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Authors: Ren, Guoru, Yang, Maofa, Liang, Wenqin, and Xie, Lixia

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Two new species of *Papillacarus* (Acari, Oribatida, Lohmanniidae) from China

GUORU REN[1], MAOFA YANG[1*], WENQIN LIANG[1, 2] & LIXIA XIE[3]

[1] *Institute of Entomology, Guizhou University, Guizhou Provincial Key Laboratory for Agricultural Pest Management of the Mountainous Region, Guiyang, 550025, China*

[2] *Guizhou Provincial Center for Disease Control and Prevention, Guiyang, 550004, China*

[3]*College of Plant Protection, Shandong Agricultural University, Shandong Provincial Key Laboratory for Biology of Vegetable Diseases and Insect Pests, Taian, 271018, China*

[*] *Corresponding author, E-mail: gdgdly@126.com*

Abstract

Two new species of Lohmanniidae, *Papillacarus* (*Papillacarus*) *internus* **sp. nov.** from soil in Hainan Province, South China and *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.** from rotten tree and soil in Chongqing City, Southwest China are described and illustrated. *Papillacarus* (*P.*) *internus* **sp. nov.** is most similar to *Papillacarus* (*P.*) *lienhardi* (Mahunka, 1997), however, it can be distinguished from the latter by the following characters: 29–30 pairs of additional neotrichal setae, seta c_1 shorter than c_2, all genital setae setiform and smooth. *Papillacarus* (*V.*) *hexagonus* **sp. nov.** is most similar to *Papillacarus* (*V.*) *gueyeae* (Pérez-Íñigo, 1989), however, it can be distinguished from the latter by the following characters: 38 pairs of additional neotrichal setae, 7 pairs of subcapitula setae, epimeral formula 9-4-3-4.

Key words: Lohmanniidae, new species, systematics, morphology, China

Introduction

In this paper we describe two new species of Lohmanniidae: *Papillacarus* (*Papillacarus*) *internus* **sp. nov.** from soil in Hainan Province, South China, and *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.** from rotten tree and soil in Chongqing City, Southwest China.

The oribatid mite genus *Papillacarus* was proposed by Kunst (1959) with *Lohmannia murcioides aciculata* Berlese, 1905 as type species. Currently, *Papillacarus* comprises 37 species in the two subgenera *Papillacarus* and *Vepracarus*, which are distributed in tropical regions (Subías 2004, online version 2018). The main generic characters of *Papillacarus* are the following: genital plates with transverse suture, anal and adanal plates separated, preanal plate narrow, two pairs of adanal setae present, notogastral setae setiform, branched or ciliate. The main subgeneric characters of *Papillacarus* (*P.*) are the following: pygidial setae setiform, ciliate; weak additional neotrichal setae, no more than 30 pairs. The main subgeneric characters of *Papillacarus* (*V.*) are the following: pygidial setae branched or tree-shaped; strong additional neotrichal setae, more than 20 pairs (Balogh 1961; Wallwork 1962; Aoki 1965; Balogh & Balogh 1987, 1992). Prior to this study, eight species of the genus *Papillacarus* have been recorded in China (Wang & Hu 1990, Li *et al*. 1991, Chen *et al*. 2010*a*, Chen *et al*. 2010*b*, Chen & Yang 2011): *Papillacarus* (*Papillacarus*) *echinatus* Li *et al*. 1991, *Papillacarus* (*Vepracarus*) *hirsutus* Aoki, 1961, *Papillacarus* (*P.*) *ondriasi* Mahunka, 1974, *Papillacarus* (*P.*) *undirostratus* Aoki, 1965, *Papillacarus* (*V.*) *cruzae* Corpuz-Raros, 1979, *Papillacarus* (*V.*) *punctatus* Wang & Hu, 1990, *Papillacarus* (*V.*) *jinggangshanensis* Chen *et al*.

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2010*b*, *Papillacarus* (*V.*) *konglinensis* Chen & Yang, 2011. Identification keys for some species of *Papillacarus* were presented by Balogh and Balogh (1987), Ermilov *et al*. (2012), Ermilov and Tolstikov (2015).

Material and methods

For the material, see *Material examined* section of each species. The specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. The body measurements are presented in micrometers. The 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 in dorsal aspect. Lengths of body setae were measured in lateral aspect. Formulae for leg setation are given according to the sequence trochanter-femur-genu-tibia-tarsus (famulus included). Formulae for leg solenidia are given in brackets according to the sequence genu-tibia-tarsus. General terminology used in this paper follows that summarized by Grandjean (1950), Norton (1977) for leg setal nomenclature, and Norton and Behan-Pelletier (2009). Morphological description of both species follows with Ermilov and Deharveng (2016), Ermilov (2017), Ermilov *et al*. (2017). Drawings were made with a camera lucida using an Olympus transmission light microscope "Olympus CX41".

Descriptions

Papillacarus (***Papillacarus***) ***internus*** **sp. nov.**
(Figs 1–10)

Diagnosis

Body size 467–488×227–243. Rostrum rounded. Prodorsum and notogaster surface densely punctate. Prodorsal, notogastral and neotrichal setae setiform, with short cilia, and thin, smooth apex. Five transverse bands present on notogaster surface. Bothridial seta pectinate, with 12 to 13 branches. Epimeral setal formula: 7-4-3-4. Genital seta setiform, smooth. Adanal seta setiform, barbed unilaterally.

Measurements. Body length 472 (holotype), 467–488 (9 paratypes); body width 236 (holotype), 227–243 (9 paratypes).

Integument. Body yellow-brown. Surface of prodorsum, notogaster, subcapitulum, genital, adanal plates and legs densely punctate.

Prodorsum (Figs 1–3). Rostrum widely rounded. Rostral seta (*ro*, 52) setiform. All prodorsal setae setiform, with short cilia, and thin, smooth apex. Lamellar seta (*le*, 62), interlamellar seta (*in*, 70) longer than others, posterior exobothridial seta (*exp*, 65) setiform, smooth. Anterior exobothridial seta (*exa*, 59) barbed bilaterally. Bothridial seta (*bs*, 82) pectinate, with 12 to 13 branches on one side, and four barbs on the opposite side. Postbothridial transverse band (S_b) between bothridia.

