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A NEW SPECIES OF *ISOTOGASTRURA*
(COLLEMBOLA: ISOTOGASTRURIDAE) FROM NORTHEASTERN BRAZIL

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ABSTRACT

A new species of *Isotogastrura* from marine littoral sand of Fernando de Noronha Islands, Pernambuco State, Brazil is described and illustrated. It is characterized by the absence of prelabral setae, presence of a spatulate mucro, fusion of the dorsal part of Abd. IV and V and one pair of long circumgenital setae on males. It is similar to *I. veracruzana* from México. A key for the 9 species known in the genus is provided.

Key Words: pan tropical Collembola, interstitial fauna, Fernando de Noronha Islands, insular fauna

RESUMEN

Se describe e ilustra una nueva especie de *Isotogastrura* de arena del litoral marino de la Isla Fernando de Noronha, Estado de Pernambuco, Brazil. Esta nueva especie se caracteriza por la ausencia de sedas prelabrales, presencia de un mucrón en forma de espátula, fusión dorsal de los Abds. IV y V y un par de largas sedas circumgenitales en los machos. Es similar a *I. veracruzana* de México con la que es comparada más detalladamente. Se presenta una clave para las nueve especies que se conocen del género.

Palabras Clave: Collembola Pan-Tropical, fauna intersticial, Isla de Fernando de Noronha, fauna insular

RESUMO

Uma nova espécie de *Isotogastrura* de areia do litoral marinho do arquipélago de Fernando de Noronha, Pernambuco, Brasil, é descrita e ilustrada. Essa nova espécie se caracteriza pela ausência das cerdas pré-labrais, presença de um mucro em forma de espátula, Abd. IV e V fundidos dorsalmente e um par de cerdas circumgenitais longas nos machos. Assemelha-se a *I. veracruzana* do México com a qual se compara detalhadamente. Apresentamos uma chave para identificação das nove espécies conhecidas do gênero é incluída.

Palavras Chave: Collembola Pan-Tropical, fauna intersticial, Ilha de Fernando de Noronha, fauna insular

The genus *Isotogastrura* is distributed in tropical coasts and comprises 8 known species, all described from sand in tropical littoral areas (Potapov et al. 2011).

We describe here a new species of *Isotogastrura* from Fernando de Noronha, a group of oceanic islands in equatorial Atlantic, Northeastern Brazil. This is the first record for the genus in South

America, extending its known distribution to the southern tropics, and reinforcing its pan tropical distribution pattern.

The phylogenetic position of the monotypic family *Isotogastruridae*—between the families *Isotomidae* and *Hypogastruridae*, which are representatives of Orders *Entomobryomorpha* and *Poduromorpha* respectively—is controversial and poses taxonomic uncertainties (Fjellberg 1995). The new species brings interesting new features that contribute to this discussion, i.e., dorsal fusion of Abd. IV and V; and this condition is seen also in the *Entomobryomorpha*, but not in the *Poduromorpha* in which the apical sensory organ of Ant. III has been displaced to the base of Ant. IV (Bonet 1946).

MATERIAL AND METHODS

The material studied comes from marine littoral sand of Fernando de Noronha Islands, Pernambuco State, Brazil. Collecting was done by a washing technique and the extraction of floating specimens manually with the aid of brushes. Specimens were fixed in 80% ethanol, cleared on KOH and lactophenol, and mounted under a cover in Hoyer's solution for subsequent analysis by phase contrast microscopy. Ten specimens, not included in type material, were dehydrated and metalized for observation by scanning electron microscopy.

The new species was compared with all available bibliographic information and the types of *I. ahuzotli* and *I. veracruzana* were checked. Abbreviations used in the text are: Ant. = antennal segment; Abd. = abdominal segment; Th. = thoracic segment.

RESULTS

Isotogastrura Thibaud & Najt 1992

Diagnosis

Members of this genus are very small, less than 0.5 mm long, with appearance intermediate between the families *Isotomidae* and *Hypogastruridae*. Body with short setae and sensorial setae. Antennae shorter than head. Ant. organ III partly displaced to Ant. IV, with 2 fanlike sensilla and 2 cuticular conic papillae. With square and prognathous head. Four eyes per side. No postantennal organ. Mandibles with apical teeth and molar surface, maxillae with fringed lamellae. Pronotum well developed with 4 cuticular vesicles but without setae. Dorsal chaetotaxy of second and third thoracic tergites and all abdominal tergites with 3 rows of setae. Most tergites subequal in size, some with a pair of posterior cuticular ves-

icles. No microsensilla on Th. II and III. Unguis with a big dorsal teeth and unguiculus filiform, longer than unguis. Abdomen segment V with a dorsal glandular opening and often with one median posterior cuticular tubercle. Tenaculum and furcula well developed. No anal spines.

