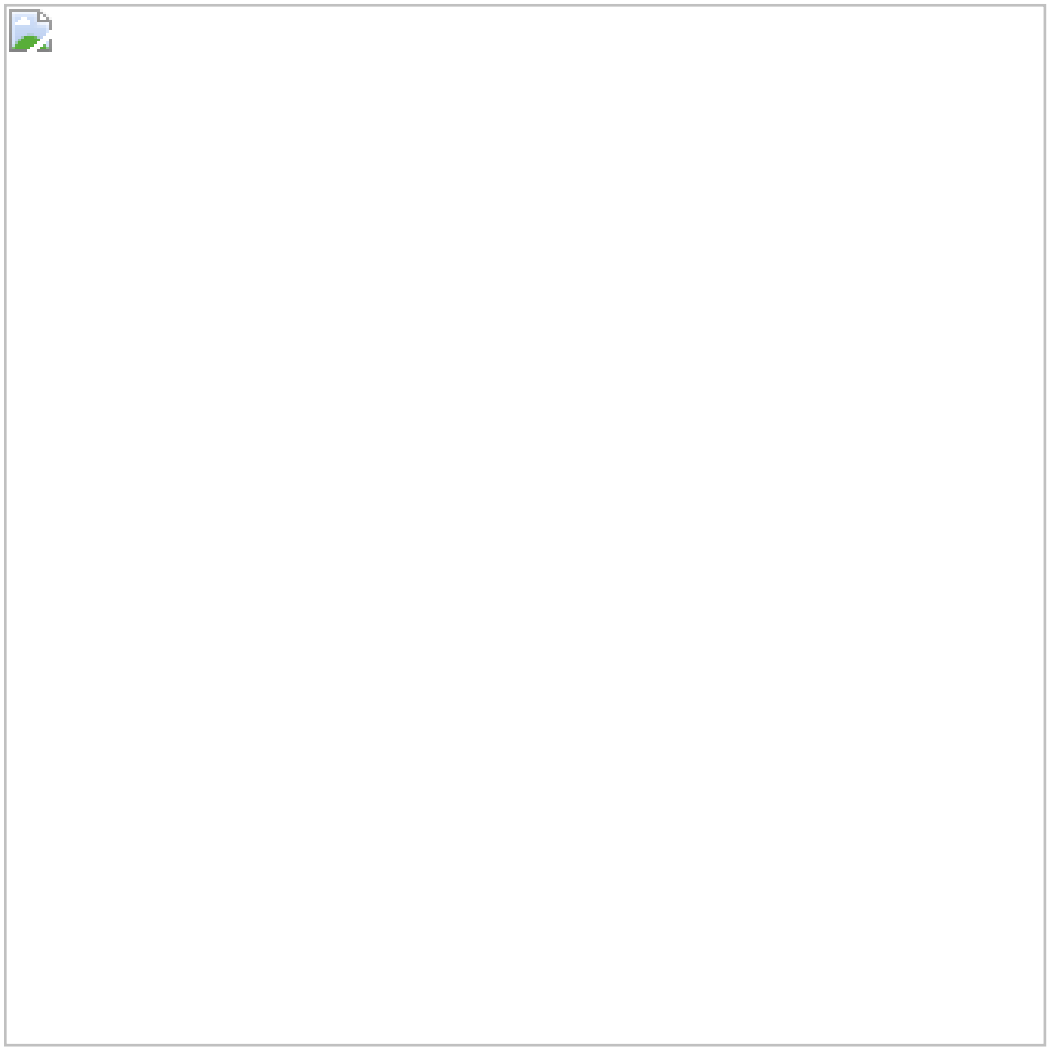

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New record and redescription of *Mullederia sichuanensis* Wang from evergreen forests in Japan, with remarks on morphological variations among world species of *Mullederia* Wood (Acari: Stigmaeidae)

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Abstract

The *Mullederia* Wood, 1964 (Acari: Stigmaeidae) is a species-limited genus with a geographic distribution so far restricted to eastern Palaearctic, Indomalaya and Australasia regions. *Mullederia sichuanensis* Wang, 1986 is newly recorded from Japan based on specimens collected from two different evergreen broad-leaved forests at Bōsō Peninsula, Chiba Prefecture (Honshu). Adult females, males and deutonymphs are redescribed and illustrated. Interspecific morphological variations among world species of *Mullederia* are provided. Also, stigmaeid mite species recorded from Japan are listed.

Key words: Trombidiformes, Raphignathoidea, morphology, description, mites, taxonomy

Introduction

Many species of the family Stigmaeidae Oudemans, 1931 (Acari: Trombidiformes) are important predators, after the phytoseiid mites, against phytophagous mites and insects (Santos & Laing 1985; Gerson *et al*. 2003; Fan & Flechtmann 2015). This family comprises 33 genera and about 600 described species (Fan & Ueckermann 2016; Fan *et al*. 2016; Stathakis *et al*. 2016; Rehman *et al*. 2018; Khaustov 2019). The genus *Mullederia* was established by Wood (1964) assigning *M. arborea* Wood, 1964 as type species. Fan and Ueckermann (2016) redefined the generic status and provided a key to the known species, excluding *M. parryorum* (Gupta, 1991) due to inadequate original description. Accordingly, the genus includes six species restricted to 3 biogeographic realms: *M. sichuanensis* Wang, 1986—China (Palaearctic); *M. filipina* Rimando & Corpuz-Raros, 1996—Philippines, *M. parryorum* (Gupta, 1991)—India (Indomalaya); and *M. arborea* Wood, 1964, *M. procurrens* Fan & Zhang, 2005, *M. scutellaris* Fan & Zhang, 2005—New Zealand (Australasia).

Although several works have been published about the taxonomy of stigmaeid mites in Japan (Ehara 1962, 1964, 1967, 1980, 1985; Ehara & Ueckermann 2006; Negm *et al*. 2015; Negm & Gotoh 2019), species richness is still limited (Table 1). Also, Shiba (2015) listed an unidentified species of *Mullederia* collected from evergreen oak trees (Fagaceae) in Shikoku. The present study aims to redescribe and illustrate females, males and deutonymphs of *M. sichuanensis* as a new record of Stigmaeidae from Japan.

TABLE 1. List of stigmaeid mites known from Japan.

