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Authors: Liao, Jhih-Rong, Ho, Chyi-Chen, Fang, Xiao-Duan, and Ko, Chiun-Cheng

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Contribution to the knowledge of the genera *Euseius* Wainstein and *Gynaseius* Wainstein (Acari: Mesostigmata: Amblyseiinae) from Taiwan

JHIH-RONG LIAO[1], CHYI-CHEN HO[2], XIAO-DUAN FANG[3] & CHIUN-CHENG KO[1,4]

[1] *Department of Entomology, National Taiwan University, Taipei City 10617, Taiwan*

[2] *Taiwan Acari Research Laboratory, Taichung City, Taiwan*

[3] *Guangdong Key Laboratory of Animal Conservation and Resource Utilization, Guangdong Public Laboratory of Wild Animal Conservation and Utilization, Guangdong Institute of Applied Biological Resources, Guangzhou, China*

[4]*Corresponding author. E-mail: kocc2501@ntu.edu.tw*

Abstract

Euseius nicholsi (Ehara & Lee), *E. sojaensis* (Ehara), and *Gynaseius santosoi* (Ehara) are reported for the first time from Taiwan. The new records were re-described based on Taiwanese specimens collected from various plants. In addition, a new species, *E. oolong* **sp. nov.,** was described and illustrated. Identification keys for Taiwanese species of *Euseius* Wainstein and world species of genus *Gynaseius* Wainstein are provided.

Key words: *Euseius*, *Gynaseius*, taxonomy, Taiwan, new species, new record

Introduction

Phytoseiid mites have been intensively surveyed in Taiwan during the past several decades (Ehara 1970; Lo 1970; Tseng 1972; 1973; 1975; 1976; Chang & Tseng 1978; Tseng 1983; Ho & Lo 1989; Ho *et al*. 2003) because of their potential as biological control agent (Huffaker *et a*l. 1970; McMurtry *et al*. 1970; 2013). Knowledge regarding the fauna of Phytoseiidae in Taiwan is still increasing, with detailed investigations conducted by the present authors. To date, 59 species have been recorded from Taiwan and neighboring islands (Ehara 1970; Lo 1970; Tseng 1972; 1973; 1975; 1976; Chang & Tseng 1978; Tseng 1983; Ho & Lo 1989; Ho *et al*. 2003; Liao *et al*. 2017a; 2017b; 2017c).

The genus *Euseius* Wainstein is a large genus in the subfamily Amblyseiinae with about 190 valid species (Demite *et al*. 2018). In general, *Euseius* species are recorded in tropical and subtropical areas, especially in Africa (approximately 35% of total species) (Moraes *et al*. 2001; Chant & McMurtry 2005; 2007). *Euseius* species are considered to be pollen feeding generalist predators with type IV feeding habits (McMurtry *et al*. 2013). Some of them, such as *E. scutalis* (Athias-Henriot), may survive in the absence of prey by sucking plant tissues (Nomikou *et al*. 2003; Adar *et al*. 2012). Several studies have noted the biological potential of *Euseius* species to control small agricultural pests (Döker *et al*. 2014; Lopes *et al*. 2015; Liao *et al*. 2017a; De Alfaia *et al.* 2018). Among them, *E. gallicus* Kreiter & Tixier has been used commercially for whiteflies and thrips control (Biobest, 2018). In a decade-long survey conducted by the authors of the present study, six species—*E. aizawai* (Ehara & Bhandhufalck), *E. circellatus* (Wu & Li), *E. daluensis* Liao & Ho, *E. macaranga* Liao & Ho, *E. ovalis* (Evans), and *E. paraovalis* Liao & Ho—were found in Taiwan (Liao *et al*. 2017a).

The genus *Gynaseius* Wainstein also belongs to the subfamily Amblyseiinae, which contains 12 valid species that have been recorded in various host plants (e.g. rice, soybean, blackberry, papaya, and *Hibiscus* sp.) in the Pacific area, except *G. larum* El-Banhawy & Knapp, which has been identified from an unknown host in Kenya (Chant & McMurtry 2006; El-Banhawy & Knapp 2011; Demite *et al*. 2018). This genus is unique in that its peritrematic shield is not fused anteriorly with the dorsal shield in the Amblyseiinae (Chant & McMurtry 2006).

In the present study, we described a new species and presented three new records that were observed during our surveys in Taiwan. Identification keys for Taiwanese species of *Euseius* and world species of *Gynaseius* were included.

Materials and Methods

Specimens examined in this study were collected from various plants from the main island and surrounding islands of Taiwan and also a trip in Guangzhou for comparison. Specimens examined under Olympus BX51 microscope, and measurements were taken using a stage-calibrated ocular micrometers and as well as ImageJ 1.47 (Schneider *et al*. 2012). Photos were taken by using Motic® Moticam 5+ camera attached to the microscope. All measurements were provided in micrometers and holotype measurements are shown in bold type for the new species and *E. nicholsi*, followed by their mean and range in parenthesis, missing values were code with question mark "?". The general terminology used for morphological descriptions in this study follows that of Chant & McMurtry (2007), while for idiosomal seta terminology followed Rowell *et al*. (1978) and Chant & Yoshida-Shaul (1991; 1992); for adenotaxy and poroidotaxy terminology we followed Beard (2001).

Type specimens and voucher specimens were deposited in the following institutions: GIABR (Guangdong Institute of Applied Biological Resources, Guangzhou, China), NCHU (Department of Entomology, National Chung Hsing University, Taichung, Taiwan), NMNS (National Museum of Natural Science, Taichung, Taiwan), NTU (Department of Entomology, National Taiwan University, Taipei, Taiwan), TARL (Taiwan Acari Research Laboratory, Taichung City, Taiwan). Other specimens were received on loan from acarological collections of HUM (Hokkaido University Museum, Sapporo, Japan) and NSMT (National Museum of Nature and Science, Tsukuba, Japan). If necessary, the locality names were translated using the Geographic Name Information System, Department of Land Administration, Ministry of the Interior (Taiwan) (http://gn.moi.gov.tw/geonames/Translation/Translation.aspx).

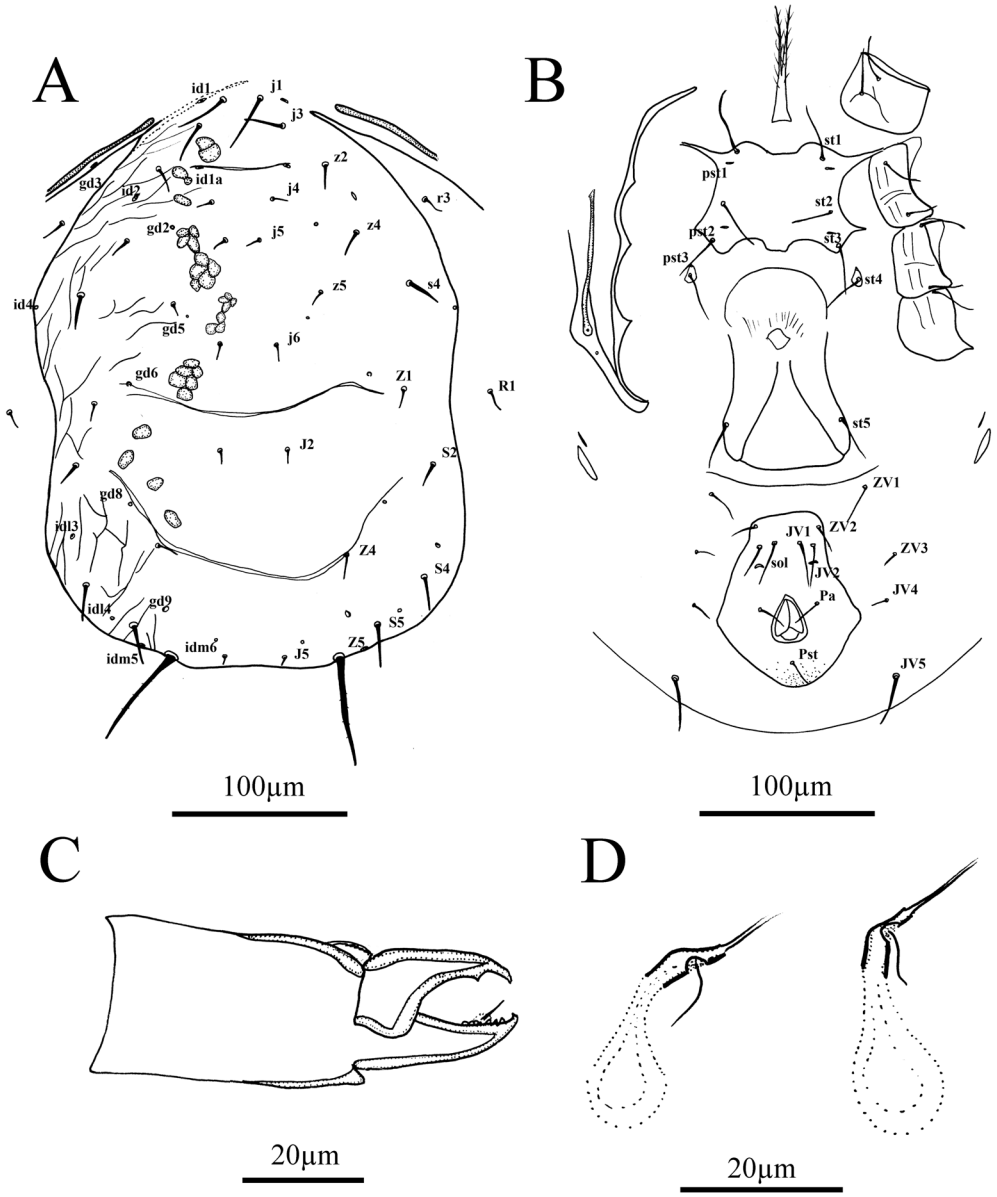
Results

Family Phytoseiidae Berlese
Subfamily Amblyseiinae Muma
Tribe Euseiini Chant & McMurtry
Subtribe Euseiina Chant & McMurtry
Genus *Euseius* Wainstein

***Euseius oolong* Liao & Ho sp. nov.**
(Figures 1–2)

Diagnosis. Female dorsal surface mostly reticulated, bearing 19 pairs of dorsal setae (including *r3*, *R1*). All setae smooth, except *Z5* serrated. Five pairs of solenostomes, (*gd2*, *gd5*, *gd6*, *gd8*, *gd9*)

visible on the dorsal shield. Peritreme extending to level of setae *z2*. Sternal shield with three pairs of setae; ventrianal shield bearing three pairs of pre-anal setae, *JV1* migrate next to *JV2*, with solenostomes. Fixed digit of chelicera with five teeth; movable digit with one tooth. Calyx of spermatheca short and cup-shaped with distal half only lightly sclerotized. Leg III and leg IV both with three pair of macrosetae; genu II with seven setae.

