research project of the senior author (ZK), a fourth species of Siphonocryptida was found in the collections of some Taiwanese institutions (Korsós et al. 2008). It belongs to the more slender genus

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Hirudicryptus Enghoff and Golovatch, 1995. Its discovery did not help much in understanding the unusual distribution pattern (east Asia and the Mediterranean) of the order. When sorting out unidentified Nepalese millipede samples in the collection of the Muséum national d'Histoire naturelle (MNHN) in Paris, the first author of the present paper came across the fifth siphonocryptidan species, which we describe here along with some zoogeographical remarks on the importance of its discovery.

Materials and methods

The samples studied were found among the unidentified material originating from Nepal, and collected by the expedition of A. Smetana in 1985. The specimens are on loan from the Muséum d'Histoire Naturelle, Genève (GMNH), to the second author (JPM), and are currently under study.

The three available specimens of the new species were studied accordingly: holotype retained intact, only external morphological characters were noted, and habitus drawings were made. One of the paratypes was dissected for a preparation of the female vulvae, which were observed and illustrated, together with the second legpair, in a temporary glycerine mount. Head and first legpair, and the last 10 terga including the terminal one were permanently mounted for scanning electron microscope (SEM) studies using a JEOL JSM-25S III SEM in the MNHN, Paris.

Description of new species

Hirudicryptus quintumelementum sp. nov.
(Figures 1–9)

Material studied

3 ♀♀, Nepal, Siwapuri Dara (=Sheopuri Lekh), 15 km NE of Kathmandu, 2450 m, dry mature oak forest; little brook in a shallow gulley, sifting of vegetation, fallen leaves and other debris on moist to wet habitats along the brook (No. 250), 29. April 1985, leg. A. Smetana.

Holotype

Intact female specimen (34 segments), GMNH.

Paratypes

Female with 35 segments (dissected for temporary glycerine, and permanent SEM mounts); and another female with 27 segments, MNHN [MNHN BB001].

Etymology

The species is named as the fifth member of the millipede order Siphonocryptida; but also in honour of the alien custodians (called ''mondoshawans'') in the movie by Luc Besson (''Le cinquième élément'' 1997) who eventually saved the Earth from a catastrophe, and whom the head and the collum of the new species (and actually all members of the order) resemble superficially.

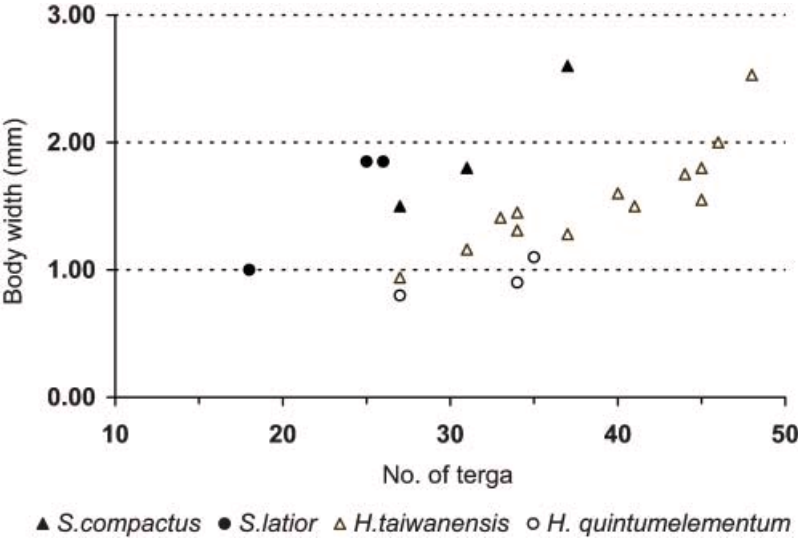

Figure 1. Body size relationships (max. body width plotted against number of terga) of four species of Siphonocryptida.

Diagnosis

Member of the genus *Hirudicryptus* (family Siphonocryptidae, order Siphonocryptida) as defined by Enghoff and Golovatch (1995), in having a narrow body (length/width ratio is >6) with midbody terga ca. four times wider than long, and a broad, crescent-shaped collum with no earlike lobes. Differs from other species of the genus in colouration and in the surface of the body terga being strongly granulate, with a transverse row of about 9–11 well-developed dark tubercles at the posterior margin on each side.

Figure 2. *Hirudicryptus quintumelementum* sp. nov. Paratype (27 terga), lateral view.

Figure 3. Midbody terga of paratype (27 terga), dorsal view.