Type species: *Isotogastrura arenicola* Thibaud & Najt 1992

Isotogastrura mucrospatulata sp. nov. Figs. 1-15

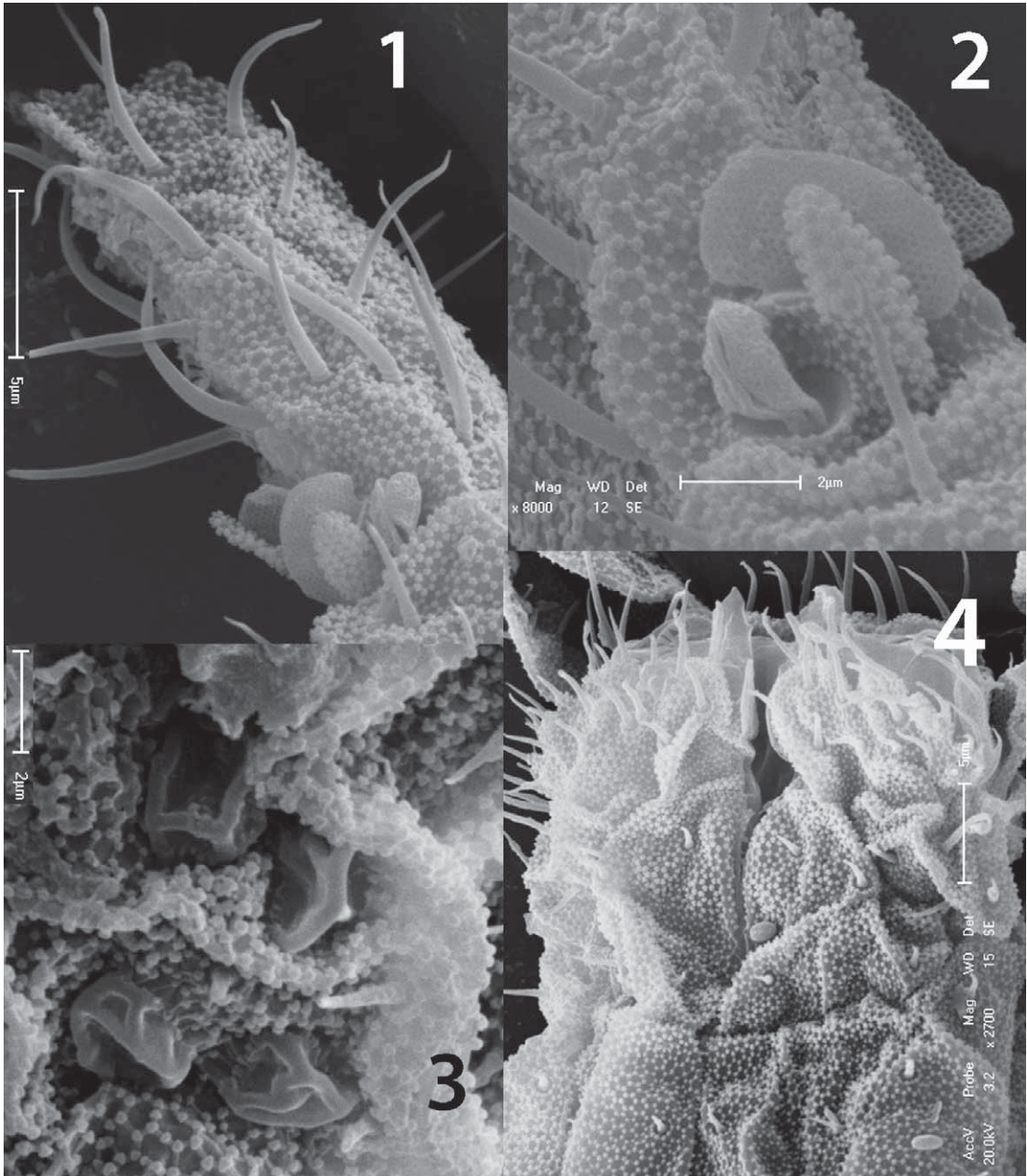
Holotype: male, BRAZIL: Pernambuco, Fernando de Noronha Islands, Boldró, from marine littoral sand, 20-VII-2012, coll. Lima and Zeppellini, deposited at Coleção de Referência em Fauna de Solo da Paraíba (LSCC-CRFS/UEPB) number 3680,

Paratypes: 6 males and 2 females, same data as holotype, deposited at LSCC-CRFS/UEPB number 3681-3688. Two male adults, same data as holotype, deposited at Museu Nacional da Universidade Federal do Rio de Janeiro number 2427 and 2428. One female and 1 male adult from the same locality will be deposited at senior author's institution (LESM/UNAM) number 2991 and 2992.

Description

Body length ($n = 10$): 0.35 mm (range 0.3-0.4 mm). White in alcohol, with grey pigmentation uniformly distributed over dorsal areas except for the darker eye patches. Body shape typical of genus, only with primary hexagonal granulation, ventral side of abdomen wrinkled with some smooth areas (Figs. 1, 2 and 5). Setae smooth and short about 5-8 μm . Sensorial body setae about 10 μm , thicker than setae with blunt tips. Head large, with exerted mouth parts as common for the genus. Th. I with 4 dorsal tubercles. Posterior edge of Abd. IV and anterior edge of Abd. V dorsally fused (Fig. 13), separation only noticeable by the lateral constrictions between them, ventrally well separated; with a dorsal glandular opening on Abd. V partly covered by cuticular fold. One pair of small tubercles present at middle posterior edge from Th. II to Abd. II (Figs. 11 and 13).