Notogaster (Figs 1–3). Five transverse bands (S_2–S_6) present on notogaster, S_2 and S_4 complete, while S_3, S_5 and S_6 interrupted medially. Sixteen pairs of primary notogastral setae and 29–30 pairs of additional neotrichal setae present, all setiform, with short cilia bilaterally or unilaterally and smooth apex. Setae c_1, d_1, e_1, and f_1 never reaching the margin of notogaster, seta c_1 shorter than distance c_1–d_1, setae d_1, d_2 lie on (d_1) resp. inside of a duplication (d_2) of the transverse band S_4. Neotrichal setae of two types: 3 pairs long (*m*, 45–48; *n*, 50–53; *r*, 58–60) and 26–27 pairs short (21–33). Lyrifissures *ia*, *im*, *ip*, *ih* distinct, *ia* laterally to seta c_3, *ip* anterior laterally to f_2, *ih* laterally to h_3, *ips* not distinct. Notogastral setal lengths: $c_1 \approx h_1 = 41$ (39–42), $c_2 \approx d_1 \approx e_1 \approx f_1 = 52$ (51–54), $c_3 \approx d_2 \approx e_2 = 57$ (56–58), $f_2 \approx h_2 = 63$ (62–64), $d_3 \approx h_3 \approx p_1 \approx p_2 \approx p_3 = 69$ (68–71).

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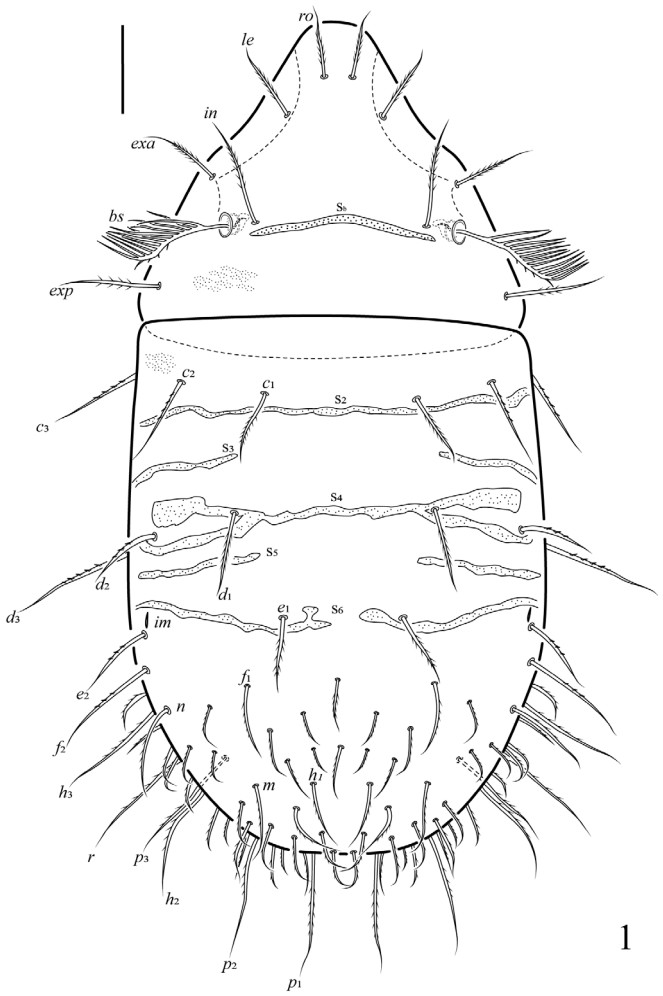


FIGURE 1. *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**, adult: dorsal view. Scale bar 50 μm.

Gnathosoma (Figs 2, 4–6). Subcapitulum longer than wide (116–122×92–97). Setae *h*, m_1 and m_2 (11–20) thickened in medio-basal part, barbed bilaterally, represented by four pairs: *a* (26), *h* (17), m_1 (11), m_2 (18). Adoral setae smooth: or_1 (23) more or less triangular, wide in proximal part, blunt-ended; or_2 (30) long, setiform, blunt-ended; or_3 (25) long, setiform, pointed-ended. Palp (49) with setal formula 0-1-0-1-10(+1ω). Chelicera (139) with two setae, seta *cha* (17) short, thorn-like, seta *chb* (27) long, setiform and barbed. Trägårdh's organs (*Tg*) triangular, tip slightly pointed.

Epimeral region (Fig. 2). Epimeral plates distinct, partly distinct ridges, epimeral setae setiform, setae *1a*, *2a*, *3a*, *4a*, *4b* and one pair of lateral setae of epimere I smooth (6–9); other setae barbed bilaterally. Epimeral formula 7-4-3-4.

Anogenital region (Figs 2–3). Ten pairs of genital setae, setiform and smooth, four setae in outer row and six setae in inner row, setae g_2, g_5, g_7, g_8 longer (17–22), others setae shorter (8–10). Two pairs of anal setae, setiform, barbed unilaterally. Four pairs of adanal setae (*ad*, 56–72), setiform, barbed unilaterally. Lyrifissure *iad* distinct.

Legs (Figs 7–10). All legs with one simple claw each of which with small basoventral tooth. Famulus ε conical and short, posterior to solenidion ω_1. Solenidion ω_1 on tarsus I, ω_1 and ω_2 on tarsus II, φ on tibia III thickened and blunt distally. Other solenidia setiform, with thinner tips. Formulae

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of leg setation and solenidia: I 0-5-3(2)-4(1)-18(2), II 0-6-3(1)-4(1)-13(2), III 2-4-2(1)-3(1)-12(0), IV 2-3-2(1)-3(0)-12(0) (see Table 1).