Description

♀ (holotype) 34 segments (incl. collum, without telson), body length 6.2 mm, max. width 0.9 mm; paratypes (♀♀): 35 and 27 segments, body length 7.7 and 4.8 mm, max. width 1.1 and 0.8 mm, respectively. Body length/width ratio: 6.9, 7, and 6, for the three specimens. See also Figure 1.

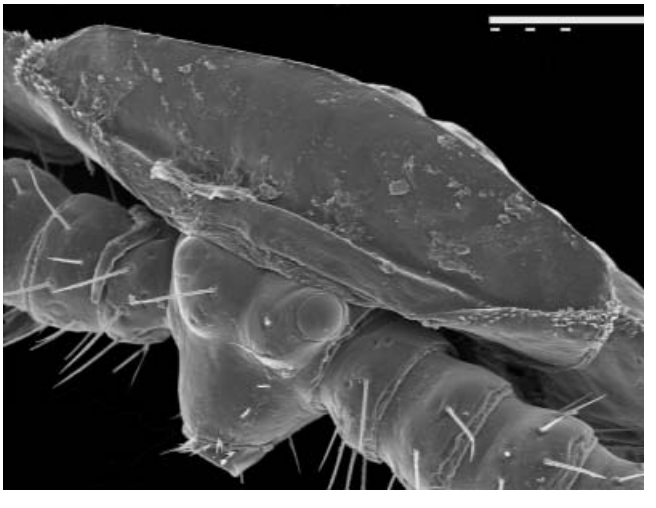

Figure 4. Head with collum and second tergum, fronto-lateral view. Scanning electron micrograph. Scale 0.1 mm.

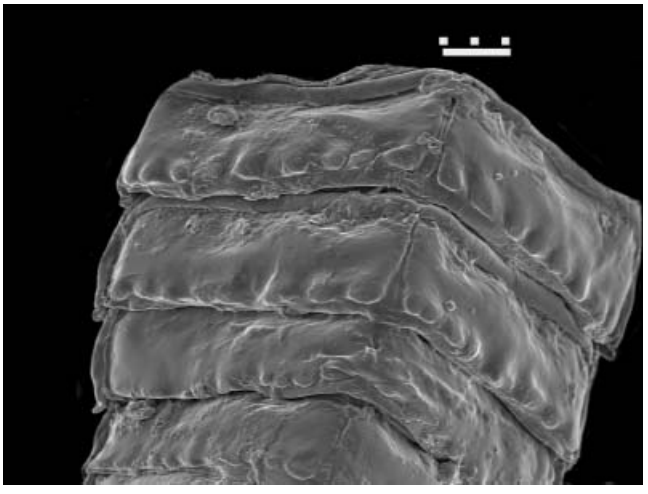

Figure 5. Midbody terga, showing enlarged tubercles at posterior margin in dorsal view. Scanning electron micrograph. Scale 0.1 mm.

Colour (Figures 2 and 3). A light yellow mid-dorsal and two dark brown lateral stripes make the animal appear to have three equal stripes . This pattern is unique in the order except for *S. latior* where the light median stripe is less pronounced and also narrower (Enghoff and Golovatch 1995). Tubercles at the posterior margin of the marbled paraterga are dark brown. Antennal segments distally, and sides of head are darker brown, eyespots black in dark patches. Underside, legs, telson uniformly light yellowish.

Head (Figures 4, 7–8). Elongated, proboscoid, sharply pointed triangular, about as long as wide. In dorsal view completely hidden under collum, only antennae visible.

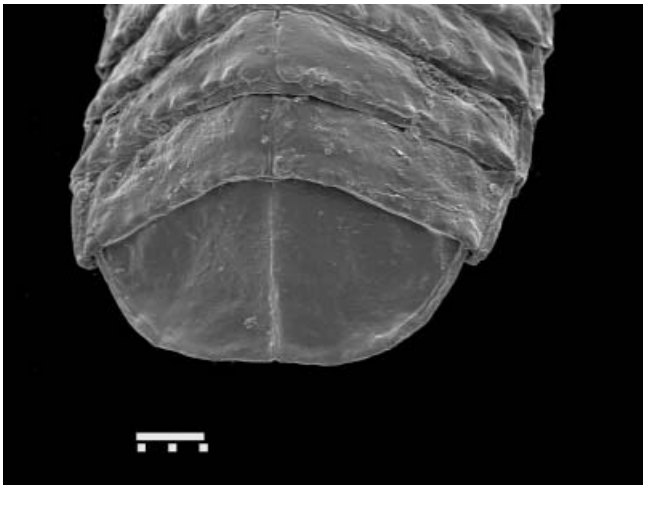

Figure 6. Last tergum, dorsal view. Scanning electron micrograph. Scale 0.1 mm.

