

# *Agistemus aimogastaensis* sp. n. (Acari, Actinedida, Stigmaeidae), a recently discovered predator of eriophyid mites *Aceria oleae* and *Oxycenus maxwelli*, in olive orchards in Argentina

Sergio Leiva<sup>1,†</sup>, Nestor Fernandez<sup>2,‡</sup>, Pieter Theron<sup>3,§</sup>, Christine Rollard<sup>3,||</sup>

**1** Fellowship, National Institute Agricultural Technology (INTA). Experimental Rural Agency, Aimogasta. 5310. La Rioja. Argentina **2** National Council of Scientific and Technological Research (C.O.N.I.C.E.T.) La Rioja University Campus. Research and Technology City. Av. Luis Mansueto de la Fuente S/N. (5300) La Rioja, Argentina **3** Research Unit for Environmental Sciences and Management, North-West University, Potchefstroom Campus, 2520, South Africa **4** Muséum National d'Histoire Naturelle, Département Systématique et Evolution Unité OSEB, Section Arthropodes, 57 rue Cuvier. 75231, Paris, cedex 05, France

† [urn:lsid:zoobank.org:author:5F55A6B4-9221-4C62-B6F1-25B258FC89E4](https://zoobank.org/urn:lsid:zoobank.org:author:5F55A6B4-9221-4C62-B6F1-25B258FC89E4)

‡ [urn:lsid:zoobank.org:author:32F81CCB-5D14-4A4E-950C-C3CD94D78AA9](https://zoobank.org/urn:lsid:zoobank.org:author:32F81CCB-5D14-4A4E-950C-C3CD94D78AA9)

§ [urn:lsid:zoobank.org:author:2C8D7CCB-3013-459D-A606-F60CD0CE13E0](https://zoobank.org/urn:lsid:zoobank.org:author:2C8D7CCB-3013-459D-A606-F60CD0CE13E0)

|| [urn:lsid:zoobank.org:author:068E86AE-4CA3-42CF-93BC-30D9D6E2E06E](https://zoobank.org/urn:lsid:zoobank.org:author:068E86AE-4CA3-42CF-93BC-30D9D6E2E06E)

Corresponding author: Nestor Fernandez (nestorfernand51@yahoo.fr)

---

Academic editor: Vladimir Pesic | Received 13 May 2013 | Accepted 12 June 2013 | Published 26 June 2013

[urn:lsid:zoobank.org:pub:834FC658-F9F4-4ABE-9A08-71990C3D551B](https://zoobank.org/pub:834FC658-F9F4-4ABE-9A08-71990C3D551B)

---

**Citation:** 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 312: 65–78. doi: 10.3897/zookeys.312.5520

---

## Abstract

A new species, *Agistemus aimogastaensis*, is described with the aid of optical and Scanning Electron Microscopy. This mite is an important predator of two eriophyid mites (*Aceria oleae* and *Oxycenus maxwelli*) in olive orchards (*Olea europaea*, variety Arauco) in La Rioja Province. The problems related to eriophyids in olive orchards in Argentina are highlighted and photos of the damage on leaves and fruit are included.

## Keywords

*Agistemus aimogastaensis*, new species, predator, *Aceria olea*, *Oxycenus maxwelli*, Olive orchards, Argentina

## Introduction

Species of the genus *Agistemus* are considered important predators on phytophagous mites, scale insects and their eggs. Recently several studies have been done on agriculturally important crop plants, such as apple, pear and citrus orchards, blackberry fruits, coconut, coffee, and fig trees, grapevines, leguminous plants, Yerba mate trees, medicinal and ornamental plants as well as vegetable crops and the stored products of these plants (Ehara 1962; Gonzalez-Rodriguez 1961; Momen 2012; Liana and Juarez 2012; Momen 2011; Al-Atawi 2011; Marchetti and Juarez 2011; Saber and Rasmy 2010; Thakur et al. 2010; Roy et al. 2006, 2008, 2009; Fadamiro et al. 2009; Kawashima et al. 2008; Jamieson et al. 2008; Matioli et al. 2007; Gotoh and Shida 2007; Matioli and De Oliveira 2007; De Gouvea et al. 2007; El-Sawi and Momen 2006; Mineiro et al. 2006; De Vis et al. 2006; Bostanian et al. 2006; Putatunda 2005; Yousuf and Chouhan 2004; Arbabi and Singh 2002; Abou-Awad et al. 2000).

Little is known about *Agistemus* species as predators of eriophyid mites in Olive orchards (Momen 2012; Abou-Awad et al. 2010) and this is the first report of this genus from olive orchards in Argentina.

The genus *Agistemus* was erected by Summers (1960) based on type species *Caligionus terminalis* Quayle 1912. Grandjean (1944) published a work on the family Stigmaeidae, and established a series of characteristics with reference to legs and palp chaetotaxy. Further contributions to the present definition of the family were made by Gonzalez-Rodriguez (1961, 1963, 1965) and Summers and Ehara (1965).

## Material and methods

All specimens were collected individually from tree surfaces (vegetative buds, leaves, inflorescences, or fruits) and preserved in 70% ethanol. Specimens studied by means of light microscopy were macerated in lactic acid and observed in the same medium, using the open-mount technique (cavity slide and cover slip) as described by Grandjean (1949) and Krantz and Walter (2009). Drawings were made using an Olympus BHC compound microscope (Rungis, France) equipped with a drawing tube. Some specimens were studied by means of a Scanning Electron Microscope (SEM). For this purpose, specimens preserved in ethanol were carefully rinsed by sucking them several times into a Pasteur pipette, and these were then transferred to buffered glutaraldehyde (2.5%) in Sørensen phosphate buffer: pH 7.4; 0.1 M for 2 hours. After postfixation for 2 hours in buffered 2% OsO<sub>4</sub> solution and rinsing in buffer solution, all specimens were dehydrated in a series of graded ethanols and dried in a critical point apparatus. Specimens were mounted on Al-stubs with double-sided sticky tape and then gold coated in a sputter apparatus (Alberti and Fernandez 1988; Alberti and Fernandez 1990a, 1990b; Alberti et al. 1991; Fernandez et al. 1991; Alberti et al. 1997; Alberti et al. 2007). For a study of the genito-anal plates and genital structures, specimens were dissected and monitored during the lactic acid maceration process

(in warm 70% lactic acid) before being stained with chlorazol black E, a well-known stain (Coineau 1974). Measurements taken: total length (tip of rostrum to posterior edge of notogaster) and width (widest part of notogaster) in micrometres ( $\mu\text{m}$ ). Leg chaetotaxy studies made using standard, polarized and phase contrast microscopes. Setal formulae of the legs include the number of solenidia (in parentheses); Setal length measured with SEM.

