Acarological Studies
Vol 7 (1): 5-11
doi: 10.47121/acarolstud.1551808

RESEARCH ARTICLE

Rhinella alata (Anura: Bufonidae), *Tityus jaimei* and *Tityus festae* (Scorpiones: Buthidae) as new carriers of phoretic mites *Archegozetes magnus* (Oribatida: Trhypochthoniidae) in Panama

Roberto J. MIRANDA[1,3], Ángel SOSA-BARTUANO[2], Lillian DOMÍNGUEZ[1], Samuel SUCRE[2], Macario GONZÁLEZ-PINZÓN[2], Sergio BERMÚDEZ[1]

[1]*Medical Entomology Research Department, Gorgas Memorial Institute for Health Research, Panama City, Panama*
[2]*Natural Tanks, Via Argentina, Panama City, Panama*
[3]Corresponding author*:* rmiranda@gorgas.gob.pa

Received: 17 September 2024 Accepted: 18 October 2024 Available online: 30 January 2025

ASBTRACT: In this paper, we report the mite, *Archegozetes magnus* immatures and females, in non-parasitic interactions with Bishop's Toad, *Rhinella alata* (Anura: Bufonidae), and the Buthidae scorpions *Tityus jaimei* and *Tityus festae*. The reports in both species of scorpions represent news phoretic interactions. Possible behavior is discussed.

Keywords: Leaf litter mites, parthenogenetic, scorpions, toad, Central America
Zoobank: https://zoobank.org/0CDD86EF-C8F3-4B7B-88E0-58C3319DAB48

INTRODUCTION

The family Trhypochthoniidae (Oribatid) contains 7 genera, 61 species and 14 subspecies (Subias, 2004, updated 2024). Among these genera, *Archegozetes* is a small genus with a complex taxonomy (Heethoff et al., 2013). In this sense, Subias (2004, updated 2024) recognizes one species, *Archegozetes magnus* (Sellnick) and two subspecies *Archegozetes magnus magnus* (Sellnick) and *Archegozetes magnus longisetosus* Aoki) as valid, considering the other species descripted in the genus as synonyms or subspecies. Thus, *Archegozetes magnus* currently has a wide distribution with reports in America, Asia (continental and insular) and Africa (Badejo et al., 2002).

Similar to other trhypochthoniid, *Archegozetes* mites inhabit soil, leaf litters, decay woods or bark in humid areas as peatlands and feed algae, fungi or even leaves (Palacios-Vargas and Iglesias, 1997; Estrada-Venegas et al., 1999; Smrž and Norton, 2004; Norton and Behan-Pelletier, 2009). Under these conditions, *Archegozetes* subsist together with other groups of vertebrates and invertebrates that live in these environments, promoting different interactions between them. In this sense, *Archegozetes* spp. are reported as prey for vertebrates (McGugan et al., 2016; Salazar-Filippo et al., 2024). Furthermore, phoretic behavior has been reported in *A. magnus*. Townsend et al. (2008) reported *A. magnus* (identified post-publication in Beaty et al., 2013) in a species of *Cynortula* (Opiliones, Cosmetidae) in Trinidad, and later Beaty et al. (2013) reported it on the Leptodactylidae frog *Engystomops pustulosus* (Cope) in Panama. Other reports of carriers of phoretic *A. magnus* include *Triatoma dimidiata* (Latreille) (Hemiptera, Reduviidae) in Yucatan, Mexico (Waleckx et al., 2018), and the Bufonid toad *Rhinella major* Müller and Hellmich in Brazil (Mendoza-Roldán et al., 2020).

In this work, we add new information on invertebrates and vertebrates carrying *A. magnus* in Panama.

MATERIAL AND METHODS

Mites from the "Dr. Eustorgio Méndez" Zoological Collection (CoZEM-ICGES) of the Gorgas Memorial Institute for Health Research, Panama, were revised. Mites were examined under the stereomicroscope Leica S9D cleared in Nesbitt's fluid and mounting in microscopy slides using Hoyer's medium (Singer, 1967). The mites were photographed with Leica ICC50 E digital camera integrated into the Leica DM750 microscope. The photographs were captured and edited (scale bar) with the Leica Application Suite version 4.13. Darkfield photographs were taken under the Olympus CX43 microscope. The identification was made using the redescription proposed by Badejo et al. (2002).