Taxa*	Host plant; Locality	Reference
Agistemus citrinus Ehara, 1967	ex *Hibiscus tiliaceus* L. (Malvaceae); Okinawa	Ehara (1967)
A. exsertus González-Rodríguez, 1963[a]	ex orange (Rutaceae); Kyushu	González-Rodríguez (1963)
A. iburiensis Ehara, 1985	ex bamboo, *Sasa apoiensis* Nakai. (Poaceae); Hokkaido	Ehara (1985)
A. lobatus Ehara, 1964	ex apple, *Malus* sp. (Rosaceae); Honshu	Ehara (1964)
A. summersi Ehara, 1964	ex bamboo, *Sasa* sp.; Hokkaido	Ehara (1964)
A. terminalis (Quayle, 1912)	ex citrus (Rutaceae); Honshu	Ehara (1962)
Eryngiopus sp.	no information available	Shiba (2015)
Eustigmaeus anauniensis (Canestrini, 1889)[b]	not specified; Shikoku, Kyushu	Ehara (1980)
E. arcuatus (Chaudhri, 1965)	not specified; Hokkaido	Ehara (1980)
E. lirellus (Summers & Price, 1961)	not specified; Honshu, Shikoku, Kyushu	Ehara (1980)
E. segnis (Koch, 1836)	not specified; Honshu, Shikoku, Kyushu	Ehara (1980)
Gymnostigmaeus akaminei Ehara & Ueckermann, 2006	ex lawn grass, *Zoysia tenuifolia* Willd. (Poaceae); Okinawa	Ehara & Ueckermann (2006)
Ledermuelleriopsis sp.	no information available	Shiba (2015)
Mullederia sp.	ex oak trees (Fagaceae); Shikoku	Shiba (2015)
Mullederia sichuanensis Wang, 1986	ex shrubs, *Maesa japonica* Merr. (Primulaceae) and *Ilex* sp. (Aquifoliaceae); Honshu	Present study
Stigmaeus callunae Evans, 1954	not specified; Shikoku	Ehara (1980)
S. fissuricolus Halbert, 1920	not specified; Shikoku, Kyushu	Ehara (1980)
Storchia robusta (Berlese, 1885)[c]	not specified; Shikoku	Ehara (1980)
Zetzellia camphorae Negm, Johann, Ferla & Amano, 2015	ex camphor trees, *Cinnamomum camphora* (L.) J. Presl. (Lauraceae); Honshu	Negm *et al.* (2015)

* Species epithets might have different endings than in Japanese literature, to match the gender of the genus name. For example: Ehara (1980) reported the species *Ledermuelleria lirella*, and since this species was transferred from the genus *Ledermuelleria* to *Eustigmaeus*, the epithet '*lirella*', which is feminine, was consecutively changed to '*lirellus*' to fit the new masculine genus name '*Eustigmaeus*' (see Fan *et al*., 2016).
[a] *Agistemus exsertus* was misidentified as *A. fleschneri* Summers, 1960 by Ehara (1962).
[b] Ehara (1980) identified *Eustigmaeus* species under genus *Ledermuelleria* Oudemans, and reported *E. anauniensis* from its synonym *Ledermuelleria pectinata* (Ewing, 1917).
[c] *Storchia robusta* was reported from its synonym *Apostigmaeus navicella* Grandjean by Ehara (1980).

Materials and methods

Mites were directly picked up from detached plant leaves under stereomicroscope (SZ40®, Olympus, Japan) and mounted on glass slides using Hoyer's medium. Permanent slides were placed on a hot plate at 50ºC to dry, then sealed with Thorne's cement® (FHK, Fujihira Industry, Japan) applied around the edge of the coverslip using a slide ringer. Mites were examined for their different taxonomic features with the aid of phase contrast (BX43®, Olympus) and differential interference contrast (BX53®, Olympus) compound microscopes and drawn by a camera lucida (U-DA, Olympus) attached to the microscope. Final illustrations were done with Adobe Illustrator (Adobe Systems Incorporated, USA). Measurements were performed using the imaging software Sensiv Measure® ver. 2.6.0 and correspond to the mean followed by minimum and maximum values. Tubercles of dorsal stout setae and leg coxae were not included in measuring setae and legs.

In the present description, the idiosomal and leg setation follow Grandjean (1939, 1944). Voucher materials are deposited in the Laboratory of Applied Entomology and Zoology, Ibaraki University (AEZIU) under the serial voucher specimen numbers.

Systematics

Family Stigmaeidae Oudemans, 1931
Genus *Mullederia* Wood, 1964
Type species: *Mullederia arborea* Wood, 1964: 1, by original designation.

Mullederia sichuanensis Wang, 1986

(Figures 1−6)

Redescription

Female (Figures 1 & 2) (n=10)

Idiosomal dorsum (Figure 1A): Relatively round 337 (330–344) long, 313 (307–320) wide. Dorsum sclerotized with rounded and polygonal subcuticular reticulations, eye 20 (19−22) in diameter and post-ocular body (*pob*) 19 (17−21) in diameter. Dorsal setae stout and slightly barbed except dorsal seta *d1* and humeral seta *c2* simple. Lengths of prodorsal setae: *vi* 114 (112−116), *ve* 122 (120−125), *sci* 102 (98−106), *sce* 111 (110−113). Distances between their bases: *vi−vi* 60 (58−63), *vi−ve* 92 (90−94), *ve−ve* 214 (207−221), *ve−sci* 34 (33−36), *sci−sci* 166 (163−170), *sci−sce* 74 (72−77), *sce−sce* 305 (287−324). Lengths of hysterosomal setae: *c1* 94 (92−97), *c2* 12 (11−14) in lateral position, *d1* 9 (7−11), *d2* 110 (107−113), *e1* 77 (76−79), *e2* 107 (106−109). Distances between their bases: *c1−c1* 66 (62−70), *d1−d1* 191 (189−194), *d2−d2* 288 (285−292), *c1−d2* 116 (112−120), *d2−e2* 78 (75−81), *e2−e2* 174 (166−183), *e1−e2* 68 (64−72), *e1−e1* 57 (54−60).

Idiosomal venter (Figure 1B): Three pairs of slender setae present between coxae, *1a* 29 (27−32) at level of coxa I, *3a* 20 (19−22) anterior to coxa III and *4a* 18 (17−20) at level between coxae III and IV. Distances between their bases: *1a−1a* 45 (43−47), *3a−3a* 143 (141−146), *4a−4a* 70 (68−73). Anogenital region with two pairs of aggenital setae *ag1* 11 (10−12), *ag2* 10 (9−11), *ag1−ag2* 22 (20−24) laterad genital opening and three pairs of pseudanal setae *ps3* 7 (6−8), *ps2* 10 (9−11), *ps1* 8 (8−9). Suranal shield with two pairs of stout setae *h1* 40 (39−42), *h2* 34 (33−35). Distances between their bases: *h1–h1* 19 (18−21), *h2–h2* 46 (45−48).

Gnathosoma (Figures 1C & D): Chelicera 60 (57−63), movable digit 36 (34−39). Palp 79 (73−85), palp-coxa with a supracoxal seta (*elcp*) dorsally. Number of setae on palpal segments: Tr 0, Fe 3 (*d*, *l'*, *v''*), Ge 2 (*d*, *l''*), Ti 2 (*d*, *l'*), Ts 8 (1) (fused eupathidia *sul*, eupathidion *acm*, *ba*, *bp*, *lp*, *va*, 1 solenidion *ω*). Subcapitulum 96 (90−103) wide, with two pairs of slender setae proximally, *m* 20 (18−22), *n* 22 (21−24) and two pairs of adoral setae distally, *ro2* 13 (12−14), *ro1* 16 (15−18). Distances between bases of subcapitular setae: *n−n* 39 (37−41), *m−m* 17 (15−19), *ro1−ro1* 7 (7−8), *ro2−ro2* 13 (11−16), *n−m* 20 (19−21), *m−ro1* 34 (32−37), *ro1−ro2* 9 (8−10).

