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## Redescription of *Anaulaciulus tonginus* (Karsch, 1881) (Diplopoda, Julida, Julidae)

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A redescription of *Anaulaciulus tonginus* (Karsch, 1881) is given based on topotypic material. Male gonopods and female vulvae are illustrated for the first time together with other characters (telson, penis). *Fustulus trilobus khuuae* Wang, 1963, is synonymized with *A. tonginus*. The position of *tonginus* in the genus *Anaulaciulus* is discussed.

Key words: *Anaulaciulus tonginus* (Karsch, 1881), Diplopoda, Julida.

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### INTRODUCTION

The genus *Anaulaciulus* Pocock, 1895 is another major group of millipedes belonging to the family Julidae (besides *Nepalmatoiulus* Mauriès) which is well represented in East Asia (Enghoff 1987, Korsós in press, a). However, species of *Nepalmatoiulus* tend to penetrate into subtropical/tropical areas (e.g., Vietnam), whereas those of *Anaulaciulus* are mainly confined to the temperate zone, the only overlap between the two genera being in the southern Himalaya region. The known distribution of *Anaulaciulus* includes China, Taiwan, Korea, Russian Far East, and Japan (south of Hokkaido) as well. At present the genus comprises 38 nominal species or subspecies (cf. Enghoff 1986), plus a well defined group of eleven further species (the *inaequipes*-group) in the Himalaya Mts (Korsós in prep. a). Internal relationships and gonopod conformation patterns of the genus are preliminarily discussed elsewhere (Korsós in prep. b).

In the present paper, as a first step of a revision of the whole genus, a peculiar member of *Anau-*

*laciulus* is fully redescrbed. The species was known almost only by its name for more than a century; however, according to the recent study, it represents an important link both zoogeographically and morphologically between the western (Himalayan) and the eastern (Korean and Japanese) members of the genus.

The name of *Julus tonginus* was introduced by Karsch (1881) in his "Prodomus". The description was very short, without illustration, and based on a single female specimen from Hong Kong. Consequently, the form became a "species inquirenda" for more than a century, until 1983, when new topotypic material was collected by Dr. Paul Lam, University of Hong Kong. Later the animals were directly compared to the type specimen, now deposited in the Zoological Museum, Humboldt University, Berlin, and a full agreement (incl. vulval structure) proved them to be conspecific (Enghoff 1986, and in litt.).

The original description sounds as follows (Karsch 1881, translated from Latin):

"*Julus tonginus*, nob., ♀, gracile, brown, almost monochromous; collum laterally significantly narrowed, rounded, ven-

trally hardly reaching the margin of the 2nd segment, its posterior margin with 6-7 striae directed longitudinally and anteriorly shortened; segments strongly vaulted, anterior part glabrous, posterior part with dense, longitudinal, subtle striae; ozopores large, lying in posterior part of segment, behind suture about midheight; preanal segment pilose, epiproct acute, far surpassing anal valves, anal valves pilose, strongly con-vex; antennae hardly reaching the 5th segment; number of segments ca. 50; body length ca. 30 mm. Single specimen in alcohol from Hong Kong (coll. E. v. Martens)."

This description is not satisfactory according to modern standards, thus a redescription of the species based on the present sample seems to be necessary, especially regarding its peculiar position in the genus.

## MATERIAL AND METHODS

The material studied belonged originally to the Zoological Museum, University of Copenhagen, Copenhagen (ZMUC), and it is shared now between the following institutions: ZMUC, Hungarian Natural History Museum, Budapest (TMB), and Zoological Museum of the Moscow State University, Moscow (ZMMU).

Some selected specimens (males and females) were examined as follows: temporary glycerin slides of gonopods, permanent slides mounted in Euparal for studying gnathochilarium, left antenna, 1st legpair, 2nd legpair, penis, anterior and posterior legpairs of a midbody segment, and limb, as well as permanent slides of vulvae in Faure-Berlese medium.