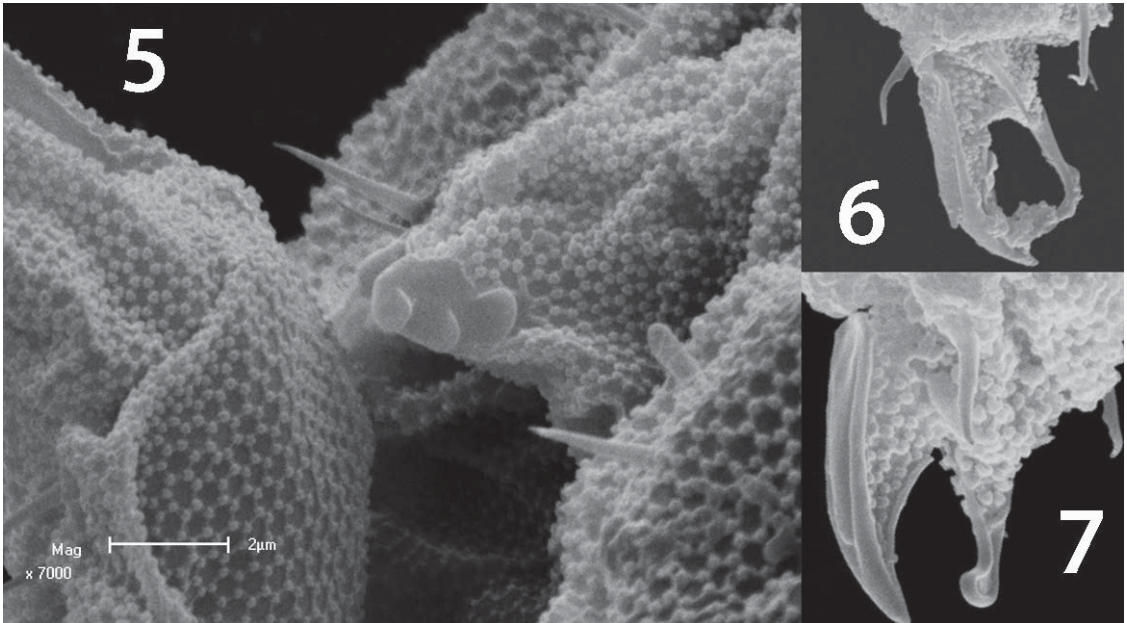
Ant. I and II with 7 and 11 setae, respectively. Sensorial organ of Ant. III with 2 conical cuticular papillae granulated, 2 fan-like inner sensilla, and 2 outer tubular bifid sensilla, 1 of which is grouped together with inner ones, another 1 more proximal and associated with lateral microsensillum, which is small and pointed (Figs. 1, 2 and 10). Ant. IV with 8 sensilla, 2 of which are thicker and longer (Figs. 1 and 10). Subapical organ small and strongly depressed. Labrum with 0/3,3,4 setae and 4 lobules. No prelabral microsetae. Maxillary outer lobe with apical palp



Figs. 1-4. *Isotogastrura mucrospatulata* **sp. nov.** 1, electro scanning microphotograph of apex of Ant. III and Ant. IV; 2, sensorial organ of Ant. III; 3, eyes from left side; and 4, labium.

and 2 sublobal hairs. Labium with 5 basolateral and 4 basomedian setae postlabial setae (Fig. 4). Some elements of labial palp difficult to interpret. Mandibles slender as typical for the genus, each with 4 apical teeth and molar surface well developed. Maxillary head with most lamellae strong and serrated. Head with 4+4 ocelli, 2 in-

ner smaller (Figs. 3 and 11). Postantennal organ absent. Dorsal chaetotaxy shown in Fig. 11 and 13. Th. II-Abd. III with 3+3 axial setae each. Number of sensilla 2,2/1,1,1,1,1, microsensilla absent. Sensilla longer than setae and distinguished from them by hyaline appearance and more blunt tips. Legs chaetotaxy from subcoxa 1,



Figs. 5-7. *Isotogastrura mucrospatulata* **sp. nov.** 5, electro scanning microphotographs of tenaculum; 6, apex of tibiotarsus III with unguis and unguiculus; and 7, foot complex showing bent apical filament of the unguiculus.

subcoxa 2, coxa, trochanter, femur and tibiotarsus is: 1,1,4, 6,11,12; 1,3,7, 6,11,12 and 2,3,9,5,10,11 from I to III, respectively. Ungues without inner teeth but a big dorsal tooth $\frac{3}{4}$ the length of unguis (Fig. 6). Unguiculus filiform, sinuous and longer than unguis (Fig. 6), easily bent (Fig. 7). Thorax without ventral setae. Ventral tube with 6+6 lateral paired setae (4+4 in distal and 2+2 in basal position) and 1 unpaired posterior seta (Fig. 14). Tenaculum with 3+3 teeth, setae absent (Fig. 5). Manubrium without anterior setae, posteriorly with 8+8 setae on main part and 5+5 on basolateral fields (Figs. 8 and 14). Anterior *subcoxae furcalis* with 5 setae, posterior with 2 setae. Dens with 3 posterior and 1 antero-medial setae (Figs. 8 and 9), 1 inner seta thicker than others, mucro spatulate (Fig. 9). Abdominal segment IV and V fused in the dorsal side (Fig. 13). Female genital plate with 4 pairs of pregenital setae, 2 circumgenital setae and 2 eugenital setae (Fig. 12). Male genital plate with 4 pairs of pregenital setae, 5 circumgenital setae, 2 of them longer than others, and 4 pairs of short eugenital setae (Fig. 15). Each lateral anal valve with 14 setae + 2 microsetae, posterior valve with only 2 setae (Fig. 14). No anal spines.

