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

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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. 2010a, Chen et al. 2010b, Chen & Yang 2011): *Papillacarus (Papillacarus) echinatus* Li et al. 1991, *Papillacarus (Vepracarus) hirsutus* Aoki, 1961, *Papillacarus (P.) undirostratus* 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.

**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**


**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 bars on the opposite side. Postbothridial transverse band (Sb) between bothridia.

**Notogaster** (Figs 1–3). Five transverse bands (S2–S6) present on notogaster. S2 and S1 complete, while S3, S4 and S5 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 c1, d1, e1, and f1 never reaching the margin of notogaster, seta c1 shorter than distance c1–d1, setae d1, d2 lie on (d1) resp. inside of a duplication (d1) of the transverse band S4. 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 c1, ip anterior laterally to f1, ih laterally to h1, ips not distinct. Notogastral setal lengths: c1 ≈ h1 = 41 (39–42), c2 ≈ d1 ≈ e1 ≈ f1 = 52 (51–54), c3 ≈ d1 ≈ e2 = 57 (56–58), f2 ≈ h2 = 63 (62–64), d1 ≈ h1 ≈ p1 ≈ p2 ≈ p3 = 69 (68–71).
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, m₁ and m₂ (11–20) thickened in medio-basal part, barbed bilaterally, represented by four pairs: a (26), h (17), m₁ (11), m₂ (18). Adoral setae smooth: or₁ (23) more or less triangular, wide in proximal part, blunt-ended; or₂ (30) long, setiform, blunt-ended; or₃ (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 g₂, g₅, g₆ 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 ω₁. Solenidion ω₀ on tarsus I, ω₁ and ω₂ 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)-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.

<table>
<thead>
<tr>
<th>Leg</th>
<th>Trochanter</th>
<th>Femur</th>
<th>Genu</th>
<th>Tibia</th>
<th>Tarsus</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>–</td>
<td>d, (l), bν′″, v′″</td>
<td>(l), dν″, α″</td>
<td>x12, x1, f, v′″, φ</td>
<td>(f), (c), (d), (p), (a), a′, s, m, n, (pv), ε, oν, o″</td>
</tr>
<tr>
<td>II</td>
<td>–</td>
<td>d, (l), Lν″, bν″″, v′″</td>
<td>(l), dν″</td>
<td>x12, x1, f, v′″, φ</td>
<td>(f), (c), (p), (a), a′, s, (pv), oν, o″</td>
</tr>
<tr>
<td>III</td>
<td>l″, v′″</td>
<td>d, Lν″, Lν″″, ev′″</td>
<td>d, f, α</td>
<td>d, f, v″, φ</td>
<td>(f), (c), (p), (a), a′″, x, (pv)</td>
</tr>
<tr>
<td>IV</td>
<td>l″, v′″</td>
<td>d, f, ev′″</td>
<td>d, f, α</td>
<td>d, f, v″</td>
<td>(f), (c), (p), (a), a′″, x, (pv)</td>
</tr>
</tbody>
</table>

Note: Roman letters for normal setae Greek letter for solenidia, except ε for famulus. dν″-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 (19°63'N, 110°3'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 *S₄*. 
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.
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).

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

**Diagnosis**


**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.
**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 (Sb) between bothridia.

**Notogaster** (Figs 11–13). Four transverse bands (S2–S5) 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 c1, c2, d1, e1, h1 and f1 never reaching margin of notogaster, setae d1, e1, looking like hexagram in dorsal view. Lyrifissures ia, im, ip, ih distinct, ia laterally to seta c1, ip laterally to f2, ih anterior laterally to h1, ips not distinct. Lengths of notogastral setae: c1, c2, d1, d2, e1, f1, h1, p1, p2 (13–25); c2, d1, e2, f2, h2, h3, p3 (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; m1 and m4 (18–23) setiform, barbed unilaterally; h1, h2, m2, m3 (12–17) setiform, barbed.
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 \( \mu \)m (13), 25 \( \mu \)m (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 1a, 2a, 3a, 4a, and one pair of lateral setae of epimere I setiform and smooth (6–10); other setae tree-shaped (11–26).
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, $g_5$, $g_6$, $g_9$ 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.

*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 ω₁. Solenidion ω₁ on tarsus I, ω₁ and ω₂ 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).
Material examined

Holotype, Simian Mountain (28°34'N, 106°20'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 $g_5$–$g_6$ tree-shaped; $g_{10}$ setiform and smooth (versus $g_5$–$g_6$ 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 $g_5$–$g_6$ tree-shaped; $g_{10}$ setiform and smooth (versus all genital setae bilaterally barbed).

Acknowledgements

We would like to express our gratitude to Dr. Yong Chen (Institute of Entomology, Guizhou University, Guiyang, China) and Professor Roy A. Norton (State University of New York, Syracuse, U.S.A.) for providing literature. This project was supported by the Program of Ministry of Science and Technology of the People’s Republic of China (2015FY210300); the Program of Excellent Innovation Talents, Guizhou Province, China (No. 20164022); the Funds for National Natural Sciences Foundation of China (No. 31501847), the key research and development program of Shandong Province (2016GNC110012).

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

<table>
<thead>
<tr>
<th>Leg</th>
<th>Trochanter</th>
<th>Femur</th>
<th>Genu</th>
<th>Tibia</th>
<th>Tarsus</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>–</td>
<td>$d_1$, $bv'$, $v'$</td>
<td>($l_1$, $dc_{1}''$, $c_{1}'$, $d_{1}$, $vt_{2}$, $xt_{1}$, $l$, $v'$, $v''$, $q$)</td>
<td>($l_4$, $tc$, $d_{4}$, $p$, $a$, $m$, $n$, $p_{4}$, $c$, $a_{1}$, $a_{2}$)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>–</td>
<td>$d_1$, $l_1$, $b_1'$, $v'$</td>
<td>($l_1$, $dc_{1}''$, $c_{1}'$, $d_{1}$, $vt_{2}$, $xt_{1}$, $l$, $v'$, $v''$, $q$)</td>
<td>($l_4$, $tc$, $d_{4}$, $p$, $a$, $m$, $n$, $p_{4}$, $c$, $a_{1}$, $a_{2}$)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>$l$, $v'$</td>
<td>$d_1$, $l_1$, $b_1$, $ev'$</td>
<td>$d_1$, $l$, $v'$, $q$</td>
<td>($l_4$, $tc$, $d_{4}$, $p$, $a$, $m$, $n$, $p_{4}$, $c$, $a_{1}$, $a_{2}$)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>$l$, $v'$</td>
<td>$d_1$, $l_1$, $b_1$, $ev'$</td>
<td>$d_1$, $l$, $v'$, $q$</td>
<td>($l_4$, $tc$, $d_{4}$, $p$, $a$, $m$, $n$, $p_{4}$, $c$, $a_{1}$, $a_{2}$)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Roman letters for normal setae, Greek letter for solenidia, except for famulus, 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.
References


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