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Discovery of a new species of genus *Typhlodromus* Scheuten (Acari: Phytoseiidae: Typhlodrominae) on rocky shore habitat from Lanyu Island

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Abstract

Phytoseiid mites have been intensively surveyed in Taiwan during the past decades because of their potential as biological control agent. Despite the fact, many regions of Taiwan remain under-explored especially in mountain areas and neighboring islands. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** was collected from *Crossostephium chinense* (L.) Makino (Asteraceae) on rocky shore habitat during a survey on Lanyu Island. In this paper, presence of a phytoseiid mite on rocky shores is reported for the first time. A detailed morphological description of the new species and a key to the Taiwanese species of subgenus *Anthoseius* are provided.

Key words: Phytoseiidae, Taxonomy, Lanyu Island, rocky shore, new species

Introduction

Phytoseiid mites have received considerable attention because of their potential as biological control agents of phytophagous mites and other small arthropods (McMurtry *et al.* 2013). Thus far, more than 2,700 species included in 91 genera and three subfamilies, have been recorded worldwide (Chant & McMurtry 2007; Demite *et al.* 2017). Lanyu Island (also called Botel Tobago Island or Orchid Island) is located southeast of Taiwan and north of Luzon Island, Philippines. Since the 19th century, the great diversity of fauna found in this 48 km^2 island has attracted several taxonomists. Tseng (1975) reported three phytoseiid species in Lanyu Island, including *Shiehia multispinosa* Tseng (= *Neoseiulella compta* (Corpuz)), *Typhlodromus* (*Anthoseius*) *tridentiger* Tseng, and *T.* (*A.*) *lanyuensis* Tseng. Liao *et al*. (2017) described *Euseius paraovalis* Liao & Ho. However, knowledge of Lanyu phytoseiid mites is fragmented.

Phytoseiid mites are free-living and terrestrial mites distributed worldwide, with diverse habitats, from the tundra region to tropical rain forests (Chant 2007; McMurtry *et al.* 2013). These mites extensively exploit the foliage habitat of higher plants, and can be discovered in any place covered with vegetation (Chant & McMurtry, 2007; McMurtry *et al*. 2013). However, the phytoseiid fauna of coastal regions remains poorly identified, particularly those on the rocky shores. Moraes & Oliveira (1982) and Stathakis *et al.* (2016) reported phytoseiid mites found in the coastal areas, but only in the vegetative lands, not the rocky shores. A rocky shore is a harsh habitat for mites. Mites found in rocky shores are typically oribatids and rarely mesostigmatids (e.g. families Digamasellidae, Rhodacaridae) (Barendse *et al.* 2002). This study presents one new species *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** found on *C. chinense* on the rocky shores of

Lanyu Island. Descriptions of both sexes are provided, along with a key to Taiwanese *Typhlodromus* (*Anthoseius*) species.

Materials and Methods

Specimens examined in this study were collected from Lanyu Islands during 2009–2016, with a particular focus on coastal region. Specimens were mounted in Hoyer's medium. Phytoseiid mites were examined under an optical microscope (Olympus® BX51), and measured using stage-calibrated ocular micrometers and ImageJ 1.47 computer program (Schneider *et al.* 2012), photos taken by microscopic camera (Motic® Moticam 5^{+}). All measurements were provided in micrometers, holotype measurements are shown in bold type for the new species, followed by their mean and range in parentheses. 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: ESALQ-USP (Escola Superior de Agricultura Luiz de Queiroz, Piracicaba, State of São Paulo, Brazil), 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), NPUST (National Pingtung University of Science and Technology, Pintung County, Taiwan), TARI (Taiwan Agricultural Research Institute, Taichung City, Taiwan), TARL (Taiwan Acari Research Laboratory, Taichung City, Taiwan). Additionally, two paratypes (Aca25-3, 6) and two voucher specimens (Aca4301, 4335) of the closely related species *T. philippinensis* were received on loan from UPLB-MNH (Museum of Natural History, University of the Philippines Los Banos, Los Banos, Philippines), in order to confirm important morphological characters. 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

Description of new species

Typhlodromus (*Anthoseius*) *crossostephium* **sp. nov.** Liao & Ho

Diagnosis

Female dorsal surface mostly reticulated, bearing 21 pairs of dorsal setae (including *r3*, *R1*). All setae smooth, shovel-shaped apically except for *Z4* and *Z5* which are distinct shovel-shaped apically with expanded blade [1]. Five pairs of solenostomes, (*gd2*, *gd4*, *gd6*, *gd8*, *gd9*) visible on the dorsal shield. Peritreme extending to level of setae *j1*. Sternal shield with three pairs of setae; ventrianal shield bearing four pairs of pre-anal setae, with solenostomes (*gv3*). Fixed digit of chelicera with four teeth; movable digit with three teeth. Spermatheca with calyx bell-shaped. Leg III and leg IV both with

1. Previous studies described the shape called "knobbed, blunt". We observed lateral view of setae with transparent ends (e.g. dorsal setae and *JV5*), and considered the transparent end shaped like shovel, and *Z4*, *Z5* with expanded blade (Fig. 3–E).

three pair of shovel-shaped macrosetae; genu II with seven setae. Male ventrianal shield bearing six pairs of pre-anal setae; spermatodactyl foot L-shaped.

