

## REDESCRIPTION OF THE FEMALE OF *PODOCINUM CATENUM* ISHIKAWA, 1970 (ACARI: MESOSTIGMATA: PODOCINIDAE) WITH NEW RECORDS IN WESTERN SIBERIA

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ABSTRACT: A detailed redescription of a female *Podocinum catenum* Ishikawa, 1970 is provided with the aid of SEM microscopy. *P. catenum* is recorded for the first time from Western Siberia. Our finding is the northernmost locality for the family Podocinidae (57°21'N). A key to the species of *Podocinum* occurring in Asian Russia is provided.

KEY WORDS: Mite, Parasitiformes, Gamasina, morphology, SEM microscopy.

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### INTRODUCTION

Predatory mites of the genus *Podocinum* Berlese, 1882 are free-living representatives of the soil fauna. Most species of this genus are known from Asia, but some species have been reported from the North and South America, Europe, Africa, and Australia (Evans and Hyatt 1958; Athias-Henriot 1959; De Leon 1964; Bregetova 1977; Błaszak and Alberti 1985; Lindquist and Wu 1987; Halliday 1990; Yan *et al.* 2012; Santos *et al.* 2017). Currently, the genus *Podocinum* includes 31 described species (Yan *et al.* 2012; Santos *et al.* 2017).

Three species of the genus *Podocinum* have been reported from the Asian Russia: *Podocinum aokii* Ishikawa, 1970; *P. catenum* Ishikawa, 1970; *P. sibiricum* Volonikhina, 1999. All of them, with the exception of *P. sibiricum*, are known only from the Far East (Bregetova 1977; Volonikhina 1999).

During the survey of the soil mites in Western Siberia (Tyumen Region), a series of female specimens of the genus *Podocinum* were collected. They were identified as *Podocinum catenum*. This species was described from Japan, although it also occurs in the Far East of Russia (Kamchatka Peninsula, Sakhalin and Kunashir Islands, Primorsky Territory, Khabarovskii Territory) (Bregetova 1977; Volonikhina 1999).

The purpose of this paper is to redescribe and provide SEM illustrations of *Podocinum catenum* females.

### MATERIAL AND METHODS

The mites were collected from the soil and litter using Berlese funnels, and were preserved in

plastic vials filled with ethanol. Some specimens were mounted in Hoyer's medium for the purposes of light-microscopy. The morphology of mites was studied with the aid of an Axioskop 40 microscope (Carl Zeiss) and an Axio Imager A2 microscope (Carl Zeiss) with DIC and phase-contrast objectives. For SEM microscopy, alcohol-preserved mites were dried in a JFD 320 freeze dryer (JEOL), dusted with gold and scanned using a JSM-6510LV SEM microscope (JEOL).

The morphological terminology generally follows Evans and Till (1979). Dorsal and ventral setae were labelled according to the systems of Lindquist and Evans (1965). Palpal and leg chaetotaxy follows Evans (1963a, b). All pore-like structures on dorsal shield, glandular openings (solenostomes) and poroids (lyrifissures) are designated as "pores". The notation for ventral idiosomal pore-like structures, both gland pores and poroids, generally follows Athias-Henriot (1971, 1975). Lengths of shields were measured from the anterior to posterior shield margins along the midline. The length of the second cheliceral segment was measured from its base to the apex of the fixed digit. The lengths of legs were measured from the base of the coxa to the apex of the tarsus, excluding the ambulacrum. The measurements are given in micrometers (µm). *Podocinum catenum* Ishikawa, 1970 is redescribed based on the specimens collected in Western Siberia (Tyumen Region). The main measurements of mites from Western Siberia and other regions of Russia (Northern Altai, Khabarovskii Territory, Primorskii Territory and

Sakhalin) are given in Table 1. The studied material has been deposited in the Zoological Museum of Tyumen State University (Tyumen, Russia), in the collections of the Department of Zoology of Odessa I.I. Mechnikov National University (Odessa, Ukraine) and in the Zoological Museum of Institute of Systematics and Ecology of Animals (Novosibirsk, Russia).

## SYSTEMATICS

### Family Podocinidae

#### Genus *Podocinum* Berlese, 1882b

Type species: *Laelaps sagax* Berlese, 1882a, by original designation

**Diagnosis.** The diagnosis of *Podocinum* used here is based on that of Santos *et al.* (2017).

#### **PODOCINUM CATENUM ISHIKAWA, 1970**

Figs. 1–29

*Podocinum catenum* Ishikawa, 1970, p. 116, figs. 14–20.

**Diagnosis.** Dorsal shield without lateral incisions; all surface covered by small angular protuberances connected by bridges (generally) and arranged in a distinct polygonal network of pentagons–heptagons; with 19 pairs of setae (setae *j1*, *j3*, *j5*, *j6*, *z5*, *s2*–*s5*, *S4* smooth and blunted; setae *j2*, *J3*–*J5*, *Z3*, *Z4*, *S5* thick, long and strongly serrated; setae *J1*, *Z1* slightly thickened and serrated). Ventrianal shield inverted dome-shaped; its length/width ratio 0.75–0.90; setae *JV5* absent. Left and right peritremes fused in front of anterior margin of dorsal shield. Central extension of epistome with two–five branches (usually bifurcate); subcapitular seta *hp2* inserted slightly posteriad of *hp3*; palptarsal apotele 3-tined. Tarsi II–IV with 18 setae (3 3/2 1/1 3/2 3); largest sub-distal seta on tarsus I short, usually shorter than the half of the distance between its base and apex of tarsus.

