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SYNONYMY OF *SPICATELLA* THIBAUD, 2002 WITH *DELAMAREPHORURA* WEINER & NAJT, 1999, AND DESCRIPTION OF TWO NEW SPECIES (COLLEMBOLA: TULLBERGIIDAE)

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ABSTRACT. — The monospecific genus *Spicatella* Thibaud, 2002 is synonymised with *Delamarephorura* Weiner & Najt, 1999. *Delamarephorura* is redefined and a key to its species is given. *Delamarephorura capensis*, new species, from South Africa and *D. tami*, new species, from Vietnam are described and illustrated. *D. capensis*, new species, is the only species of the genus with pseudocellar formula 11/111/11111; *D. tami*, new species, is the only species of the genus with chaetae M absent on tibiotarsi.

KEY WORDS. — taxonomy, chaetotaxy, extinction risk, South Africa, Vietnam

INTRODUCTION

Weiner & Najt (1999) established the genus *Delamarephorura* for *Mesaphorura salti* Delamare-Deboutteville, 1953 from Tanzania, on the basis of a set of morphological features: Abd. VI with a medial process ventrally, double crescentic ridges and two strong spiniform processes dorsally; simple vesicles in the PAO; pseudocelli shape; and pseudocellar formula. A few years later, Thibaud (2002) proposed a new genus *Spicatella* for a new species *S. bedosae* collected in littoral dunes of southern Vietnam, based on a combination of characters among which its ear-shaped postantennal organ was the most characteristic, but omitted in the description to compare it to *Delamarephorura*. Another form collected more recently in Madagascar was considered by Thibaud (2008) to be very close to *S. bedosae*. In 2009, Barra and Weiner described a second species of *Delamarephorura* from South Africa, *D. szeptyckii*, which is very similar to *D. salti*. The two new species described in this paper, one from South Africa and one from Vietnam, have characters of both *Spicatella* and *Delamarephorura*, making the differences between the two genera indistinct. This led us to carefully re-examine the five concerned species, and propose that *Spicatella* is considered as a synonym of *Delamarephorura*, as shown below. *Delamarephorura* is re-diagnosed accordingly.

MATERIAL AND METHODS

Studied material. — Besides the two new species described here, the following specimens were examined for the re-evaluation of the status of *Spicatella* and *Delamarephorura*:
Mesaphorura salti Delamare-Deboutteville, 1953 (type species of *Delamarephorura*): holotype and two paratypes from Tanzania
Spicatella bedosae Thibaud, 2002 (type species of *Spicatella*): holotype and 1 paratype from Ca Na (Vietnam); 3 non-type specimens from Binh Chau (Vietnam)
Spicatella cf. *bedosae*: 5 specimens from Madagascar (Thibaud, 2008)
Delamarephorura szeptyckii Barra & Weiner, 2009: holotype and two paratypes from South Africa

Fresh specimens were cleared in lactic acid, and permanently mounted on slide in Marc André II. They were observed and illustrated using a Leica DMLB microscope.

Material deposited. — Specimens are deposited in the South African Museum, Cape Town, South Africa (SAMC), Institute of Systematics

and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland (ISEA), Institute of Tropical Biology, Ho Chi Minh City, Vietnam (ITB) and Muséum national d'Histoire naturelle, Paris, France (MNHN).

Abbreviations used. — AIIIO, organite of third antennal segment; Abd., abdominal tergum; Ant., antennal segment; Th., thoracic tergum; Tita, tibiotarsus.

TAXONOMY

We followed Rusek (1971) and D'Haese (2003) for antennal chaetae, and Fjellberg (1991) for tibiotarsal chaetae. The strong reduction of tibiotarsal chaetotaxy and induced shifts in chaeta positions makes the notation uncertain (hence homology) of some dorsal chaetae of tibiotarsi with those of the standard pattern described for Poduromorpha (Deharveng, 1983). The same partly holds for terga chaetotaxy (see Barra & Weiner, 2009: 59).

