

A new species of *Neoseiulus* Hughes (Acari: Phytoseiidae) from Karnataka, India with an identification key to Indian species of the genus

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Original research

ABSTRACT

Neoseiulus ramabettaensis n. sp. Döker and Jose is described based on specimens collected from Karnataka, India. The new species is accommodated to the *cucumeris* species group and *ceratoni* species subgroup in the genus *Neoseiulus* Hughes (Acari: Phytoseiidae). The morphological characters including conspicuously longer setae *j1* and *j3*, in addition to *Z4* and *Z5*, chelicera dentition, wider ventrianal shield at anterior corners, large crescentic preanal pores, absence of macroseta on legs II-IV, and presence of macroseta on genu I distinguished the new species from its congeners in the *ceratoni* species subgroup. The current study describes a macroseta on leg I (*SgeI*) for a species listed in the *ceratoni* species subgroup for the first time. Indeed, the presence of *SgeI*, and the absence of macroseta on leg IV are unusual characters for the genus *Neoseiulus*, except *SgeI* present in a few species in *Neoseiulus desertus* species group. Therefore, chaetotaxy of legs frequently used in the systematics of other groups of Mesostigmata which are closely related to the phytoseiid mites, seems to be an important morphological character and should be included in future descriptions. In addition, we constructed an identification key for the Indian species of the genus.

Keywords taxonomy; Neoseiulini; leg chaetotaxy; biological control; identification key; Indomalayan realm

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Introduction

Species of the family Phytoseiidae (Acari: Mesostigmata) are one of the most studied groups because of their potential as predators of economically important mites and some other soft-bodied arthropods (McMurtry *et al.* 2013). The genus *Neoseiulus* Hughes is one of the largest groups of phytoseiid mites with about 400 species including synonyms (Zannou *et al.* 2006; Tsolakis and Ragusa 2016; Ferragut and Navia 2022; Demite *et al.* 2023; Döker *et al.* 2023).

Studies on phytoseiid taxonomy from India date back to the beginning of the 1960s with a series of new species being described since 1960 to date (Narayanan and Kaur 1960; Gupta 1975, 1977, 1986). However, most of early descriptions or re-descriptions did not include many important characters which are currently used to discriminate phytoseiid species, except the studies published in the last decade (Karmakar *et al.* 2017; Kar and Karmakar 2022; Biswas and Karmakar 2023). The inadequate descriptions and re-descriptions or the absence of redescrptions for many phytoseiid species have made accurate species identifications a

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challenge in India. These situations have often resulted in misidentifications and overall confusion among taxonomists.

In the country, the faunistic studies on native phytoseiid species have reported more than 200 species belonging to 24 genera (Gupta and Karmakar 2015; Pramanik and Karmakar 2016; Jayaram *et al.* 2016; Santhosh *et al.* 2018; Kar and Karmakar 2021). Despite the large number of native phytoseiids reported, only 13 species of *Neoseiulus* are known in the country (Gupta and Karmakar 2015; Bhowmik and Karmakar 2021; Demite *et al.* 2023).

The Karnataka state located in the southwestern region is a part of highly biodiversity rich regions of India. The state comprises of three geographical regions: coastal region of Karavali and Tulu Nadu, Bayaluseeme region comprising the plains of Deccan plateau and the Hilly Malenadu comprising of Western Ghats, which is one of the 36 biodiversity hotspots in the world. Due to the varying geographic and physiographic conditions, Karnataka experiences climatic variations that range from arid–semi arid in plateau region, sub humid–humid tropical in Western Ghats and humid tropical monsoon in the coastal plains. Therefore, the region may have a great potential for the discovery of new phytoseiid species. However, the state's phytoseiid fauna is less explored compared to northern states of India (Karmakar *et al.* 2017; Kar and Karmakar 2021; Biswas and Karmakar 2023). In this study, we described a new species of *Neoseiulus* from Karnataka, India.