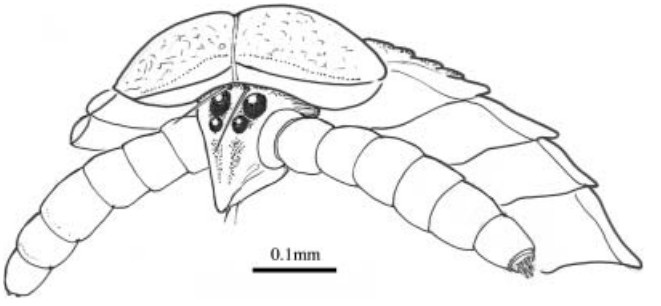

Figure 7. *Hirudicryptus quintumelementum* sp. nov. Holotype, anterior part of body, fronto-lateral view. Antennal setae have been omitted. Scale 0.1 mm.

Antennae stout, slightly bent ventrad, with six antennomeres subequal in length, the last (seventh) much shorter, its length about one-third of the sixth. Ocelli 2+2, black, posterior bigger than anterior ones. A pair of long frontal setae present.

Collum (Figures 4, 7–8). Distinctly separate from second tergum, dorsally and in anterior view crescent-shaped, forming two smooth subrectangular lobes, without ventro-lateral "ears". In lateral view dorsal part highly elevated and protruded forwards, casque or helmet-shaped, widely separated from second tergum.

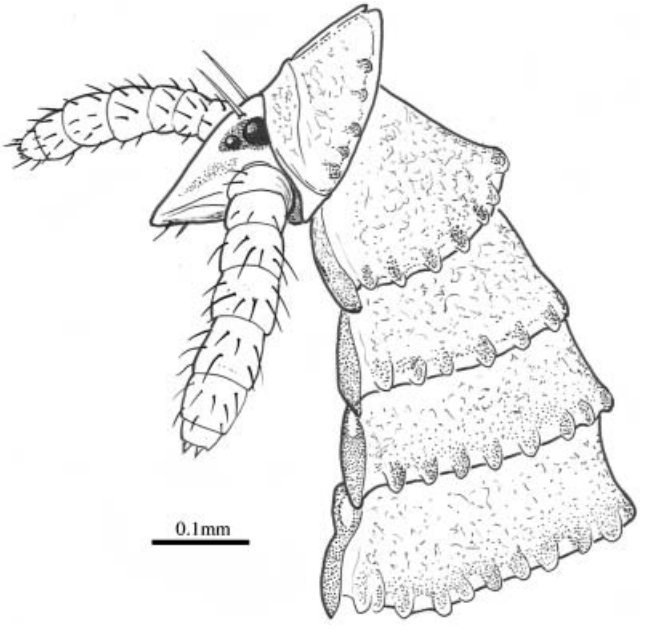

Figure 8. *Hirudicryptus quintumelementum* sp. nov. Holotype, anterior part of body, left lateral view. Scale 0.1 mm.

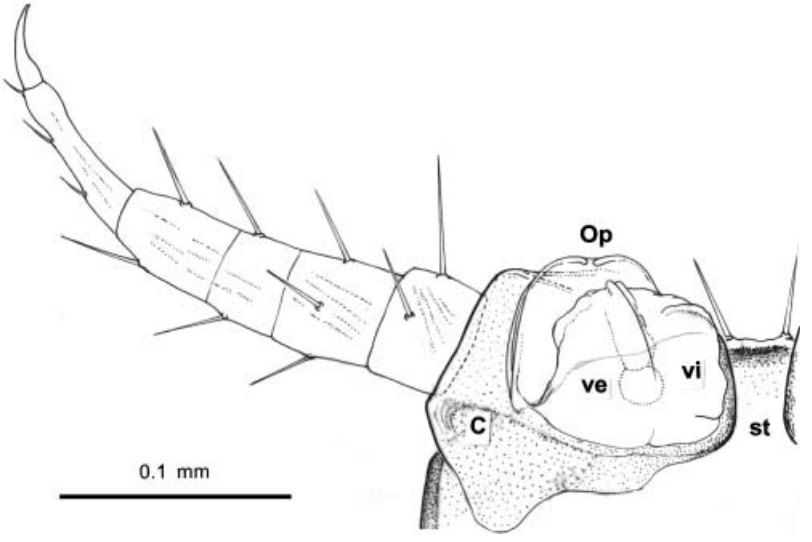

Figure 9. Right second leg and vulva, ventro-caudal view. Notes: Op, operculum; vi-ve, internal and external valves; C, coxa; st, sternum. Scale 0.1 mm.