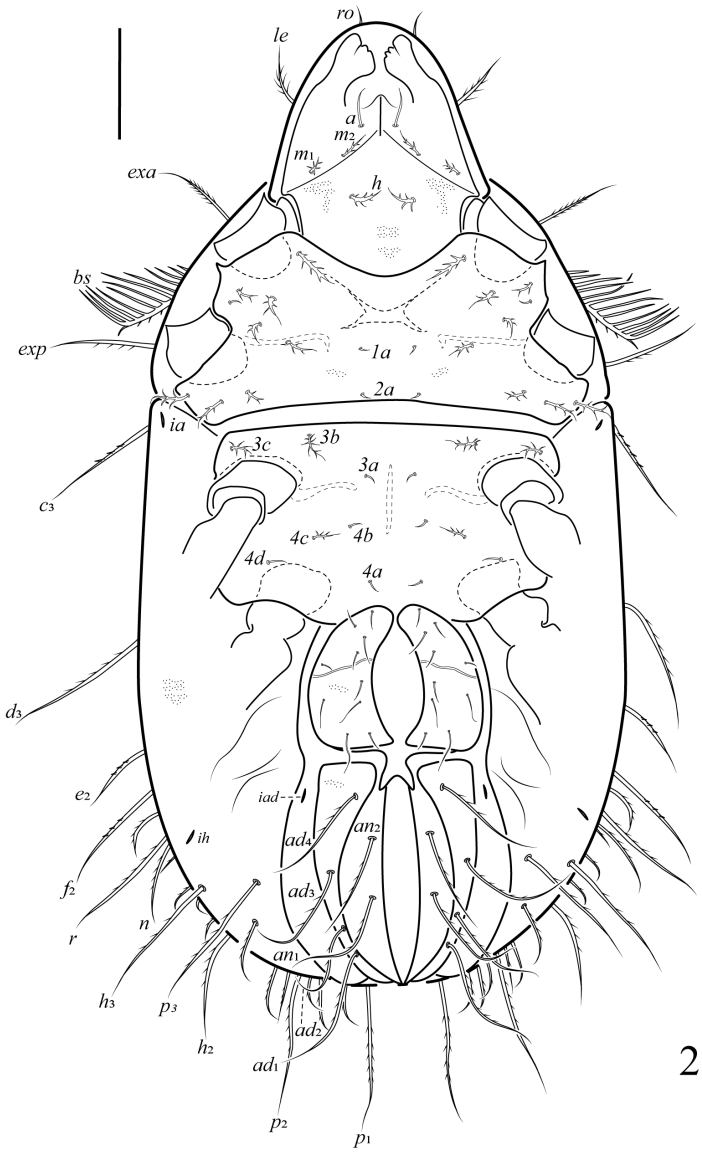


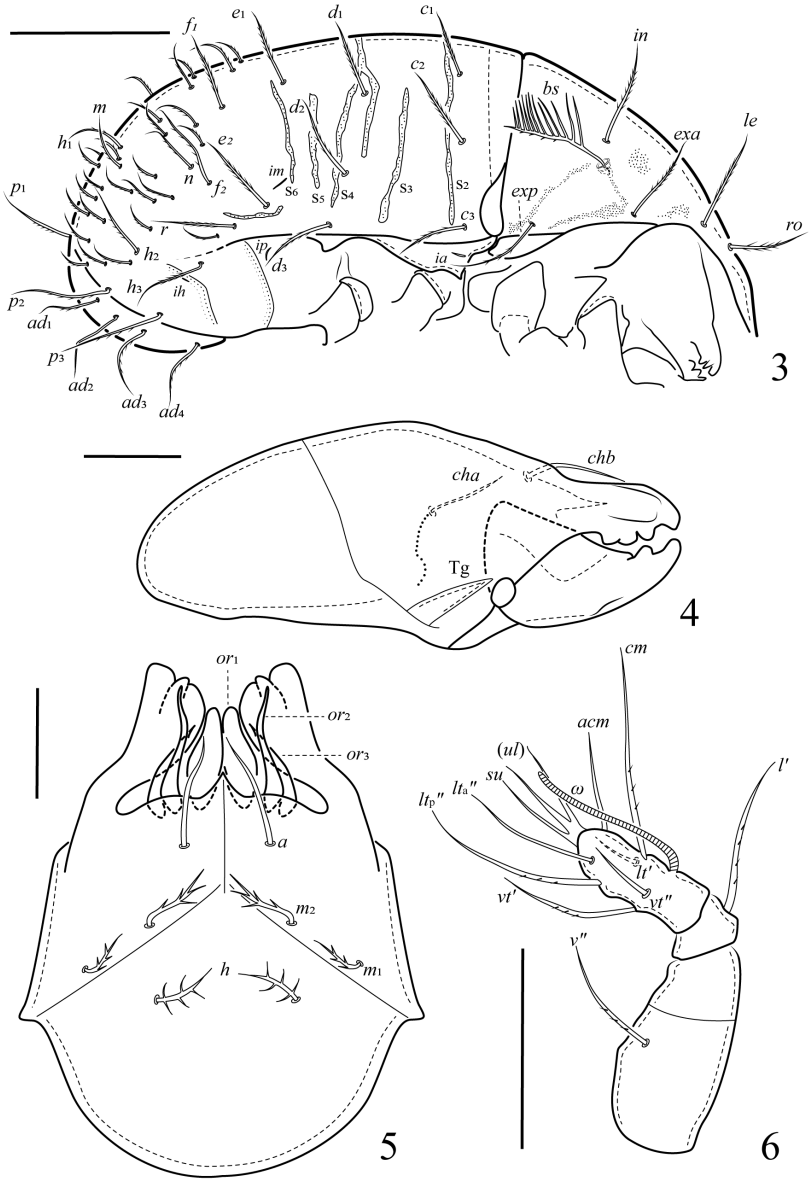
FIGURE 2. *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**, adult: ventral view. Scale bar 50 μm.

TABLE 1. Leg setation and solenidia of adult *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	–	*d*, (*l*), *bv*", *v*"	(*l*), *dσ*", σ'	*xt2*, *xt1*, *l'*, *v'*, φ	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, *m*, *n*, (*pv*), ε, ω_1, ω_2
II	–	*d*, (l_1), l_2", *bv*", *v*"	(*l*), *dσ*	*xt2*, *xt1*, *l'*, *v'*, φ	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), ω_1, ω_2
III	*l'*, *v'*	*d*, l_1', l_2', *ev'*	*d*, *l'*, σ	*d*, *l'*, *v'*, φ	(*ft*), (*tc*), (*p*), (*u*), *a'*, *s*, (*pv*)
IV	*l'*, *v'*	*d*, *l'*, *ev'*	*d*, *l'*, σ	*d*, *l'*, *v'*	(*ft*), (*tc*), (*p*), (*u*), *a'*, *s*, (*pv*)

Note: Roman letters for normal setae Greek letter for solenidia, except ε for famulus, *dσ*–seta and solenidion 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.

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FIGURES 3–6. *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**, adult: 3. lateral view; 4. chelicera, left; 5. subcapitulum, ventral view; 6. palp, left. Scale bar 100 μm (3), 25 μm (4, 5, 6).