TULLBERGIIDAE Bagnall, 1935

Delamarephorura Weiner & Najt, 1999

Syn. — *Spicatella* Thibaud, 2002: 206
Type species. — *Mesaphorura salti* Delamare-Deboutteville, 1953

Diagnosis. — Habitus and dorsal chaetotaxy similar to *Metaphorura* Stach, 1954. Antenna III-organ with two large sensory clubs and two sensory rods protected by three large guard papillae and four guard chaetae dorsally; one large sensory club ventrally. Antennal segment IV with a small simple exsertile vesicle, subapical organite in latero-dorsal position, close to microsensillum; five thickened sensilla. Postantennal organ ear-like with 8–18 simple, rather large vesicles arranged obliquely to the axis in two regular rows. Pseudocelli faintly double-striate (type II of Weiner & Najt [1991], not type III as hypothesized with doubt by Thibaud [2002]), their formula per half tergite 11/122/22221 or 11/111/11111. Abdomen VI with or without crescentic ridges close to chaeta a2, with two simple anal spines, and often two lateral spiniform processes, chaetae a0 and p0 present, a small to minute medioventral process often present. Distal whorl of tibiotarsi I–III with five chaetae (ventral chaetae A4 and A5 absent); proximal whorl of tibiotarsi I–III with 3–6 chaetae; chaeta M present or absent.

Discussion. — Some chaetotaxic details given in literature descriptions have to be corrected. In the original description of *Spicatella bedosae* (Thibaud, 2002: 205, Fig.7) chaeta a0 on Abd. VI has been overlooked. In the re-description of *Delamarephorura salti* by Weiner & Najt (1999), the tibiotarsal chaeta M is given as absent, while it is actually present. In the description of *D. szeptyckii* Barra & Weiner, 2009, the tibiotarsal chaetotaxy is given as 5, 5, 4 in row B; it is actually 5, 5, 5, like in most other *Delamarephorura*.

Spicatella is here synonymised with *Delamarephorura*. In its original description (Thibaud 2002), *Spicatella* was not compared to *Delamarephorura*, probably because the characterisation of this last genus by the presence of strong dorsal processes on the sixth abdominal tergum placed it at first sight well apart from *Spicatella*. Today however, several species that might be placed in these two genera are intermediate between them for this character. Actually, within this group of species, no morphological character allows to separate *Delamarephorura* and *Spicatella* except one: the presence of a very unusual interno-distal sac inside the fourth antennal segment in *S. bedosae*, type species of *Spicatella*, and only in this species (Table 1). However, in other morphological characters, *S. bedosae* is very similar to other species of the group; this similarity is illustrated by the fact that Thibaud (2008) assigned to *Spicatella* a species that was devoid of the internal sac inside the fourth antennal segment. At this stage, this character cannot be retained as diagnostic without other morphological support, and we propose that *Spicatella* is sunk into *Delamarephorura*.

The genus *Delamarephorura* keys out near *Dinaphorura* in Dunger & Schlitt (2011) due to the development of spiniform process on Abd. VI. However, these processes vary from large to absent in *Delamarephorura* as redefined here, and several other characters of generic value differ between the two genera (especially PAO and AIIIO morphology). Actually, *Delamarephorura* is more similar to *Metaphorura* in most characters of supra-generic value, particularly the large size of its three guard papillae of AIIIO. The only consistent differences between these two genera is the morphology and arrangement of vesicles in postantennal organ (8–18 large, simple vesicles arranged as ear-like versus 14–28 often bilobed vesicles not arranged as ear-like in *Metaphorura*). However, there are puzzling differences in the published representation of the morphology of both the AIIIO papillae and the PAO vesicles in a species like *M. affinis* (Börner, 1902), suggesting that the discrimination between *Delamarephorura* and *Metaphorura* needs to be re-evaluated, which is beyond the scope of this paper.

KEY TO KNOWN SPECIES OF THE GENUS *DELAMAREPHORURA* WEINER & NAJT, 1999

1. Pseudocellar formula: 11/122/22221. Tibiotarsal chaeta M present or absent.....2
– Pseudocellar formula: 11/111/11111. Tibiotarsal chaeta M present. Furcal area not individualised, covered with secondary granulation.....*D. capensis* new species, South Africa
2. Strong spine-like processes on abdominal tergum VI present. 3
– Spine-like processes on abdominal tergum VI absent or very small.....4
3. Dorsal mesochaetae of relatively large size. Head with p_2 small, two to three times shorter than p_1. Medioventral process of Abd. VI distinct. Claw with inner tooth ....*D. salti* (Delamare-Deboutteville, 1953), Tanzania
– Dorsal mesochaetae very short. Chaetae p_1 and p_2 on the head short and subequal. Medioventral process of Abd. VI very small. Claw without inner tooth..... ..... *D. szeptyckii* Barra & Weiner, 2009, South Africa
4. Antennal segment IV without a large internal sac distally. Furcal area individualised, devoid of secondary granulation 5

Table 1. Differential characters of the species of *Delamarephorura*.