### Morphological terminology

Morphological terms and abbreviations used are those developed by Grandjean (1944), Summers (1960) and Gonzalez-Rodriguez (1963), Kethley (1990), We add the term: longitudinally aligned tiny round-convex elevations (*r.c.e*) in reference to structures on the postocular body.

### New taxon description

#### *Agistemus aimogastaensis* sp. n.

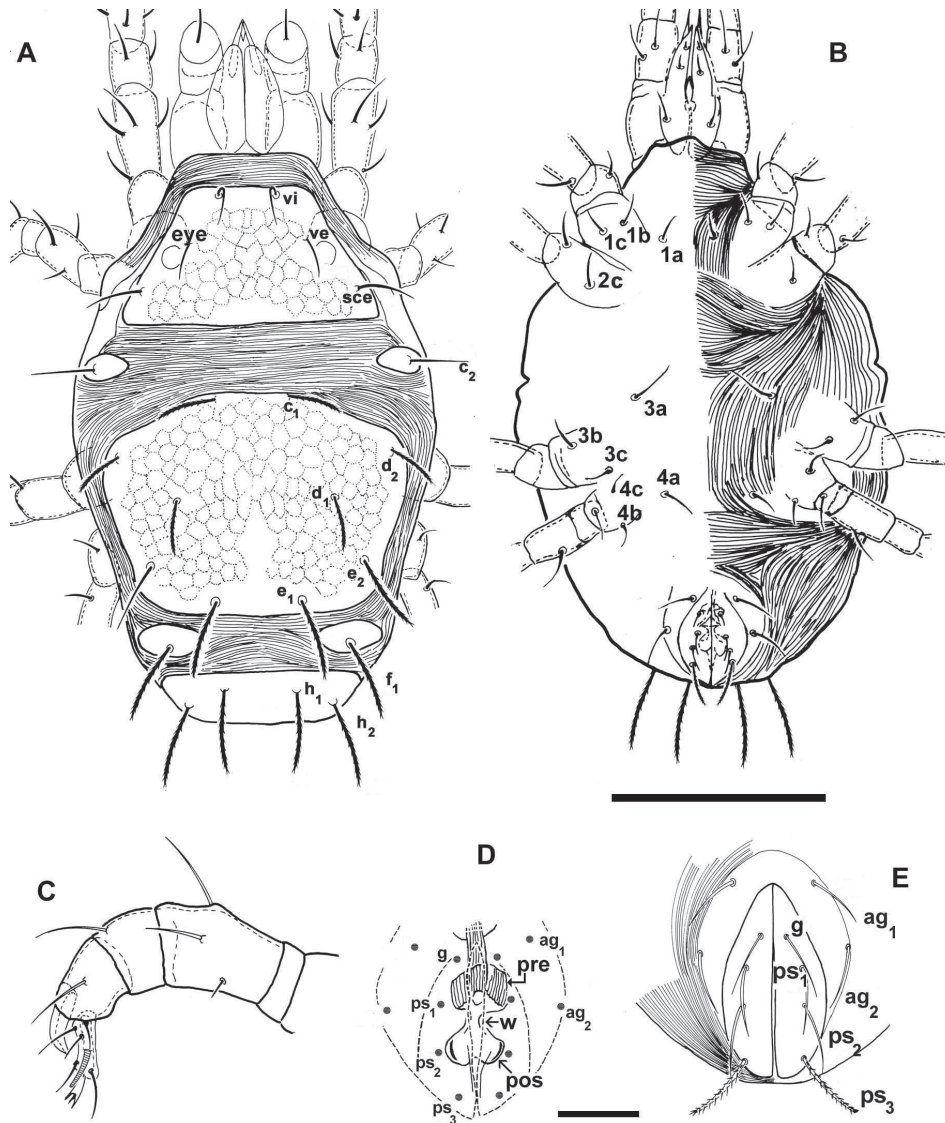
urn:lsid:zoobank.org:act:21DBBD18-3CF8-42B0-9F79-41FEC0BB98D2

[http://species-id.net/wiki/Agistemus\\_aimogastaensis](http://species-id.net/wiki/Agistemus_aimogastaensis)

**Etymology.** The specific epithet is dedicated to the city of Aimogasta, La Rioja, Argentina, where the specimens were found.

