

Review of the Millipede Genus *Pacidesmus* Golovatch, 1991, with Descriptions of Three New Species from Caves in Southern China (Diplopoda: Polydesmida: Polydesmidae)

SERGEI I. GOLOVATCH^{1*}, JEAN-JACQUES GEOFFROY² AND JEAN-PAUL MAURIÈS³

¹Institute for Problems of Ecology and Evolution, Russian Academy of Sciences, Leninsky pr. 33,
Moscow 119071 RUSSIA

²Muséum national d'Histoire naturelle, Département Ecologie et Gestion de la Biodiversité, UMR 7179 du CNRS,
Equipe EVOLTRAIT, 4, Avenue du Petit Château, F-91800 Brunoy, FRANCE

³Muséum national d'Histoire naturelle, Département Systématique et Evolution, UMR7205, Case postale 53, 61,
rue Buffon, F-75231 Paris, FRANCE

* Corresponding author. E-mail: sgolovatch@yandex.ru

Received: 1 April 2010; Accepted: 20 August 2010

ABSTRACT.— The small Southeast to East Asian genus *Pacidesmus* currently encompasses seven species, all keyed and mapped, including three new from caves in Guangxi Province, China: *P. tiani* n. sp., *P. bedosae* n. sp. and *P. armatus* n. sp. All six congeners from southern China have only been found in caves, all likely representing troglobites, whereas the sole epigeal species is known from a high-montane forest in northern Thailand. Such a vast disjunction is certainly due to undercollecting, also meaning a far more diverse fauna of *Pacidesmus* to actually exist.

KEY WORDS: Diplopoda, *Pacidesmus*, new species, key, cave, China

INTRODUCTION

The small Oriental genus *Pacidesmus* Golovatch, 1991 has hitherto been known to comprise four species. This genus was originally based on the sole, and type, species *Pacidesmus shelleyi* Golovatch, 1991, described epigeally from the top (2200 m a.s.l.) of Mt Doi Inthanon in northern Thailand (Golovatch, 1991).

A second possible congener was first assigned to *Pacidesmus* with reservations. First it was proposed, and provisionally referred to as *?Epanerchodus sinensis* Golovatch and Hoffman, 1989, to replace *Polydesmus hamatus* Loksa, 1960, a name long preoccupied by both *P. hamatus* Brandt, 1841, a Malagasy millipede, and *P. hamatus* Verhoeff, 1897, a Carpathian species (Golovatch and Hoffman, 1989). *Polydesmus hamatus* Loksa, 1960 was

originally described by Loksa (1960) from a cave located near Luodian, Guizhou Province, China; then it was redescribed from new samples taken from the same cave (Chen and Meng 1990), and renamed as *Polydesmus guizhouensis* Chen and Meng, 1990, which thus immediately became a junior objective synonym of *?E. sinensis* (see Golovatch, 1991).

Golovatch and Geoffroy (2006), in their first review of *Pacidesmus*, not only described a third congener, *P. martensi* Golovatch and Geoffroy, 2006, from two further caves in Guizhou Province, but also definitively placed *?E. sinensis* in *Pacidesmus* and compiled a key to all of its three species then known (Golovatch and Geoffroy, 2006). A little later, a fourth species was added, *P. superdraco* Golovatch, Geoffroy and Mauriès, 2006, from another cave in Guizhou Province, as

well as a new record of *P. martensi* from still one more cave in the same province (Golovatch et al., 2006).

Prompted by the discovery of three further new congeners, this time in several caves in the adjacent Guangxi Province, we provide a new review of *Pacidesmus* and key all of its seven currently known species. These new species live in the globe's largest karst region, southern China, more precisely in the Mulun Karst, in Guangxi Province, China (Deharveng et al., 2008). This karst is known to host the richest cave fauna in China. Two of the new species which show especially long extremities are undisputed troglobites, one of which already referred to as *Pacidesmus* sp. in Deharveng et al. (2008).

Material has been shared between the collections of the following institutions, as indicated thereafter. **SCAU**: South China Agricultural University, Guangzhou, China; **IZB**: Institute of Zoology of the Chinese Academy of Sciences, Beijing, China; **MNHN**: Muséum national d'Histoire naturelle, Paris, France; **ZMUM**: Zoological Museum, University of Moscow, Russia.

SYSTEMATICS

Pacidesmus tiani n. sp.

(Figs 1 and 2A)

Holotype.— ♂ (SCAU), China, Guangxi Prov., Huanjiang, Cave Gang Lai Dong, 12.03.2005, leg. L. Deharveng and A. Bedos (CHIgx05-075).

Paratypes.— 1 juvenile ♀ (19 segments) (SCAU), 1 juvenile ♀ (19 segments) (MNHN JC 328), same locality, together with holotype. 1 ♂ (gonopod micropreparation, torso misplaced) (MNHN JC 328), 1 juv. (17 segments) (IZB), Huanjiang, Cave

Gang Lai Dong 2, 13.03.2005, leg. L. Deharveng and A. Bedos (CHIgx05-085).

Etymology.— Honours Tian Mingyi (SCAU), one of the most active collectors in the caves of Mulun Karst.

