

Two New Species of the Brazilian Millipede Genus *Rhcnosthetus* Hoffman, 2006 (Polydesmida: Chelodesmidae), Including a Key to Males

Rodrigo Salvador Bouzan^{1,2,*} , Luiz Felipe Moretti Iniesta^{1,2} , and Antonio Domingos Brescovit¹ 

¹Laboratório de Coleções Zoológicas, Instituto Butantan, Avenida Vital Brasil, 1500, 05503-090, São Paulo, Brasil.

*Correspondence: E-mail: rodrigobouzan@outlook.com (Bouzan)

E-mail: antonio.brescovit@butantan.gov.br (Brescovit)

²Pós-graduação em Zoologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, Brasil. E-mail: luiz-moretti@hotmail.com (Iniesta)

Received 9 November 2019 / Accepted 18 February 2021 / Published 25 May 2021
Communicated by Benny K.K. Chan

The genus *Rhcnosthetus* Hoffman, 2006 is revisited. Two new species from state of Mato Grosso, Brazil are described: *Rhcnosthetus chagasi* sp. nov. and *Rhcnosthetus penabarbosai* sp. nov. In addition, a new record for *R. rondoni* Hoffman, 2006, a key to males and a distribution map of all species are included.

Key words: Neotropical, Diplopoda, Millipedes, Chelodesminae, Amazon rainforest.

BACKGROUND

Millipedes (class Diplopoda) are known by their low vagility and limited distribution, with taxa restricted in determined mountains, islands and patches of forest (Golovatch and Kime 2009; Enghoff 2015; Nguyen et al. 2019). Members of the class are distributed on all continents except for Antarctica and can be found, mainly, in all soil extracts, in litter and under logs and stones (Hopkin and Read 1992). Millipedes are also recognized by their important biological role as detritivores, feeding on decaying vegetable matter and mineral soils (Golovatch and Kime 2009; David 2015). The class has approximately 12,000 described species (Sierwald and Bond 2007), although it is estimated that this number may be as high as 80,000 species (Adis 2002). Currently, Diplopoda consists of 16 orders, 144 families and about 2,950 genera (Shelley 2003).

Chelodesmidae is the second largest family in the class Diplopoda with almost 800 described species (Hoffman 1980). The family is divided into two subfamilies: Chelodesminae from the Neotropical region and Prepodesminae from Africa and Spain.

Currently, 345 species are recognized in 19 tribes for Chelodesminae and only one tribe for Prepodesminae (Hoffman 1980; Enghoff et al. 2015).

For the remaining species, no assignment to any tribal position has been proposed (Hoffman 1980; Bouzan et al. 2017). Among these taxa, the genus *Rhcnosthetus* (Fig. 1) was described by Hoffman (2006) to accommodate the species *R. coriaceus* (Schubart, 1947) described from the state of Mato Grosso, and *R. rondoni* Hoffman, 2006 described from the state of Rondônia, Brazil. According to Hoffman (2006), the genus is recognized by having a longitudinally striated podosterna (see discussion below), microgranular tergal texture, a prolonged gonapophysis and seminal groove running along a broad lobe on the acropodite.

Based on recently collected material of *Rhcnosthetus*, the present study revisits the genus with a new record of *R. rondoni*, and the designation of a lectotype for *R. coriaceus*. The species *Rhcnosthetus chagasi* sp. nov. and *R. penabarbosai* sp. nov., from the state of Mato Grosso are also described. A key to males and a distribution map for all species of the genus are also provided.

MATERIALS AND METHODS

The material examined is deposited in the following institutions (curators in parentheses): CZUFMT, Universidade Federal do Mato Grosso, Cuiabá, Brazil (A. Chagas-Jr); IBSP, Instituto Butantan, São Paulo, Brazil (A. D. Brescovit); MNRJ, Museu Nacional do Rio de Janeiro, Rio de Janeiro (A. B. Kury); MZSP, Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (R. Pinto da Rocha); VMNH, Virginia Museum of Natural History, Virginia, USA (K. Ivanov).

Morphological drawings were made using a Leica MZ12 stereoscope with a *camera lucida*. Photographs were taken with a Leica DFC 500 digital camera mounted on a Leica MZ16A stereomicroscope. Extended focal range images were composed with Leica Application Suite version 2.5.0. Scanning electron micrographs were acquired from Instituto Butantan using a FEI Quanta 250 SEM with a digital SLR camera attached. All measurements are in millimeters, and are omitted after the first occurrence. For gonopod terminology we follow Pena-Barbosa et

al. (2013), Koch (2015) for vulvae and Attems (1898) and Brölemann (1900) for other somatic characters. The geographical coordinates were obtained from the original literature (when provided). For the material examined without any information about geographic coordinates, we georeferenced using the central point of the municipality labeled.

RESULTS

TAXONOMY

Order Polydesmida Pocock, 1887
Suborder Leptodesmidea Brölemann, 1916
Family Chelodesmidae Cook, 1895
Subfamily Chelodesminae Cook, 1895
Genus *Rhichnothetus* Hoffman, 2006

Rhichnothetus Hoffman, 2006: 43–55.

Type species: Rhichnothetus rondoni Hoffman, 2006, by original designation.



Fig. 1. Live male specimen of *Rhichnothetus chagasi* sp. nov., from Fazenda São Nicolau, Cotriguaçu, Mato Grosso, Brazil. Photographed by: Dr. Domingos de Jesus Rodrigues.

Diagnosis: Males of *Rhcnosthetus* differ from those of other chelodesmid genera by the combination of the following characters: microgranular tergal texture (Fig. 2a–b), seminal groove running along a broad lobe on the acropodite (Figs. 6e, 7a, c–d) (reduced in *R. penabarbosai* sp. nov.; Figs. 9e, 10a, c–d), small spine in the median region of the prefemoral process (Fig. 4a–b) (reduced in *R. chagasi* sp. nov.; Figs. 6d, 7a) and a hook-shaped acropodital process (Fig. 3a–b).

Distribution: Known from the Brazilian states of Rondônia and Mato Grosso (Fig. 11).

Composition: Four species, *Rhcnosthetus rondoni*, *R. coriaceus*, *R. chagasi* sp. nov. and *R. penabarbosai* sp. nov.

Key to males of *Rhcnosthetus*

- 1. Prefemoral process reaching only half the size of the acropodite (Fig. 3a, c) *R. rondoni* Hoffman, 2006
- 1'. Prefemoral process exceeding half the size of the acropodite (Fig. 4a) 2

- 2. Solenomere and acropodital process divided at the base of the acropodital region (Fig. 9e) *R. penabarbosai* sp. nov.
- 2'. Solenomere and acropodital process not divided at the base of the acropodital region, divided apically (Fig. 7a, c) 3
- 3. Acropodital process longer than the solenomere (Fig. 7a–d) *R. chagasi* sp. nov.
- 3'. Acropodital process about same length as the solenomere (Fig. 4a–d) *R. coriaceus* (Schubart, 1947)

***Rhcnosthetus rondoni* Hoffman, 2006**
(Figs. 3, 11)

Rhcnosthetus rondoni Hoffman, 2006: 52, figs. 21–25 (Male holotype and three males paratypes from Nova Esperança (-8.727772°; -63.867630°), Porto Velho, Rondônia, Brazil, 6-8/XII/1983, P.E. Vanzolini coll., deposited in MZSP, not found; male paratype from Nova Brasília, Ji-Paraná (-10.886901°; -61.913764°), Rondônia, Brazil, 6-11/XI/1984, P.E. Vanzolini coll., deposited in VMNH, not examined).