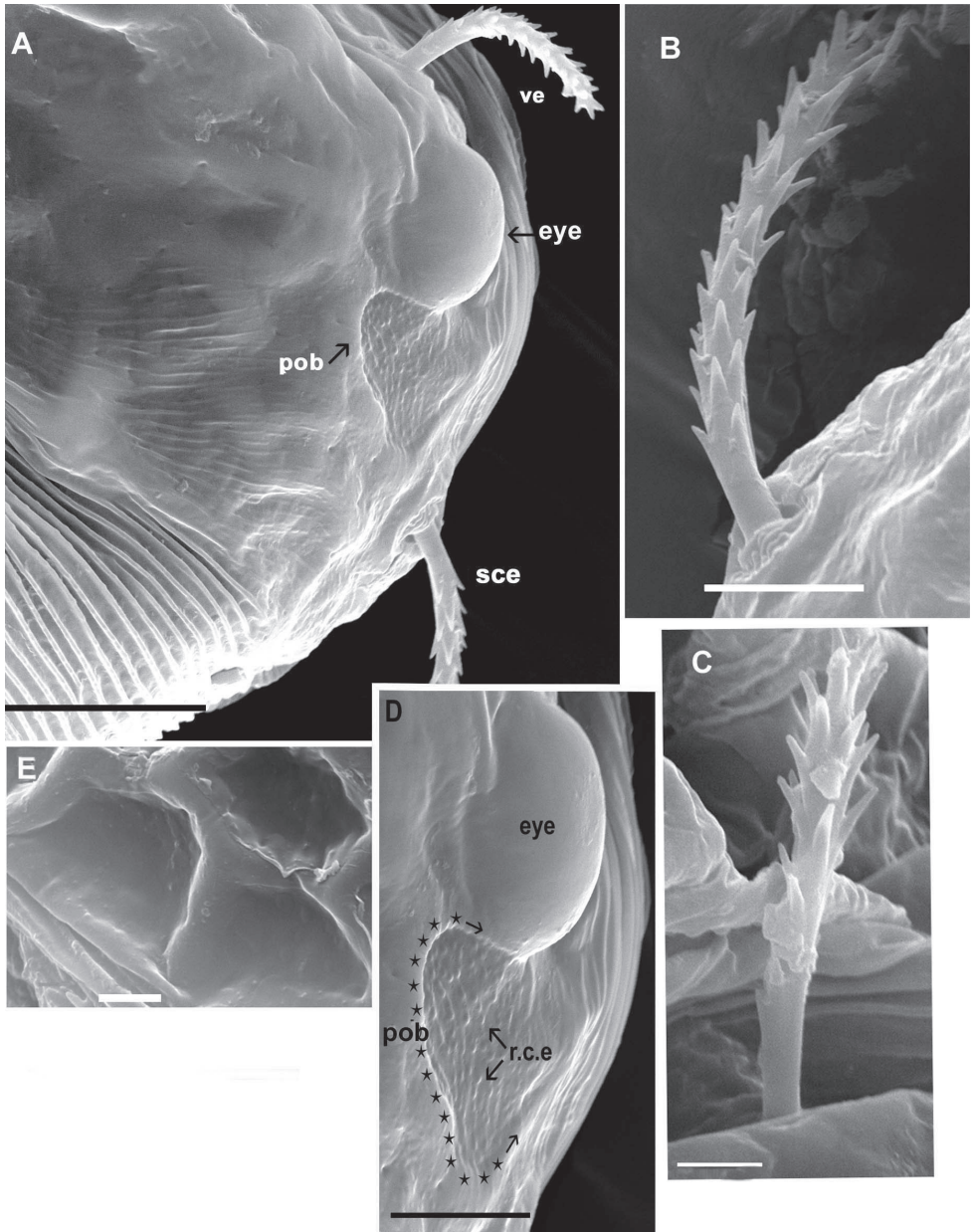
**Material examined.** Holotype female and 2 female paratypes, Aimogasta, Province de La Rioja, Argentina 11-NOV-2012 deposited in Instituto Nacional de Tecnologia Agropecuaria (INTA), Aimogasta, La Rioja Argentina; 4 Paratype females, same date and locality as holotype deposited in Museum National d'Histoire Naturelle, Paris, France and 4 paratypes, same date and locality as holotype deposited in Geneva Natural History Museum, Switzerland. All preserved in 70% ethanol. All type specimens were collected from vegetative buds, leaves, inflorescences and fruit of *Olea europaea*, variety Arauco.

**Diagnosis (adult female).** **Propodosomal plate:** trapezoidal; ornamented with a faintly accentuated, polyhedral reticulate pattern; eyes clearly visible, ovoid convex, smooth; post ocular body triangular, rounded extremities, with series of longitudinally aligned small round-convex elevations, joined by thread-like strands. **Metapodosomal plate** hexagonal to polyhedral; ornamented with accentuated transverse polyhedral reticulate pattern. Wide area with fine transverse integumental striae, separating propodosomal and metapodosomal plates. **Humeral** and **intercalar** plates marginally. **Setae** *g*, *ps*<sub>1</sub>, *ps*<sub>2</sub> similarly shaped, finely barbate, sharply tipped; *ps*<sub>3</sub> minutely dentate, truncate *g*, *ps*<sub>1</sub>, *ps*<sub>2</sub> larger than *ps*<sub>3</sub> and very different in shape and appearance in optical and SEM. **Legs:** genua II, III, IV setal formula 0-0-0; leg IV lacks solenidium. Ambulacra with two claws and empodium with three pairs of bicapitate, fan shaped Y-raylets.



**Figure 1.** *Agistemus aimogastaensis* sp. n. Adult female, optical microscopy. **A** dorsal view **B** ventral view **C** palp **D** cuticular components of genital chamber; the anogenital covers are presented as indication of its relation to genital organs. **E**, anogenital covers. Abbreviations see Material and methods. Scale bars: **A, B:** 100  $\mu$ m; **C, D, E:** 15  $\mu$ m.

This species most closely resembles *Agistemus collyerae* Gonzalez-Rodriguez 1963, principally in relation to the setation of leg IV. However *A. aimogastaensis* can be easily differentiated from the latter on account of the disposition and shape of propodosomal, metapodosomal, humeral and intercalary plates; as well as the length and disposition of dorsal setae. Specific characters given by Gonzalez-Rodriguez for *A. collyerae* in relation to the unusual lengths of the  $ag_2$  setae ( $pg_2$  sensu Gonzalez-Rodriguez



**Figure 2.** *Agistemus aimogastaensis* sp. n. Adult female, SEM. **A** eye and post ocular body, lateral view **B** external scapular setae (*sce*), lateral view **C** internal vertical setae (*vi*), lateral view **D** eye and postocular body, detail, lateral view (indicated by stars and arrow) **E** ornamentation, metapodosomal plate. Abbreviations: see Material and Methods. Scale bars: **A**: 10µm; **B**, **D**, **E**: 5µm; **C**: 2µm.

1963) and *g* setae ( $g_1$  sensu Gonzalez-Rodriguez 1963), and the equal lengths of the other setae  $ag_p$ ,  $ps_p$ ,  $ps_2$  and  $ps_3$  ( $g_2$ ,  $g_3$ ,  $g_4$ ,  $pg_p$ , Fig. 8, Gonzalez-Rodriguez 1963) is very different to the situation found in *A. aimogastaensis*, where these setae are equal in size

and shape; but setae  $ps_3$  ( $g_4$  sensu Gonzalez-Rodriguez 1963) is completely different to the other setae, both in shape and length. Finally, another important character is the post-ocular body (*pob*) and the microsculpture around this zone. The *pob* in *A. aimogastaensis* is triangular with rounded extremities, and the microsculpture around this zone is smooth to fine integumental striations; in *A. collyerae* the *pob* is round and the surrounding microsculpture is a thin-walled network or reticulate.

**Description. Measurements:** SEM: 325 (312–351) × 160 (152–173) Light microscopy: 336 (331–339) × 168 (166–174) (n=10).