Legs (Figure 2): Lengths of legs: leg I 209 (204−215), leg II 210 (202−218), leg III 196 (191−202), leg IV 194 (192−197). Coxa I with setae *1b* 20 (19−22) and *1c* minute, coxa II with seta *2c* minute, coxa III with setae *3b* and *3c* minute, coxa IV with setae *4b* and *4c* minute. Measurements of solenidia: *φp* on Ti I 21 (20−21), *ω* on Ts I 24 (23−25); *φp* on Ti II 21 (20−21), *ω* on Ts II 23 (22−23); *φp* on Ti III 20 (20−21), *ω* on Ts III 24 (24−25). Chaetotaxy (I–IV): coxae 2-1-2-2; trochanters 1-1-1-1; femora 5-5-2-1 or 5-5-2-2, in some specimens; genua 2-0-0-0; tibiae 5+(1*φρ*)-5+(1*φρ*)-5+(1*φρ*)-5; tarsi 12+(1*ω*)-9+(1*ω*)-7+(1*ω*)-7.

Male (Figures 3 & 4) (n=3)

Idiosomal dorsum (Figure 3A): As in female except posterior margin with median invagination, 251 (247–255) long, 223 (218–228) wide. Eye 16 (15–18) in diameter and *pob* 16 (14–19) in diameter. Dorsal setae shorter than in female. Lengths of prodorsal setae: *vi* 78 (75–81), *ve* 88 (86–90), *sci* 63 (61–65), *sce* 68 (66–71). Distances between their bases: *vi–vi* 44 (43–45), *vi–ve* 64 (62–

67), *ve–ve* 142 (140–145), *ve–sci* 31 (29–34), *sci–sci* 112 (110–114), *sci–sce* 63 (60–66), *sce–sce* 214 (211–218). Lengths of hysterosomal setae: *c1* 54 (52–56), *c2* 16 (15–17), *d1* 5 (5–6), *d2* 61 (59–63), *e1* 35 (34–37), *e2* 65 (64–66). Distances between their bases: *c1–c1* 44 (43–46), *d1–d1* 115 (112–118), *d2–d2* 180 (178–182), *c1–d2* 85 (83–88), *d2–e2* 58 (56–60), *e2–e2* 110 (109–111), *e1–e2* 42 (41–44), *e1–e1* 36 (35–37).

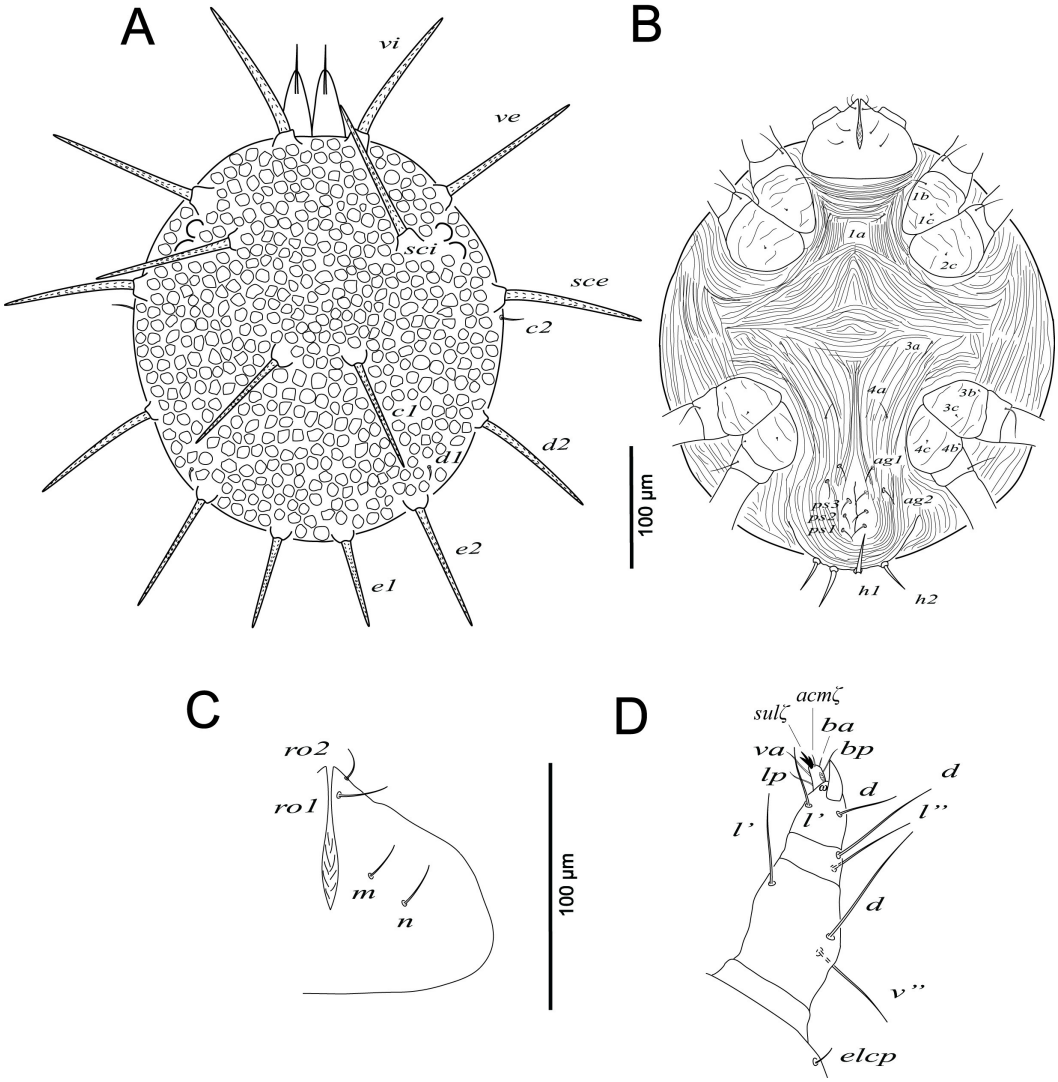

FIGURE 1. *Mullederia sichuanensis* Wang, 1986. Female. A—dorsum; B—venter; C—subcapitulum; D—palp.

Idiosomal venter (Figure 3B): Lengths of intercoxal setae: *1a* 19 (17–22), *3a* 15 (12–19) and *4a* 16 (14–18). Distances between their bases: *1a–1a* 24 (22–26), *3a–3a* 97 (94–100), *4a–4a* 39 (38–41). Aggenital setae: *ag1* 7 (7–8), *ag2* 10 (9–11), situated as in female. Pseudanal setae: *ps3* 6 (5–6), *ps2* 4 (4–5), *ps1* 3 (3–4). Suranal setae *h1* 14 (13–15), *h2* 16 (16–17). Distances between their bases: *h1–h1* 15 (14–17), *h2–h2* 39 (38–41).

Gnathosoma (Figures 3C & D): Chelicera 46 (44−49), movable digit 25 (24−27). Palp 67 (66−69), chaetotaxy of palp as in female. Subcapitulum 73 (72–75) wide, with subcapitular setae, *m*

13 (13–14), *n* 14 (13–15) and adoral setae, *ro2* 13 (12–15), *ro1* 11 (10–13). Distances between bases of subcapitular setae: *n–n* 31 (30–32), *m–m* 13 (11–16), *ro1–ro1* 8 (7–10), *ro2–ro2* 13 (12–14), *n–m* 16 (14–18), *m−ro1* 33 (30−36), *ro1−ro2* 10 (10−11).