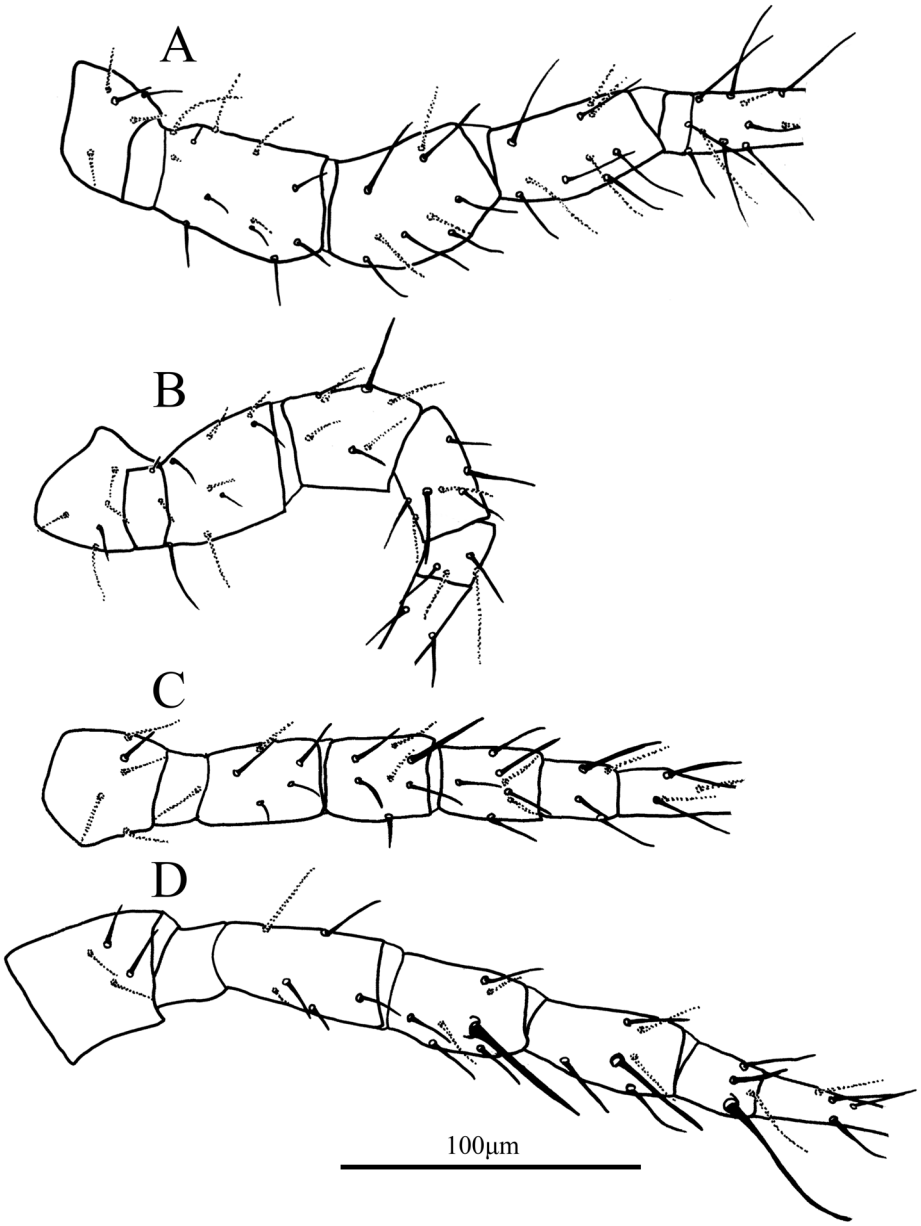


FIGURES 1. *Euseius oolong* **sp. nov.** Female, A. dorsal shield, B. ventral idiosoma, C. chelicera, D. spermatheca.

Female (n=6).

A lightly sclerotized mite. Idiosomal setal pattern: 10A:9B/JV-3:ZV.

Dorsum (Figure 1A). Dorsal shield laterally reticulated; **328** 341 (324–361) long (*j1–J5* level) and **237** 246 (236–266) wide at level of *j6*, **221** 237 (221–260) wide at level of *S4*; five pairs of solenostomes on dorsal shield, (*gd2*, *gd4*, *gd6*, *gd8*, *gd9*), seven pairs of lyrifissures (*id1*, *id1a*, *id2*, *id4*, *idl3*, *idl4*, *idm5*); muscle-marks (sigilla) visible on podosoma; length of setae: *j1* **32** 28 (24–32), *j3* **20** 22 (20–25), *j4* **7** 8 (7–10), *j5* **7** 8 (7–11), *j6* **9** 9 (6–11), *J2* 8 10 (8–12), *J5* **6** 5 (3–6), *z2* **12** 15 (12–18), *z4* **11** 13 (11–19), *z5* **6** 8 (6–10), *Z1* **8** 10 (7–15), *Z4* **8** 11 (8–16), *Z5* **53** 58 (53–63), *s4* **18** 25 (18–36), *S2* **13** 16 (13–18), *S4* **17** 22 (17–27), *S5* **22** 25 (22–29), *r3* **9** 12 (9–15), *R1* **9** 10 (9–13). All setae smooth, except *Z5* slightly serrate.



FIGURES 2. *Euseius oolong* **sp. nov.** Female, legs A. leg I anterior view, B. leg II posterior view, C. leg III dorsal view, D. leg IV anterior view.

Peritreme (Figure 1A). Peritreme extending beyond *z2* level, peritrematic shield smooth, lightly sclerotized, with one pair of solenostomes (*gd3*).

Venter (Figure 1B). Sternal shield smooth, posterior margin with medium projection, much wider than long, **61** 61 (51–70) long, **94** 93 (86–96) wide, with three pairs of setae *st1* **26** 27 (26–31), *st2* **23** 25 (23–28), *st3* **26** 24 (22–26), and two pairs of lyrifissures (*pst1*, *pst2*). Exopodal shield at coxae I-IV. Metasternal platelets tear-shaped, with one pair metasternal setae, *st4* **21** 21 (19–23), with one pair of lyrifissuress (*pst3*). Genital shield smooth, with one pair of genital setae *st5* **20** 23 (15–28), **75** 87 (75–92) wide at level of genital setae. Distances between *st1-st1* **49** 54 (45–61), *st2-st2* **63** 62 (48–69), *st3-st3* **75** 74 (65–79), *st1-st3* **56** 58 (52–63), *st5-st5* **68** 76 (68–82). Ventrianal shield vase-shaped **96** 102 (96–108) long, **49** 49 (45–56) wide at level of *ZV2*, **82** 81 (77–85) wide at level of anus; with three pairs of pre-anal setae, *JV1* migrate next to *JV2*, *JV1* **26** 24 (19–26), *JV2* **18** 19 (15–24), *ZV2* **15** 17 (13–20), solenostomes *gv3* crescentic; *Pa* **17** 13 (9–17), *Pst* **14** 12 (9–15) on shield. Setae *JV4* **11** 10 (8–11), *JV5* **24** 29 (24–34), *ZV1* **20** 18 (16–20), *ZV3* **8** 8 (8–8) on interscutal membrane. All ventral setae smooth. Two metapodal plates **23** 22 (20–26) long, **4** 6 (4–9) wide, **10** 10 (9–11) long, **1** 2 (1–3) wide.

Chelicera (Figure 1C). Movable digit **23** 24 (22–26) long, with one tooth; fixed digit **23** 24 (23–25) long, anterior half with five teeth, with pilus dentilis.

Spermatheca (Figure 1D). Calyx cup-shaped with distal half only lightly sclerotized, **7** 6 (5–8) long, **4** 3 (3–4) wide, atrium incorporated within the calyx, without neck, with a thin major duct, minor duct visible.

Legs (Figure 2). Coxal formula 2-2-2-1. Chaetotaxy (femur to basitarsus): leg I, 2-3/2-2/1-2, 2-2/1-2/0-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 2-2/0-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg IV, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-0, 1-1/1-1. Macrosetae: *Sge* II (pd2) **23** 23 (20–24), *Sge* III (ad2) **26** 30 (26–35), *Sti* III (ad) **23** 23 (19–26), *St* III (d) **26** 26 (24–30), *Sge* IV (ad2) **44** 44 (37–50), *Sti* IV (ad) **32** 34 (27–37) and *St* IV (d) **50** 58 (50–61).

Type specimens. Female Holotype: TAIWAN: Tea Research and Extension Station, Yangmei Dist., Taoyuan City (24°33.924' N, 121°05.433' E, 771m), one female (no. 1688–3) from *Camellia sinensis* (L.) O.Kuntze var. *oolong* (Theaceae), 11.v.2016, J. R. Liao (NTU). Paratypes: two females (no.1688–1, 2) data same with holotype (NTU). CHINA: Sun Yat-sen University, Guangzhou City, Guangdong Province, one female (no. 2028–2) from *Macaranga tanarius* (Euphorbiaceae), 23.ii.2017, J. R. Liao (NMNS); Guangdong Institute of Applied Biological Resources, Guangzhou City, Guangdong Province, two females (no. 2029–1, 2) from *Bauhinia purpurea* (Caesalpiniaceae), 23.ii.2017, J. R. Liao (GIABR).

Etymology. The epithet *oolong* refers to habitat plants of holotype specimens; oolong is a special tea variety.

Distribution. Asia: China (Guangdong (present study)), Taiwan (present study).

Remarks. This new species is similar to *E. aizawai* (Ehara & Bhandhufalck), *E. australis* (Wu & Li), *E. daluensis* (Liao & Ho), *E. finlandicus* (Oudemans), *E. jiangxiensis* Wu & Ou, *E. nicholsi* (Ehara & Lee), *E. sojaensis* (Ehara), *E. utilis* (Liang & Ke), *E. wyebo* (Schicha & Corpuz-Raros). Differences between *E. oolong* **sp. nov.** and related species are given in Table 1. This species is also different based on its short and cup-shaped calyx of spermatheca which is fuunel-shaped and/or longer in above mentioned closely related species.

This species is recorded in Taiwan and Southern China. However, few specimens have been found. The biological control potential of this species needs further study in the future.

TABLE 1. Differences between *Euseius oolong* **sp.nov.** and related species.