Material and methods

Leaves of plants were inspected with a 10X hand magnifier and those with phytoseiid mites were collected. They were inspected in the laboratory, collecting all mites into MA 80 (Methanol 40 parts, acetic acid 40 parts and water 20 parts) and mounted them on microscope slides in Hoyer's medium. Pictures were taken by using compound microscope Zeiss Axio Imager A1, equipped with differential interference contrast (DIC) optical system and Nikon D7500 camera. Line drawings were performed using a computer program Adobe Photoshop (version CS6) based on the photos. 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 setal pattern is based on Chant and Yoshida-Shaul (1992). Nomenclature of dorsal solenostomes (gland pores) is based on Athias-Henriot (1975). Leg chaetotaxy follows that of Evans (1963). Measurements were taken using ProgRes® Image Capture Software. The measurements for each structure are given in micrometers and presented as mean followed by the respective range, in parenthesis.

Results

Neoseiulus ramabettaensis n. sp. Döker and Jose

Zoobank: 407705E8-EB09-42CA-8ECC-A698D516E287

(Figures 1–2)

Diagnosis

Idiosomal setal pattern 10A:9B/JV-3:ZV (*r3* and *R1* off shield). Dorsal shield reticulated with seven pairs of solenostomes (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8*, and *gd9*) with strong waist at level of seta *R1*. Dorsal setae short, except *j1*, *j3*, *Z4* and *Z5* conspicuously longer than others. Dorsal setae smooth, except *Z4* and *Z5* serrated. Peritremes long, extending to setae level of *j1*. All ventral shields smooth. Sternal shield with three pairs of setae, posterior margin slightly concave, ventrianal shield pentagonal, with three pairs of preanal setae and with large crescentic preanal solenostomes. Calyx of spermatheca elongated, tubular and flaring distally, atrium c-shaped, nodular attached to calyx without neck. Fixed digit of chelicera with 11-12

teeth and movable digit with two teeth. Genu II with eight setae (2 2/1 2/0 1). Leg I with a short macroseta on genu and other legs without macroseta.

Description

Female (n=5)

Dorsum — (Figure 1A). Dorsal setal pattern 10A:9B (*r3* and *R1* off shield). Dorsal shield entire, well sclerotized, strongly reticulated, with waist at level of seta *R1*, with seven pairs of solenostomes (*gd1*, *gd2*, *gd4*, *gd5*, *gd6*, *gd8* and *gd9*) and 16 pairs of poroids (*id1*, *id2*, *id4*, *id5*, *id6*, *idm1*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *idx*, *is1*, *idl1*, *idl3* and *idl4*); muscle-marks (sigillae) visible mostly on podosoma. Length of dorsal shield 380 (373–393), width at level of *s4* 224 (222–227), width at level of *S2* 199 (194–205). Peritremes long, extending to seta level of *j1*. Dorsal setae smooth, except *Z4* and *Z5*, serrated. Dorsal setae generally short (shorter than 30) except *j1*, *j3*, *Z4* and *Z5* noticeably longer than others. Measurements of dorsal setae as follows: *j1* 37 (35–39), *j3* 41 (39–43), *j4* 15 (14–16), *j5* 14, *j6* 18 (17–19), *J2* 17 (16–18), *J5* 11 (10–12), *z2* 20 (18–21), *z4* 19 (16–20), *z5* 15 (13–15), *Z1* 18 (18–19), *Z4* 43 (41–47), *Z5* 74 (69–79), *s4* 27 (26–29), *S2* 21 (20–24), *S4* 22 (19–24), *S5* 22 (18–24), *r3* 22 (19–24) and *R1* 22 (21–23).