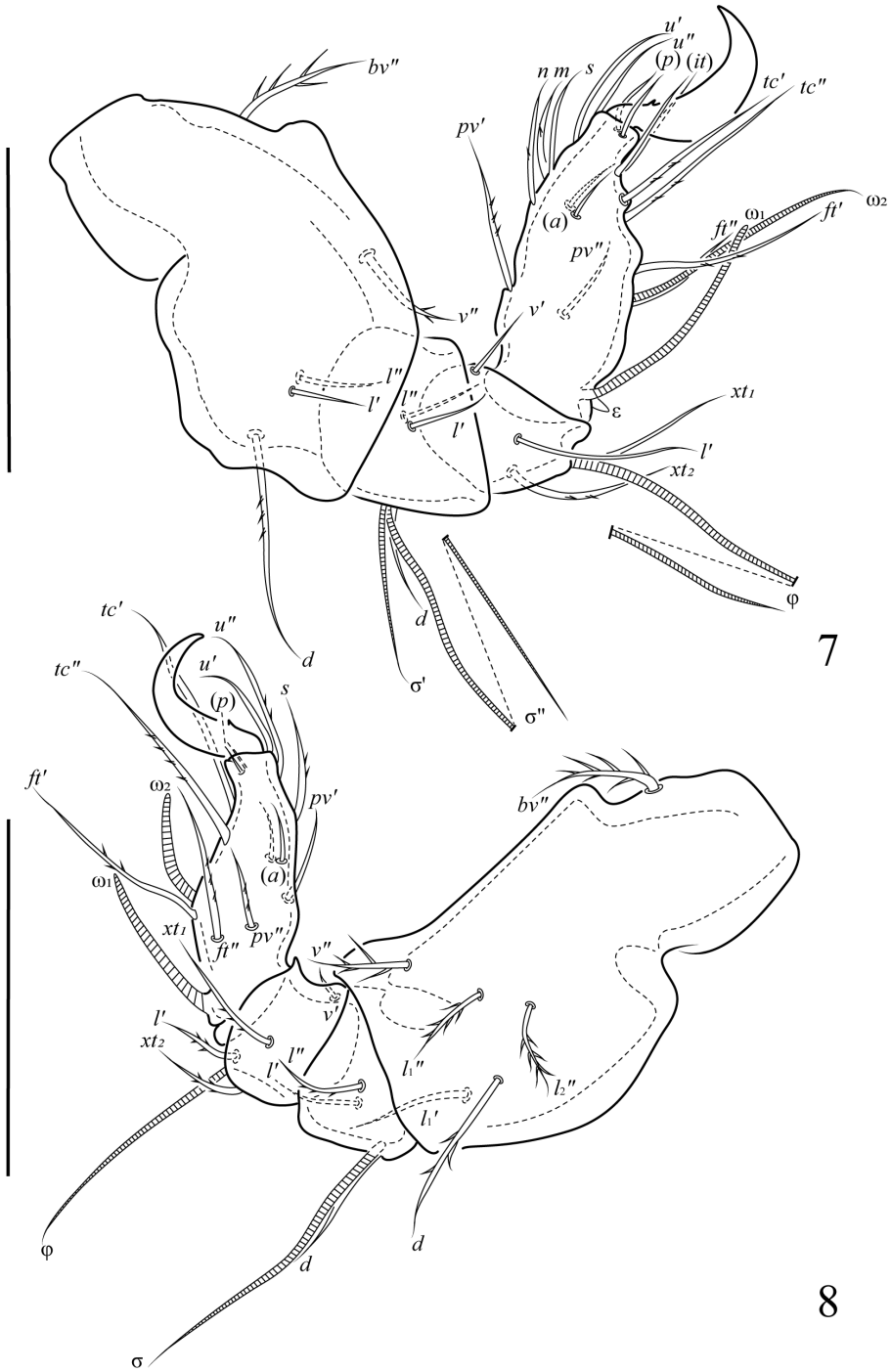
Material examined

Holotype, Chengmai County (19º63'N, 110º3'E), Haikou City, Hainan Province, 9 Jan. 2016, Guoru Ren, in soil. Nine paratypes, same data as holotype. The holotype and nine paratypes are deposited in the Institute of Entomology, Guizhou University, Guiyang of China (GUGC).

Etymology

The new specific name "*internus*" is derived from the Latin "internus", and refers to the notogastral setae d_1 and d_2 which are situated on and inside of the duplication of the transverse band S_4.

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FIGURES 7–8. *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**, adult: legs, femur to tarsus, antiaxial view. 7. leg I, right; 8. leg II, right. Scale bar 50 μm.

