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Complementary description of the female of *Typhlodromus* (*Anthoseius*) *xini* Wu (Acari: Phytoseiidae) with the first description of its male from Sri Lanka

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Original research

ABSTRACT

Typhlodromus (*Anthoseius*) *xini* Wu is reported for the first time in Sri Lanka. Its original description is not very detailed, being based on simple drawings and an absence of diagnostic characters that include chelicera dentition and leg chaetotaxy. Therefore, a complementary description and new illustrations of this species are provided, based on specimens from both sexes collected from *Cocos nucifera* L. (Arecaceae) infested by spiralling whiteflies in Puttalam District, North Western Province, Sri Lanka. In addition, this is the first discovery and the first description of the unknown male. We also provide a brief comparison between *T.* (*A.*) *xini* and some other species of the subgenus such as *T.* (*A.*) *diumbokus* Schicha & Corpuz-Raros, *T.* (*A.*) *foraminosus*, *T.* (*A.*) *hartlandrowei* Evans, *T.* (*A.*) *neohartlandrowei* Zannou, Moraes & Oliveira, and *T.* (*A.*) *transvaalensis* (Nesbitt). All of these species are similar to each other based on the nature of their dorsal and ventral aspects, chelicera dentition, and spermatheca morphology. Most importantly, ventral seta *JV3* is absent in all of these species. In our opinion, it is apparent that all of the aforementioned species share a common ancestor. Therefore, additional molecular analysis, in combination with the use of morphological characters, would help to confirm the taxonomic relationship and evolutionary history of these species. Finally, we also proposed *T.* (*A.*) *gosabaensis* Kar & Karmakar as a new junior synonymy of *T.* (*A.*) *xini* based on the examination of its holotype.

Keywords taxonomy ; Typhlodromini ; leg chaetotaxy ; synonymy ; Indomalayan realm
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Introduction

Species of the family Phytoseiidae (Acari: Mesostigmata) are of great importance for their potential as predators of phytophagous mites and some small soft bodied insects (McMurtry *et al.* 2013). The subgenus *Anthoseius* De Leon is one of the largest groups of phytoseiid mites with more than 400 species including synonyms (Ueckermann *et al.* 2008; Tsolakis and Ragusa 2015; Ferragut and Baumann 2019; Kreiter *et al.* 2021; Jose *et al.* 2024).

In Sri Lanka, the family Phytoseiidae has been scarcely studied and only 21 species belonging to 11 genera are known from the country (Demite *et al.* 2014; Moraes *et al.* 2004; Khaustov *et al.* 2021). Among them, *Typhlodromus* (*Anthoseius*) *bifurcutus* Wu, 1983 is the only known species of the subgenus (Moraes *et al.* 2004).

In this study, we reported *Typhlodromus* (*Anthoseius*) *xini* Wu, 1983 for the first time in Sri Lanka. A complementary description based on its females is provided. In addition, the male of *T.* (*A.*) *xini* is described for the first time.

Material and methods

Leaf samples of *Cocos nucifera* L. (Arecaceae) infested by spiralling whiteflies were collected from Wennapuwa, Puttalam District, North Western Province, Sri Lanka. Materials were collected and brought to the Department of Agricultural Biology, Faculty of Agriculture, University of Jaffna in sealed polyethylene bags. Individual leaflets were examined under a stereomicroscope (Nikon SMZ18), and predatory mites collected were kept in 70% alcohol. The collected mites were clarified in 60% lactic acid at 50 °C in a hotplate and they were mounted in Hoyer's medium on microscope slides. The permanent slides were examined with an Olympus® CX-41 microscope. Illustrations were prepared by using a U-Da drawing attachment, Camera Lucida. Final corrections were made using a computer program Adobe Photoshop (version CS6). The taxonomic system follows that of Chant and McMurtry (2007). Dorsal setal nomenclature is based on Lindquist and Evans (1965), as adapted by Rowell *et al.* (1978); ventral setal nomenclature is based on Chant and Yoshida-Shaul (1991); idiosomal dorsal and ventral setal patterns, on Chant and Yoshida-Shaul (1989, 1992); symbols of leg macrosetae, on Athias-Henriot (1957). Nomenclature for idiosomal solenostomes (gland pores) and poroids are based on Athias-Henriot (1971, 1975) and ventral poroids are based on Athias-Henriot (1971). Leg chaetotaxy follows that of Evans (1963). The measurements of each structure are given in micrometers, presented as the mean followed by the respective range in parentheses if more than two specimens examined. The voucher specimens are deposited in the mite collection of the Acarology Laboratory, Cukurova University, Adana, Turkey. As part of our study, we also examined the type specimens of *Anthoseius* species deposited in National Zoological collections, Prani Vigyan Bhawan, Zoological Survey of India, New Alipore, Kolkata, India.

