Redescription of the Snail Mite *Riccardoella reaumuri* (Acariformes: Prostigmata: Ereynetidae)

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(Received 16 May 2018; Accepted 12 April 2019)

Riccardoella (*Prorriccardoella*) *reaumuri* Fain and van Goethem, 1986 (Ereynetidae Oudemans, 1931) is one of the parasitic mites reported from lungs of land mollusks. This paper provides a morphological redescription of this species, with some information of leg setation and chaetotaxy, lyrifissures and aggenital region. *Riccardoella reaumuri* is distinct from and can be distinguished from the other seven species of genus *Riccardoella* Berlese, 1923 by the following features: all setae on idiosoma, palptarsi and legs not prolonged with apical filament; palptarsus with three setae; tibia I with five setae; femur I with one seta; trochanters I and III each with one seta; coxae I and III each with two setae; famulus forked distally and ca. 60% long of its guard seta; two pairs of pseudanal setae.

Key Words: Ereynetidae, mite, parasite, redescription.

Introduction

The world fauna of mites of the genus *Riccardoella* Berlese, 1923 (Ereynetidae Oudemans, 1931) includes eight species described up to now. Six of them have been described from lungs of terrestrial gastropods (Turk and Phillips 1946; Fain and van Goethem 1986; Fain and Klompen 1990; André *et al.* 2004; Waki *et al.* 2018a, b). The remaining two species were thought to be free-living species since they found from soil (Fain and van Goethem 1986; André *et al.* 2004). *Riccardoella* (*Prorriccardoella*) *reaumuri* Fain and van Goethem, 1986 is one of the parasitic mites reported from lungs of land mollusks. In the original description (Fain and van Goethem 1986), four individuals (holotype and three paratypes) were obtained from lungs of the land snails *Arianta arbustorum* Linnaeus, 1758 in France and used for morphological description. This paper provides a morphological redescription of the original type series.

Materials and Methods

The holotype (adult female) and three paratypes (adult male and female, and nymph) of *R. reaumuri* were used in the original description (Fain and van Goethem 1986). Among them, the paratype and two paratypes are kept in the collection of the Royal Belgian Institute of Natural Sciences, Brussels, Belgium with accession numbers from 5-10-17 to 5-10-19 (Fig. 1). The slides of the type series were observed under a compound microscope to confirm their sexes and life stages based on Baker (1970), and were found to be holotype female, paratype female and paratype

male specimens. The holotype and the female paratype were in good preservation and appropriate for morphological observation. Unfortunately, due to deterioration of Hoyer's solution during a long storage period after the description, the male paratype was not clearly observed under the microscope. In addition, we found that the nymph paratype was not included in the type series sent at this time. Thus, we redescribed this species based on the adult female holotype. Line drawings were prepared with a camera lucida attached to the compound microscope (Eclipse Ni-U, Nikon). Body parts were measured under the microscope and using the camera control unit (DS-L3, Nikon). Morphological terminology follows that of André *et al.* (2004), Walter *et al.* (2009) and Waki *et al.* (2018a). All measurements of the holotype in the redescription are given in micrometers (µm).

Results

Family **Ereynetidae** Oudemans, 1931

Subfamily **Ereynetinae** Oudemans, 1931

Genus ***Riccardoella*** Berlese, 1923

Subgenus ***Prorriccardoella*** Fain and van Goethem, 1986

Riccardoella* (*Prorriccardoella*) *reaumuri

Fain and van Goethem, 1986

(Figs 1–7; Table 1)

Diagnosis. Body (gnathosoma and idiosoma, length×width) 378×277. Color orangish-white under a stereomicroscope. Surface of idiosoma, gnathosoma, and legs folded by cuticle containing striation. No eyespot. Oval idiosoma with barbed and cylindrical setae, except long sensillae *sci* and *f*₂. Lyrifissures (*im*, *ip*, and *ih*) present. Aggenital

Fig. 1. Holotype of *Riccardoella* (*Prorickardoella*) *reaumuri*: A. Slide with mounted holotype. B. Body in dorsal view. Scale bar 100 μ m.

region with 2 pairs of genital papillae. Palp with 3 segments. Palptarsus with 3 setae. Tibia I with 5 setae. Femur I with 1 seta. Trochanters I and III each with 1 seta. Coxae I and III each with 2 setae. One subcylindrical solenidion (ω) present in each tarsi I and II, inserted in almost dorsal position, close to seta fi'' . Length of solenidia 7. Tibia I with forked famulus (k'') being as long as ca. 60% of the length of its guard seta (l''). All setae on idiosoma, palptarsi and legs not prolonged with apical filament.

Description. Body (gnathosoma and idiosoma) (Fig. 2). Length excluding legs $\times$ width 378 $\times$ 277.

Integuments. Color orangish-white under a compound microscope. Surface of idiosoma, gnathosoma, and legs with striated cuticle.