**Shape:** ovoid (Figures 1A,B).

**Colour:** variable. Specimens observed in reflected light: orange-yellow, slightly shiny or white. We studied specimens of different colors and all were female.

**Integument:** (Figures 1A,B; 2A,D,E)

Microsculpture complicated, varying according to body region.

Propodosomal plate (P) polyhedral reticulate pattern: tiny accentuated polyhedral reticulated pattern, extending behind *vi* setal insertion and paraxially to *ve* and *sce* setal insertion, and paraxial to eye (*eye*) and post ocular body (*pob*). Near the eye and post ocular body and antiaxially to the *ve* and *sce* setal insertion smooth (Figs 2A,D). Existing paraxially to eye and *pob*, very fine integumental striae.

Metapodosomal (M) plate with polyhedral reticulate pattern, accentuate (Fig. 2D). Humeral plate (H), Intercalary plate (I), and Suranal plate (SA), more or less smooth (Fig. 1A).

Fine integumental striae covering zone between Propodosomal, Metapodosomal, Humeral, Intercalar and Suranal plates (Figs. 1A, 2A).

Fine integumental striae covering venter of idiosoma, epimeral zone smooth (Fig. 1B).

Legs: cuticular surface smooth.

**Setation.** All dorsal setae minutely denticulate and truncate (Fig.3C,D). Length: *vi* 12.60 (12.04-13.012); *ve* 13,78 (13.05-13.92); *sce* 18.80 (18.78-18.93);  $c_2$  20.70 (19.89-21.01);  $c_1$  19.5 (19.56-19.80);  $d_1$  16.45 (16.43-16.48);  $e_1$  18.1 (18.00-18.09);  $d_2$  19.33 (19.23-19.92);  $e_2$  17.80 (17.77-17.84);  $f_1$  17.85 (16.01-17.69);  $h_1$  14.20 (14.18-14.24);  $h_2$  17.20 (17.16-17.24) .

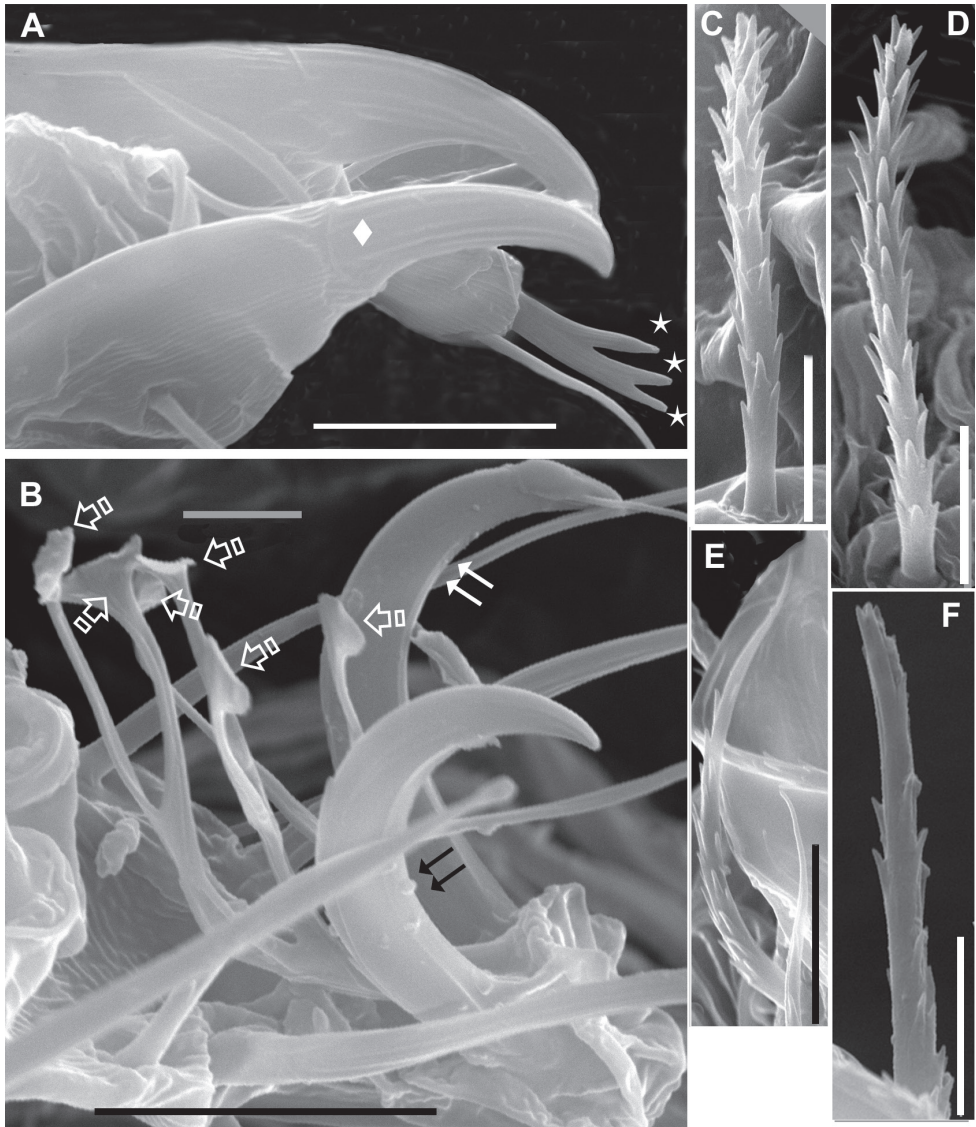
Ventral setae: epimeric smooth (*1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *3c*, *4a*, *4b*, *4c*); ( $ag_1$ ,  $ag_2$ ) and *g*,  $ps_1$ ,  $ps_2$ , finely barbate (Fig.3E), sharply tipped;  $ps_3$  minutely dentate, truncate (Fig.3F).

Length:  $ag_1$  17.61 (17.58-17.66);  $ag_2$  17.70 (17.68-17.75); *g* 17.25 (17.17-17.29);  $ps_1$  17.40 (17.38-17.43);  $ps_2$  18.20 (18.18-18.24);  $ps_3$  17.05 (17.00-17.12).

In optical microscopy the dorsal setae and genital  $ps_3$  appear as dark, while epimerics, paragenital and genitals (*g*,  $ps_1$ ,  $ps_2$ ) appear transparent. Scanning Electron Micrographs depicted in Figure 3.

