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Morphological ontogeny of *Platynothrus troendelagicus* sp. nov. (Acari, Oribatida, Camisiidae) from Norway

ANNA SENICZAK[a*], STANISŁAW SENICZAK[b], KRISTIAN HASSEL[c] & KJELL IVAR FLATBERG[c]

[a]*Department of Natural History, University Museum of Bergen, University of Bergen, Bergen, Norway*
[b]*Department of Evolutionary Biology, Faculty of Biological Sciences, Kazimierz Wielki University, Bydgoszcz, Poland*
[c]*Department of Natural History, NTNU University Museum, Norwegian University of Science and Technology, Trondheim, Norway*
[*]*Corresponding author: Anna.Seniczak@uib.no*

Abstract

The morphological ontogeny of *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.** is described and illustrated. This species was found in two Atlantic raised bogs in Trøndelag, Norway, and based on comparison of cytochrome oxidase I (COI) nucleotide sequences, it also occurs in Ireland and Canada. It is the most similar to *P. punctatus* (L. Koch, 1879) as adult, but differs from it mainly by having more genital setae, longer seta f_2, alveolar seta *exp* and only one pair of hypostomal setae *m*. In all juveniles of *P. troendelagicus*, the bothridial seta and exobothridial seta *exa* are short, and *exp* is alveolar. In the larva, seta f_1 is setiform, but in the nymphs it is alveolar. Most prodorsal and gastronotal setae are short and smooth, except for longer and barbed f_2 and h_1 in the larva, and longer and finely barbed f_2, and *h*- and *p*-series in the nymphs. In all instars, one pair of hypostomal setae *m* is present, and palp femur has one seta. In the ontogeny of this species, many *l* setae appear on trochanter III and femora I–III, and *l* and *v* setae on tarsi, and the number of setae on femora of deutonymph to adult is diagnostic. Both species differ also by COI nucleotide sequence.

Keywords: oribatid mites, juveniles, leg setation, ecology, COI, Atlantic raised bog

Introduction

While working on the oribatid mites from two Atlantic raised bogs in Trøndelag, Central Norway, we found one species of *Platynothrus* Berlese, 1913, which is similar, but slightly smaller than *P. punctatus* (L. Koch, 1879) and is new to science. Systematic problems of *Platynothrus* were discussed by Seniczak *et al.* (2022), which also gave the diagnosis of this genus as follows: species of medium size to large (595–1220), with bacilliform bothridial seta and thickened head; number of hypostomal setae *m* varies within species and developmental stages; notogaster with 1–3 longitudinal ridges and 15 pairs of setae (f_1 absent, only alveolus of this seta remains), posterior setae without distinct apophyses; epimeres IV separated from each other and epimeres III separated from each other in half of diameter; epimere IV with three or four setae, 11–38 pairs of genital setae present, leg tarsi with one or three claws. Seniczak and Seniczak (2022) also gave the diagnosis of juveniles of *Platynothrus*: prodorsal setae *ro*, *le* and *in* of medium size or long, *exa* short and *exp* alveolar. Bothridium small, rounded, bothridial seta short or minute. Number of hypostomal setae *m* and length of gastronotal setae varies between species and developmental stages, seta f_1 setiform in larva, and alveolar in nymphs. Posterior gastronotal setae of nymphs without distinct apophyses. Number of genital setae and setae on femora of deutonymph and tritonymph varies between nymphs and species. According to Subías (2004, updated electronic version 2022), Seniczak *et al.* (2022) and

Seniczak and Seniczak (2022), *Platynothrus* comprises 26 nominative species and two subspecies, from which one is considered by Subías (2004, updated electronic version 2022) *species inquirenda*.

The morphology of juveniles of *Platynothrus* is insufficiently known. According to Norton and Ermilov (2014) and further literature (Seniczak *et al.* 2022; Seniczak & Seniczak 2022), the full morphological ontogeny of *P. altimontanus* Hammer, 1958, *P. bicarinatus* (Jacot, 1938), *P. coulsoni* A. *et* S. Seniczak, 2022, *P. peltifer* C.L. Koch, 1839 and *P. punctatus* (L. Koch, 1879) is only known, which constitutes 21% of *Platynothrus* species.

This paper aims to describe the morphological ontogeny of *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.** and compare it with congeners.

Material and methods

The adults and juveniles of *P. troendelagicus* A. *et* S. Seniczak **sp. nov.** used in this study were collected on June 29th and 30th 2020 by A. Seniczak, K.I. Flatberg and K. Hassel from *Sphagnum* mosses in two Atlantic raised bogs located in Trøndelag, Central Norway (Hitra, 63°29'20.4"N, 8°52'26.4"E, 49 m a. s. l. and Høstadmyra 63°24'18.0"N, 10°07'12.0"E, 107 m a. s. l.).

The Hitra island is characterised by mild oceanic climate, with the following data in the year of study (2020): a mean annual temperature of 8.1°C, annual precipitation of 1436.2 mm, the lowest temperature was -4.9°C, and the highest was 31.3°C. Høstadmyra has slightly colder and drier climate, comparing to Hitra, with a mean annual temperature of 6.6°C and annual precipitation of 1192.8 mm (both in 2020). The minimum temperature was -13.2°C and the maximum temperature was 30.8°C. Climatic data were taken from Norwegian Centre for Climate Services (available at https://seklima.met.no/).

In total 64 samples of *Sphagnum* mosses, each of 500 cm^3 were collected, including 28 samples in Hitra and 36 in Høstadmyra. Samples were transported in plastic bags in cool boxes for four days and extracted with Tullgren funnels in the Department of Natural History (University Museum of Bergen, University of Bergen, Norway) for ten days. The type specimens originate from a sample of *Sphagnum compactum* Lam. *et* DC. collected in a poor fen carpet site in Høstadmyra.

We investigated the density and stage structure of mites and based on 20 randomly selected adults we measured the body length and width, determined the sex ratio and number of gravid females and carried eggs. We measured total length (tip of rostrum to posterior edge of notogaster) in lateral aspect and width (widest part of notogaster) of mites in dorsal aspect, and size of anal and genital openings and setae perpendicularly to their length in µm. In a similar way we measured the morphological characters given in Table 1. Apical part of notogastral and gastronotal setae of *P. troendelagicus* is fragile, so we measured these setae, which looked undamaged.

The illustrations are limited to the body regions that show substantial differences between instars and were prepared from individuals mounted temporarily on slides in lactic acid. We used the following abbreviations in the text and figures: rostral (*ro*), lamellar (*le*), interlamellar (*in*) and exobothridial (*exa*, *exp*) setae, bothridium (*bo*), bothridial seta (*bs*), notogastral or gastronotal setae (*c*-, *d*-, *e*-, *f*-, *h*-, *p*-series), lyrifissures or cupules (*ia*, *im*, *ip*, *ih*, *ips*, *iad*, *ian*), cheliceral setae (*cha*, *chb*), Trägårdh organ (*Tg*), palp setae (*sup*, *d*, *l*, *cm*, *acm*, *lt*, *ul*, *su*) and solenidion ω, epimeral setae (*1a–c*, *2a*, *3a–c*, *4a–d*), genital setae (*g*), aggenital setae (*ag*), adanal and anal setae (*ad*-, *an*-series), leg solenidia (σ, φ, ω), famulus (ε) and setae (*bv*, *ev*, *d*, *l*, *v*, *ft*, *tc*, *it*, *pv*, *pl*, *a*, *s*, *p*, *u*). The leg setae *l* on femora, and *l* and *v* on tarsi were labelled according to their appearance in the ontogeny. Terminology used follows that of Grandjean (1939, 1953, 1971, 1972, 1974) and Norton and Behan-Pelletier (2009). The species nomenclature follows partly Subías (2004) and Norton and Ermilov (2014).

TABLE 1. Some morphological characters of instars of *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, (mean measurements of 2–10 specimens in µm); nd—not developed.

Morphological characters	Larva	Protonymph	Deutonymph	Tritonymph	Adult
Body length	314	400	494	578	709
Body width	139	185	225	286	397
Length of prodorsum	120	145	165	198	234
Length of: seta *ro*	17	20	24	27	40
seta *le*	21	23	32	61	79
seta *in*	22	28	37	41	63
seta *bs*	2	2	3	3	53
seta c_1	18	21	24	25	45
seta c_2	16	17	22	24	38
seta c_3	26	28	32	36	62
seta *cp*	19	21	24	26	54
seta d_1	17	23	28	32	42
seta d_2	18	26	35	38	56
seta e_1	19	24	30	34	45
seta e_2	24	34	38	43	42
seta f_1	16	lost	lost	lost	lost
seta f_2	27	42	55	64	96
seta h_1	32	45	59	82	85
seta h_2	17	36	56	80	82
seta h_3	nd	38	58	82	86
seta p_1	nd	38	57	81	71
seta p_3	nd	27	42	56	59
genital opening	nd	35	54	75	145
anal opening	64	89	99	148	185

For scanning electron microscopy (SEM), the mites were air-dried and coated with Au/Pd in a Polaron SC502 sputter coater and placed on Al-stubs with double-sided sticky carbon tape. Observations and micrographs were made with a QUANTA FEG 450 scanning electron microscope.