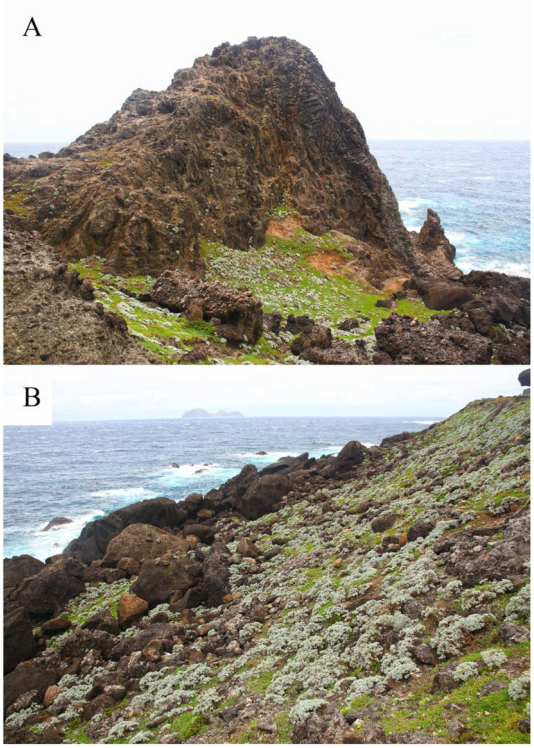

FIGURE 1. The location where the *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** were found. A. Type locality; B. Neighboring rocky shores.

Female (n=10)

A lightly sclerotized mite. Idiosomal setal pattern: 12A:8A/JV:ZV.

Dorsum (Fig. 2–A). Dorsal shield nearly oval, constricted at level of *R1*, with lateral reticulation; **317** 319 (308–328) long (*j1–J5* level) and **187** 193 (187–206) wide at level of *j6*, **183** 190 (180–199) wide at level of *S4*; five pairs of solenostomes on dorsal shield, (*gd2*, *gd4*, *gd6*, *gd8*, *gd9*), 13 pairs of lyrifissures, (*id1*, *id2*, *id1a*, *id4*, *id6*, *idm2*, *idl2*, idm3, *idl3*, *idx*, *idl4*, *idm5*, *idm6*); length of setae: *j1* **20** 21 (19–23), *j3* **22** 22 (19–24), *j4* **14** 14 (11–18), *j5* **13** 14 (12–16), *j6* **17** 17 (16–19), *J2* **24** 23 (21–27), *J5* **9** 8 (6–11), *z2* **16** 14 (13–16), z3 **17** 19 (16–21), *z4* **21** 21 (17–23), *z5* **15** 16 (13–20), *Z4* **32** 31 (26–37), *Z5* **44** 45 (41–51), *s4* **21** 21 (19–24), *s6* **24** 25 (22–29), *S2* **23** 27 (23–31), *S4* **19** 23 (19–31), *S5* **16** 14 (9–18), *r3* **15** 16 (14–19), *R1* **13** 13 (11–15). All setae smooth, shovel-shaped apically except for *Z4* and *Z5* which are distinct shovel-shaped apically with expanded blade (Fig. 2–E).

Peritreme (Figs. 2–A, B). Peritreme extend to level of *j1*; peritremal shield lightly sclerotized, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

Venter (Fig. 2–B). Sternal shield smooth, posterior margin irregular, much wider than long, **52** 55 (46–63) long, **79** 84 (75–89) wide, with three pairs of setae *st1* **25** 25 (22–29), *st2* **21** 20 (19–21), *st3* **25** 20 (15–25), and two pairs of lyrifissures (*pst1*, *pst2*). Exopodal shield at coxae II–IV. Metasternal platelets tear-shaped, with one pair of metasternal setae, *st4* **17** 19 (15–22), with one pair of lyrifissures (*pst3*). Genital shield smooth, with one pair of genital setae *st5* **23** 17 (12–23), **69** 70 (65–75) wide at level of genital setae. Distances between *st1–st1* **46** 46 (43–49), *st2–ST2* **57** 60 (56–

64), *st3–st3* **67** 69 (66–72), *st1–st3* **62** 62 (59–64), *st5–st5* **62** 619 (59–67). Ventrianal shield pentagonal, smooth, **99** 103 (98–109) long, **85** 90 (84–95) wide at level of *ZV2*, **66** 67 (63–71) wide at level of anus; with four pairs of pre-anal setae, *JV1* **15** 13 (11–16), *JV2* **14** 12 (8–16), *JV3* **10** 13 (10–15), *ZV2* **16** 14 (9–17), solenostomes *gv3* crescentic; *Pa* **10** 10 (8–14), *Pst* **9** 10 (8–12) on shield. Setae *JV4* **11** 11 (9–13), *JV5* **30** 31 (26–37), *ZV1* **17** 16 (13–19), *ZV3* **8** 9 (6–12) on interscutal membrane. All setae smooth, sharp pointed, *JV5* shovel-shaped. Two metapodal plates **20** 21 (18–27) long, **3** 4 (3–5) wide, **10** 8 (5–12) long, **2** 2 (1–2) wide.

Spermatheca (Fig. 2–D). Calyx bell-shaped, **17** 16 (14–19) long, **7** 8 (7–10) wide, atrium connected to the calyx with a neck, minor and major ducts visible.