**Redescription of female** (Figs. 1–29). Twelve specimens from Western Siberia measured.

*Idiosomal dorsum* (Figs. 1, 16–22). Dorsal shield ovoid, golden-brown in colour, without lateral incisions, its laterocaudal margin bent ventrally; 437–497 long and 304–381 maximum wide at *Z1* level; surface covered by small protuberances usually connected by bridges and arranged in a distinct polygonal pentagon–heptagon network (Figs. 19, 21); with 19 pairs of setae (*j1*–*j3*, *j5*, *j6*, *z5*, *s2*–*s5*, *J1*, *J3*, *J4*, *J5*, *Z1*, *Z3*, *Z4*, *S4*, *S5*, setae *S4* and base of setae *S5* visible ventrally) and nine pairs of distinguishable pore-like structures (Fig. 22). Setae *j1*, *j3*, *j5*, *j6*, *z5*, *s2*–*s5*, *S4* smooth and blunted (Fig. 21);

setae *j2*, *J3*–*J5*, *Z3*, *Z4*, *S5* thick, long and strongly serrated (Figs. 18, 20); setae *J1*, *Z1* slightly thickened and serrated; lengths of setae: *j1* 9–13, *j2* 90–104, *j3* 11–15, *j5* 11–15, *j6* 11–15, *z5* 11–15, *s2* 11–14, *s3* 9–13, *s4* 11–15, *s5* 18–25, *J1* 21–27, *J3* 44–53, *J4* 82–107, *J5* 80–101, *Z1* 25–31, *Z3* 88–105, *Z4* 95–104, *S4* 13–20, *S5* 82–105.

*Idiosomal venter* (Figs. 2, 3, 23–26). Base of tritosternum indistinguishable; laciniae minute, smooth, 26–32 long, separated for about 95% of their total length. Pre-sternal area without platelets. Sternal shield fused with endopodal platelets of coxae I/II and coxae II/III; 59–63 long along midline, 126–150 wide at level of endopodal projections between coxae I/II, 138–164 wide at level of endopodal projections between coxae II/III, 84–103 wide at mid-level of coxae II (narrowest part); with three pairs of setae (*st1*–*st3*), without pores; posterior margin weakly concave; reticulated over all of surface except smooth area between setae *st1*. Setae *st4* located on metasternal platelets; poroids *iv3* absent. Epigynal shield triangular with rounded anterior margin; 116–139 long, with greatest width in posterior part 135–147; with number of longitudinal lines; with a pair of setae *st5* and poroids *iv5*. Clear endopodal plates formed between coxae III and IV (Fig. 24). Gland pores *gv2* located on soft cuticle behind coxae IV. Ventrianal shield roundish triangular in form, posterior margin indented medially; 147–163 long and 176–197 wide, length/width ratio 0.79–0.90; shield ornamented with transverse lines anteriorly; anus flanked by ornamental archeslaterally; cribrum well developed; shield with four pairs of opisthogastric setae (*JV1*, *JV3*, *JV4* and *ZV2*) in addition to circumanal setae and two pairs of pores (including *gv3*) (Fig. 25). Soft cuticle around ventrianal shield without metapodal platelets and setae. All ventral setae simple and pointed; lengths of setae: *st1* 20–26, *st2* 20–26, *st3* 20–24, *st4* 19–21, *st5* 17–24, *JV1* 17–24, *JV3* 17–24, *JV4* 26–33, *ZV2* 18–26, para-anal seta 15–20, post-anal seta 13–19. Exopodal platelets laterad coxae II–IV merged into a band fused posteriorly with reduced peritrematal shield. Left and right peritremes fused in front of anterior margin of dorsal shield. Peritrematic plate fused with dorsal shield at level of setae *j3*–*s2*, extending posteriad beyond coxa IV up to level of posterior margin of epigynal shield (Figs. 19, 26), bearing only one pore, namely *gp3*. Spermathecal apparatus weakly sclerotized; induction pore (solenostome) apparently at posteroproximal region of coxa III; tubuli long and fusing before entering sacciform sacculus (Fig. 3).