Body terga. Midbody terga (Figures 3 and 5) about four to five times broader than long, slightly tapering towards both ends, with deep, distinct middorsal suture along entire length. Large, dark brown tubercles from the fourth tergum onwards, 9–11 on each half, uneven, partly paired and distributed at the posterior margin (1−2−2−1−2−1−1+1−1−2−1−2−2−1 is a usual arrangement). The 1+1 median ones usually the largest, and most conspicuous with their dark brown colour against the light median dorsal stripe. Postero-lateral projections on each tergum from third onwards strong, but not passing posterior tergal contour, also coloured dark brown. Arrangement of paraterga normal, 2–5 not overlying the preceding ones. Lateral margin of paraterga forming strong peritreme from fifth onwards, occupying almost entire length of paraterga, large ozopore on the fifth anteriorly, from the sixth onwards more or less in median position. Last tergum (Figure 6) rounded or subtrapeziform, with a median longitudinal suture, but without posterior lobes, and no indication of (diplo)fusion.

Sterna. At midbody much wider than long, about two times wider than coxae.

Telson. Very small, completely hidden under last tergum, with two strong setae. Anal valves with two smaller setae directed ventrad.

Legs. Long, slender, in normal position not surpassing body margin (except under posteriormost terga). Coxa widely separated from each other. Telopodite comprising five podomeres. No accessory claw.

Male sexual characters. In the absence of males in the present sample, no description of gonopods can be presented.

Female sexual characters (Figure 9). It should be emphasized that this is the first time that the vulvae of a female siphonocryptid have been properly studied (i.e. after removal, under a compound microscope). The following description is essentially based on polyzoniid terminology, and compared with members of that order.

Coxae of second legpair hypertrophied and very close to each other due to the fact they use the space usually occupied by the coxal sacs of other subsequent legpairs. Vulval cavity (termed "lucarne" by Brölemann 1935: 50), very large, using mesally more than half of posterior part of coxa, in a similar way as in Polyzoniida. In contrast, however, each vulva provided with a strongly developed operculum, entirely closing the vulval cavity. Operculum simple, rectangular plate, apically rounded and slightly concave. No setae or hairs could be observed at all, unlike most other diplopod vulvae. Bursa more or less globular as in Polyzoniida, with prominent vertical cleft dividing it into two subequal and poorly chitinized halves. In analogy with the structures generally encountered in other diplopod vulvae these two parts could be termed as internal and external "valves". Under a compound microscope, in continuation of medial cleft the outline of an apodematic tube can be distinguished (see dotted line in Figure 9), together with a spherical *receptaculum seminis* beneath.

Updated key to the five species of Siphonocryptida

1. Body very broad, length/width ratio of body 1.9–3.0, midbody terga ca. six times wider than long. First five paraterga overlying preceding paraterga, collum anteriorly with two extra, subrectangular lobes ("ears"). No frontal setae . . . . . *Siphonocryptus* 2
   Body much narrower, length/width ratio >4 (except in very small juveniles), midbody terga ca. four times wider than long. Anterior paraterga not overlapping "reversely", collum simple crescent-shaped, with broad lobes in anterior view. Two long frontal setae . . . . . *Hirudicryptus* 3

2. With a dorsal colour pattern of three dark and two light longitudinal stripes, body narrow, paratergal projections surpassing posterior contour of tergum, apical part of terminal podomere of posterior gonopods longer. (Sumatra) . . . . . *S. compactus*
   A mid-dorsal light stripe (or body uniformly pale), body broad, paratergal projections not surpassing posterior contour of tergum, apical part of terminal podomere of posterior gonopod shorter. (Malaya) . . . . . *S. latior*

3. With a dorsal colour pattern of five longitudinal stripes: one median and two lateral dark ones, with two light ones between. 4
   Dorsal colour pattern different: only three longitudinal stripes of equal width, one median light and two lateral dark ones. (Nepal) . . . . . *H. quintumelementum* sp. nov.

4. Body very narrow, adult specimens even with more than 50 paraterga are only 1.2 mm wide. Number of tubercles on posterior margin of each half of midbody paraterga 14–15. Terminal podomere of male posterior gonopod long, slender, simple. (Macaronesian islands). . . . . *H. canariensis*

Body less narrow, adult specimens with approximately 50 paraterga are 2.0–2.5 mm wide (almost like *S. latior*). Tubercles on posterior margin of midbody paraterga large, the number on each half only 6–8. Terminal podomere of male posterior gonopod with a clearly visible, distinct shoulder at its proximal third. (Taiwan) . . . . . *H. taiwanensis*

Discussion

The new species shows a close relationship to that recently described from Taiwan (Korsós et al. 2008). Shared characters like the casque-shaped collum and similar body length/width ratio almost unite these two species and suggest the possibility of erecting a new genus for them. However, in the absence of males of the present new species it seems too early to do so, hence we tentatively keep it in *Hirudicryptus*.