	D. salti	*D. szeptyckii*	*D. bedosae*	*D. capensis*	*D. tami*	*D.* cf. *bedosae*
Size (in mm)	1.5	0.77–0.86	0.40–0.55	1.07–1.16	0.65–0.78	up to 0.7
Pseudocellar formula	11/122/22221	11/122/22221	11/122/22221	11/111/11111	11/122/22221	11/122/22221
Large internal sac apically on ant. IV	absent	absent	present	absent	absent	absent
PAO: number of vesicles	14 or 15	12	12 to 18	8 to 12	15	15 or 16
Number of chaetae of tibiotarsi	10, 10, 9	10, 10, 10	10, 10, 10	10, 10, 10	11, 11, 10	10, 10, 10
Tita: chaeta M	present	present	present	present	absent	present
Tita: whorl B*	B3B4B5(B6)	B3B4B5B6	B3B4B5B6	B3B4B5B6	(B1)B2B3B4B5B6	B3B4B5B6
Secondary granules on furcal area	absent	absent	present	present	absent	absent
Crescentic ridges	present	well marked	indistinct	absent or very faint	present	indistinct
Dorsal spine-like processes	present	present	absent	absent	present	very small
Ventro-medial process	present	very small	very small	small	absent	small
Distribution	Tanzania	South Africa	Southern Vietnam	South Africa	Southern Vietnam	Madagascar
Ecology	about 4000 m a.s.l.	grassland, 1600 m a.s.l.	seashore	sandy soil under bushes, sea level	lowland secondary forest, in soil	seashore

*Between brackets, chaetae absent on Tita III

– Antennal segment IV with a large internal sac distally. Furcal area not individualised, covered with secondary granulation. Tibiotarsal chaeta M present ....*D. bedosae* (Thibaud, 2002), Vietnam

5. Antennal sensilla thick. Tibiotarsal chaeta M absent ....*D. tami* new species, Vietnam

– Antennal sensilla thinner. Tibiotarsal chaeta M present..... .....*D.* cf. *bedosae* in Thibaud (2008), Madagascar

***Delamarephorura capensis*, new species**

Fig. 1, Table 2

Material examined. — Holotype: 1 female (deposited in SAMC), South Africa, Western Cape province, Kleinmond, Betty's Bay, sandy soil, Berlese extraction, coll. Louis Deharveng & Anne Bedos (SAF-064), 11 Mar.2008.
Paratypes: 4 paratypes (1 male and 3 juveniles) in SAMC; 4 paratypes (1 male, 1 female and 2 juveniles) in MNHN; 3 paratypes (2 females and 1 juveniles) in ISEA; same data as holotype.

Description. — Length. Holotype female: 1.16 mm, paratype male length: 1.07 mm, paratypes juvenile: 0.47–0.55 mm. Colour: white in alcohol. Granulation coarser on dorsal side of the body, with secondary granules larger on axial and lateral areas from Th. I to Abd. IV. Double-striate pseudocelli (type II after Weiner & Najt, 1991), their formula per half terga as 11/111/11111 (Fig. 1A).

Antennal segment IV with five sensilla S1, S4, S7, S8 and S9 (after D'Haese, 2003) = a–e (after Rusek, 1971), a microsensillum, a subapical organite very short, rooting deeply into the integument, and a small exsertile apical vesicle. Antennal III-organ dorsally with two large ovoid sensory clubs and two small sensory rods, protected by three large guard papillae and four guard chaetae; ventrally, one ovoid bent sensory club (Fig. 1C, D). Antennal segment I and II with 7 and 11 chaetae respectively. Postantennal organ ear-shaped, 2.5 times longer than pseudocellus diameter, with 10 (8–12) simple vesicles in two regular rows (Fig. 1B). Labral chaetotaxy: 2/42.

