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Taito adrik, a new harvestman species from the Área de Conservación Privada Panguana, Peruvian Amazonia (Opiliones: Laniatores: Cosmetidae)

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Abstract

A new species of the cosmetid harvestman genus *Taito* Kury & Barros 2014 is described from the Área de Conservación Privada (ACP) Panguana, Peruvian Amazonia, which extends the distribution range of the genus to the south-west. The herein described species *Taito adrik* **sp. nov.** differs from all other known species of the genus by the distinct shape of the equuleus, the armature of leg IV in males, and the structure of male genitalia, in combination with features of the chelicerae and the anal operculum. In addition, COI barcodes of the new species are provided.

Key words: Neotropics, primary rainforest, Opiliones, new species, COI barcode

Introduction

In 2014, Kury & Barros described the new genus *Taito* within the New World family Cosmetidae of Opiliones Laniatores (Kury & Barros 2014). In their study, eight new species of *Taito* from Brazil were described: the type species *Taito spaceinvaders* Kury & Barros, 2014, along with *T. galaga* Kury & Barros, 2014, *T. honda* Kury & Barros, 2014, *T. kakera* Kury & Barros, 2014, *T. kawaiikei* Kury & Barros, 2014, *T. medinae* Kury & Barros, 2014, *T. osmari* Kury & Barros, 2014, and *T. rorschachi* Kury & Barros, 2014. Six additional species were transferred to *Taito* by Kury & Barros (2014) from other genera: *Cynorta insperata* Soares, 1970, *Eucynortella juruensis* Mello-Leitão, 1923, *Cynorta litterata* Soares, 1970, *Cynortula oblongata* Roewer, 1928, *Cynortula serriperna* Mello-Leitão, 1932, and *Cynortula unapunctata* Goodnight and Goodnight, 1943. The distribution of these 14 *Taito* species is the Upper Amazon Basin of Brazil, Colombia, Ecuador and Perú.

The genus *Taito* is characterized by a combination of the following features: 1. The equuleus, a whitish structure on the dorsal scutum; 2. The free tergite zero, where the presence of a coda (Kury 2012) at the posterior margin of the dorsal scutum gives the impression of an additional free tergite; 3. A unique armature of male leg IV, and the anal operculum; 4. Sexual dimorphism in length/width ratio of the dorsal scutum (Kury & Barros 2014); 5. The penis with a characteristic pattern of macrosetae on the ventral plate, dorsal process of the glans thumb-like and smooth, and the glans sac with a cellulite-like texture (Kury 2018, personal communication).

Between 2009 and 2018, 35 specimens of a new species of the genus *Taito* were collected in the primary evergreen lowland rainforest of the Área de Conservación Privada (ACP) Panguana (Peruvian Amazonia), which is located in Central Perú between the eastern slopes of the Andes and the Sira Mountains (Fig. 1 B). All specimens were collected and exported legally (see below). The goal of this study is to describe this new species of *Taito*—the first since the genus has been established in 2014—and provide sequence data for the COI barcoding gene.

Material and methods

Specimens were collected by hand at night and fixed in 75% to 96% ethanol. Photo series were taken either with a NIKKOR 85mm f/3.5G lens mounted on a Nikon D7000, combined with a Cognisys STKS-C-StackShot apparatus

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or with a NIKON V1 camera mounted on a LEICA Z16 APO stereo microscope. Up to 20 photos were combined to a single composite image with a greater field of depth using Helicon Focus 5.3 (HeliconSoft). For SEM preparation, specimens were dehydrated in 100% ethanol, dried chemically (HMDS—Hexamethyldisilazane), and coated with gold using a BIO-RAD Sputter Coater. SEM pictures were made with a LEO 1430VP electron microscope at 10–20 kV. DNA extraction, amplification and sequencing were carried out by AIM—Advanced Identification Methods GmbH in Munich. Part of a leg with muscle tissue from each specimen was taken for DNA extraction and further sequencing. Either dgLCO (GGWACWGGWTGAACWGTWTAYCCYCC) and dgHCO (TAAACTTCAGGGTGACCAAARAAYCA) or LCO1490-JJ (CHACWAAYCATAAAGATATYG) and HCO2198-JJ (AWACTTCVGGRTGVCCAAARAATCA) were used as primers. Six specimens were barcoded successfully (Table 1). Sequences were aligned in MEGA (Kumar *et al.* 2016) and P-distances were analyzed in MEGA (Tamura *et al.* 2004).

TABLE 1. COI p-distances for *Taito adrik* **sp. nov.** specimens sequenced in this study (* holotype MUSM 0513700).

Collection ID	Sex	Collection date	BOLD ID	1.	2.	3.	4.	5.	6.
1. ZSMA20190290	female	01.–21.v.2015	AIMEI005-19	-					
2. MUSM 0513700*	male	21.iv.–04.v.2018	AIMEI006-19	0.008	-				
3. ZSMA20190291	male	24.viii.–06.ix.2018	AIMEI007-19	0.008	0.000	-			
4. ZSMA20190292	male	24.viii.–06.ix.2018	AIMEI008-19	0.020	0.012	0.012	-		
5. MUSM 0513701	female	24.viii.–06.ix.2018	AIMEI009-19	0.004	0.004	0.004	0.016	-	
6. MUSM 0513702	female	24.viii.–06.ix.2018	AIMEI010-19	0.004	0.004	0.004	0.016	0.000	-

Terminology is following Kury *et al.* (2007), Kury (2012), Kury & Barros (2014), Kury & Villarreal Manzanilla (2015), Kury (2016), and Medrano & Kury (2016).