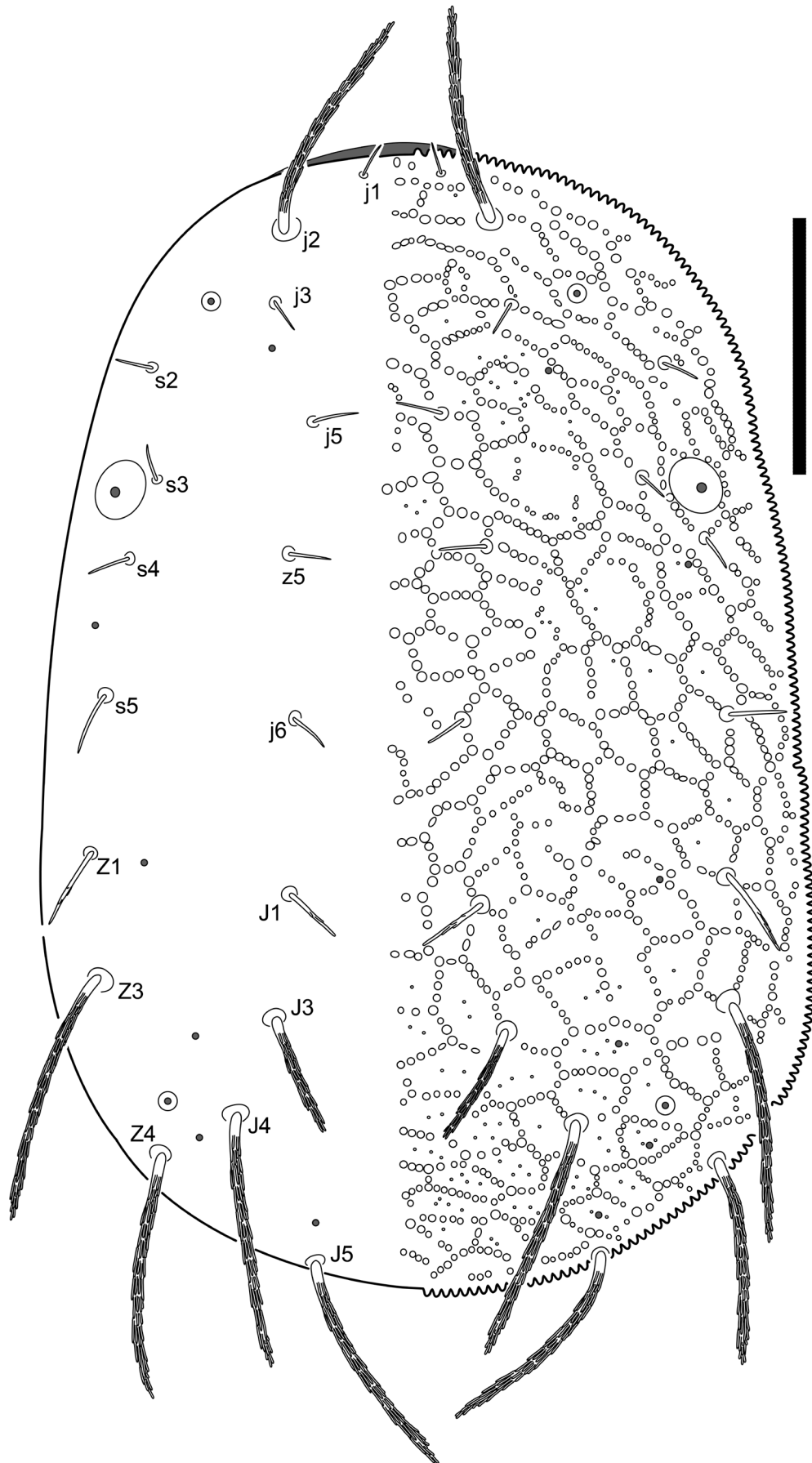
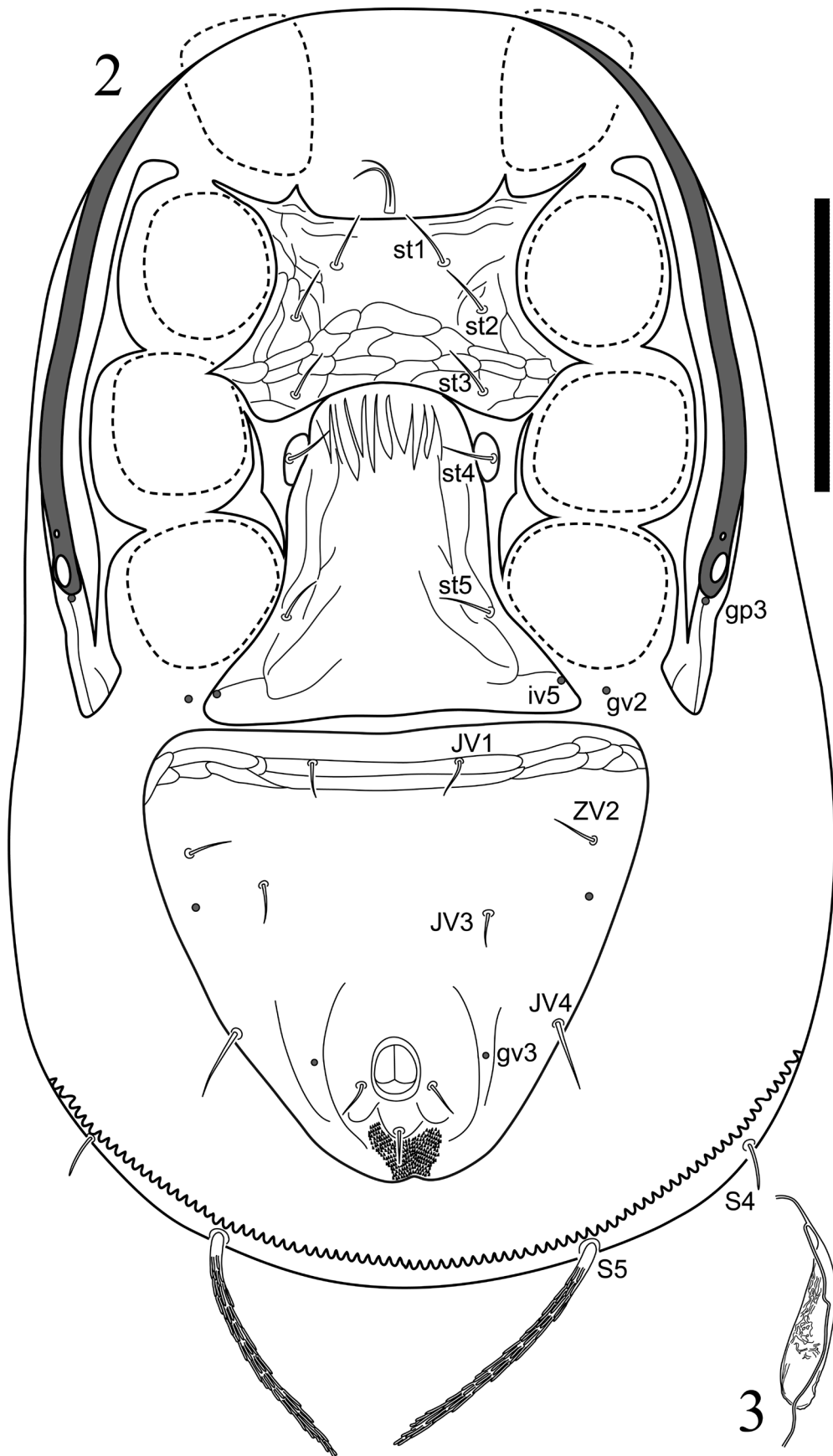
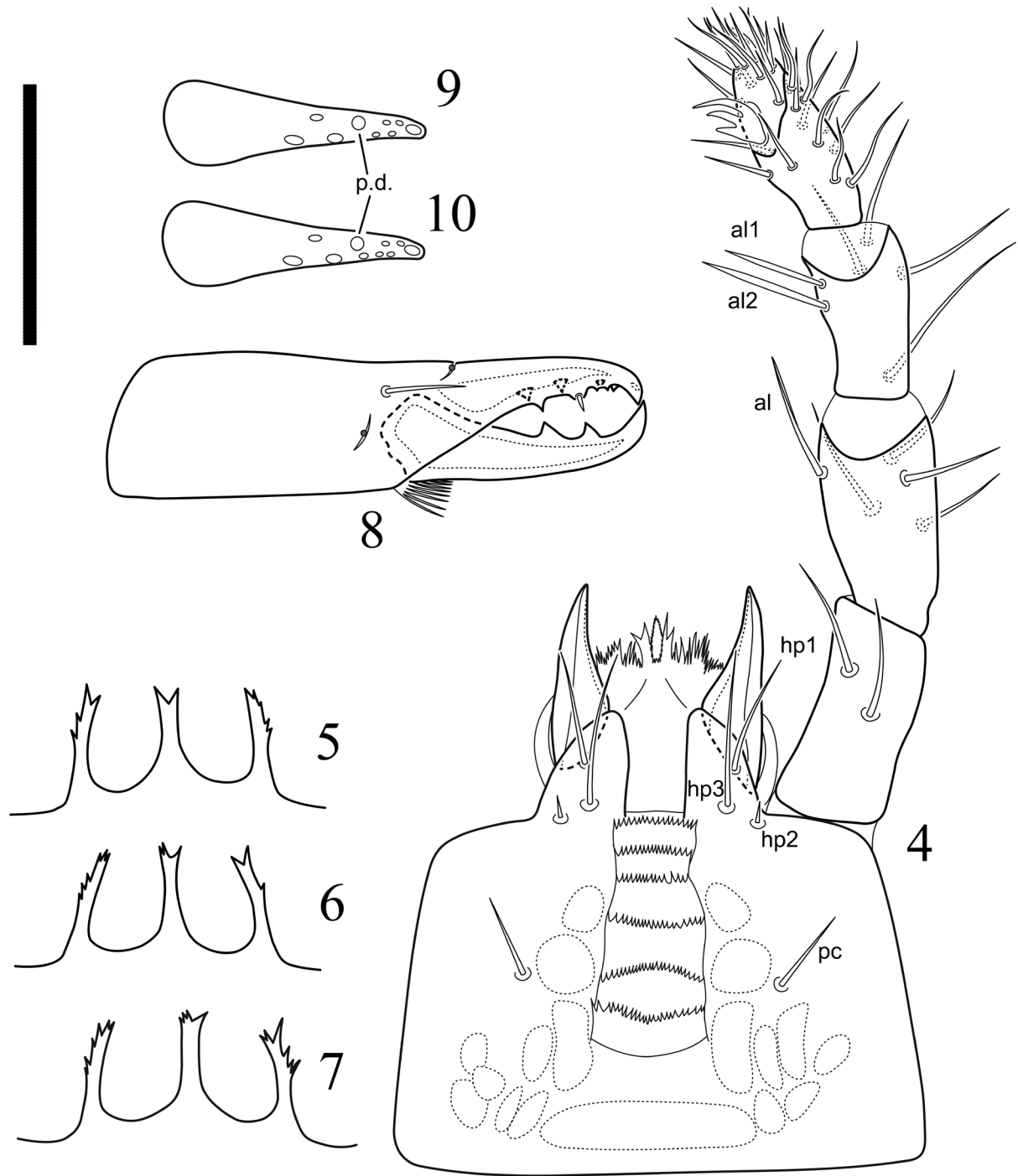


