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Survey of phytoseiid mites (Acari: Mesostigmata) in the Penghu Islands with two new records and descriptions of two new species

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Abstract

Phytoseiidae (Acari: Mesostigmata) is a well-known mite family, and more than 2,700 species have been recorded worldwide. Prior this study, 64 phytoseiid species had been recorded in main island of Taiwan and its neighboring islands. Nevertheless, many areas are still unexplored and need further investigation, such as the Penghu Islands. The present study was based on phytoseiid mite materials collected from the Penghu Islands in 1989 and 2020. A list of identified phytoseiid mites is provided herein, 16 species, eight genera, and three subfamilies. *Proprioseiopsis penghuensis* **sp. nov.** and *Neoseiulus xiaomenensis* **sp. nov.** are new to science, and *Amblyseius cinctus* Corpuz-Raros & Rimando, *A. fletcheri* Schicha, *Phytoseius rachelae* Swirski & Shechter are new records for the country. The further comprehensive phytoseiid investigation in Penghu Islands is needed for exploring the relationships among environmental and agricultural changes, and phytoseiid mites.

Key words: phytoseiid mites, fauna, the Penghu Islands

Introduction

The Penghu (Pescadores) Islands are an archipelago of 90 islands in the Taiwan Strait. The largest island has an area of 65 km^2 (Fig. 1). Summers in Penghu are hot and dry, but winters are cold with strong winds (Hsu 2005). Farmlands are usually surrounded by walls made of coral stones for protection. The soil of Penghu is rich in salinity and poor in fertility; thus, agricultural development is limited. Population aging and migration are serious problems, and most farmland is fallow. Additionally, the exotic plant *Leucaena leucocephala* (Fabaceae) has invaded these islands and become a serious concern (Wei *et al*. 2020).

The main island of Taiwan is neighbored by many islands, such as Lanyu Island, Green Islands, and the Penghu Islands. Little is known about the mite fauna, except ticks (Robbins 2005), chigger mites (Chuang *et al.* 2015), and a species of podapolipid mites on a locust species (Lo 1990), of the Penghu Islands. Knowledge of the taxonomy of phytoseiid mites has grown considerably over the last 30 years due to their use as biological control agents worldwide (Huffaker *et al*. 1970; McMurtry *et al*. 1970, 2013). To date, more than 90 genera and 2,700 species have been recorded worldwide (Demite *et al*. 2020), but little is known about the distribution of this mite family in some areas. According to Liao *et al*. (2020), 64 phytoseiid species have been recorded in Taiwan and neighboring islands; however, nothing is known in the Penghu Islands.

In this study, we present the results of phytoseiid mite collections in the Penghu Islands from 1989 to date. In total, 16 species are reported, including two new species: *Proprioseiopsis*

penghuensis **sp. nov.** and *Neoseiulus xiaomenensis* **sp. nov.**. Identification key for phytoseiid species found in the Penghu Islands is proposed.

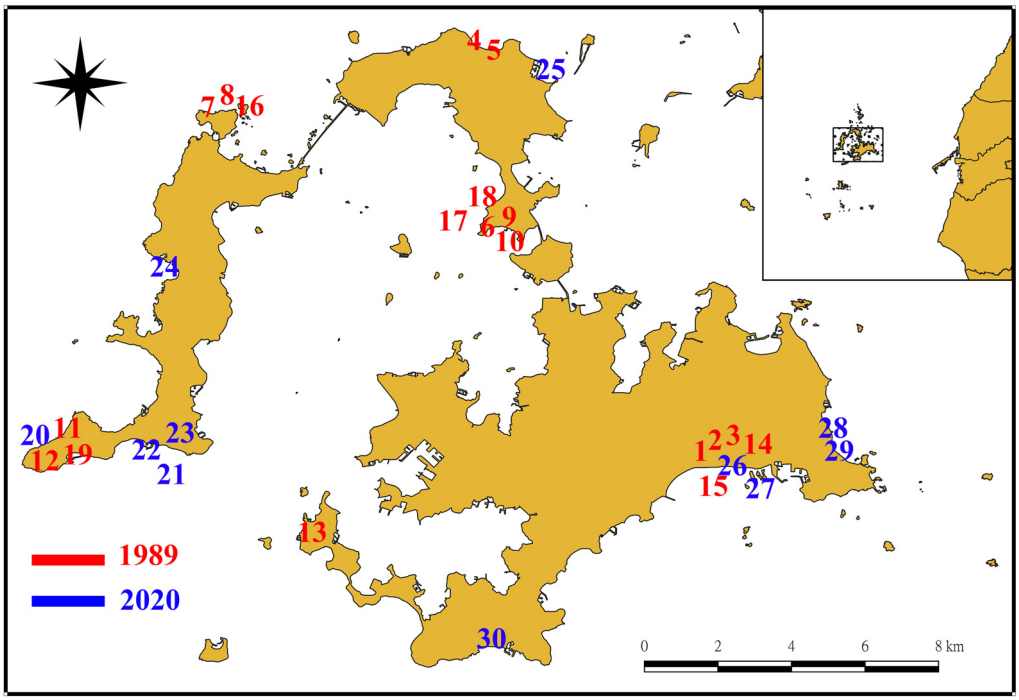


FIGURE 1. Investigation sites of phytoseiid mites in Penghu Islands.

Materials and Methods

Mite specimens examined in this study were collected from various plants and soils from the Penghu Islands in 1989 and 2020 (Fig. 2). Specimens were mounted in Hoyer's medium. Additionally, old specimens in poor condition were soaked with water at least one day, clean by lactic acid, bleached by high concentration (50%) H_2O_2 in the blacken specimen, rinsed in ethanol (75%), and remounted in Hoyer's medium (Yeh *et al*. 2008). Specimens were examined under Olympus BX51 microscope, and measurements taken using a stage-calibrated ocular micrometers and as well as ImageJ 1.47 (Schneider *et al*. 2012). All measurements were provided in micrometers (μm), holotype measurements are shown in boldface type for the specimens, followed by their mean and range in parenthesis. The dorsal shield lengths were measured from anterior to posterior margins along the midline and widths measured at *j6* and *S4* level. The sternal shield lengths and widths were taken from anterior to posterior margin along the midline and at broadest level, respectively. The genital shield widths were taken from broadest level. The ventrianal shield lengths were taken from anterior to posterior margins along the midline and *ZV2* and anus levels. The general terminology used for morphological descriptions in this study follows that of Chant & McMurtry (2007). The notation for idiosomal setae follows that of Lindquist & Evans (1965) and Lindquist (1994), as adapted by Rowell *et al*. (1978) and Chant & Yoshida-Shaul (1992). The notation for gland pores and poroids is based on Athias-Henriot (1975). Specimens were deposited in the following institutions: five females of *Typhlodromus* (*Anthoseius*) *obesus* in NMNS (National Museum of Natural Science, Taichung, Taiwan), collection data #1 to #19 in TARL (Taiwan Acari Research Laboratory,

Taichung City, Taiwan), collection data #20 to #30 in NTU (Department of Entomology, National Taiwan University, Taipei, Taiwan), type specimens were deposited based on the specimens examined section, respectively. 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). The map of the Penghu Islands was prepared using the Quantum GIS (QGIS Development Team 2020), based on the label data of examined material in this study.

FIGURE 2. Collection areas in Penghu Islands. A. Yuwengdao Lighthouse (#20). B. Nei'an Village (#23).

Result

Collection data (Figure 1)

#1—Lintou, Huxi Township, Penghu County, *Achyranthes obtusifolia* (Amaranthaceae), 21 Apr 1989, C. C. Ho.
#2—Lintou Park, Huxi Township, Penghu County, *Euphorbia heterophylla* (Euphorbiaceae), 21 Apr 1989, C. C. Ho.
#3—Lintou Park, Huxi Township, Penghu County, *Lantana camara* (Verbenaceae), 21 Apr 1989, C. C. Ho.
#4—Baisha Township, Penghu County, *Achyranthes obtusifolia* (Amaranthaceae), 21 Apr 1989, C. C. Ho.
#5—Baisha Township, Penghu County, *Cirsium japonicum* (Asteraceae), 21 Apr 1989, C. C. Ho.
#6—Chengqian Village, Baisha Township, Penghu County, *Xanthium strumarium* (Asteraceae), 21 Apr 1989, C. C. Ho.
#7—Xiaomen Village, Xiyu Township, Penghu County, Penghu, soil, 21 Apr 1989, C. C. Ho.
#8—Xiaomen Village, Xiyu Township, Penghu County, Penghu, unknown plant, 21 Apr 1989, C. C. Ho.
#9—Chengqian Village, Baisha Township, Penghu County, *Anagallis arvensis* (Primulaceae), 21 Apr 1989, C. C. Ho.
#10—Chengqian Village, Baisha Township, Penghu County, soil, 21 Apr 1989, C. C. Ho.
#11—Wai'an Village, Xiyu Township, Penghu County, *Achyranthes obtusifolia* (Amaranthaceae), 21 Apr 1989, C. C. Ho.
#12—Wai'an, Xiyu Township, Penghu County, *Macaranga tanarium* (Euphorbiaceae), 21 Apr 1989, C. C. Ho.

#13—Fenggui, Magong City, Penghu County, *Oxalis corniculata* (Oxalidaceae), 22 Apr 1989, C. C. Ho.
#14—Lintou Park, Huxi Township, Penghu County, *Achyranthes obtusifolia* (Amaranthaceae), 22 Apr 1989, C. C. Ho.
#15—Lintou Park, Huxi Township, Penghu County, *Chloris barbata* (Gramineae), 22 Apr 1989, C. C. Ho.
#16—Xiaomen Village, Xiyu Township, Penghu County, wilt weed, 22 Apr 1989, C. C. Ho.
#17—Chengqian Village, Baisha Township, Penghu County, *Achyranthes obtusifolia* (Amaranthaceae), 22 Apr 1989, C. C. Ho.
#18—Chengqian Village, Baisha Township, Penghu County, soil, 22 Apr 1989, C. C. Ho.
#19—Wai'an Village, Xiyu Township, Penghu County, unknown plant, 22 Apr 1989, C. C. Ho.
#20—Yuwengdao Lighthouse, Wai'an Village, Xiyu Township, Penghu County (N 23°33.766'E 119°28.150', 47m), *Bidens pilosa* (Asteraceae), 13 Jan 2020, J. R. Liao.
#21—Wai'an Village, Xiyu Township, Penghu County (N 23°33.916'E 119°29.166', 43m), *Broussonetia papyrifera* (Moraceae), 13 Jan 2020, J. R. Liao.
#22—Wai'an Village, Xiyu Township, Penghu County (N 23°33.916'E 119°29.166', 43m), *Mallotus japonicus* (Euphorbiaceae), 13 Jan 2020, J. R. Liao.
#23—Nei'an Village, Xiyu Township, Penghu County (N 23°34.233'E 119°29.650', 11m), *Hibiscus tiliaceus* (Malvaceae), 13 Jan 2020, J. R. Liao.
#24—Dream Beach, Xiyu Township, Penghu County (N 23°36.733'E 119°30.550', 9m), *Hibiscus tiliaceus* (Malvaceae), 13 Jan 2020, J. R. Liao.
#25—North Sea Visitor Center, Baisha Township, Penghu County (N 23°40.166'E 119°36.083', 10m), *Glebionis coronaria* (Asteraceae), 13 Jan 2020, J. R. Liao.
#26—Lintou Park, Huxi Township, Penghu County (N 23°33.433'E 119°38.400', 6m), *Artemisia argyi* (Asteraceae), 13 Jan 2020, J. R. Liao.
#27—Lintou Park, Huxi Township, Penghu County (N 23°33.433'E 119°38.400', 6m), *Hibiscus tiliaceus* (Malvaceae), 13 Jan 2020, J. R. Liao.
#28—Longmen Beach, Huxi Township, Penghu County (N 23°33.916'E 119°40.883', 6m), *Hibiscus tiliaceus* (Malvaceae), 16 Jan 2020, J. R. Liao.
#29—Longmen Beach, Huxi Township, Penghu County (N 23°33.916'E 119°40.883', 6m), unknown plant, 16 Jan 2020, J. R. Liao.
#30—Shanshuei, Magong City, Penghu County (N 23°30.800'E 119°35.366', 6m), *Hibiscus tiliaceus* (Malvaceae), 16 Jan 2020, J. R. Liao.

A list of identified phytoseiid mites during Penghu surveys*
*Numbers indicate locations where species was collected.

