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Abstract: A review of the oribatid mites of the genus Papillacarus Kunst, 1959 (Oribatida: Lohmanniidae) in Vietnam, with remarks on the taxonomic status of P. arboriseta, is presented. The article provides also a key to nine species recorded in Vietnam, namely P. arboriseta Jeleva et Vu, 1987, P. benenensis Vu, Ermilov et Dao, 2010, P. cornutus (Sarkar et Subias, 1984), P. hirsutus (Aoki, 1961), P. indistinctus Ermilov, Anichkin et Wu, 2012, P. polygonatus Ermilov et Anichkin, 2011, P. polysetosus Ermilov, Anichkin et Wu, 2012, P. ramosus Balogh, 1961, and P. undirostratus Aoki, 1965. For each species, a list of synonyms, information on types and type localities, a brief new description, an illustration, taxonomic problems, as well as remarks on the ecology and distribution are included. These species are known from the Oriental Region and Southeast Asia, and five of them are recorded only from Vietnam.

Keywords: Oribatida, Lohmanniidae, Papillacarus arboriseta, Vietnam

Introduction

Oribatid mites (Acari: Oribatida) play an important role in soil ecosystems, particularly for decomposition of plant litter, nutrient cycling, soil formation, and for distribution of a number of parasites and diseases (Balogh, Balogh 2002, Beron 2011). The oribatids are one of the major acarine groups, which occur mainly in the soil environment, and are still little known in Asian tropical ecosystems (Vu 1990, Vu, Nguyen 2000, Yin Wenying et al. 2000, Corpuz-Raros 2005, Hasegawa, Kitayama 2006). In Vietnam, after the first work of Balogh, Mahunka (1967), some studies on oribatids started in the 1980s. Recently the oribatid fauna of Vietnam was studied by Vu (2007, 2012), Dao et al. (2010), Ermilov, Vu (2012), and Nguyen, Vu (2012).

Lohmanniidae is a moderately diverse oribatid family, which comprises more than 20 genera and is distributed mainly in the tropical and subtropical regions. The genus Papillacarus, one of the most diverse genera in the family Lohmanniidae, was described in 1959 by Kunst with the type species Lohmannia murcioides aciculata Berlese, 1904. The genus Papillacarus Kunst, 1959 is known with more than 30 species, and most of them have a restricted pantropical and subtropical distribution (Grandjean 1950, Balogh 1961, Balogh, Balogh 2002, Norton 2009, Subias 2013).

The knowledge of the oribatid genus Papillacarus Kunst, 1959 in Vietnam is insufficient (Jeleva, Vu 1987, Vu 2009, Vu et al. 2010, Ermilov et al. 2011, 2012). The aim of this study is to provide a review of the genus, as well as remarks on the taxonomic status of P. arboriseta Jeleva et Vu, 1987, and, based on the specimens obtained throughout Vietnam, to give a key to nine species recorded in the country.
Material and Methods
The samples were obtained from six habitat types as follows: forest, disturbed forest, scrub, grassland, poly-annual cultivated and annual cultivated habitat. The mites were taken from the following four different vertical layers: decaying wood debris and moss lying on 0 – 100 cm above surface forest litter, forest litter lying on the soil surface, soil top layer of 0-10 cm below surface, and soil deep layer of 11-20 cm below surface. The studied soils were grouped into four main types after the classification introduced by the Vietnamese National Institute for Soils and Fertilizers (2002), namely: neutral alluvial soil, ferralitic reddish brown soil, ferralitic brownish soil derived from limestone, and dark loamy soil. All study sites were distributed within six geographic regions: northwest upland, northeast upland, Red River Delta, north central Vietnam, central north Vietnam, and southern Vietnam (Vietnam Ministry of Agriculture and Rural Development 2006).

The oribatid mites were extracted using a Berlese funnel apparatus and preserved in 70% ethanol, then mounted in lactic acid on temporary cavity slides for measurement and illustration. The body length was measured in dorsal view, from the tip of the rostrum to the posterior edge of the ventral plate. The notogastral width refers to the maximum width in dorsal aspect. Some specimens were dissected for detailed study. The terminology used in the text is follows Balo h, Mahunka (1983).

Results and Discussion
Genus Papillacarus Kunst, 1959


Type species: Lohmannia murcioides Berlese, 1896 var. aciculata Berlese, 1904. Redia, II: 24, Tav. 2, fig. 39.