Results

Typhlodromus (*Anthoseius*) *xini* Wu

Typhlodromus xini Wu, 1983: 16. *Typhlodromus* (*Anthoseius*) *xini* Wu, in Wu *et al.* 2009: 336. *Typhlodromus* (*Anthoseius*) *gosabaensis* Kar and Karmakar, 2021: 55. **New synonymy.**

(Figures 1–3)

Material examined

Three females and two males from *Cocos nucifera* L. (Arecaceae) infested by spiralling whiteflies (*Aleurodicus* sp., Hemiptera: Aleyrodidae) in Wennapuwa, Puttalam District, North Western Province, Sri Lanka, 7°19′01.97″ N and 79°51′54.47″ E, 18 meters above sea level, 10 January 2024. Two females from the same location, 01 May 2024. All materials collected by Weliwattage A.T.M. Holotype female of *Typhlodromus* (*Anthoseius*) *gosabaensis* has also been examined.

Diagnosis

Female — Idiosomal setal pattern 12A:8A/*JV*–3:*ZV* (*r3* and *R1* off shield). Dorsal shield lightly reticulated; with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*); dorsal setae

serrated; setae *Z4*, *Z5* and *S5* spatulate (see description for variations). Peritremes extending between setae *j1* and *j3*. Sternal shield lightly striated or reticulated, with two pairs of setae and with posterior lobe; ventrianal shield pentagonal, reticulated with three pairs of preanal setae and a pair of small preanal solenostomes; seta *JV5* serrated and spatulate (bulbs not visible in some specimens). Spermatheca presents a funnel shaped calyx, and distally sclerotized walls; atrium well developed and nodular. Fixed digit of chelicera with two teeth clustered apically and movable digit with one tooth. Most of dorsal and lateral leg setae on most segments serrated. Ventral leg setae simple. Three spatulate macrosetae on leg IV. Trochanter I with six and genu II with seven setae.

Male — Idiosomal setal pattern 12A:8A/11:*JV*–3,4:*ZV*–1, 3 (*r3* and *R1* on shield). Dorsal shield lightly reticulated with six pairs of solenostomes (*gd2*, *gd3*, *gd4*, *gd6*, *gd8* and *gd9*). Peritremes extending to base of setae *j3*. Morphology of dorsal setae similar to female (see description for variations). Ventrianal shield fused with peritrematal shield, triangular, reticulated with three pairs of preanal setae, with minute preanal solenostomes. Fixed digit with two teeth and movable digit with one tooth. Spermatophoral process L-shaped with tip of toe bulbous.

Complementary description

Female (n = 5)

(Figures 1–2)

Dorsal idiosoma (Figure 1A) – Dorsal setal pattern 12A:8A (*r3* and *R1* off shield). Dorsal shield entire, slightly reticulated with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*) and 13 pairs of visible poroids (*id4*, *id5*, *id6*, *idm1*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *idl1*, *idl3*, *idl4* and *idx*). Length of dorsal shield 308 (298–330), width at level of *s4* 171 (160–180), width at level of *S2* 184 (160–195). Dorsal setae serrated; setae *Z4* and *Z5* spatulate, except one specimen, bulb absent in seta *Z4* on right side; setae *S5* spatulate only in one specimen. Measurements of dorsal setae as follows: *j1* 27 (25–28), *j3* 41 (38–43), *j4* 31 (30–33), *j5* 34 (30–36), *j6* 50 (48–54), *J2* 54 (50–58), *J5* 11 (9–13), *z2* 32 (30–34), *z3* 42 (39–45), *z4* 45 (43–46), *z5* 39 (38–40), *Z4* 56 (50–60), *Z5* 57 (55–63), *s4* 53 (50–55), *s6* 52 (50–53), *S2* 57 (53–60), *S4* 53 (50–55), *S5* 51 (48–53), *r3* 40 (38–40) and *R1* 46 (43–48). Peritremes extending between setae *j1* and *j3*; solenostome *gd3* not visible, and poroid *id3* visible on peritrematal shield.

