The genus *Raphignathus* (Acari: Raphignathidae) from China

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Abstract

The genus *Raphignathus* from China is reviewed. The morphology of *R. zhaoi* Hu, Jing & Liang is studied. Four new species of *Raphignathus* are described: *R. aciculatus* Fan from moss in Fujian (southeastern China), *R. membranatus* Fan from fallen leaves in Beijing (north China), *R. evidus* Fan from moss in Beijing and *R. hsiufui* Fan from moss in Fujian and from tea (*Camellia sinensis*) in Zhejiang adjacent to Fujian. A key to the known species from China is provided.

Key words: Acari, *Raphignathus*, new species, China

Introduction

The modern concept of the genus *Raphignathus* includes species that were formerly assigned to the genera *Caligonus* Canestrini, *Syncaligus* Berlese, *Acheles* Oudemans and *Raphignathus* Dugès. In the past our understanding of this genus was nebulous due to abbreviated descriptions and the loss of type specimens. Species of *Caligonus* were moved to other genera and the name of this genus was discarded. Although Berlese (1910) stated that *Syncaligus* was based on *Caligonus petrobis* Canestrini, according to his earlier description (Berlese, 1894), this species has the characters of the genus *Raphignathus*: confluent coxae, fused chelicerae and peritremes situated between gnathosoma and podosoma. For these reasons Oudemans (1923) and Grandjean (1944) treated *Syncaligus* as a junior synonym of *Raphignathus*. Oudemans (1903) erected a monotypical genus, *Acheles*, later distinguishing it from *Raphignathus* by the separation between coxae II and coxae III (Oudemans 1927). However, in his unpublished figures of the type species, *Acheles mirabilis*, Oudemans (1903) drew adjacent coxae II and III. It follows that *Acheles* is a synonym of *Raphignathus* (Robaux 1976, Meyer & Ueckermann 1989).

In this paper we review the genus *Raphignathus* from China and add four new species. Type specimens are deposited in the Department of Plant Protection, Fujian Agricultural University. Measurements are in micrometers.

Genus *Raphignathus* Dugès

Raphignathus Dugès, 1834, 22; Oudemans, 1923, 138; Oudemans, 1927, 260; Meyer & Ryke, 1960, 228; Atyeo, Baker & Crossley, 1961, 15; Vainstein & Kuznetsov, 1978, 149; Chaudhri, Akbar & Rasool, 1979, 193; Zaher & Gomaa, 1979, 198; Meyer & Ueckermann, 1989, 28.

Acheles Oudemans, 1903, 101; Oudemans, 1927, 260; Meyer & Ryke, 1960, 231.

Syncaligus Berlese, 1910, 202.

Type species: *Raphignathus ruberrimus* Dugès, 1834

Diagnosis. Body soft to sclerotized, lengths 280-600; red or yellow in life. Chelicerae fused to form a stylophore; peritremes club-like, arising from mid-basal part of stylophore, projecting to anterior margin of podosoma. Palptibial claw small, at most one half length of palptarsus. Subcapitulum with 2 pairs of subcapitular setae and 2 pairs of adoral setae. Dorsum with 3 podosomal shields and an opisthosomal shield; a pair of eyes situated on lateral podosomal shields, no postocular bodies. Dorsum with 11-12 pairs of setae. Ventrally, coxae II adjacent to coxae III. Two pairs of aggenital setae in front of genital pore, which located on a shield and has 3 pairs of setae. Anal pore clearly separated from genital shield, with 3 pairs of setae. Empodium with 2 rows of 4 or more pairs of tenent hairs. Tarsus I with 2 solenidia ω . Number of male and female solenidia on tarsi often similar. Dorsal body shields of male somewhat fused.

The mites of this genus are found on tree barks, in litter, moss, soil, in stored products and bird nests and have a world wide distribution.

Key to species of genus *Raphignathus* Dugès from China

1. Palpfemur with 3 setae 2
- Palpfemur with 2 setae 5
2. Tibia I with 1 solenidion 3
- Tibia I with 2 solenidia *R. collegiatus* Atyeo, Baker & Crossley
3. Femur IV with 3 setae 4
- Femur IV with 2 setae *R. zhaoi* Hu, Jing & Liang
4. Tarsus II with 16 setae and 1 solenidion; Length of dorsal body setae from 24 to 28
- *R. aciculatus* Fan **sp. nov.**
- Tarsus II with 15 setae and 1 solenidion; Length of dorsal body setae from 38 to 50
- *R. orientalis* Fan & Li
5. Palpgenu with 2 setae 6
- Palpgenu with 1 seta *R. membranatus* Fan **sp. nov.**
6. Femur IV with 3 setae 7
- Femur IV with 2 setae *R. hsiufui* Fan **sp. nov.**
7. Lateral podosomal shield small, c_2 situated on membrane *R. evidus* Fan **sp. nov.**
- Lateral podosomal shield normal, c_2 situated on this shield *R. gracilis* (Rack)

Notes on *Raphignathus zhaoi* Hu, Jing & Liang (Figs. 1-24)

Raphignathus zhaoi Hu, Jing & Liang, 1995, 23-25.

Raphignathus hongchengensis Hu & Chen, 1998, 15-18. **syn. nov.**

The present authors examined this species described by Hu *et al.* (1995) and discovered that there are 3 palpfemoral setae, instead of 2, as originally stated. Hu and Chen (1998) established another new species, *Raphignathus hongchengensis*, whose distinguishing characters were a striated stylophore (also present in *R. zhaoi*) and the palpfemoral setation. It follows that *R. hongchengensis* is a junior synonym of *R. zhaoi*, a very common species in south China that occurs on tree barks, in moss and in the soil (Fig. 1).

