



To the knowledge of oribatid mites of the genus *Nothrus* (Acari, Oribatida, Nothridae) from Taiwan

Sergey G. Ermilov¹ · Jhih-Rong Liao²

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Abstract

Two species of oribatid mites of the genus *Nothrus* (Oribatida, Nothridae) were collected during an expedition to Taiwan in 2017. The species *Nothrus anauniensis* Canestrini and Fanzago, 1876 is redescribed and illustrated in detail; the main morphological traits for this species are summarized. A new species *Nothrus xuejianensis* Ermilov sp. n. is described; it differs from the closest species, *Nothrus meakanensis* Fujikawa, 1999 by the morphology and length of notogastral setae h_2 and number of subcapitular setae m .

Keywords Nothrid mites · Morphology · Systematics · Oriental region

Introduction

The oribatid mite genus *Nothrus* (Acari, Oribatida, Nothridae) was proposed by Koch (1835) with *Nothrus palustris* Koch, 1839 as type species. Currently, it comprises 87 species, which collectively have a cosmopolitan distribution (Subías 2004, updated 2018). The selective generic characters are summarized by Sellnick and Forsslund (1955), Sitnikova (1975), Olszanowski (1996) and Fujikawa (1999). Identification keys to some *Nothrus* species groups have been presented in several papers: e.g., Sellnick and Forsslund (1955), Beck (1962), Sitnikova (1975), Mahunka (1978), Olszanowski (1996), Fujikawa (1999), Balogh and Balogh (2002), Weigmann (2006), Lochynska (2008), Bayartogtokh (2010), Ermilov and Hugo-Coetzee (2012).

During taxonomic identification of oribatid mites from Taiwan, we found two species of *Nothrus*, one is known *Nothrus anauniensis* Canestrini and Fanzago, 1876 (Canestrini and Fanzago 1876), and the other species is new to science. The main goal of the paper is to present a supplementary description

of *N. anauniensis*, on the basis of specimens from Taiwan, and to describe the new species under the name *Nothrus xuejianensis* Ermilov sp. n.

At present, the oribatid mite fauna of Taiwan is poorly investigated (e.g., Tseng 1982, 1984; Aoki 1991, 1995; Ohkubo 1995; Chu and Aoki 1997; Bayartogtokh et al. 2009; Ermilov and Liao 2017a, b, c), and only two records of *Nothrus* are known: *N. anauniensis* (see Chu and Aoki 1997); *N. praeoccupatus* Subías, 2004 (see Tseng 1982; as *Vigilomicrozetes pulchellus* Tseng, 1982).

Material and methods

Samples were collected by hand method and extracted into 96% ethanol using Berlese's funnels without use of an electric lamp during 7 days in the laboratory. Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width of the notogaster in dorsal view. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (femulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus.

✉ Sergey G. Ermilov
ermilovacari@yandex.ru

¹ Tyumen State University, Semakova 6, 625003 Tyumen, Russia

² National Taiwan University, No. 1, Section 4, Roosevelt Rd, Da'an District, 10617 Taipei City, Taiwan

Drawings were made with a camera lucida using a Leica transmission light microscope “Leica DM 2500”.

Morphological terminology used in this paper follows that of F. Grandjean: see Travé and Vachon (1975) for references, Norton (1977) for leg setal nomenclature, and Norton and Behan-Pelletier (2009) for overview.

The following abbreviations are used: *dep* – depression; *br* – bothridial ridge; *ro*, *le*, *in*, *bs*, *ex* – rostral, lamellar, interlamellar, bothridial and exobothridial setae, respectively; *cf.* – circummarginal furrows; *cr* – caudal ridge; *c*, *d*, *e*, *f*, *h*, *p* – notogastral setae; *ia*, *im*, *ip*, *ih*, *ips* – notogastral lyrifissures; *gla* – opisthonotal gland opening; *h*, *m*, *a* – subcapitular setae; *or* – adoral seta; *l*, *d*, *cm*, *acm*, *ul*, *sul*, *vt*, *lt* – palp setae; ω – palp and leg solenidium; *ep* – postpalpal seta; *cha*, *chb* – cheliceral setae; *Tg* – Trägårdh’s organ; *g*, *an*, *ad* – genital, anal and adanal setae, respectively; *ian* – anal lyrifissure; *iad* – adanal lyrifissure; σ , φ – solenidia; ε – leg famulus; ν , *ev*, *bv*, *l*, *d*, *ft.*, *tc*, *p*, *u*, *a*, *s*, *pv*, *pl* – leg setae.

The following abbreviations of collections are used: NTU – National Taiwan University, Taipei, Taiwan; TSUMZ – Tyumen State University Museum of Zoology, Tyumen, Russia.

Systematics

Nothrus anauniensis Canestrini and Fanzago, 1876 (Figs 1–20)

Supplementary description *Measurements*. Body length: 697–747 (five specimens, all females); notogaster width: 348–381 (five specimens).

Integument (Figs 1, 12–14). Body color yellow-brownish, covered with thin layer of gel-like cerotegument. Surface densely microfoveolate (visible under high magnification, $\times 1000$). Prodorsum, notogaster and genital plates with rounded or elongate oval alveoles (their diameter or length up to 14).

