

**University of São Paulo
“Luiz de Queiroz” College of Agriculture**

**Free living astigmatid mites (Astigmatina): new taxa, rearing and use for
mesostigmatid (Mesostigmata) predatory mite production**

Marina Ferraz de Camargo Barbosa

Thesis presented to obtain the degree of Doctor in
Science. Area: Entomology

**Piracicaba
2016**

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B.S. and B.Ed. in Biology

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To my husband

Marcelo Elias Delaneze

For his love and unbreakable support. You are the salt of the Earth.

To my parents

Anna Maria Perosa Ferraz de Camargo

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RESUMO

Ácaros Astigmatina de vida livre (Astigmatina): novos táxons, criação e uso para a produção de ácaros predadores Mesostigmata

A coorte Astigmatina é dividida em dois grandes grupos: Psoroptidia, composto majoritariamente por ácaros de pena e pelos, e Não-Psoroptidia, componente dominante da acarofauna de habitats efêmeros. Nestes ambientes, os Astigmatina geralmente são saprófagos ou se alimentam de fungos e bactérias. Protoninfas de Astigmatina passam por uma completa reorganização da estrutura corporal levando à produção de deutoninfas heteromórficas geralmente especializadas para dispersão por forese utilizando artrópodes e vertebrados como forontes. Apesar de a maioria dos Astigmatina ocorrer em ambientes naturais, algumas espécies passaram a ocupar ambientes antrópicos, como depósitos de alimentos, onde algumas se tornaram pragas; alguns Astigmatina infestam órgãos subterrâneos de plantas. A despeito de sua importância econômica e ecológica, estudos sobre a diversidade e taxonomia dos Astigmatina no Brasil têm sido raros nas últimas décadas. O objetivo geral desta tese foi colaborar para o conhecimento da diversidade e avaliar o potencial de uso prático de espécies Astigmatina no Brasil. Para isso, novos gêneros e espécies foram descritos, métodos para criação de ácaros de poeira foram estudados e a eficiência de Astigmatina como presas para ácaros predadores edáficos foi avaliada. Uma nova espécie de *Thyreophagus* (Astigmatina: Acaridae) foi descrita com base em espécimes coletados no Brasil, uma revisão sobre três outras espécies deste gênero associadas com alimentos armazenados foi realizada e uma chave para todas as espécies deste gênero foi elaborada. O gênero *Neotropacarus* (Astigmatina: Acaridae), comumente associado a folhas de plantas, foi revisado, com redescrição de duas espécies e descrição de novas espécies coletadas no Brasil e nas Filipinas. Dois novos gêneros e sete novas espécies de Acaridae associados à família de abelha Apidae foram descritos e uma chave para os gêneros da subfamília Horstiinae foi elaborada. Diversas espécies de Astigmatina foram avaliadas como presas para os ácaros predadores *Stratiolaelaps scimitus* (Womersley) (Mesostigmata: Laelapidae) e *Protogamasellopsis zaheri* Abo-Shnaf, Castilho e Moraes (Mesostigmata: Rhodacaridae), que ovipositaram em todas os Astigmatina avaliados, sendo *Tyrophagus putrescentiae* (Schrank) e *Aleuroglyphus ovatus* (Troupeau) (Acaridae) as presas mais promissoras. Sete alimentos e dois períodos de desenvolvimento, 30 e 60 dias, após inoculação de 400 fêmeas de duas espécies importantes na poeira residencial, *Blomia tropicalis* van Bronswijk, de Cock e Oshima e *Dermatophagoides pteronyssinus* (Trouessart) foram avaliados. Com os alimentos mais adequados, o crescimento populacional nas colônias foram maiores que 20.2 e 15.3 para *B. tropicalis* e *D. pteronyssinus*, respectivamente.

Palavras-chave: Astigmatina; Ácaros de alimentos armazenados; Ácaros associados a abelhas; Acaridae; Pyroglyphidae; Echimyopodidae; Criação massal; Laelapidae; Rhodacaridae

ABSTRACT

Free living astigmatid mites (Astigmatina): new taxa, rearing and use for Mesostigmata predatory mites production

The cohort Astigmatina is divided in two major groups: Psoroptidia, composed mainly by feather and fur mites, and Non-psoroptidia, a dominant component of the acarofauna in ephemeral habitats. In these environments Astigmatina usually are saprophages or feed on fungi or bacteria. Astigmatina protonymphs undergo a complete reorganization of the body structure leading to the production of heteromorphic deutonymphs, generally specialized for dispersion through phoresy using arthropods and vertebrates as phoronts. Although most Astigmatina occur in natural environments, some species live in anthropic environments, such as food deposits, where some of them became pests; some Astigmatina infest subterranean plant organs. Despite their economic and ecological importance, studies on the diversity and taxonomy of Astigmatina in Brazil have been rare over the last decades. The general objective of this thesis was to collaborate to the knowledge of the diversity and to evaluate the potential practical uses of these mites in Brazil. For this, new genera and species were described, method for rearing dust mites was studied and the efficiency of Astigmatina as prey for edaphic predators was evaluated. A new species of *Thyreophagus* (Astigmatina: Acaridae) was described based on specimens collected in Brazil, the association of three other species of this genus with stored food was reviewed and a key to all species of this genus was prepared. The genus *Neotropacarus* (Astigmatina: Acaridae), commonly found on plant leaves, was reviewed with the redescription of two species and description of new species collected in Brazil and from the Philippines. Two new genera and seven new species of Acaridae associated with the bee family Apidae was described and a key to Acaridae genera in subfamily Horstiinae was prepared. Several species of Astigmatina were evaluated as prey for predatory mites *Stratiolaelaps scimitus* (Womersley) (Mesostigmata: Laelapidae) and *Protogamasellopsis zaheri* Abo-Shnaf, Castilho and Moraes (Mesostigmata: Rhodacaridae), which oviposited on all evaluated astigmatids, with *Tyrophagus putrescentiae* (Schrank) and *Aleuroglyphus ovatus* (Troupeau) (Acaridae) being the most suitable prey. Seven foods and two development period, 30 and 60 days, after the introduction of 400 females of two important dust mite species, *Blomia tropicalis* van Bronswijk, de Cock e Oshima and *Dermatophagoides pteronyssinus* (Trouessart) were evaluate. With the most suitable foods, the population growth were higher than 20.2 and 15.3 for *B. tropicalis* and *D. pteronyssinus*, respectively.

Keywords: Astigmatina; Food stored mites; Bee associated mites; Acaridae; Pyroglyphidae; Echimyopodidae; House dust mites rearing; Laelapidae; Rhodacaridae

1 INTRODUCTION

Astigmatina has been considered an order [Astigmata, by Evans, Sheals and MacFarlaney (1961)] or suborder [Acaridida, by Krantz (1978) or Astigmata, by OConnor (1982a)]. Norton (1998) cited that 14 derived characters support the inclusion of Astigmatina in the suborder Oribatida, more specifically in the supercohort Desmonomatides. Therefore, Astigmatina is currently considered a Cohort within Oribatida (OConnor, 2009). Main morphological characteristics of feeding stages of Astigmatina are: body poorly sclerotized, except for a dorsal sclerite (more derived groups have heavily sclerotized body; e.g. Guanolichidae and some Algophagidae); sejugal furrow retained in ancestral groups (lost in numerous derived groups); cuticle smooth or covered by striae or other forms of ornamentation; many taxa with ventrally sclerotized coxal fields and reduced number of setae on legs I-IV; empodial claw usually present and well developed (absent or reduced in some groups); chelicerae are usually chelatedentate to crush solid food or act as scrapers (chelicerae highly modified to filter particles are present in Histiostomatoidea); rutella is diverse and cover most of the ventral apex of sucapitulum; stigmata or tracheal system are absent, so the respiration is presumed to be integumental; Grandjean's organ, simple or very elaborated in shape, is found at the apex of the podecephalic sclerite; position of genital opening highly variable, ranging from far posterior and almost confluent with the anus to far between coxal fields I; two pairs of genital papillae usually present in postprotonymphal stages, may be absent in parasitic taxa (OConnor, 2009).

Astigmatina is divided in two major groups: one, a paraphyletic taxon composed by free-living species, and another, virtually monophyletic taxon, composed mostly by parasitic species (Psoroptidia) (OCONNOR, 2009). Non-psoroptidian groups differ from Psoroptidia by the presence of genital papillae (absent in Psoroptidia), tibia I-II with one or two tactile setae (*c*'' always absent in Psoroptidia) and by the formation of heteromorphic deutonymph in several groups (always absent in Psoroptidia) (KRANTZ, 1978; OCONNOR, 2009).

Psoroptidia species are mainly feather or fur mites, living on the integumentary system of birds and mammals (OCONNOR, 2009). These species primarily feed on the oil produced by uropygial gland of birds (PROCTOR, 2003) or cambial cells on the skin epithelium or sebaceous secretions of mammals (BOCHKOV, 2006; OCONNOR, 1982b), but may also feed on skin flakes, keratinous medulla of rachis, fluids present at the basis of the feather and fungi or algae present in these microhabitats (PROCTOR, 2003).

Non-psoroptidian Astigmatina are the most abundant component of the acarofauna in ephemeral habitats and may occur in dung, carrion, bat guano, nests of arthropods or other invertebrates, house dust, stored products, soil litter, plant foliage, flowers, caves and aquatic environments such as sap fluxes, phytotelmata and intertidal and to subtidal zones (OCONNOR, 2009).

In these environments Astigmatina usually are saprophages, but also feed on fungi or bacteria (OCONNOR, 2009). Within this group, most Histiostomatidae species are adapted to filter feeding (FASHING, 1998, 2010; KRANTZ, 1978; OCONNOR, 2009; WALTER; KAPLAN, 1990); more rarely Astigmatina may be predators of insects (BRUST; HOUSE, 1988; CANEVARI et al., 2012; HOUCK; COHEN, 1995; IZRAYLEVICH; GERSON, 1995; PAPADOPOULOU, 2006), other mites and nematodes (ABOU EL-ATTA; OSMAN, 2015; EKMEH et al., 2010; WALTER; HUDGENS; FRECKMAN, 1986). Some have developed the ability to consume vegetable tissue, especially bulbs and tubers (DÍAZ et al., 2000; MANSON, 1972; LESNA; SABELIS; CONIJN, 1996); fully aquatic species may consume algae (BÜCKING, 1999; FASHING; CAMPBELL, 1992).

Protonymphs of Astigmatina undergo a complete reorganization of the body structure leading to the formation of heteromorphic deutonymphs (OCONNOR, 2009). The most common heteromorphic type of deutonymph is specialized for dispersion, presenting a rudimentary gnathosoma, without mouth, extensive sclerotization and a caudoventral attachment organ (HOUCK; OCONNOR, 1991; OCONNOR, 2009). These features allow Astigmatina to disperse through phoresy using arthropods and vertebrates as phoronts and deutonymphal morphology is highly variable according to the phoront (FAIN, 1968, 1969, 1981; HOUCK; OCONNOR, 1991; VOLGIN, 1971).

A second type of deutonymph is specialized to resist unfavorable condition just waiting for the reestablishment of suitable temperature and humidity condition without moving to other places (HUGHES, 1976; HOUCK; OCONNOR, 1991; OCONNOR, 1994, 2009). These are called inert or regressive deutonymphs; they have even greater reduction of body appendices, legs and attachment organ becoming vestigial (calyptostase), and they remain within the protonymphal cuticle (eg. GRIFFITHS, 1966; HUGHES, 1955; van ASSELT, 2000).

Although most Astigmatina occur in natural environments, not affecting human activities, some species ancestrally found in nests of rodents and birds were taken by these animals to anthropic environments, such as food deposits, where they became pests (OCONNOR, 1979). In these places, these mites reduce the volume of stored food (SOLOMON, 1946; ŽDÁRKOVÁ; REŠKA, 1976), derail the germination of the seeds

(WHITE; HENDERSON; SINHA, 1979), introduce fungi in the products (HUBERT et al., 2003) or affect the health of the workers, causing respiratory or cutaneous allergy (BLAINEY, 1989; CUTHBERT et al., 1979; IVERSEN et al., 1990). Some astigmatid species might infest subterranean plants organs, such as bulb and tubercles, damaging the production of some important plants, as garlic, onion and ornamentals (DÍAZ et al., 2000; FAN; ZHANG, 2004).

Despite their economic and ecological importance, studies on the diversity and taxonomy of Astigmatina in Brazil have been rare over the last decades. As a result, the real diversity of species of this group both in natural and anthropic environments is not adequately known.

The motivation to the development of this thesis was: to contribute to the enhancement of the knowledge about the diversity of astigmatid mites in Brazil; to increase information about the use of astigmatid mites as factitious prey for mesostigmatid predators and to provide preliminary results to the development of methods for mass production of house dust mites.

Thus, the specific objectives of this thesis were:

- To provide the description of a new species of *Thyreophagus* (Acari: Acaridae) collected in Piracicaba, Brazil, a key for species of this genus and to discuss the importance of *Thyreophagus* species as stored food pests;
- To review the genus *Neotropacarus* (Acaridae: Acaridae), redescribing two species and describing three new species of this genus, as well as providing a key to the species of this genus;
- To describe two new genera and seven new species of Acaridae associated with Apidae bees;
- To evaluate the efficiency of Astigmatina species as factitious prey for rearing edaphic predators;
- To assess the potential of different foods and two development period for production of two species of house dust mite.

References

ABOU EL-ATTA, D.A.; OSMAN, M.A. Development and reproductive potential of *Tyrophagus putrescentiae* (Acari: Acaridae) on plant-parasitic nematodes and artificial diets. **Experimental and Applied Acarology**, Amsterdam, v. 68, p. 477-483, 2016.

BLAINEY, A.D.; TOPPING M.D, OLLIER S., DAVIES R.J. Allergic respiratory disease in grain workers: The role of storage mites. **Journal of Allergy and Clinical Immunology**, Saint Louis, v. 84, n. 3, p. 296-303, 1989.

BOCHKOV, A. Morphological adaptations of acariform mites (Acari: Acariformes) to permanent parasitism on mammals. **Parazitologija**, St. Petersburg, v. 41, n. 6, p. 428-458, 2006.

BRUST, G.E.; HOUSE, G.J. A study of *Tyrophagus putrescentiae* (Acari: Acaridae) as a facultative predator of southern corn rootworm eggs. **Experimental and Applied Acarology**, Amsterdam, v. 4, n. 4, p. 335-344, 1988.

BÜCKING, J. Population biology of a phytophagous mite of marine and estuarine rocky shores (Astigmata, Hyadesiidae). In: BRUIN, J.; VAN DER GEEST, L.P.S.; SABELIS, M.W. (Ed.). **Ecology and Evolution of the Acari**. New York: Springer, 1999. chap. 36, p. 441-450.

CANEVARI, G.C.; REZENDE, F.; SILVA, R.B; FARONI, L.R.D.; ZANUNCIO, J.C.; PAPADOPOULOU, S.; SERRÃO, J.E. Potential of *Tyrophagus putrescentiae* (Schrank) (Astigmata: Acaridae) for the biological control of *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae). **Brazilian Archives of Biology and Technology**, Curitiba, v. 55, n. 2, p. 299-303, 2012.

CUTHBERT, O.D.; BROSTOFF J.; WRAITH, D.G.; BRIGHTON, W.D. Barn allergy: asthma and rhinitis due to storage mites. **Clinical & Experimental Allergy**, Oxford, v. 9, n. 3, p. 229-236, 1979.

DÍAZ, A.; OKABE, K.; ECKENRODE, C.J.; VILLANI, M.G.; OCONNOR, B.M. Biology, ecology, and management of the bulb mites of the genus *Rhizoglyphus* (Acari: Acaridae). **Experimental and Applied Acarology**, Amsterdam, v. 24, n. 2, p. 85-113, 2000.

EKMEN, Z.I.; CAKMAK, I.; KARAGOZ, M.; HAZIR, S.; OZER, N.; KAYA, H.K. Food preference of *Sancassania polyphyllae* (Acari: Acaridae): living entomopathogenic nematodes or insect tissues? **Biocontrol Science and Technology**, Oxford, v. 20, n. 6, p. 553-566, 2010.

EVANS, G.O.; SHEALS, J.G.; MACFARLANE, D. **The terrestrial acari of the British Isles: an introduction to their morphology, biology and classification**. London: British Museum, 1961. 219 p.

FAIN, A. A new heteromorphic deutonymph (hypopus) of a sarcoptiform mite parasitic under the skin of a toucan. **Journal of Natural History**, London, v. 2, n. 4, p. 459-461, 1968.

_____. Adaptation to parasitism in mites. **Acarologia**, Paris, v. 11, n. 3, p. 429-449, 1969.

_____. A revision of the phoretic deutonymphs (hypopi) of the genus *Sennertia* Oudemans, 1905 (Acari, Astigmata, Chaetodactylidae). **Systematic Parasitology**, Dordrecht, v. 3, n. 3, p. 145-183, 1981.

FAN, Q-H.; ZHANG, Z-Q. **Revision of *Rhizoglyphus* Claparède (Acari: Acaridae) of Australasia and Oceania**. London: Systematic and Applied Acarology Society, 2004. 374 p

FASHING, N.J. Functional morphology as an aid in determining trophic behaviour: the placement of astigmatic mites in food webs of water-filled tree-hole communities. **Experimental and Applied Acarology**, Amsterdam, v. 22, n. 8, p. 435-453, 1998.

_____. Life history and biology of *Hormosianoetus mallotae* (Fashing) (Histiostomatidae: Astigmata), an obligatory inhabitant of water-filled treeholes. **International Journal of Acarology**, Oak Park, v. 36, n. 3, p. 189-198, 2010.

FASHING, N.J.; CAMPBELL, D.M. Observations on the feeding biology of *Algophagus pennsylvanicus* (Astigmata: Algophagidae), a mite restricted to water-filled treeholes. **International Journal of Acarology**, Oak Park, v. 18, n. 2, p. 77-81, 1992.

GRIFFITHS, D.A. Nutrition as a factor influencing hypopus formation in the *Acarus siro* species complex (Acarina, Acaridae). **Journal of Stored Products Research**, Oxford, v. 1, n. 4, p. 325-340, 1966.

HOUCK, M.A.; COHEN, A.C. The potential role of phoresy in the evolution of parasitism: radiolabelling (tritium) evidence from an astigmatid mite. **Experimental and Applied Acarology**, Amsterdam, v. 19, n. 12, p. 677-694, 1995.

HOUCK, M.A.; OCONNOR, B.M. Ecological and evolutionary significance of phoresy in the Astigmata. **Annual Review of Entomology**, Stanford, v. 36, n. 1, p. 611-636, 1991.

HUBERT, J.; STEJSKAL, V.; KUBÁTOVÁ, A.; MUNZBERGOVÁ, Z.; VÁNOVÁ, M.; ŽDÁRKOVÁ, E. Mites as selective fungal carriers in stored grain habitats. **Experimental and Applied Acarology**, Amsterdam, v. 29, n. 1/2, p. 69-87, 2003.

HUGHES, A.M. On the inert hypopial form of *Acarus siro* L. (= *Tyroglyphus farinae* L.). (Acarina). **The Entomologist's Monthly Magazine**, Oxford, v. 91, p. 99-102, 1955.

_____. **The mites of stored food and houses**. London: Ministry of Agriculture and Fisheries, 1976. 400 p. (Technical Bulletin, 9).

IVERSEN, M.; KORSGAARD, J.; HALLAS, T.; DAHL, R. Mite allergy and exposure to storage mites and house dust mites in farmers. **Clinical and Experimental Allergy**, Oxford, v. 20, n. 2, p. 211-219, 1990.

IZRAYLEVICH, S.; GERSON, U. Host scale effects on the parasitic mite *Hemisarcoptes coccophagus* Meyer and their implications for the biological control of diaspidid pests. **Israel Journal of Entomology**, Tel Aviv, v. 29, p. 291-296, 1995.

KRANTZ, G.W. **A manual of acarology**. 2nd ed. Corvallis: Oregon State University Bookstores, 1978. 509 p.

LESNA, I.; SABELIS, M.; CONIJN, C. Biological control of the bulb mite, *Rhizoglyphus robini*, by the predatory mite, *Hypoaspis aculeifer*, on lilies: predator-prey interactions at various spatial scales. **Journal of Applied Ecology**, Oxford, v. 33, n. 2, p. 369-376, 1996.

MANSON, D.C.M. Contribution to the study of the genus *Rhizoglyphus* Claparede, 1869 (Acarina: Acaridae). **Acarologia**, Paris, v. 13, n. 4, p. 621-650, 1972.

NORTON, R.A. Morphological evidence for the evolutionary origin of Astigmata (Acari: Acariformes). **Experimental and Applied Acarology**, v. 22, n. 10, p. 559-594, 1998.

CONNOR, B.M. Evolutionary origins of astigmatid mites inhabiting stored products. In: RODRIGUEZ, J.G. (Ed.). **Recent Advances in Acarology**. Cambridge: Academic Press, 1979. p. 273-278.

_____. Astigmata. In: PARKER, S.P. (Ed.). **Synopsis and classification of living organisms**. New York: McGraw-Hill, 1982a. p. 146-169.

_____. Evolutionary ecology of astigmatid mites. **Annual Review of Entomology**, Stanford, v. 27, n. 1, p. 385-409, 1982b.

_____. Life-history modifications in astigmatid mites. In: HOUCK, M.A. (Ed.). **Mites: ecological and evolutionary analyses of life-history patterns**. New York: Springer, 1994. chap. 6, p. 136-159.

_____. Cohort astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A Annual of Acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

PAPADOPOULOU, S.C. *Tyrophagus putrescentiae* (Schrank) (Astigmata: Acaridae) as a new predator of *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae) in tobacco stores in Greece. **Journal of Stored Products Research**, Oxford, v. 42, n. 3, p. 391-394, 2006.

PROCTOR, H.C. Feather mites (Acari: Astigmata): ecology, behavior, and evolution. **Annual Review of Entomology**, Stanford, v. 48, n. 1, p. 185-209, 2003.

SOLOMON, M.E. Tyroglyphid mites in stored products. Nature and amount of damage to wheat. **Annals of Applied Biology**, Warwick, v. 33, n. 3, p. 280-289, 1946.

van ASSELT, L. Observations on the life cycle of *Chaetodactylus osmiae* (Dufour, 1839) (Acari: Chaetodactylidae) parasitic on the solitary bee, *Osmia rufa* (L.), 1758 (Insecta: Hymenoptera) in Belgium. **International Journal of Acarology**, Oak Park, v. 26, n. 3, p. 221-228, 2000.

VOLGIN, V.I. The hypopus and its main types. In: MILAN, D.; ROSICKÝ, B. (Ed.). **Proceedings of the 3rd International Congress of Acarology**. New York: Springer, 1971. p. 381-383.

WALTER, D.E.; HUDGENS, R.A.; FRECKMAN, D.W. Consumption of nematodes by fungivorous mites, *Tyrophagus* spp. (Acarina: Astigmata: Acaridae). **Oecologia**, Berlin, v. 70, n. 3, p. 357-361, 1986.

WALTER, D.E.; KAPLAN, D.T. Feeding observations on two astigmatic mites, *Schwiebia rocketti* (Acaridae) and *Histiostoma bakeri* (Histiostomatidae) associated with *Citrus* feeder roots. **Pedobiologia**, Jena, v. 34, n. 5, p. 281-286, 1990.

WHITE, N.D.G.; HENDERSON, L.P.; SINHA, R.N. Effects of infestation by three stored-product mites on fat acidity, seed germination, and microflora of stored wheat. **Journal of Economic Entomology**, Lanham, v. 72, p. 763-766, 1979.

ŽDÁRKOVÁ, E.; REŠKA, M. Weight losses of groundnuts (*Arachis hypogaea* L.) from infestation by the mites *Acarus siro* L. and *Tyrophagus putrescentiae* (Schrank). **Journal of Stored Products Research**, Oxford, v. 12, n. 2, p. 101-104, 1976.

2 A NEW SPECIES OF *Thyreophagus* (ACARI: ACARIDAE) FROM BRAZIL, WITH NOTES ON SPECIES ASSOCIATED WITH STORED FOOD AND HUMAN HABITATS AND A KEY TO SPECIES OF THIS GENUS

Abstract

A new species *Thyreophagus* n. sp. is described morphologically based on adult females, adult homeomorphic and heteromorphic males collected from chicken feed in Brazil. The *Thyreophagus* species associated with stored food and human habitats are reviewed, and a key to separate species of this genus is provided.

Keywords: Taxonomy; Stored food mites; *Thyreophagus*

a. Introduction

Most species of the genus *Thyreophagus* Rondani, 1874 are associated with insects or subcortical environments (FAIN, 1982), but some species are known to occur in house dust and in stored food, sometimes damaging these products (FAIN, 1982; HUGHES, 1976). One species of this genus *Thyreophagus entomophagus* (Laboulbène) has been reported to affect human health when ingested (BLANCO et al., 1997; IGLESIAS-SOUTO et al., 2009; SÁNCHEZ- MACHÍN et al., 2010).

A new species of *Thyreophagus* was recently found in southeastern Brazil. The aim of this work is to describe this new species based on morphological characters of adult females and males, to summarize information about *Thyreophagus* species from human habitats and stored food, and to provide a key to separate species of this genus.

b. Material and Methods

Infested samples of chicken feed were obtained from Piracicaba, São Paulo state, Brazil, in August 2012. Mites were extracted using a Berlese funnel and mounted in Hoyer's medium for examination under an interference contrast microscope (Nikon Eclipse 80i). After determining it to be an undescribed species of *Thyreophagus*, adult females and males were photographed with a digital camera connected to the microscope. Photos were then processed with a digital tablet (Wacom Bamboo CTH-470L), using the Adobe Illustrator® program. For the description, average measurements in micrometres are followed (in parentheses) by the minimum and the maximum. Idiosomal chaetotaxy follows that of

OConnor (2009), which is based on the system developed by Grandjean (1939) and applied to the Astigmatina by Griffiths et al. (1990). Leg chaetotaxy also follows that proposed by OConnor (2009).

c. Results

Systematics

Thyreophagus Rondani

Thyreophagus Rondani, 1874: 67 [type species *Thyreophagus entomophagus* Rondani, 1874 (= *Acarus entomophagus* Laboulbène, 1852, by monotypy); Zachvatkin 1940: 43; Zachvatkin 1941: 208; Türk & Türk 1957: 145 (part); Mahunka 1974: 374 (part); Hughes 1976: 123; Chmielewski 1977: 65 (part); Fain 1982: 7; Bugrov 1997: 151; Klimov 1998: 4.

Monieziella Berlese, 1897: 107 (part) [type species *Monieziella entomophaga* (Laboulbène, 1852) (= *Thyreophagus entomophagus*), by subsequent designation (Jacot 1936)]; Jacot 1936: 628 (part). Synonymized by Fain & Johnston (1974).

Fumouzea Zachvatkin, 1953: 57 [type species *Fumouzea entomophaga* (Laboulbène 1852) (= *Thyreophagus entomophagus* Laboulbène, 1852), by monotypy]. Synonymized by Klimov (1998).

Michaelopus Fain and Johnston, 1974: 411 [type species *Tyroglyphus corticalis* Michael, 1885, by original designation]; Fain 1982: 18; Cruz 1990: 1; Sevastianov & Kivganov 1992: 25. Synonymized by Halliday (1998).

Thyreophagus n. sp.

(Figs. 1–5)

Diagnosis. Females and homeomorphic males with tarsi III bearing 7 apical spine-like setae [1 dorso apical and 6 ventral (4 apical, 1 subapical and 1 median)]; prodorsal sclerite ornamented with broken striae on most of its extent, with slightly longer sections near posterior margin, punctate near anterior margin and over rounded anterolateral extensions; dorsal setae *cp*, *e2*, *h2* and *h3* smooth, filiform and slender; *ro* and *ex* slightly longer and thicker. Grandjean's organ anteriorly expanded into membranous finger-like extensions. Base of spermathecal sclerite arched.

Description. FEMALE (Figs. 1–4; n= 6). *Dorsum* (Figures 1A; 2A–2B): Idiosoma elongate, 485 (460–515) long, 195 (170–220) wide at coxa III level; cuticle smooth. Prodorsal sclerite 84 (78–87) long and 75 (68–78) wide at anterior margins, with lateral incisions; ornamented with broken striae on most of its extent, with sections slightly longer near posterior margin and punctate near anterior margin and over rounded anterolateral extensions. Grandjean’s organ anteriorly expanded in 9–10 membranous finger-like extensions; supracoxal seta (*elc I*) smooth and arched, 16 (12–19) long. Dorsal idiosomal setae smooth, filiform and slender, except rostral (*ro*) and exobothridial (*ex*), setiform, thicker than other dorsal setae, tapering from base to tip. Setal lengths: *ro* 29 (24–36), *ex* 53 (43–56), *cp* 31 (23–38), *d2* 26 (21–32), *e2* 35 (31–40), *h1* 24 (21–27) and *h2* 37 (32–47). Opisthonotal gland slightly anterior of setal base *e2*.

Venter (Figures 1B; 2C): Ventral surface with 4 pairs of coxal setae (*1a*, *3a*, *4a* and *4b*) and 1 pair of genital setae. Genital region between legs III and IV; genital valves shaped as an inverted V; epigynal apodeme well-developed. Anal opening on posterior margin of idiosoma, sided by *h3* 31 (24–38) long and *pl* 42 (41–44).

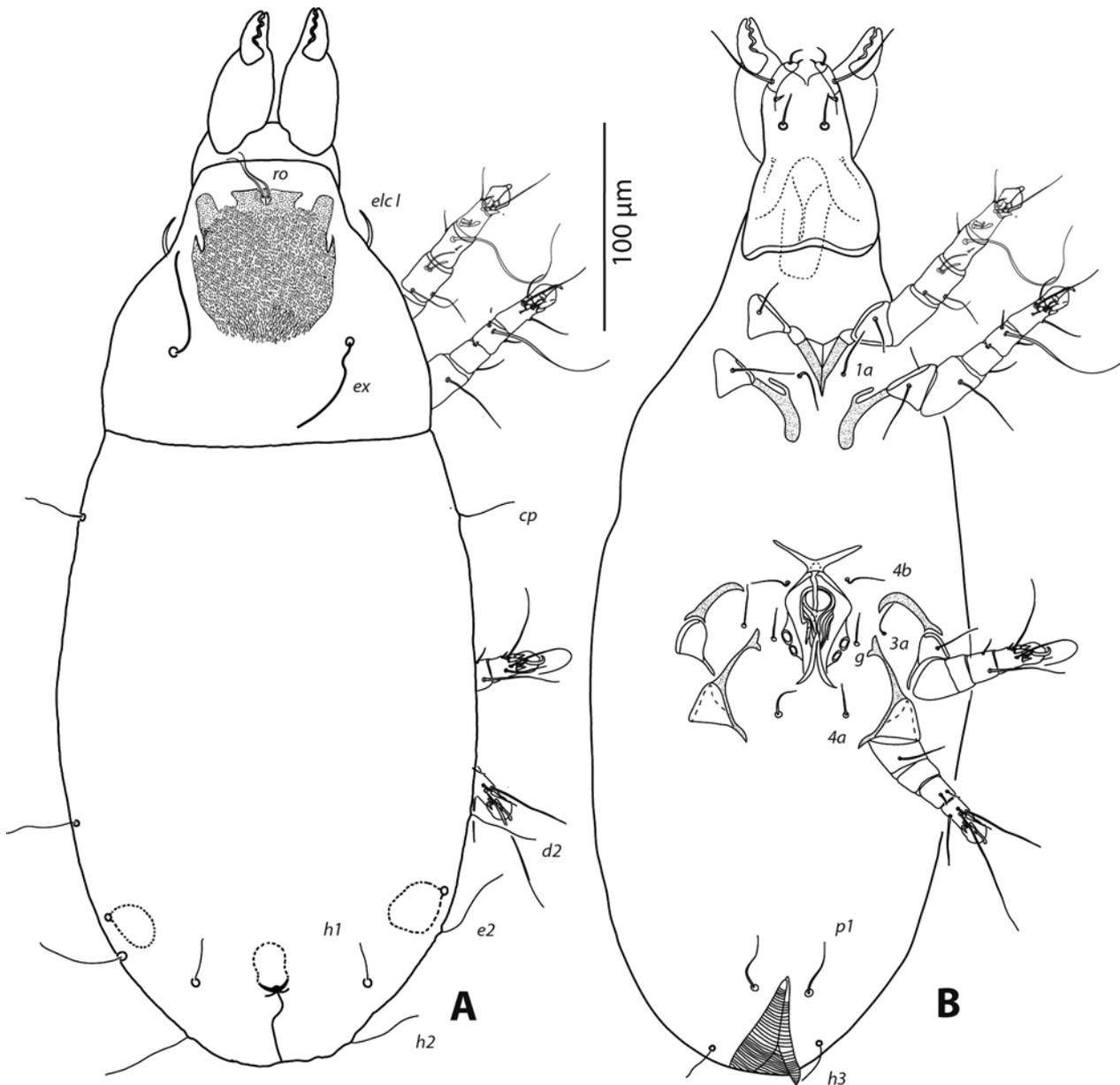


Figure 1 - *Thyreophagus n. sp.* (female). (A) Dorsal view. (B). Ventral view

Reproductive apparatus (Figs. 2D; 3): *Copulatory opening*, 6 (5–6) in diameter located near the posterior region of opisthosoma. *Spermathecal duct*, slender tube 60 (51–62) long and uniformly 1 (1 - 2) wide leading from copulatory opening to spermatheca. *Spermatheca*, composed of sclerotized, arched base, 15 (13–19) wide, and elliptical vesicle where sperm is stored. *Ovaries*, where fertilization takes place, paired and connected to sclerotized structure of spermatheca by *efferent ducts*. *Oviducts* trident-shaped near ovaries and continuing as thick tube. Considering the reduced diameter of the visible part of oviducts, especially tube, it seems that fertilized egg cells rather than developed eggs move along the oviducts to uterus. *Uterus* and final portion of oviduct indistinguishable. *Gnathosoma* (Fig. 2E, F): Chelicera

chelate, 79 (72–83), fixed digit 23 (19–27), with 3 teeth in addition to apical tooth; movable digit 25 (23–27) long, with 2 teeth in addition to apical tooth; cheliceral seta (*cha*) spine-like, 3 (2–4) long. Subcapitular seta (*subc*) 22 (18–26) long, palp tibial seta spine-like; lateral palp tibial seta setiform; dorsal palp tarsal seta setiform and terminal palp tarsal solenidion minute; seta *elcp* setiform, 12 (9–13).

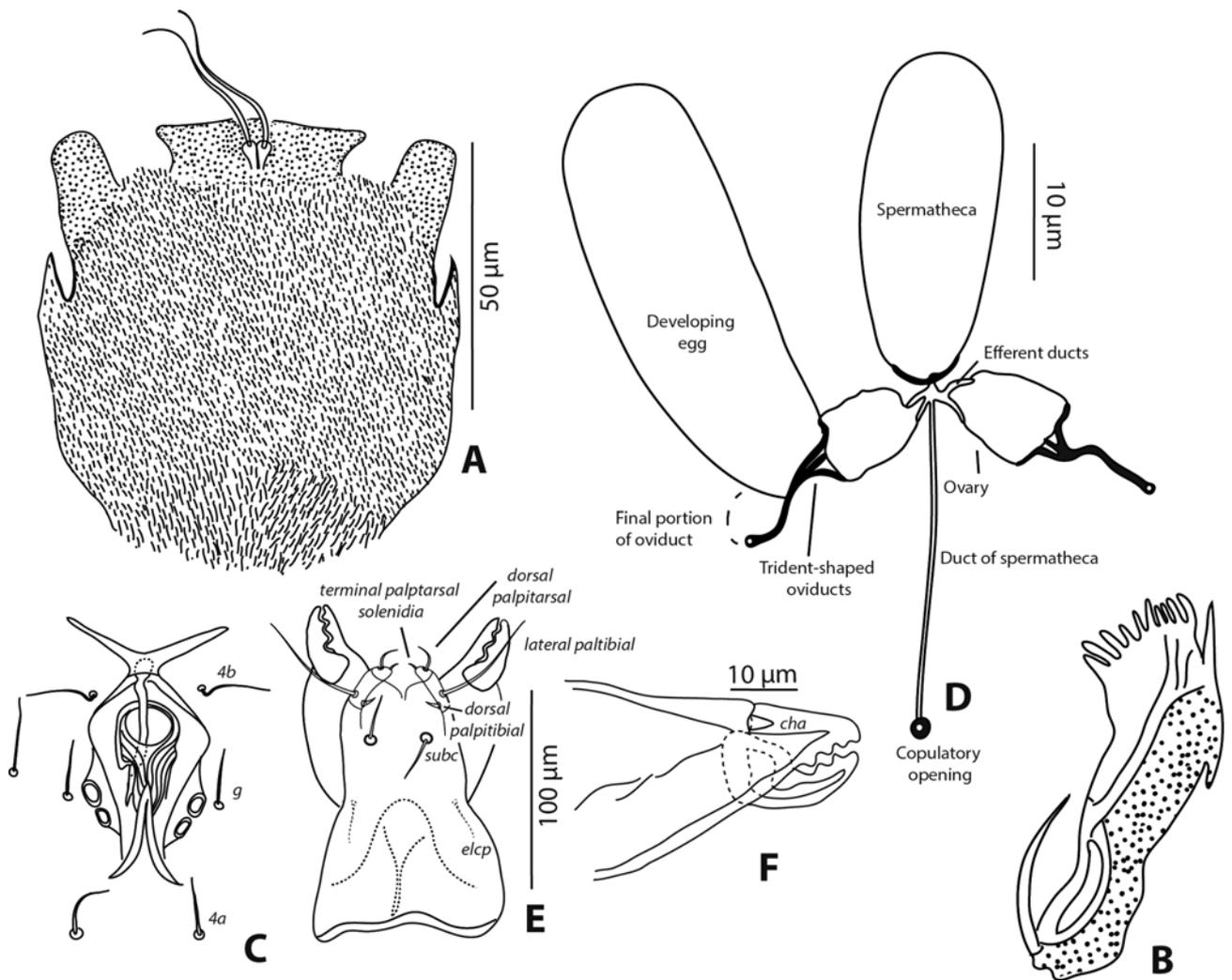


Figure 2 - *Thyreophagus n. sp.* (female). (A) Prodorsal sclerite. (B) Grandjean's organ. (C) Genital region. (D) Reproductive apparatus. (E) Gnathosoma. (F) Chelicera.



Figure 3 - *Thyreophagus n. sp.* (female). Photomicrography of the reproductive apparatus

Legs (Figs. 4A-K): Leg I 105 (90 – 110) long; tarsus with 4 apical spine-like setae [1 dorso-apical and 3 ventral (2 apical and 1 subapical)], 3 solenidion and 4 setiform tactile setae; tibia with 1 solenidion and 2 setiform tactile setae; genu with 2 solenidion and 2 setiform tactile setae; femur with 1 setiform tactile seta; trochanter with 1 setiform tactile seta. Lengths of solenidion: $\omega 1$ curved, distally swollen, 12 (10–14), $\omega 2$ 5 (4–7), $\omega 3$ 14 (12–18), φ 68 (59–72), σ' 17 (14–20), σ'' 12 (9–13). Leg II 96 (87–105) long; tarsus with 4 apical spine-like setae [1 dorso-subapical and 3 ventral (2 apical and 1 subapical)], 1 solenidion and 4 setiform tactile setae; tibia with 1 solenidion and 2 tactile setae; genu with 1 solenidion and 2 tactile setae; femur with 1 tactile seta; trochanter with 1 setiform tactile seta. Lengths of solenidion: ω curved, distally swollen, 8 (7 – 10), φ 67 (58 – 71), σ 3 (2–5). Leg III 66 (58–71) long; tarsus with 7 apical spine-like setae [1 dorso-apical and 6 ventral (4 apical, 1 subapical and 1 median)] and 3 setiform tactile setae; tibia with 1 solenidion and 1 setiform tactile seta; genu and femur without seta; trochanter with 1 setiform tactile seta. Solenidion φ 60 (58–73) long. Leg IV 69 (60 – 80) long; tarsus with 6 apical spine-like setae [1 dorso-subapical and 5 ventral (4 apical and 1 subapical)] and 4 tactile setae; tibia with 1 solenidion and 1 setiform tactile seta; genu without seta; femur with 1 setiform tactile seta; trochanter without seta; solenidion φ setiform, 14 (10–19) long.

(21–26), *ex* 32 (27–33), *cp* 22 (18–24), *d2* 14 (12–19), *e2* 20 (16–23), *h1* 14 (10–16) and *h2* 28 (22–32).

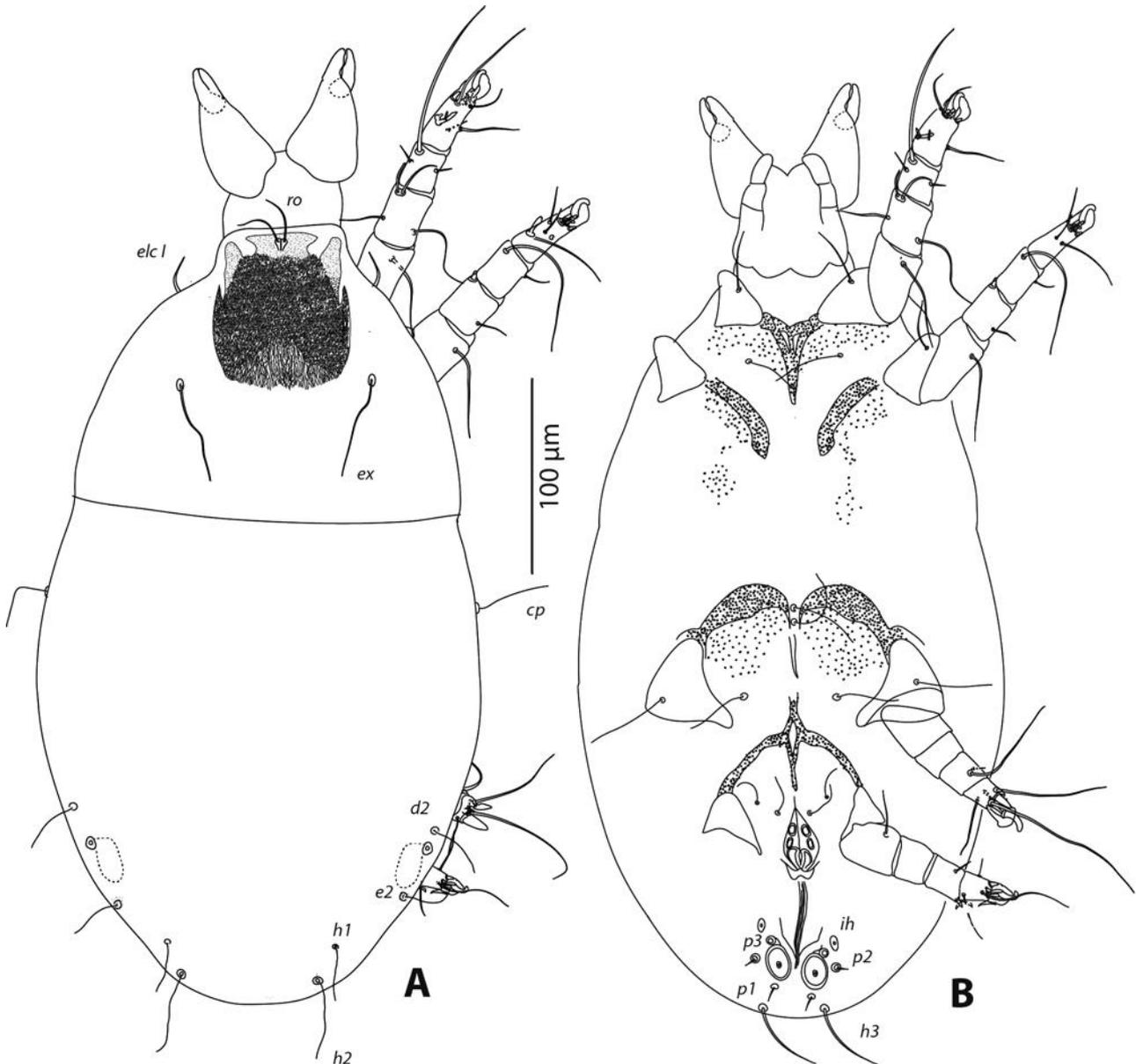


Figure 5 - *Thyreophagus* n. sp. (homeomorphic male). (A) Dorsal view. (B). Ventral view

Venter (Figs. 5B, 6B): Aedeagus slightly curved, 8 (6–12) long, between coxae IV; *h3* 44 (38 – 49) long. Para-anal suckers 10 (9–10) in diameter surrounded by 3 pairs of paraproctal setae: *p1*, posteriad of each sucker, 5 (4–5) long; *p2* laterad of suckers and 5 (4 – 5) long; and *p3*, anteriad of suckers and vestigial.

Gnathosoma: Chelicera 45 (56 – 64) long; fixed digit 12 (19 – 27), with 3 teeth; movable digit 14 (20 – 23) long, with 2 teeth; cheliceral seta (*cha*) 3 (2 – 3) long. Subcapitular seta (*subc*), 17 (16–29) long; supracoxal seta *elcp* 7 (6 – 8) long.

Legs (Figs. 7A–L): Leg I 71 (67–82) long; tarsus with 4 apical spine-like setae [1 dorso-apical and 3 ventral (2 apical, and 1 subapical)], 3 solenidion and 4 setiform tactile setae; tibia with 1 solenidion and 2 setiform tactile setae; genu with 2 solenidion and 2 setiform tactile setae; femur with 1 setiform tactile seta; trochanter with 1 setiform tactile seta. Lengths of solenidion: $\omega 1$ 6 (5–9), $\omega 2$ 4 (4–5), $\omega 3$ 4 (2–6), φ 44 (34–47), σ' 11 (10 – 16), σ'' 6 (5 – 7). Leg II 60 (53–76) long; tarsus with 4 apical spine-like setae [1 dorso-subapical and 3 ventral (2 apical and 1 subapical)], 1 solenidion and 4 setiform tactile setae; tibia with 1 solenidion and 2 setiform tactile setae; genu with 1 solenidion and 2 setiform tactile setae; femur with 1 setiform tactile seta; trochanter with 1 setiform tactile seta. Lengths of solenidion: $\omega 1$ 7 (6–7), φ 42 (33–52), σ 3 (3–4). Leg III 51 (42–57) long; tarsus with 7 apical spine-like setae [1 dorso-subapical and 6 ventral (4 apical, 1 subapical and 1 median)]; tibia with 1 solenidion and 1 setiform tactile seta; genu and femur without seta; trochanter with one setiform tactile seta; solenidion φ 43 (40–47) long. Leg IV 57 (53–64); tarsus with 4 apical spine-like setae [1 dorso-subapical and 3 ventral (2 apical and 1 subapical)], 2 setiform tactile setae and 2 suck-like setae; solenidion φ 5 (4–5) long.

