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Complementary description of two *Anthoseius* De Leon (Acari: Phytoseiidae) species based on their holotypes with new synonyms

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Original research

ABSTRACT

Due to the inadequacy of prior descriptions and the absence of redescrptions, studies on the taxonomy of the subgenus *Anthoseius* De Leon (Acari: Phytoseiidae) have become challenging and often cause confusion among taxonomists. *Typhlodromus* (*Anthoseius*) *ghanii* (Muma) and *T. (A.) loralaiiana* (Muma) were described from Pakistan almost sixty years ago. Their original descriptions are not very detailed, being based on simple drawings and an absence of diagnostic characters that include measurements of dorsal setae. Most likely due to its inadequate description, *T. (A.) ghanii* was not recognized by acarologists and was therefore repeatedly described as a new species under different names. We examined the holotypes of *T. (A.) homalii* Gupta and *T. (A.) sagaricus* Karmakar *et al.* concluding both species to be junior synonyms of *T. (A.) ghanii*. Moreover, *T. (A.) kuznetsovi* (Denmark & Welbourn), described from Tajikistan, is proposed as a new junior synonym of *T. (A.) loralaiiana* based on the examination of their holotypes. Hence, complementary descriptions of *T. (A.) ghanii* and *T. (A.) loralaiiana*, based on their holotypes, are provided to facilitate species identification and to improve their diagnosis.

Keywords predatory mites; taxonomy; redescription

Zoobank <http://zoobank.org/1911F24F-A40B-414D-8C96-BB4F16B0D4E7>

Introduction

The phytoseiids (Acari: Phytoseiidae) constitute a group of predatory mites of the superorder Parasitiformes, most widely studied due to their potential as biological control agents (McMurtry *et al.* 2013). Their accurate identification is considered of utmost importance for achieving effective biological control of target pests (Gerson 2014).

The subgenus *Anthoseius* De Leon of the genus *Typhlodromus* Scheuten is the largest group of predators in the subfamily Typhlodrominae, with about 400 nominal species (Ueckermann *et al.* 2008; Demite *et al.* 2014; Ferragut and Baumann 2019; Kreiter *et al.* 2021). Studies on the taxonomy of the Asian species of the subgenus, including India and Pakistan, date back to early 1960s, with a series of new species being described by various authors (Chant 1960; Chaudhri 1965; Gupta 1970). Yet, most of these descriptions did not include crucial taxonomical characters currently used for species delimitation, such as dorsal setal lengths, dorsal solenostomes, shape of spermatheca, cheliceral dentition, and leg chaetotaxy. The inadequate descriptions and the absence of redescrptions of *Typhlodromus* (*Anthoseius*)

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species have made accurate species identifications a challenge and caused confusion among taxonomists.

Among species of *Typhlodromus* (*Anthoseius*), Muma (1967) described both *T. (A.) ghanii* (Muma) and *T. (A.) loralaiana* (Muma) based on mites collected from Pakistan. Those descriptions were not very detailed, being based on simple drawings and an absence of diagnostic characters mentioned earlier. We suspected that most likely due to its inadequate description, *T. (A.) ghanii* was not properly recognized by acarologists and it was therefore described as a new species under different names. Indeed, based on literature information, we were unable to find reliable morphological differences between this and several other species described from India and Pakistan, namely *T. (A.) homalii* Gupta 1970, *T. (A.) plebeius* (Chaudhri *et al.* 1974), *T. (A.) incasus* (Chaudhri, 1975), and *T. (A.) sagaricus* Karmakar *et al.* (in Molla *et al.* 2021).

Therefore, in this study, we tried to access type specimens of the aforementioned species to confirm our hypothesis, with success only for *T. (A.) homalii* and *T. (A.) sagaricus*. The holotype of *T. (A.) kuznetsovi* (Denmark & Welbourn, 2002) was also examined due to its great morphological similarity with *T. (A.) loralaiana* (Khaustov *et al.* 2022). Hence, complementary descriptions of *T. (A.) ghanii* and *T. (A.) loralaiana* are provided, based on their holotypes, to improve their diagnosis and facilitate species identification.