Diagnosis.— Differs from congeners in the highly troglomorphic facies, coupled with the particularly poorly armoured gonopod endo- and exomere (see also key below).

Description.— Length of holotype ca 23 mm, width of pro- and metazona 1.5 and 2.5 mm, respectively. Coloration in alcohol uniformly pallid (Fig. 1).

Body with 20 segments. Head very densely pilose, only vertex nearly bare; epicranial suture distinct. Antennae very long and slender (Fig. 1D), overreaching segment 5 dorsally; antennomere 3 longest; antennomeres 5 and 6 each with a large, compact, distodorsal group of bacilliform sensilla; antennomere 7 with a very evident dorsoparabasal cone (Fig. 1E). In width, head = collum < segment 2 < 3 < 4 < 5=17, thereafter body rapidly tapering toward telson. Paraterga very strongly developed, upturned starting from collum, ending above level of dorsum on collum and following segments 2-4, level to dorsum and subhorizontal until segment 17, slightly below dorsum thereafter. Starting from segment 4, paraterga increasingly well surpassing rear tergal contour, caudal tips very narrowly rounded to pointed. Paraterga of collum with an evident indentation at margin in front of caudal corner; following paraterga 2-4 (Fig. 1A), as well as subsequent poreless paraterga each with three, all pore-bearing paraterga (Fig. 1B) with four, increasingly poorly developed indentations at lateral margin. Front margin slightly rebordered and upturned, on

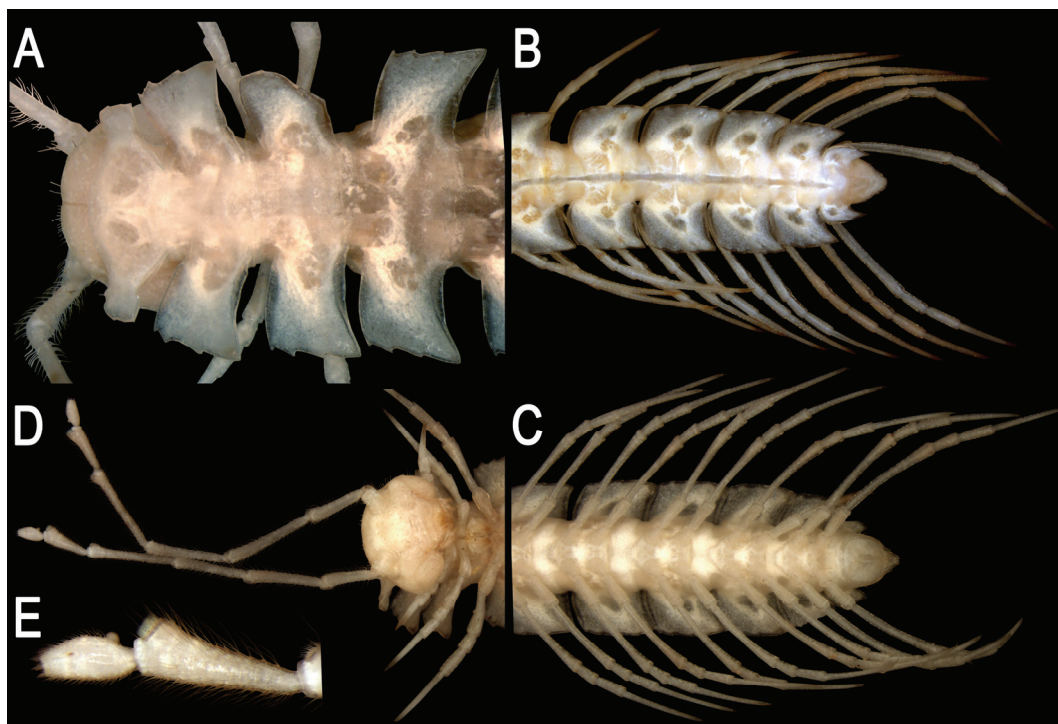


FIGURE 1. *Pacidesmus tiani* n. sp., holotype ♂. **A:** anterior body portion, dorsal view; **B** and **C:** posterior body portion, dorsal and ventral views, respectively; **D:** head with antennae, ventral view; **E:** distal part of antenna. Photographed not to scale by L. Deharveng.

paraterga 2-4 very faintly convex, nearly straight, thereafter first subrectangular, then increasingly obtusangular, more convex, forming a distinct shoulder with anterior indentation at lateral margin until segment 19, on 19th broadly rounded. Pore formula normal, ozopores evident, dorsolateral, located just behind 4th indentation. Metatergal sculpture typical, with three transverse rows of setiferous bosses: bosses in anterior row especially large, polygonal, paramedian 2+2 a little higher; those in both middle and posterior rows much smaller, paramedian 2+2 and 2+2 also a little higher; middle and posterior rows separated from anterior one by a vague transverse sulcus. Surface of prozona, of metaterga below paraterga and of stricture between pro- and metazona finely shagreened and alveolate, poorly shining; only metaterga, albeit with

same texture, more evidently shining due to smooth bosses in middle and posterior rows, as well as paraterga. Tergal setae very short, pointed, partly retained only on collum. Very small pleurosternal carinae present only on segment 2. Epiproct short, conical (Fig. 1B, C). Hypoproct roundly subtrapeziform; caudal, paramedian, setiferous papillae very long and only slightly separated.