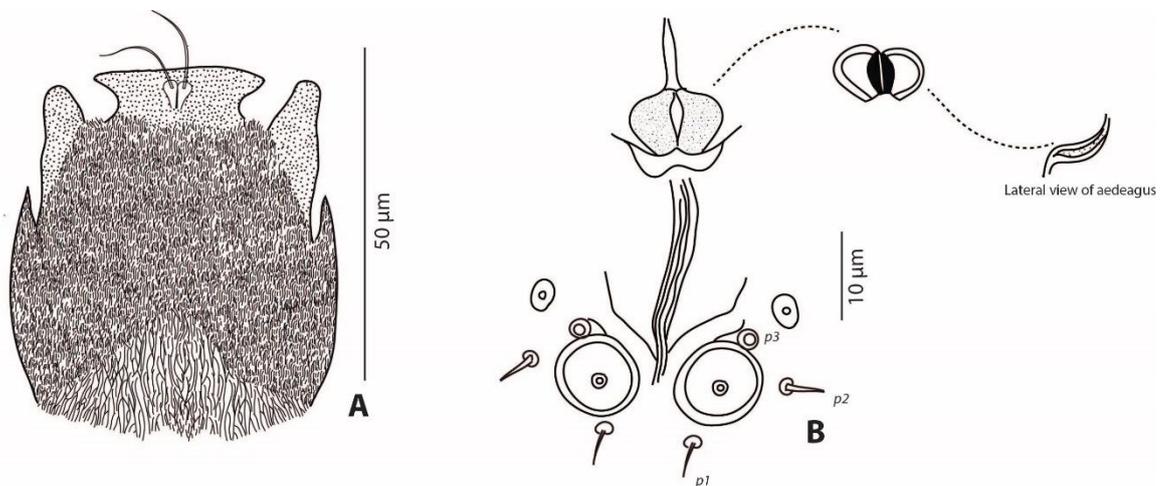


Figure 6 - *Thyreophagus n. sp.* (homeomorphic male) (A) Prodorsal sclerite. (B) Genital region

HETEROMORPHIC MALE (Figs. 7M–O; n= 20, unless otherwise noted, shape of structures similar to homeomorphic male). Tarsus of leg III strongly modified, with 2 thick dorso-apical spines and 2 ventral spine-like setae, and without pretarsus. In addition, with coxisternal region more sclerotized and with most dorsal and leg setae longer. Idiosoma ellipsoidal, slightly flattened dorso-ventrally, 335 (325–345) long and 180 (165–195) wide at coxa III level. Chelicera 60 (56–64); fixed digit 19 (19–27); movable digit 21 (20–23);

cheliceral seta (*cha*) 3 (2–3). Subcapitular seta (*subc*) 19 (16–20) long; supracoxal seta *elcp* 9 (8–9) long.

Dorsum: Prodorsal sclerite 66 (62–68) and 49 (44–53) wide at anterior margins; supracoxal seta (*elc I*) 14 (12–16). Dorsal idiosomal setae lengths: *ro* 26 (22–29), *ex* 47 (41–53), *cp* 37 (29–38), *d2* 24 (19–26), *e2* 30 (24–33), *h1* 22 (18–24) and *h2* 36 (32–42). *Venter*: Aedeagus 8 (6–12) long. Para-anal suckers 11 in diameter, *h3* 44 (38–49), *p1* and *p2* 3 (3–4) and 5 (4–6) long, respectively, *p3* vestigial. *Legs* (Figs. 7M–O): Legs I–II and IV similar to homeomorphic male. Leg I 105 (87 – 110) long; lengths of solenidion: $\omega 1$ 10 (9–10), $\omega 2$ 5 (4–7), $\omega 3$ 4 (2–6), ε 3 (2–3), φ 60 (54–67), σ' 18 (16–20), σ'' 10 (8–12). Leg II 96 (83– 105) long; lengths of solenidion: ω 8 (6–9); φ 61 (59–62); σ 3 (2–3). Leg III 71 (63 – 78) long, with 2 thick dorso-apical spines and 3 ventral spine-like setae (2 apical and 1 subapical); φ 55 (51–59) long. Pretarsus III absent. Leg IV 67 (61–72) long, φ 4 (3–5).

HETEROMORPHIC DEUTONYMPH. Unknown.

homeomorphic male are deposited at the University of Michigan Museum of Zoology (UMMZ), Ann Arbor, Michigan, USA.

Remarks. The genus *Thyreophagus* is known from adults and heteromorphic deutonymphs. *Thyreophagus n. sp.* is the second species of this genus reported from Brazil and the first described as new from this country. This new species strongly resembles *T. tridens* (FAIN; LUKOSCHUS, 1986) by having similar body length, prodorsal sclerite and having most dorsal setae similar in length. In addition, *T. tridens* has the spermathecal sclerite arched and the same number of spine-like setae on tarsi of legs I–IV as *Thyreophagus n. sp.* However, *T. tridens* differs from *Thyreophagus n. sp.* by having a different pattern of punctation on the prodorsal sclerite (punctate on its anterior two thirds or three quarters and fine striations on the rest of the sclerite) and smaller φ III and φ IV (1.7 and 3.5 times smaller, respectively).

This new species resembles *Thyreophagus spinatarsis* (FAIN, 1982) by having similar patterns on the prodorsal sclerite. The latter differs from *Thyreophagus n. sp.* by having the idiosoma about 1.9 times as long, most of the dorsal idiosomal setae about 1.5 times as long and by having the sclerotized base of the spermatheca approximately bell-shaped.

Thyreophagus australis Clark, 2009 is similar to this new species by having Grandjean's organ anteriorly expanded in membranous finger-like extensions and the male without any projection or sclerite on the posterior opisthosomal region. However, *T. australis* differs by having females with the idiosoma globose instead of elongate, setae *ro* and *ex* more than four times longer and the sclerotized base of the spermatheca as a transverse band.

Thyreophagus gallegoi gallegoi Fain, 1982 resembles this new species by having the idiosoma and dorsal setae of about the same lengths, similar shape of sclerotized base of spermatheca and by producing heteromorphic males. This subspecies differs by $\omega 1$ strongly curved and thin apically and the prodorsal sclerite mostly covered by uniformly fine striae.

d. Discussion

Several mite species are widely used as biological control agents and need to be mass-produced for commercial application. Due to the high costs to produce their natural prey, some of them are reared using alternate prey, usually a species of Acaridae (GERSON et al., 2003; HOY, 2011). Acarids are reared in containers supplied with organic substrates such as brans or flours (RAMAKERS; van LIEBURG, 1982). Given that the acarids used for that purpose are not harmful to crops, the whole content of the container may be collected for direct application

in the field, or the predatory mites may be quantified and placed in standardized numbers in units containing the same substrate and the acarid prey for field release (GERSON et al., 2003).

The species described here, *Thyreophagus n. sp.*, was found on stored human and animal food in Piracicaba, São Paulo State, Brazil. Besides chicken feed, the substrate from which the population used for the present description was collected, this species was also found in soy and corn flours. In addition, colonies of this species were successfully kept in the laboratory on yeast, wheat germ, cornmeal and oatmeal. *Thyreophagus n. sp.* was evaluated as prey for species of Phytoseiidae (the predatory mite family most widely used for biological control of plant inhabiting pests) and Laelapidae (commonly used for control of edaphic pests) in our laboratory. The results showed a high potential of *Thyreophagus n. sp.* as alternate prey for mass rearing the evaluated phytoseiid and laelapid species. Barbosa and Moraes (2015) reported details of the efficiency of *Thyreophagus n. sp.* as factitious prey for mass rearing phytoseiids.

Thyreophagus entomophagus, a cosmopolitan synanthropic species, has been collected mostly in association with insects and from stored food (FAIN, 1982). Hughes (1976) mentioned this species as an inhabitant of storehouses containing grain, flour, animal feed, etc. This is one of the most common mites found infesting foods and the only species of the genus reported to cause anaphylaxis when ingested (DUTAU, 2002; SÁNCHEZ-BORGES et al., 2013). In Spain, this species is the main cause of oral allergies (SÁNCHEZ-BORGES et al., 2013), being reported to cause anaphylaxis in several cases (BLANCO et al., 1997; IGLESIAS-SOUTO et al., 2009; SÁNCHEZ-MACHÍN et al., 2010). Anaphylaxis caused by this mite was also reported in the southern Brazilian state of Santa Catarina (MAZZUCCO et al., 2000).

Thyreophagus gallegoi was reported from house dust in Spain (FAIN, 1982; PORTUS; GOMEZ, 1979) and China (FAN et al., 2010; JIANG, 1991). It was also reported from wheat flour in Spain (PORTUS; GOMEZ, 1979) and intercepted in the USA from bean curd originating from Hong Kong and from the Philippines and from hoisin sauce from Hong Kong (OLSEN, 1983). *Thyreophagus macfarlanei* (FAIN, 1982) is known only from its type specimens, collected on wheat in England (FAIN, 1982).

None of the other 22 species in this genus have been reported from stored food or human habitats.

Key to species of *Thyreophagus*.

Adults of the following species are unknown: *T. africanus* Mahunka, 1974, *T. sminthurus* (Fain and Johnston, 1974), *T. johnstoni* (Fain, 1982), *T. leclercqi* (Fain, 1982) and *T. rwandanus* (Fain, 1982).

The following species are inadequately described and are not included in this key: *T. angustus* (Banks, 1906), *T. berlesiana* (Zachvatkin, 1941), *T. lignieri* (Zachvatkin, 1953), and *T. magna* (Berlese, 1910). *Thyreophagus cercus* Zhang, 1994 should probably be transferred to the genus *Reckiacarus*.

FEMALES

1. Very large species, body length > 1500 μm ; Egypt
 *T. cynodactylon* El-Bishlawy, 1990
- 1'. Smaller species, body length < 700 μm 2.
2. Tarsi III with 4 apical spine-like setae, 1 dorsal (*ft*"') and 3 ventral [*s*, (*u*)], proral setae vestigial or absent, and 3-4 filiform setae (seta *pv*"' III filiform, setiform or absent) 3.
- 2'. Tarsus III with 6 or 7 well developed, apical, spine-like setae (proral seta distinct) and 3 or 4 simple setae (seta *pv*"' III filiform or spine-like); tarsus IV with 6 spine-like setae and 4 simple setae 5.
3. Prodorsal sclerite wider than long, almost entirely punctate, with a few short longitudinal striae in posteromedian region; sclerite of spermatheca in form of an inverted bell, with base 18-20 μm wide; tarsus III with seta *pv*"' filiform; solenidion ωI of tarsus I narrowed apically; posterior ventral seta (*c*"') of tibiae I-II setiform about 5 μm long; widespread.
 *T. entomophagus* (Laboulbene, 1852)
- 3'. Prodorsal sclerite clearly longer than wide, almost entirely covered with fine longitudinal striae; sclerite of spermatheca not in form of a bell, and smaller; tarsus III with *pv*"' as small spine-like seta or absent; solenidion ωI of tarsus I expanded apically; posterior ventral seta of tibiae I-II tiny and spine-like or absent 4.
4. Idiosomal length 270-360 μm , width 87-150 μm , sclerite of spermatheca very small, slightly wider (6 μm) than long (5 μm) and not narrowed toward its center; seta *pv*"' of tarsus III very short and spine-like; tibiae I-II without posterior ventral seta; Morocco *T. cooremani* Fain, 1982
- 4'. Idiosomal length 525-675 μm , width 210-280 μm ; sclerite of spermatheca vase-shaped, 12 μm long, maximum width 12 μm , narrowed toward the center where it is 5 μm wide;

- narrowed toward middle and widened proximally; seta pv'' of tarsus III absent; tibiae I–II with aposterioventral tiny spine-like seta (c''); Europe *T. odyneri* Fain, 1982
5. Tarsus III with 7 spine-like and 3 simple setae; prodorsal sclerite mostly covered by fine, longitudinal striae except in 1 species where sclerite punctate 6.
- 5'. Tarsus III with 6 spines and 4 simple setae; prodorsal sclerite almost entirely punctate; longitudinal striae confined to posterior quarter of sclerite or absent. 13.
6. Prodorsal sclerite entirely punctate, without linear striae 7.
- 6'. Prodorsal sclerite with at least some portion bearing linear striae (striae very short in *Thyreophagus n. sp.*) 8.
7. Prodorsal sclerite with posterior median lobe; posterior hysterosomal seta $h1$ less than half as long as $h2$; Colombia *T. incanus* (Fain, 1987)
- 7'. Prodorsal sclerite broadly rounded posteriorly; hysterosomal setae $h1$ and $h2$ elongate, similar in length; New Zealand. *T. australis* Clark, 2009
8. With 1 pair of large, sclerotized, funnel-like, internal structures near posterior end of body (not to be confused with small, bellshaped structures at base of spermatheca) 9.
- 8'. Without paired, funnel-like inner, posterior structures. 10.
9. Solenidion ϕ of tibia IV very short (4 μm); USA, California *T. tridens* (Fain and Lukoschus, 1986)
- 9'. Solenidion ϕ of tibia IV longer (14 μm); Brazil *Thyreophagus n. sp*
10. Prodorsal sclerite with linear striae restricted to posterior half of sclerite; Great Britain *T. vermicularis* Fain and Lukoschus, 1982
- 10'. Prodorsal sclerite with linear striae extending over at least 75% of its length 11.
11. Base of spermatheca with sclerite in form of a broad arc, much wider than long; widespread *T. gallegoi* Portus and Gomez, 1979
- 11'. Base of spermatheca with sclerite not wider than long. 12.
12. Base of spermatheca with sclerite quadrate, about as long as wide; Europe *T. spinitarsus* (Fain, 1982)
- 12'. Base of spermatheca with sclerite at least three times longer than wide; Europe *T. corticalis* Michael, 1885.
13. Tarsi I–II with 4 spine-like setae (pv' absent); solenidion σ' and σ'' of genu I similar in length; Ukraine *T. annae* (Sevastianov and Kivganov, 1992)
- 13'. Tarsi I–II with 5 spine-like setae (pv' present); solenidion of genu I dissimilar in length 14.
14. Tibiae I–II with 2 setae 15.

- 14'. Tibiae I–II with 1 seta (c'' absent) 16.
15. Prodorsal sclerite with narrow, posterior lobe bearing longitudinal striae; anterior margin of sclerite with paired lateral indentations; Ireland *T. evansi* (Fain, 1982)
- 15'. Prodorsal sclerite smoothly rounded posteriorly, without distinct posterior, striated lobe; anterior margin of sclerite without paired indentations; Cuba *T. passerinus* (Cruz, 1990)
16. Long terminal setae $h2$ and $h3$ with bases inflated, conical; spermathecal sclerite forming thin sclerotized arc divided anteriorly into 4 short, fine sclerotized lines; genu I with σ' and σ'' with 8 and 6 μm long, respectively (ratio 1.4:1); Great Britain. *T. macfarlanei* (Fain, 1982)
- 16'. Long terminal setae $h2$ and $h3$ with very thin bases; spermathecal sclerite forming a U-shaped structure with thick sides, 6 μm long, 5 μm wide; genu I with σ' and σ'' with 18–20 and 12 μm long, respectively (ratio 1.58: 1); Morocco *T. athiasae* (Fain, 1982)

MALES

Males unknown or inadequately described in *T. athiasae*, *T. cooremani*, *T. evansi*, *T. macfarlanei*, *T. spinitarsis*, *T. tridens*, and *T. vermicularis*.

1. Prodorsal sclerite punctate 2
- 1'. Prodorsal sclerite with short longitudinal striae, at least near posterior margin 5.
2. Posterior venter with sclerotized projection very poorly developed or absent; Colombia *T. incanus* (Fain, 1987)
- 2'. Posterior venter with sclerotized projection well developed 3.
3. Body 6 times longer than wide; large species (> 700 μm); Egypt *T. cynodactylon* El-Bishlawy, 1990
- 3'. Body ovoid, 1.5–2 times longer than wide; (< 500 μm); widespread 4.
4. Tarsus IV with 5 spine-like setae [s , (p), (u)], 3 filiform setae [(pv), tc']; Ireland *T. evansi* (Fain, 1982)
- 4'. Tarsus IV with 3 spine-like setae [s , (u)] (proral setae vestigial or absent), 3 filiform setae [(pv), tc']; widespread *T. entomophagus* (Laboulbène, 1852)
5. Posterior body with distinct sclerotized projection 6.
- 5'. Posterior body smoothly rounded, without ventral projection 7.
6. Entire width of prodorsal sclerite covered by longitudinal striae; tarsus IV with 3 spine-like setae (proral setae vestigial or absent); Europe. *T. odyneri* Fain, 1982

- 6'. Longitudinal striae on prodorsal sclerite restricted to median region, lateral areas simply punctate; tarsus IV with 5 spinelike setae (proral setae distinct); Europe
. *T. corticalis* (Michael, 1885)
7. Posterior hysterosoma with a large sclerotized area extending posteriad from level of setae *e2*; Ukraine *T. annae* (Sevastyanov and Kivganov, 1992)
- 7'. Posterior hysterosoma unsclerotized or at most with short terminal sclerotization posterior to setae *h1* 8.
8. Posterior idiosoma with short sclerotized area posterior to setae *h1* 9.
- 8'. Posterior idiosoma unsclerotized 10.
9. Genu I with solenidion σ' and σ'' approximately equal in length; widespread
. *T. gallegoi* Portus and Gomez, 1979
- 9'. Genu I with solenidion σ' only half of length of σ'' ; Cuba *T. passerinus* (Cruz, 1990)
10. Dorsal hysterosomal setae relatively long, setae *d2* and *e2* much longer than distance between their alveoli; New Zealand *T. australis* Clark, 2009
- 10'. Dorsal hysterosomal setae much shorter, setae *d2* and *e2* shorter than distance between their alveoli; Brazil *Thyreophagus n. sp.*

DEUTONYMPHS

Translated and updated from Fain (1982)

Deutonymphs of the following species are unknown: *T. annae* (Sevastyanov and Kivganov, 1992), *T. athiasae* (Fain, 1982), *T. cynodactylon* El-Bishlawy, 1990, *T. cooremani* Fain, 1982, *Thyreophagus n. sp.*, *T. evansi* (Fain, 1982), *T. gallegoi* Portus and Gomez, 1979, *T. incanus* (Fain, 1987), *T. macfarlanei* (Fain, 1982), *T. odyneri* Fain, 1982, *T. spinitarsus* (Fain, 1982), *T. tridens* (Fain and Lukoschus, 1986), and *T. vermicularis* Fain and Lukoschus, 1982.

1. Dorsal surface completely striated; Afrotropical *T. africanus* Mahunka, 1974
- 1'. Dorsal surface smoothly punctate, without striae 2.
2. Body ovoid, 1.3–1.5 times longer than wide 3.
- 2'. Body elongate, more than 1.7 times longer than wide 5.
3. Tibiae I–II with posterior seta (*c''*) more than half the length of anterior ventral seta (*v'*); Europe *T. leclercqi* (Fain, 1982)
- 3'. Tibiae I–II with posterior seta (*c''*) less than half the length of anterior ventral seta (*v'*) 4

4. Opisthotal gland openings approximately equidistant from setae *c3* and *cp*; widespread *T. entomophagus* (Laboulbène, 1852)
- 4'. Opisthotal gland openings much closer to ventral seta *c3* than to dorsolateral seta *cp*; New Zealand *T. australis* Clark, 2009
5. Tibiae I–II with only 1 ventral seta (*v'*), posterior seta *c''* absent; Great Britain
. *T. sminthurus* (Fain and Johnston, 1974)
- 5'. Tibiae I–II with 2 ventral setae, *v'* and *c''* present6.
6. Tibia II both ventral setae (*v'*, *c''*) in the form of short spines similar in length; ocelli relatively small (width 8.5–9 µm); Afrotropical. *T. rwandanus* (Fain, 1982)
- 6'. Tibia II with anterior ventral seta (*v'*) setiform to filiform, twice of length of spine-like posterior ventral seta (*c''*); ocelli larger (width 12–19 µm)7.
7. Width of ocellus about 19 µm, distance between ocelli about 60 µm; hysterosomal sclerite about 2 times longer than prodorsal sclerite; widespread. . . *T. corticalis* (Michael, 1885)
- 7'. Width of ocellus about 12 µm, distance between ocelli about 42 µm; hysterosomal sclerite about 1.7 times longer than prodorsal sclerite; Nearctic. *T. johnstoni* (Fain, 1982)

References

- BANKS, N. **A revision of the Tyroglyphidae of the United States**. Washington: USDA, 1906. 33 p. (Technical Series, 13).
- BARBOSA, M.F.C.; MORAES, G.J. Evaluation of astigmatid mites as factitious food for rearing four predaceous phytoseiid mites (Acari: Astigmatina; Phytoseiidae). **Biological Control**, Orlando, v. 91, p. 22-26, 2015.
- BERLESE, A. **Acari, Myriapoda et Scorpiones hucusque in Italia reperta**. Padova: Sumptibus Auctoris, 1882/1903. 425 p.
- BLANCO, C.; QUIRALTE, J.; CASTILLO, R.; DELGADO, J.; ARTEAGA, C.; BARBER, D.; CARRILLO, T. Anaphylaxis after ingestion of wheat flour contaminated with mites. **Journal of Allergy and Clinical Immunology**, Saint Louis, v. 99, n. 3, p. 308-312, 1997.
- BUGROV, S. Free-living astigmata (Acariformes) of the Moscow district fauna. **Zoologicheskii Zhurnal**, Moscow, v. 76, p. 147-156, 1997.
- CHMIELEWSKI, W. Wyniki obserwacji powiazan roztoczy z owadami (Acari Insecta). **Polskie Pismo Entomologiczne**, Gdynia, v.47, p. 59-78, 1977.
- CLARK, J.M. A new *Thyreophagus* mite from honeydew scale insects on black beech (Nothofagus). **Records of the Canterbury Museum**, Christchurch, v. 23, p. 1-9, 2009.

CRUZ, J. Nest-dwelling mites of Cuba. I. New species of the genus *Michaelopus* Fain et Johnston, 1974 (Acari, Acaridae). **Poeyana**, Habana, n. 399, p. 1-6, 1990.

DUTAU, G. Les acariens, de nouveaux allergènes alimentaires masqués. **Revue Française D'Allergologie et D'Immunologie Clinique**, Paris, v. 42, n. 2, p. 171-177, 2002.

EL-BISHLAWY, S. A new species of the genus *Thyreophagus* Rondani (Acaridae-Acaridia-Acari). **Bulletin of Faculty of Agriculture of University of Cairo**, Cairo, v. 41, n. 2, p. 535-542, 1990.

FAIN, A. Revision des genres *Thyreophagus* Rondani, 1874 et *Michaelopus* Fain & Johnston, 1974 (Acari, Acaridae) avec description de neuf especes nouvelles. **Bulletin de l'Institut Royal des Sciences Naturelles de Belgique. Entomologie**, Bruxelles, v. 54, p. 1-47, 1982.

_____. Notes on the mites living in the flowers of *Espeletia* spp.(Asteraceae) in Colombia. II. *Espeletiacarus andinus*, **Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg**, Hamburg, p. 37-47, 1987.

FAIN, A.; JOHNSTON, D. Three new species of Hypopi Phoretic on Springtails (Collembola) in England (Acari: Acaridiae). **Journal of Natural History**, London, v. 8, n. 4, p. 411-420, 1974.

FAIN, A.; LUKOSCHUS, F.S. *Thyreophagus vermicularis* sp. n. (Acari, Acaridae) from *Crocidura suaveolens cassiteridum* in Scilly Islands, Great Britain. **Bulletin et Annales de la Société royale belge d'Entomologie**, Brixelles, v.118, p.87-90, 1982.

_____. *Michaelopus tridens* spec. nov. (Acari, Acaridae) from a North American rodent. **Bulletin de l'Institut Royal des Sciences Naturelles de Belgique**, Bruxelles, v. 56, p. 55-57, 1986.

FAN, Q.; CHEN, Y.; WANG, Z. Acaridia (Acari: Astigmatina) of China: a review of research progress. **Zoosymposia**, Auckland, v. 4, p. 225-259, 2010.

GRANDJEAN, F. Les segments post-larvaires de l'hysterosoma chez les Oribates (Acariens). **Bulletin de la Societe Zoologique de France**, Paris, v.64, 273-284, 1939.

GRIFFITHS, D.A.; ATYEO, W.T.; NORTON, R.A.; LYNCH, C.A. The idiosomal chaetotaxy of astigmatid mites. **Journal of Zoology**, London, v. 220, n. 1, p. 1-32, 1990.

HALLIDAY, R.B. **Mites of Australia**: a checklist and bibliography. Melbourne: CSIRO, 1998. 327 p.

HOY, M.A. **Agricultural acarology**: introduction to integrate mite management. Boca Raton: CRC Press, 2011. 430 p.

HUGHES, A. M. **The mites of stored food and houses**. London: Ministry of Agriculture and Fisheries, 1976. 400 p. (Technical Bulletin, 9).

IGLESIAS-SOUTO, J.; SÁNCHEZ-MACHÍN, I.; IRAOLA, V.; POZA, P.; GONZÁLEZ, R.; MATHEU, V. Oral mite anaphylaxis by *Thyreophagus entomophagus* in a child: a case report. **Clinical and Molecular Allergy**, London, v. 7, n. 1, p. 1, 2009.

JACOT, A. P. Three possible mite vectors of the Dutch elm disease. **Annals of the Entomological Society of America**, College Park, v. 29, n. 4, p. 627-635, 1936.

JIANG, Z. A new species and a genus and three newly recorded species of the Acaridae, Glycyphagidae from China (Acariformes, Acaroidea). **Jiangxi Science**, Jiangxi, v. 9, n. 4, p. 240-246, 1991.

KLIMOV, P. A new tribe of acarid mites of the subfamily Rhizoglyphinae (Acariformes, Acaridae). **Far Eastern Entomologist**, Vladivostok, v. 59, p. 1-19, 1998.

KLIMOV, P.; TOLSTIKOV, A. Acaroid mites of northern and eastern Asia (Acari: Acaroidea). **Acarina**, Moscow, v. 19, n. 2, p. 252-264, 2011.

LABOULBÉNE, A. Description de *Acarus entomophagus*. **Annales de la Société Entomologique de France**, Paris, v.2, p. 317-338, 1852.

MAHUNKA, S. Auf Insekten lebende Milben (Acari: Acarida, Tarsonemida) aus Afrika. IV. **Acta Zoologica Academiae Scientiarum Hungaricae**, Budapest, v. 20, n. 3/4, p. 367-402, 1974.

MAZZUCO, R.M.; LEBARBENCHON, M.A.; MOECKE, E.H.S.; MEYER, E.; SPÍNDOLA-BATTI, M.A.; FRÖDE, T.; MORATO, E.F. Anafilaxia por ingestão de ácaros de estocagem. **Revista Brasileira de Alergia e Imunopatologia**, São Paulo, v. 23, p. 189, 2000.

MICHAEL, A.D. Notes on the life-histories of some little-known Tyroglyphidae. **Journal of the Royal Microscopical Society**, Oxford, v.5, p.19-32, 1885.

OCONNOR, B. Cohort astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A manual of acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

OLSEN, A.R. Food-contaminating mites from imported foods entering the United States through southern California. **International journal of acarology**, Oak Park, v. 9, n. 4, p. 189-193, 1983.

PORTUS, M.; GOMEZ, M. *Thyreophagus gallegoi* a new mite from flour and house dust in Spain (Acaridae, Sarcoptiformes). **Acarologia**, Paris, v. 21, p. 477-481, 1979.

RAMAKERS, P.M.J.; VAN LIEBURG, M.J. Start of commercial production and introduction of *Amblyseius mekenziei* Sch. & Pr. (Acarina: Phytoseiidae) for the control of *Thrips tabaci* Lind. (Thysanoptera: Thripidae) in glasshouses. **Mededelingen van de Faculteit van de Diergeneeskunde van de Rijksuniversiteit te Gent**, Gent, v. 47, p. 541-545, 1982.

RONDANI, C. Degli insetti nocivi e dei loro parassiti: enumerazione con note. **Bollettino della Società Entomologica Italiana**, Genova, v. 4, p. 43-68, 1874.

SÁNCHEZ-BORGES, M.; SUÁREZ CHACÓN, R.; CAPRILES-HULETT, A.; CABALLERO-FONSECA, F.; FERNÁNDEZ-CALDAS, E. Anaphylaxis from ingestion of mites: pancake anaphylaxis. **Journal of Allergy and Clinical Immunology**, Saint Louis, v. 131, n. 1, p. 31-35, 2013.

SÁNCHEZ-MACHÍN, I.; GLEZ-PALOMA, P.R.; IGLESIAS-SOUTO, J.; IRAOLA, V.; MATHEU, V. Oral mite anaphylaxis. **Allergy**, Copenhagen, v. 65, n. 10, p. 1345-1347, 2010.

SEVASTIANOV, V.; KIVGANOV, D. Review of the genus *Michaelopus* (Acari, Acaridae) of the world fauna with description of new species. **Vestnik zoologii**, Kyiv, v. 2, p. 25-30, 1992.

TÜRK, E.; TÜRK, F. Systematik und Ökologie der Tyroglyphiden Mitteleuropas. In: STAMMER, H.J. (Ed.), **Beiträge zur Systematik und Ökologie mitteleuropäischer Acarina**. Band 1. Tyroglyphidae und Tarsonemini. Leipzig: Akademische Verlagsgesellschaft Geest & Portig K.-G, 1957. p. 4–384.

ZACHVATKIN, A.A. Key to mites damaging crops in USSR. **Uchenye Zapiski Moskovskogo Gosudarstvennogo Universiteta**, Moscow, v. 14, p.7–68, 1940.

_____. **Tiroglifoidnye kleshchi Tyroglyphoidea, fauna SSSR**. Moscow; Leningrad: Nauka, 1941. 475 p.

_____. Investigations on the morphology and postembryonic development of tyroglyphids (Sarcoptiformes, Tyroglyphoidea). In: DUBININ, V.B.; LANGE, A.B. (Ed.). **Sbornik nauchnykh rabot**. Moscow: Moscow State University, 1953. p. 19–120.

ZHANG, Z.-F.; JIANG, J.-G.; ZENG, H.W. Two new species of Acaridae (Acari) from China. **Acta Entomologica Sinica**, Peking, v. 37, p. 374-377, 1994.

3 REVISION OF THE GENUS *Neotropacarus* BAKER, 1985 (ASTIGMATINA: ACARIDAE) WITH DESCRIPTION OF THREE NEW SPECIES

Abstract

The genus *Neotropacarus* is revised. Two species, *Neotropacarus bakeri* (Collyer, 1966) and *Neotropacarus mumai* (Cunliffe, 1964), are redescribed and three new species, *Neotropacarus n. sp. 1*, *Neotropacarus n. sp. 2* and *Neotropacarus n. sp. 3*, are described from specimens from plant leaves and bird nests collected in Brazil and the Philippines

Keywords: Taxonomy; *Neotropacarus*; Acaridae

a. Introduction

Cunliffe (1964) established the genus *Tropacarus* based on a single species, *Tropacarus mumai* Cunliffe. A few years later, Baker (1985) renamed it as *Neotropacarus*, because that name was preoccupied by *Tropacarus* Ewing, 1917 (Acari: Oribatida). *Neotropacarus* was placed by Klimov (2000) in Caloglyphini, Acaridae.

The original diagnosis of *Neotropacarus* was based on specimens collected by E. W. Baker from various unidentified plants in the Democratic Republic of Congo (mentioned as Congo). Cunliffe (1964) reported that besides the type locality, *Neotropacarus mumai* (Cunliffe, 1964) had also been found in “Florida, Costa Rica, Nicaragua, India, and Brazil (U.S. Quarantine)”. Since then, this species has been found on plants of different families from several tropical and subtropical regions. The only other species of this genus, *Neotropacarus bakeri* (Collyer, 1966), was described from New Zealand from 16 plant species and the only additional record of this species was published by Zhang (2012).

The morphology of *Neotropacarus* is known only from adult females and homeomorphic adult males; heteromorphic deutonymphs were never reported (KLIMOV, 2000). These mites are found in clusters that include eggs, juveniles and adults on the abaxial leaf surface, often in light depressions, where they feed on fungi (MUMA, 1961). If the colonies are disturbed, they move clumsily until a new hiding place is found or the cluster is reallocated. Collyer (1966) reported *N. bakeri* to be preyed upon by the phytoseiid mite *Phytoscutus acaridophagus* (Collyer, 1964).

The diagnosis of *Neotropacarus* merely state this genus to have “certain of the body setae long and whip like, in that certain body setae are missing” (CUNLIFFE, 1964). The objective of this work was better characterize and provide a more detailed description of this

genus, redescribe *N. mumai* and *N. bakeri* and describe three new species of belonging to this genus.

b. Material and Methods

The paratypes of *N. bakeri* examined in this study and types of two of the new species here described (*Neotropacarus n. sp. 2* and *Neotropacarus n. sp. 3*) were obtained from the mite collection of the University of Michigan Museum of Zoology, Ann Arbor, Michigan, USA; the paratypes of *N. mumai* were obtained from the National Museum of Natural History, Washington, DC, USA. The types of *Neotropacarus n. sp. 1* were collected in northeastern Brazil, whereas the other two new species (*Neotropacarus n. sp. 2* and *Neotropacarus n. sp. 3*) were collected in the Phillipines.

Examination, measurements and illustrations were done using a microscope (Nikon Eclipse 80i); to prepare the illustrations, mites were initially photographed with a digital camera connected to the microscope, and the photos were then processed with a digital tablet (Wacom Bamboo CTH-470L), using the Adobe Illustrator® program. For the descriptions and the redescrptions, average measurements in micrometers are followed (in parenthesis) by the minimum and the maximum; when only two specimens were examined, averages were not given. Idiosomal chaetotaxy follows the system developed by Grandjean (1939) and applied to the Astigmatina by Griffiths (1990). Leg setation follows that proposed by OConnor (2009).

c. Results

Systematics

Neotropacarus Baker

Tropacarus Cunliffe, 1964: 181; name preoccupied in *Tropacarus* (Acari: Oribatida) Ewing, 1917: 111.

Neotropacarus Baker, 1985: 289; Klimov, 2000: 28.

Type species: Tropacarus mumai Cunliffe, 1964.

Description of adults. Gnathosoma short and massive, not more than 1.5 times as long as wide. Chelicera chelate, movable and fixed digit with three teeth. Idiosoma globose and smooth. Prodorsal sclerite entire, wider than long. Proposoma with three or four pairs of setae (*ro*, *in*

and *ex* always present; *le* present or absent, when present short); *vi* inserted at anterior edge of sclerite. Hysterosomal chaetotaxy complete; at least setae *ex* (*sce*), *cp*, *e2*, *h1* and *h2* very long; *e1* either short (shorter than the distance between its basis and the posterior edge of idiosoma) or very long (extending beyond posterior edge of the body); other hysterosomal setae short. All setae setiform and smooth. Oopore and aedeagus between legs III and IV, variously shaped; oopore longer than wide. Anal opening near posterior end of the body; anal region with one, two or three pairs of paraproctal setae (setae *p1* and *p2* present or absent and *p3* always present) and males without paranal suckers. Tarsi elongate, more than twice as long as tibiae; genu I with only one solenidion; tibiae I-II with or without *c''*; tarsus I with or without and tarsus II without *a''* (*aa*) and *ft'* (*ba*); seta *tc'* present or absent on tarsi I-IV; $\omega 2$ inserted posteriad of $\omega 1$; setae *a'* and *pv''* acute or as thin spines; *tc''*, *p'*, *p''*, *u'*, *u''* and *s* short, spine-shaped. Male tarsal copulatory suckers medial, with rod-shaped bases and wider, flat discs.

Neotropacarus mumai (Cunliffe).

(Figs.1 – 6)

Tropacarus mumai Cunliffe, 1964: 181.

Neotropacarus mumai. – Baker, 1985: 289.

Material examined

Three paratype females and two paratype males from the Democratic Republic of Congo (mentioned as Congo): Kinshasa, on unidentified tree, 16.iv.1955, E.W. Baker coll., deposited at National Museum of Natural History, Washington, DC, USA.

Diagnosis

Females and males with dorsal seta *le* present, seta *e1* shorter than the distance between its basis and the posterior edge of idiossoma; anal region with three pairs of proctal setae; tibiae I-II without *c''*; tarsus I with *a''* and *ft'*; tarsi I-II without *a'* e *pv''*

Description

Female (Figs. 1 – 3; n = 3)

Idiosoma: rounded, 380 – 400 long.

Dorsum: prodorsal sclerite 70 – 82, 85 – 88 wide at posterior margins and 70 – 74 at anterior margins; evenly punctate. Grandjean's organ divided in terminal branches; supracoxal seta (*elc I*) 38 (35 – 40). Dorsal setae lengths: *ro* 71 (70 – 74), *le* 9 (9 – 10), *in* 48 (38 – 56), *ex* 302 (265 – 350), *c1* 30 (27 – 32), *c2* 31 (28 – 36), *cp* 354 (325 – 412), *d1* 27 (23 – 30), *d2* 28 (24 – 34), *e1* 33 – 48, *e2* 365 (320 – 425), *f2* 20 – 22, *h1* 380 – 500, *h2* 315 (275 – 350) and *h3* 137 (112 – 162). Opisthonotal gland slightly posteriad of *e1*; liryfissure *ia* close to *c1*; *im* close to opisthonotal gland and *ip* close to *h1*.

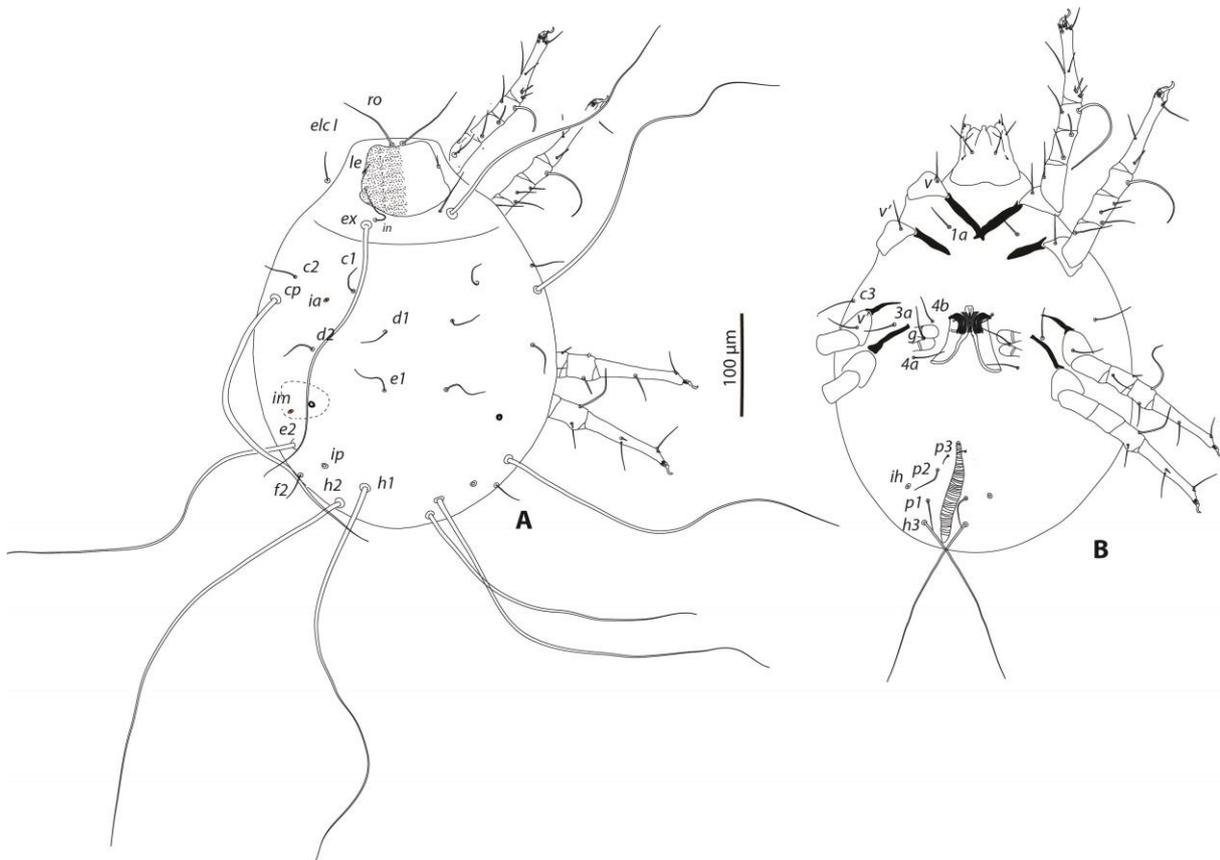


Figure 1 - *Neotropacarus mumai* (Cunliffe) (female). (A) Dorsal view. (B) Ventral view.

Venter: setal lengths: *1a* 26 (25 – 27), *3a* 28 (24 – 32) and *4a* 31 (29 – 34), *4b* 33 (24 – 44), *g* 40 (36 – 43), *p1* 30 (29 – 31), *p2* 29 (25 – 35) and *p3* 22 (18 – 26). Genital region between legs III and IV. Copulatory opening at posterior edge of the body. Spermathecal duct as a cylindrical duct, 2 (2 – 3) wide; spermatheca sclerites U-shaped; base of spermatheca flat, with internal structure sclerotized, 10 (8 – 10) wide at basis.

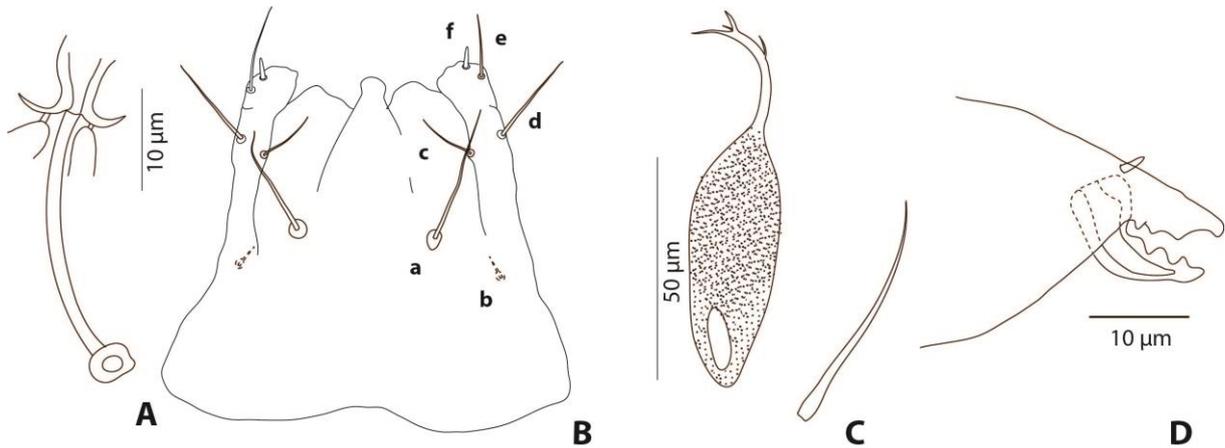


Figure 2 - *Neotropacarus mumai* (Cunliffe) (female). (A) Spermatheca. (B) Gnathosoma - a- subcapitular (*subc*); b- supracoxal (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion. (C) Grandjean's organ. (D) Chelicera.

Gnathosoma: chelicera 86; fixed and movable digits respectively 21 and 26 long. Setal lengths: cheliceral 4 (spiniform), subcapitular 26 – 35, dorsal palptibial 10, lateral palptibial 18 (18 – 19), dorsal palptarsal 13 – 14, terminal palptarsal solenidion 4 and *elcp* 9 long.

Legs: leg I 140 – 182, tarsus 72 (70 – 73). Setal lengths: trochanter- *v'* 38 (32 – 43); femur- *bv''* 36 (34 – 40); genu- *l'* 45 (42 – 48), *l''* 43 (39 – 50), σ' 20 (19 – 21); tibia- *v'* 26 (22 – 28), Φ 100 (92 – 108); tarsus- $\omega 1$ thin and straight, 17 (15 – 19), ε as a small spine 4 (4 – 5), $\omega 2$ straight, 4 (4 – 5), *a''* 18 (15 – 21), $\omega 3$, straight, 13 (12 – 13), *ft'* 21 (18 – 25), *pv'* 37 (34 – 42), *ft''* 31 (27 – 35), *tc''* 6, *p'* 8 (8 – 9), *p''* 9, *u'* 5, *u''* 5 (5 – 6) and *s* 4 (4 – 5).

Leg II 167 (160 – 175), tarsus 76 (73 – 78). Setal lengths: trochanter- *v'* 29 (24 – 32); femur- *bv''* 44 (38 – 50); genu- *l'* 33 (32 – 34), *l''* 34 (32 – 35), σ' 17 (15 – 18); tibia- *v'* 27 (25 – 29), Φ 98 (90 – 106); tarsus- $\omega 1$ 17 (14 – 19), *pv'* 35 (32 – 39), *ft''* 33 (31 – 35), *tc''* 5 (4 – 5), *p'* 7 (7 – 8), *p''* 7, *u'* 6 (5 – 6), *u''* 6 (5 – 6) and *s* 5.

Leg III 175 (170 – 180), tarsus 77 (76 – 78). Setal lengths: trochanter- *v'* 33 (30 – 35); genu- *l'* 37 (34 – 42), σ' 9 (7 – 10); tibia- *v'* 42 (39 – 45), Φ 105 (95 – 112); tarsus- *ft''* 39 (33 – 45), *tc''* 6, *p'* 6 (6 – 8), *p''* 6 (6 – 7), *u'* 5 (5 – 6), *u''* 5 and *s* 5.

Leg IV 148 – 188, tarsus 85 (80 – 90). Setal lengths: femur- *bv''* 32 – 35; tibia- *v'* 34 (32 – 38), Φ 56 (50 – 64); tarsus- *pv'* 10 (9 – 10), *pv''* 39 (32 – 50), *ft''* 36 (32 – 41), *tc''* 5 (4 – 6), *p'* 5, *p''* 5 (5 – 6), *u'* 4, *u''* 5 and *s* 4.

Male (Figures 4 – 6; n = 2).

Idiosoma: rounded, 260 – 265 long.