DNA barcoding

Six specimens of *P. troendelagicus* (three from Hitra and three from Høstadmyra) were used in this study. They were compared with *P. punctatus* from two sites: submerged mosses growing at the edge of a pool in Finse (Vestland, Western Norway, 60°34'48.0"N, 7°28'19.2"E, 1341 m a. s. l., 22.09.2019, leg. Anna Seniczak) and from *Sphagnum* mosses in peatland on Lydehorn (Bergen, Vestland, Western Norway, 60°22'12.0"N, 5°14'38.4"E, 293 m a. s. l., 05.10.2018, leg. Anna Seniczak). We used species of putatively close genera as outgroups, *Capillonothrus thori* (Berlese, 1904) (collected in peatland Borreguil de la Virgen in Sierra Nevada, Spain, 37°05'13.2"N, 3°22'26.4"W, 2494 m a. s. l., 18.08.2017, leg. Anna Seniczak and Emilia F. Ondoño), *Heminothrus targionii* (Berlese, 1885) (collected in Hitra together with *P. troendelagicus*, see above for details), and *Camisia foveolata* Hammer, 1955 (collected in Vestland, Hardanger, Finse, 60°35'34.8"N, 7°25'55.2"E, 1356 m a. s. l., 07.09.2018, leg. Anna Seniczak) (Table 2).

TABLE 2. Information about specimens used in this study; labels correspond to specimen numbers in BOLD database; ad—adult, juv—juvenile, NA—not available.

Species	Label	Stage	GeneBank access No	Locality	Coordinates	Elevation (m a. s. l.)	Sampling date
P. troendelagicus A. *et* S. Seniczak **sp. nov.**	MARBN222-21_*P. troendelagicus*	ad	ON964459	NO: Trøndelag, Høstadmyra	63°24'18.0"N, 10°07'12.0"E	107	30.07.2020
	MARBN223-21_*P. troendelagicus*	ad	ON964457	NO: Trøndelag, Høstadmyra	63°24'18.0"N, 10°07'12.0"E	107	30.07.2020
	MARBN224-21_*P. troendelagicus*	ad	ON964456	NO: Trøndelag, Høstadmyra	63°24'18.0"N, 10°07'12.0"E	107	30.07.2020
	MARBN225-21_*P. troendelagicus*	ad	ON964453	NO: Trøndelag, Hitra	63°29'20.4"N, 8°52'26.4"E	49	29.07.2020
	MARBN226-21_*P. troendelagicus*	ad	ON964455	NO: Trøndelag, Hitra	63°29'20.4"N, 8°52'26.4"E	49	29.07.2020
	MARBN227-21_*P. troendelagicus*	ad	ON964458	NO: Trøndelag, Hitra	63°29'20.4"N, 8°52'26.4"E	49	29.07.2020
	MARBN347-21_*Platynothrus*	ad	ON964454	IR: Leinster, Lullymore	53°16'48.0"N, 6°57'00.0"W	80	09.12.2014
	SSFDA3509-14_*Platynothrus*	NA	MF911250	CA: New Brunswick, Fundy NP	45°37'30.0"N, 65°03'36.0"W	336	30.05.2013
P. punctatus	MARBN096-21_*P. punctatus*	juv	OL671030	NO: Vestland, Hardanger, Finse	60°34'48.0"N, 7°28'19.2"E	1356	22.09.2019
	MARBN097-21_*P. punctatus*	ad	OL671034	NO: Vestland, Hardanger, Finse	60°34'48.0"N, 7°28'19.2"E	1356	22.09.2019
	MARBN098-21_*P. punctatus*	ad	OL671021	NO: Vestland, Hardanger, Finse	60°34'48.0"N, 7°28'19.2"E	1356	22.09.2019
	MARBN144-21_*P. punctatus*	ad	OL671029	NO: Vestland, Bergen, Lydehorn	60°22'12.0"N, 5°14'38.4"E	210	05.10.2018
	MARBN145-21_*P. punctatus*	ad	OL671037	NO: Vestland, Bergen, Lydehorn	60°22'12.0"N, 5°14'38.4"E	210	05.10.2018
	MARBN146-21_*P. punctatus*	ad	OL671031	NO: Vestland, Bergen, Lydehorn	60°22'12.0"N, 5°14'38.4"E	210	05.10.2018
Cam. foveolata	MARBN342-21_*C. foveolata*	ad	OL671028	NO: Vestland, Hardanger, Finse	60°35'34.8"N, 7°25'55.2"E	1356	07.09.2018
Cap. thori	MARBN185-21_*C. thori*	ad	OL671033	SP: Andalusia, Borreguil de la Virgen	37°05'13.2"N, 3°22'26.4"W	2502	18.08.2017
Hem. targionii	MARBN320-21_*H. targionii*	ad	OL671022	NO: Trøndelag, Hitra	63°29'20.4"N, 8°52'26.4"E	48	29.07.2020

Each specimen was photographed, and the photos are the vouchers that are available at Barcode of Life Data System (BOLD, http://boldsystems.org). The specimens were subsequently placed in a well containing 50 ml of 90% ethanol in a 96-well microplate and send to the Canadian Centre for DNA Barcoding (CCDB 2021). Mites were sequenced for the barcode region of the COI gene according to standard protocols at CCDB (www.ccdb.ca 34), using either LepF1/LepR1 (Hebert *et al.* 2003) or LCO1490/HCO2198 (Folmer *et al.* 1994) primer pairs. The DNA extracts were placed in archival storage at -80°C at the Canadian Centre for DNA Barcoding. The sequences are available in GenBank (accessions numbers in Table 2).

COI sequences (sequence length ≥ 407 bp) were blasted against GenBank in order to detect and exclude possible contaminations. In blast search two sequences of *Platynothrus* from other countries turned out to be very similar to those of *P. troendelagicus*, so they were included in the analyses. One of them was from Ireland (Leinster, Lullymore, 53°16'48.0"N, 6°57'00.0"W, 80 m a. s. l., 09.12.14, leg. Anna Seniczak and Thomas Bolger) and another one from Canada (Fundy National Park, New Brunswick, (45°37'30.0"N, 65°03'36.0"W, 336 m a. s. l., GenBank Accession number MF911250, Young *et al*. 2019). Sequence variation within *P. troendelagicus* specimens and between-species was calculated in BOLD using Kimura 2 Parameter distance model, pairwise deletion, and BOLD Aligner (Amino Acid based HMM). The sequences were aligned by eye and Neighbor joining trees were constructed using MEGA6 (Tamura *et al*. 2013). Joint neighborhood topologies were visualized in FigTree 1.4.2 (available at http://tree.bio.ed.ac.uk/software/figtree).

Platynothrus troendelagicus **A.** ***et*** **S. Seniczak sp. nov.**
(Figs. 1–21)

Diagnosis

Adult of medium size (length 663–722), with characters of *Platynothrus* given by Seniczak *et al.* (2022). Prodorsal setae *in* thin and of medium size, alveolar seta *exp* present. Bothridial seta of medium size, bacilliform, with thickened, barbed head. Notogastral setae (15 pairs) of medium size, setae f_2 longer than e_2. Adult with one pair of hypostomal setae *m*, palp femur with one seta. Three pairs of adanal setae and two pairs of anal setae present. Leg tarsi with one claw.

Juveniles with characters of *Platynothrus* given by Seniczak and Seniczak (2022). Most prodorsal and gastronotal setae short and smooth, except for longer and barbed f_2 and h_1 in larva, and longer and finely barbed f_2 and *h*- and *p*-series in nymphs. All juveniles with one pair of hypostomal setae *m*, palp femur with one seta.

Formula of genital setae of species 2-4-9-14 (protonymph to adult), and segments AD (protonymph to adult)—0333 and AN (deutonymph to adult) − 022. Formula of setae on femora I–IV of deutonymph 6-6-3-2, tritonymph 7-8-3-2 and adult 8-9-5-3.

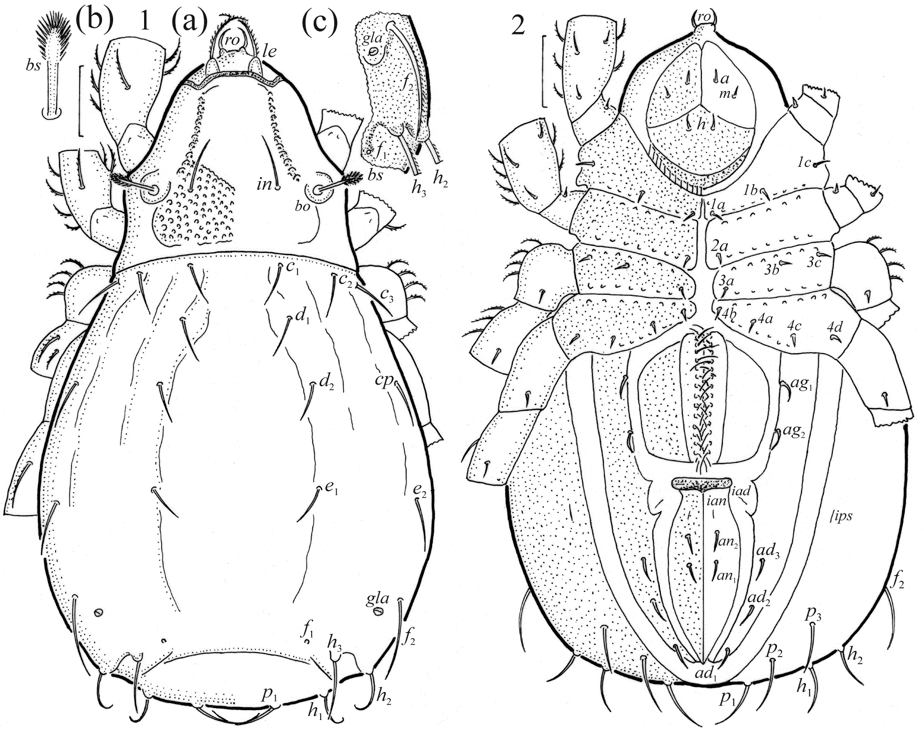
Morphology of adult

Measurements: body length (and range) of females 693.6±20.0 (663–722, n= 20) and width 418.9±12.2 (377–436), males absent.

Cerotegument. Brown with light spots and microporose.