RESULTS AND DISCUSSION

Archegozetes magnus (Sellinick)

Materials examined

14 ♀♀ *ex Rhinella alata* (Thominot); anatomical location: dorsum of head and fore and hind limbs (Fig. 1). PANAMÁ: Darién province. Darien National Park, Rancho Frio Station. 12 June 2017. Coll: Lillian Domínguez, Dmitry Apanaskevich. Note: Not all mites on the toad were collected.

8 ♀♀, 1 nymph *ex Rhinella alata* (Thominot); anatomical location: dorsum of head and fore limbs (Fig. 2). PANAMÁ: Panamá province. Soberanía National Park. 12 June 2023. Coll: Samuel Sucre, Macario González.

4 ♀♀ *ex Tityus jaimei*, Miranda, Bermúdez, Flores and de Armas 2020; anatomical location: dorsum of segments I and II of metasoma and leg IV (Fig. 3). PANAMÁ: Veraguas province, Santa Fe, Las Filipinas, 23 June 2017, *ex Tityus jaimei* male, coll. Roberto Miranda, Ingrid Murgas, Juan "Largo" Lezcano, Lyska Castillo.

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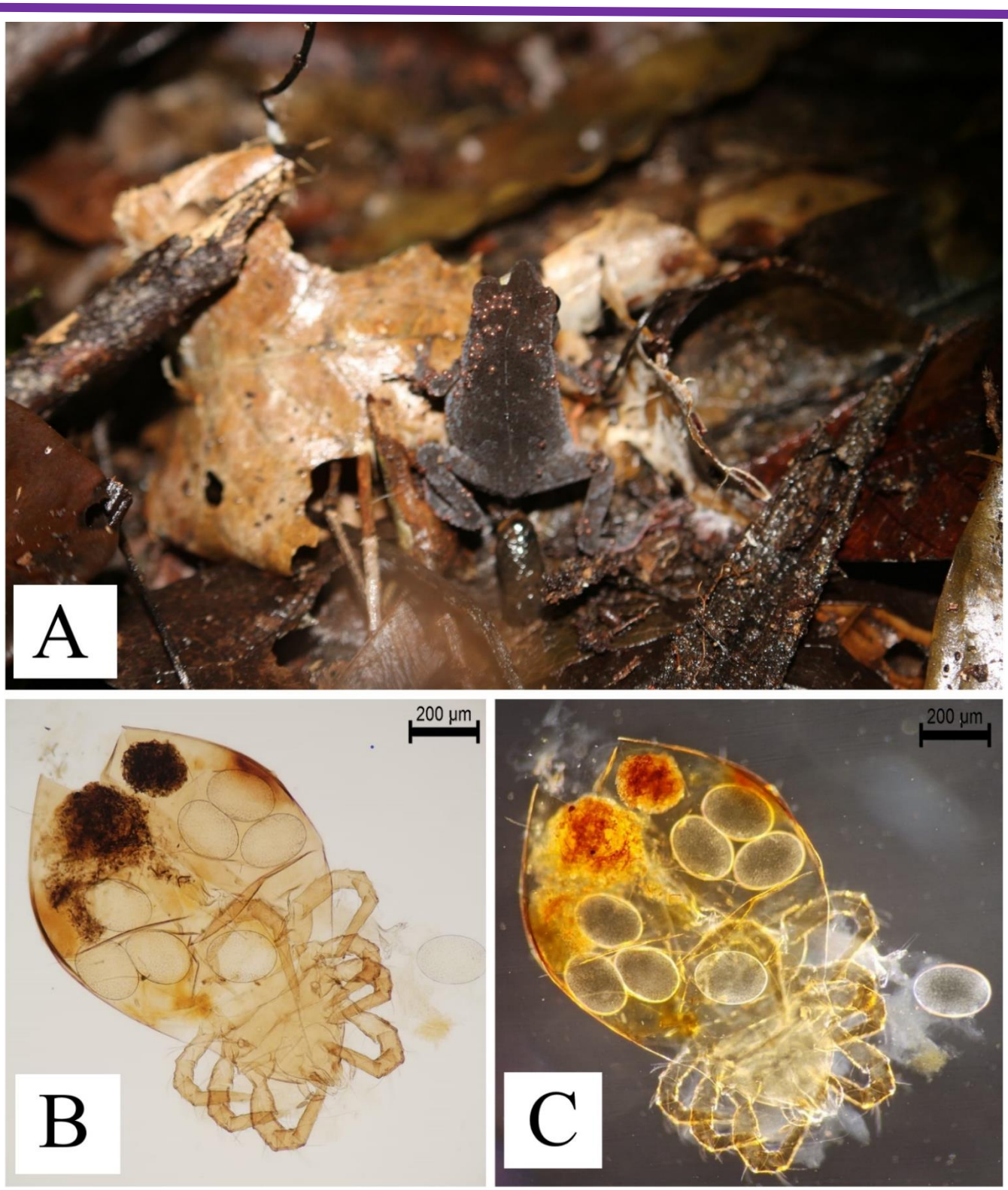