Material examined: BRAZIL. *Mato Grosso:* Aripuanã (-10.654524°; -59.915741°), Mata margem esquerda do rio Aripuanã, jusante do Salto de

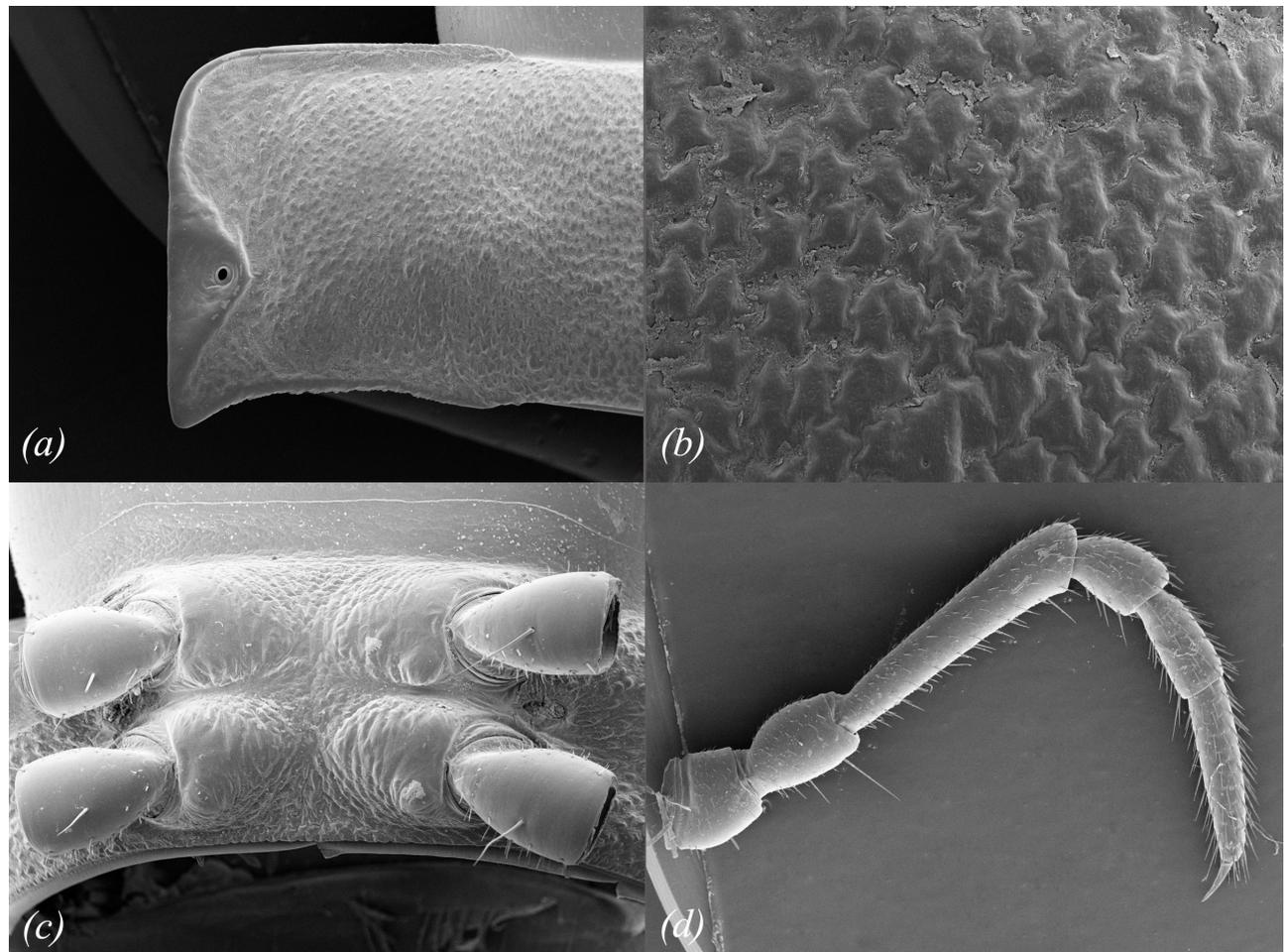


Fig. 2. Male of *Rhcnosthetus chagasi* sp. nov. (CZUFMT MYR 851). (a) Paranota, dorsal view; (b) Detail of the microgranular tergal texture; (c) sternite of body ring 9 in ventral view; (d) leg (7th leg pair) in lateral view. Scale bars: a, c = 1 mm; b = 300 µm; d = 2 mm.

Dardanelos, 2M, VII/2003, C. Strussmann coll. (CZUFMT-MYR 864).

Diagnosis: Males of *R. rondoni* differ from all other species of the genus based on the combination of gonopodal characteristics: prefemoral process reaching half the size of the acropodite (Fig. 3c) and falciform acropodital process exceeding the size of the solenomere (Fig. 3b).

Distribution: Known from the states of Mato Grosso and Rondônia, Brazil (Fig. 11).

***Rhynchosthetus coriaceus* (Schubart, 1947)**
(Figs. 4–5, 11)

Leptodesmus coriaceus Schubart, 1947: 11, figs. 10–11 (syntypes: 10 males, 10 females and 6 juveniles from Santa Terezinha, (-10.471803°; -50.515290°), formerly Barra do Tapirapé, Mato Grosso, Brazil, 23.XI.1939–15.III.1940, A. L. de Carvalho coll., deposited in MZSP and MNRJ). Only 2M and 2F deposited in MZSP, and 3M 2F deposited in MNRJ were examined (male lectotype, MNRJ 11812, and all remaining material as

paralectotypes are here designated).
Rhynchosthetus coriaceus: Hoffman, 2006: 55, figs. 26–27.

Diagnosis: Males of *R. coriaceus* differ from all other species of the genus based on the combination of gonopodal characteristics: prefemoral process robust and reaching half the size of the acropodite (Fig. 4a) and acropodital process not exceeding the size of the solenomere (Fig. 4d).

Descriptive notes on females: (Paralectotype, MNRJ 11625). Pair of legs on body ring 3 with the coxae possessing a small process. Posterior margin of the vulvae aperture smooth, without projections (Fig. 8b). Vulvae rounded shaped in ventral view (Fig. 5a) and elliptical shaped in lateral view (Fig. 5b). Apical region with the intermediate membrane elevated (Fig. 5d) and medial region with a small aperture (Fig. 5c), ventral view. Total length: 55.41. Total width: 8.35. Posterior margin of the vulvae aperture: 1.59 width. Vulvae: length 0.75, width 0.50. External valve: length