Material and methods

The examination of mite specimens was undertaken with a Zeiss Axio Imager.M2 compound microscope equipped with differential interference contrast optical systems and a AxioCam 820 mono camera, as well as with a Zeiss Axioscope 5 compound microscope equipped with a phase contrast optic system and a Canon EOS 90D camera. Most images were captured in stacks and combined using Helicon Focus 7.6.4 Pro (Helicon Soft Ltd., 2000). The drawings were prepared using Adobe Photoshop CS2 software. Measurements were taken via ZEN 2012 software (version 8.0) and given in micrometers. 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). Nomenclature of dorsal solenostomes (gland pores) is based on Athias-Henriot (1975). Leg chaetotaxy follows that of Evans (1963).

The holotypes examined in this study are deposited at: *T. (A.) ghanii* and *T. (A.) loralaiana*, Florida Department of Agriculture and Consumer Services 1911 SW 34th St, Gainesville, FL 32608, USA; *T. (A.) homalii* and *T. (A.) sagaricus*, National Zoological Collections, Prani Vigyan Bhawan, Zoological Survey of India, New Alipore, Kolkata, India; and *T. (A.) kuznetsovi*, Tyumen State University, Museum of Zoology, Tyumen, Russia.

Results

Typhlodromus (*Anthoseius*) *ghanii* Muma

(Figures 1–2)

Amblydromella ghanii Muma, 1967: 279.

Typhlodromus homalii Gupta, 1970: 188. **New synonym.**

Amblydromella plebeius Chaudhri, Akbar & Rasool, 1974: 209. Suspected junior synonym.

Amblydromella incasus Chaudhri, 1975: 206. Suspected junior synonym.

Typhlodromus (*Anthoseius*) *sagaricus* Karmakar *et al.*, in Molla *et al.* 2021: 550. **New synonym.**



Figure 1 *Typhlodromus (Anthoseius) ghanii* (Muma, 1967), holotype female. A – Dorsal idiosoma, B – Ventral idiosoma, C – Chelicera, D – Spermathecae.

Material examined

Holotype female, *Amblydromella ghanii*, on *Punica granatum* L. (Punicaceae), 1 November 1965, Multan, Pakistan, coll. M.A. Ghani.

Holotype female, *Typhlodromus homalii*, on *Homalium tomentosum* (Vent.) Benth. (Salicaceae), February 1967, Botanical Garden, Howrah, West Bengal, India, coll. S.K. Gupta.

Holotype female, *Typhlodromus* (*Anthoseius*) *sagaricus*, on *Phyllanthus emblica* L. (Phyl-