Abbreviations for measurements: CL (carapace length), CW (carapace width), AL (abdominal scutum length), AW (abdominal scutum width). All measurements are provided in mm.

Abbreviations of the type depositing institutes: MUSM (Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Perú), ZSM (Bavarian State Collection of Zoology, Munich, Germany), MNRJ (Museu Nacional, Universidade Federal do Rio de Janeiro, Brazil), ZMH (Zoological Museum Hamburg, Germany), MHNG (Muséum d'Histoire Naturelle, Geneva, Switzerland).

Permits: Collecting (No. 334-2009-AG-DGFFS-DGEFFS, No. 0276-2013-AG-DGFFS-DGEFFS, No. 007-2014-SERFOR-DGGSPFFS (for 5 years)) and export (No. 001075-AG-DGFFS, No. 000521-MINAGRI-DGFFS, No. 0001757-SERFOR, No. 003052-SERFOR, No. 003214-SERFOR, No. 003281-SERFOR, No. 003320-SERFOR) permits for the years x.2009, ix/x.2013, iv–v.2015, iv–v.2016, ix/x.2017, iv–v 2018 and viii/ix 2018 were issued by DGFFS (Dirección General Forestal y de Fauna Silvestre, Perú) or SERFOR (Servicio Nacional Forestal y de Fauna Silvestre, Perú).

Results

Taito adrik sp. nov.

(Figs. 1–7)
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Etymology. The specific name is an indeclinable noun in apposition, given in honour of the outstanding arachnologist Adriano B. Kury (nickname "Adrik"), who established the genus *Taito*, together with Carla M.L. Barros, in 2014. As professor and senior curator of arachnids in the Museu Nacional/UFRJ, Rio de Janeiro, Brazil, he lost most of his invaluable collections and fruits of his many field trips through the fire catastrophe in September 2018.

Type material. PERÚ, *Huánuco Department*, Puerto Inca Province, Yuyapichis District, Rio Yuyapichis, ACP Panguana (9°37'S, 74°56'W, 230 m a.s.l.): holotype male (MUSM 0513700), 21.iv.–04.v.2018 (E. Diller); 1 female paratype (ZSMA20190295), 02.–18.x.2009 (E.-G. Burmeister); 3 male and 1 female paratypes (MUSM 0513706/707, ZSMA20190294, ZMH-A0002240), 20.ix.–07.x.2013 (S. Friedrich & F. Wachtel); 2 female paratypes (ZSMA20190289/290), 01.–21.v.2015 (S. Friedrich, F. Wachtel & M. Steinherr); 2 male paratypes (ZMH-A0002241, MHNG-ARTO-18641), 23.iv.–09.v.2016 (S. Friedrich, F. Wachtel & D. Hauth); 1 male paratype (ZSMA20190296), 22.ix.–10.x.2017 (S. Friedrich, F. Wachtel, D. Hauth & T. Lehmann); 1 female paratype (MHNG-ARTO-18642), 22.ix.–10.x.2017 (E.-G. Burmeister); 2 male and 3 female paratypes (MNRJ 6033–036, ZSMA20190297), 21.iv.–04.v.2018 (E. Diller); 7 male and 11 female paratypes (ZSMA20190291–293/298–304, MUSM 0513701–705/708–710), 24.viii.–06.ix.2018 (E. Diller). All specimens were collected at night on the ground in primary evergreen lowland rainforest.

Diagnosis. Dorsal scutum sturdy (average ratio length/width *ca.* 1.18 in females, *ca.* 1.21 in males), β-type (normal β) (Kury *et al.* 2007) and not βL-type (elongate β) (Kury & Medrano 2016) (Fig. 2 A). Equuleus butterfly-shaped with discrete feet and arms, and elongated, slim horns (Figs. 1 A; 2 A, C; 3); two whitish blots on minute tubercles at posterior margin of scutal area III (in some specimens two smaller additional blots beside) (Figs. 1 A; 2 A, C). Groin warts (Kury & Barros 2014) on dorso-proximal part of coxa IV (Fig. 2 A, B), coxa IV with dorsal triangular apophysis (Fig. 2 F). Leg IV of male: femur IV gently curved with comb of five to six curved apophyses on distal-prolateral side; patella IV with coarse granules and one single apophysis proximal-retrolateral; tibia IV unarmed, covered with granules (Figs. 2 E, F; 5).

Distribution. Only known from the type locality (Fig. 1 B). This extends the distribution range of the genus *Taito* to the south-west. So far, the genus was known from the Upper Amazon Basin up the eastern slope of the Andes. Now, the distribution reaches to a territory west of the Ucayali River, into the Pachitea Basin, which is located between the eastern slopes of the Andes and the Sira Mountains (Fig. 1 B).

Description. Male holotype (MUSM 0513700)

Color (in ethanol) (Fig. 2). Body medium brown, densely covered with small, lighter orange-brown islands. Appendages also showing this pattern, but a little bit lighter. Equuleus on dorsal scutum and interrupted stripe on coda nearly white. Shape of equuleus very consistent (Fig.3).

Measurements. CL = 2.3, CW = 3.6, AL = 4.2, AW = 5.7; legs I to IV: Table 2.

Dorsum (Figs. 2 A, D; 4 F). Dorsal scutum sturdy (ratio *ca.* 1.19), maximum width at scutal area III, thickened laterals with granulate surface; two minute tubercles on area III. Posterior margin of scutum sub-straight in dorsal view. Posterior margin of free tergite I also sub-straight, that of free tergite II weekly convex, and of free tergite III strongly convex (Fig. 2 A). All free tergites with a row of transverse granules. Anal operculum unarmed, with two dorso-lateral indentations, covered with granules (Figs. 2 D; 4 F).