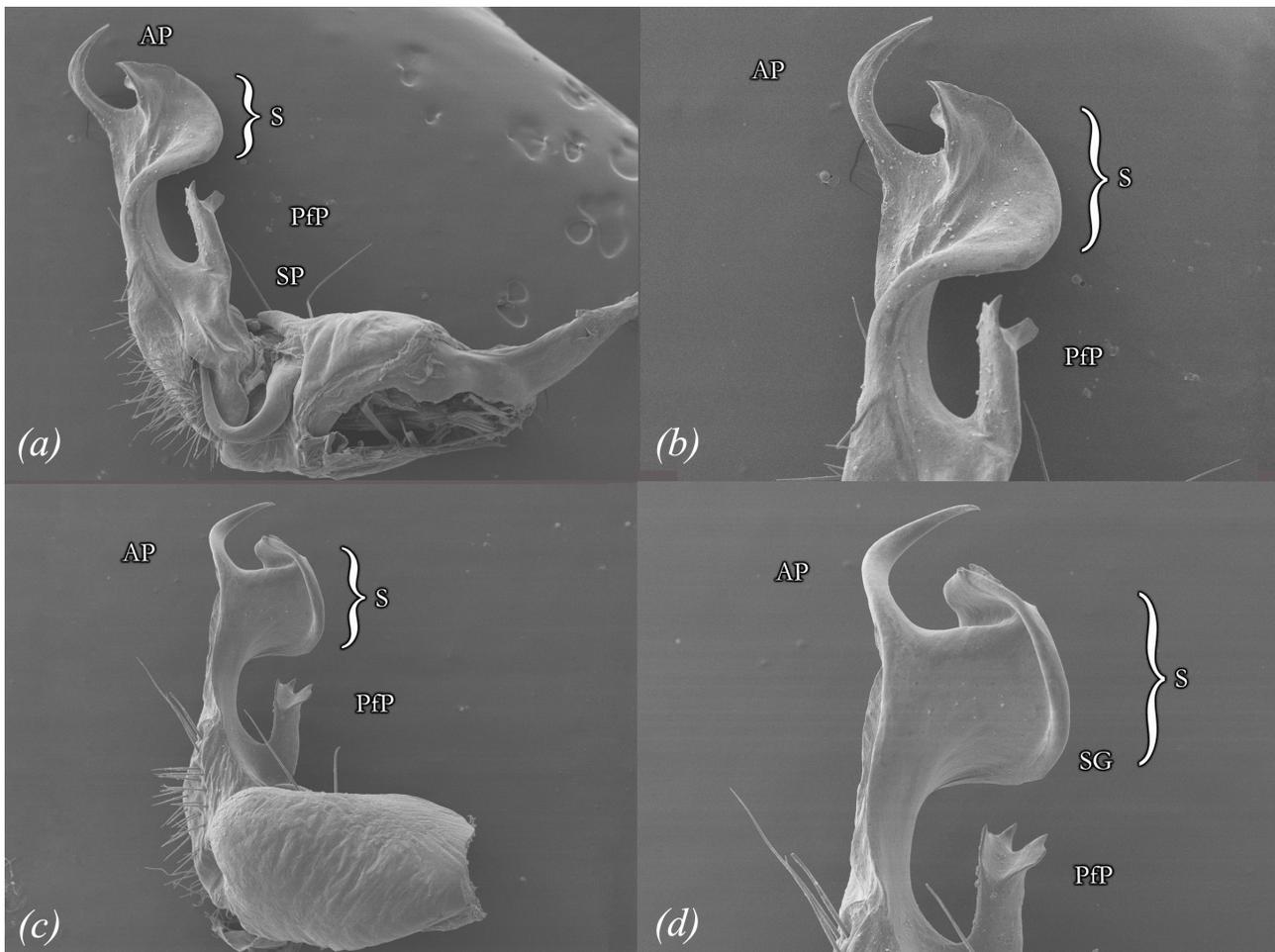


Fig. 3. *Rhynchosthetus rondoni* (CZUFMT MYR 864), left gonopod. (a) mesal view; (b) detail of the acropodite and prefemoral process, mesal view; (c) ectal view; (d) detail of the acropodite and prefemoral process, ectal view. Scale bars: a, c–d = 500 µm; b = 400 µm. Abbreviations: AP, acropodital process; PFP, prefemoral process; S, solenomere; SG, seminal groove; SP, spiniform process.

0.62, width 0.32. Internal valve: length 0.48, width 0.24. Operculum: length 0.28, width 0.42. External valve (EV, Fig. 5a, 5d) bigger; with long and scattered setae in comparison of the internal valve (IV, Fig. 5a, 5d). Operculum large and densely covered by setae (OP, Fig. 5a–b).

Distribution: Known only from the state of Mato Grosso, Brazil (Fig. 11).

***Rhcnosthetus chagasi* sp. nov.**

(Figs. 1–2, 6–8, 11)

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Material examined: Male holotype and female paratype from Chácara dos Idosos, Cotriguaçu (-9.901695°; -58.570062°), Mato Grosso, Brazil, deposited in IBSP 7782 and IBSP 7783, respectively. *Non-types:* BRAZIL. *Mato Grosso:* Cotriguaçu (-9.901695°; -58.570062°), Chácara dos Idosos, no

data and collector, Mato Grosso, Brazil, 2M and 1F (CZUFMT MYR 851); Fazenda São Nicolau, 13.XII.2009, L. D. Battirola coll., 4M and 3F (IBSP 5366).

Etymology: The specific epithet is a patronym in honor of Dr. Amazonas Chagas Júnior, for his friendship and several contributions to our knowledge of Myriapods in Brazil.

Diagnosis: Males of *R. chagasi* sp. nov. differ from all other species of the genus based on the combination of gonopodal characteristics: prefemoral process slender and reaching half the size of the acropodite (Fig. 6d) and a falciform acropodital process exceeding the size of the solenomere (Fig. 6f).

Description: Male (Holotype, IBSP 7782). Coloration in life: head reddish brown. Antennae with yellow and brown antennomeres. Body dark brown, with the paranota tip yellow (Fig. 1); (long-preserved in 70% ethanol): Head ocher with the apex brown. Antennae