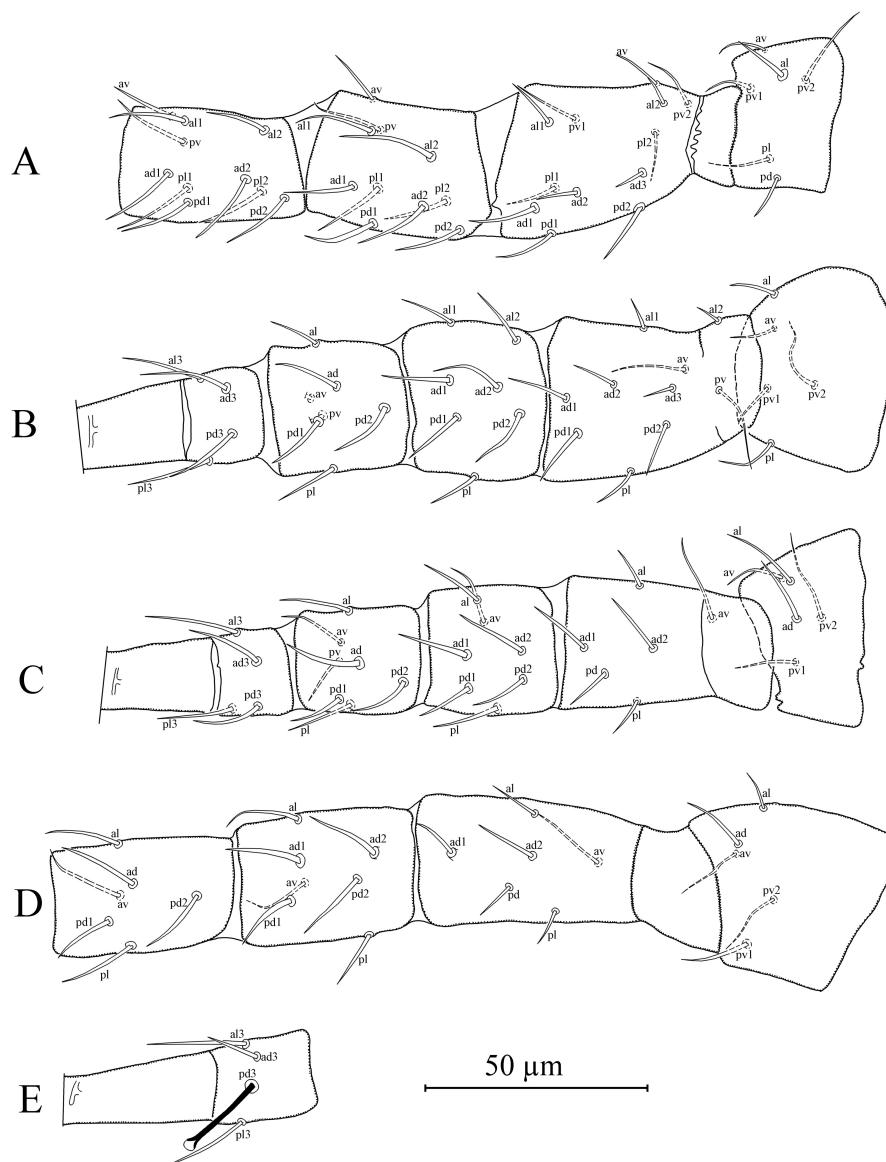


Figure 2 *Typhlodromus (Anthoseius) ghanii* (Muma, 1967), left legs of holotype female. A – leg I (trochanter-tibia), B – leg II (trochanter-basitarsus), C – leg III (trochanter-basitarsus), D – leg IV (trochanter-tibia), E – leg IV (basitarsus). Macroseta drawn in solid black for clarity.

lanthaceae), 15 November 2019, Sagar Island, India, coll. unknown.

Diagnosis

Idiosomal setal pattern 12A:8A/JV:ZV (*r3* and *R1* off shield). Dorsal shield strongly reticulate with strong waist at level of seta *R1*; with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*). Dorsal setae smooth and acuminate, except *Z4* and *Z5*, serrate, and *Z5*, with large apical knob. Peritremes extending to base of *j1*. Sternal area striated anteriorly. Ventrianal shield pentagonal, smooth, with four pairs of preanal setae and with crescentic preanal solenostomes. Seta *JV5* smooth with large apical knob. Spermatheca with bell-shaped calyx and nodular atrium without neck. Fixed digit of chelicera with five teeth and movable digit with three teeth. Genu II with seven setae (2 2/0 2/0 1). Leg IV with one knobbed macroseta on tarsus; other legs without macrosetae.

Complementary description

Holotype Female — (The specimen described by Muma 1967).