Dorsal chaetotaxy as in Fig. 1A, G and Table 2 with macro-, meso- and microchaetae, sensory chaetae "s" not clearly recognised. Lateral microsensilla on thoracic terga II and III present. Head with chaetae p1 and p2 as microchaetae, p3 as mesochaeta, p4 as tiny microchaeta and p5 as macrochaeta. Abdominal tergum VI with crescentic ridges very faint or absent, dorsal processes absent, a very small ventro-medial process (Fig. 1H) and two anal spines on distinct papillae. Anal spines 1.5 times as long as inner edge of claw and 1.8 times as long as their basal diameter. Thoracic sterna II and III with 1+1 chaetae each.

Ventral abdominal chaetotaxy as in Fig. 1H. Abdominal sternum I with 2+2 chaetae and ventral tube with 4+4 latero-distal chaetae. No fine granulated area on abdominal sternum IV but 2+2 chaetae present in the position of the furcal rudiment.

Tibiotarsi I, II and III with 10, 10, 10 chaetae (A1, A2, A3, A6, A7 in whorl A; B3, B4, B5, B6 in whorl B; chaeta M present, Fig. 1E, F). Femora I, II and III each with 8 chaetae;

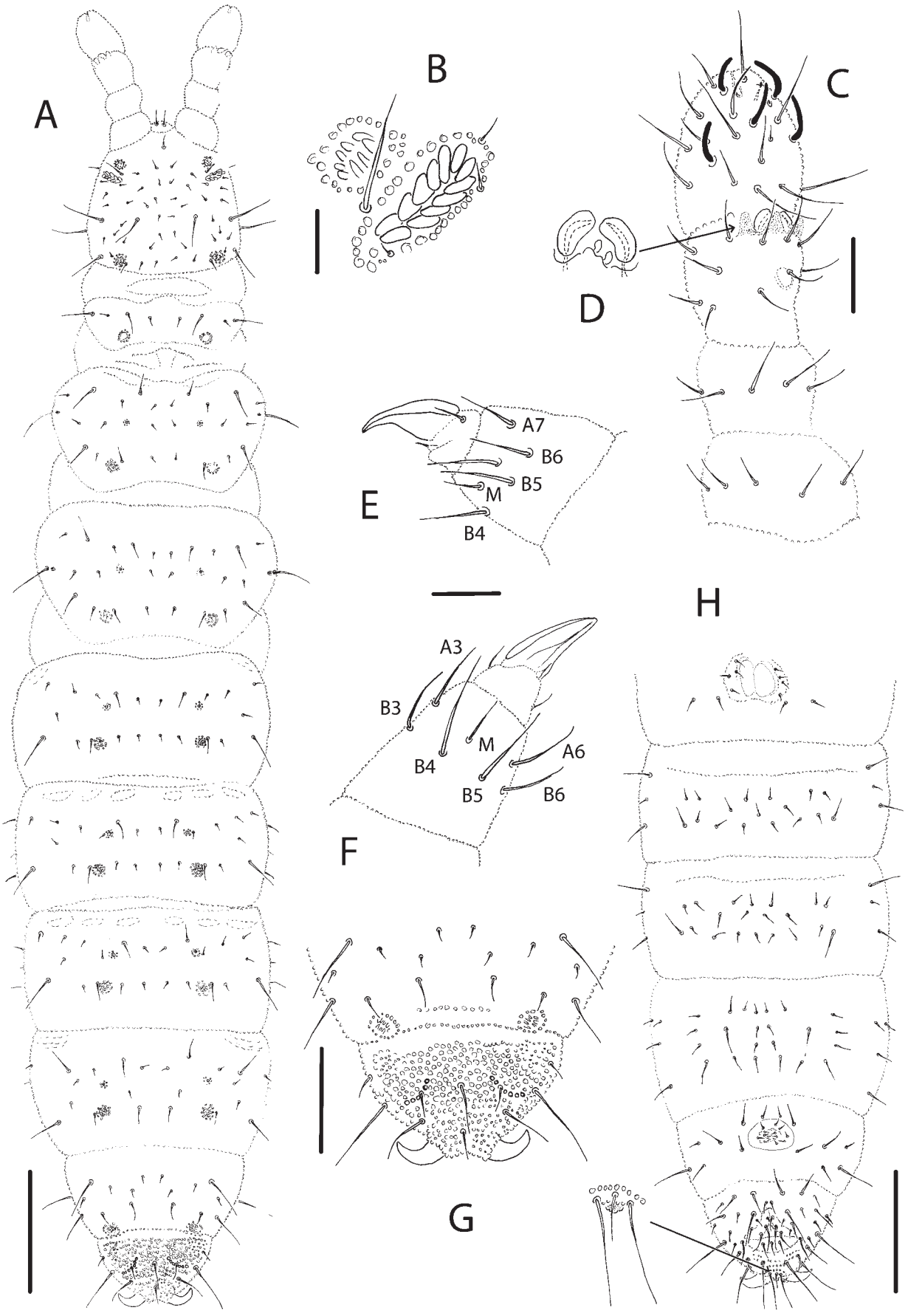

Fig. 1. *Delamarephorura capensis*, new species: A, dorsal chaetotaxy; B, postantennal organ and pseudocellus; C, antenna; D, antenna III-organ: sensory clubs and sensory rods; E, ventro-lateral view of tibiotarsus III; F, ventral view of tibiotarsus III, other specimen; G, chaetotaxy of abdominal terga V and VI; H, ventral chaetotaxy of abdomen, with ventral process of abdomen VI. Scale bars = 0.1 mm (A, H), 0.05 mm (G), 0.01 mm (B, C, E, F).

Table 2. Formula of dorsal chaetotaxy per half tergum (scx, subcoxa 1; pl, abdominal pleurite) of *Delamarephorura capensis*, new species.