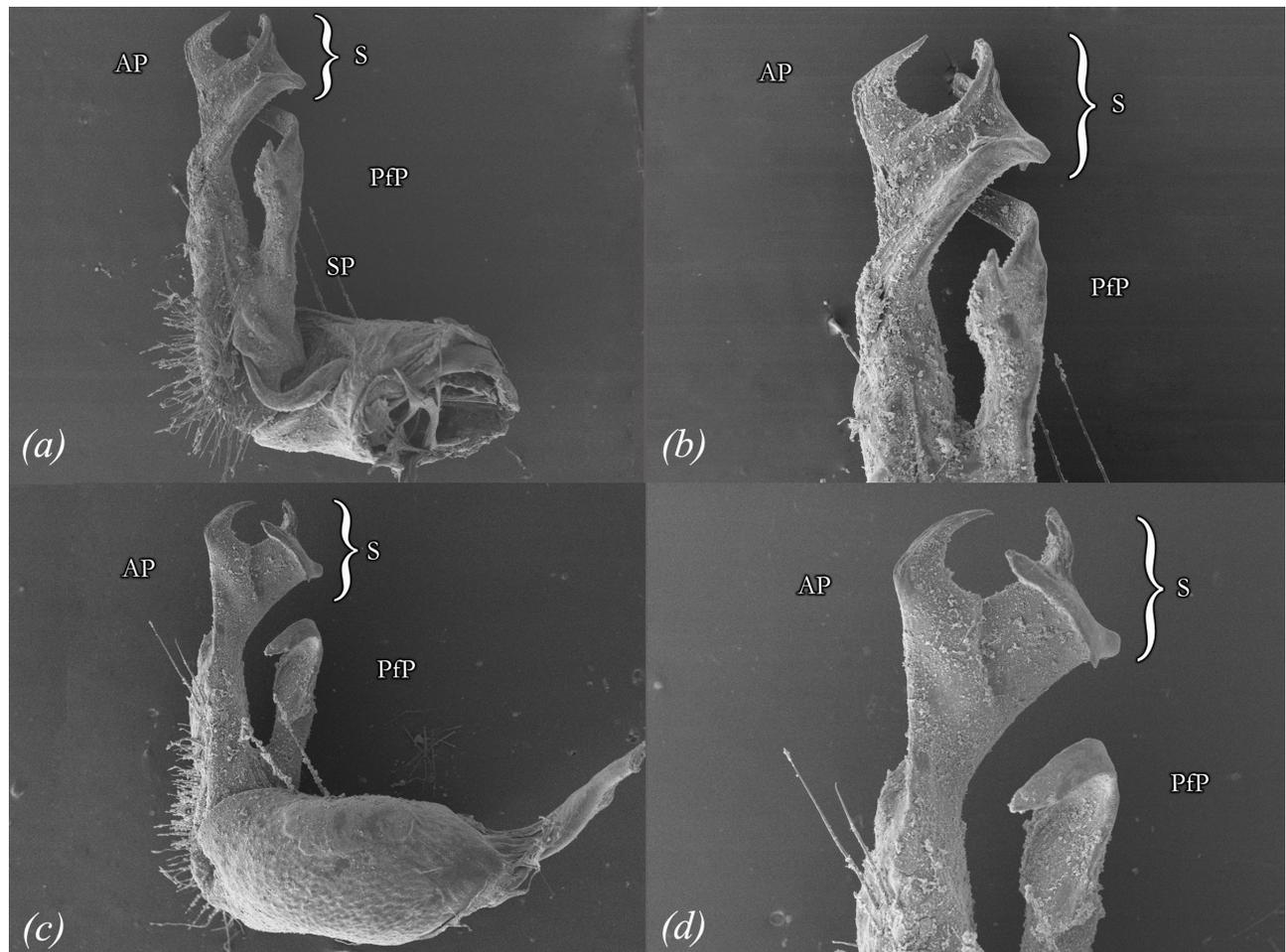


Fig. 4. *Rhcnosthetus coriaceus* (MNRJ 11625), left gonopod. (a) mesal view; (b) detail of the acropodite and prefemoral process, mesal view; (c) ectal view; (d) detail of the acropodite and prefemoral process, ectal view. Scale bars: a–c = 500 µm; d = 400 µm. Abbreviations: AP, acropodital process; Pfp, prefemoral process; S, solenomere; SG, seminal groove; SP, spiniform process.

yellowish. Body light brown and paranota tip yellowish (Fig. 6a–c). Body rings: cuticle with microgranular texture (Fig. 2b); paranota rectangular with posterior edges slightly produced (Fig. 2a); ozopore central-posteriorly situated on paranota (Fig. 2a). Stigma oval. Sternites with podosterna rough (= longitudinally striated – Hoffman, 2006) (Fig. 2c). Sternite of body ring 4 with a pair of small rounded projections appressed against each other. Sternite of all the body rings with two pairs of small rounded projections (Fig. 2c). Pair of legs on body ring 3 with coxae possessing a rectangular-shaped gonapophysis. Gonopod aperture on seventh body ring oval, posterior edge without any modifications. Legs yellowish, without modifications, with scattered thin setae (Fig. 2d). Telson with the same color as the body. Total length: 54.60. Total width: 8.04. Collum, length, 1.88, width, 6.81. Antennomere lengths (1 > 7): 0.65; 1.39; 1.38; 1.43; 1.29; 1.37 0.35. Podomeres lengths (1 > 7): 0.66; 0.95; 2.38; 0.77; 0.84;

1.47; 0.45. Gonopod aperture, length 0.94, width 1.81 Telson, length 1.57. Gonopod: length 2.11, width 1.72. Coxae: length 0.74, width 1.00. Telopodite: length 2.11, width 0.80.

Gonopods (Figs. 6d–f, 7a–d): coxae equivalent to about half the length of the telopodite and prominently rounded in ectal view (Figs. 6f, 7c). Coxae with two setae on the distal dorsal side. Presence of small spiniform process hidden by the coxa in mesal view (SP; Fig. 6d). Cannula: hook-shaped. Prefemoral region long, 1/2 length of telopodite. Prefemoral process long and slim, with the apical region curved and reaching half the length of the acropodite (PfP; Figs. 6d, 7a). Prefemoral process with a reduced small spine in the medial region of the process. Acropodite elongated and robust; composed of a large and concave lobe on dorsal side conducting the seminal groove along its edge (SG; Fig. 6d, f); and distal and falciform acropodital process (AP; Fig. 6d, f). Solenomere and acropodital process

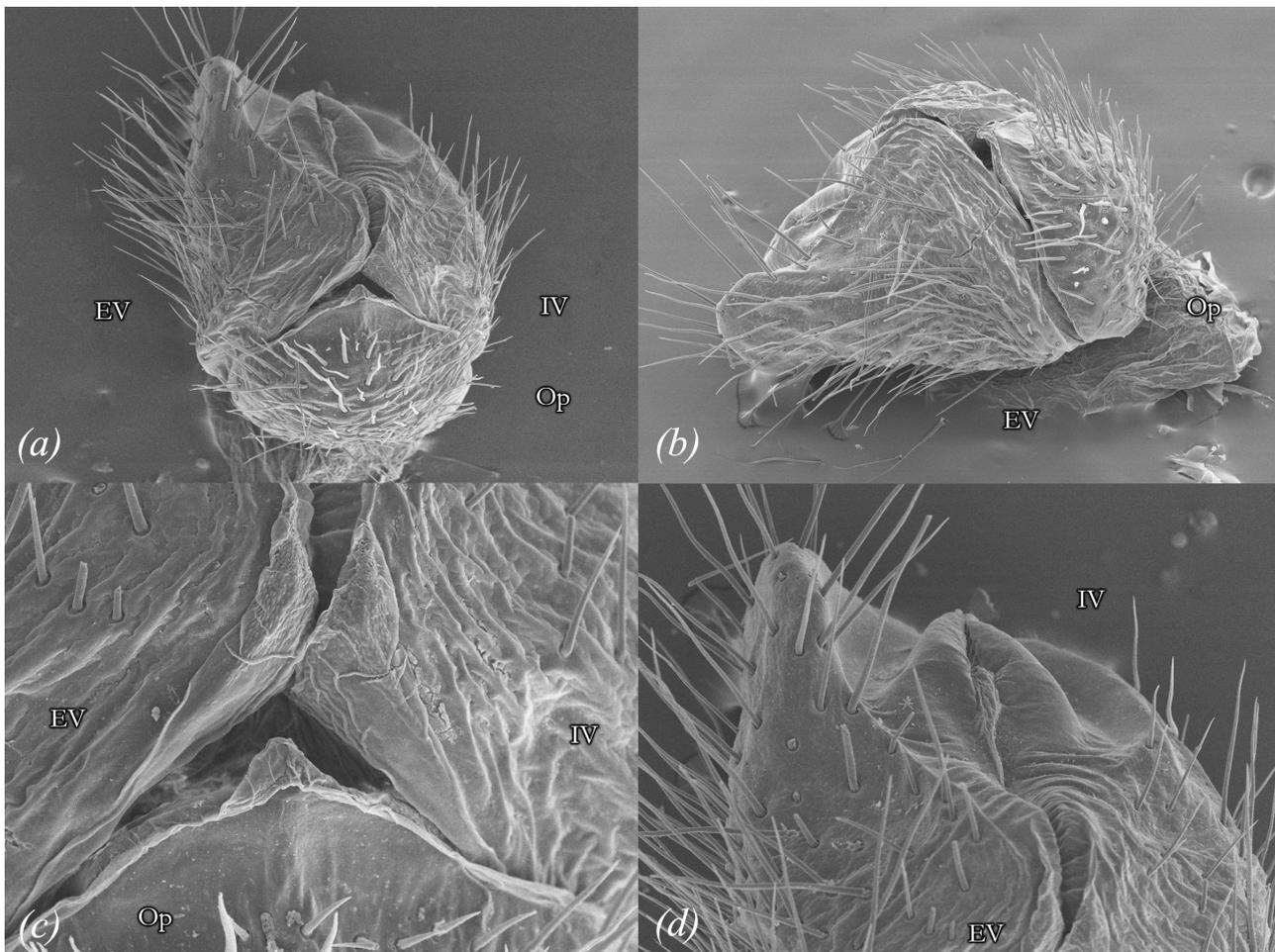


Fig. 5. *Rhicnosthetus coriaceus* (MNRJ 11625), left vulva. (a) ventral view; (b) latero-ventral view; (c) detail of the medial region, ventral view; (d) detail of the apex, ventral view. Scale bars: a = 300 μm; b = 400 μm; c–d = 100 μm. Abbreviations: EV, external valve; Op, operculum; IV, internal valve.

close to the apical region of the acropodite (Fig. 6d–f).