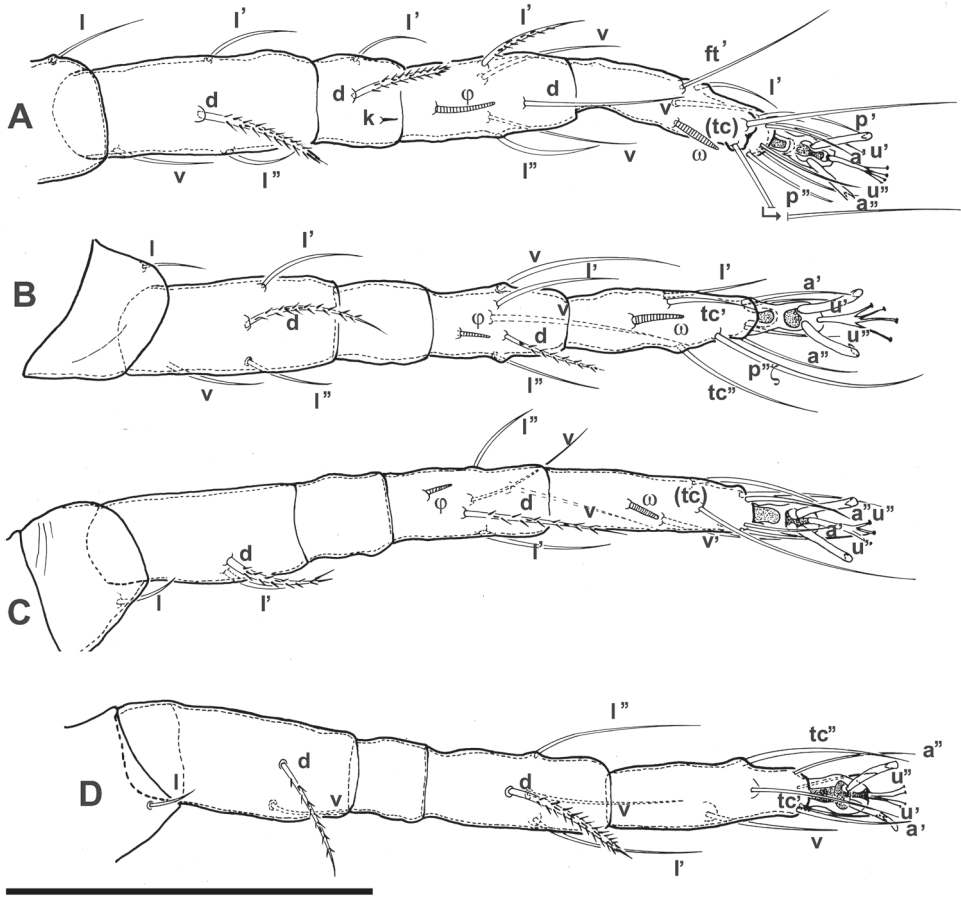
**Dorsal region** (Figure 1A). Propodosomal plate (P) trapezoidal, with three pairs of setae: *vi* situated close to the anterior margin of plate; *ve* situated slightly anteriorly and paraxially to the eye and the postocular body (*pob*); *sce*, situated posteriorly and antiaxially to *pob*. All setae situated on very small protuberances.

Observation of eye and the postocular body (*pob*) (not shown on Fig.1A) is complex, because on mites not cleared the eye and the *pob* can both be observed, but in cleared animals only the eye is visible. Position of *ve* setae complicating observation in



**Figure 3.** *Agistemus aimogastaensis* sp. n. Adult female, SEM. **A** palp, tibia and tarsus lateral view **B** ambulacrum leg I, lateral view **C** dorsocentral *a* setae **D** dorsolateral *la* setae **E** *ps*<sub>2</sub> setae. **F** *ps*<sub>3</sub> setae. Abbreviations see material and Methods. Scale bars: **B**, **E**: 5µm; **A**, **C**, **D**, **F**: 5µm. Small stars indicate the association of eupathidia *ul*, *ul'* and *sul*. Diamond indicates palp tibial claw. Double arrow, indicates claw, and special single arrow indicate capitate fan-shaped raylets.

optical microscopy. SEM permits observation of the eye in dorsal view (Fig.2A,D) as a smooth structure, ovoid and convex in lateral view; length: 9.55 (9.48-9.56) ; width: 6.28 (6.26-6.29) . The *pob* has a more or less triangular shape with rounded extremities (Fig.2A, D); 5.81(5.79-5.83) in length and 5.34 (5.32-5.37) in width; a series of longitudinally aligned slightly rounded-convex elevations (*r.c.e*) present, joined by



**Figure 4.** *Agistemus aimogastaensis* sp. n. Adult female, legs. All legs in dorsal view. Abbreviations: see Materials and Methods. Scale bar A–D: 50  $\mu$ m.

thread-like strands. In recently mounted specimens (observed in optical microscopy), the *pob* presenting small red-yellow spots, disappearing quickly; possibly these spots are the *r.c.e* observed in SEM.