Prodorsum (Figs 1–4). One unpaired mediobasal (in interbothridial region) and one pair of laterobasal (anteriorly to bothridia) depressions clearly visible. Rostrum broadly rounded, with distinct medial indentation. Rostral (20–24), lamellar (36–41) and interlamellar (45–49) setae covered with broad, phylliform cerotegument, heavily barbed, inserted on tubercles, *ro-ro* and *le-le* connected by thin ridges. Bothridial setae long (213–217), rod-like, slightly dilated distally, sparsely barbed. Bothridial ridges distinct. Exobothridial setae (8–10) covered with narrow, phylliform cerotegument, smooth.

Notogaster (Figs 1, 5–8, 12, 13). Anterior notogastral margin straight. Posterior part evenly rounded (not dilated). Weakly convex in dorsocentral and lateral parts and with

circummarginal furrows between them. Caudal ridges strong. Sixteen pairs of notogastral setae covered with broad, phylliform cerotegument, inserted on small tubercles, *c*_{1–3}, *d*₁, *d*₂, *cp*, *e*₁, *e*₂ heavily barbed, *h*₂ smooth, other setae sparsely barbed; *h*₂ (90–98) longer than *c*₁, *d*₁, *d*₂, *e*₁ (49–57), *c*₃, *cp*, *e*₂, *f*₁, *f*₂, *h*₁, *h*₃, *p*_{1–3} (41–49) and *c*₂ (28–32). Setae *c*₁, *d*₁, *d*₂ almost reaching the insertions of *d*₁, *d*₂, *e*₁, respectively. Distance between setae *c*_{1–2} shorter than between *c*_{2–3}. Lyrifissures *ia*, *im*, *ip*, *ih*, *ips* and opisthonotal gland openings well visible, located in typical positions.

Gnathosoma (Figs 14–16). Subcapitulum longer than wide (151–157 \times 131–135). Subcapitular setae *h* (20–22) and *m*₂ (8) covered with narrow phylliform cerotegument, smooth, *m*₁ (20–22) and *a* (26–28) setiform, barbed. Two pairs of adoral setae (24–28) present; *or*₁ setiform, smooth, *or*₂ dilated distally, truncate, smooth. Palps (82–86) with setation 0–1–1–3–9(+1 ω). Postpalpal setae (12–14) simple, erect. Chelicerae (151–157) with two setiform, barbed setae; *cha* (49–53) longer than *chb* (32–36). Trägårdh’s organ elongate triangular.

Epimeral and lateral podosomal regions (Fig. 12). Anterior tectum of epimere I distinctly incised medially. Epimeral setal formula 7–4–6–8. Setae short (12–16), covered with narrow phylliform cerotegument, smooth.

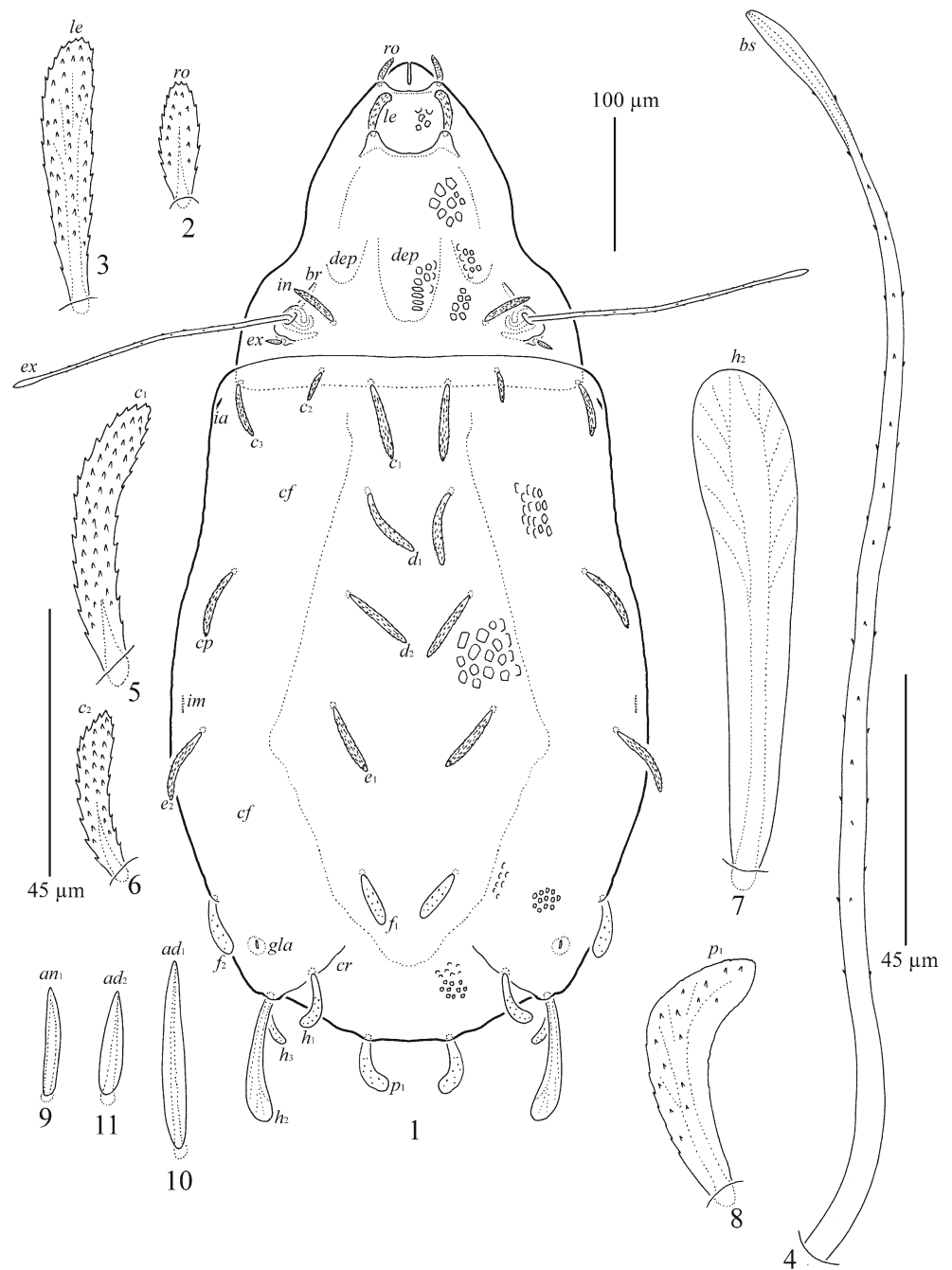
Anogenital region (Figs 9–13). Nine pairs of genital (16–20), two pairs of anal (16–20) and 3 pairs of adanal (*ad*₁, 30–32; *ad*₂, *ad*₃, 16–20) setae covered with narrow phylliform cerotegument, smooth. Lyrifissures *ian* and *iad* clearly visible.