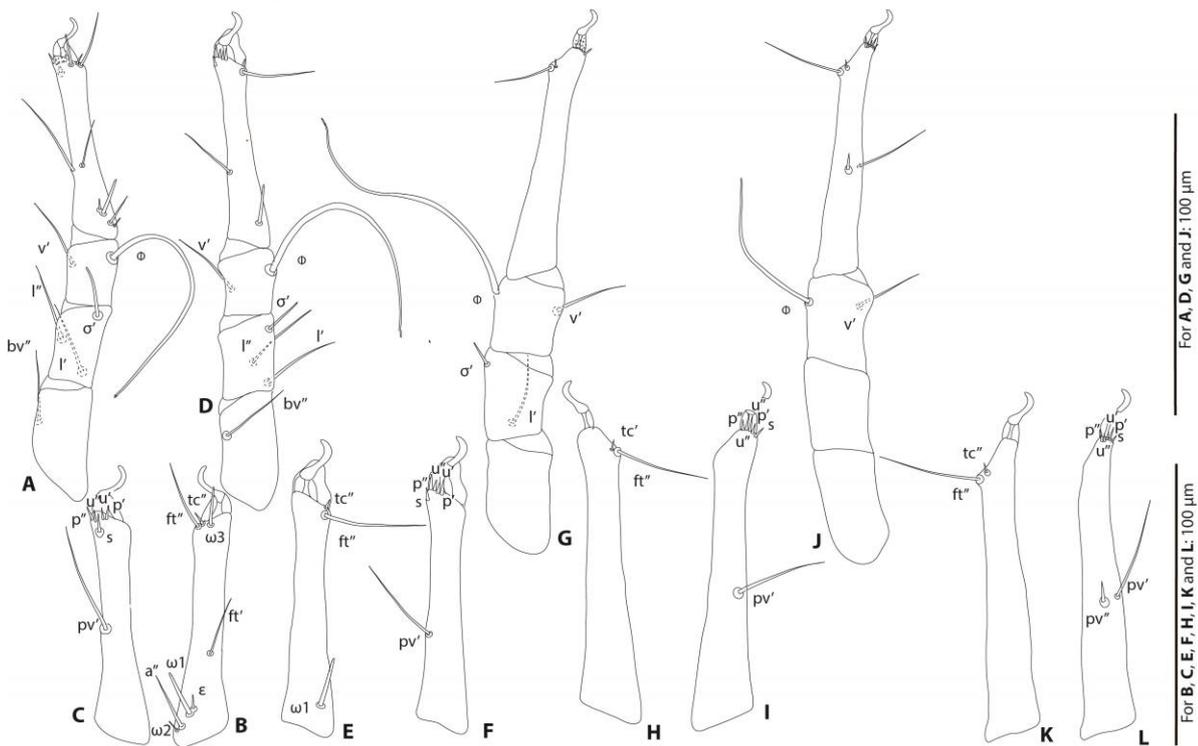


Figure 3 - *Neotropacarus mumai* (Cunliffe) (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Dorsum: prodorsal sclerite 55 – 58, 45 – 48 wide at anterior margin and 64 – 68 wide at posterior margin. Supracoxal seta (*elc I*) 25 – 26. Setal lengths: *ro* 48 – 55, *le* 4 – 5, *in* 24 – 30, *ex* 200 – 225, *c1* 14, *c2* 18 – 21, *cp* 180 – 185, *d1* 17 – 20, *d2* 15 – 18, *e1* 28 – 29, *e2* 175 – 180, *f2* 12 – 13, *h1* 212 – 250, *h2* 157 – 170 and *h3* 85 – 90. Opisthotal gland about in transverse line with *e1*.

Venter: setal lengths: *c3* 22 – 24, *1a* 18 – 20, *3a* 18 – 20, *4a* 20 – 22, *4b* 16 – 17, *g* 20 – 23, *p1* 10, *p2* 11 and *p3* 5 – 6. Aedeagus curved at the tip, 12.

Gnathosoma: chelicera 74; fixed and movable cheliceral digits 16 and 23. Setal lengths: cheliceral 3, subcapitular 15, dorsal palptibial 8, lateral palptibial 14, dorsal palptarsal 12, terminal palptarsal solenidion 4 and *elcp* 4.

Legs: leg I 137, tarsus 53. Setal lengths: trochanter- *v'* 20 – 22; femur- *bv''* 21 – 29; genu- *l'* 23 – 28, *l''* 19 – 20, *σ'* 14 – 15; tibia- *v'* 13 – 14, Φ 75 – 78; tarsus- $\omega 1$ 12 – 14, ϵ 3, $\omega 2$ 3 – 4, *a''* 12 – 13, $\omega 3$ 13 – 16, *ft'* 13 – 20, *pv'* 15 – 18, *ft''* 20 – 22, *tc''* 4, *p' 5*, *p'' 5*, *u' 4*, *u'' 4* and *s* 3.

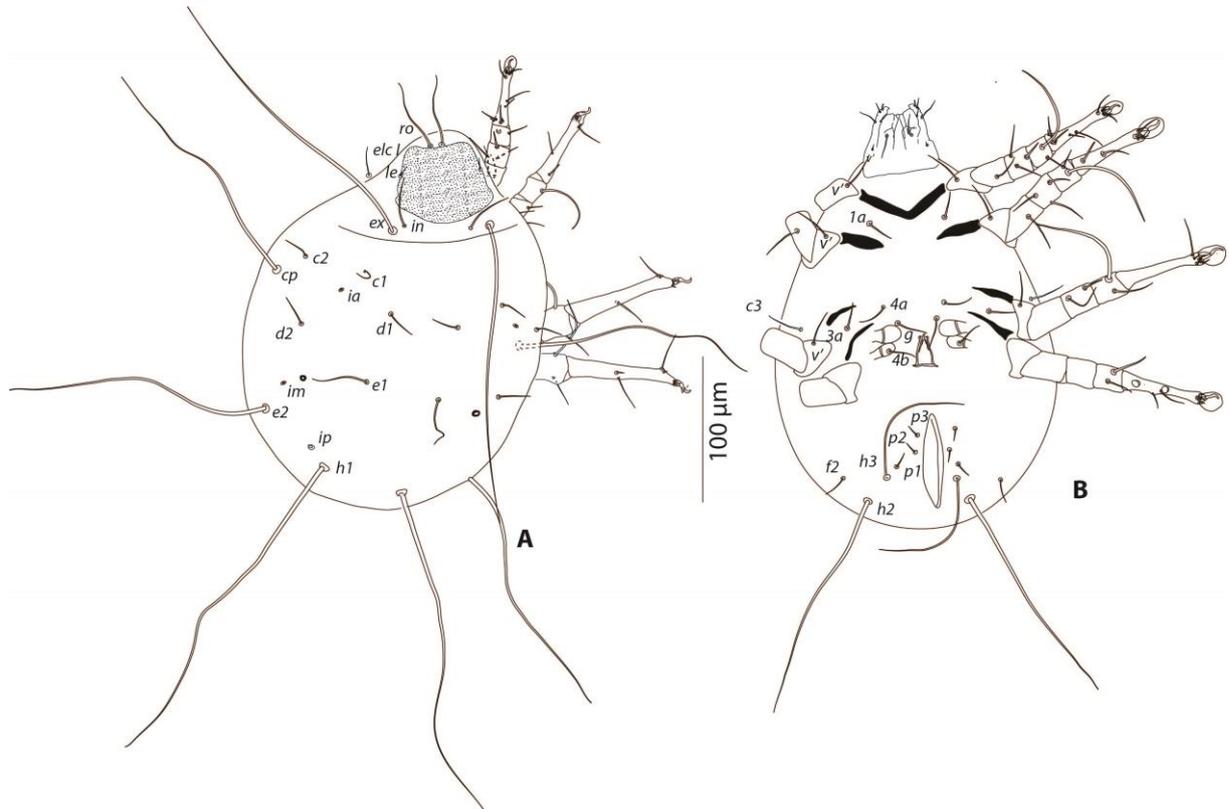


Figure 4 - *Neotropacarus mumai* (Cunliffe) (male). (A) Dorsal view. (B) Ventral view.

Leg II 125, tarsus 55. Setal lengths: trochanter- v' 19 – 20; femur- bv'' 25 – 28; genu- l' 23 – 25, l'' 19 – 20, σ' 13 – 14; tibia- v' 14, Φ 74 – 80; tarsus- ωl 13 – 14, pv'' 22 – 24, ft'' 21 – 25, tc'' 4, p' 4 – 5, p'' 4, u' 3 – 4, u'' 4 and s 3.

Leg III 142, tarsus 54. Setal lengths: trochanter- v' 18 – 20; genu- l' 16, σ' 6 – 7; tibia- v' 22 – 28, Φ 65 – 70; tarsus- ft'' 26 – 30, tc'' 4 – 5, p' 4, p'' 4, u' 3, u'' 3 and s 3 (3 – 4).

Leg IV 125, tarsus 54. Setal lengths: femur- bv'' 18 – 19; tibia- v' 21 – 23, Φ 24 – 29; tarsus pv' 17 – 20, pv'' 7 – 8, p' 5 – 6, p'' 5 – 6, u' 5, u'' 4 – 5 and s 3 (2 – 3).

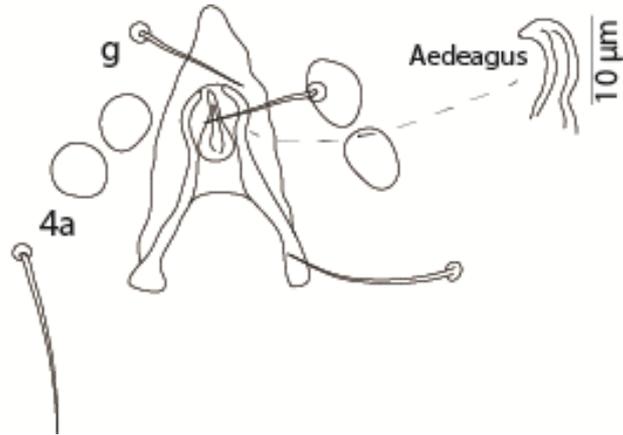


Figure 5 - *Neotropacarus mumai* (Cunliffe) (male). (A) Aedeagus.

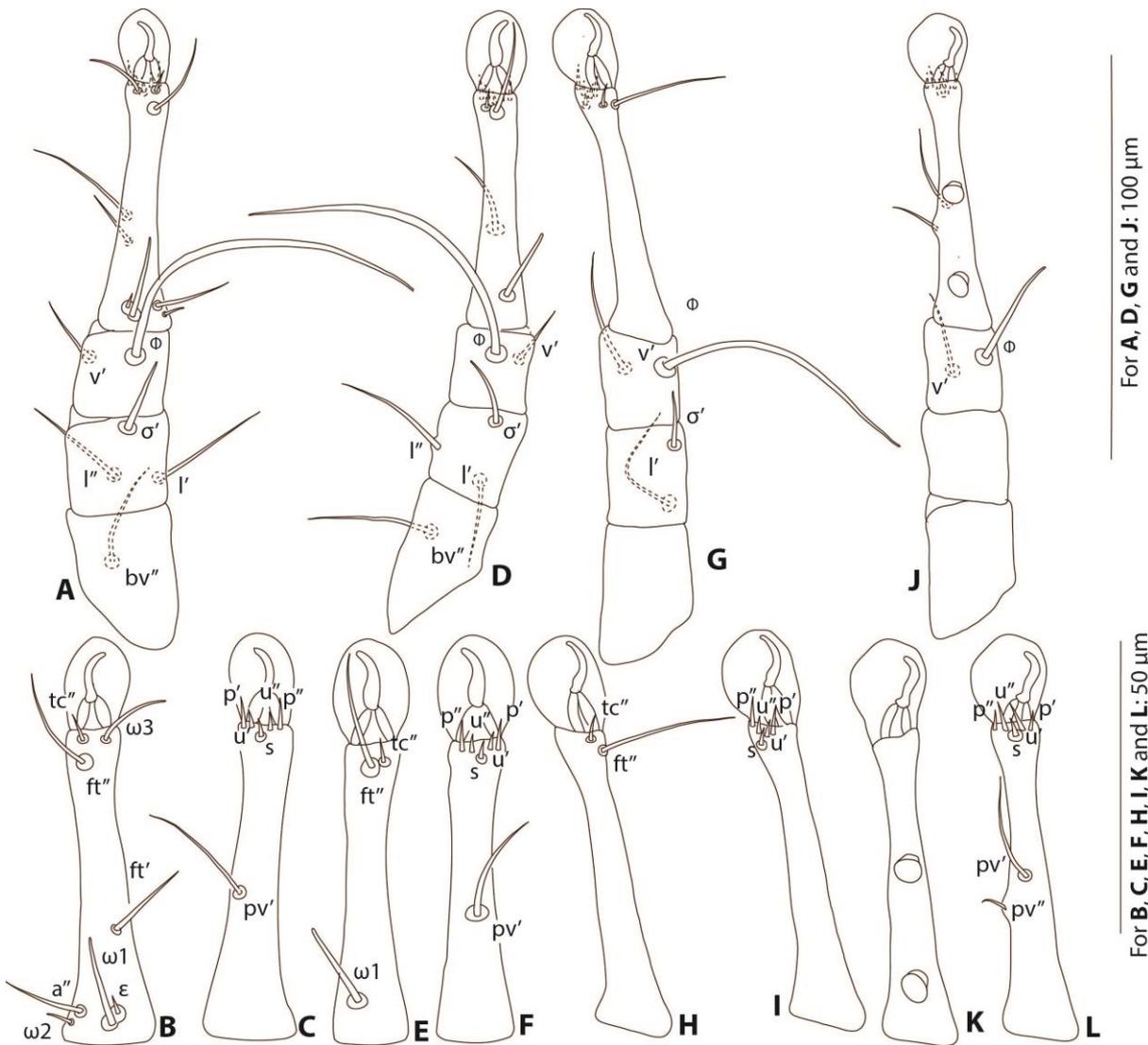


Figure 6 - *Neotropacarus mumai* (Cunliffe) (male). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Neotropacarus bakeri (Collyer).

(Figs. 7 – 12)

Tropacarus bakeri Collyer, 1966: 13.

Neotropacarus bakeri. – Baker, 1985: 289; Zhang, 2012: 242.

Material examined

Two paratype females and two paratype males from New Zealand: Fringed Hill, on *Nothofagus menziesii* Oerst., 18.vi.1966, E. Collyer coll., deposited at University of Michigan Museum of Zoology, Ann Arbor, MI, USA.

Diagnosis

Females and males with *le* present, *e1* shorter than the distance between its basis and the posterior edge of idiosoma; anal region with three pairs of paraproctal setae; tibiae I-II without *c''*; tarsus I with *a''* and *ft'*; tarsi I-II with *a'* and *pv''*.

Description

Female (Figs. 7 – 9; n = 2)

Idiosoma: rounded, 435 – 445 long.



Figure 7 - *Neotropacarus bakeri* (Collyer) (female). (A) Dorsal view. (B). Ventral view.

Dorsum: prodorsal sclerite 120, 112 – 124 wide at anterior margin and 112 – 128 wide at posterior margin; very lightly sclerotized. Shape of Grandjean's organ not distinguishable; supracoxal seta (*elc I*) 32 – 35. Setal lengths: *ro* 98 – 100, *le* 9 – 13, *in* 100 (95 – 104), *ex* 354 – 457, *c1* 60, *c2* 50 – 55, *cp* 442 – 488, *d1* 70– 73, *d2* 75 – 78, *e1* 103 – 105, *e2* 460 – 463, *f2* 18 – 23, *h1* 507 – 538, *h2* 337 – 400 and *h3* 112 – 200. Opisthonotal gland in transverse line with *e1*; liryfissures not distinguishable.

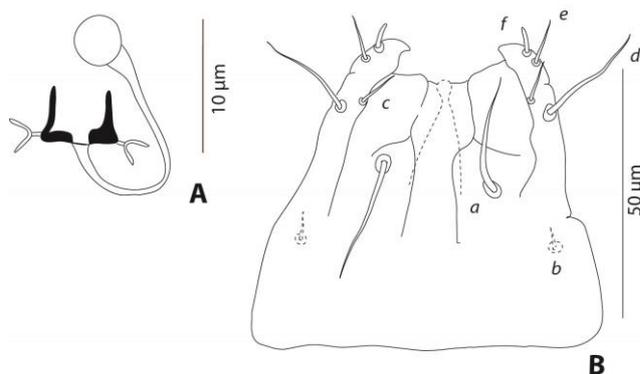


Figure 8 - *Neotropacarus bakeri* (Collyer) (female). (A) Spermatheca. (B) Gnathosoma - a- subcapitular seta (*subc*); b- supracoxal seta (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion.

Venter: setal lengths: *c3* 65 – 75, *1a* 26 – 33, *3a* 48 – 50, *4a* 55 – 58, *4b* 27 – 38, *g* 28 – 30, *p1* 21 – 24, *p2* 55 – 58 and *p3* 17 – 20. Copulatory opening at hind margin of idiosoma. Spermathecal duct cylindrical, slightly swollen at both ends, 3 – 2 wide at thinner part; spermathecal sclerites V-shaped; well sclerotized base of spermatheca approximately U-shaped, 9 – 12 wide.

Gnathosoma: chelicera 83; fixed and movable digits respectively 20 and 23 long. Setal lengths: cheliceral (*cha*) 6 (spiniform), subcapitular (*subc*) 30, dorsal palptibial 10, lateral palptibial 21 – 25, dorsal palptarsal 9, terminal palptarsal solenidion 4 and *elcp* 7 – 9.

Legs: leg I 233 – 242, tarsus 90 – 112. Setal lengths: trochanter- *v'* 50 – 55; femur- *bv''* 59 – 60; genu- *l'* 58 – 60, *l''* 55 – 58, *σ'* 33 – 38; tibia- *v'* 34 – 40, Φ 125 – 140; tarsus- $\omega 1$ thin and straight, 19 – 27, ε as a small spine 4 – 5, $\omega 2$ straight, 9, *a''* 18, $\omega 3$, straight, 24 – 27, *ft'* 36, *a'* 27 – 28, *pv'* 38 – 46, *pv''* 32 – 33, *ft''* 36 – 41, *tc'* 16 – 21, *tc''* 4 – 5, *p'* 5, *p''* 6 – 7, *u'* 6, *u''* 6 – 7 and *s* 4.

Leg II 222 – 235, tarsus 90 – 93. Setal lengths: trochanter- *v'* 29; femur- *bv''* 68 – 72; genu- *l'* 42 – 60, *l''* 53 – 55, *σ'* 18 – 23; tibia- *v'* 30 – 33, Φ 150; tarsus- $\omega 1$ thin and straight, 23 – 24, *a'* 23 – 30, *pv'* 43 – 50, *pv''* 40 – 41, *ft''* 38, *tc'* 20, *tc''* 4, *p'* 6, *p''* 6, *u'* 7, *u''* 7 and *s* 5.

Leg III 230, tarsus 93 – 96. Setal lengths: trochanter- *v'* 38 – 55; genu- *l'* 43 – 50, *σ'* 8 – 9; tibia- *v'* 47 – 60, Φ 150 – 162; tarsus- *pv'* 43 – 48, *pv''* 25 – 30, *ft''* 38 – 42, *tc'* 19 – 22, *tc''* 3 – 5, *p'* 6, *p''* 6, *u'* 7, *u''* 7 and *s* 5.

Leg IV 235 – 237, tarsus 97 – 98 Setal lengths: femur- *bv''* 30 – 40; tibia- *v'* 32 – 41, Φ 80 – 87; tarsus- *pv'* 40 – 41, *pv''* 27 – 28, *ft''* 38, *tc'* 20, *tc''* 4, *p'* 3 – 4, *p''* 3 *u'* 5, *u''* 5 and *s* 4.

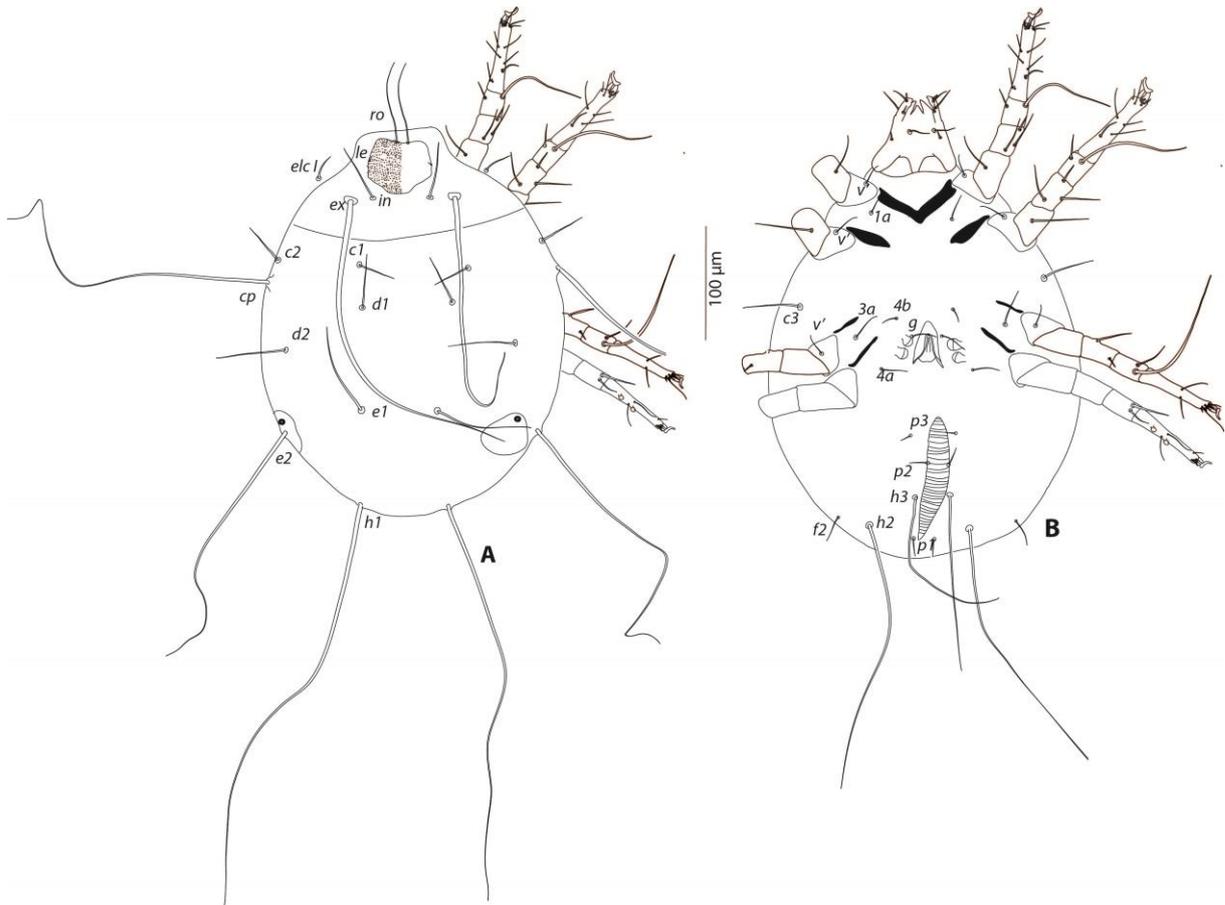


Figure 10 - *Neotropacarus bakeri* (Collyer) (male). (A) Dorsal view. (B). Ventral view.

Dorsum: prodorsal sclerite 74, 78 – 86 wide at anterior margin and 80 – 85 wide at posterior margin. Supracoxal seta (*elc I*) 28. Dorsal setal lengths: *ro* 72 – 95, *le* 7 – 8, *in* 52 – 74, *ex* 312 – 342, *c1* 43, *c2* 35 – 46, *cp* 310 – 350, *d1* 53, *d2* 55 – 77, *e1* 88 – 100, *e2* 305 – 330, *f2* 20 – 30, *h1* 345 – 362, *h2* 225 – 235 and *h3* 154 – 1162. Opisthonotal gland about in transverse line with *e1*; liryfissures not distinguishable.

Venter: setal lengths: *c3* 48 – 52, *1a* 22, *3a* 43 – 45, *4a* 34 – 38, *4b* 20, *g* 26 – 27, *p1* 8 – 12, *p2* 18 – 25 and *p3* 9 – 13. Aedeagus curved at the tip, 12.

Gnathosoma: chelicera 67; fixed and movable digits respectively 17 and 19 long. Setal lengths: cheliceral 3, subcapitular 23, dorsal palptibial 9, lateral palptibial 20 – 22, dorsal palptarsal 9, terminal palptarsal solenidion 3 – 4 and *elcp* 25.

Legs: leg I 175 – 200, tarsus 68. Setal lengths: trochanter- *v'* 20 – 40; femur- *bv''* 40 – 50; genu- *l'* 22 – 50, *l''* 22 – 25, *σ'* 15 – 18; tibia- *v'* 12 – 18, Φ 107 – 112; tarsus- $\omega 1$ 13 – 15, ϵ 3 – 4, $\omega 2$ 8, *a''* 11 – 13, $\omega 3$ 18 – 19, *ft'* 16 – 18, *a'* 20 – 23, *pv'* 36 – 40, *pv''* 20 – 30, *ft''* 31 – 33, *tc'* 11, *tc''* 4, *p'* 5, *p''* 5, *u'* 4, *u''* 4 – 5 and *s* 4.

Leg II 185, tarsus 68 – 75. Setal lengths: trochanter- v' 30 – 34; femur- bv'' 53 – 55; genu- l' 38 – 40, l'' 40 – 43, σ' 15 – 20; tibia- v' 15 – 25, Φ 115 – 120; tarsus- ωl 15 – 18, a' 16 – 23, pv' 44 – 50, pv'' 35 – 38, ft'' 40, tc' 10, tc'' 3, p' 3 – 4, p'' 4, u' 4 – 5, u'' 5 and s 3.

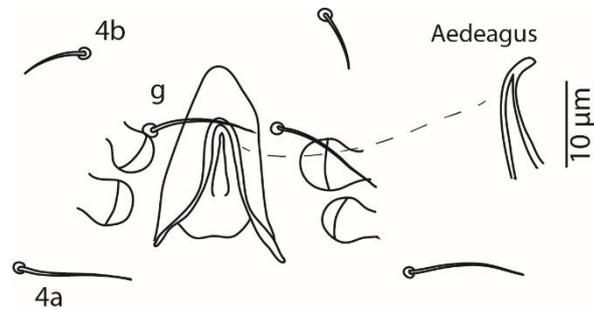


Figure 11 - *Neotropacarus bakeri* (Collyer) (male) Aedeagus.

Leg III 190, tarsus 78. Setal lengths: trochanter- v' 24 – 38; genu- l' 28 – 30, σ' 8 – 10; tibia- v' 32, Φ 112 – 132; tarsus- pv' 32, pv'' 24 – 28, ft'' 32, tc' 11, tc'' 3, p' 5, p'' 4 – 5, u' 5, u'' 5 – 6 and s 4.

Leg IV 180, tarsus 73. Setal lengths: femur- bv'' 20 – 25; tibia- v' 28 – 36, Φ 48 – 56; tarsus- pv' 45 – 50, pv'' 25 – 38, tc' 12, p' 3 – 4, p'' 4, u' 4 – 5, u'' 5 and s 3.

Neotropacarus n. sp. 1

(Figs. 13 – 15)

Material examined

Holotype female and three paratype females from Brazil: Alagoas, Teotonio Vilela, from *Cupania* sp. (Sapindales: Sapindaceae), 12.ii.2012, M.E. Duarte coll., deposited at mite reference collection of Departamento de Entomologia e Acarologia, Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo. Two paratype females, same collection data as holotype, deposited at University of Michigan Museum of Zoology.

Diagnosis

Females without *le*, anal region with one pair of paraproctal seta, and tarsus I without a'' and ft' ; with c'' of tibiae I-II, and a' and pv'' of tarsi I-II; $e1$ longer than the distance between its basis and the posterior edge of idiossoma, extending far beyond posterior edge of idiossoma.



Figure 13 - *Neotropacarus n. sp. 1* (female). (A) Dorsal view. (B). Ventral view.

Venter: setal lengths: *c3* 41 (36 – 45), *1a* 26 (25 – 28), *3a* 36 (34 – 40), *4a* 40 (36 – 49), *4b* 34 (32 – 39), *g* 28 (21 – 32) and *p3* 36 (34 – 37) (*p1* and *p2* absent). Genital region between legs III and IV. Spermathecal duct and copulatory opening not distinguishable; spermathecal sclerites V-shaped; base of spermatheca small and flat 8 (6 – 9) in width.

Gnathosoma: chelicera 105 (100 – 108); fixed and movable digits respectively 22 (19 – 24) and 24 (23 – 25). Setal lengths: cheliceral 4 (spiniform), subcapitular 25 (21-30), dorsal palptibial 8 (8 – 9), lateral palptibial 29 (24 – 31), dorsal palptarsal 10 (9 – 13), terminal palptarsal solenidion 5 (4 – 6) and *elcp* 3 (3 – 4).

Legs: leg I 220 (217 – 223), tarsus 102 (97 – 110). Setal lengths: trochanter- *v'* 20 (18 – 24); femur- *bv''* 69 (65 – 76); genu- *l'* 26 (22 – 29), *l''* 23 (22 – 29), σ' 35 (34 – 36); tibia- *v'* 29 (28 – 30), *c''* 24 (22 – 26), Φ 123 (118 – 133); tarsus- $\omega 1$ 23 (20 – 24) (thick and clavate), ϵ as a small spine 3 (3 – 4), $\omega 2$ 7 (7 – 8) (straight), $\omega 3$ 16 (13 – 17) (straight), *a'* 12 (8 – 13), *pv'* 58 (55 – 65), *pv''* 11 (9 – 13), *ft''* 40 (37 – 43), *tc'* 12 (10 – 14), *tc''* 4 (3 – 4), *p'* 3 (2 – 3), *p''* 3 (2 – 3), *u'* 3 (3 – 4), *u''* 3 (3 – 4) and *s* 3 (2 – 3); *a'* and *pv''* on legs I-II and *pv' I* and *pv''* on legs III-IV spiniform.

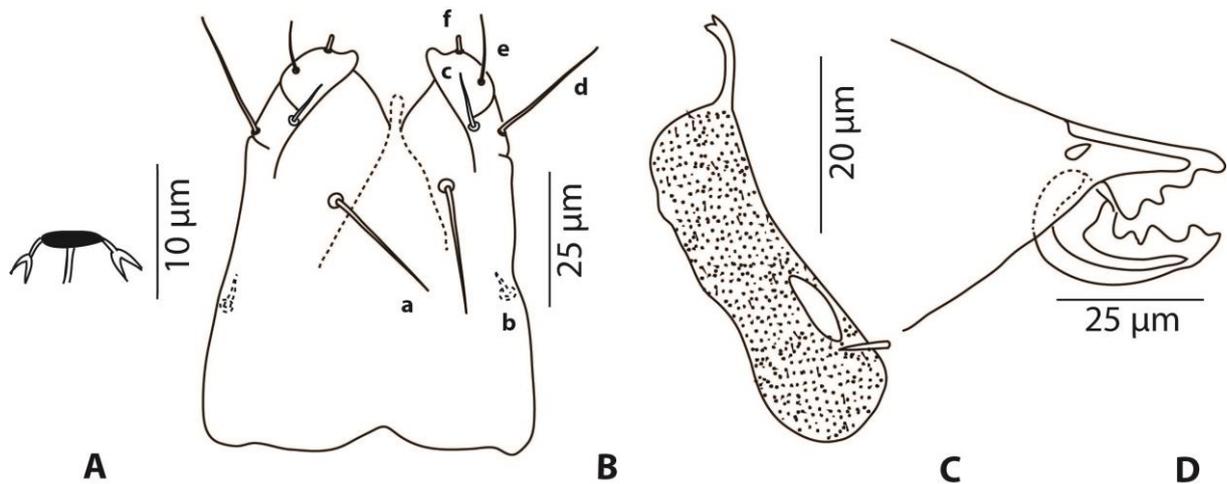


Figure 14 - *Neotropacarus n. sp. 1* (female). (A) Spermatheca. (B) Gnathosoma - a- subcapitular (*subc*); b- supracoxal (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion. (C) Grandjean's organ. (D) Chelicera.

Leg II 206 (198 – 212), tarsus 99 (98 – 103). Setal lengths: trochanter- v' 20 (18 – 23); femur bv'' 67 (63 – 73); genu- l' 20 (17 – 23), l'' 21 (20 – 22), σ' 25 (23 – 25); tibia- v' 27 (26 – 28), c'' 19 (17 – 20), Φ 101 (95 – 110); tarsus- ωl 31 (30 – 33) (thick and clavate), a' 8 (7 – 10), pv' 53 (52 – 55), pv'' 12 (9 – 14), ft'' 40 (39 – 42), tc' 12 (10 – 15), tc'' 4 (3 – 4), p' 3 (2 – 3), p'' 3 (2 – 3), u' 3 (3 – 4), u'' 3 (3 – 4) and s 3 (2 – 3).

Leg III 205 (200 – 210), tarsus 99 (90 – 105). Setal lengths: trochanter- v' 26 (24 – 30); genu- l' 32 (29 – 35), σ' 13 (11 – 13); tibia- v' 34 (28 – 39), Φ 91 (80 – 100); tarsus- pv' 15 (14 – 17), pv'' 27 (25 – 28), ft'' 52 (46 – 61), tc' 14 (13 – 15), tc'' 4 (3 – 4), p' 3, p'' 3 (3 – 4), u' 4 (3 – 4), u'' 3 (3 – 4) and s 3 (2 – 3).

Leg IV 252 (238 – 263), tarsus 120 (113 – 130). Setal lengths: tibia- v' 33 (27 – 39), Φ 77 (74 – 83); tarsus- pv' 16 (14 – 18), pv'' 22 (20 – 23), ft'' 59 (48 – 65), tc' 15 (12 – 19), tc'' 5 (4 – 8), p' 5 (5 – 6), p'' 5 (5 – 6), u' 5 (4 – 5), u'' 5 (4 – 5) and s 5 (5 – 6); ft'' more basal than other dorsoapical setae.

Male

Unknown.

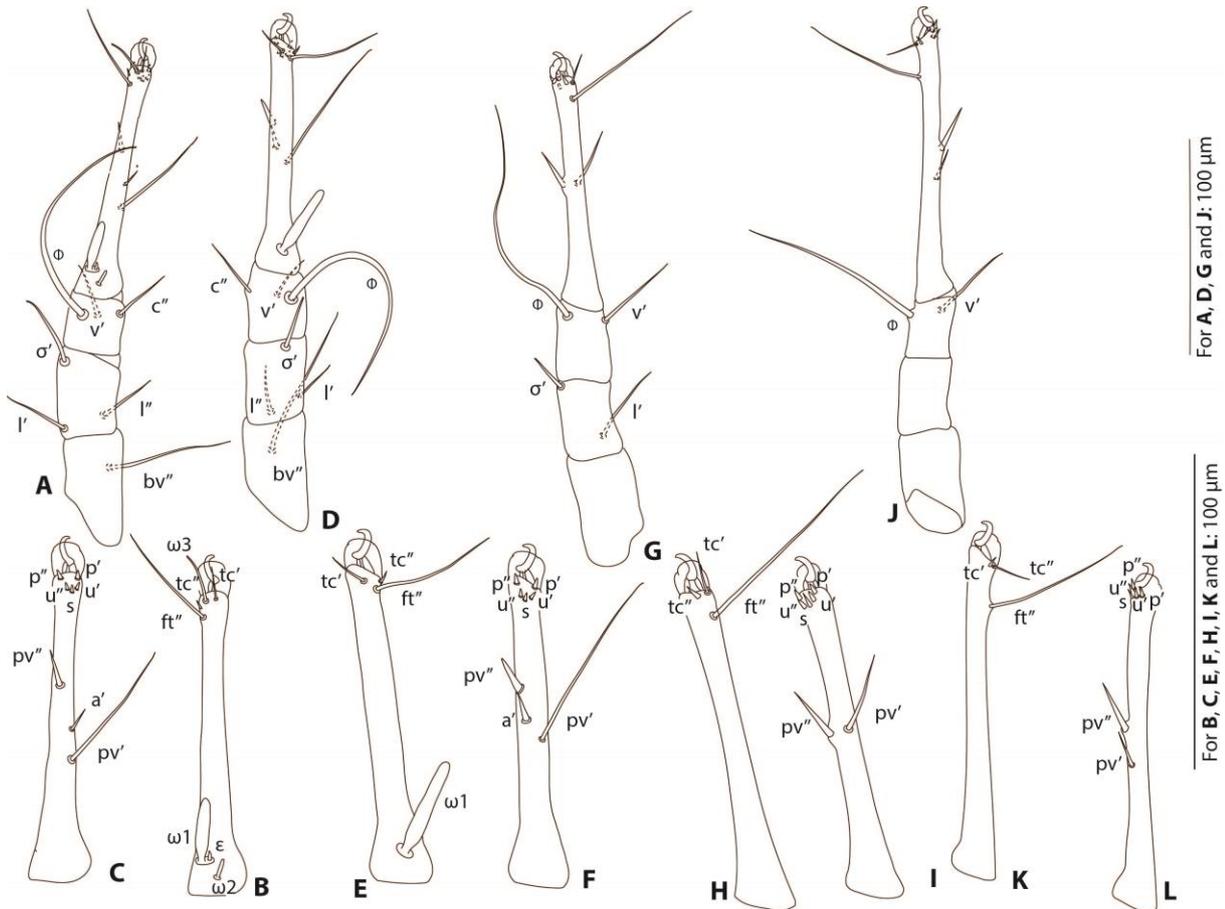


Figure 15 - *Neotropacarus n. sp. 1.* (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Neotropacarus n. sp. 2.

(Figs. 16 – 21)

Material examined

Holotype female, one paratype female and five paratype males from the Philippines: Leyte, 8.5 km N and 2.5 km E of Baybay, from nests of *Rhipidura* sp. (Passeriformes: Rhipiduridae), 23.v.1984, P.D. Heidman coll., deposited at University of Michigan Museum of Zoology. One paratype male, same collection data as holotype, deposited at mite reference collection of Departamento de Entomologia e Acarologia, Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo.

Diagnosis

Females and males with seta *le*, anal region with two pairs of paraproctal setae, tibiae I-II with *c''*, tarsus I with *a''* and *ft'*; tarsi I-II with *a'* and *pv''*; seta *e1* much shorter than distance between its base and the posterior edge of idiosoma.

Description

Female (Figs. 16 – 18; n = 2)

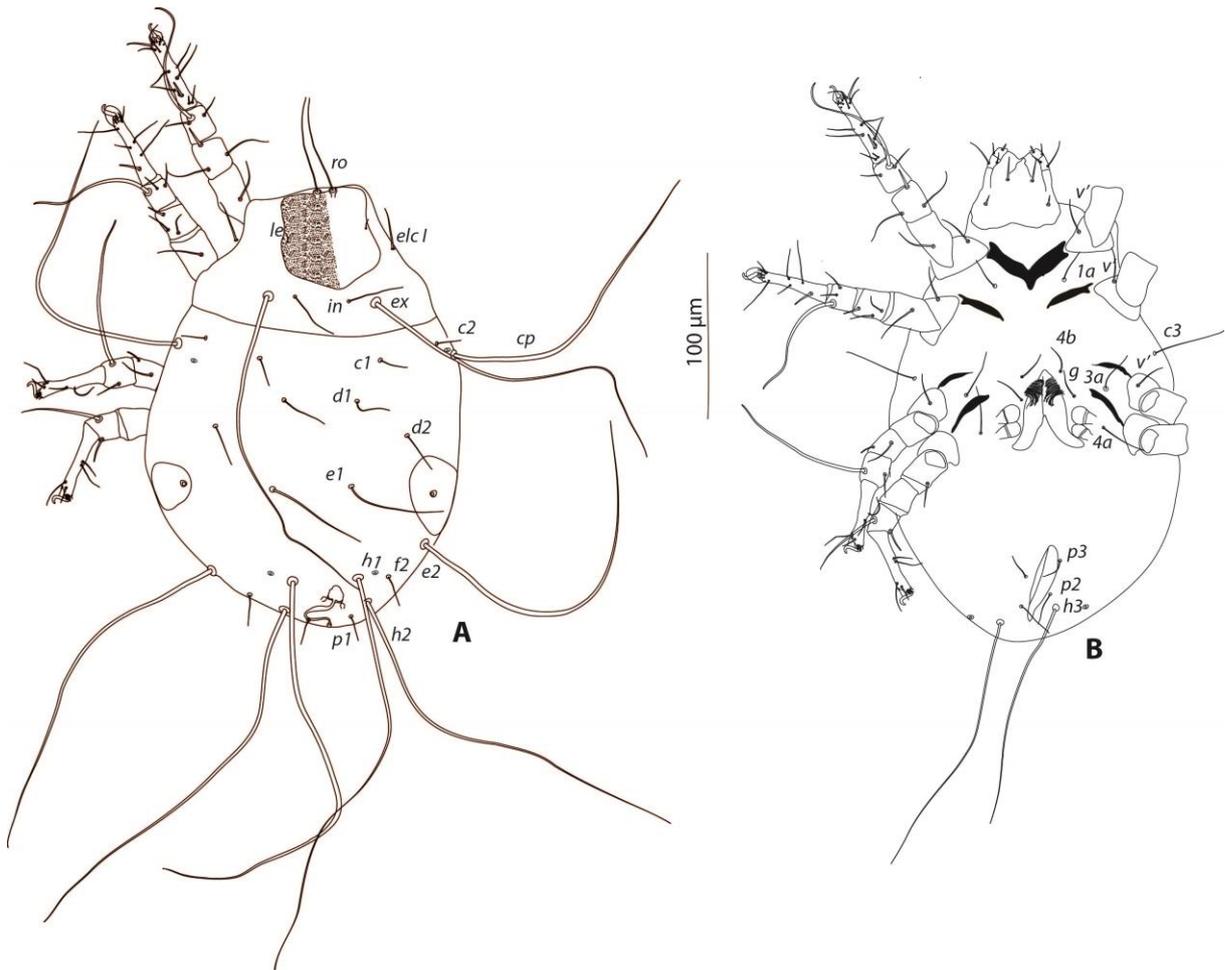


Figure 16 - *Neotropacarus* n. sp. 2 (female). (A) Dorsal view. (B). Ventral view.

Idiosoma: rounded, 345 – 362 long.

Dorsum: prodorsal sclerite 112 – 116, 76 – 85 at anterior margin and 84 – 96 wide at posterior margin; evenly punctate. Grandjean's organ bifurcate distally; supracoxal seta (*elc I*) slightly serrate, 26 – 30. Setal lengths: *ro* 75 – 80, *le* 6 – 9, *in* 45 – 50, *ex* 237 – 262, *c1* 23 – 24, *c2* 20 – 22, *cp* 212 – 225, *d1* 26 – 30, *d2* 27 – 35, *e1* 74, *e2* 210 – 230, *f2* 25 – 28, *h1* 225 – 240, *h2* 280 – 300 and *h3* 200. Opisthonotal gland about in transverse line with *e1*.

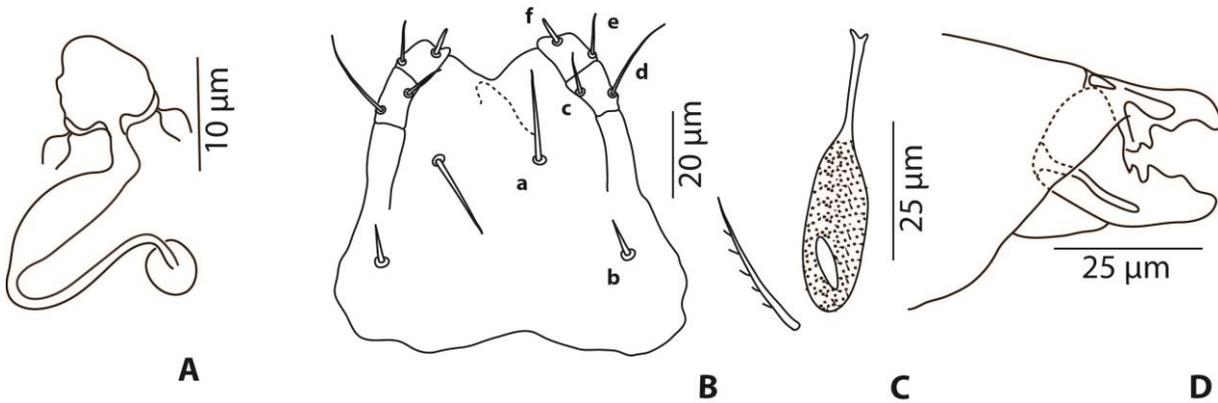


Figure 17 - *Neotropacarus n. sp. 2* (female). (A) Spermatheca. (B) Gnathosoma - a- subcapitular (*subc*); b- supracoxal (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion. (C) Grandjean's organ. (D) Chelicera.

Venter: setal lengths: *c3* 53 – 61, *1a* 18 – 24, *3a* 28 – 30, *4a* 36, *4b* 15 – 18, *g* 18 – 23, *p1* 22 (22 – 23), *p2* 26 and *p3* 19 (18 – 20). Genital region between legs III and IV. Copulatory opening at hind margin of idiosoma. Spermathecal duct swollen medially, 2 (2 – 3) in narrower section and 4 (4 – 5) in swollen section; spermathecal sclerites U-shaped; base of spermatheca approximately U-shaped, 8 in width.

Gnathosoma: chelicera 92; fixed and movable digits 19 and 27. Setal lengths: cheliceral 3 (spiniform), subcapitular 28, dorsal palptibial 11, lateral palptibial 24 – 26, dorsal palptarsal 9, terminal palptarsal solenidion 3 – 4 and *elcp* 7 – 8.

Legs: leg I 137 – 160, tarsus 55 – 60. Setal lengths: trochanter- *v'* 24 – 23; femur- *bv''* 35 – 40; genu- *l'* 23 – 35, *l''* 30 – 34, *σ'* 12 – 13; tibia- *v'* 15, *c''* 13, Φ 105 – 120; tarsus- ωl 12 – 13 (thin and straight), ϵ as a small spine 3 (3 – 4), $\omega 2$ 5 – 6 (straight), *a''* 20 – 22, $\omega 3$ 18 – 20 (straight), *ft'* 35, *a'* 23 – 30, *pv'* 37 – 42, *pv''* 29 – 36, *ft''* 25 – 28, *tc'* 8 – 11, *tc''* 3, *p'* 4, *p''* 4, *u'* 5, *u''* 5 and *s* 3.

