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Complementary description of *Podocinella misella* (Berlese, 1913) (Acari: Podocinidae) and a key to world species of the genus

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Original research

ABSTRACT

Podocinidae Berlese is known in South America from only one species described from Brazil and several other locations on the continent. A complementary description of *Podocinella misella* (Berlese) is presented based on the morphology of adult females from litter collected in different parts of Brazil. Complementary characterization of the genus and a key to distinguish the five recognizable world *Podocinella* species are also presented.

Keywords predatory mites; Phytoseioidea; taxonomy

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Introduction

Podocinidae *sensu* Lindquist *et al.* (2009) is a small family of mesostigmatic mites, comprising only two genera: *Podocinum* Berlese, 1882, with thirty-one species, and *Podocinella* Evans & Hyatt, 1958, with five species (Yan *et al.*, 2012; Santos *et al.*, 2017). Podocinidae has also been used by other authors to comprise a different set of taxa, as discussed by Sourassou *et al.* (2015).

Podocinids are frequently found in litter samples in Brazil (Mineiro & Moraes, 2001). In a recent publication, we reviewed the species of *Podocinum* occurring in the country, describing a new species (Santos *et al.*, 2017). The objective of this paper is to provide morphological information about specimens of Brazilian populations identified as *Podocinella misella* (Berlese, 1913), revise the concept of *Podocinella* as to integrate additional morphological attributes observed in this study, and finally to present a key to world species of the genus.

Material and methods

Mites were extracted from litter samples using a Berlese funnel. They were then slide-mounted in Hoyer's medium and examined under phase (Leica, DMLB) and interference (Nikon, Eclipse 80i) contrast microscopes for species identification, using the world taxonomic literature (Ho & Wang, 2009). In addition to the specimens collected during this work, we also examined specimens of the same species previously collected by other people and deposited in the reference collection of Departamento de Entomologia e Acarologia, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, São Paulo.

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Photos of taxonomically relevant structures were taken using a digital camera connected to the interference contrast microscope. Illustrations were produced using a digital tablet and the software Adobe Illustrator®. Measurements were done with a graded ocular. For each character, the average measurement followed (in parentheses) by the minimum and the maximum measurements are given in micrometers. Setal nomenclature is based on Lindquist & Evans (1965) and Lindquist (1994) as interpreted for the Podocinidae by Yan *et al.* (2012). However, that assignment is tentative, pending adequate ontogenetical study of this mite group, as for example done for Zerconidae by Lindquist & Moraza (1999). Nomenclature of opisthogastric setae is different from what was proposed by Santos *et al.* (2017) and in accordance with what was used by Lindquist & Moraza (1999), to better match what was reported in the latter publication as well as in other publications concerning the ontogenetic development of mesostigmatid mites. Leg setal notation and chaetotactic formulae are based on Evans (1963).

The key to species was constructed taking into account the original descriptions of all species, as well as the redescription of *Podocinella misella* (Berlese) by Evans & Hyatt (1958) and the examination of specimens of this species collected in Brazil.

Results

Podocinella misella (Berlese, 1913)

Podocinum misellum Berlese, 1913: 83.

Podocinella misella, Evans & Hyatt, 1958: 929.

Type depository — Istituto Sperimentale per la Zoologia Agraria, Florence, Italy.

Previous records — Indonesia (Berlese, 1913 and Evans & Hyatt, 1958), Jamaica (Evans & Hyatt, 1958), Tanzania (Hurulbutt, 1972).

Specimens examined — Alagoas State: three females collected by L.R. Santos on December 11, 2003 at Teotônio Vilela. Minas Gerais State: one female collected by J.C. Santos on March 4, 2013 at Inconfidentes. São Paulo State; two females collected by J.L. de C. Mineiro on June 13, 2011 at Campinas; seven females collected by J.C. Santos on November 27, 2013 at Jaboticabal; two females collected by A.R. Oliveira on July 11, 2000 at Pariqueira-Açu; eight females collected by J.C. Santos on July 4, 2013 at Piracicaba; one female collected by J.L. Munhoz on January 5, 2014 at Ipaussu. All specimens collected from litter.