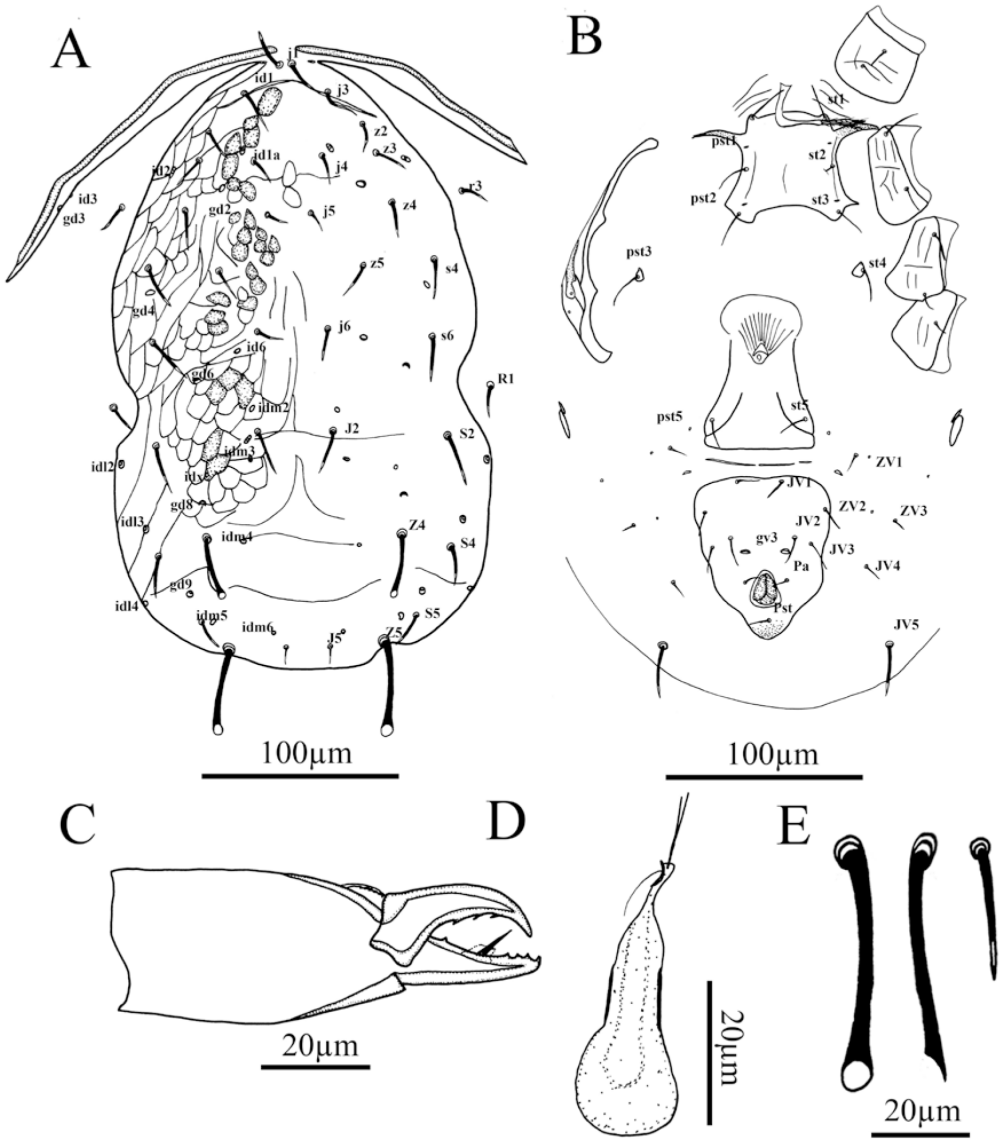

FIGURE 2. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** female. A. Dorsal shield; B. Ventral idiosoma; C. Chelicera; D. Spermatheca; E. Setae *Z5* dorsal and lateral views and seta *S2*.

