Acarologia
Open Science in Acarology

# A new species of *Agistemus* Summers (Acari: Stigmaeidae), and key to all known species from Peru

Hector Alonso Escobar-Garcia[a,b], Daniel Júnior De Andrade[b], André Luis Matioli[c], Francisco Jose Rojas-Espinoza[d], Edward A. Ueckermann[e]

[a] Facultad de Agronomía, Universidad Nacional de Piura (UNP), Piura, Peru.
[b] College of Agricultural and Veterinary Sciences, São Paulo State University (FCAV/UNESP), São Paulo, Brazil.
[c] Laboratório de Acarologia, Instituto Biológico de Campinas, São Paulo, Brazil.
[d] Laboratorio de Valparaiso, Servicio Agricola y Ganadero (SAG), Chile.
[e] Unit for Environmental Sciences and Management, Potchefstroom Campus, North-West University, Private Bag X6001, Potchefstroom, 2520, South Africa.

**Original research**

**ABSTRACT**

A new species of the family Stigmaeidae, the genus *Agistemus* group *terminalis*, namely: *A. peruvianus* **n. sp.**, inhabiting foliage of a native forest tree called algarrobo, *Neltuma piurensis* (Fabaceae), from Piura, north-western Peru, is described and illustrated based on females, males, and deutonymphs. The mites were found during spring, summer, and autumn, but more frequently observed autumn (March to June). A key to the Peru species of the genus *Agistemus* is provided.

**Keywords** Trombidiformes; Prostigmata; taxonomy; predatory mites; forest
**Zoobank** http://zoobank.org/8EDDBA9E-BAAA-471C-88F3-23B07F50FC7B

## Introduction

Stigmaeidae is one of the mite families in the superfamily Raphignathoidea (Acari: Trombidiformes: Prostigmata) and is one of the best-studied mite families, as several genera of the family were revised recently (Fan *et al.* 2016). The first key to the genera of Stigmaeidae was developed by González-Rodríguez (1965). Forty years later, Fan & Zhang (2005) compiled a key to the 26 genera then known and the first key to life stages of Stigmaeidae. Subsequently, Fan & Flechtmann (2015) summarized the research on the taxonomy, biology, and ecology of this family and counted 534 species in 33 genera. A year later, Fan *et al.* (2016) provides a catalogue that contained information on the systematic position of 577 species in 34 genera, their host plant range, and their referenced geographical distribution, and present a pictorial key to genera, of which in the Neotropics they reported 49 species in 8 genera, with *Agistemus* the most abundant. Recently Rehman, *et al.* (2018), separated the genus *Agistemus* species into two species groups; namely: *fleschneri* based on one pair of aggenital setae with 14 species; and *terminalis* based on two pairs of aggenital setae with 69 species. In the present study, we follow the definition of the genus *Agistemus* provided by Fan & Zhang (2005).

The genus *Agistemus* is one of the largest genera of the Stigmaeidae containing 85 valid species (Beron 2020), *A. piquinnus* Monjarás-Barrera & Johann, *A. bahiensis* Bizarro & Johann, *A. neocollyerae* Kamran *et al.*, and *A. arabensis* Kamran et al. in Saudi Arabia were recently described and illustrated, adding up to 89 species (Beron 2020, Monjarás-Barrera *et al.* 2020, Bizarro *et al.* 2022, Kamran *et al.* 2023). Some species of this genus are known to prey on

Received 17 May 2023
Accepted 18 July 2023
Published 26 July 2023

Corresponding author
Hector Alonso Escobar-Garcia:
hescobarg@unp.edu.pe

Academic editor
Faraji, Farid

https://doi.org/10.24349/s8la-ulzi

ISSN 0044-586X (print)
ISSN 2107-7207 (electronic)

phytophagous mites of three families namely, Tetranychidae, Tenuipalpidae, and Eriophyidae, and on eggs of phytophagous insects (González-Rodríguez 1963; Elbadry *et al.* 1969; Muma & Selhime 1971; Hafez *et al.* 1983; Ehara 1985; Osman & Zaki 1986; Kethley 1990; Abou-Awad & Elsawi 1993; Momen 2001; Ferla & Moraes 2003; Gerson *et al.* 2003; Zhang 2003; Fan & Zhang 2005; Moraes & Flechtmann 2008; Leiva *et al.* 2013; Da Silva *et al.* 2015; Fan & Flechtmann 2015). Some of these species are associated with citrus (Muma & Selhime 1971; Garcia-Mari *et al.* 1986; Matioli *et al.* 2002, 2007; Childers & Ueckermann 2014), grapevines (*Vitis vinifera* L., *Vitis labrusca* L.) (Vitaceae), weeds associated with vineyard agroecosystem in Brazil (Johann *et al.* 2013), olive, *Olea europaea* L. (Oleaceae), variety Arauco in Argentina (Leiva *et al.* 2013), and *Capsicum annuum* L. (Solanaceae) in Mexico (Monjarás-Barrera *et al.* 2020).

Four species of *Agistemus* Summers were previously reported from Peru, namely: *Agistemus fleschneri* Summers, *A. longisetus* González-Rodríguez, *A. floridanus* González-Rodríguez, and *A. terminalis* (Quayle) (González-Rodríguez 1963; González-Rodríguez 1965; Fan *et al.* 2016). Herein, *Agistemus peruvianus* **n. sp.**, is described and illustrated as a new species from specimens collected on *Neltuma piurensis* (L. Vásquez, Escurra & Huamán) C.E. Hughes & G.P. Lewis (Fabaceae) (Hughes *et al.* 2022) in Piura, north-western Peru, a forest tree recognized for its great economic, and ecological benefits (SERFOR 2021), and a key to all species of the genus *Agistemus* in Peru is presented.

## Material and methods

The *Agistemus* specimens were collected from leaves of the native forest tree *Neltuma piurensis* on the campus of the Universidad Nacional de Piura (UNP), Peru (5°10′46.89″S; 80°37′04.31″W; 34 m a.s.l.) during June 2020 to June 2021. The climatic dataused (average daily temperatures and relative humidity for the sampling period) were obtained from the MetRadarUdep1 located within Universidad de Piura (UDEP), about 2.5km from the sampled trees (5°10′14″S; 80°38′18″W; 36 m a.s.l.). A total of 50 leaves, were collected randomly every two weeks, from the lower third of the trees and placed into paper bags and transferred to the laboratory. Thereafter, yellow mites were collected with a fine-tipped brush under the stereomicroscope (ZEISS Stemi 508) and were preserved in 70% ethanol. The preserved mites were then mounted dorso-ventrally on a microscope slide in Hoyer's medium and put in an oven at 50 °C for 7 days (Walter and Krantz 2009), then the slides were sealed with nail polish. All mites were examined under a Nikon Eclipse E200 phase-contrast compound microscope. Measurements were done using the same microscope and are given in µm. Setae were measured from the centre of the seta base to the tip of the seta; distances between setae were measured as the distance from the centre of one seta base to the other. The nomenclature for gnathosomal and leg setation follows that of Grandjean (1944) and for the idiosomal setae that of Kethley (1990). The photos were taken using a AixoCam MRc5 camera mounted on a Zeiss Axio Imager.Z2 AX10 DIC compound microscope. The type materials are deposited in UNP— Acarology collection of the Entomology Laboratory, SL01LA68, at the Universidad Nacional de Piura, Peru; ESALQ— Departamento de Entomologia e Acarologia, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Brazil; and IB— Instituto Biológico de Campinas, São Paulo, Brazil.

## Taxonomy

### Family Stigmaeidae Oudemans, 1931

### Genus *Agistemus* Summers, 1960

*Agistemus* Summers, 1960: 234.

**Type species** — *Caligonus terminalis* Quayle 1912, by original designation.

### *Agistemus terminalis* (Quayle), Summers 1960: 234

**Diagnosis** — Based on Fan & Zhang 2005.

Species group *terminalis*

**Type species** — *Agistemus terminalis* (Quayle). **Diagnosis** Based on Rehman *et al.* 2018. Two pairs of aggenital setae ($ag_{1\text{-}2}$).

### *Agistemus peruvianus* Escobar-Garcia, Matioli & Ueckermann n. sp.

Zoobank: E29BA6C8-8C2F-453B-B08C-7135705998BE

(Figures 1–6, Tables 1–3)

#### Type material examined

**Holotype female** — Peru, campus of the Universidad Nacional de Piura, Piura (5°10′46.9″S 80°37′04.31″W), May 10, 2021, Hector Escobar (SL01LA68).

**Paratypes** — Six females, two males, and two deutonymphs on separate microscope slides in (SL01LA68); two females on separate microscope slides in ESALQ; one female and one deutonymph, on separate microscope slides in IB, same data as holotype, except collected between October 12, 2020 to June 07, 2021.

#### General diagnosis

**Female**

Aggenital shield entire with two pairs of aggenital setae ($ag_{1\text{-}2}$); prodorsal and hysterosomal shields without reticulation (smooth); humeral plates present, setae $c_2$ on humeral plates; dorsal idiosomal setae long, barbed, and inserted on strong tubercles, ratios *sci*/*pob* 4.2 ± 0.1, *pob*/*eye* 2.04 ± 0.0, *vi*/*vi*–*vi* 2.9 ± 0.1, *ve*/*ve*–*sci* 2.4 ± 0.1, $c_1/c_1$–$c_1$ 3.2 ± 0.1, $d_1/d_1$–$d_1$ 1.2 ± 0.1, $e_1/e_1$–$e_1$ 2.9 ± 0.1; tibia I and II with one barbed seta; tibia III and IV with two of this type of seta.