Venter — (Figure 1B). Ventral setal pattern 14: *JV*-3:*ZV*. Sternal shield smooth, sclerotized, posterior margin slightly concave; with three pairs of setae (*ST1*, *ST2* and *ST3*), two pairs of poroids (*pst1* and *pst2*); distance between *ST1*–*ST3* 83 (82–84), *ST2*–*ST2* 82 (81–83). Metasternal setae *ST4* and a pair of pores (*pst3*) on metasternal platelets. Genital shield smooth; width at level of setae *ST5* 87 (81–89). Ventrianal shield pentagonal, smooth; with three pairs of pre-anal setae (*JV1*, *JV2* and *ZV2*); one pair of paraanal (*Pa*) and a postanal seta (*Pst*); with large crescentic preanal solenostomes; distance between *gv3*–*gv3* 24 (21–25). Length of ventrianal shield 138 (132–153), width at level of setae *ZV2* 109 (105–114), width at level of paraanal setae 77 (76–80). Setae *ZV1*, *ZV3*, *JV4* and *JV5* and six pairs of poroids on integument surrounding ventrianal shield. Seta *JV5* smooth, 24 (23–26) in length.

Chelicera — (Figure 1C). Fixed digit 43 (41–44) long with 11–12 teeth and pilus dentilis; movable digit 45 (44–47) long with two teeth, one normal in size other conspicuously larger.

Spermatheca — (Figure 1D). Calyx elongated, tubular, flaring distally, 27 (26–28) in length; atrium c-shaped and nodular attached to calyx without neck.

Legs — (Figure 2A–D). Length of legs (excluding pretarsus): I, 330 (301–342); II, 307 (298–311); III, 297 (273–309); IV, 376 (352–387). Chaetotactic formulae as follows: Leg I: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 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 I with a short macroseta on genu, thicker and relatively longer than other setae on the same segment, *SgeI* 29 (28–30) in length, other legs without macroseta. Setae *pd3* and *al3* on basitarsus IV are similar in length and thickness. Seta *pd3* usually modified as macroseta in other phytoseiid species is not noticeably different than seta *al3*.

Male

Unknown.

Type material

Holotype female from *Milletia pinnata* (L.) Panigrahi. (Fabaceae) and a paratype female from *Achyranthes* sp. (Amaranthaceae) in Ramadevarabetta, Karnataka, India, 12°45'05.6124" N, 077°18'04.9104" E, 871 meters above sea level, December 2, 2022, Anna Jose coll. Three paratype females from *M. pinnata* in Shimoga, Karnataka, India, November 25, 2006, C. Chinnamade Gowda Coll.