Female (Paratype, IBSP 7783). Body as in male. Pair of legs on body ring 3 with the coxae possessing a small, blunt process (Fig. 8a). Posterior margin of the

vulvae aperture smooth, without projections (Fig. 8b). Vulvae rounded shaped in ventral view (Fig. 8c) and elliptical shaped in lateral view (Fig. 8d). Apical region with a large aperture (Fig. 8f) and medial region with

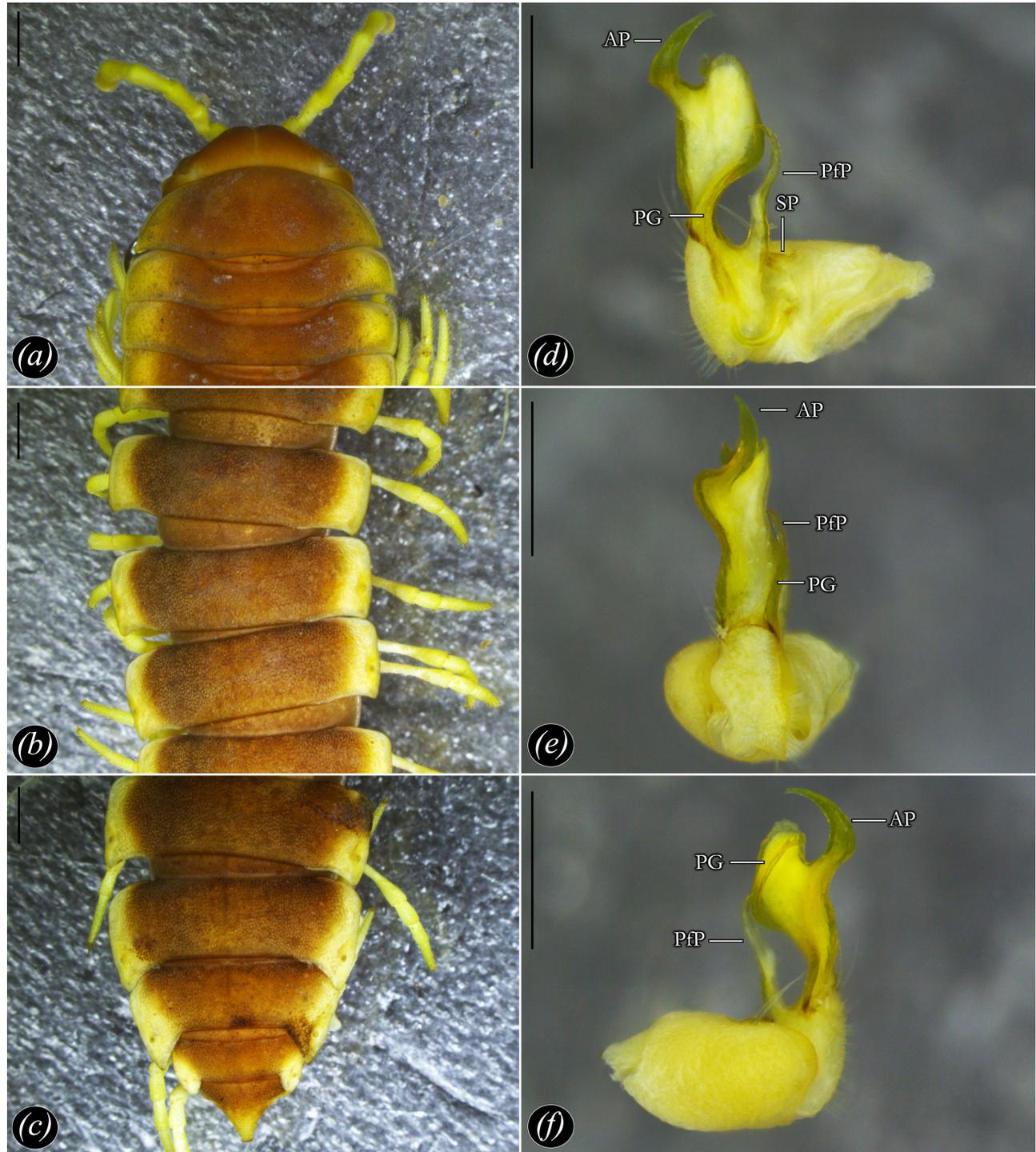


Fig. 6. *Rhicnosthetus chagasi* sp. nov. (holotype, IBSP 7782), dorsal view of anterior (a), midbody (b) and posterior (c) body rings. Scale bars = 2 mm. Left gonopod. (d), mesal view; (e), ventral view; (f), ectal view. Scale bars: 1 mm. Abbreviations: AP, acropodital process; PFP, prefemoral process; SG, seminal groove; SP, spiniform process.

a small aperture (Fig. 8e), ventral view. Total length: 54.72. Total width: 7.78. Posterior margin of the vulvae aperture: 1.73 width. Vulvae: length 0.77, width 0.573. External valve: length 0.51, width 0.24. Internal valve: length 0.54, width 0.18. Operculum: length 0.24, width 0.38. External valve (EV, Fig. 8c–d) with long and scattered setae in comparison of the internal valve (IV, Fig. 8c–d). Operculum large and densely covered by long setae; small setae restricted in the centro-apical part (OP, Fig. 8c–d).

Distribution: The species is known from the region of Cotriguaçu, state of Mato Grosso, Brazil (Fig. 11).

***Rhcnosthetus penabarbosai* sp. nov.**

(Figs. 9–11)

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Material examined: Male holotype and male

paratype from Chapada dos Parecis (-14.339394°; - 56.39202°), Diamantina, Mato Grosso, Brazil, XI.1993, D. Novaes & R. Pardini coll., deposited in IBSP 7784 and IBSP 7785, respectively.

Etymology: The specific epithet is a patronym in honor of Dr. João Paulo P. Pena Barbosa, for his outstanding contributions to our knowledge concerning the Chelodesmidae, and for his friendship and advice over the years.

Diagnosis: Males of *R. penabarbosai* sp. nov. differ from all other species of the genus by having the prefemoral process as long as the acropodite (Figs. 9d–f, 10a–d) and by having the solenomere and acropodital process divided at the base of the acropodital region (Fig. 9e).