Etymology

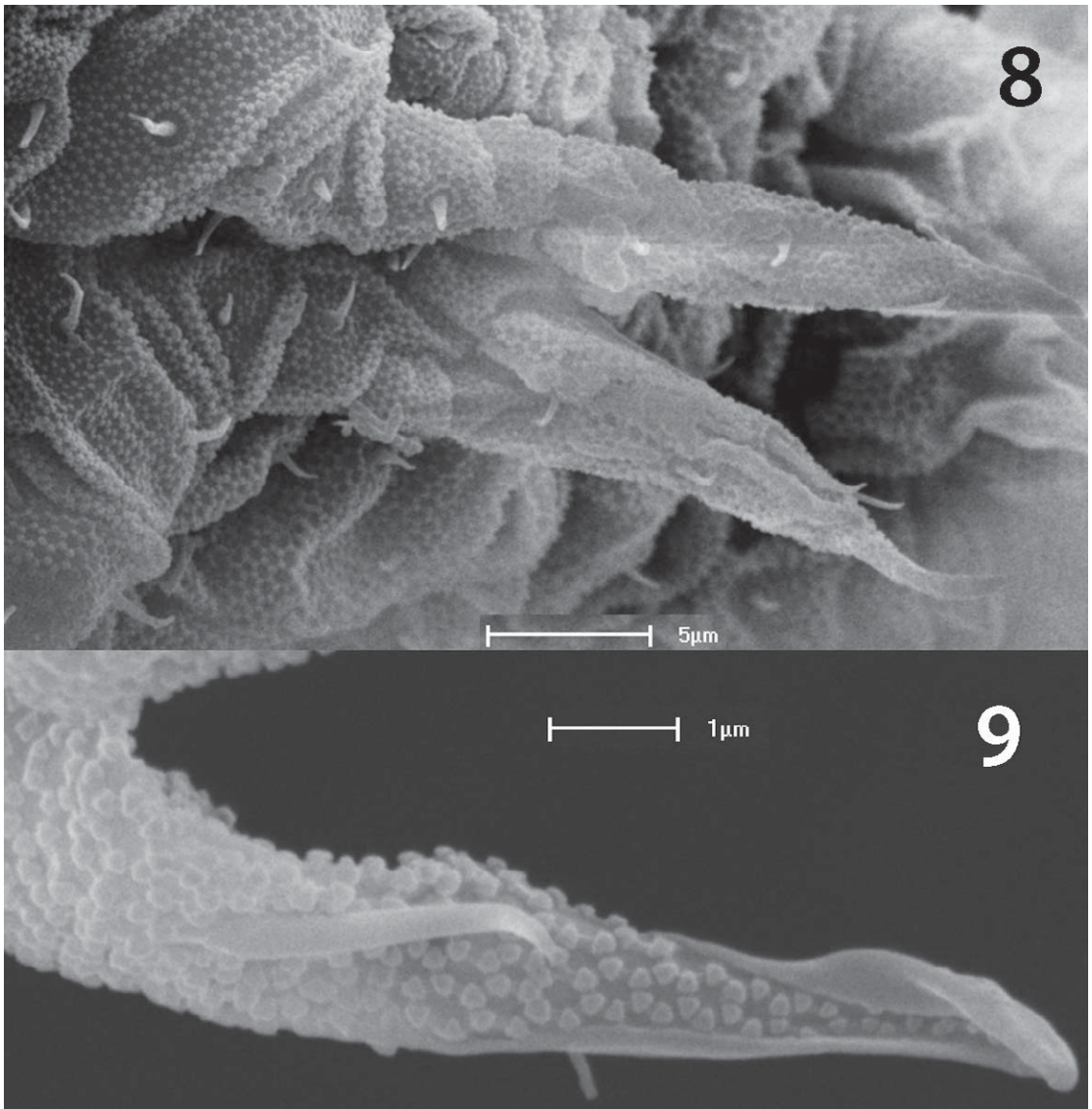
The new species is named *I. mucrospatulata* **sp. nov.** after the shape of the mucro.

Habitat and Distribution

The new species is known only in the sand beaches of Fernando de Noronha Islands. The type locality is located at Boldró, S 03 50' 44.5" W 32 25' 47.1". Small body size of *I. mucrospatulata* **sp. nov.** indicates that it inhabits narrow passages among the grains of sand (Potapov et al. 2011). Interstitial Collembola look like typical euedaphic species, but are flexible and slender enough to be able to move between sand grains of small size without changing the pore architecture (Thibaud 2007). All specimens in this study (total of 22) were found in sand at the intertidal zone. The species *I. mucrospatulata* **sp. nov.** was the only collembolan species found in sand samples from 6 different beaches in Fernando de Noronha and there are no records of it from elsewhere.