1. *Amblyseius cinctus* #5, #8, #9, #13
2. *Amblyseius eharai* #2, #3, #6, #12, #16#19 #22 #25
3. *Amblyseius fletcheri* #20 #29
4. *Euseius ovalis* #22
5. *Neoseiulus barkeri* #8, #11, #18, #19
6. *Neoseiulus xiaomenensis* **sp. nov.** #7
7. *Neoseiulus womersleyi* #13
8. *Scapulaseius cantonensis* #23
9. *Paraphytoseius orientalis* #23 #24 #26 #27 #28 #30
10. *Proprioseiopsis penghuensis* **sp. nov.** #5, #9, #15
11. *Phytoseius rachele* #1, #4, #5, #9, #11, #14, #17

12. *Phytoseius coheni* #3 #24 #28 #29
13. *Phytoseius hongkongensis* #21
14. *Typhlodromus* (*Anthoseius*) *obesus* #15
15. *Typhlodromus* (*Anthoseius*) *neocrassus* #15
16. *Typhlodromus* (*Anthoseius*) *serrulatus*#16

Key to phytoseiid species from the Penghu Islands based on adult females

1. Setae *z3* and *s6* absent 2
- Either or both of setae *z3* and *s6* present 11
2. Setae *JV2* and *ZV2* forward migrate to a row. . . . . *Euseius ovalis*
- Setae *JV2* and *ZV2* locate in normal position. 3
3. Setae *S4* absent . . . . . *Paraphytoseius orientalis*
- Setae *S4* present 4
4. Ratio seta *s4*:*Z1* > 3.0:1.0. 5
- Ratio seta *s4*:*Z1* < 3.0:1.0. 8
5. Setae *J2* absent . . . . . *Proprioseiopsis penghuensis* **sp. nov.**
- Setae *J2* present 6
6. Ventrianal shield pentagonal . . . . . *Amblyseius cinctus*
- Ventrianal shield vase-shaped 7
7. Posterior margin of sternal shield with median projection. . . . . *Amblyseius eharai*
- Posterior margin of sternal shield straight . . . . . *Amblyseius fletcheri*
8. Genua II and III with macrosetae . . . . . *Scapulaseius cantonensis*
- Genua II and III without macroseta 9
9. Leg IV with three macrosetae . . . . . *Neoseiulus xiaomenensis* **sp. nov.**
- Leg IV with only one macroseta 10
10. Setae *j5*, *j6* and *J2* longer than distance to base of *j6*, *J2* and *Z4*. . . . . *Neoseiulus womersleyi*
- Setae *j5*, *j6* and *J2* shorter than distance to base of *j6*, *J2* and *Z4* . . . . . *Neoseiulus barkeri*
11. Setae *Z1*, *S2*, *S4* and *S5* absent 12
- At least one of above mentioned setae present. 14
12. Setae *J2* and *R1* present . . . . . *Phytoseius hongkongensis*
- Setae *J2* and *R1* absent 13
13. Setae *s4* much longer than *s6* . . . . . *Phytoseius rachelae*
- Setae *s4* approximately as long as *s6* . . . . . *Phytoseius coheni*
14. Sternal shield with three pairs of setae. . . . . *Typhlodromus* (*Anthoseius*) *serrulatus*
- Sternal shield with two pairs of setae. 15
15. Movable digit of chelicera with one tooth . . . . . *Typhlodromus* (*Anthoseius*) *obesus*
- Movable digit of chelicera with three teeth . . . . . *Typhlodromus* (*Anthoseius*) *neocrassus*

Proprioseiopsis penghuensis **Liao & Ho sp. nov.**
(Figures 3–10)

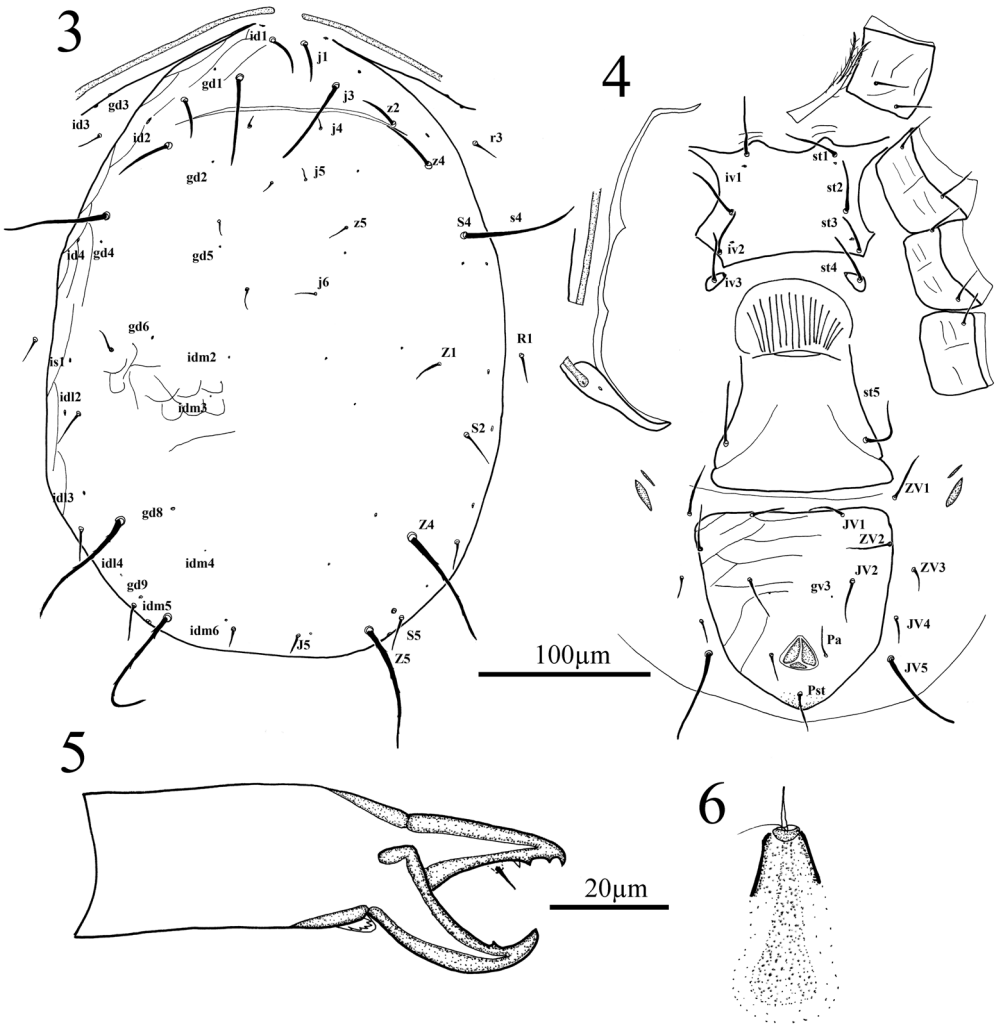
Diagnosis

Female dorsal shield smooth, except some patches of reticulations visible laterally, and slightly reticulated in central part of podosoma, bearing 18 pairs of dorsal setae (including *r3* and *R1*). All setae smooth, except *Z4* and *Z5* slightly serrated. Seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*) visible on dorsal shield. Peritreme extending to *j1* level. Sternal shield with three pairs of setae; ventrianal shield pentagonal, bearing three pairs of pre-anal setae, with small and rounded gland pore *gv3*. Fixed digit of chelicera with three teeth; movable digit with one tooth. Calyx of spermatheca bell-shaped. Leg IV with three macrosetae; genu II with eight setae.

Female (n=3)

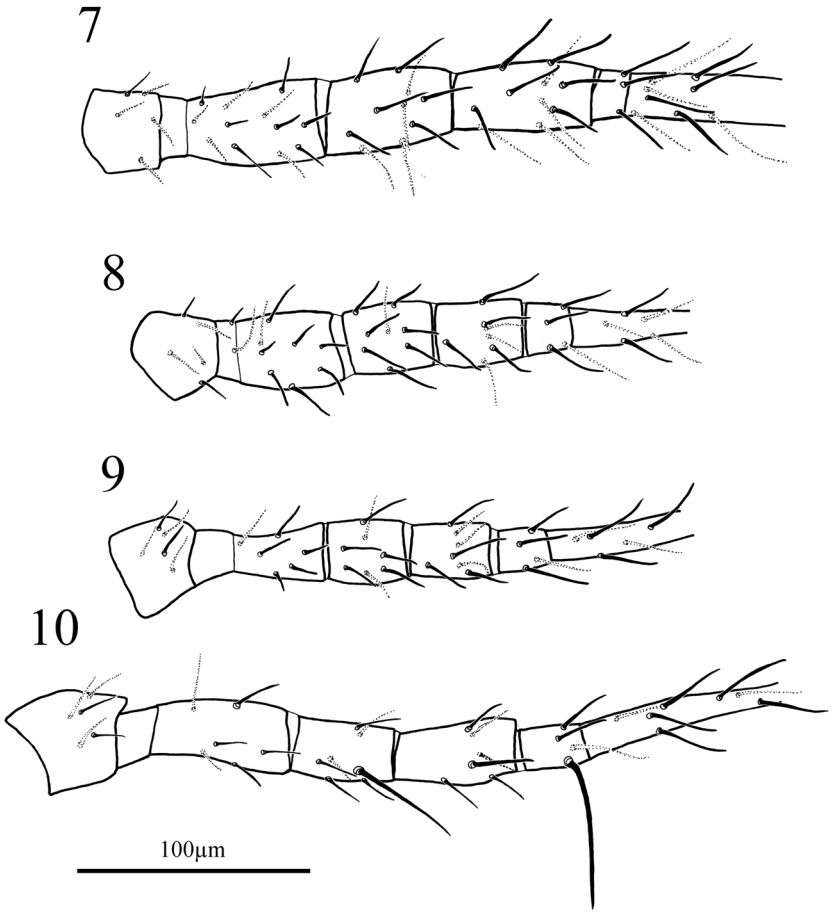
A lightly sclerotized mite. Idiosomal setal pattern: 10A:8E/JV-3:ZV.

Dorsal idiosoma (Figure 3). Dorsal shield smooth, laterally reticulated, central part of podosoma slightly reticulated; **364** 356 (346–364) long (*j1–J5* level) and **257** 251 (243–257) wide at level of *j6*, **231** 233 (229–237) wide at level of *S4*; seven pairs of gland pores on dorsal shield (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), twelve pairs of poroids (*id1*, *id2*, *id4*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of setae: *j1* **22** 22 (21–23), *j3* **51** 48 (46–51), *j4* **4** 5 (4–7), *j5* **5** 5 (5–6), *j6* **11** 7 (5–11), *J5* **9** 10 (9–11), *z2* **24** 24 (19–29), *z4* **37** 35 (35–37), *z5* **5** 5 (4–6), *Z1* **13** 16 (13–17), *Z4* **64** 64 (64–64), *Z5* **66** 65 (64–67), *s4* **63** 61 (56–64), *S2* **22** 24 (22–26), *S4* **16** 18 (16–21), *S5* **19** 18 (15–20), *r3* **14** 16 (14–19), *R1* **19** 16 (14–19). All setae smooth, except for *Z4* and *Z5* slightly serrated. Peritreme extending to *j1* level; peritremal shield with one pair of gland pores (*gd3*), and one pair of poroids (*id3*).



FIGURES 3–6. *Proprioseiopsis penghuensis* **sp. nov.**, female. 3. Dorsal shield; 4. Ventral idiosoma; 5. Chelicera; 6. Spermatheca.

Ventral idiosoma (Figure 4). Sternal shield smooth, much wider than long, posterior margin concave, **61** 60 (57–62) long, **95** 98 (95–99) wide, and with three pairs of setae *st1* **28** 32 (28–36), *st2* **23** 26 (23–29), *st3* **26** 23 (20–26), and two pairs of poroids (*iv1*, *iv2*). Exopodal shield at coxae I–IV. Metasternal platelets tear-shaped, with one pair of metasternal setae, *st4* **26** 26 (22–29), with one pair of poroids (*iv3*). Genital shield reticulated, posteriorly truncate, **91** 95 (91–99) wide at level of genital seta, *st5* **20** 26 (20–30). Distances between *st1*-*st1* **51** 53 (51–57), *st2*-*st2* **69** 70 (69–72), *st3*-*st3* **83** 80 (78–83), *st1*-*st3* **59** 60 (59–62), *st5*-*st5* **82** 83 (79–89). Ventrianal shield pentagonal, reticulated, **107** 115 (107–119) long, **118** 118 (115–121) wide at level of *ZV2*, **76** 79 (76–83) wide at level of anus; with three pairs of pre-anal setae, *JV1* **23** 23 (21–25), *JV2* **26** 26 (24–27), *ZV2* **25** 24 (23–25), *Pa* **13** 14 (13–16), *Pst* **21** 21 (21–22) on shield. Setae *JV4* **14** 13 (13–14), *JV5* **51** 49 (48–51), *ZV1* **24** 22 (21–24), *ZV3* **14** 14 (13–15) on interscutal membrane. All setae smooth. Two pairs of metapodal platelets: primary platelet **19** 23 (19–26) long, secondary platelet **5** 6 (5–7) wide; **11** 10 (9–11) long, **1** 1 (1–2) wide.



FIGURES 7–10. *Proprioseiopsis penghuensis* **sp. nov.**, female, legs (trochanter–basitarsus). 7. Leg I; 8. Leg II; 9. Leg III; 10. Leg IV.

Chelicera (Figure 5). Movable digit **28** 28 (28–28) long, with one tooth; fixed digit **27** 28 (26–29) long, anterior half with three teeth, with pilus dentilis.

Spermatheca (Figure 6). Calyx bell-shaped, **11** 12 (11–13) long, **11** 14 (11–17) wide; atrium nodular incorporated within calyx, major duct long, minor duct visible.

Legs (Figures 7–10). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 2-2/1-2/0-1, 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* IV (*ad2*) **45** 39 (34–45), *Sti* IV (*ad*) **25** 24 (22–25), *St* IV (*d*) **61** 64 (61–68). Macrosetae setiform.

Type specimens

Holotype: one female (89-Am-0964) from #5 (TARL). Paratypes: one female (89-Am-0987) from #9 (NMNS); one female (89-Am-0985) from #15 (NTU).

Etymology

The epithet *penghuensis* refers to the Penghu Island, that type material of this species were collected.