On analysed specimens, in addition to measuring total length and midbody (maximum) vertical diameter, length and width of antenno- and midbody podomeres were recorded (according to the method of Enghoff 1982), the number of podous segments, ocelli per eye field, gnathochilarial and vulval setae were counted. Calculations for relative length of antennae and legs (total length/midbody vertical diameter), and leg slenderness (sum of length/width ratios of prefemur, femur, postfemur and tibia) were also made.

## TAXONOMIC ACCOUNT

### *Anaulaciulus tonginus* (Karsch, 1881)

Figs. 1-8.

*Julus tonginus* Karsch, 1881: 20.

*Anaulaciulus tonginus*: Enghoff 1986: 124.

*Fusiulus trilobus khuuae* Wang, 1963: 92. **New synonymy!**

*Anaulaciulus trilobus khuuae*: Enghoff 1986: 124.

Material examined: 4 ♂♂, 5 ♀♀, 1 juv. (ZMUC, incl. 1 ♂ SEM mount and slide prep. no. AN-133); 1 ♂, 1 ♀ (TMB, slide prep. no. AN-131, 132, 134); 1 ♂, 1 ♀ (ZMMU), Hong Kong, P. Lam ded., 1983.

Total material: 6 ♂♂, 7 ♀♀, 1 juv.

### Description

Length 16-21 mm (♂♂), 14-23 mm (♀♀); maximum vertical body diameter 1.5-1.7 mm (♂♂), 1.4-2.2 mm (♀♀); number of podous segments 44-49 (♂♂), 43-47 (♀♀).

**Colouration:** Body generally brown with common julid pattern, head, collum, preanal ring and anal valves darker brown. Between two dorsolateral pale yellowish stripes a black middorsal line, present on both pro- and metazonae; sometimes faded, not so clear, brownish. Legs whitish, lighter than body colour in both sexes.

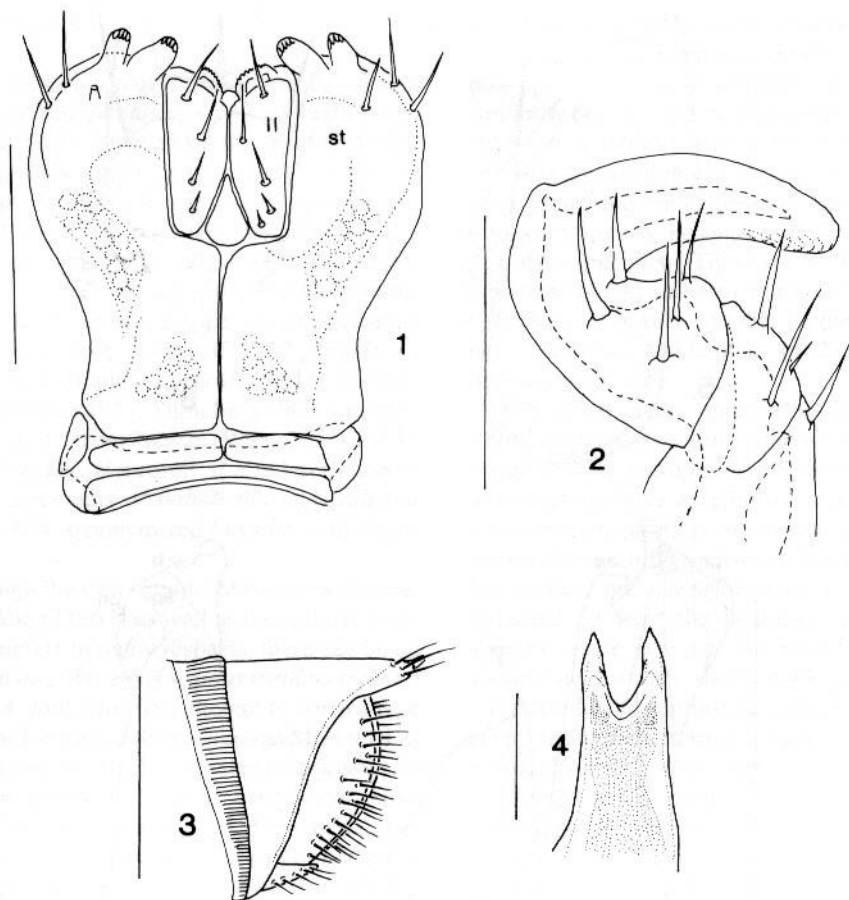
**Head:** Each eye with 49-61 (♂♂), 46-52 (♀♀) ocelli in a rectangular field; 2 frontal setae, 4 supralabral setae and a row of numerous labral setae; length of antennae 112% (♂), 81% (♀) of body height, last antennomere with 4 apical sensilla. *Gnathochilarium* (Fig. 1) with 2-3 setae on apical part of stipites, and with 4-5 setae distributed evenly on lamellae linguales (numbers vary even within individuals). Male cheek lobes not expanded.