Fig. 1. *Podocinum catenum* Ishikawa, 1970, female: idiosoma, dorsal view. Scale bar=100  $\mu$ m.



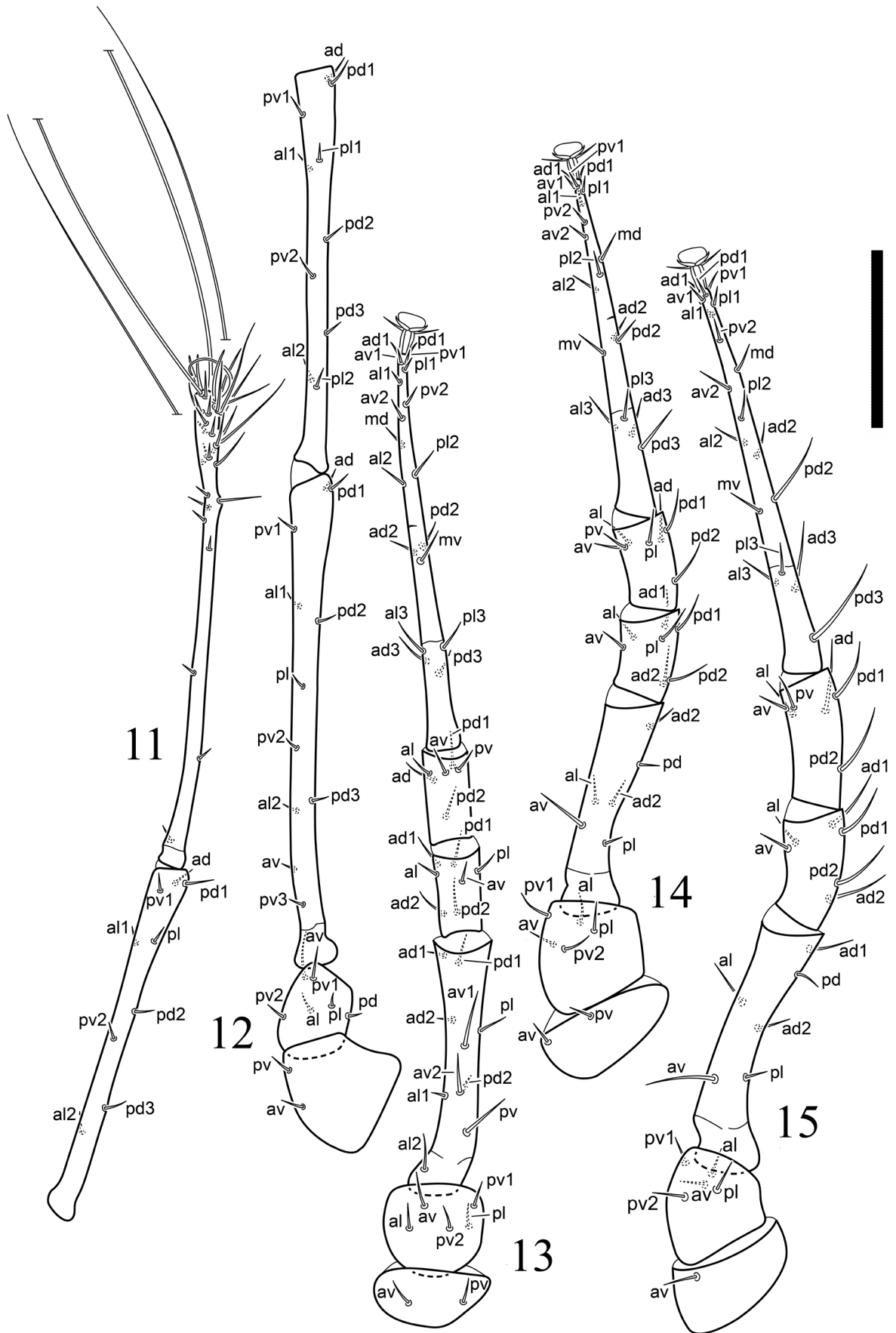
Figs. 2–3. *Podocinum catenum* Ishikawa, 1970, female: 2—idiosoma, ventral view; 3—spermathecal apparatus. Scale bar=100  $\mu$ m.