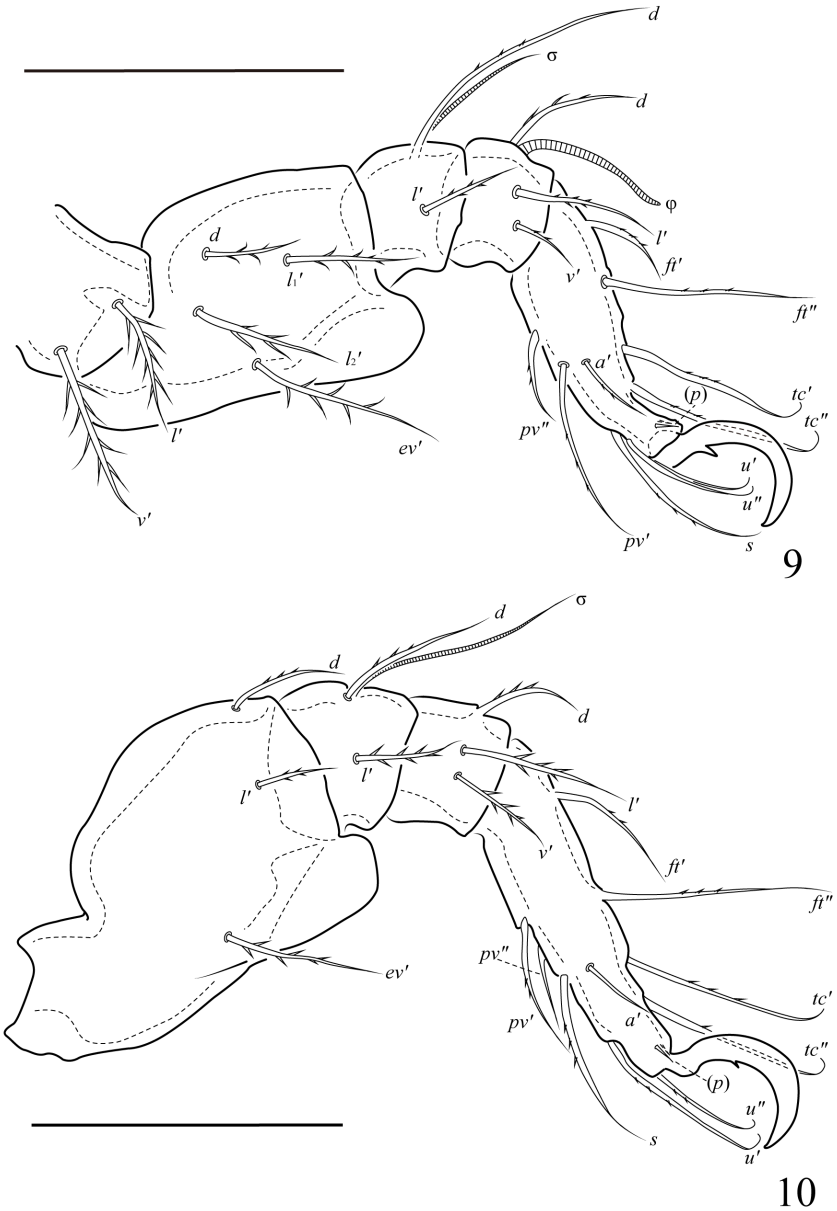
Remarks

The new species *Papillacarus* (*P.*) *internus* **sp. nov.** is most similar to *Papillacarus* (*P.*) *lienhardi* (Mahunka, 1997) from Brunei in having setiform prodorsal and notogastral setae.

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However, the new species differs from the latter by the following characters: (1) 29–30 pairs of additional neotrichal setae (*versus* approximately 25 pairs *P. lienhardi*); (2) seta c_1 shorter than c_2 (*versus* seta c_1 longer than c_2); (3) five transverse bands, S_4 complete (*versus* four transverse bands, S_4 interrupted medially); (4) all genital setae setiform and smooth (*versus* all genital setae ciliate).

The new species *Papillacarus* (*P.*) *internus* sp. nov. is also similar to *Papillacarus* (*P.*) *gramenicus* (Bayartogtokh, 2010) from Mongolia in having setiform prodorsal and notogastral setae. However, the new species differs from the latter by the following characters: (1) 29–30 pairs of additional neotrichal setae (versus 13 pairs); (2) epimeral formula 7-4-3-4 (*versus* 8-4-4-4); (3) four pairs of subcapitular setae (*versus* five pairs).



FIGURES 9–10. *Papillacarus* (*Papillacarus*) *internus* **sp. nov.**, adult: legs, femur to tarsus, antiaxial view. 9. leg III, left; 10. leg IV, left. Scale bar 50 μm.

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***Papillacarus* (*Vepracarus*) *hexagonus* sp. nov.**
(Figs 11–20)

Diagnosis

Body size 455–472×210–228. Rostrum truncate, but medially convex. Prodorsum and the whole surface of notogaster covered with bacilliar papillae. Prodorsal, notogastral and neotrichal setae with branches, tree-shaped. Four transverse bands present on notogaster surface. Bothridial seta pectinate, with 9 to 10 branches. Epimeral setal formula: 9-4-3-4. Genital seta setiform or tree-shaped. Adanal seta branched.

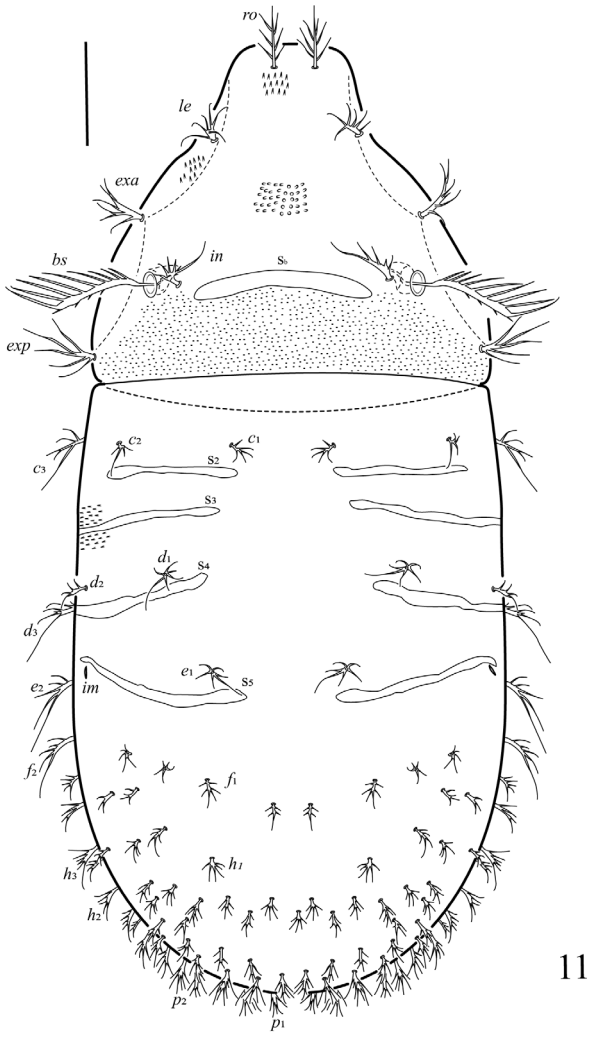


FIGURE 11. *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.**, adult: dorsal view. Scale bar 50 μm.

Measurements. Body length 462 (holotype), 455–472 (15 paratypes); body width 213 (holotype), 210–228 (15 paratypes).

Integument. Body yellow-brown. Surface of Prodorsum, notogaster, subcapitulum, genital, adanal plates and legs papilliform.

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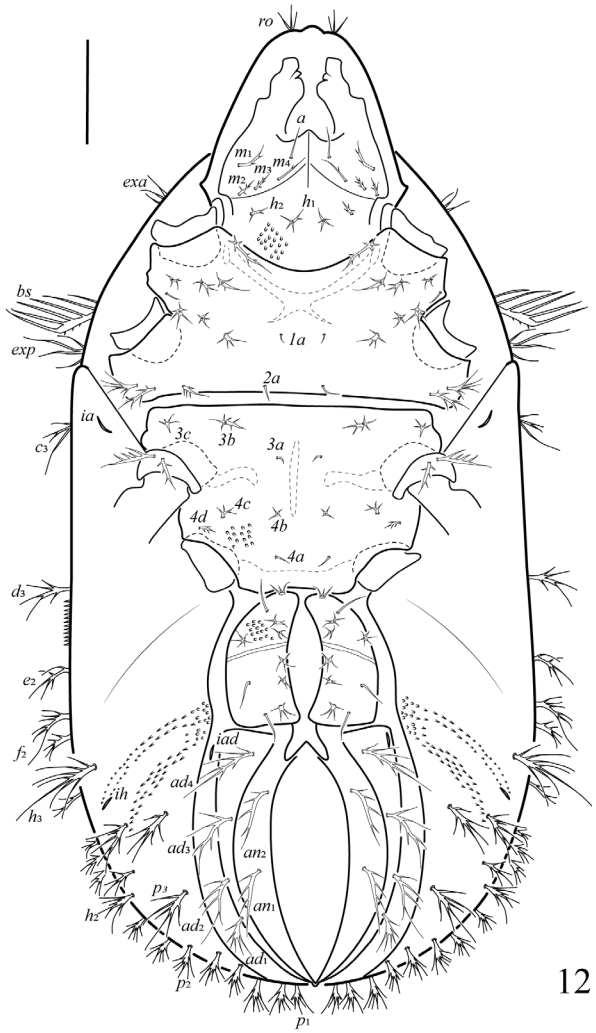


FIGURE 12. *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.**, adult: ventral view. Scale bar 50 μm.