#### Description

**Female (n=10)**

(Figures 1–4)

**Body** — Yellowish, and with eyes red, lateral on prodorsal shield. The length of the body was measured from the posterior margin of the idiosoma to the tip of the infracapitulum 365 ± 3.3 (340–420).

**Idiosomal dorsum** — Idiosoma broadly oval. Prodorsal shield subtriangular smooth, with one pair of eyes 9.0 ± 0.2 (8–10); two post ocular bodies *pob* 18.3 ± 0.3 (17–20), and 3 pairs of setae (*vi*, *ve* and *sci*) (Fig. 1); *sci*/*pob* 4.2 ± 0.1 (3.8–4.5); *pob*/*eye* 2.04 ± 0.0 (2.0–2.1). Humeral shields smooth, small and bearing setae $c_2$. Hysterosomal shield polygonal without reticulations (smooth), bearing five pairs of setae ($c_1$, $d_1$, $d_2$, $e_1$ and $e_2$), intercalary shields smooth and with setae *f*, suranal shield entire and smooth, with two pairs of setae ($h_1$ and $h_2$) (Fig. 2). Dorsal setae inserted on tubercles, long, barbed, $h_1$ and $h_2$ comparatively shorter than other dorsal setae ($ve \geq e_1 \geq e_2 \geq d_1 > c_1 \geq d_2 \geq sci > f > vi > c_2 > h_1 > h_2$, based on mean ± SE with 95% confidence interval of the means). Setae $h_1$ longer than setae $h_2$; setae $h_2$ inserted anterior to setae $h_1$. Ratios: *vi*/*vi*–*vi* 2.9 ± 0.1 (2.6–3.1), *ve*/*ve*–*sci* 2.4 ± 0.1 (2.2–2.6), $c_1/c_1$–$c_1$ 3.2 ± 0.1 (2.6–4.3),$d_1/d_1$–$d_1$ 1.2 ± 0.1 (1.1–1.4),$e_1/e_1$–$e_1$ 2.9 ± 0.1 (2.5–3.2). Lengths of dorsal setae and distance between dorsal setae are presented in Table 1.

**Gnathosoma** — The infracapitulum bearing subcapitular setae *m* 25.8 ± 0.3 (22.5–30.0), *n* 39.2 ± 1.0 (35–45), adoral setae $or_1$ 15.8 ± 0.3 (15–17) and $or_2$ 10.6 ± 0.4 (8–15). Distances *m*–*m* 40.4 ± 1.1 (35–45), *n*–*n* 33.3 ± 0.7 (30–35), $or_1$–$or_1$ 14.1 ± 0.4 (12–15), $or_2$–$or_2$ 7.3 ± 0.2 (6–8). Cheliceral stylet 37.1 ± 0.7 (35–40) slightly longer than palp tarsus 22 ± 0.1 (20–23). Palp with pair supracoxal setae *elcp*; palp trochanter without setae; palp femur with two smooth setae (*l′*, *v″*) and one barbed seta (*d*); palp genu with one smooth seta (*l′*); palp tibia with two smooth setae (*l′*, *l″*), one well-developed claw (18–22), one seta associated with claw (*l′T*); palp

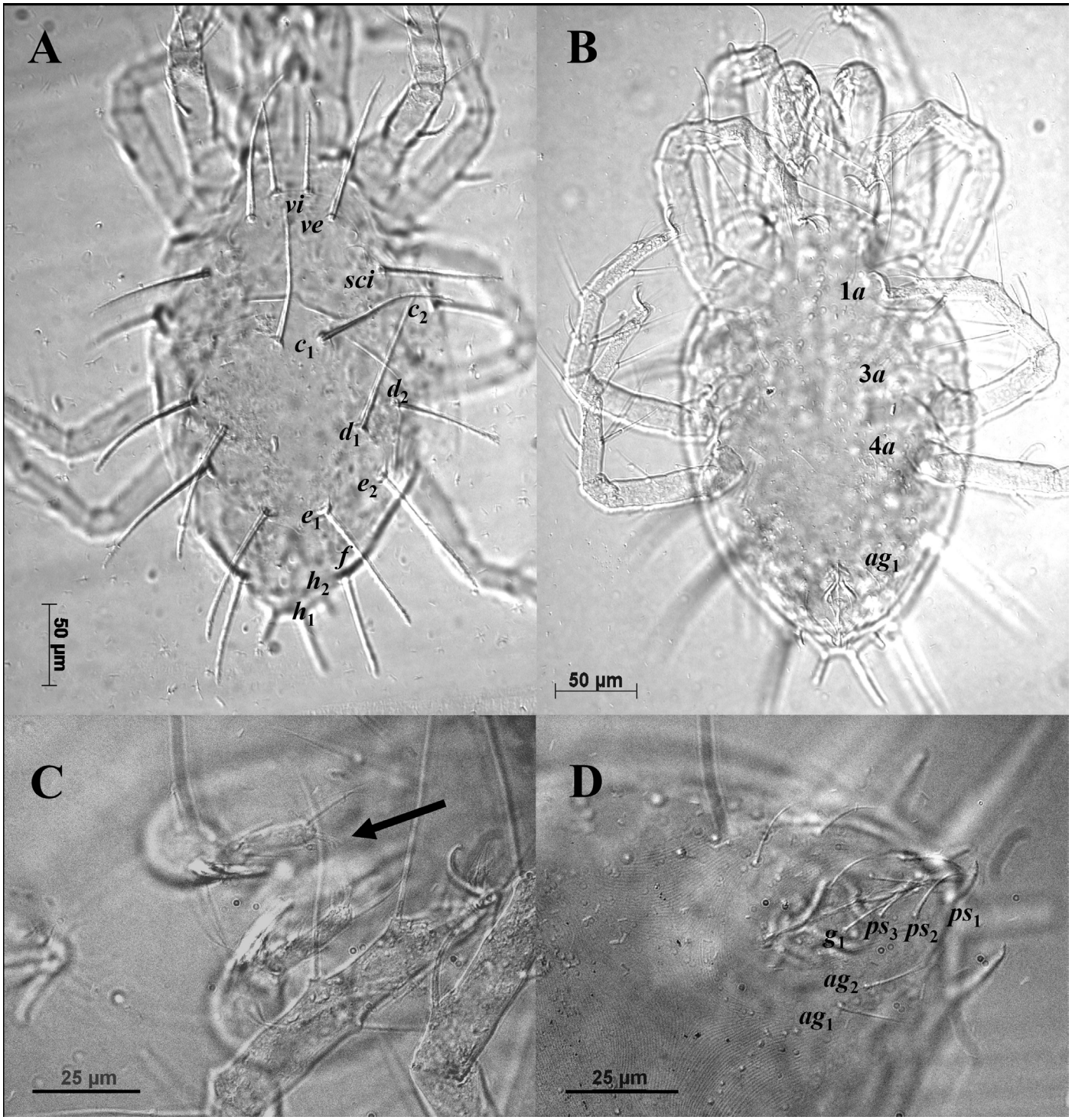


**Figure 1** *Agistemus peruvianus* **n. sp.**, (Holotype female). A – Dorsum; B – Venter; C – Palptarsus with eupathidia, fused at basis, trifid distally (indicated by arrow); D – Aggenital shield entire, horseshoe-shaped, bearing two pairs of setae ($ag_1$ and $ag_2$), and anogenital covers with one pair of genital setae ($g_1$) and three pairs of pseudanal setae ($ps_{1\text{-}3}$).

tarsus (22–23) with four simple setae (*ba*, *bp*, *va* and *lp*), one solenidion (*ω*) (6–8), subapical eupathidium (*acmζ*) and three eupathidia (*sulζ*, *ul'ζ*, *ul"ζ*), fused at basis, trifid distally (Fig. 3).