GNATHOSOMA (Figs. 2-4, 7-8; Table 1)

In all stages, stylophore densely covered with veins that arise from basal upper part of subcapitulum. Movable digits needle-like with curved bases and inserted in subtip of chelicerae. Fixed digits reduced to thin sheath. Palpal supracoxal setae, *elcp*, present in all stages. Counts of setae and so-

lenidia from trochanter to tarsus of palp in larva: 0, 2, 1, 3+1claw, 4+1 ω +4 eupathidia; in protonymph: 0, 2, 2, 3+1claw, 4+1 ω +4 eupathidia; in deutonymph and in adult: 0, 3, 2, 3+1claw, 4+1 ω +4 eupathidia. Adoral setae ad_1 and ad_2 on subdistal subcapitulum in all stages and often branched. Subcapitular setae m present after protonymph and n present after deutonymph.

FIGURE 1-6. *Raphignathus zhaoi*. (female). 1, lateral view of body; 2, lateral view of stylophore; 3, dorsal view of stylophore; 4, palp tarsus; 5, genital and anal region; 6, claws and empodium of leg IV.

TABLE 1. Ontogenetic patterns of setae and solenidia on the palp and subcapitulum in *Raphignathus zhaoi*.

	Larva	Protonymph	Deutonymph	Adult
Palp				
Femur	<i>d, l</i>	<i>d, l</i>	<i>d, l, pl</i>	<i>d, l, pl</i>
Genu	<i>d</i>	<i>d, l</i>	<i>d, l</i>	<i>d, l</i>
Tibia	<i>d, l, va</i>	<i>d, l, va</i>	<i>d, l, va</i>	<i>d, l, va</i>
Tarsus	<i>bp, lp, ba, va, acm, (ulζ), sul, ω</i>	<i>bp, lp, ba, va, acmζ, (ulζ), sulζ, ω</i>	<i>bp, lp, ba, va, acmζ, (ulζ), sulζ, ω</i>	<i>bp, lp, ba, va, acmζ, (ulζ), sulζ, ω</i>
Subcapitular setae	-	<i>m</i>	<i>m, n</i>	<i>m, n</i>

DORSUM (Figs. 9-13; Table 2)

Dorsum covered by one median podosomal shield, a pair of lateral podosomal shields and one opisthosomal shield in all stages, except in adult male (all shields confluent). Shields finely punctated. Membrane between podosomal shields and opisthosomal shield variable in stages. Larva with widest membrane. Membrane wider in protonymph than in deutonymph and adult female. In adult male membrane reduced to a small band behind lateral shield. Ontogenetic patterns of dorsal body

shields, setae and lyrifissures shown in Table 2. Dorsal setae gradually broadened from larva to adult except c_1 , d_1 , e_1 , h_1 which in male slender and short.

FIGURES 7-13. *Raphignathus zhaoi*. 7, left palp of female; 8, left palp of larva; 9, dorsum of larva; 10, dorsum of protonymph; 12, dorsum of adult female; 13, dorsum of adult male; 11, dorsal opisthosoma of deutonymph.

VENTER (Figs. 5, 14-20; Table 3)

Podosomal venter covered by 2 pairs of punctated endopodal shields around inner sides of coxae I-II and coxae III-IV (coxae III in larva), respectively. Coxae II conjunct with coxae III. All shields with finely punctations. Genital pore present only in female deutonymph and female adult. Ontogenetic patterns of ventral, aggenital and genital setae shown in Table 3.

Copulatory male organ consisting of 3 parts, a funnel-like basiphallus, a bulb-like mesophallus and a complex distiphallus which includes an aedeagus, a pair of parameres and a pair of harpagones.

TABLE 2. Ontogenetic patterns of the setae on the dorsum of *Raphignathus zhaoi*.

	Opisthosoma shield	Number of setae	Lytrifissures
Larva	reduced, with h_1, h_2	11 pairs	ia, im & ip on membrane
Protonymph	reduced, with e_1, f_1, h_1, h_2	11 pairs	ia & ip on shields, im on membrane
Deutonymph	nomal, with e_1, f_1, h_1, h_2, h_3	12 pairs	ia & ip on shields, im on membrane
Adalt (female)	nomal, with e_1, f_1, h_1, h_2, h_3	12 pairs	ia & ip on shields, im on membrane
Adalt (male)	confluent with podosomal shields, with e_1, f_1, h_1, h_2, h_3	12 pairs	ia, im & ip on shields

FIGURES 14-20. *Raphignathus zhaoi*. 14, venter of larva; 15, venter of protonymph; 17, venter of adult female; 18, venter of male; 16, ventral opisthosoma of deutonymph; 19, dorsal view of copulatory organ; 20, ventral view of front part of copulatory organ.

TABLE 3. Ontogenetic patterns of the setae on the venter of *Raphignathus zhaoi*.