Prodorsum. Rostrum rounded, with rostral setae short (*ro*, 39–41) and smooth (Figs. 1a, 2, 3a, 4, 5a, 6a, 6b, 7c, 7d), lamellar setae longer (*le*, 77–82) and finely barbed, inserted posterior to setae *ro* on large apophyses and transverse ridge; interlamellar setae *in* longest (*in*, 91–95), but thinner than *le* and smooth. Setal pair *ro* inserted close to each other, mutual distance between setal pair *le* about two times longer than between setal pair *ro*, and between setal pair *in* about four times longer than between setal pair *ro*. Bothridium (*bo*) small and rounded, located on large tubercle, bothridial seta (*bs*) of medium size (99–105), bacilliform, with thickened, barbed head (Figs. 1a, 1b, 3a, 4a–c, 5a, 5b, 6, 7a). Exobothridial seta *exa* short (18) and smooth, inserted lateral to *bo*, alveolar *exp* present. Central and anterior part of prodorsum with foveae (Figs. 1a, 4a–c, 5a, 5b, 6a–c).

Notogaster. Longer (444–484) than wide (377–436), with three pairs of longitudinal ridges, inner ridges better formed and longest, medial ridges shortest (Figs. 1a, 4a–c, 5c, 5d). Most notogastral setae (15 pairs, excluding alveolar f_1) relatively short or of medium size (38–86, Table 1) and smooth. Seta f_2 longer than e_2. Opisthonotal *gla* opening posteromedial to seta f_2 (Figs. 1a, 1c, 5c, 5d, 7b). Transverse ridge present posterior to setal pair h_3, alveolar seta f_1 anteromedial to seta h_3. Lyrifissure *ia* posterolateral to seta c_3, *im* posterolateral to seta *cp*, *ip* anterolateral to seta h_2, *ian* anterior to seta an_2, *iad* lateral to anterior part of anal plate, *ips* and *ih* displaced anterolateral to seta ad_3 (Figs. 2, 3a).



FIGURES 1–2. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, legs partially drawn, scale bars 50 µm. 1. (a) Dorsal aspect, (b) bothridial seta, (c) region of *gla* opening (b, c, enlarged). 2. Ventral aspect.

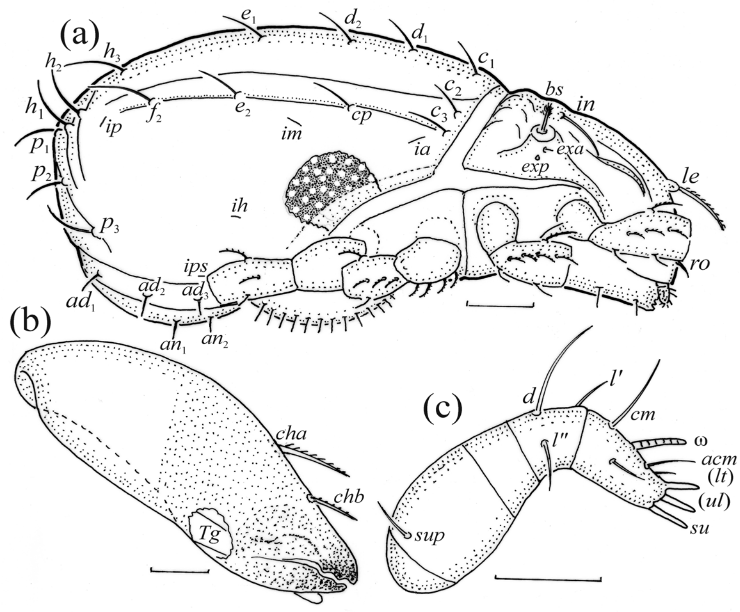


FIGURE 3. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult. (a) Lateral aspect, legs partially drawn, scale bar 50 µm; mouthparts, scale bars 20 µm, (b) chelicera, right side, antiaxial aspect, (c) palp, lateral aspect.

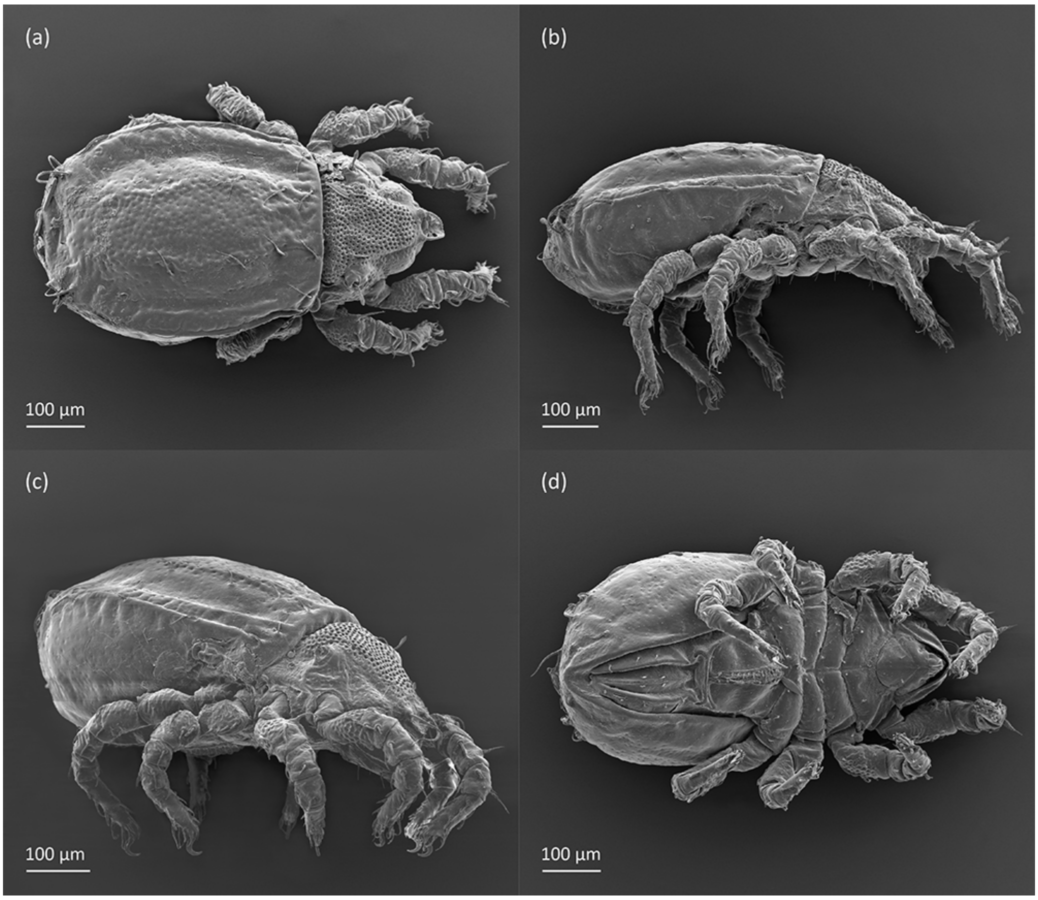


FIGURE 4. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov**, adult, SEM micrographs. (a) Dorsal view, (b) lateral view, (c) frontolateral view, (d) ventral view.

Gnathosoma. Subcapitular setea *h, m* and *a* short (5) and smooth, one pair of setae *m* present (Figs. 2, 7c, 7d). Chelicera (length 149, width 53) with short (23–25), barbed setae, *cha* slightly longer and thicker than *chb* (Fig. 3b). Palp short (length 61–63), with most setae short and smooth, except for slightly longer *d* and *cm* (Fig. 3c). Formula of palp setae (trochanter to tarsus + solenidion ω): 0-1-0-3-7(1).

Ventral aspect. All epimeral setae short (7–10) and smooth (Figs. 2, 4d, 7c, 8a, 8b), formula of epimeral setae 3-1-3-4. Aggenital setae (2 pairs) longer (17–19) than epimeral setae, genital setae (14 pairs) longest (38–42) and inserted on inner part of genital plates (Figs. 2, 8a, 8b); all smooth. Adanal setae (3 pairs) and anal setae (2 pairs) short (16–19), all smooth (Figs. 2, 8a, 8c).

Legs. Femora with reticulate integument (Figs. 4, 5, 6a, 6b, 7c, 8d, 9a, 10b). Most leg setae relatively thick, finely barbed, or smooth, except for longer setae on distal part of tarsi (Figs. 4, 5a, 5c, 5d, 6a, 6b, 7c, 8a, 8b, 8d, 9, 10). Seta *d* coupled to solenidion present on all genua and tibiae. Formulae of leg setae (and solenidia), trochanter to tarsus: I—1-8-5(1)-5(2)-23(3); II—1-9-5(1)-5(1)-21(2); III—5-5-4(1)-4(1)-21; IV—1-3-4(1)-4(1)-18 (Table 3). Leg tarsi monodactylous.