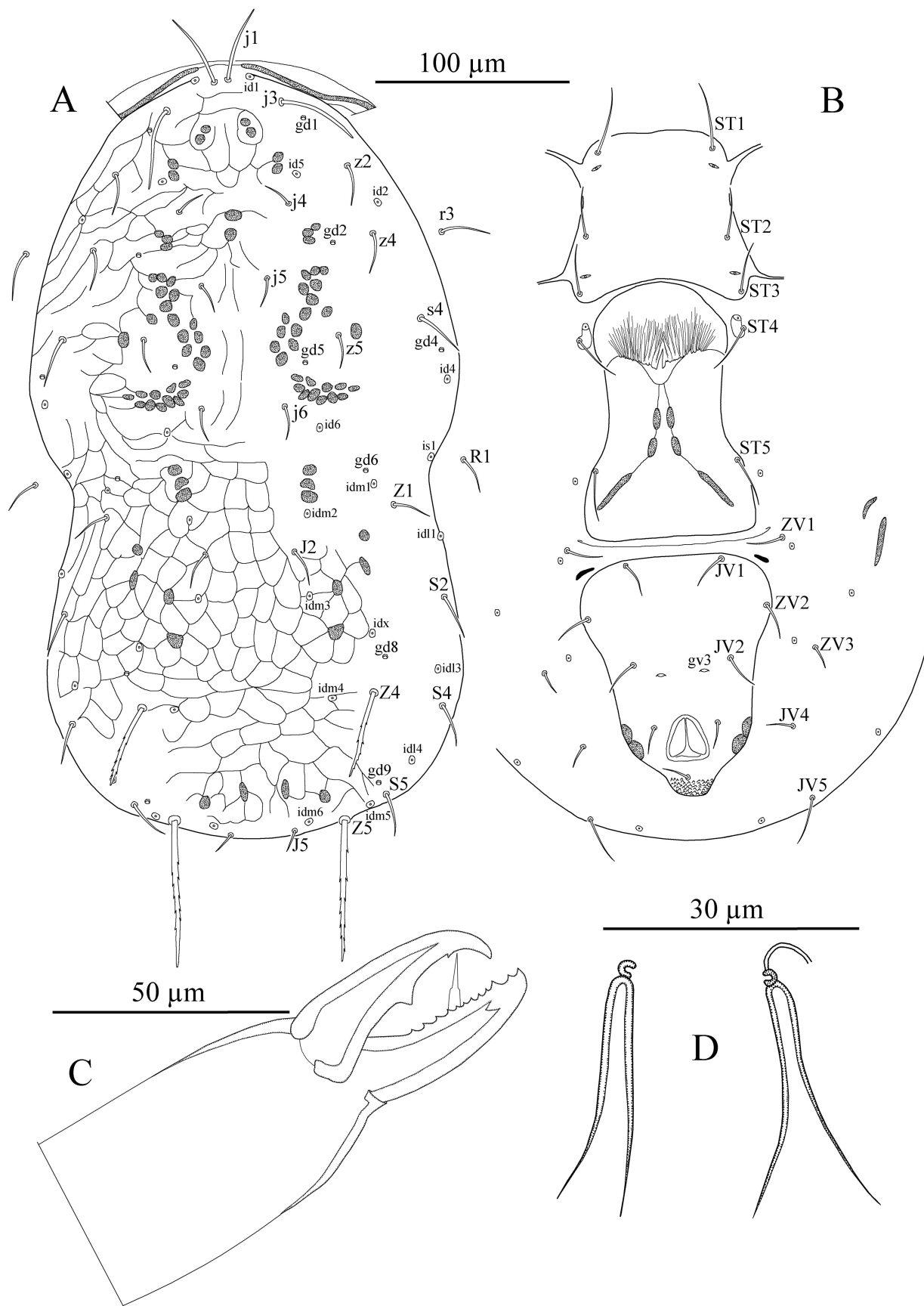


Figure 1 *Neoseiulus ramabettaensis* n. sp., female. A – Dorsal idiosoma; B – Ventral idiosoma; C – Chelicera; D – Spermathecae.