**Idiosomal venter** — Striae between setae 1*a*–1*a*, 3*a*–3*a*, and 4*a*–4*a* obliquely longitudinal. Striae form a diamond-shaped pattern between setae 1*a*–3*a*, and 4*a*–$ag_1$ (Fig. 2B). In addition,

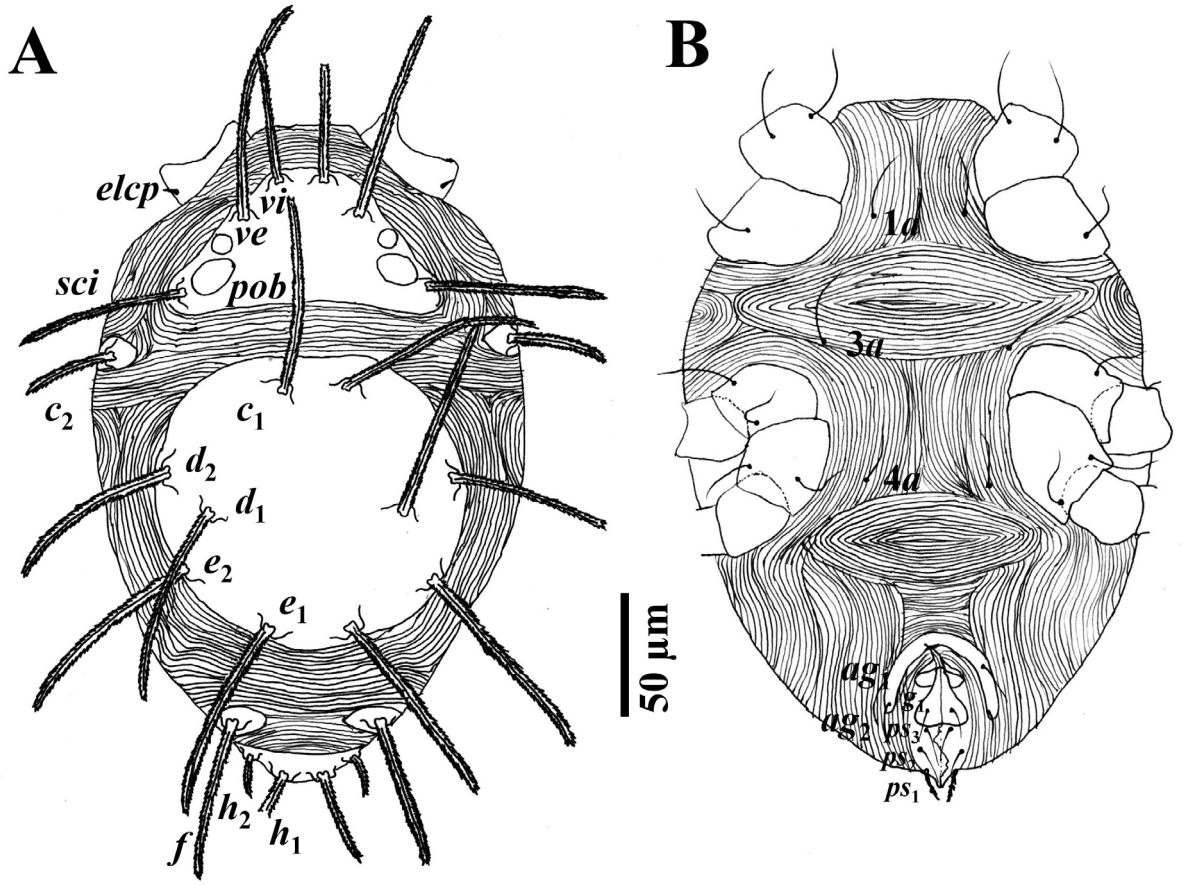


**Figure 2** *Agistemus peruvianus* **n. sp.** (Holotype female). A – Idiosomal dorsum; B – Idiosomal venter.

the area between setae 3*a*–4*a* with longitudinal striation. Aggenital shield entire, horseshoe-shaped, bearing two pairs of setae ($ag_1$ and $ag_2$). Anogenital covers with one pair of genital setae ($g_1$) and three pairs of pseudanal setae ($ps_{1\text{-}3}$), $ps_1$ barbed (Fig.1D). Lengths of ventral setae and distance between ventral setae are presented in Table 2.

**Leg chaetotaxy** — Legs I–IV with two tarsal claws and an arolium with tenent hairs between the claws. Number of setae on leg segments, with solenidia (on tibiae and tarsus), supracoxal setae (on coxae), and specialized setae (on genua) given in parentheses: coxae 2 (+1*elcp*)–1–2–2, trochanters 1–1–1–1, femora 5–4–2–2, genua 3 (+1$\kappa$)–1–0–0, tibiae 5 (+1$\varphi\rho$)–5 (+1$\varphi\rho$)–5 (+1$\varphi\rho$)–5 (+1$\varphi\rho$), and tarsi 12 (+1$\omega$)–9 (+1$\omega$)–7 (+1$\omega$)–7 (Fig. 4). Dorsal seta on femur I (*dFI*) barbed 44.4 ± 1.8 (38–53), equal than $h_1$, 1.0 ± 0.1 (0.9–1.1) times length of $h_1$; dorsal seta on genu I (*dGI*) barbed 33.3 ± 0.8 (30–38). Length of solenidion on tibia ($\varphi\rho$): Tibia I $\varphi\rho$ 20.9 ± 0.3 (20–22); Tibia II $\varphi\rho$ 17.6 ± 0.5 (16–20); Tibia III $\varphi\rho$ 16.0 ± 0.3 (15–18); Tibia IV $\varphi\rho$ 15.6 ± 0.2 (15–17). Length of solenidion on tarsus ($\omega$): tarsus I $\omega$ 22.4 ± 0.7 (20–25); tarsus II $\omega$ 21.6 ± 0.6 (20–25); tarsus III $\omega$ 15.3 ± 0.2 (15–17). Length tarsal claws I–IV (15–17). Leg chaetotaxy also is as in Table 3.

**Male (n=2)**

(Figure 5)

**Body** — Yellowish, with eyes red lateral on prodorsal shield. The male is smaller than the female, with a body that tapers posteriorly. The length of the body was measured from the posterior margin of the idiosoma to tip of infracapitulum 290–300, width of idiosomal 155–157.

**Idiosomal dorsum** — Prodorsal shield subtriangular smooth, with one pair of eyes; two

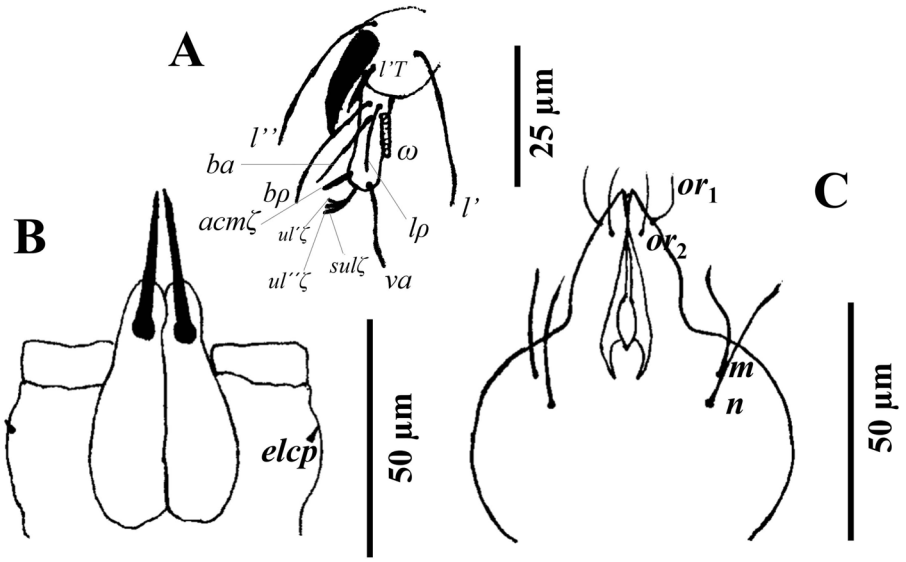


**Figure 3** Gnathosoma of *Agistemus peruvianus* **n. sp.** (Holotype female). A – Palp tibia and tarsus; B – Dorsum of gnathosoma; C – Venter of gnathosoma.

*pob* and three pairs of setae (*vi*, *ve* and *sci*); ratio: *sci*/*pob*: (3.9–4.2); *pob*/*eye* (2.0–2.1). Humeral shields smooth, small and bearing setae $c_2$. Hysterosomal shield polygonal without reticulations (smooth), bearing six pairs of setae ($c_1$, $d_1$, $d_2$, $e_1$, $e_2$, and *f*) (Fig. 5A); suranal shield entire and smooth, with two pairs of setae ($h_1$ and $h_2$). Dorsal setae inserted on tubercles, long, barbed, $h_1$ and $h_2$ comparatively shorter than other dorsal setae. Lengths of dorsal setae: *vi* (49–52), *ve* (70–80), *sci* (63–70), $c_1$ (60–65), $c_2$ (45–47), $d_1$ (57–58), $d_2$ (63–65), $e_1$ (25–32), $e_2$ (58–60), *f* (50–57), $h_1$ 18, $h_2$ 20, distances between dorsal idiosomal setae: *vi*–*vi* (21–22), *ve*–*ve* (42–47), *ve*–*sci* 40, *sci*–*sci* (89–95), $c_1$–$c_1$ (19–25), $c_2$–$c_2$ 150, $d_1$–$d_1$ (55–57), $d_2$–$d_2$ (90–100), $e_1$–$e_1$ 22, $e_2$–$e_2$ (76–80), *f*–*f* (39–40), $h_1$–$h_1$ 10, $h_2$–$h_2$ (35–37). Ratios: *vi*/*vi*–*vi* (2.3), *ve*/*ve*–*sci* (1.7–2.0), $c_1/c_1$–$c_1$ (2.6–3.2), $d_1/d_1$–$d_1$ 1.0, $e_1/e_1$–$e_1$ (1.1–1.4).

**Gnathosoma** — Similar to that of female. The infracapitulum bearing subcapitular setae *m* (27–28), *n* (37–45), adoral setae $or_1$ 15, $or_2$ 13. Distances *m*–*m* (39–42), *n*–*n* (29–35), $or_1$–$or_1$ 14, $or_2$–$or_2$ 6. Cheliceral stylet 35 slightly longer than palptarsus (18–20). Palp with pair supracoxal setae *elcp*; palp trochanter without setae; palp femur with two smooth setae (*l′, v″*) and one barbed seta (*d*); palp genu with one smooth seta (*l′*); palp tibia with two smooth setae (*l′, l″*), one well-developed claw 20, one seta associated with claw (*l′T*); palptarsus, with four simple setae (*ba*, *bp*, *va* and *lp*), one solenidion (*ω*) 8, subapical eupathidium (*acm*) and three eupathidia (*sul*, *ul′*, *ul″*), fused at basis, trifid distally (Fig. 5B).