Venter (Figs. 2 B; 4 F). Coxae I–II nearly transverse, parallel and sub-equal in size. Coxa III larger. Coxa IV much stronger and slanted backwards. Anterior part of genital operculum elliptical, posterior margin truncated. Stigmatic area y-shaped with large elliptical stigmata. Stigmatic area deeply concave relative to the greatly bulging coxa IV. Free sternites I–VI strongly concave, with a dense row of granules.

Chelicerae (Fig. 4 E). Basichelicerite with an ectal row of six tubercles; three anterior tubercles large and connected, and a posterior row of 12 granulate tubercles with nearly equal size. One single large and rounded antero-mesal process.

Pedipalps (Fig. 4 A–D). Trochanter with a single ventral spine. Femur with dorsal proximal keel with two anterior teeth, ventral row of 17 teeth, the middle one largest. Tibia with an apophysis at distal end, near tarsus.

Legs (Figs. 2 E, F; 5). Legs I–III granulous and unarmed. Femur IV gently curved both laterally and dorso-ventrally, finely granulous; it is armed with a prolateral comb of six posteriorly curved spine-shaped apophyses, at distal end. Patella IV covered with coarse granulation and armed with a single retrolateral apophysis at the proximal end. Tibia IV unarmed with granulous surface. Tarsal count: 6–6/14–14/7–7/9–9. Measurements of leg segments provided in Table 2.

TABLE 2. *Taito adrik* **sp. nov.**, male holotype (MUSM 0513700): Articles measurements of left legs (in mm).

legs	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus
I	1.0	4.8	1.2	3.0	4.8	2.9
II	1.4	9.7	1.5	7.9	10.1	5.9
III	1.3	6.9	1.6	3.8	6.2	3.3
IV	1.5	9.0	1.8	5.6	9.2	4.2

Male genitalia (Figs. 6 A–C; 7 A–H). Penis: slender trunk with distal bulge. Dorsal process of glans thumb-like and smooth. Glans sac with cellulite texture. Stylus covered with spiny tubercles on its ventral border. Ventral plate with macrosetae C1 and C2 large, curved and spatulate. D1 short and straight, or large and curved in a paratype (see Discussion). D2 reduced. Only one pair of macrosetae A and B. A small and straight, B reduced, E1 and E2 reduced. Microsetae (ms) on ventral plate with a wide central gap and made up of type 4 ms distally, which gradually become type 1 ms proximally.

FIGURE 1. A. Living female paratype (ZSMA20190293) of *Taito adrik* **sp. nov.** from the type locality, ACP Panguana (photo: Konrad Wothe); B. Location of the type locality; C. Habitat at type locality.