**Collum** smooth, with a few short striae in postero-lateral corner.

**Body segments:** Second and 3rd segment in males without modification, 7th forming an opening for the male gonopods, but without anterior and posterior protecting projections. Prozonae smooth; metazonal striation strong, dense, ca. 25 striae per dorsal quarter, without metazonal setae; ozopores touching suture from behind.

**Telson:** Preanal ring with a short dorsal projection, hyaline tip turned upwards; epiproct, subanal scale, anal valves densely pilose (Fig. 3).

**Legs** slender, length of a midbody pair 57% (♂), 48% (♀) of body height, leg slenderness 8.2 (♂) and 7.9 (♀), in females without modification; accessory claw long, thin, seta-like, its length 124-160% of claw proper.



Figs. 1-4. *Anaulaciulus tonginus*. - 1: gnathochilarium, 2: first leg (left) of male, 3: posterior end of body (female), 4: penis. Scales 1: 0.5 mm, 2: 0.2 mm, 3: 1 mm, 4: 0.2 mm. - st: stipes, ll: lamella lingualis.

#### Male sexual characters

*First legpair* medium sized, open hooks (Fig. 2); *2nd legpair* without coxal modification, *adhesive pads* present from 2nd legpair onwards.

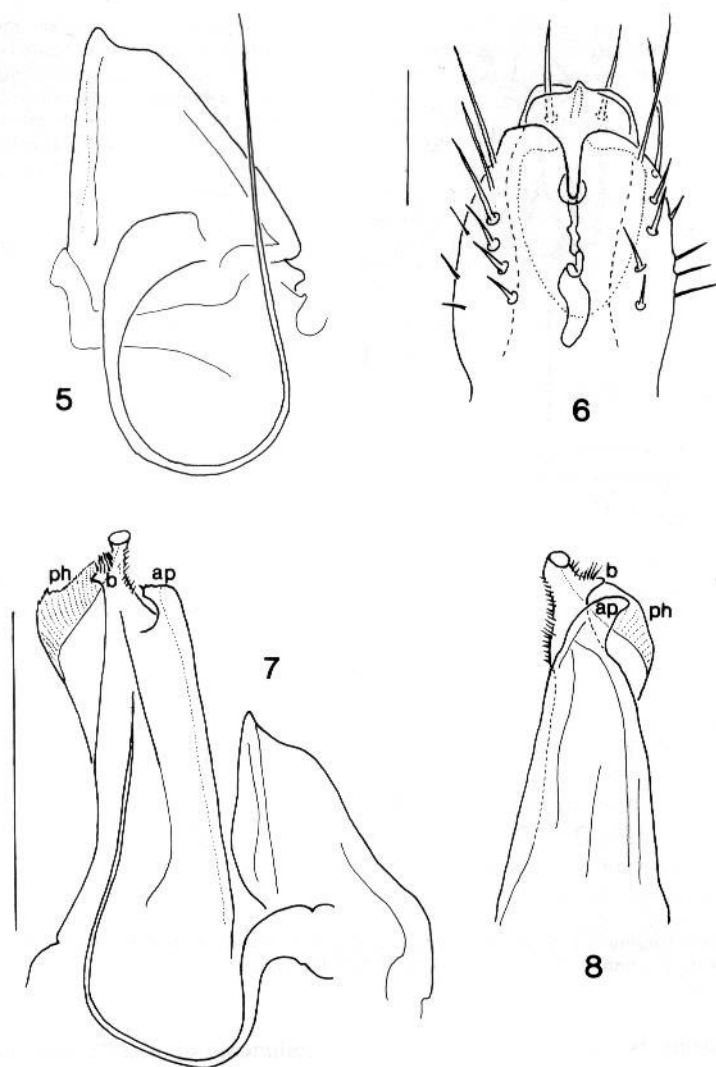
*Penis* (Fig. 4) closely behind 2nd legpair, in situ visible, strong, bifurcate, branches membranous, leaflike, their length a bit shorter than the stalk of penis, opening of the seminal canal probably at their basis, on caudal side.