Legs (Figs 17–20). Tarsi with 3 smooth claws, median claw distinctly thicker than laterals. Formulas of leg setation and solenidia: I (1–9–5–6–27) [1–2–3], II (1–8–5–5–25) [1–1–1], III (3[or 4]–5–5–5–22) [1–1–0], IV (2–6–5–5–22) [1–1–0]; homologies of setae and solenidia indicated in Table 1.

Material examined Five specimens (all females): Taiwan, Miaoli County, Tai’an Township, SheiPa National Park, Xuejian Area, 24°25.464’N, 121°00.796’E, 1855 m a.s.l., sample #32, soil and lichen, 13.XI.2017 (collected by J.-R. Liao and H.C. Lee).

Remarks 1. *Nothrus anauniensis* has a cosmopolitan distribution except the Antarctic region (Subías 2004, updated 2018). Adult of this species was redescribed and illustrated by several authors: e.g., Hammen (1950; as *N. biciliatus*), Sellnick and Forsslund (1955; as *N. biciliatus*), Hammer (1966; as *N. biciliatus*), Mahunka (1978; as *N. pseudoborussicus*), Seniczak and Norton (1993), Olszanowski (1996), Bayartogtokh (2010) and Ermilov and Hugo-Coetzee (2012). The specimens from Taiwan (data in this paper) are similar in general appearance to those from the redescriptions, however, partial morphological were observed:

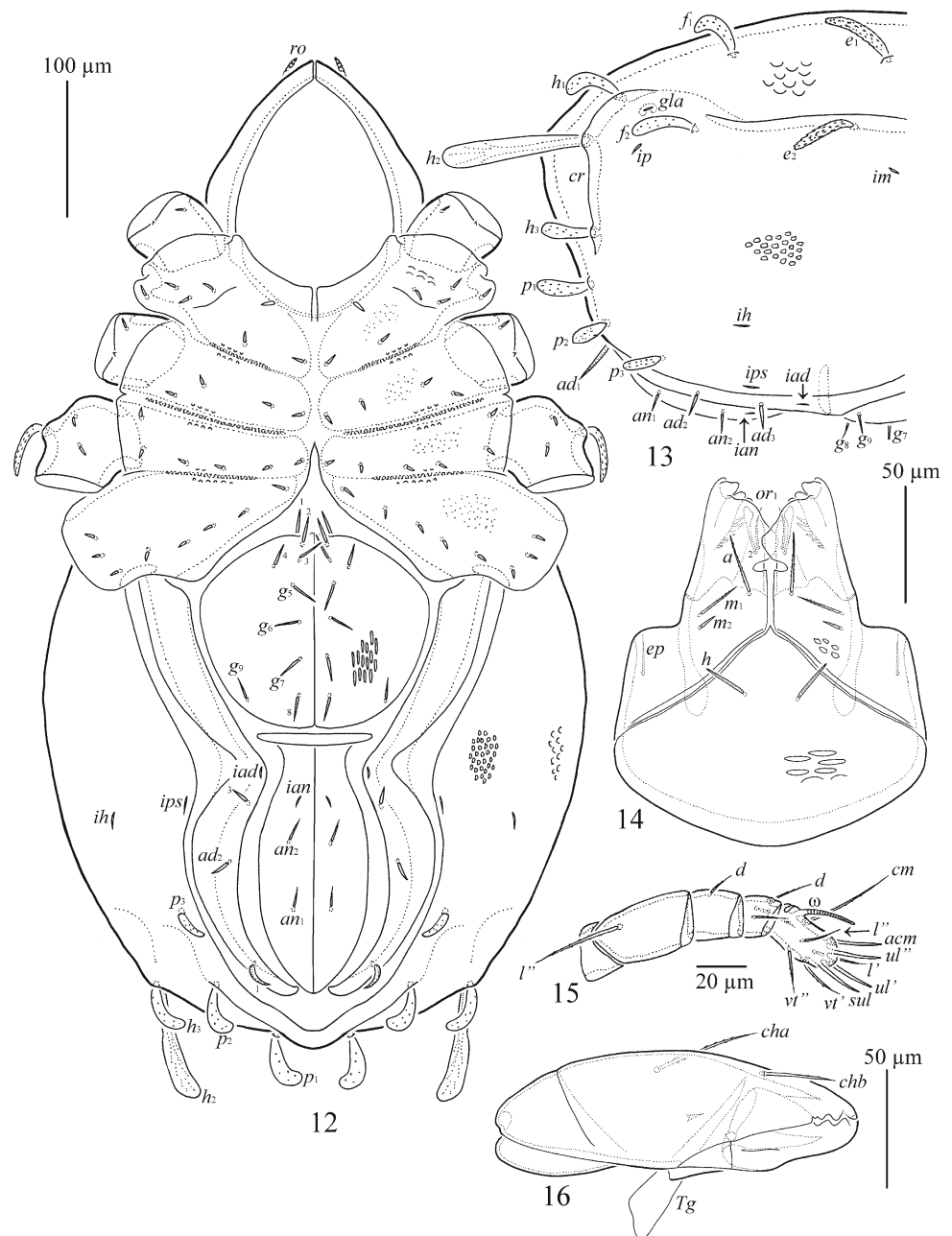
Figs 1–11 *Nothrus anauiensis* Canestrini and Fanzago, 1876, adult. **1** Dorsal view **2** Rostral seta **3** Lamellar seta **4** Bothridial seta **5** Notogastral seta c_1 **6** Notogastral seta c_2 **7** Notogastral seta h_2 **8** Notogastral seta p_1 **9** Anal seta an_1 **10** Adanal seta ad_1 **11** Adanal seta ad_2