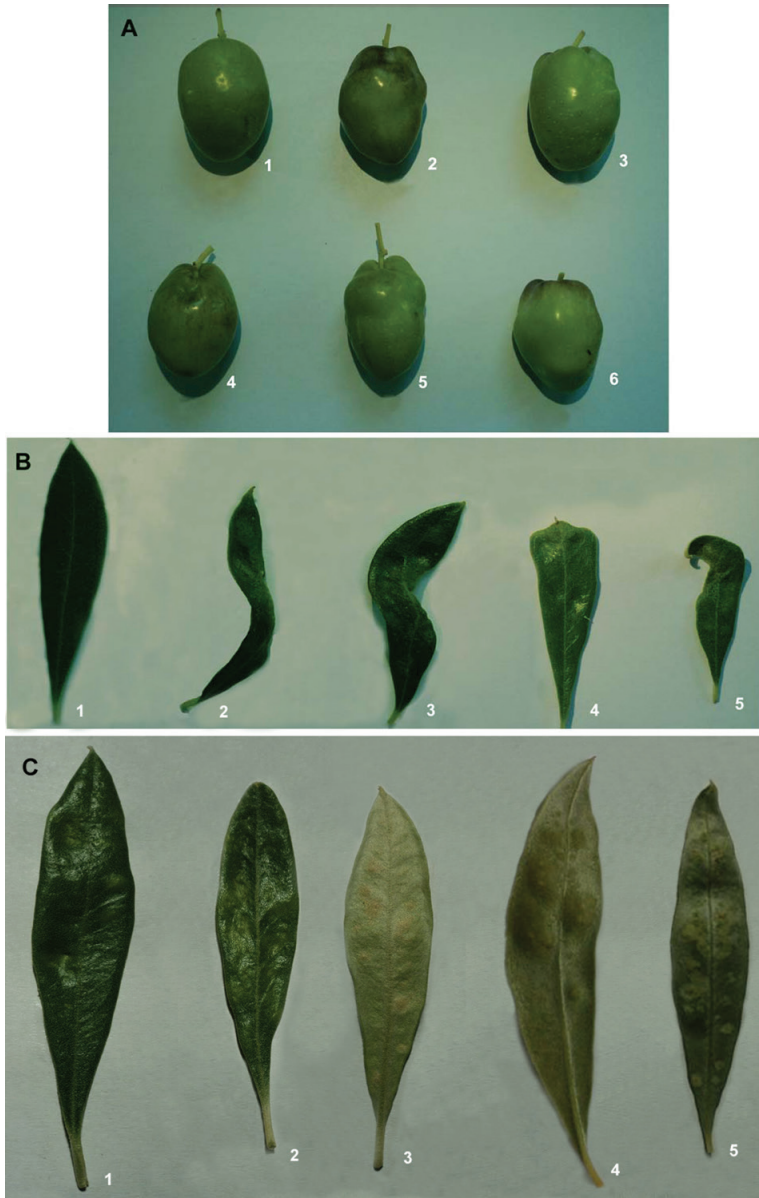
Propodosomal and metapodosal plates separated by a relatively large expanse of fine integumental striae (Fig. 1A, 2A).

Humeral plate (H) ovoid, situated antiaxially to P-plate and slightly antiaxially to M-plate; setae  $c_2$  insertion situated slightly paraxially to  $d_2$  insertion level (Fig. 1A).

Metapodosomal plate (M) hexagonal to polyhedral.

Dorsocentral setae: insertions  $c_1$  and  $e_1$  situated on the same longitudinal level;  $d_1$  insertion situated antiaxially to  $c_1$  and  $e_1$  insertion level. Dorsolateral setae:  $d_2$  insertion situated externally and close to plate margin, posteriorly to  $c_1$  insertion level but anteriorly to  $d_1$  insertion level;  $e_2$  situated slightly paraxially to the  $d_2$  insertion level and posteriorly and antiaxially to  $d_1$  insertion level (Fig. 1A).





**Figure 5.** Malformations induced by eriophyid mites on leaves and fruit. **A** affected leaves **B** affected fruit. The upper left fruit is normal, others with malformations **C** young fruit attacked by *A. oleae* **D** detail of attack in **C**.

Intercalary plates (I) ovoid, situated near the body margin (Fig. 1A);  $f_1$  setal insertion situated paraxially to  $e_2$  insertion level and anti-axially to  $e_1$  insertion level.

**Ventral region.** Epimera well defined (Fig. 1B). Setal formulae: 3-1-3-3. Anogenital region clearly discernible. Two pairs of paragenital setae:  $ag_1$ ,  $ag_2$ ; and four pairs

of setae: *g*, and three anal setae *ps*<sub>1</sub>, *ps*<sub>2</sub>, *ps*<sub>3</sub> (see Setation). *g*, *ps*<sub>1</sub>, *ps*<sub>2</sub> and *ps*<sub>3</sub> differing in shape (See Setation).

Cuticular components of the genital chamber with *preatrium* (*pre*), saucer-shaped structure, longitudinal striate and *postatrium* (*post*) bilobed; between *pre* and *pos* a constriction or waist (*w*) (Fig. 1D).

**Legs** (Figure 4A–D). All legs with ambulacrum, composed of two claws with small tooth, and an empodium with three pairs of capitate fan-shaped raylets (resembling leaves of *Ginkgo biloba* tree) (Fig. 3B).

Setal formulae (solenidia in parentheses) I (1-4-2(1)-5(1)-11(1)); setae *k* on genu I; II (1-4-0-5(1)-8(1)); III (1-2-0-5(1)-7(1)); IV (1-2-0-4-7).

Setal formulae of palp (3-1-2-8(1)) (Fig. 1C); tarsus with four eupathidia and solenidion  $\omega$ ; (*ul*)  $\zeta$ , *sul*  $\zeta$  united in fork, with typical characteristics of Stigmaeidae (Grandjean 1944). Palp tibial claw present (Fig. 3A).

**Remarks.** The post ocular body, delimited by red-yellow spots, is clearly visible in fresh recently prepared specimens, but these spots disappear quickly making it difficult to view; this situation is similar to observations made on *Hydrozetes lemnae* (Oribatida, Hydrozetidae) and at the base of the ultrastructural studies of secondary eye (Alberti and Fernandez 1988, 1990a,b).

Our observations on cuticular components of the genital chamber using optical microscopy must be indicated as relative, and we stress that their value for taxonomic studies is limited as their main significance is only to confirm adulthood [as indicated by Summers and Ehara (1965)].

### Problems with Olive orchards in Argentina related to eriophyid mites and their predator *Agistemus aimogastaensis* sp. n.

The Olive industry in Argentina is significant, with several provinces such as Mendoza, San Juan, San Luis, La Rioja and Catamarca producing olive fruit and their derivatives, though levels of production may vary. Olive production plays a very important socio-economic role as principal provider of employment in La Rioja and Catamarca Provinces.

In olive orchards eriophyid mites are considered a secondary pest (International Olive Council 2007; Spooner et al. 2007) relating to young trees, and a problem in greenhouses or in zones with high humidity and temperature (Spooner et al. 2007). Regrettably, in Argentina, this problem has high incidence and produces large losses in olive industry yield, reaching up to 20%.

The predominant species of eriophyid mites found in Catamarca and La Rioja Provinces on *Olea europaea* (variety Arauco) are *Aceria oleae* and *Oxycemus maxwelli*. Of these two, *A. olea* is predominant with a maximum on leaves and fruit in April and November. These two eriophyid mites cause a significant impact on regional economies due to significant fruit and leaf malformations (Figure 5).