Remarks

The new species was compared with all known species of the genus *Proprioseiopsis*. The species belongs to the *belizensis* subspecies of the *belizensis* species group as genu I without macroseta and spermatheca with calyx bell-shaped. Within the subgroup, it exhibits a close affinity to *P. basis* Karg, *P. beatus* (Chaudhri), *P. campanulus* Karg, *P. exitus* (Schuster), *P. exopodalis* (Kennett), *P. fragariae* (Kennett), *P.lineatus* (Wu & Lan), *P. marginatus* Denmark, *P. mauiensis* (Prasad), *P. okanagensis* (Chant), *P. ovatus* (Garman), *P. phaseoloides* Denmark & Evans, *P. poculus* Tuttle & Muma, *P. reventus* (Zack), *P. rosellus* (Chant), *P. rotundus* (Muma), *P. weintraubi* (Chant & Hansell) based on dorsal setae *S2*, *Z4*, *Z5* length not extremely long. The differences between *P. penghuensis* **sp. nov.** and related species are given in Table 1. In addition, *P. lineatus* and *P. okanagensis* are most resembling species to the new species. The new species differs from *P. lineatus* by having *z2<z4* (vs. *z2>z4* in *P. lineatus*), and length of *Z4* and *Z5* about 65 (vs. about 80 and 100, respectively, in *P. lineatus*). Also, the new species differs from *P. okanagensis* in length of *z2*, *z4*, *s4*, *S2*, *Z4*, and *Z5* (24, 37, 63, 22, 64, and 66 as oppose to 36, 62, 82, 40, 80, and 106 in *P. okanagensis*).

***Neoseiulus xiaomenensis* Liao & Ho sp. nov.**

(Figures 11–25)

Diagnosis

Female dorsal shield reticulated, bearing 19 pairs of dorsal setae (including *r3*, *R1*). All setae smooth, except *Z4*, *Z5* serrated. Six pairs of gland pores (*gd1*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*) visible on dorsal shield. Peritreme extending to *j1-j3* level. Sternal shield with three pairs of setae; ventrianal shield pentagonal, bearing three pairs of pre-anal setae, with crescentic gland pore *gv3*. Fixed digit of chelicera with four teeth; movable digit with three teeth. Calyx of spermatheca bell-shaped; atrium connect to calyx with neck. Leg IV with three pairs of macrosetae; genu II with eight setae.

Female (n=5)

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

Dorsal idiosoma (Figure 11). Dorsal shield reticulated, **364** 356 (346–364) long (*j1–J5* level) and **172** 168 (162–174) wide at level of *s4*, **179** 175 (167–180) wide at level of *S4*; six pairs of gland pores (*gd1*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), fourteen pairs of poroids (*id1*, *id1a*, *id2*, *id4*, *id6*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of dorsal setae: *j1* **22** 21 (17–24), *j3* **42** 42 (32–50), *j4*

34 32 (30–35), *j5* **34** 34 (34–34), *j6* **39** 42 (39–46), *J2* **?** 47 (41–53), *J5* **10** 11 (9–12), *z2* **39** 36 (33–39), *z4* **44** 42 (40–44), *z5* **25** 26 (25–26), *Z1* **47** 50 (46–55), *Z4* **62** 63 (62–64), *Z5* **82** 83 (82–86), *s4* **50** 53 (48–61), *S2* **48** 57 (48–65), *S4* **42** 44 (40–49), *S5* **35** 36 (32–44), *r3* **29** 28 (26–31), *R1* **29** 26 (22–32). All setae smooth, setiform, except *Z4* and *Z5* slightly serrated. Peritreme extending to *j1* level; peritremal shield smooth, with one pair of gland pores (*gd3*), and one pair of poroids (*id3*).

Ventral idiosoma (Figure 12). Sternal shield reticulated, posterior margin almost straight; **70** 67 (65–70) long, **84** 79 (75–84) wide at level of *st3*, with three pairs of setae *st1* **28** 27 (26–28), *st2* **27** 26 (23–27), *st3* **19** 22 (19–24), and two pairs of poroids (*iv1*, *iv2*). Metasternal platelets tear-shaped, with a pair of metasternal setae, *st4* **18** 20 (18–23), one pair of poroids (*iv3*). Genital shield reticulated, truncate posteriorly, with one pair of genital setae *st5* **19** 21 (19–21), **80** 75 (67–80) wide at level of genital setae. Exopodal shield at coxae II–IV. Distances between *st1-st1* **51** 47 (44–51), *st2-st2* **54** 56 (54–57), *st3-st3* **75** 69 (63–75), *st1-st3* **58** 61 (58–67), *st5-st5* **68** 64 (61–68). Ventrianal shield reticulated, pentagonal, **119** 117 (111–122) long, **101** 100 (98–102) wide at *ZV2* level, **74** 69 (65–74) wide at level of anus; with three pairs of preanal setae, *JV1* **17** 17 (15–20), *JV2* **15** 16 (14–19), *ZV2* **13** 13 (13–13), one pair of para-anal; *Pa* **15** 15 (14–15), *Pst* **14** 17 (14–19) on shield; gland pore *gv3* crescentic. Setae *ZV1* **11** 15 (11–18), *ZV3* **13** 13 (11–14), *JV4* **13** 15 (13–16), *JV5* **55** 55 (50–60) on interscutal membrane. All setae smooth, setiform. Two pairs of metapodal platelets: primary platelet **23** 24 (23–26) long, **5** 4 (2–5) wide; secondary platelet **12** 12 (11–13) long, **3** 2 (1–3) wide.

Chelicera (Figure 13). Movable digit **22** 21 (19–23) long, with three teeth; fixed digit **24** 21 (20–24) long, with four teeth, with pilus dentilis.

Spermatheca (Figure 14). Calyx bell-shaped, **10** 10 (8–13) long, **8** 9 (8–10) wide; atrium connect to calyx with neck, major duct and minor duct visible.

TABLE 1. Differences between *Proprioseiopsis penghuensis* **sp. nov.** and related species.

	VAS shape	shape of *gv3*	No. of teeth on FD/MD*	relative length of macrosetae
penghuensis [1]	pentagonal	small round	3/1	*St* IV>*Sge* IV>*Sti* IV
basis [2]	pentagonal	round	3/1	unknown
beatus [3]	triangular	crescentic	3/1	*St* IV>*Sge* IV>*Sti* IV
campanulus [4]	broader	absent	102	unknown
exitus [5]	triangular	round	4/2	*Sge* IV=*St* IV>*Sti* IV
exopodalis [6]	pentagonal	round	4/1	*St* IV>*Sge* IV>*Sti* IV
fragariae [7]	pentagonal	round	4/1	*St* IV>*Sge* IV>*Sti* IV
lineatus [8]	pentagonal	round	unknown	*St* IV>*Sge* IV>*Sti* IV
marginatus [9]	pentagonal	round	unknown	*St* IV>*Sge* IV>*Sti* IV
mauiensis [10]	broader	round	3/1	*St* IV>*Sge* IV>*Sti* IV
okanagensis [11]	pentagonal	round	8/1	unknown
ovatus [12]	pentagonal	round	7/1	*Sge* IV>*St* IV>*Sti* IV
phaseoloides [13]	pentagonal	crescentic	10/1	*Sge* IV>*St* IV>*Sti* IV
poculus [14]	pentagonal	round	unknown	*St* IV>*Sge* IV>*Sti* IV
reventus [15]	pentagonal	round	unknown	*St* IV>*Sge* IV>*Sti* IV
rosellus [16]	broader	crescentic	unknown	unknown
rotundus [17]	pentagonal	round	unknown	*St* IV>*Sge* IV>*Sti* IV
weintraubi [18]	pentagonal	crescentic	?/2	*Sge* IV=*St* IV>*Sti* IV

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TABLE 1. (Continued)

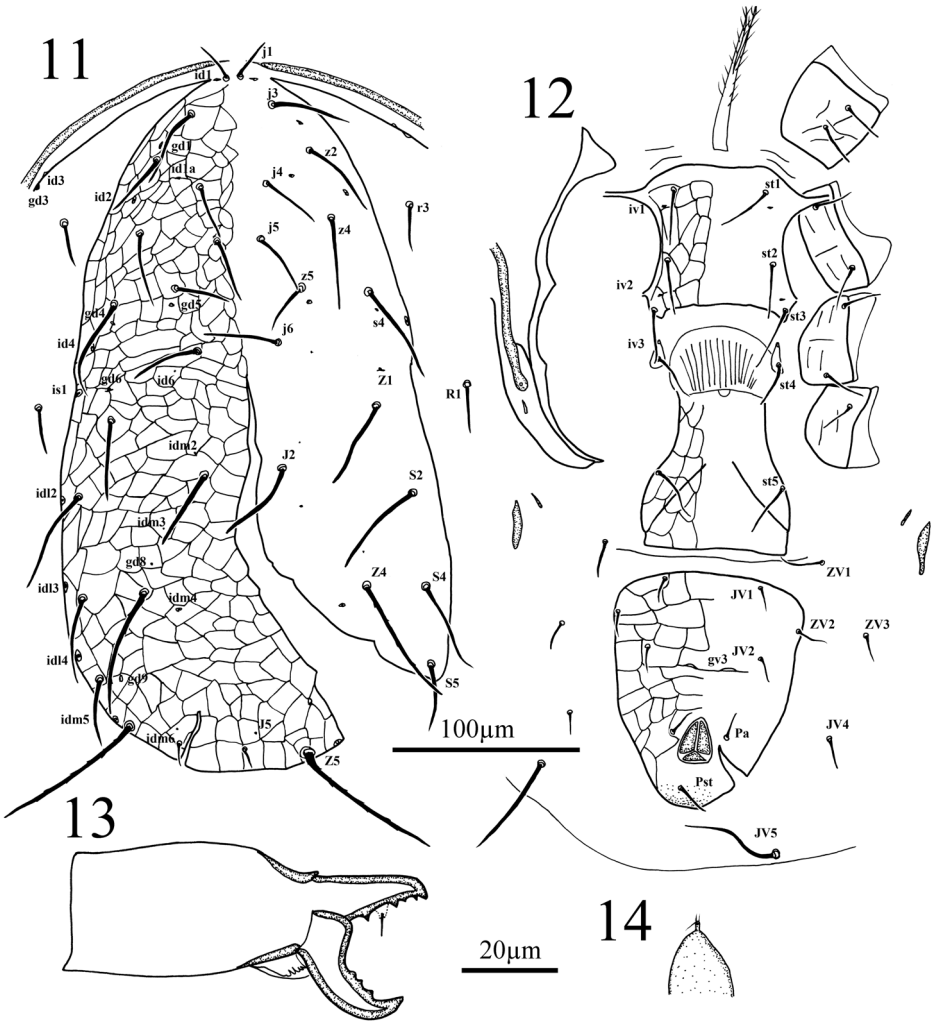
	j1	j3	z2	z4	s4	S2	Z4	Z5
penghuensis [1]	**22** 22 (21–23)	**51** 48 (46–51)	**24** 24 (19–29)	**37** 35 (35–37)	**63** 61 (56–64)	**22** 24 (22–26)	**64** 64 (64–64)	**66** 65 (64–67)
basis [2]	30	?	40	25	93	20	106	85
beatus [3]	26	42	38	62	78	36	75	78
campanulus [4]	25	50	20	75	95	100	125	120
exitus [5]	22	39	11	11	72	8	100	75
exopodalis [6]	?	41	?	?	68	?	84	92
fragariae [7]	?	68	?	?	96	?	93	86
lineatus [8]	22.5–25	40–41.25	17.5	12.5	57.5–60	10	77.5–82.5	102.5
marginatus [9]	20	39	25	17	72	20	90	91
mauiensis [10]	22	42	25	19	77	27	96	92
okanagensis [11]	?	52	36	62	82	40	80	106
ovatus [12]	26 (25–29)	58 (48–65)	29 (29–30)	12 (11–14)	68 (65–71)	14 (11–16)	112 (98–120)	104 (97–113)
phaseoloides [13]	19	20	8	7	65	7	87	71
poculus [14]	?	?	?	?	?	?	?	?
reventus [15]	18	33	18	9	45	10	57	60
rosellus [16]	?	?	?	?	?	?	?	?
rotundus [17]	37	75	18	18	106	23	102	122
weintraubi [18]	30	22	8	16	64	16	10	10

[1] present study; [2] Karg (1994); [3] Chaudhri (1968); [4] Karg (1979); [5] Schuster (1966); [6] Kennett (1958); [7] Kennett (1958); [8] Wu & Lan (1991); [9] Denmark (1974); [10] Prasad (1968); [11] Chant (1957) and Chant & Hansell (1971); [12] Garnan (1958) and Liao *et al*. (2020); [13] Denmark *et al.* (1999); [14] Tuttle & Muma (1973); [15] Zack (1969); [16] Chant (1959); [17] Muma (1961) and Fouly *et al*. (1994); [18] Chant & Hansell (1971). * Teeth number of fixed digit and movable digit of chelicerae.