Dorsal idiosoma – (Figure 1A). Dorsal setal pattern 12A:8A (*r3* and *R1* off shield). Dorsal shield much longer than wide, entire, strongly reticulated with strong waist at level of seta *R1*; with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*), and 13 pairs of visible poroids (*id2*, *id4*, *id5*, *id6*, *idm2*, *idm3*, *idm4*, *idm6*, *idx*, *is1*, *idl1*, *idl3*, *idl4*). Muscle-marks (sigillae) visible mostly on podosoma; length of dorsal shield 335, width at level of *s4* 184, width at level of *S2* 207. Dorsal setae smooth and acuminate, except *Z4* and *Z5*, serrate, and *Z5*, with large apical knob. Measurements of dorsal setae as follows: *j1* 19, *j3* 23, *j4* 18, *j5* 19, *j6* 21, *J2* 24, *J5* 11, *z2* 21, *z3* 21, *z4* 23, *z5* 20, *Z4* 33, *Z5* 46, *s4* 25, *s6* 27, *S2* 28, *S4* 30, *S5* 20, *r3* 23 and *R1* 22. Peritremes extending to base of *j1*.

Ventral idiosoma – (Figure 1B). Ventral setal pattern 15:JV:ZV. Sternal shield lightly sclerotized, sternal area striated anteriorly; with four pairs of setae (*ST1*, *ST2*, *ST3* and *ST4*), two pairs of poroids (*iv1* and *iv2*), metasternal platelet and poroid *iv3* not visible; distance between *ST1*–*ST3* 66, *ST2*–*ST2* 58. Genital shield smooth; one pair of para-genital poroids *iv5* on soft cuticle; width at level of setae *ST5* 62. Ventrianal shield pentagonal, smooth; with four pairs of pre-anal setae (*JV1*, *JV2*, *JV3* and *ZV2*), one pair of paranal (*Pa*) and one post-anal seta (*Pst*); with one pair of crescentic solenostomes located posteromesad *JV2*; distance between *gv3* pores 20. Length of ventrianal shield 110, width at level of setae *ZV2* 79, width at level of paranal setae 79. Setae *ZV1*, *ZV3*, *JV4* and *JV5* and five pairs of poroids (*ivo*, *ivo*, *ivo*, *ivo*, *ivp*) on integument surrounding ventrianal shield. Seta *JV5* smooth, with large apical knob, 35 in length.

Chelicera – (Figure 1C). Fixed digit 22 long with five teeth and pilus dentilis; movable digit 23 long with three teeth.

Spermatheca – (Figure 1D). Calyx bell-shaped, flaring slightly distally, 12 long; atrium nodular incorporated with calyx without neck.

Legs – (Figures 2A–E). Length of legs (excluding pretarsus): I, 284; II, 244; III, 237; IV, 358. Chaetotactic formulae as follows; Leg I: 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 0/1 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. Leg IV with one macroseta knobbed apically, *StIV* (*pd3*) 22 in length. Other legs without macroseta.

Remarks

Typhlodromus (*A.*) *ghanii* is closely related to four other species namely *T. (A.) ndibu* Pritchard & Baker 1962, *T. (A.) fleschneri* Chant 1960, *T. (A.) zafari* Chaudhri 1965, and *T. (A.) yasumatsui* Ehara 1966. However, it can be easily separated from these four species by having only one bulbous macroseta on leg IV. In contrast, all other species have three bulbous macrosetae on this leg, and *T. (A.) ndibu* also has bulbous setae on leg III in addition to leg IV.

According to the original description of *T. (A.) homalii*, the cheliceral movable digit is toothless. However, our examination of the holotype showed the presence of three teeth on this digit. After confirming a complete similarity to all other morphological and morphometric characters, we conclude that *T. (A.) homalii* is a new junior synonym of *T. (A.) ghanii*.

In the original description of *T. (A.) sagaricus*, *gd5* is mentioned to be present and *gd4* absent. So far, the presence of *gd5* in *Typhlodromus* (*Anthoseius*) has only been reported in recent descriptions of Indian mites (Molla *et al.* 2021; Kar and Karmakar 2022). Moreover, the location of *gd5* shown in the illustration of the original description of *T. (A.) sagaricus*, in transverse alignment with *z5*, is unusual, contrasting with its usual placement, about in line with *z5* and *j6*, as shown in phytoseiids by Athias-Henriot (1975). Our examination of the holotype of *T. (A.) sagaricus* confirmed the presence of *gd4*, but we could not distinguish *gd5*. In addition, we also confirmed a complete similarity between *T. (A.) ghanii* and *T. (A.) sagaricus*,

in relation to other morphometric and morphological characters, including leg chaetotaxy. Therefore, we here proposed the latter as a new junior synonym of the former.