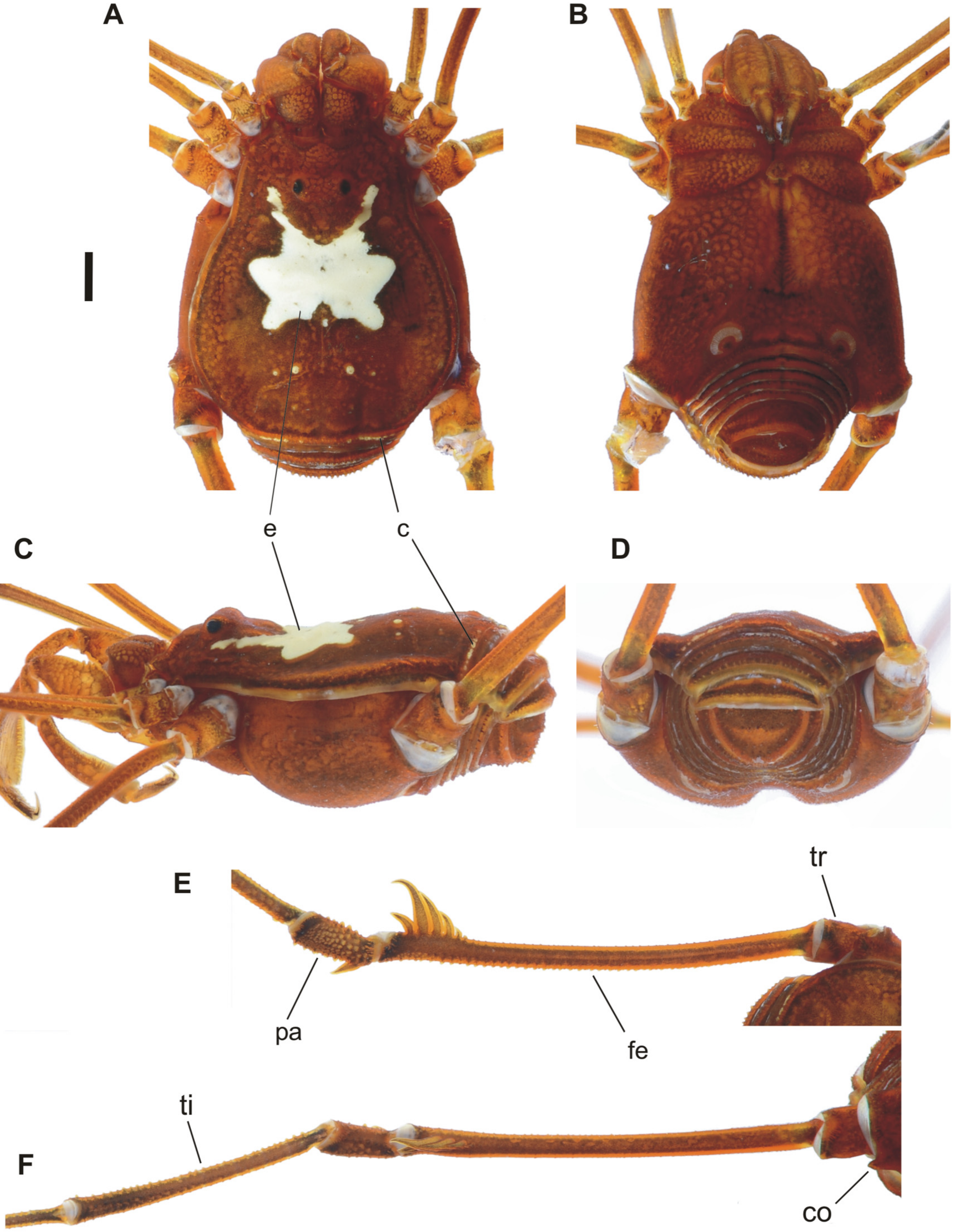

FIGURE 2. *Taito adrik* **sp. nov.**, holotype male (MUSM 0513700): A. Dorsal view; B. Ventral view; C. Left side, lateral view; D. Posterior view; E. Left leg IV, dorsal view. F. Left leg IV, prolateral view. (c: coda, co: coxa IV, e: equuleus, fe: femur IV, pa: patella IV, ti: tibia IV, tr: trochanter IV). Overall scale bar = 1 mm.

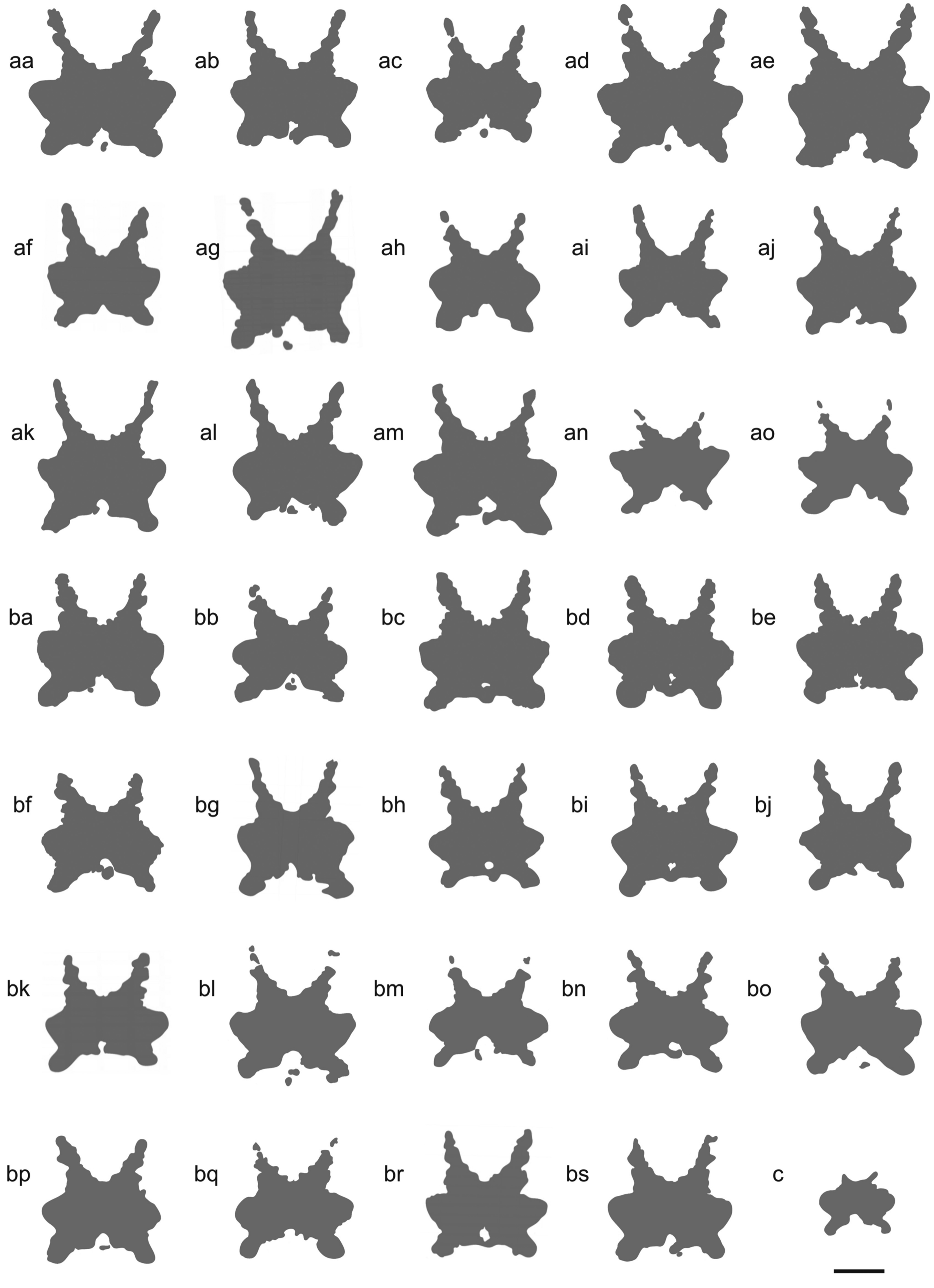

FIGURE 3. *Taito adrik* **sp. nov.**: Outline of equulei of all specimens of the type series (aa: male holotype (MUSM 0513700), ab–ao: male paratypes, ba–bs: female paratypes, c: juvenile male paratype ZSMA20190294), showing minimal variation. Overall scale bar = 1 mm.