Legs (Figures 15–18). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 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, 1-1/1-2/0-1, 1-1/1-1. Macrosetae: *Sge* IV (*ad2*) **25** 27 (24–30), *Sti* IV (*ad*) **29** 31 (25–37), *St* IV (*d*) **53** 54 (49–61). Macrosetae setiform. Male (n=1)

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

Dorsal idiosoma (Figure 19). Dorsal shield reticulated, 295 long (*j1-J5* level) and 183 wide at level of *j6*, 158 wide at level of *S4*; six pairs of gland pores (*gd1*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), fourteen pairs of poroids (*id1*, *id1a*, *id2*, *id4*, *id6*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of setae: *j1* 17, *j3* 31, *j4* 24, *j5* 26, *j6* 25, *J2* 40, *J5* 8, *z2* 28, *z4* 34, z5 22, *Z1* 42, *Z4* 60, *Z5* 70, *s4* 38, *S2* 45, *S4* 38, *S5* 28, *r3* 29, *R1* 22. All setae smooth, except *Z5* slightly serrated. Setae *r3* and *R1* inserted on dorsal shield. Peritreme extending beyond *j3* level; peritremal shield smooth



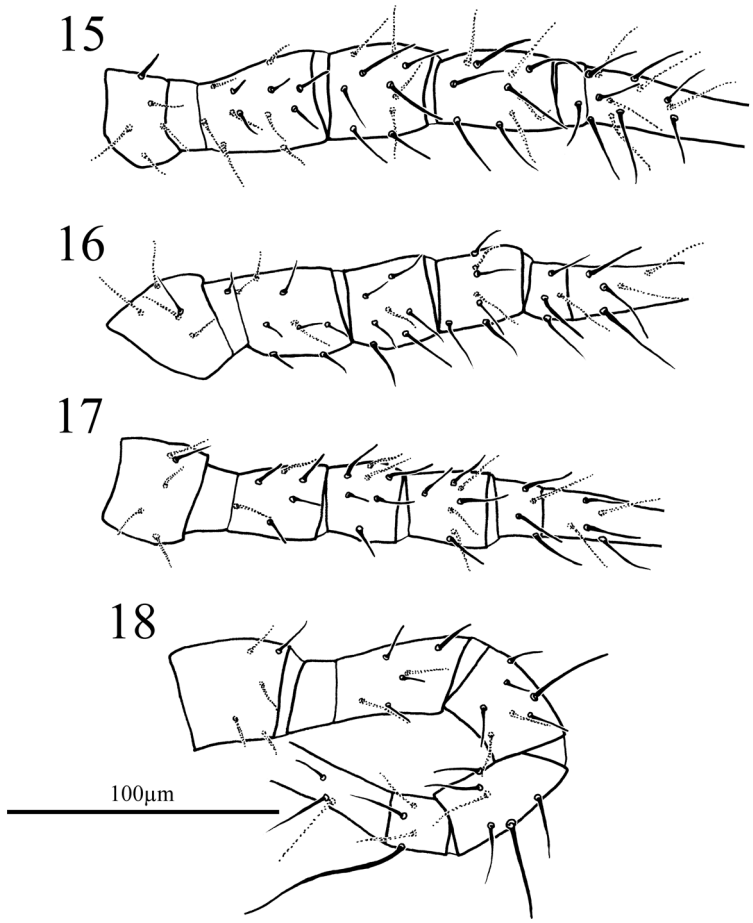
FIGURES 11–14. *Neoseiulus xiaomenensis* **sp. nov.**, female. 11. Dorsal shield; 12. Ventral idiosoma; 13. Chelicera; 14. Spermatheca.

Ventral idiosoma (Figure 20). Sternogenital shield lateral slightly reticulated, longer than wide, 120 long, 77 wide at level of *st2*, with five pairs of setae, *st1* 20, *st2* 16, *st3* 14, *st4* 13, *st5* 15, three pairs of poroids (*iv1*, *iv2*, *iv3*). Exopodal shield at coxae II–IV. Distances between *st1–st1* 45, *st2–st2* 53, *st3–st3* 57, *st4–st4* 52, *st5–st5* 38, *st1–st5* 109. Ventrianal shield subtriangular, reticulated, 120 long and 165 wide at level of anterior corner, 70 wide at level of anus, not fused with peritremal shield; with three pairs of preanal setae, *JV1* 9, *JV2* 8, *ZV2* 13; gland pore *gv3* crescentic; *Pa* 8, *Pst* 8 on shield. Setae *JV5* 30 on interscutal membrane.

Chelicera (Figure 21). Movable digit 19 long, with one tooth. Fixed digit 18 long, with one tooth, with pilus dentilis; spermatodactyl heel-and-toe variant, shaft 13 long, heel rounded, foot 8 long.

Legs (Figures 22–25). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 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, 1-1/1-2/0-1, 1-1/1-1. Macrosetae: *Sge* IV (*ad2*) 19, *Sti* IV (*ad*) 26, *St* IV (*d*) 47. Macrosetae setiform.



FIGURES 15–18. *Neoseiulus xiaomenensis* **sp. nov.,** female, legs (trochanter–basitarsus). 15. Leg I; 16. Leg II; 17. Leg III; 18. lLeg IV.

Type specimens

Holotype: one female (89-Am-92) from #7 (NTU). Paratypes: seven females one male (89-Am-0966, 1059, 60, 61, 64, 67, 68) from #7 (NMNS, NCHU, TARL).

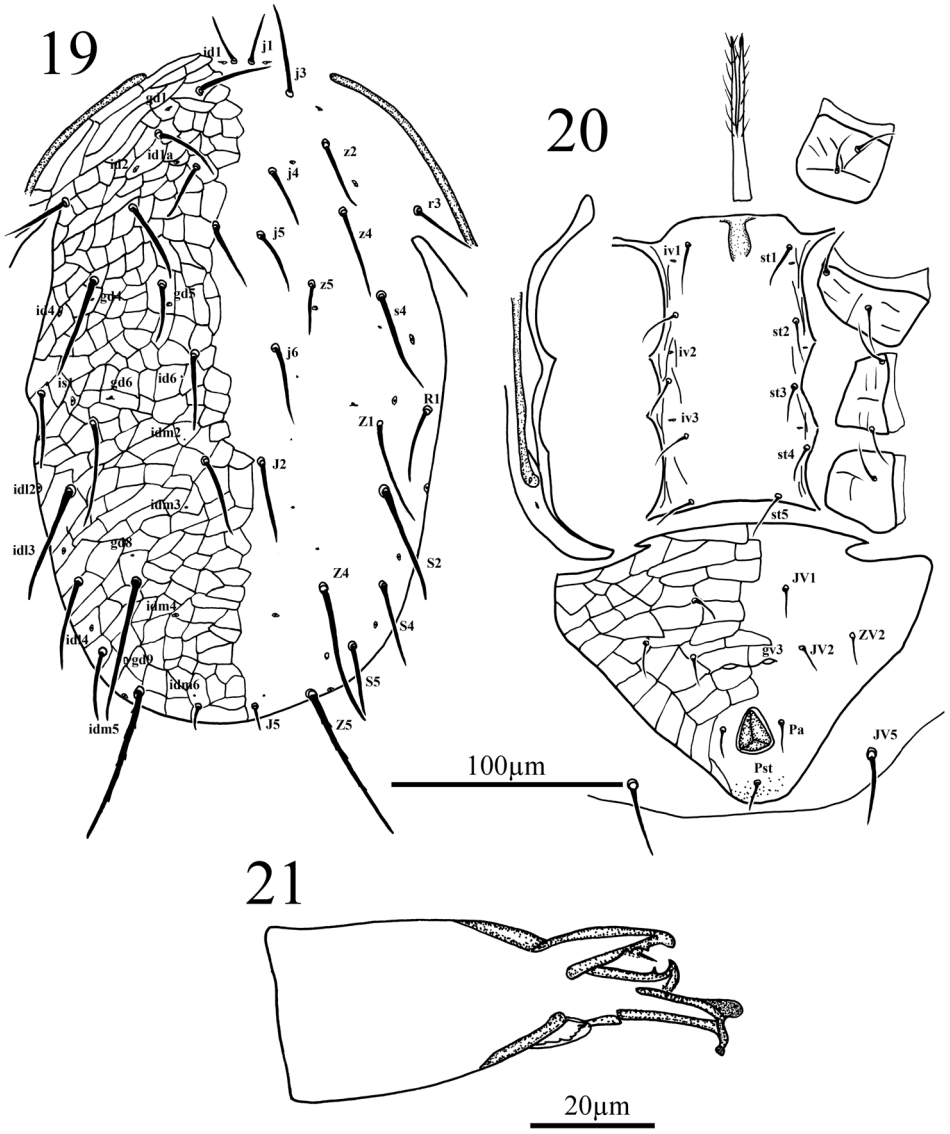
Etymology

The epithet *xiaomenensis* refers to Xiaomen, the village that type material of this species were collected.

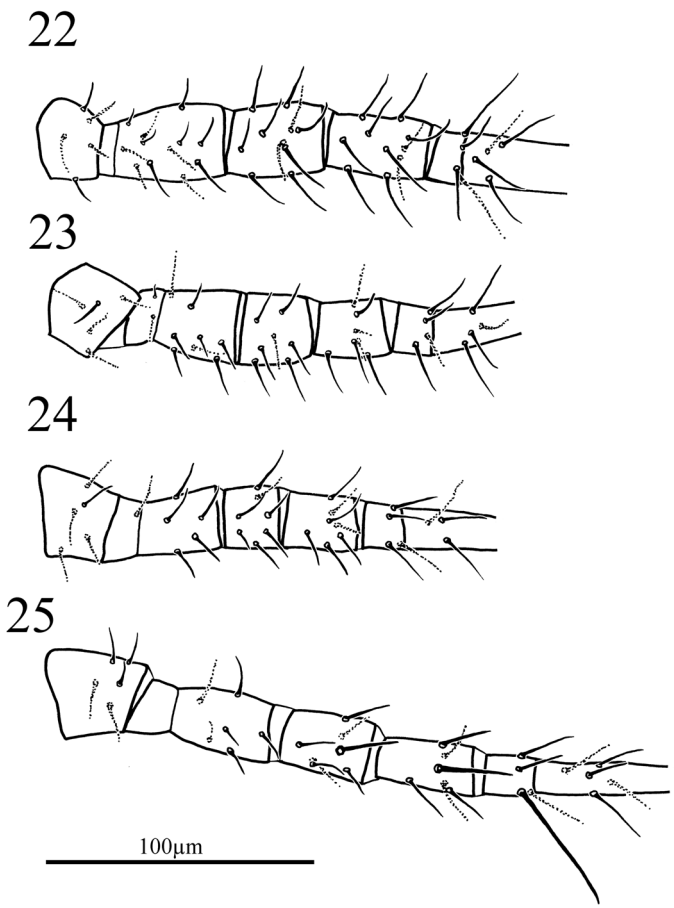
Remarks

The new species was compared with all species of the *cucumeris* species subgroup in the genus *Neoseiulus* for identification. It shows a close affinity to 16 known species, *N. aegyptocitri* (Kandeel & El-Halawany), *N. anonymus* (Chant & Baker), *N. argillaceus* (Kolodochka & Bondarenko), *N. bayviewensis* (Schicha), *N. bellinus* (Womersley), *N. crataegi* (Jorgensen & Chant), *N. curvus* (Wu & Li), *N. esculentus* (El-Badry), *N. fallacis* (Garman), *N. fallacoides* Tuttle & Muma, *N. idaeus* Denmark & Muma, *N. imbricatus* (Corpuz & Rimando), *N. lamticus* (Athias-Henriot), *N. malaban*

Beard, *N. placitus* (Khan & Chaudhri), *N. tarapacensis* Peralta, and most based on the longer dorsal setae, ventrianal shield pentagonal, calyx of spermatheca bell-shaped, and they were considered as "*N. fallacis* appearance". These species are different in the relative lengths of dorsal setae. The differences between *N. xiaomenensis* **sp. nov.** and related species are given in Table 2. *Neoseiulus fallacis* and *N. imbricatus* which seems most close to the new species, but the new species differs from *N. fallacis* in spermatheca with neck (vs. without neck in *N. fallacis*), and lengths of setae *z2*, *z4*, *Z1*, *S2*, *S4*, and *S5* (39, 44, 47, 48, and 42 as oppose to 47, 51, 57, 66 and 54 in *N. fallacis*). Additionally, the new species differs from *N. imbricatus* in length of seta *S5* about 35 (vs. 55 in *N. imbricatus*), posterior margin of sternal shield straight (vs. with a median projection in *N. imbricatus*).



FIGURES 19–21. *Neoseiulus xiaomenensis* **sp. nov.**, male. 19. Dorsal shield; 20. Ventral idiosoma; 21. Chelicera and spermatodactyl.



FIGURES 22–25. *Neoseiulus xiaomenensis* **sp. nov.**, male, legs (trochanter–basitarsus). 22. Leg I; 23. Leg II; 24. Leg III; 25. Leg IV.

Amblyseius cinctus Corpuz & Rimando, 1966

Amblyseius cinctus Corpuz & Rimando, 1966: 119
(Figures 26–40)

Female (n=2)

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

Dorsal idiosoma (Figure 26). Dorsal shield, smooth, 327 (316–338) long, 216 (214–219) wide at level of *s4*, 209 (201–217) wide at level of *S4*; seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), twelve pairs of poroids (*id1*, *id2*, *id4*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of dorsal setae: *j1* 25 (21–28), *j3* 41 (36–46), *j4* 10 (9–11), *j5* 11 (10–12), *j6* 8 (7–10), *J2* 9 (8–10), *J5* 9 (8–10), *z2* 10 (8–12), *z4* 10 (8–11), *z5* 9 (8–9), *Z1* 10 (10–11), *Z4* 93 (86–101), *Z5* 226 (210–242), *s4* 80 (73–88), *S2* 11 (10–12), *S4* 10 (9–11), *S5* 9 (8–11), *r3* 9 (9–10), *R1* 10 (8–12). Setae *j1*, *j3*, *s4* longer and smooth; *Z4*, *Z5* greatly elongated, slightly serrated; other minute. Peritreme extending beyond to *j1*, peritremal shield smooth, lightly sclerotized, with one pair of gland pores (*gd3*) and one pair of poroids (*id3*).