*Gonopods*: Promerites rather flat, scale-like (Fig. 5), in situ almost entirely covering the opening of the 7th segment and partly the opisthomerites; short, their length half of the opisthomerite; antero-posteriorly not completely flattened (note mesal view!, Fig. 7); tapering towards tip; with

rudiments of a telopodite in the latero-caudal corner, and with long, slender flagella. Opisthomerite (Fig. 8) long, straight; with a mesal furrow and a lamella along its axis for accommodating flagellum; frontally with a strong, blunt process bent mesad (ap); caudally with broad lamella bent mesad, with membranous phylacum (ph) and small fringes at its margin; subapically with a small hairy process pointed mesad and slightly downwards (b); tip of opisthomerite rounded, concave, densely surrounded by fringes and hairs.

#### Female sexual characters

*Vulvae* (Fig. 6) situated behind 2nd legpair, deeply enveloped in a membranous sack. In some speci-



Figs. 5-8. *Anaulaciulus tonginus*. - 5: left gonopodal promerite, posterior view, 6: vulva, posterior view, 7: right gonopods, mesal view, 8: left gonopodal opisthomerite, anterior view. Scales 5, 7, 8: 0.5 mm, 6: 0.2 mm. - b: beaklike process, ap: anterior process, ph: phylacum.

mens tip of vulvae covered with thick, wax-like, dark brown material, possibly deposited by the male in order to close the bursal opening of the receptaculum seminis after copulation. This phenomenon has hitherto only been reported for chordeumatids (Enghoff in litt.). Bursa slightly flattened in antero-posterior direction, median cleft moderately deep, with 18-19 setae altogether: 11-12 in two rows on posterior median plate, 3-4

on each mesal and lateral sclerites; ampulla elongated, with a slight constriction; apodematic tube short, slightly coiled. Operculum flat, slightly longer than bursa, rectangular, with two lateral cusps and a tiny median tooth, with 7 setae in two rows on frontal side.

#### *Distribution*

Hong Kong, Taiwan, ?Hunan Prov.

## DISCUSSION

Pocock's description of *Anaulaciulus* based on a Chinese species, *paludicola*, was generally overlooked probably because of the lack of proper illustration. The increasing number of closely related East Asian julid millipedes with similar gonopods described subsequently were usually assigned to the genus *Fusiulus* erected by Attems (1909). In the second half of the 1960's *Fusiulus* accommodated already 26 species/subspecies: 2 from the continent (Verhoeff 1937, Takakuwa 1941), 21 from Japan (Takakuwa 1941, Takashima & Shinohara 1957, Shinohara 1960, Murakami 1966), and 3 from Taiwan (Wang 1955, 1963). In 1966 Causey, as a result of a redescription of the type specimens of *paludicola* and *vallicola* Pocock, 1895, synonymized *Fusiulus* with *Anaulaciulus*.

Although the descriptions of two new subspecies by Wang (1963) as well as their illustrations are incomplete in many respects, there can be no doubt that one of them (*Fusiulus trilobus khuuuae*) refers to *A. tonginus*. (An attempt to borrow type specimens for study from the Taiwan Museum has remained unsuccessful.) The other (*Fusiulus trilobus quemoyensis*), described firstly, was introduced as "Sp. nov.", and, since a nominate subspecies has never been mentioned, is a junior synonym of *Anaulaciulus trilobus* sensu stricto (Engelhoff 1986). (The name *trilobus* itself appears in four different ways in the paper in question: "tribolus", "trilolus", "trilolius", "trilobus", but it is clear from the description that the author's intention was to refer to the "trilobed" posterior gonopod). Recently Zhang (1993) described a new species of *Anaulaciulus*, namely *otigonopus*, from China, Hunan Prov., Changsha City. Although there are illustrations on gonopods, and also on penis and vulvae, the details of the tip of the opisthomerite cannot be judged properly. No information is given on the shape of the epiproct, or the colouration of the new species. However, with regard to the similarity of other characters, and the locality (which is not very far from the type locality of *tonginus*), it is not unlikely that *otigonopus* is identical with *tonginus*. It would, however, be premature to propose a formal synonymy.