Ventral idiosoma (Figure 1B) – Ventral setal pattern 14: *JV*–3: *ZV*. Sternal shield lightly striated or reticulated in some specimens; with two pairs of setae (*ST1* and *ST2*), two pairs of poroids (*iv1* and *iv2*) and a posterior lobe; distance between *ST1–iv2* 49 (48–50), *ST2–ST2* 51 (48–55). Setae *ST3* on separate platelets; metasternal setae *ST4* and a pair of poroids (*iv3*) on metasternal platelets. Genital shield striated some patches of reticulations visible in some specimens, much narrower than ventrianal shield; width at level of setae *ST5* 60 (58–60); one pair of para-genital poroids *iv5* on soft cuticle. Ventrianal shield pentagonal, reticulated with three pairs of pre-anal setae (*JV1*, *JV2* and *ZV2*); one pair of paraanal (*Pa*) and a postanal seta (*Pst*); with a pair of minute preanal solenostomes (*gv3*) posteromesad setae *JV2*, distance between *gv3* pores 42 (38–47). Length of ventrianal shield 114 (110–117), width at level of setae *ZV2* 94 (88–100). Setae *ZV1*, *ZV3*, *JV4* and *JV5* and five pairs of poroids (four pairs of *ivo* and *ivp*) on integument surrounding ventrianal shield. Setae *JV5* serrated with spatulate tip, except two specimen bulbs not visible; much longer and thicker than other ventral setae, 60 (55–63) in length.

Chelicera (Figure 1C) – Fixed digit 26 (25–28) long, with two subapical teeth and pilus dentilis; movable digit 26 (25–26) long with one tooth.

Spermatheca (Figure 1D) – Calyx funnel-shaped, distally well sclerotized walls and connecting atrium with lightly sclerotized (membranous) walls, 21 (19–22) long including atrium, atrium c-shaped and nodular, strongly sclerotized.

Legs (Figures 2A–D) – Length of legs (excluding pretarsus): I, 273 (260–288); II, 225 (220–230); III, 234 (225–245); IV, 286 (275–300). Chaetotactic formulae as follows: leg I:

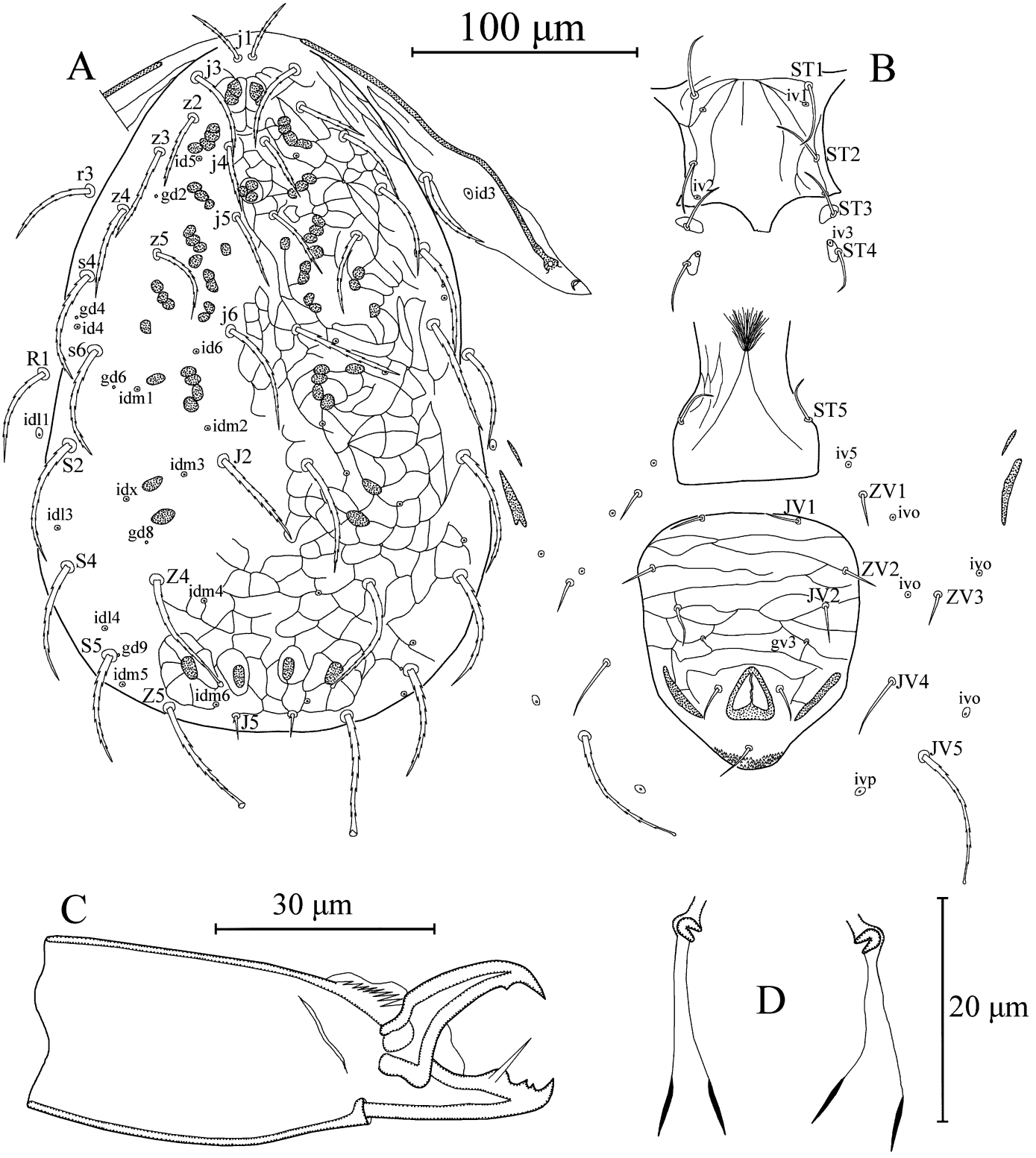

Figure 1 *Typhlodromus* (*Anthoseius*) *xini* Wu, 1983 female. A – Dorsal idiosoma; B – Ventral idiosoma; C – Chelicera; D – Spermathecae.