Idiosoma (Figs 2, 7A, B). Idiosoma oval. Idiosoma length $\times$ width 352 $\times$ 277. Lengths of dorsal idiosomal setae vi 30; ve 9; sci 95; sce 32; c_1 26; c_2 33; d_1 27; e_1 30; f_1 29; f_2 73; h_1 25; h_2 21. Lengths of ventral idiosomal setae $1a$ 13; $3a$ 12; $4a$ 13. Setae f_2 and sci long and narrow, ve short, and others subcylindrical (Figs 2, 7A, B). Three pairs of lyrifissures (im , ip and ih) present (Figs 2B, 7H–J).

Aggenital region (Fig. 3). Setae making 2 pairs rows.

Based on seta base, genital area with external row (aggenital setae (ag)) of 5 setae and internal row (genital setae (g)) of 5–6 setae (Fig. 3). Defluxion of seta found right g_1 and ag_4 . Right g_4 adjacent to g_5 probably due to variation. Lengths of ag_1 – ag_6 10–14. Lengths of g_1 – g_5 6–9. Two pairs of pseudanal setae (ps) present and lengths of ps_1 and ps_2 10. Two pairs of genital papillae present.

Gnathosoma (Fig. 4). No eyespot. Length $\times$ width 52 $\times$ 73. All setae not prolonged with apical filament. Palptarsus with 3 barbed setae and 1 solenidion (ω) (Fig. 7E, G).

Legs (Figs 5, 6, 7C–E; Table 1). Claws as long as ca. 10 times its width and containing inconspicuous dents. Femur IV subdivided (Fig. 5D). All legs setae not prolonged with apical filament. Setation on legs as follows (I–II–III–IV, solenidia and famulus in parentheses): tarsi 12(ω)-9(ω)-8-8; tibiae 5(k'' , φ)-3-3-3; genua 4-4-3-3; femora 6-4-3-3; trochanters 1-1-1-0; coxae 2-1-2-1. Solenidial complement on Tarsi 1-1-0-0 (Fig. 7C). Subcylindrical solenidion on tarsi I–II and inserted dorsally, near seta fi'' (Fig. 7C). Length of solenidia on tarsi I and II 7 and 6–8, respectively. Leg chaetotaxy and solenidiotaxy in Table 1. Setae p'' on tarsus II, (p) on tarsi III–IV, and u' on tarsus IV wider than other leg setae (Figs 5B–D, 6B–D). Setae (p), (u), (pv) well barbed on ventral side, except p' on tarsi III–IV and u' on tarsus IV. Setae on coxa III shortest among epimeral setae, and $3c$ shorter than $3b$. Ereyntal organ (φ) on tibia I oval (Fig. 7D). Ereyntal organ with famulus (k'') 13 long and ordinaly seta (l''), named guard seta, 21 long; length of famulus 59% of length of guard seta (Figs 5A, 7E). Famulus (k'') forked distally (Figs 5A, 7E). Eupathidion unclear.

Distribution. Jura near Pontarlier, France (Fain and van Goethem 1986).

Host. *Arianta arbustorum* Linnaeus, 1758 in Fain and van Goethem (1986).

Type materials and deposition. Adult female (holotype), adult female and male (paratypes) collected from *Arianta arbustorum* Linnaeus, 1758 in Jura near Pontarlier, France (23 April 1963) are deposited in the collection of the Royal Belgian Institute of Natural Sciences, Brussel, Belgium (coll. RBINS) with accession numbers 5-10-19, 5-10-17 and 5-10-18, respectively.

Remarks. This species belongs to the genus *Riccardoella* Berlese, 1923 because of the following morphological characteristics (Fain and van Goethem 1986; Fain and Barker 2003; André *et al.* 2004; Waki *et al.* 2018a): palp with 3 segments; tibia I with 5 setae; femur IV with 3 setae; lyrifissure *im* present; idiosoma with two pairs of long and narrow setae. *R. reaumuri* belongs to the subgenus *Prorickardoella* Fain and van Goethem, 1986 since it has following morphological features (Fain and van Goethem 1986): trochanter III with one seta; coxa I with two setae; tarsus I with famulus (k'') consisting ca. 60% the length of its guard seta (l''); all setae on idiosoma palptarsi and legs not prolonged with apical filament.

This species can be morphologically distinguished from the other seven *Riccardoella* species based on the following features: idiosoma and leg setae not prolonged with apical filament; palptarsus with 3 setae; tibia I with 5 setae; femora

Fig. 2. *Riccardoella (Prorickardoea) reaumuri*: holotype, female. A. Body in ventral view. B. Dorsal view of idiosoma. Scale bar 100 μm. Arrow: base lacking setae 1a.

Fig. 3. *Riccardoella (Prorickardoea) reaumuri*: holotype, female. Aggenital region. Scale bar 50 μm. Arrows: bases lacking setae. Open arrow: right g₄ adjacent to right g₅.

Fig. 4. *Riccardoella (Prorickardoea) reaumuri*: holotype, female. Gnathosoma in ventral view. Scale bar 50 μm.

I with 1 seta; trochanters I and III each with 1 seta; coxae I and III each with 2 setae; famulus forked distally and ca. 60% long of its guard seta; 2 pairs of pseudanal setae.