DISCUSSION

Isotogastrura mucrospatulata **sp. nov.** is characterized by the absence of prelabral setae, presence of one spatulate mucro, fusion of the dorsal part of Abd. IV and V and one pair of long circumgenital setae on males. It is similar to *I. veracruzana* from México in the absence of prelabral microsetae, but differs in the shape of mucro, dental setae shape, fusion of the dorsal part of Abd. IV and V (noticeable by the absence of thinner granulation in intersegmental areas) and setae of genital plate of male. When dorsal body chaeto-

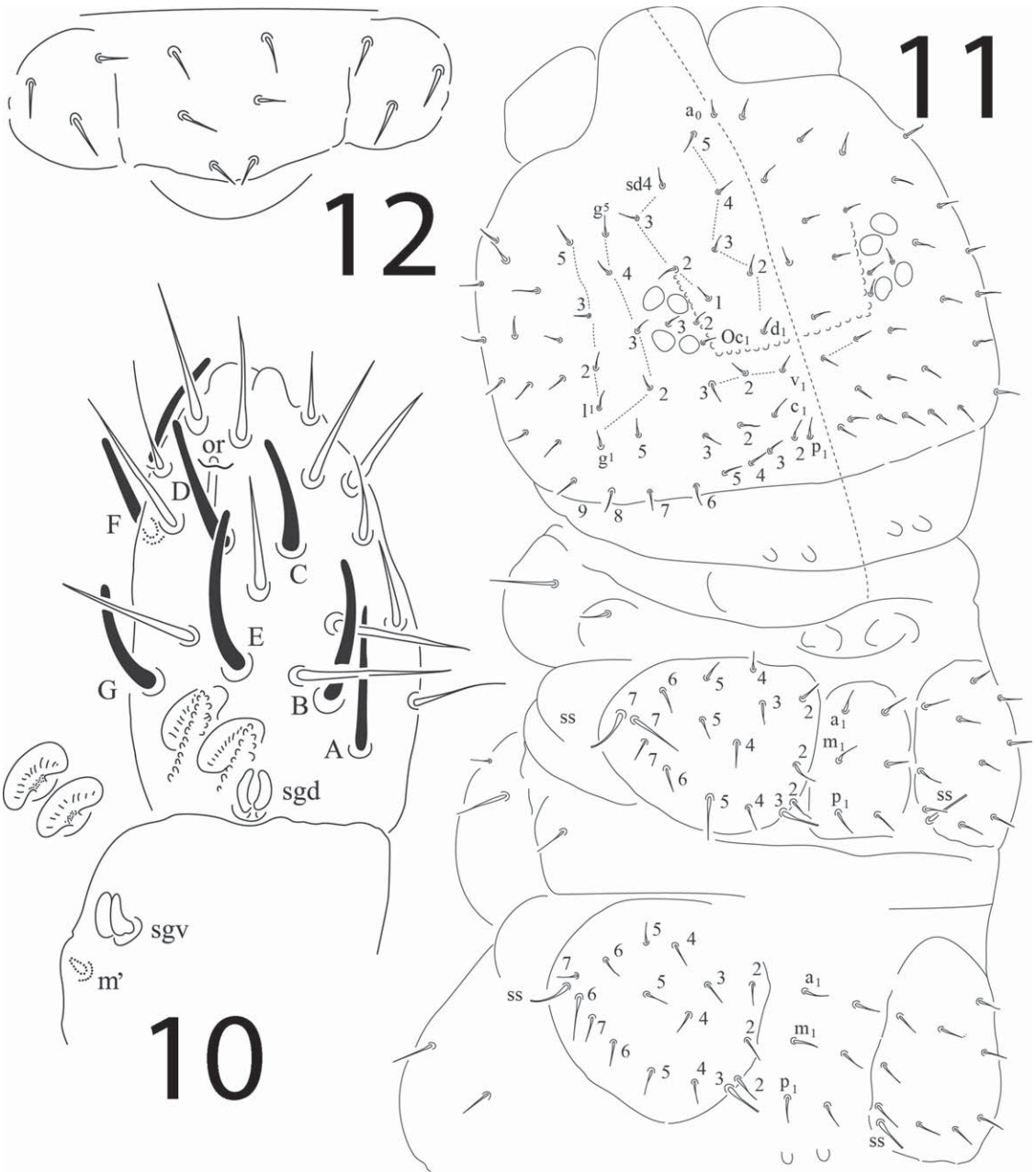


Figs. 8 and 9. *Isotogastrura mucrospatulata* **sp. nov.** 8, electro scanning microphotographs of furcula posterior view; and 9, mucro antero-medial view.

taxy is compared, the stability of the chaetotaxic pattern within the genus is remarkable. All the segments have the 3 rows of setae, anterior, median and posterior. We noticed that only *I. mucrospatulata* **sp. nov.** lacks 2 setae on the m row of Th. II and III (only 5 setae on m row versus 7 in *I. veracruzana*; see Table 1). The stronger setal reduction on row m of Abd. I occurs on *I. trichaetosa*. All the species have only one seta on row m of Abd. V (Table 1).