Leg II 145 – 147, tarsus 53 – 60. Setal lengths: trochanter- *v'* 21 – 25; femur- *bv''* 40 – 36; genu- *l'* 22 – 25, *l''* 21 – 25, *σ'* 10 – 15; tibia- *v'* 13 – 15, *c''* 10, Φ 95; tarsus- ωl 14 – 15 (thin and straight), *a'* 13 – 14, *pv'* 39 – 45, *pv''* 29 – 35, *ft''* 28 – 30, *tc'* 9 – 11, *tc''* 2 – 3, *p'* 4 – 5, *p''* 4, *u'* 4 – 5, *u''* 5 and *s* 4.

Leg III 137 – 145, tarsus 55 – 60. Setal lengths: trochanter- *v'* 16 – 22; genu- *l'* 18 – 25, *σ'* 8 – 9; tibia- *v'* 22 – 24, Φ 120 – 145; tarsus- *pv'* 20 – 26, *pv''* 17 – 19, *ft''* 26 – 32, *tc'* 12 – 14, *tc''* 3 – 5, *p'* 4 – 5, *p''* 4 – 5, *u'* 4 – 5, *u''* 5 and *s* 4.

Leg IV 135 – 140, tarsus 50 – 55. Setal lengths: trochanter- *bv''* 18; tibia- *v'* 17 – 18, Φ 60 – 65; tarsus- *pv'* 15 – 18, *pv''* 23 – 25, *ft''* 22 – 23, *tc'* 13 – 15, *tc''* 3, *p'* 5, *p''* 4 – 5, *u'* 6, *u''* 5 – 6 and *s* 5.

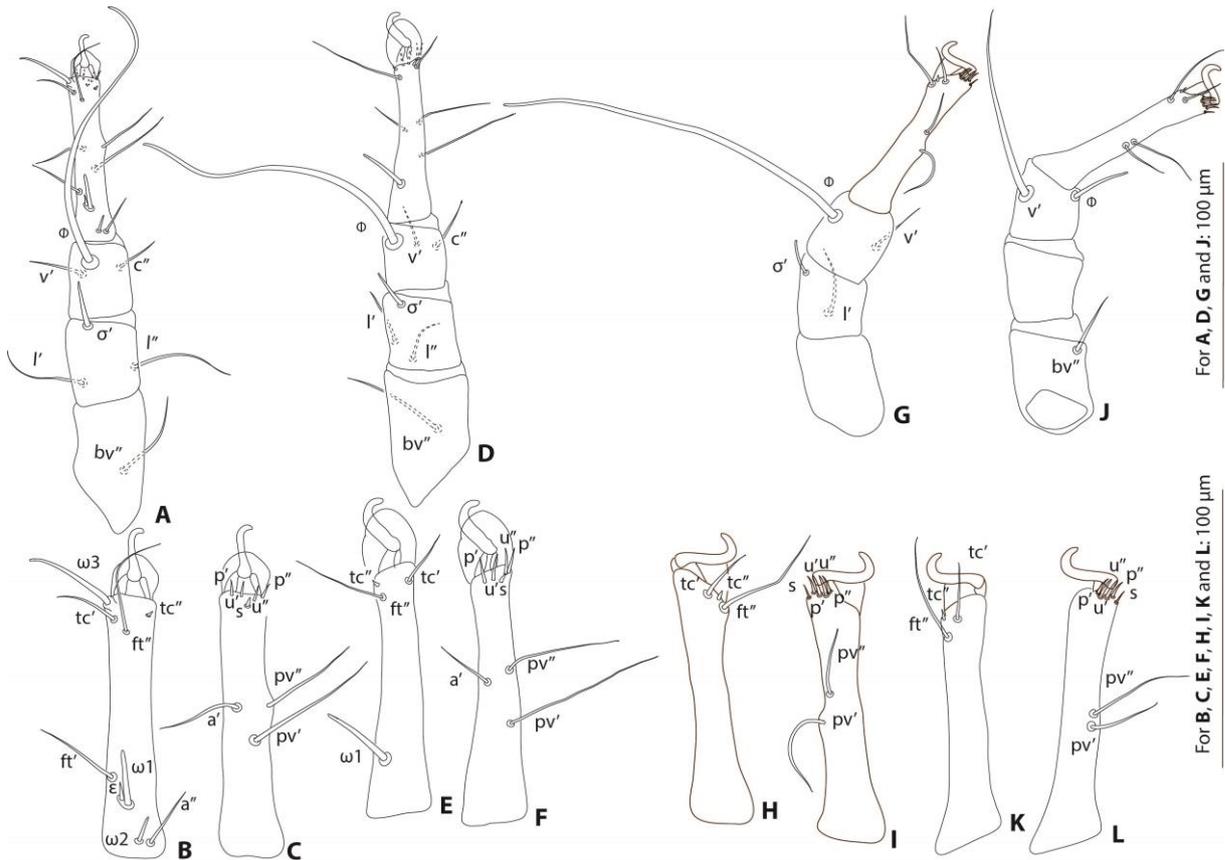


Figure 18 - *Neotropacarus n. sp. 2* (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Male (Figs. 19 – 21; n = 6)

Idiosoma: rounded, 248 (245 – 252) long.

Dorsum: prodorsal sclerite 94 (93 – 99), 91 (84 – 96) wide at anterior margin and 104 (100 – 110) wide at posterior margin; lightly sclerotized. Supracoxal seta (*elc I*) 21 (18 – 23). Setal lengths: *ro* 76 (75 – 78), *le* 9 (8 – 9), *in* 40 (40 – 41), *ex* 235 (230 – 238), *c1* 17 (14 – 19), *c2* 21 (19 – 21), *cp* 227 (225 – 230), *d1* 21 (21 – 22), *d2* 23 (23 – 24), *e1* 51 (50 – 53), *e2* 283 (275 – 288), *f2* 20 (18 – 21), *h1* 254 (187 – 288), *h2* 258 (250 – 263) and *h3* 161 (160 – 163). Opisthonotal gland about in transverse line with *e1*.

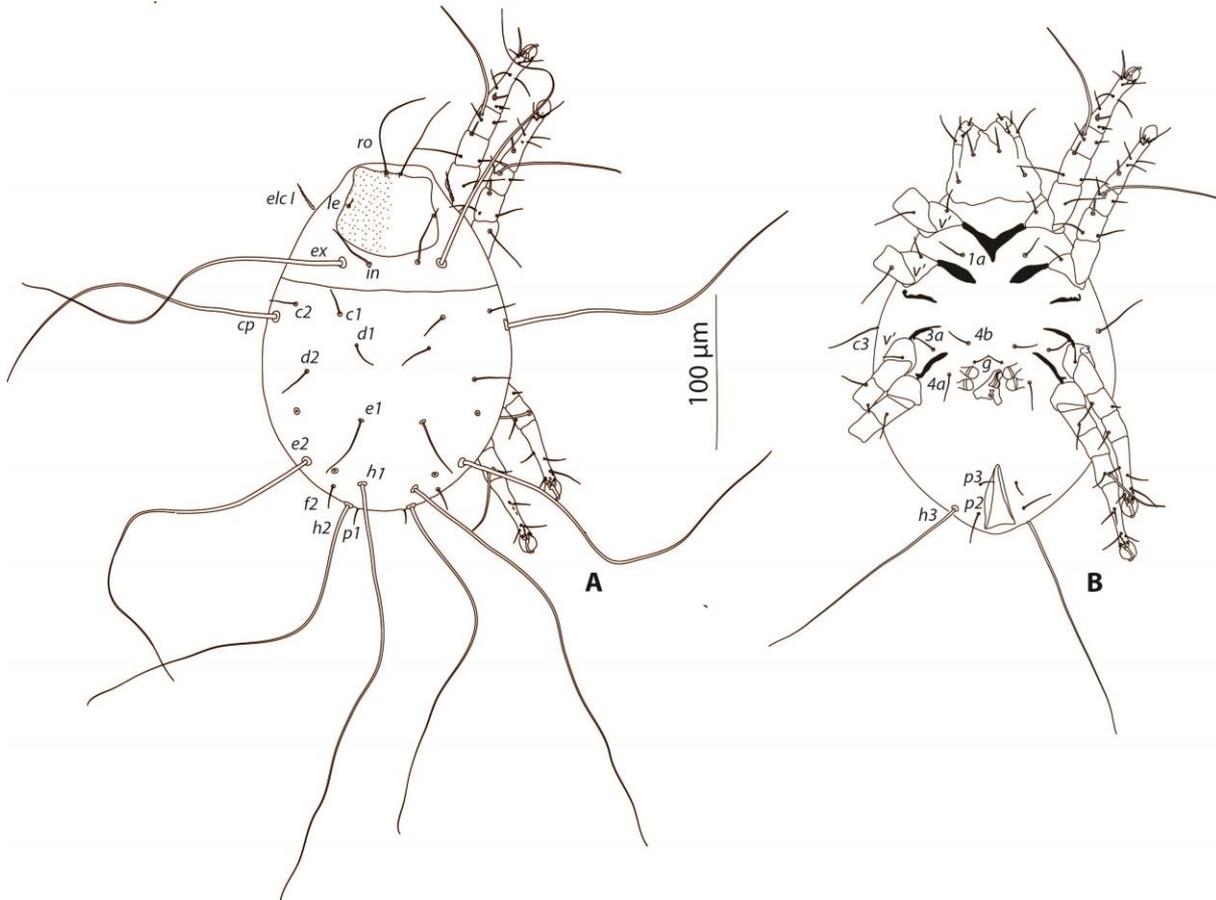


Figure 19 - *Neotropacarus* n. sp. 2 (male). (A) Dorsal view. (B). Ventral view.

Venter: setal lengths: *c3* 35 (31 – 40) *1a* 21 (18 – 23), *3a* 22 (22 – 23), *4a* 30 (27 – 31), *4b* 19 (18 – 20), *g* 15 (15 – 16), *p1* 15 (14 – 16), *p2* 20 (19 – 22) and *p3* 17 (16 – 18). Aedeagus curved at the tip, 9 (8 – 12).

Gnathosoma: chelicera 92; fixed and movable digits 19 and 27. Setal lengths: cheliceral 3, subcapitular 28, dorsal palptibial 11, lateral palptibial 24 – 26, dorsal palptarsal 9, terminal palptarsal solenidion 3 – 4 and *elcp* 7 – 8.

Legs: leg I 117 (110 – 135), tarsus 45 (41 – 47). Setal lengths: trochanter- *v'* 14 (13 – 15); femur- *bv''* 31 (29 – 32); genu- *l'* 23 (21 – 25), *l''* 32 (28 – 35), σ' 12 (11 – 13); tibia- *v'* 8 (8 – 9), *c''* 12 (12 – 13), Φ 105 (100 – 123); tarsus- $\omega 1$ 11 (11 – 12), ε 4 (3 – 4), $\omega 2$ 6 (5 – 6), *a''* 8 (7 – 11), $\omega 3$ 18 (17 – 18), *ft'* 11 (10 – 14), *a'* 11 (10 – 12), *pv'* 27 (25 – 28), *pv''* 21 (19 – 23), *ft''* 21 (20 – 23), *tc'* 10 (8 – 10), *tc''* 2 (2 – 3), *p'* 5 (4 – 5), *p''* 5, *u'* 4, *u''* 4 and *s* 3.

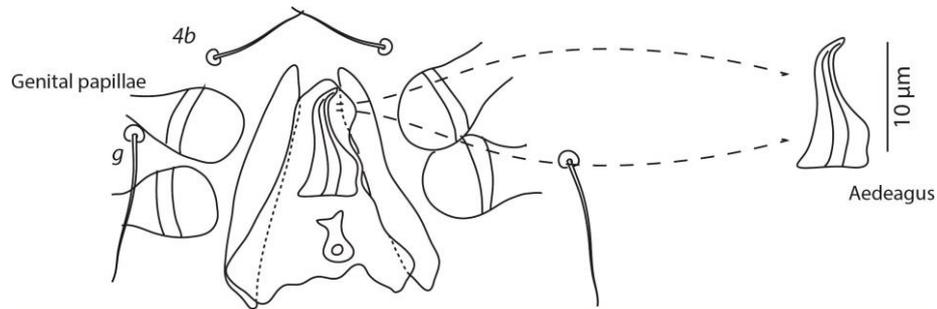


Figure 20 - *Neotropacarus n. sp. 2* (male) (A) Aedeagus.

Leg II 121 (120 – 127), tarsus 46 (45 – 49). Setal lengths: trochanter- v' 20 (18 – 22); femur- bv'' 26 (24 – 28); genu- l' 21 (19 – 23), l'' 17 (16 – 18), σ' 9 (9 – 10); tibia- v' 9 (8 – 9), c'' 11 (11 – 13), Φ 82 (75 – 100); tarsus- ωl 11 (10 – 13), a' 10 (9 – 12), pv' 31 (27 – 32), pv'' 20 (19 – 23), ft'' 23 (22 – 24), tc' 10 (10 – 11), tc'' 3 (2 – 3), p' 5 (4 – 5), p'' 5 (4 – 5), u' 4, u'' 4 and s 3.

Leg III 115 (112 – 120), tarsus 42 (41 – 44). Setal lengths: trochanter- v' 14 (11 – 16); genu- l' 21 (21 – 23), σ' 8 (7 – 10); tibia- v' 15 (12 – 17), Φ 105 (96 – 112); tarsus- pv' 14 (13 – 16), pv'' 18 (16 – 20), ft'' 22 (21 – 23), tc' 9 (8 – 11), tc'' 3, p' 5 (3 – 5), p'' 5 (4 – 5), u' 4 (3 – 4), u'' 4 and s 3 (2 – 3).

Leg IV 113 (108 – 121), tarsus 42 (41 – 44). Setal lengths: Femur- bv'' 14 (13 – 16); tibia- v' 13 (11 – 14), Φ 48 (46 – 52); tarsus- pv' 15 (14 – 16), pv'' 20 (18 – 21), tc' 8 (7 – 8), p' 6 (4 – 6), p'' 6 (5 – 6), u' 4 (3 – 4), u'' 4 and s 3 (2 – 3).

Neotropacarus n. sp. 3.

(Figs. 22 – 24)

Material examined

Holotype male and one paratype male from the Philippines: Leyte, 8.5 km N and 2.5 km E of Baybay, from nests of *Rhipidura* sp. (Passeriformes: Rhipiduridae), 23.v.1984, P.D. Heidman coll., deposited at University of Michigan Museum of Zoology.

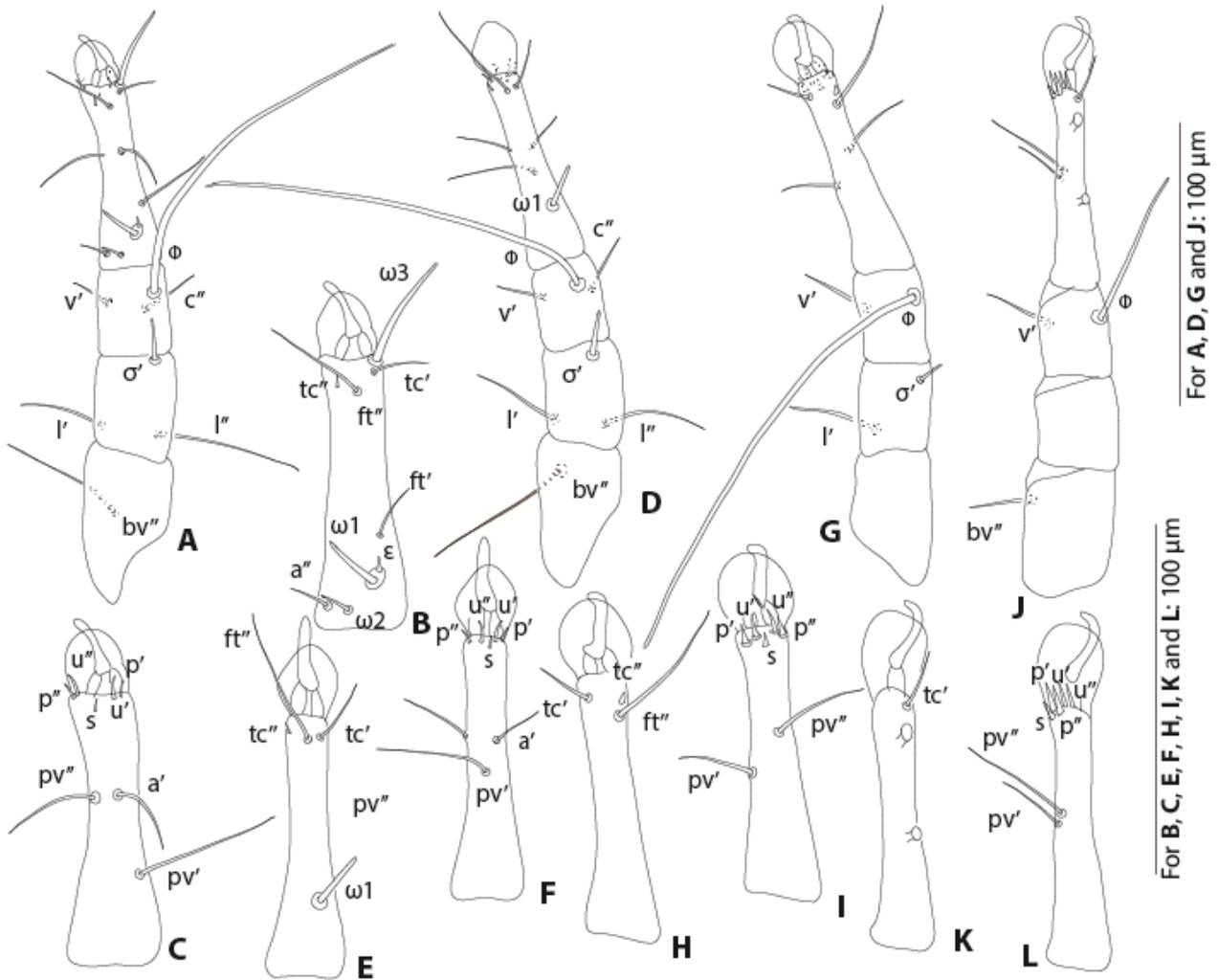


Figure 21 - *Neotropacarus n. sp. 2* (male). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view

Diagnosis

Males without le, c'' of tibiae I and II, and a'' and ft' of tarsus I; anall region with two pairs of setae, and a' and pv'' of tarsi I-II; el longer than the distance between its basis and the posterior edge of idiossoma, extending far beyond posterior edge of idiossoma.

Description

Female

One poorly sclerotized pharate female was observed, but none of the diagnostic character could be observed.

Male (Figs. 28 – 30; n = 2) long.

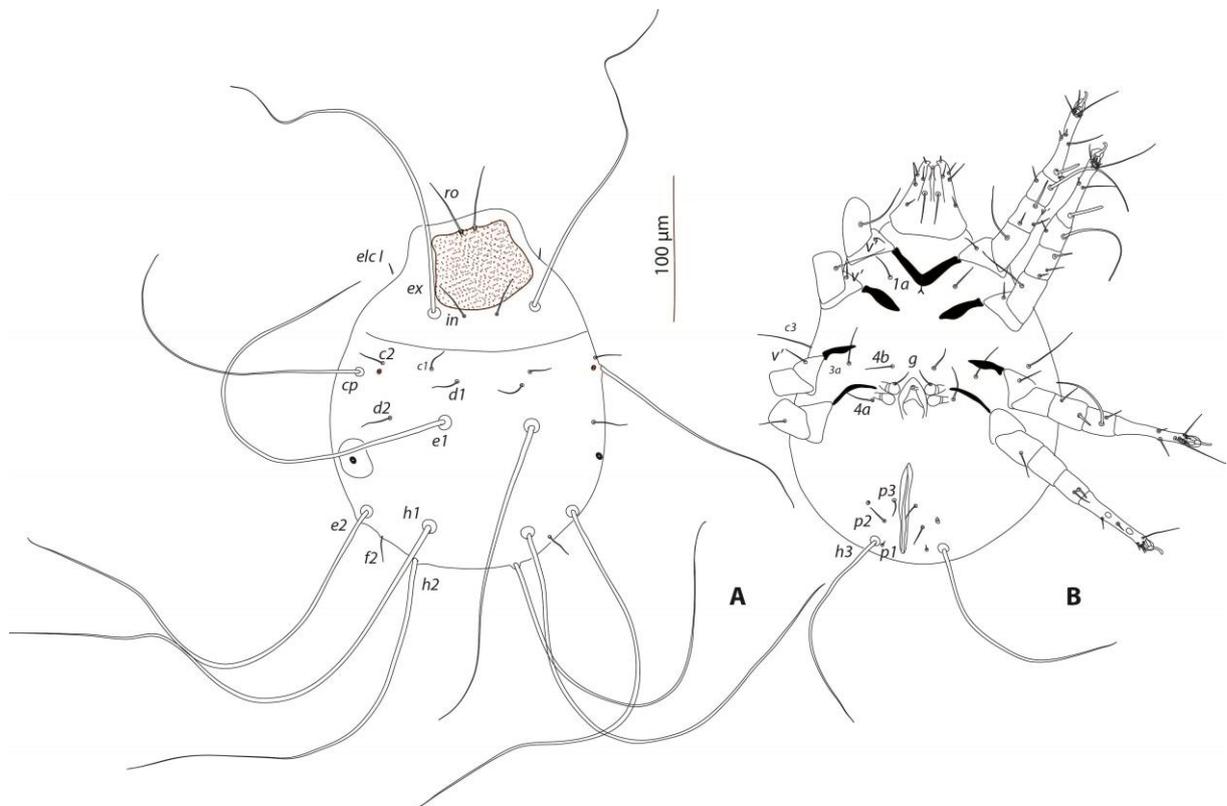


Figure 22 - *Neotropacarus* n. sp. 3 (male). (A) Dorsal view. (B). Ventral view.

Idiosoma: rounded, 195 – 257.

Dorsum: prodorsal sclerite 63 – 66, 52 – 56 wide at anterior margin and 72 wide at posterior margins; lightly sclerotized. Grandjean's organ bifurcate distally; supracoxal seta (*elc I*) 8 – 9 (spiniform). Setal lengths: *ro* 58 – 72, *in* 28 – 34, *ex* 242 – 325, *c1* 14 – 18, *c2* 18 – 19, *cp* 267 – 300, *d1* 21 – 22, *d2* 22 – 26, *e1* 325 – 375, *e2* 325 – 362, *f2* 18 – 20, *h1* 325 – 337, *h2* 350 – 375 and *h3* 162 – 175. Opisthotal gland posterolaterad of *e1*.

Venter: setal lengths: *c3* 17 – 20, *1a* 18 – 19, *3a* 21 – 25, *4a* 26 – 28, *4b* 12 – 22, *g* 14 – 18, *p1* 4 – 5, *p2* 9 – 10 and *p3* 13 – 14. Aedeagus curved, 16 – 18.

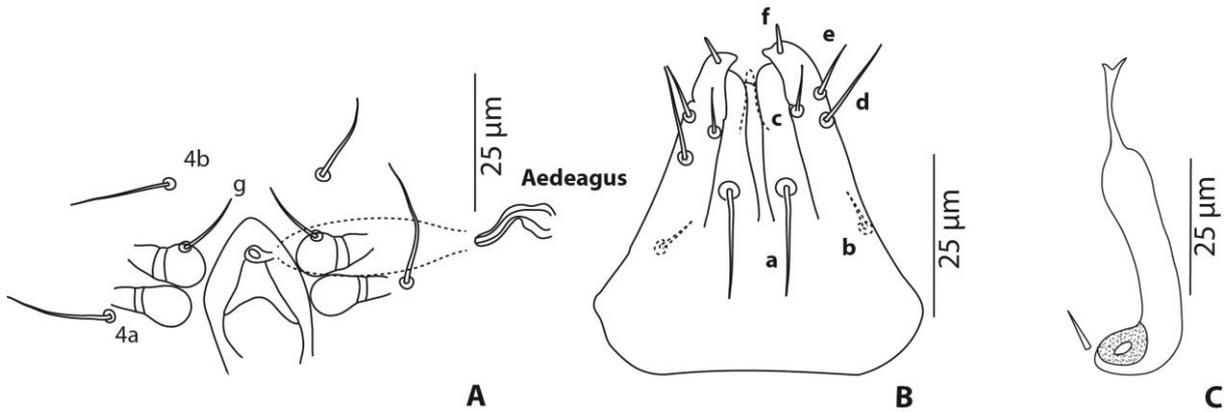


Figure 23 - *Neotropacarus* n. sp. 3 (male). (A) Aedeagus. (B) Gnathosoma - a- subcapitular (*subc*); b- supracoxal (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion. (C) Grandjean's organ.

Gnathosoma: chelicera 92 long; fixed and movable digits respectively 19 and 23 long. Setal measurements: Cheliceral seta not distinguishable, subcapitular 15 – 16, dorsal palptibial 12 – 13, lateral palptibial 7 – 8, dorsal palptarsal 16 – 18, terminal palptarsal solenidion 4 – 5 and *elcp* 7 – 8.

Legs: leg I 133 – 157, tarsus 58 – 64. Setal lengths: trochanter- v' 11 – 13; femur- bv'' 38 – 43; genu- l' 16 – 20, l'' 10 (spiniform), σ' 18 – 20; tibia- v' 7 – 9, Φ 65 – 70; tarsus- $\omega 1$ 21 (moderately tick and straight), ε as a small spine 2 – 3, $\omega 2$ 5 – 6 (straight), $\omega 3$ 13 – 14 (straight), a' 7 – 8 (spiniform), pv' 5 – 6 (spiniform), pv'' 32 – 34, ft'' 35 – 37, tc' 14 – 16, tc'' 2 – 3 (spiniform), p' 3, p'' 3 – 4, u' 4 – 5, u'' 5 and s 4.

Leg II 125 – 132, tarsus 50 – 56. Setal lengths: trochanter- v' 11 – 12; femur- bv'' 40 – 43; genu- l' 13 – 16, l'' 5 (spiniform), σ' 12 – 13; tibia- v' 6 – 7, Φ 80 – 89; tarsus- $\omega 1$ 25 – 27 (moderately tick and straight), a' 4 (spiniform), pv' 3 (spiniform), pv'' 20 – 23, ft'' 41 – 43, tc' 13 – 14, tc'' 2 – 3 (spiniform), p' 3 – 4, p'' 3, u' 4, u'' 4 and s 4.

Leg III 115 – 120, tarsus 50 – 53. Setal lengths: trochanter- v' 14 – 15; genu- l' 12 – 13, σ' 8 – 9; tibia- v' 10 – 11, Φ 80 – 85; tarsus- pv' 4 – 5 (spiniform), pv'' 16 – 18, ft'' 45 – 48, tc' 21 – 23, tc'' 2 – 3, p' 3 – 4, p'' 3, u' 4 – 5, u'' 4 and s 3.

Leg IV 130 – 137, tarsus 55 – 58. Setal lengths: femur- bv'' 14 – 15; tibia- v' 13 – 14, Φ 9 – 10; tarsus- pv' 7 – 8, pv'' 7 – 8, tc' 31 – 32, p' 4, p'' 3 – 4, u' 5, u'' 4 – 5 and s 4.

Taxonomic key to species of *Neotropacarus* (females and males)

In the separation of *Neotropacarus n. sp. 1* from *Neotropacarus n. sp. 3*, it is assumed that the chaetotaxy does not vary between females and males, as suggested by what is known for the other species of this genus.

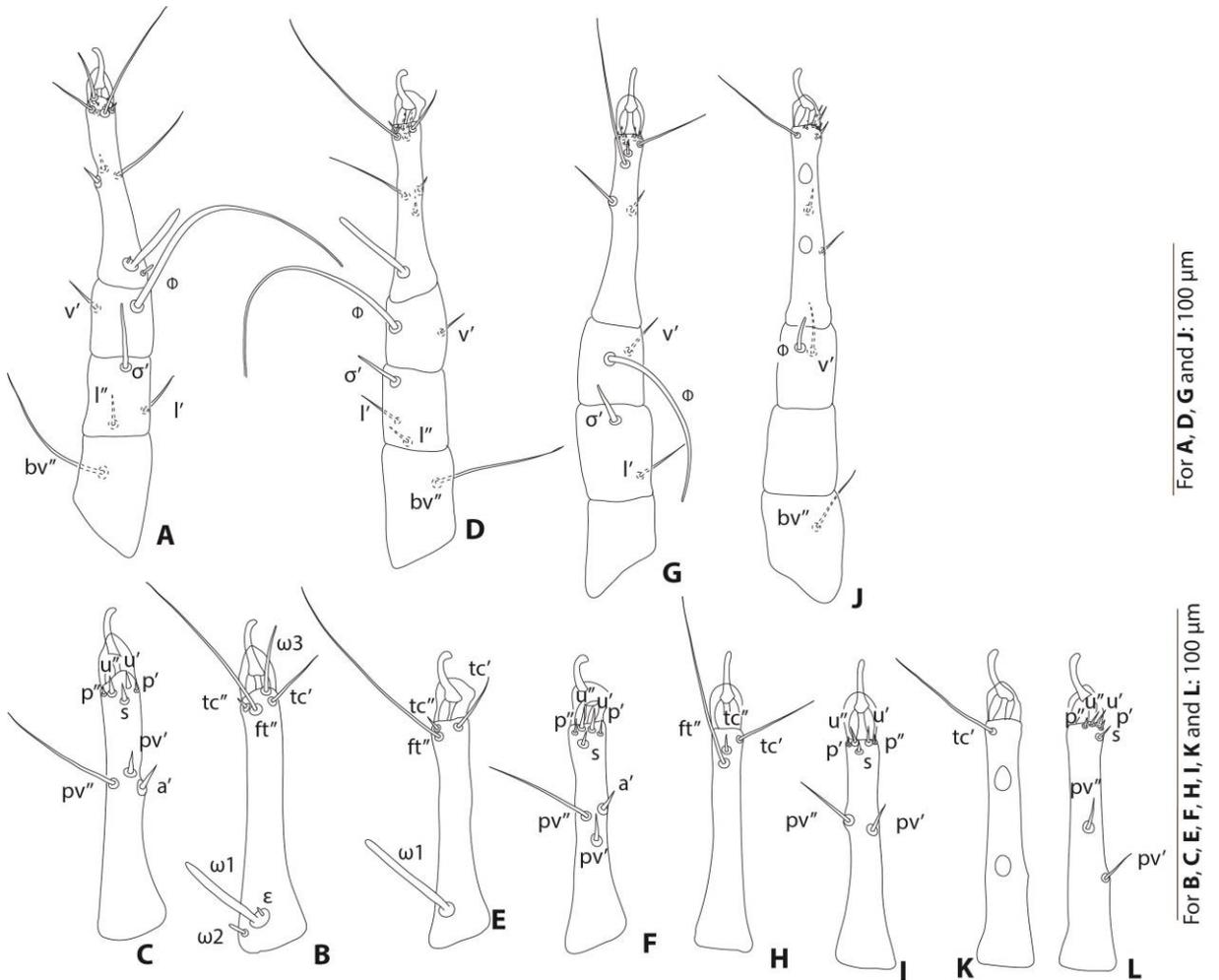


Figure 24 - *Neotropacarus n. sp. 3* (male). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

1. Seta *el* much longer than the distance between its basis and the posterior edge of idiosoma; *le* absent2
- 1'. Seta *el* shorter or as long as the distance between its basis and the posterior edge of Idiosoma; *le* presente.....3

2. Tibiae I-II with *c*”; one pair of paranal seta (*p3*).....*Neotropacarus n. sp.* 1
- 2’. Tibiae I-II without *c*”; three pairs of paranal setae (*p1 – p3*)*Neotropacarus n. sp.* 3
3. Tarsi I-II without *a*’ and *pv*”*Neotropacarus mumai* (Cunliffe)
- 3’. Tarsi I-II with *a*’ and *pv*”4
4. Tibiae I-II with *c*”.....*Neotropacarus n. sp.* 2
- 4’. Tibiae I-II without *c*”*Neotropacarus bakeri* (Collyer)

References

- BAKER, E.W. *Neotropacarus*, new name for *Tropacarus* Cunliffe (Acari: Acaridae). **International Journal of Acarology**, Oak Park, v. 11, n. 4, p. 289, 1985.
- COLLYER, E. The occurrence of some mites of the family Phytoseiidae in New Zealand, and descriptions of seven new species. **Acarologia**, v. 6, n. 4, p. 632-646, 1964.
- _____. A description of the female *Iphiseius acaridophagus* Collyer (Acarina: Phytoseiidae) and of *Tropacarus bakeri* n. sp. (Acaridae) and their association together. **New Zealand Entomologist**, Nelson, v. 3, n. 5, p. 11-16, 1966.
- CUNLIFFE, F. *Tropacarus*, a new genus of Acaridae (Acarina). **Proceedings of the Entomological Society of Washington**, Washington, v. 66, n. 3, p. 181-183, 1964.
- EWING, H.E. A synopsis of the genera of beetle-mites, with special reference to the North American fauna. **Annals of the Entomological Society of America**, College Park, v. 10, p. 117-132, 1917.
- GRANDJEAN, F. La chaetotaxie des pattes chez les Acaridae. **Bulletin de la Société zoologique de France**, Paris, v. 64, p. 50-60, 1939.
- GRIFFITHS, D.A.; ATYEO, W.T.; NORTON, R.A.; LYNCH, C.A. The idiosomal chaetotaxy of astigmatid mites. **Journal of Zoology**, London, v. 220, p. 1–32, 1990.
- KLIMOV, P. A review of acarid mites of the tribe Caloglyphini (Acaridae: Acariformes) with description of a new genus and species from Siberia and Russian Far East. **Vestnik Zoologii**, Kyiv, v. 34, p. 27-35, 2000.
- MUMA, M.H. Mites associated with citrus in Florida. **Florida Agricultural Experiment Stations Bulletin**, Gainesville, v. 640, p. 1-39, 1961.
- CONNOR, B. Cohort Astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A Manual of Acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

ZHANG, Z.-Q. *Neotropacarus bakeri* (Collyer, 1967) rediscovered (Sarcoptiformes: Acaridae). **Systematic and Applied Acarology**, London, v. 17, p. 242, 2012.

4 DESCRIPTION OF TWO NEW GENERA AND SIX NEW SPECIES OF ACARID (ACARIDAE: HORSTIINAE) MITES ASSOCIATED WITH APID (HYMENOPTERA: APIDAE) BEES

Abstract

Two new genera of Horstiinae (Acaridae), **Gen. 1** and **Gen. 2** and seven new species, **Gen. 1 n. sp. 1**, **Gen. 1 n. sp. 2**, **Gen. 1 n. sp. 3**, **Gen. 1 n. sp. 4**, **Gen. 1 n. sp. 5**, **Gen. 1 n. sp. 6** and **Gen. 2 n. sp. 1** are described from Euglossini bees (Apoidea: Apidae). **Gen. 1** is unique in having deutonymphs with dorsal sclerite punctate and covered by scale-like structures; coxal setae *1a* and *4b* setiform, *3a* and *4a* represented by vestigial alveoli; tarsi much longer than wide; tarsi I-II with five foliate setae (*a'*, *pv''*, *tc'*, *tc''* and *p'*); tarsus III with six foliate setae (*pv''*, *tc'*, *tc''*, *ft''*, *p'* and *p''*) and tarsus IV with five foliate setae (*tc'*, *tc''*, *ft''*, *p'* and *p''*); adult females with dorsal setae stout, *le* positioned at podocephalic shield and *tc'* and *tc''* slightly asymmetrical; adult males with same characteristics as females, besides aedeagus distally curved; setae *h3*, *ps1* and *ps2* in line and posterior to suckers. **Gen. 2 n. sp. 1** is unique in having deutonymphs with dorsal sclerite punctate and striate; coxal setae *1a* and *4b* setiform, *3a* and *4a* represented by vestigial alveoli; tarsi almost as long as wide; empodial claws strongly hooked and with basal lobe, base of claws with flattened medial expansion; tarsi I-II with five foliate setae (*a'*, *pv''*, *tc'*, *tc''* and *p'*), tarsus III with six foliate setae (*pv''*, *tc'*, *tc''*, *ft''*, *p'* and *p''*) and tarsus IV with five foliate setae (*tc'*, *tc''*, *ft''*, *p'* and *p''*).

Keywords: Taxonomy; Bee mites; Acaridae

a. Introduction

Horstiinae was proposed by Fain (1984) within the Acaridae to include two bee associated genera, *Horstia* Oudemans, 1905 and *Ceroglyphus* Vitzthum, 1919. OConnor (1988) constituted nine Astigmatina groups (including two distinct acarid groups) that he considered to have evolved permanent ecological associations with bees. He also expanded the concept of Horstiinae to include one of the two bee associated acarid groups that he proposed. This group consisted of eleven genera, including two undescribed genera, one collected from *Anthophora* Latreille, 1803 and *Amegilla* Friese, 1897 and the other from *Epicharis* Klug, 1807. OConnor (1988) also synonymized *Horstia* and *Ceroglyphus*, and mentioned two additional bee genera (*Eulaema* Lepeletier de Saint-Fargeau, 1841 and *Euglossa* Latreille, 1802) (Hymenoptera: Apidae) as host for *Horstiella* Turk, 1948, one of the genera composing the acarid group he placed in Horstiinae.

Ochoa and OConnor (2000) considered that the species reported by OConnor (1988) in association with *Euglossa* and *Eulaema* and placed by him in *Horstiella* actually belonged to

two undescribed genera. The objective of this work is to describe those two new genera based on the specimens studied by OConnor (1988).

b. Material and Methods

Mites were collected from bees deposited at The Field Museum, Chicago, Illinois, USA. Bees were examined under stereomicroscope and mites found were mounted in Hoyer's medium by B. M. OConnor. Measurements were taken using a microscope provided with a graded ocular, while illustrations were done by first photographing the mites with a digital camera connected to the microscope and latter processing the photos with a digital tablet (Wacom Bamboo CTH-470L), using the Adobe Illustrator® program. Measurements are given in micrometers; in the text, average measurements are given, followed (in parentheses) by the respective ranges. Idiosomal chaetotaxy follows the system developed by Grandjean (1939) and applied to the Astigmatina by Griffiths (1990). Leg setation follows that proposed by OConnor (2009).

c. Results

Systematics

Gen. 1 n. gen.

(Figs. 1 – 24)

Type species. Gen. 1 n. sp. 4, by original designation.

Description

Adult female and male

Dorsum (Figs. 1A; 2B; 13A; 16A; 17A)- Smooth. Prodorsal sclerite subrectangular, connected to podocephalic shield by a sclerotized transverse band. Holotrichous; all dorsal setae setiform, smooth and stout, except *le* and *elc I*, slender; *ro* seta close together at apex of prodorsum; *le* almost in transverse line with *ro*, near connection between sclerotized band and podocephalic shield; *ex* only slightly anterior of *in*. Opisthonotal gland posterolaterad of *d2*, anterior of *e2*.

Venter (Figs. 1B; 13B; 16B)- Distance between posterior edge of anal opening and posterior edge of idiosoma about the same as length of anal opening, the latter surrounded by six pairs of setae, *ps1* and *ad1* longest. Copulatory opening between anal opening and posterior edge of idiosoma. Oopore and aedeagus between coxae III and IV; oopore longer than wide and aedeagus distally curved.

Gnathosoma (Figs. 2C-D; 14B-C)- Short and massive, not more than 1.5 times as long as wide. Fixed cheliceras digit bearing 3 – 5 teeth and movable cheliceral digit with three teeth, cheliceral seta (*cha*) setiform.

Legs (Figs. 3A-L; 15A-L; 18A-L)- Tarsi elongate, more than twice longer than respective basal width; $\omega 2$ anterior of $\omega 1$; *a'* and *pv''* setiform; *ft''* slightly foliate. Tarsal copulatory suckers in male antereomedian, with rod-shaped base and wide, flat.

Deutonymph

Dorsum (Figs. 4A; 7A; 10A; 19A; 22A; 25A)- Prodorsal sclerite subtriangular; both prodorsal and hysterosomal shields punctate, with punctation densest posteriad of *e1*, ornamented with scalelike structures variable in size and distribution. On both shields setae thin and short, *h3* longest; *ro* seta contiguous, at apex of prodorsal; *ex* anteroterad of *in*; *h1* well anterior of *h2* and *h3*; each *h3* seta arising from a tubercle.

Venter (Figs. 4B; 7B; 10B; 19B; 22B; 25B)- Sternal apodeme straight, with posterior end bifurcate or entire and swollen, reaching level of anterior apodeme II. Coxal field III open or closed. Inner end of posterior apodeme II fused with anterior apodeme III. Posterior apodeme III fused with apodeme IV. Coxal setae *1a* and *4b* setiform; *3a* and *4a* represented by vestigial alveoli. Genital papillae distally pointed. Attachment organ well developed, with two pairs of conoidal setae, *ps1* and *ps2*, that are respectively posteriad and laterad of *ad1* + *ad2*, which is in line and posteriad of *ad3*; with five cuticular suckers; *ps3* represented by alveoli.

Gnathosoma (Figs. 5; 8; 11; 29; 23; 26)- Gnathosoma not protruding beyond anterior edge of prodorsum, varying from shorter to longer than wide.

Legs (Figs. 6A-L; 9A-L; 12A-L; 21A-L; 24A-L; 27A-L)- Tarsi more than twice longer than respective basal width. Tarsus I unusual for retaining *ft'*; $\omega 2$ anterior of $\omega 1$; $\omega 3$ positioned at the middle of the tarsus. Tarsi I-II with five foliate setae (*a'*, *pv''*, *tc'*, *tc''* and *p'*) and without *p''*, tarsus III with six foliate setae (*pv''*, *tc'*, *tc''*, *ft''*, *p'* and *p''*) and tarsus IV with five foliate setae (*tc'*, *tc''*, *ft''*, *p'* and *p''*). Seta *pv'* III setiform and *s* III-IV spiniform. Empodial claw of legs I-IV strongly hooked.

Remarks

Two acarid diagnostic characteristics are unusual in adults of this new genus: tc' and tc'' only slightly different in length (tc' distinctly longer than tc'' in other acarids) and u' and u'' only slightly larger and thicker than than prorals p' and p'' (instead of distinctly larger and stouter). These features could lead to uncertainty about the placement of **Gen. 1** in Acaridae or Gaudiellidae, but we here follow the decision of OConnor (1992), who transferred *Rhypoglyphus indicus* (Potter and Olsen), from Gaudiellidae to Acaridae, despite the fact that it also presented tc' and tc'' only slightly different in length and u' and u'' only slightly larger and thicker than than prorals p' and p'' .

Adults of *Cerophagopsis* Zachvatkin, 1941 are similar to **Gen. 1** in relation to those characteristics and in having le displaced anterolaterally (in that case, on podocephalic shield), but they have dorsal setae filiform and ex well anterior of in .

Deutonymphs of **Gen. 1** are similar to *Cerophagopsis* by having seta a'' present on tarsus I, s absent on tarsi I-II; ft' present on tarsi I-II, but differ by having empodial claw regular in shape (strongly hooked, base of claw with flattened medial expansion in *Cerophagopsis*) and by the absence of seta p'' on tarsi I-II.

Deutonymphs of other genera of Horstiinae differ from **Gen. 1** by the following characters:

Horstia- Seta $1a$ absent; ft' and a'' absent on tarsus I; tarsus IV with ft'' , tc' and tc'' longer than leg IV.

Diadasiopus OConnor- Setae $3a$ and $4a$ present; ft' absent on tarsus I; tarsus IV with pv' and tc'' longer than leg IV; p'' present on tarsi I-II; s of tarsi III-IV foliate.

Horstiella Turk- Setae $1a$ and $4b$ absent and $4a$ as a large conoid; ft' and a'' absent on tarsus I; p'' present on tarsi I-II; s of tarsi III-IV foliate.

Medeus Volgin- Setae $3a$ and $4a$ present and $4b$ absent; ft' and a'' absent on tarsus I; p'' present on tarsi I-II; s on tarsi III-IV foliate.

Megachilopus Fain- Seta s on tarsi III-IV filiform.

Sennertionyx Zachvatkin- Setae ft' and a'' absent on tarsus I; ft'' , tc' and tc'' of tarsus IV longer than leg IV.

Gen. 1 n. sp. 1.

(Figs. 1 – 3)

Material examined

Holotype female and three paratype females in nest cells with meconium and pre-emergent adults of *Euglossa townsendi* Cockerel, Panama: Panama City, 14.V.1991, coll. B.M. OConnor.

Diagnosis of adult female

Most dorsal setae shorter than 30 μm ; seta *in* much shorter than *ex*; *cp* similar in length to *c1* and *c2*; *h3* much longer than other *h* setae. In all legs, *ft*'' in transverse line with *tc*' and *tc*''.

Description of adult female

Dorsum (Figs. 1A; 2B): Idiosoma subpentagonal, 410 (400 – 425) long, cuticle smooth. Prodorsal sclerite subrectangular, evenly punctate, 92 long and 86 wide at sejugal furrow level, connected to podocephalic shield by a sclerotized apical, transverse band. Dorsal setae smooth and stout, except *le* and *elc I*, setiform. Grandjean's organ divided in 7–9 terminal branches. Setae *ro* close to each other, at apex of prodorsal sclerite; *le* about in transverse line with *ro*, at the connection between the sclerotized apical transverse band and the podocephalic shield. Opening of opisthonotal gland posterolaterad of *d2*. Setal lengths: *ro* 41 (38 – 43), *le* 11, *in* 18, *ex* 45, *elc I* 41 (40 – 42), *c1* 16 (13 – 18), *c2* 23 (20 – 30), *cp* 28 (20 – 36), *d1* 17 (14 – 18), *d2* 17 (15 – 21), *e1* 24 (21 – 29), *e2* 20 (17 – 23), *f2* 15, *h1* 29 (28 – 30), *h2* 37 (35 – 40), *h3* 87 (85 – 90).

Venter (Fig. 1B): Setal lengths: *c3* 22 (20 – 24), *1a* 36 (35 – 38), *3a* 20 (18 – 22), *4a* 26 (22 – 30), *4b* 17, *g* 24 (19 – 28), *ad1* 50 (42 – 60), *ad2* 9 (8 – 11), *ad3* 11, *ps1* 19 (18 – 22), *ps2* 11 (10 – 12) and *ps3* 17 (16 – 20).