Hirudicryptus, in the sense of Enghoff and Golovatch (1995), differs from *Siphonocryptus* in two characters: body shape and collum structure. In terms of the length/width ratio of the body, the Taiwanese and now the Nepalese specimens occupy an intermediate position in a graph where maximum body width is plotted against number of terga (Fig. 1, and cf Fig. 7 in Enghoff and Golovatch (1995) where the body width data for *H. canariensis* are generally under 1 mm). On the other hand, the shape of the collum (resembling, in lateral view, a helmet or casque) is more pronounced in these two Asiatic species than in *H. canariensis*. (There are no illustrations available for the collum of *S. latior*, however.)

When describing *Hirudicryptus*, Enghoff and Golovatch (1995) also added two more characters to their key: one is that in *Hirudicryptus* the anterior (2–4) terga are positioned normally (in contrast to *Siphonocryptus* where they overlap "reversely", with the previous terga); and the other is that the terminal podomere of the posterior gonopod is smooth and undivided. *H. taiwanensis* and *H. quintumelementum* sp. nov. agree in having normal anterior terga, but the terminal podomere of the posterior gonopod of *H. taiwanensis* has a distinct shoulder (an indication of perhaps two segments), somewhat similar to what can be observed in *S. compactus*.

All three species of *Hirudicryptus* also differ from *Siphonocryptus* in having two long frontal setae on the head. The last tergum in *Hirudicryptus* is more or less undivided; there are only faint indications (parallel lines) of tergal fusion (in contrast to *S. compactus* where there are four distinct lobes). In colouration, on the other hand, *H. canariensis* and *H. taiwanensis* are similar, whereas *H. quintumelementum* strongly differs with its three longitudinal stripes.

Summarizing these sometimes contradictory observations, we believe that the generic separation of the family is far from being resolved.

Zoogeographical remarks

It seems that the millipede order Siphonocryptida, with its five known species scattered from the Macaronesian archipelago to south-east Asia, is one of the most ancient, if not the oldest group of the class Diplopoda. However, a large part of the territory between these two extreme distribution areas has never been, and will not be easily investigated. In addition, the animals in question are minute in size, and, judged from the scarcity of records, probably have a very secretive lifestyle, and their habitats are often extremely difficult to access.

The discovery of a siphonocryptidan species in a high altitude valley of the Himalayas may at first be surprising, but there are several other examples which suggest a zoogeographical relationship between the Himalayas and Taiwan, home of *H. taiwanensis* (see, for example, László et al. (2000) and Ronkay (2002)). The history of the discovery of two millipede groups, on the other hand, indicates another possibility. Genera such as *Nepalmatoiulus* (Julida) or *Nepalella* (Chordeumatida) were thought to be endemic to a small region, then they have become known to be widely distributed across of south-east Asia (Enghoff 1987; Golovatch et al. 2006; Mauriès 1983; Shear 1979). *Nepalmatoiulus* also has close relationships with isolated and perhaps relict genera in Europe (Enghoff 1987; Mauriès 1983). A possible parallel with the Siphonocryptida could support a hypothesis of a relatively recent extinction process of potential siphonocryptidans from the European region.

A species of Siphonocryptida exists, geographically very close to Europe. The isolation of *H. canariensis*, and the entire diplopod community of Macaronesian Islands from the Iberian Peninsula or North Africa can be considered as relatively recent; the Canary Islands and Madeira are "recently" emerged volcanic islands. Assuming that the Siphonocryptida have not been introduced to these islands by human activities (which seems likely as they are found in the primaeval "laurisilva" forests there), then they must have expanded there from the nearest continental zone, that is from North Africa and/or south-eastern Europe. They have so far not been encountered there, but their absence between the north Atlantic islands and the Himalayas (i.e. southern Europe, northern Africa, the Near and the Middle East, Asia Minor, the Caucasus, etc.) does not mean they have never existed. Their absence from this large area (if that is the case) may be better explained as a result of a recent extinction (following human activities such as forest clearings and habitat destruction) than due to incomplete investigations, because a large part of the area (especially Europe and Turkey) is now relatively well known for its diplopod fauna.

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