Figure 1. *Archegozetes magnus* (Trhypochthoniidae) on dorsum of *Rhinella alata* (Bufonidae) in leaf litter Darien National Park, Panama (**A**), a female specimen in microscope slide in light field (**B**) and dark field (**C**).

32 nymphs *ex Tityus festae* Borelli; anatomical location: mainly on the dorsum of the body, 2 individuals on carapace, 2 and 17 individuals on tergites IV and VII of mesosoma respectively, and 7 individuals in segments I and II of metasoma (Fig. 4). PANAMÁ: Darién province, Santa Fe, Quintín. 9 July 2019. Coll. Roberto Miranda, Ingrid Murgas, Juan "Largo" Lezcano, Lyska Castillo.

Immature and adult mites were identified as *A. magnus*, according to Badejo et al. (2002). In addition, we considered as valid on *bona fide* the criteria of Subías (2004, updated 2024) to the establish of *A. magnus* as the only species of the genus. Since *A. magnus* lives in humid areas, contact with its hosts must occur in this type of environment.

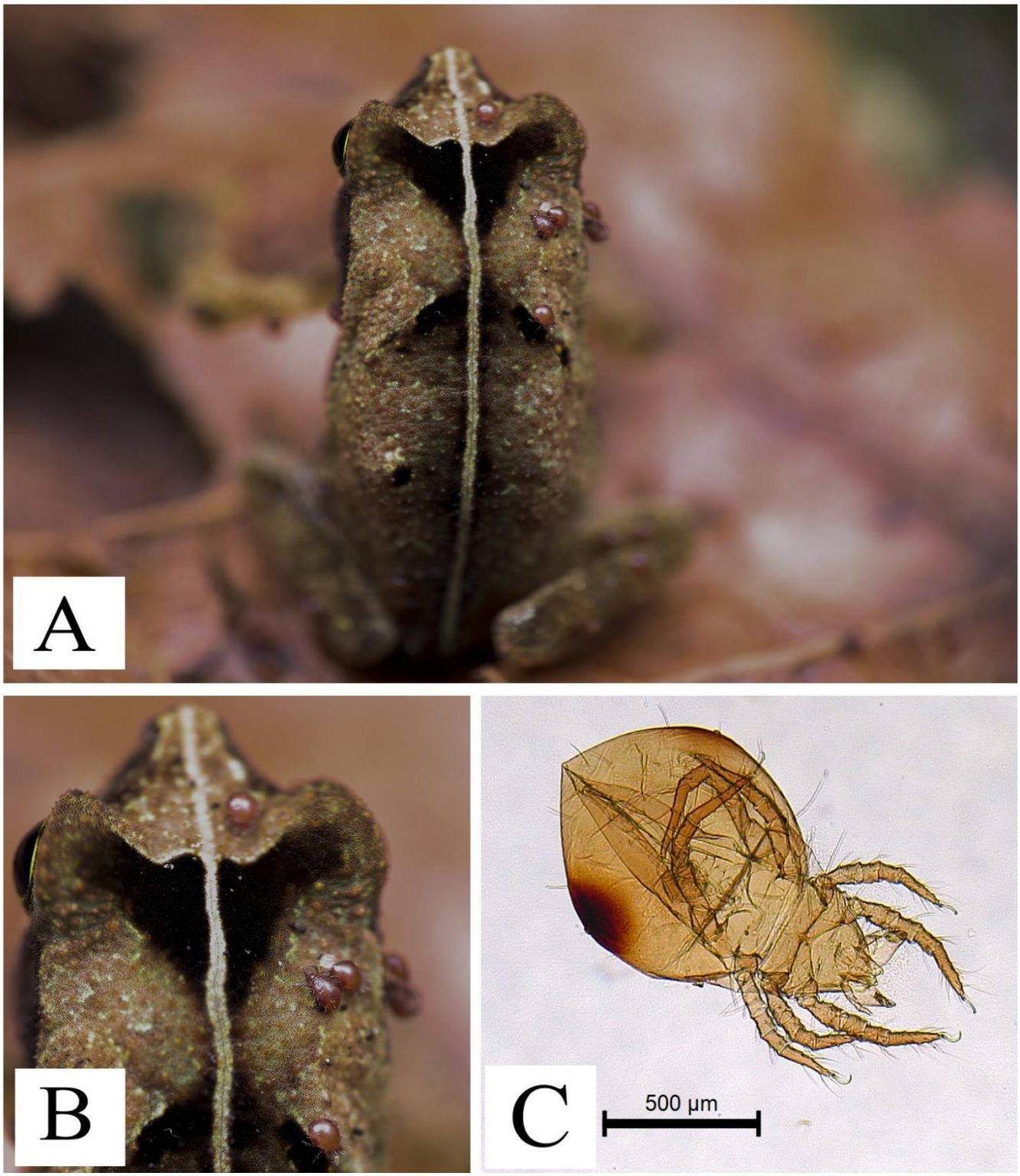

Figure 2. *Archegozetes magnus* on dorsum of *Rhinella alata* (Bufonidae) in leaf litter Soberanía National Park, Panama (**A**, **B**), a female specimen mounted in microscope slide (**C**).

Archegozetes magnus is a prolific parthenogenetic species (Badejo et al., 2002; Beaty et al., 2013), which explains the finding of females and immatures in our new phoretic association reports. In figures 1 (B, C) and 3 (B, C) the females have 8 and 20 eggs inside their body. In the case of the toad *R. alata*, this species is present in western Panama, Colombia and Ecuador (Ibáñez et al., 1999; dos Santos et al., 2015; Samudio et al., 2015). *Rhinella alata* has diurnal and terrestrial habits and is frequently observed among leaf litter, under rocks, logs or decaying wood, in places near bodies of water, or on trails used by the leaf-cutting ant *Atta colombica* (Guérin-Méneville), which they include as prey (Ibáñez et al., 1999; McElroy, 2015; Turcios-Casco, 2018). On the other hand, this species usually perches at the night on leaves at a low height (Ibáñez et al., 1999; Sosa-Bartuano, pers. obs.). Thus, the fact that both species inhabit the same type of environment, humid areas, increases the possibility of contact.