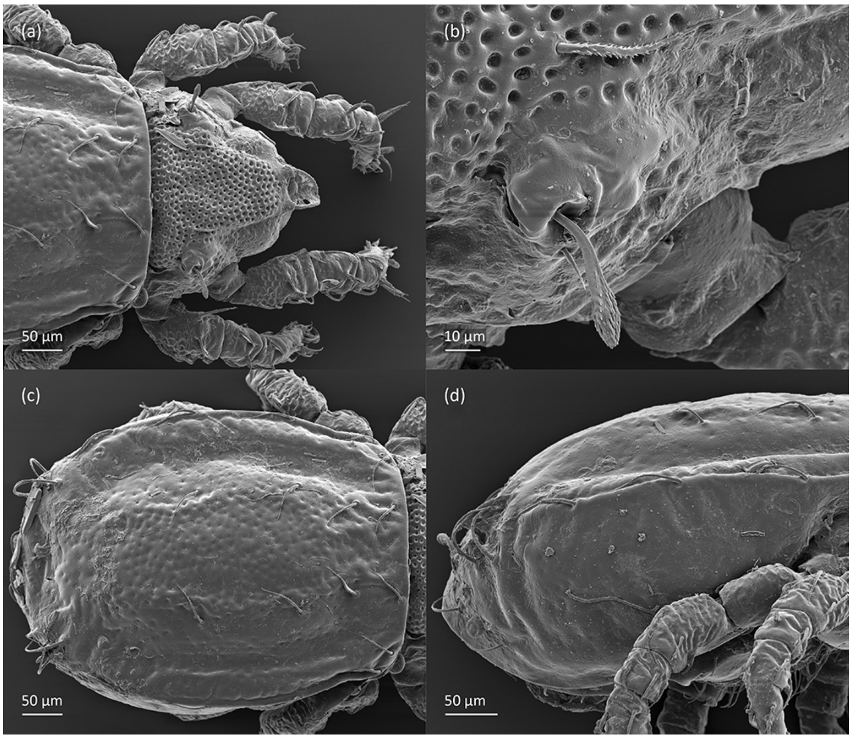


FIGURE 5. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, SEM micrographs. Dorsal view, (a), (b) anterior part, (c) posterior part; (d) posterior part, lateral view.

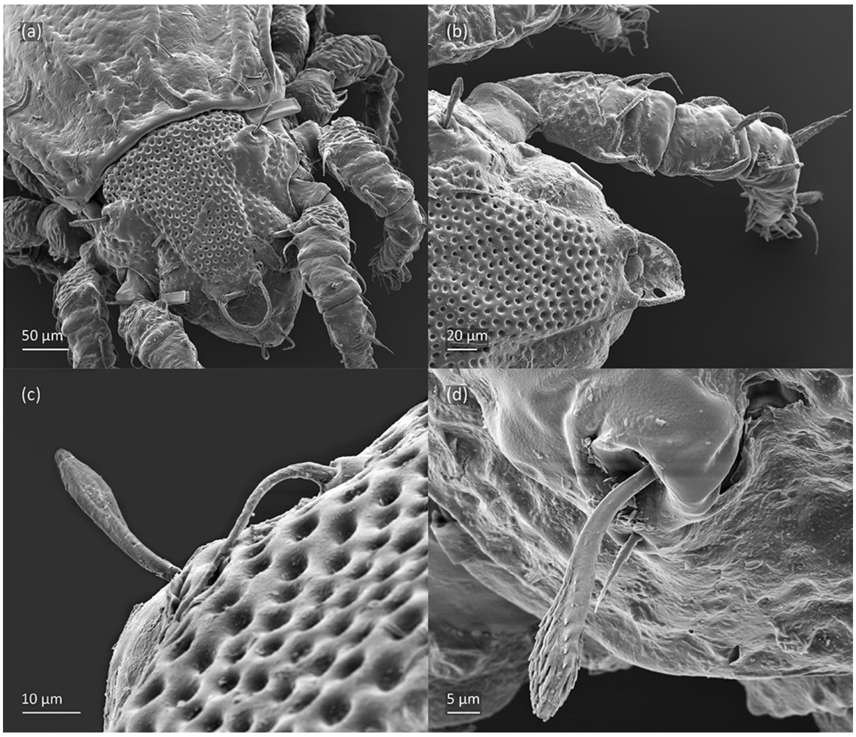


FIGURE 6. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, SEM micrographs. Dorsal view, (a), (b) anterior part, (c), (d) bothridium and bothridial seta, dorsal view.

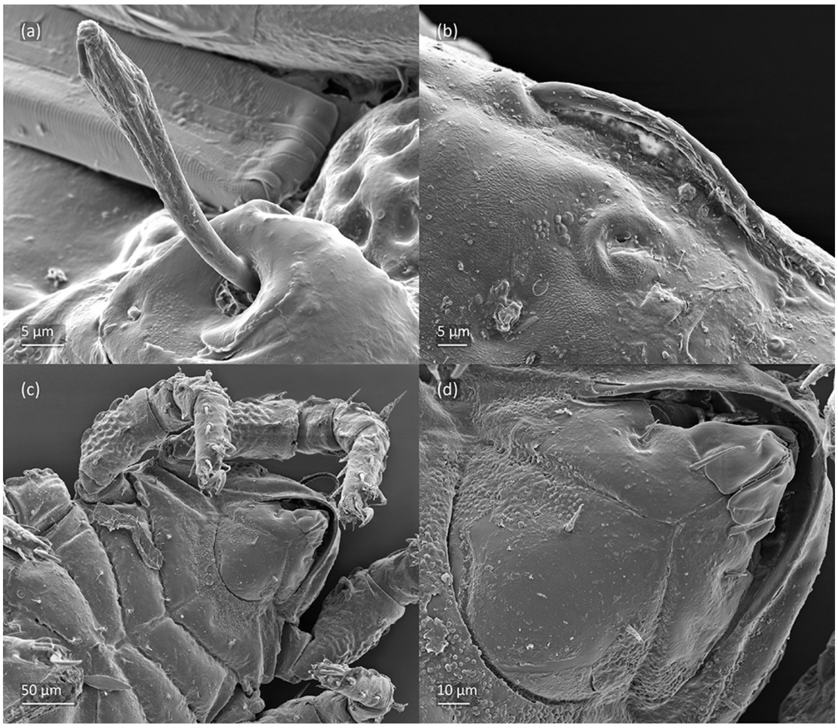


FIGURE 7. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, SEM micrographs. Bothridium and bothridial seta, dorsal view; (b) opisthonotal *gla* opening, dorsal view; (c), (d) anterior part, ventral view.

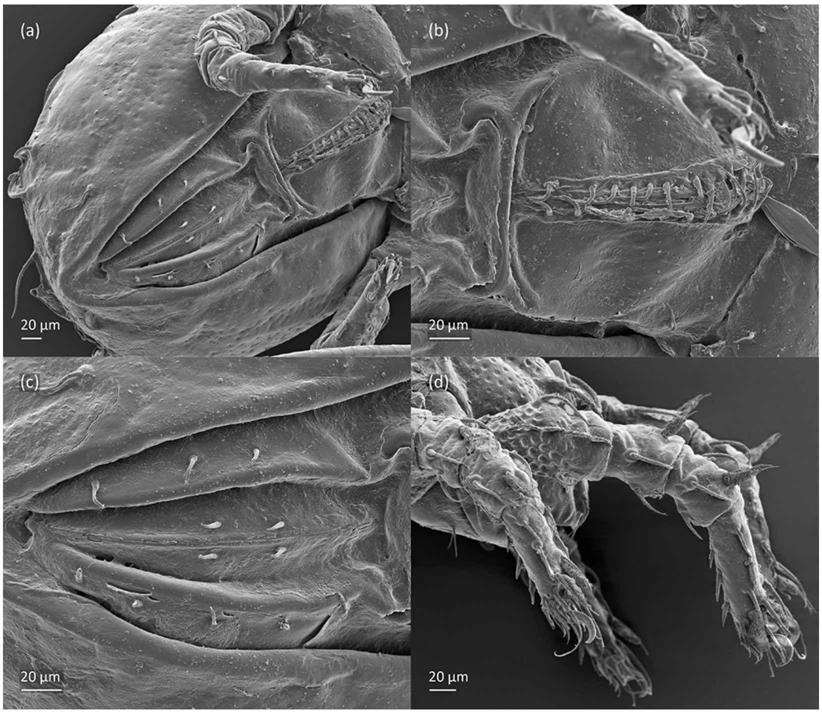


FIGURE 8. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, SEM micrographs. Posterior part of body, ventral view (a), (b) genital plates, (c) anal plates; (d) legs I and II, lateral view.

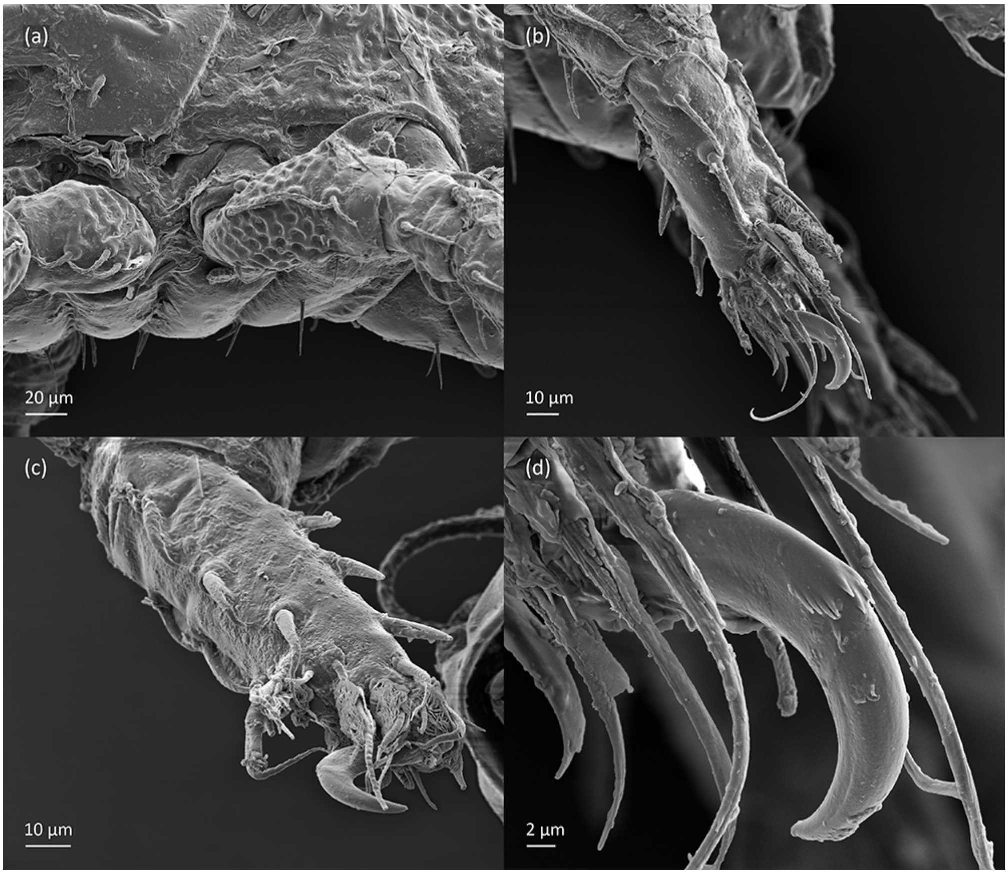


FIGURE 9. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, adult, SEM micrographs. (a) Femora II and III, lateral view; leg I, (b) lateral view, (c) tarsus, frontolateral view, (d) claw I, lateral view.