- (1) Bothridial setae rod-like, dilated distally in specimens from Taiwan (it correspond to data from Hammen 1950; Hammer 1966; Olszanowski 1996) versus rod-like, not dilated distally in data from Sellnick and Forslund (1955), Mahunka (1978), Seniczak and Norton (1993), Bayartogtokh (2010), Ermilov and Hugo-Coetzee (2012).
- (2) Notogastral setae h_2 considerably longer than p_1 in specimens from Taiwan (it correspond to data from Sellnick and Forslund 1955; Seniczak and Norton 1993) versus h_2 and p_1 only slightly different in length in data from

- Hammen (1950), Hammer (1966), Mahunka (1978), Olszanowski (1996), Bayartogtokh (2010), Ermilov and Hugo-Coetzee (2012).
- (3) Some notogastral setae heavily barbed, other setae smooth or slightly barbed in specimens from Taiwan (it correspond to data from Mahunka 1978) versus smooth or slightly barbed, not heavily barbed in data from Hammen (1950), Sellnick and Forslund (1955), Hammer (1966), Seniczak and Norton (1993), Olszanowski (1996), Bayartogtokh (2010), Ermilov and Hugo-Coetzee (2012).

Figs 12–16 *Nothrus anauniensis* Canestrini and Fanzago, 1876, adult. **12** Ventral view (gnathosoma and legs except trochanters I–III not shown) **13** Posterior part of body, lateral view **14** Subcapitulum, ventral view **15** Palp, right, antiaxial view **16** Chelicera, right, antiaxial view