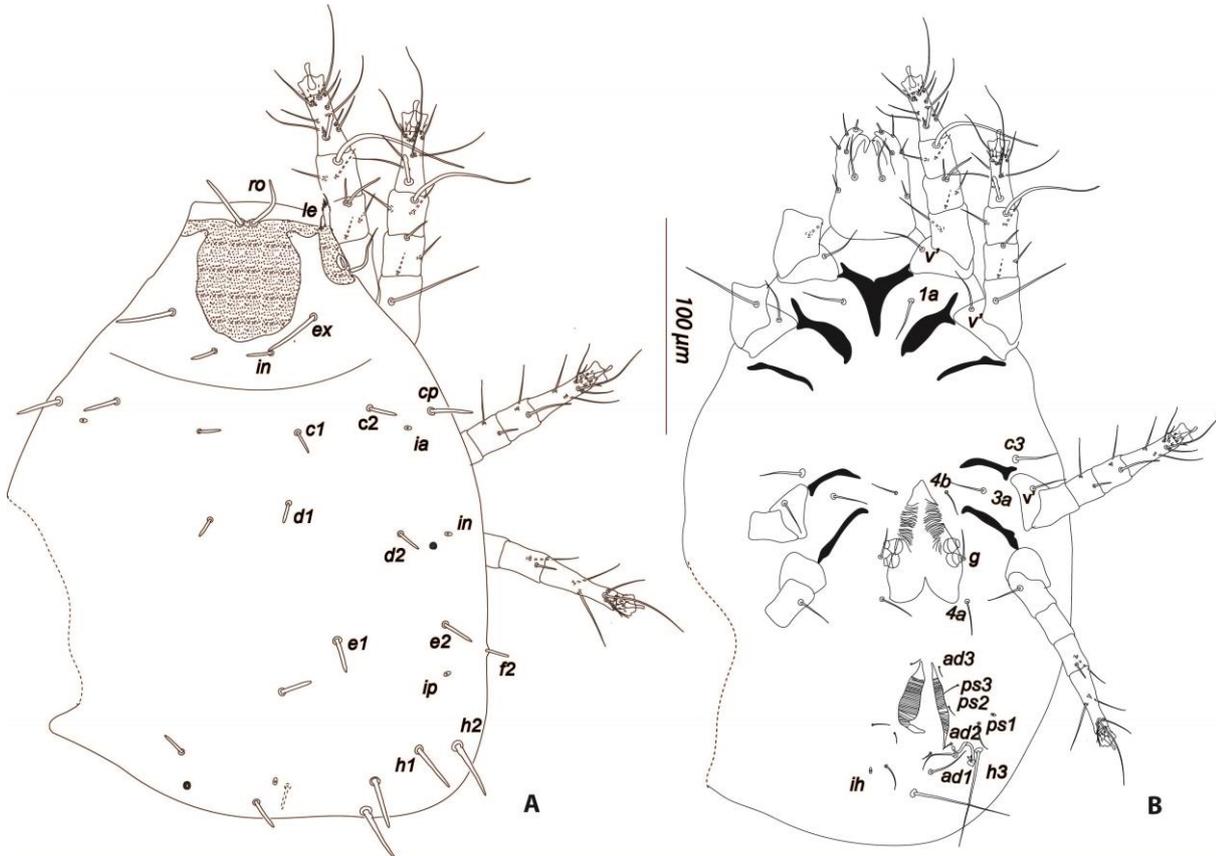


Figure 1 - **Gen. 1 n. sp. 1** (female). (A) dorsal view. (B) ventral view.

Spermatheca (Fig. 2A): Shape of sclerotized basis of spermatheca not distinguishable because of position of specimen; distance between sclerites 18 (16 – 24), spermathecal duct as a wide tube.

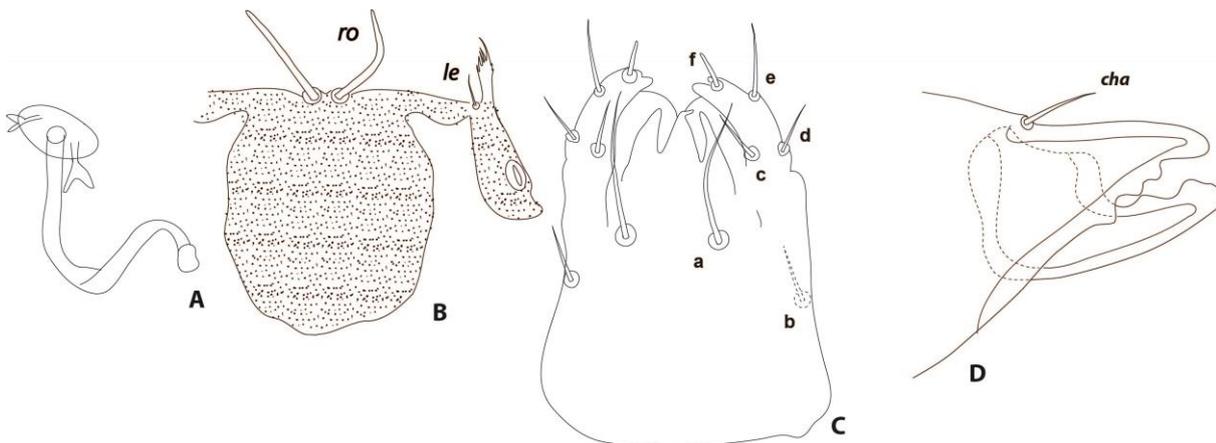


Figure 2 - **Gen. 1 n. sp. 1** (female). (A) spermatheca. (B). prodorsal sclerite. (C) Gnathosoma [a- subcapitular seta (*subc*); supracoxal seta (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion]. (D) chelicera.

Gnathosoma (Fig. 2C-D): Chelicera chelate; shaft 90 (83 – 89), fixed digit 21 (18 – 26), with three teeth; movable digit 30 (25 – 32), with three teeth, the apical one distinctly larger than other two teeth; cheliceral seta (*cha*) setiform, 8 (7 – 10). Subcapitular seta (*subc*) 34, dorsal palptibial seta 13; lateral palptibial seta 18; dorsal palptarsal seta 17 and terminal palptarsal solenidion 7; seta supracoxal (*elcp*) 14.

Legs (Fig. 3A-L): Leg I 120, tarsus 34 (32 – 35), *v'* 30 (24 – 35), *bv''* 50 (45 – 53), *l'* 14, *l''* 19 (17 – 22), σ' 11 (9 – 15), σ' 22 (19 – 27), *v'* 15 (12 – 18), *c''* 16 (13 – 20), Φ 61 (60 – 65), $\omega 1$ 14 (13 – 15), slightly swollen at the tip, ε 7, $\omega 2$ 12 (10 – 13), $\omega 3$ 14 (12 – 16), *a''* 22 (18 – 25), *ft'* 19 (16 – 20), *a'* 14 (13 – 15), *pv'* 20 (17 – 23), *pv''* 40 (38 – 42), *tc'* 42 (46 – 52), *ft''* 67 (61 – 70), *tc''* 24 (22 – 26), *p'* 8, *p''* 8 (8 – 9), *u'* 11, *u''* 12 (11 – 12) and *s* 8.

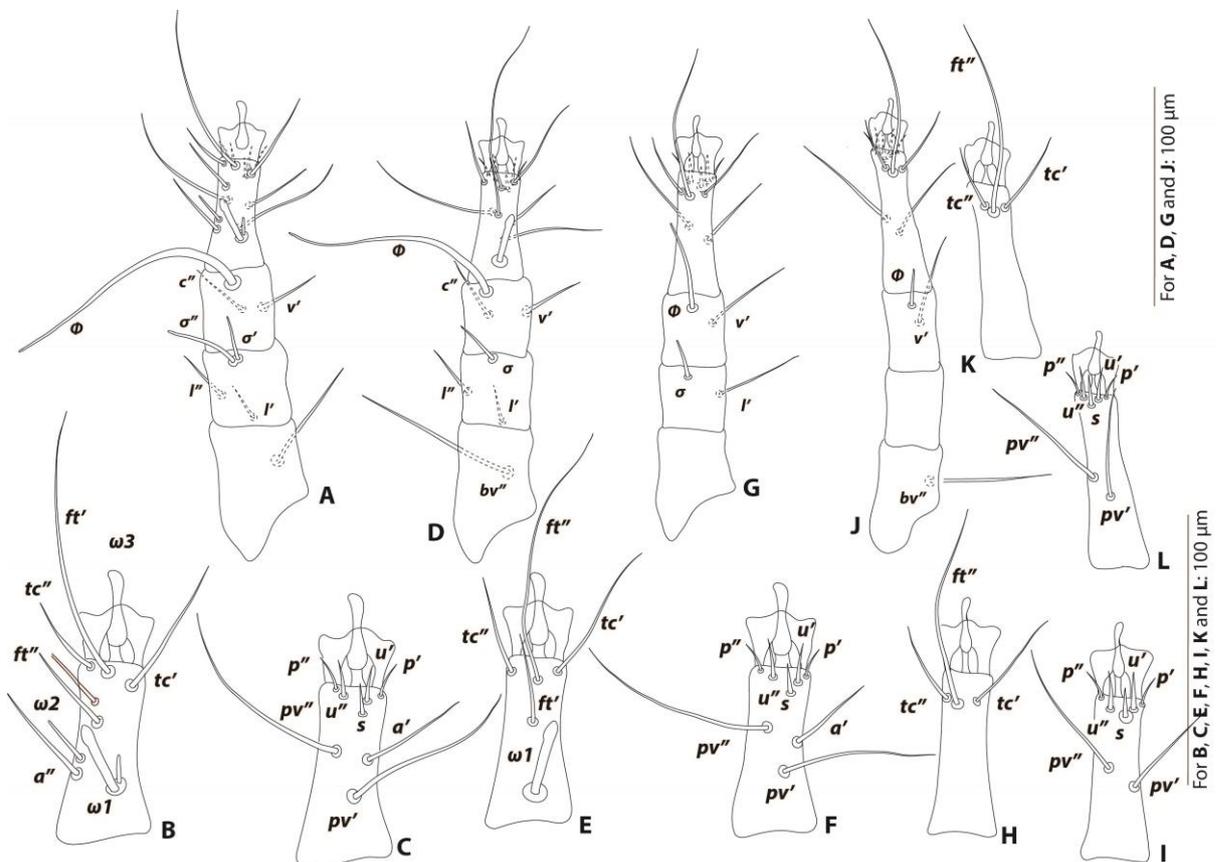


Figure 3 - **Gen. 1 n. sp. 1** (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Leg II 115 (112 – 118), tarsus 34 (32 – 35), *v'* 33 (30 – 35), *bv''* 50 (47 – 53), *l'* 11 (10 – 13), *l''* 17 (13 – 21), σ 13 (11 – 15), *v'* 16 (13 – 19), *c''* 19 (15 – 25), Φ 58 (55 – 60), $\omega 1$ 16 (15 – 17), slightly swollen at the tip, *ft'* 20 (18 – 23), *a'* 18 (17 – 18), *pv'* 34 (30 – 36), *pv''* 42 (34 –

46), *tc'* 27 (25 – 30), *ft''* 52 (48 – 58), *tc''* 27 (25 – 30), *p'* 8, *p''* 9, *u'* 9, *u''* 10 and *s* 8; *ft''* foliate.

Leg III 108 (107 – 110), tarsus 34 (32 – 35), *v'* 41 (40 – 42), *l'* 24 (23 – 24), σ 9 (8 – 9), *v'* 27, Φ 25, *pv'* 29 (25 – 33), *pv''* 35 (33 – 37), *tc'* 25, *ft''* 56 (53 – 60), *tc''* 19 (19 – 20), *p'* 8, *p''* 9, *u'* 9, *u''* 9 and *s* 10.

Leg IV 123 (117 – 130), tarsus 42, *bv''* 30, *v'* 24 (23 – 25), Φ 12 (11 – 13), *pv'* 29 (25 – 33), *pv''* 31 (28 – 34), *tc'* 35, *ft''* 110, *tc''* 20, *p'* 9, *p''* 8, *u'* 10, *u''* 10 and *s* 9.

Adult male and deutonymph- Unknown.

Gen. 1 n. sp. 2.

(Figs 4 – 6)

Material examined

Holotype deutonymph and three paratype deutonymphs under posterior metasomal sternite of *Euglossa asarophora* Moure & Sakagami from San José, San Jeronimo and Sabanilla, Costa Rica, 21.V.1971, coll. A. Wille and E. Orozco.

Diagnosis of deutonymph

Seta *ro* longer than *le*. Posterior end of sternal apodeme bifurcate; coxal field III closed. Gnathosoma longer than wide and gnathosomal solenidion about 1.8 times longer than the length of the gnathosoma. Seta *tc''* of tarsi I about 4.2 times longer than *ft''*; seta *ft''* of tarsi III about 2.2 times longer than *tc''* and seta *ft''* of tarsi IV about 3.0 times longer than *tc''*.

Description of deutonymph

Dorsum (Fig. 4 A): Idiosoma 381 (375 – 387) long and 248 (235 – 260) wide at widest level. Prodorsal sclerite 116 (107 – 125), ornamented with diagonal or transverse scalelike structures. Hysterosomal shield 275 (262 – 287), ornamented with uniform and mostly longitudinal scalelike structures. Dorsal setal lengths: *ro* 10 (9 – 10), *le* 7 (7 – 8), *in* 6 (5 – 7), *ex* 6 (5 – 6), *elc I* 15 (14 – 16), *c1* 6 (5 – 7), *c2* 5 (5 – 6), *cp* 8 (7 – 9), *d1* 5 (5 – 6), *d2* 5 (5 – 6), *e1* 8, *e2* 9 (7 – 10), *f2* 9 (8 – 11), *h1* 7 (6 – 7), *h2* 10 (9 – 11), *h3* 22 (20 – 24).

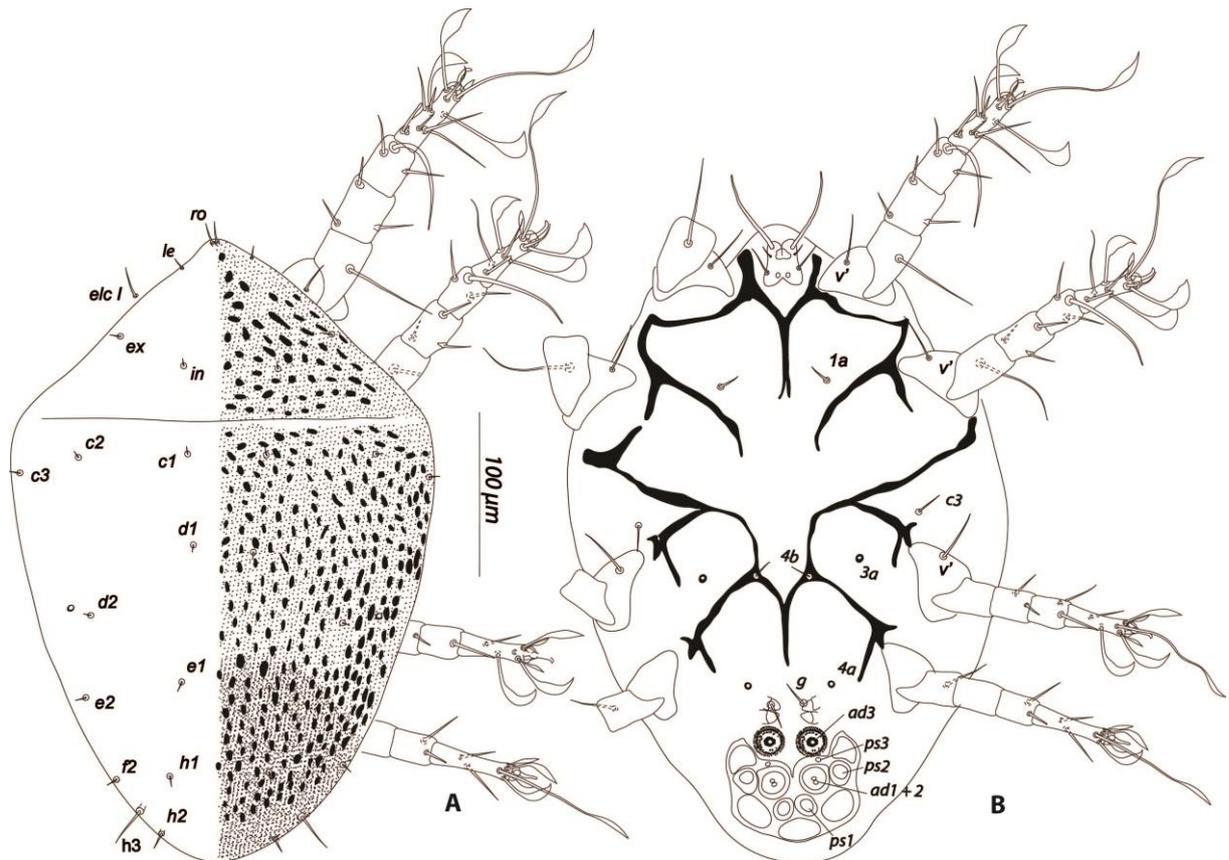


Figure 4 - **Gen. 1 n. sp. 2** (deutonymph). (A) dorsal view. (B) ventral view.

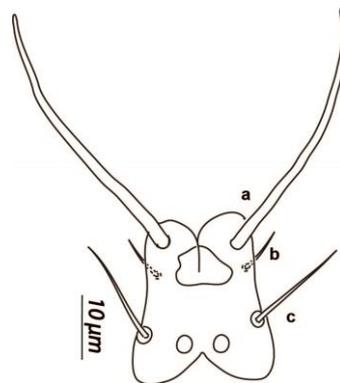


Figure 5 - **Gen. 1 n. sp. 2** (deutonymph). Gnathosoma [a- gnathosomal solenidion; b- anterior gnathosomal seta; c- posterior gnathosomal seta].

Venter (Fig. 4B): Sternal apodeme bifurcate at posterior end; coxal field III closed. Setae *1a*, *4b* and *g* 14 (11 – 15), 11 (9 – 13) and 17 (16 – 17), respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1 + ad2*) 12 (11 – 15) and 17 (13 – 18), respectively. Cupule *ih* not distinguishable.

Gnathosoma (Fig. 5): 21 (20 – 23) long and 17 (17 – 18) wide at basis, anterior gnathosomal seta 5 (4 – 5), posterior gnathosomal seta 12 (12 – 13), gnathosomal solenidion 36 (35 – 49).

Legs (Fig. 6A-L): Leg I 152 (147 – 160), tarsus 47 (40 – 55) long and 13 (12 – 15) wide at basis, v' 24 (22 – 27), bv'' 64 (63 – 65), l' 17 (16 – 18), l'' 20 (19 – 21), σ' 17 (13 – 15), v' 21 (18 – 24), c'' 23 (23 – 24), Φ 64 (63 – 65), $\omega 1$ 21 (19 – 23), straight, ε 6 (5 – 6), $\omega 2$ 12 (9 – 13), $\omega 3$ 12 (11 – 13), a'' 34 (32 – 37), ft' 25 (23 – 26), a' 44 (46 – 53), pv' 39 (35 – 43), pv'' 61 (60 – 62), tc' 62 (59 – 67), ft'' 26 (25 – 27), tc'' 116 (103 – 135), p' 22 (19 – 23).

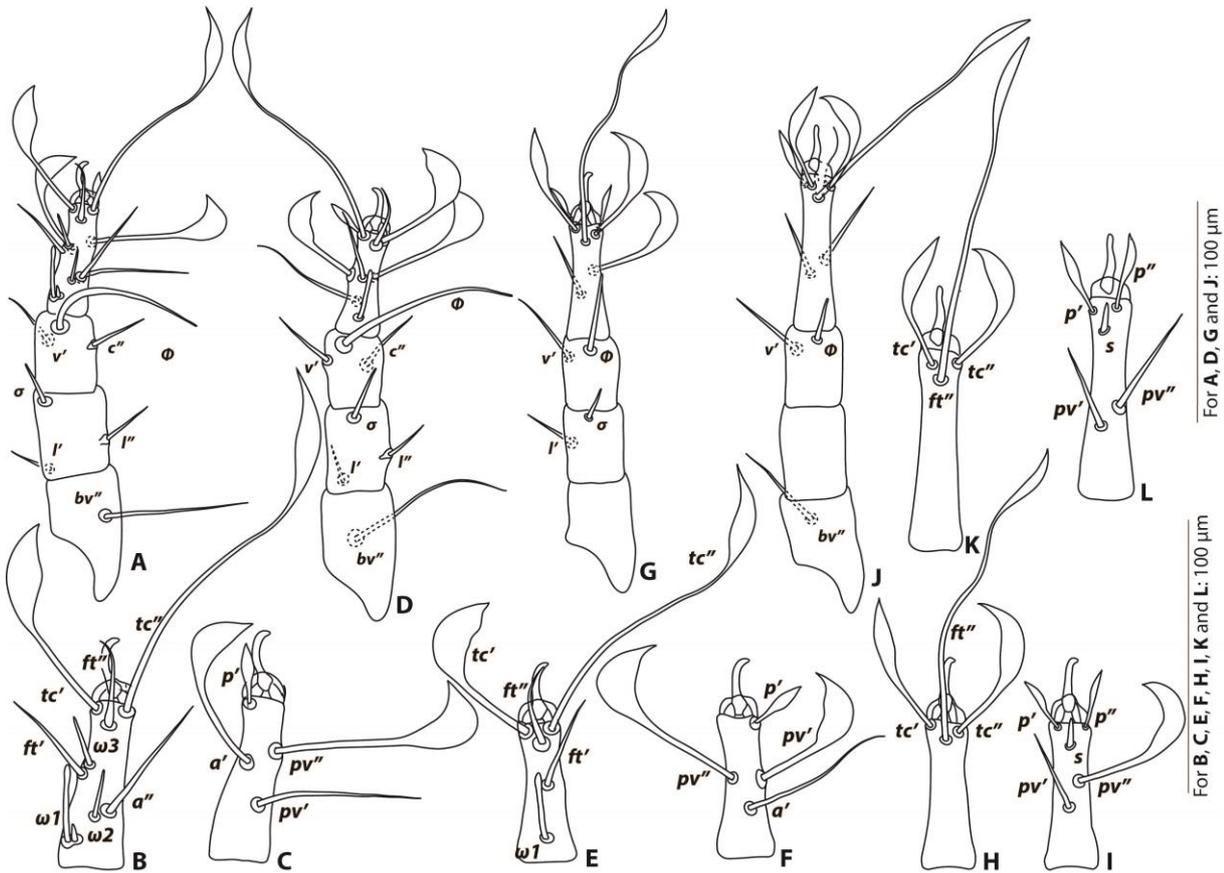


Figure 6 - **Gen. 1 n. sp. 2** (deutonymph). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Leg II 139 (136 – 142), tarsus 37 (36 – 38) long and 13 (12 – 13) wide at basis, v' 26 (24 – 29), bv'' 64 (62 – 65), l' 16 (14 – 18), l'' 18 (17 – 20), σ' 18 (17 – 18), v' 21 (20 – 23), c'' 25 (23 – 28), Φ 62 (61 – 63), $\omega 1$ 23 (21 – 24), straight, ft' 21 (20 – 21), a' 40 (38 – 43), pv' 42 (37 – 47), pv'' 56 (53 – 60), tc' 59 (54 – 63), ft'' 26 (23 – 29), tc'' 105 (96 – 115), p' 22 (21 – 23).

Leg III 121 (115 – 128), tarsus 37 (36 – 38) long and 14 (12 – 14) wide at basis, v' 26 (24 – 28), l' 19 (18 – 19), σ' 10 (9 – 11), v' 29 (28 – 29), Φ 26 (24 – 29), pv' 22 (21 – 23), pv'' 43 (40 – 46), tc' 37 (32 – 42), ft'' 93 (90 – 96), tc'' 43 (42 – 44), p' 16 (15 – 18), p'' 16 (16 – 17), s 9 (8 – 9).

Leg IV 135 (130 – 137), tarsus 43 (39 – 46) long and 13 (12 – 13) wide at basis, *bv*'' 27 (26 – 29), *v*' 25 (23 – 26), Φ 12 (11 – 13), *pv*' 22 (21 – 24), *pv*'' 25 (24 – 29), *tc*' 31 (28 – 32), *ft*'' 97 (88 – 105), *tc*'' 33 (30 – 39), *p*' 18 (16 – 21), *p*'' 19 (18 – 21), *s* 10 (9 – 10).

Adults- Unknown.

Gen. 1 n. sp. 3.

(Figs. 7 – 9)

Material examined

Holotype deutonymph and two paratype deutonymphs associated with *Euglossa dilemma* Bembé and Eltz from Fort Lauderdale, Broward County, Florida, USA, 28.VIII.2004, coll. R. W. Pemberton.

Diagnosis of deutonymph

Seta *ro* slightly longer than *le*. Sternal apodeme bifurcate; coxal field III closed. Gnathosoma longer than wide and gnathosomal solenidion about 2.1 times longer than the length of the gnathosoma. Seta *tc*'' of tarsi I-II as about 3.2 times longer than *ft*''; seta *ft*'' of tarsi III about 1.5 times longer than *tc*'' and seta *ft*'' of tarsi IV about 1.6 times longer than *tc*''.

Description of deutonymph

Dorsum (Fig. 7A): Idiosoma 287 (285 – 300) long and 174 (157 – 185) wide at widest level. Prodorsal sclerite 84 (80 – 85), ornamented with diagonal or transverse scalelike structures. Hysterosomal shield 205 (194 – 212), ornamented with scalelike structures uniform and longitudinal behind *d1* and sorted in parallel and mesally convergent lines anterior of *d1*. Dorsal setal lengths: *ro* 12 (11 – 13), *le* 8 (8 – 9), *in* 4 (4 – 5), *ex* 6 (5 – 7), *elc I* 18 (17 – 19), *c1* 4 (3 – 4), *c2* 5, *cp* 7 (6 – 8), *d1* 4 (4 – 5), *d2* 5 (5 – 6), *e1* 8 (7 – 8), *e2* 5 (5 – 6), *f2* 7 (7 – 8), *h1* 6 (5 – 8), *h2* 9 (8 – 10), *h3* 23 (23 – 24).

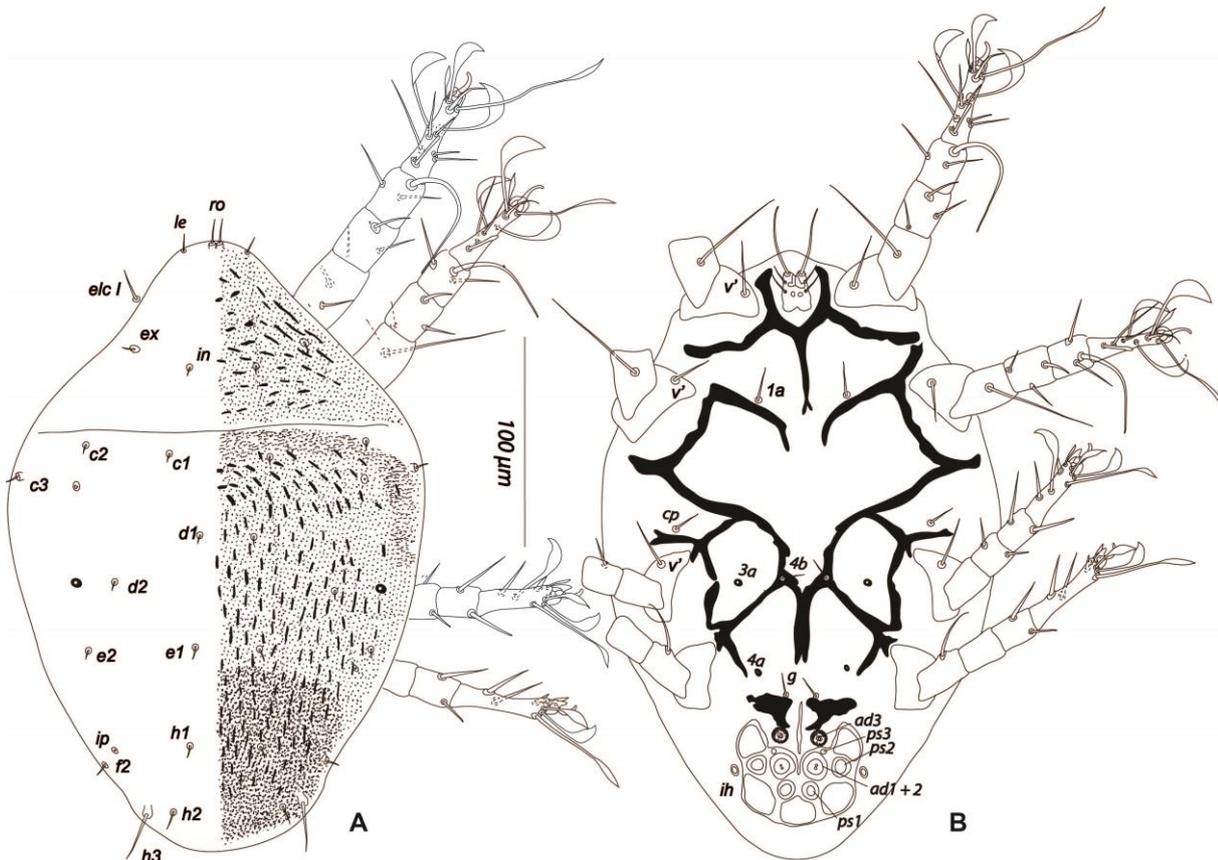


Figure 7 - **Gen. 1 n. sp. 3** (deutonymph). (A) dorsal view. (B). ventral view.

Venter (Fig. 7B): Sternal apodeme bifurcate at the tip; coxal field III closed. Setae *1a*, *4b* and *g* 20 (18 – 22), 13 (13 – 14) and 13 (13 – 14), respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1 + ad2*) 10 (9 – 12) and 15 (13 – 17), respectively. Cupule *ih* laterad of attachment organ.

Gnathosoma (Fig. 8): 18 (17 – 19) long and 14 (17 – 18) wide at basis, anterior gnathosomal seta 8 (7 – 9), posterior gnathosomal seta 12 (11 – 12), gnathosomal solenidion 39 (38 – 40).

Legs (Fig. 8 A – L): Leg I 131 (118 – 142), tarsus 45 (43 – 48) long and 14 (14 – 15) wide at basis, *v'* 29 (28 – 30), *bv''* 51 (48 – 53), *l'* 13 (12 – 14), *l''* 17 (16 – 18), σ' 14 (13 – 15), *v'* 21 (21 – 22), *c''* 21 (15 – 22), Φ 62 (55 – 69), $\omega 1$ 18 (14 – 20), straight, ε 6 (5 – 7), $\omega 2$ 13 (12 – 15), $\omega 3$ 12 (10 – 16), *a''* 23 (22 – 23), *ft'* 18 (11 – 24), *a'* 49 (46 – 53), *pv'* 44 (42 – 48), *pv''* 40 (38 – 43), *tc'* 40 (37 – 44), *ft''* 22 (20 – 23), *tc''* 77 (76 – 80), *p'* 18 (18 – 19).

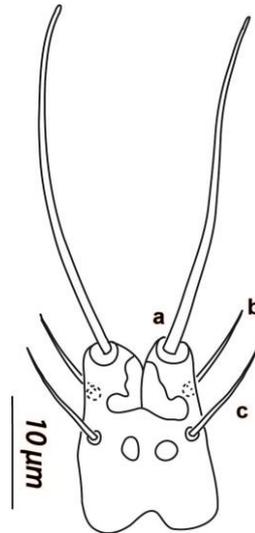


Figure 8 - **Gen. 1 n. sp. 3** (deutonymph). Gnathosoma [a- gnathosomal solenidion; b- anterior gnathosomal seta; c- posterior gnathosomal seta].

Leg II 95 (91 – 111), tarsus 37 (36 – 38) long and 13 (12 – 13) wide at basis, v' 26 (24 – 28), bv'' 53 (47 – 58), l' 10, l'' 15 (14– 16), σ' 14 (12 – 14), v' 22 (20 – 24), c'' 22 (19 – 23), Φ 52 (52 – 53), ωl 15 (12 – 18), straight, ft' 20 (20 – 21), a' 31 (28 – 36), pv' 31 (29 – 32), pv'' 47 (43 – 50), tc' 30 (28 – 31), ft'' 21 (20 – 22), tc'' 64 (60 – 66), p' 17 (16 – 18).

Leg III 92 (90 – 102), tarsus 33 (31 – 34) long and 11 (10 – 12) wide at basis, v' 27 (25 – 28), l' 18 (17 – 18), σ' 10 (9 – 11), v' 27 (24 – 29), Φ 19 (18 – 20), pv' 21 (20 – 21), pv'' 33 (29 – 38), tc' 26 (25 – 26), ft'' 46 (43 – 48), tc'' 26 (25 – 26), p' 16 (14 – 18), p'' 16 (13 – 20), s 9 (8 – 9).

Leg IV 107 (102 – 110), tarsus 37 (36 – 37) long and 10 (9 – 11) wide at basis, bv'' 28 (28 – 29), v' 25 (24 – 26), Φ 12 (9 – 14), pv' 23 (21 – 24), pv'' 24 (20 – 27), tc' 24 (19 – 22), ft'' 47 (43 – 53), tc'' 30 (29 – 32), p' 16 (14 – 18), p'' 13 (12 – 15), s 10 (9 – 10).

Adults- Unkown.

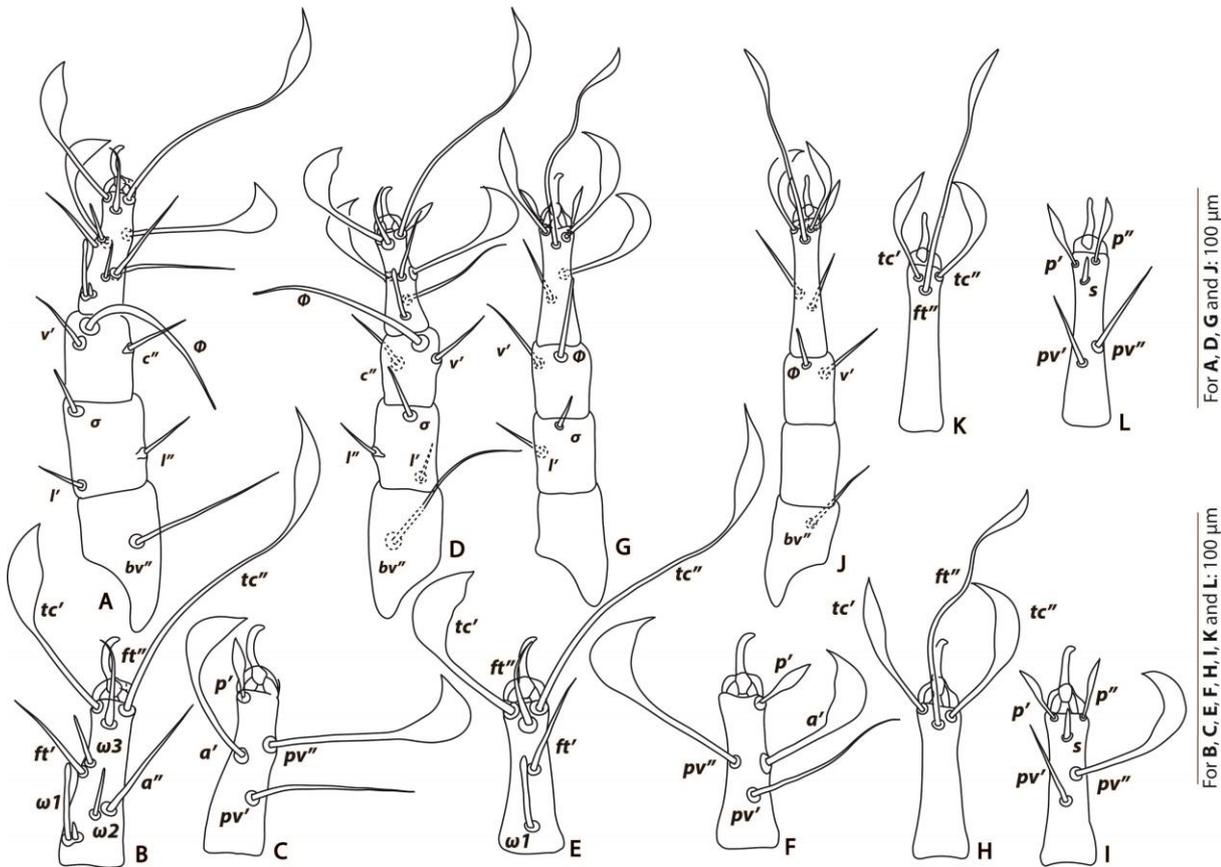


Figure 9 - **Gen. 1 n. sp. 3** (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Gen. 1 n. sp. 4.

(Figs. 10 – 18)

Material examined

Holotype deutonymph and eight paratype deutonymphs under posterior metasomal sternite of *Euglossa imperialis* Cockerel, from Reserva Biologica de San Ramon, Alajuela, Costa Rica, 6.VI.1995, coll. J. Lobo; six paratype deutonymphs on legs of *E. imperialis* Corcovado National Park, Puntarenas, Osa Peninsula, Costa Rica, 6.VII.1977, coll. D.H. Janzen; five paratype deutonymphs on petiole of *E. imperialis*, Piña, Panama, 22.VII.1965, coll. C.H. Dodson; six paratype deutonymphs under posterior metasomal sternite of *E. imperialis*, San Jeronimo, San José, Costa Rica, 16. I.1971, coll. A. Wille and E. Orozco; six paratype deutonymphs under posterior metasomal sternite of *E. imperialis*, 18 km N Quepos, Puntarenas, Costa Rida, 20-23.I.1971, coll. A. Wille and E. Orozco; nine paratype deutonymphs under distal abdominal sternite and in genital capsule of *E. imperialis*, Monteverde, Puntarenas, Costa Rica, 3-

9.II.1983, coll. B. Crespi; four paratype deutonymphs on legs of *E. imperialis*, Corcovado National Park, Puntarenas, Osa Peninsula, Costa Rica, 6.VII.1977, coll. D.H. Janzen. One paratype female and one paratype male from nest of *E. imperialis*, Portete, Limón, Costa Rica, 22. VIII.1964, coll. R.G. Roberts.

Diagnosis

Deutonymph- Seta *ro* slightly longer than *le*. Posterior end of sternal apodeme swollen; coxal field III varying from widely open to almost closed, but never totally closed. Gnathosoma shorter than wide and gnathosomal solenidion about 1.7 times longer than length of gnathosoma. Seta *tc''* of tarsi I-II about 2.3 times longer than *ft''*; seta *ft''* of tarsus III about 1.5 times longer than *tc''* and seta *ft''* of tarsus IV about 1.8 times longer than *tc''*.

Adult male and female- Most dorsal setae longer than 50 μm ; seta *in* and *ex* similar in length; *cp* much shorter than *c1* and *c2*; *h3* similar in length to other *h* seta; seta *ft''* I more basal than *tc'* and *tc''*.

Description of deutonymph

(Figs. 10 – 12)

Dorsum (Fig. 10A): Idiosoma 301 (272 – 345) long and 187 (162 – 220) wide at widest level. Prodorsal sclerite 95 (88 – 125), ornamented with longitudinal, diagonal near anterior corners, scalelike structures. Hysterosomal shield 207 (180 – 242), scalelike structures progressively longer and thinner at the posterior area of the dorsum, longitudinal behind *d1* and sorted in parallel and mesally convergent lines anterior of *d1*. Dorsal setae lengths: *ro* 6 (6 – 7), *le* 5 (4 – 6), *in* 3 (2 – 3), *ex* 4 (3 – 5), *elc I* 12 (11 – 14), *c1* 3 (3 – 4), *c2* 3, *cp* 5 (4 – 7), *d1* 3 (3 – 4), *d2* 3 (3 – 4), *e1* 4 (3 – 4), *e2* 5 (4 – 7), *f2* 5 (4 – 6), *h1* 4 (3 – 4), *h2* 7 (7 – 8), *h3* 19 (17 – 21).

Venter (Fig. 10B): Sternal apodeme swollen at posterior end; coxal field III varying from widely open to almost closed, but never totally closed. Setae *1a*, *4b* and *g* 10 (9 – 12), 9 (7 – 12) and 12 (10 – 14), respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1* + *ad2*) 13 (12 – 14) and 15 (13 – 17), respectively. Cupule *ih* laterad of attachment organ.

Gnathosoma (Fig. 11): 12 (10 – 13) long and 16 (12 – 20) wide at basis, anterior gnathosomal seta 6 (5 – 6), posterior gnathosomal setae 9 (9 – 12), gnathosomal solenidion 21 (18 – 23).

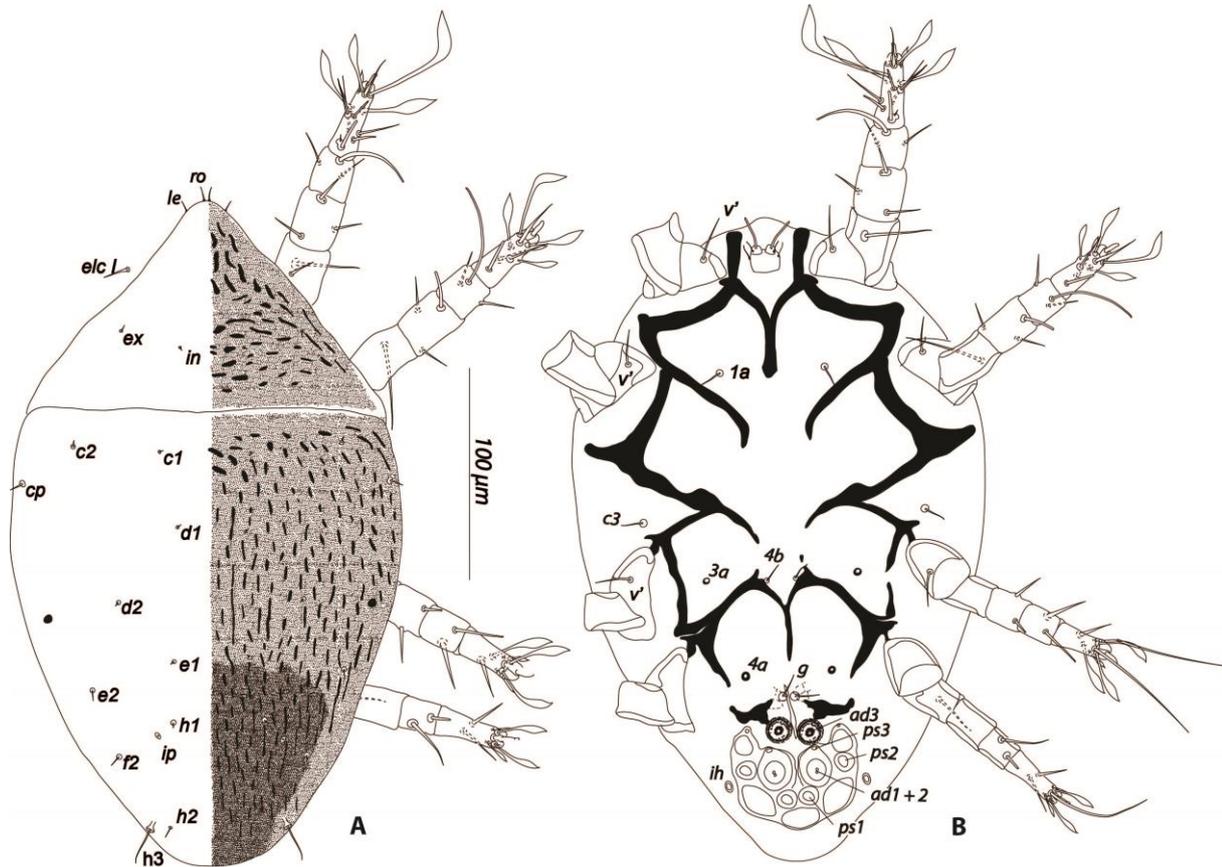


Figure 10 - **Gen. 1 n. sp. 4** (deutonymph). (A) dorsal view. (B). ventral view.

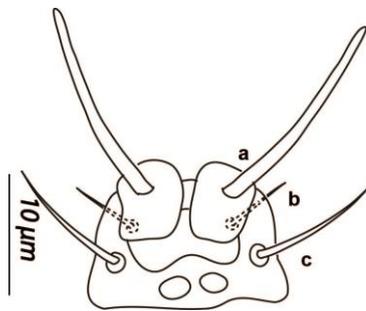


Figure 11 - **Gen. 1 n. sp. 4** (deutonymph). Gnathosoma [a- gnathosomal solenidion; b- anterior gnathosomal seta; c- posterior gnathosomal seta].

Legs (Fig. 12A-L): Leg I 119 (108 – 133), tarsus 35 (30 – 48) long and 15 (14 – 16) wide at basis, v' 19 (13 – 24), bv'' 36 (27 – 42), l' 11 (8 – 13), l'' 14 (11 – 18), σ' 13 (9 – 16), v' 17 (13 – 21), c'' 18 (13 – 23), Φ 40 (34 – 46), $\omega 1$ 16 (14 – 20), straight, ε 5 (4 – 7), $\omega 2$ 12 (10 – 15), $\omega 3$ 11 (10 – 13), a'' 21 (17 – 26), ft' 21 (13 – 21), a' 27 (21 – 33), pv' 26 (21 – 34), pv'' 35 (30 – 46), tc' 33 (30 – 42), ft'' 22 (18 – 24), tc'' 54 (45 – 60), p' 15 (10 – 16).