Ventral idiosoma (Figure 27). Sternal shield lateral slightly reticulated, posterior margin straight, wider than long, 71 (67–74) long, 88 (84–92) wide at *st3* level, with three pairs of setae *st1*

27 (27–27), *st2* 25 (23–27), *st3* 24 (23–25) and two pairs of poroids (*iv1*, *iv2*). Exopodal shield at coxae II–IV. Metasternal platelets tear-shaped, with a pair metasternal setae, *st4* 20 (19–21), and one pair of poroids (*iv3*). Genital shield smooth, with one pair of genital setae *st5* 20 (18–21), 74 (69–78) wide at level of genital setae. Distance between *st1–st1* 52 (49–54), *st2–st2* 64 (58–70), *st3–st3* 69 (68–70), *st1–st3* 61 (61–62), *st5–st5* 65 (59–71). Ventrianal shield smooth, pentagonal; 103 (102–103) long, 87 (79–95) wide at level of *ZV2* and 71 (69–72) wide at level of anus; with three pairs of pre-anal setae, *JV1* 16 (15–16), *JV2* 17 (14–20), *ZV2* 11 (10–12), gland pore *gv3* crescentic, *Pa* 13 (12–14), *Pst* 13 (12–15). Setae *JV4* 12 (11–13), *JV5* 76 (71–82), *ZV1* 14 (13–16), *ZV3* 11 (9–12) on interscutal membrane. All ventral setae smooth. Two pairs of metapodal platelets: primary platelet 19 (19–20) long, 6 (6–6) wide; secondary platelet 10 (10–11) long, 2 (1–2) wide.

Chelicera (Figure 28). Movable digit 30 (29–30) long, with three teeth; fixed digit 30 (29–30) long, with eleven teeth, with pilus dentilis.

Spermatheca (Figure 29). Calyx tubular, 9 (8–11) long, 3 (3–3) wide; atrium incorporate with calyx, minor and major ducts visible.

Legs (Figures 30–33). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 1-2/1-2/0-1, 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* I (*pd2*) 41 (39–44), *Sge* II (*pd2*) 29 (29–30), *Sge* III (*ad2*) 60 (58–62), *Sti* III (*ad*) 44 (44–44), *Sge* IV (*ad2*) 102 (100–105), *Sti* IV (*ad*) 70 (67–72), *St* IV (*d*) 80 (80–80). Macrosetae setiform.

Male (n=2)

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

TABLE 2. Differences between *Neoseiulus xiaomenensis* **sp. nov.** and related species.

	No. solenostomes	peritreme length	posterior margin of sternal shield	shape of *gv3*	No. of teeth on FD/MD*	relative length of macrosetae
xiaomenensis [1]	6	*j1*	almost straight	crescentic	4/3	*St* IV>*Sti* IV>*Sge* IV
aegyptocitri [2]	?	*j1*	straight	round	5/3	*Sge* IV>*St* IV>*Sti* IV
anonymus [3]	?	*j1*	concave	crescentic	11/4	only *St* IV
argillaceus [4]	5	*j3*	concave	round	3/1	*St* IV>*Sge* IV>*Sti* IV
bayviewensis [5]	6	*j1*	straight	round	4/2	*St* IV>*Sge* IV>*Sti* IV
bellinus [6]	?	*j3*	straight	crescentic	4/1	only *St* IV
crataegi [7]	?	*j1*	slightly concave	round	3/1	*St* IV longest
curvus [8]	?	*j1*	irregular	crescentic	10/?	*St* IV>*Sti* IV>*Sge* IV
esculentus [9]	?	*j1*	straight	round	8/1	*St* IV>*Sti* IV>*Sge* IV
fallacis [10]	?	*j1-j3*	straight	crescentic	5/3	*St* IV>*Sti* IV>*Sge* IV
fallacoides [11]	4	*j3-z2*	straight	crescentic	?/3	only *St* IV
idaeus [12]	?	*j3*	concave	crescentic	5/3	only *St* IV
imbricatus [13]	5	*j1*	with median projection	crescentic	10/3	*St* IV>*Sti* IV>*Sge* IV
lamticus [14]	5	*j1*	straight	crescentic	7/1	*St* IV>*Sti* IV=*Sge* IV
malaban [15]	4	*j1*	straight	crescentic	3/1	only *St* IV
sharonensis [16]	5	*j1*	almost straight	crescentic	10/3	*St* IV>*Sti* IV>*Sge* IV
tarapacensis [17]	3	*j3-z2*	irregular	crescentic	5/3	only *St* IV

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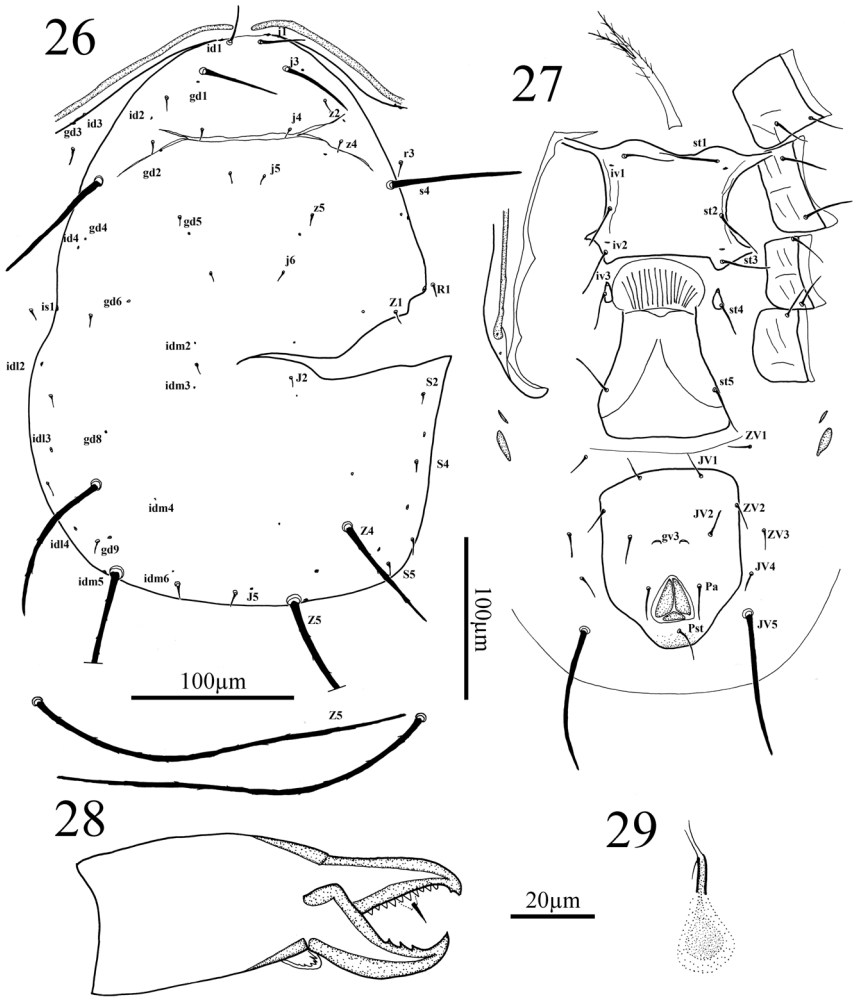
TABLE 2. (Continued)

	j4	z2	z4	Z1	Z4	Z5	S2	S4	S5
xiaomenensis [1]	**34** 32 (30–35)	**39** 36 (33–39)	**44** 42 (40–44)	**47** 50 (46–55)	**62** 63 (62–64)	**82** 83 (82–86)	**48** 57 (48–65)	**42** 44 (40–49)	**35** 36 (32–44)
aegyptocitri [2]	?	?	?	?	?	?	?	?	?
anonymus [3]	28	18	38	45	65	78	63	35	35
argillaceus [4]	25	32	44	48	68	61	59	34	28
bayviewensis [5]	23–25	35–38	38–43	32–38	47–50	57–61	43–49	36–39	26–29
bellinus [6]	27	31	30	28	39	70	36	36	33
crataegi [7]	7–15	27–30	27–30	27–30	57	69	27–30	27–30	27–30
curvus [8]	25–27.5	40–42.5	42.5–50	52.5	62.5–67.5	70–78.5	55–60	62.5–65	52.5–62.5
esculentus [9]	28	42	46	46	60	77	54	61	55
fallacis [10]	**37** 34 (28–39)	**47** 41 (36–47)	**51** 45 (36–51)	**57** 53 (48–57)	**69** 68 (60–73)	**87** 80 (70–88)	**66** 63 (54–67)	**54** 52 (45–59)	**45** 40 (34–46)
fallacoides [11]	34	?	?	39	?	69	?	?	?
idaeus [12]	42	42	54	62	50	62	55	30	26
imbricatus [13]	22 (26–30)	38	42	47	62 (66)	77 (78)	52	53	55
lamticus [14]	?	?	?	?	?	?	?	?	?
malaban [15]	29–30	35	35	34	38–39	36–37	38–39	34	20–21
sharonensis [16]	22.5 (22–23)	39 (38–40);	44 (42–45)	44 (42–45)	64 (61–66)	75 (71–78)	56 (51–58)	56 (51–58)	56 (51–58)
tarapacensis [17]	**22** (19–26)	**28** (25–37)	**27** (22–29)	**28** (23–33)	**43** (40–48)	**66** (60–71)	**36** (32–39)	**27** (24–30)	**25** (21–30)

[1] present study; [2] Kandeel & El-Halawany (1986) ; [3] Chant & Baker (1965) and Ferla *et al.* (2011); [4] Kolodochka & Bondarenko (1993); [5] Schicha (1977); [6] Womersley (1954); [7] Jorgensen & Chant (1960); [8] Wu & Li (1985); [9] El-Badry (1968); [10] Garman (1948) and Tsolakis & Ragusa (2016); [11] Tuttle & Muma (1973) and Tsolakis & Ragusa (2016); [12] Denmark & Muma (1973); [13] Corpuz & Rimando (1966) and Schicha & Corpuz-Raros (1992); [14] Athias-Henriot (1977); [15] Beard (2001); [16] Rivnay & Swirski (1980). * Teeth number of fixed digit and movable digit of chelicerae.

Dorsal idiosoma (Figure 34). Dorsal shield smooth, anterolaterally reticulated; 258 (250–266) long, 188 (184–192) wide at level of *s4*, 156 (142–169) wide at level of *S4*, with seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), twelve pairs of poroids (*id1*, *id2*, *id4*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of setae: *j1* 19 (19–19), *j3* 41 (37–46), *j4* 7 (7–7), *j5* 6 (5–6), *j6* 6 (5–7), *J2* 5 (4–6), *J5* 7 (6–8), *z2* 6 (5–6), *z4* 7 (5–9), *z5* 5 (4–6), *Z1* 6 (5–7), *Z4* 81 (73–89), *Z5* 191 (191–191), *s4* 62 (58–67), *S2* 6 (6–6), *S4* 6 (6–7), *S5* 6 (6–6), *r3* 10 (9–10), *R1* 9 (8–10). Setae *j1*, *j3*, *s4* longer and smooth; *Z4*, *Z5* greatly elongated, slightly serrated; other minute. Setae *r3* and *R1* inserted on dorsal shield. Peritreme extending to *j1* level; peritremal shield lightly sclerotized.

Ventral idiosoma (Figure 35). Sternogenital shield smooth, lateral slightly reticulated, posterior margin almost straight, longer than wide 117 (115–119) long, 79 (79–80) wide at level *st2*, with five pairs of setae *st1* 21 (20–23), *st2* 19 (17–20), *st3* 20 (17–23), *st4* 13 (12–13), *st5* 13 (13–14), three pairs of poroids (*iv1*, *iv2*, *iv3*). Exopodal shield at coxae II–IV. Distance between *st1-st1* 50 (50–51), *st2-st2* 57 (55–59), *st3-st3* 52 (52–53), *st4-st4* 45 (43–47), *st5-st5* 34 (33–34), *st1-st5* 102 (101–104). Ventrianal shield subtriangular, reticulated, 110 (108–111) long, 141 (138–144) wide at level of anterior corner and 47 (46–49) wide at level of anus, fused with peritremal shield cingulum; with three pairs of pre-anal setae, *JV1* 12 (11–13), *JV2* 10 (10–10), *ZV2* 9 (9–9), gland pore *gv3* crescentic, *Pa* 9 (7–11), *Pst* 11 (11–12) on shield; *JV5* 34 (34–34) on interscutal membrane. All ventral setae smooth.