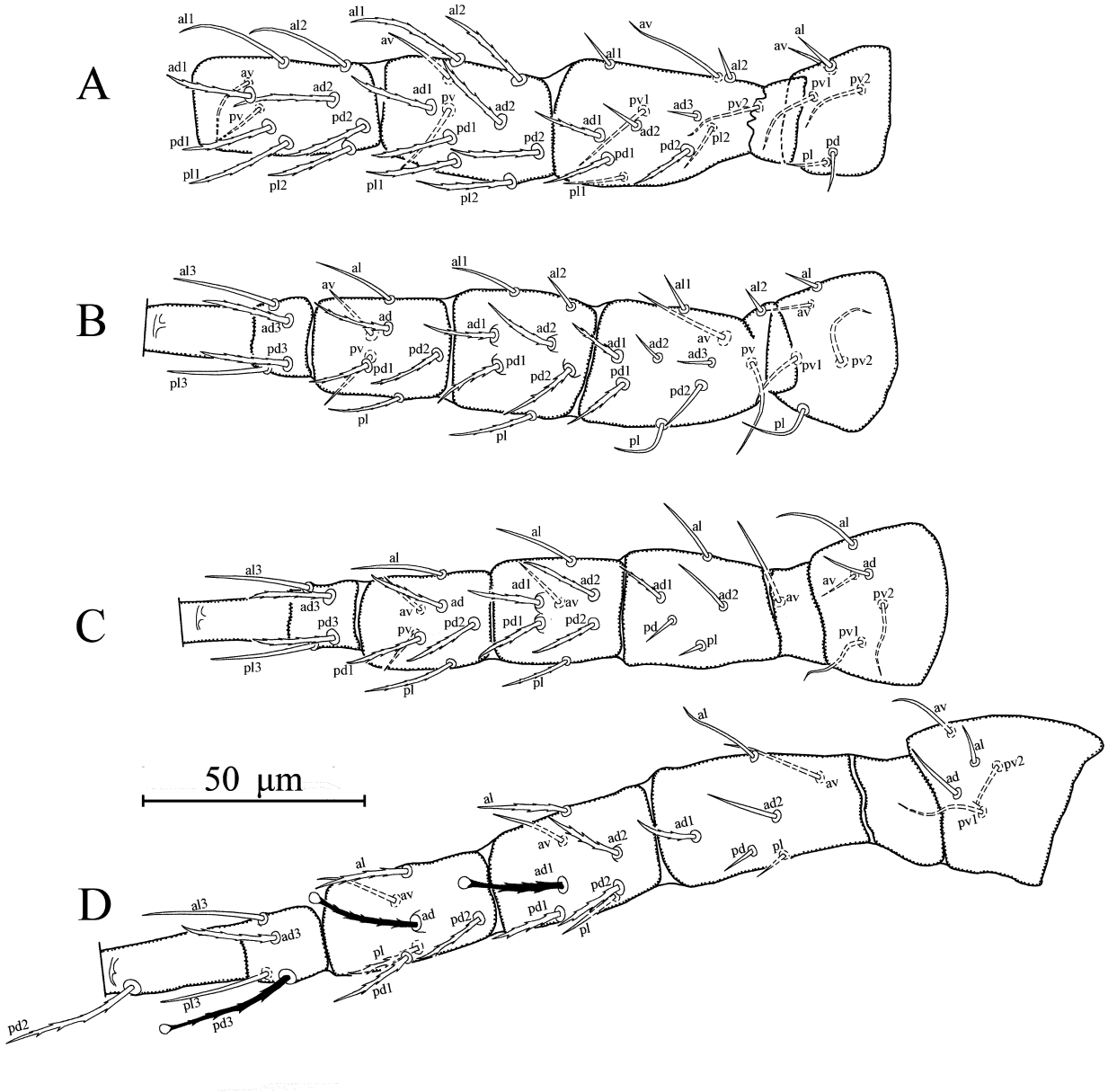

Figure 2 *Typhlodromus* (*Anthoseius*) *xini* Wu, 1983, female left legs. A – Leg I (trochanter-tibia); B – leg II (trochanter-basitarsus); C – Leg III (trochanter-basitarsus); D – Leg IV (trochanter-basitarsus). Macrosetae drawn in solid black for clarity.

coxa 0 0/1 0/1 0, trochanter 1 0/1 1/2 1, femur 2 3/1 2/2 2, genu 2 2/1 2/1 2, tibia 2 2/1 2/1 2; leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/1 1, genu 2 2/0 2/0 1, tibia 1 1/1 2/1 1; leg III: coxa 0 1/0 0/1 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 1 2/1 2/0 1, tibia 1 1/1 2/1 1; leg IV: coxa 0 0/1 0/ 0 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 1 2/1 2/0 1, tibia 1 1/1 2/0 1. Serrated setae as follows, leg I: femur *ad1*, *pd1* and *pd2*, genu *al1*, *al2*, *ad1*, *ad2*, *pd1*, *pd2*, *pl1*, and *pl2*, tibia *ad1*, *ad2*, *pd1*, *pd2*, *pl1*, and *pl2*; legII: femur *ad1*and *pd1*, genu *ad1*, *ad2*, *pd1*, *pd2* and *pl*, tibia *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*; leg III: femur *ad1*, genu *ad1*, *ad2*, *pd1*, *pd2* and *pl*, tibia *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*; leg IV: femur *ad1*, genu *al*, *ad1*, *ad2*, *pd1* and *pd2*, tibia *al*, *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*. Leg IV with three spatulate macroseta; *SgeIV* (*ad1*) 25 (23–26), *StiIV* (*ad*) 24 (23–25) and *StIV*

(*pd3*) 32 (30–33) long; other legs without macroseta.

Description of Male (n = 2)

(Figure 3)

Dorsal idiosoma (Figure 3A) – Dorsal setal pattern 12A:8A (*r3* and *R1* on shield). Dorsal shield entire; oval; lightly reticulated, reticulations in anterior part of the illustrated specimen not visible, with six pairs of solenostomes (*gd2*, *gd3*, *gd4*, *gd6*, *gd8* and *gd9*) and 15 pairs of visible poroids (*id2*, *id4*, *id5*, *id6*, *idm1*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *is1*, *idl1*, *idl3*, *ild4* and *idx*). Length of dorsal shield 245–250, width at level of *s4* 150–155, width at level of *S2* 153–165. Dorsal setae serrate, only setae *Z5* spatulate in the illustrated specimen, setae *Z4*, *Z5* and *R1* and seta *S5* (right side) spatulate in another specimen. Measurements of dorsal setae as follows: *j1* 23–24, *j3* 37–38, *j4* 26–28, *j5* 28–30, *j6* 40–42, *J2* 44, *J5* 10–11, *z2* 31–34, *z3* 35–36, *z4* 40–41, *z5* 30–32 (right side 38 in the illustrated specimen), *Z4* 45–47, *Z5* 45–47, *s4* 44–48, *s6* 44–48, *S2* 47–51, *S4* 43–46, *S5* 38–41, *r3* 37–38 and *R1* 40–42. Peritremes extending level of setae *j3*.