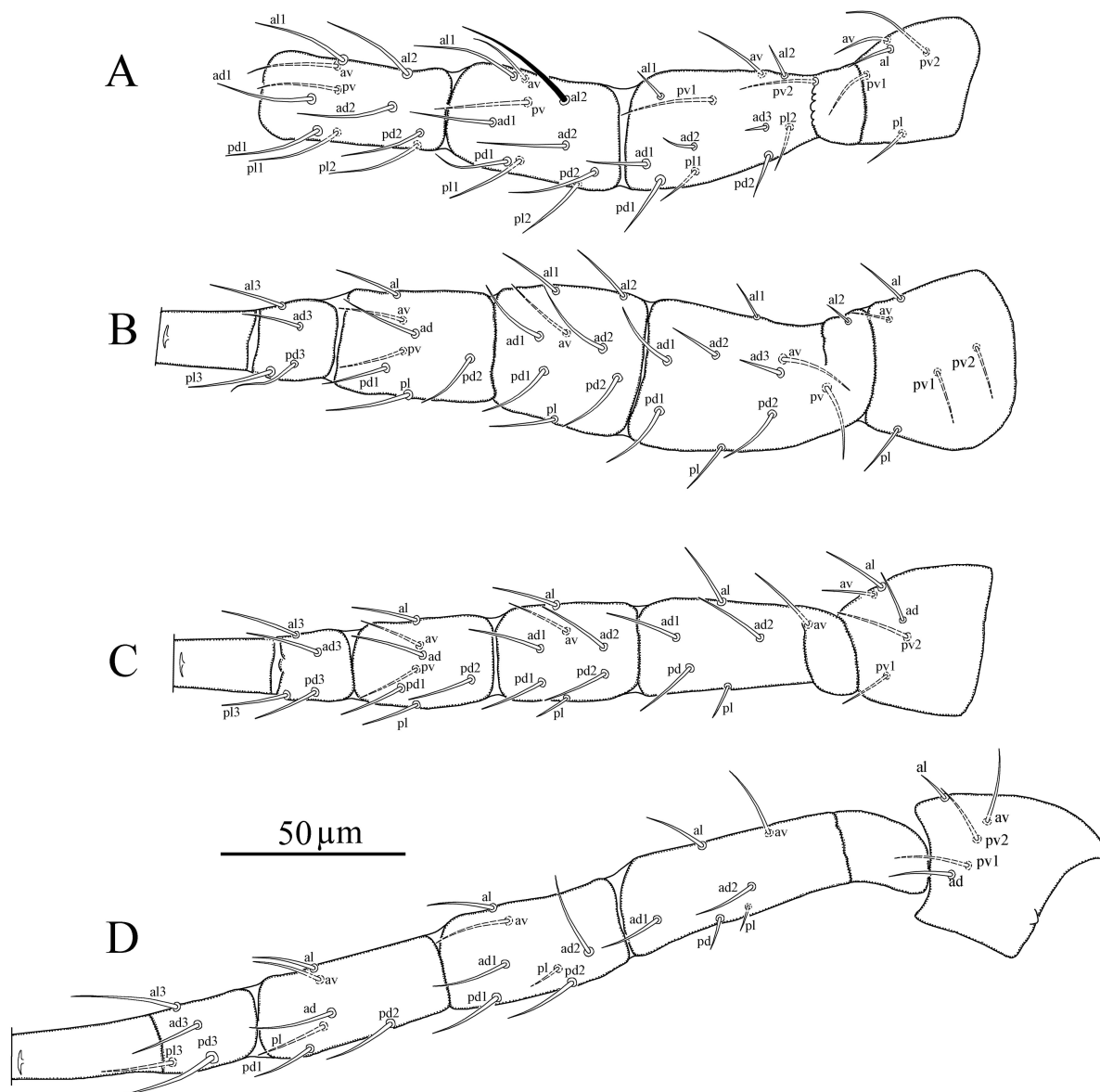


Figure 2 *Neoseiulus ramabettaensis* n. sp., female left legs. A – Leg I (trochanter-tibia), B – leg II (trochanter-basitarsus), C – Leg III (trochanter-basitarsus), D – Leg IV (trochanter-basitarsus). Macroseta on genu I (*al3*) drawn in solid black for clarity.

Depository — The type materials were deposited in the mite collection of the All India Network Project on Agricultural Acarology, Department of Agricultural Entomology, University of Agricultural Sciences, Karnataka, India.

Etymology

The name of the new species “*ramabettaensis*” is derived from the type locality Ramadevarabetta, Karnataka, India where the holotype and a paratype specimens were collected.