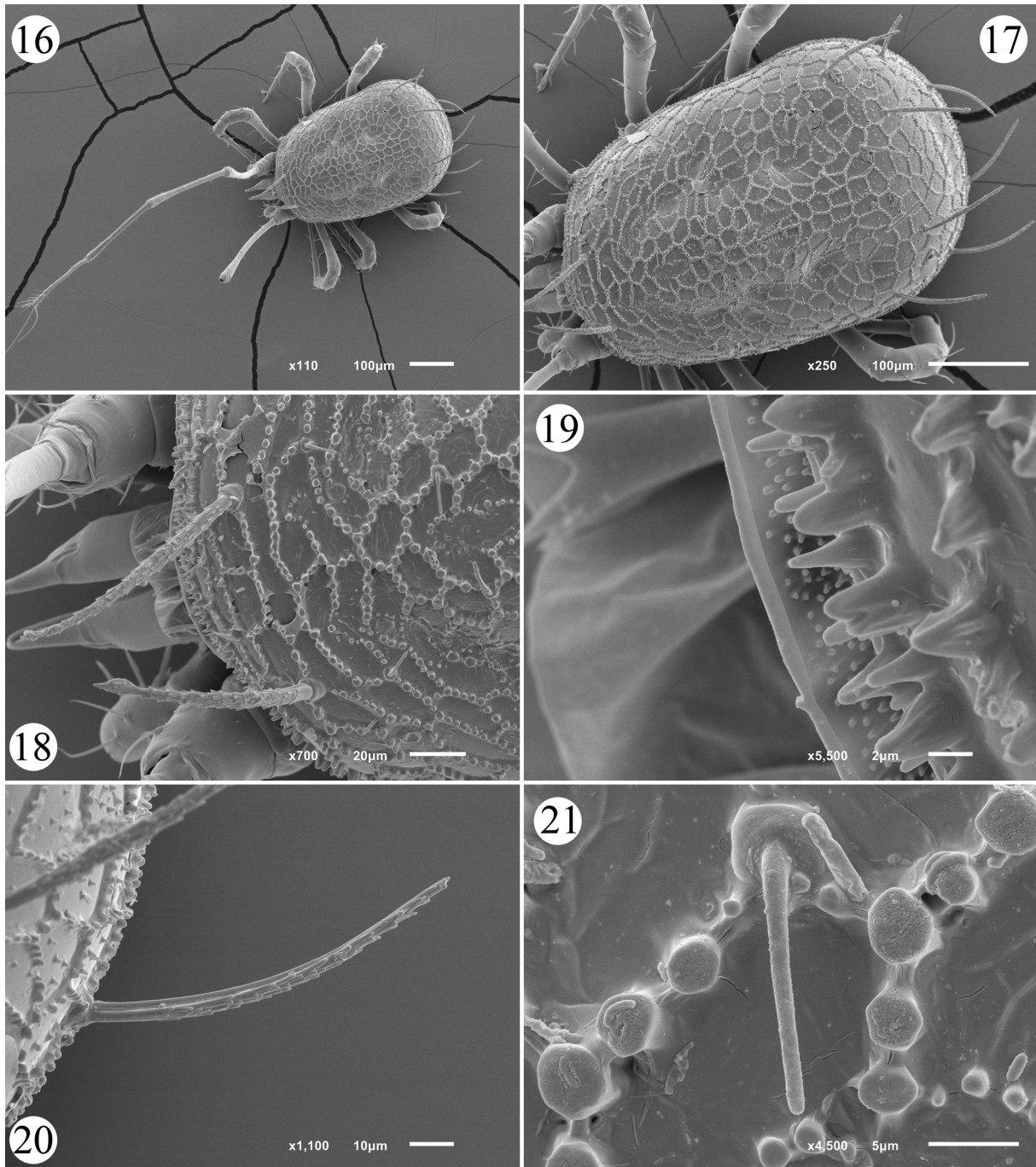
Figs. 4–10. *Podocinum catenum* Ishikawa, 1970, female: 4—subcapitulum and palp; 5–7—variety of shape of epistome; 8—chelicera, lateral view; 9–10—variety of shape of fixed digit, ventral view. Scale bar=50  $\mu$ m.