Riccardoella reaumuri resembles *Riccardoella oudemansi* Thor, 1932 because both species have 3 setae on palptarsus, 6 setae on tibia I, 1 seta on trochanter I. However, *R. reaumuri* is distinguished from *R. oudemansi* in having the following features: 2 setae on coxa III; famulus ca. 60% long of its guard seta (3 setae and famulus slightly shorter than its guard seta in *R. oudemansi*). *Riccardoella reaumuri* also

Fig. 5. *Riccardoella* (*Prorickardoella*) *reaumuri*: holotype, female. A–D: Leg I–IV without coxae. Scale bar 50 μ m.

Fig. 6. *Riccardoella* (*Prorickardoella*) *reaumuri*: holotype, female. Tarsi I–IV in lateral view (A–D). Scale bar 20 μ m.

resembled *Riccardoella canadensis* Fain and van Goethem, 1986 because both species have 6 setae on tibia I, 1 seta on trochanter I and forked famulus on tibia I; however, these two species are distinguished since *R. reaumuri* has 3 setae on palptarsus and famulus *ca.* 60% long of its guard seta (palptarsus with 4 setae and famulus as long as its guard seta in *R. canadensis*).

Discussion

In the original description of *R. reaumuri* (Fain and van Goethem 1986), morphological features of lyrifissures, aggenital region and leg chaetotaxy were not well informed. Especially, presence or absence of lyrifissures *im* is one of the important keys to distinguish genera *Riccardoella* and *Hanriccardoella* André *et al.*, 2004, and mites having the organ are identified as genus *Riccardoella* (André *et al.* 2004), although only two species, *Riccardoella zadeliensis* André *et al.*, 2004 and *Riccardoella tokyoensis* Waki and Shimano, 2018, had been reported to have the organ at present. The present study clarified the presence of lyrifissures *im* on idiosoma of *R. reaumuri*, indicating that this species belongs to this genus.

Leg setation is one of the most important morphological features for species-identification in genus *Riccardoella*; however, the setation of femur III had been confused as for *R. reaumuri*. In the original description of this species (Fain and van Goethem 1986), three setae were illustrated on femur III of the holotype. On the other hands, Fain and Barker (2004) described that four setae present on femur III in a satation table of the *Riccardoella* species. We observed the holotype to confirm that the original description was correct; this species has 3 setae on femur III.

Fig. 7. *Riccardoella* (*Prorriccardoella*) *reaumuri*: holotype, female. Setae, ereynetal organ and lyrifissures. A. setae f_1 and f_2 . B. setae ve . C. solenidion ω and seta ft' on tarsus I. D. erenynetal organ ϕ on tibia I. E. famulus k'' and guard seta l'' on tibia I. F–G. solenidion ω and seta (arrows: d , l' and l'') on palptarsus. H–J. lyrifissures im , ip , and ih (arrows). Scale bars 20 μm (A–G) and 5 μm (H–J).

Table 1. Leg chaetotaxy and solenidiotaxy of *Riccardoella* (*Prorriccardoella*) *reaumuri*

Leg	Coxa	Trochanter	Femur	Genu	Tibia	Tarsus
I	1b, 1c	v'	d , (l), (v), bv''	d , l'' , (v)	d , (l), (v), k'' ϕ	(ft), (tc), (it), (p), (u), (pv), ω
II	2b	v'	(l), v'' , bv''	(l), (v)	d , v''	(ft), (tc), (p), (u), pv' , ω
III	3b, 3c	v'	d , l' , v'	(l), v'	l'' , (v)	ft'' , (tc), (p), (u), pv'
IV	4c	—	d , l'' , v'	(l), v'	d , (v)	ft'' , (tc), (p), (u), pv'

Single and double prime marks setae on anterior and posterior sides of the given leg segment, respectively. Parentheses refer to a pair of setae.

As for the aggenital region, setae making 2 pairs lines, external and internal rows. The numbers of the setae were not identical between right and left sides, due to variation or defluxion, resulting in asymmetric setation of the holotype. Similar asymmetric pattern can be found in *Riccardoella tokyoensis* Waki and Shimano in Waki *et al.*, 2018b and *Riccardoella novaezealandiae* Fain and Barker, 2003, since their type series had asymmetric setation in genital or aggenital setae, probably due to their variation or defluxion. It is likely that such variation in setation occurs frequently on the aggenital regions in genus *Riccardoella*.

The adult male paratype was not appropriate for observation due to deterioration of Hoyer's solution over long time.

Because of this, female is the only adult specimen which can be used for morphological study in the type series. Adult male paratypes should be probably sampled from the type locality and added to the type series in near future. In addition, Waki *et al.* (2018b) reported the presence of this species in Okinawajima island, Japan, which is approximately 10,000 km far from the type locality in France, suggesting that *R. reaumuri* have wide range distribution.

Acknowledgments

We thank the Royal Belgian Institute of Natural Sciences,

Brussels, Belgium (RBINS) for lending us the type series. We thank Camille Locatelli (RBINS) who helped our research. This work was supported by JSPS KAKENHI Grant Numbers 15K07201, 18K06392 for SS and “LNest Grant Natural History Award” of “Leave a Nest Co., Ltd.” Foundation, Japan for TW.

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