Ventral idiosoma (Figure 3B) – Ventral setal pattern 11: *JV*–3,4: *ZV*–1,3 (seta *JV2* absent in left side in one specimen). Sternogenital shield reticulated; with five pairs of setae (*ST1*, *ST2, ST3, ST4* and *ST5*), three pairs of poroids (*iv1*, *iv2* and *iv3*) and a straight posterior margin; distance between *ST1–ST5* 95–96, *ST3–ST3* 50–51. Ventrianal shield fused with peritrematal shields, triangular, reticulated; with three pairs of pre-anal setae (*JV1*, *JV2*, and *ZV2*), seta *JV2* in left side absent in one specimen; one pair of paraanal (*Pa*) and a postanal seta (*Pst*); with a pair of minute preanal solenostomes (*gv3*); distance between *gv3–gv3* 19 in the illustrated specimen, 36 in another specimen; and with three pairs of poroids (*iv5* and two pairs of *ivo*). Length of ventrianal shield 106–108, width at anterior margins 143–150. Setae *JV5*, serrate without knob, 45–47 in length. A pair of *ivo* and *ivp* on integument surrounding ventrianal shield.

Chelicera (Figure 3C) – Fixed digit 20 long with two subapical teeth and pilus dentilis; movable digit 18 long with one tooth. Spermatophoral process L-shaped, with toe strongly developed, bulbous and with hyaline bulb.

Legs – Length of legs (excluding pretarsus): I, 225–233; II, 190–195; III, 185–203; IV, 250–255. Leg chaetotaxy same as female. Serrated setae as follows, leg I: femur *ad1* and *pd1*, genu *al1*, *al2*, *ad1*, *ad2*, *pd1*, *pd2*, *pl1*, and *pl2*, tibia *ad1*, *ad2*, *pd1*, *pd2*, *pl1*, and *pl2*; legII: femur *ad1*and *pd1*, genu *ad1*, *ad2*, *pd1*, *pd2* and *pl*, tibia *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*; leg III: femur *ad1*, genu *ad1*, *ad2*, *pd1*, *pd2* and *pl*, tibia *al*, *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*; leg IV: femur *ad1*, genu *al*, *ad1*, *ad2*, *pd1* and *pd2*, tibia *al*, *ad*, *pd1*, *pd2* and *pl*, basitarsus *ad3* and *pd3*. Leg IV with three spatulate macrosetae; *SgeIV* (*ad1*) 21–22, *StiIV* (*ad*) 22 and *StIV* (*pd1*) 25–28; other legs without macroseta.

Remarks

Typhlodromus (*Anthoseius*) *xini* was described by Wu (1983) based on the holotype female collected from banana in Hainan Island, Guangdong, China. This is the first report of *T.* (*A.*) *xini* in Sri Lanka. The unknown males of the species are also described for the first time. Morphological characters and measurements of the female specimens examined in this study fit well with those provided in its original description. However, setae *Z4*, *Z5*, *S5* (in some specimens), and *JV5* (in some specimens) are spatulate in the examined females but forked in the holotype (Wu 1983; Wu *et al.* 2009). It should be noted here that these setal bulbs consist of hyaline membranes that are lightly sclerotized and might not be visible under the optic material used at that time. However, the well-sclerotized apical parts of these setae at the connection of hyaline membranes exactly seem to be forked. Furthermore, preanal pores are present in the current material but absent in the holotype. It should also be noted here that these preanal pores are smaller than those of other mites in the subgenus *Anthoseius*, and observable only by using an oil lens (1.25 NA). Therefore, we consider these differences as variations or flaws of the original description due to the quality of the microscope used at that time.