Terga/Chaetae rows	Th.I	Th.II	Th.III	Abd.I	Abd.II	Abd.III	Abd.IV	Abd.V
A	—	5^{1}	5^{1}	5^{4}	5^{4}	5^{4}	5^{7}	5^{8}
M	—	4^{2}	4^{2}	1^{5}	1^{5}	1^{5}	–	–
P	4	4^{3}	4^{3}	5^{6}	5^{6}	5^{6}	5^{9}	3^{10}
scx/pl	2	3	3	2	3	3	6	2

1 – a4 absent; 2 – m1, m4, m5, m6=s present; 3 – p2, p6 absent; 4 – a6 absent, 5 – m5 present; 6 – p5 absent; 7 –a3 absent; 8 – a6 absent, 9 – p3 absent, 10 – p2, p4, p5 present.

Table 3. Formula of dorsal chaetotaxy per half tergum of *Delamarephorura tami*, new species.

Terga / Chaetae rows	Th.I	Th.II	Th.III	Abd.I	Abd.II	Abd.III	Abd.IV	Abd.V
A	–	5^{1}	5^{1}	5^{4}	5^{4}	5^{4}	5^{7}	5^{8}
M	–	5^{2}	4^{2}	1^{5}	1^{5}	1^{5}	–	–
P	4	4^{3}	4^{3}	5^{6}	5^{6}	5^{6}	5^{9}	3^{10}
scx/pl	2	3	3	2	3	3	6	2

1 – a4 absent; 2 – m1, m3, m4, m5, m6=s present; 3 – p2, p6 absent; 4 – a4 absent, 5 – m5 present; 6 – p5 absent; 7 –a3 absent; 8 – a3 absent, 9 – p3 absent, 10 – p2, p5, p6 present.

trochanters I, II and III with 5, 5, 4 chaetae; coxae I, II and III with 3, 6, 7 chaetae; subcoxae 2 of legs I without chaetae, of legs II and III, each with 4 chaetae; subcoxae 1 of legs I, II and III with 2, 3, 3 chaetae. Claw stout, without tooth. Empodial appendage relatively thin and pointed, subequal on all legs, about 1/2.5 as long as inner edge of claw.

Etymology. — The species is named after the biogeographical province where it was collected.

Distribution. — Only known thus far from the type locality, in sandy soil of coastal fynbos vegetation, probably endemic.

Remarks. — *Delamarephorura capensis*, new species, is the only species of the genus with pseudocellar formula as 11/111/11111. See Table 1 for other differential characters.