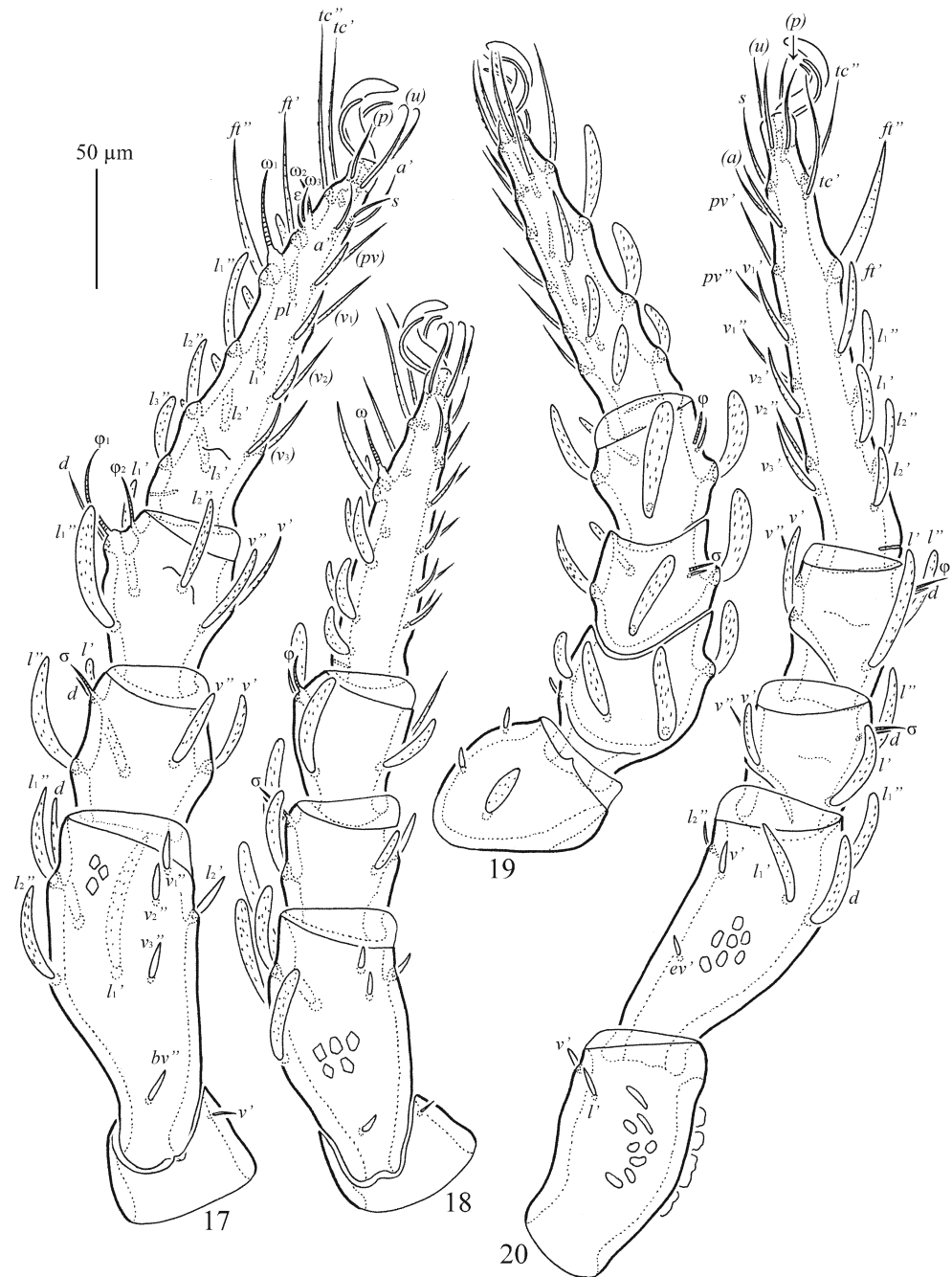


- (4) Dorsal notogastral setae comparatively long (c_1 , d_1 , d_2 almost reaching the insertions of d_1 , d_2 , e_1) in specimens from Taiwan (it correspond to data from Sellnick and Forslund 1955) versus comparatively short (c_1 , d_1 , d_2 clearly not reaching the insertions of d_1 , d_2 , e_1) in data from Hammen (1950), Hammer (1966), Mahunka (1978), Seniczak and Norton (1993), Olszanowski (1996), Bayartogtokh (2010), Ermilov and Hugo-Coetzee (2012).
- (5) Caudal notogastral ridges well-developed in specimens from Taiwan (it correspond to data from

Sellnick and Forslund 1955; Hammer 1966; Seniczak and Norton 1993; Ermilov and Hugo-Coetzee 2012) versus not developed or indistinctly developed in data from Hammen (1950), Mahunka (1978), Olszanowski (1996), Bayartogtokh (2010).

2. Based on the supplementary description of *N. anauniensis* from Taiwan and other redescriptions (e.g., Hammen 1950; Sellnick and Forslund 1955; Hammer 1966; Mahunka 1978; Seniczak and Norton 1993;

Figs 17–20 *Nothrus anauniensis* Canestrini and Fanzago, 1876, adult. **17** Leg I, right, antiaxial view **18** Leg II, right, antiaxial view **19** Leg III, right, antiaxial view **20** Leg IV, right, antiaxial view



Olszanowski 1996; Bayartogtokh 2010; Ermilov and Hugo-Coetzee 2012), we propose the following diagnostic morphological traits for this species:

Large species, size 697–1050 × 348–500. Surface of prodorsum and notogaster alveolate. Rostral, lamellar and interlamellar setae covered with broad phylliform cerotegument, rarely *ro* simple. Bothridial setae long, rod-like, sometimes slightly dilated distally, sparsely barbed. Notogastral setae of medium size, covered with broad, phylliform cerotegument, *h*₂ smooth, other setae barbed; *h*₂ longer than *p*₁. Distance

between *c*₁–*c*₂ shorter than between *c*₂–*c*₃. Epimeral and anogenital setae covered with narrow phylliform cerotegument, smooth. Leg tarsi with 3 claws.