Description: Male (Holotype, IBSP 7784). Coloration (long-preserved in 70% ethanol): Head ocher. Antennae yellowish ocher. Body ocher and paranota tip yellowish – not uniform throughout the

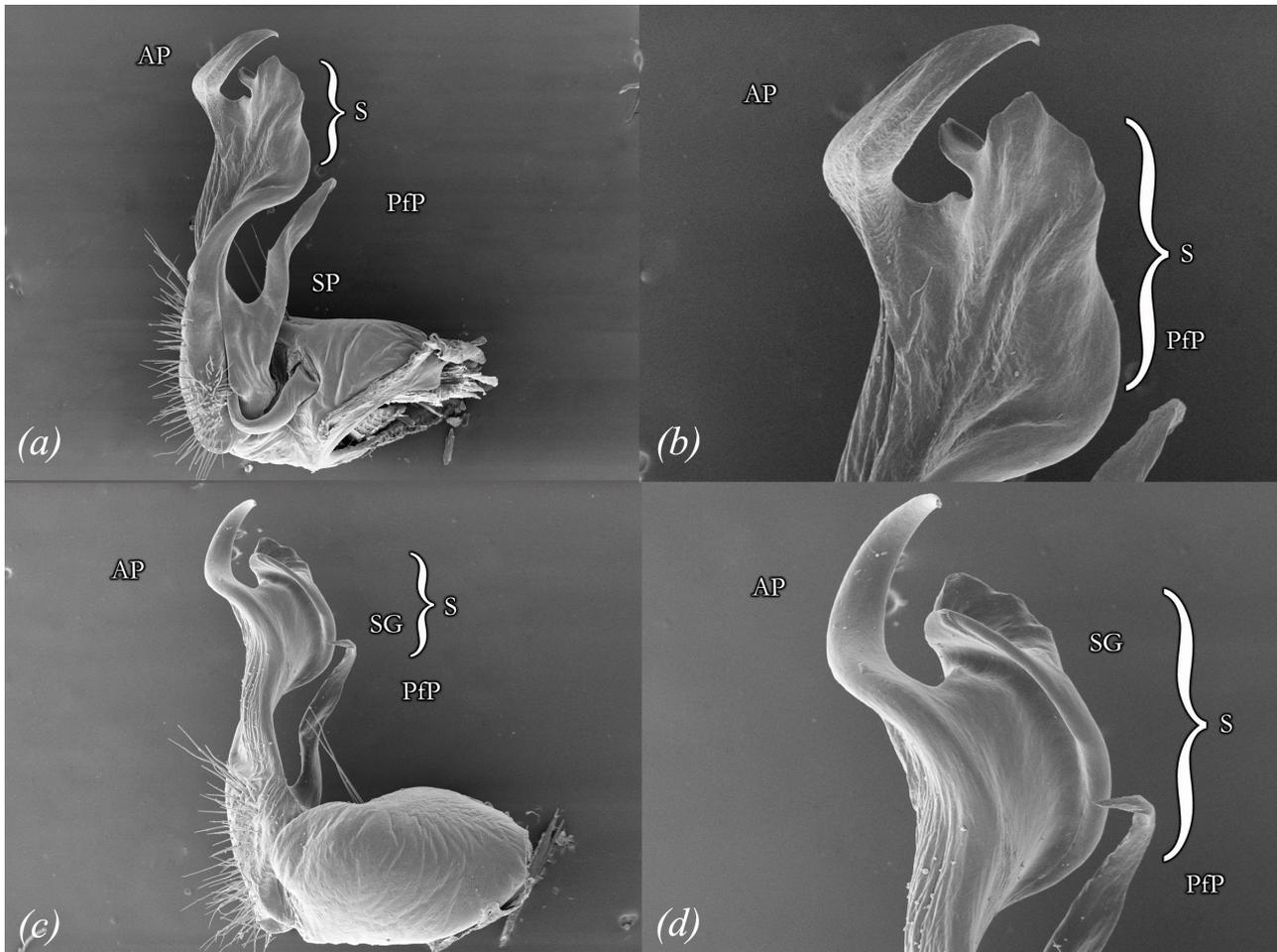


Fig. 7. *Rhcnosthetus chagasi* sp. nov. (CZUFMT MYR 851), left gonopod. (a) mesal view; (b) detail of the acropodite, mesal view; (c) ectal view; (d) detail of the acropodite and prefemoral process, ectal view. Scale bars: a–c = 500 µm; d = 400 µm. Abbreviations: AP, acropodital process; PFP, prefemoral process; S, solenomere; SG, seminal groove; SP, spiniform process.

body, probably due to ethanol depigmentation (Fig. 9a–c). Body rings: cuticle with microgranular texture; paranota rectangular with posterior edges slightly produced (Fig. 9b); ozopore central-posteriorly situated

on paranota. Stigma oval. Sternites with podosterna smooth. Sternite of body ring 4 with a pair of small rounded projections appressed against each other. Sternite of all the body rings with two pairs of small

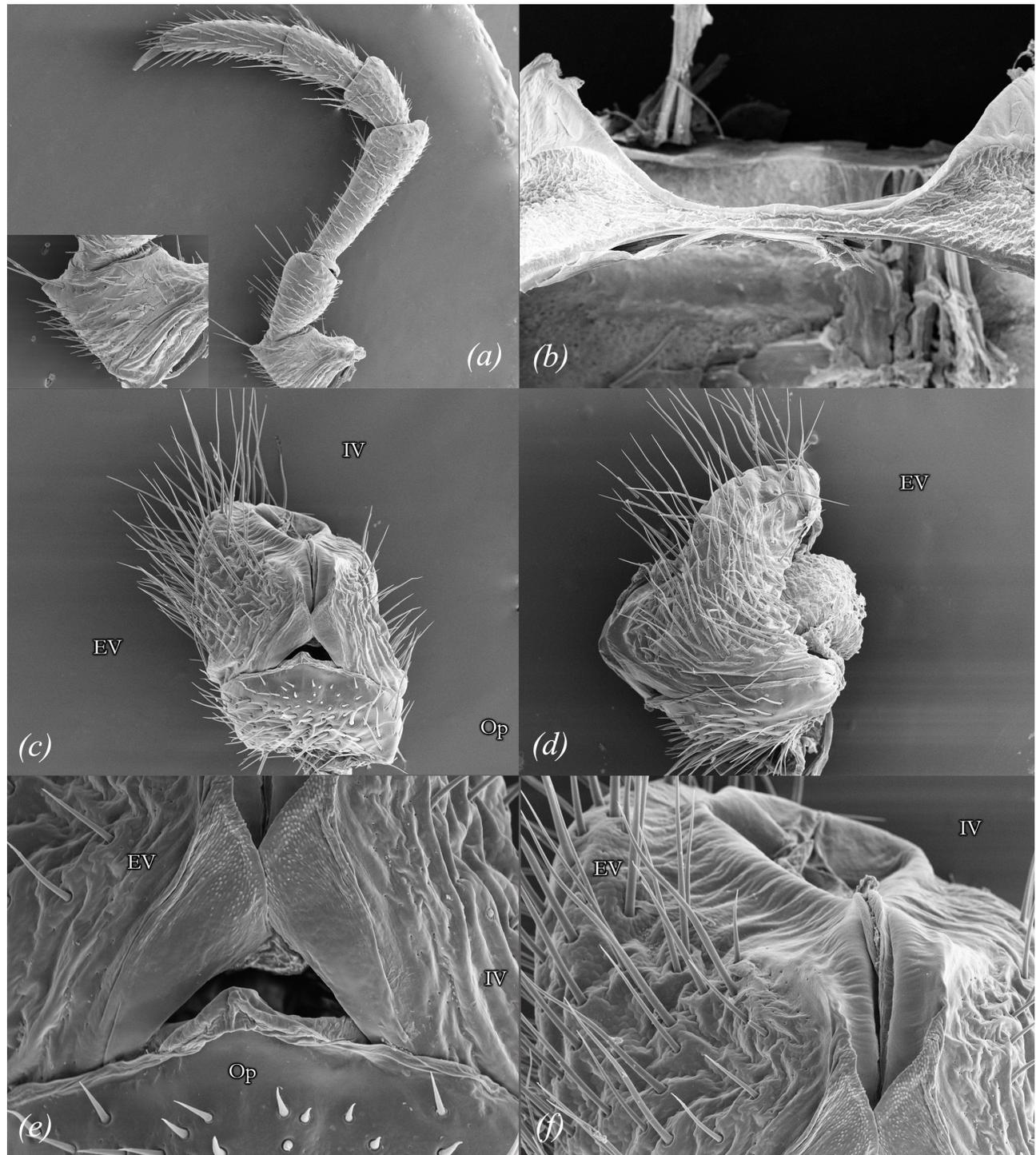


Fig. 8. *Rhicnosthetus chagasi* sp. nov. (CZUFMT MYR 851), female. (a) Legs of body ring 3, lateral view; (b) posterior margin of the vulvae aperture; (c) ventral view; (d) lateral view; (e) detail of the medial region, ventral view; (f) detail of the apex, ventral view. Scale bars: a = 1 mm; b = 500 μ m; c–d = 400 μ m; e–f = 100 μ m. Abbreviations: EV, external valve; Op, operculum; IV, internal valve.