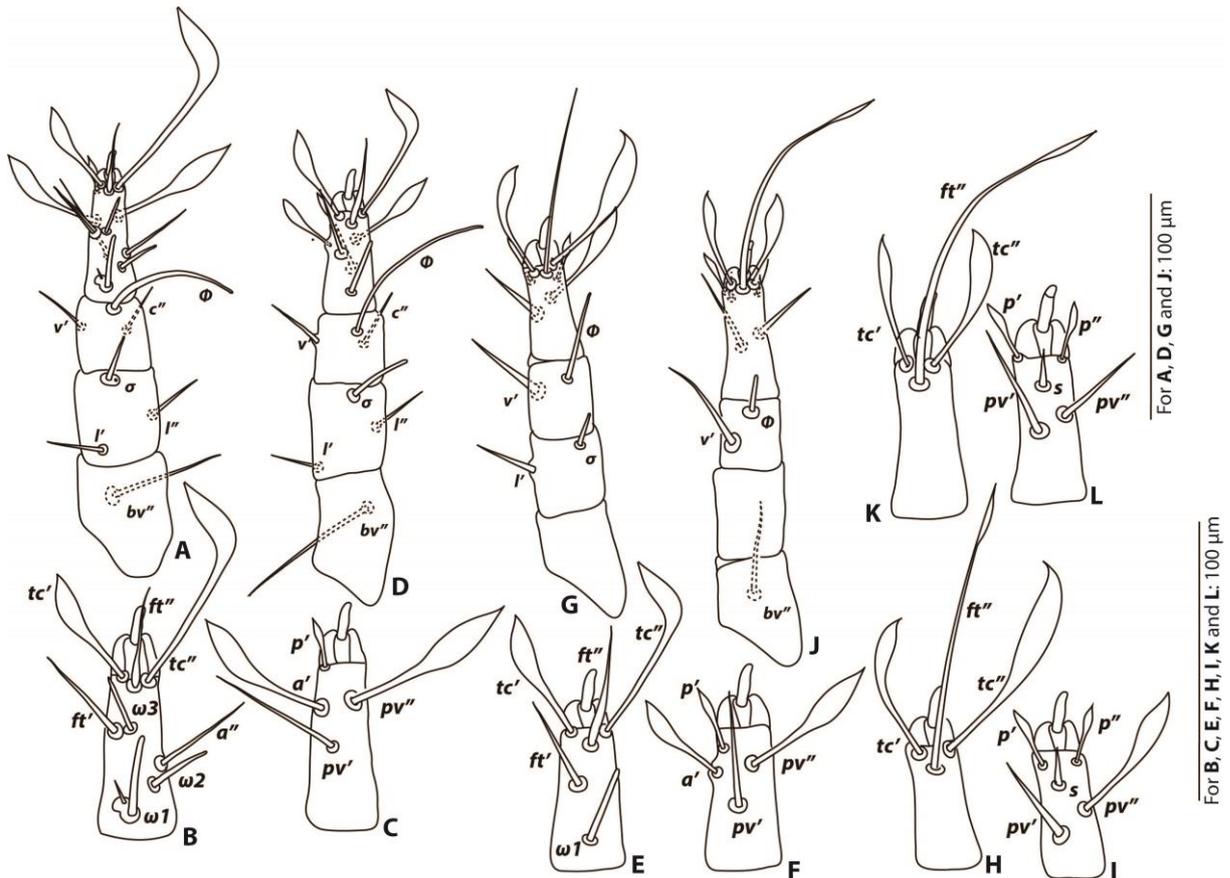


Figure 12 - **Gen. 1 n. sp. 4** (deutonymph). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Leg II 110 (100 – 123), tarsus 30 (25 – 35) long and 14 (13 – 14) wide at basis, v' 18 (13 – 22), bv'' 39 (38 – 52), l' 11 (9 – 15), l'' 13 (10 – 21), σ' 14 (12 – 20), v' 15 (14 – 18), c'' 17 (15 – 19), Φ 38 (32 – 41), $\omega 1$ 16 (14 – 18), straight, ft' 19 (16 – 22), a' 23 (21 – 32), pv' 29 (24 – 37), pv'' 33 (28 – 41), tc' 29 (26 – 34), ft'' 20 (18 – 22), tc'' 45 (44 – 51), p' 17 (14 – 20).

Leg III 91 (82 – 100), tarsus 28 (24 – 33) long and 13 (12 – 13) wide at basis, v' 19 (15 – 22), l' 17 (16 – 20), σ' 8 (6 – 10), v' 19 (14 – 21), Φ 17 (14 – 20), pv' 16 (17 – 20), pv'' 24 (23 – 32), tc' 24 (17 – 30), ft'' 39 (33 – 45), tc'' 26 (25 – 32), p' 15 (12 – 18), p'' 15 (13 – 17), s 7 (6 – 8).

Leg IV 101 (95 – 111), tarsus 31 (27 – 36) long and 14 (12 – 14) wide at basis, bv'' 22 (20 – 24), v' 20 (18 – 21), Φ 9 (7 – 11), pv' 19 (18 – 22), pv'' 15 (11 – 16), tc' 23 (21 – 26), ft'' 43 (38 – 50), tc'' 25 (22 – 28), p' 16 (15 – 18), p'' 15 (13 – 17), s 8 (7 – 9).

Description of adult female

(Figs. 13 – 15)

Dorsum (Fig. 13A): Idiosoma subpentagonal, 580 long, cuticle smooth. Prodorsal sclerite subrectangular and punctate; densest punctuations on anterior third, connected to podocephalic shield by a sclerotized apical transverse band. Dorsal setae smooth and stout, except *ro*, *le* and *elc I*, setiform. Grandjean's organ not distinguishable. Setae *ro* close to each other, at apex of prodorsal sclerite; *le* almost in transverse line with *ro*, at the end of the sclerotized band next to the podocephalic shield. Opisthonotal gland posterolaterad of *d2*. Setal lengths: *ro* 38, *le* 10, *in* 57, *ex* 55, *elc I* 30, *c1* 58, *c2* 63, *cp* 52, *d1* 65, *d2* 64, *e1* 65, *e2* 58, *f2* 50, *h1* 56, *h2* 57, *h3* 58.

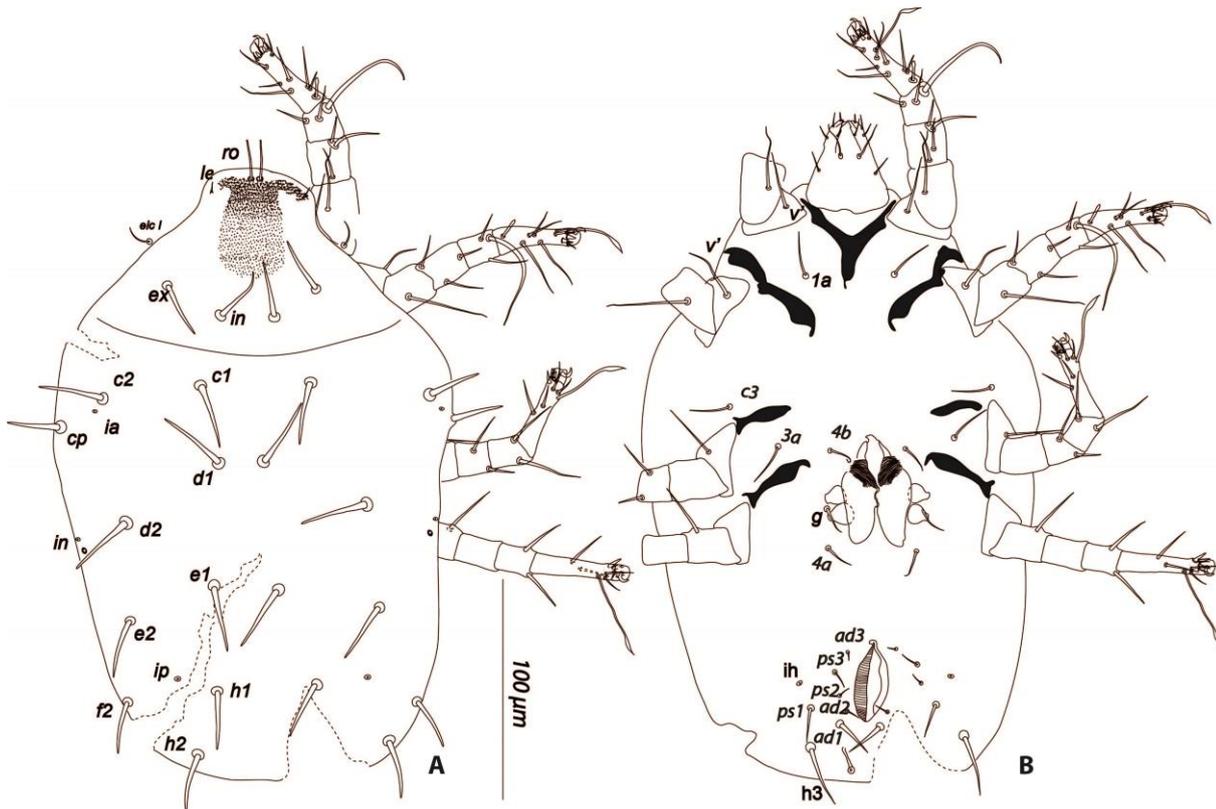


Figure 13 - **Gen. 1 n. sp. 4** (female). (A) dorsal view. (B). ventral view.

Venter (Fig. 13B): Genital region between legs III and IV. Distance between posterior edge of anal opening and posterior edge of idiosoma about the same as length of anal opening; the latter surrounded by six pairs of setae. Setal lengths: *c3* 52, *1a* 36, *3a* 27, *4a* 26, *4b* 25 and *g* 29, *ad1* 34, *ad2* 13, *ad3* 9, *ps1* 31, *ps2* 13 and *ps3* 23.

Spermatheca (Fig. 14 A): Copulatory opening placed next to posterior edge of idiosoma. Shape of sclerotized basis of spermatheca not distinguishable because of position of specimen; distance between sclerites 22, spermathecal duct as a broad tube.

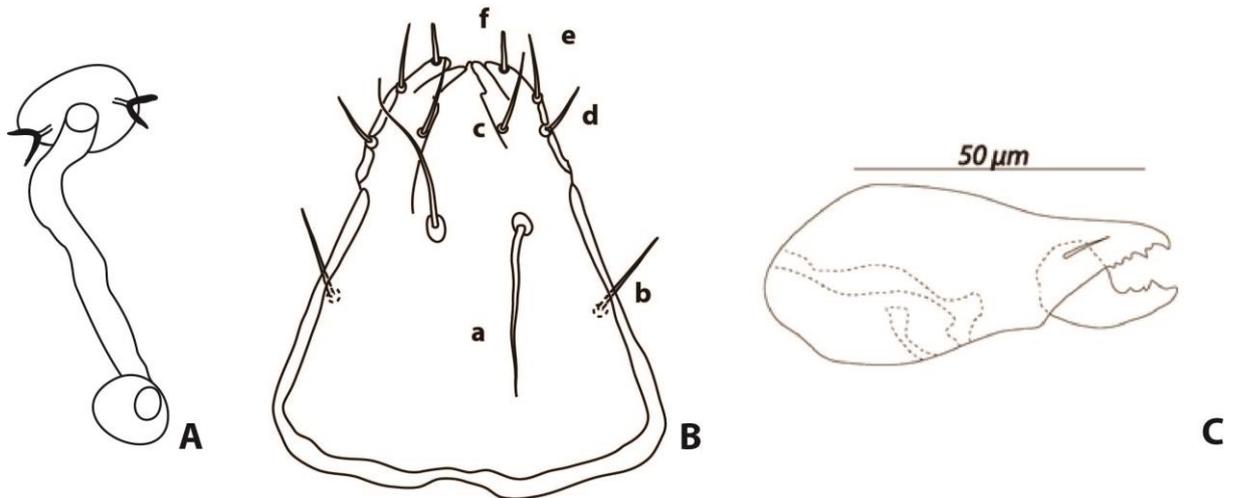


Figure 14 - **Gen. 1 n. sp. 4** (female). (A) spermatheca. (B) gnathosoma [a- subcapitular (*subc*); b- supracoxal (*elcp*); c- dorsal palptibial; d- lateral palptibial; e- dorsal palptarsal; f- terminal palptarsal solenidion]. (C) chelicera.

Gnathosoma (Fig. 14B–C): Chelicera chelate, shaft 84, fixed digit 18, with five teeth in addition to apical tooth; movable digit 23, with three teeth in addition to apical tooth; cheliceral seta (*cha*) not distinguishable. Subcapitular seta (*subc*) 35, dorsal palptibial seta 24; lateral palptibial seta 15; dorsal palptarsal seta 10 and terminal palptarsal solenidion 7; seta *elcp* 23.

Legs (Fig. 15 A-L): Leg I 197, tarsus 65, v' 50, bv'' 70, l' 28, l'' 28, σ' 23, σ' 40, v' 24, c'' 30, Φ 90, $\omega 1$ 19, swollen at the tip, ε 4, $\omega 2$ 18, $\omega 3$ 13, a'' 38, ft' 31, a' 24, pv' 50, pv'' 45, tc' 27, ft'' 55, tc'' 16, p' 10, p'' 10, u' 8, u'' 8 and s 9; ft'' more basal than tc' and tc'' and foliate.

Leg II 177, tarsus 55, v' 55, bv'' 70, l' 26, l'' 30, σ 27, v' 26, c'' 33, Φ 100, $\omega 1$ 19, slightly swollen at the tip, ft' 29, a' 28, pv' 55, pv'' 50, tc' 25, ft'' 56, tc'' 20, p' 10, p'' 10, u' 8, u'' 8 and s 9; ft'' foliate.

Leg III 192, tarsus 70, v' 56, l' 35, σ 27, v' 50, Φ 80, pv' 33, pv'' 20, tc' 30, ft'' 65, tc'' 16, p' 10, p'' 11, u' 10, u'' 10 and s 13.

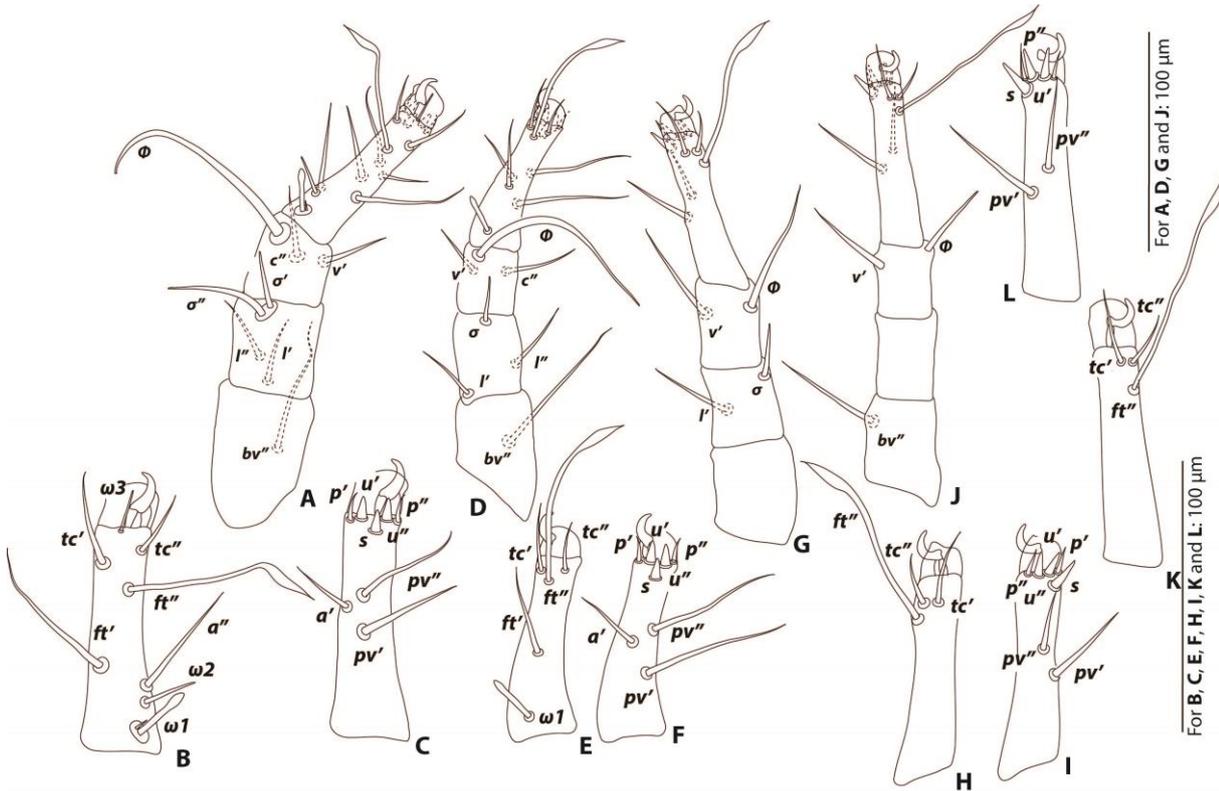


Figure 15 - **Gen. 1 n. sp. 4** (female). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Leg IV 212, tarsus 80, bv'' 50, v' 40, Φ 37, pv' 38, pv'' 35, tc' 35, ft'' 110, tc'' 20, p' 11, p'' 11, u' 11, u'' 10 and s 14.

Description of adult male

(Figs. 16 – 18)

Shape of structures similar to female, unless otherwise noted.

Dorsum (Fig. 16A; 17A): Idiosoma 580 long. Prodorsal sclerite 94 long and 67 wide at posterior margins. Grandjean's organ divided in 12 terminal branches. Dorsal setal lengths: ro 30, le 9, in 33, ex 34, elc 1 25, $c1$ 50, $c2$ 49, cp 40, $d1$ 55, $d2$ 49, $e1$ 56, $e2$ 43, $f2$ 56, $h1$ 49, $h2$ 43, $h3$ 35.

Venter (Fig. 16B; 17B): Genital region between legs IV. Ventral setae lengths: $c3$ 21, $1a$ 32, $3a$ 20, $4a$ 24, $4b$ 18 and g 25. Aedeagus distally curved, 12. Para-anal suckers 10 (9-10) in diameter, surrounded by $h3$ 35, $ps3$ 15, $ps2$ 65 and $ps1$ 30.



Figure 16 - **Gen. 1 n. sp. 4** (male). (A) dorsal view. (B) ventral view.

Gnathosoma: chelicera chelate, shaft 78, fixed digit 20, with five teeth in addition to apical tooth; movable digit 25, with three teeth in addition to apical tooth; cheliceral seta (*cha*) spinelike, 3. Subcapitular seta (*subc*) 30, dorsal palptibial seta 24; lateral palptibial seta 13; dorsal palptarsal seta 12, terminal palptarsal solenidion 8, subcapitular (*elcp*) 13.

Legs (Fig. 18 A-L): Leg I 180, tarsus 70, *v'* 40, *bv''* 55, *l'* 25, *l''* 28, σ' 18, σ'' 40, *v'* 24, *c''* 27, Φ 80, $\omega 1$ 18, ε 6, $\omega 2$ 16, $\omega 3$ 17, *a''* 38, *ft'* 30, *a'* 21, *pv'* 54, *pv''* 42, *tc'* 28, *ft''* 58, *tc''* 20, *p'* 10, *p''* 10, *u'* 8, *u''* 8 and *s* 11.

Leg II 167, tarsus 57, *v'* 40, *bv''* 60, *l'* 21, *l''* 26, σ 23, *v'* 23, *c''* 26, Φ 85, $\omega 1$ 20, *ft'* 26, *a'* 22, *pv'* 55, *pv''* 40, *tc'* 26, *ft''* 54, *tc''* 18, *p'* 12, *p''* 10, *u'* 8, *u''* 9 and *s* 9.

Leg III 175, tarsus 60, *v'* 40, *l'* 33, σ 18, *v'* 40, Φ 58, *pv'* 30, *pv''* 32, *tc'* 30, *ft''* 58, *tc''* 18, *p'* 8, *p''* 9, *u'* 8, *u''* 9 and *s* 9.

Leg IV 182, tarsus 55, *bv''* 38, *v'* 31, Φ 36, *pv'* 36, *pv''* 24, *tc'* 42, *p'* 10, *p''* 9, *u'* 10, *u''* 10 and *s* 12.

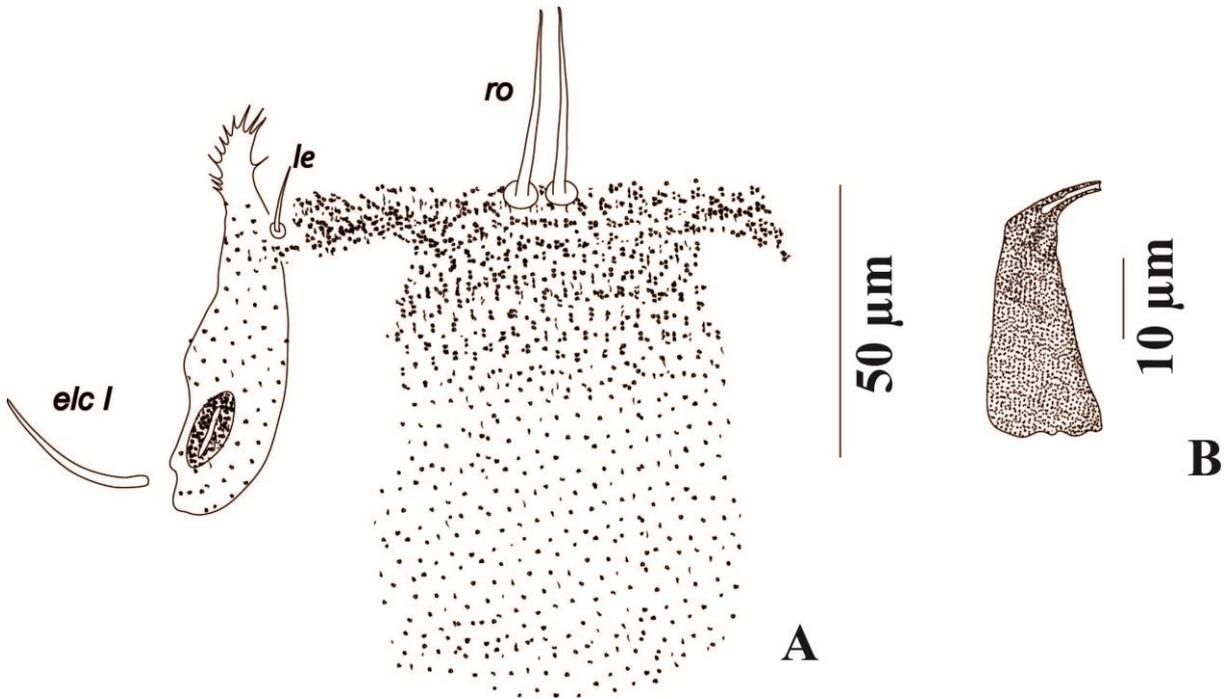


Figure 17 - **Gen. 1 n. sp. 4** (male). (A) prodorsal sclerite. (B) aedeagus.

Gen. 1 n. sp. 5.

(Fig. 19 – 21)

Material examined

Holotype deutonymph and eight paratype deutonymphs on propodeum of an unidentified *Euglossa* species, Juquiá, São Paulo, Brazil, IV.2001, coll. J. Lane.

Diagnosis

Seta *ro* slightly shorter than *le*. Posterior end of sternal apodeme bifurcate; and coxal field III closed. Gnathosoma shorter than wide and gnathosomal solenidion about 2.2 times longer than the length of the gnathosoma. Seta *tc*'' of tarsi I-II about 3.8 times longer than *ft*''; seta *ft*'' of tarsi III about 2.5 times longer than *tc*'' and seta *ft*'' of tarsi IV about 2.9 times longer than *tc*''.

Description of deutonymph

Dorsum (Fig. 19A): Idiosoma 333 (295 – 342) long and 216 (182 – 235) wide at widest level. Prodorsal sclerite 110 (100 – 107), ornamented with diagonal or transverse scalelike structures. Hysterosomal shield 228 (195 – 242), ornamented with longitudinal, diagonal near anterior corners, scalelike structures. Dorsal setal lengths: *ro* 5 (4 – 6), *le* 9 (8 – 9), *in* 5 (4 – 7), *ex* 5 (4

– 5), *elc I* 12 (10 – 14), *cl* 5 (4 – 6), *c2* 5 (4 – 6), *cp* 5 (5 – 6), *d1* 5 (4 – 5), *d2* 5 (5 – 7), *e1* 6 (5 – 9), *e2* 6 (5 – 9), *f2* 8 (7 – 8), *h1* 7 (6 – 7), *h2* 8 (7 – 9), *h3* 25 (20 – 27).

Venter (Fig. 19B): Sternal apodeme bifurcate at posterior end; coxal field III closed. Setae *1a*, *4b* and *g* 12 (8 – 14), 10 (9 – 10) and 16 (13 – 18), respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1* + *ad2*) 11 (10 – 13) and 16 (13 – 18), respectively. Cupule *ih* not distinguishable.

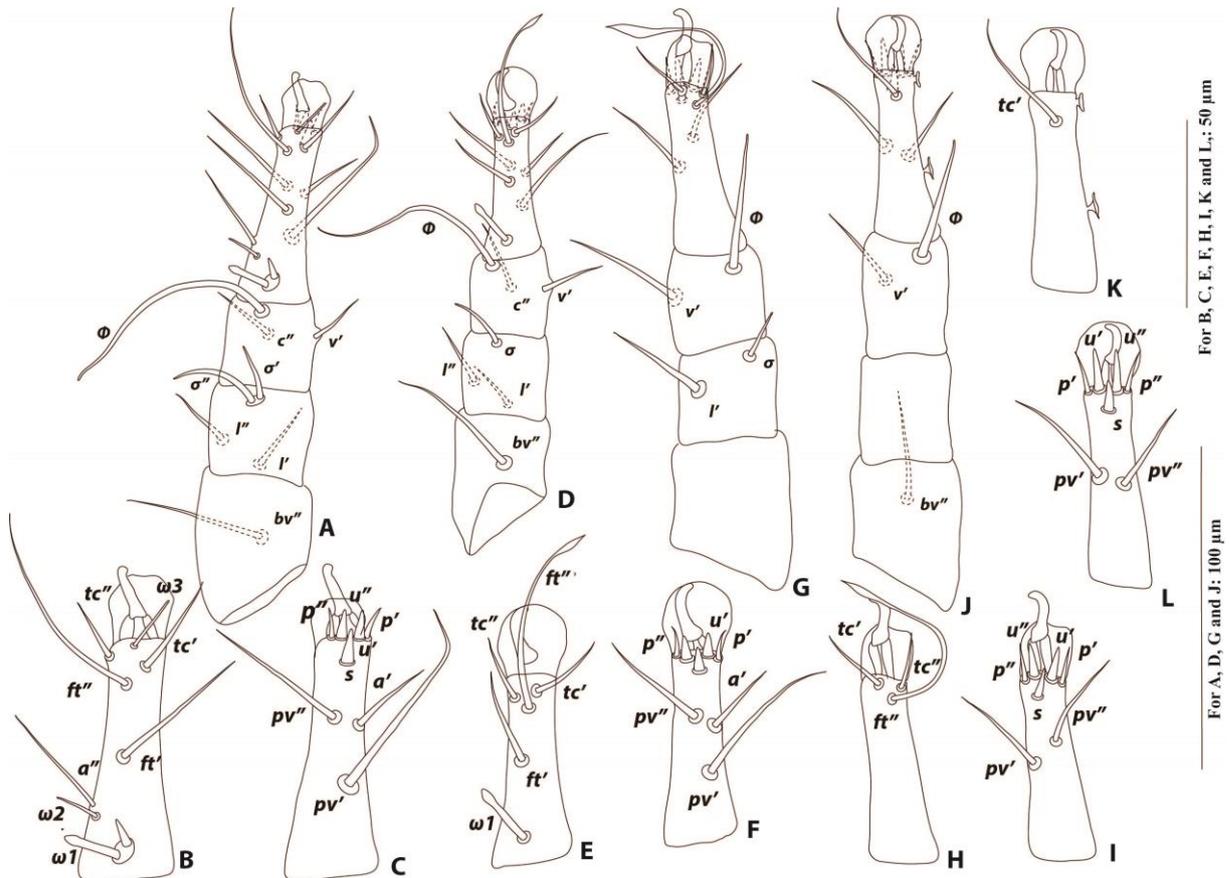


Figure 18 - **Gen. 1 n. sp. 4** (male). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view.

Gnathosoma (Fig. 20): 15 (14 – 16) long and 18 (16 – 19) wide at basis, anterior gnathosomal seta 7 (6 – 8), posterior gnathosomal seta 10 (9 – 11), gnathosomal solenidion 32 (28 – 33).

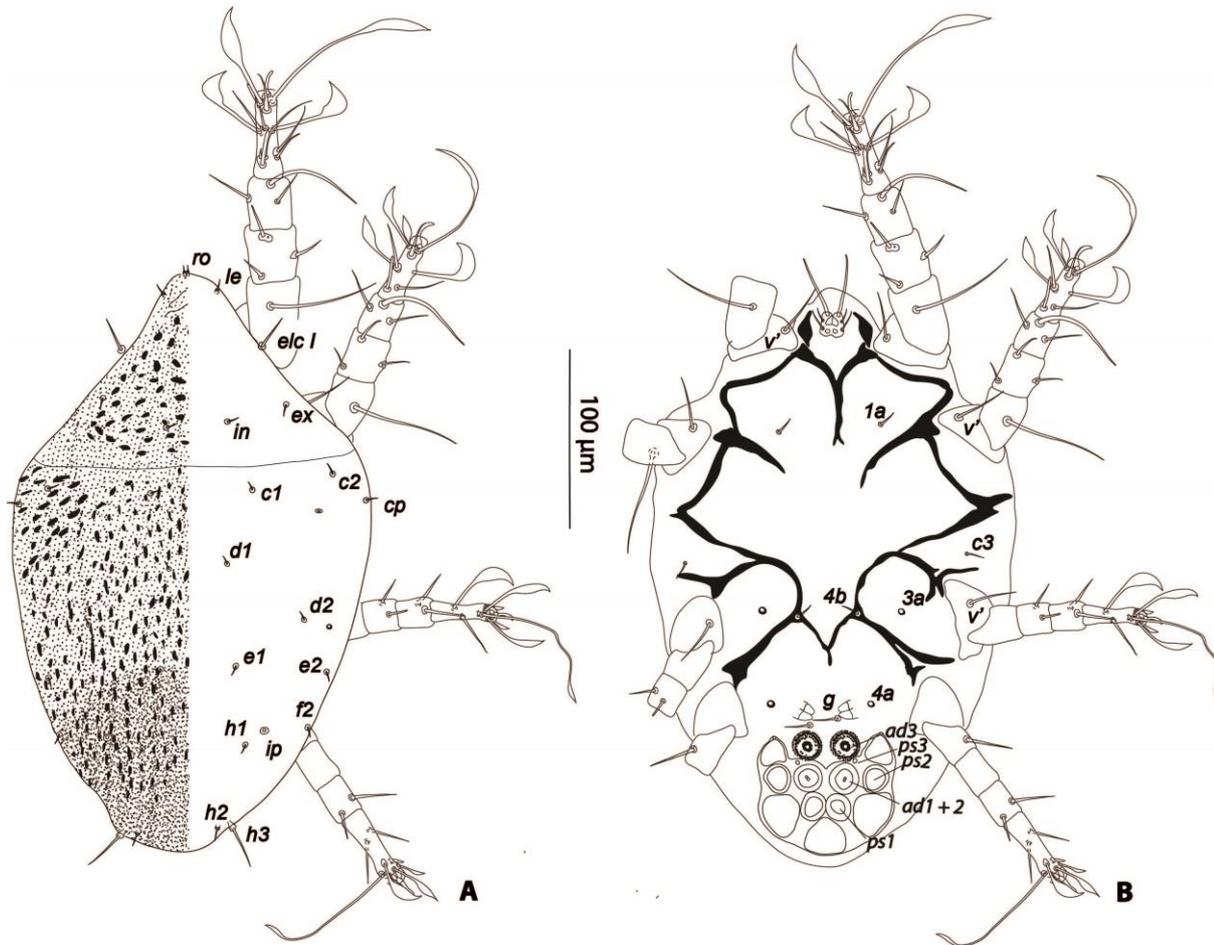


Figure 19 - **Gen. 1 n. sp. 5** (deutonymph). (A) dorsal view. (B). ventral view.

Legs (Fig. 21A-L): Leg I 125 (115 – 133), tarsus 39 (35 – 43) long and 16 (15 – 16) wide at basis, v' 26 (23 – 28), bv'' 48 (43 – 52), l' 12 (10 – 14), l'' 15 (11– 17), σ' 17 (13 – 18), v' 21 (17 – 24), c'' 19 (15 – 22), Φ 49 (38 – 60), $\omega 1$ 20 (18 – 21), straight, ε 6 (5 – 7), $\omega 2$ 15 (13 – 17), $\omega 3$ 12 (10 – 14), a'' 26 (23 – 30), ft' 26 (25 – 28), a' 35 (33 – 40), pv' 35 (30 – 42), pv'' 48 (44 – 55), tc' 41 (37 – 45), ft'' 24 (21 – 28), tc'' 96 (92 – 105), p' 23 (18 – 28).

Leg II 116 (104 – 121), tarsus 33 (30 – 34) long and 14 (11 – 15) wide at basis, v' 27 (26 – 29), bv'' 57 (51 – 60), l' 12 (10 – 13), l'' 13 (9– 14), σ' 14 (10 – 17), v' 21 (18 – 23), c'' 19 (18 – 21), Φ 49 (43 – 50), $\omega 1$ 18 (17 – 20), straight, ft' 25 (20 – 27), a' 35 (27 – 42), pv' 36 (30 – 40), pv'' 40 (35 – 48), tc' 37 (30 – 43), ft'' 23 (22 – 23), tc'' 84 (70 – 90), p' 19 (14 – 21).

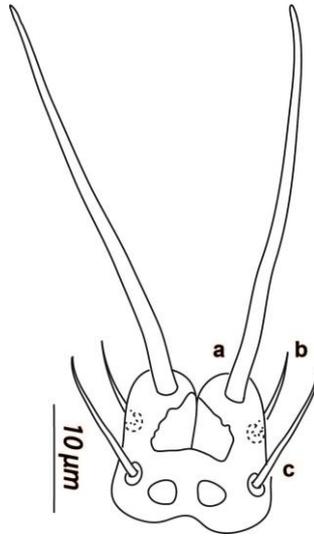


Figure 20 - **Gen. 1 n. sp. 5** (deutonymph). Gnathosoma [a- gnathosomal solenidion; b- anterior gnathosomal seta; c- posterior gnathosomal seta].

Leg III 101 (89 – 110), tarsus 33 (31 – 37) long and 13 (12 – 15) wide at basis, v' 23 (21 – 24), l' 17 (16 – 25), σ' 9 (9 – 10), v' 25 (22 – 27), Φ 24 (20 – 26), pv' 22 (20 – 24), pv'' 33 (25 – 36), tc' 33 (29 – 40), ft'' 84 (80 – 85), tc'' 34 (29 – 38), p' 17 (16 – 18), p'' 18 (18 – 21), s 9.

Leg IV 110 (102 – 117), tarsus 38 (34 – 40) long and 13 (12 – 13) wide at basis, bv'' 27 (23 – 34), v' 24 (21 – 25), Φ 11 (9 – 14), pv' 22 (18 – 26), pv'' 23 (21 – 26), tc' 24 (19 – 28), ft'' 91 (90 – 98), tc'' 31 (28 – 35), p' 17 (14 – 18), p'' 18 (16 – 20), s 8 (7 – 10).

Adults- Unknown.

Gen. 1 n. sp. 6.

(Figs. 22 – 24)

Material examined

Holotype deutonymph and eight paratype deutonymphs on propodeum of *Euglossa viridissima* (Friese), Tecolotlan, Jalisco, Mexico, 18.IX.1975, coll. B. Villegas.

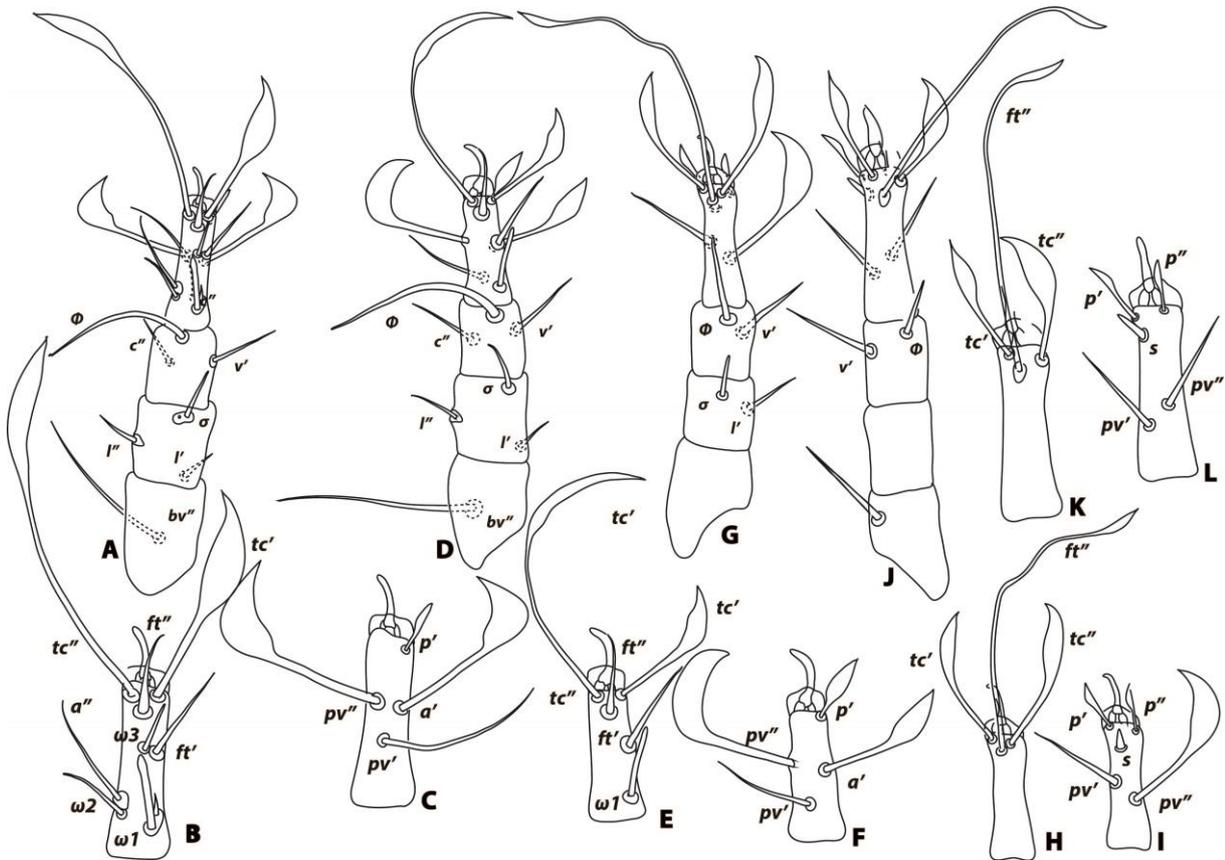


Figure 21 - **Gen. 1 n. sp. 5** (deutonymph). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view

Diagnosis

Seta *ro* longer than *le*. Posterior end of sternal apodeme bifurcate; coxal field III closed. Gnathosoma longer than wide and gnathosomal solenidion about 2.5 times longer than the length of the gnathosoma. Seta *tc''* of tarsi I-II about 3.3 longer than *ft''*; seta *ft''* of tarsi III about 2.1 times longer than *tc''* and seta *ft''* of tarsi IV about 2.5 times longer than *tc''*.

Description of deutonymph

Dorsum (Fig. 22A): Idiosoma 277 (262 – 300) long and 156 (137 – 170) wide at widest level. Prodorsal sclerite 79 (70 – 85), ornamented with diagonal or transverse scalelike structures. Hysterosomal shield 196 (187 – 217), ornamented with longitudinal behind *d1* and dorted in parallel and mesally convergent lines antieriad of *d1* scalelike structures. Dorsal setal lengths: *ro* 13 (13 – 15), *le* 9 (8 – 9), *in* 4 (4 – 5), *ex* 7 (6 – 8), *elc I* 15 (14 – 18), *c1* 4 (4 – 6), *c2* 5 (5 – 6), *cp* 8 (6 – 10), *d1* 6 (5 – 6), *d2* 5, *e1* 7 (5 – 8), *e2* 8 (8 – 12), *f2* 8 (6 – 10), *h1* 7 (6 – 9), *h2* 12 (10 – 13), *h3* 29 (26 – 31).

Venter (Fig. 22B): Sternal apodeme bifurcate at posterior end; coxal field III closed. Setae *1a*, *4b* and *g* 27 (21 – 34), 13 (10 – 16) and 13 (12 – 14) respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1 + ad2*) 11 (10 – 13) and 16 (13 – 18), respectively. Cupule *ih* not distinguishable.

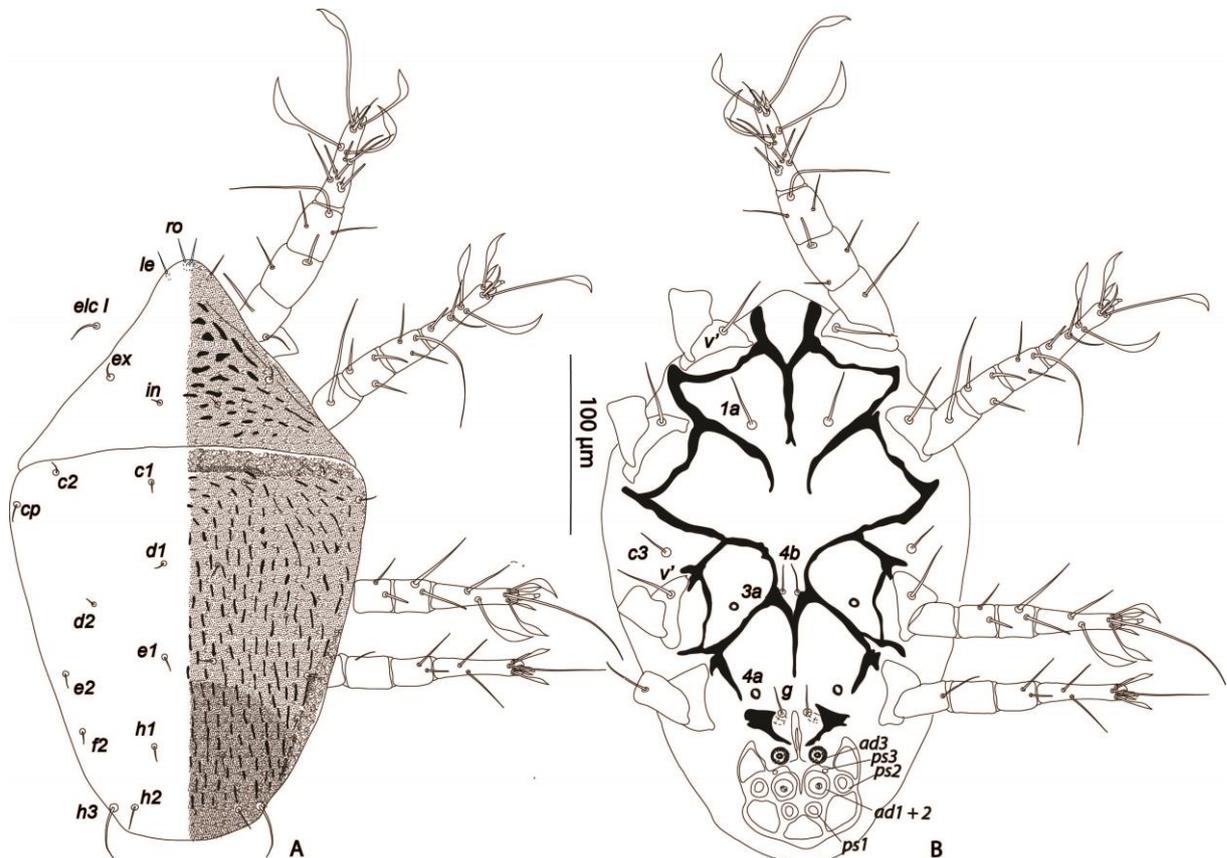


Figure 22 - **Gen. 1 n. sp. 6** (deutonymph). (A) dorsal view. (B). ventral view

Gnathosoma (Fig. 23): 18 (15 – 20) long and 14 (13 – 15) wide at basis, anterior gnathosomal seta 9 (8 – 10), posterior gnathosomal seta 12 (10 – 13), gnathosomal solenidion 41 (39 – 43). *Legs* (Fig. 24A-L): Leg I 124 (121 – 129), tarsus 43 (41 – 46) long and 14 (12 – 15) wide at basis, *v'* 29 (28 – 31), *bv''* 53 (42 – 56), *l'* 13 (10 – 17), *l''* 19 (17 – 24), σ' 16 (13 – 20), *v'* 21 (19 – 23), *c''* 20 (19 – 22), Φ 64 (60 – 75), $\omega 1$ 18 (16 – 20), straight, ϵ 5 (4 – 5), $\omega 2$ 14 (12 – 18), $\omega 3$ 16 (13 – 20), *a''* 24 (19 – 26), *ft'* 25 (23 – 27), *a'* 33 (30 – 40), *pv'* 36 (31 – 48), *pv''* 49 (41 – 53), *tc'* 34 (30 – 37), *ft''* 23 (22 – 26), *tc''* 81 (73 – 85), *p'* 17 (15 – 19).

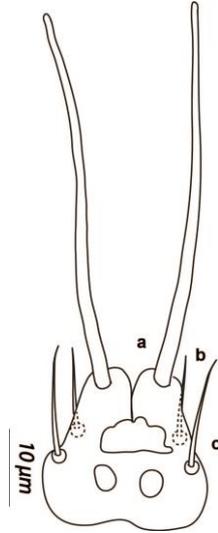


Figure 23 - **Gen. 1 n. sp. 6** (deutonymph). Gnathosoma [a- gnathosomal solenidion; b- anterior gnathosomal seta; c- posterior gnathosomal seta].

Leg II 114 (106 – 120), tarsus 38 (34 – 42) long and 14 (14 – 15) wide at basis, v' 29 (27 – 30), bv'' 56 (52 – 60), l' 12 (8 – 14), l'' 15 (13 – 16), σ' 14 (11 – 18), v' 22 (21 – 24), c'' 20 (18 – 23), Φ 56 (50 – 62), ωl 18 (17 – 22), straight, ft' 25 (23 – 30), a' 28 (25 – 33), pv' 35 (31 – 40), pv'' 39 (35 – 45), tc' 30 (26 – 39), ft'' 21 (18 – 23), tc'' 63 (53 – 68), p' 17 (14 – 19).

Leg III 97 (82 – 107), tarsus 36 (32 – 40) long and 12 (11 – 12) wide at basis, v' 28 (27 – 30), l' 20 (19 – 20), σ' 11 (9 – 13), v' 26 (23 – 27), Φ 20 (18 – 21), pv' 19 (16 – 20), pv'' 28 (22 – 30), tc' 22 (19 – 25), ft'' 52 (48 – 65), tc'' 26 (20 – 30), p' 15 (13 – 18), p'' 13 (12 – 15), s 9.

Leg IV 110 (106 – 118), tarsus 40 (37 – 44) long and 14 (11 – 14) wide at basis, bv'' 26 (19 – 28), v' 26 (24 – 28), Φ 10 (9 – 11), pv' 23 (19 – 25), pv'' 25 (23 – 30), tc' 21 (18 – 22), ft'' 58 (52 – 63), tc'' 19 (16 – 20), p' 15 (13 – 20), p'' 14 (12 – 16), s 8 (7 – 10).

Adults- Unknown.