According to Potapov et al. (2011) *Isotogastrura trichaetosa* is the most primitive species of the genus, having more homonomic axial chaetotaxy

of abdomen (3,3,3,3) than is common in the genus (3,3,3,2), normal shape of body, (elongated in other species) and thin sensilla on Ant. IV (very variable in different species). Another primitive character, the simple (vs. bifurcate) dorsal and ventral guard sensilla of antennal organ III, is shared with *I. coronata* (Canary Islands) and *I. madagascariensis* (Madagascar). It is interesting the fact that species from Canary Islands, Madagascar and China have the dorsal and ventral guard sensilla of the sensorial organ of Ant. III simple while all the species from America have bifid guard sensilla (Table 2). Other characters

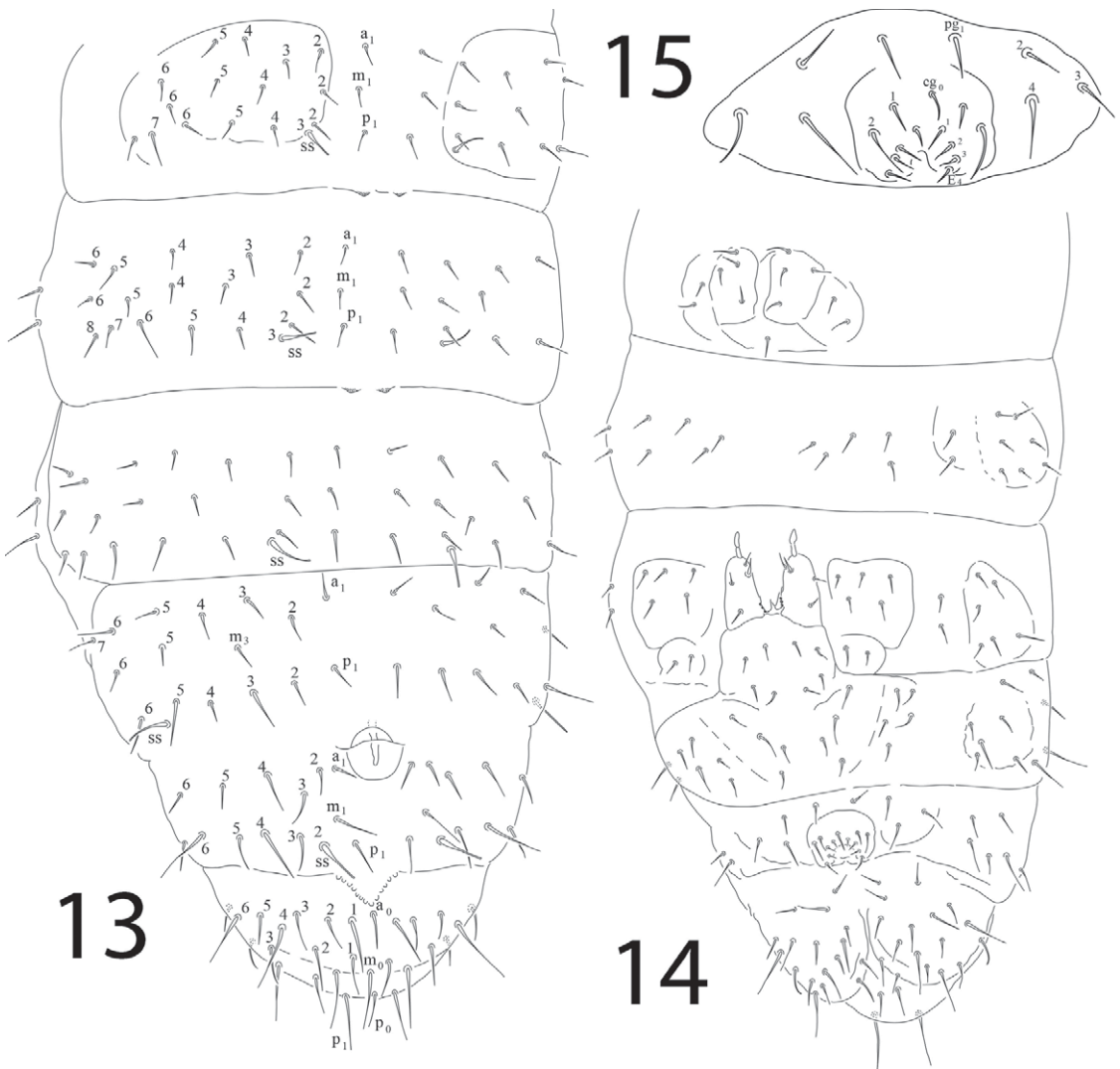


Figs. 10-12. *Isotogastrura mucrospatulata* sp. nov. 10, apex of Ant. III and Ant. IV in dorsal view, 11, dorsal chaetotaxy of head and thorax; and 12, genital plate of female.

have no correlation with the continental distribution of the genus.

Most species of the genus occur between the Tropic of Capricorn and the Tropic of Cancer, except *I. coronata*, which extends into the Mediterranean. The new Brazilian species indicates that *Isotogastrura* is also distributed in the tropical part of South America, and thus the genus is completely pan-tropical as proposed by Potapov et al. (2011).