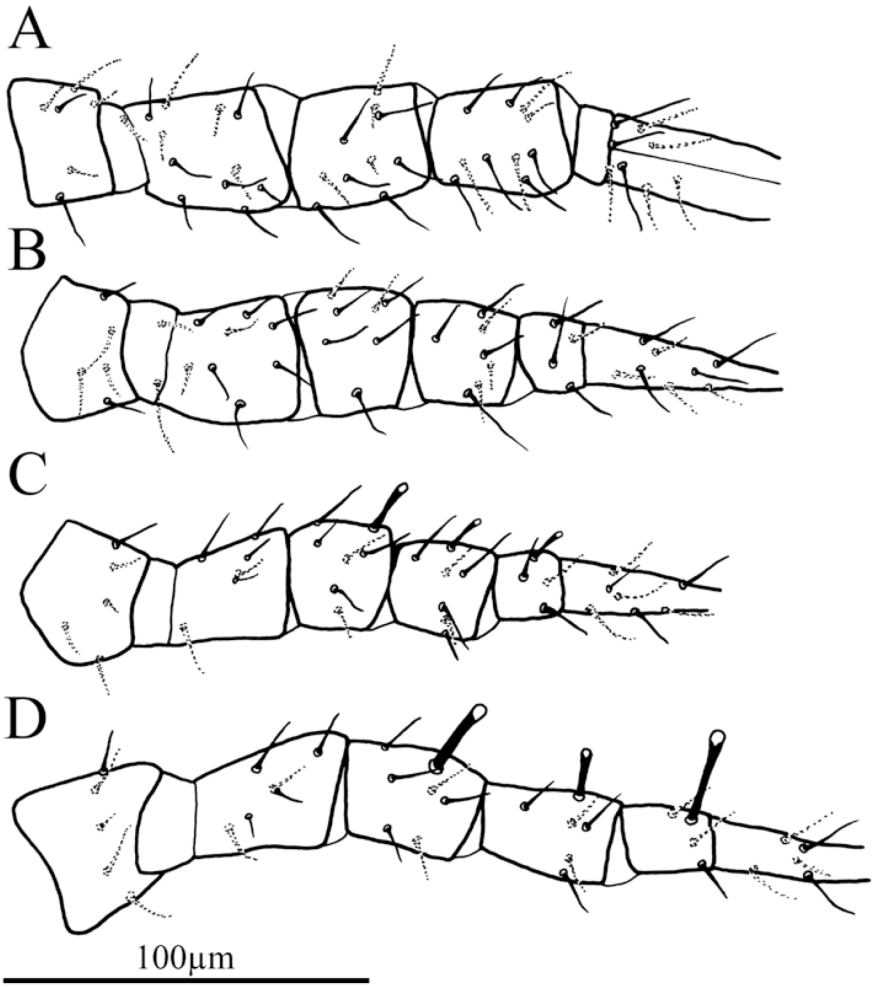

FIGURE 3. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** female, legs. A. Leg I anterior view; B. Leg II dorsal-posterior view; C. Leg III posterior view; D. Leg IV posterior view.

Chelicera (Fig. 2–C). Movable digit **25** 26 (25–28) long, with three teeth; fixed digit **26** 25 (23–26) long, anterior half with three teeth, posterior half with one tooth, with pilus dentilis.

Legs (Figs. 3). Coxal formula 2-2-2-1. 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, 1-2/0-2/1-1, 1-1/0-2/1-1, 1-1/1-1. Macrosetae: *Sge* III (ad2) **14** 14 (14–16), *Sti* III (ad) **11** 11 (10–13), *St* III (ad) **9** 9 (7–10), *Sge* IV (ad2) **22** 22 (21–23), *Sti* IV (ad) **13** 13 (12–15), *St* IV (ad) **24** 25 (22–27). Marcrosetae apically shovel-shaped.

Male (n=10)

A lightly sclerotized mite. Idiosomal setal pattern: 13A: 8B/JV-4: ZV-1, 3.

Dorsum (Fig. 4–A). Dorsal shield nearly oval, constricted at level of *R1*, with lateral reticulation; 252 (240–270) long (*j1-J5* level) and 168 (160–178) wide at level of *j6*, 135 (131–140) wide at level of *S4*, five pairs of solenostomes on dorsal shield, (*gd2*, *gd4*, *gd6*, *gd8*, *gd9*), thirteen

pairs of lyrifissures, (*id1*, *id2*, *id1a*, *id4*, *id6*, *idm2*, *idl2*, idm3, *idl3*, *idx*, *idl4*, *idm5*, *idm6*); length of setae: *j1* 14 (10–19), *j3* 18 (16–20), *j4* 13 (11–16), *j5* 12 (11–14), *j6* 14 (11–16), *J2* 18 (16–21), *J5* 8 (6–10), *z2* 12 (10–13), *z3* 15 (13–17), *z4* 16 (14–18), *z5* 13 (11–16), *Z4* 24 (22–26), *Z5* 31 (29–34), *s4* 17 (15–21), *s6* 20 (18–23), *S2* 21 (20–22), S4 18 (16–19), *S5* 13 (11–15), *r3* 13 (11–16), *R1* 10 (9–12). All setae smooth, shovel-shaped apically except for *Z5* which are distinct shovel-shaped apically with expanded blade.