	Reticulation on dorsal shield	No. of solenostomes	peritreme length	No. of teeth on FD/MD	*j3*	*Sge* IV	*Sti* IV	*St* IV
aizawai[a]	anterolateral margin	6	*z2* level	6/1	30 (24–40)	37 (32–41)	35 (31–38)	58 (48–66)
australis[b]	smooth	unknown	*z2* level	5-6/1	21	43	33	65
daluensis[c]	anterolateral margin	5	*z2* level	5/1	21 (15–27)	38 (33–46)	34 (30–36)	59 (50–67)
finlandicus[d]	most surface	6	*r3* level	?/1	36	35	35	60
jiangxiensis[e]	anterolateral margin	unknown	*z2* level	3/1	21	34	31	41
nicholsi[f]	most surface	7	over *z2* level	4/1	27 (26–28)	50 (48–53)	38 (38–39)	68 (60–73)
oolong[g]	lateral margin	5	over *z2* level	5/1	21 (20–23)	43 (41–44)	31 (27–35)	55 (50–59)
sojaensis[h]	most surface	5	over *z2* level	3/1	25 (20–33)	34 (26–37)	30 (25–34)	55 (48–63)
ultilis[i]	lateral margin	unknown	*z4* level	6/1	24	26	28	54
wyebo[j]	lateral margin	7	over *z2* level	5/1	20	42	37	62

[a] from Ehara & Bhandhufalck (1977), Liao *et al*. (2017a); [b] Wu & Li (1983); [c] Liao *et al*. (2017a); [d] Yoshida-Shaul & Chant (1995); [e] Wu *et al*. (2009); [f] Ehara & Lee (1971), present study; [g] present study; [h] Ehara (1964), present study; [i] Liang & Ke (1983); [j] Schicha & Corpuz-Raros (1992).

Euseius nicholsi (Ehara & Lee, 1971) (Figures 3–5)

Amblyseius (*Amblyseius*) *nicholsi* Ehara & Lee 1971: 67.
Euseius nicholsi—Wu *et al*. 1997: 115.

Female (n=3).

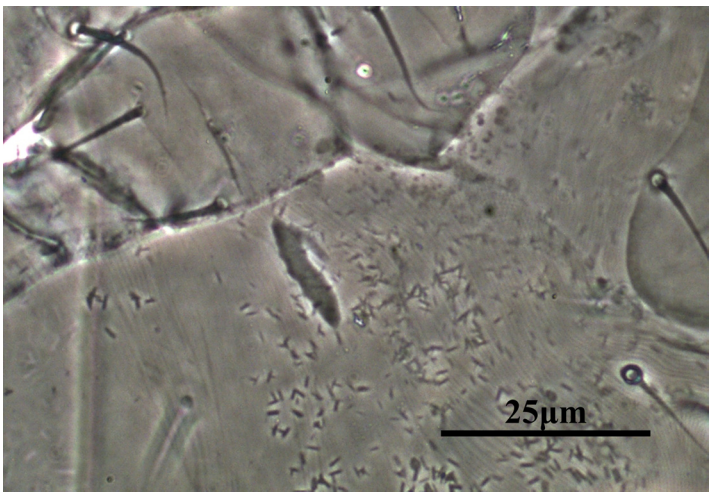
A lightly sclerotized mite. Idiosomal setal pattern: 10A:9B/JV-3:ZV.

Dorsum (Figure 4A). Dorsal shield most surface strongly reticulated, **360** 353 (350–360) long (*j1-J5* level) and **256** 250 (243–256) wide at level of *j6*, **236** 237 (231–243) wide at level of *S4*; with seven pairs of solenostomes (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), seven pairs of lyrifissures (*id1*, *id1a*, *id2*, *is1*, *idl3*, *idl4*, *idm5*, *idm6*); muscle-marks (sigilla) visible on podosoma; length of dorsal setae: setae *j1* **34** 32 (29–34), *j3* **28** 27 (26–28), *j4* **11** 9 (7–11), *j5* **?** 7 (5–10), *j6* **?** 7 (5–10) *J2* **14** 10 (7–14), *J5* **6** 5 (4–6), *z2* **17** 15 (14–17), *z4* **17** 18 (17–19), *z5* **11** 8 (7–11), *Z1* **13** 10 (8–13), *Z4* **15** 13 (10–15), *Z5* **60** 60 (60–60), *s4* **29** 27 (24–29), *S2* **18** 15 (12–18), *S4* **25** 21 (18–25), *S5* **26** 22 (19–26), *r3* **14** 17 (14–19), *R1* **?** 12 (11–13). All setae smooth, except *Z5* slightly serrate.

Peritreme (Figure 4A). Peritreme extending over *z2*, peritrematic shield smooth, lightly sclerotized, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

Venter (Figures 1, 4B). Sternal shield smooth, projection of posterior margin invisible, wider than long, **54** 61 (54–65) long, **88** 89 (88–89) wide at level of *st3*, with three pairs of setae *st1* 27 27 (26–27), *st2* 28 24 (20–28), *st3* **24** 20 (15–24), and two pairs of lyrifissures (*pst1*, *pst2*). Exopodal shield at coxae II-IV. Metasternal platelets tear-shaped, with one pair metasternal setae, *st4* **21** 18 (16–21), and one pair of lyrifissures (*pst3*). Genital shield smooth, **85** 87 (82–93) wide at level of genital setae, with one pair of genital setae *st5* **27** 22 (16–27). Distances between *st1–st1* **52** 56 (52–60), *st2–st2* **60** 63 (60–65), *st3–st3* **71** 73 (71–75), *st1–st3* **56** 59 (56–62), *st5–st5* **76** 76 (76–77). Ventrianal shield smooth, vase-shaped, **95** 90 (87–95) long, **45** 48 (45–51) wide at level of *ZV2*, **75** 72 (65–77) wide at level of anus; with three pairs of pre-anal setae, *JV1* migrate next to *JV2*, *JV1* **28** 24 (21–28), *JV2* **26** 23 (20–26), *ZV2* **18** 15 (13–18), solenostomes *gv3* crescentic; *Pa* **15** 13 (12–15),

Pst **16** 14 (11–16) on shield. Setae *JV4* **10** 10 (10–10), *JV5* **29** 32 (29–35), *ZV1* **23** 19 (16–23), *ZV3* **13** 13 (13–13) on interscutal membrane. All ventral setae smooth. Two pairs of metapodal platelets **22** 22 (22–22) long, **5** 4 (4–5) wide, **8** 11 (8–13) long, **1** 2 (1–2) wide.



FIGURES 3. Metapodal platelets of *Euseius nicholsi* Ehara & Lee, 1971 (female holotype Ac-13078).

Chelicera (Figure 4C). Movable digit **21** 24 (21–27) long, with one tooth; fixed digit **24** 24 (24–24) long, anterior half with four teeth, with pilus dentilis.

Spermatheca (Figure 4D). Calyx funnel-shaped, **7** 7 (7–8) long, **4** 4 (3–4) wide, atrium with indistinguible embolus, connect with a major duct, minor duct visible.

Legs (Figure 5). Coxal formula 2-2-2-1. Chaetotaxy (femur to basitarsus): leg I, 2-3/2-2/1-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 1-2/0-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/1-2/1-0, 1-1/1-2/1-1, 1-1/1-1; leg IV, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-0, 1-1/1-1. Macrosetae: *Sge* II (pd2) **21** 20 (19–21) [25]; *Sge* III (ad2) **31** 28 (25–31), *Sti* III (ad) **25** 26 (25–27), *St* III (d) **24** 25 (24–27); *Sge* IV (ad2) **48** 50 (48–53), *Sti* IV (ad) **38** 38 (38–39) and *St* IV (d) **60** 68 (60–73).

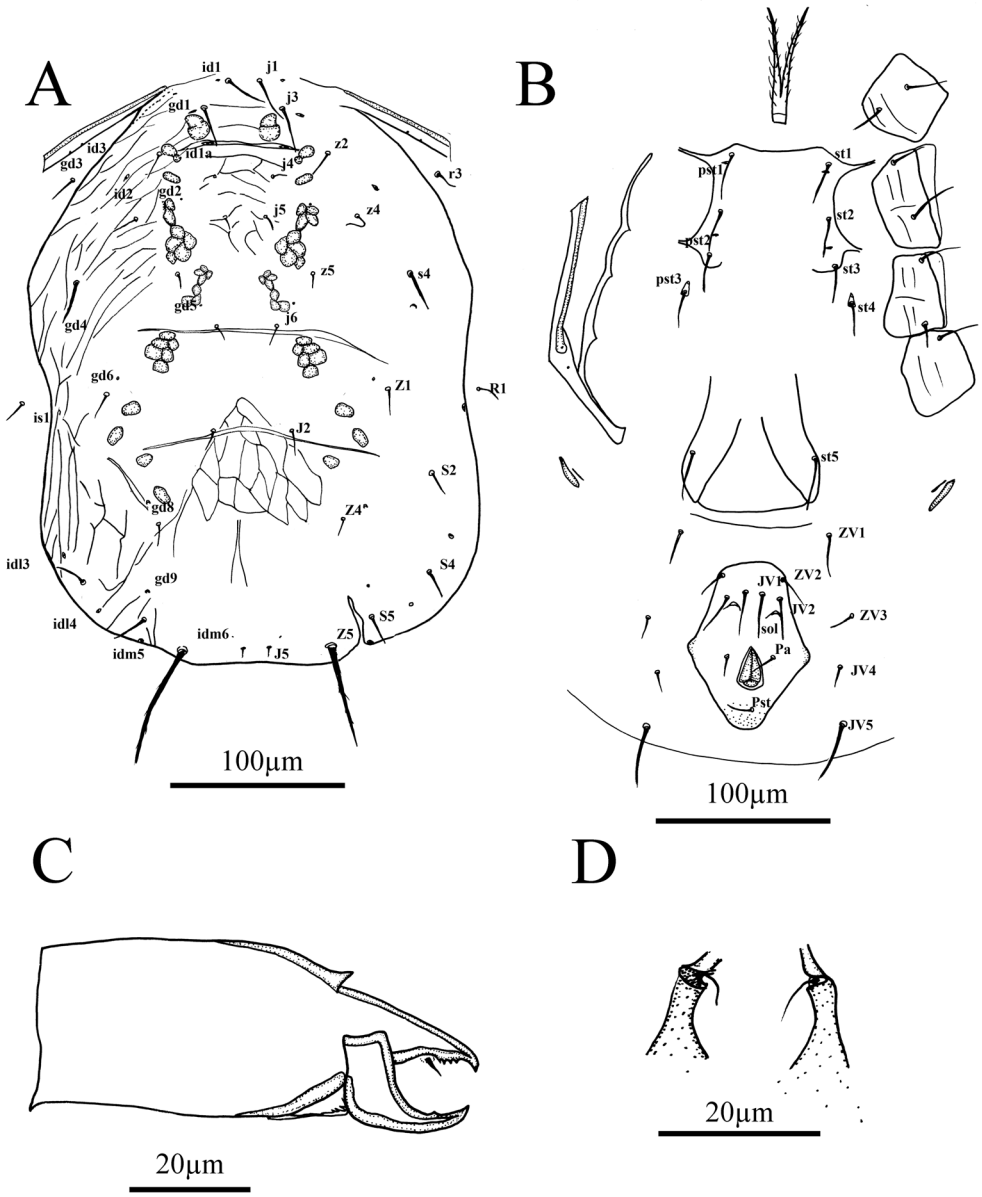
Specimens examined. CHINA: Chai Wan, Hong Kong, one holotype female (NSMT-Ac-13078) from grass, 18.x.1970, S. Ehara (NSMT); TAIWAN: Shoushan National Nature Park, Gushan Dist., Kaohsiung City (22°38.952'N, 120°16.128' E, 156m), one female (no. 388–1) from *Macaranga tanarius* (Euphorbiaceae), 11.iii.2010, J. R. Liao & S. W. Kong (NTU); Liugui Dist., Kaohsiung City (22°55.785'N, 120°39.148'E, 224m), one female (no. 942–6) from *Bauhinia variegate* (Fabaceae), 20.xi.2010, J. R. Liao (NTU).