Sterna without modifications, modestly setose; cross-impressions evident (Fig. 1C). Legs extremely long and slender (Fig. 1B, C), increasingly longer towards a little shorter last two pairs; midbody legs about as long as four body segments combined; sphaerotrichomes missing.

Gonopods (Fig. 2A) with two distodorsal macrochaetae on coxa; endomere (a) particularly simple, long and very slender,

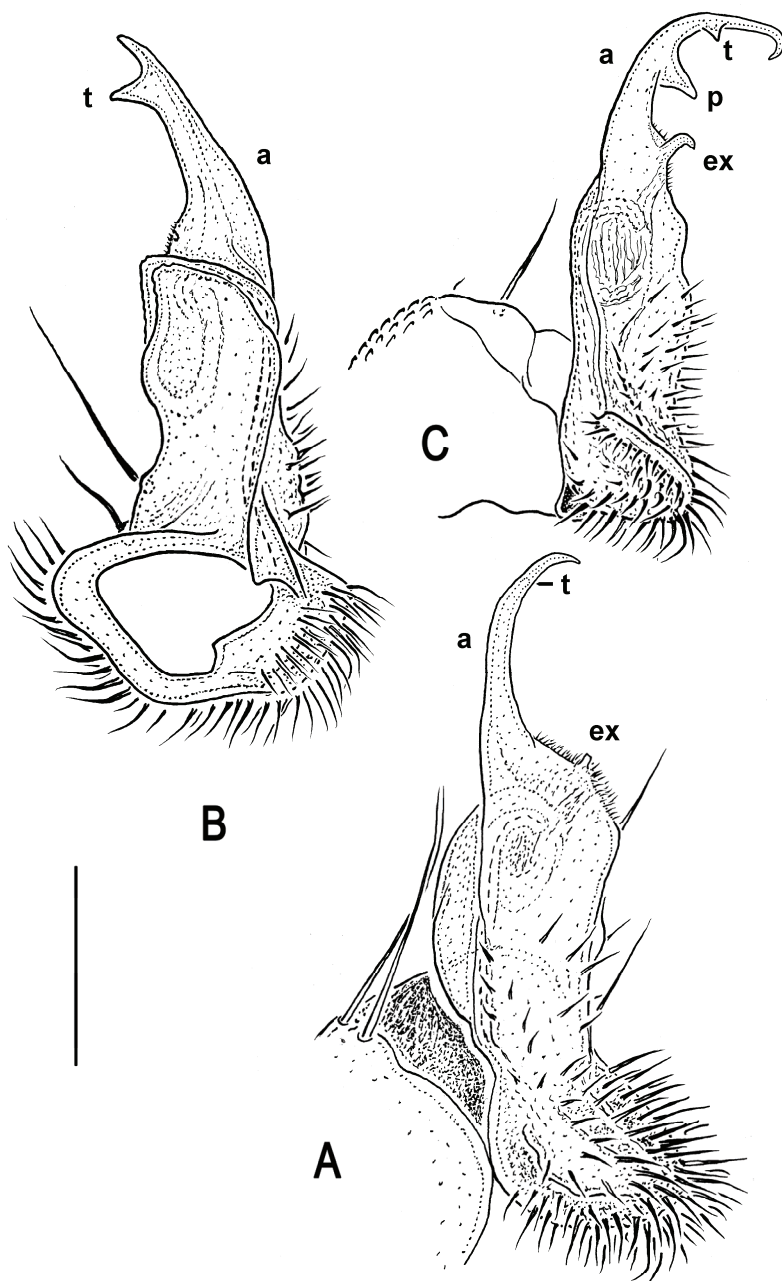


FIGURE 2. A. Right gonopod of *Pacidesmus tiani* n. sp., holotype ♂. B. Right gonopod of *P. bedosae* n. sp., paratype ♂ from Cave Dong Tu Dong. C. *P. armatus* n. sp., holotype ♂, lateral, mesal and lateral views. Scale bar: 0.2 mm.

subfalcate, with a small, rounded lappet (t) distally on mesal face; exomere (ex) abundantly pilose, supplied with a small denticle near midway.

Remarks.— Based on the evident troglomorphic traits (large body size, extremely long extremities, unpigmented tegument), this species is a doubtless troglobite. The large dorsoparabasal knob on antennomere 7 rather strongly reminds of that observed in the small European genus *Serradium* Verhoeff, 1941 (also Polydesmidae), several species of which are known as troglobites (Enghoff et al., 1997).

***Pacidesmus bedosae* n. sp.**
(Figs 2B and 3)

Holotype.— ♂ (SCAU), China, Guangxi Prov., Huanjiang, Cave Dong Tu Dong, 28.10.2009, leg. Tian Mingyi and Mulun Nature Reserve staff (CHIGx09-019).