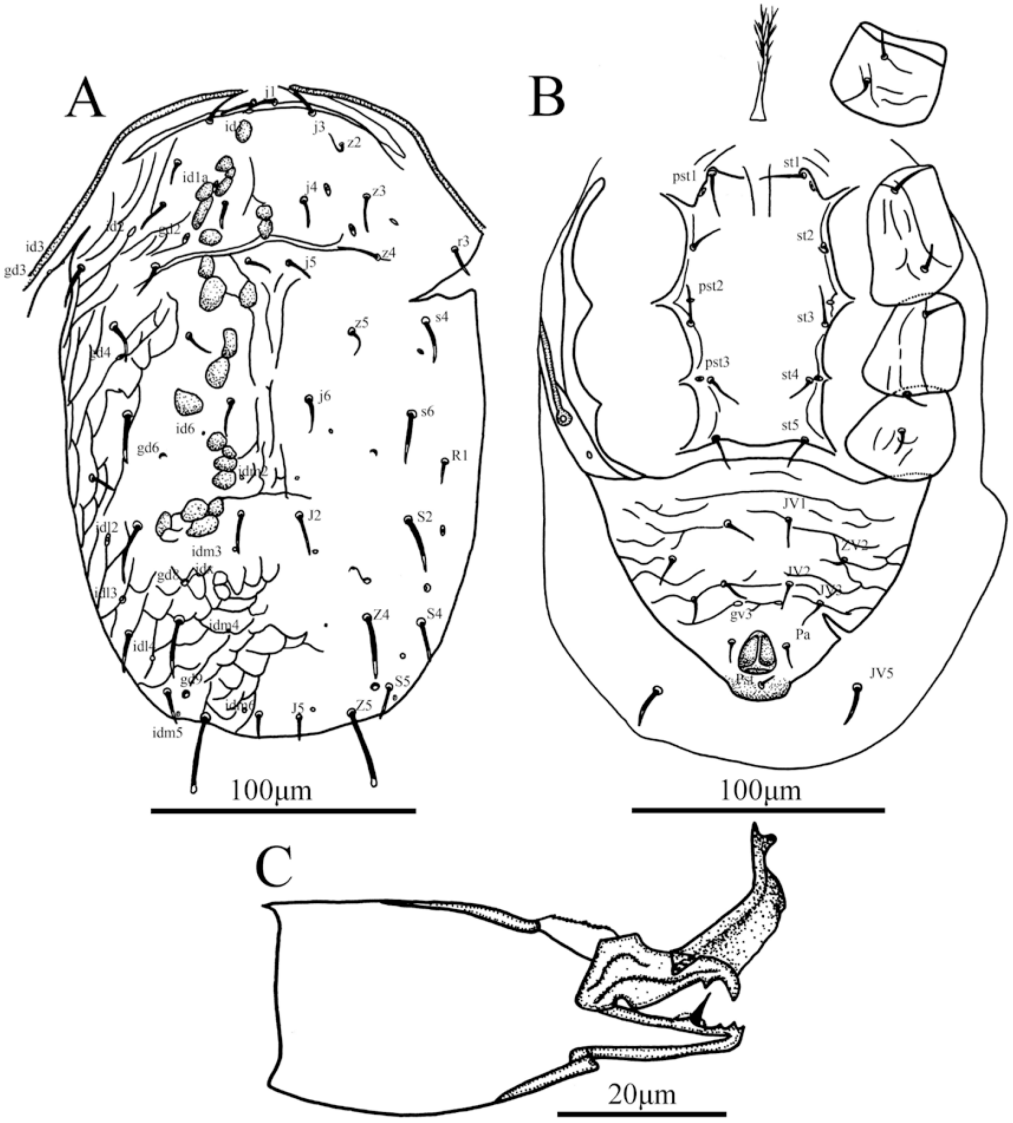

FIGURE 4. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** male. A. Dorsal shield; B. Ventral idiosoma; C. Chelicera and spermatodactyl.

Peritreme (Figs. 4–A, B). Peritreme extending to level of *j1*; peritremal shield lightly sclerotized, with one pair of solenostomes (*gd3*), one pair of lyrifissures (*id3*).

Venter (Figs. 4–B). Sternogenital shield smooth, lateral slightly reticulated, posterior margin with slightly medium projection, longer than wide, 110 (105–123) long, 65 (60–73) wide at level of

st5, with five pairs of setae, *st1* 16 (13–18), *st2* 11 (7–15), *st3* 14 (9–18), *st4* 13 (9–16), *st5* 12 (10–15), three pairs of lyrifissures (*pst1*, *pst2*, *pst3*). Distances between *st1–st1* 38 (36–42), *st2–st2* 54 (50–57), *st3–st3* 56 (53–61), *st4–st4* 42 (39–46), *st5–st5* 37 (34–42), *st1–st5* 110 (106–118). Exopodal shield at coxae II–IV. Ventrianal shield subtriangular, with striation, 97 (93–101) long, 136 (129–144) wide at anterior corner, 60 (52–97) at level of anus, fused with peritremal shield cingulum; with four pairs of pre-anal setae, *JV1* 12 (9–14), *JV2* 11 (10–12), *JV3* 10 (7–12), *ZV2* 11 (9–13), solenostomes *gv3* crescentic; *Pa* 8 (7–12), *Pst* 9 (7–12) on shield. Setae *JV5* 16 (13–18) on interscutul membrane. All setae smooth, sharp pointed, *JV5* shovel-shaped.

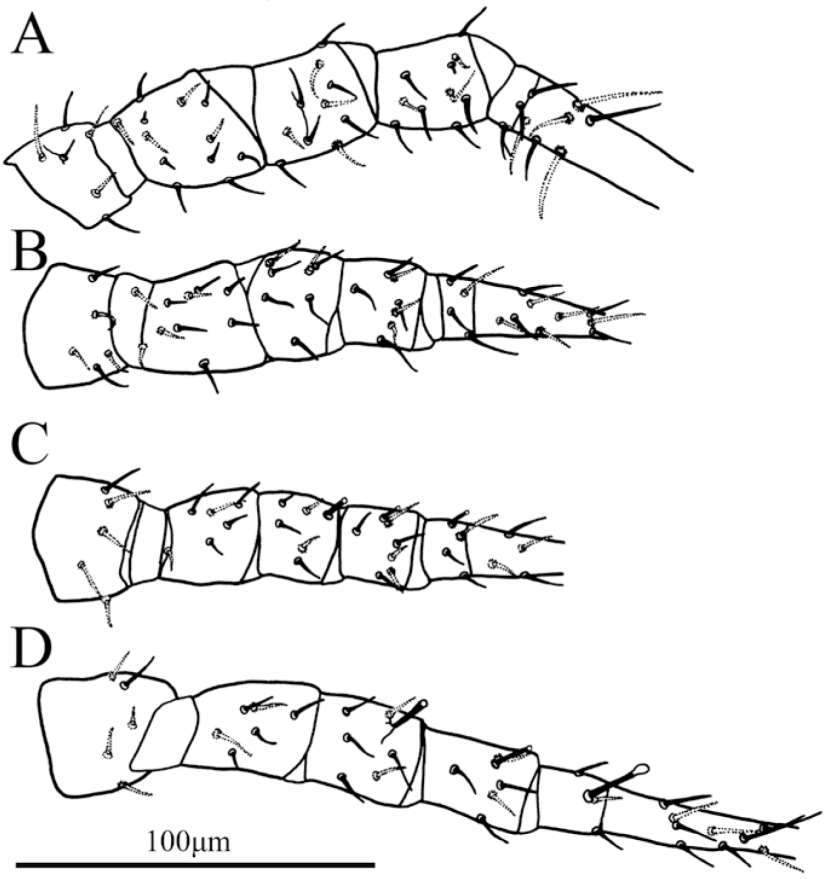

FIGURE 5. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** male, legs. A. Leg I anterior view; B. Leg II dorsal-posterior view, C. leg III dorsal-posterior view; D. Leg IV dorsal-posterior view.