	Larva	Protonymph	Deutonymph (female)	Deutonymph (male)	Adult (female)	Adult (male)
Ventral setae	1a, 3a	1a, 3a, ag ₁	1a, 3a, 4a	1a, 3a, 4a	1a, 3a, 4a	1a, 3a, 4a
Aggenital setae	-	ag ₁	ag ₁ , ag ₂	ag ₁	ag ₁ , ag ₂	ag ₁
Genital setae	-	-	g ₁	-	g ₁ , g ₂ , g ₃	-

FIGURES 21-24. *Raphignathus zhaoi*. (female). 21, leg I; 22, leg II; 23, leg III; 24, leg IV.

TABLE 4. Ontogenetic patterns of setae and solenidia on legs of *Raphignathus zhaoi*.

	Larva	Protonymph	Deutonymph	Adult
LEG I				
Coxa	<i>1b</i>	<i>1b, 1c</i>	<i>1b, 1c</i>	<i>1b, 1c</i>
Trochanter	-	<i>v'R</i>	<i>v'R</i>	<i>v'R</i>
Femur	<i>d, bv'', v'</i>	<i>d, bv'', (v)</i>	<i>d, l, bv'', (v')</i>	<i>d, (l), bv'', (v)</i>
Genu	<i>d, l', (v), k</i>	<i>d, (l), (v), k</i>	<i>d, (l), (v), k</i>	<i>d, (l), (v), k</i>
Tibia	<i>dp, (l), (v), ϕ</i> <i>pl', vs', (ve), (a), (u),</i>	<i>dp, (l), (v), ϕ</i> <i>pl', vs', (ve), (a), (u),</i>	<i>dp, (l), (v), ϕ</i> <i>(bl), (bv), (pl), vs',</i>	<i>dp, (l), (v), ϕ</i> <i>(bl), (bv), (pl), vs',</i>
Tarsus	<i>(ft), (tc), tcζ', pζ'',</i> <i>ω₁</i>	<i>(ft), (tcζ), (pζ),</i> <i>ω₁, ω₂</i>	<i>(ve), (a), (u), (ftζ),</i> <i>(tcζ), (pζ), ω₁, ω₂</i>	<i>(ve), (a), (u), (ftζ),</i> <i>(tcζ), (pζ), ω₁, ω₂</i>
LEG II				
Coxa	-	<i>2b</i>	<i>2b, 2c</i>	<i>2b, 2c</i>
Trochanter	-	<i>v'R</i>	<i>v'R</i>	<i>v'R</i>
Femur	<i>d, bv'', v'</i>	<i>d, bv'', v'</i>	<i>d, (l), bv'', v'</i>	<i>d, (l), bv'', v'</i>
Genu	<i>d, l', (v), k</i>	<i>d, (l), (v), k</i>	<i>d, (l), (v), k</i>	<i>d, (l), (v), k</i>
Tibia	<i>dp, (l), (v), ϕp</i>	<i>d, (l), (v), ϕp</i>	<i>d, (l), (v), ϕp</i> <i>(bl), (bv), pl', vs',</i>	<i>d, (l), (v), ϕp</i> <i>(bl), (bv), pl', vs',</i>
Tarsus	<i>pl', vs', (ve), (a),</i> <i>(u), (tc), tc'ζ, ω</i>	<i>pl', vs', (ve), (a),</i> <i>(u), (tcζ), pζ', ω</i>	<i>(ve), (a), (u), (tcζ),</i> <i>pζ', ω</i>	<i>(ve), (a), (u), (tcζ),</i> <i>pζ', ω</i>
LEG III				
Coxa	-	-	<i>3b, 3c</i>	<i>3b, 3c</i>
Trochanter	-	<i>v'R, l</i>	<i>v'R, l</i>	<i>v'R, l</i>
Femur	<i>d, v'</i>	<i>d, v'</i>	<i>d, l, v'</i>	<i>d, l, v'</i>
Genu	<i>d, l', v</i>	<i>d, l', (v)</i>	<i>d, l', (v)</i>	<i>d, l', (v)</i>
Tibia	<i>dp, (l), (v), ϕp</i>	<i>d, (l), (v), ϕp</i>	<i>d, (l), (v), ϕp</i> <i>(bl), (bv), vs', (ve),</i>	<i>d, (l), (v), ϕp</i> <i>(bl), (bv), vs', (ve),</i>
Tarsus	<i>vs', (ve), (a), (u),</i> <i>(tc), ω</i>	<i>vs', (ve), (a), (u),</i> <i>(tc), ω</i>	<i>(a), (u), (tc), ω</i>	<i>(a), (u), (tc), ω</i>
LEG IV				
Coxa	-	-	-	<i>4b</i>
Trochanter	-	-	<i>v'R</i>	<i>v'R</i>
Femur	-	-	<i>d, v'</i>	<i>d, v'</i>
Genu	-	<i>d</i>	<i>d, l', (v)</i>	<i>d, l', (v)</i>
Tibia	-	<i>d, (v), ϕp</i>	<i>d, l, (v), ϕp</i>	<i>d, l, (v), ϕp</i>
Tarsus	-	<i>vs', ve', (a), (u), (tc)</i>	<i>vs', (ve), (a), (u), (tc),</i> <i>ω</i>	<i>(bl), (bv), vs', (ve),</i> <i>(a), (u), (tc), ω</i>

LEGS (Figs. 6, 21-24; Table 4)

Tarsal empodium carrying 4 pairs of tenent hairs directly. Solenidia ω on male tarsi larger than those of female.