Description of juvenile stages

Larva stocky (Figs. 11, 12a, 13a), unpigmented, prodorsum, epimeres and legs light brown. Prodorsum subtriangular, central part punctate, with small pits. Prodorsal setae *ro* inserted close to each other on rostrum, pair *le* inserted posterior to *ro* on transverse ridge, pair *in* inserted in central part, posteromedial to bothridial setae (*bs*); *ro* and *exa* short, *le* and *in* of medium size (Table 1), seta *exp* alveolar, *le* finely barbed, other setae smooth. Ridge present anterior to seta *exa* in direction of seta *le* and posterior to seta *exa* in direction of seta c_1. Mutual distance between setal pair *le* about five times longer than between setal pair *ro*, and between setal pair *in* about eight times longer than between setal pair *ro*, setae *le* inserted closer to *ro* than to *in* (Figs. 11, 13a). Opening of bothridium small, rounded, bothridial seta minute. One pair of hypostomal setae *m* present.

Gastronotum of larva with transverse folds and lateral tubercles and 12 pairs of setae, including f_1 placed anterior to seta h_1, and h_2 inserted lateral to posterior part of anal valves (Figs. 11, 12a, 13a); most setae of medium size and smooth, except for longer and barbed f_2 and h_1 (Table 1). Cupule *ia* posterior to seta c_3, *im* anterior to seta e_2, *ip* not observed between folds, *ih* lateral to anterior part of anal valves (Figs. 12a, 13a). Opisthosomal gland opening anteromedial to seta f_2. Anal valves of larva (segment P) glabrous. Leg segments relatively thick, and most leg setae relatively thick and short or conical, except for longer apical setae on tarsi (Fig. 14). Seta *d* coupled to solenidion present on all genua and tibiae.

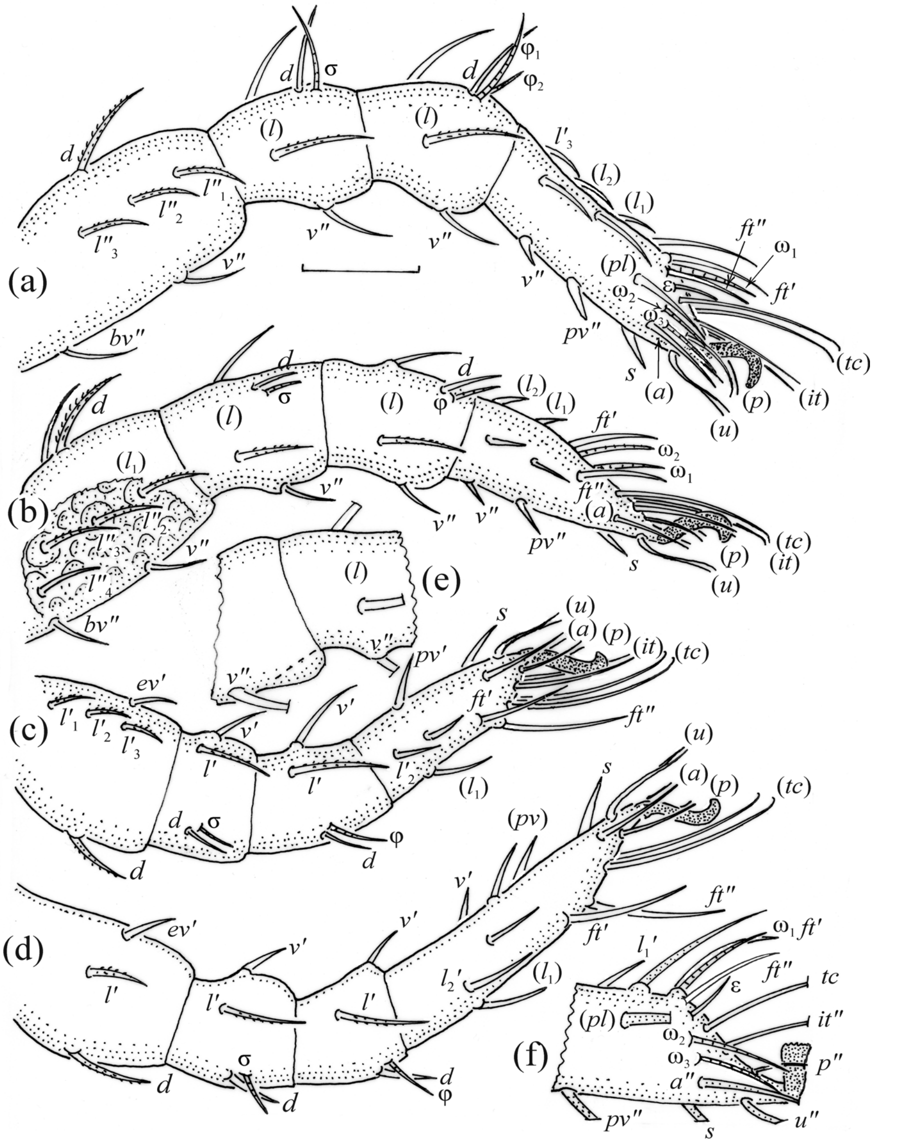
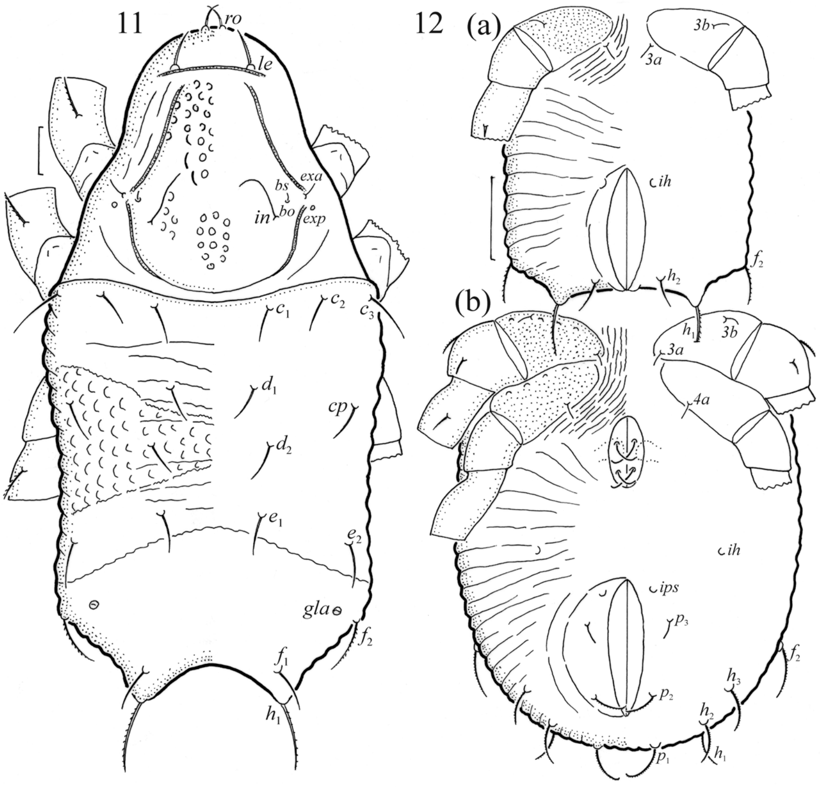


FIGURE 10. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, leg segments of adult (part of femur to tarsus), right side, antiaxial aspect, setae on the opposite side not illustrated are indicated in the legend, scale bar 20 µm. (a) Leg I, femur (l', v'), genu (v'), tibia (v'), tarsus (v', pv'); (b) leg II, femur (v'), genu (v'), tibia (v'), tarsus (v', pv'); (c) leg III, genu (v''), tibia (v''), tarsus (pv''); (d) leg IV, genu (v''), tibia (v''), tarsus (v''); (e) connection of femur I with genu I, (f) part of tarsus I (e, f enlarged).

Shape and color of protonymph and prodorsal setae of nymphs as in larva, but in central part of prodorsum pits denser than in larva. Bothridium weakly developed, rounded, bothridial seta short, *exa* short and *exp* alveolar. One pair of hypostomal setae *m* present. Gastronotum of protonymph with folds and small pits and 15 pairs of setae because seta f_1 lost and alveolus of seta remaining and present in other instars, and setae h_3 and *p*-series appearing and remaining in deutonymph and tritonymph, most setae relatively short and smooth, except for longer finely barbed f_2 and *h*- and *p*-series, but in protonymph p_3 short and smooth (Fig. 12b, Table 1). In protonymph, two pairs of setae appearing on genital valves, and two pairs added in deutonymph and five pairs in tritonymph (Figs.