Paratypes.— 1 ♀ (fragment) (SCAU), 1 ♂ (MNHN JC 329), same locality, together with holotype. 1 ♀ (IZB), 1 ♀ (ZMUM), Huanjiang, Cave Huo Ka Dong, 02.11.2009; leg. Tian Mingyi and Mulun Nature Reserve staff (CHIGx09-054). 1 ♂ (SCAU), Huanjiang, Cave Ganxiao Dong, 07.11.2009; leg. Tian Mingyi and Mulun Nature Reserve staff (CHIGx09-087)

Etymology.— Honours Anne Bedos (MNHN), one of the most active collectors in the caves of Mulun Karst and globally.

Diagnosis.— Differs from congeners in the highly troglomorphic facies, coupled with the relatively short, stout and bifid gonopod endomere (see also key below).

Description.— Length ca 23–24 mm, width of pro- and metazona 1.5 and 2.5 (♂) or 1.6 and 2.7 mm (♀), respectively. Coloration in alcohol uniformly pallid (Fig. 3).

Nearly all characters like in *P. tiani* n. sp. (Fig. 3), except as follows. Antennae a little shorter, surpassing segment 4 dorsally; dorsoparabasal knob on antennomere 7 very small, usual (Fig. 1B). In width, head < collum < segment 2 < 3=4 < 5=17, thereafter body rapidly tapering toward telson. Paraterga very strongly developed, upturned starting from collum, ending above level of dorsum on collum and following segments 2–5, level to dorsum and subhorizontal until segment 18, slightly below dorsum on segment 19 (♂). Starting from segment 3, paraterga increasingly well surpassing rear tergal contour, caudal tips very narrowly rounded to pointed. Front margin slightly rebordered and upturned, on paraterga 2–5 very faintly convex, nearly straight, thereafter first subrectangular, then increasingly obtusangular and convex, forming a distinct shoulder with anterior indentation at lateral margin until segment 19, on 19th slightly more broadly rounded. Hypoproct roundly subtriangular; caudal, paramedian, setiferous papillae very long, digitiform, only slightly separated.

Sterna without modifications, modestly setose; cross-impressions evident (Fig. 3E). Legs extremely long and slender (Fig. 3A, B, E), increasingly longer towards a little shorter last two pairs; midbody legs about as long as three body segments combined; sphaerotrichomes missing.

Epigynal ridge behind ♀ legs 2 high, thin, regularly rounded.

Gonopods (Fig. 2B) with a much thicker and bifid endomere (a), branch (t) being subequal to tip proper; exomere devoid of any projections.