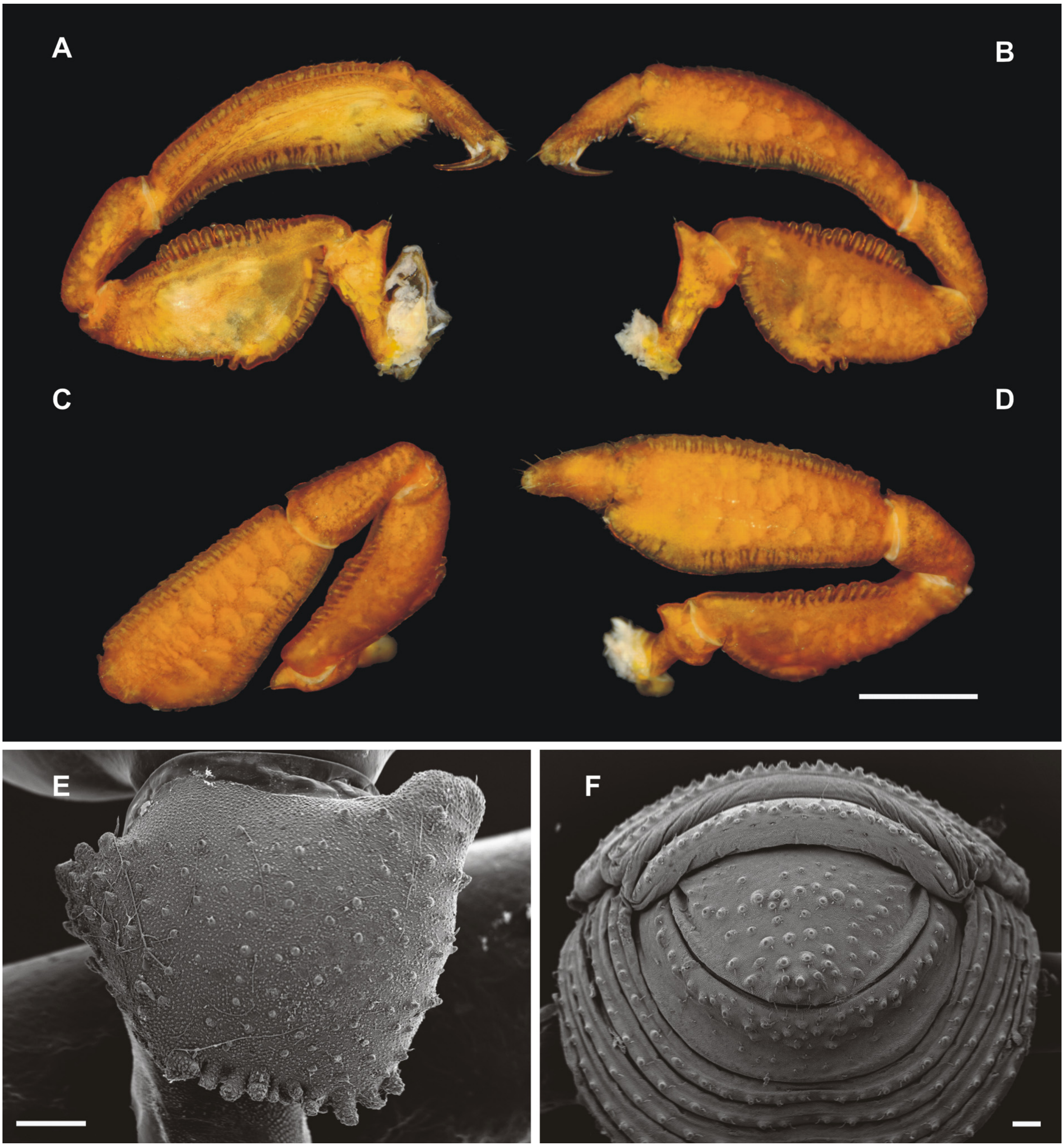

FIGURE 4. *Taito adrik* **sp. nov.**, male holotype (MUSM 0513700): A. Left pedipalp: mesal view; B. ectal view; C. patella-tibia, dorsal view and femur lateral view; D. tibia-tarsus, dorsal view and femur-patella, lateral view; E. Left chelicera: dorsal view of basichelicerite; F. Anal operculum and free sternites, posterior view. Scale bars: A–D = 1 mm; E, F = 200 µm.