HABITATS

Barks of *Actinidia chinensis* Planch, *Bischofia javanica* Bl., *Bombax malabaricum* DC., *Camellia* sp., *Canarium album* (Lour.), *Caslanopsis* sp., *Castanopsis eyeri* (Champ. ex Benth), *Castanopsis sclerophylla* (Lindl.), *Casuarina equisetifolia* (Forst), *Cinnamomum* sp., *Cunninghamia lanceolata* (Lamb.), *Dimocarpus longan* Lour., *Ficus retusa* Linn., *Grevillea* sp.,

Mangifera indica L., *Magnolia* sp., *Pinus massoniana* Lamb., *Platanus orientalis* Linn., *Pterocarya stenoptera* Dc., *Pyrus* sp., *Sapium sebiferum* (L.), *Schima superba* Gardn. & Champ, *Taxus chinensis* var. *mairei* (Lemee & Levl), *Torreya grandis* Fort.; living leaves of *Ipomoea cairica* (L.); fallen leaves of *Castanea mollissima* Blume; soil and moss.

DISTRIBUTION

China (Anhui, Fujian, Guangxi, Henan, Hubei, Jiangsu, Jiangxi, Shanghai, Sichuan and Zhejiang).

Raphignathus gracilis (Rack, 1962)

Acheles gracilis Rack, 1962, 168: 281.

Raphignathus gracilis (Rack, 1962), Atyeo, 1963, 181-182; Gerson, 1968, 434-435; Vainstein & Kuznetsov, 1978, 150-151; Zaher & Gomaa, 1979, 198; Ehara, 1980, 248-249; Kuznetsov & Petrov, 1984, 99; Meyer & Ueckermann, 1989, 39-41; Koç & Ayyildiz, 1996, 210-214.

DIAGNOSIS

Female. Palptibial claw about one half as long as palptarsus. Counts of setae and solenidia from palpgenu to palptarsi: 0, 2, 2, 3+1 claw, 4+1 ω +4 eupathidia. Membrane between dorsal shields bearing 2 pairs of setae, setae f_I close to margin of membrane. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1.4 : 1.6 : 1$. Coxae III and IV with endopodal shields. Counts of setae and solenidia on legs I-IV: coxae $Ia+2$, 2, $3a+2$, 1, trochanters 1, 1, 2, 1, femora 6, 5, 3, 3, genua 5+1 κ , 5+1 κ , 4, 4, tibiae 5+1 ϕ , 5+1 ϕ p, 5+1 ϕ p, 4+1 ϕ p, tarsi 19+2 ω , 15+1 ω , 13+1 ω , 13; tarsi I ω_1 9, II ω 8, III ω 6.

Male. Podosomal shields fused with opisthosomal shield, only marginal areas with striation. All shields with punctations. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1.5 : 1.6 : 1$. Tarsus IV with 13 setae and 1 solenidium ω ; I ω_1 , II ω , III ω and IV ω about equal in length (12.5).

Specimens examined. 22 females, 9 males, 3 larvae, ex. dried *Auricularia auricula-judae*; barks of *Cinnamomum* sp., *Cynodon dactylon* (L.), *Eucalyptus tereticornis* Smith, *Platanus orientalis* L., *Psidium guayava* L.; leaves of pteridophyte; soil under *Dimocarpus longan* Lour.; moss.

Distribution. China (Anhui, Chongqing, Fujian, Hunan, Jiangxi, Shanghai, Sichuan); Egypt, former USSR, Germany, Israel, Japan, South Africa, USA, Turkey.

Raphignathus orientalis Fan & Li

Raphignathus orientalis Fan & Li, 1993, 322-323.

DIAGNOSIS

Female. Palptibial claw approximately one third as long as palptarsus. Counts of setae and solenidia of palp: 0, 3, 2, 3+1 claw, 4+1 ω +4 eupathidia. Dorsal shields with fine striae. Membrane between shields bearing 2 pairs of setae. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1 : 1.5 : 2.1$. Venter with 1 pair of small endopodal shields near coxae III and IV. Counts of setae and solenidia of legs I-IV: coxae $Ia+2$, 2, $3a+2$, 1, trochanters 1, 1, 2, 1, femora 6, 5, 3, 3, genua 5+1 κ , 5+1 κ , 4, 4, tibiae 5+1 ϕ , 5+1 ϕ p, 5+1 ϕ p, 4+1 ϕ p, tarsi 19+2 ω , 15+1 ω , 13+1 ω , 13; tarsi I ω_1 10, II ω 7, III ω 5.

Male. Medial podosomal shield confluent with opisthosomal shield, but separated from lateral podosomal shields. Dorsal body setae c_I , d_I , e_I , h_I prominently shorter than others. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1 : 1.4 : 1.3$. Genito-anal pore dorso-terminal. Counts of setae and solenidia of legs similar to female except tarsi IV: 13+1 ω . Lengths of solenidia on tarsi: I ω_1 19, II ω 19, III ω 20, IV ω 20.

Specimens examined. 5 females, 1 male, from *Auricularia auricula-judae*, *Pennisetum* sp.
Distribution: China (Chongqing, Fujian).

***Raphignathus collegiatus* Atyeo, Baker & Crossley**

Raphignathus collegiatus Atyeo, Baker & Crossley, 1961, 17-20; Kuznetsov & Petrov, 1984, 100-101; Meyer & Ueckermann, 1989, 42.