12b, 15a, 15b). In deutonymph, one pair of aggenital setae appearing, and one pair added in tritonymph, all short and smooth. Anal valves of protonymph (segments AD) and deutonymph (segments AN) glabrous, in tritonymph two pairs of short and smooth setae present (Figs. 12a, 15a, 15b). In all nymphs, posterior setae on small apophyses. In tritonymph, cupules *ia* and *im* placed as in larva, *ip* not observed between folds, cupule *ian* anterior to seta an_2, *iad* lateral to anterior part of anal valves, cupules *ips* and *ih* pushed anterolateral to seta ad_3 (Figs. 15b, 16). Opisthonotal gland opening medial to seta f_2 and alveolus of seta f_1 anterior to seta h_1. In all nymphs, central and anterior part of prodorsum with foveae (Figs. 16, 17a, 17b, 18b). Leg segments relatively thick (Figs. 17a–c, 18–20), and femora with reticulate integument (Figs. 17a, 17b, 20b). Most leg setae of tritonymph short or of medium size, relatively thick and smooth, except for longer apical setae on tarsi (Fig. 20). Seta *d* coupled to solenidion present on all genua and tibiae.



FIGURES 11–12. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, legs partially drawn, scale bars 20 μm. 1. Larva, dorsal aspect. 2. Ventral aspect of hysterosoma, (a) larva, (b) protonymph.

Remarks. Neighbor-joining tree based on cytochrome oxidase I (COI) nucleotide sequences confirmed morphological observations that *P. troendelagicus* differs from *P. punctatus* also on the molecular level (Fig. 21). The sequences of *P. troendelagicus* were identical (distance 0%), the maximum mitochondrial DNA variation within *P. punctatus* was 2.62%, while the minimum distance to compared representatives within the genus was 28.69%.

Summary of ontogenetic transformations

In all instars of *P. troendelagicus*, the prodorsal setae *ro*, *le* and *in* are short or of medium size, and *exp* is alveolar. In all juveniles, the bothridium is weakly developed, and the bothridial seta is short, whereas in the adult the bothridium is large, located on large tubercle, with small, rounded opening, and bothridial seta is bacilliform, with thickened, barbed head. The larva has 12 pairs of gastronotal setae, including f_1 and h_2, whereas the nymphs and adult have 15 pairs (in protonymph f_1 is lost and only alveolus of this seta remains, and setae h_3 and *p*-series are added). Formula of gastronotal setae of *P. troendelagicus* is 12-15-15-15-15 (larva to adult, excluding alveolar f_1). Formulae of epimeral setae are 3-1-2 (larva, including scaliform *1c*), 3-1-3-1 (protonymph), 3-1-3-3 (deutonymph) and 3-1-3-4 (tritonymph and adult). In all instars, one pair of hypostomal setae *m* is present. Formula of genital setae is 2-4-9-14 (protonymph to adult), aggenital setae is 1-2-2 (deutonymph to adult), and setae of segments PS−AN is 03333-0333-022. The ontogeny of leg setae and solenidia is given in Table 3.

TABLE 3. Ontogeny of leg setae (Roman letters) and solenidia (Greek letters) in *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
Larva	–	d, bv''	(l), d, σ	(l), v', d, φ_1	(ft), (tc), (p), (u), (a), s, (pv), ε, ω_1
Protonymph	–	–	–	–	ω_2
Deutonymph	v'	(l'_1), l'_2, v''	(v)	v'', φ_2	–
Tritonymph	–	v'	–	–	ω_3, (v_1), (it)
Adult	–	l'_3	–	–	(l_1), (l_2), l_3'
Leg II					
Larva	–	d, bv''	(l), d, σ	(l), v', d, φ	$ft)$, (tc), (p), (u), (a), s, (pv), ω_1
Protonymph	–	–	–	–	–
Deutonymph	v'	(l'_1), l'_2, v''	(v)	v''	ω_2
Tritonymph	–	l'_3, v'	–	–	(l_1), (it)
Adult	–	l'_4	–	–	(l_2), (v_1)
Leg III					
Larva	–	d, ev'	l', d, σ	l', v', d, φ	(ft), (tc), (p), (u), (a), s, (pv)
Protonymph	l'_1	–	–	–	–
Deutonymph	l'_2, v'	l'_1	v'	v''	–
Tritonymph	l'_3	–	v''	–	l'_1, (it)
Adult	l'_4	l'_2, l'_3	–	–	l''_1, (l_2), (v_1)
Leg IV					
Protonymph		–	–	–	ft'', (pv), (p), (u)
Deutonymph	v'	d, ev'	v', l', d, σ	v', l', d, φ	ft', (tc), (a), s
Tritonymph	–	–	v''	v''	l'_1
Adult	–	l'	–	–	l_1'', l'_2, (v_1)

Note: structures are indicated where they are first added and are present through the rest of ontogeny; pairs of setae in parentheses, dash indicates no additions.

Distribution, ecology and biology

Platynothrus troendelagicus was found in ten samples (out of the total of 64 samples) collected in Hitra and Høstadmyra, only in the moist habitats. It was the most abundant and represented by all developmental stages in a sample of *Sphagnum compactum* Lam. et DC. collected in a poor fen carpet site in Høstadmyra, where the density of this species was 69 individuals/500 cm^3. The adults dominated in extracted sample, constituting 51% of population. The stage structure of *P. troendelagicus* was the following: 3 larvae, 10 protonymphs, 19 deutonymphs, 2 tritonymphs and 35 adults. Among 20 individuals investigated, 50% of females were gravid, carrying 1−5 large eggs (each 155 x 80), constituting 22% of the length of females.

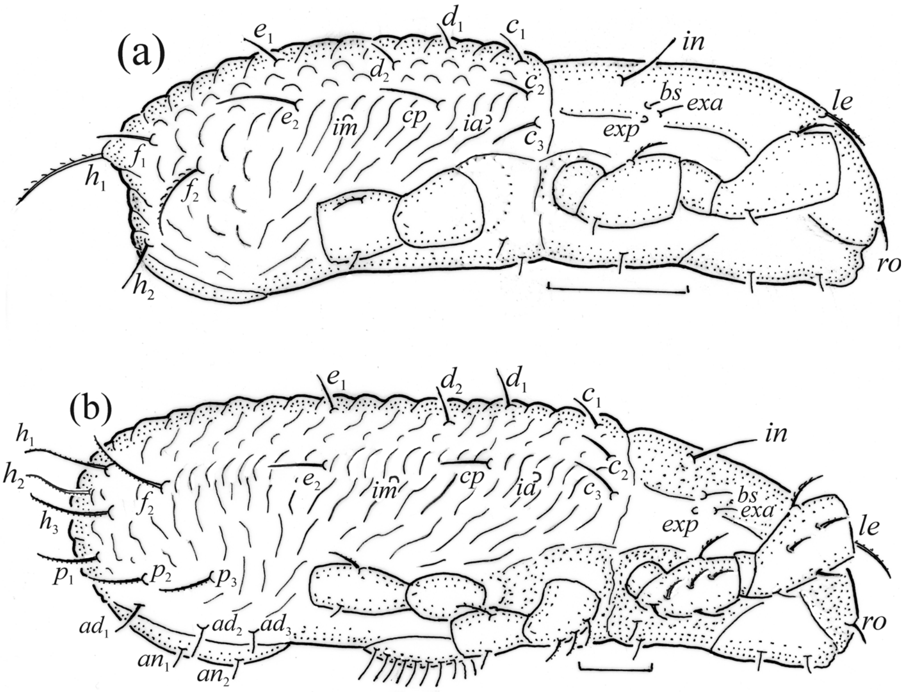


FIGURE 13. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, lateral aspect, legs partially drawn, scale bars 20 µm. (a) Larva, (b) tritonymph.

The species was also found in samples collected from lawns and carpets in Hitra and Høstadmyra: in *Sphagnum medium* Limpr., *S. cuspidatum* Ehrh. ex Hoffm., *S. rubellum* Wilson, and at the pond with a mixture of *Sphagnum* species [*S. inundatum* Russow, *Sphagnum papillosum* Lindb. and *Sphagnum tenellum* (Brid.) Brid.]. Based on COI nucleotide sequences, the species also occurs in the peatlands in Ireland (Lullymore, Leinster) and Canada (Fundy National Park, New Brunswick, Young *et al*. 2019) (Table 2, Fig. 21).

Type material

The holotype (female) and five paratypes (females) with the above collection data are deposited in the University Museum of Bergen, University of Bergen, Bergen, Norway (ZMUB).

Etymology

This species is named after the county Trøndelag in the central part of Norway where it was discovered.

Comparison of morphology of *Platynothrus troendelagicus* A. *et* S. Seniczak sp. nov. with congeners and remarks

Seniczak and Seniczak (2022) compared the morphology of adults of *Platynothrus* species with most gastronotal setae short or of medium size, and *P. troendelagicus* is the most similar to *P. punctatus* but differs from it mainly by slightly smaller body size, larger number of genital setae, presence of alveolar seta *exp*, which in *P. punctatus* is absent, presence of only one pair of hypostomal setae *m* (*vs*. 1, 2, 3, 4, 5 pairs of this setae in larva, protonymph, deutonymph, tritonymph and adult of *P. punctatus*, respectively). It differs also by COI nucleotide sequence.