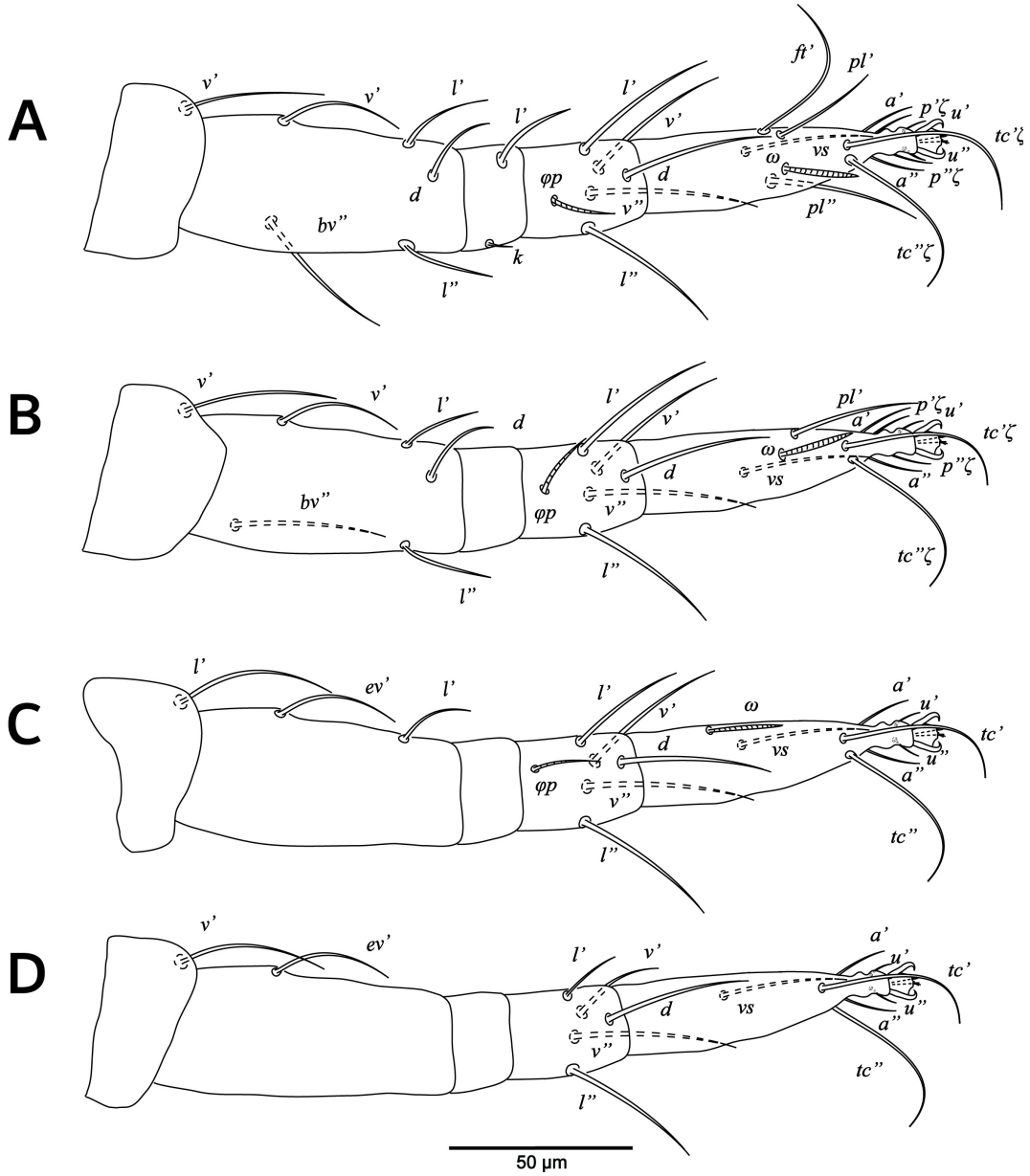

FIGURE 2. *Mullederia sichuanensis* Wang, 1986. Female. A—leg I; B—leg II; C—leg III; D—leg IV.

Legs (Figure 4). Lengths of legs: leg I 175 (171–180), leg II 169 (167–172), leg III 165 (162–168), leg IV 167 (164–170). Measurements of solenidia: φp on Ti I 16 (16−17), ω_1 on Ts I 17 (16−18), ω_2 on Ts I 24(24−25); φp on Ti II 15 (15−16), ω_1 on Ts II 17 (17−18), ω_2 on Ts II 25 (25−26); φp on Ti III 16 (15−17), ω_1 on Ts III 18 (18−19), ω_2 on Ts III 24 (23−25); ω_1 on Ts IV 19 (19−20), ω_2 on Ts IV 26 (25−27). Chaetotaxy (I–IV): coxae 2-1-2-2; trochanters 1-1-1-1; femora 5-5-2-1 or 5-5-2-2, in one specimen; genua 2-0-0-0; tibiae 5+(1$\varphi\rho$)-5+(1$\varphi\rho$)-5+(1$\varphi\rho$)-5; tarsi 12+(2ω)-9+(2ω)-7+(2ω)-7+(2ω).

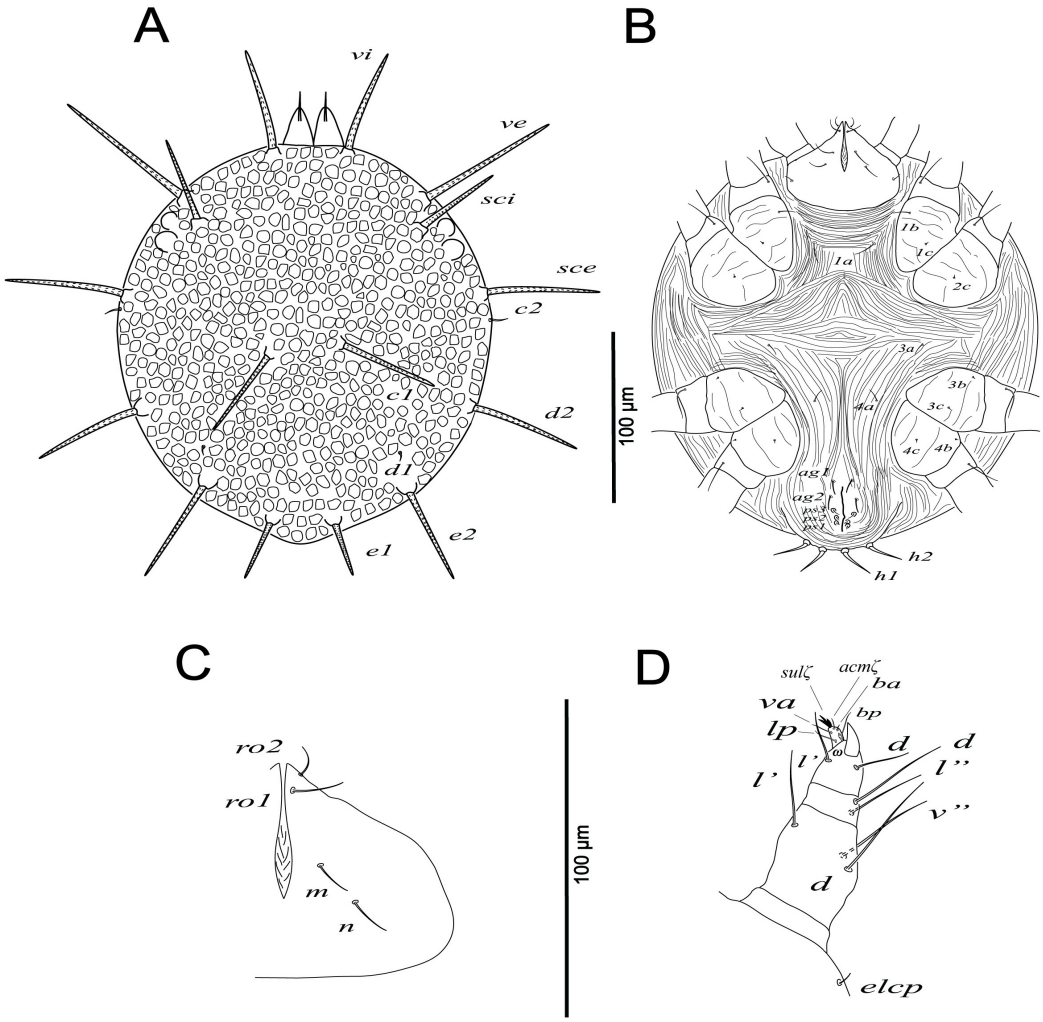

FIGURE 3. *Mullederia sichuanensis* Wang, 1986. Male. A—dorsum; B—venter; C—subcapitulum; D—palp.