Raphignathus guianensis Hu, Jing & Liang, 1995, 21-23. **syn. nov.**

DIAGNOSIS

Female. Counts of setae and solenidia on palp: 0, 3, 2, 3+1 claw, 4+1 ω + 4 eupathidia. Adoral setae simple, without branches. Body dorsum developed, with fine punctations. Membrane with 1 pair of small shields and 1 pair of setae (d_I). Dorsal body setae 11 pairs. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1 : 1.8 : 1.4$. Coxae I, II and III, IV with endopodal shields. Counts of setae and solenidia on legs I-IV: coxae 1a+2, 2, 3a+2, 1, trochanters 1, 1, 2, 1, femora 6, 6, 4, 4, genua 5+1 κ , 5+1 κ , 4, 4, tibiae 5+2 ϕ , 5+1 ϕ p, 5+1 ϕ p, 4+1 ϕ p, tarsi 19+2 ω , 15+1 ω , 13+1 ω , 13. Lengths of solenidia on tarsi: I ω_1 7.5, II ω 6, III ω 3.5.

Male. Lateral podosomal shields separate from medial podosomal shield, which confluent with opisthosomal shield. Tarsus IV with 13 setae and 1 solenidion ω .

Specimens examined: 2 females, from moss, bark of *Bischofia javanica* Bl.

Distribution: China (Guizhou, Shanghai), Egypt, former USSR, USA.

Discussion: Atyeo *et al.* (1961) miscounted the setal numbers as 0, 1, 2, 1 on trochanters and as 6, 5, 4, 4 on femora. Kuznetsov & Petrov (1984) corrected these faults. Hu *et al.* (1995) erected a new species, *R. guianensis* according to the description of Atyeo *et al.* (1961). The authors studied the paratype of *R. guianensis* and found that it is a junior synonym of *R. collegiatus*.

***Raphignathus aciculatus* Fan sp. nov. (Figs. 25-32)**

FEMALE. Dark red in life. Length of idiosoma 367, width 254

Gnathosoma. Dorsal stylophore with striae, 66 long (including digits), movable digits 54 long. Length of palpus 119, tibial claw about one half as long as palptarsus. Counts of setae and solenidia (from trochanter to tarsus): 0, 3, 2, 3+1 claw, 4+1 ω +4 eupathidia. Setae on subcapitulum with small prongs, m 46, n 42.

Dorsum. Dorsal shields striated and punctated. Medial podosomal shield with 1 pair of lateral ornaments. Each lateral podosomal shield with 1 eye, 3 dorsal setae and 1 lyrifissure (ia). Membrane with 2 pairs of setae (d_I and e_I), 1 pair of lyrifissure (im) and 1 pair of small shield near podosomal shields. Opisthosomal shield bearing 4 pairs of setae, 1 pair of lyrifissure. Ratios $d_I-d_I : e_I-e_I : f_I-f_I = 1 : 1.6 : 2.2$. Lengths of setae: vi 27, ve 28, sci 28, sce 27, c_I 24, c_2 27, d_I 24, e_I 26, f_I 28, h_I 28, h_2 27, h_3 26; distances between setae: $vi-vi$ 23, $vi-ve$ 66, $vi-sci$ 41, $ve-sci$ 33, $sci-sci$ 59, c_I-c_I 26, c_I-c_2 66, c_I-d_I 41, d_I-d_I 53, d_I-e_I 38, e_I-e_I 84, e_I-f_I 51, f_I-f_I 115, f_I-h_I 51, h_I-h_I 33, h_I-h_2 46, h_2-h_2 66, h_2-h_3 26. Anal pore dorso-terminal, with 3 pairs of setae, ps_I 25, ps_2 24, ps_3 24.

Venter. Without endopodal shields. Ventral setae 1a (37), 3a (36) close to coxae I and III, respectively, and slightly longer than third pair, 4a 29. Aggenital setae 2 pairs, ag_I (29) about 1.7 times of ag_2 (17). Genital valves punctated, bearing 3 pairs of genital setae; g_I (26) slightly longer than g_2 (23) and g_3 (23). Lyrifissure (ip) situated on membrane lateral to genital valves.

Legs. Lengths of legs I-IV (from base of trochanter to tip of tarsal claw): 289, 248, 247, 321. Empodium with 4 pairs of tenent hairs. Counts of setae and solenidia on legs I-IV: coxae 1a+2, 2,

3a+2, 1, trochanters 1, 1, 2, 1, femora 6, 5, 3, 3, genua 5+1κ, 5+1κ, 4, 4, tibiae 5+1φ, 5+1φp, 5+1φp, 4+1φp, tarsi 19+2ω, 16+1ω, 13+1ω, 13. Lengths of solenidia on tarsi: Iω₁ 13, IIω 10, IIIω 6.

FIGURES 25-32. *Raphignathus aciculatus* Fan **sp. nov.** 25, dorsum of female; 26, dorsal seta f_1 of female; 27, venter of female; 28, palp of female; 29, solenidia on tarsus I of female; 30, femur IV; 31, solenidia on tarsus I of male; 32, solenidion on tarsus II.

MALE. Idiosoma 320 long, 207 wide.

Gnathosoma. Stylophore 54 long, movable digit 41 long. Number of setae and solenidia on palp similar to female. Subcapitular setae m 38 long, n 37.