As we were unable to examine type specimens of *T. (A.) plebeius* and *T. (A.) incasus*, we considered them as suspected junior synonyms of *T. (A.) ghanii*. Because the type materials maybe related to some other species mentioned earlier that differ in number of bulbous setae on legs. In addition, the original descriptions of both *T. (A.) plebeius* and *T. (A.) incasus*, are not sufficiently detailed to conclude their synonymy. Therefore, further examination on the type series of these two species may confirm our hypothesis.

***Typhlodromus (Anthoseius) loralaiana* (Muma)**

(Figures 3–4)

Amblydromella loralaiana Muma, 1967: 278.

Amblydromella (Aphanoseia) kuznetsovi Denmark & Welbourn, 2002: 297. replacement name for *Anthoseius richteri* Kuznetsov, 1984: 385.

Typhlodromus (Anthoseius) kuznetsovi (Denmark & Welbourn, 2002), Khaustov *et al.* 2022: 226. **New synonym.**

Amblydromella dalfardica Daneshvar, 1987: 23. Suspected junior synonym.

Typhlodromus (Anthoseius) dalfardicus (Daneshvar), Kazemi *et al.* 2022: 724.

Material examined

Holotype female, *Amblydromella loralaiana*, on *Punica granatum* L. (Punicaceae), 27 September 1964, Loralai, Pakistan, coll. M.A. Ghani.

Holotype female, *Anthoseius richteri*, on *Cydonia oblonga* Mill. (Rosaceae), 2 September 1976, Botanical Garden, Dushanbe, Tajikistan, coll. N.N. Kuznetsov.

Diagnosis

Idiosomal setal pattern 12A:8A/*JV:ZV* (*r3* and *R1* off shield). Dorsal shield reticulate, except for smooth marginal area posteriad *s6* and central between setae *S4*; with strong waist at level of seta *R1*; with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*). Dorsal setae smooth and acuminate, except *Z4* and *Z5*, serrate. Setae *S5* short, subequal to *J5* in length, and at least four times shorter than other setae in *s-S* series. Peritremes extending almost to base of *j1*. Sternal shield smooth, lightly sclerotized, with two pairs of setae. Ventrianal shield vase-shaped, much longer than wide, smooth, with four pairs of preanal setae and with rounded preanal solenostomes. Seta *JV5* smooth and acuminate. Spermatheca with broad tubular calyx, flaring slightly next to vesicle, and large atrium without neck. Fixed digit of chelicera with four apical teeth and movable digit with three teeth. Genu II with eight setae (2 2/1 2/0 1). Leg IV with two macrosetae on tarsus; other legs without macroseta.

Complementary description

Holotype Female — (The specimen described by Muma 1967).

Dorsal idiosoma – (Figure 3A). Dorsal setal pattern 12A:8A (*r3* and *R1* off shield). Dorsal shield much longer than wide, entire, reticulate, except for smooth marginal area posteriad *s6* and central between setae *S4*; with strong waist at level of seta *R1*; with five pairs of solenostomes (*gd2*, *gd4*, *gd6*, *gd8* and *gd9*). Muscle-marks (sigillae) visible mostly on podosoma; length of dorsal shield 323, width at level of *s4* 172, width at level of *S2* 196. Dorsal setae smooth and acuminate, except *Z4* and *Z5*, serrate. Measurements of dorsal setae as follows: *j1* 23, *j3* 29, *j4* 23, *j5* 23, *j6* 31, *J2* 38, *J5* 9, *z2* 20, *z3* 30, *z4* 33, *z5* 23, *Z4* 56, *Z5* 57, *s4* 37, *s6* 44, *S2* 49, *S4* 53, *S5* 8, *r3* 27 and *R1* 31. Peritremes extending almost to base of *j1*.