1. Papillacarus arboriseta Jeleva et Vu, 1987 (Fig. 1: a, b, c)


Specimens Examined and Ecological Notes. 1) Dinh Hoa (Thai Nguyen province), 21°40’N-105°46’E, 25.1.1988, Natural forest, Ferralitic brownish soil derived from limestone, Northeast uplands, 600-900 m a.s.l., 0-10 cm (n=3), 2) Tam Dao National Park (Vinh Phuc province), 21°27’N-105°38’E, 27.5.1995, Grassland, Ferralitic reddish brown soil, Northeast uplands, 900 m a.s.l., 0-10 cm (n=5), 3) Xuan Nha Nature Reserve (Son La province), 20°38’N-104°41’E, 19.11.1991, Forest, Ferralitic brownish soil derived from limestone, Northwest uplands, 1450 m a.s.l., 0-10 cm (n=5), 4) Phu Tho town (Phu Tho province), 21°25’N-105°14’E, 23.12.1983, Annual cultivated land, Neutral alluvial soil, Northwest uplands, 200-400 m a.s.l., 0-10 cm, a.s.l. (n=2), 5) Xuan Son National Park (Phu Tho province), 21°07’-104°56’E, 26.4.2005 & 15.10.2009, Forest, Disturbed forest, Scrub, Poly-annual cultivated habitat, Ferralitic brownish soil derived from limestone, Northwest uplands, 400-900 m a.s.l., 0-10 cm (n=3+7), 6) Ba Vi National Park (Hanoi), 21°03’N-105°22’E, 10.12.2003 & 25.8.2004, Forest, Ferralitic brownish soil derived from limestone, Red River delta, Forest litter & 0-100 cm above Forest litter, 400-900 m a.s.l., 0-20 cm (n=3+4), 7) Phong Nha – Ke Bang National Park (Quang Binh province), 17°22’N-105°45’E, 14.3.2010 & 25.8.2004, Forest, Ferralitic brownish

Fig. 1. P. arboriseta: a. Dorsal side, b. Ventral side, c. Sensillus. Scale bar 100 μm (a, b) and 10 μm (c)
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soil derived from limestone, Central North Vietnam, 800-900 m a.s.l., 0-10 cm (n=3).

**Measurements (Body length X Notogastral width).** 378-412 X 157-168 μm.

**Description.** Rostrum truncate. Sensillus pectinate with 7-8 setae. All prodorsal setae bilaterally strongly barbed, tree-shaped. Rostral setae basis lying on clear traversal line, excinate. Chitinous thickness can be seen posteriorly, reaching to front exobothrydium setae basis and posteriorly to bothrydium. Chitinous sculpture with rough spots. Posteriorly to the prosoma there is a transversal zone covered with fine spots, forming cross lines. Body surface covered with densely situated chitinous cylindrical papillae, considerably rising over the surface. There are slightly manifested fossulae vitiforms. All dorsal setae considerably rising over the surface. All dorsal setae tree-shaped as prosomal. Among them, there are some separate filiform setae considerably longer than the others. No pygidial neothrychi can be seen.

Genital plates with transversal suture. Ventral setae structure similar to dorsal one, except the genital setae, which always are common, setiform. Chitinous sculpture resembling that of the notogaster dorsal side.

**General distribution.** At present, the species is recorded only from Vietnam.

**Ermilov et al.** (2011), based on the specimens obtained only from central and southern Vietnam, considered *P. arboriseta* Jeleva et Vu, 1987, as a synonym of *P. hirsutus* (Aoki, 1961). On the basis of numerous specimens obtained throughout the country, particularly from northern, central and southern Vietnam, *P. arboriseta* clearly differs from *P. hirsutus* by the morphological features presented in Table 1.

2. *Papillacarus benenensis* Vu, Ermilov et Dao, 2010 (Fig. 2: a, b, c)


Holotype is deposited in the collection of the Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia. Paratype is deposited in the collection of the Center for Biodiversity Resources Education and Development (CEBRED), Hanoi National University of Education, Vietnam, 136 Xuan Thuy Rd., Cau Giay, Vietnam, and in the collection of the Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia (n=2).

**Specimens Examined and Ecological Notes.**
1) Xuan Son National Park (Phu Tho province), 21°07’N-104°56’E, 22.4.2005, Forest, Ferralitic red-brown soil, Northwest uplands, 300-400 m a.s.l., 0-10 cm (n=2), 2) Ben En National Park (Thanh Hoa province), 19°31’N-19°40’N & 105°23’E -105°35’E, 15.7.2008 & 10.1.2009, Forest, Ferralitic reddish brown soil, North Central, 200-300 m a.s.l., 0-10 cm (n=5).