Dorsum. Dorsal body shields fused, only striated near lateral margin of body. Ratios $d_1-d_1 : e_1-e_1 : f_1-f_1 = 1.3 : 1.3 : 1$. Lengths of setae: vi 23, ve 23, sci 21, sce 22, c_1 15, c_2 21, d_1 15, e_1 15, f_1 20, h_1 18, h_2 25, h_3 25; distances between setae: $vi-vi$ 16, $vi-ve$ 59, $vi-sci$ 30, $ve-sce$ 26, c_1-c_1 20, c_1-c_2 59, c_1-d_1 43, d_1-d_1 61, d_1-e_1 31, e_1-e_1 63, e_1-f_1 33, f_1-f_1 48, f_1-h_1 23, h_1-h_1 38, h_1-h_2 30. Genital pore fused with anal pore, dorso-terminal. 3 pairs of paraproctal setae present, ps_1 27, ps_2 14 and ps_3 20. Genital setae absent.

Venter. Similar to female, ventral setae $1a$ 34, $3a$ 34, $4a$ 16.

Legs. Lengths of legs I-IV: 273, 237, 258, 310. Counts of setae and solenidia similar to female, except tarsi IV: $13+1\omega$; $I\omega_1$ 25, $II\omega$ 25, $III\omega$ 29, $IV\omega$ 27.

Etymology. The specific name is from the Latin *aciculatus* (needle like), referring to the shape of dorsal body setae.

Type materials. Holotype female, allotype male, 4 paratype females, 1 paratype male and 1 paratype deutonymph, from moss, Campus of Fujian Agricultural University, Fuzhou, Fujian, 13 February 1996, Fan.

Remarks. This new species is very close to *Raphignathus scutatus* Kuznetsov, differing from the latter in: (1) tibiae III with 5 setae and 1 solenidion (with 4 setae and 1 solenidion in the latter); (2) distances between setae $f_1-f_1 > e_1-e_1 > d_1-d_1$ (in *R. scutatus* $e_1-e_1 > f_1-f_1 > d_1-d_1$).

***Raphignathus membranatus* Fan sp. nov. (Figs. 33-37)**

FEMALE. Idiosoma length 351, width 238.

Gnathosoma. Stylophore 56 long, movable digits 48 long; palp 102 long, tibial claw approximately one half as long as palptarsus. Counts of setae and solenidia on palp: 0, 2, 1, 3+1 claw, 4+1 ω +4 eupathidia. Subcapitulum with 2 pairs of setae, m 32, n 34; adoral setae with small prongs.

Dorsum. Dorsal shields developed, with fine punctations. Membrane with 2 pairs of setae. Dorsal body setae stout and short, with fine denticles. Ratios $d_1-d_1 : e_1-e_1 : f_1-f_1 = 1.7 : 1.3 : 1$. Lengths of setae: vi 26, ve 28, sci 25, sce 27, c_1 21, c_2 28, d_1 21, e_1 21, f_1 25, h_1 26, h_2 23, h_3 23; distances between setae: $vi-vi$ 18, $vi-sci$ 46, $ve-sci$ 25, $ve-sce$ 21, c_1-c_1 20, c_1-c_2 84, c_1-d_1 64, d_1-d_1 89, d_1-e_1 79, e_1-e_1 66, e_1-f_1 53, f_1-f_1 51, f_1-h_1 36, h_1-h_1 21, h_2-h_2 29, h_2-h_3 34.

Venter. With endopodal shields near coxae III and IV. Ventral setae $1a$ 32, $3a$ 29, $4a$ 19. Aggenital setae 2 pairs ag_1 21, ag_2 16. Genital valves with 3 pairs of stout setae, about equal in length, 18. Paraproctal setae stout, ps_3 14, ps_2 15, ps_1 15.

Legs. Lengths I-IV: 218, 171, 175, 229. Each tarsal empodium with 5 pairs of tenent hairs. Solenidia on tarsi prominent. Count of setae and solenidia on legs I-IV: coxae $1a+2$, 2, $3a+2$, 1, trochanters 1, 1, 2, 1, femora 6, 5, 3, 3, genua $5+1\kappa$, $5+1\kappa$, 4, 4, tibiae $5+1\phi$, $5+1\phi$, $5+1\phi$, $4+1\phi$, tarsi $19+2\omega$, $15+1\omega$, $13+1\omega$, 13; tarsi $I\omega_1$ 13, $II\omega$ 11, $III\omega$ 4.5.

MALE. Unknown.

Etymology. The specific name is from the Latin *membran* (skin), referring to the striation of the dorsum.

Type material. Holotype female, fallen leaves, Yuanming Park, Beijing, 25 June 1981, Wang.

Remarks. The new species is similar to *Raphignathus karrooi* Meyer & Ueckermann, 1989, but differs from in (1) 3 setae on femur IV (the latter with 2) and (2) with 1 solenidion on tarsus III (absent in *R. karrooi*).

FIGURES 33-37. *Raphignathus membranus* Fan **sp. nov.** (female). 33, dorsum; 34, dorsal seta f_1 ; 35, solenidia on tarsus I; 36, solenidia on tarsus II; 37, genito-anal region.

***Raphignathus evidus* Fan sp. nov. (Figs. 38-42)**

FEMALE. Length of idiosoma 331, width 207; red in life.

Gnathosoma. Stylophore 54 long, with fine striae dorsally, movable digit 48 long. Palptibial claw approximately one half as long as palptarsus. Counts of setae and solenidia: 0, 2, 2, 3+1 claw, 4+1 ω +4 eupathidia. Subcapitular setae, m 34, n 35. Adoral setae with small prongs.