Distribution. Asia: China (Fujian (Wu 1982), Guangdong (Chen *et al*. 1980; Wu 1982; Liang & Ke 1983), Guangxi (Wu 1982; Liang & Ke 1983), Hainan (Wu *et al*. 1997), Hong Kong (Ehara & Lee 1971), Hunan (Wu 1982), Jiangsu (Wu 1982; Liang & Ke 1983), Jiangxi (Wu 1982), Sichuan (Wu 1982; Liang & Ke 1983)), Taiwan (present study), Thailand (Ehara & Bhandhufalck 1977; Oliveira *et al*. 2012).

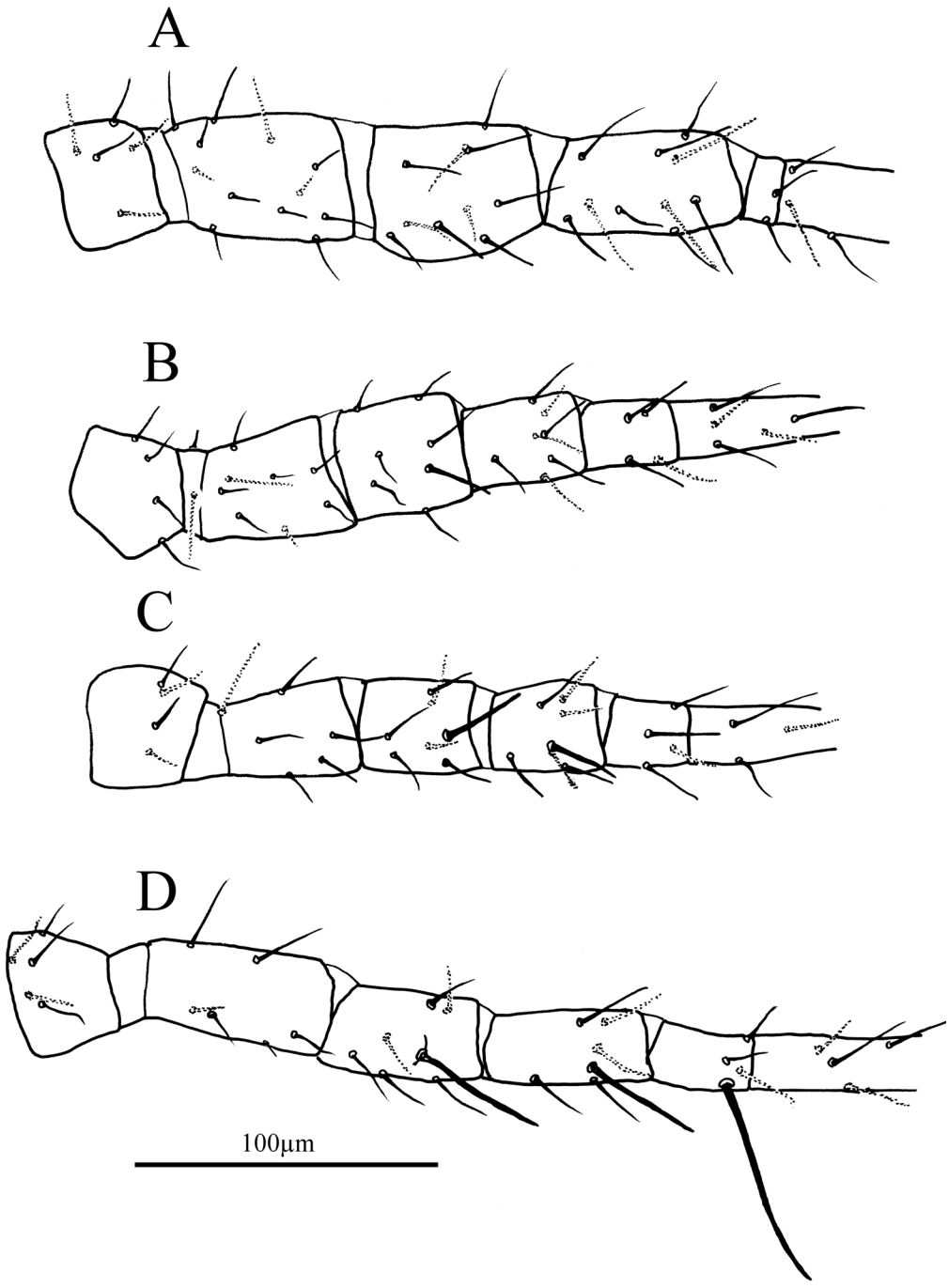
Remarks. *Euseius nicholsi* (Ehara & Lee) is reported for the first time for Taiwanese fauna. This species is widely distributed in Southern China, and also a dominated biological control agent for spider mites (e.g. *Panonychus citri* McGregor, *Eotetranychus kankitus* Ehara) in citrus orchard (Wu *et al*. 2009). However, only two specimens have been found in Southern Taiwan and the biological control potential of this species needs further investigations.

Liao *et al*. (2017a) reported that Taiwanese *E. aizawai* specimens had two morphological types on the dorsal shield (e.g. anterolateral dorsal shield reticulated and entire dorsal shield reticulated).

After comparing holotypes of *E. aizawai* (from HUM), *E. nicholsi* (from NSMT), Chinese specimens of *E. nicholsi* (from GIABR), and discussing with Dr. Toyoshima (Pers. Comm., January 28, 2018), these Taiwanese specimens should belong to three different species, including *E. aizawai*, *E. nicholsi*, and *E. sojaensis*. *E. aizawai* differs from others in having anterolateral reticulation on dorsal shield (the remaining two species strongly reticulated on dorsal shield). *E. nicholsi* and *E. sojaensis* could be separated by the lengths of macrosetae. Additionally, Ehara & Lee (1971) reported *E. nicholsi* is characterized by hook-shaped metapodal platelets. However, we found two slender metapodal platelets are overlapping on the left side, but separated on right side of the holotype of *E. nicholsi* (NSMT AC-13078) (Figures 3).



FIGURES 4. *Euseius nicholsi* Ehara & Lee, 1971, Female, A. dorsal shield, B. ventral idiosoma, C. chelicera, D. spermatheca.



FIGURES 5. *Euseius nicholsi* Ehara & Lee, 1971, Female, legs A. leg I anterior view, B. leg II dorsal view, C. leg III anterodorsal view, D. leg IV anterior view.

***Euseius sojaensis* (Ehara, 1964)**
(Figures 6–9)
Amblyseius sojaensis Ehara 1964: 381.
Amblyseius (*Amblyseius*) *sojaensis*—Ehara 1966: 24.
Amblyseius (*Euseius*) *sojaensis*—Ehara & Amano 1998: 42.
Euseius sojaensis—Moraes *et al*. 2004: 83.

Female (n=10).

A lightly sclerotized mite. Idiosomal setal pattern: 10A:9B/JV-3:ZV.

Dorsum (Figure 6A). Dorsal shield most surface strongly reticulated, 336 (314–366) long (*j1–J5* level) and 233 (211–256) wide at level of *j6*, 221 (198–253) wide at level of *S4*; with five pairs of solenostomes (*gd2*, *gd5*, *gd6*, *gd8*, *gd9*), eight pairs of lyrifissures (*id1*,*id1a* , *is1*, *idl3*, *idl4*, *idm3*, *idm5*, *idm6*); muscle-marks (sigilla) visible on podosoma; length of setae: *j1* 29 (24–34), *j3* 25 (20–33), *j4* 9 (6–14), *j5* 8 (6–10), *j6* 9 (6–11), *J2* 11 (9–15), *J5* 6 (4–7), *z2* 18 (15–21), *z4* 15 (11–20), *z5* 9 (6–10), *Z1* 12 (10–13), *Z4* 11 (8–15), *Z5* 56 (52–63), *s4* 26 (22–34), *S2* 17 (14–21), *S4* 22 (19–26), *S5* 21 (16–28), *r3* 13 (9–18), *R1* 12 (8–13); All setae smooth, except *Z5* slightly serrate.

Peritreme (Figure 6A). Peritreme over *z2* level, peritrematic shield smooth, lightly sclerotized, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

Venter (Figure 6A). Sternal shield smooth, with projection of posterior margin, wider than long, 60 (48–66) long, 87 (77–95) wide at *st3* level, with three pairs of setae *st1* 28 (20–32), *st2* 24 (17–32), *st3* 21 (17–25), and two pairs of lyrifissures (*pst1*, *pst2*). Exopodal shield at coxae I-IV. Metasternal platelets tear-shaped, with one pair metasternal setae, *st4* 19 (16–25), and one pair of lyrifissures (*pst3*). Genital shield smooth, 81 (75–87) wide at level of genital setae, with one pair of genital setae *st5* 21 (16–25). Distances between *st1–st1* 55 (49–59), *st2–st2* 63 (57–70), *st3–st3* 69 (60–74), *st1–st3* 59 (52–76), *st5–st5* 70 (63–77). Ventrianal shield smooth, vase-shaped, 97 (91–104) long, 50 (44–61) wide at level of *ZV2*, 74 (69–80) wide at level of anus; with three pairs of pre-anal setae, arranged in triangular pattern, *JV1* 23 (20–27), *JV2 20* (16–25), *ZV2* 14 (12–16), solenostomes *gv3* crescentic; *Pa* 11 (10–15), *Pst* 11 (8–13) on shield. Setae *JV4* 8 (5–11), *JV5* 31 (26–36), *ZV1* 17 (14–23), *ZV3* 9 (7–11) on interscutal membrane. All ventral setae smooth. Two pairs of metapodal platelets 19 (16–21) long, 5 (4–7) wide, 10 (8–11) long, 2 (2–3) wide.