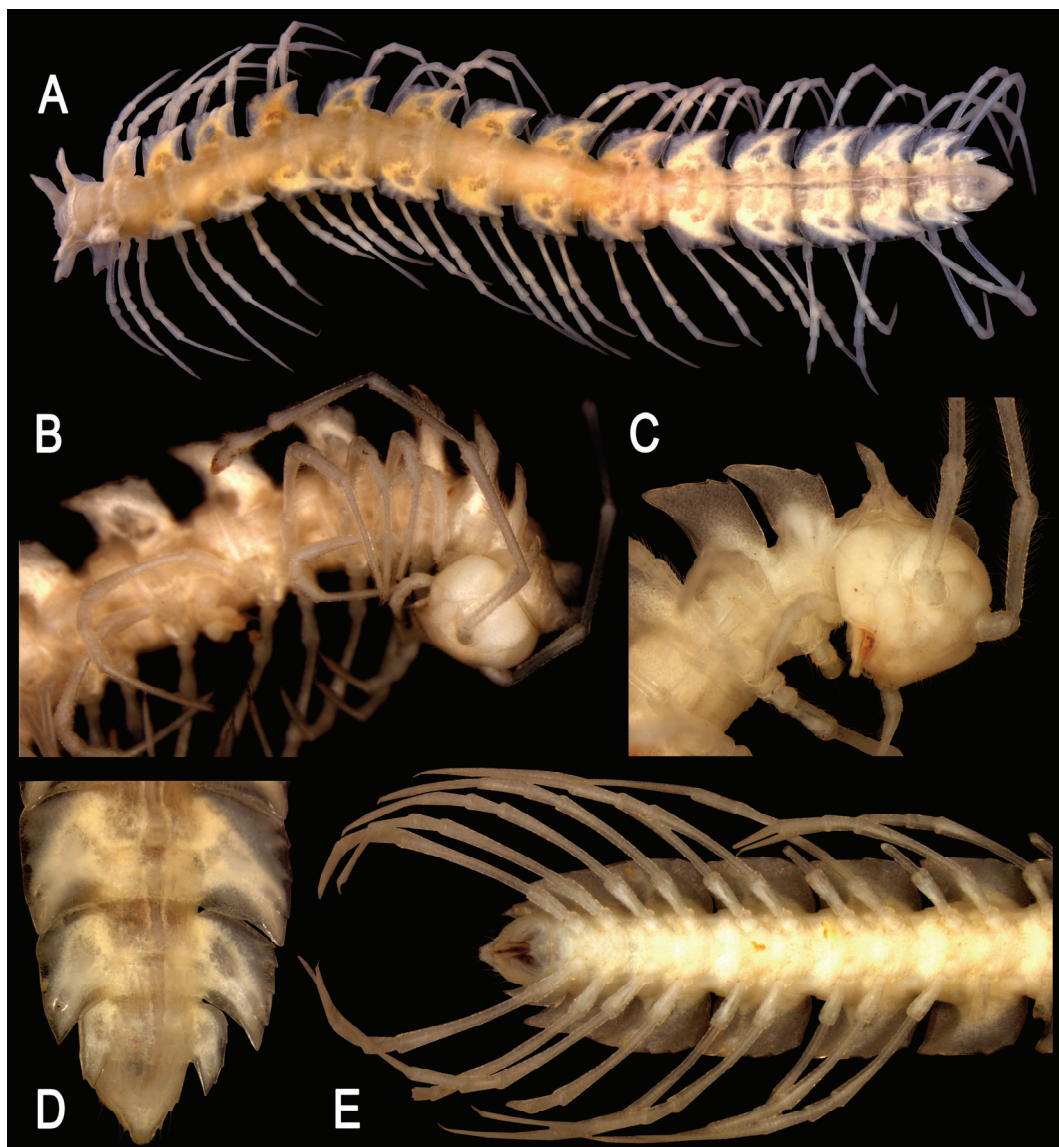


FIGURE 3. *Pacidesmus bedosae* n. sp., paratype ♂ from Cave Dong Tu Dong. **A:** habitus, dorsal view; **B** and **C:** anterior body portion, ventrolateral view; **D** and **E:** posterior body portion, dorsal and ventral views, respectively. Photographed not to scale by L. Deharveng.

Remarks.— Based on the evident troglomorphic traits (large body size, very long extremities, unpigmented tegument), this species is a doubtless troglobite.

***Pacidesmus armatus* n. sp.**
(Figs 2C and 4)

Holotype.— ♂ (SCAU), China, Guangxi Prov., Huanjiang, Cave Xiao Lan Dong, 21.10.2009; leg. Tian Mingyi and Mulun Nature Reserve staff (CHlgx09-016).

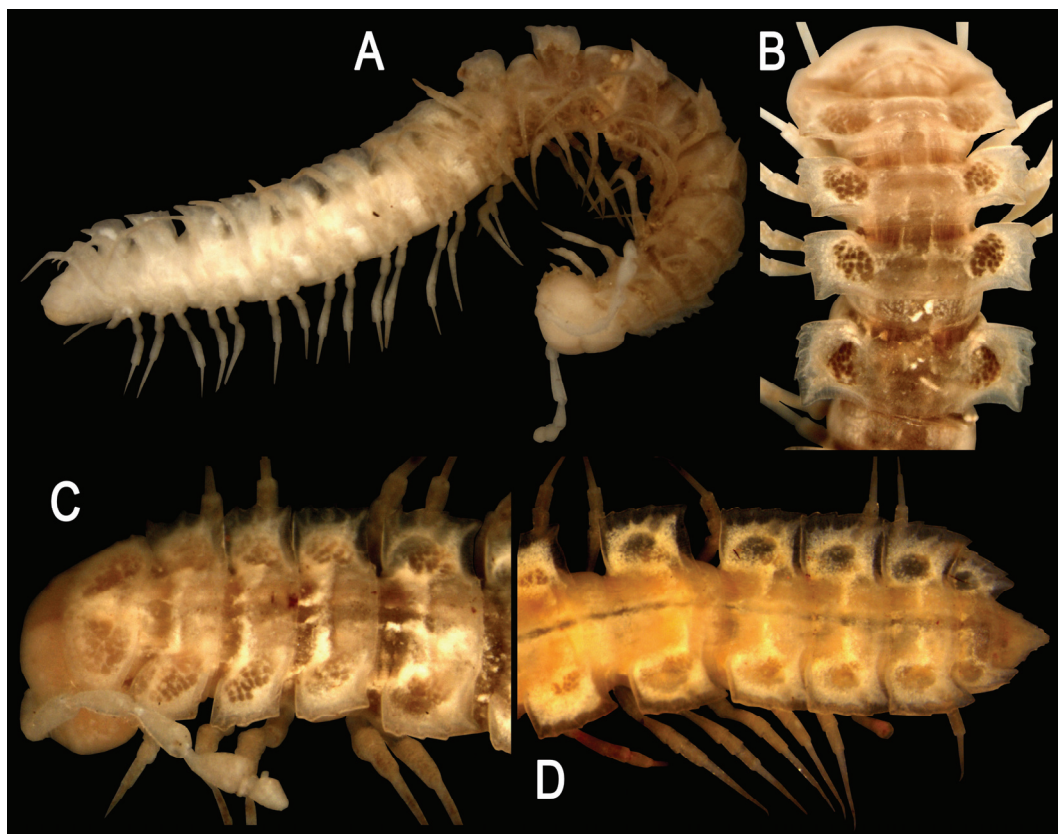


FIGURE 4. *Pacidesmus armatus* n. sp., holotype ♂. **A:** habitus, sublateral view; **B** and **C:** anterior body portion, dorsal and subdorsal views, respectively. **D:** caudal body portion, dorsal view. Photographed not to scale by L. Deharveng.