Differential diagnosis

The new species is accommodated to the genus *Neoseiulus* by having dorsal setal pattern 10A:9B, ratio setae $s4:Z1 < 3.0$, many teeth on fixed digit of chelicera and lack of macroseta on legs II, III and IV. *Neoseiulus ramabettaensis* n. sp. Döker and Jose can be included in the *cucumeris* species group and *ceratoni* species subgroup due to the morphological characters already mentioned as well as the tubular calyx of spermatheca and its nodular atrium (Chant and McMurtry 2003). The new species can be separated from all known species of the *ceratoni* species subgroup by having setae $j1$ and $j3$, in addition to $Z4$ and $Z5$, conspicuously longer than other dorsal setae. In contrast, only setae $Z4$ and $Z5$ conspicuously longer than others, and setae $j1$ and $j3$ are similar in length with the rest of setae in other known species (Muma *et al.* 1967; Ueckermann and Loots 1988; Karg 1989; Zannou *et al.* 2006; Papadoulis *et al.* 2009; Wu *et al.* 2009; Denmark and Evans 2011; Döker *et al.* 2021a). In addition, the new species is distinctly different than other known species in the subgroup by having 11-12 teeth on fixed digit and two teeth on movable digit of chelicera, conspicuously wider ventrianal shield at anterior corners, and large crescentic preanal pores. In contrast, fixed digit with a few apical teeth, ventrianal shield not wider at anterior corners and preanal pores simple and rounded in the other species. *Neoseiulus ramabettaensis* n. sp. Döker and Jose show affinity to *N. disparis* described by Chaudhri, Akbar and Rasool in 1979 from Pakistan. Movable digit of chelicera of the new species has two teeth as oppose to one in *N. disparis* (Chaundri *et al.* 1979). The chelicera dentition is widely used as a diagnostic character in the genus *Neoseiulus* (Faraji *et al.* 2007; Kreiter *et al.* 2018; Tsolakis and Ragusa 2020; Döker *et al.* 2021b; Ferragut and Navia 2022). Indeed, the usefulness of movable digit dentition to separate closely related species in *Kampimodromus*, another genus in the subfamily Amblyseiinae, have been confirmed by molecular analyses in several cases (Tixier *et al.* 2008; Döker *et al.* 2018). In addition, according to the original description, seta $Z4$ reaches the base of $Z5$ in *N. disparis* but not in the new species. Furthermore, *N. disparis* has a macroseta on basitarsus IV which is at least two times longer than the other three setae on the same segment (Chaundri *et al.* 1979). In contrast, macroseta is absent on this leg segment in the new species, and setae $pd3$ and $al3$ are similar in length and thickness. In other words, seta $pd3$ usually modified as macroseta in other phytoseiid species is not noticeably different than seta $al3$. Moreover, the new species has large crescentic preanal pores, but these pores are absent in *N. disparis*. Indeed, Chaundri *et al.* (1979) illustrated not only large crescentic but also small rounded preanal pores for many other species in the same publication, but not for *N. disparis*. The new species also shows affinity to *N. rancidus* (Chaudhri *et al.* 1979) based on the dorsal setae measurements and shape of ventrianal shield, however, dorsal seta $J1$ is present in this species.

If we ignore the absence of macroseta on legs II, III and IV, on the other hand, the new species can be placed in the *lugubris* species group in the genus *Typhlodromips* De Leon, due to chelicera dentition and spermatheca morphology (Chant and McMurtry 2005; 2007). In this case, it can be separated from all other species listed in that species group by the shape of ventrianal shield and the relative measurements of setae $j1$, $j3$, $Z4$ and $Z5$ compared to the other dorsal setae.

Remarks

The current study describes a macroseta on leg I ($SgeI$) for a species listed in the *ceratoni* species subgroup for the first time. Indeed, the presence of $SgeI$, and the absence of macroseta on leg IV are unusual characters for the genus *Neoseiulus*, except a few previous studies that reported $SgeI$ in some species in the *desertus* species group (Chant and McMurtry 2003; Bas *et al.* 2022). Therefore, chaetotaxy of legs frequently used in the systematics of other groups of Mesostigmata which are closely related to phytoseiid mites, seems to be an important morphological character and should be included in future descriptions.