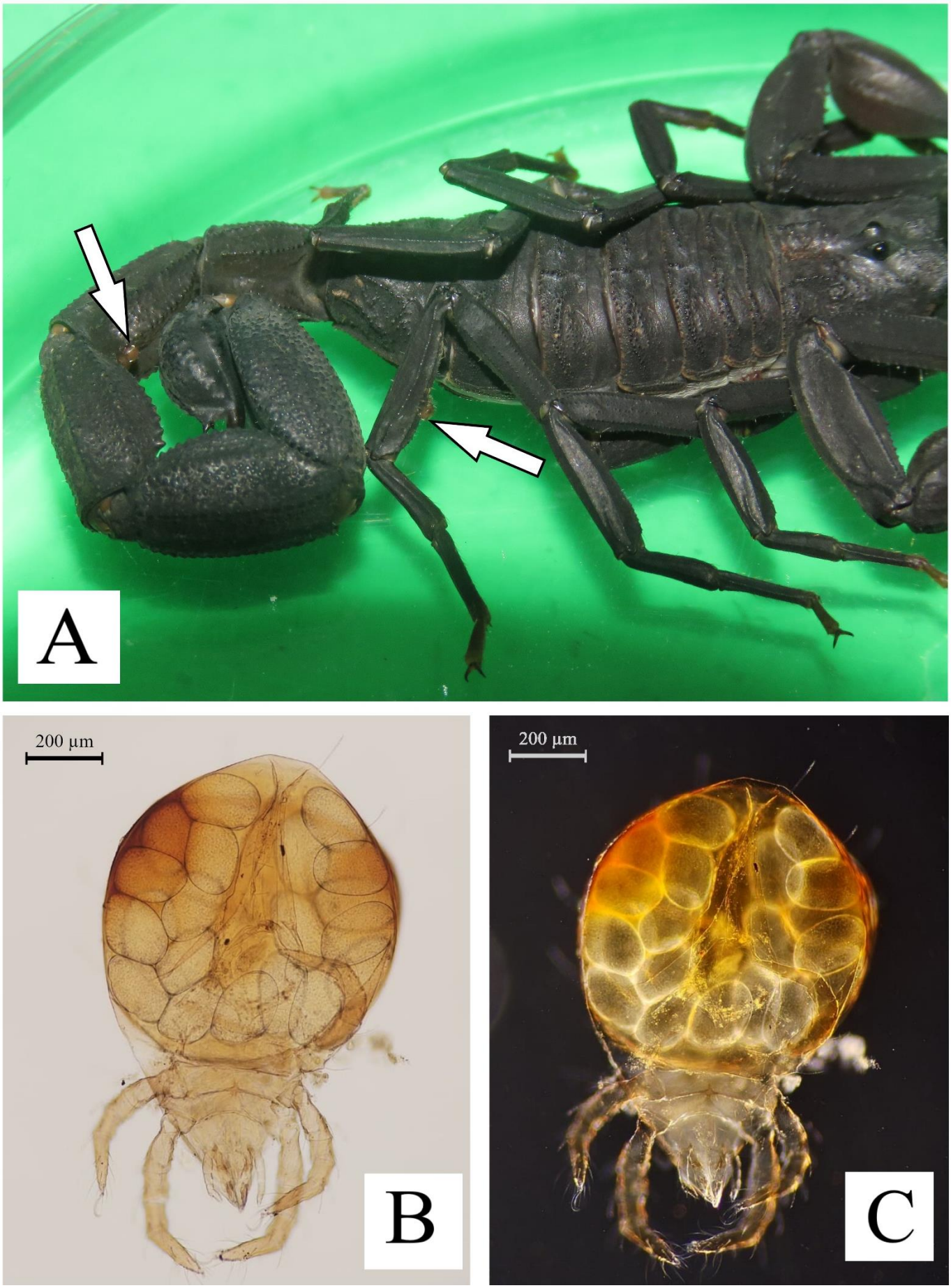

Figure 3. *Archegozetes magnus* on *Tityus jaimei* (Buthidae) male collected from Santa Fe National Park, Veraguas (**A**), a female specimen mounted in microscope slide in light field (**B**) and dark field (**C**).