***Nothrus xuejianensis* Ermilov sp. n. (Figs 21–34)**

Diagnosis Body size: 713–763 × 332–381. Surface of prodorsum and notogaster alveolate. Rostral, lamellar and interlamellar setae covered with broad, phylliform cerotegument, smooth. Bothridial setae long, rod-like,

Table 1 Leg setation and solenidia of adult *Nothrus anauniensis* Canestrini and Fanzago, 1876 and *N. xuejianensis* Ermilov sp. n

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	v'	$d, (l_1), (l_2), bv'', v_1'', v_2'', v_3''$	$\frac{d\sigma}{(v)}, (l)$	$\frac{d\varphi_1}{\varphi_2}, (l_1), l_2'', (v)$	$(ft), pl', (l_1), (l_2), (l_3), (tc), (p), (u), (a), s, (pv), (v_1), (v_2), (v_3), \varepsilon, \omega_1, \omega_2, \omega_3$
II	v'	$d, (l_1), (l_2), bv'', v_1'', v_2''$	$\frac{d\sigma}{(v)}, (l)$	$\frac{d\varphi}{(v)}, (l), (v)$	$(ft), (l_1), (l_2), (l_3), (tc), (p), (u), (a), s, (pv), (v_1), (v_2), (v_3), \omega$
III	l_1, l_2, l_3^*, v'	$d, (l), bv'', v''$	$\frac{d\sigma}{(v)}, (l)$	$\frac{d\varphi}{(v)}, (l), (v)$	$(ft), (l_1), (l_2), (tc), (p), (u), (a), s, (pv), (v_1), (v_2), v_3'$
IV	l', v'	$d, (l_1), l_2'', bv'', v''$	$\frac{d\sigma}{(v)}, (l)$	$\frac{d\varphi}{(v)}, (l), (v)$	$(ft), (l_1), (l_2), (tc), (p), (u), (a), s, (pv), (v_1), (v_2), v_3'$

roman letters refer to normal setae, Greek letters to solenidia (except ε = famulus), $\frac{d\varphi}{(v)}$ and $\frac{d\sigma}{(v)}$ – seta and solenidium coupled. Single prime (') marks setae on anterior and double prime (") setae on posterior side of the given leg segment. Parentheses refer to a pair of setae

*– seta l_3 present or absent

sparsely barbed. Notogastral setae covered with broad, phylliform cerotegument, smooth; h_2, c_1, d_1, d_2, e_1 longest. Distance between c_1 – c_2 shorter than between c_2 – c_3 . Subcapitular setae h and m_2 covered with narrow phylliform cerotegument, smooth, m_1 and a setiform, barbed. Epimeral setal formula 7–4–6–7. Epimeral and anogenital setae covered with narrow phylliform cerotegument, smooth. Leg tarsi with one claw.

Description *Measurements*. Body length: 730 (holotype, female), 713–763 (3 paratypes, 3 females); notogaster width: 348 (holotype), 332–381 (3 paratypes).

Integument (Figs 21, 32, 33). Body color yellow-brownish, covered with thin layer of gel-like cerotegument. Surface densely microfoveolate (visible under high magnification, $\times 1000$). Prodorsum, notogaster and genital plates with rounded or elongate oval alveoles (their diameter or length up to 16).

Prodorsum (Figs 21–24). One unpaired mediobasal (in interbothridial region) and one pair of laterobasal (anteriorly to bothridia) depressions poorly visible. Rostrum broadly rounded, with distinct medial indentation. Rostral (20–24), lamellar (41–49) and interlamellar (53–61) setae covered with broad, phylliform cerotegument, smooth, ro and le inserted on tubercles, le – le connected by thin ridge. Bothridial setae very long (278–287), rod-like, sparsely barbed. Bothridial ridges distinct. Exobothridial setae (10–12) covered with narrow, phylliform cerotegument, smooth.

Notogaster (Figs 21, 25–28, 32, 33). Anterior notogastral margin slightly convex. Posterior part evenly rounded (not dilated). Weakly convex in dorsocentral and lateral parts and with circummarginal furrows between them. Caudal ridges not developed. Sixteen pairs of notogastral setae covered with broad, phylliform

cerotegument, smooth, inserted on small tubercles; h_2, c_1, d_1, d_2, e_1 (77–90) longer than f_1, h_1 (61–69), c_3, cp, e_2 (49–57) and c_2, f_2, h_3, p_1 – p_3 (36–41). Setae c_1, d_1, d_2 reaching the insertions of d_1, d_2, e_1 , respectively. Distance between setae c_1 – c_2 shorter than between c_2 – c_3 . Lyrifissures ia, im, ip, ih, ips and opisthonotal gland openings well visible, located in typical positions.