Adult female: (five specimens measured)

Gnathosoma — Chelicera with antiaxial and dorsal lyrifissures, and dorsal seta distinct (Fig. 1A); fixed digit 28 (28–29) long, with six teeth and a minute setiform pilus dentilis; movable digit 28 (28–29) long, with two teeth. Palp setae (Fig. 1B) (trochanter to tarsus): 2-5-6-14-15, regular for the Gamasina (Evans, 1964); all setae aciculate and smooth; apotele 3-tined. Anterior region of epistome with three distally spiculate extensions (Fig. 1C). Deutosternum with anteriormost transverse ridge smooth followed by six transverse rows of denticles, each with 12–21 denticles; corniculus horn-shaped, about 18 (18–20) long and 7 (7–8) wide basally (Fig. 1D). Measurements of setae: *h1* 11 (10–11), *h2* 6, *h3* 10 (9–10), *pc* 12 (12–13).

Dorsal idiosoma — Dorsal shield 292 (275–300) long and 212 (202–220) wide (Fig. 1E), covered by small protuberances aligned to constitute a polygonal network (Figs. 1E, 1F and 1G). Dorsal shield with a lateral notch at level of Z3 (often difficult to see when posterior end of dorsal shield is ventrally curved) (Fig. 1F). Podonotal region with ten pairs of setae (*j1–j3*, *j5*, *j6*, *z5*, *z6 s2–s4*) (*z5* minute, usually difficult to discern), one pair of distinguishable lyrifissures (near *j2*) and three pairs of distinguishable pores. Opisthonotal region with seven pairs of setae (*J1*, *J3–J5*, *Z1*, *Z3*, *Z5*), and two pairs of distinguishable pores. Setal lengths: *j1* 14 (13–14), *j2* 66 (65–68), *j3* 22 (21–24), *j5* 36 (35–38), *j6* 52 (52–53), *z5* 3 (3–4), *z6* 46 (45–47), *s2* 11 (11–12), *s3* 11 (10–11), *s4* 14 (14–15), *J1* 64 (63–65), *J3* 63 (61–65), *J4* 70