Chelicera (Fig. 4–C). Movable digit 18 (16–21) long, with one tooth; fixed digit 20 (18–21) long, anterior half with two teeth, with pilus dentilis. Spermatodactyl L-shaped, shaft 18 (18–18) long, heel rounded, foot 11 (9–13) long, with expanded toe and lateral thorn-like projection.

Legs (Figs. 5). Coxal formula 2-2-2-1. 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, 1-2/0-2/1-1, 1-1/0-2/1-1, 1-1/1-1. Macrosetae: *Sge* III (ad2) 9 (7–12), *Sti* III (ad) 8 (7–10), *St* III (ad) 7 (7–8), *Sge* IV (ad2) 14 (13–16), *Sti* IV (ad) 9 (7–12), *St* IV (ad) 19 (16–21).

Type specimens

Holotype female: Lanyu Island, Elephant trunk rock (22°01.077' N, 121°35.990' E, 24 m), no. 1901–3 from *Crossostephium chinense* (Compositae), 23.ix.2016, H. Y. Lin (NTU). Paratypes: Lanyu Island, Elephant trunk rock (22°01.077' N, 121°35.990' E, 24 m), six females (no. 467–1, 2, 3, 4, 5, 8) from *C. chinense*, 5.iv.2010, J. R. Liao & C. C. Ho (NMNS); Lanyu Island, Elephant trunk rock (22°01.077' N, 121°35.990' E, 24 m), 65 females 12 males (HAL099B481, 483, 484, 486, 488, 489, 490, 491, 492, 493, 495, 497, 498, 501, 502, 503, 505, 506, 507, 508, 509, 511, 512, 513, 514, 515, 516, 517, 519, 520, 522, 523, 524, 525, 526, 527, 528, 530, 531, 533, 534, 535, 536, 537, 539, 540, 541, 543, 544, 546, 547, 548, 549, 551, 553, 554, 555, 556, 557, 558, 559, 560, 561, 563, 565, 569, 571, 573, 574, 575, 577, 578, 579, 581) from *C. chinense*, 5.iv.2010, C. C. Ho (5 females in NTU, 4 females 4 males in NSNM, remaining in TARL); Lanyu Island, Elephant trunk rock (22°01.077' N, 121°35.990' E, 24 m), one female (no. 1647–2) from *C. chinense*, 4.ix.2016, H.Y. Lin (NPUST); Lanyu Island, Five holes cave (22°4.914' N 121°30.664' E, 4 m), two females (no. 1895–1, 2) from *C. chinense*, 4.ix.2016, H. Y. Lin (TARI); Lanyu Island, Lovers cave (22°3.693' N, 121°34.427' E, 12 m), one female (no. 1896–1) from *C. chinense*, 4.ix.2016, H. Y. Lin (ESALQ-USP); three females and eight males (no. 1901–2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14) data as holotype (NTU); Lanyu Island, Red head rock (22°01.077' N, 121°35.990' E, 24 m), one female one male (no. 2064–1, 2) from *C. chinense*, 4.ix.2016, C. F. Hsu (NCHU).

Etymology

The name *crossostephium* refers to the host plant *Crossostephium chinense* (L.) Makino.

Remarks

This new species is similar to *T.* (*A.*) *acaciae* Schultz, 1973, *T.* (*A.*) *betulae* (Kolodochka, 1992), *T.* (*A.*) *brisbanensis* Schicha, 1978, *T.* (*A.*) *bullatus* van der Merwe, 1968, *T.* (*A.*) *gressitti* McMurtry & Moraes, 1985, *T.* (*A.*) *gutierrezi* Blommers, 1973, *T.* (*A.*) *krimbasi* Papadoulis & Emmanouel, 1997, *T.* (*A.*) *philippinensis* Corpuz, 1966, *T.* (*A.*) *tridentiger* Tseng (1975) by having four pairs of pre-anal setae, pre-anal pores present and peritreme extend to setae *j1*, setae *R1* off dorsal shield, 3 teeth on movable digit, *st3* on sternal shield, seta *Z5* with shovel-shaped end, leg IV with 3 macrosetae. Differences between *T.* (*A*). *crossostephium* **sp. nov.** and related species are given in Table 1.

TABLE 1. Differences between *Typhlodromus* (*A.*) *crossostephium* **sp. nov.** and related species.

	solenostomes	Calyx of spermatheca	Teeth on FD/MD	*Z4* shape	*Z4* end	*Z5* shape	*Z5* end
acaciae [a]	5	bell-shaped	6/3	barbed	sharp pointed	barbed	shovel-shaped with expanded bladed
betulae [b]	5	annulated	5/3	smooth	sharp pointed	barbed	shovel-shaped with expanded bladed
brisbanensis [c]	5	fundibular	8/3	barbed	sharp pointed	barbed	shovel-shaped with expanded bladed
bullatus [d]	5	fundibular	5/3	barbed	sharp pointed	barbed	shovel-shaped with expanded bladed
gressitti [e]	5	bell-shaped	4/3	smooth	sharp pointed	barbed	shovel-shaped with expanded bladed
gutierrezi [f]	5	bell-shaped	4/3	barbed	sharp pointed	barbed	shovel-shaped with expanded bladed
krimbasi [g]	5	annulated	4/3	barbed	sharp pointed	barbed	shovel-shaped with expanded bladed
philippinensis [h]	5	bell-shaped	3/3	smooth	sharp pointed	barbed	shovel-shaped with expanded bladed
tridentiger [i]	unknown	V-shaped	3/3	smooth	sharp pointed	smooth	shovel-shaped with expanded bladed
crossostephium [j]	5	bell-shaped	4/3	smooth	shovel-shaped	withsmooth	shovel-shaped with expanded bladed

.....continued on the next page

TABLE 1. (continued).