Deutonymph (Figures 5 & 6) (n=7)

Idiosomal dorsum (Figure 5A): Shape as in female, 275 (268–282) long, 262 (258–266) wide. Eye 17 (16−18) in diameter and *pob* 18 (16−20) in diameter. Lengths of prodorsal setae: *vi* 74 (72−76), *ve* 87 (85−89), *sci* 64 (63−65), *sce* 70 (68−72). Distances between their bases: *vi−vi* 44 (40−48), *vi−ve* 72 (70−74), *ve−ve* 173 (170−176), *ve−sci* 26 (25−27), *sci−sci* 142 (140−144), *sci−sce* 64 (60−68), *sce−sce* 235 (229−241). Lengths of hysterosomal setae: *c1* 61 (60−62), *c2* 8 (7−9), *d1* 5 (5−6), *d2* 70 (67−73), *e1* 45 (43−47), *e2* 68 (65−71). Distances between their bases: *c1−c1* 48 (46−50), *d1−d1* 146 (139−153), *d2−d2* 215 (211−219), *c1−d2* 94 (92−96), *d2−e2* 65 (64−66), *e2−e2* 137 (132−142), *e1−e2* 54 (52−56), *e1−e1* 40 (36−44).

Idiosomal venter (Figure 5B): Lengths of intercoxal setae: *1a* 18 (17–19), *3a* 14 (13–15) and *4a* 15 (13–17). Distances between their bases: *1a−1a* 35 (32−37), *3a−3a* 108 (102−114), *4a−4a* 38 (35−41). Aggenital setae: *ag1* 7 (7−8), *ag2* 8 (7−9). Pseudanal setae: *ps3* 6 (6−7), *ps2* 7 (7−8), *ps1* 7 (7−8). Suranal setae *h1* 20 (18−22), *h2* 24 (23−25). Distances between their bases: *h1–h1* 11 (10−12), *h2–h2* 35 (35−36).

Gnathosoma (Figures 5C & D): Chelicera 54 (52−56), movable digit 23 (20−26). Palp 50 (45−55). Subcapitulum 73 (70−76) wide, with subcapitular setae, *m* 18 (18−19), *n* 17 (17−18) and

adoral setae, *ro2* 9 (8−10), *ro1* 10 (10−11). Distances between bases of subcapitular setae: *n*−*n* 30 (28−32), *m*−*m* 22 (22−23), *ro1*−*ro1* 6 (6−7), *ro2*−*ro2* 10 (9−11), *n*–*m* 17 (15–19), *m*−*ro1* 35 (33−37), *ro1*−*ro2* 7 (7−8).

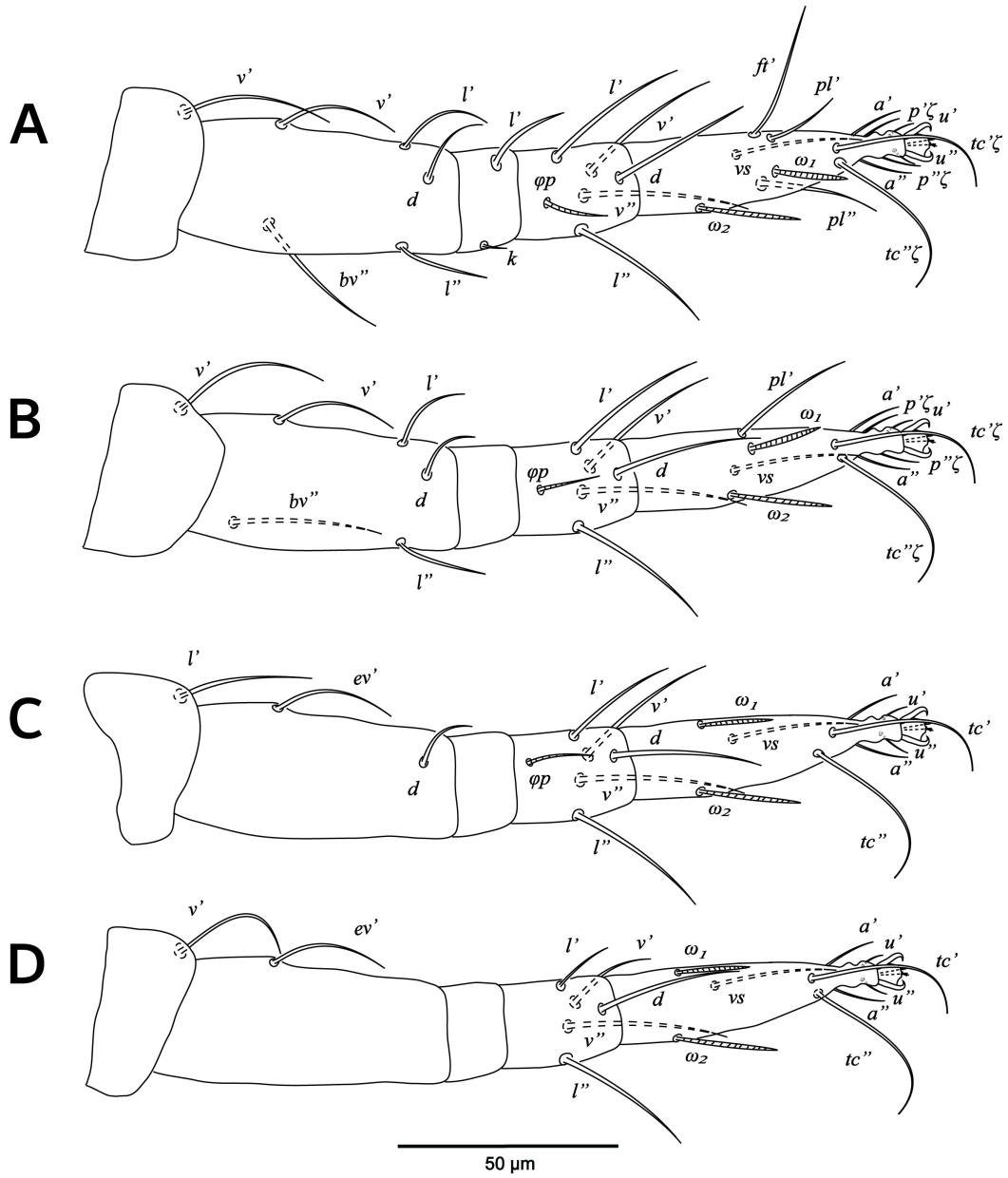

FIGURE 4. *Mullederia sichuanensis* Wang, 1986. Male. A—leg I; B—leg II; C—leg III; D—leg IV.