Key to Indian species of *Neoseiulus* Hughes

1. Spermatheca with atrium forked for at least half its length at juncture with major duct, or atrium appearing thick-walled, vacuolated 2
 — Spermatheca with atrium not deeply forked at juncture with major duct, nor appearing thick-walled, vacuolated 4
2. Dorsal setae usually short not reach to the base of following setae 3
 — Dorsal setae longer, most of them reach and passes the base of the following setae
 *Neoseiulus longispinosus* (Evans)
3. Dorsal shield smooth *Neoseiulus barkeri* Hughes
 — Dorsal shield faintly reticulate *Neoseiulus indicus* (Narayanan & Kaur)
4. Female ventrianal shield large, square or rectangular, rounded posteriorly (L/W ratio.= 1.0-1.3:1.0); dorsal shield with marked shoulder at level of seta *z4* 5
 — Female ventrianal shield pentagonal or with lateral margins slightly rounded or shield shaped; dorsal shield without marked shoulder at level of seta *z4* 7
5. Preanal pores *gv3* present 6
 — Preanal pores *gv3* absent *Neoseiulus aceriae* (Gupta)
6. Preanal pores *gv3* crescentic, located close to each other
 *Neoseiulus baraki* (Athias-Henriot)
 — Preanal pores *gv3* rounded, located apart from each other
 *Neoseiulus paspalivorus* (De Leon)
7. Spermatheca with calyx elongate, tubular, flaring distally 8
 — Spermatheca with calyx cup-, bell-, dish or V-shaped, or short saccular 10
8. Genu II with eight setae; leg IV without macroseta; movable digit of chelicera with two teeth; fixed digit with many teeth evenly distributed along the digit
 *Neoseiulus ramabettaensis* n. sp. Döker & Jose
 — Genu II with seven setae; leg IV with three macrosetae; movable digit of chelicera with one tooth; fixed digit a few teeth apically 9
9. Genu III with eight setae; macrosetae on genu IV and basitarsus IV subequal in length
 *Neoseiulus pranadae* Karmakar & Gupta
 — Genu III with seven setae; macrosetae on genu IV shorter than that on basitarsus IV
 *Neoseiulus cynodona* (Gupta)
10. Calyx of spermatheca bell-shaped or saccular 11
 — Calyx of spermatheca cup-shaped 12
11. Calyx of spermatheca bell-shaped; movable digit of chelicera with three teeth
 *Neoseiulus fallacis* (Garman)
 — Calyx of spermatheca saccular; movable digit of chelicera with one tooth
 *Neoseiulus cucumeris* (Oudemans)
12. Dorsal setae *Z4* and *Z5* subequal in length or *Z4* slightly shorter than *Z5* 13
 — Dorsal seta *Z5* conspicuously longer (at least two times) than seta *Z4* 14

13. Dorsal seta *Z4* slightly shorter than *Z5* *Neoseiulus imbricatus* (Corpuz & Rimando)
 — Dorsal setae *Z4* and *Z5* subequal in length *Neoseiulus lablabi* (Ghai & Menon)
14. Ratio setae *Z4/Z5* about 1:2 *Neoseiulus ficusi* (Gupta)
 — Ratio setae *Z4/Z5* about 1:5 *Neoseiulus neoghanii* (Gupta)

Notes on the identification key

1. The preliminary list of *Neoseiulus* species was obtained from the most recent checklist of Indian phytoseiid mites constructed by Gupta and Karmakar (2015). In addition, subsequent reports of species under the genus *Neoseiulus* were also considered (Suresh *et al.* 2016; Sathish *et al.* 2019; Bhowmik and Karmakar 2021).
2. None of the material of any Indian species of the genus treated in the current key was examined in this study, except the new species. Therefore, we just considered valid species names reported from India and have relied on their original descriptions and acceptable redescrptions to construct the key. The preliminary separation of the species based on the most widely used classification system suggested by Chant and McMurtry (2007).
3. Two species, *N. bindrai* and *N. dhooriai* both described by Gupta (1977) were considered junior synonyms of *N. indicus* and *N. baraki*, respectively, as suggested by the descriptor in his subsequent monograph (Gupta 1986).
4. *Neoseiulus oahuensis* (Prasad) was considered as junior synonym of *N. barkeri* according to Ragusa and Athias-Henriot (1983).
5. *Neoseiulus reticulatus* (Oudemans) reported by Gupta (1975, 1977) was not included in the current key, because of a possible misidentification. Indeed, a subsequent illustration by the same author (Gupta 1986) shows a smooth movable digit as opposed to two teeth in a redescription of the species by Kolodochka (1988).
6. The original description of *N. daturae* by Suresh *et al.* (2016) shows many teeth on the fixed digit, and macrosetae on legs II and III, in addition to leg IV, are present. Therefore, the species is not fit the definition of the genus in the tribe Neoseiulini but maybe with *Typhlodromips* in the tribe Typhlodromipsini (Chant and McMurtry 2007). For this reason, the type material of *N. daturae* requires reconsideration. Consequently, we did not include this species in the identification key.

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