Chelicera (Figure 6C). Movable digit 22 (21–25) long, with one tooth; fixed digit 23 (20–27) long, anterior half with four teeth, with pilus dentilis.

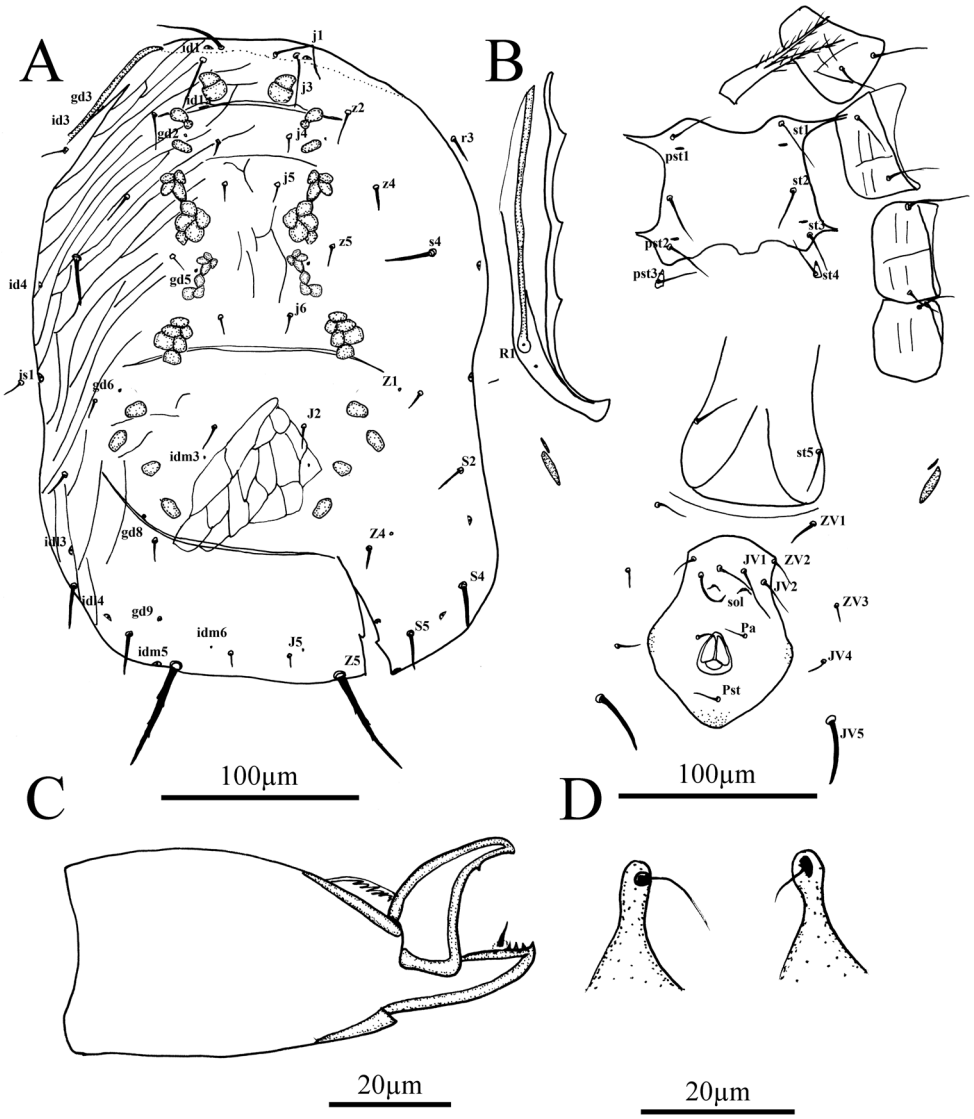
Spermatheca (Figure 6D). Calyx funnel-shaped, 12 (11–13) long, 7 (6–8) wide, minor duct visible.

Legs (Figure 7). Coxal formula 2-2-2-1. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-1, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/2-2/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg IV, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/0-1, 1-1/1-1. Macrosetae: *Sge* III (ad2) 27 (22–31), *Sti* III (ad) 22 (18–27), *St* III (d) 22 (16–30), *Sge* IV (ad2) 34 (26–37), *Sti* IV (ad) 30 (25–34) and *St* IV (d) 55 (48–63).

Male (n=5)**.**

A lightly sclerotized mite. Idiosomal setal pattern: 10A:9B/JV-3, 4:ZV-1, 3.

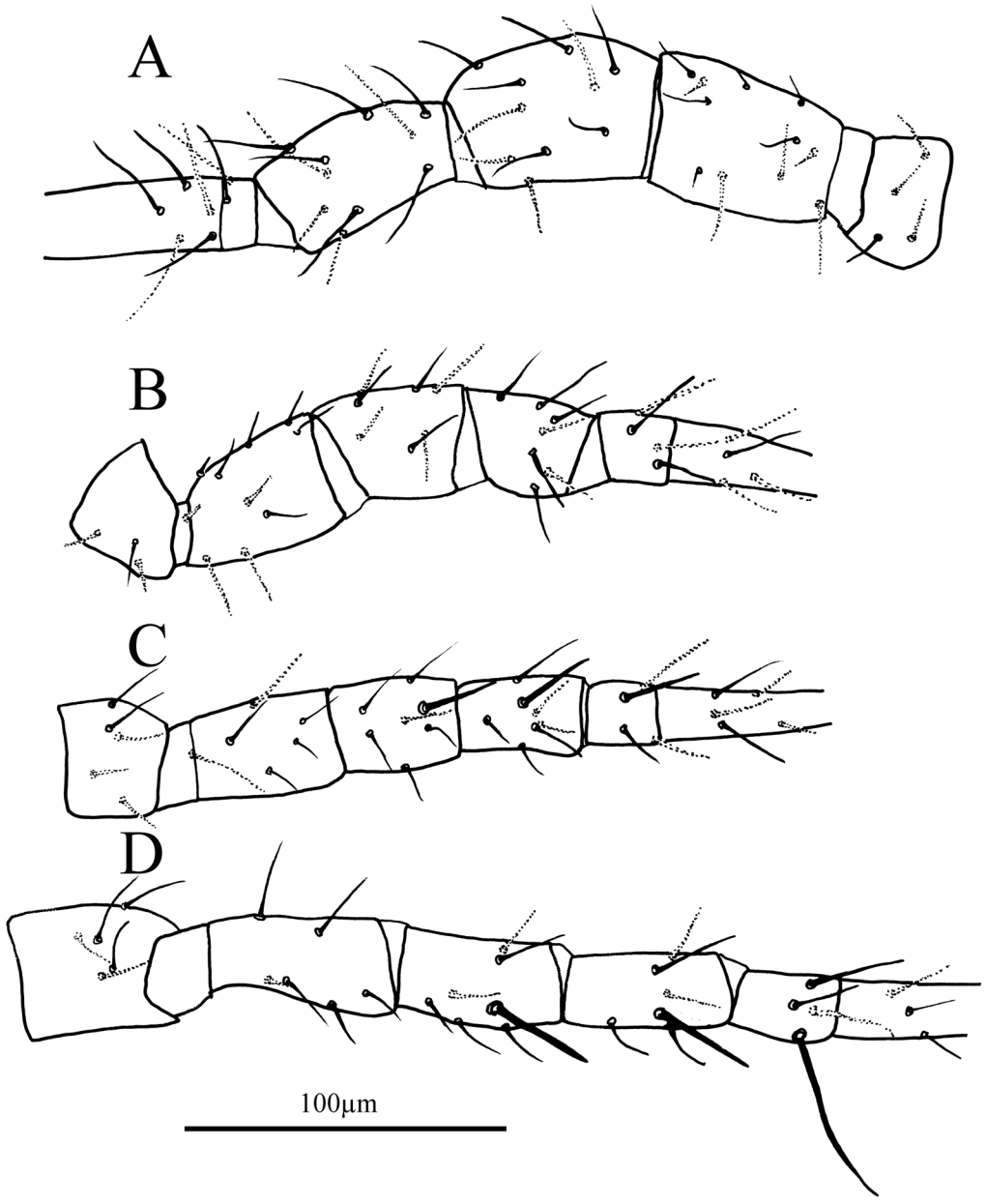
Dorsum (Figure 8A). Dorsal shield most surface strongly reticulated, 249 (238–273) long (*j1-J5* level) and 190 (176–200) wide at level of *j6*, 169 (152–189) wide at level of *S4*; with five pairs of solenostomes (*gd2*, *gd5*, *gd6*, *gd8*, *gd9*), five pairs of lyrifissures (*id1*, *id1a*, *id4*, *is1*, *idl3*, *idl4*); muscle-marks (sigilla) visible on podosoma; length of setae: *j1* 24 (22–28), *j3* 25 (21–28), *j4* 7 (6–8), *j5* 6 (5–8), *j6* 8 (5–10), *J2* 8 (6–11), *J5* 4 (4–5), *z2* 14 (10–17), *z4* 12 (8–16), *z5* 7 (6–9), *Z1* 9 (8–11), *Z4* 8 (7–11), *Z5* 45 (40–50), *s4* 24 (21–31), *S2* 15 (13–17), *S4* 18 (14–26), *S5* 19 (14–23), *r3* 11 (8–16), *R1* 12 (9–14); All setae smooth, except *Z5* slightly serrate.



FIGURES 6. *Euseius sojaensis* Ehara, 1964, Female, A. dorsal shield, B. ventral idiosoma, C. chelicera, D. spermatheca.