*Gnathosoma* (Figs. 4–10, 18, 27–29). Anterior region of epistome with three distally divided extensions, lateral extensions with outer margin denticulate, central extension with two–five branches (usually bifurcate) (Figs. 5–7, 29). Subcapitulum 97–108 wide, 107–119 long. Deutosternum with six rows of small denticles, all rows

connected by lateral lines; anterior three rows each with 15–20 denticles, posterior three rows each with 20–25 denticles. Subcapitular setae lengths: palpcoxal seta (*pc*) 17–20, *hp1* 19–26, *hp2* 5–8, *hp3* 25–34; seta *hp3* inserted slightly anterior of *hp2*. Corniculi 30–37 long, 10–15 wide, horn-like. Internal malae fused and fringed, their internal



Figs. 11–15. *Podocinum catenum* Ishikawa, 1970, female: 11—tibia I-tarsus I; 12—coxa I-genu I; 13—leg II; 14—leg III; 15—leg IV, ventral view. Scale bar=100  $\mu$ m.

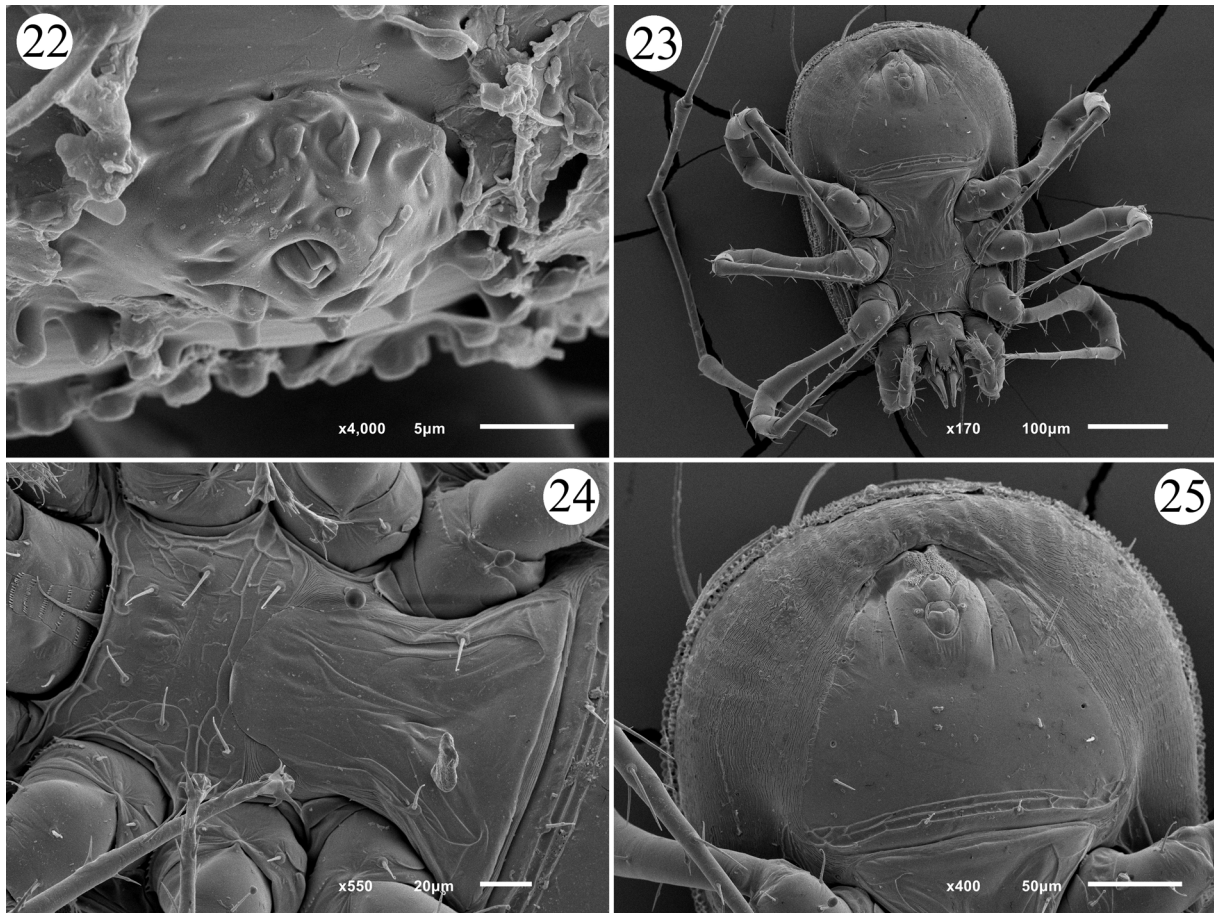


Figs. 16–21. *Podocinum catenum* Ishikawa, 1970, female, SEM micrographs: 16—general view, dorsally; 17—idiosoma, dorsally; 18—front of idiosoma, dorsal view; 19—anterior margin of dorsal shield with fused peritremes; 20—modified dorsal seta; 21—simple dorsal seta and fragment of dorsal shield ornamentation.

processes reaching tip of labrum and not reaching tips of corniculi (Figs. 4, 27, 28). Palp length from trochanter base to tarsus apex 164–174; setal formula: 2–5–6–14–15; palpfemoral seta *al* slightly curved and spatulate, palpgenual setae *all* and *al2* xiphoid, palptarsal apotele 3-tined (Figs. 27, 28). Second cheliceral segment length 105–109, movable and fixed digits of equal length, 48–53. Fixed cheliceral digit with three larger teeth, four (rarely

five) smaller teeth and pilus dentilis on a roundish elevated base in addition to apical hook; antiaxial and dorsal lyrifissure, and chelaseta distinct; movable digit with two teeth in addition to apical hook (Figs. 8–10, 29).

*Legs* (Figs. 11–15). Lengths: I 1,022–1,144, II 539–558, III 493–539, IV 586–632. Leg chaetotactic formulae – leg I: coxa 2, trochanter 6 (1 0/1 1/2 1), femur 11 (2 1/1 3/2 2), genu 10 (2 1/0 3/2 2),



Figs. 22–25. *Podocinum catenum* Ishikawa, 1970, female, SEM micrographs: 22—largest dorsal pore; 23— general view, ventrally; 24—sternal–genital region; 25—ventrianal region.