**Measurements.** 620-680 X 320-350 μm.

**Description.** The body colour is yellow. Surface of all body with reticulate sculpturing, though only weakly visible on prodorsum. Roughly triangular form, occupying about 1/3 of total body length. Anterior margin of rostrum undulate. All setae weakly

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**Table 1.** Differences in morphological features between *P. arboriseta* Jeleva et Vu, 1987 and *P. hirsutus* (Aoki, 1961)

<table>
<thead>
<tr>
<th>Character</th>
<th>Data on the specimens of <em>P. arboriseta</em> obtained from Vietnam.</th>
<th>Data on the specimens of <em>P. hirsutus</em> obtained from Vietnam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rostral setae</td>
<td>Rostral setae basis lying on clear transversal line.</td>
<td>Rostral setae basis not lying on a transversal line.</td>
</tr>
<tr>
<td>Sensillus</td>
<td>Sensillus pectinate with 7-8 long cilia.</td>
<td>Sensillus pectinate with 13-14 short cilia.</td>
</tr>
<tr>
<td>Prodorsum sculpture</td>
<td>With rough spots.</td>
<td>With fine spots.</td>
</tr>
<tr>
<td>Notogaster setae</td>
<td>Tree-shaped and always there are a few separate filiform setae considerably longer than the others.</td>
<td>Tree-shaped and there are not separate filiform setae considerably longer than the others.</td>
</tr>
<tr>
<td>Genital setae</td>
<td>Setiform.</td>
<td>Tree-shaped form or setiform.</td>
</tr>
</tbody>
</table>

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**Fig. 2.** *P. benenensis* (After Vu et al. 2010): a. Dorsal side, b. Epimeral area, c. Anogenital area. Scale bar 100 μm (a, b, c)
thickened proximally, conspicuously ciliate on both sides. Sensilli pectinate branches. Bothridia funnel-shaped. Notogaster about 1.25 times as long as wide. One pair of incomplete transversal bands (S3) observable between rows of setae c and d. Posterior margin rounded. Setae both heteromorphic and strong neotrichous. With 18 pairs of long setae, weakly thickened proximally and conspicuously ciliate.

Epimeral region is similar to that in other species of the genus. Epimera neotrichous, especially I and II, and setal formula: 10-9-5-4. Most setae thin, with long, thin ciliate. Six pairs of setae longer, thicker. Anogenital region is similar to that of other species of the genus, but the length of setae differs. Anal (two pairs) and adanal (four pairs) setae long. Genital setae heterogeneous: four lateral pairs long, six medial pairs shorter; divided between two pairs of plates as typical for the genus.

General distribution. At present, the species is recorded only from Vietnam.

3. Papillacarus cornutus (Sarkar et Subias, 1984) (Fig. 3: a, b)
Measurements. 342-349 X 134-141 μm.

Description. The body colour is yellowish to brownish. Body surface covered with polygonal network sculpture, turbeculate-reticulate in large cornutus. Rostrum is rounded; ro. setae inserted far below rostral tip and bilaterally branched; le. in., anterior exostigmatic and posterior exostigmatic setae similar to rostral but shorter; horn-like projection present just in front of exa setae; in. setae very close to bothridium which being cup-shaped, and se. bilaterally barbed with thick stem, distal barbs longer than basal ones (Sarkar, Subias 1984). Notogaster with 16 pairs of normal setae, similar to prodorsal and with bilateral branching which being decreasing in long towards the tip; in the pygidial region neotrichous setae small and star-shaped, approximately 18 pairs.
Genital setae 10 pairs, 5 pairs on anterior genital plates and rest 5 on posterior one, all setae very short and bilaterally barbed; anal setae – 2 pairs, adanal setae – 4 pairs, very similar to normal notogatral setae.

General distribution. An Oriental species, known from India and Vietnam.

4. Papillacarus hirsutus (Aoki, 1961) (Fig. 4: a, b, c)
Papillacarus hirsutus (Aoki, 1961); Hammer 1972: figs. 11, 11a.
Specimens Examined and Ecological Notes. 1) Phong Nha – Ke Bang National Park (Quang Binh province), 14.3.2010: 17°22’N-105°45’E, 800-900 m a.s.l., and 17°50’N-106°24’E, Central North Vietnam, 500-600 m a.s.l., Forest litter and top soil layer of 0-10 cm (n=5); 2) Cat Tien National Park (Dong Nai province), 11°25’N-107°25’E, 2-3.2009, Forest, Dark loamy soil, Southern Vietnam, 149 m a.s.l. (n=20); 3) Yokohama city (Kanagawa prefecture, Japan), 33°28’N-139°35’E, 8.8.2011, Forest, Dark loamy soil, Forest litter, 42 m a.s.l. (n=4).
Measurements. 336-360 X 143-155 μm; and 384-422 X 141-169 μm (Japanese specimens: Aoki 1961), and 363-394 X 173-185 μm (Philippine specimens: Corpuz-Raros 1979).