Comparisons. In several *Taito* species, femur IV is armed with a row/comb of a few distal spines; in *T. medinae*, there are eight spines, while in *T. spaceinvaders*, *T. osmari*, *T. insperatus*, and *T. oblongatus* there are seven spines. Only in *T. adrik* **sp. nov.** the number of distal spines is six (Fig. 2 E, F; 5). Generally, the armature of leg IV in *T. adrik* **sp. nov.** is similar to two closely related species, *T. insperatus* and *T. oblongatus*. However, these species differ in having dorsal scutum elongated, while it is sturdy in *T. adrik* **sp. nov.**, a feature only shared with *T. serriperna* and *T. kawaiikei*. These species in turn are easily separated from *T. adrik* **sp. nov.** especially by the armature of leg IV (apophyses on coxa, femur, and patella). With respect to coxa IV, in *T. adrik* **sp. nov.** it has a single small apophysis (Fig. 2 A, F), just like in *T. insperatus*, *T. kakera*, *T. medinae*, *T. oblongatus*, *T. osmari*, *T. rorschachi*, and *T. spaceinvaders*; in contrast, *T. galaga* and *T. honda* have a single large apophysis, and *T. juruensis*, *T. kawaiikei*, and *T. serriperna* have a double apophysis. Patella IV is unarmed in most species; in a few species, this article is covered with acuminate/setiferous tubercles (*T. galaga*, *T. kakera*, *T. osmari*, and *T. rorschachi*). *T. adrik* **sp. nov.** is the only species with a single retrolateral conspicuous apophysis (Fig. 2 E, F; 5). *T. galaga* and *T. rorschachi* are the only species that share a butterfly-shaped equuleus with the new species. In *T. adrik* **sp. nov.** the design of the butterfly is most similar to *T. galaga*, but only in the new species the equuleus has elongated, slim horns reaching the ocularium (Fig. 1 A; 2 A, C; 3). Moreover, *T. adrik* **sp. nov.** differs from *T. galaga* and *T. rorschachi* in several other features (scutal area III, anal operculum, and armature of leg IV). In the genus *Taito*, scutal area III has either high spines (*T. galaga* and *T. honda*) or small granules/minute tubercles (all other species, including *T. adrik* **sp. nov.**, Fig. 2 A, C, D). Finally, the dorsal anal operculum is either unarmed (*T. adrik* **sp. nov.**, Fig. 2 D; 4 F), as well as *T. kakera*, *T. honda*, *T. insperatus*, *T. oblongatus*, *T. kawaiikei*, *T. juruensis*, and *T. serriperna*), or armed with a median spine, a blunt protuberance or a crown of tubercles (*T. spaceinvaders*, *T. galaga*, *T. honda*, *T. medinae*, *T. osmari*, *T. rorschachi*, and *T. spaceinvaders*); however, only in *T. adrik* **sp. nov.** the anal operculum has two dorso-lateral indentations, which can be seen with the SEM and were not described in all other *Taito* species so far.

The new species can be inserted in the key of Kury & Barros (2014:20), at the dichotomy 7(2) (then adjusting the numbering of dichotomies by changing the former 7(2) to 8(7), and so on), as follows:

7(2) Equuleus butterfly-shaped with elongated, slim horns (Fig. 2 A, 3 aa–bs); femur IV armed with a comb of 6 distal spines (Fig 2 E, F; 5); patella IV armed with a single retrolateral conspicuous apophysis (Fig 2 E, F; 5). . . . . ***Taito adrik* sp. nov.**
– Equuleus H- or easel-shaped; femur IV with a comb of 7 or 8 distal spines; patella IV unarmed 8

COI barcoding. Specimen data and DNA sequences of the studied species are available from BOLD (Ratnasingham & Hebert 2007). The genetic divergences between the six sequenced specimens (holotype and five paratypes) range between 0.0%, and 2.0% (average 0.8%, see Table 1). A search in BOLD revealed specimens of the cosmetids *Cynorta* sp. (86.49% similarity), *Vonones* sp. (85.71% similarity), and *Paravonones* sp. (85.65% similarity) as the closest matches.

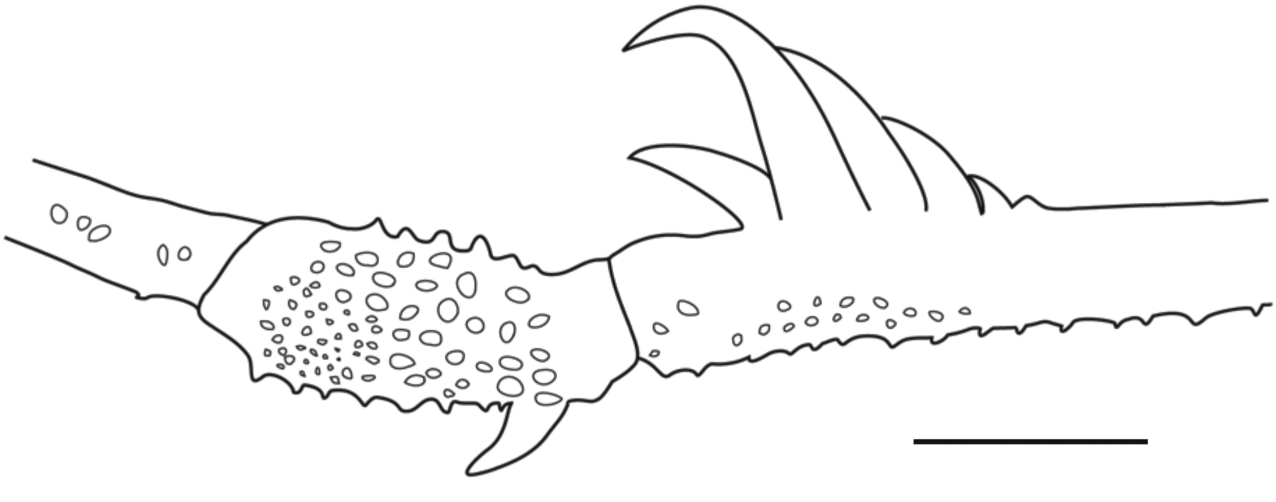

FIGURE 5. *Taito adrik* **sp. nov.**, left leg IV of male holotype (MUSM 0513700), dorsal view: Patella, distal part of femur, and proximal part of tibia. Scale bar = 1 mm**.**

Discussion

The most conspicuous feature in *Taito adrik* **sp. nov.** is certainly the equuleus, a typical pattern of white markings on the dorsal scutum (Kury & Barros 2014). It is present in all species belonging to genus *Taito* and in other presumably related cosmetid genera such as *Vononoides* Roewer, 1912 and *Eucynortella* Roewer, 1912. According to Kury & Barros (2014), *Taito* species can be mostly recognized by the shape of the equuleus, although there is some overlap among species. Kury & Barros (2014) described four basic patterns of the equuleus: (1) the H-shaped, (2) the more typical easel-shaped, (3) the butterfly-shaped, and (4) the compact-shaped. In *Taito adrik* **sp. nov.** the equuleus is butterfly-shaped with little variation across the studied sample (Fig. 3). It differs from the other *Taito* species with a butterfly-shaped equuleus (*T. galaga* and *T. rorschachi*) in having elongated, slim horns, while in the mentioned species it is more compact. This certainly allows a rapid preliminary identification in the field, both for males and females.