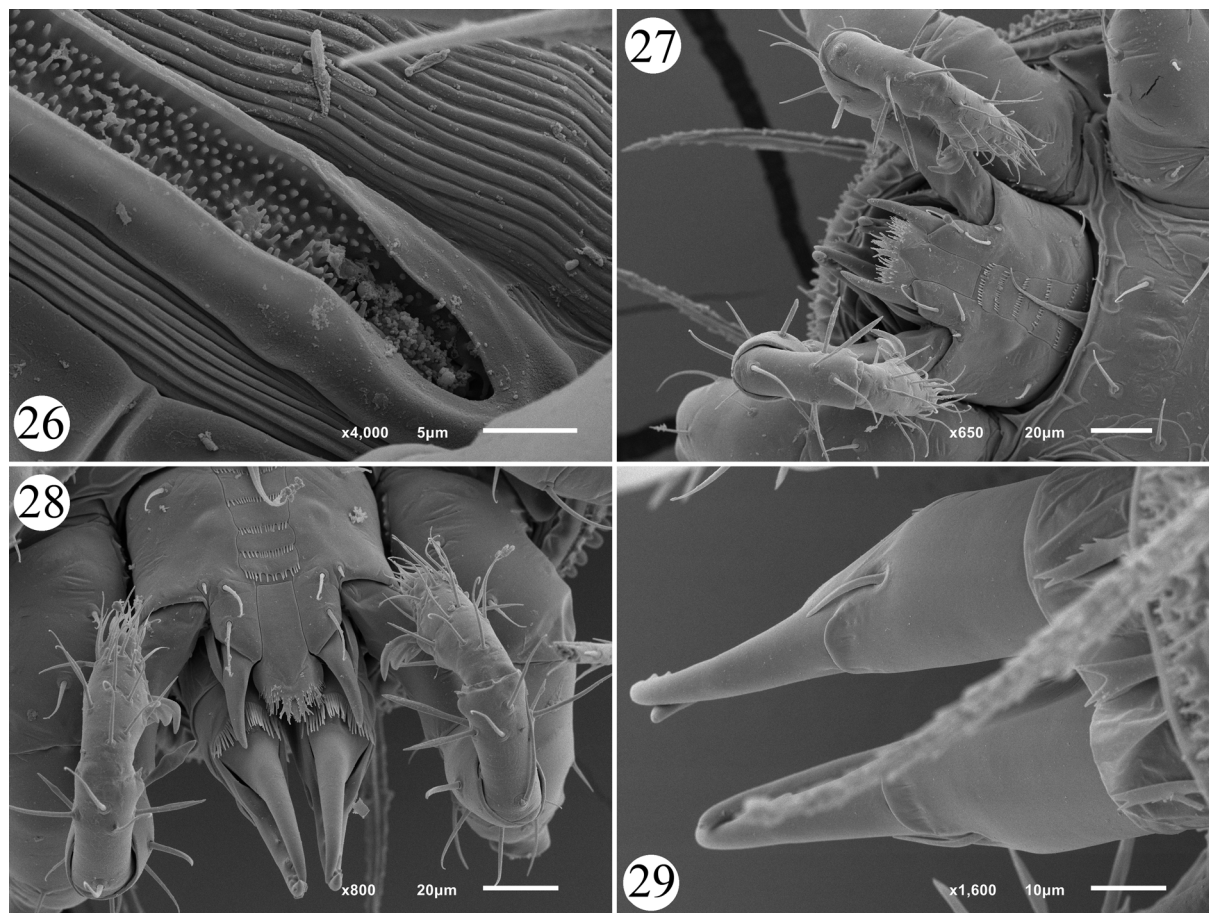
tibia 9 (2 1/0 3/2 1); leg II: coxa 2, trochanter 5 (1 0/1 0/2 1), femur 10 (2 2/2 2/1 1), genu 7 (1 2/1 2/0 1), tibia 7 (1 1/1 2/1 1); leg III: coxa 2, trochanter 5 (1 0/1 0/2 1), femur 6 (1 2/1 1/0 1), genu 7 (1 2/1 2/0 1), tibia 7 (1 1/1 2/1 1); leg IV: coxa 1, trochanter 5 (1 0/1 0/2 1), femur 6 (1 2/1 1/0 1), genu 6 (1 2/0 2/1 0), tibia 6 (1 1/1 2/1 0). Tarsi II–IV: 18 (3 3/2 1/1 3/2 3). Tarsus I without ambulacrum, with a pair of very long (ca. 400 long) terminal setae, lengths of largest sub-distal setae 23–26, length from its base to apex of tarsus 59–66. Ambulacra of II–IV with claws, pulvilli rounded, paradactyli elongate and acuminate. All leg setae simple (excluding whip-like terminal setae on tarsus I).

**Material examined.** Five females, Russia, Tyumen Region, Nizhnetavdinsky District, vicinity of Lake Kuchak, 57°21'N, 66°03'E, from rotting wood in the linden forest, 1 August 2018, A.A. Khaustov coll.; seven females, same locality, 26 September 2018, A.A. Khaustov coll.; one female, North Altai, vicinity of Cherga village, 51°34'N, 85°33'E, *Betula* sp. forest, in litter, 22 July 1994, I.I. Volonikhina coll.; five females,

Khabarovskii Territory, Range Bolschoi Khekhtsir, 48°03'N, 134°41'E, mixed forest with *Pinus koraiensis*, in litter, 29 August 1991, I.I. Volonikhina coll.; five females, Khabarovskii Territory, Komsomolsk-na-Amure District, vicinity of Pivan village, 50°43'N, 137°04'E, *Quercus* sp. forest, in litter, 9 August 2009, V.V. Dubatolov coll.; five females, Primorskii Territory, Ussuriiskii Natural Reserve, 43°40'N, 132°32'E, mixed forest, in litter, 23 August 1978, V.V. Nikolskii; five females, South Sakhalin, vicinity of Nevelsk, 46°40'N, 141°51'E, mixed forest, in litter, 31 July 1990, I.I. Volonikhina coll.