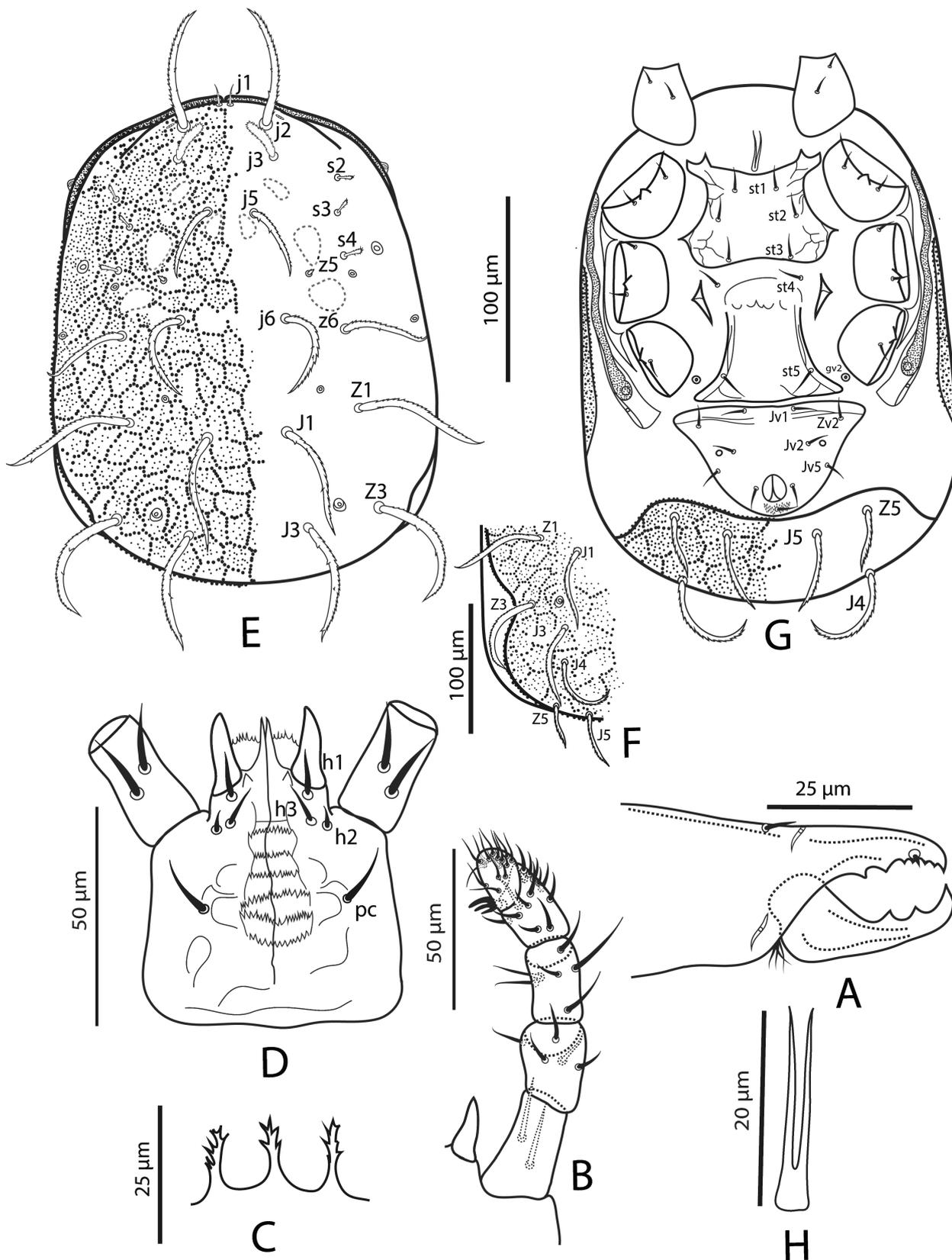


Figure 1 *Podocinella misella* (Berlese, 1913). Adult female. A – Antiaxial view of chelicera; B – Palpus; C – Epistome; D – Hypostome; E – Dorsal view of idiosoma; F – Detail of the lateral concavity. G – Ventral view of idiosoma; H – Tritosternum. Lyrifissures and pores enlarged for improved visibility. Based on specimens collected in Jaboticabal, Brazil.

(70–71), *J5* 42 (41–43), *Z1* 71 (70–72), *Z3* 70 (70–71), *Z5* 32 (31–32). All dorsal setae stout and serrate, except *j1* slender and slightly serrate (Figs. 1E, 1F and 1G).

Ventral idiosoma (Fig. 1G) — Base of tritosternum indistinguishable; laciniae 19 (18–20) long, fused at their base for about 20% of their total length (Fig. 1H). Sternal shield 54 (53–55) long at mid line and 53 (50–55) wide between setae *st1* and *st2*, mostly smooth, except for lateral lines; posterior margin slightly concave. With three pairs of setae (*st1–st3*); seta *st4* apparently inserted on soft cuticle; lyrifissures (*iv1–iv5*) indiscernible. Genital shield widened posteriorly; mostly smooth, except for lateral lines; hyaline anterior region rounded and brief, not overlapping sternal shield; posterior margin truncate. Distance *st5–st5* 47 (46–48). Pore *gv2* on unsclerotised cuticle. Ventrianal shield subtriangular, 110 (110–111) long at mid-line and 77 (75–80) wide at widest level; with four pairs of setae (*Jv1*, *Jv2*, *Jv5* and *Zv2*) in addition to circumanal setae, and a pair of pores laterad and transversely aligned with *Jv3*; para-anal and post-anal setae similar in length, the former inserted at about mid-length of anal opening. Unsclerotised opisthogastric cuticle without setae. Exopodal plate apparently not fused with peritrematic plate, usually fragmented into two small and triangular strips, but some specimens with a narrow line connection them; extending forward up to posterior end of coxa II. Measurements of setae: *st1* 11 (11–12), *st2* 11 (11–12), *st3* 11 (11–12), *st4* 14 (14–15), *st5* 20 (19–20); *Jv1* 14 (14–15), *Jv2* 10 (10–11), *Jv5* 14 (13–15), *Zv2* 10 (10–11); para-anal 12 (11–12), post-anal 14 (14–15). All setae aciculate and smooth.