Ventral idiosoma – (Figure 3B). Ventral setal pattern 15:*JV:ZV*. Sternal shield smooth, lightly sclerotized, posterior margin not visible, smooth with two pairs of setae (*ST1* and *ST2*) and two pairs of poroids (*iv1* and *iv2*); seta *ST3* on soft integument, seta *ST4* and poroid *iv3* on

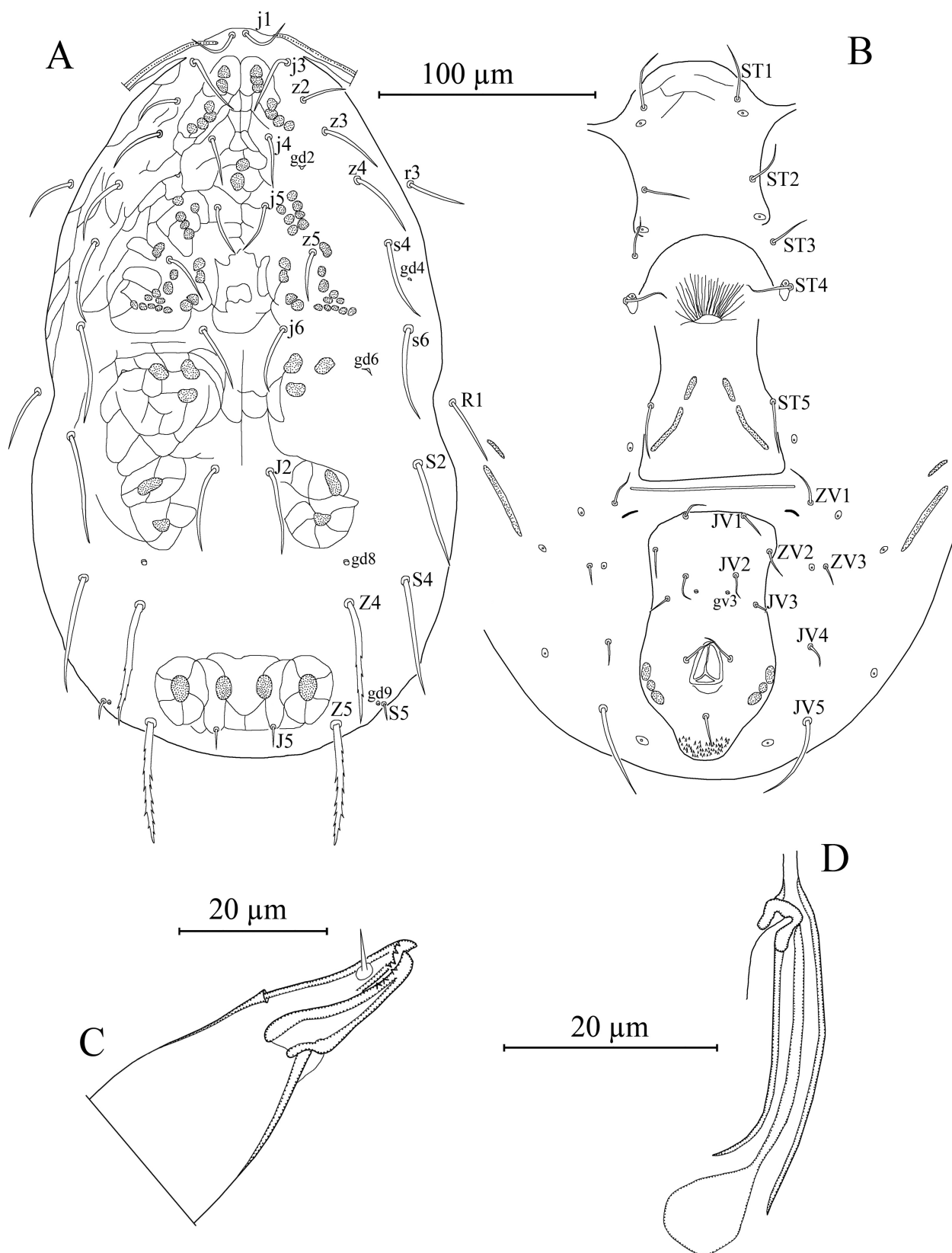


Figure 3 *Typhlodromus (Anthoseius) loralaiana* (Muma, 1967), holotype female. A – Dorsal idiosoma, B – Ventral idiosoma, C – Chelicera, D – Spermatheca.