rounded projections. Pair of legs on body ring 3 with coxae possessing a rectangular-shaped gonapophysis. Gonopod aperture on seventh body ring oval, posterior edge without any modifications. Legs yellowish ocher,

without modifications, with scattered, thin setae. Telson with the same color as the body. Total length: 43.05. Total width: 6.04. Collum, length, 1.80, width, 5.70. Antennomere lengths (1 > 7): 0.55; 1.31; 1.19; 1.05;



Fig. 9. *Rhicnosthetus penabarbosai* sp. nov. (holotype, IBSP 7784), dorsal views of anterior (a), midbody (b) and posterior (c) body rings. Scale bars = 2 mm. Left gonopod. (d), mesal view; (e), ventral view; (f), ectal view. Scale bars: 1 mm. Abbreviations: AP, acropodital process; Pfp, prefemoral process; SG, seminal groove; SP, spiniform process.

1.22; 1.21 0.25. Podomeres lengths ($l > 7$): 0.65; 0.75; 1.98; 0.63; 0.86; 1.23; 0.37. Gonopod aperture, length 0.74, width 1.35 Telson, length 1.16. Gonopod: length 1.66, width 1.27. Coxae: length 0.51, width 0.98. Telopodite: length 1.55, width 0.52.

Gonopods (Figs. 9d–f, 10a–d): coxae equivalent to about half the length of the telopodite and prominently rounded in ectal view (Figs. 9f, 10c). Coxae with two setae on the distal dorsal side. Presence of small spiniform process hidden by the coxae in mesal view (SP; Fig. 10a). Cannula: hook-shaped. Prefemoral region long, 1/2 length of telopodite. Prefemoral process long and slender, with the apical region curved and as long as the solenomere (Pfp; Fig. 9d–f). With small spine in the medial region of the process. Acropodite elongated and slender in comparison with the other species of the genus; consisting of a reduced concave process without a lobe and conducting the seminal groove along its edge on dorsal side (SG; Fig. 10d) and

distal, slender and falciform acropodite process (AP; Figs. 9d–f, 10c–d). Solenomere and acropodite process divided at the base of the acropodite region (Fig. 9e). Solenomere with a broad large apex (Fig. 10b).

Female: Unknown.

Distribution: The species is known only from the type locality (Fig. 11).

DISCUSSION

Hoffman (2006) discussed a possible tribal assignment for the members of *Rhichnothetus* based on a small gonopod aperture, body rings granulate, shape of paranota, size and position of the coxal apophysis of the gonopod, suggesting a relationship with the genera of Chondrodesmini. An important feature described by Hoffman (2006) for *Rhichnothetus* is the longitudinal striation on the sterna (= longitudinally striated

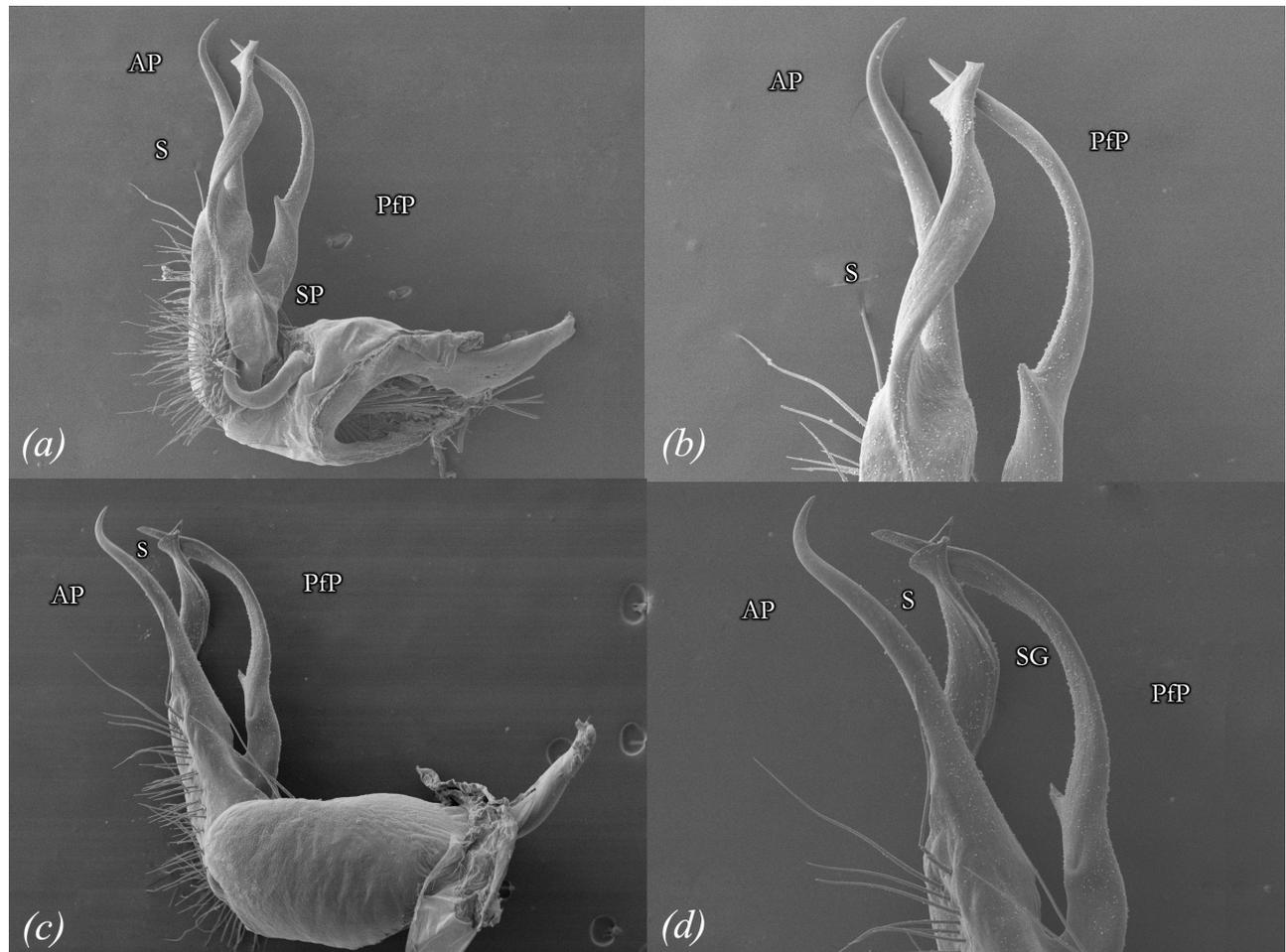


Fig. 10. *Rhichnothetus penabarbosai* sp. nov. (paratype, IBSP 7785), left gonopod. (a) mesal view; (b) detail of the acropodite and prefemoral process, mesal view; (c) ectal view; (d) detail of the acropodite and prefemoral process, ectal view. Scale bars: a–b = 500 μ m; c = 400 μ m; d = 300 μ m. Abbreviations: AP, acropodite process; Pfp, prefemoral process; S, solenomere; SG, seminal groove; SP, spiniform process.

podosterna). The author suggested this characteristic as a possible generic apomorphy, although this condition in *R. coriaceus* was not examined. Based on examination of the type specimens of *R. coriaceus* and *R. penabarbosai* sp. nov., the sterna of both species are smooth. A rough sterna (not longitudinally striated, as described by Hoffman 2006) (Fig. 2c) is observed only in *R. rondoni* and *R. chagasi* sp. nov. This feature could possibly indicate a relationship between these species.