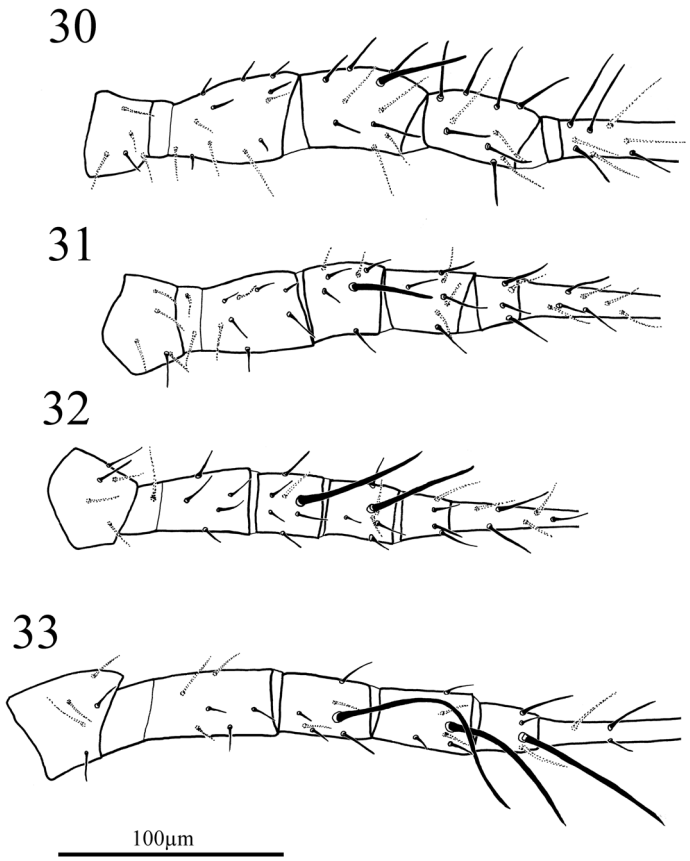
FIGURES 26–29. *Amblyseius cinctus* **Corpuz & Rimanos, 1966**, female. 26. Dorsal shield; 27. Ventral idiosoma; 28. Chelicera; 29. Spermatheca.

Chelicera (Figure 36). Movable digit 18 (17–18) long, with one tooth; fixed digit 20 (20–20), with eight teeth, with pilus dentilis; spermatodactyl heel-and-toe variant, shaft 14 (14–15) long, heel rounded, foot 13 (12–13) long.

Legs (Figures 37–40). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 1-2/1-2/0-1, 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* I (*pd2*) 31 (30–32), *Sge* II (*pd2*) 28 (28–29), *Sge* III (*ad2*) 36 (35–37), *Sti* III (*ad*) 34 (33–36), *Sge* IV (*ad2*) 66 (64–68), *Sti* IV (*ad*) 48 (48–49), *St* IV (*d*) 58 (56–60). Macrosetae setiform.

Specimens examined

Two females (89-Am-0963, 65) from #5 (TARL); one female and two males (89-Am-0989, 90, 1052) from #8 (TARL); one female and one male (89-Am-0986, 92) from #9 (TARL); one female (89-Am-1051) from #13 (TARL).



FIGURES 30–33. *Amblyseius cinctus* **Corpuz & Rimanos, 1966**, female, legs (trochanter–basitarsus). 30. Leg I; 31. Leg II; 32. Leg III; 33. Leg IV.

Distribution

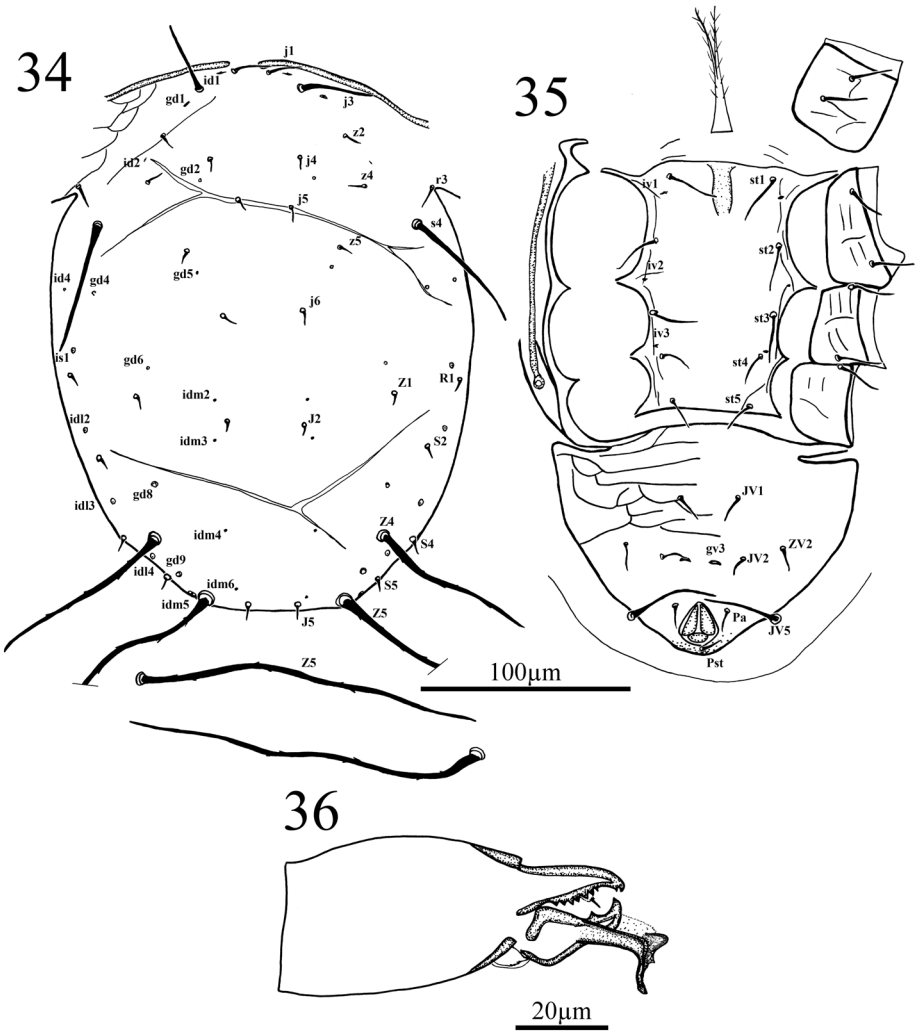
Asia: China (Chen *et al*. 1980), Malaysia (Ehara 2002), Philippines (Corpuz & Rimando 1966), Singapore (Corpuz-Raros 1995), Taiwan [Penghu island (present study)], Thailand (Ehara & Bhandhufalck 1977), Vietnam (Kreiter *et al.* 2020);

Remarks

Corpuz & Rimando (1966) described this species on *Panicum pilipes* (Poaceae) in the Philippines. The second author of present study collected individuals on three different plant families, namely Asteraceae, Primulaceae, and Oxalidaceae. We compared the holotype (deposited in the University of the Philippines Los Baños Museum of Natural History [UPLB-MNH]) with these specimens, and no major difference were observed.

This species was only found in the Penghu Islands but not in the main island of Taiwan. Of the two Penghu Island investigations, this species was found on low-growing plants only in the 1989 survey, possibly owing to environmental changes in the past 30 years.

Vichitbandha & Chandrapatya (2009) evaluated the biological control potential of using this species against *Polyphagotarsonemus latus* (Banks), a major pest that affects cultivated (crop) plants worldwide.



FIGURES 34–36. *Amblyseius cinctus* **Corpuz & Rimanos, 1966**, male. 34. Dorsal shield; 35. Ventral idiosoma; 36. Chelicera and spermatodactyl.

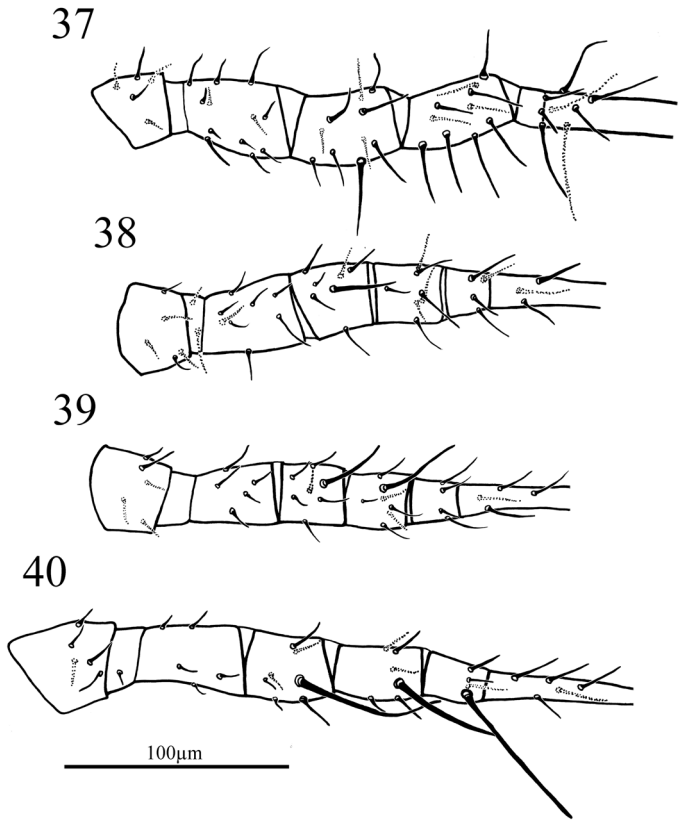
Amblyseius fletcheri **Schicha, 1981**

Amblyseius fletcheri Schicha, 1981: 102.
(Figures 41–48)

Female (n=2)

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

Dorsal idiosoma (Figure 41). Dorsal shield, smooth, 358 (339–376) long, 219 (211–227) wide at level of *s4*, 222 (221–223) wide at level of *S4*; seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), fourteen pairs of poroids (*id1*, *id1a*, *id2*, *id4*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *idx*, *is1*, *idl2*, *idl3*, *idl4*); length of dorsal setae: *j1* 37 (33–40), *j3* 52 (50–54), *j4* 7 (6–8), *j5* 6 (4–7), *j6* 7 (7–7), *J2* 8 (7–9), *J5* 8 (7–10), *z2* 8 (8–9), *z4* 7 (7–8), *z5* 9 (7–10), *Z1* 10 (9–11), *Z4* 128 (128–128), *Z5* 283 (260–307), *s4* 119 (108–130), *S2* 10 (10–11), *S4* 10 (8–11), *S5* 9 (9–9), *r3* 12 (11–14), *R1* 11 (11–11). Setae *j1*, *j3*, *s4* longer and smooth; *Z4*, *Z5* greatly elongated, slightly serrated; other minute. Peritreme extending beyond to *j1*, peritremal shield smooth, lightly sclerotized, with one pair of gland pores (*gd3*) and one pair of poroids (*id3*).



FIGURES 37–40. *Amblyseius cinctus* **Corpuz & Rimanos, 1966**, male, legs (trochanter–basitarsus). 37. Leg I; 38. Leg II; 39. Leg III; 40. Leg IV.

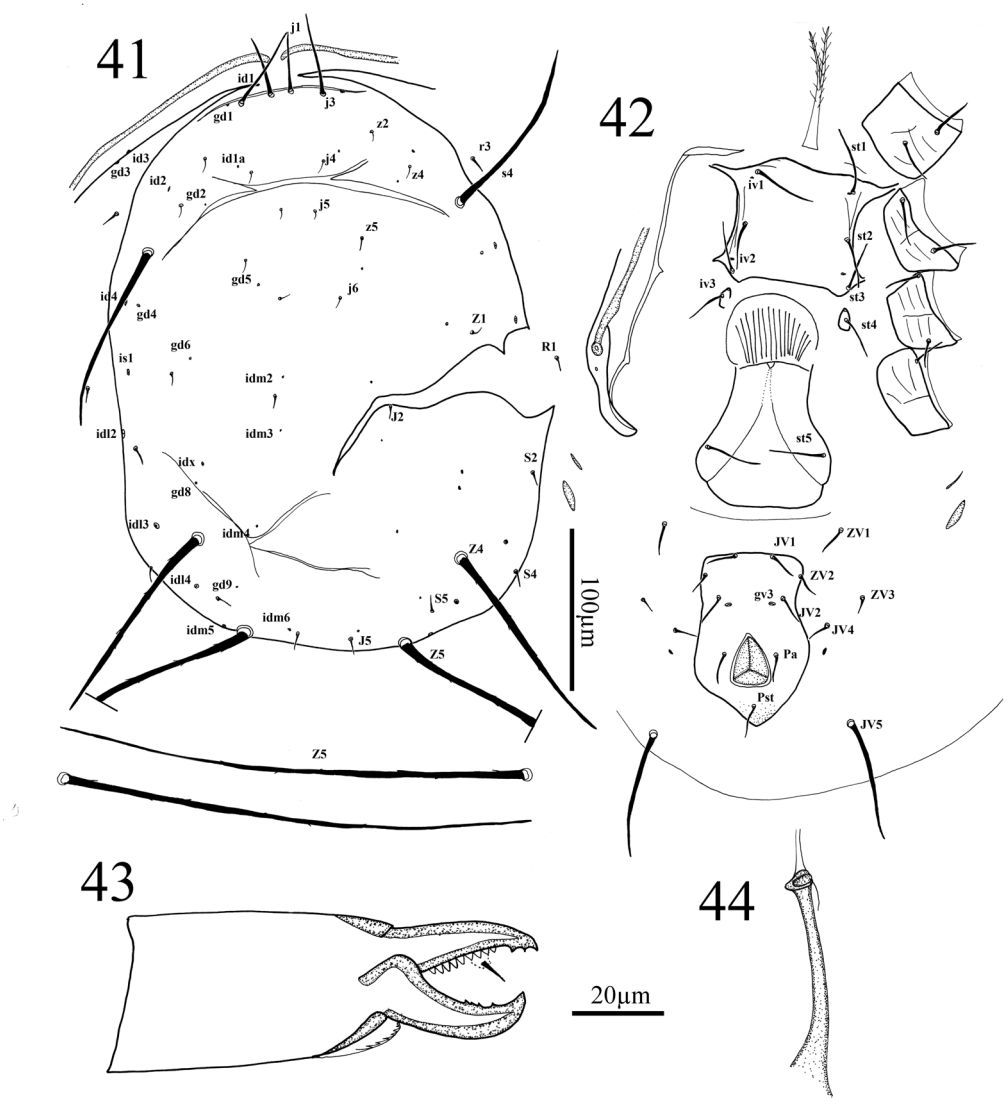
Ventral idiosoma (Figure 42). Sternal shield lateral slightly reticulated, posterior margin straight, wider than long, 67 (63–70) long, 94 (93–94) wide at *st3* level, with three pairs of setae *st1* 34 (32–37), *st2* 22 (19–25), *st3* 27 (21–32) and two pairs of poroids (*iv1*, *iv2*). Exopodal shield at coxae II–IV. Metasternal platelets tear-shaped, with a pair metasternal setae, *st4* 24 (22–25), and one pair of poroids (*iv3*). Genital shield smooth, with one pair of genital setae *st5* 29 (28–30), 78 (77–80) wide at level of genital setae. Distance between *st1-st1* 62 (58–67), *st2-st2* 66 (64–68), *st3-st3* 70 (70–70), *st1-st3* 61 (61–61), *st5-st5* 70 (65–75). Ventrianal shield smooth, pentagonal with waist at *JV2* level; 111 (109–113) long, 62 (61–62) wide at level of *ZV2* and 72 (70–74) wide at level of anus; with three pairs of pre-anal setae, *JV1* 16 (13–20), *JV2* 19 (18–21), *ZV2* 15 (14–15), gland pore *gv3* crescentic, *Pa* 17 (15–18), *Pst* 19 (18–20). Setae *JV4* 12 (12–12), *JV5* 76 (69–83), *ZV1* 12 (9–15), *ZV3* 11 (9–12) on interscutal membrane. All ventral setae smooth. Two pairs of metapodal plates: primary platelet 23 (22–24) long, 7 (6–7) wide; secondary platelet 14 (12–16) long, 2 (1–2) wide.