Paratypes.— 4 ♀♀ (SCAU), 1 ♀ (IZB), 1 ♀ (ZMUM), same locality, together with holotype. 1 ♂, 1 ♀ fragment, 1 juv. (19 segments), 1 juv. fragment (MNHN JC 330), Huanjiang, Cave Shui Dong Mulun, 322 m, 23.05.2007; leg. F. Bréhier (CHIGx07-23-06). 1 ♀ (IZB), Huanjiang, Cave Sheng Long Dong, by hand, 31.10.2009, leg. Tian Mingyi and Mulun Nature Reserve staff (CHIGx09-022).

Etymology.— To emphasize the armoured gonopod telopodite.

Diagnosis.— Differs from congeners in the far less troglomorphic facies, coupled with

the particularly well armoured gonopod endo- and exomere (see also key below).

Description.— Length ca 13-15 mm, width of pro- and metazona 0.9-1.0 and 1.4-1.5 mm, respectively. Holotype ca 15 mm, width of pro- and metazona 0.9 and 1.4 mm, respectively. Coloration in alcohol uniformly pallid, only head slightly yellowish (Fig. 4).

Many characters like in *P. tiani* n. sp. (Fig. 4), except as follows. Vertex also densely pilose. Antennae long, slightly clavate (Fig. 4A-C), extending caudally to end of segment 3 dorsally; antennomeres 5 and 6 each with a large, compact, distodorsal group of bacilliform sensilla;

antennomere 7 with an evident dorsoparabasal cone (Fig. 16). In width, head > collum < segment 3 = 4 < 2 ≤ 5 = 17, thereafter body rapidly tapering toward telson. Paraterga very strongly developed, slightly declivous starting from collum, always subhorizontal and lying below level of dorsum thereafter. Starting from segment 5, caudal corner of paraterga increasingly well surpassing rear tergal contour, caudal tips very narrowly rounded to pointed. Paraterga of collum with an evident indentation at margin in front of caudal corner, following paraterga 2-4 (Fig. 4B, C), as well as subsequent poreless paraterga each with three, all pore-bearing paraterga (Fig. 4B-D) with four, increasingly poorly developed indentations at lateral margin. Front margin slightly rebordered and upturned, nearly straight and subrectangular on paraterga 2-18, forming a distinct shoulder with anterior indentation at lateral margin until segment 19, on 19th slightly obtusangular. Tergal setae very short, subbacilliform, partly retained on collum, several anterior segments and at some indentations of paraterga. Hypoproct roundly subtrapeziform; caudal, paramedian, setiferous papillae rather long and well separated.

Legs modestly long, all podomeres except for tarsus slightly enlarged, tarsus longest and slender (Fig. 4), midbody legs about as long as two body segments combined; sphaerotrichomes missing.

Epigynal ridge behind ♀ legs 2 low, thin, regularly rounded.

Gonopods (Fig. 2C) with endomere (a) falcate, long and slender, and particularly well armoured with teeth (t and p); exomere (ex) abundantly pilose, supplied with an uncus near midway.

Remarks.— Even though this species shows far less evident troglomorphic traits, it may also prove to be a troglobite.

DISCUSSION

The distribution of the currently known *Pacidesmus* species shows a pattern remarkable in several ways. Firstly, there is a huge gap between the montane epigean *P. shelleyi* from northern Thailand, on the one hand, and the remaining six congeners, all presumed troglobites in southern China, on the other hand (Fig. 5). This disjunction is certainly an artifact reflecting insufficient collecting in the regions in-between. Secondly, the species from southern China have recently been considered to form a cluster of particularly closely related congeners, differing mainly in the degrees of development of the paraterga and of troglomorphic traits, as well as in some minor details of gonopod structure (Golovatch et al., 2006). However, based on gonopod conformation alone, which in *Pacidesmus* is believed to be among the basalmost in the entire family Polydesmidae (Golovatch 1991), this statement is now to be questioned. The most troglomorphic *P. superdraco*, *P. tiani* n. sp. and *P. bedosae* n. sp. alone show the degree of diversity covering much of the entire range of interspecific variation in gonopod structure. Thus, the endomere (a) ranges from relatively short, stout and bifid (*P. superdraco* and, to a lesser extent, *P. bedosae* n. sp.) to long, slender and rather simple (*P. tiani* n. sp.), whereas the exomere (ex) can be devoid of (*P. bedosae* n. sp.) or supplied with an outgrowth near the midway (*P. superdraco* and *P. tiani* n. sp.). In the apparently less troglomorphic *P. martensi*, *P. armatus* n. sp. and *P. sinensis*, as well as in *P. shelleyi*, this outgrowth is more