Concerning the male genitalia, we probably came across an interesting intraspecific variation. We inspected three penises with SEM (holotype MUSM 0513700 and two paratypes ZSMA20190291/2). In two of them (holotype and paratype ZSMA20190291), the D1 macrosetae are small and straight, pointing proximad (Fig. 7 A–D, H). Surprisingly, in the remaining specimen (paratype ZSMA20190292) this macroseta appears to be asymmetric: on the right side, D1 is large and horn-like curved, closely resembling C1 and C2 (Fig. 7 E), but on the left side, D1 is small and straight (Fig. 7 F, G). Plausible explanations are that there is some intraspecific variation or teratological difference concerning the shape and size of D1.

As detailed in the Comparisons section above, *Taito adrik* **sp. nov.** has several unique features, *e.g.,* patella IV with conspicuous apophysis, femur IV with six spines, butterfly-shaped equuleus with elongated, slim horns, and probably the dorso-lateral indentations of the anal operculum (which can be seen with the SEM and is not described in other species). Hence, from the morphological analysis alone it is impossible to determine which species in the genus is closest to *Taito adrik* **sp. nov.**. Integrative taxonomy (Dayrat 2005, Padial *et al.* 2010, Schlick-Steiner *et al.* 2010), which combines morphological species determination by means of classical taxonomy with modern methodological developments, like COI barcoding, could lead to further knowledge in this respect.

According to Kury & Barros (2014), the status of *Taito* as a clade is uncertain. There is not a single character state, which can be confidently interpreted as a synapomorphy for all species of *Taito*. Furthermore, the affinities within the genus are sometimes difficult. Thus, providing COI barcodes for *Taito adrik* **sp. nov.** can be seen as a first step in the direction of clearing the mentioned affinities. The genetic divergences between the sequenced specimens (0.0%–2.0%; average 0.8%, see Table 1) confirm that they are all conspecific. Usually, more than 3% divergence between two sister species is expected (Hendrich *et al.* 2010). Interestingly, the specimen differing the most from the others is that having a large and curved D1 on one side, and a short and straight D1 on the other side (ZSMA20190292, p-distances ranging from 1.2%–2.0%). However, exomorphologically we found no additional difference to the other specimens (*e.g.,* equuleus, armature of leg IV). Hence, we concluded this divergent specimen to belong to the same species. Preliminary analysis in BOLD revealed undetermined species of the genera *Cynorta* Koch, 1839, *Vonones* Simon, 1879 and *Paravonones* Pickard-Cambridge, 1904 as the closest matches within Cosmetidae, and so, they are candidates for a phylogenetic analysis to test the monophyly of *Taito*. However, these sequences as such might be of little use, as these "genera" are actually not well defined and are probably not monophyletic. In this case, the precise species identity of the vouchers with sequences available in BOLD is the first requisite to do the comparisons.