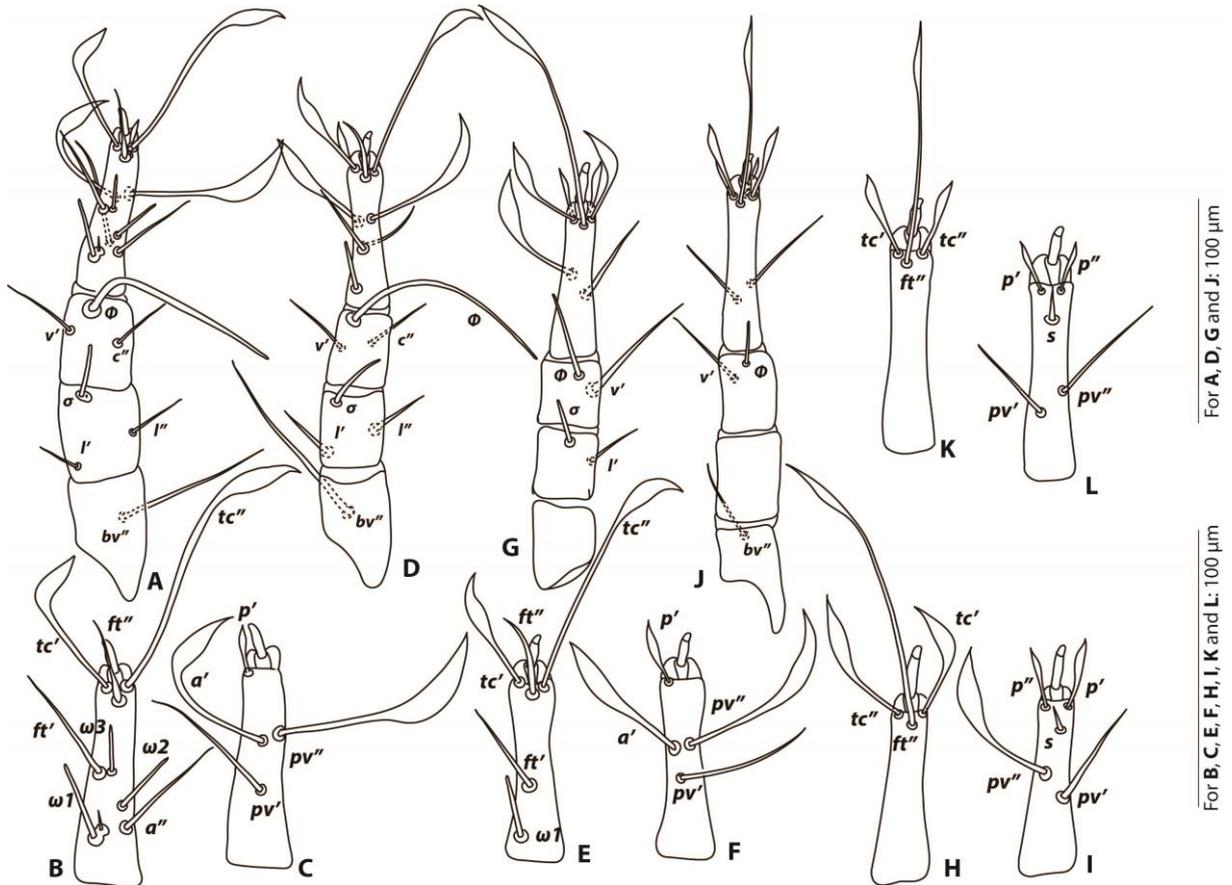


Figure 24 - **Gen. 1 n. sp. 6** (deutonymph). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view

Gen. 2 n. gen.

(Figs. 25 – 27)

Type species. Gen. 2 n. sp. 1, by original monotypy.

Diagnosis of deutonymph

Dorsum (Fig. 25A): Prodorsal sclerite subtriangular, both prodorsal and hysterosomal shields punctate, with densest punctation posterioriad of *e1*, ornamented with elongate elements, except along lateral margins. On both shields setae thin and short, *elc 1* and *h3* longest; *ro* seta contiguous, at apex of prodorsum; *ex* anterolaterad of *in*; *h1* well anterior of *h2* and *h3* (distance *h1* and *h2* to *h3* longer than length of *h3*); *h3* arising from a tubercle.

Venter (25B): Sternal apodeme straight and with posterior end bifurcate, reaching level of anterior apodeme II. Coxal field III closed. Inner end of posterior apodeme II fused with anterior

apodeme III. Posterior apodeme III fused with apodeme IV. Coxal seta *1a* and *4b* setiform; *3a* and *4a* represented by vestigial alveoli. Genital papillae pointed. Attachment organ well developed, with two pairs of conoidal setae, *ps1* and *ps2*, that are respectively posteriad and laterad of *ad1 + ad2*, which is in line and posteriad of *ad3*; with five cuticular suckers; *ps3* represented by alveoli anterior of anterior suckers.

Gnathosoma (Fig. 26): Gnathosoma not protruding beyond anterior edge of prodorsum, shorter than wide.

Legs (Fig. 27): Tarsi less than 1.5 times longer than wide at basis. Tarsi I unusual for retaining *ft'*, *ω2* varying from in line with to anterior of *ω1* (even within a single species); *ω3* positioned at the middle of the tarsus. Tarsi I-II with five foliate setae (*a'*, *pv''*, *tc'*, *tc''* and *p'*) and *p''* absent, tarsus III with six foliate setae (*pv''*, *tc'*, *tc''*, *ft''*, *p'* and *p''*) and tarsus IV with five foliate setae (*tc'*, *tc''*, *ft''*, *p'* and *p''*). Empodial claw strongly hooked and with basal lobe; base of claw with flattened medial expansion.

Remarks

Deutonymphs are similar to *Cerophagopsis* by having empodial claw strongly hooked and with basal lobe, base of claw with flattened medial expansion; seta *a''* present on tarsus I; *s* absent on tarsi I-II and *ft'* present on tarsi I-II. But it differs from *Cerophagopsis* by the absence of seta *p''* on tarsi I-II and by having seta *s* on tarsi III-IV spiniform (filiform on *Cerophagopsis*). Deutonymphs of **Gen. 2** also resemble **Gen. 1** in having seta *a''* on tarsus I, *ft'* on tarsi I-II, *s* absent on tarsi I-II and spiniform on tarsi III-IV. They differ from **Gen. 1** by having dorsal sclerite ornamented with striae (ornamented with scale-like structures on **Gen. 1**), tarsi less than 1.5 times longer than wide (more than twice longer in **Gen. 1**) and claws strongly hooked and with basal lobe, base of claws with flattened medial expansion (empodial claws simply claw-like in **Gen. 1**).

Other genera of subfamily Horstiinae differ from **Gen. 2** as follows:

Horstia- Empodial claw regular; seta *1a* absent; *ft'* and *a''* absent on tarsus I; tarsus IV with *ft''*, *tc'* and *tc''* longer than leg IV.

Diadasiopus- Empodial claw regular; seta *3a* and *4a* present; *ft'* absent on tarsi I; tarsus IV with *pv'* and *tc''* longer than leg IV; *p''* present on tarsi I-II; *s* of tarsi III-IV foliate.

Horstiella- Empodial claw regular; seta *1a* and *4b* absent and *4a* as a large conoid; *ft'* and *a''* absent on tarsus I; seta *p''* present on tarsi I-II; *s* of tarsi III-IV foliate.

Medeus- Empodial claw regular; setae *3a* and *4a* present and *4b* absent; *ft'* and *a''* absent on tarsus I; *p''* present on tarsi I-II; *s* on tarsi III-IV foliate.

Megachilopus- Empodial claw regular and seta *s* on tarsi III-IV filiform.

Sennertionyx- Setae *ft'* and *a''* absent on tarsus I; *ft''*, *tc'* and *tc''* of tarsus IV longer than leg IV.

Gen. 2 n. sp. 1.

(Figs. 25 – 27)

Material examined (only deutonymphs)

Holotype and four paratypes on abdominal tergites of *Eulaema nigrita* Lepeletier, El Tecuco, Zulia, Venezuela, 24.VI.1979, coll. J. McLaughlin, A.A. Grigarick, R.O. Schuster and R.W. Brooks; five paratypes under metasomal tergites and sternite of *E. nigrita*, Floresta Duque, Manaus, Amazonas, Brazil, 5.II.1976, coll. R.M. Bohart; five paratypes under metasomal tergites and sternite of *E. nigrita* 19 km N El Llano, Panama Provincia, Panama, 3.IV.1975, coll. L.M. Siri; five paratypes on last abdominal tergite of *Eulaema bombiformis* (Packard) Corcovado National Park, Puntarenas, Osa Peninsula, Costa Rica, 6.VII.1977, coll. D.H. Janzen; five paratypes in genital capsule of *Eulaema polychroma* (Mocsáry), Zamorano, Francisco Morazán, Honduras, 20.VII.1948, coll. T.H. Hubbell; three paratypes in genital capsule of *E. polychroma*, Finca La Paz, San Marcos, Guatemala, 05. V.1956, coll. T.H. Hubbell; five paratypes under the edges of fourth metasomal tergite of *E. polychroma*, Siguatepeque, Comayagua, Honduras, 23. III.1974, coll. J.V. Mankins; three paratypes under metasomal sternite of *E. polychroma*, San Pedro, San José, Costa Rica, 4. V.1983, coll. F. Hernandez; three paratypes on leg II of *E. polychroma*, Oaxtepec, Morelos, Mexico, 13-19.VII.1960, coll. C. Benschoter; three paratypes under distal abdominal sternite of *E. polychroma*, Lake Chapala, Jalisco, Mexico, 5.XII.1923, coll. J.H. Williamson; ; three paratypes on genitalia of *E. polychroma*, Felipe Carillo Puerto, Quintana, Mexico, 6-8.VII.1966, coll. D.H. Janzen; ; eight paratypes on genitalia of *E. polychroma* 13.5 km S. Managua, Managua, Nicaragua, 15.VI.1976, coll. J.B. Kimsey; eight paratypes under edges of metasomal tergites of *Eulaema meriana* (Olivier), OCumare de La Costa, Aragua, Venezuela, 15.VII.1979, coll. R.W. Brooks; eight paratypes under last abdominal sternite and in genital capsule of *Eulaema boliviensis* (Friese), Hacienda Cincinnati, Magdalena, Colombia, 9.VI.1920, coll. F.M. Galge; three paratypes on genital capsule and under posterior sternite of *Eulaema cingulata* (Fabricius), Maquipucuna, Pichincha, Ecuador, 1.XII.1992, coll. R. Raguso; three paratypes under lateral edges of abdominal tergites and in genital capsule of *E. cingulata*, Los Tuxtlas, Veracruz, Mexico, 29.VI.1976, coll. E. Barrera; five paratypes on genitalia and

abdominal tergites of *E. cingulata*, 13 km S. Managua, Managua, Nicaragua, VII.1976, coll. R.B. and L.S. Kimsey; five paratypes on *E. cingulata*, 11 km S. Kourou, French Guiana, 10.VII.1977, coll. C.D. Michener; five paratypes under metasomal sternite of *E. cingulata* Cartago, Turrialba, Costa Rica, 23. II.1965, coll. H. Nanne; six paratypes in genital capsule of *Eulaema sebrai* Moure, Finca La Selva, Heredia, Costa Rica, VI-VII.1991, coll. J. Doubles.

Diagnosis

Deutonymphs of this new species are distinguished from other acarid species by the combination of characters given in the description of the genus.

Description of deutonymph

Dorsum (Fig. 25A): Idiosoma 296 (220 – 450) long and 181 (135 – 287) wide at widest level. Prodorsal sclerite 109 (90 – 150), ornamented with diagonal striae. Hysterosomal shield 186 (172 – 300); ornamented with striae distinctly thicker at the posterior half of hysterosoma. Dorsal setal lengths: *ro* 7 (4 – 8), *le* 7 (5 – 8), *in* 5 (4 – 6), *ex* 6 (4 – 7), *elc I* 16 (12 – 22), *c1* 5 (4 – 6), *c2* 5 (3 – 6), *cp* 6 (4 – 8), *d1* 5 (4 – 8), *d2* 5 (4 – 6), *e1* 6 (5 – 8), *e2* 6 (4 – 8), *f2* 5 (4 – 7), *h1* 7 (6 – 8), *h2* 7 (6 – 9), *h3* 26 (18 – 32).

Venter (Fig. 25B): Sternal apodeme bifurcate at posterior end; coxal field II varying from widely open to almost closed, but never totally closed. Setae *1a*, *4b* and *g* 7 (6 – 9), 7 (6 – 8) and 11 (8 – 13), respectively. Diameter of anterior sucker (*ad3*) and of medium sucker (*ad1* + *ad2*) 13 (12 – 14) and 15 (13 – 17), respectively. Cupule *ih* not distinguishable.

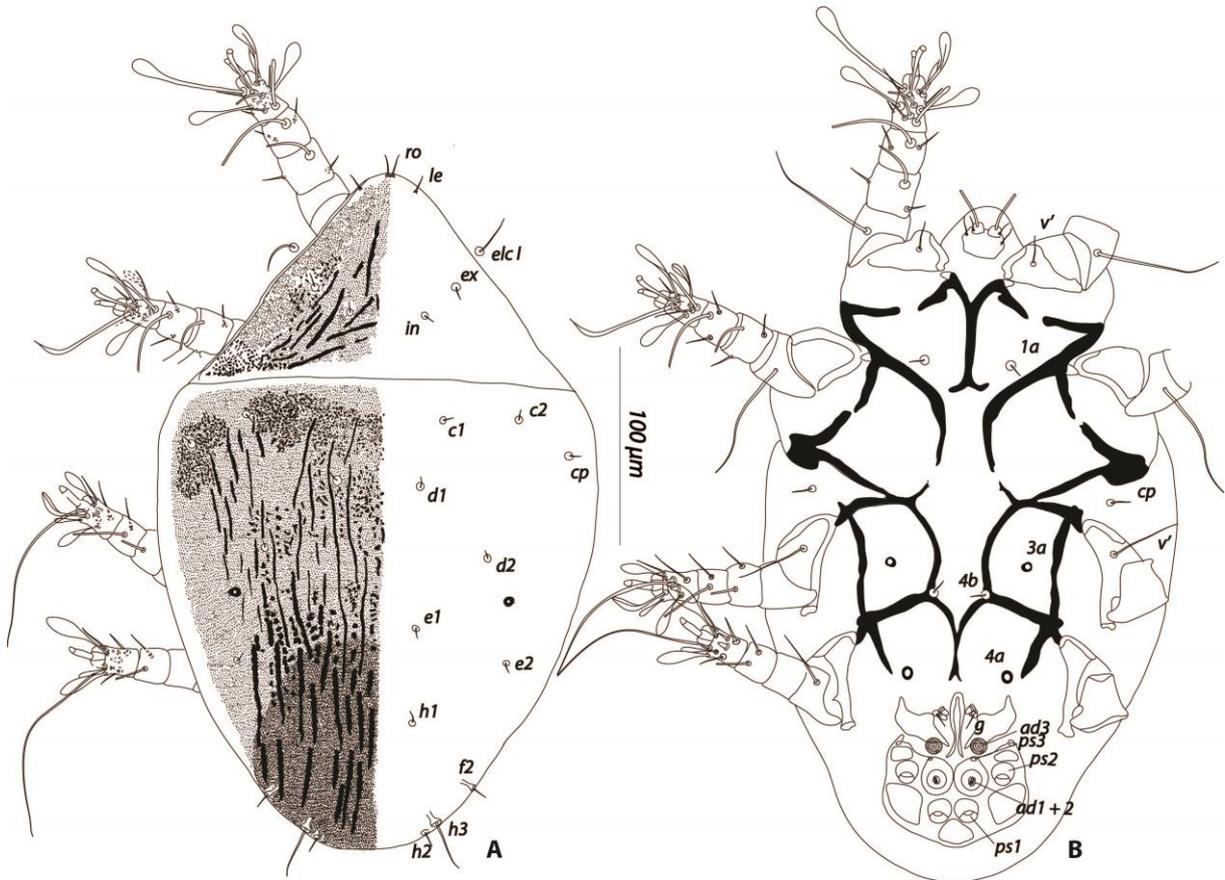


Figure 25 - **Gen. 2 n. sp. 1** (deutonymph). (A) dorsal view. (B). ventral view

Gnathosoma (Fig. 26 A): 15 (13 – 18) long and 22 (12 – 20) wide at basis, anterior gnathosomal seta 7 (6 – 8), posterior gnathosomal seta 8 (6 – 9), gnathosomal solenidion 16 (15 – 17).

Legs (Fig. 26 B; 27 A – L): Leg I 111 (90 – 170), tarsus 26 (20 – 40) long and 17 (12 – 24) wide at basis, v' 13 (10 – 19), bv'' 55 (45 – 65), l' 10 (8 – 13), l'' 10 (7 – 13), σ' 15 (13 – 18), v' 12 (18 – 10), c'' 10 (8 – 13), Φ 34 (28 – 40), $\omega 1$ 15 (13 – 20), very lightly swollen at the tip, ϵ 4 (4 – 5), $\omega 2$ 8 (6 – 9), $\omega 3$ 9 (8 – 12), a'' 9 (8 – 12), ft' 14 (10 – 16), a' 39 (32 – 50), pv' 21 (19 – 26), pv'' 43 (32 – 50), tc' 40 (35 – 55), ft'' 22 (18 – 28), tc'' 67 (57 – 76), p' 17 (13 – 20).

Leg II 105 (73 – 166), tarsus 25 (20 – 40) long and 16 (15 – 17), v' 14 (12 – 18), bv'' 52 (45 – 65), l' 10 (9 – 13), l'' 10 (7 – 13), σ' 13 (10 – 16), v' 12 (9 – 15), c'' 11 (9 – 18), Φ 32 (28 – 40), $\omega 1$ 15 (12 – 20), straight, ft' 14 (12 – 18), a' 35 (32 – 43), pv' 22 (19 – 30), pv'' 38 (30 – 50), tc' 35 (29 – 48), ft'' 21 (19 – 22), tc'' 66 (54 – 85), p' 16 (11 – 20).

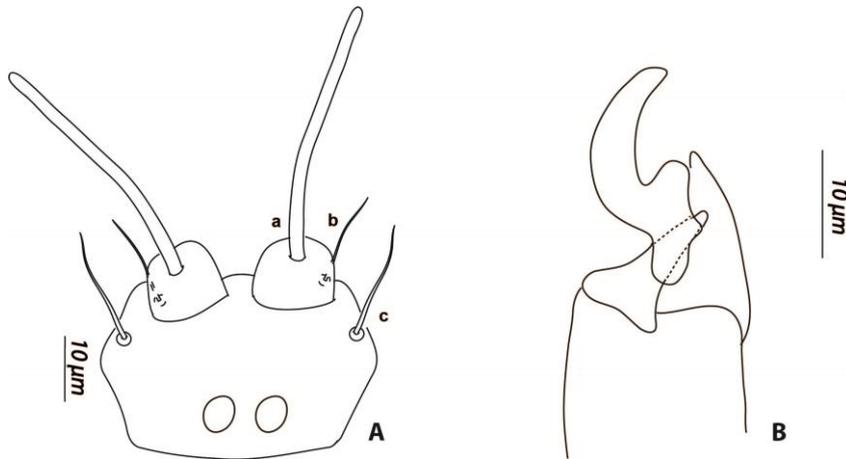


Figure 26 - **Gen. 2 n. sp. 1** (deutonymph). (A) Gnathosoma [a- gnathosomal solenidium; b- anterior gnathosomal seta; c- posterior gnathosomal seta]. (B) empodial claw

Leg III 85 (73 – 118), tarsus 21 (17 – 32) long and 16 (14 – 16) wide at basis, v' 23 (15 – 27), l' 14 (11 – 19), σ' 10 (9 – 13), v' 13 (11 – 18), Φ 19 (15 – 23), pv' 14 (10 – 18), pv'' 28 (26 – 40), tc' 33 (32 – 42), ft'' 79 (72 – 90), tc'' 32 (28 – 46), p' 14 (11 – 17), p'' 14 (12 – 18), s 7 (6 – 8).

Leg IV 90 (79 – 130), tarsus 22 (18 – 32) long and 14 (13 – 14) wide at basis, bv'' 23 (18 – 30), v' 12 (10 – 17), Φ 12 (9 – 17), pv' 12 (10 – 16), pv'' 13 (10 – 14), tc' 32 (26 – 40), ft'' 80 (74 – 92), tc'' 30 (25 – 38), p' 15 (11 – 17), p'' 14 (10 – 18), s 8 (7 – 9).

Adults- Unknown.

Remarks

Deutonymphs of **Gen. 2** have also been found on species of a different bee genus, *Eufriesea* (Apidae), collected in Brazil, Guatemala, Guyana, Mexico, Panama, Peru and Venezuela. It is not possible to distinguish morphologically those deutonymphs from deutonymphs of **Gen. 1 n. sp. 1**. However, based on the usual specificity of mites of this group, the specimens from *Eufriesea* could belong to a different species. Decision about their con-specificity with **Gen. 1 n. sp. 1** will benefit from the examination of adults and/ or molecular analysis.

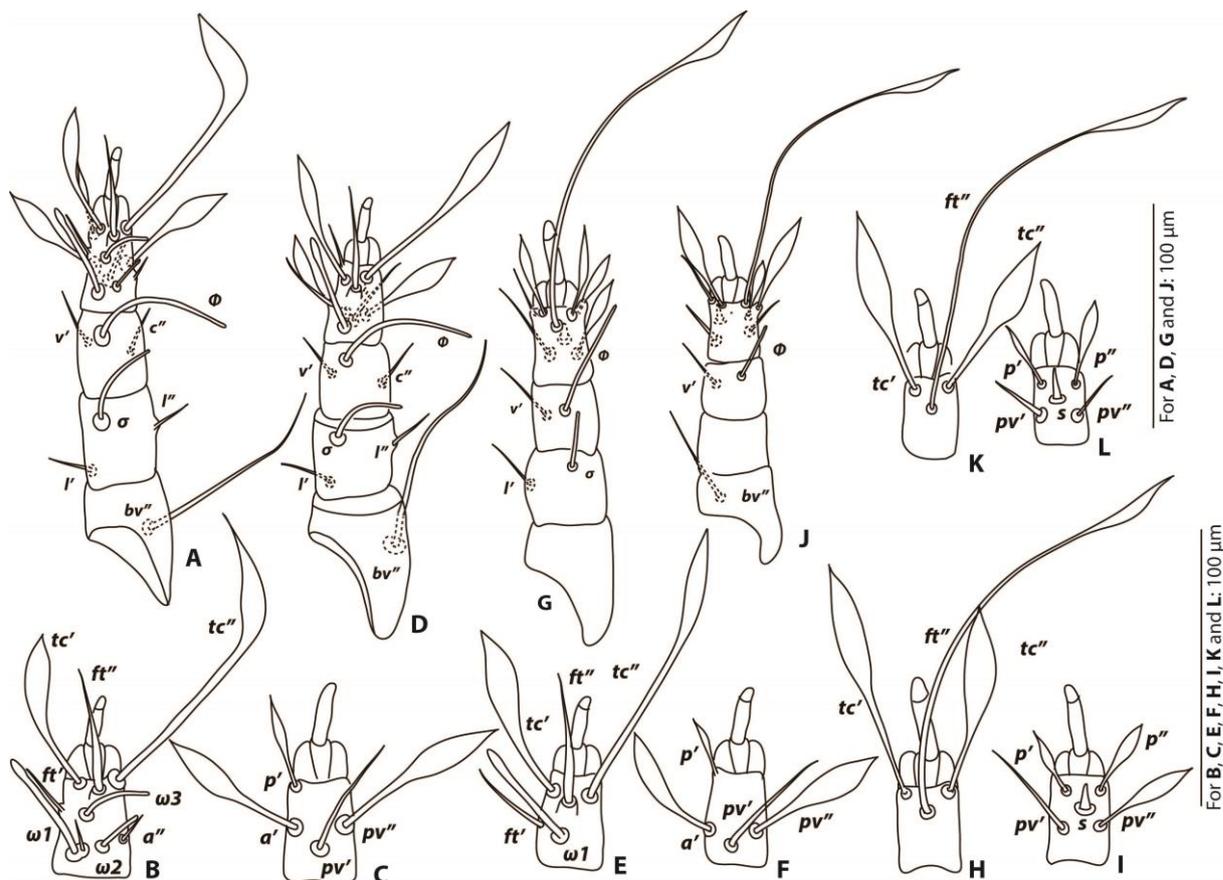


Figure 27 - **Gen. 2 n. sp. 1** (deutonymph). (A) Leg I. (B) Tarsus I- dorsal view. (C) Tarsus I- ventral view. (D) Leg II. (E) Tarsus II- dorsal view. (F) Tarsus II- ventral view. (G) Leg III. (H) Tarsus III- dorsal view. (I) Tarsus III- ventral view. (J) Leg IV. (K) Tarsus IV- dorsal view. (L) Tarsus IV- ventral view

Key to genera of Horstiinae and to the new species of the genera here described

Deutonymphs

1. Empodial claws enlarged and hook-like; genital papillae often elongate and tapering to a fine point, rarely rounded; setae of coxal fields I and III filiform or absent..... 2.
- 1'. Empodial claws small, if enlarged then not hook-like; genital papillae short, broadly rounded apically; setae of coxal fields often conoidal.....10.
2. Tarsus IV with 2 or 3 setae longer than leg IV.....3.
- 2'. Tarsus IV with at most one seta longer than leg IV5.
3. Empodial claws large, twisted and hook-like; claws I-III distinctly larger than claws IV; associated with *Anthidium* and related bee genera of Megachilidae.....
.....*Sennertionyx* Zachvatkin, 1941
- 3'. Empodial claws variously shaped, but never twisted; claws I-IV of similar sizes.....4

4. Empodial claws I-IV short, strong, barely hooked apically; posterior apodeme of coxal field II entire, running obliquely in relation to anterior apodeme III; tibiae I-II with 1 ventral seta; associated with *Xylocopa* bees (Apidae)*Horstia* Oudemans, 1905
- 4'. Empodial claws I-IV regular in shape, with distinct apical hook; posterior apodeme of coxal field II divided, with only medial portion parallel to anterior apodeme III; tibiae I-II with 2 ventral setae; associated with *Diadasia* and *Anthophora* bees (Apidae); Nearctic, Neotropical.....*Diadasiopus* OConnor, 1996
5. Coxal seta 1a represented by vestigial alveoli; coxal seta 4a shaped as a large conoid; associated with *Epicharis* bees (Apidae); Neotropical*Horstiella* Turk, 1948
- 5'. Coxal seta 1a normally developed, filiform; coxal seta 4a filiform or represented by vestigial alveoli6
6. Coxal setae 3a and 4a present, filiform; seta 4b absent; posterior apodeme of coxal field II divided; posterior dorsum with well developed longitudinal apodemes; associated with *Anthophora* and *Diadasia* (Apidae); Holarctic*Medeus* Volgin, 1974
- 6'. Coxal setae 3a and 4a absent; seta 4b present, filiform; posterior apodeme of coxal field II undivided; posterior dorsum without longitudinal apodemes; associated with *Megachile* (*Chalicodoma*) (Megachilidae)7
7. Empodial claws I-IV with rounded basal flange; cosmopolitan8
- 7'. Empodial claws I-IV without basal flange.....9
8. Seta *p*'' present on tarsi I-II*Cerophagopsis* Zackvatkin, 1941
- 8'. Seta *p*'' absent on tarsi I-II**Gen. 2.**
.....**Gen. 2 n. sp. 1.**
9. Seta *s* on tarsi III-IV filiform.....*Megachilopus* Fain, 1974
- 9'. Seta *s* on tarsi III-IV spine-shaped.....**Gen. 1**.....9.1.
- 9.1. Coxal area III open or almost closed, never totally closed; sternal undivided.....**Gen. 1 n. sp. 4.**
- 9.1'. Coxal area III closed; sternal bifurcated.....9.2.
- 9.2. Seta *ro* shorter than *le*; gnathosoma shorter than wide.....**Gen. 1 n. sp. 5.**
- 9.2'. Seta *ro* longer than *le*; gnathosoma longer than wide.....9.3.
- 9.3. Seta *tc*'' more than four times longer than *ft*'.....**Gen. 1 n. sp. 2.**
- 9.3'. Seta *tc*'' less than four times longer than *ft*'.....9.4.
- 9.4. Seta *ft*'' more than twice longer than *tc*' and *tc*''.....**Gen. 1 n. sp. 6.**
- 9.4'. Seta *ft*'' less than twice longer than *tc*' and *tc*''.....**Gen. 1 n. sp. 3.**

10. External conoidal seta (*ps*₂) of attachment organ anterior of median sucker (ad₁₊₂)..... *Schulzea* Zachvatkin, 1941
- 10'. External conoidal seta of attachment organ lateral or posterior of median sucker..... 11
11. Genu III with a short dorsal solenidion (σ) in addition to lateral seta..... *Kuzinia* Zachvatkin, 1941
- 11'. Genu III without solenidion 12
12. Empodial claws of pretarsi IV much smaller than claws of pretarsi I-III; 1 species associated with *Halictus* bees (Halictidae); South Africa.....*Halictacarus* Mahunka, 1974
- 12'. Empodial claws of pretarsi I-IV similar in shape *Neohorstia* Zachvatkin, 1941

Adults

1. Prodorsal sclerite as inverted U-shaped; seta *4b* absent; two pairs of paraproctal setae.....*Medeus* Volgin, 1974
- 1'. Prodorsal sclerite not posteriorly concave; seta *4b* present; six pairs of paraproctal setae.....2.
2. Tibiae I-II with one ventral seta; tibia IV without ventral seta.....*Horstia* Oudemans, 1905
- 2'. Tibiae I-II with two ventral setae; tibia IV with one ventral seta.....3
3. All dorsal setae setiform; seta *in* much longer than *ex*.....*Cerophagopsis* Zachvatkin, 1941
- 3'. Most dorsal setae stout; seta *in* at most as long as *ex*.....**Gen. 1**3.1
- 3.1. Most dorsal setae shorter than 30 μ m; seta *in* much shorter than *ex*; *cp* similar in length to *c1* and *c2*; *h3* much longer than other *h* setae; seta *ft*" of tarsus I positioned at same level to *tc*' and *tc*"**Gen. 1 n. sp. 1.**
- 3.1'. Most dorsal setae longer than 50 μ m; seta *in* and *ex* similar in length; *cp* much shorter than *c1* and *c2*; *h3* similar in length to other *h* setae; seta *ft*" of tarsus I positioned basally to *tc*' and *tc*"**Gen. 1 n. sp. 4.**

References

EICKWORT, G.C. Evolution and life-history patterns of mites associated with bees. In: HOUCK, M.A. **Mites: ecological and evolutionary analyses of life-history patterns.** New York: Springer, 1994. chap. 9, p. 218-251.

FAIN, A. Deux nouveaux Hypopes vivant en association phoretique sur des Hymenopteres africains (Acarina: Sarcoptiformes). **Revue de Zoologie Africaine**, Bruxelles, v. 88, n. 2, p. 421-426, 1974.

_____. Notes sur les hypopes du genre *Horstia* Oudemans, 1905 (Acari, Acaridae), phorétiques sur les hyménoptères. **Acarologia**, Paris, v. 25, n. 3, p. 259-270, 1984.

GRANDJEAN, F. Les segments post-larvaires de l'hysterosoma chez les Oribates (Acariens). **Bulletin de la Société Zoologique de France**, Paris, v.64, 273-284, 1939.

GRIFFITHS, D.A.; ATYEO, W.T.; NORTON, R.A.; LYNCH, C.A. The idiosomal chaetotaxy of astigmatid mites. **Journal of Zoology**, London, v. 220, n. 1, p. 1-32, 1990.

LOMBERT, H.A.P.M.; OCONNOR, B.M.; LUKOSCHUS, F.S.; WHITAKER, J.O. Ontogeny, systematics and ecology of *Sennertia* (*Amsennertia*) *americana* Delfinado & Baker, 1976 (Acari: Chaetodactylidae) from the nest of the carpenter bee, *Xylocopa virginica* (Hymenoptera: Anthophoridae). **International Journal of Acarology**, Oak Park, v.13, n.2, p. 113-129, 1987.

MAHUNKA, S. Auf Insekten lebende Milben (Acari: Acarida und Tarsonemida) aus Afrika, V. **Acta Zoologica Academiae Scientiarum Hungaricae**, Budapest, v. 21, p. 39-72, 1975.

OCONNOR, B.M. Two new mites (Acari: Acaridae) associated with long-tongued bees (Hymenoptera: Apidae) in North America. **Journal of the Kansas Entomological Society**, Manhattan, v. 69, n. 4, p. 15-34, 1996.

_____. Evolutionary ecology of astigmatid mites. **Annual Review of Entomology**, Stanford, v. 27, p. 385-409, 1982.

_____. Coevolution in astigmatid mite-bee associations. In: NEEDHAM, G.R.; PAIGE Jr., R.E.; DELFINADO-BAKER, M.; BOWMAN, C.E. **Africanized Honey Bees and Bee Mites**. Chichester: Harwood, 1988. p. 339-346.

_____. Cohort Astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A Manual of Acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

_____. Historical ecology of the Acaridae (Acari): Phylogenetic evidence for host and habitats shifts. In: WALTER, R.B.E.; PROCTOR, H.C.; NORTON, R.A.; COLLOFF, M.J. (Ed.). **Acarology: Proceedings of the 10th International Congress**. Melbourne: CSIRO Publishing, 2001. p. 76-82.

_____. Ontogeny and systematics of the genus *Cerophagus* (Acari: Gaudiellidae), mites associated with bumblebees. **The Great Lakes Entomologist**, v. 25, p. 173-189, 1992.

OCHOA, R.; OCONNOR, B.M. Revision of the genus *Horstiella* (Acari: Acaridae): mites associated with neotropical *Epicharis* bees (Hymenoptera: Apidae). **Annals of the Entomological Society of America**, College Park, v. 93, n. 4, p. 713-737, 2000.

OUDEMANS A. Acarologische Aanteekeningen XX. **Entomologische Berichten**, Amsterdam, v. 2, p. 15-23, 1905.

TURK, F.A. Insecticolous Acari from Trinidad, BWI. **Proceedings of the Zoological Society of London**, London, v. 118, n. 1, p. 82-125, 1948.

VITZTHUM, H. Acarologische Beobachtungen (3. Reihe). **Archiv für Naturgeschichte**, Berlin, v. 85A, n. 5, p. 1-62, 1919.

VOLGIN, V.I. No vie rodi i vidi akaroidnith kleshchei (Acariformes, Acaroidea) iz Kazakhstana. **Entomologicheskoe Obozrenie**, Leningrad, n. 53, p. 218-225, 1974.

ZACHVATKIN, A.A. **Fauna of USSR, Arachnoidea, Tyroglyphidae**. Saint Petersburg: Zoological Institute of the Academy of Science of the USSR, 1941. 573 p. (English translation by American Institute of Biological Sciences).

5 POTENTIAL OF ASTIGMATID MITES (ACARI: ASTIGMATINA) AS PREY FOR REARING EDAPHIC PREDATORY MITES OF THE FAMILIES LAELAPIDAE AND RHODACARIDAE (MESOSTIGMATA)

Abstract

Laelapidae and Rhodacaridae are important families of edaphic predatory mites. Species of these families have been considered for use in biological control programs of soil pests. Mites of the Cohort Astigmatina (Sarcoptiformes) have been largely used as factitious prey in the mass rearing of different edaphic or plant inhabiting predatory mites. *Stratiolaelaps scimitus* (Womersley) (widely commercialized for the control of fungus gnats and thrips) and *Protogamasellopsis zaheri* Abo-Shnaf, Castilho and Moraes (not available commercially but promising for the control of thrips and nematods) are known to be reared on *Tyrophagus putrescentiae* (Schrank) but the possibility to find a perhaps more efficient prey has not been evaluated. The objective of this work was to evaluate different species of astigmatid as prey for these predators. *Stratiolaelaps scimitus* and *P. zaheri* oviposited on all evaluated astigmatids, but *T. putrescentiae* and *Aleuroglyphus ovatus* (Tropeau) were the most suitable prey; to confirm the effect of prey on oviposition rates, pregnant females of the predators were kept without any food and in this case, oviposition was negligible or null. Survivorship was always higher than 78% and was not influenced by prey species or starvation.

Keywords: Factitious prey; Biological control; Mass rearing

a. Introduction

The literature about the ability of predatory mites to consume small arthropods commonly found in agricultural areas is extensive, indicating the role played by those organisms in nature and their potential to be used in applied biological control control (CARRILLO; MORAES, PEÑA, 2015).

Biological control of mites and small insect pests have been extensively done in several countries around the world. While the control of plant pests have been done mostly with the use of predatory mite of the family Phytoseiidae (GERSON; SMILEY; OCHOA, 2008; MCMURTRY; SOURASSOU; DEMITE, 2015), soil pests have been controlled with predatory mites of other families, especially Laelapidae (MOREIRA; MORAES, 2015). The potential of the use of predators of other families exist, including those of the family Rhodacaridae (CASTILHO; VENANCIO; NARITA, 2015).

The laelapid mite *Stratiolaelaps scimitus* (Womersley) is currently commercialized by several companies (Promip- Brazil; Evergreen and Growers Supply- USA and Koopert- Europe) for the control of fungus gnats (*Bradysia* spp.; Diptera: Sciaridae) and thrips

(*Frankliniella occidentalis* (Pergande), *Thrips tabaci* Lindeman and *Echinothrips americanus* Morgan) (MOREIRA; MORAES, 2015). Two other species of the same family, *Stratiolaelaps miles* (Berlese) and *Gaeolaelaps aculeifer* (Womersley) are also produced commercially and used for the control of *Bradysia* spp (MOREIRA; MORAES, 2015).

The rhodacarid *Protogamasellopsis zaheri* Abo-Shnaf, Castilho and Moraes is not available commercially, but Castilho et al. (2009) demonstrated its ability (mentioned as *P. posnaniensis* Wisniewski and Hirschmann, according to R. de C. Castilho, personal communication) to reproduce on different prey, namely *Bradysia matogrossensis* (Lane), *F. occidentalis*, the astigmatid mites *Tyrophagus putrescentiae* (Schrank) and *Rhizoglyphus echinopus* (Fumouze and Robin), and the bacteriophagous nematode *Rhabditella axei* (Cobbold) (mentioned as *Protorhabditis* sp., according to R. de C. Castilho, personal communication). Among these prey, highest oviposition and/ or prey consumption rates of this prey were observed on *T. putrescentiae*, followed by *F. occidentalis* and *R. axei* (Cobbold) (CASTILHO et al., 2009).

Although extensive use of a few species of predatory mites has also been done in open fields, especially in orchards (e.g. MCMURTRY; SOURASSOU; DEMITE, 2015; SCHMIDT et al., 2013; SZABÓ et al., 2014), the practical use of most predatory mites for pest control has been done mostly on protected crops (ZHANG, 2003). One of the main reasons for this seems to be the cost of biological control, highly influenced by the production cost of natural enemies. Most certainly considerable efforts have been dedicated by private companies to develop less costly production techniques. This paper is the third of a series of papers recently conducted in our laboratory about the possible use factitious astigmatid prey for the mass production of known or potentially useful predatory mites. The previous three papers relate to the use of phytoseiid mites (BARBOSA; MORAES, 2015; SILVA; MORAES, in preparation).

Methods for rearing *S. scimitus* under laboratory conditions were reported by Wright and Chambers (1994), Steiner et al. (1999) and Cabrera et al. (2005). A pilot system for the mass production of *S. scimitus* was proposed by Freire and Moraes (2007), who reported highest oviposition rate 30 days after the introduction of females of the predator in units containing *T. putrescentiae* as prey.

The ability of predatory mites to survive and reproduce when fed with astigmatids is very auspicious, given that several species of the later are easily produced in large numbers on flour, bran or similar substrates in relatively small spaces (GRIFFITHS, 1964; SINHA, 1979; HUGHES, 1976). This in turn leads to reduced production cost (GERSON et al., 2003), making biological control more competitive with other control methods.

Although it is known that both *S. scimitus* and *P. zaheri* may reach high population levels when fed with *T. putrescentiae* (CASTILHO et al., 2009; FREIRE; MORAES, 2007), the possibility to use other Astigmatina as prey, perhaps more efficiently, has not been evaluated. The objective of this work was to evaluate populations of Brazilian astigmatid mites as food sources for those predators.

b. Material and Methods

Stock colonies

Astigmatina evaluated as prey were: *Acalvolia squamata* (Oudemans) (Winterschmidtidae), *Aeroglyphus robustus* (Banks) (Aeroglyphidae), *Aleuroglyphus ovatus* (Tropeau), *Cosmoglyphus oudemansi* (Zachvatkin), *Thyreophagus n. sp.* and *T. putrescentiae* (Acaridae), *Blomia tropicalis* Bronswijk, de Cock and Oshima (Echimyopodidae), *Chortoglyphus arcuatus* (Tropeau) (Chortoglyphidae), *Dermatophagoides pteronyssinus* (Trouessart) (Pyroglyphidae), *Glycyphagus domesticus* (De Geer) (Glycyphagidae) and *Suidasia nesbitti* Hughes (Suidasiidae). *Tyrophagus putrescentiae* was evaluated only for *S. scimitus*, because, although known to be a suitable prey for this predator, oviposition of this predator fed on *T. putrescentiae* was never quantified (the oviposition of *P. zaheri* on this prey was evaluated by Castilho et al., 2009). Predators were obtained from colonies maintained at Escola Superior de Agricultura “Luiz de Queiroz” (Esalq), Piracicaba, São Paulo, Brazil, initiated in 2005 and were fed on *T. putrescentiae*.

. Stock colonies of astigmatids and predators were maintained in plastic containers similar to those described by Freire and Moraes (2007), at $25 \pm 1^\circ\text{C}$, $75 \pm 10\%$ R.H., in the dark. Astigmatids were fed with 50% of brewer’s yeast and 50% of wheat germen, except *C. oudemansi*, reared in a plastic container with the bottom filled with a mixture of 90% of gypsum and 10% of charcoal and fed on humid brewer’s yeast.

Oviposition test

Experimental units were maintained in incubators at $25 \pm 1^\circ\text{C}$, $90 \pm 10\%$ R.H., in the dark. Each experimental unit consisted of a plastic dish (2.7 cm in diameter x 1.2 cm high) about half filled with a solidified paste made with a mixture of nine parts gypsum to one part activated charcoal (Abbatiello, 1965), with humidity maintained by daily additions of distilled water. Each unit was sealed with a piece of transparent plastic film (Magipack®) to prevent

mites from escaping. Every other day predators were transferred to a new experimental unit to avoid negative effects of accumulated debris.

Using a stereomicroscope (Leica MZ12.5), an apparently healthy gravid female ($n = 30$) was transferred from the stock colony, to an experimental unit and fed *ad libitum* with a mixture of all stages of the evaluated prey. Each experimental unit was examined daily for 11 consecutive days to count the number of eggs laid, survivorship as well as to replace the food. As control treatment, 30 females of each species were isolated in experimental units without foods. Eggs laid on the first day were excluded from analysis because they were presumed to reflect effects of pre-trial feeding.

Data analysis

Statistical analysis were performed on SAS University Edition. Because the data did not satisfy the assumptions of normality (Shapiro Wilk's test) and homoscedasticity (Levene test), nonparametric tests were used to determine statistical significance (Kruskal–Wallis ANOVA) and to compare treatments (Mann–Whitney U test). Survivorship was analyzed using the Chi square tests.

c Results

Prey species had significant effect on oviposition of both predatory mites (Table1; $H = 200.14$; $df = 11$ and $p < .0001$ for *S. scimitus* and $H = 204.44$; $df = 10$ and $p < .0001$ for *P. zaheri*) and both oviposited on all evaluated prey.

Highest oviposition of *S. scimitus* was obtained when fed on *T. putrescentiae*, followed by *A. ovatus*. Lowest oviposition rates were obtained when fed on *A. robustus* and *C. arcuatus*. Oviposition when no food was offered was negligible. Survivorship of *S. scimitus* after 11 days did not vary on evaluated prey or in the absence of food and was always at least 79% ($\chi^2 = 7.81$; $df = 11$; $p = 0.64$) (Table 1).

Highest oviposition of *P. zaheri* was obtained when fed *A. ovatus*, followed by *C. oudemansi*. Also for this species, lowest oviposition rate was obtained when fed *C. arcuatus*. No eggs were laid when food was no offered. Survivorship of *P. zaheri* after 11 days did not vary on evaluated prey or in the absence of food and was always at least 78% ($\chi^2 = 9.44$; $df = 10$; $p = 0.49$) (Table 1).

Table 5.1 - Mean (\pm SE) daily oviposition and survival (after 11 days) of *Stratiolaelaps scimitus* and *Protogamasellopsis zaheri* fed different astigmatid prey species at 25 ± 1 °C, $70 \pm 10\%$ RH and in the dark

	<i>Stratiolaelaps scimitus</i>			<i>Protogamasellopsis zaheri</i>		
	N	Daily oviposition ^a	Survival (%) ^b	N	Daily oviposition ^a	Survival (%) ^b
<i>Acalvolia squamata</i>	30	1.6 \pm 0.08 cd	90 a	26	4.5 \pm 0.16 c	88 a
<i>Aeroglyphus robustus</i>	27	0.6 \pm 0.03 f	93 a	27	3.2 \pm 0.18 e	93 a
<i>Aleuroglyphus ovatus</i>	29	2.3 \pm 0.10 b	93 a	26	8.5 \pm 0.40 a	92 a
<i>Blomia tropicalis</i>	30	1.0 \pm 0.12 e	90 a	25	3.8 \pm 0.14 d	84 a
<i>Chortoglyphus arcuatus</i>	29	0.6 \pm 0.08 f	90 a	25	2.2 \pm 0.09 fg	92 a
<i>Cosmoglyphus oudemansi</i>	28	1.5 \pm 0.11 cd	93 a	26	5.1 \pm 0.13 b	92 a
<i>Dermatophagoides pteronyssinus</i>	29	1.2 \pm 0.08 de	90 a	28	2.0 \pm 0.11 g	93 a
<i>Glycyphagus domesticus</i>	28	1.5 \pm 0.07 cd	93 a	28	2.5 \pm 0.13 f	93 a
<i>Suidasia nesbitti</i>	29	1.7 \pm 0.09 c	97 a	25	3.6 \pm 0.12 de	100 a
<i>Thyreophagus n. sp.</i>	29	1.4 \pm 0.08 d	79 a	23	3.8 \pm 0.29 de	78 a
<i>Tyrophagus putrescentiae</i>	29	3.4 \pm 0.10 a	97 a	- ^c		
Without food	28	0.1 \pm 0.01 g	96 a	29	0 h	93a

Means within a column followed by the same letter are not significantly different (^aKruskal–Wallis ANOVA- Mann–Whitney U test; ^bChi-square test; $p < 0.05$; ^c not evaluated)

d Discussion

The much higher oviposition rates of *P. zaheri* on all tested prey compared with those of *S. scimitus* was already expected, given the results of previous studies offering other food types to those predators (ALI; DUNNE; BRENNAN, 1997; CABRERA; CLOYD; ZABORSKI, 2005; CASTILHO et al., 2009; ENKEGAARD; SARDAR; BRØDSGAARD, 1997). Interestingly, the two prey allowing the highest oviposition rates in this study for *S. scimitus* (*A. ovatus* and *T. putrescentiae*) were also the ones allowing the highest oviposition rates for *P. zaheri*, as indicated by the results of this study complemented by the results of the study of Castilho et al. (2009).