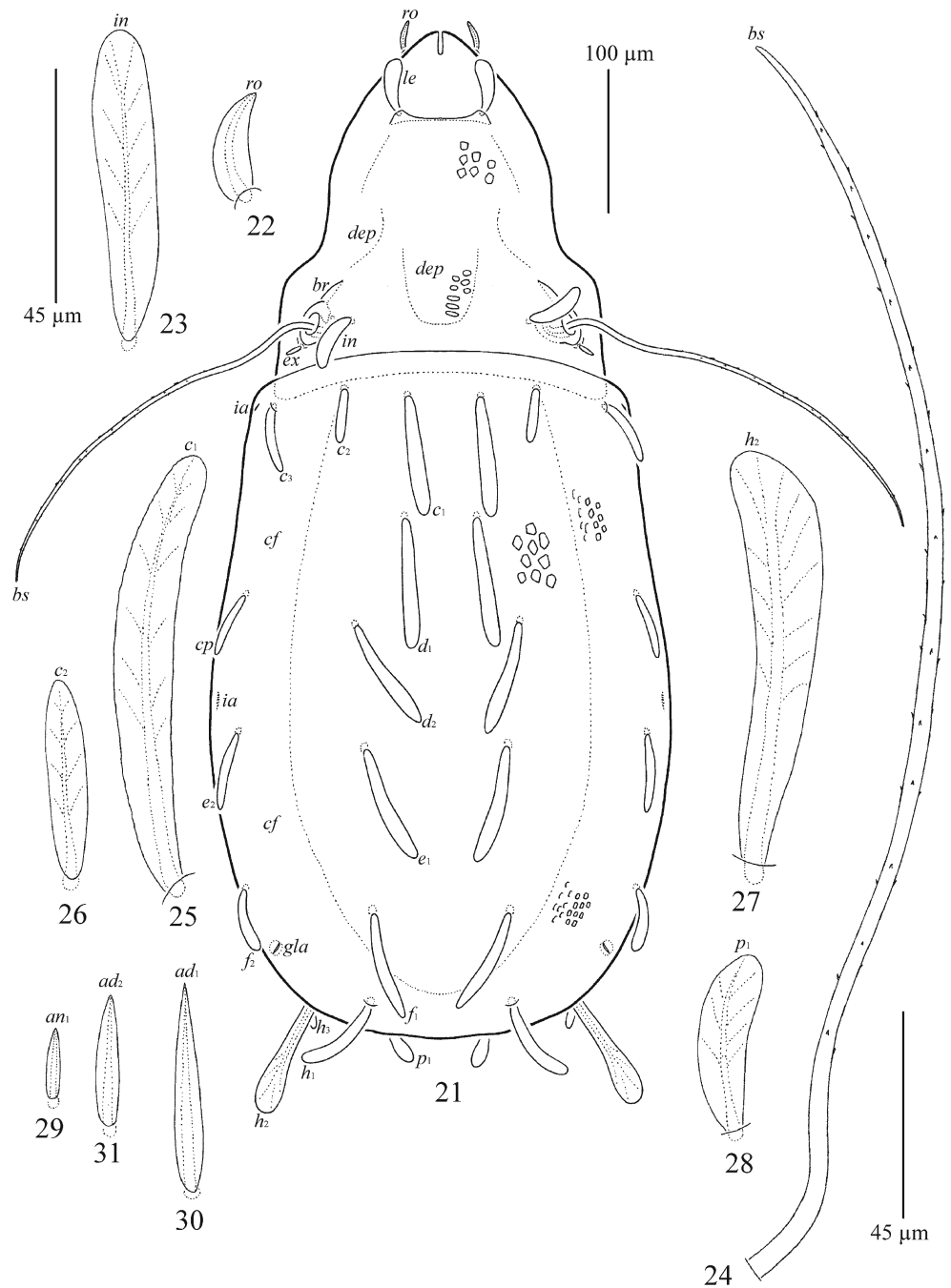
Gnathosoma. Generally, the morphology of gnathosoma, palps and chelicerae is similar to *N. anauniensis*. Subcapitulum longer than wide (157–164 \times 135–143). Subcapitular setae h (20–22) and m_2 (8) covered with narrow phylliform cerotegument, smooth, m_1 (20–22) and a (24–26) setiform, barbed. Two pairs of adoral setae (24–26) present; or_1 setiform, smooth, or_2 dilated distally, truncate, smooth. Palps (86–90) with setation 0–1–1–3–9(+1 ω). Postpalpal setae (12–14) simple, erect. Chelicerae (157–164) with two setiform, barbed setae; cha (53–57) longer than chb (36–41). Trägårdh's organ elongate triangular.

Epimeral and lateral podosomal regions (Fig. 32). Anterior tectum of epimere I distinctly incised medially. Epimeral setal formula 7–4–6–7. Setae short (14–16), covered with narrow phylliform cerotegument, smooth.

Anogenital region (Figs 29–33). Nine pairs of genital (16–20), two pairs of anal (16–20) and 3 pairs of adanal ($ad_1, 41$ – 45 ; $ad_2, ad_3, 22$ – 24) setae covered with narrow phylliform cerotegument, smooth. Lyrifissures ian and iad clearly visible.

Legs (Fig. 34). Tarsi with one strong smooth claw. Generally, the morphology of leg segments, setae and solenidia is similar to *N. anauniensis*. Formulas of leg setation and solenidia: I (1–9–5–6–27) [1–2–3], II (1–8–5–5–25) [1–1–1], III (3[or 4]–5–5–5–22) [1–1–0], IV (2–6–5–5–22) [1–1–0]; homologies of setae and solenidia indicated in Table 1.

Figs 21–31 *Nothrus xuejianensis* Ermilov sp. n., adult. **21** Dorsal view **22** Rostral seta **23** Interlamellar seta **24** Bothridial seta **25** Notogastral seta c_1 **26** Notogastral seta c_2 **27** Notogastral seta h_2 **28** Notogastral seta p_1 **29** Anal seta an_1 **30** Adanal seta ad_1 **31** Adanal seta ad_2