Peritreme and peritrematic plate (Figs. 1E, 1G) — Apices of peritremes nearly contiguous between setae *j1*. Peritrematic plate fused with dorsal shield anteriorly, extending posteriorly slightly behind coxa IV, and apically truncate; with a distinguishable pore next to coxa II; section posteriorly of stigma with a pore and no distinct lyrifissures. Spermathecal apparatus. Indistinct.

Legs (Figs. 2A–2G) — Median section of pulvilli of legs II–IV rounded; paradactyli of these legs elongate and acuminate (Fig. 2A). Lengths: I: 408 (400–415); II: 312 (300–325); III: 268 (265–270); IV: 332 (330–335). Chaetotaxy – Leg I coxa: I: 0,0/1,0/1,0; trochanter: 1,0/1,1/2,1; femur: 2, 3/1,1/2,2. Leg II coxa: 0,0/1,0/1,0; trochanter: 1,0/1,0/2,1; femur: 2,2/2,2/1,1; genu: 1,2/0,2/1,1; tibia: 1,1/1,2/1,1. Leg III coxa: 0,0/1,0/1,0; trochanter: 1,1/2,0/1,0; femur: 1,2/1,1/0,1 genu: 1,2/1,2/0,1; tibia: 1,1/1,2/1,1. Leg IV coxa: 0,0/1,0/0,0; trochanter: 1,1/2,0/1,0; femur: 1,2/1,1/0,1; genu: 1,2/1,2/0,0; tibia: 1,1/1,2/0,1. Numbers of setae on other leg I segments: genu 10 and tibia 8; given their reduce diameter, chaetotaxy could not be reliably accounted for. Number of setae on tarsus I not counted; number of setae on other tarsi: 18. Most setae aciculate and smooth (except *av* femur IV clearly 3–4 tined); some dorsal setae of genu, tibia and basi-tarsus of legs II–IV discreetly barbed (usually difficult to discern). Remarks. The number and position of setae on femur I of this species is essentially the same as reported by Santos *et al.* (2017) for *Podocinum*, based on the examination of *P. bengalensis* Bhattacharyya, *P. pacificum* (Berlese), *P. sagax* (Berlese) and *P. tupinamba* Santos, Martins, Britto & Moraes, except that *al2* is distinctly more anteriorly of *av* and that *pl1* and *pl2* migrate ventrally.

A comparison of the specimens collected with type specimens of *P. misella* was not possible, because the type specimens could not be located; according Castagnoli & Pegazzano (1985) the types are missing. Evans & Hyatt (1958) provided a complementary description of this species based on specimens collected in Tomohon, Sulawesi (mentioned as N.E. Celebes), Indonesia and Jamaica. Hurlbutt (1972) presented a new complementary description based on specimens collected from Morogoro river (Tanzania) and reviewed the specimens used by Evans & Hyatt (1958) collected in Celebes.