Daily oviposition rates obtained in this study for *S. scimitus* on *A. ovatus* and *T. putrescentiae* were high compared with results of Cabrera, Cloyd and Zaborski (2005) that reported daily oviposition of 1.4 on *Bradysia* sp. larvae and 2.0 on unidentified Enchytraeidae (Oligochaeta); oviposition was null and immatures did not reach deutonymphal stage on *Sancassania* aff. *sphaerogaster*. Oviposition rate comparable to the best values obtained in this study was reported by Ali and Brennan (1997) for a related predator species, *Stratiolaelaps miles* (Berlese), on the acarid *Acarus siro* L. (2.6 eggs per female per day). Much lower levels were reported by Shereef et al. (1980) and Enkegaard; Sardar and Brødsgaard (1997) for this same predator on *T. putrescentiae* (0.7) and by Shereef et al. (1980) and Hoda et al. (1986) on *R. echinopus* (0.8).

When fed on *A. ovatus*, the oviposition rate of *P. zaheri* was slightly higher than reported by Castilho et al. (2009) for the same predator on *T. putrescentiae* (7.6 eggs per female per day) and much higher than reported by the same authors on *R. echinopus* (1.9).

Cosmoglyphus oudemansi also promoted high oviposition of *P. zaheri* in this study, but the mass rearing of that prey seems more difficult than the rearing of other prey, due to its requirement for levels of relative humidity nearing saturation (BARBOSA personal observation). *Aleuroglyphus ovatus* and *T. putrescentiae* are ubiquitous acarids (OCONNOR, 2009) that can be easily reared on several cheap substrates (e.g. CANFIELD; WRENN, 2009; CHMIELEWSKI, 1999; RIVARD, 1961; SASA et al., 1970; XIA et al., 2009), what is an additional advantage of using these species in the mass production of those and possibly other predators of the same families.

Castilho et al. (2009) stated that the ability of *P. zaheri* to feed on astigmatids suggested that to be a generalist predator, given that the astigmatids are often uncommon in microhabitats where those predators are regularly found; this seems also to apply to laelapid predators.

Astigmatids of the genus *Rhizoglyphus* are major pests of some crops in different countries (DIAZ et al., 2000; LESNA; SABELIS; CONJIN, 1996), but much less so in Brazilian soils where these predators have been found (our unpublished observation). The acceptance of all evaluated prey as food by this predator as well as by *S. scimitus* in the present study corroborates the assumption of Castilho et al. (2009).

High survivorship of *P. zaheri* and *Stratiolaelaps* species was already reported on different prey (CASTILHO et al., 2009; ENKEGAARD; SARDAR; BRØDSGAARD, 1997) and in the absence of food (IGNATOWICZ, 1974; MOREIRA; MORAES, 2015; WHRIGHT; CHAMBERS, 1994). Thus, the high survivorship of both predators evaluated in this study on all prey species was expected, reflecting the absence of deleterious effect of the prey on the predators. The ability to stand starvation is an important characteristic to be considered in the practical use of predators for pest control. Wright and Chambers (1994) mentioned that *S. miles* searched for protected sites in the experimental units to oviposit. Similar behavior was observed in this study for *S. scimitus* while always oviposited next to prey food.

e Conclusion

The results obtained, complemented by the results of Castilho et al. (2009), demonstrate the possibility of using *A. ovatus* as newsuitable species for mass rearing *S. scimitus* and *P. zaheri*, besides confirming the efficacy of *T. putrescentiae* as a factitious prey for those predators.

References

- ABBATIELLO, M. A culture chamber for rearing soil mites. **Turtox News**, Chicago, v. 43, p. 162-164, 1965.
- ALI, O.; DUNNE, R.; BRENNAN, P. Biological control of the sciarid fly, *Lycoriella solani* by the predatory mite, *Hypoaspis miles* (Acari: Laelapidae) in mushroom crops. **Systematic and Applied Acarology**, London, v. 2, n. 1, p. 71-80, 1997.
- BARBOSA, M.F.C.; MORAES, G.J. Evaluation of astigmatid mites as factitious food for rearing four predaceous phytoseiid mites (Acari: Astigmatina; Phytoseiidae). **Biological Control**, Orlando, v. 91, p. 22-26, 2015.
- CABRERA, A.R.; CLOYD, R.A.; ZABORSKI, E.R. Development and reproduction of *Stratiolaelaps scimitus* (Acari: Laelapidae) with fungus gnat larvae (Diptera: Sciaridae),

potworms (Oligochaeta: Enchytraeidae) or *Sancassania* aff. *sphaerogaster* (Acari: Acaridae) as the sole food source. **Experimental and Applied Acarology**, Amsterdam, v. 36, p. 71-81, 2005.

CANFIELD, M.S.; WRENN, W.J. *Tyrophagus putrescentiae* mites grown in dog food cultures and the effect mould growth has on mite survival and reproduction. **Veterinary Dermatology**, Oxford, v. 21, n. 1, p. 58-63, 2010.

CARRILLO, D.; MORAES, G.J.; PEÑA, J.E. **Prospects for biological control of plant feeding mites and other harmful organisms**. Cham: Springer International, 2015. 328 p.

CASTILHO, R.C.; VENANCIO, R.; NARITA, J.P.Z. Mesostigmata as biological control agents, with emphasis on Rhodacaroidea and Parasitoidea. In: CARRILLO, D.; MORAES, G.J.; PEÑA, J.E. (Ed.). **Prospects for biological control of plant feeding mites and other harmful organisms**. Cham: Springer International, 2015. chap. 1, p. 1-31.

CASTILHO, R.C.; MORAES, G.J.; SILVA, E.S.; SILVA, L.O. Predation potential and biology of *Protogamasellopsis posnaniensis* Wisniewski & Hirschmann (Acari: Rhodacaridae). **Biological Control**, Orlando, v. 48, n. 2, p. 164-167, 2009.

CHMIELEWSKI, W. Acceptance of buckwheat grain as a food by *Tyrophagus putrescentiae* (Schr.) (Acari: Acaridae). **Fagopyrum**, Ljubljana, v. 16, p. 95-97, 1999.

DIAZ, A.; OKABE, K.; ECKENRODE, C.J.; VILLANI, M.G.; OCONNOR, B.M. Biology, ecology, and management of the bulb mites of the genus *Rhizoglyphus* (Acari: Acaridae). **Experimental and Applied Acarology**, Amsterdam, v. 24, p. 85-113, 2000.

ENKEGAARD, A.; SARDAR, M.; BRØDSGAARD, H. The predatory mite *Hypoaspis miles*: biological and demographic characteristics on two prey species, the mushroom sciarid fly, *Lycoriella solani*, and the mould mite, *Tyrophagus putrescentiae*. **Entomologia Experimentalis et Applicata**, Dordrecht, v. 82, n. 2, p. 135-146, 1997.

FREIRE, R.A.P.; MORAES, G.J. Mass production of the predatory mite *Stratiolaelaps scimitus* (Womersley) (Acari: Laelapidae). **Systematic and Applied Acarology**, London, v. 12, p. 117-119, 2007.

GERSON, U.; SMILEY, R.L.; OCHOA, R. **Mites (Acari) for pest control**. Oxford: Blackwell Science, 2003. 539 p.

GRIFFITHS, D.A. A revision of the genus *Acarus* L., 1758 (Acaridae, Acarina). **Bulletin of the Natural History Museum (Zoology)**, London, v. 11, p. 415-464, 1964.

HODA, F.M.; TAHA, H.A.; IBRAHIM, G.A.; EL-BEHERI, M.M. Biological observations on the predatory mite, *Hypoaspis miles* Berlese (Acarina: Laelapidae). **Bulletin of the Entomological Society of Egypt**, Cairo, v. 66, p. 103-106, 1986.

HUGHES, A.M. **The Mites of Stored Food and Houses**. London: Ministry of Agriculture and Fisheries, 1976. 400 p. (Technical Bulletin, 9).

IGNATOWICZ, S. Observations on the biology and development of *Hypoaspis aculeifer* Canestrini, 1885 (Acarina, Gamasides). **Zoologica Poloniae**, Wroclaw, v. 24, p. 41–59, 1974.

LESNA, I.; SABELIS, M.; CONIJN, C. Biological control of the bulb mite, *Rhizoglyphus robini*, by the predatory mite, *Hypoaspis aculeifer*, on lilies: predator-prey interactions at various spatial scales. **Journal of Applied Ecology**, Oxford, v. 33, n. 2, p. 369-376, 1996.

MCMURTRY, J.A.; SOURASSOU, N.F.; DEMITE, P.R. The Phytoseiidae (Acari: Mesostigmata) as biological control agents. In: CARRILLO, D.; MORAES, G.J.; PEÑA, J.E. (Ed.). **Prospects for biological control of plant feeding mites and other harmful organisms**. Cham: Springer International, 2015. chap. 5, p. 133-149.

MOREIRA, G.F.; MORAES, G.J. The potential of free-living laelapid mites (Mesostigmata: Laelapidae) as biological control agents. In: CARRILLO, D.; MORAES, G.J.; PEÑA, J.E. (Ed.). **Prospects for biological control of plant feeding mites and other harmful organisms**. Cham: Springer International, 2015. chap. 3, p. 77-102.

OCONNOR, B. Cohort Astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A Manual of Acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

RIVARD, I. Influence of temperature and humidity on longevity, fecundity, and rate of increase of the mite *Tyrophagus putrescentiae* (Schrank) (Acarina: Acaridae) reared on mold cultures. **Canadian Journal of Zoology**, Ottawa, v. 39, n. 6, p. 869-876, 1961.

SASA, M.; MIYAMOTO, J.; SHINOHARA, S.; SUZUKI, H.; KATSUHATA, A. Studies on mass culture and isolation of *Dermatophagoides farinae* and some other mites associated with house dust and stored food. **Japanese Journal of Experimental Medicine**, Tokyo, v. 40, n. 5, p. 367-382, 1970.

SCHMIDT, R.A.; BEERS, E.H.; UNRUH, T.R.; HORTON, D.R. Releases of insectary-reared *Galendromus occidentalis* (Acari: Phytoseiidae) in commercial apple orchards. **Journal of Economic Entomology**, Lanham, v. 106, n. 5, p. 1996-2005, 2013.

SHEREEF, G.M.; SOLIMAN, Z.R.; AFIFI, A.M. Economic importance of the mite, *Hypoaspis miles* (Berlese) (Mesostigmata: Laelapidae) and its life history. **Bulletin of the Entomological Society of Egypt**, Cairo, v. 30, p. 103-108, 1980.

SINHA, R.N. Role of Acarina in the stored grain ecosystem. In: RODRIGUEZ, J.G. (Ed.). **Recent advances in acarology**. London: Academic Press, 1979. p. 263-271.

STEINER, M.; GOODWIN, S.; WELLHAM, T. A simplified rearing method for *Stratiolaelaps (Hypoaspis) miles* (Acari: Laelapidae). **IOBC-WPRS Bulletin**, Waedenswil, v. 22, p. 241-242, 1999.

SZABÓ, Á.; PÉNZES, B.; SIPOS, P.; HEGYI, T.; HAJDÚ, Z.; MARKÓ, V. Pest management systems affect composition but not abundance of phytoseiid mites (Acari: Phytoseiidae) in apple orchards. **Experimental and Applied Acarology**, Amsterdam, v. 62, p. 525-537, 2014.

WRIGHT, E.M.; CHAMBERS, R.J. The biology of the predatory mite *Hypoaspis miles* (Acari: Laelapidae), a potential biological control agent of *Bradysia paupera* (Dipt.: Sciaridae). **Entomophaga**, Paris, v. 39, n. 2, p. 225-235, 1994.

XIA, B.; LUO, D.; ZOU, Z.; ZHU, Z. Effect of temperature on the life cycle of *Aleuroglyphus ovatus* (Acari: Acaridae) at four constant temperatures. **Journal of Stored Products Research**, Oxford, v. 45, n. 3, p. 190-194, 2009.

ZHANG, Z-Q. **Mites of greenhouses**: identification, biology and control. Wallingford: CABI, 2003. 244 p.

6 PRODUCTION OF THE HOUSE DUST MITES *Blomia tropicalis* BRONSWIJK, DE COCK AND OSHIMA (ECHIMYOPODIDAE) AND *Dermatophagoides pteronyssinus* (TROUESSART) (ASTIGMATINA: ECHIMYOPODIDAE; PYROGLYPHIDAE)

Abstract

Astigmatina is the dominant group in the acarofauna of house dust worldwide, where they feed mainly on skin scales and fungi. They are known as house dust mites. The mites themselves and their secretions and excretions might be harmful to humans. Due to their medical importance, the biology, ecology and diversity of house dust mites have been extensively studied over the years, using methods to maintain small colonies under laboratory conditions. Large colonies of those mites are maintained for the production of allergens to be used in diagnostic tests and treatment of allergy. *Blomia tropicalis* Bronswijk, de Cock and Oshima (Echimyopodidae) and *Dermatophagoides pteronyssinus* (Trouessart) (Pyroglyphidae) are two of the main dust mite species in Brazil. The objective of this work was to evaluate the effect of seven substrates for eventual use as food sources for the production of those species, as well as to conduct a preliminary evaluation of the most adequate colony growing period in a rearing process. The most suitable substrate for the production of those mites were: 50% of fish food + 50% of brewer's yeast and fishmeal for *B. tropicalis* and 50% of fishmeal + 50% of brewer's yeast for *D. pteronyssinus*. In these foods, population growth was higher than 20. 2 times and 15.3 times for *B. tropicalis* and *D. pteronyssinus*, respectively. Intrinsic rate of increase (rm) for *B. tropicalis* fed on 50% of fish food + 50% of brewer's yeast was 0.111 and for *D. pteronyssinus* fed on 50% Nutrivil® + 50% of brewer's yeast was 0.084.

Keywords: House dust mite; Rearing; *Dermatophagoides*; *Blomia*

a. Introduction

Mites of the Cohort Astigmatina (Sarcoptiformes: Oribatida) are very commonly found in human residences, being most abundant in places where dust accumulates and where humidity is high. In these places, astigmatids find their main food items, skin scale and fungi (COLLOFF, 2009; FAIN; GUERIN; HART, 1990; PLATTS-MILLS et al., 1989), as well as other items that they also accept as food, such as bacteria, their own feces and organic debris (COLLOFF, 2009; ERBAN; HUBERT, 2008; PLATTS-MILLS et al., 1989; van BRONSWIJK, 1973).

Acaridae, Aeroglyphidae, Chortoglyphidae, Echimyopodidae, Euglycyphagidae, Glycyphagidae, Pyroglyphidae and Suidasiidae are astigmatids commonly found in house dust (COLLOFF, 2009; FAIN; GUERIN; HART, 1990; OCONNOR, 2009). Species of genus *Blomia* may occur in stored food and houses in many parts of the world (OCONNOR, 2009; van BRONSWIJK, 1973) whereas *B. tropicalis* has been reported from tropics and subtropics

(COLLOFF, 2009), being one of the dominant species in house dust in Brazil (BINOTTI et al., 2001; ROSA; FLECHTMANN, 1979). *Dermatophagoides* species are the most important house dust mites in terms of global frequency and abundance (COLLOFF, 2009), with *Dermatophagoides pteronyssinus* being the most important house dust mite species in Brazil (BINOTTI et al., 2001).

The dust mites as well as their secretions and excretions such as feces, saliva and content of supracoxal gland are extremely important sources of allergens to humans (ARLIAN; PLATTS-MILLS, 2001; COLLOFF, 2009). Due to their medical importance, house dust mites have been the focus of several studies on their diversity and taxonomy (e.g. COLLOFF, 1987; FLANNIGAN; SAMSON; MILLER, 2002; HIRSCH et al., 1998; ROSA; FLECHTMANN, 1979), biology (e.g. ARLIAN, 1989; ARLIAN; MORGAN, 2003; HART, 1998; HART; FAIN, 1988) and physiology (e.g. ARLIAN; 1992; EVANS, 1992; ERBAN et al., 2009; WHARTON; DUKE; EPSTEIN, 1979).

Despite the importance of diet in the biology of any species, most papers about the biology of house dust mites deal with the effect of other factors, especially temperature and humidity, diet being often a constant (COLLOFF, 2009). Several papers mention methods for maintaining small colonies of dust mites (e.g. COLLOFF, 2009; MIYAMOTO; ISHII; SASA, 1975; SOLOMON; CUNNINGTON, 1964; SASA et al., 1970; VOORHORST; SPIEKSMAN; VAREKAMP, 1969). However, maintaining large colonies of dust mites is a fundamental process and one of the main difficulties in the preparation of allergens for the diagnostic and treatment for allergy caused by them (VENTOSA; CURVO, 1998). Information about methods for mass rearing dust mites is scarce. Sasa et al. (1970) kept large colonies of *Dermatophagoides farina* Hughes, with food for laboratory rats and mice as food for the mites.

Maintaining large scale colonies of house dust mites requires: (1) the definition of an optimum artificial diet; (2) the determination of adequate environmental conditions; (3) the prevention of contamination by microorganisms and other mite species (4) the determination of the optimal growing period in a rearing process (COLLOFF, 2009).

The objective of this work was to evaluate the effect of seven substrates for eventual use as food sources for the production of *B. tropicalis* and *D. pteronyssinus*, as well as to conduct a preliminary evaluation of the most adequate colony growing period in a rearing process.

b. Material and methods

Stock colonies

Blomia tropicalis and *D. pteronyssinus* were obtained from cattle food and house dust, respectively, in Piracicaba, São Paulo state, Brazil. Colonies of those species were maintained in the laboratory for about two years before beginning of studies, in containers similar to those used by Freire and Moraes (2007), consisting basically of plastic pots (height x diameter, 12 x 7.5 cm), containing holes (2cm in diameter) for ventilation closed with a polyester screen of 0.2mm mesh. The mites were fed with brewer's yeast and held at uncontrolled room temperature (ca. 20 – 28 °C) and humidity (ca. 60 – 80%)

Production of astigmatid mites

These tests were conducted from October 2012 to May 2013 in containers similar to those in which the stock colonies were maintained, in incubators at 25±1°C, 65±5% R.H. Evaluated diets, each constituting a treatment and respective label composition, were: **a)** brewer's yeast; **b)** fish food (Tetra Min Tropical Flakes[®], composition: water 10%, crude protein 45%, ether extract 5%, fibrous matter 5%, mineral matter 15%, calcium 5%, phosphor 0,7%, Mannan oligosaccharides 0,02%, protease (350 UI), amylase (15 UI), cellulase (20 UI)); **c)** rodent chow (Club Roedores Frutas e Legumes[®], composition: crude protein (22%), mineral matter (10%), fibrous matter (8%), ether extract (4%), calcium (1,4%), phosphor (0,8%), antioxidant (100 mg), choline (600 mg), copper (10 mg), cobalt (1,5 mg), iron (50 mg), iodine (2 mg), manganese (60 mg), selenium (0,05 mg), zinc (60 mg), vit. A (1200 UI), vit. B12 (20 mg), vit. D3 (1800 UI), vit. E (30 mg), vit. B1 (5 mg), vit. B6 (7 mg), vit. K3 (3 mg), niacin (60 mg), vit. B2 (6 mg), biotin (0,05 mg), pantothenic acid (20 mg), folic acid (1 mg), methionine (300 mg), lysine (100 mg)); **d)** fishmeal (Nutrivil[®], composition: humidity (8%), crude protein (52%), ether extract (4%), mineral matter (24%), pepsin digestibility (45%), peroxide value (10 Meq), HCl insoluble residue (1%), ratio calcium/ phosphor (1,8), sodium chloride (3%), acidity (3 mg NaOH/g)); **e)** mixture (1w:1w) fishmeal (Nutrivil[®]) + brewer's yeast; **f)** mixture (1w:1w) 50% of fish food flakes (Tetra Min Tropical Flakes[®]) + brewer's yeast; **g)** mixture (1w:1w) fishmeal (Nutrivil[®]) + brewer's yeast.

Each experimental unit consisted of a container with about 500 ml of a 1v/1v mixture of vermiculite and rice husk (sufficient to fill about two thirds of the volume of the container) and 50 grams of the evaluated diet. In the beginning of the experiment and every 3-4 days the content within each experimental unit was gently mixed with a spoon and the unit was gently rolled over to distribute the diet as uniformly as possible. Using a stereomicroscope, 400 females of the evaluated astigmatid species were transferred to each experimental unit at the

beginning of the experiment. Each treatment had eight replicates, each corresponding to an experimental unit.

Thirty days after the inoculation of the females, the number of mites in each of four units was evaluated; 30 days later, the number of mites in the remaining four units was evaluated. For the evaluation, the mites of each unit were extracted using a Berlese funnel during five days, being collected in a vial containing 50 ml of 70% ethanol. After extraction, the volume in each vial was completed to 100ml, and the number of mites was calculated by extrapolation, based on the count done in 10 aliquots of 1ml taken from each vial. The vial was agitated before each disquiet was collected.

Life tables

For each astigmatid species, life table parameters were calculated using as food the respective diet allowing the highest population growth, at $25\pm 1^{\circ}\text{C}$, $65\pm 5\%$ R.H. Each experimental unit consisted of a transparent plastic dish (2.7 cm in diameter x 1.2 cm high) about half filled with a solidified paste prepared with a mixture (9v:1v) of gypsum and activated charcoal (ABBATIELLO, 1965) maintained humid by daily additions of distilled water. The units were sealed with a piece of transparent plastic film (Magipack[®]) to prevent mites from escaping.

The study was initiated with eggs of similar ages. To obtain them, 50 gravid females were transferred from the respective stock colony to an experimental unit; twelve hours later, the unit was examined and the eggs laid were isolated in 50 experimental units. Mites were fed *ad libitum* with the selected diet.

Units were observed every 8 hours to determine the duration of each immature stage. After the mites reached adulthood, the units were examined once a day to determine the duration of the adult phases, as well the oviposition. Eggs laid by all females of the same species were grouped in new experimental units, where the mites were maintained to adulthood, to determine sex ratio.

Data analysis

As the data about the production test did not satisfy the assumption of normality (Shapiro-Wilk's test) and homoscedasticity (Levene test), data were transformed using log transformation ($\log(x+1)$) and after that data were again submitted to normality and homoscedasticity test to confirm the efficiency of the transformation.

For each period (30 or 60 days) the number of mites obtained on all treatments were compared using ANOVA followed by post hoc Tukey tests $\alpha = 0.05$ and, if significant, treatments were compared in pairs for each period using Student's t-test. For each treatment, number of mites obtained 30 and 60 days after inoculation were compared using Student's t-test. Life table parameters were calculated using the software Two Sex-MS Chart (CHI, 2005).

c. Results

Production of astigmatid mites

Blomia tropicalis: diet type had significant influence in the population growth of *B. tropicalis* (Table 1; $F=14.5$; $p<0.001$ and $df= 6$ for 30 days and $H=21.04$; $p<0.001$ and $df= 6$ for 60 days). At 30 and 60 days after inoculation, higher rates of population growth were recorded for the following treatments: fish food, fishmeal and fish food + brewer's yeast, which did not differ significantly among themselves. These diets allowed rates of increase of at least 20.2 times both for 30 and 60 days after inoculation.

Dermatophagoides pteronyssinus: also in this case diet type had significant influence in population growth (Table 1; $F=33.58$; $p=0.0006$ and $df= 6$ for 30 days and $H=34.23$; $p=0.0008$ and $df= 6$ for 60 days). At 30 days after inoculation, higher rates of population growth was observed on the mixture of fishmeal + brewer's yeast; 60 days after inoculation, higher oviposition rates were recorded on both mixture of fishmeal + brewer's yeast and fish food + brewer's yeast. These diets allowed rates of increase of at least 12.2 times both for 30 and 60 days after inoculation.

For all evaluated diets, no significant differences were found between the numbers of mites 30 and 60 days after inoculation of *B. tropicalis* (Table 1). For *D. pteronyssinus* the number of mites at 60 days after inoculation was significantly higher than at 30 after inoculation only on brewer's yeast, but even so, the difference was small. Although no differences were observed between the two evaluate periods, probably due to variability among repetitions, for all food items and for both mite species the number of mites in each unit was larger 60 than 30 days after the initial inoculation of the units.

Table 1 - Numbers of mites after population growth periods of 30 and 60 days and respective population growth rates of two astigmatid mites on different diets at 25±1°C, 97±3% R.H. and in the dark. Number of mites inoculated in each experimental unit: 400

Diet	Periods	<i>Blomia tropicalis</i>		<i>Dermatophagoides pteronyssinus</i>	
		Mean (±SE)	Population growth	Mean (±SE)	Population growth
Brewer's yeast	30	3260 ± 499 c A	8.2	2610 ± 238 c A	6.5
	60	4603 ± 512 bc A	11.5	3215 ± 93 b B	8.0
Fish food	30	8810 ± 726 a A	22.0	3470 ± 352 c A	8.6
	60	9213 ± 457 a A	23.0	3735 ± 215 b A	9.3
Rodent chow	30	2310 ± 506 c A	5.8	893 ± 111 d A	2.2
	60	3215 ± 870 c A	8.0	1348 ± 80 d A	3.3
Fishmeal	30	8070 ± 774 a A	20.2	3058 ± 325 c A	7.6
	60	8750 ± 522 a A	21.9	3940 ± 195 b A	9.8
50% of fishmeal + 50% of brewer's yeast	30	5135 ± 748 b A	12.8	6138 ± 313 a A	15.3
	60	6745 ± 431 b A	16.9	6445 ± 165 a A	16.11
50% of fish food + 50% of brewer's yeast	30	8890 ± 984 a A	22.2	4895 ± 267 b A	12.2
	60	9450 ± 628 a A	23.6	5198 ± 133 a A	12.9
50% of Rodent chow + 50% of brewer's yeast	30	3870 ± 672 c A	9.7	2496 ± 289 c A	6.2
	60	5153 ± 831 b A	12.9	3253 ± 157 b A	8.1

For each species, same low case letters indicate no significant differences between diets for a same period (Tukey test; $p < 0.05$), while same capital letters indicate no significant differences between periods for a same diet (Student's t-test).

Life table

Blomia tropicalis: The life table study was conducted using the mixture of fish food + brewer's yeast as food source. The duration of individual immature stages ranged from 3.1 (protonymph) to 5.0 (tritonymph); total immature development period was 16.4 days (Table 2). Survivorship of each immature stage was at least 91%, leading to 76% survivorship for the whole immature phase.

Oviposition period corresponded to about 83% of total female longevity (Table 3). During this period, each female laid an average of 2.1 eggs/female/day, of which about 58% were females. These parameters led to a calculated production of 0.111 female/female/ day (r_m), or a 15.91-fold increase (R_o) of the population at each generation (every 24.84 days) (Table 3).

Table 2 - Duration and survivorship of immature stages of two astigmatid mites fed with fish food + brewer's yeast and fishmeal + brewer's yeast, respectively at $25\pm 1^\circ\text{C}$, $65\pm 5\%$ R.H

Parameters	<i>Blomia tropicalis</i> (n=50)		<i>Dermatophagoides pteronyssinus</i> (n=48)	
	Days	Surv. (%)	Days	Surv. (%)
Egg	4.5 ± 0.10	94	6.6 ± 0.24	87
Larva	3.7 ± 0.08	91	5.5 ± 0.20	95
Protonymph	3.1 ± 0.06	91	5.9 ± 0.20	92
Tritonymph	5.0 ± 0.09	97	6.6 ± 0.16	100
Development period	16.4 ± 0.16	76	26.2 ± 0.48	80

Dermatophagoides pteronyssinus: The life table study was conducted using fishmeal + brewer's yeast as food source. The duration of individual immature stages ranged from 5.6 (larva) to 6.7 (tritonymph); total immature development period was 26.3 days (Table 2). Survivorship of each immature stage was at least 87%, leading to 80% survivorship for the whole immature phase

Oviposition period corresponded to about 84% of total female longevity (Table 3). During this period, each female laid an average of 2.4 eggs/female/day, of which about 66% were females. These parameters led to a calculated production of 0.084 female/female/ day (r_m), or a 22.70-fold increase (R_o) of the population at each generation (every 37.07 days) (Table 3).

Table 3 - Life table parameters of two astigmatid species fed with fish food + brewer's yeast and fishmeal + brewer's yeast, respectively at $25\pm 1^\circ\text{C}$, $65\pm 5\%$ R.H.

Parameters	<i>Blomia tropicalis</i>	<i>Dermatophagoides pteronyssinus</i>
	(n=26)	(n=25)
Preoviposition period (days)	2.0 ± 0.15	3.4 ± 0.12
Oviposition period (days)	18.5 ± 0.96	26.9 ± 0.92
Post-oviposition period (days)	2.1 ± 0.45	2.1 ± 0.08
Total female longevity	22.4 ± 1.08	32.2 ± 1.11
No. eggs/female/day	2.1 ± 0.11	2.3 ± 0.06
Fecundity	41.3 ± 2.30	63.2 ± 2.27
Sex ratio (% females)	58	66
Intrinsic rate of increase (r_m)	0.111	0.084
Net reproductive rate (R_0)	15.91	22.70
Mean generation time in days (t)	24.84	37.07

d. Discussion

Food quality

Fish food, fishmeal and a mixture of fish food + brewer's yeast were shown to be the most adequate for the production of *B. tropicalis*, whereas fish food + brewer's yeast and fishmeal + brewer's yeast were shown to be most adequate for the production of *D. pteronyssinus*. Thus, in a first consideration, the selection of the specific food to use could be determined by the relative cost of those items in each specific region, as well as other factors related to other specific logistic matters.

Complementary works should be conducted to understand details about the food preference of each mite species, for optimizing a production process. Aspects to be evaluated include the amount of food offered per predator, effect of the size of containers, frequency of feeding, etc. In the rearing of *B. tropicalis*, the lack of significant differences between growth rates determined by fish food by itself and fish food mixed with brewer's yeast is intriguing, given that brewer's yeast by itself was not shown to be an adequate food substrate. The actual consumption of each food item was not evaluated in the present work, and thus, it is possible that in the mixture the mite fed only (or mainly) on fish food, letting brewer's yeast untouched. For *D. pteronyssinus*, the results suggested a complementary effect of either fish food or fishmeal, and brewer's yeast, given that any of those items offered as exclusive food source resulted in lower population rate of increase when compared with those mixtures.

Growth period

The reduced population growth between 30 and 60 days after mite inoculation in the rearing units, using procedures similar to those used in the present work, was also observed by Freire and Moraes (2007) and M.M. Silva and G.J. Moraes (unpublished). The first referred to the rearing of *Stratiolaelaps scimitus* (Womersley) (Laelapidae) on *T. putrescentiae* developing on dog food (Deli Dog® - Purina) and the second, to the rearing of *Amblyseius tamatavensis* Blommers (Phytoseiidae) on *Thyreophagus n. sp.* (Acaridae) developing on wheat germ and brewer's yeast. Quite often, the decline has been attributed to what has been termed super population, without the determination of the real cause. This problem seems particularly important for arthropods that live in or on their food substrate, and that thus can become inappropriate for intake because of contamination with its excreta and secretions, as well as by microbial deterioration of the substrate or of the dead reared organisms (COLLOFF, 2009).

To reduce the effect of the environment, the adoption of a system providing forced ventilation might be beneficial. In addition, several authors have mentioned the beneficial effect to the presence of a layer of a solidified paste of a mixture of gypsum and activated charcoal at the base of the unit for small scale lab rearing (e.g. ABBATIELLO, 1965; WHARTON, 1946). This effect is probably related to the presence of activated charcoal, a material widely used in filter systems to retain volatile toxic substrates. Given that charcoal gypsum layer was not added to containers used, it is possible that volatiles were maintained in the colony disturbing population growth.

Biological parameters

Most of studies involving life tables of Astigmatina were performed for Acaridae species, especially those commonly found on stored food, such as *Tyrophagus* spp. (e.g. KHERADMAND ET AL., 2007; SÁNCHEZ-RAMOS; ÁLVAREZ-ALFAGEME; CASTAÑERA, 2007); *Acarus siro* L. (DAVIS; BROWN, 1969), *Aleuroglyphus ovatus* (Troupeau) (XIA et al., 2009) and *Rhizoglyphus* sp. (EL-NAGGAR; TAHA; HODA, 1989). Life table studies were developed for dust mites belonging to the superfamily Glycyphagoidea (superfamily in which *B. tropicalis* is placed) for *Gohieria fusca* (Oudemans) (Taha et al., 2010), and *Euroglyphus maynei* Fain (Colloff, 2009) and never calculated for pyroglyphid species. Value of r_m obtained for *B. tropicalis* and *D. pteronyssinus* are lower than obtained for *G. fusca* (0.24), but higher than obtained for *E. maynei* (0.0252).

Period of development of immature, duration of female stages and fecundity obtained in this work are similar to previous results for *B. tropicalis* (MARIANA; HO; HEAH, 1996) and for *D. pteronyssinus* (ARLIAN; RAPP; AHMED, 1990; BLYTHE, 1976; PIKE; CUNNINGHAM; LESTER, 2005). However, much higher fecundity rates (about 100 eggs/female) were determined by Hart et al. (2007) and Gamal-Eddin et al. (1983) for *D. pteronyssinus* on diets composed at least in part of animal tissues (respectively porcine liver, skin scales and yeast, and bovine liver and yeast). Although very efficient, diets based on animal tissues may not be suitable for rearing large colonies due to the cost and difficult formulation.

The rates of increase in the test for the production of astigmatid mites are compatible with what would be expected from the determined life table parameters, when mites are maintained at “optimum” conditions for their determination. Taking into account only numbers of females, the increase rates in this study (after 30 days of the inoculation of the mite, i.e., the experimental growth period) were respectively 12.9 and 10.1 for *B. tropicalis* and *D. pteronyssinus*. These values are much lower than the respective values of R_o (rate of increase at each generation). For *B. tropicalis*, the experimental growth period was slightly longer than the mean generation time (T), and thus the expected rate of increase should be higher than R_o ; the lower value effectively obtained in this study reflects the suboptimum condition for the mites in the rearing unit, in comparison with the conditions for the life table study. Conversely, for *D. pteronyssinus*, the experimental growth period was shorter than the mean generation time; in this case, the lower rate of increase might in part be attributed to that, but expectedly also to the suboptimum condition for the mites in the rearing unit.

e. Conclusion

Given the importance of food source on mass rearing of mites, population growth rates obtained on the most suitable diets represent an important advance in the establishment of methods for maintaining large colonies of *B. tropicalis* and *D. pteronyssinus*. Further studies, mainly involving the understanding and avoiding population decline, will contribute to the enrichment of results here obtained.

References

- ABBATIELLO, M.J. A culture chamber for rearing soil mites. **Turtox News**, Chicago, v. 43, p. 162-164, 1965.
- ARLIAN, L.G. Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. **Immunology and Allergy Clinics of North America**, Philadelphia, v. 9, n. 2, p. 339-356, 1989.
- _____. Water balance and humidity requirements of house dust mites. **Experimental and Applied Acarology**, Amsterdam, v. 16, n. 1-2, p. 15-35, 1992.
- ARLIAN, L.G.; MORGAN, M.S. Biology, ecology, and prevalence of dust mites. **Immunology and Allergy Clinics of North America**, Philadelphia, v. 23, n. 3, p. 443-468, 2003.
- ARLIAN, L.G.; PLATTS-MILLS, T.A.E. The biology of dust mites and the remediation of mite allergens in allergic disease. **Journal of Allergy and Clinical Immunology**, Saint Louis, v. 107, n. 3, p. 406-413, 2001.
- ARLIAN, L.G.; RAPP, C.M.; AHMED, S.G. Development of *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae). **Journal of Medical Entomology**, Lanham, v. 27, n.6, p. 1035-1040, 1990.
- BINOTTI, R.S.; MUNIZ, J.R.O.; PASCHOAL, I.A.; PRADO, A.P.; OLIVEIRA, C.H. House dust mites in Brazil-an annotated bibliography. **Memórias do Instituto Oswaldo Cruz**, Rio de Janeiro, v. 96, n. 8, p. 1177-1184, 2001.
- BLYTHE, M.E. Some aspects of the ecological study of house dust mites. **British Journal of Diseases of the Chest**, London, v. 70, p. 3-31, 1976.
- CHI, H. **TWOSEX-MSChart: a computer program for the age-stage, two-sex life table analysis**. 2005. Disponível em: <<http://140.120197>>. Acesso em: 08 fev. 2016.
- COLLOFF, M.J. Mites from house dust in Glasgow. **Medical and Veterinary Entomology**, Oxford, v. 1, n. 2, p. 163-168, 1987.
- COLLOFF, M.J. **Dust mites**. Melbourne: CSIRO, 2009. 583 p.
- DAVIS, R.; BROWN, S.W. Some population parameters for the grain mite, *Acarus siro*. **Annals of the Entomological Society of America**, College Park, v. 62, n. 5, p. 1161-1166, 1969.
- ERBAN, T.; HUBERT, J. Digestive function of lysozyme in synanthropic acaridid mites enables utilization of bacteria as a food source. **Experimental and Applied Acarology**, Amsterdam, v. 44, n. 3, p. 199-212, 2008.

ERBAN, T.; ERBANOVA, M.; NESVORNA, M.; HUBERT, J. The importance of starch and sucrose digestion in nutritive biology of synanthropic acaridid mites: α -Amylases and α -glucosidases are suitable targets for inhibitor-based strategies of mite control. **Archives of Insect Biochemistry and Physiology**, New York, v. 71, n. 3, p. 139-158, 2009.

EVANS, G. O. **Principles of acarology**. Wallingford: CAB international, 1992. 563 p.

FAIN, A.; GUERIN, B.; HART, B.J. **Mites and allergic disease**. Varennes en Argonne: Allerbio, 1990. 190 p.

FLANNIGAN, B.; SAMSON, R.A.; MILLER, J. D. **Microorganisms in home and indoor work environments: Diversity, health impacts, investigation and control**. Boca Raton: CRC Press, 2011. 539 p.

FREIRE, R.A.P.; MORAES, G.J. Mass production of the predatory mite *Stratiolaelaps scimitus* (Womersley) (Acari: Laelapidae). **Systematic and Applied Acarology**, London, v. 12, p. 117-119, 2007.

GALVÃO, A.B.; GUITTON, N. Ácaros em poeira domiciliar das capitais brasileiras e Ilha Fernando de Noronha. **Memórias do Instituto Oswaldo Cruz**, Rio de Janeiro, v. 81, n. 4, p. 417-430, 1986.

GAMAL-EDDIN, F.M.; SHEHATA, K.K.; TAYEL, S.E.; ABOU-SINNA, F.M.; ABOUL-ATTA, A.M.; SEIF, A.I.; IMAM, M.H.; HAFEZ, A.H. Duration of the developmental stages of house dust mites *Dermatophagoides farinae* and *D. pteronyssinus* under controlled conditions, to pave the way in front of the workers in the field of house-dust mite asthmatic bronchitis. 2. Oviposition period, fecundity and oval duration. **Journal of the Egyptian Society of Parasitology**, v. 13, n. 2, p. 557-581, 1983.

HART, B. Life cycle and reproduction of house-dust mites: environmental factors influencing mite populations. **Allergy**, Copenhagen, v. 53, n. 48, p. 13-17, 1998.

HART, B.; FAIN, A. Morphological and biological studies of medically important house-dust mites. **Acarologia**, Paris, v. 29, n. 3, p. 285-296, 1988.

HART, B.J.; CROWTHER, D.; WILKINSON, T.; BIDDULPH, P.; UCCI, M.; PRETLOVE, S.; RIDLEY, I.; ORESZCZYN, T. Reproduction and development of laboratory and wild house dust mites (Acari: Pyroglyphidae) and their relationship to the natural dust ecosystem. **Journal of Medical Entomology**, Annapolis, v. 44, n. 4, p. 568-574, 2007.

HIRSCH, T.H.; RANGE, U.; WALTHER, K.U.; HEDERER, B.; LÄSSIG, S.; FREY, G.; LEUPOLD, W. Prevalence and determinants of house dust mite allergen in East German homes. **Clinical and Experimental Allergy**, Oxford, v. 28, n. 8, p. 956-964, 1998.

KHERADMAND, K.; KAMALI, K.; FATHIPOUR, Y.; GOLTAPEH, E.M. Development, life table and thermal requirement of *Tyrophagus putrescentiae* (Astigmata: Acaridae) on mushrooms. **Journal of Stored Products Research**, Oxford, v. 43, n. 3, p. 276-281, 2007.

MARIANA, A.; HO, T.M.; HEAH, S.K. Life-cycle, longevity and fecundity of *Blomia tropicalis* (Acari: Glycyphagidae) in a tropical laboratory. **The Southeast Asian Journal of Tropical Medicine and Public Health**, Bangkok, v. 27, n. 2, p. 392-395, 1996.

MIYAMOTO, J.; ISHII, A.; SASA, M. A successful method for mass culture of the house dust mite, *Dermatophagoides pteronyssinus* (Trouessart, 1897). **The Japanese Journal of Experimental Medicine**, Tokyo, v. 45, n. 2, p. 133-138, 1975.

EL-NAGGAR, M.E.; TAHA, H.A.; HODA, F.M. Biological studies on *Rhizoglyphus ismaili* (Astigmata: Acaridae) and the effect of types food on duration and fecundity. **Bulletin of the Entomological Society of Egypt**, Cairo, v. 38, p. 81-86, 1989.

OCONNOR, B. Cohort Astigmatina. In: KRANTZ, G.W.; WALTER, D.E. (Ed.). **A manual of acarology**. Lubbock: Texas Tech University Press, 2009. chap. 16, p. 565-657.

PIKE, A.J.; CUNNINGHAM, M.J.; LESTER, P.J. Development of *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae) at constant and simultaneously fluctuating temperature and humidity conditions. **Journal of Medical Entomology**, Annapolis, v. 42, n. 3, p. 266–269, 2005.

PLATTS-MILLS, T.A.E.; WECK, A.L.; AALBERSE, R.C.; BESSOT, J.C.; BJORKSTEN, B.; BISCHOFF, E.; BOUSQUET, J.; van BRONSWIJK, J.E.M.H.; CHANNABASAVANNA, G.P.; CHAPMAN, M.; COLLOFF, M.; GOLDSTEIN, R.A.; GUERIN, B.; HART, B.; HONG, C-H.; ITO, K.; JORDE, W.; KORSGAARD, J.; MAO, J.L.; MIYAMOTO, T.; LIND, P.; LOWENSTEIN, H.; MITCHELL, E.B.; MURRAY, A.B.; NOLTE, D.; NORMAN, P.S.; PAULI, G.; RANGANATH, H.R.; REED, C.; REISER, J.; STEWART, G.; TURNER, K.; VERVLOET, D.; WEN, T. Dust mite allergens and asthma - A worldwide problem. **Journal of Allergy and Clinical Immunology**, Saint Louis, v. 83, n. 2, p. 416-427, 1989.

ROSA, A.E.; FLECHTMANN, C.H.W. Mites in house dust from Brazil. **International Journal of Acarology**, Oak Park, v. 5, n. 3, p. 195-198, 1979.

SÁNCHEZ-RAMOS, I.; ÁLVAREZ-ALFAGEME, F.; CASTAÑERA, P. Reproduction, longevity and life table parameters of *Tyrophagus neiswanderi* (Acari: Acaridae) at constant temperatures. **Experimental and Applied Acarology**, Amsterdam, v. 43, n.3, p. 213-226, 2007.

SASA, M., MIYAMOTO, J., SHINOHARA, S., SUZUKI, H. AND KATSUHATA, A. Studies on mass culture and isolation of *Dermatophagoides farinae* and some other mites associated with house dust and stored food. **Japanese Journal of Experimental Medicine**, Tokyo, n. 5, v. 40, p. 367–382, 1970.

SOLOMON, M.E.; CUNNINGTON, A.M. Rearing acaroid mites. **Acarologia**, v. 6 (Suppl.), 399-403, 1964.

TAHA, H.A.; MAHMOUD, H.I.; HASSAN, M.I.; OMAR, N.R.; NASR, H.M. Effect of different food types on the biology, fecundity and life table parameters of the stored grain mite *Gohieria fusca* (OUD) (Acari: Astigmata: Lapidophoridae). **Egyptian Journal of Agricultural Research**, Giza, v. 88, n. 1, p. 133-142, 2010.

XIA, B.; LUO, D.; ZOU, Z.; ZHU, Z. Effect of temperature on the life cycle of *Aleuroglyphus ovatus* (Acari: Acaridae) at four constant temperatures. **Journal of Stored Products Research**, Oxford, v. 45, n. 3, p. 190-194, 2009.

van BRONSWIJK, J.E.M.H. *Dermatophagoides pteronyssinus* (Trouessart, 1897) in mattress and floor dust in a temperate climate (Acari: Pyroglyphidae). **Journal of Medical Entomology**, Annapolis, v. 10, n. 1, p. 63-70, 1973.

VENTOSA, L.; CUERVO, N. Cultivos massivos de *Dermatophagoides pteronyssinus* y *D. siboney* (Acari, Pyroglyphidae) en un medio hipoalergénico. **Iheringia**, Série Zoologia, Porto Alegre, v. 85, p. 147-150, 1998.

VOORHORST, R.; SPIEKSMAN, F.T.M.; VAREKAMP, N. **House dust atopy and the house dust mite, *Dermatophagoides pteronyssinus* (Trouessart, 1897)**. Leiden: Stafleu's Scientific, 1969. 159 p.

WHARTON, G. W. Observations on *Ascoshongastia indica* (Hirst 1915) (Acarinida: Trombiculidae). **Ecological Monographs**, Durham, v. 16, n. 3, p. 152-184, 1946.

WHARTON, G.W.; DUKE K.M.; EPSTEIN, H.M. Water and the physiology of house dust mites. In: RODRIGUEZ, J.G. (Ed.). **Recent advances in acarology**, volume I. New York: Academic Press, 1979, p. 325- 335.