The predator *Agistemus aimogastaensis* was found in these two provinces in large numbers, principally in relation to the population level of eriophyid mites.

The possibility exists of using this predator as biological control measure of problematic eriophyid mites. Our laboratory observations show that *A. aimogastaensis* is a voracious predator, principally on *A. olea*. All ontogenetic stages prey on the mites. Several studies on different predation aspects are being conducted.

## Acknowledgements

We thank Prof Dr Yves Coineau (former Director of Arthropod Section at MNHN), for his support in interpreting several morphological aspects of the mite, Prof Eddie Ueckermann (ARC, Plant-Protection Research Institute, Private Bag X134, Queenswood 0121 South Africa) for additional comments, and Leone Hudson for her contribution towards technical and language aspects of the paper.

This work is based on research supported in part by the National Research Foundation of South Africa (UID) 85288. Any opinion, findings and conclusions or recommendations expressed in the material are those of the authors and therefore the NRF does not accept any liability in regard thereto.

## References

- Abou-Awad BA, El-Sawaf BM, Reda AS (2000) Environmental management and biological aspects of the two eriophyid fig mites *Aceria ficus* (Cotte) and *Rhyncaphytoptus ficifoliae* Keifer in Egypt. *Anzeiger für Schaedlingskunde* 73 (1): 5–12. doi: 10.1046/j.1439-0280.2000.00005.x
- Abou-Awad BA, Hassan MF, Romeih AHM (2010) Biology of *Agistemus olivi*, a new predator of eriophyid mites infesting olive trees in Egypt. *Archives of Phytopathology and Plant Protection* 43 (8): 817–824. doi: 10.1080/03235400802246986
- Al-Atawi FJ (2011) Phytophagous and predaceous mites associated with vegetable crops from Riyadh, Saudi Arabia. *Saudi Journal of Biological Sciences* 18 (3): 239–246. doi: 10.1016/j.sjbs.2011.02.004
- Alberti G, Fernandez NA (1988) Fine structure of a secondarily developed eye in the freshwater moss-mite *Hydrozetes lemnae* (Coggi 1889) (Acari: Oribatida). *Protoplasma* 146: 106–117. doi: 10.1007/BF01405919
- Alberti G, Fernandez NA (1990a) Aspects concerning the structure and function of the lenticulus and clear spot of certain oribatids (Acari: Oribatida). *Acarologia* 31: 65–72.
- Alberti G, Fernandez N (1990b) Fine structure and function of the lenticulus and clear spot of Oribatids (Acari: Oribatida). In: Andre HM, Lions J-CI (Eds) *L'ontogenese et le concept de stase chez les Arthropodes*. Agar Publishers Wavere, Belgium 343–354.
- Alberti G, Fernandez N, Kummel G (1991) Spermatophores and spermatozoa of Oribatid mites (Acari: Oribatida). Part II. Functional and systematical considerations. *Acarologia* 32 (4): 435–449.
- Alberti G, Norton RA, Adis JL, Fernandez NA, Franklin E, Kratzmann M, Moreno IA, Ribeiro EF, Weigmann G, Woas S (1997) Porose integumental organs of oribatid mites (Acari,

- Oribatida). 2. Fine structure. In: Alberti G, Norton RA (Eds) Porose integumental organs of oribatid mites (Acari, Oribatida). *Zoologica* 48 (146): 33–114.
- Alberti G, Fernandez N, Coineau Y (2007) Fine structure of spermiogenesis, spermatozoa and spermatophore of *Saxidromus delamarei*, Coineau 1974 (Saxidromidae, Actinotrichida, Acari). *Arthropod Structure & Development* 36 (2): 221–231. doi: 10.1016/j.asd.2006.11.002
- Arbabi M, Singh J (2002) Studies on *Agistemus industani* Gonzalez-Rodriguez (Acarina: Stigmaeidae), an efficient predator of *Tetranychus ludeni* Zacker on mulberry. *Acarina* 10 (1): 85–89.
- Bostanian NJ, Hardman JM, Racette G (2006) Inventory of predacious mites in Quebec commercial apple orchards where integrated pest management programs are implemented. *Annals of the Entomological Society of America* 99 (3): 536–544. doi: 10.1603/0013-8746(2006)99[536:IOPMIQ]2.0.CO;2
- Coineau Y (1974) Eléments pour une monographie morphologique, écologique et biologique des Caeculidae (Acariens). *Mémoires Muséum National Histoire Naturelles*, 22 Zoologie 81: 299 pp.
- De Gouvea A, Zanella CF, Mazaro SM (2007) Association and populational density of mites predators in the mate-tea tree *Ilex paraguariensis* St. Hil. (Aquifoliaceae) with or without the presence of phytophagous mites. *Ciencia Rural* 37 (1): 1–6.
- De Vis R, De Moraes G, Bellini M (2006) Initial screening of little known predatory mites in Brazil as potential pest control agents. *Experimental and Applied Acarology* 39 (2): 115–125. doi: 10.1007/s10493-006-9004-7
- Ehara S (1962) Notes on some predatory mites (Phytoseiidae and Stigmaeidae). *Japanese Journal Applied Entomology Zoology* 6: 53–60. doi: 10.1303/jjaez.6.53
- El-Sawi S, Momen F (2006) *Agistemus exertus* Gonzalez (Acari: Stigmaeidae) as a predator of two scale insects of the family Diaspididae (Homoptera: Diaspididae). *Archives of Phytopathology and Plant Protection* 39 (6): 421–427. doi: 10.1080/03235400500321388
- Fadamiro HY, Xiao Y, Nesbitt M, Childers, CC (2009) Diversity and seasonal abundance of predacious mites in Alabama satsuma citrus. *Annals of the Entomological Society of America* 102 (4): 617–628. doi: 10.1603/008.102.0406
- Fernandez N, Alberti G, Kümmel G (1991) Spermatophores and spermatozoa of some oribatid mites (Acari: Oribatida) Part I. Fine structure and histochemistry. *Acarologia* 32 (3): 261–286.
- Gonzalez-Rodriguez RH (1961) Contribucion al conocimiento de los ácaros del Manzano en Chile central. *Universidad de Chile, Estacion Experimental Agronomica. Boletín Técnico* 11: 35–39.
- Gonzalez-Rodriguez RH (1963) Four new mites of the genus *Agistemus* Summers, 1960 (Acarina:Stigmaeidae). *Acarologia* 5 (3): 342–350.
- Gonzalez-Rodriguez RH (1965) A taxonomic study of the genera *Mediolata*, *Zetzellia* and *Agistemus* (Acari: Stigmaeidae). *University of California Publications in Entomology* 41: 66.
- Gotoh T, Shida T (2007) Life cycles and interactions in spider mites (Acari: Tetranychidae) on dwarf bamboo, *Sasa senanensis* (F. & S.) (Poaceae), in Japan. *International Journal of Acarology* 33 (3): 259–273. doi: 10.1080/01647950708684531
- Grandjean F (1944) Observations sur les Acariens de la famille des Stigmaeidae. *Archives Sciences Physiques et Naturelles* 26: 103–131.