Peritreme (Figure 8A). Peritreme over *z2* level, peritrematic shield smooth, lightly sclerotized, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

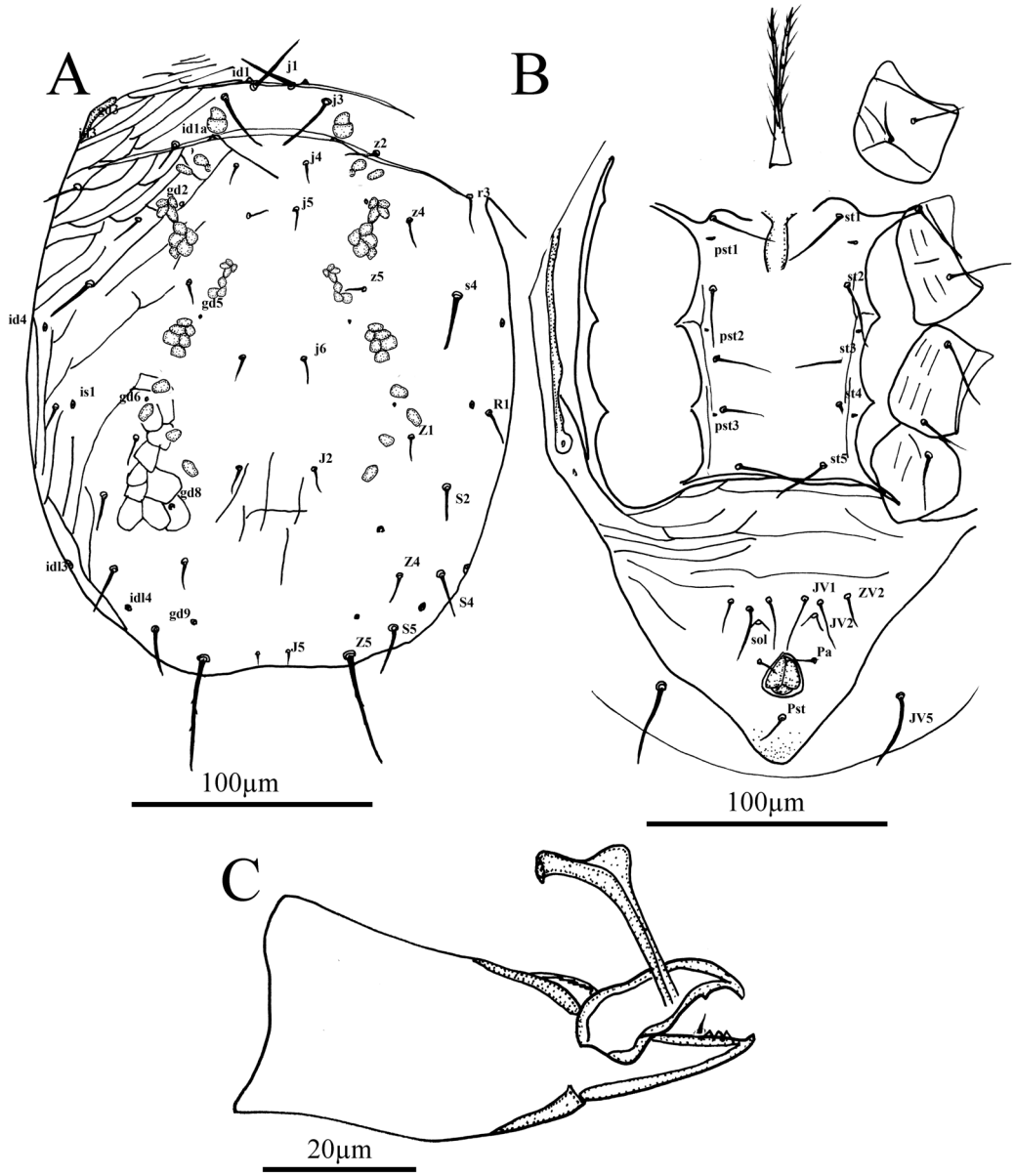
Venter (Figure 8B). Sternogenital shield smooth, slightly lateral reticulated, posterior margin almost straight, longer than wide, 115 (113–117) long, 78 (72–90) wide at level of *st5*, with five pairs of setae *st1* 19 (13–23), *st2* 19 (14–26), *st3* 19 (17–23), *st4* 13 (11–17), *st5* 15 (10–18), and three pairs of lyrifissures (*pst1*, *pst2*, *pst3*). Distances between *st1–st1* 53 (49–59), *st2–st2* 55 (46–61), *st3–st3* 55 (52–59), *st4–st4* 49 (48–52), *st5–st5 36* (35–39), *st1–st5* 108 (103–112). Exopodal shield at coxae I-IV. Ventrianal shield subtriangular, slightly reticulated, 99 (87–114 long and 156 (145–177) wide at level of anterior corner, 68 (53–81) wide at level of anus, fused with peritrematic shield cingulum, with three pairs of pre-anal setae, arranged in triangular pattern, solenostome *gv3* crscentic, *JV1* 17 (14–20), *JV2* 13 (10–18), *ZV2* 11 (8–16); *Pa* 8 (7–11), *Pst* 9 (6–12) on shield. Setae *JV5* 21 (17–29) on interscutal membrane. All ventral setae smooth.



FIGURES 7. *Euseius sojaensis* Ehara, 1964, Female, legs A. leg I posterior view, B. leg II posterior view, C. leg III dorsal view, D. leg IV anterior view.

Chelicera (Figure 8C). Movable digit 20 (18–21) long, with one tooth; fixed digit 21 (17–23) long, anterior half with three teeth, with pilus dentilis. Spermatodactyl U-shaped, shaft 25 (19–3) long, heel rounded, foot 11 (10–12) long, with expanded toe and lateral thorn-like projection.

Legs (Figure 9). Coxal formula 2-2-2-1. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-1, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/2-2/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg IV, 1-2/1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/0-1, 1-1/1-1. Macrosetae: *Sge* III (ad2) 21 (18–23), *Sti* III (ad) 19 (17–24), *St* III (d) 20 (17–25), *Sge* IV (ad2) 29 (25–32), *Sti* IV (ad) 25 (19–35) and *St* IV (d) 46 (40–53).



FIGURES 8. *Euseius sojaensis* Ehara, 1964, Male, A. Dorsal shield; B. Ventral idiosoma; C. Chelicera and spermatodactyl.

Specimens examined. TAIWAN: Anma Mountain, Heping District, Taichung City, eight females from unknown plant, 9.iv.1990, C.C. Ho (TARL); East Xue Trail, Heping District, Taichung City, one female from unknown plant, 29.xi.2006, C.C. Ho (TARL); Lishan, Helping District, Taichung City, five females one male from unknown plant, 1.xii.2006, C.C. Ho (TARL); Lishan, Helping District, Taichung City, one female from *Morus australis* (Moraceae), 1.xii.2006, C.C. Ho (TARL); Qingjing Farm, Ren'ai Township, Nantou County, one female from *Pyrus communis* (Rosaceae), 5.xii.2006, S.C. Chang (TARL); Formosan Aboriginal Culture Village, Yuchi Township, Nantou County, one female one male from *Prunus serrulata* (Rosaceae), 15.v.2007, C.C. Ho (TARL); Huanshan, Heping District, Taichung City, three females one male from *Prunus* sp.

(Rosaceae), 20.x.2009, C.C. Ho (TARL); Huanshan, Heping District, Taichung City, three females from *Prunus salicina* (Rosaceae), 20.x.2009, C.C. Ho (TARL); Huanshan, Heping District, Taichung City, two females from unknown plant, 20.x.2009, C.C. Ho (TARL); Shigilan Suspension Bridge, Heping District, Taichung City, four females one male from unknown plant, 21.x.2009, C.C. Ho (TARL); Wanfeng Village, Wufeng District, Taichung City, four females two males from bamboo (Poaceae), 9.iii.2010, C.C. Ho (TARL); Lushan, Ren'ai Township, Nantou County, one female from *Calocedrus formosana* (Cupressaceae), 22.xi.2010, C.C. Ho (TARL); Xuejian, Tai'an Township, Miaoli County, two females from unknown plant, 23.iii.2012, C.C. Ho (TARL); Maokong, Wenshan District, Taipei City (24°58.062' N, 121°35.332' E, 313m), two females (no. 584–1, 2) from *Cocos nucifera* (Arecaceae), 9.vi.2010, J.R. Liao & A.K. Dubey (NTU); Maokong, Wenshan District, Taipei City (24°58.062' N, 121°35.332' E, 313m), six females (574–1, 2, 3, 4, 5, 6) from unknown plant, 9.vi.2010, J.R. Liao & A.K. Dubey (NTU); Paomagudao, Jiaoxi Township, Yilan County (24°50.276' N, 121°46.346' E, 147m), one female (no. 1113–1) from *Carica papaya* (Caricaceae), 9.ii.2011, J.R. Liao (NTU); Xiouluan Road, Jianshi Township, Hsinchu County (24°38.252' N, 121°16.430' E, 1010m), one female (no. 1268–1) from *Dendrocalamus latiflorus* (Poaceae), 17.iv.2014, J.R. Liao (NTU); Xiakelo Historic Trail, Jianshi Township, Hsinchu County (24°35.346' N, 121°15.273' E, 1260m), one female (no. 1283–2) from *Machilus sp.* (Lauraceae), 17.iv.2014, J.R. Liao (NTU); TsaoPingTou, Jianshi Township, Hsinchu County (23°33.447' N, 120°52.515' E, 1095m), two females (no. 1292–1, 2) from *Prunus campanulata* (Rosaceae), 24.iv.2014, J.R. Liao (NTU); TsaoPingTou, Jianshi Township, Hsinchu County (23°33.447' N, 120°52.515' E, 1095m), two females (no. 1293–1, 2) from *Machilus zuihensis* (Lauraceae), 24.iv.2014, J.R. Liao (NTU); Shenshan, Wutai Township, Pingtung County (22°44.986' N, 120°43.640' E, 708m), one female (no. 1471–1) from *Pachira aquatica* (Malvaceae), 25.iv.2014, J.R. Liao (NTU); Jiangshuying Old trail, Wutai Township, Pingtung County (22°24.459' N, 120°45.404' E, 1496m), one female (no. 1461–1) from *Turpinia formosana* (Staphyleaceae), 24.iv.2014, J.R. Liao (NTU); Shihmen Farm, Longtan District, Taoyuan City (24°48.876' N, 121°12.897' E, 544m), three females (no. 1513–1, 2, 3) from *Morus* sp. (Moraceae), 30.v.2015, J.R. Liao (NTU); Jianshi Township, Hsinchu County (24°41.896' N, 121°13.120' E, 376m), three females (no. 1585–1, 4, 5) from *Bauhinia variegata* (Fabaceae), 31.xii.2015, J.R. Liao (NTU); Jianshi Township, Hsinchu County (24°40.122' N, 121°16.512' E, 1185m), three females (no. 1591–2, 7, 9) from *Debregeasia orientalis* (Urticaceae), 31.xii.2015, J.R. Liao (NTU).