Dorsum. Lateral podosomal shields and opisthosomal shield reduced, each bearing only 2 setae, ve and sce . Setae c_2 situates on membrane. Membrane among shields with 4 pairs of setae, 3 pairs of lyrifissures and 2 pairs of looped bubbles. Seta h_1 situated on anterior margin of opisthosoma shield. Ratios $d_1-d_1 : e_1-e_1 : f_1-f_1 = 1.3 : 1.6 : 1$. Lengths of setae: vi 25, ve 28, sci 23, sce 29, c_1 23, c_2 28, d_1 25, e_1 28, f_1 29, h_1 28, h_2 30, h_3 28; distances between setae: $vi-vi$ 23, $vi-sci$ 30, $ve-sci$ 30, $ve-sce$ 30, c_1-c_1 23, c_1-c_2 46, c_1-d_1 51, d_1-d_1 61, d_1-e_1 53, e_1-e_1 77, e_1-f_1 38, f_1-f_1 48, f_1-h_1 25, h_1-h_1 20, h_1-h_2 26, h_2-h_2 43, h_2-h_3 14.

Venter. Striated and decorated with fine punctations. Endopodal shields present around coxae III and IV. Length of ventral setae: $1a$ 37, $3a$ 33, $4a$ 28. Aggenital setae: ag_1 26, ag_2 23. Genital valves with small punctations, bearing 3 pairs of genital setae, g_1 22, g_2 21, g_3 20. Anal pore terminal, lengths of paraproctal setae, ps_1 21, ps_2 19, ps_3 18.

Legs. Lengths of legs I-IV: 268, 222, 248, 299. Each tarsal empodium with 4 pairs of tenent hairs. Counts of setae and solenidia on legs I-IV: coxae $1a+2$, 2, $3a+2$, 1, trochanters 1, 1, 2, 1,

femora 6, 5, 3, 3, genua 5+1 κ , 5+1 κ , 4, 4, tibiae 5+1 ϕ , 5+1 $\phi\phi$, 5+1 $\phi\phi$, 4+1 $\phi\phi$, tarsi 19+2 ω , 15+1 ω , 13+1 ω , 13; tarsi I ω ₁ 7, II ω 7, III ω 3.

MALE. Unknown.

Etymology. The specific name is from the Latin *evidens* (distinct), referring to the pattern of dorsal body shields.

Type material. Holotype female, bark of unknown tree, Yuanming Park, Beijing, 9 October 1995, Fan.

Remarks. This species is different from all known species of the genus in: (1) a small lateral podosomal shield, with only 2 setae (*ve* and *sce*), *c*₂ situated on membrane; (2) a very small opisthosomal shield.

FIGURES 38-42. *Raphignathus evidus* Fan **sp. nov.** (female). 38, dorsum; 39, palp; 40, solenidion on tarsus I; 41, femur IV; 42, genital and anal region.

***Raphignathus hsiufui* Fan **sp. nov.** (Figs. 43-46)**

Female. Length of idiosoma 331, width 202; dark-red in life.

Gnathosoma. Stylophore 49 long, dorsal surface striated; movable digit 46 long. Palp 109 long, tibial claw small, no more than one third as long as tarsus. Counts of setae and solenidia: 0, 2, 2, 3+1claw, 4+1 ω +4 eupathidia. Subcapitular setae 2 pairs, *m* 31, *n* 35; adoral setae with small prongs.

FIGURES 43-46. *Raphignathus hsiufui* Fan **sp. nov.** (female). 43, dorsum; 44, venter; 45, palp; 46, genu, tibia and tarsus of leg I.

Dorsum. Lateral podosomal shields reduced, with only 2 setae, setae c_2 situated on membrane. Membranes bearing 4 pairs of setae (c_2, d_1, e_1, f_1) and 3 pairs of lyrifissures. Setae f_1 placed on edges of membrane. Opisthosomal shield also reduced, with 3 pairs of dorsal setae, h_1, h_2, h_3 . Ratios $d_1-d_1 : e_1-e_1 : f_1-f_1 = 1.4 : 1.5 : 1$. Lengths of setae: vi 39, ve 38, sci 38, sce 39, c_1 35, c_2 37, d_1 36, e_1 37, f_1 36, h_1 37, h_2 39, h_3 35; distances between setae: $vi-vi$ 17, $vi-sci$ 38, $ve-sci$ 21, $ve-sce$ 30, c_1-c_1

20, c_1 - c_2 46, c_1 - d_1 52, d_1 - d_1 65, d_1 - e_1 25, e_1 - e_1 70, e_1 - f_1 17, f_1 - f_1 46, f_1 - h_1 30, h_1 - h_1 21, h_1 - h_2 29; h_2 - h_2 41, h_2 - h_3 15.

Venter. With 2 pairs of endopodal shields near coxae I, II and coxae III, IV. Lengths of ventral setae: $1a$ 40, $3a$ 37, $4a$ 38. Aggenital setae 2 pairs, ag_1 35, ag_2 29. Genital shields prominent, bearing 3 pairs of genital setae: g_1 21, g_2 18, g_3 19.

Legs. Length of legs I-IV: 294, 258, 289, 310. Counts of setae and solenidia on legs I-IV: coxae $1a+2$, 2, $3a+2$, 1, trochanters 1, 1, 2, 1, femora 6, 5, 3, 2, genua $5+1\kappa$, $5+1\kappa$, 4, 4, tibiae $5+1\phi$, $5+1\phi$, $5+1\phi$, $4+1\phi$, tarsi $19+2\omega$, $15+1\omega$, $13+1\omega$, 3; tarsi $I\omega_1$ 7, $II\omega$ 6.5, $III\omega$ 3.