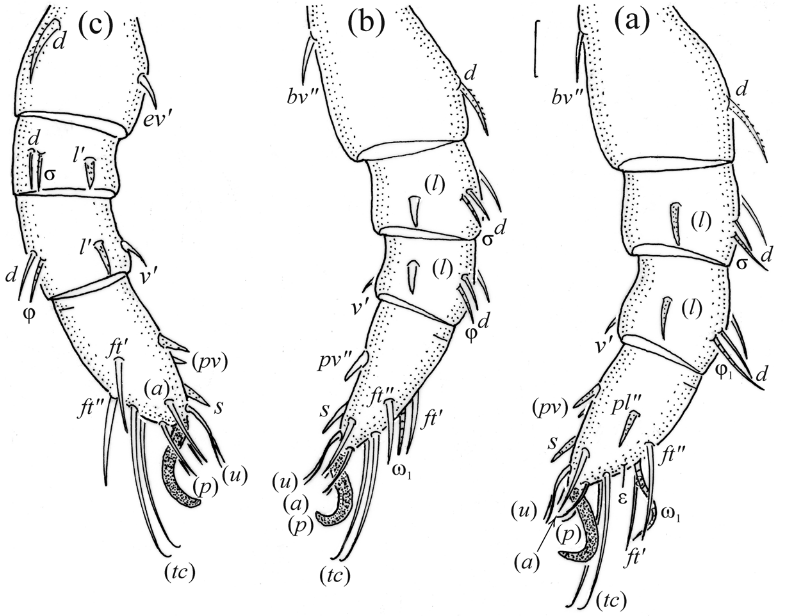
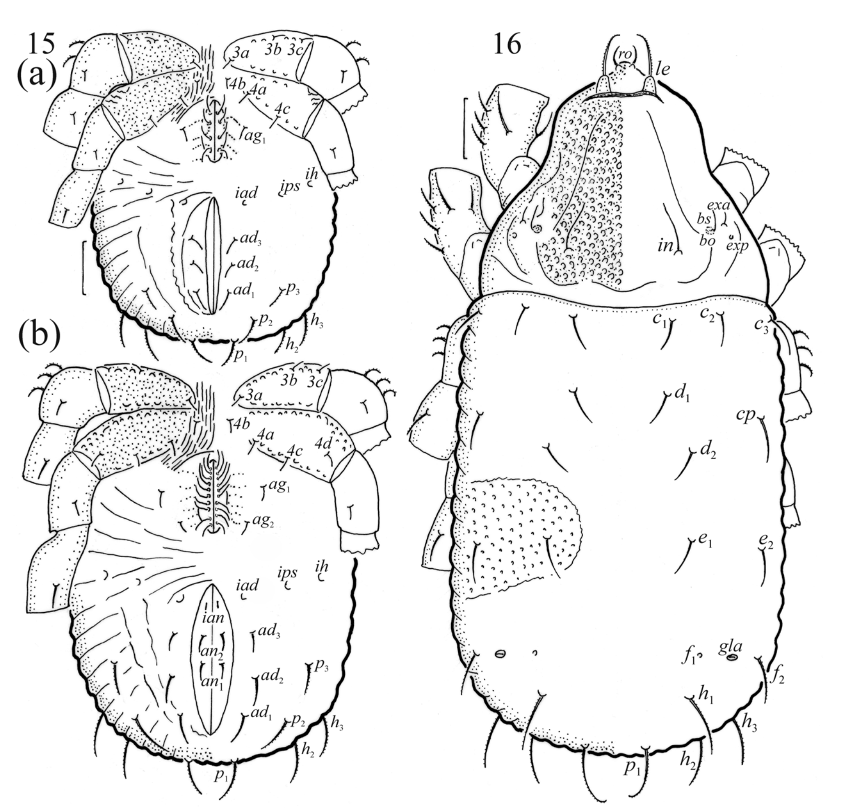


FIGURE 14. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, leg segments of larva (part of femur to tarsus), right side, antiaxial aspect, setae on the opposite side not illustrated are indicated in the legend, scale bar 20 μm. (a) Leg I, tibia (*pl′*); (b) leg II, tarsus (*pv′*); (c) leg III.



FIGURES 15–16. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, legs partially drawn, scale bars 50 μm. 15. Ventral aspect of hysterosoma, (a) deutonymph, (b) tritonymph. 16. Tritonymph, dorsal aspect.

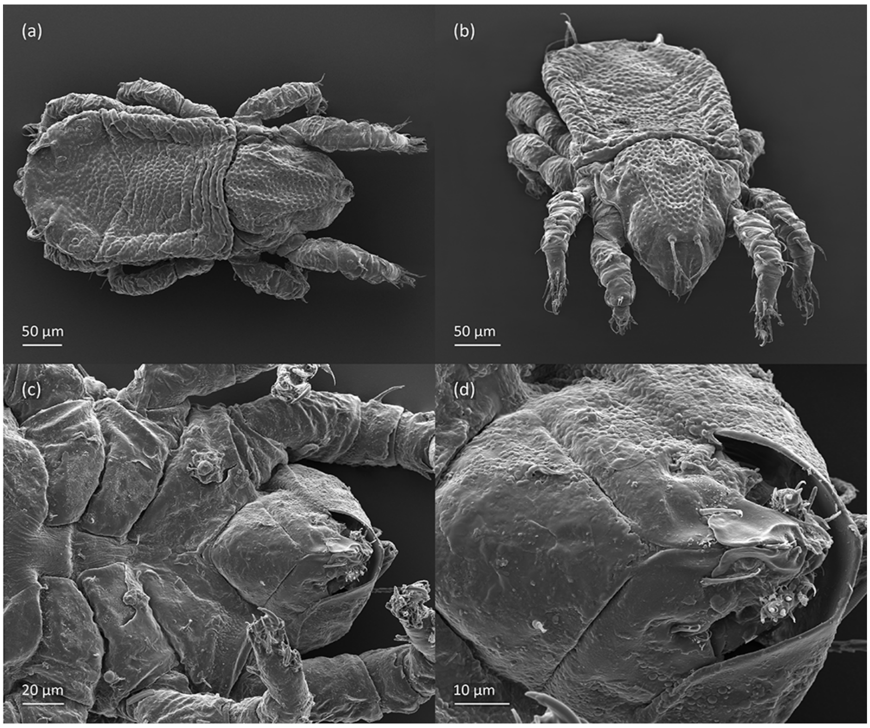


FIGURE 17. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, deutonymph, SEM micrographs. (a) Dorsal view, (b) frontal view, (c), (d) anterior part, ventral view.

FIGURE 18. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, deutonymph, SEM micrographs. Anterior part, (a) ventral view, (b) dorsal view; (c) leg I and II, frontal view; (d) leg I, lateral view.

In the juveniles of *P. troendelagicus*, the number, shape and distribution of setae are similar to those of other species of Camisiidae (Seniczak 1990a, b, 1991a–c; Seniczak & Klimek 1990; Seniczak & Seniczak 2022; Seniczak *et al*. 2022). In all species, the larva has seta f_1, but this seta is lost in the protonymph and only alveolus of this setae remains. However, in the nymphs of *Platynothrus*, the posterior gastronotal setae are inserted on small apophyses (Seniczak 1990a; Seniczak & Klimek 1990; Seniczak & Seniczak 2022; Seniczak *et al*. 2022), whereas in the other genera of this family, such as *Heminothrus* Berlese, 1913 and *Camisia* Heyden, 1826 these apophyses are clearly larger (Seniczak 1990b; Seniczak 1991a–c). In the nymphs of other genera of Crotonioidea, such as *Hermannia* Nicolet, 1855, *Phyllhermannia* Berlese, 1916 and *Nothrus* C.L. Koch, 1836, seta f_1 is present (Seniczak 1992; Seniczak & Żelazna 1992; Seniczak & Norton 1993; Colloff 2011; Seniczak *et al*. 2017a, b).

The morphology of successive developmental instars of *P. troendelagicus* is generally similar to those of *P. coulsoni* and *P. punctatus*, but the morphological ontogeny of these species differs by formulae of hypostomal setae, genital, adanal, and anal setae and the number of leg setae on femora and tarsi (Table 4). Moreover, the successive developmental instars of these species differ in the body size (*P. coulsoni* is larger than other species) and length of some setae. Generally, these species are most similar to each other in the larva, and their differentiation of morphology increases during the ontogeny (Table 4, Seniczak & Seniczak 2022; Seniczak *et al*. 2022). Based on Table 4, the larvae of compared species differ clearly in one morphological character, protonymphs in two characters (formulae of hypostomal and genital setae) and deutonymphs, tritonymphs and adults at least in six morphological characters, on the main body (number of hypostomal, palpal, genital, adanal and anal setae), and on leg segments (the number of setae on femora and tarsi, at least on legs I–III). In the adults, the cuticle is better sclerotized than in the juveniles, with more morphological characters.

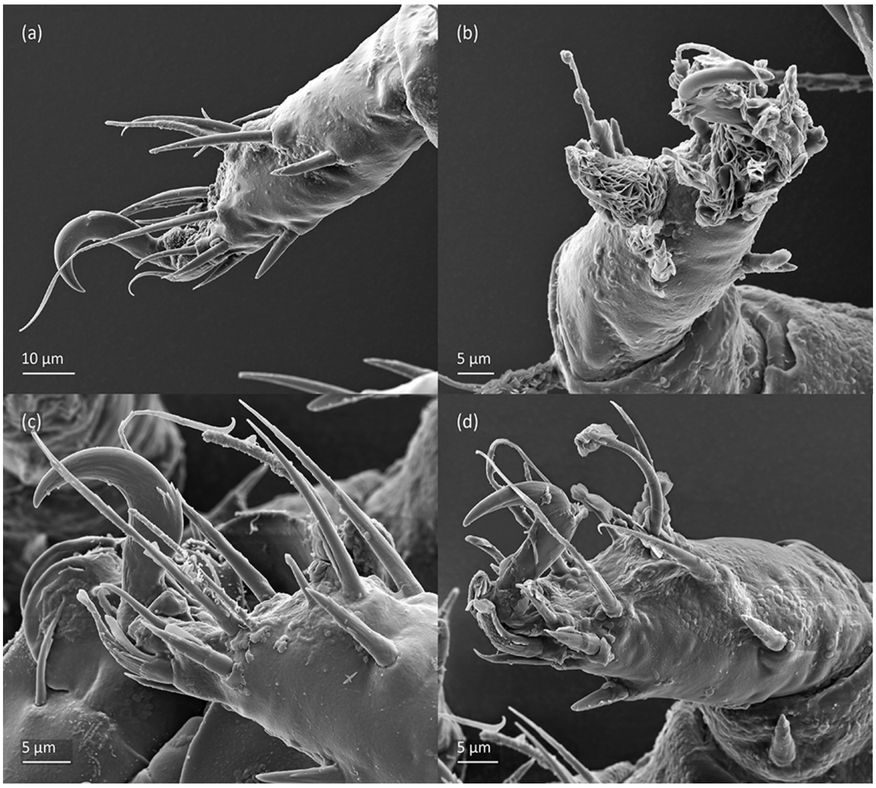


FIGURE 19. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, deutonymph, leg I, SEM micrographs. (a) Dorsal view, (b) ventral view, (c), (d) lateral view.