Legs (Figure 6): Lengths of legs: leg I 165 (160−170), leg II 170 (167−173), leg III 162 (160−164), leg IV 155 (151−159). Measurements of solenidia: *φp* on Ti I 18 (17−19), *ω* on Ts I 22 (21−22); *φp* on Ti II 19 (19−20), *ω* on Ts II 21 (20−22); *φp* on Ti III 17 (16−18), *ω* on Ts III 23 (23−24). Chaetotaxy (I–IV): coxae 2-1-2-2; trochanters 1-1-1-0; femora 5-5-2-1; genua 2-0-0-0; tibiae 5+(1*φρ*)-5+(1*φρ*)-5+(1*φρ*)-5; tarsi 12+(1*ω*)-9+(1*ω*)-7+(1*ω*)-7.

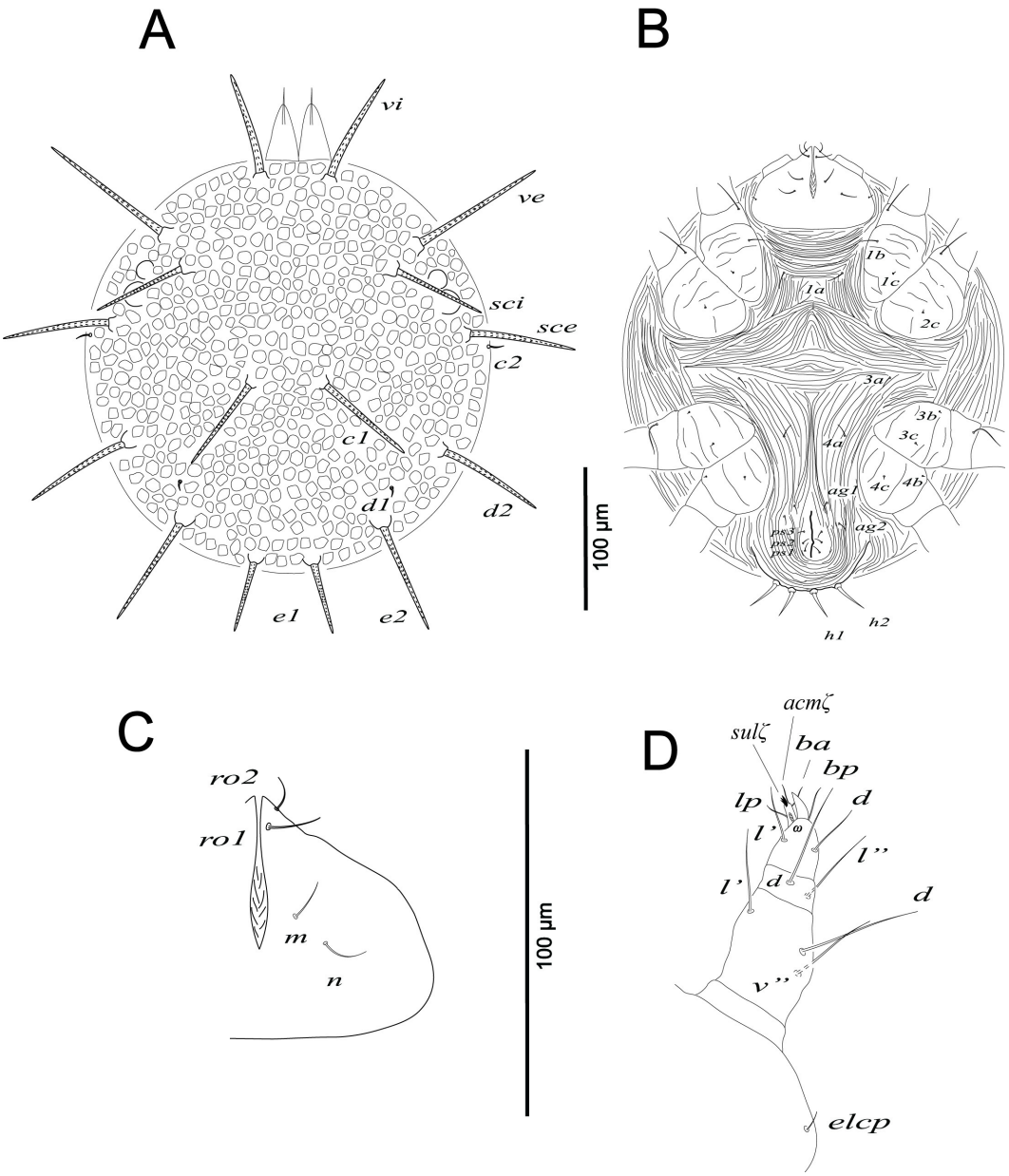

FIGURE 5. *Mullederia sichuanensis* Wang, 1986. Deutonymph. A—dorsum; B—venter; C—subcapitulum; D—palp.

Material examined

Ten females and 2 males, ex *Maesa japonica* Merr. (Primulaceae), Bōsō Peninsula, Chiba Prefecture, Japan, 35°10’14’’N, 140°10’09’’E, 320 m, 23 July 2018, M.W. Negm leg. (voucher specimen no. 890); 2 females, 1 male and 7 deutonymphs, *Ilex* sp. (Aquifoliaceae), Bōsō Peninsula, Chiba Prefecture, Japan, 35°09’21’’N, 140°11’33’’E, 80 m, 26 May 2018, M.W. Negm leg. (voucher specimen no. 891).