Delamarephorura tami, new species

Fig. 2, Table 3

Material examined. — Holotype: 1 female (deposited in MNHN), Vietnam, Kien Giang province, Kien Luong, Hon Chong hills, Nui Bai Voi, cirque du Français, soil, Berlese extraction, coll. Quan-Mai (Vn04Hol-055), 2 Mar.2004.
Paratypes: 1 female and 1 male juvenile deposited in MNHN; 1 male juvenile in ITB; 1 male juvenile in ISEA; same data as holotype.

Description. — Length. Holotype female: 0.65 mm, paratype male: 0.78 mm. Colour: white in alcohol. Granulation coarser on dorsal side of the body, with secondary granules larger on axial and lateral areas from Th. I to Abd. IV. Double-striate pseudocelli (type II after Weiner & Najt, 1991), their formula per half terga as 11/122/22221 (Fig. 2A).

Antennal segment IV with five rather strong sensilla S1, S4, S7, S8, and S9 (after D'Haese, 2003) = a–e (after Rusek, 1971), a microsensillum, a subapical organite very short, rooting deeply into the integument and a small exsertile apical vesicle. Antennal III-organ dorsally with two large ovoid sensory clubs and two small sensory rods protected by three large guard papillae and four guard chaetae, thick; ventrally, one ovoid bent sensory club (Fig. 2C, D). Antennal segment I and II with 7 and 11 chaetae respectively. Postantennal organ ear-shaped, 3 times as long as pseudocellus diameter, with 15 simple vesicles in two regular rows (Fig. 2B). Labral chaetotaxy: 2/42.

Dorsal chaetotaxy as in Figs. 2A, G and Table 3 with macro-, meso- and microchaetae, S-chaetae not clearly recognized. Lateral microsensilla on thoracic terga II and III present. Head with chaetae p1, p2 and p3 as mesochaetae, p4 as microchaeta and p5 as macrochaeta. Abdominal tergum VI with crescentic ridges, two conspicuous dorsal process and two anal spines on distinct papillae; no ventro-medial process. Anal spines 1.3 as long as inner edge of claw and 2.2 times as long as their basal diameter. Thoracic sterna II and III with 1+1 chaetae each.

Ventral abdominal chaetotaxy as in Fig. 2H. Abdominal sternum I with 2+2 chaetae and ventral tube with 4+4 latero-distal chaetae. Fine granulated area on abdominal sternum IV present in the position of the furcal rudiment, with 2+2 chaetae.

Tibiotarsi I, II and III with 11, 11, 10 chaetae: A1, A2, A3, A6 and A7 in whorl A; B1, B2, B3, B4, B5, B6 (B1 absent in tibiotarsus III, Fig. 2E, F); chaeta M absent. Femora I, II and III, each with 9 chaetae; trochanters I, II and III each with 5 chaetae; coxae I, II and III with 3, 6, 7 chaetae; subcoxae 2 of legs I without chaetae, of legs II and III, each with 4 chaetae; subcoxae 1 of legs I, II and III with 2, 3, 3 chaetae. Claw without tooth. Empodial appendage relatively thin and pointed,subequal on all legs, about 1/5 as long as inner edge of claw.