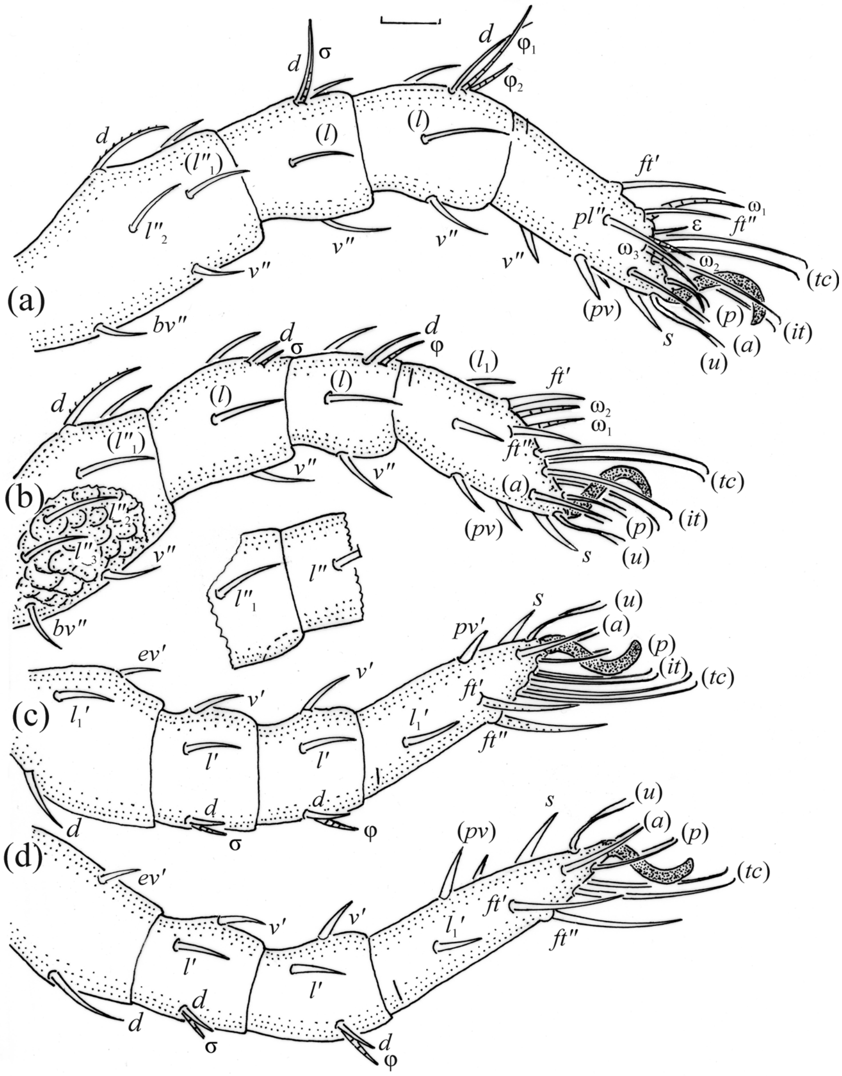


FIGURE 20. *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, leg segments of tritonymph (part of femur to tarsus), right side, antiaxial aspect, seta on the opposite side not illustrated are indicated in the legend, scale bar 20 μm. (a) Leg I, femur (*v*′), genu (*v*′), tibia (*v*′), tarsus (*pl*′, *v*′); (b) leg II, femur (*v*′), genu (*v*′), tibia (*v*′); (c) leg III, genu (*v*″), tibia (*v*″), tarsus (*pv*″); (d) leg IV, genu (*v*″), tibia (*v*″); (e) connection of femur and genu I.

The ontogeny of leg setae and solenidia of *P. troendelagicus* differs from that of *P. coulsoni* and *P. punctatus*, but in all species many *l* setae are present on trochanter III and at least on femora I–IV, and setae *l* and *v* on tarsi. In these species, typical tarsal setae (*ft*, *pl*, *tc*, *p*, *u*, *a*, *s*, *pv*) are inserted on 1/3 apical part of tarsi, but nevertheless in *P. troendelagicus* fewer setae *v* appear on all tarsi than in other species.

The chelicera of the adult of *P. troendelagicus* is similar to that of *P. punctatus*, by having well-developed Trägårdh organ that protrudes beyond the line of chelicera in lateral aspect. In both species, cheliceral setae are of similar length and barbed, as in other species of *Platynothrus* (Trägårdh 1910; Lee 1985; Olszanowski 1996). The palp of adult of *P. troendelagicus* is similar to that of *P. punctatus*, except for absence of seta *inf* on femur, which in *P. punctatus* is present.

TABLE 4. Comparison of some morphological characters of *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.**, *P. coulsoni* and *P. punctatus*.

Characters	*P. troendelagicus*	*P. coulsoni*[1]	*P. punctatus*[2]
All instars			
Formula of: hypostomal setae *m*	1-1-1-1-1	1-1-1-1-1	1-2-3-4-5
palp setae	0-1-0-3-7(1)	0-1-0-3-7(1)	0-2-0-3-7(1)
genital setae	2-4-9-14	1-5-11-(16-17)	2-4-9-(12-13)
segments AD	3333	03(3-4)(3-4)	3333
segments AN	022	0(2-3)(2-3)	022
Length of seta f_2	Longer than e_2	About as long as e_2	About as long as e_2
Adult			
Formula of femora I–IV	8-9-4-3	(8-9)-9-(4-5)-4	(8-9)-(8-9)-(4-5)-3
Formula of tarsi I–IV	23-21-21-18	(27-28)-(26-27)-(22-23)-21	(23-24)-(22-23)-(21-22)-(19-20)
Tritonymph			
Formula of femora I–IV	7-8-3-2	7-7-3-(2-3)	7-7-3-2
Formula of tarsi I–IV	23-21-21-18	24-22-21-19	23-22-21-19
Deutonymph			
Formula of femora I–IV	6-6-3-2	5-5-2-2	5-5-2-2
Formula of tarsi I–IV	14-13-13-13	18-17-15-13	15-13-13-13
Larva			
Seta h_1 inserted on	large apophyse	large apophyse	small apophyse

[1]According to Seniczak *et al*. (2022); [2]Seniczak and Seniczak (2022).

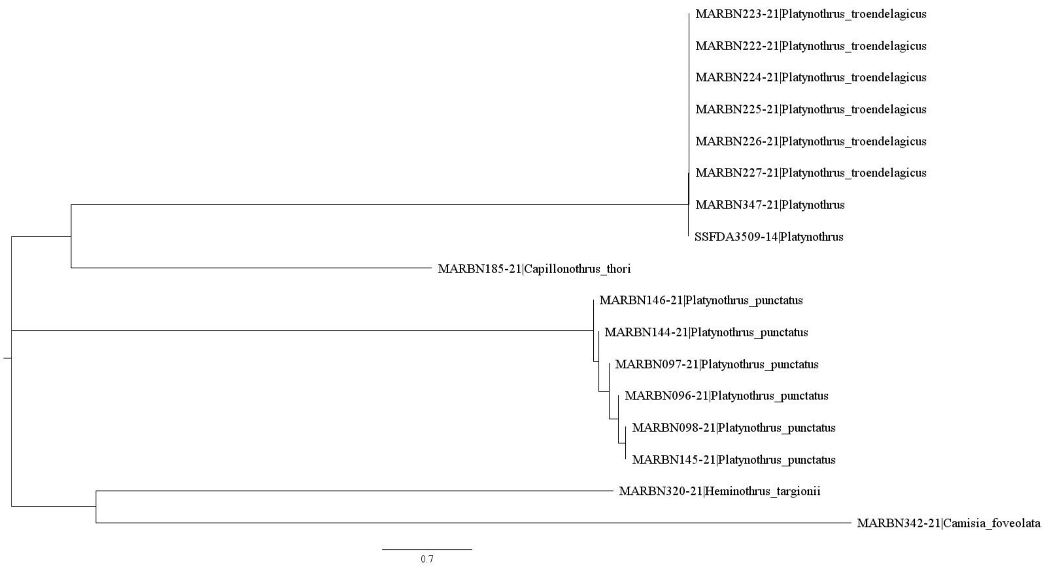


FIGURE 21. Neighbor-joining tree showing relationships among cytochrome oxidase I (COI) nucleotide sequences of *Platynothrus troendelagicus* A. *et* S. Seniczak **sp. nov.** and *P. punctatus*; *Camisia foveolata*, *Capillonothrus thori*, and *Heminothrus targionii* are outgroups.

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We express our gratitude to Dr. Steffen Roth (University Museum of Bergen, Bergen, Norway) for assistance with field work, to anonymous reviewers for helpful comments and suggestions that improved the quality of this paper, and to Mr. Jian-Feng Liu for nice editorial work. The study was partly supported by the grant to the University Museum of Bergen from the Norwegian Taxonomy Initiative "Mites of Atlantic Raised Bogs" (Grant No. 6-20, 70184243). The sequencing was financed by Norwegian Barcode of Life (NorBOL).

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