**Idiosomal Venter** — Striae between the setae 1*a*–1*a*, 3*a*–3*a*, and 4*a*–4*a* with obliquely longitudinal. Striae also form a diamond-shaped pattern between the setae 1*a*–3*a*, and 4*a*–$g_1$. Area between setae 3*a*–4*a* with longitudinal striation. Anogenital covers with three pairs of pseudanal setae ($ps_{1\text{-}3}$). Lengths of ventral setae: 1*a* (20–21), 3*a* 20, 4*a* 18, $ag_1$ (10–14), $ag_2$ (10–12); distances between ventral idiosomal setae: 1*a*–1*a* (30–32), 3*a*–3*a* (42–45), 4*a*–4*a* (26–42), $ag_1$–$ag_1$ 20, $ag_2$–$ag_2$ 27.

**Leg chaetotaxy** — Leg setal counts as in female except tarsi 12 (+2*ω*) –9 (+2*ω*) –7 (+1*ω*) –7 (+1*ω*). Dorsal seta on femur I (*dFI*) barbed (47–48), longer than $h_1$, 2.6–2.7 times length of $h_1$; dorsal seta on genu I (*dGI*) barbed (34–35). Length of solenidion on tibia (*φρ*): Tibia I *φρ* (20–22), tibia II *φρ* (15–16); tibia III *φρ* 15; tibia IV *φρ* 15. Length of solenidion on tarsus (*ω*): tarsus I ωI (32–35), ωII 22, distance *ω*I–*ω*II 15 (Fig. 5B); tarsus II *ω*I (30–32), *ω*II (22–24), distance *ω*I–*ω*II (2–3); tarsus III *ω*I (12–13); tarsus IV *ω*I (14–16). Length tarsal claws I–IV 15.

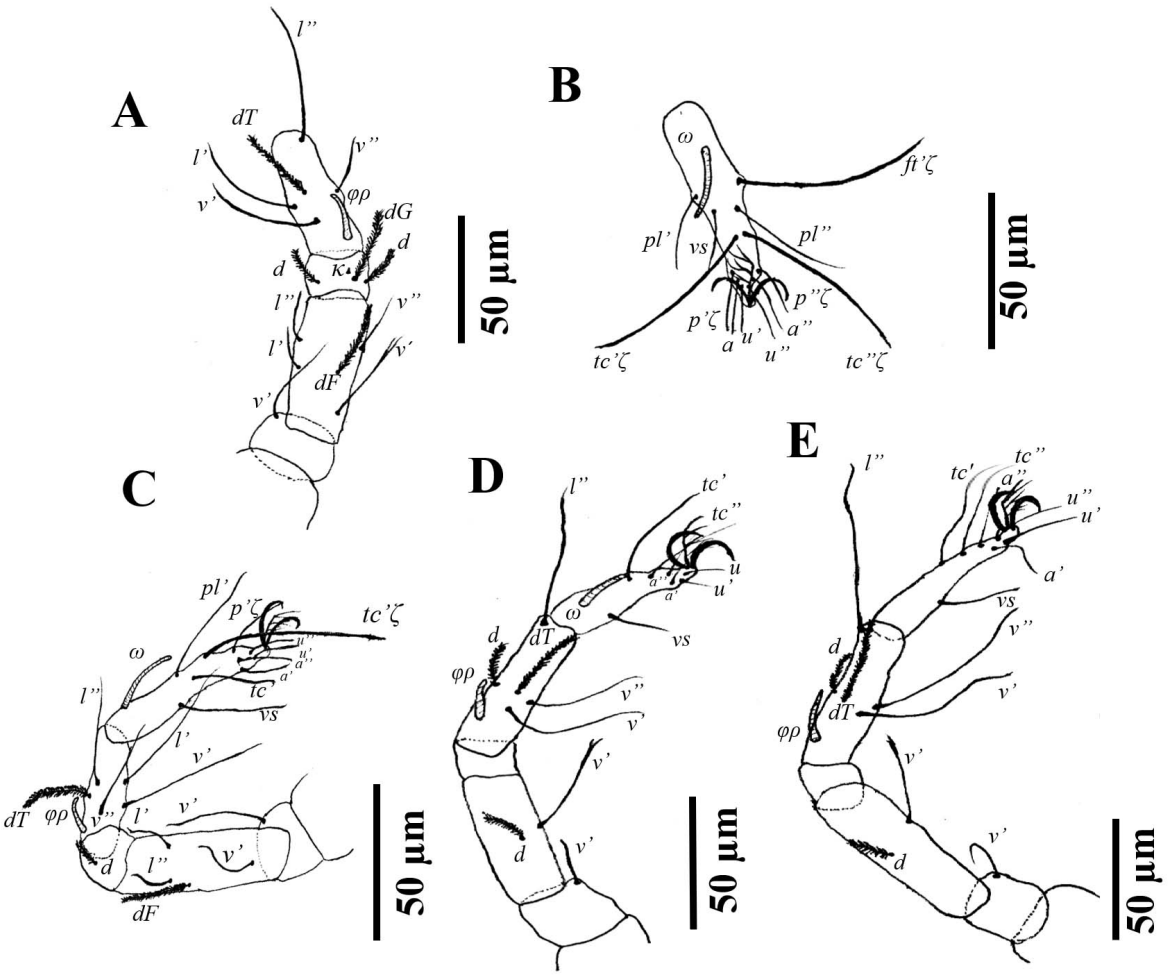


**Figure 4** *Agistemus peruvianus* **n. sp.** (Holotype female). A – Leg I without tarsus I; B – Tarsus I; C – Leg II; D – Leg III; E – Leg IV.

**Aedeagus**. Aedeagus an elongated shaft, 50–55 long, terminal third bifid. Posterior half enclosed in a broad sheath (11–12 height, 16–17 width) which ends in two pointed sclerotized structures which may act as a guide.

**Deutonymph (n=3)**

(Figure 6)

**Body** — Deutonymph also yellowish with red eyes lateral on prodorsal shield. The deutonymph is smaller than the female. The length of the body was measured from the posterior margin of the idiosoma to the tip of the infracapitulum 316.1 ± 8.4; width of idiosomal 156.0 ± 6.5 (Fig. 6A).

**Idiosomal dorsum** — Prodorsal shield subtriangular smooth, with one pair of eyes; two post ocular bodies (*pob*) (Fig. 6B), and three pairs of setae (*vi*, *ve* and *sci*); ratio: *sci*/*pob*: 3.2; *pob*/*eye* 2.5; humeral shields smooth, small and bearing setae $c_2$. Hysterosomal shield polygonal without reticulations (smooth), bearing five pairs of setae ($c_1$, $d_1$, $d_2$, $e_1$ and $e_2$); intercalary shields smooth and with setae *f* (Fig. 6C); suranal shield entire and smooth, with two pairs of setae ($h_1$ and $h_2$). Dorsal setae inserted on tubercles, long, barbed, $h_1$ and $h_2$ comparatively shorter than other dorsal setae. Setae $h_1$ longer than setae $h_2$. Lengths of dorsal setae: *vi* 43.3 ± 3.3, *ve* 66.8 ± 6.8, *sci* 57.1 ± 1.1, $c_1$ 59.6 ± 1.5, $c_2$ 40.6 ± 0.6, $d_1$ 62.8 ± 4.2, $d_2$ 62.0 ± 3.9, $e_1$ 65.4 ± 2.8, $e_2$ 66.2 ± 2.5, *f* 43.0 ± 5.3, $h_1$ 31.4 ± 2.8, $h_2$ 19.0 ± 2.2; distances between dorsal idiosomal setae: *vi*–*vi* 18.5 ± 1.1, *ve*–*ve* 42.5, *sci*–*sci* 92.5, $c_1$–$c_1$ 22.3 ± 2.7,

$c_2$–$c_2$ 150, $d_1$–$d_1$ 63.5 ± 5.6, $d_2$–$d_2$ 100, $e_1$–$e_1$ 27.2 ± 0.3, $e_2$–$e_2$ 90, $f$–$f$ 58.1 ± 8.1, $h_1$–$h_1$ 16.1 ± 1.1, $h_2$–$h_2$ 37.5. Ratios: *vi*/*vi*–*vi* 2.4, *ve*/*ve*–*sci* 1.7, $c_1/c_1$–$c_1$ 2.8, $d_1/d_1$–$d_1$ 1.0, $e_1/e_1$–$e_1$ 2.5.

**Gnathosoma** — Similar to that of the female. The infracapitulum with subcapitular setae *m* 16, *n* 30, adoral setae $or_1$ 10, $or_2$ 8. Cheliceral stylet 28 slightly longer than palp tarsus 15.