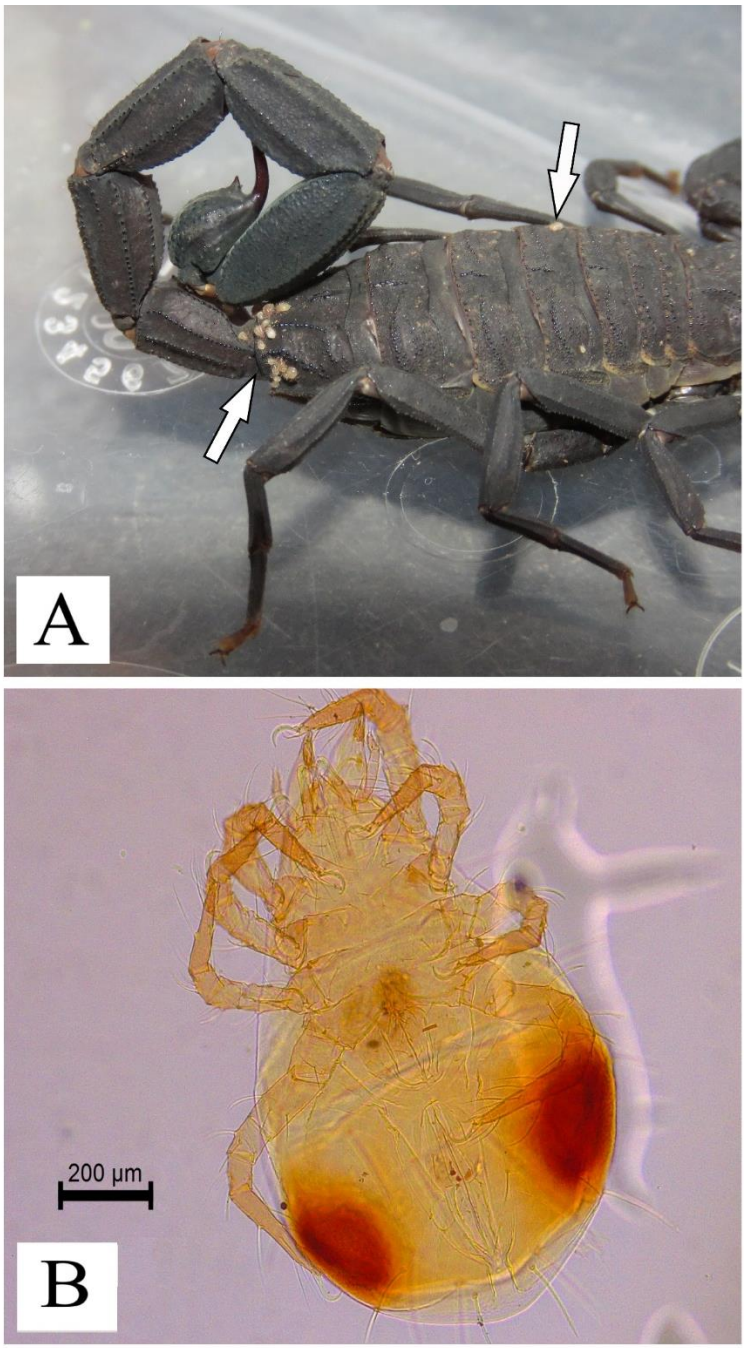

Figure 4. *Archegozetes magnus* on *Tityus festae* (Buthidae) female collected from Quintín, Santa Fe, Darién (**A**), a nymph specimen mounted in microscope slide (**B**).

To our knowledge, the finding of two *R. alata* in Panama correspond to the second species of amphibian as carrier of *A. magnus*, being *E. pustulosus* the first one (Beaty et al., 2013). Similar to Beaty et al. (2013), our observations are consistent with phoresis and not parasitism, which contrasts with the opinion of Mendoza-Roldan et al. (2020), who reported *A. longisetosus* mites parasitizing *R. major* Müller & Hellmich in Brazil. However, these authors did not present evidence of damage, without taking into account the evidence of mycophagous and predatory/scavenging habits previously reported for this species (Heethoff et al., 2013).

On the other hand, Salazar-Filippo et al. (2024) reported *Archegozetes* spp. as preys of *E. pustulosus* arguing that predation could occur due to the generalist behavior of this species of frog. Another report of *Archegozetes* spp. as prey of Anura includes the Dendrobatid frog *Oophaga sylvatica* (Funkhouser) (McGugan et al., 2016).

Regarding the finding of *Archegozetes* mites on the scorpions *T. jaimei* and *T. festae*, both species are considered of health importance in Panama and are mainly associated with humid forests (Borges et al., 2012). These scorpion species present vertical and horizontal displacements during their hunt and mate activities, and refuge in the bark of trees, epiphytes, palm bracts, and on the ground in fallen trunks and roots (Miranda, 2022). Considering the behavior of both species, contact must have occurred during the scorpions' passage through points with a high density of *A. magnus* or when the scorpions took refuge near the ground.