Distribution. Asia: Japan (Ehara 1964; Ohno *et al*. 2012), Taiwan (present study).

Remarks. *Euseius sojaensis* (Ehara) is reported for the first time for Taiwanese fauna.

This species is distributed in Japan (e.g. Honshu, Shikoku, Kyushu, and Okinawa islands) (Ehara 1964; Ohno *et al.* 2012; Toyoshima *et al*. 2018). Shibao *et al*. (2004) reported *E. sojaensis* has potential to be a predator for yellow tea thrips (*Scirtothrips dorsalis* Hood) in Japanese vineyards. This species is widely distributed in Taiwan. It may have biological control potential in the field, but needs further studies.

As previously mentioned, *E. aizawai* specimens in Liao *et al*. (2017a) should be separated to three different species. *E. sojaensis* could be identified by strongly reticulation on most part of the dorsal shield and 5 pairs of solenostomes on the dorsal shield.

A revised identification key to females of *Euseius* species from Taiwan

1. Dorsal shield length relatively smaller, c.a. 250 μm; *JV1* and *JV2* on normal position; only leg IV with macrosetae 2

- Dorsal shield length relatively larger, c.a. 350 µm; *JV1* and *JV2* arranged in tangential row; leg III and leg IV with macrosetae 3
2. Calyx of spermatheca long and narrow funnel-shaped, atrium sac-shaped with thick walls. . . . . *circellatus* (Wu & Li, 1983)
- Calyx of spermatheca horn-shaped, atrium c-shaped with a pair of petal-shaped structure . . . . . *macaranga* Liao & Ho, 2017
3. Dorsal setae *j1* and *Z5* conspicuously longer, others minute; calyx of spermatheca tubular 4
- Dorsal setae *j1* and *Z5* not conspicuously longer, remaining setae not minute; calyx of spermatheca funnel or cup-shaped 5
4. Dorsal shield reticulated anterolaterally. . . . . *ovalis* (Evans, 1953)
- Dorsal shield strongly reticulated except for central podosoma . . . . . *paraovalis* Liao & Ho, 2017
5. Calyx of spermatheca short cup-shaped. . . . . *oolong* **sp. nov.**
- Calyx of spermatheca relative longer, funnel shaped, flaring distally 6
6. Dorsal shield most surface reticulated 7
- Dorsal shield mostly smooth except reticulated in anterolateral region 8
7. *St* IV longer than 60 µm . . . . . *nicholsi* (Ehara & Lee, 1971)
- *St* IV c.a. 50 µm . . . . . *sojaensis* (Ehara, 1964)
8. Dorsal shield with six pairs of solenostomes . . . . . *aizawai* (Ehara & Bhandhufalck, 1977)
- Dorsal shield with five pairs of solenostomes . . . . . *daluensis* Liao & Ho, 2017

Tribe Indoseiulini Ehara and Amano
***Gynaseius* Wainstein**

***Gynaseius santosoi* (Ehara, 2005)**
(Figures 10–11)
Indoseiulus santosoi Ehara 2005: 36.

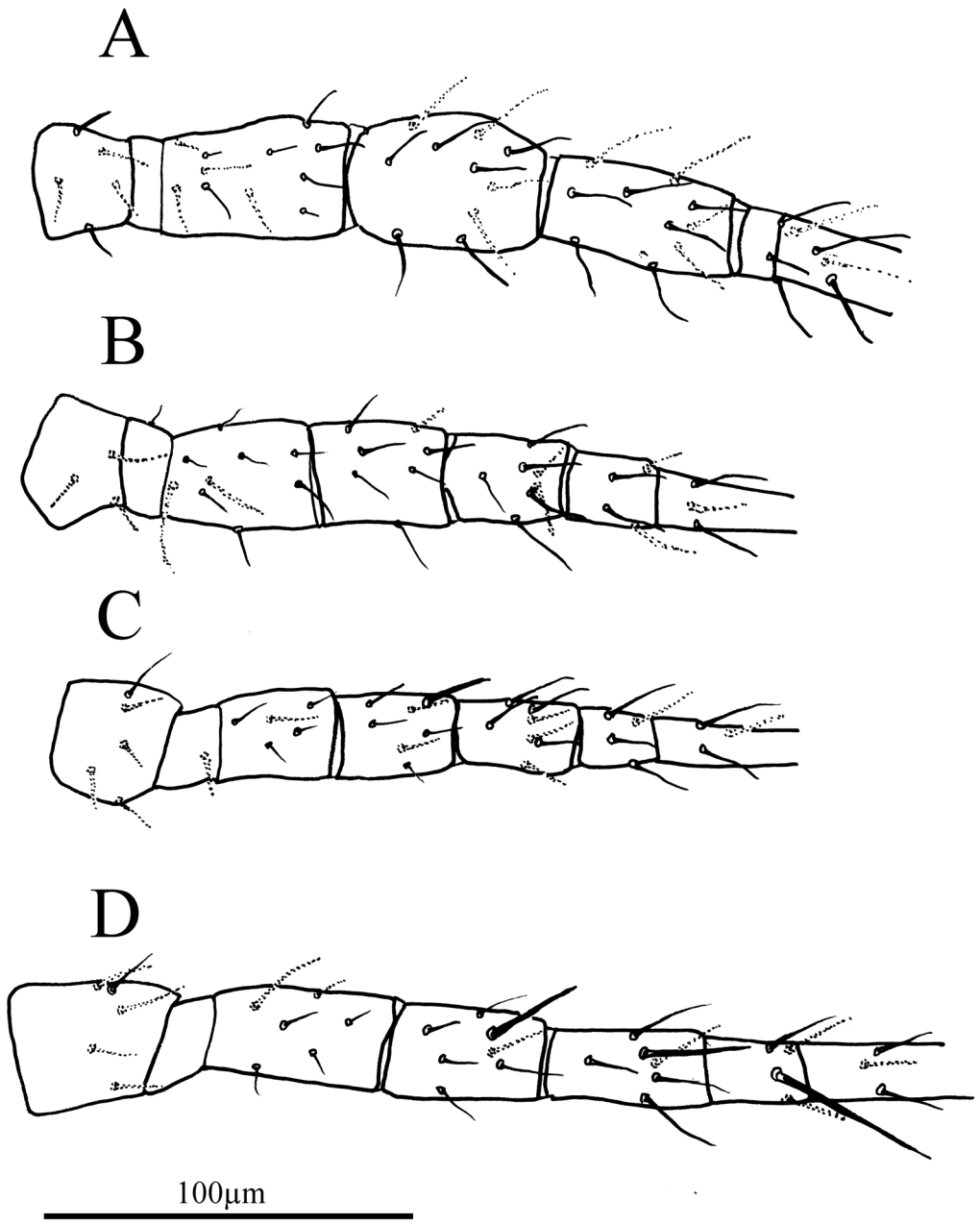
Female (three specimen).

A lightly sclerotized mite. Idiosomal setal pattern: 10A:8C/JV-3:ZV.

Dorsum (Figure 10A). Dorsal shield smooth; 382 (358–406) long (*j1–J5* level) and 251 (247–255) wide at level of *j6*, 230 (230–231) wide at level of *S4*; seven pairs of solenostomes on dorsal shield, (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), nine pairs of lyrifissures (*id2*,*id3*, *id4*, *is1*, *idm3*, *idx*, *idm4*, *idl4*, *idm6*); muscle-marks (sigilla) visible on podosoma; length of setae: *j1* 28 (27–30), *j3* 15 (15–15), *j4* 7 (7–8), *j5* 7 (6–8), *j6* 7 (6–8), *J2* 9 (8–10), *J5* 6 (6–7), *z2* 10 (9–11), *z4* 8 (6–9), *z5* 7 (4–11), *Z1* 9 (7–11), *Z4* 15 (10–18), *Z5* 17 (16–19), *s4* 13 (13–14), *S2* 12 (11–13), *S5* 7 (5–9), *r3* 9 (6–11), *R1* 8 (7–9). All setae smooth.

Peritreme (Figure 10A). Peritreme extending beyond seta *j3*; peritrematic shield not being fused with dorsal shield anteriorly, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

Venter (Figure 10B). Sternal shield smooth, posterior margin slightly concave, much wider than long, 80 (75–86) long, 97 (90–106) wide, with three pairs of setae *st1* 34 (31–36), *st2* 31 (28–33), *st3* 28 (21–33), and two pairs of lyrifissures (*pst1*, *pst2*). Exopodal shield at coxae II–IV. Metasternal platelets tear-shaped, with one pair metasternal setae, *st4* 26 (23–29), with one pair of lyrifissuress (*pst3*). Genital shield smooth, with one pair of genital setae *st5* 33 (28–35), 98 (95–101) wide at level of genital setae. Distances between *st1*-*st1* 64 (56–72), *st2*-*st2* 67 (59–75), *st3*-*st3* 76 (66–82), *st1*-*st3* 70 (58–81), *st5*-*st5* 86 (77–90). Ventrianal shield margin invisible; with three pairs of pre-anal setae, *JV1* 25 (22–28), *JV2* 24 (22–26), *ZV2* 21 (21–23), solenostomes *gv3* crescentic; *Pa* 12 (11–14), *Pst* 18 (17–20) on shield. Setae *JV4* 19 (16–20), *JV5* 44 (40–46), *ZV1* 24 (20–27), *ZV3* 19 (19–20) on interscutal membrane. All ventral setae smooth. One pair of metapodal plates 21 (20–22) long, 5 (4–6) wide.