MALE. Unknown.

Etymology. The species is named in honour of Prof. Hsiu-fu Chao, Biological Control Institute, Fujian Agricultural University, China.

Type materials. Holotype female, 1 paratype female, from moss, Huaian, Fuzhou, Fujian, 12 October 1994, Fan; 2 paratype females, tea, Lin.

Remarks. The new species is similar to *Raphignathus evides* **sp. nov.** in having small lateral and opisthosomal shields, but can be distinguished from the latter by (1) bearing 2 setae on femur IV (the latter with 3) and (2) having longer dorsal body setae (35 to 39), mostly extending to bases of setae behind them (much shorter in *R. evides*, 23 to 31 long, not extending to bases of setae behind them).

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References

- Atyeo, W.T. (1963) New and redescribed species of Raphignathidae (Acarina) and a discussion of the chaetotaxy of the Raphignathoidea. *Journal of the Kansas Entomological Society*, 36(3), 172-186.
- Atyeo, W.T., Baker E.W. & Crossley D.A. (1961) The genus *Raphignathus* Dugès (Acarina, Raphignathidae) in the United States with notes on the old World species. *Acarologia*, 3(1), 14-20.
- Berlese, A. (1894) *Acari, Myriapoda et Scorpiones* usque in Italia reperta. Padova, 72, 1.
- Berlese, A. (1910) *Acari Nuovi-Manipulus V. Redia*, 6, 199-214.
- Chaudhri, W.M., Akbar, S. & Rasool, A. (1979) *Studies on the predatory leaf inhabiting mites of Pakistan*. US Department of Agriculture and Pakistan Agricultural Research Council. PL 480 programme. Project no. PKARS, 30, pp. 139-229.
- Dugès, A. (1834) Sur les Acariens. *Annales des science naturelle* 29 sér. zoologie, 2, 42-45.
- Ehara, S. (1980) *Illustrations of the mites and ticks of Japan*. Zenkoku Noson Kyoiku Kyokai, pp. 248-249.
- Fan, Q.-H. & Li, L.-S. (1993) Descriptions of three new species of superfamily Raphignathoidea (Acari: Actinedida). *Journal of Fujian Agricultural University*, 22(3), 321-324. (in Chinese with English abstract)
- Gerson, U. (1968). Some raphignathoid mites from Israel. *Journal of Natural History*, 2, 429-437.
- Grandjean, F. (1944) Observations sur les acariens de la famille des Stigmaeidae. *Archives des Sciences Physiques et Naturelles*, 26, 103-131.
- Hu, C.-Y., Jing, Z.-Q. & Liang, L.-R. (1995) Two new species and one new record of the genus *Raphignathus* Dugès (Acari: Raphignathidae). *Journal of Suzhou Railway Teachers College*, 12(3), 21-26. (in Chinese with English abstract).
- Hu, S. & Chen, X. (1998) A new species of *Raphignathus* from Jiangxi, China (Acari: Raphignathidae). *Acta Arachnologica Sinica*, 7(1), 15-18.

- Koç, K. & Ayyildiz, N. (1996) Türkiye faunası için yeni iki *Raphignathus* Dugès (Acari, Prostigmata, Raphignathidae) Türü. *Türkiye Journal of Zoology*, 20, 209-214.
- Kuznetsov, N.N. & Petrov, V.M. (1984) Predacious mites of the Baltic region (Parasitiformes: Phytosiidae, Acariformes: Prostigmata). *Riga, Zinatne*, 90-111.
- Meyer, M.K.P. & Ryke, P.A.J. (1960) Mites of the superfamily Raphignathoidea (Acarina: Prostigmata) associated with South African plants. *Annals and Magazine of Natural History*, 13(2), 209-234.
- Meyer, M.K.P. (Smith) & Ueckermann, E.A. (1989) African Raphignathoidea (Acari: Prostigmata). *Entomology Memoir. Department of Agriculture and Water Supply, Republic of South Africa*, 74, 1-58.
- Oudemans, A.C. (1903) Acarologische aantekeningen, VIII. *Entomologische Berichten*, 14, 100-103.
- Oudemans, A.C. (1923) Acarologische aantekeningen LXX. *Entomologische Berichten*, 6(129), 138-144.
- Oudemans, A.C. (1927) Acarologische aantekeningen LXXXVIII. *Entomologische Berichten*, 7(158), 257-263.
- Rack, G. (1962) Milben aus Taubennestern mit Beschreibung einer neuen Art, *Acheles gracilis* (Acarina, Raphignathidae). *Zoologischer Anzeiger*, 168(7-10), 276-292.
- Robaux, P. (1976) Observations sur quelques Actinédida (=Prostigmata) du sol d'Amérique du nord. VII. - Sur deux espèces nouvelles de Raphignathidae (Acari). *Revue d'Ecologie et de Biologie du Sol*, 13(3), 505-516.
- Vainstein, B.A. & Kuznetsov, N.N. (1978) *Identification key of soil inhabiting mites, Trombidiformes*. in Gil'yarov M. S. ed. Nauka, Moscow, pp. 147-171.
- Zaher, M.A. & Gomaa, E.A. (1979) Three new species of the genus *Raphignathus* in Egypt (Prostigmata: Raphignathidae). *Acarologia*, 21(2), 187-203.

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