**Table 1** Dorsal setal measurements of *Agistemus peruvianus* **n. sp.**

| Setae | Female Holotype | Females Paratypes (n=9) | Means ± SE* | SD** | 95% confidence interval of the means |
|---|---|---|---|---|---|
| *vi* | 62 | 52–62 | 57.5±0.9 | 2.9 | 55.4–59.6 |
| *ve* | 97 | 85–100 | 94.5±1.7 | 5.3 | 90.7–98.4 |
| *sci* | 77 | 70–90 | 76.8±1.8 | 5.8 | 72.7–80.9 |
| $c_1$ | 87 | 80–90 | 83.4±1.2 | 3.8 | 80.7–86.0 |
| $c_2$ | 50 | 45–55 | 49.7±0.8 | 2.4 | 47.8–51.5 |
| $d_1$ | 90 | 82–96 | 88.5±1.1 | 3.4 | 86.0–90.9 |
| $d_2$ | 75 | 75–85 | 79.2±1.0 | 3.3 | 76.9–81.5 |
| $e_1$ | 92 | 87–97 | 91.5±0.8 | 2.7 | 89.6–93.3 |
| $e_2$ | 90 | 85–97 | 90.2±0.8 | 2.6 | 88.3–92.1 |
| *f* | 67 | 62–74 | 67.7±1.1 | 3.5 | 65.2–70.2 |
| $h_1$ | 42 | 37–49 | 42.8±0.8 | 2.4 | 41.0–44.7 |
| $h_2$ | 20 | 20–30 | 24.3±1.2 | 3.8 | 21.6–27.0 |
| *vi*–*vi* | 20 | 17–23 | 20.3±0.6 | 1.6 | 18.9–21.6 |
| *ve*–*ve* | 50 | 42–55 | 49.2±1.5 | 4.1 | 45.8–52.6 |
| *ve*–*sci* | 43 | 35–45 | 39.8±1.4 | 3.6 | 37.2–42.4 |
| *sci*–*sci* | 107 | 95–108 | 101.2±1.8 | 5.1 | 96.9–105.5 |
| $c_1$–$c_1$ | 30 | 20–30 | 26.8±1.0 | 2.7 | 24.3–29.4 |
| $c_2$–$c_2$ | 167 | 155–202 | 177.3±4.6 | 12.2 | 166.0–188.6 |
| $d_1$–$d_1$ | 80 | 62–80 | 73.8±2.3 | 6.5 | 68.5–79.3 |
| $d_2$–$d_2$ | 120 | 107–125 | 118.5±2.1 | 6 | 113.5–123.6 |
| $e_1$–$e_1$ | 37 | 28–38 | 31.1±1.2 | 3.3 | 28.1–34.2 |
| $e_2$–$e_2$ | 107 | 95–110 | 106.0±1.9 | 5.6 | 101.3–110.7 |
| *f*–*f* | 62 | 60–73 | 65.4±1.4 | 4.1 | 62.0–68.8 |
| $h_1$–$h_1$ | 17 | 17–20 | 18.3±0.5 | 1.4 | 17.2–19.5 |
| $h_2$–$h_2$ | 45 | 45–53 | 49.6±0.9 | 2.6 | 47.5–51.8 |

* Means ±Standard error (SE) (Includes Holotype and Paratypes). **Standard deviation (SD).

**Table 2** Ventral setal measurements of *Agistemus peruvianus* **n. sp.**

| Setae | Female Holotype | Females Paratypes (n=9) | Means ± SE* | SD** | 95% confidence interval of the means |
|---|---|---|---|---|---|
| 1*a* | 25 | 20–25 | 23.5±1.0 | 2.7 | 21.0–26.1 |
| 3*a* | 25 | 25–30 | 25.6±0.6 | 1.9 | 24.1–27.0 |
| 4*a* | 20 | 20–30 | 23.3±1.2 | 2.9 | 20.3–26.4 |
| $ag_1$ | 17 | 15–17 | 15.7±0.5 | 1.4 | 14.4–17.0 |
| $ag_2$ | 15 | 15–20 | 16.6±0.7 | 2.1 | 14.8–18.3 |
| 1*a*–1*a* | 32 | 32–43 | 36.8±0.7 | 1.9 | 35.3–38.3 |
| 3*a*–3*a* | 67 | 50–73 | 65.7±1.7 | 4.8 | 61.6–69.7 |
| 4*a*–4*a* | 47 | 40–55 | 46.2±1.4 | 3.7 | 42.8–49.6 |
| $ag_1$–$ag_1$ | 37 | 30–45 | 36.2±2.0 | 5.6 | 31.5–40.9 |
| $ag_2$–$ag_2$ | 37 | 37–45 | 41.7±0.7 | 2.1 | 39.9–43.4 |

* Means ±Standard error (SE) (Includes Holotype and Paratypes). **Standard deviation (SD)

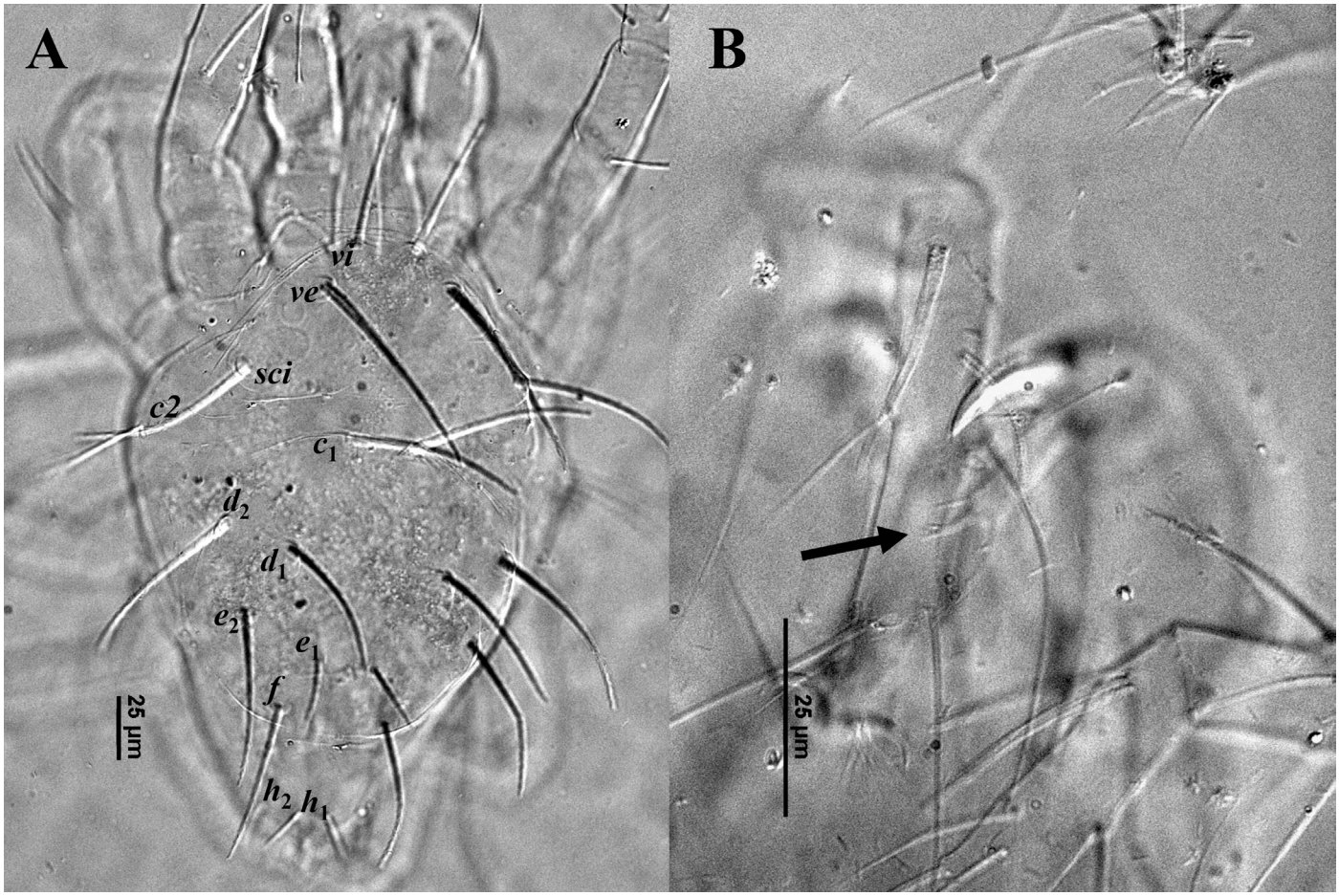


**Figure 5** *Agistemus peruvianus* **n. sp.** (male). A – Dorsum; B – Palptarsus with eupathidia, fused at basis, trifid distally (indicated by arrow).

Distances *m–m* 30, *n–n* 22.5, $or_1$–$or_1$ 10, $or_2$–$or_2$ 6. Palp with pair supracoxal setae *elcp*; palp trochanter without setae; palp femur with two smooth setae (*l′*, *v″*) and one barbed seta (*d*); palp genu with one smooth seta (*l′*); palp tibia with two smooth setae (*l′, l″*), one well-developed claw (13–15), one seta associated with claw (*l′T*); palptarsus 15, with four simple setae (*ba*, *bp*, *va* and *lp*), one solenidion (*ω*) 5, subapical eupathidium (*acm*) and three eupathidia (*sul*, *ul′*, *ul″*), fused at basis, trifid distally.