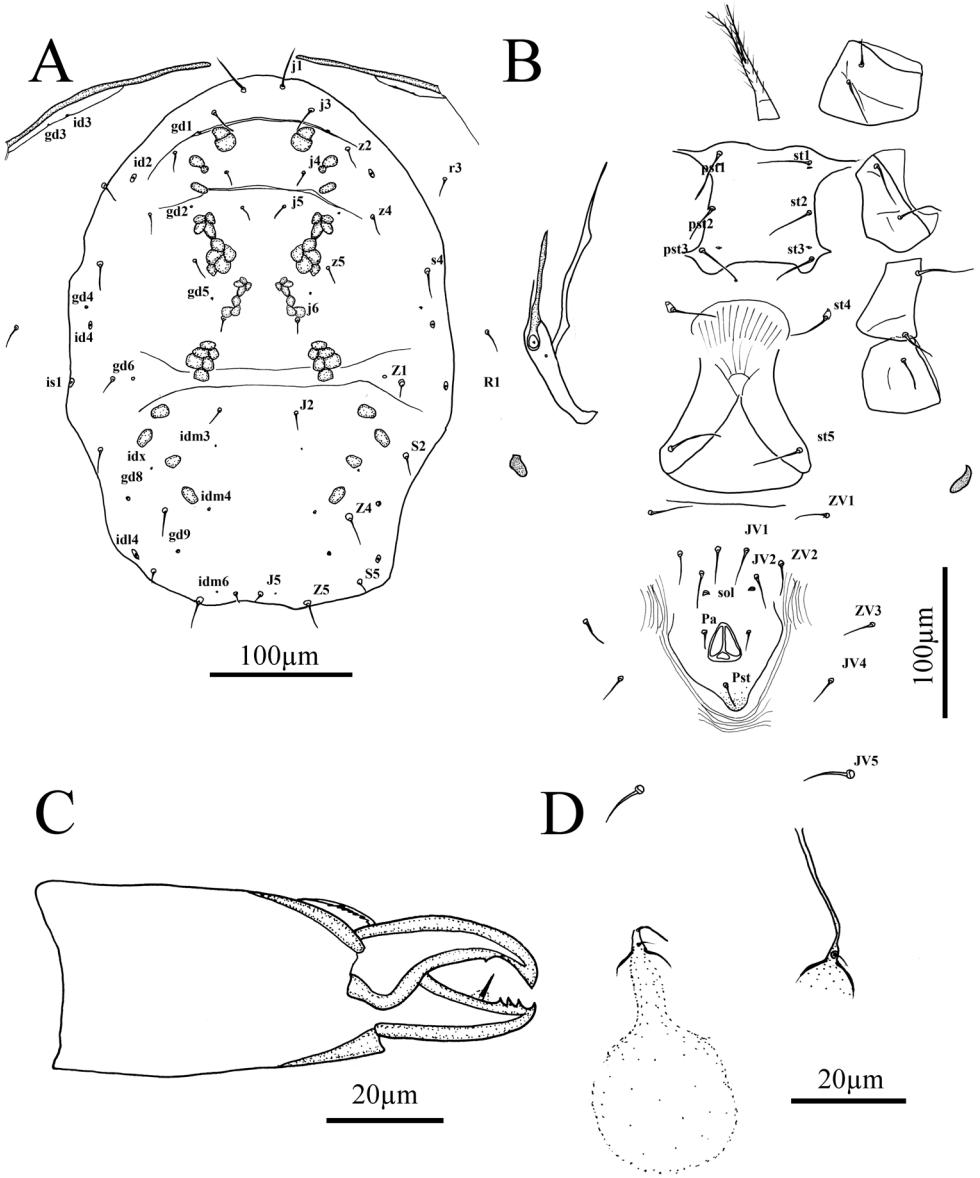
FIGURES 9. *Euseius sojaensis* Ehara, 1964, Male, legs A. leg I dorsal view, B. leg II dorsal view, C. leg III anterodorsal view, D. leg IV dorsal view.

Chelicera (Figure 10C). Movable digit 31 (30–33) long, with one tooth; fixed digit 28 (25–30) long, anterior half with three teeth, with pilus dentilis.

Spermatheca (Figure 10D). Calyx cup-shaped, 4 (3–5) long, 8 (7–10) wide, atrium incorporated without neck, with a thin major duct, minor duct visible.

Legs (Figures 11). Coxal formula 2-2-2-1. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 1-2/1-1/2-1, 1-2/1-2/2-2, 1-1/1-1; leg II, 2-3/2-2/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/

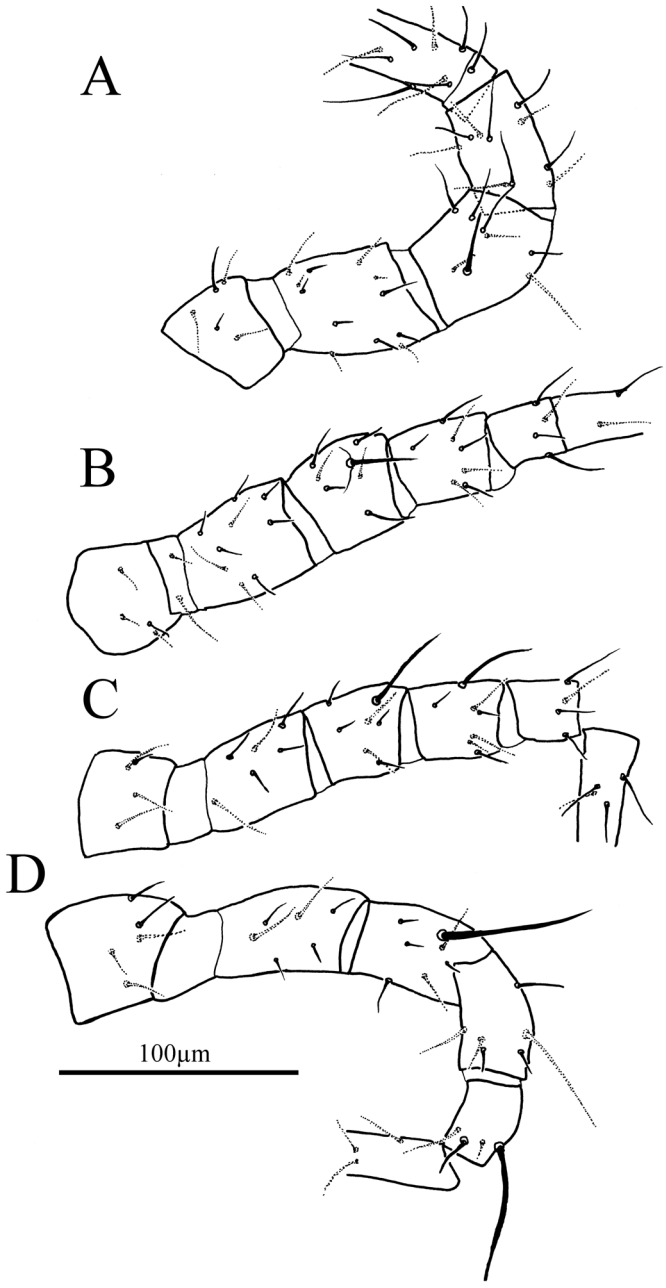
1-1/0-1, 1-2/1-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg IV, 1-2/1-1/0-1, 1-2/0-2/1-1, 1-1/0-2/1-1, 1-1/1-1. Macrosetae: *Sge* I (pd1) 28 (27–31), *Sge* II (pd2) 32 (30–35), *Sge* III (ad2) 41 (40–43), *Sti* III (ad) 35 (33–37), *St* III (d) 23 (21–27), *Sge* IV (ad2) 59 (55–62), *Sti* IV (ad) 44 (42–49) and *St* IV (d) 54 (51–55).



FIGURES 10. *Gynaseius santosoi* Ehara, 2005, Female, A. dorsal shield, B. ventral idiosoma, C. chelicera, D. spermatheca.

Specimens examined. TAIWAN: Lanyu Island, Taitung County (22°00.881' N, 121°33.970' E, 39m), one female (no. 462–1) from *Morus alba* (Moraceae), 4.iv.2010, J. R. Liao & C. C. Ho (NTU); Lanyu Island, Taitung County (22°03.846' N, 121°30.655' E, 21m), one female (no. 1646–2) from *Morus alba* (Moraceae), 14.iv.2016, H. Y. Lin (NCHU); Cihou Fort, Qijin District, Kaohsiung City

(22°36.933' N, 120°15.917' E, 13m), one female (no. 2016–2) from *Macaranga tanarius* (Euphorbiaceae), 22.i.2017, J. R. Liao & H. C. Lee (NMNS).



FIGURES 11. *Gynaseius santosoi* Ehara, 2005, Female, A. leg I anterior view, B. leg II posterior view, C. leg III posterior view, D. leg IV posterior view.

Distribution. Asia: Indonesia (Java (Ehara, 2005), Taiwan (Kaohsiung, Lanyu Island (present study)).

Remarks. *Gynaseius santosoi* (Ehara) is reported for the first time for Taiwanese fauna. Ehara (2005) described this species based on a single female specimen from a fabaceous climbing plant

from Indonesia. The present study found several differences with the original description: leg III with three macrosetae (two in Ehara (2005)), one macroseta on Ge I (two macrosetae in Ehara (2005)), posterior margin of sternal shield concave (indented in Ehara (2005)).

The Lanyu specimens were collected from the habitat plants when *Neoseiulus longispinosus* and *Eotetranychus suginamensis* occured. However, futher observation is still needed for feeding habit and lifestyle of this species.

Key to females of *Gynaseius* species of the world

1. Seta *r3* on dorsal shield 2
- Seta *r3* on integument. 3
2. *Sge* IV > *St* IV > *Sti* IV. . . . . *semiiregularis* (Schicha & Corpuz-Raros, 1992)
- *Sti* IV > *Sge* IV > *St* IV. . . . . *herbridensis* (McMurtry & Moraes, 1984)
3. Setae *S2*, *S4* present; only one macroseta on leg IV . . . . . *larum* El-Banhawy & Knapp, 2011
- At least one of setae *S2*, *S4* present 4
4. Seta *S2* occupy a position far behind its normal position; movable digits of chelicera without teeth . . . . . *christinae* (Schicha, 1981)
- Seta *S2* in normal position; movable digits of chelicera at least with one teeth 5
5. Spermatheca calyx dish-shaped . . . . . *irregularis* (Evans, 1953)
- Spermatheca calyx cup-shaped, or tubular. 6
6. Ventrianal shield vase-shaped or pentagonal 7
- Margin of ventrianal shield invisible 8
7. Ventrianal shield vase-shaped, spermatheca calyx cup-shaped . . . . . *duanensis* (Liang & Zeng, 1992)
- Ventraianl shield pentagoanl, spermatheca short tube, coiled . . . . *ghaiae* (Denmark & Kolodochka, 1993)
8. Movable digits of chelicera with one tooth 9
- Movable digits of chelicera with three teeth 10
9. *Sge* IV > *Sti* IV > *St* IV. . . . . *eharai* (Gupta, 1986)
- *Sge* IV > *St* IV > *Sti* IV. . . . . *santtosoi* (Ehara, 2005)
10. Dorsal shield with seven pairs of solenostomes. . . . . *liturivorus* (Ehara, 1982)
- Dorsal shield with five pairs of solenostomes on dorsal shield . . . . . *ricini* (Ghai & Menon, 1969)

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