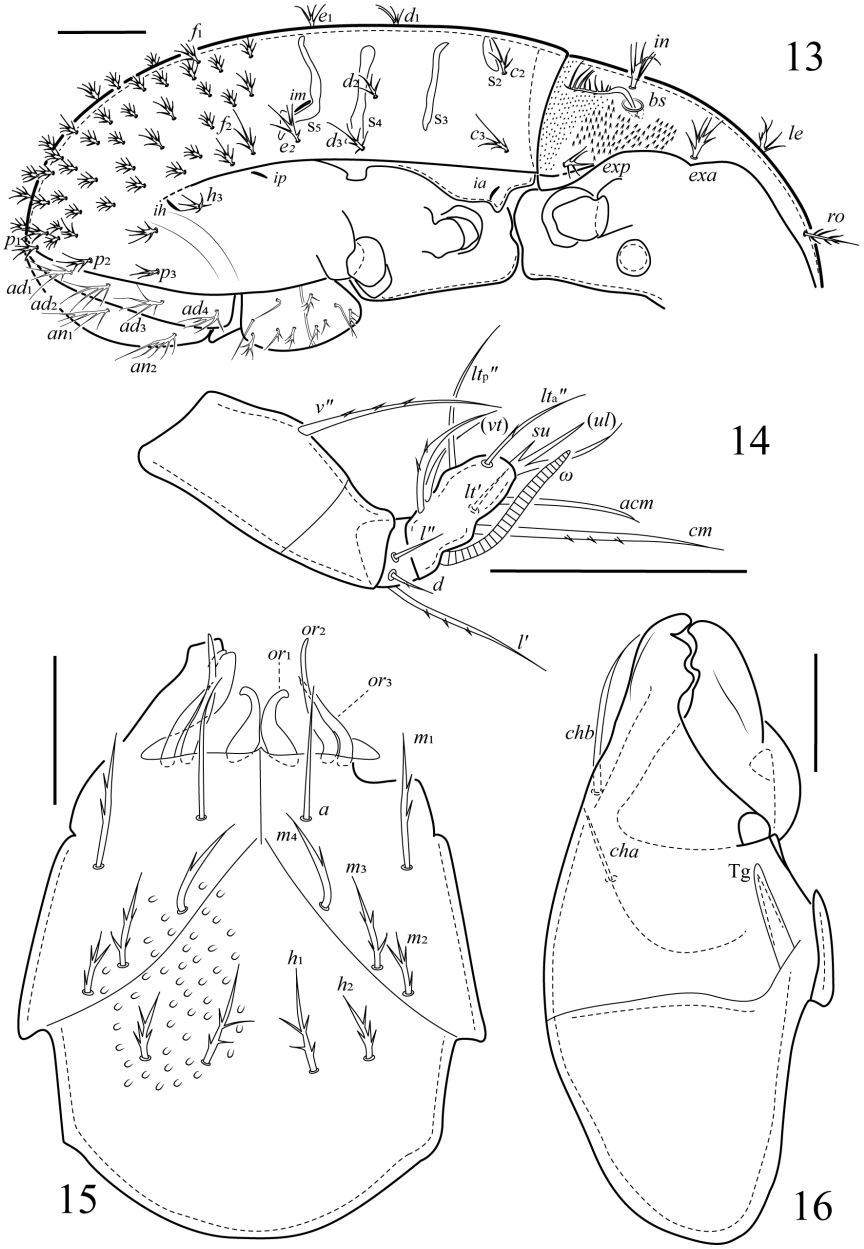
Prodorsum (Figs 11–13). Rostrum truncate, but medially convex. Rostral seta (*ro*, 30) bear several long branches on each side. Prodorsal surface papilliform in front of postbothridial transverse band and covered with fine spots posterior of this band. Lamellar seta (*le*, 26), interlamellar seta (*in*, 36), anterior exobothridial seta (*exa*, 32), posterior exobothridial seta (*exp*, 38) tree-shaped. Bothridial seta (*bs*, 69) pectinate, with 9 to 10 branches on one side, and three barbs on the opposite side. Postbothridial transverse band (S_b) between bothridia.

Notogaster (Figs 11–13). Four transverse bands (S_2–S_5) present on notogaster, all interrupted medially. Sixteen pairs of primary notogastral setae and 38 pairs of additional neotrichal setae present, all with 5–7 branches, tree-shaped. Setae c_1, c_2, d_1, e_1, h_1 and f_1 never reaching margin of notogaster, setae d_1, e_1, looking like hexagram in dorsal view. Lyrifissures *ia*, *im*, *ip*, *ih* distinct, *ia* laterally to seta c_3, *ip* laterally to f_2, *ih* anterior laterally to h_3, *ips* not distinct. Lengths of notogastral setae: c_1, c_2, d_1, d_2, e_1, f_1, h_1, p_1, p_2 (13–25); c_3, d_3, e_2, f_2, h_2, h_3, p_3 (31–48).