**Idiosomal Venter** — Similar to that of female. Aggenital shield entire, horseshoe-shaped, bearing two pairs of setae ($ag_{1-2}$). Anogenital covers with three pairs of pseudanal setae ($ps_{1-3}$), $ps_1$ barbed seta (Fig. 6D). Distances between dorsal idiosomal setae: 1*a*–1*a* 40; 3*a*–3*a* 72.

**Leg chaetotaxy** — Similar to that of the female (see Table 3). Dorsal seta on femur I (*dFI*)

**Table 3** Leg chaetotaxy of *Agistemus peruvianus* **n. sp.**

| Legs | Coxa | Trochanter | Femur | Genu | Tibia | Tarsus |
|---|---|---|---|---|---|---|
| I | 2+ 1*elcp* | 1 | 4+ 1*dF* | 2*d*+1*dG*+ 1κ | 4+1*dT*+ 1*φρ* | 12+1*ω* |
| II | 1 | 1 | 3+ 1*dF* | 1*d* | 4+1*dT*+ 1*φρ* | 9+1*ω* |
| III | 2 | 1 | 1+ 1*d* | 0 | 3+1*dT*+1*d*+ 1*φρ* | 7+1*ω* |
| IV | 2 | 1 | 1+ 1*d* | 0 | 3+1*dT*+1*d*+ 1*φρ* | 7 |

*d*=barbed setae.

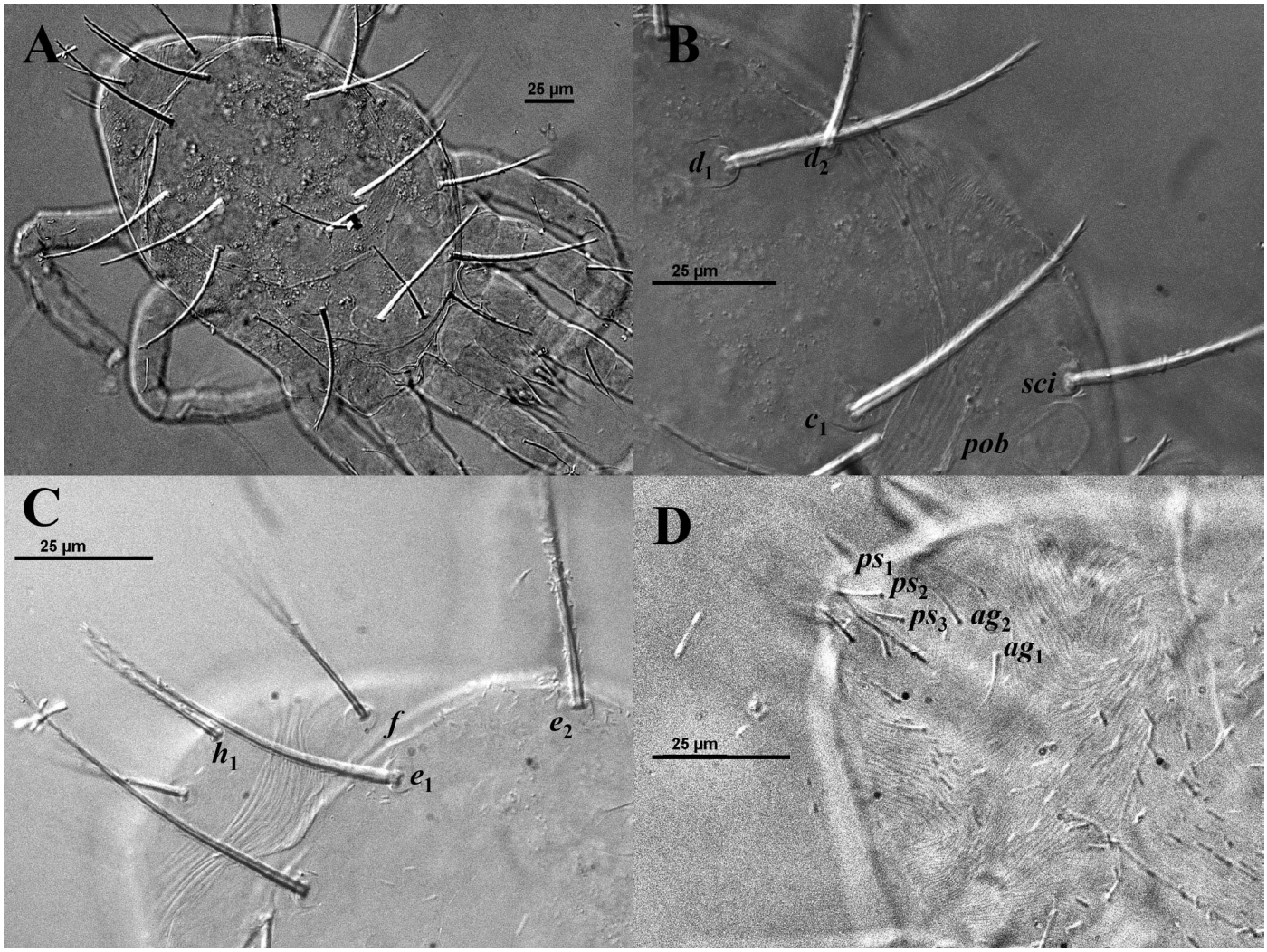


**Figure 6** *Agistemus peruvianus* **n. sp.** (deutonymph). A – Dorsum; B – Prodorsal and hysterosomal shield subtriangular smooth; C – Intercalary shields smooth and with setae *f*; D – Aggenital shield entire with two pairs of setae ($ag_{1\text{-}2}$), and anogenital covers with three pairs of pseudanal setae ($ps_{1\text{-}3}$).

barbed 28, 0.89 times length of $h_1$; dorsal seta on genu I (*dGI*) barbed 33. Length of solenidion on tibia ($\varphi\rho$): Tibia I $\varphi\rho$ 12; Tibia II $\varphi\rho$ 11; Tibia III $\varphi\rho$ 11; Tibia IV $\varphi\rho$ 10. Length of solenidion on tarsus ($\omega$): Tarsus I $\omega$ 16; Tarsus II $\omega$ 15; Tarsus III $\omega$ 10. Length tarsal claws I–IV 10.

**Etymology** — The specific epithet "*peruvianus*" is derived from the country, Peru.

**Remarks** — The new species resembles *Agistemus longisetus* González-Rodríguez, 1963; *A. mechotrichus* Fan & Zhang 2005; and *A. piquinnus* Monjarás-Barrera & Johann 2020; nevertheless *Agistemus peruvianus* **n. sp.**, can be distinguished from *A. longisetus* by a) body size (365.0 ± 3.3), and color in life (yellow), dorsal setae strongly developed inserted on strong tubercles, post ocular bodies small, and tarsi III and IV without a barbed setae, are different (vs 527 ± 21, bright red, dorsal setae strongly developed inserted on small tubercles, post ocular bodies big, and tarsi III and IV with a barbed setae respectively); b) lengths of prodorsal setae *vi* (57.5 ± 0.9), *ve* (94.5 ± 1.7), and *sci* (76.8 ± 1.8) are shorter, (vs 77 ± 8, 123 ± 12.3, and 111 ± 7.8, respectively); c) lengths of hysterosomal setae $c_1$ (83.4 ± 1.2), $d_1$ (88.5 ± 1.1), $e_1$ (91.5 ± 0.8), $e_2$ (90.2 ± 0.8), are shorter (vs 104 ± 12, 103 ± 11.6, 118 ± 12.5, and 123 ± 19, respectively); d) lengths of *f* (67.7 ± 1.1), and suranal setae $h_1$ (42.8 ± 0.8), $h_2$ (24.3 ± 1.2) are shorter, (vs 90 ± 6.4, 56 ± 3.5, and 36 ± 1.9, respectively); e) the ratio *ve/ve–sci* (2.4),

*sci*/*pob* (4.2), and *pob*/*eye* (2) are different (vs < 2, ≤ 3, and 3, respectively); f) lengths setae $ag_1$ (15–17), and $ag_2$ (15–20), are shorter [vs (18–19), and (22–23), respectively]; g) in male: ratio $\omega$IV/$\omega$III= 1.2 (vs 1.5).

*Agistemus peruvianus* **n. sp.**, can be distinguished from *A. mechotrichus* by a) lengths of prodorsal setae *vi* (57.5), *ve* (94.5), and *sci* (76.8) are shorter, (vs 101, 145, and 139, respectively); b) lengths of hysterosomal setae $c_1$ (83.4) , $d_1$ (88.5), $d_2$ (79.2), $e_1$ (91.5), $e_2$ (90.2) are shorter, (vs 115, 112, 134, 120, and 139, respectively); c) lengths of *f* (67.7), and suranal setae $h_1$ (42.8), $h_2$ (24.3) are shorter, (vs 94, 56, and 36, respectively); d) the ratio *vi*/*vi*–*vi* (2.9), and *ve*/*ve*–*sci* (2.4), are different (vs 2.3, and > 2.5, respectively).

*Agistemus peruvianus* **n. sp.**, can be distinguished from *A. piquinnus* by a) lengths of hysterosomal setae $c_1$ (83.4), $d_1$ (88.5), $d_2$ (79.2), $e_1$ (91.5), $e_2$ (90.2) are longer, (vs 73, 72, 67, 73, and 76, respectively); b) the ratio *ve*/*ve*–*sci* (2.4), $c_1/c_1$–$c_1$ (3.2), and *pob*/*eye* (2.0) are different (vs 1.74, 2.1, and 3.2, respectively); c) dorsal setae strongly developed inserted on strong tubercles, and aggenital shield entire and horseshoe-shape, are different (vs dorsal setae strongly developed inserted on small tubercles, and aggenital shield separate and not horseshoe-shape).