Usually, littoral species are distributed widely along the coasts because of transportation possibilities by water and by similar habitat conditions. With respect to Collembola, Thibaud (2007) remarked that many species from interstitial littoral sands have trans-oceanic distributions; even though this is true for several species, some genera seem to have many species with restricted distributions, such as *Isotogastrura*.



Figs. 13-15. *Isotogastrura mucrospatulata* **sp. nov.** 13, dorsal chaetotaxy of abdomen; 14, ventral chaetotaxy of abdomen; and 15, genital plate of male.

Systematic Position of Isotogastruridae

The family Isotogastruridae Thibaud & Najt 1992 is monotypic, and only the genus *Isotogastrura* is known. It has an intermediate position between the orders Poduromorpha and Entomobryomorpha (Thibaud & Najt 1992). It is generally accepted that the family belongs to Poduromorpha although its phylogenetic position is still not fully understood (Fjellberg 1995). The character which is taken into account to compare, is the individualized prothoracic tergite, together with many special characters shared either with the Isotomidae or the Hypogastruridae.

When the morphology of the antennae of *Isotogastrura* is compared with other genera, it is found that the sensorial organ of Ant. III has been displaced to Ant. IV. Also in the genus *Tafallia* (Hypogastruridae), Bonet (1946) clearly described this fact: "en el Ant. III sólo queda la sensila lateroventral que en tamaño y forma es muy semejante a la sensila externa del Ant. IV". Therefore this character seems to have a common origin in both genera, *Tafallia* and *Isotogastrura*. The organ in both genera is partly displaced to Ant. IV in that 2 sensilla and 1 guard sensillum are placed at the base of Ant. IV, while only the ventral guard sensillum and the microsensillum remain on the apex of Ant. III. Similar condition occurs in other basal Poduromorpha

TABLE 1. COMPARISON OF CHAETOTAXY AMONG THE SPECIES OF *ISOTOGASTRURA* (BY DEMI-TERGITE).

| Species | Th II | Th III | Abd I | Abd IV | Abd V | Distribution |
|------------------------|-------|--------|-------|----------|-------|--------------|
| <i>ahuizotli</i> | 7 7 7 | 7 6 7 | 6 5 7 | 6 4 6 6 | 6 1 6 | Mexico |
| <i>arenicola</i> | 7 7 7 | 7 7 7 | 6 5 7 | 5 3 6 3 | 5 1 6 | Martinica |
| <i>atuberculata</i> | 7 7 8 | 7 7 8 | 6 5 8 | 7 4 7 6 | 7 1 8 | Mexico |
| <i>coronata</i> | ??? | ??? | ??? | 4 4 7 3 | 6 1 8 | South Europe |
| <i>litoralis</i> | 7 7 7 | 7 7 8 | 6 5 8 | 5 3 5 5 | 6 1 6 | New Caledony |
| <i>madagascarensis</i> | 6 7 6 | ??? | ??? | 5 3 5 4 | 5 1 6 | Madagascar |
| <i>mucrospatulata</i> | 7 5 7 | 7 5 7 | 6 5 7 | 6 3 6 5 | 6 1 6 | Brazil |
| <i>trichaetosa</i> | 7 6 8 | 7 7 8 | 5 4 6 | 7 6 7 4 | 5 1 6 | China |
| <i>veracruzana</i> | 7 7 7 | 7 7 7 | 6 5 8 | 6 4 8 6 | 6 1 8 | Mexico |
| | a m p | a m p | a m p | a m p ss | a m p | |

Th, thoracic segment; Abd, abdominal segment; a, anterior row; m, median row; p, posterior row; ss, position of sensorial seta on Abd IV.

(e.g., Onychiuridae and Tulbergiidae). This feature supports Fjellberg (1995) hypothesis, that Isotogastruridae is a Poduromorpha more related with Hypogastruridae.

Anal valves and Abd. VI chaetotaxies resemble those of some species of *Friesea* (Neanuridae) and to *Willemia* (Hypogastruridae), both belonging to Poduromorpha. The presence of cuticular tubercles has been also found in *Willemia meyboholae* Palacios-Vargas 1987 (Hypogastruridae) from marine littoral sand.

The fusion of abdominal segments is seen in different families of Entomobryomorpha, but

not in Poduromorpha, this is an interesting character that is in discordance with Fjellberg (1995), and must be taken into account when comparing the families. The reduction of Abd. VI to anal valves also occurs in Actaletidae and some members of Isotomidae, indicating that this condition must be developed several times during the evolution of different groups of Collembola.

A phylogenetic analysis should establish the actual relationship of the genus with the family Hypogastruridae and Order Entomobryomorpha.