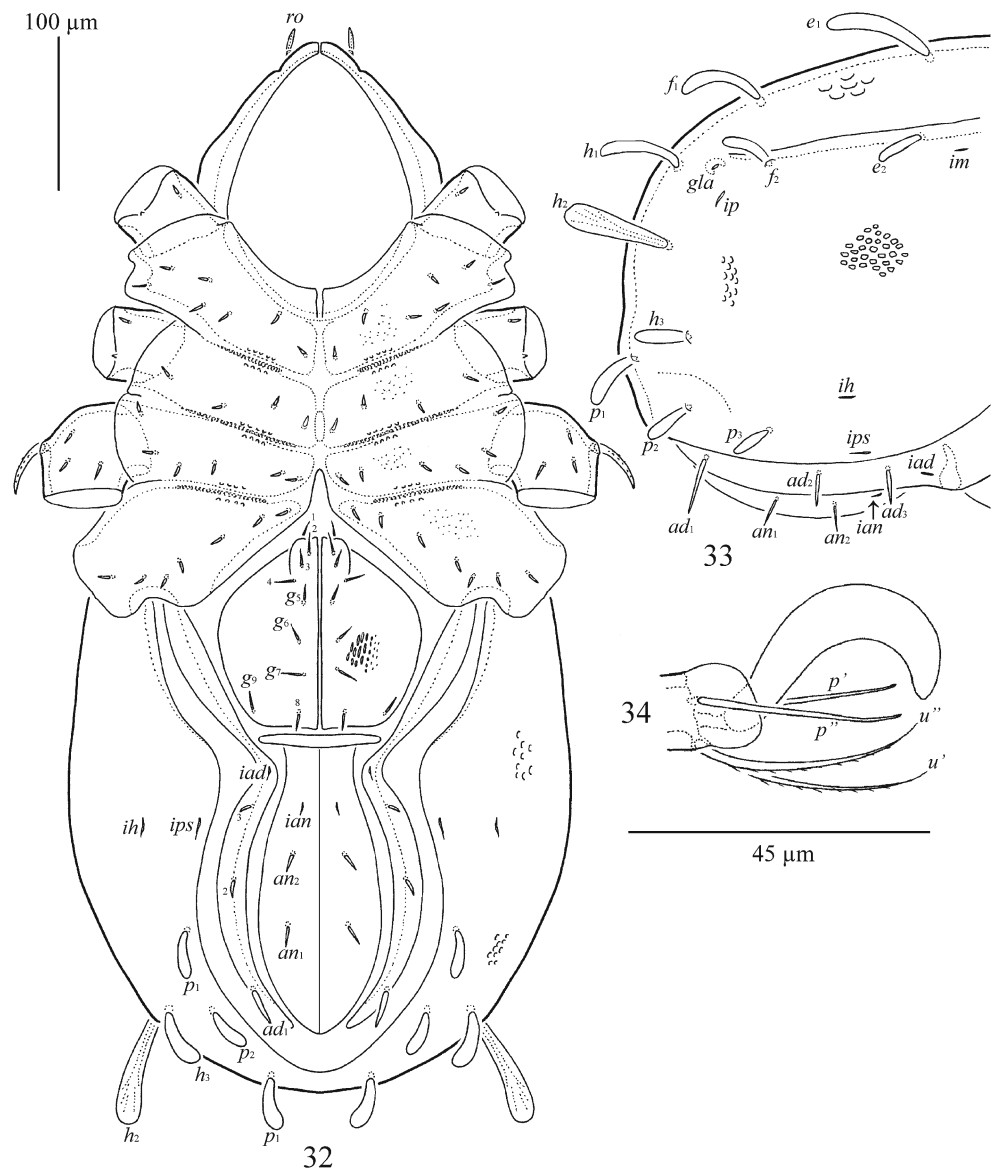


Material examined Holotype (female) and two paratypes (two females): Taiwan, Miaoli County, Tai'an Township, SheiPa National Park, Xuejian Area, 24°25.464'N, 121°00.796'E, 1855 m a.s.l., sample #31, moss, 13.XI.2017 (collected by J.-R. Liao and H.C. Lee). One paratype (one female): Taiwan, Yilan County, Nan'ao Township, Cueifong Lake Circular Trail, 24°30.771' N, 121°36.616' E, 1885 m a.s.l., sample #24, soil, 5.XI.2017 (collected by J.-R. Liao and H.C. Lee).

Type deposition The holotype (in ethanol with drop of glycerol) is deposited in the collection of NTU. Three paratypes (all in ethanol with drop of glycerol) are deposited in the collection of TSUMZ.

Etymology The specific name *xuejianensis* refers to the Xuejian Area, where the holotype and some paratypes were collected.

Figs 32–34 *Nothrus xuejianensis* Ermilov sp. n., adult. **32** Ventral view (gnathosoma and legs except trochanters I–III not shown) **33** Posterior part of body, lateral view **34** Distal part of leg tarsus I, right, antiaxial view



Remarks In general morphological traits (body elongate oval, without dilatation posteriorly; bothridial setae very long, rod-like; notogastral setae with broad, phylliform cerotegument, dorsomedial setae comparatively long; monodactylous legs), *Nothrus xuejianensis* Ermilov sp. n. is morphologically most similar to *Nothrus meakanensis* Fujikawa, 1999 from Japan and Nepal, but differs from the latter by the notogastral setae h_2 with broad, phylliform cerotegument, similar to dorsomedial setae c_1, d_1, d_2, e_1 in length (versus h_2 with thin cerotegument, considerably longer than other notogastral setae) and presence of two pairs of subcapitular setae m (versus 3 pairs).

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Compliance with ethical standards

Conflict of interests No potential conflict of interest was reported by the authors.

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