The presence of barbed setae in the leg segments, is a character used for the description of species (González-Rodríguez 1963, 1965). According to this, *Agistemus peruvianus* **n. sp.**, would have the same distribution of barbed setae on the femur, genu, and tibia on all 4 legs with the species *Agistemus novazelandicus* Gonzales-Rodrigues 1963 (review based on 43 species with chaetotaxy available in the literature), namely: femur–tibia I (1–3–1), femur–tibia II (1–1–1); femur–tibia III and IV (1–0–2). However, *A. peruvianus* **n. sp.**, can be distinguished from *A. novazelandicus* by a) prodorsal and hysterosomal shields without reticulation (smooth), seta *sci* > $c_2$, *vi*/*vi*–*vi* 2.9, are different (vs prodorsal and hysterosomal shields with reticulation, seta *sci*=$c_2$, and *vi*/*vi*–*vi* 1.5, respectively); b) lengths of prodorsal setae *vi* (57.5 ± 0.9), *ve* (94.5 ± 1.7), and *sci* (76.8 ± 1.8) are longer, (vs 39 ± 2.3, 63 ± 5, and 54 ± 2.2, respectively); c) lengths of hysterosomal setae $c_1$ (83.4 ± 1.2), $d_1$ (88.5 ± 1.1), $e_1$ (91.5 ± 0.8), $e_2$ (90.2 ± 0.8) are longer, (vs 45 ± 4.6, 46.1 ± 3.9, 53.5 ± 2.2, and 53 ± 3, respectively); d) lengths of *f* (66.8 ± 1.2) is longer, (vs 49 ± 2.9).

### Ecological observations

The mites were found during spring, summer, and autumn, being more frequent in the months of March and June corresponding to the autumn season. The environmental conditions during the autumn season were: minimum temperature is ranged 18.9 to 22.3 °C, maximum temperature 27.0 to 33.8 °C, and relative humidity 65.1 to 79.6% (Fig. 7). The new species inhabits abaxial surface of the leaves of *N. piurensis*.

## Key to the *Agistemus* species of Peru (based on adult females)

1. One pair of aggenital setae ($ag_1$); median hysterosomal shield reticulated . . . . . *A. fleschneri* Summers
— Two pairs of aggenital setae ($ag_1$, $ag_2$); median hysterosomal shield smooth . . . . . 2

2. Setae $c_1$ shorter than distance between the bases of $c_1$–$d_1$; setae $e_1$ at least reaching to the bases of *f* . . . . . 3
— Setae $c_1$ longer than distance between the bases of $c_1$–$d_1$, setae $e_1$ crossing to the bases of *f* . . . . . 4

3. Ratio *vi*/*vi*–*vi* ≤ 1.2; ratio $c_1/c_1$–$c_1$ ≤ 0.6; dorsal setae not set on tubercles; dorsal setae of hysterosomal shield < 50 µm . . . . . *A. terminalis* (Quayle)
— Ratio *vi*/*vi*–*vi* ≤ 1.7; ratio $c_1/c_1$–$c_1$ ≤ 1.6; dorsal setae set on tubercles; dorsal setae of hysterosomal shield ≥ 50 µm . . . . . *A. floridanus* Gonzalez-Rodriguez

4. Ratio *ve*/*ve–sci* < 2; *pob*/*eye* 3; dorsal setae set on small tubercles; dorsal setae of hysterosomal shield ≥ 100 µm . . . . . *A. longisetus* González-Rodríguez
— Ratio *ve*/*ve–sci* ≥ 2.4; *pob*/*eye* 2; dorsal setae set on strong tubercles; dorsal setae of hysterosomal shield < 100 µm . . . . . *A. peruvianus* Escobar-Garcia, Matioli & Ueckermann **n. sp.**

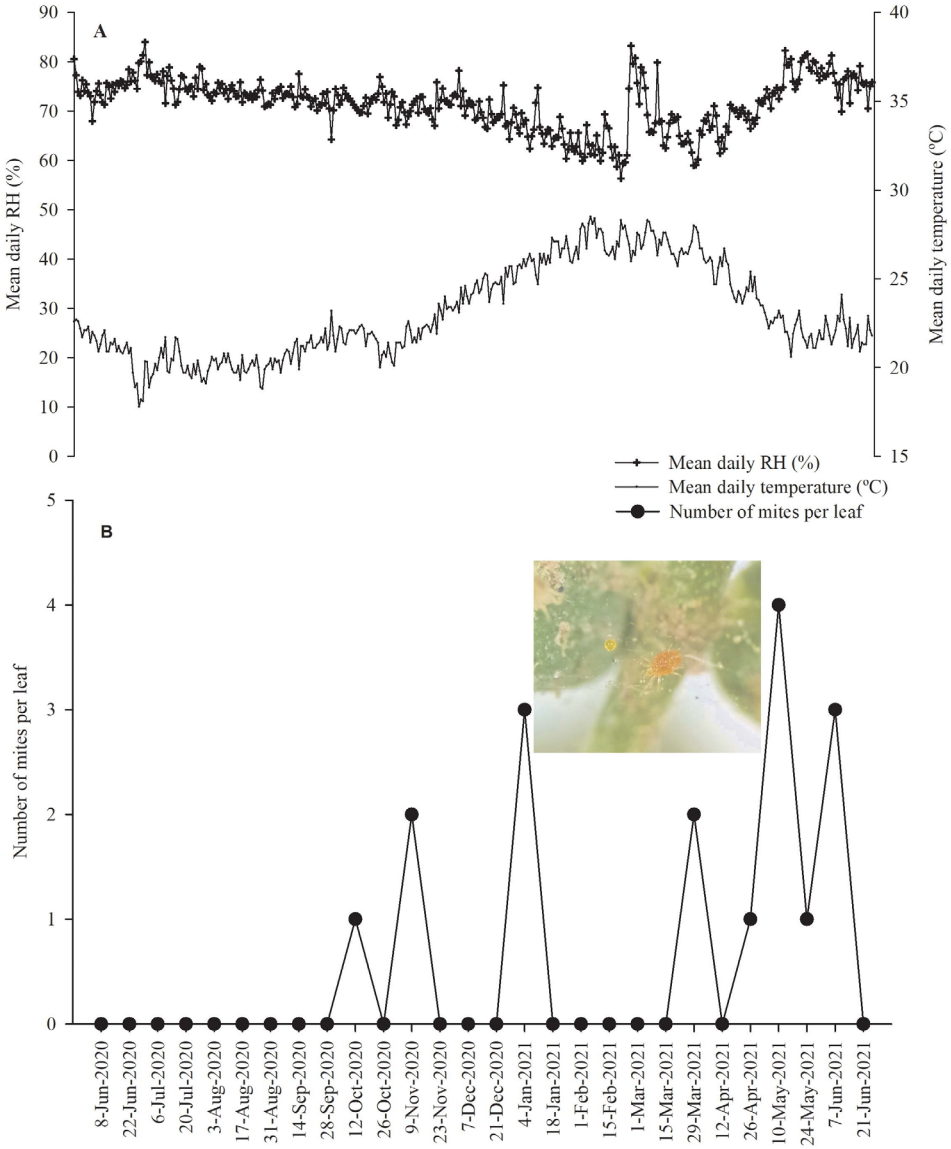


**Figure 7** A – The climatic data; B – Population fluctuation of *Agistemus peruvianus* **n. sp.**, in abaxial surface of the leaves of *N. piurensis*.

## Acknowledgments

We want to express our thanks to Universidad de Piura (UDEP), Peru for the information on the meteorological data of MetRadarUdep1 station. We thank Invertebrate Morphology Laboratory- DBAA-FCAVJ/UNESP-Brazil for the help with the figures. We thank Laboratory

of Entomology and Acarology of the SAG, Valparaiso, Chile for support and assistance with type materials of *Agistemus longisetus* (voucher n° 4453, 52661, 84826, and 85180). We also thank you to express our special thanks go to Division of Plant Protection (DPP), Department of Agriculture, Pretoria, South Africa for support and assistance with type materials of *A. longisetus* (voucher n° Acy:09/375).