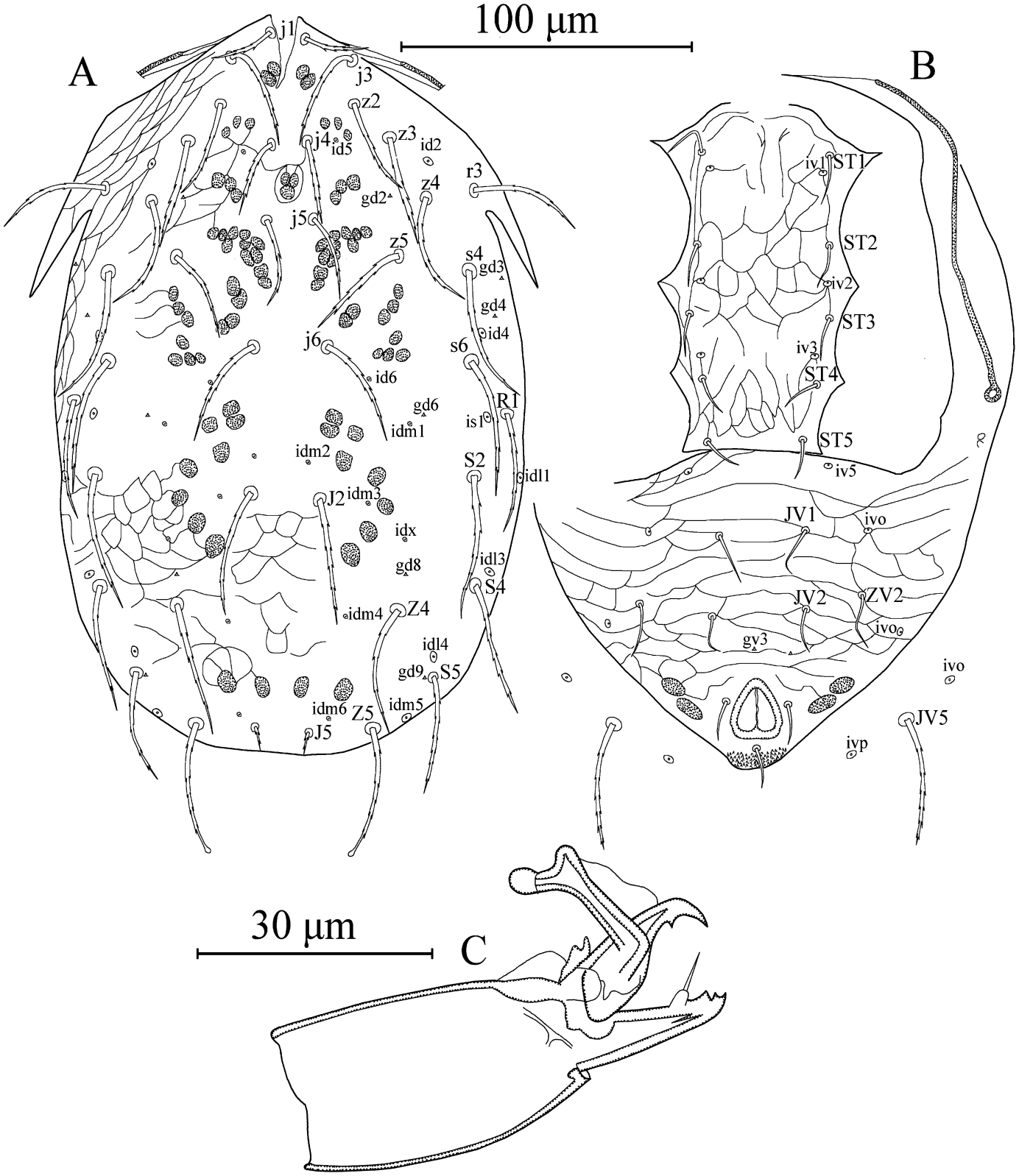

Figure 3 *Typhlodromus* (*Anthoseius*) *xini* Wu, 1983 male. A – Dorsal idiosoma; B – Ventral idiosoma; C – Chelicera.