Gnathosoma (Figs 12, 14–16). Subcapitulum longer than wide (98–105×80–84). Surface of subcapitulum papilliform. Seven pairs of subcapitula setae, *a* (22–24) setiform, smooth, pointed-ended; m_1 and m_4 (18–23) setiform, barbed unilaterally; h_1, h_2, m_2, m_3 (12–17) setiform, barbed

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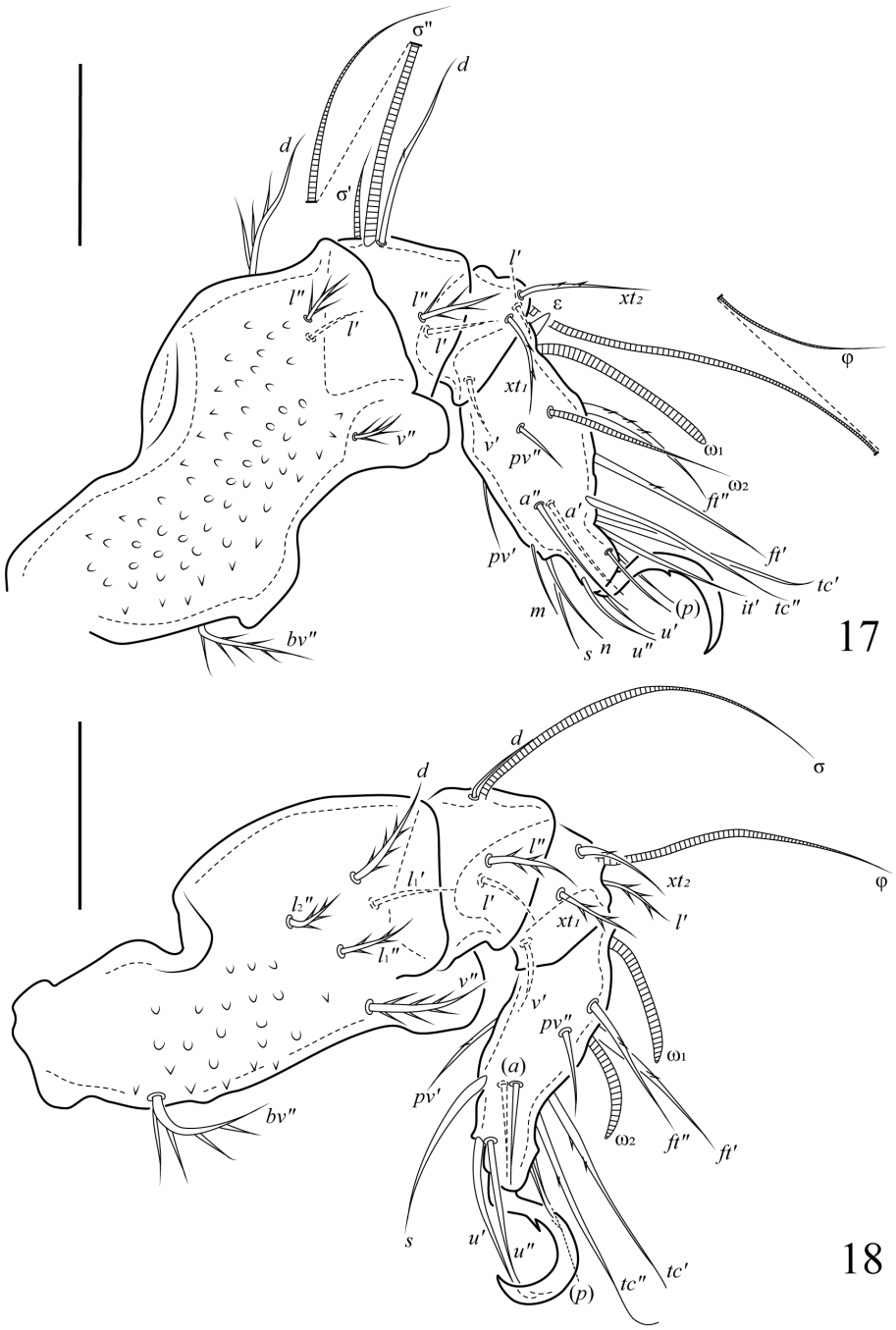
bilaterally. Three pairs of smooth adoral setae: or_1 (14) wide in proximal part, tapering up, blunt-ended; or_2 (22) long, setiform, blunt-ended; or_3 (17) long, setiform, pointed-ended. Palp (38) with setal formula 0-1-0-3-10(+1ω). Chelicera (134) with two setae, seta *cha* (4) short, thorn-like, seta *chb* (36) long, setiform and smooth. Trägårdh's organs (*Tg*) triangular, rounded distally.



FIGURES 13–16. *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.**, adult: 13. lateral view; 14. palp, right; 15. subcapitulum, ventral view; 16. chelicera, left. Scale bar 50 μm (13), 25 μm (14, 15, 16).

Epimeral region (Fig. 12). Epimeral plates distinct, partly distinct ridges, epimeral I and II neotrichous, setae setiform or tree-shaped, epimeral formula 9-4-3-4, setae 1*a*, 2*a*, 3*a*, 4*a*, and one pair of lateral setae of epimere I setiform and smooth (6–10); other setae tree-shaped (11–26).