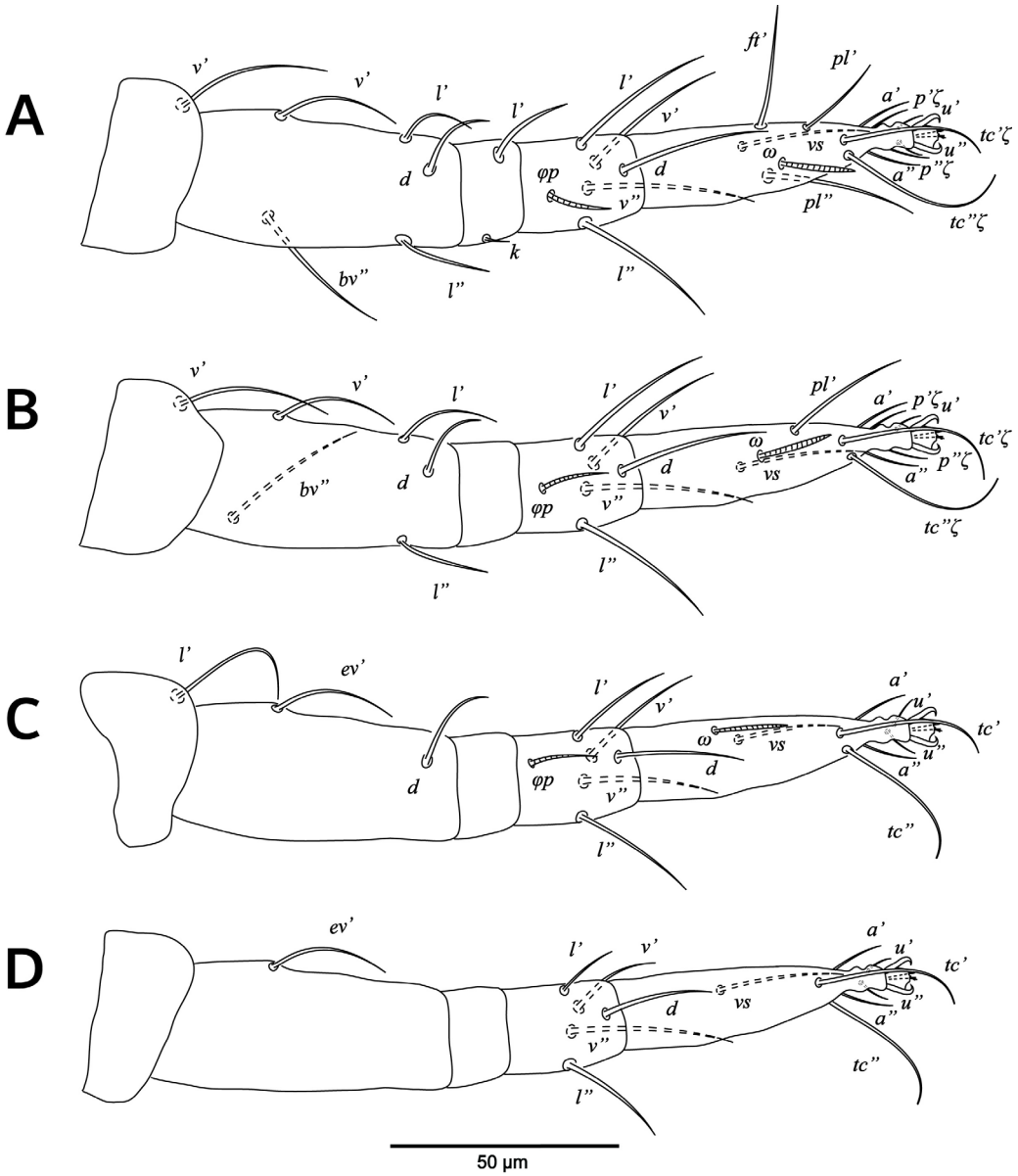

FIGURE 6. *Mullederia sichuanensis* Wang, 1986. Deutonymph. A—leg I; B—leg II; C—leg III; D—leg IV.

Remarks

Mullederia sichuanensis Wang, 1986 was originally described from China based on materials collected from different host plants, *Holboellia* sp. (Lardizabalaceae), *Rubus lambertianus* Ser. (Rosaceae) and *Viburnum brachybotryum* Hemsl. (Adoxaceae) (Wang 1986), which are deciduous broad-leaved plants. However, the Japanese specimens were found on another flowering host plants of the families Primulaceae and Aquifoliaceae, which are evergreen broad-leaved plants.

The Japanese specimens of *M. sichuanensis* can be separated from other species within the genus by the presence of the dorsal seta *d1* (= *li*—in original description) and the absence of seta *f1*. Conversely, the New Zealand species (*arborea* Wood; *procurrens* Fan & Zhang; *scutellaris* Fan &

Zhang) lack seta *d1* and bear seta *f1*. Table 2 lists the interspecific morphological variations among females of *Mullederia* species of the world.

TABLE 2. Morphological diagnostic variations among females of *Mullederia* species of the world.

Species	Setae (*d1*)	Setae (*f1*)	Coxae (I–IV)	Trochanters (I–IV)	Femora (I–IV)	Genua (I–IV)	Tibiae (I–IV)	Tarsi (I–IV)	References
arborea Wood	absent	present	2+1*elcp*-1-2-2[a]	1-1-1-0	5-5-2-1	2+1κ-1-0-0	5+1φρ-5+1φρ-5+1φρ-5+1φρ	12+1ω-9+1ω-7+1ω-7	Fan & Zhang (2005)
filipina Rimando & Corpuz-Raros	absent	present (*f2*)	1-0-0-0	1-1-1-1	5-5-2-1	2-0-0-0	5+1ω-5+1ω-5+1ω-5	11+1ω-8+1ω-7+1ω-7	Rimando & Corpuz-Raros (1996)
parryorum (Gupta)[b]	absent	absent	n/a	n/a	n/a	n/a	n/a	n/a	Gupta (1991)
procurrens Fan & Zhang	absent	present	2+1*elcp*-1-2-2	1-1-1-0	5-5-2-1	2+1κ-1-0-0	5+1φρ-5+1φρ-5+1φρ-5+1φρ	12+1ω-9+1ω-7+1ω-7	Fan & Zhang (2005)
scutellaris Fan & Zhang	absent	present	2+1*elcp*-1-2-2	1-1-1-0	5-5-2-1	2+1κ-1-0-0	5+1φρ-5+1φρ-5+1φρ-5+1φρ	12+1ω-9+1ω-7+1ω-7	Fan & Zhang (2005)
sichuanensis Wang	present (*li*)	absent	2-1-1-1 (2-1-2-2)[c]	1-1-1-1	5-5-2-2+ω (5-5-2-1)	2-0-0-0	6-6-6-5	13-9-6-6 (12+1ω-9+1ω-7+1ω-7)[c]	Wang (1986)

[a] Fan and Zhang (2005) depicted coxa IV with a single seta only.
[b] This species is questionable due to inadequate original description.
[c] The correct chaetotaxy after Fan and Ueckermann (2016), in parenthesis.

The examined mites conform to the original description of this species, considering the corrections published by Fan & Ueckermann (2016). However, most of the Japanese specimens have femur IV with one seta, while few individuals with two setae. We consider this alteration in setal counts as an intraspecific variation.

The current species is newly recorded from Japan based on specimens of females, males and deutonymphs. The chaetotaxy of legs between females, males and deutonymphs is relatively similar. However, males differ from females and deutonymphs in the presence of additional solenidia on tarsi I–IV, whereas deutonymphs differ from females and males in having trochanter IV nude.

Discussion

The present work redescribes a new record of stigmaeid mites in Japan, increasing their fauna to 9 genera and 19 species, including three unidentified species, to date. Also, deutonymphal stage of the genus *Mullederia* is described herein for the first time. Reporting such few numbers of stigmaeid species from Japan, in a rich family with about 600 species described globally, may indicate that this country is expected to contain more species awaiting discovery. The world distribution of *Mullederia* mites comprises only New Zealand, India, Philippines, China and Japan (Shiba 2015; present study), making this genus quite restricted to eastern Palaearctic, Indomalaya and Australasia biogeographic realms.

Rimando & Corpuz-Raros (1996) provided a key to *Mullederia* species and stated that *M. sichuanensis* has coxae I–IV with 2-1-1-1; however, the coxal chaetotaxy was recently corrected to 2-1-2-2 by Fan & Ueckermann (2016). They also re-examined paratype females and corrected the number of tenent hairs on the empodial shaft to 3 rather than 2 in contrast with Wang (1986) and Rimando & Corpuz-Raros (1996), and highlighted that tarsi I–IV with 12+1ω, 9+1ω, 7+1ω, 7 rather

than 12+1ω, 8+1ω, 6, 6. Rimando & Corpuz-Raros (1996) mentioned about *M. sichuanensis* to be the only species that has 3 setae (2+1) on femur IV; however, the present specimens agree with the genus revised diagnosis (Fan & Ueckermann 2016) to have 1 seta (most specimens) or 2 setae (few specimens).