The specimens of *T.* (*A.*) *xini* examined in this study resemble *T.* (*A.*) *gosabaensis* Kar & Karmakar, 2021, a species recently described from West Bengal (India), in many aspects such as the nature of the dorsal and ventral idiosoma (including the shape and the length of the setae). However, based on the original description, *T.* (*A.*) *gosabaensis* show important morphological differences with *T.* (*A.*) *xini*: (1) the absence of *gd4* and the presence of *gd5* (*vs* opposite situation stands for *T.* (*A.*) *xini*; (2) chelicera dentition (including arrangement and positions of teeth); (3) only dorsal and lateral setae are serrated on some leg segments but serration never observed for ventral setae in *T.* (*A.*) *xini* (*vs* all leg setae serrated); (4) Chaetotactic formula of genu II 2 2/0 2/0 1 in *T.* (*A.*) *xini* (*vs* 1 2/0 2/1 1); (5) measurements of seta *z4* 45 (43–46) in *T.* (*A.*) *xini* (*vs* 33 (32–34)). We could successfully reach and examine the holotype, which was deposited in the National Zoological Collections, Prani Vigyan Bhawan, Kolkata, India. Our observation on *T.* (*A.*) *gosabaensis* holotype revealed that the *gd5* solenostomes are absent and *gd4* are present. Moreover, we also considered other differences mentioned above and concluded that these are different from the original description of *T.* (*A.*) *gosabaensis* but identical to the complementary description of *T.* (*A.*) *xini* provided here. Therefore, *T.* (*A.*) *gosabaensis* is proposed as a new junior synonymy of *T.* (*A.*) *xini*.

Taxonomic relationship of *Typhlodromus* (*Anthoseius*) *xini* with other species in the subgenus *Anthoseius*

Typhlodromus (*Anthoseius*) *xini* shows affinity to several species in the subgenus *Anthoseius* such as *T.* (*A.*) *diumbokus* Schicha & Corpuz-Raros, 1992, *T.* (*A.*) *hartlandrowei* Evans, 1958, *T.* (*A.*) *neohartlandrowei* Zannou, Moraes & Oliveira, in Ueckermann *et al.* (2008), and *T.* (*A.*) *transvaalensis* (Nesbitt, 1951). All of these species are similar to each other based on the nature of their dorsal and ventral aspects, chelicera dentition, and spermetheca morphology. Most importantly, ventral seta *JV3* is absent in all of these species.

Typhlodromus (*A.*) *xini* can be separated from *T.* (*A.*) *diumbokus* by having much longer and serrated dorsal seta *S5* which is minute and smooth in the latter species. It is also different from *T.* (*A.*) *hartlandrowei* by having much shorter setae *z4*, *S2* and *S4*, and by having longer setae *z2* and *S5* (Kreiter *et al.* 2020). From, *T.* (*A.*) *neohartlandrowei* by having longer seta *S5* and shorter setae *z4*, *Z4*, *s6*, *S2*, *S4*, and *R1* (Ueckermann *et al.* 2008). Moreover, *T.* (*A.*) *xini* is also different from *T.* (*A.*) *transvaalensis* by having seven setae on genu II as oppose to eight in the latter species. In addition, *T.* (*A.*) *xini* has much longer dorsal setae compared to *T.* (*A.*) *transvaalensis*. Shape of the ventrianal shield is also one of the basic differences between these two species (Ueckermann *et al.* 2008; Liao *et al.* 2020).

It is interesting to report that *T.* (*A.*) *xini* is also similar to *T.* (*A.*) *foraminosus* (Schuster, 1966) described from Galapagos Islands located in Neotropical realm, based on the dorsal setal measurements. However, it can be separated from the latter species by having a pentagonal ventrianal shield, which is narrower and slightly elongated in *T.* (*A.*) *foraminosus*. In addition, measurements of macrosetae *SgeIV* and *StIV* are 25 (23–26) and 32 (30–33) in *T.* (*A.*) *xini* as oppose to 38 and 50 in *T.* (*A.*) *foraminosus*, respectively.

Finally, *T.* (*A.*) xini is also different from all of the aforementioned species, by having many serrated dorsal and lateral setae on most of the leg segments. Considering all of the morphological similarities between these species, it is apparent that all of the aforementioned species share a common ancestor. Therefore, additional molecular analysis, in combination with the use of morphological characters, would help to confirm the taxonomic relationship and evolutionary history of these species.

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of the holotype female of *T.* (*A.*) *gosabaensis* deposited in National Zoological collections, Prani Vigyan Bhawan, New Alipore, Kolkata, India. Study of Ismail Döker was supported by Cukurova University Scientific Projects Foundation Units, grant number, FAY-2022-14495. We also extend our gratitude to Prof. K. Pakeerathan, Head, Department of Agricultural Biology, Faculty of Agriculture, University of Jaffna, for the continuous support given throughout the research period.

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