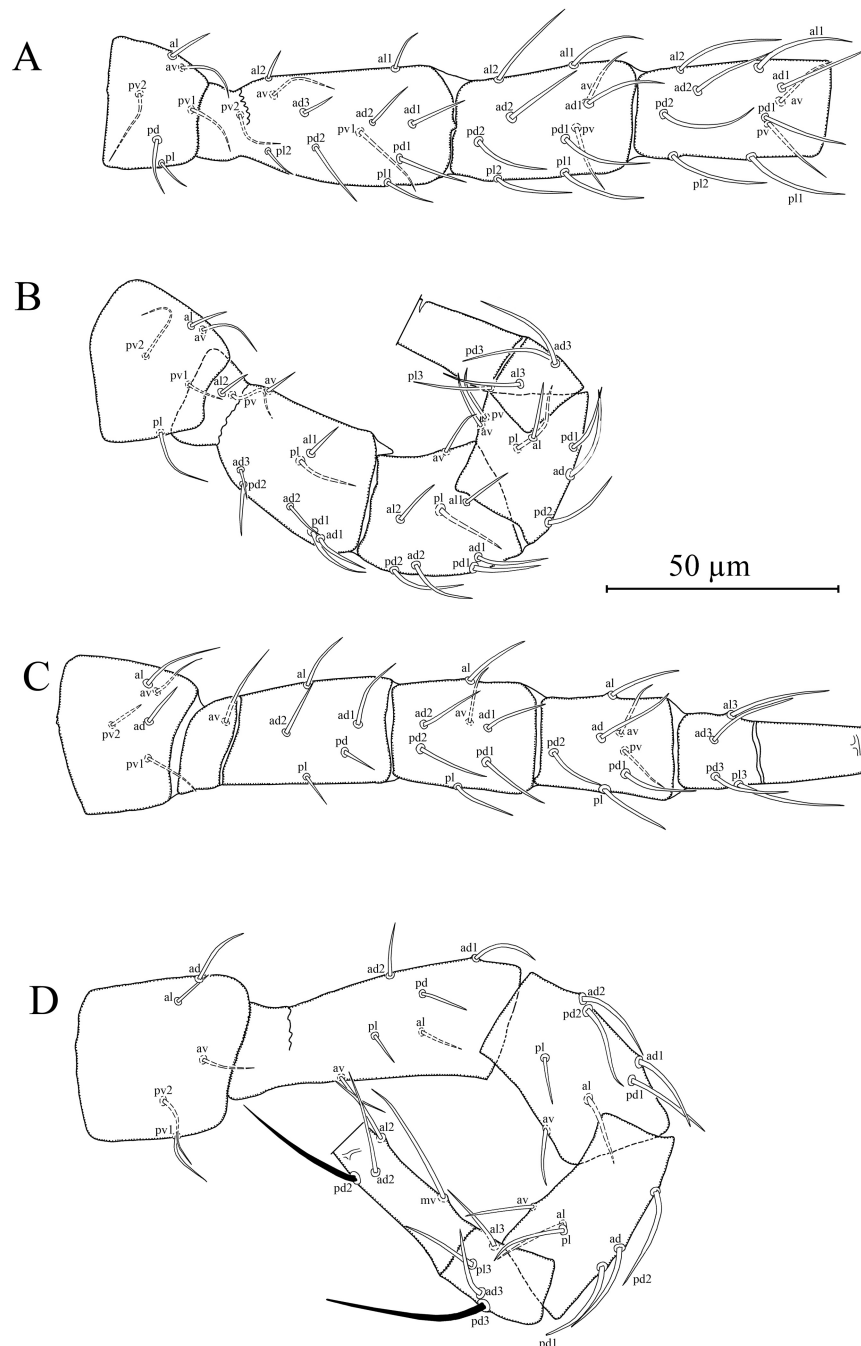


Figure 4 *Typhlodromus (Anthoseius) loralaiana* (Muma, 1967), right legs of holotype female. A – leg I (trochanter-tibia), B – leg II (trochanter-basitarsus), C – leg III (trochanter-basitarsus), D – leg IV (trochanter-basitarsus and partly telotarsus). Macrosetae drawn in solid black for clarity.

metasternal platelets; distance between *ST1–iv2* 55, *ST2–ST2* 52. Genital shield smooth; one pair of para-genital poroids *iv5* on soft cuticle; width at level of setae *ST5* 60. Ventrianal shield elongated, vase-shaped, smooth; with four pairs of pre-anal setae (*JV1*, *JV2*, *JV3* and *ZV2*); one pair of paranal (*Pa*) and a post-anal seta (*Pst*); with one pair of rounded solenostomes located posteromesad of *JV2*; distance between *gv3* pores 17. Length of ventrianal shield 114, width at level of setae *ZV2* 59, width at level of paranal setae 61. Setae *ZV1*, *ZV3*, *JV4* and *JV5* and five

pairs of poroids (*ivo, ivo, ivo, ivo, ivp*) on integument surrounding ventrianal shield. Seta *JV5* smooth, acuminate, 44 in length.

Chelicera – (Figure 3C). Fixed digit 23 long with four apical teeth and pilus dentilis; movable digit 23 long with three teeth. The unusual direction of pilus dentilis in the illustrated chelicera is probably because of mounting as its position is normal in the other chelicera.

Spermatheca – (Figure 3D). Calyx broad, elongate, tubular, flaring slightly next to vesicle, 28 long; atrium large and incorporated into base of calyx without neck.

Legs – (Figures 4A–D). Length of legs (excluding pretarsus): I, 282; II, 235; III, 218; IV, 300. Chaetotactic formulae as follows; Leg I: 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 2/1 2/0 1, tibia 1 1/1 2/1 1. Leg III: coxa 0 0/1 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. Leg IV with two acuminate macrosetae, *StIV* (*pd3*) 36 in length, and that on telotarsus 32 in length. Other legs without macroseta.