	Setae on tubercules	Remaining setae[2]	dorsal*Z4* length	*Z5* length	Setae with shovel-shaped end	Relative length of macrosetae on leg IV
acaciae [a]	lateral setae and *Z4* on tubercules	smooth	45	57	Z5	*St* IV > *Sge* IV > *Sti* IV
betulae [b]	without tubercules	smooth	31	52	Z5	*St* IV > *Sti*IV > *Sge* IV
brisbanensis [c]	without tubercules	smooth	22–34	41–59	Z5	*St* IV > *Sti*IV > *Sge* IV
bullatus [d]	without tubercules	smooth	22–34	37–54	Z5	*St* IV > *Sti*IV > *Sge* IV
gressitti [e]	without tubercules	smooth	25	48	Z5	*St* IV > *Sti*IV > *Sge* IV
gutierrezi [f]	without tubercules	smooth	30	45	Z5	*St* IV > *Sti*IV > *Sge* IV
krimbasi [g]	*S2*, *S4*, *S5*, *Z4*, *Z5* on tubercules	*j1*, *j4*, *j5*, *z2*, *z5* smooth, others barbed	49	62	Z5	*St* IV > *Sti*IV > *Sge* IV
philippinensis [h]	without tubercules	smooth	32	48	all dorsal setae	*Sge* IV > *St* IV > *Sti* IV
tridentiger [i]	without tubercules	smooth	32.5	45	none	*Sge* IV > *St* IV > *Sti* IV
crossostephium [i]	without tubercules	smooth	32	44	all dorsal setae and *JV5*	*St* IV > *Sge* IV > *Sti* IV

[a] from Schultz (1973), Ueckermann *et al.* (2008); [b] Kolodochka (1992); [c] Schicha (1978); [d] Ueckermann *et al.* (2008); [e] McMurtry & Moraes (1985); [f] Blommers (1973); [g] Papadoulis & Emmanouel (1997); [h] Corpuz (1966), Schicha & Corpuz-Raros (1992); [i] Tseng (1975), and [j]present study.

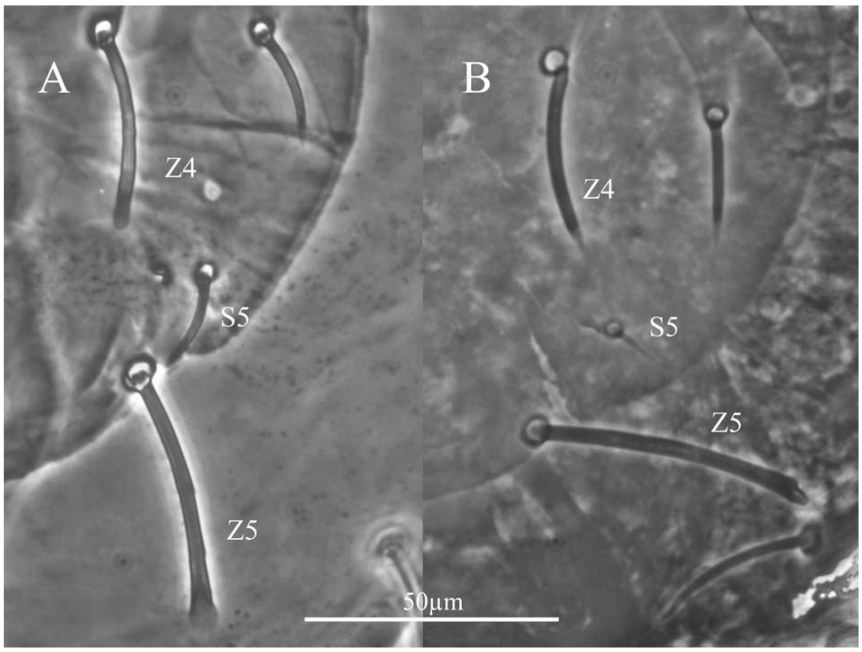

FIGURE 6. Dorsal setae *Z4*, *Z5*, *S5*. A. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** (female holotype); B. *Typhlodromus* (*Anthoseius*) *philippinensis* Corpuz, 1966 (female paratype Aca025-6).

T. (*A.*) *philippinensis* and *T.* (*A.*) *tridentiger* which seems most close to the new species. The new species differs from *T.* (*A.*) *philippinensis* in the shovel-shaped end of seta *Z4* with expanded blade (*Z4* shovel-shaped without expanded blade in *philippinensis*), *Z5* smooth (barbed in *philippinensis*), seta *S5* thicker and longer **16** 14 (9–18) (8 in *philippinensis*), relative length of macrosetae *St* IV > *Sge* IV > *Sti* IV (*Sge* IV > *St* IV > *Sti* IV in *philippinensis*), *JV5* with shovel-shaped (*JV5* normal in

2. Remaining dorsal setae refers to dorsal setae except *Z4* and *Z5*.

philippinensis), fixed digit with 4 teeth (3 teeth in *philippinensis*) (Figures 6, 7). These characters are persistent in the two paratypes and four voucher specimens of *T. philippinensis* we loaned from UPLB-MNH.