Chelicera (Figure 43). Movable digit 30 (29–32) long, with three teeth; fixed digit 36 (34–39) long, with eleven teeth, with pilus dentilis.

Spermatheca (Figure 44). Calyx elongated, tubular, wider toward vehicle, 36 (34–39) long, 4 (4–4) wide; atrium incorporate with calyx, minor and major ducts visible.

Legs (Figures 45–48). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): leg I, 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 1-2/1-2/0-1, 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* I (*pd2*)

48 (43–52), *Sge* II (*pd2*) 35 (34–36), *Sge* III (*ad2*) 56 (47–65), *Sti* III (*ad*) 43 (39–47), *St* III (*d*) 29 (28–30), *Sge* IV (*ad2*) 125 (120–130), *Sti* IV (*ad*) 98 (98–98), *St* IV (*d*) 74 (67–82). Macrosetae setiform.



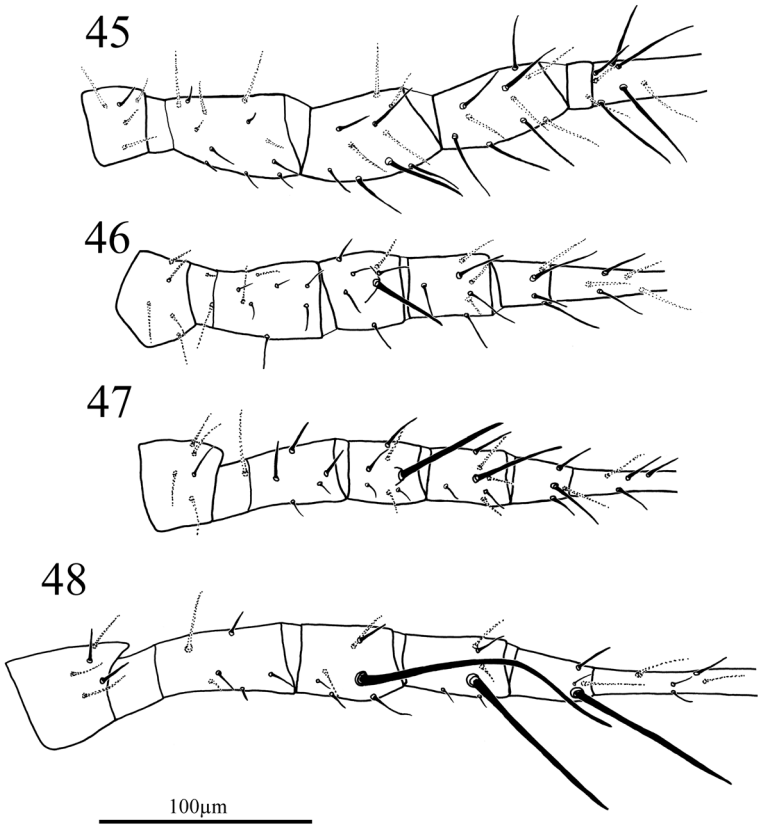
FIGURES 41–44. *Amblyseius fletcheri* **Schicha, 1981**, female. 41. Dorsal shield; 42. Ventral idiosoma; 43. Chelicera; 44. Spermatheca.

Specimens examined

One female (no. 2522–1) from #20 (NTU); one female (no. 2540–4) from #29 (NTU).

Distribution

Africa: Madagascar (Schicha 1987). Asia: Philippines (Schicha & Corpuz-Raros 1992), Taiwan [Penghu Islands (present study)]. Oceania: Australia (Schicha 1987), New Caledonia (Schicha 1981).



FIGURES 45–48. *Amblyseius fletcheri* **Schicha, 1981**, female, legs (trochanter–basitarsus). 45. Leg I; 46. Leg II; 47. Leg III; 48. Leg IV.

Remarks

Schicha (1981) described the species based on the material collected from *Musa paradisiaca* in New Caledonia. We compared the specimens (deposited in UPLB-MNH) with these specimens, and no major differences were identified.

***Phytoseius rachelae* Swirski & Shechter, 1961**

Phytoseius (*Dubininellus*) *rachelae* Swirski & Shechter, 1961: 108
Phytoseius (*Phytoseius*) *rachelae.*—Ehara 1966: 26.
(Figures 49–63)

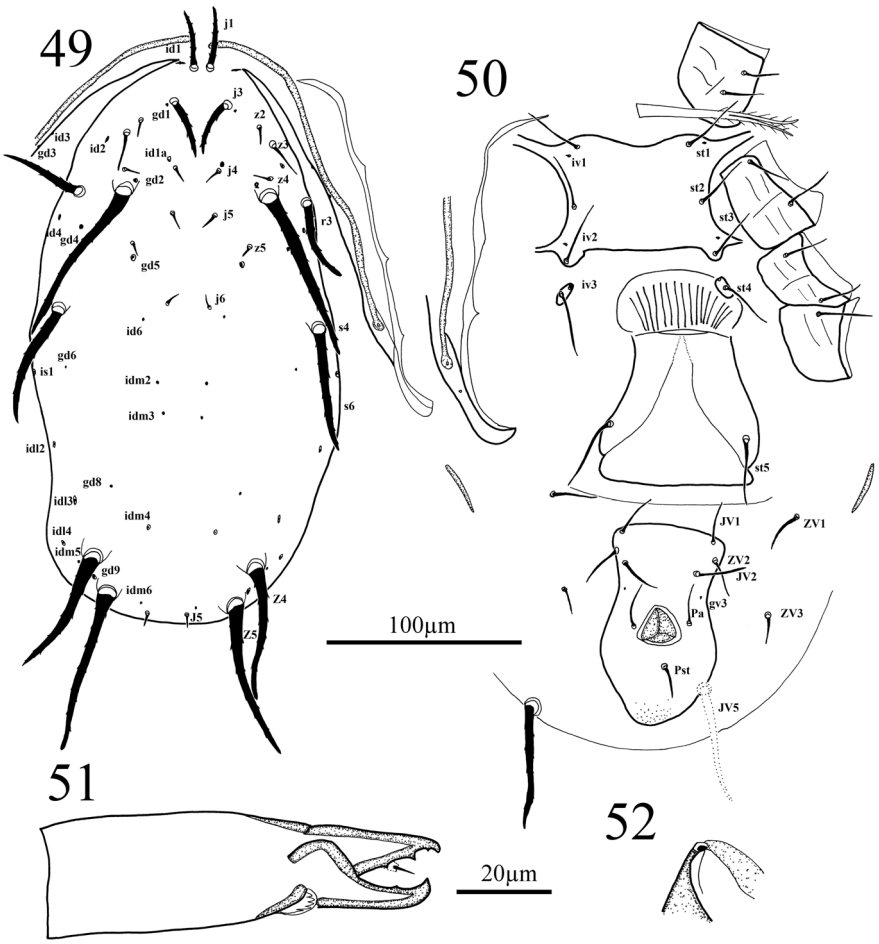
Female (n=5)

A lightly sclerotized mite. Idiosomal setal pattern: 12A:3A/JV-3,4:ZV.

Dorsal idiosoma (Figure 49). Dorsal shield smooth, longer than wide, 298 (284–313) long, 147 (132–168) wide at level of *s4*, 133 (119–140) wide at level of *S4*, seta *r3* inserted on dorsal shield; seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), fourteen pairs of poroids (*id1*, *id1a*, *id2*, *id4*, *id6*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of dorsal setae: *j1* 30 (27–32), *j3* 30 (27–32), *j4* 8 (6–10), *j5* 7 (6–8), *j6* 6 (5–7), *J5* 8 (6–11), *z2* 8 (6–10), *z3* 18 (16–21), *z4* 9 (7–14), *z5* 7 (6–9), *Z4* 64 (59–67), *Z5* 75 (65–80), *s4* 92 (87–97), *s6* 63 (56–71), *r3* 41 (35–44). Setae *j1*, *j3*, *z3*, *Z4*, *Z5*, *s4*, *s6*, *r3* longer, thickened and serrated, other short and smooth. Setae *r3* inserted

on dorsal shield. Peritreme extending to *j1* level, peritremal shield smooth, lightly sclerotized, with one pair of gland pores (*gd3*) and one pair of poroids (*id3*).

Ventral idiosoma (Figure 50). Sternal shield smooth, much wider than long, posterior margin straight, 67 (63–71) long, 88 (84–91) wide at *st3* level, with three pairs of setae *st1* 29 (25–34), *st2* 26 (19–33), *st3* 24 (19–27) and two pairs of poroids (*iv1*, *iv2*). Exopodal shield at coxae II–IV. Metasternal platelets tear-shaped, with a pair metasternal setae, *st4* 24 (16–27), and one pair of poroids (*iv3*). Genital shield smooth, posteriorly truncate, *st5* 25 (22–27), 80 (77–85) wide. Distances between *st1*-*st1* 56 (55–58), *st2*-*st2* 65 (62–69), *st3*-*st3* 74 (70–78), *st1*-*st3* 59 (54–62), *st5*-*st5* 71 (68–73). Ventrianal shield smooth, much longer than wide, with waist, 92 (84–101) long, 55 (50–64) wide at level of *ZV2* and 55 (50–67) wide at level of anus; with three pairs of pre-anal setae, *JV1* 17 (16–20), *JV2* 15 (13–17), *ZV2* 13 (10–16); gland pore *gv3* small, round, migrate to the margin of ventrianal shield, *Pa* 14 (13–15), *Pst* 14 (12–16) one shield. Setae *JV5* 48 (41–51), *ZV1* 19 (17–20), *ZV3* 13 (10–17) on interscutal membrane. All ventral setae smooth, except seta *JV5* thickened and serrated. One pair of metapodal plates: primary platelet 24 (18–29) long, 4 (3–4) wide.



FIGURES 49–52. *Phytoseius rachelae* **Swirski & Shechter, 1961**, female. 49. Dorsal shield; 50. Ventral idiosoma; 51. Chelicera; 52. Spermatheca.

Chelicera (Figure 51). Movable digit 24 (23–27) long, with one tooth; fixed digit 25 (23–28) long, with three teeth, with pilus dentilis.

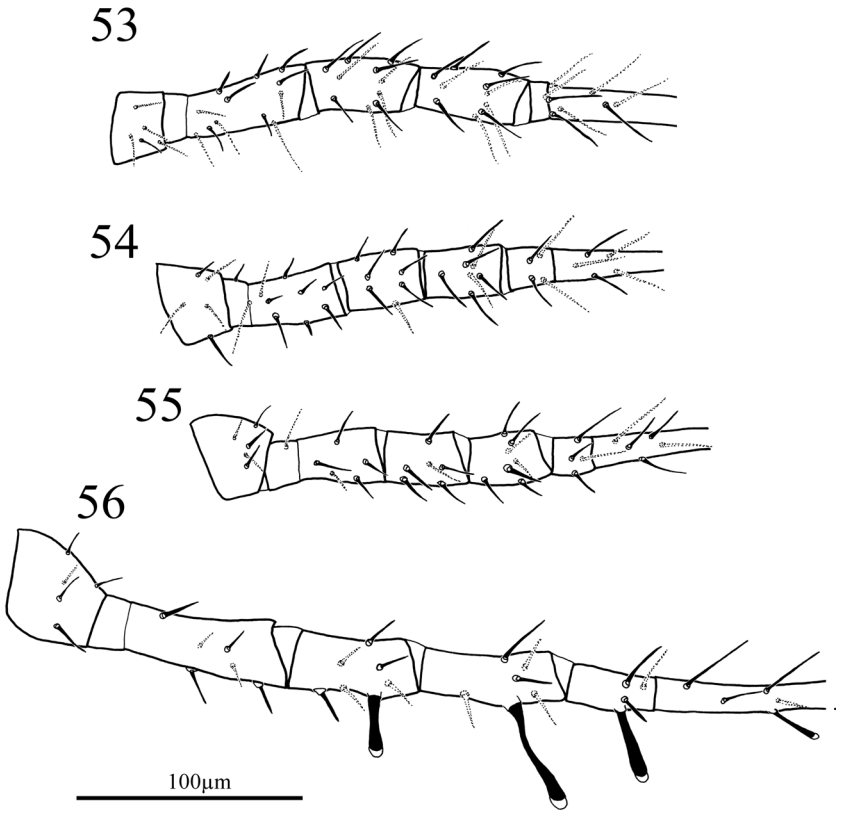
Spermatheca (Figure 52). Calyx of spermatheca goblet-shaped, flaring distally, 9 (8–11) long, 5 (5–6) wide, and atrium nodular, major and minor ducts visible.