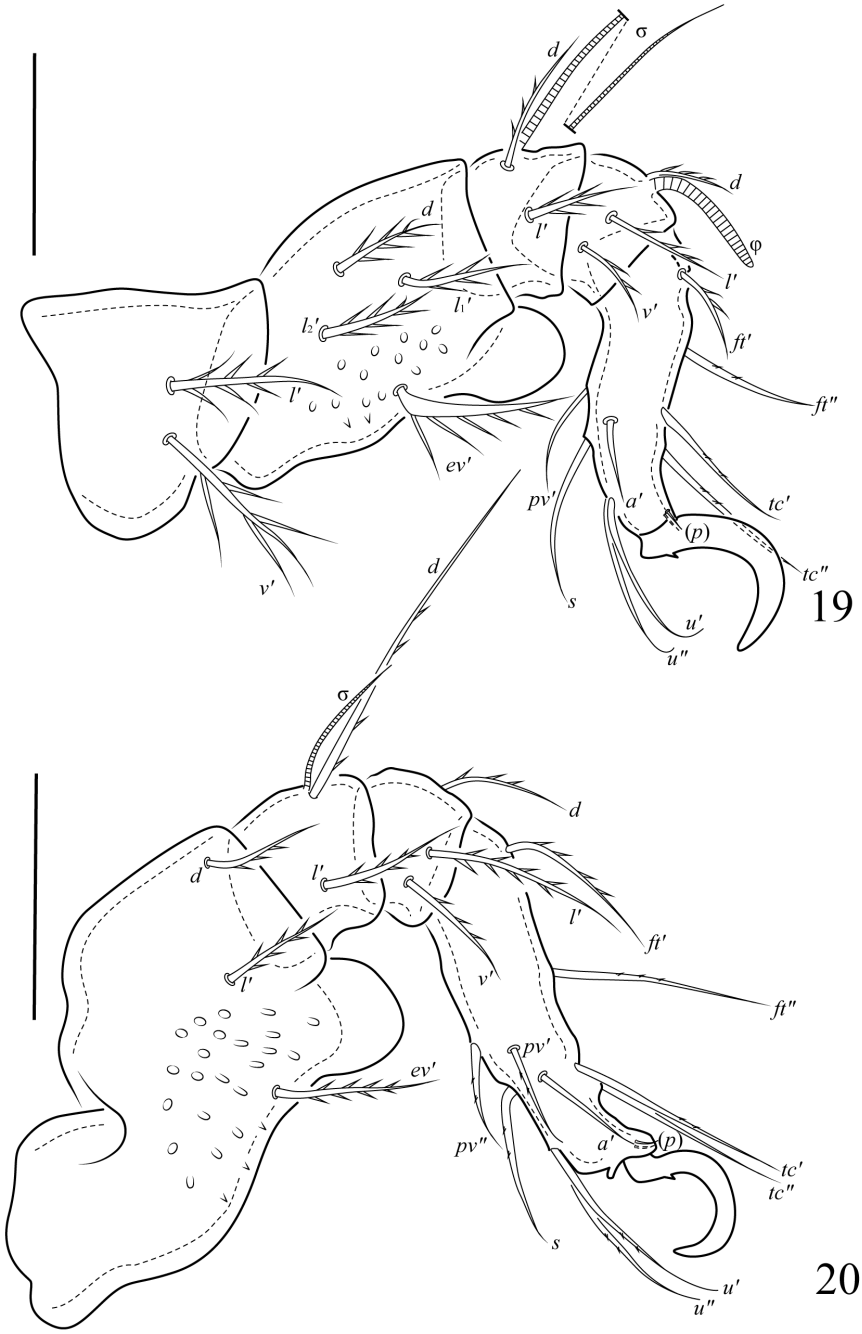
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FIGURES 17–18. *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.**, adult: legs, femur to tarsus, antiaxial view. 17. leg I, right; 18. leg II, right; Scale bar 50 µm.

Anogenital region (Figs 12– 13). Ten pairs of genital setae, setiform or tree-shaped, four setae in outer row and six setae in inner row, g_7, g_8, g_{10} setiform and smooth (17–19), other setae tree-shaped (11–14). Two pairs of anal setae bearing several long branches unilaterally (*an*, 31–34). Four pairs of adanal setae with several long branches (*ad*, 33–42). Lyrifissure *iad* distinct.

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FIGURES 19–20. *Papillacarus* (*Vepracarus*) *hexagonus* sp. nov., adult: legs, femur to tarsus, antiaxial view. 19. leg III, left; 20. leg IV, left. Scale bar 50 μm.

Legs (Figs 17–20). Surface of leg femur papilliform. All legs with one simple claw each of which with small basoventral tooth. Famulus ε conical short, posterior to solenidion ω_1. Solenidion ω_1 on tarsus I, ω_1 and ω_2 on tarsus II, φ on tibia III thickened and blunt distally. Other solenidia setiform, with thinner tips. Formulae of leg setation and solenidia: I 0-5-3(2)-4(1)-17(2), II 0-6-3(1)-4(1)-11(2), III 2-4-2(1)-3(1)-11(0), IV 2-3-2(1)-3(0)-12(0) (see Table 2).

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TABLE 2. Leg setation and solenidia of adult *Papillacarus* (*Vepracarus*) *hexagonus* **sp. nov.**

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	–	*d*, (*l*), *bv*", *v*"	(*l*), *dσ*", σ'	*xt2*, *xt1*, *l'*, *v'*, φ	(*ft*), (*tc*), *it'*, (*p*), (*u*), (*a*), *s*, *m*, *n*, (*pv*), ε, ω_1, ω_2
II	–	*d*, (l_1), l_2", *bv*", *v*"	(*l*), *dσ*	*xt2*, *xt1*, *l'*, *v'*, φ	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), ω_1, ω_2
III	*l'*, *v'*	*d*, l_1', l_2', *ev'*	*d*, *l'*, σ	*d*, *l'*, *v'*, φ	(*ft*), (*tc*), (*p*), (*u*), *a'*, *s*, *pv'*
IV	*l'*, *v'*	*d*, *l'*, *ev'*	*d*, *l'*, σ	*d*, *l'*, *v'*	(*ft*), (*tc*), (*p*), (*u*), *a'*, *s*, (*pv*)

Note: Roman letters for normal setae Greek letter for solenidia, except ε for famulus, *dσ*–seta and solenidion 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.

Material examined

Holotype, Simian Mountain (28º34'N, 106º20'E), Chongqing City, 23 Sept. 2017, Guoru Ren, in rotten tree and soil. Fifteen paratypes, same data as holotype. The holotype and fifteen paratypes are deposited in the Institute of Entomology, Guizhou University, Guiyang of China (GUGC).

Etymology

The new specific name "*hexagonus*" is derived from the Latin "hexagonus", and refers to the notogastral setae d_1 and e_1, which look like a hexagram in dorsal view.

Remarks

The new species *Papillacarus* (*V.*) *hexagonus* **sp. nov.** is most similar to *Papillacarus* (*V.*) *gueyeae* (Pérez-Íñigo, 1989) described from Senegal, in having tree-shaped prodorsum and notogastral setae. However, the new species differs from the latter by the following characters: (1) 38 pairs of additional neotrichal setae (*versus* 46–50 pairs in *Papillacarus* (*V.*) *gueyeae*); (2) bothridial seta with 9 to 10 branches (*versus* 13 to 15 branches); (3) epimeral formula 9-4-3-4 (*versus* 8-5-3-3); (4) seven pairs of subcapitular setae (*versus* six pairs); (5) genital setae g_4–g_6 tree-shaped; g_{10} setiform and smooth (*versus* g_4–g_6 setiform, smooth; g_{10} tree-shaped).

The new species *Papillacarus* (*V.*) *hexagonus* **sp. nov.** is also similar to *Papillacarus* (*V.*) *cornutus* (Sarkar & Subías, 1984) described from India in having tree-shaped prodorsal and notogastral setae. However, the new species differs from the latter by the following characters: (1) body size 455–472×210–228 (*versus* 342–349×134–141 in *Papillacarus* (*V.*) *cornutus*); (2) body surface covered with polygonal network sculpture (*versus* without); (3) 38 pairs of additional neotrichal setae (*versus* 18 pairs); (4) genital setae g_4–g_6 tree-shaped; g_{10} setiform and smooth (*versus* all genital setae bilaterally barbed).

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