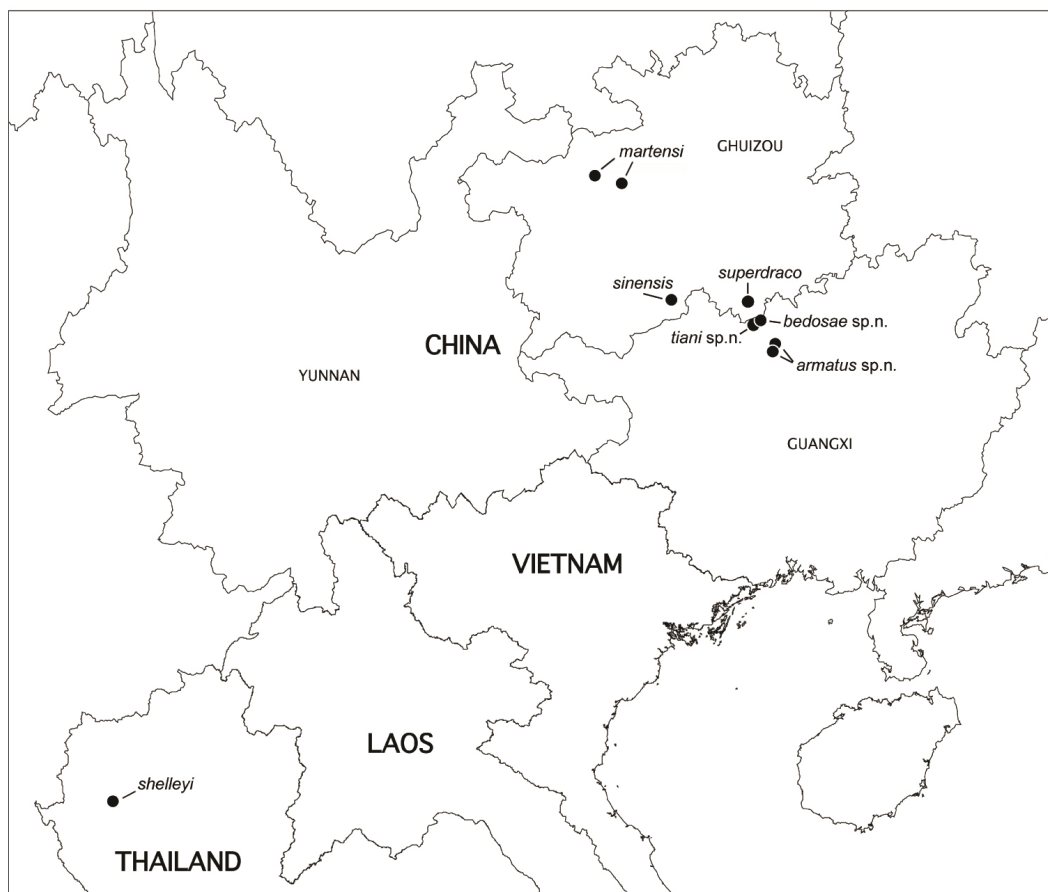


FIGURE 5. Distribution map of the known *Pacidesmus* species.

evident, being placed either at the base (*P. shelleyi*, *P. martensi*, *P. sinensis*) or again near the middle of the exomere (*P. armatus* n. sp.). In spite of this variation, the original diagnosis of *Pacidesmus* as given by Golovatch (1991) still holds.

The frequently to exclusively troglobites observed in the karst regions of southern China as opposed to the remaining parts of the range appears to be characteristic not only of *Pacidesmus*, but also of the large genus *Desmoxytes* Chamberlin, 1923 (Polydesmida, Paradoxosomatidae). *Desmoxytes* species are very common in Southeast Asia and southern China, but it is only in southern China that three congeners are

most probably troglobites (Golovatch and Enghoff, 1994; Golovatch et al., 2010). Furthermore, one of them, *Desmoxytes scolopendroides* Golovatch et al., 2010, shares its cave with *Pacidesmus armatus* n. sp., while one more, *Desmoxytes scutigeroideus* Golovatch et al., 2010, with *Pacidesmus tiani* n. sp. (Golovatch et al., 2010). In each such case strict parapatry and vicariance are observed.

Key to *Pacidesmus* species

In conclusion, the following key can serve to separate the known species of *Pacidesmus*. It is mainly based on male characters.

- 1a Sternal cones between ♂ legs 6 and 7 for accommodation of distal parts of gonopods present. Epigeal from northern Thailand. *P. shelleyi*
- 1b No such sternal modifications. Cavernicoles from southern China. 2
- 2a Adult body smaller: length ≤ 15 mm, width of midbody pro- and metazona 0.9-1.0 and 1.4-1.5 mm, respectively. All paraterga lying below level of dorsum. Endomere with two teeth (Fig. 2C, t and p). *P. armatus* n. sp.
- 2b Adult body larger: length ≥ 17 mm, width of midbody pro- and metazona ≥ 1.3 and ≥ 2.1 mm, respectively. At least some of anterior paraterga reaching above level of dorsum. Endomere with one tooth at most. 3
- 3a Even anterior paraterga barely above level of dorsum. Gonopod exomere with a rather long, slender, unciform process at base; endomere long, bifid, slightly broadened distally. *P. sinensis*
- 3b At least paraterga 1-4 evidently elevated above level of dorsum. Gonopod exomere without such process at base; endomere attenuating distally. 4
- 4a Only paraterga 1-4 evidently elevated above level of dorsum. Legs about as long as four midbody segments (Figs 2 and 3). Gonopod endomere (a) slender, subfalcate, carrying a small tooth (t) distally on median face (Fig. 2A) *P. tiani* n. sp.
- 4b At least paraterga 1-5 evidently elevated above level of dorsum. Legs shorter, as long as 2.5-3 midbody segments. Gonopod endomere either slender, but then devoid of a tooth distally, or considerably stouter. 5
- 5a Paraterga elevated above level of dorsum until about segment 10. Hypoproct subtrapeziform, caudal 1+1 setae not