- Grandjean F (1949) Observation et conservation des très petits Arthropodes. Bulletin Muséum Histoire Naturelles, Paris. 21(2): 363–370.
- International Olive Council (2007) Production Techniques in olive growing. 346 pp. <http://www.internationaloliveoil.org>
- Jamieson LE, Chhagan A, Charles JG (2008) Predation of citrus red mite (*Panonychus citri*) by *Stethorus* sp. and *Agistemus longisetus*. New Zealand Plant Protection 61: 317–321.
- Kawashima M, Chung B-K, Jung C (2008) Herbivorous and predacious mites on persimmon trees, *Diospyros kaki* Thunb., in Korea. International Journal of Acarology 34 (2): 167–174. doi: 10.1080/01647950808683720
- Kethley J (1990) Acarina: Prostigmata (Actinedida). In: Dindal DL (Ed) Soil Biology Guide. John Wiley & Sons, 667–756.
- Krantz GW, Walter DE (2009) A manual of acarology. 3rd ed. Lubbock (TX): Texas Tech, University Press, 807 pp.
- Liana J, Juarez F (2012) Mite (Acari) population dynamics in grapevines (*Vitis vinifera*) in two regions of Rio Grande do Sul, Brazil. International Journal Acarology 38 (5): 386–393. doi: 10.1080/01647954.2012.657240
- Marchetti M, Juarez F (2011) Diversity and population fluctuation of mites (Acari) in blackberry (*Rubus fruticosus*, Rosaceae) in the state of Rio Grande do Sul, Brazilia. Iheringia Serie Zoologia 101 (1–2): 43–48. doi: 10.1590/S0073-47212011000100005
- Matioli AL, de Oliveira CAL (2007) Biology of *Agistemus brasiliensis* Matioli, Ueckermann & Oliveira (Acari: Stigmaeidae) and its predation potential on *Brevipalpus phoenicis* (Geijskes) (Acari: Tenuipalpidae). Neotropical Entomology 36 (4): 577–582. doi: 10.1590/S1519-566X2007000400016
- Matioli AL, Tavares MG, Pallini A (2007) *Agistemus pallinii* n. sp. (Acari: Stigmaeidae) from citrus orchards in Brazil. International Journal of Acarology 33 (3): 245–251. doi: 10.1080/01647950708684529
- Mineiro C, Sato ME, Raga A (2006) Diversity of mites (Arachnida: Acari) on five cultivars of two species of coffee (*Coffea* spp.) in Garca, State of Sao Paulo, Brazil. Arquivos do Instituto Biologico Sao Paulo 73 (3): 333–341.
- Momen FM (2011) Natural and factitious prey for rearing the predacious mite *Agistemus exsertus* Gonzales (Acari: Stigmaeidae). Acta Phytopathologica et Entomologica Hungarica 46 (2): 267–275. doi: 10.1556/APhyt.46.2011.2.11
- Momen FM (2012) Influence of life diet on the biology and demographic parameters of *Agistemus olivi* Romeih, a specific predator of Eriophyid Pest Mites (Acari: Stigmaeidae and Eriophyidae). Tropical Life Sciences Research 23 (1): 25–34.
- Putatunda B (2005) Mites (Acarina) associated with stored food products in Himachal Pradesh, India: a taxonomic study. Journal of Entomological Research (New Delhi) 29 (1): 79–82.
- Roy I, Gupta S, Saha G (2006) Two new species of prostigmatid mites infesting medicinal plants in West Bengal, India. Entomon 31(4): 307–313.
- Roy I, Gupta S, Saha G (2008) New reports of predatory mites (Acari: Prostigmata, Mesostigmata) from medicinal plants of Darjeeling district, West Bengal, India with description of a new species. Entomon 33 (2): 119–128.

- Roy I, Gupta S, Saha G (2009) Predatory mites of the genus *Agistemus* (Acari: Stigmaeidae) from medicinal plants of West Bengal, India, with description of a new species. *Entomon* 34 (3): 175–180.
- Saber S, Rasmy A (2010) Influence of plant leaf surface on the development, reproduction and life table parameters of the predacious mite, *Agistemus exsertus* Gonzalez (Acari: Stigmaeidae). *Crop Protection* 29 (8): 789–792. doi: 10.1016/j.cropro.2010.04.001
- Spooner HR, Tesoriero L, Hall B (2007) Field guide to olive Pests, Diseases and Disorders in Australia. Rural industries Research and Development Corporation 68 pp.
- Summers FM (1960) Several stigmaeid mites formerly included in *Mediolata* redescribed in *Zetzellia* Ouds, and *Agistemus*, new genus. *Proceeding Entomological Society Washington* 62 (4): 233–247.
- Summers FM (1966) Genera of the mite family Stigmaeidae Oudemans (Acarina). *Acarologia* 8: 230–250
- Summers FM, Ehara S (1965) Revaluation of the taxonomic characters in four species of the genus *Cheylstigmaeus* Willmann (Acarina: Stigmaeidae). *Acarologia* 7: 49–62
- Thakur M, Dinabandhoo CL, Chauhan U (2010) Host Range, distribution, and morphometrics of predatory mites associated with phytophagous mites of fruit crops in Himachal Pradesh, India. *Trends in acarology. Proceedings of the 12th International Congress*: 431–434.
- Yousuf M, Chouhan S (2004) Observations on two predatory mites belonging to the families: Stigmaeidae & Cheyletidae, associated with forestry phytophagous mites. *Bulletin of Pure & Applied Sciences A Zoology* 23A (2): 93–97.