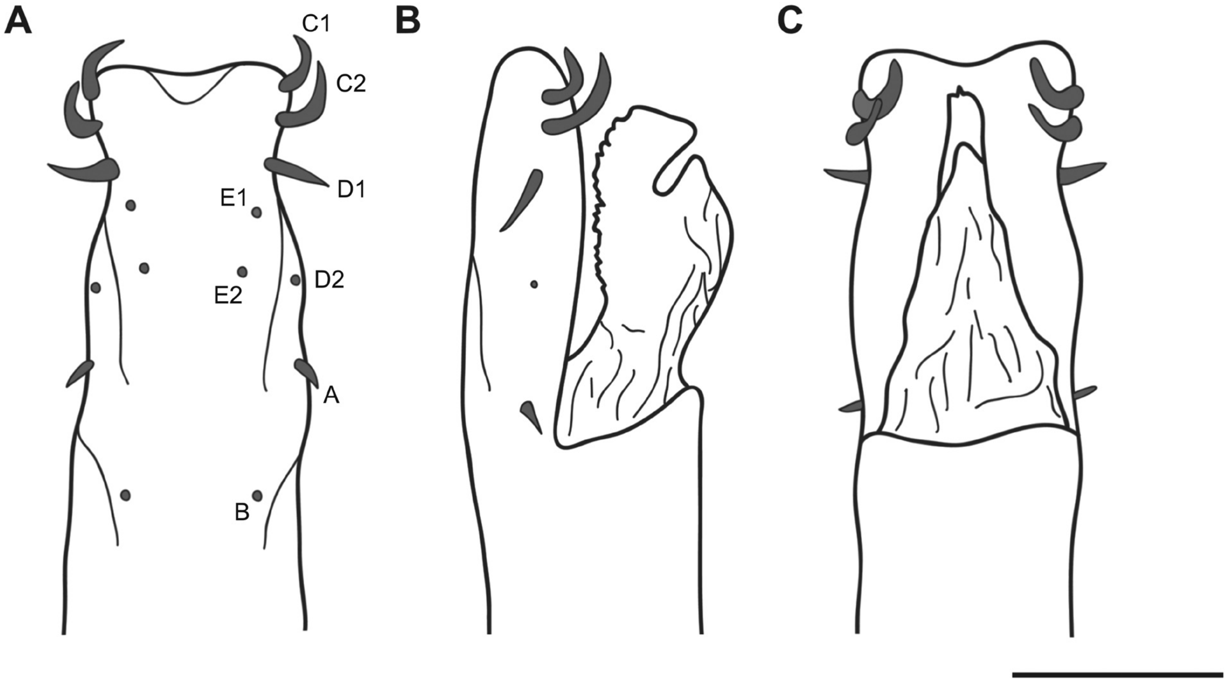

FIGURE 6. *Taito adrik* **sp. nov.**, representation of male genitalia, showing distal part of truncus, ventral plate with macrosetae, and glans: A. Ventral view; B. Lateral view; C. Dorsal view. Scale bar = 100 μm.

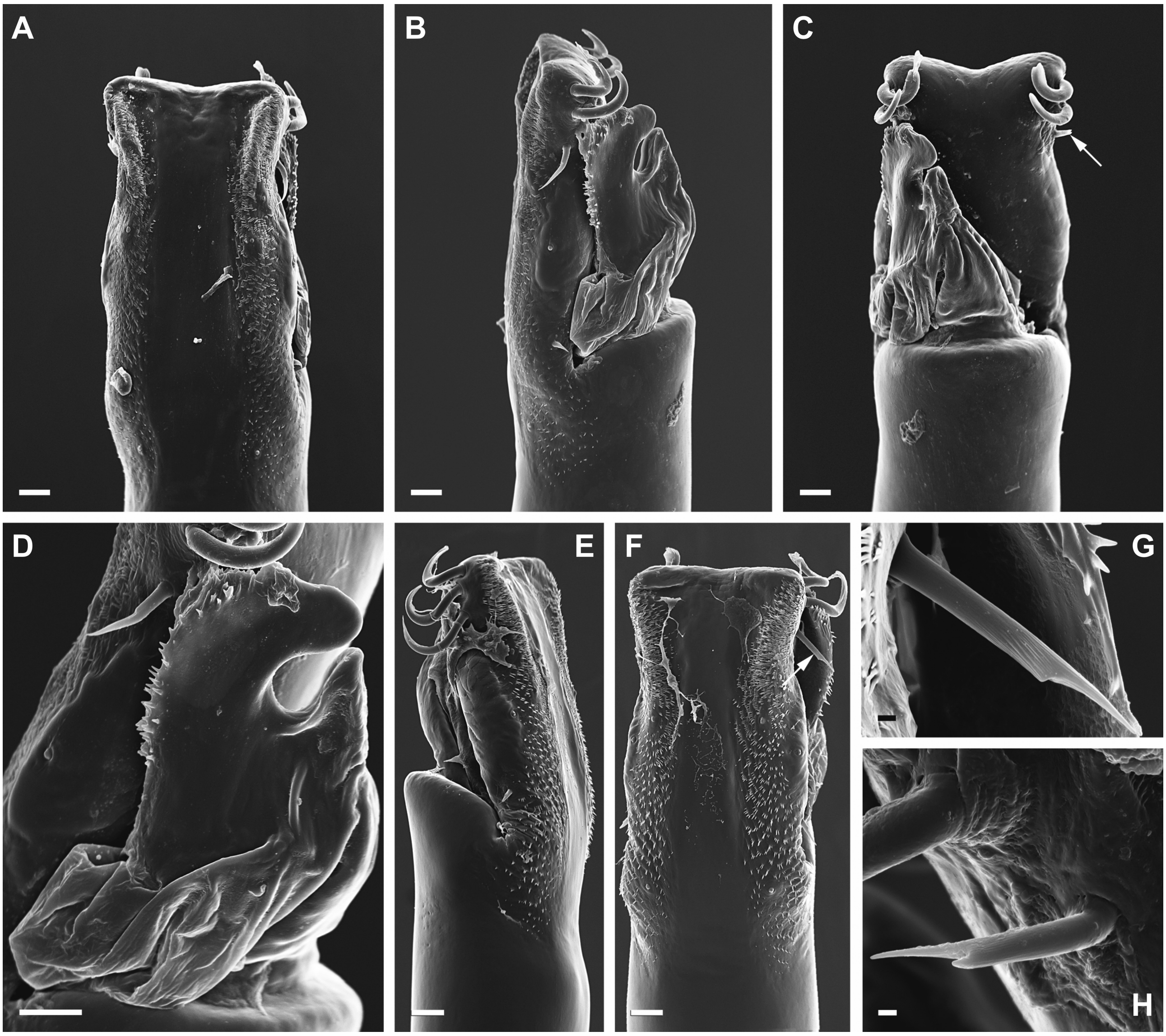

FIGURE 7. *Taito adrik* **sp. nov.**, S.E.M. micrographs of distal part of penis of two male paratypes (A–D, H: paratype ZSMA20190291, E–G: paratype ZSMA20190292): A. Ventral plate and distal part of truncus, ventral view; B. Lateral view; C. Glans and distal part of truncus, dorsal view (arrow shows small and straight D1, see also figure 7H); D. Dorsolateral view of glans; E./F. Lateral (E) and ventral (F) views of the specimen with large and curved D1 on one side and small and straight D1 on the other side (arrow, see also figure 7G); G. Detail of small and straight D1 in figure F; H. Detail of small and straight D1 in figure C. Scale bars: A–F = 20 µm; G, H = 2 µm.

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