The species *M. filipina* was described from the Philippines due to the number of coxal setae on legs (I–IV) which were (1-0-0-0). This setal formula is questionable, especially because the coxal setae (*1c*, *2c*, *3b*, *3c*, *4b*, *4c*) are minute and rather difficult to be observed. Also, the description of *M. parryorum* from India is brief and lacks specific information which makes the species difficult to be identified and distinguished from other species in the genus (Gupta 1991; Fan & Ueckermann 2016). Therefore, the genus *Mullederia* may be in need of updated revision.

Information about the biological traits of *Mullederia* mites is still unknown. Up to our knowledge, no studies have evaluated the predatory performance of *Mullederia* mites. This may be due to some difficulties in mite rearing. Despite preliminary trials have failed to rear these mites in laboratory, few individuals were seen attacking the eggs of *Tetranychus urticae* Koch (unpublished data). Such predation ability may encourage for more ecological studies to figure out the predator-prey interaction between the *Mullederia* mites and other pestiferous species. Further research should be directed to investigate their efficiency for a better use in biocontrol programs. Hopefully, this work would encourage for setting up new series of biological studies on *Mullederia* mites.

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References

Ehara, S. (1962) Notes on some predatory mites (Phytoseiidae and Stigmaeidae). *Japanese Journal of Applied Entomology and Zoology*, 6(1), 53–60. https://doi.org/10.1303/jjaez.6.53

Ehara, S. (1964) Predaceous mites of the genus *Agistemus* in Japan (Acarina: Stigmaeidae). *Annotationes Zoologicae Japonenses*, 37(4), 226–232.

Ehara, S. (1967) Raphignathoid mites associated with plants in Okinawa Island (Eupalopsellidae, Stigmaeidae). *Proceedings of the Japan Academy*, 43, 322–326. https://doi.org/10.2183/pjab1945.43.322

Ehara, S. (1980) (Ed.) *Illustrations of the mites and ticks of Japan*. Japan Tokyo, Zenkoku Nōson Kyōiku Kyōkai. 562 pp. [in Japanese with English summary]

Ehara, S. (1985) A new species of the genus *Agistemus* Summers from Hokkaido (Acarina: Stigmaeidae). *Proceedings of the Japan Academy*, 61B(2), 60–62. https://doi.org/10.2183/pjab.61.60

Ehara, S. & Ueckermann, E.A. (2006) A new genus of Stigmaeidae (Acari: Prostigmata) from Okinawa Island. *Zootaxa*, 1160, 29–36. https://doi.org/10.11646/zootaxa.1160.1.3

Fan, Q.-H. & Flechtmann, C.H.W. (2015) Chapter 7. Stigmaeidae. *In*: Carrillo, D., Moraes, G.J. de & Peña, J. (eds.), *Prospects for biological control of plant feeding mites and other harmful organisms.* NY, Springer, pp. 185–206. https://doi.org/10.1007/978-3-319-15042-0_7

Fan, Q.-H. & Ueckermann, E.A. (2016) Resurrection of the genus *Nonocaligus* Habeeb with redefinition of *Nonocaligus* and *Mullederia* Wood (Acari: Stigmaeidae). *Systematic and Applied Acarology*, 21(11), 1447–1449.
https://doi.org/10.11158/saa.21.11.1

Fan, Q.-H. & Zhang, Z.-Q. (2005) Raphignathoidea (Acari: Prostigmata). *Fauna of New Zealand*, 52, 1–396.

Fan, Q.-H., Flechtmann, C.H. & de Moraes, G.J. (2016) Annotated catalogue of Stigmaeidae (Acari: Prostigmata), with a pictorial key to genera. *Zootaxa*, 4176(1), 1–199.
https://doi.org/10.11646/zootaxa.4176.1.1

Gerson, U., Smiley, R.L. & Ochoa, R. (2003) *Mites (Acari) for pest control*. Oxford, Blackwell Science, 539 pp.
https://doi.org/10.1002/9780470750995

González-Rodríguez, R.H. (1963) Four new mites of the genus *Agistemus* Summers, 1960 (Acarina: Stigmaeidae). *Acarologia*, 5(3), 342–350.

Grandjean, F. (1939) Les segments postlarvaires de l'hysterosoma chez les oribates (Acariens). *Bulletin Societe Zoology France*, 64, 273–284.

Grandjean, F. (1944) Observations sur les acariens de la famille des Stigmaeidae. *Archives des Sciences Physiques et Naturelles*, 26, 103–131.

Gupta, S.K. (1991) Studies on predatory prostigmatid mites of northeast India with descriptions of new species and new records from India. *Records of the Zoological Survey of India*, 88, 207–239.

Khaustov, A.A. (2019) Contribution to systematics of the genus *Eustigmaeus* (Acari: Stigmaeidae) of Russia. *Acarologia*, 59(1), 152–173.

Negm, M.W. & Gotoh, T. (2019) Redescription of *Agistemus lobatus* Ehara, 1964 and *A. terminalis* (Quayle, 1912) (Acari: Trombidiformes: Stigmaeidae) with DNA barcoding. *Systematic and Applied Acarology*, 24, 33–44.
https://doi.org/10.11158/saa.24.1.3

Negm, M.W., Johann, L., Ferla, N.J. & Amano, H. (2015) A new species of *Zetzellia* Oudemans (Acari, Trombidiformes, Raphignathoidea, Stigmaeidae) and a key to Stigmaeidae of Japan. *Systematic and Applied Acarology*, 20, 961–966.
https://doi.org/10.11158/saa.20.8.11

Oudemans, A.C. (1931) Acarologische aanteekeningen CVIII. *Entomologische Berichten*, 8(179), 251–263.

Rehman, M.U., Kamran, M. & Alatawi, F. (2018) Genus *Agistemus* Summers (Acari: Trombidiformes: Stigmaeidae) from Saudi Arabia and a key to the world species. *Systematic and Applied Acarology*, 23, 1051–1072.
https://doi.org/10.11158/saa.23.6.5

Rimando, L.C. & Corpuz-Raros, L.A. (1996) Some Philippine Raphignathoidea (Acari). II. The genus *Mullederia* Wood and two new genera of stigmaeid mites. *Asia-life Science*, 5(2), 141–161.

Santos, M.A. & Laing, J.E. (1985) *Stigmaeid predators*. *In:* Helle, W. & Sabelis, M.W. (Eds.) *Spider mites. Their biology, natural enemies and control*. Vol. 1B. Amsterdam, Elsevier, pp. 197–203.

Shiba, M. (2015) *Arachnida, Acari, Prostigmata*. *In:* Aoki, J. (Ed.) *Pictorial keys to soil animals of Japan*, 2nd Edition. Tokyo, Tokai University Press, pp. 203–313. [in Japanese]

Stathakis, T.I., Kapaxidi, E.V. & Papadoulis, G.T. (2016) The genus *Eustigmaeus* Berlese (Acari: Stigmaeidae) from Greece. *Zootaxa*, 4191, 1–102.
https://doi.org/10.11646/zootaxa.4191.1.1

Wang, H.-F. (1986) A new species of the genus *Mullederia* (Acarina: Stigmaeidae). *Acta Zootaxonomica Sinica*, 11(2), 187–190.

Wood, T.G. (1964) A new genus of Stigmaeidae (Acari: Prostigmata) from New Zealand. *New Zealand Journal of Science*, 7, 579–584.

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