KEY FOR THE SPECIES OF *ISOTOGASTRURA*

- 1. Abd. IV with 3+3 axial setae, Abd. VI with 2 posterior cuticular tubercles *I. trichaetosa*
- Abd. IV with 2+2 axial setae, Abd. VI without 2 posterior cuticular tubercles 2
- 2. Abd. V dorsally with a posterior median tegumentary tubercle 3
- Abd. V dorsally without a posterior median tegumentary tubercle 5

TABLE 2. COMPARISON OF TRAITS OF *ISOTOGASTRURA* SPECIES.

| Species | µm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------|---------|---|---|---|---|----|-------|----|-----|-------|----|----|----|-----|-----|
| <i>ahuizotli</i> | 350 | + | 1 | — | + | BI | 4 | H | UN | 6 | — | ? | 16 | 5/2 | ? |
| <i>arenicola</i> | 300-400 | + | 2 | + | — | BI | 4 | H | — | 7 | — | 3 | 16 | 5/2 | 3+3 |
| <i>atuberculata</i> | 350 | — | 1 | — | — | BI | 4 | H | MOD | 7 | — | 4 | 16 | 5/2 | ? |
| <i>coronata</i> | 350 | — | 2 | — | + | SI | 4 | H | ? | 6 + 2 | — | 4 | 16 | ? | 5+5 |
| <i>litoralis</i> | 310 | — | 1 | + | — | BI | 4 | H | ? | 7 | — | ? | 16 | 5/2 | 5+5 |
| <i>madagascarensis</i> | 300 | — | 0 | — | + | SI | 3 (4) | H | ? | 7 | — | ? | 16 | 4/2 | 5+5 |
| <i>mucrospatulata</i> | 350 | + | 1 | — | — | BI | 4 | SP | MOD | 7 + 1 | — | 4 | 16 | 5/2 | 5+5 |
| <i>trichaetosa</i> | 400 | — | 1 | — | + | SI | 4 | H | ? | 8 | + | ? | 16 | 5/2 | 5+5 |
| <i>veracruzana</i> | 350 | + | 1 | — | — | BI | 4 | H | — | 8 | — | 4 | 16 | 5/2 | 5+5 |

1. Abd. V tegumentary tubercle; 2. Abd. I sternite setae number; 3. Abd. III tergite with a pair of tubercles; 4. Prelabral setae (presence vs absence); 5. Sensillum of Ant. III simple or bifid; 6. Dental setae; 7. Shape of mucro; 8. Genital setae; 9. Number of sensilla on Ant. IV; 10. Tubercles on Abd. VI; 11. Setae on labial triangle; 12. Setae on manubrium; 13. Setae on *subcoxae furcalis*; 14. Basal manubrium setae. Abbreviations: bi = bifid; h = hooked; mod = modified; si = simple; sp = spatulate; un = unmodified.

3. Abd. I ventrally with 2 median setae; Abd. III with a pair of posterior median tegumentary tubercles *I. arenicola*
- Abd. I ventrally with only 1 median setae; Abd. III without a pair of posterior median tegumentary tubercles 4
4. Prelabral microsetae absent 8
- Two prelabral setae present *I. ahuiotli*
5. Abd. III dorsally with a pair of posterior median tegumentary tubercles *I. litoralis*
- Abd. III dorsally without a pair of posterior median tegumentary tubercles 6
6. From Th. II to Abd. II dorsally with a pair of posterior median tegumentary tubercles *I. coronata*
- From Th. II to Abd. II dorsally without such tubercles 7
7. No prelabral microsetae; sensillum of sense organ of Ant. III bifid; dens with 4 setae; Abd. I sternite with 1 seta *I. atuberculata*
- Two prelabral microsetae; sensillum of sense organ of Ant. III simple; dens with 3 setae (sometimes 4); Abd. I sternite with no seta *I. madagascarensis*
8. Th. II with 21+21 setae, no genital setae of male modified *I. veracruzana*
- Th. II with 19+19 setae, 2 genital setae of male modified *I. mucrospatulata* **sp. nov.**

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REFERENCES CITED

- BONET, F. 1946. Más Hipogastrúridos anoftalmos de México (Collembola). Rev. Soc. Mexicana Hist. Nat. 7(1-4): 51-62.
- D'HAESE, C. A. 2003. Morphological appraisal of Collembola phylogeny with special emphasis on Poduromorpha and a test of the aquatic origin hypothesis. The Norwegian Acad. Sci. Lett. Zool. Scripta 32(6): 563-586.
- FJELLBERG, A. 1994. The systematic position of the monotypic family Isotogastruridae (Collembola) with description of *Isotogastrura coronata* n. sp. from Fuerteventura, Canary Islands. Misc. Zool. 17: 123-127.
- PALACIOS-VARGAS, J. G., AND THIBAUD, J. M. 1998. Two new Mexican *Isotogastrura* (Collembola: Isotogastruridae). Canadian Entomol. 130: 195-199.
- POTAPOV, M. B., BU, Y., AND GAO, Y. 2011. First record of the littoral family Isotogastruridae (Collembola) in Asia. ZooKeys 136: 23-29.
- THIBAUD, J. M. 2007. Recent advances and synthesis in biodiversity and biogeography of arenicolous Collembola. Ann. Soc. Entomol. France (n.s.) 43(2): 181-185.
- THIBAUD, J. M. 2008. Les collemboles des sables littoraux de Madagascar. Ann. Soc. Entomol. France (n.s.) 44(4): 503-519.
- THIBAUD, J. M., AND NAJT, J. 1992. Isotogastruridae, a new family of terrestrial interstitial Collembola from the Lesser Antilles. Bonn. Zool. Beitr. 43(4): 545-551.
- THIBAUD J. M., AND WEINER W. M. 1997. Collemboles interstitiels des sables de Nouvelle-Calédonie. Zool. Neocaledonica 4(171): 63-89.