## ORCID

Hector Alonso Escobar-Garcia https://orcid.org/0000-0002-5003-2268
Daniel Júnior De Andrade https://orcid.org/0000-0003-0054-879X
André Luis Matioli https://orcid.org/0000-0003-3708-5602
Francisco Jose Rojas-Espinoza https://orcid.org/0000-0002-4491-6833
Edward A. Ueckermann https://orcid.org/0000-0003-4213-4309

## References

Abou-Awad B.A., Elsawi S.A. 1993. Biology and life table of the predacious mite, *Agistemus exsertus* Gonz. (Acari: Stigmaeidae). Anzeiger Fur Schadlingskunde, 66(5): 101-103. https://doi.org/10.1007/BF01906820

Beron P. 2020. Acarorum Catalogus VII. Trombidiformes, Prostigmata, Raphignathoidea (Fam. Barbutiidae, Caligonellidae, Camerobiidae, Cryptognathidae, Dasythyreidae, Dytiscacaridae, Eupalopsellidae, Homocaligidae, Mecognathidae, Raphignathidae, Stigmaeidae, Xenocaligonellididae). Pensoft & National Museum of Natural History, Sofia, p. 140-265. https://doi.org/10.3897/ab.e55087

Bizarro G.L, Melo E.A.S.F., Oliveira A.R., Johann L. 2022. New records and a new species of *Agistemus* Summers (Raphignathoidea: Stigmaeidae) from Bahia, Brazil. Syst. Appl. Acarol., 27(5): 855-864. https://doi.org/10.11158/saa.27.5.3

Childers C.C., Ueckermann E.A. 2014. Eupalopsellidae and Stigmaeidae (Acari: Prostigmata) within citrus orchards in Florida: species distribution, relative and seasonal abundance within trees, associated vines, and ground cover plants. Exp. Appl. Acarol., 64(2): 187-205. https://doi.org/10.1007/s10493-014-9815-x

Da Silva M.Z., Sato M.E., De Oliveira C.A., Nicastro R.L. 2015. Interspecific interactions involving *Neoseiulus californicus* (Acari: Phytoseiidae) and *Agistemus brasiliensis* (Acari: Stigmaeidae) as predators of *Brevipalpus phoenicis* (Acari: Tenuipalpidae). Exp. Appl. Acarol., 65(3): 319-329. https://doi.org/10.1007/s10493-014-9874-z

Ehara S.A. 1985. New species of the genus *Agistemus* Summers from Hokkaido (Acarina: Stigmaeidae). Proc. Jpn. Acad., Tokyo, 61: 60-66. https://doi.org/10.2183/pjab.61.60

Elbadry E.A., Abo Elghar M.R., Hassan S.M., Kilany S.M. 1969. *Agistemus exsertus* as a Predator of Two Tetranychid Mites. Ann. Entomol. Soc. Am., 62(3): 660-661. https://doi.org/10.1093/aesa/62.3.660

Fan Q.-H., Flechtmann C.H.W. 2015. Stigmaeidae. In: Carrillo D., De Moraes G.J., Peña J.E. (Eds.) Prospects for biological control of plant feeding mites and other harmful organisms. Springer Verlag, p. 189-196. https://doi.org/10.1007/978-3-319-15042-0_7

Fan Q.-H., Zhang Z.-Q. 2005. Raphignathoidea (Acari: Prostigmata). Fauna of New Zealand. Manaaki Whenua Press, 52, pp. 400.

Fan Q.-H., Flechtmann C.H., de Moraes G.J. 2016. Annotated catalogue of Stigmaeidae (Acari: Prostigmata), with a pictorial key to genera. Zootaxa, 4176(1): 1-199. https://doi.org/10.11646/zootaxa.4176.1.1

Ferla N.J., Moraes G.J. 2003. Biologia de *Agistemus floridanus* Gonzalez (Acari, Stigmaeidae). Revista Brasileira de Zoologia, 20(2): 261-264. https://doi.org/10.1590/S0101-81752003000200015

Garcia-Mari F., Ferragut F., Marzal C., Costa C. J., Laborda R. 1986. Acaros que viven en las hojas de los citricosbespañoles. Investigacion Agraria: Produccion y Proteccion Vegetales, 1(2): 226-235. (in Spanish)

Grandjean F. 1944. Observations sur les acariens de la famille des Stigmaeidae. Archives des Sciences Physiques et Naturelles, 26: 103-131. (in French)

Gerson U., Smiley R., Ochoa, R. 2003. Acarine pests of citrus: overview and non-chemicalcontrol. Syst. Appl. Acarol., 8(1): 3-12. https://doi.org/10.11158/saa.8.1.1

González-Rodríguez R.H. 1963. Four new mites of the genus *Agistemus* Summers, 1960 (Acarina: Stigmaeidae). Acarologia, 5(3): 342-350.

González-Rodríguez R.H. 1965. A taxonomic study of the genera *Mediolata*, *Zetzellia* and *Agistemus* (Acarina: Stigmaeidae). University of California Publications in Entomology, 41: 1-64.

Hafez S.A., Rasmy A.H., Elsawi S.A. 1983. Influence of prey species and stage on predatory efficiency and development of the stigmaeid mite *Agistemus exsertus*. Acarologia, 24: 281-283.

Hughes C.E., Ringelberg J.J., Lewis G.P., Catalano S.A. 2022. Disintegration of the genus *Prosopis* L. (Leguminosae, Caesalpinioideae, mimosoid clade). In: Hughes C.E., de Queiroz L.P., Lewis G.P. (Eds). Advances in Legume Systematics 14. Classification of Caesalpinioideae Part 1: New generic delimitations. PhytoKeys, 205: 147-189. https://doi.org/10.3897/phytokeys.205.75379

Johann L., Carvalho G.S., Majolo F., Ferla N.J. 2013. Stigmaeid mites (Acari: Stigmaeidae) from vineyards in the state of Rio Grande do Sul, Brazil. Zootaxa, 3701(2): 238-256. https://doi.org/10.11646/zootaxa.3701.2.6

Kamran M., Mirza J.H., Elgoni N.A., Alatawi F.J. 2023. Two new species of the genus *Agistemus* Summers (Acari: Stigmaeidae) from Saudi Arabia. Acarologia, 63(2): 580-590. https://doi.org/10.24349/srli-y7eg

Kethley J. 1990. Acariformes, Prostigmata (Actinedida). In: Dindal D.L. (Ed.). Soil biology guide. John Wiley & Sons, New York, p. 667-756.

Leiva S., Fernandez N., Theron P., Rollard C. 2013. *Agistemus aimogastaensis* sp. n. (Acari, Actinedida, Stigmaeidae), a recently discovered predator of eriophyid mites *Aceria oleae* and *Oxycenus maxwelli*, in olive orchards in Argentina. Zookeys, 26(312): 65-78. https://doi.org/10.3897/zookeys.312.5520

Matioli A.L., Ueckermann E.A., Oliveira C.A.L. 2002. Some stigmaeid and eupalopsellid mites from citrus orchards in Brazil (Acari: Stigmaeidae and Eupalopsellidae). Int. J. Acarol., 28(2): 99-120. https://doi.org/10.1080/01647950208684287

Matioli A.L., Tavares M.G., Pallini A. 2007. *Agistemus pallinii* n. sp. (Acari: Stigmaeidae) from citrus orchards in Brazil. Int. J. Acarol., 33(3): 245-251. https://doi.org/10.1080/01647950708684529

Momen F.M. 2001. Effects of diet on the biology and life tables of the predacious mite *Agistemus exsertus* (Acari: Stigmaeidae). Acta Phytopathol. Entomol. Hung., 36(1): 173-178. https://doi.org/10.1556/APhyt.36.2001.1-2.20

Monjarás-Barrera J.I., da Silva G.L., Chacón-Hernández J.C., da Silva O.S, Ferla N.J., Johann L. 2020. A new species and new record of *Agistemus* Summers (Acari: Stigmaeidae) associated with *Capsicum annuum* L. var. glabriusculum (Solanaceae) from Northeastern of Mexico. Acarologia, 60(2): 470-480. https://doi.org/10.24349/acarologia/20204378

Moraes G.J., Flechtmann C.H.W. 2008. Manual de Acarologia: acarologia básica e ácaros de plantas cultivadas no Brasil. Riberao Preto (SP): Holos, Editora. p. 82-83. (in Portuguese)

Muma M.H., Selhime A.G. 1971. *Agistemus floridanus* (Acarina: Stigmaeidae), a predatory mite, on Florida citrus. Fla. Entomol., 54: 249-258. https://doi.org/10.2307/3493723

Osman A.A., Zaki A.M. 1986. Studies on the predation efficiency of *Agistemus exsertus* Gonzalez (Acarina, Stigmaeidae) on the eriophyid mite *Aculops lycopersici* (Massee). Anzeiger Fur Schadlingskunde, 59(7): 135-136. https://doi.org/10.1007/BF01903320

Quayle H.J. 1912. Red spiders and mites of citrus trees. University of California Experiment Station Bulletin, 234: 483-530. https://doi.org/10.5962/bhl.title.59342

Rehman M.U., Kamran M., Alatawi F.J. 2018. Genus *Agistemus* Summers (Acari: Trombidiformes: Stigmaeidae) from Saudi Arabia and a key to the world species. Syst. Appl. Acarol., 23(6): 1051-1072. https://doi.org/10.11158/saa.23.6.5

SERFOR. 2021. Servicio Nacional Forestal y de Fauna Silvestre. Avances sobre la investigación de "algarrobo" *Prosopis* (Fabaceae) en la costa norte del Perú. Lima-Perú. pp.73. (accessed December 15, 2022). http://repositorio.serfor.gob.pe/handle/SERFOR/905 (in Spanish)

Summers F.M. 1960. Several stigmaeid mites formerly included in *Mediolata* redescribed in *Zetzellia* Ouds and *Agistemus* new genus. Proc. Entomol. Soc. Wash., 62(4): 233-247.

Walter D.E., Krantz G.W. 2009. Collecting, rearing, and preparing specimens. In: Krantz G.W., Walter D.E. (Eds). A manual of Acarology. 3rd ed. Texas Tech University Press, p. 83-96.

Zhang Z.-Q. 2003. Mites of greenhouses: identification, biology, and control. Cambridge, MA, USA: CABI Publishing, pp. 257.