Legs (Figures 53–56). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 2-2/0-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/0-2/0-1, 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* IV (*ad2*) 21 (19–24), *Sti* IV (*ad*) 49 (48–50), *Sbta* IV (*d*) 30 (27–33), *Sdta* IV (*d*) 23 (21–25). Macrosetae apically shovel-shaped with expanded blade.

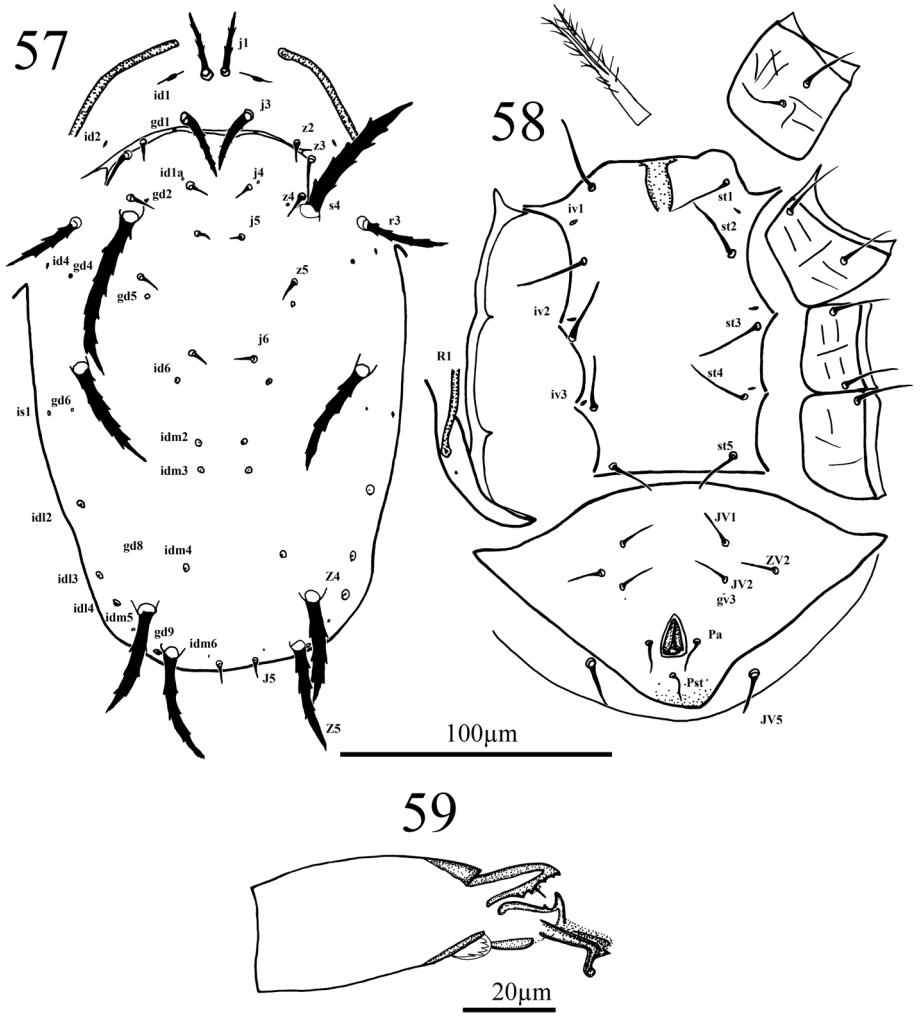
Male (n=5)

A lightly sclerotized mite. Idiosomal setal pattern: 12A:3A/JV-3,4:ZV-1,3.

Dorsal idiosoma (Figure 57). Dorsal shield smooth, longer than wide, 233 (225–245) long, 142 (130–157) wide at level of *s4*, 119 (107–135) wide at level of *S4*; seven pairs of gland pores (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, *gd9*), fourteen pairs of poroids (*id1*, *id1a*, *id2*, *id4*, *id6*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl2*, *idl3*, *idl4*); length of setae: *j1* 21 (17–23), *j3* 26 (25–26), *j4* 6 (5–8), *j5* 6 (4–7), *j6* 5 (4–6), *J5* 6 (5–7), *z2* 7 (7–8), *z3* 11 (8–14), *z4* 8 (7–9), *z5* 6 (4–9), *Z4* 39 (36–43), *Z5* 44 (40–48), *s4* 60 (52–66), *s6* 41 (38–43), *r3* 33 (28–37), Setae *j1*, *j3*, *z3*, *Z4*, *Z5*, *s4*, *s6*, *r3* longer, thickened and serrated, other short and smooth. Setae *r3* inserted on dorsal shield. Peritreme extending to *j3* level; peritremal shield lightly sclerotized.



FIGURES 53–56. *Phytoseius rachelae* **Swirski & Shechter, 1961**, female, legs (trochanter–basitarsus). 53. Leg I; 54. Leg II; 55. Leg III; 56. Leg IV.

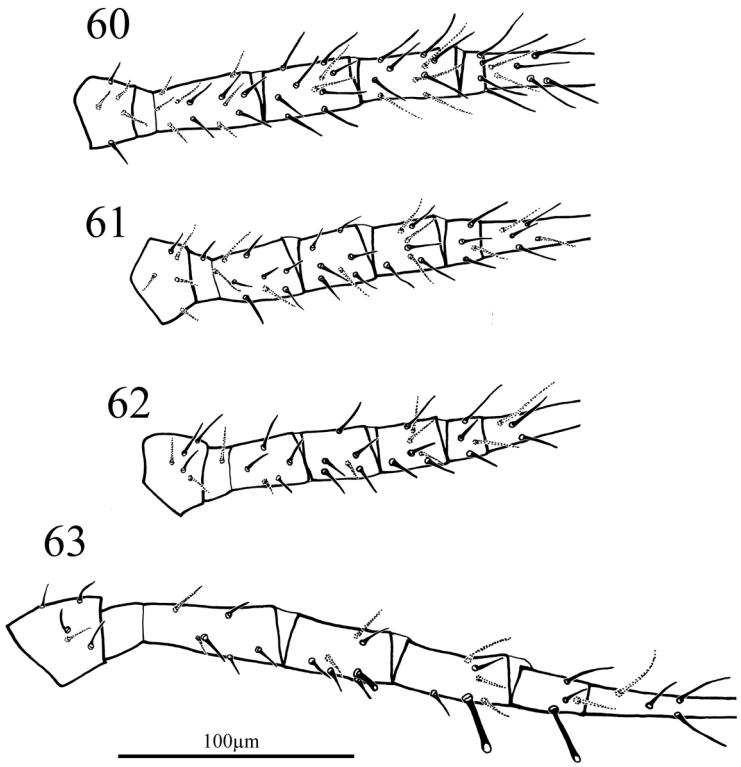


FIGURES 57–59. *Phytoseius rachelae* **Swirski & Shechter, 1961**, male. 57. Dorsal shield; 58. Ventral idiosoma; 59. Chelicera and spermatodactyl.

Ventral idiosoma (Figure 58). Sternogenital shield smooth, posterior margin almost straight, much longer than wide, 119 (117–121) long, 84 (82–89) wide at level *st2*, with five pairs of setae *st1* 25 (22–27), *st2* 22 (16–26), *st3* 21 (19–22), *st4* 19 (18–18), *st5* 17 (14–20), three pairs of poroids (*iv1*, *iv2*, *iv3*). Exopodal shield at coxae II–IV. Distance between *st1-st1* 52 (52–54), *st2-st2* 57 (54–61), *st3-st3* 66 (64–68), *st4-st4* 56 (55–57), *st5-st5* 49 (43–51), *st1-st5* 103 (99–106). Ventrianal shield subtriangular, reticulated, 95 (91–100) long, 145 (136–151) wide at level of anterior corner and 75 (70–79) wide at level of anus, not fused with peritremal shield cingulum; with three pairs of pre-anal setae, *JV1* 14 (11–16), *JV2* 12 (10–14), *ZV2* 11 (11–12); gland pore *gv3* small, round, migrate from the normal position, *Pa* 12 (11–13), *Pst* 12 (10–12) on shield; *JV5* 20 (17–22) on interscutal membrane. All ventral setae smooth.

Chelicera (Figure 59). Movable digit 17 (16–21) long, with one tooth; fixed digit 17 (16–20), with four teeth, with pilus dentilis; spermatodactyl L-shaped, shaft 15 (13–16) long, heel rounded, foot 9 (8–9) long.

Legs (Figures 60–63). Complement of setae on coxae I–IV: 2-2-2-1. Complement of setae on trochanter I–IV: 5-5-5-5. Chaetotaxy (femur to basitarsus): 2-3/1-2/2-2, 2-2/1-2/1-2, 2-2/1-2/1-2, 1-1/1-1; leg II, 2-3/1-2/1-1, 2-2/0-2/0-1, 1-1/1-2/1-1, 1-1/1-1; leg III, 1-2/1-1/0-1, 1-2/0-2/0-1, 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* IV *(ad2*) 15 (13–18), *Sti* IV (*ad*) 25 (21–30), *Sbta* IV (*d*) 28 (26–29). *Sdta* IV (*d*) 21 (19–23). Macrosetae apically shovel-shaped with expanded blade.



FIGURES 60–63. *Phytoseius rachelae* **Swirski & Shechter, 1961**, male, legs (trochanter–basitarsus). 60. Leg I; 61. Leg II; 62. Leg III; 63. Leg IV.

Specimens examined

Three females one male (89-Ph-0270, 71, 72, 80) from #1 (TARL); 11 females 5 males (89-Ph-0241, 42, 44, 51, 52, 54, 55, 56, 57, 62, 63, 74, 75, 77, 89, 90) from #4 (TARL); two females (89-Ph-0273- 76) from #5 (TARL); two females (89-Ph-0268, 86) from #9(TARL); four females two males (89-Ph-0240, 43, 53, 58, 59, 88) from #11 (TARL); seven females four males (89-Ph-0245, 46, 65, 66, 67, 81, 82, 83, 84, 85, 87) from #14 (TARL); one female (89-Ph-0264) from #17 (TARL).

Distribution

Asia: China [Hong Kong (Swirski & Shechter 1961)], India (Gupta 1980), Indonesia (Ehara 2002), Taiwan [Penghu Islands (present study)].

Remarks

Swirski & Shechter (1961) described the species, having found it on the lower side of leaves of *Rhus chinensis* (Anacardiaceae) in Hong Kong. After that, this species was reported in India (Gupta 1980) and Indonesia (Ehara 2002). Based on our phytoseiid survey, this species was only found in

the Penghu Islands; no specimens were found in the main island of Taiwan. Additionally, this species was only found in the 1989 survey.

The holotype of the species was collected from the lower side of leaves of *R. chinensis* (Anacardiaceae), and paratypes and additional specimens were collected from plants with pubescent leaves. Therefore, the species is considered to have a subtype III-a lifestyle which is characterized as a generalist predator that lives on pubescent leaves (McMurtry *et al*. 2013).

Discussion

The Phytoseiidae fauna in the Penghu Islands is studied for the first time in this study. Herein, we reported the results of two phytoseiid surveys conducted in the Penghu Islands in 1989 and 2020. We documented 16 phytoseiid species, including two new species belonging to the *Proprioseiopsis* and *Neoseiulus* genera, and three species not recorded in the main island of Taiwan (Liao *et al.* 2020). The Phytoseiidae species in the Penghu Islands are similar to the species found in the main island of Taiwan, Southern China, Okinawa, and the Philippines. The lists of phytoseiid species recorded from the investigations in 1989 and 2020, however, are quite different. Several possible reasons that may be changed over time such as climate, habitat, plant species, invasive plant influences, human activities and socioeconomic structures etc. (Hsu 2005; Wei *et al*. 2020). The comprehensive phytoseiid investigation in Penghu Islands is needed in the future to explore what factors affected the phytoseiid mite fauna.

In addition, the land of the Penghu Islands has high salinity owing to its proximity to the sea, coastal plants dominate these islands. *Hibiscus tiliaceus* is the most dominant plant on which we observed many phytoseiid individuals with a subtype III-a lifestyle. Also, Liao *et al*. (2017) described *T.* (*A.*) *crossostephium* from rocky shores on Lanyu Island, a special habitat for phytoseiid mites based on the lifestyle classification proposed by McMurtry *et al*. (2013). We assumed that the species would also be present in the Penghu Islands where rocky shores are also quite common. However, we did not find any in the present study. Many islands of the Penghu archipelago have a potential for description of new species and new records are waiting for further expedition.

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