Hoffman (2012) suggested that the morphology of the female genitalia may be useful for developing

a more solid classification within Chelodesmidae. Comparatively for some chelodesmidean groups such as Cornalatini and *Plectotrogodesmus*, conspicuous and unique modifications in feminine genitalia were observed by Hoffman (1990a) and Bouzan et al. (2019), respectively. In fact, the morphological study of Chelodesmidae females can be an important tool for the delineation of generic and tribal limits (Hoffman 1990a b; Bouzan et al. 2017 2018 2019). Based on our examination of female genitalia in *Rhichnostethus*, the external valve is densely setose and larger than

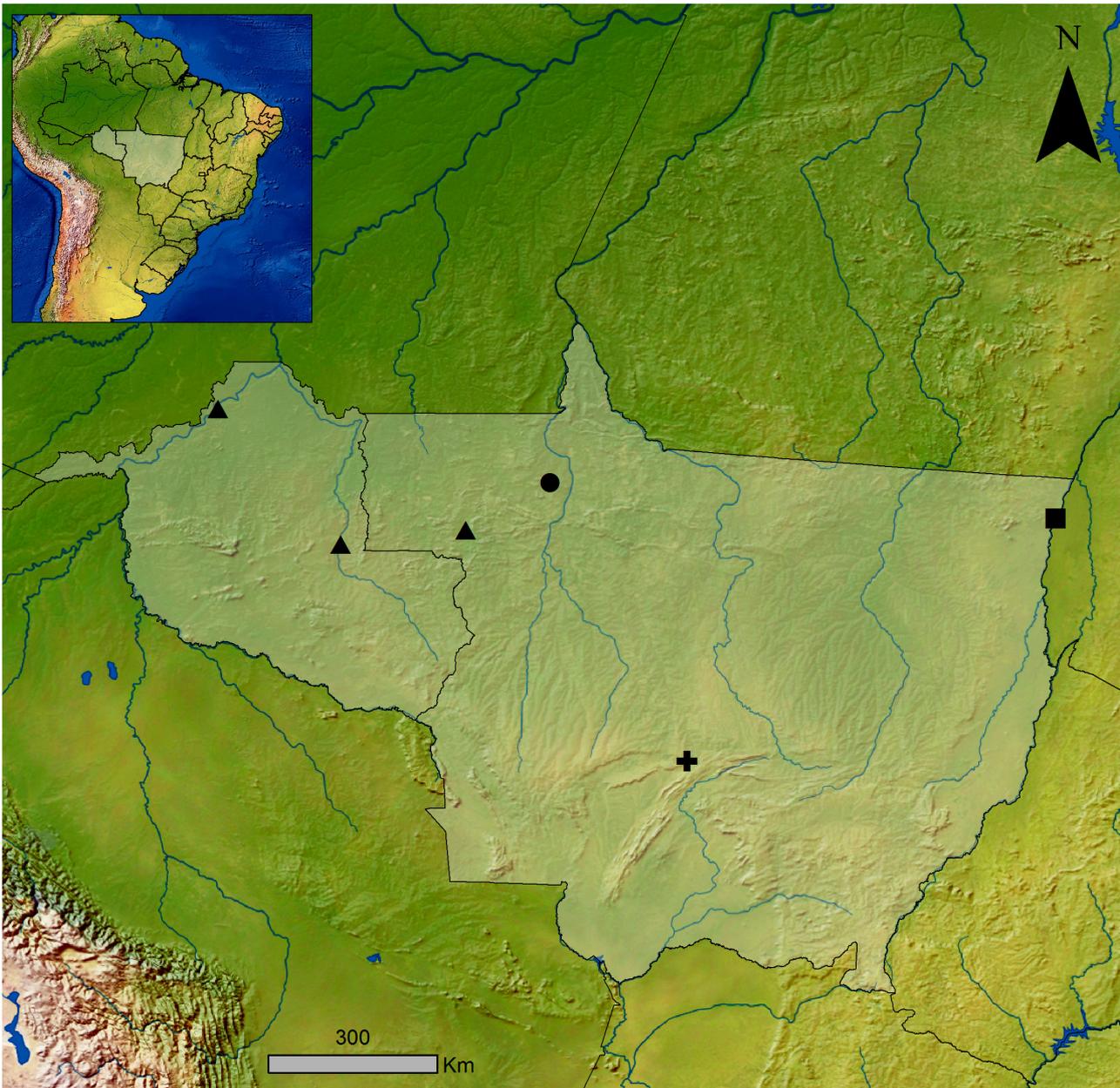


Fig. 11. Distribution map of *Rhichnostethus* species. Symbols: triangles: *R. rondoni*; square: *R. coriaceus*; circle: *R. chagasi* sp. nov.; cross: *R. penabarbosai* sp. nov.

the internal valve (Figs. 5a, 8c). A small aperture is observed in the medial region, and above this aperture a membranous rough surface is observed in both valves (Figs. 5c, 8e). A large operculum reinforces the similarity (Fig. 5a–d).

CONCLUSIONS

Although Chelodesmid millipedes are diverse and common in the Neotropics, their taxonomy and distribution are still poorly-known. In this work four species were recorded for the genus *Rhichnothetus*, including the new species *Rhichnothetus chagasi* sp. nov. and *R. penabarbosai* sp. nov., both from the state of Mato Grosso. For the first time the vulvae of *Rhichnothetus* species were illustrated. Based on this, females can be used as an important tool for the delineation of generic and /or tribal limits. However, further studies of the vulvae are still required.

Acknowledgments: This work and the two new species names were registered with ZooBank under urn:lsid:zoobank.org:pub:FFCDE425-EA3D-4C51-9FED-38CE19D94E1E. We are grateful to Ricardo Pinto da Rocha and Mauro Cardoso Júnior (MZSP), Carla Barros, Ludson Ázara and Adriano B. Kury (MNRJ) and Amazonas Chagas-Jr (UFMT) for their hospitality during visits. To Beatriz Mauricio for helping with the SEM images in the Laboratório de Biologia Celular of the Instituto Butantan. Thanks to Dr. Domingos de Jesus Rodrigues and Dr. Leandro Dênis Battirola for kindly sending us photo of live specimens. This study was financially supported by grant to RSB (2018/00103-8) from the São Paulo Research Foundation (FAPESP) and CAPES (88887.510007/2020-00). LFMI was supported by grant 2016/24248-0 from FAPESP. ADB was supported by the grant CNPq (303028/2014-9). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES - Finance Code 001).

Authors' contributions: All authors contributed equally to this work.

Competing interests: The authors declare that they have no conflicts of interests.

Availability of data and materials: All materials in this paper were deposited in the museums listed above.

Consent for publication: All authors agree to submit the manuscript to Zoological Studies, and agree to publish if accepted.

Ethics approval consent to participate: Not applicable.

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