The specimens that we examined from Brazil agree well with the redescription of *Podocinella misella* by Hurlbutt (1972). While his description was rather detailed, it included no setal measurements, leg chaetotaxy or details of the hypostome. Despite the missing information, we concluded that the specimens we collected belong to *P. misella*, because other features are sufficiently detailed, in addition to the fact that approximate setal length can

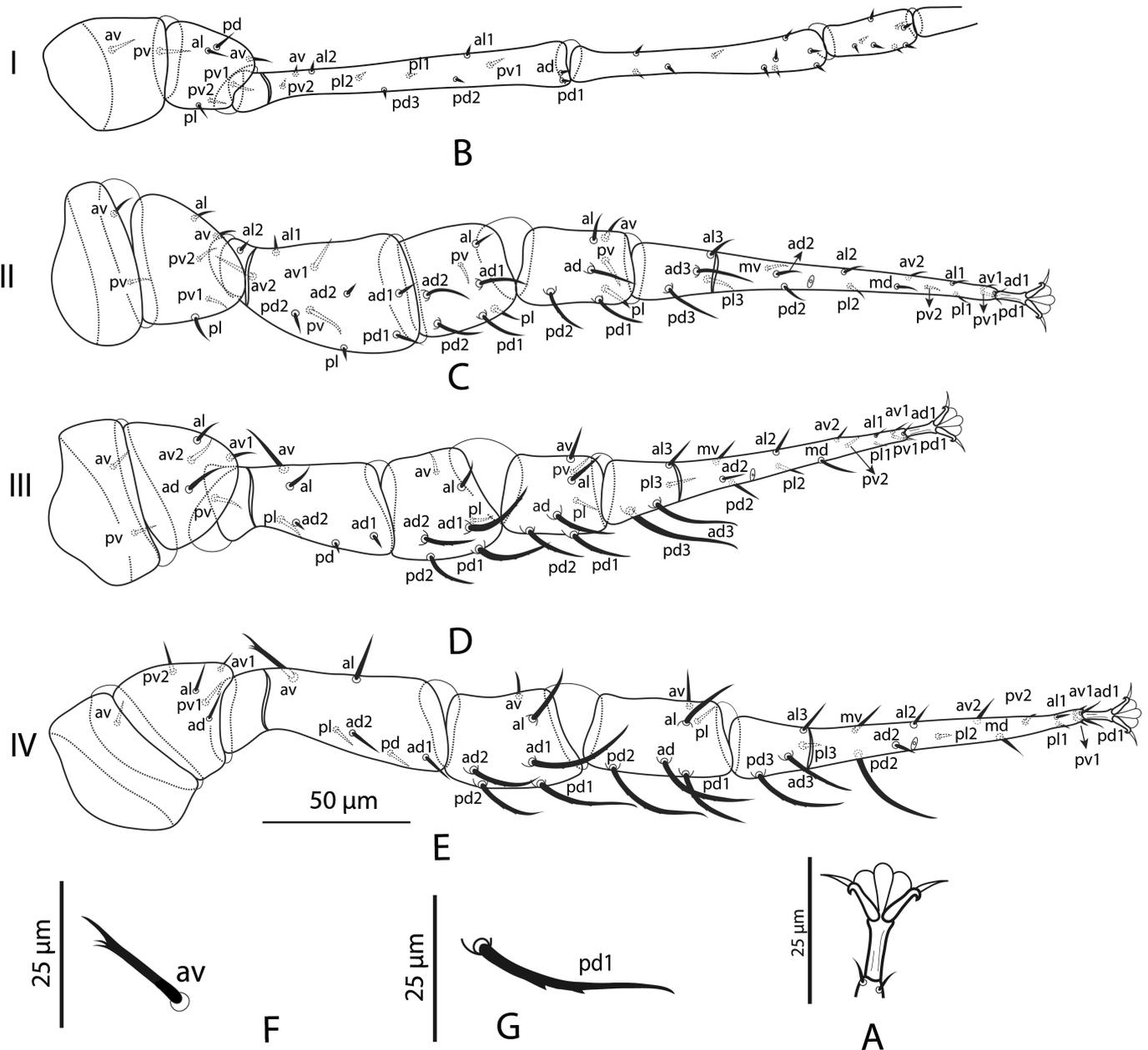


Figure 2 *Podocinella misella* (Berlese, 1913). Adult female. A – Pretarsus of leg II; B – Leg I; C – Leg II; D – Leg III; E – Leg IV; F – Detail of seta *av* of femur IV; G – Detail of seta *pd1* of genu IV. Based on specimens collected in Jaboticabal, Brazil.

be inferred from the illustrations provided and that setations of femur, genu and tibia (most variable segments between species) are provided.