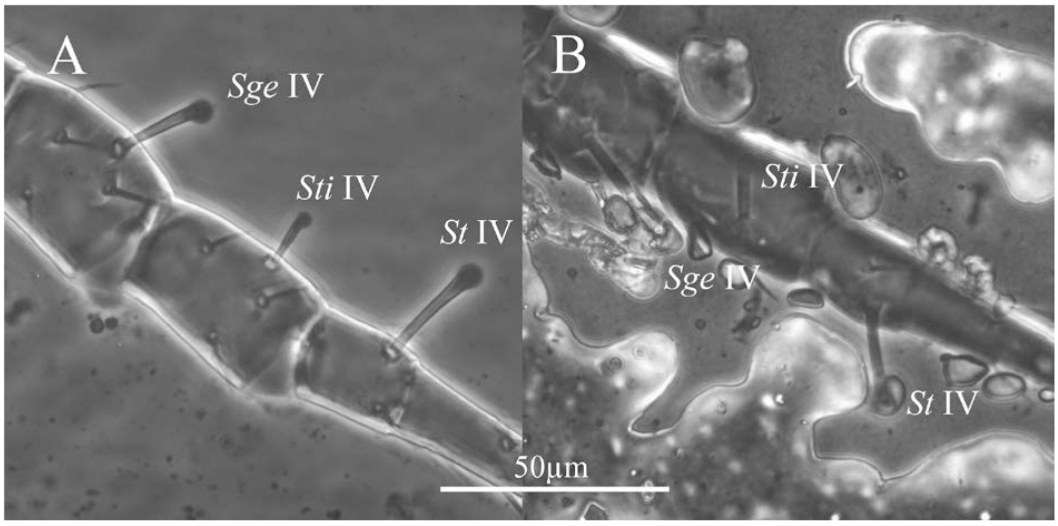

FIGURE 7. Macrosetae on leg IV. A. *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** (female holotype); B. *Typhlodromus* (*Anthoseius*) *philippinensis* Corpuz, 1966 (female paratype Aca025-6).

Tseng (1975) described *T.* (*A.*) *tridentiger* from Lanyu Island not detailed enough for the subgenus *Anthoseius*, and all specimens were lost (Liao *et al*. 2017b). It is impossible to compare the new species to type specimens of *T.* (*A.*) *tridentiger*. However, this new species is similar to *T.* (*A.*) *tridentiger* based on original description of Tseng (1975). The new species differs from *T.* (*A.*) *tridentiger* in seta *Z4* with expanded shovel-shaped end (sharp end in *tridentiger*), fixed digit with 4 teeth (3 teeth in *tridentiger*), and leg IV without additional macrosetae (with additional macrosetae on *Sge* IV, *Sti* IV in *tridentiger*). We consider *Z4* shape and additional macrosetae present/absent on leg IV could confirm they are separated species.

Key to *Typhlodromus* (*Anthoseius*) species known from Taiwan based on adult females[3]

1. Ventrianal shield with three pairs of preanal setae. . . . . ***transvaalensis***
- Ventrianal shield with four pairs of preanal setae 2
2. Preanal pores absent 3
- Preanal pores present 4
3. Sternal shield with two pairs of setae. . . . . .. ***neocrassus***
- Sternal shield with three pairs of setae. . . . . ***changi***
4. Ventrianal shield with small rounded preanal pores . . . . ***ryukyuensis***
- Ventrianal shield with crescentic preanal pores. 5
5. Sternal shield with two pairs of setae. . . . . .. ***obesus***
- Sternal shield with three pairs of setae. . . . . …6
6. Movable digit of chelicera with one tooth 7
- Movable digit of chelicera with more than one tooth 8
7. Fixed digit of chelicera with one tooth. . . . . ***lanyuensis***
- Fixed digit of chelicera with four teeth . . . . . . ***gracilentus***

3. Due to the inadequate original description, *Typhlodromus* (*Anthoseius*) *eleglidus* Tseng was not treated in the key.

8. Fixed digit of chelicera with seven teeth . . . . ***pseudoserrulatus***
- Fixed digit of chelicera with about 3–4 teeth. 9
9. Both dorsal setae *Z4* and *Z5* shovel-shaped end with expanded blade . . . . ***crossostephium* sp. nov.**
- Only dorsal setae *Z4* shovel-shaped end . . . . . ***tridentiger***

Discussion

In this study, we propose *Typhlodromus* (*Anthoseius*) *crossostephium* **sp. nov.** as a new taxon for science; this is the first report on phytoseiid species found in rocky shores. Stathakis *et al.* (2016) surveyed a coastal region, where they found phytoseiids, therefore, we suspected the natural coastal regions may have more undiscovered mite species. We observed the plant *C. chinense* on rocky shores on coastal line of the Lanyu Island. *C. chinense* naturally occurs in littoral habitats of Taiwan, Ryukyu Islands, and the Bonin Islands (Hobbs *et al.* 2013). Taiwanese people generally cultivate this plant at their home, because of its well-known efficacy in Chinese medicine. At present, finding this plant in native habitats is difficult owing to environmental destruction. Although we surveyed coastal regions surrounding the main island of Taiwan, no native *C. chinense* plants and phytoseiid mites were found. We also surveyed cultivated *C. chinense* plants, but still no phytoseiid mites were discovered. Thus, we suspected that although phytoseiid mites are strongly associated with their host plant, some other unknown factors also influence their presence; therefore, we could not find these new species on our cultivated *C. chinense* plants. Thus, further survey of the coastal ecosystem for phytoseiid mites is worth.

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