Remarks

We herein confirm that *Typhlodromus* (*A.*) *kuznetsovi* (Denmark and Welbourn), a species previously described and known only from Tajikistan, is a junior synonym of *T. (A.) loralaiana*, based on the examination of their holotypes. A full redescription of *T. (A.) kuznetsovi* was recently provided by Khaustov *et al.* (2022). In addition, *T. (A.) dalfardicus*, described by Daneshvar (1987) based on specimens collected from *Citrus* sp. (Rutaceae) in Iran, shows affinity to *T. (A.) loralaiana*. Daneshvar (1987) separated these two species based on setal lengths and cheliceral movable digit dentition. We were unable to find reliable morphometric differences between the holotype *T. (A.) loralaiana* and the original description of *T. (A.) dalfardicus*. In addition, Daneshvar (1987) implied that *T. (A.) dalfardicus* has two teeth on the movable digit of the chelicera as compared with no teeth in *T. (A.) loralaiana*. Our examination of the holotype of *T. (A.) loralaiana* shows that cheliceral digits are almost totally closed, but it was still possible to observe a movable digit and count its denticles (three teeth) by using a plan-apochromatic oil lens (1.4 NA) with a DIC microscope. This finding is still different from what was reported in the original description of *T. (A.) dalfardicus*. In conclusion, until further examination of the type specimens of the latter or until new specimens are examined, we prefer considering *T. (A.) dalfardicus* a suspected junior synonym of *T. (A.) loralaiana*.

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