New characterization of *Podocinella* (adult female)

***Podocinella* Evans & Hyatt, 1958: 926**

Type species — *Podocinum plumosa* Evans & Hyatt, 1958, by original designation.

Gnathosoma — Anterior region of epistome with three distal extensions, spiculate or not. Hypostome with *h2* much shorter than *h1*, *h3* and *pc*. Deutosternum delimited by lateral lines (*P. misella*) or not visible (*P. plumosa*), usually with smooth anteriormost transverse line followed

by five (*P. plumosa*) or six (*P. misella*) rows of 12–23 denticles each. Palp tarsal apotele 3-tined. Cheliceral digits similar in length; fixed and movable digits with 5–6 and two teeth, respectively. Idiosomal dorsum. Podonotal and opisthonotal shields fused, covered with small protuberances aligned to constitute a polygonal network (not discernible in *P. meghalayaensis* Bhattacharyya), with or without lateral notch between Z1 and Z3. Dorsal shield with 17–23 pairs of setae (11 in the illustration of *P. meghalayaensis*; a few setae not discernible, according to Bhattacharyya, 1994), without supernumerary setae; seta *j1* usually present (absent in *P. alstoni* Evans & Hyatt and *P. plumosa*). Soft lateral cuticle of idiosoma without setae. Dorsal setae serrate (also referred to as ciliate, plumose or pilose by various authors), stout or slender. Idiosomal venter. Sternal shield with three pairs of setae of similar lengths (*st1–st3*); seta *st4* inserted on metasternal plate (apparently on soft cuticle in *P. misella*); lyrifissures (*iv1–iv3*) indistinct. Genital shield bearing *st5*, posteriorly truncate to slightly convex. Pore *gv2* (*P. misella*) on unsclerotised cuticle. Without metapodal plates. Ventrianal shield with three or four pairs of setae in addition to circumanal setae; para-anal and post-anal setae similar in length. soft opisthogastric cuticle with 0–3 pairs of setae.

Peritreme and peritrematic plate — Peritreme about as wide as stigma, usually extending forward beyond level of *j1*.

Spermathecal apparatus — Indistinct.

Legs — Leg I much longer than legs II–IV, antenna-like, terminating in a whip-like seta, without pretarsi. Legs II–IV with median section of pulvilli rounded, paradactyli elongate and acuminate.

Male — Unknown.

Remarks — The indistinct sperm access system in *Podocinella* and the apparent absence of males in this genus lead to the assumption that species of this genus could reproduce by thelytoky. This type of parthenogenesis has been proven by Wong (1967) for *Podocinum pacificum*.

Key to the world species of *Podocinella* (based on females)

1. Ventrianal shield with three pairs of setae (*Jv5* absent) in addition to circumanal setae 2
— Ventrianal shield with four pairs of setae (*Jv5* present) in addition to circumanal setae 4
2. Seta *j1* present; with three pairs of opisthogastric setae on soft cuticle
..... *Podocinella meghalayaensis* Bhattacharyya 1994; India
— Seta *j1* absent; without opisthogastric setae on soft cuticle 3
3. Dorsal shield with 23 pairs of setae; ventrianal setae of approximately similar lengths
..... *Podocinella plumosa* Evans & Hyatt, 1958; Indonesia
— Dorsal shield with 18 pairs of setae; ventrianal shield with *Jv5* distinctly longer than the other opisthogastric setae
..... *Podocinella alstoni* Evans & Hyatt, 1958; Indonesia
4. Seta *j1* slightly pilose; *j2* at least 4x the length of *j1*; *z5* present
..... *Podocinella misella* (Berlese, 1913); Indonesia
— Seta *j1* strongly pilose; *j2* at least 3x the length of *j1*; *z5* absent
..... *Podocinella poetica* Ishikawa, 1976; Malaysia

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