Similar to previous reports, *A. magnus* collected in both *Rhinella alata* and the two *Tityus* species were located mainly on the dorsum of the body (Townsend et al., 2008; Beaty et al., 2013; Waleckx et al., 2018) however, in toads they were mainly found in the anterior region of the body (head and forelimbs), while in scorpions they were mainly located in the posterior part of the body (meso- and metasoma).

In summary, both the natural history and taxonomy of *Archegozetes* require further research.

Authors' contributions

Roberto J. Miranda: Conceptualization (equal), methodology (lead), investigation (lead), visualization (lead), writing- original draft (equal). **Ángel Sosa-Bartuano:** Methodology (supporting), investigation (supporting), data curation, writing-review & editing (equal). **Lillian Domínguez:** Data curation, visualization (supporting), writing-review & editing (equal). **Samuel Sucre:** Methodology (supporting), data curation, writing-review & editing (equal). **Macario González-Pinzón:** Methodology (supporting), visualization (supporting), writing-review & editing (equal). **Sergio Bermúdez:** Conceptualization (equal), investigation (supporting), writing- original draft (equal).

Statement of ethics approval

Not applicable.

Funding

A project on Poisonous Arthropods and Allergy-causing Arthropods (SINIP: 9044.57) supported by the Ministry of Economy and Finance of Panama.

Conflict of interest

We declare that we have no conflicts of interest.

Acknowledgements

To Rafael Lau (Natural Tanks, Via Argentina, Panama City, Panama) by the photo of *Rhinella alata* from Soberanía National Park.

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Edited by: Adem Keskin
Reviewed by: Two anonymous referees

Citation: Miranda, R.J., Sosa-Bartuano, Á., Domínguez, L., Sucre, S., González-Pinzón, M. and Bermúdez, S. 2025. *Rhinella alata* (Anura: Bufonidae), *Tityus jaimei* and *Tityus festae* (Scorpiones: Buthidae) as new carriers of phoretic mites *Archegozetes magnus* (Oribatida: Trhypochthoniidae) in Panama. Acarological Studies, 7 (1): 5-11.