Apart from the general resemblance between

the illustration of *Fusiulus trilobus khuuuae* by Wang (1963, Fig. 3, anterior view?) and the gonopod opisthomerites of *tonginus*, a conspicuous similarity between the two nominal species is the colouration, which seems to be an important criterium in the taxonomy of *Anaulaciulus* (Korsós in prep. b). (It may have, however, have been overlooked by Karsch, because of the poor preservation of the specimen). The shape of the promerites, which led former authors to base a number of new species on it, is very variable within the populations (see, e.g., Mikhajlova 1982), having thus little specific value.

The shape of the epiproct within the genus *Anaulaciulus* shows almost the whole scale from naught to long and upturned. Species of the *inaequipes*-group have an epiproct usually short (in one species naught), pointed, sometimes slightly turned downwards. Species in Korea and Japan have longer preanal projections, in the majority upturned (at least the hyaline tip), sometimes straight, acute (the tip can easily be broken). Having no (or very short) epiproct in julids is considered to be a primitive, plesiomorphic character, hence the upturned projection of *tonginus* represents an advanced state.

Modifications on the 2nd and 3rd (for penis) and on the 7th segments (for gonopods) of males usually occur in the genus. Especially conspicuous are the anterior and posterior projections of pleurotergites on ventral side mesally, surrounding and together with the more or less scalelike promerites partly covering the opening for the posterior gonopods. However, these modifications are almost entirely missing in *tonginus*, leaving the protecting function alone to the promerites. The 7th segment, looking like in "normal julids", hence connects *tonginus* to other members of Brachyiulini.

The long, bifurcate penis is characteristic for all species of *Anaulaciulus*; that of *tonginus*, however, is a bit different from what has been found in the *inaequipes*-group: the branches being shorter and not so diverging. This puts *tonginus* closer to the more eastern continental species (e.g., *A. golovatchi* Mikhajlova, 1982, and *koreacolus* Jedryczkowski, 1982).

The shape of promerite is widely variable in the genus; but in *tonginus* it is not so flattened antero-



posteriorly (Fig. 7, mesal view!) as in congeners. This form has not yet been reported in the genus, and being more similar to e. g. that of *Brachyiulus*, is certainly plesiomorphic, if the definitions of Brachyiulini and *Anaulaciulus* are taken into consideration (Korsós in prep. a). The opisthomerite is also more complicated and three-dimensional than in most of the other species; the presence, however, of both a mesal and a lateral lamella, the latter with a broader apical "phylacum" (bent mesad posteriorly), and a beginning of a subapical process, suggest an intermediate state between the Korean and Himalayan species. The subapical process may well be homologous to the "beak" in the *inaequipes*-group; this is further supported by the common appearance of a dense hairy patch in *tonginus* and a few hairs on the beak in members of the *inaequipes*-group. The tip of the opisthomerite (small thickening with a concavity) is also similar to that of most group-members. The strong anterior process bent mesad of *tonginus* seems to be missing in the continental species, but one can find similar structure in some Japanese species (e.g., *A. quadratus* (Takakuwa, 1941)).

The general shape of the vulva is almost cylindrical, not so flattened antero-posteriorly as it is

the case in other species (especially the *inaequipes*-group), but more similar to the vulvae found in the rest of the tribe Brachyiulini. The median cleft of bursa is moderately deep, and the shape of the ampulla and the apodemetic tube is similar to that of the Korean group of *Anaulaciulus* (i.e. simple, elongated, without appendix). All this suggests that *Anaulaciulus tonginus* is morphologically quite similar to the hypothetical ancestor of the numerous species of the genus.

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