Description. The body colour is yellowish to light brown. Surface of body and legs with dense papillae. Dorsal papillae rounded, lateral papillae conical. Rostrum slightly rounded or truncate in dorsal view, colourless. ro, le, in and both pairs of exobothridial (exa, exp) setae branched; sensilli pectinate, with 13 or 14 branches in one side. Two pairs of transverse bands (S3 and S4) well developed, and both interrupted medially. Notogastral setae multiply branched. Roughly triangular in dorsal view, occup-
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and latero-ventral setae long, setiform, thickened, with cilia (ERMILOV, ANICHKIN 2011).

Genital setae heterogeneous. Two pairs of anal and four pairs of adanal setae. Adanal setae longer than anal setae.

General distribution. At present, the species is recorded only from Vietnam.

7. *Papillacarus polysetosus* Ermilov, Anichkin et Wu, 2012 (Fig. 7: a, b)


Specimens Examined and Ecological Notes. Cave in the Cat Tien National Park (Dong Nai Province) (=Dong Nai Biosphere Reserve), 08.2012, 11°27'N-107°22'E, Southern Vietnam, Ground substratum and semidecayed leaves, 165 m a.s.l. (n=4).

Measurements. 664-680 X 298-315 μm.

Description. Rostrum relatively rounded. Surface of body foveolate.

Notogastral setae short, setiform and ciliate, and more than 80 pairs. Setae c1 and c2, d1 and d2, e1 and e2, f1 and f2 are shorter than others. Prodorsal, anal and adanal setae setiform and ciliate. *Papillacarus polysetosus* is very similar to two Chinese species *P. jinggangshanensis* Chen, Yang et Liang, 2011, and *P. konglinensis* Chen et Yang, 2011. However, *P. polygonatus* clearly differs from both mentioned species by the larger body size, the presence of polygonal ornamentation on prodorsum and notogaster, and longer notogastral setae (ERMILOV et al. 2012).

General distribution. At present, the species is recorded only from Vietnam.

8. *Papillacarus ramosus* Balogh, 1961 (Fig. 8: a, b)


Specimens Examined and Ecological Notes. Cat Tien National Park (Dong Nai province), 11°26'N-107°26'E, 2-3.2009, Forest, Dark loamy soil, Southern Vietnam, 137 m a.s.l. (n=?).

Measurements. 545-627 X 264X294 μm (Philippine specimens: Corpuz-Raros 1979), and 487 X 226 μm (Indonesian specimens: Balogh 1961).

Description. Notogaster surface covered with extensively neotrichous setae, has long and slender arboriform hairs as well as thick bushy ones. This species differs from all the other species of *Papillacarus* by the interlamellar and lamellar setae being differently shaped. Setae in has three cilia, le setae – four, and ro has a single main stern with many short cilia on both sides. Notogastral setae c1, d1 and e1 are also large and bear several long cilia on each side. The submarginals and marginal are longer, branched, but armed with a few fine barbs basally. The arboriform hairs on neotrichous part are commonly larger and sparser (CORPUZ-RAROS 1979).

General distribution. A Southeast Asian species, ranged in Indonesia, Philippines and Vietnam.

9. *Papillacarus undirostratus* Aoki, 1965 (Fig. 9: a, b, c)


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### Specimens Examined and Ecological Notes

Tam Dao National Park (Vinh Phuc province), 21°27’N-105°38’E, 27.5.1995, Poly-annual cultivated habitat, Ferralic reddish brown soil, Northeast uplands, 900 m a.s.l., 0-10 cm (n=7).

### Measurements

535-620 X 273-309 μm, and 533-611 X 270-305 μm (Thailand specimens: Aoki 1965).

### Description

The body is coloured light brown, and in oval form. Body surface not covered with dense papillae. Polygonal network sculpture is unclear. There are four distinct and rounded protrusions in the front edge of the rostrum. Surface of prodorsum with a small, rounded outgrowth. Rostral setae curved. Le. and in. setae are unbranched or with fine branches. Setae c1, d1, e1 tiny and simple. Notogaster has 16 pairs of normal setae.

**General distribution.** A Southeast Asian species, known from Thailand and Vietnam.

### Key to nine *Papillacarus* species known in Vietnam

1. Body length > 500 μm ............................................... 2
2. Body length < 500 μm ............................................... 6
3. Anterior margin of rostrum concave......................... 4
4. Anterior margin of rostrum rounded ....................... 5
5. Anterior margin of rostrum undulated. In, le and ro setae with single main stem bearing fine cilia on both sides. Surface of body with reticulate sculpturing. .................................................. *benenensis* Vu, Ermilov et Dao, 2010.

### Conclusions

The distribution of the oribatid mites, the genus *Papillacarus* Kunst, 1959, is restricted mainly to the tropical and subtropical regions. This genus is known with more than 30 species, among them nine species have been recorded from Vietnam. These...

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