**Remarks.** This discovery of *Podocinum catenum* is the northernmost locality for the family Podocinidae (57°20'N). Previously, only three species were known from the territories north of the 50°N latitude (all from Russia): *Podocinum catenum* was reported from south of Kamchatka Peninsula (exact locality not mentioned, probably ca. 50–55°N); *Podocinum pacificum* Berlese, 1895 was found in the Saratov Region (vicinity of Saratov, ca. 51°30'N); and *Podocinum sibiricum* was





Figs. 26–29. *Podocinum catenum* Ishikawa, 1970, female, SEM micrographs: 26—peritreme; 27–28—gnathosoma, ventral view; 29—chelicera, ventral view.

recorded in Northeast Altai (52°34'N) (Bregetova 1977; Marchenko 2010).

All studied individuals of *Podocinum catenum* were adult females, no males or immatures were found, although males of this species are described. Males of this genus are apparently rare. Of the 31 described species of *Podocinum*, males are known just in seven species so far (*Podocinum aciculatum* Evans and Hyatt, 1958; *P. aokii*; *P. catenum*; *P. jianfenglingense* Liang, 1993; *P. pintungense* Ho, Ma and Wang, 2009; *P. sagax* (Berlese, 1882); *P. tsushmanum* Ishikawa, 1970).

**Key to the species of *Podocinum* Berlese of Asian Russia (females)**

1. Shape of setae *J1* and *Z1* similar to shape of setae *j2*, *J3–J5*, *Z3*, *Z4*, *S5*; setae *J1* and *Z1* long enough to reach base of posterior seta next in series. Ratio (length/width) of ventrianal shield ca. 0.6. Largest sub-distal seta on tarsus I usually longer than the half of the distance between its base and apex of tarsus ..... *P. sibiricum* Volonikhina, 1999

— Setae *J1* and *Z1* slightly thickened and serrated (setae *j2*, *J3–J5*, *Z3*, *Z4*, *S5* robust and strongly serrated); setae *J1* and *Z1* shorter, never reach base posterior seta next in series. Ratio (length/width) of ventrianal shield ca. 0.8. Largest sub-distal seta on tarsus I usually shorter than the half of the distance between its base and apex of tarsus ..... 2  
2. Setae *j3*, *j5*, *j6*, *z5*, *s3–s5*, *S4* smooth. Protuberances on dorsal shield round or oval and normally connected by bridges....*P. catenum* Ishikawa, 1970  
— All or most of setae *j3*, *j5*, *j6*, *z5*, *s3–s5*, *S4* serrated. Protuberances on dorsal shield angular and not connected by bridges...*P. aokii* Ishikawa, 1970

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Redescription of the female of *Podocinum catenum*

Table 1

Measurements of *Podocinum catenum* Ishikawa, 1970 females from different regions of Asian Russia

Character	Tyumen Region		North Altai	Khabarovskii Territory (Range Bolschoi Khekhtsir)		Khabarovskii Territory (Komsomolsk-na-Amure District)		Primorskii Territory		South Sakhalin	
	n=12		n=1	n=5		n=5		n=5		n=5	
	min	max	–	min	max	min	max	min	max	min	max
length of dorsal shield	437	497	475	420	460	435	445	440	475	455	465
width of dorsal shield	304	381	350	300	327	310	320	320	325	315	330
seta <i>j1</i>	9	13	10	9	10	9	10	9	10	9	10
seta <i>j2</i>	90	104	95	100	100	95	100	90	93	88	95
seta <i>j3</i>	11	15	13	12	15	12	15	12	13	12	15
seta <i>j5</i>	11	15	13	12	15	12	15	12	15	12	15
seta <i>j6</i>	11	15	15	12	15	12	15	12	15	15	17
seta <i>z5</i>	11	15	15	12	15	12	15	12	15	12	15
seta <i>s2</i>	11	14	10	10	12	12	15	12	15	10	12
seta <i>s3</i>	9	13	10	10	12	12	15	12	15	10	12
seta <i>s4</i>	11	15	10	10	12	12	15	12	15	10	12
seta <i>s5</i>	18	25	13	10	12	20	22	17	18	12	17
seta <i>J1</i>	21	27	27	20	25	20	25	20	25	20	25
seta <i>J3</i>	44	53	50	37	50	40	45	40	48	37	43
seta <i>J4</i>	82	107	87	87	93	87	90	87	93	55	65
seta <i>J5</i>	80	101	87	75	87	87	90	80	82	55	65
seta <i>Z1</i>	25	31	30	25	30	30	35	27	35	17	23
seta <i>Z3</i>	88	105	93	85	98	90	95	75	88	55	65
seta <i>Z4</i>	95	104	95	88	100	87	90	80	88	65	80
seta <i>S4</i>	13	20	17	18	25	20	25	20	25	15	20
seta <i>S5</i>	82	105	90	75	88	95	100	75	83	65	75
width of epigynal shield	135	147	137	137	143	133	143	135	143	125	137
length of ventrianal shield	147	163	175	143	157	150	157	145	155	145	165
width of ventrianal shield	176	197	200	177	192	187	200	180	193	177	190
ratio (length / width) of ventrianal shield	0.79	0.90	0.88	0.75	0.84	0.75	0.80	0.76	0.83	0.75	0.86
seta <i>JV1</i>	17	24	17	13	17	15	17	17	18	17	20
seta <i>JV3</i>	17	24	20	13	17	17	20	17	20	17	20
seta <i>JV4</i>	26	33	33	30	33	35	37	33	40	27	30
seta <i>ZV2</i>	18	26	23	13	17	17	20	18	23	17	20
para-anal seta	15	20	20	13	17	15	17	17	20	17	20
post-anal seta	13	19	17	13	17	13	15	15	17	15	17
length of leg I	1,022	1,144	1,115	1,095	1,130	1,087	1,100	1,100	1,150	1,000	1,075
length of largest sub-distal seta on tarsus I	23	26	25	20	23	20	25	15	25	25	35
length from base of largest sub-distal seta to apex of tarsus I	59	66	63	58	63	58	63	58	65	58	63