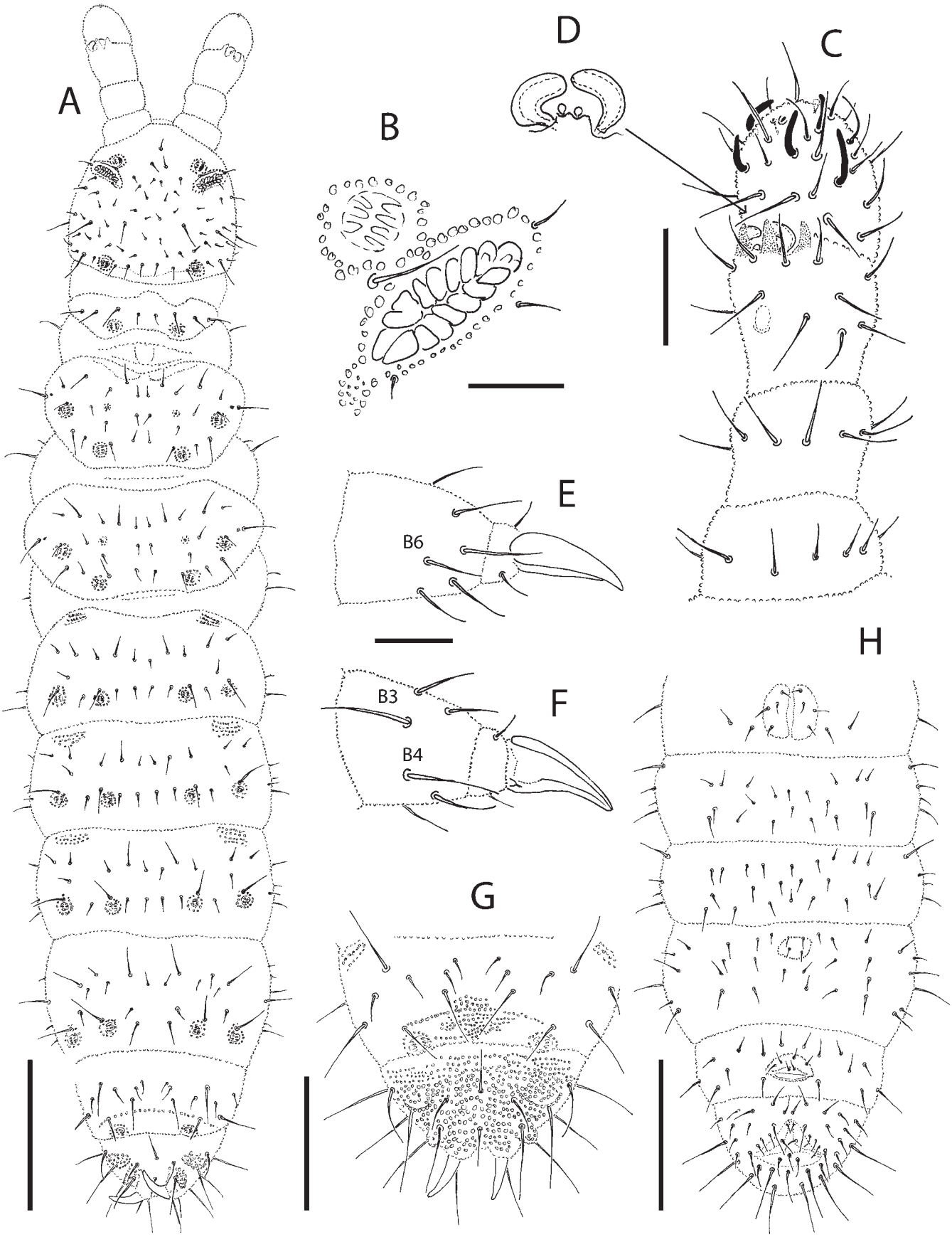

Fig. 2. *Delamarephorura tami*, new species: A, dorsal chaetotaxy; B, postantennal organ and pseudocellus; C, antenna; D, antenna III-organ: sensory clubs and sensory rods; E, F, tibiotarsus III; G, chaetotaxy of abdominal terga V and VI; H, ventral chaetotaxy of abdomen. Scale bars = 0.1 mm (A, H), 0.05 mm (G), 0.01 mm (B, C, E, F).

Etymology. — The species is named in honour of Truong Quang Tam from ITB of Ho Chi Minh City for his efforts to protect the highly threatened Hon Chong hills where the new species was collected.

Distribution. — Only known thus far from the type locality, in calcareous soil, at about 5 cm depth, under a dense thicket of broadleaved bushes, endemic species.

Remarks. — *Delamarephorura tami*, new species, is the only species of the genus with 11 chaetae on tibiotarsi I–II and chaeta M absent (See Table 1 for other differential characters). The species was collected in calcareous soil, at about 5 cm depth, under a dense thicket of broadleaved bushes. Among the hundreds of soil samples carried out in the Hon Chong hills, *D. tami*, new species, was only found in a single soil core from the "Cirque du Français", a deep depression that is currently being quarried-out, as will be most of the Bai Voi hill (Fig. 3). *D. tami*, new species, is another endemic species of the Hon Chong karst at risk of extinction , which can be added to the extensive list given by Deharveng et al. (2009).

Fig. 3. Satellite view of Bai Voi hill (Kien Giang province, Vietnam) in 2006 and in 2011, illustrating the destruction of the type and only known locality of *Delamarephorura tami*, new species, by limestone quarrying (dates of the photos were inverted in Google Earth consulted in Dec.2011).

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