- borne on stalks. Exomere with a large membranous process at base, endomere slender and flagelliform. *P. martensi*
- 5b Paraterga elevated above level of dorsum either on segments 1-5 or until segment 17 (♂) or 14 (♀). Hypoproct with caudal 1+1 setae borne on stalks. Exomere without process at base, endomere stouter and bifid. 6
- 6a Adult body smaller: length 23-24 mm, width of midbody pro- and metazona 1.5-1.6 and 2.5-2.7 mm, respectively. Paraterga elevated above level of dorsum only on segments 1-5. Endomere (a) less stout (Fig. 2B). Guangxi. *P. bedosae* n. sp.
- 6b Adult body larger: length 28-30 mm, width of midbody pro- and metazona 1.4-1.7 and 2.8-3.2 mm, respectively. Paraterga elevated above level of dorsum until segment 17 (♂) or 14 (♀). Endomere more stout. Guizhou. *P. superdraco*

ACKNOWLEDGEMENTS

We are most grateful to Tian Mingyi (SCAU), Louis Deharveng and Anne Bedos (both MNHN) for the opportunity to study their valuable material, as well as again Louis Deharveng for allowing us to publish some of his photographs and helping us technically. Thanks are expressed to Liu Jin and Anthony Whitten for facilitating the biological surveys project, as well as to the Biodiversity Office of the Guangxi Forestry Bureau and the staff of the Mulun Nature Reserve for organizing the field trips. The first author wishes to again thank the MNHN for the financial support rendered to accomplish this project in 2010.

LITERATURE CITED

- Chen, J.-X. and Meng, W.-X. 1990. Revision of the name *Polydesmus hamatus* Loksa, 1960 with a redescription (Diplopoda: Polydesmida: Polydesmidae). Journal of the Nanjing University, 26: 277-281. (In Chinese, with English summary).
- Deharveng L., Bréhier F., Bedos A., Tian, M., Li, Y., Zhang, F., Qin, W. and Tan, X. 2008. Mulun and surrounding karsts (Guangxi) host the richest cave fauna of China. Subterranean Biology. 6: 75-79.
- Enghoff, H., Caoduro, G., Adis, J. and Messner, B. 1997. A new cavernicolous, semiaquatic species of *Serradium* (Diplopoda, Polydesmidae) and its terrestrial, sympatric congener. With notes on the genus *Serradium*. Zoologica Scripta. 26: 279-290.
- Golovatch, S.I. 1991. The millipede family Polydesmidae in Southeast Asia, with notes on phylogeny (Diplopoda: Polydesmida). Steenstrupia. 17: 141-159.
- Golovatch, S.I. and Enghoff, H. 1994. Review of the dragon millipedes, genus *Desmoxytes* Chamberlin, 1923 (Diplopoda, Polydesmida: Paradoxosomatidae). Steenstrupia. 20: 45-71.
- Golovatch, S.I. and Geoffroy, J.-J. 2006. Review of the Southeast Asian millipede genus *Pacidesmus* Golovatch, with the description of a new troglobitic species from southern China (Diplopoda: Polydesmida: Polydesmidae). Zootaxa. 1325: 363-368.
- Golovatch, S.I. and Hoffman, R.L. 1989. Identity of *Polydesmus hamatus* Brandt 1841, a Malagasy millipede (Diplopoda Polydesmida Dalodesmidae). Tropical Zoology. 2: 159-164.
- Golovatch, S.I., Geoffroy, J.-J. and Mauriès, J.-P. 2006. Several new or poorly-known cavernicolous millipedes (Diplopoda) from southern China. Arthropoda Selecta. 15: 81-89.
- Golovatch, S.I., Geoffroy, J.-J. and Mauriès, J.-P. 2010. Two new species of the millipede genus *Desmoxytes* Chamberlin, 1923 (Diplopoda: Polydesmida: Paradoxosomatidae) from caves in southern China. Arthropoda Selecta, in press
- Golovatch, S.I., Geoffroy, J.-J. and Mauriès, J.-P. 2010. Two new species of the millipede genus *Desmoxytes* Chamberlin, 1923 (Diplopoda: Polydesmida: Paradoxosomatidae) from caves in southern China. Arthropoda Selecta. 19: 57-61.
- Loksa, I. 1960. Einige neue Diplopoden- und Chilopodenarten aus chinesischen Höhlen. Acta Zoologica Academiae Scientiarum Hungaricae. 6: 135-148.