Journal of
Bat Research & Conservation

OPEN ACCESS
www.secemu.org
DOI: 10.14709/BarbJ.17.1.2024.06

ORIGINAL ARTICLE

First record of the chigger mite *Whartonia sonorensis* Hoffman 1960 (Acari: Leeuwenhoekiidae) parasitizing the long-legged bat, *Myotis volans* Allen 1866 (Chiroptera: Vespertilionidae) from central Mexico

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ABSTRACT

Bats have a close relationship with their ectoparasites, such as chigger mites, which can affect their physiological, ecological, and evolutionary processes. In recent decades, several studies have examined new records of ectoparasites in bats, providing key information about the dynamics of bat populations. We captured a *Myotis volans* Allen 1866 parasitized by chigger mites in a coniferous forest in central Mexico. We extracted 24 mites from the bat's ear. According to morphology, mites corresponded to *Whartonia sonorensis* Hoffmann 1960. Our report is the first record of the chigger mite *W. sonorensis* parasitizing *M. volans* and the second record worldwide that reports the association of *W. sonorensis* with a bat of the family Vespertilionidae.

DOI: https://doi.org/10.14709/BarbJ.17.1.2024.06

Keywords: bats, host-parasite, mites, *Myotis volans*, parasitized, *Whartonia sonorensis*

received: May, 29th 2024
accepted: December, 23th 2024

INTRODUCTION

Small mammals, such as bats (order: Chiroptera), have evolved associations with their ectoparasites (Ter Hofstede et al. 2004, Dick 2007, Szentiványi et al. 2016). Around the world, there are more than 1,400 known species of bats (Simmons & Cirranello 2024). The ectoparasites associated with bats are estimated to include over 17,000 recorded species (Presley 2011). Among these, chigger mites in their larval phase are especially predominant (Zajkowska et al. 2018). Chigger mites are notable for their diversity and widespread geographic distribution. To date, a total of 3,000 species have been described and classified into approximately 200 genera (Brennan & Goff 1977, Zhang et al. 2011, Nielsen et al. 2021). Currently, chigger mites are classified into three families: Trombiculidae Ewing 1944; Leeuwenhoekiidae Womersley 1944; and Walchiidae Ewing 1946 (Zhang et al. 2011).

In particular, the Leeuwenhoekiidae family is represented by 33 identified genera (Bassini-Silva et al. 2021), which represent between 17 and 20 % of the total diversity of chigger mites (Whitaker & Morales-Malacara 2005). During the last decades, studies have described ~ 40 species of chigger mites belonging to the genus *Whartonia* Ewing 1944 (Trombidiformes: Leeuwenhoekiidae) parasitizing 26 species of Old-World bats and 14 species from the New World (De la Cruz & Daniel 1994, Takahashi et al. 2006, Da Silveira et al. 2015). Chigger mites of the genus *Whartonia* are small in size (between 0.2 to 0.4 mm) and have a life cycle that includes four stages: 1) egg, 2) larva, 3) nymph, and 4) adult (Sasa 1961, Hoffman 1990). Their life cycle is closely influenced by environmental conditions and the host's body temperature (Mendoza-Roldan & Otranto 2022). Unlike other ectoparasites, such as flies (Diptera: Streblidae and Nycteribiidae) and bugs (Hemiptera: Cimicidae and Polyctenidae) that feed on blood, chigger mites of the genus *Whartonia* feed on tissue fluids (Chen et al. 2022). These mites use specialized structures, such as hooks, legs, and chelicerae, to attach to bats' skin or membranes and position themselves in hard-to-reach areas (Daniel & Stekol'nikov 2004, Zajkowska et al. 2018). Additionally, they take advantage of bats' social behaviors, such as mutual grooming and using common roosts, to transfer between hosts (Kurta et al. 2007, Stekolnikov 2022). Contrary to other members of the Leeuwenhoekiidae family, the role of mites of the genus *Whartonia* as vectors of specific pathogens to bats is still unknown.

In general, chigger mites play an important role in the ecology, physiology and, evolution of bats (Zhang et al. 2010). Godinho et al. (2013) reported that in bats of the family Vespertilionidae, an increase in parasitic load (density of parasites on a host) from chigger mites affects immunocompetence, reduces body mass, and alters

population dynamics, such as spatial dispersal. This, in turn, influences the genetic composition of bat populations in the long term (van Schaik et al. 2014). However, for mites of the genus *Whartonia*, it is still largely unknown how parasitic load from this specific genus impacts various aspects of bat biology. Therefore, understanding parasitic associations is especially relevant in biodiversity hotspots that have been poorly explored. Here, we report the first record of the parasitic interaction between the chigger mite *Whartonia sonorensis* Hoffmann 1960 and the vespertilionid bat, *Myotis Volans* Allen 1866, in central Mexico. Previously, this mite species had been reported parasitizing to *Myotis vivesi* , from which *W. sonorensis* was described based on a holotype specimen.

MATERIAL AND METHODS

We captured the bat at the community of Santa Cruz Moxolahuac, Puebla, in central Mexico (SCM; 19° 27′ 2.188′′ N 98° 34′ 10.131′′; 3,121 m a.s.l) (Fig. 1), during monitoring we performed between September 2023 and February 2024. The individual was captured using a mist net (3 x 6 m) deployed in a shallow body water immersed into vegetation. The vegetation in the SCM is composed of coniferous forest, with a mean annual temperature of 14.0 ± 4.5 °C and mean annual precipitation of 1,800 ± 15 mm. The captured bat (adult male, body mass: 6.1 g and forearm length: 37.7 mm) was identified using a field guide for bats distributed in Mexico (Medellín et al. 2008). The capture of the bat was performed with the permission of the wildlife management department granted to our institution (SEMARNAT No. SGPA / DGVS / 00582/20).

The ectoparasites were carefully removed with entomological forceps from the base of the bat's ears and placed into vials (2 mL) containing 75 % ethyl alcohol. Vials were transferred to the Universidad Autónoma de Yucatán, in southeastern Mexico, where chigger mites were identified to species level. For identification, chiggers were cleared in lactophenol solution and mounted on slides in Hoyer's medium to be observed by microscopy (Walter & Krantz 2009, Herrera-Mares et al. 2021). Identification at the genus level was determined following Brennan & Goff (1977) and at the species level following Hoffmann (1990). Eleven of the 24 collected mites were preserved in the Laboratorio de Zoonosis y Otras Enfermedades Transmitidas por Vectores [LZOO] of the Centro Regional de Investigaciones Dr. Hideyo Noguchi from the Universidad Autónoma de Yucatán and the remaining specimens were deposited at the Centro Tlaxcala de Biología de la Conducta from the Universidad Autónoma de Tlaxcala, in central Mexico.

RESULTS

During the sampling period at the study site, we examined 112 bats from seven different species: eight *Lasiurus cinereus*, three *L. frantzii*, eight *Eptesicus fuscus*, 12 *Myotis velifer*, three *M. thysanodes*, 11 *M. volans*, and six *M. californicus*. Among these bats, we identified mites such as *W. sonorensis*, which parasitized only one individual of *M. volans* (Fig. 2A). *Whartonia sonorensis* can be distinguished from other species of the genus by the thick and sturdy

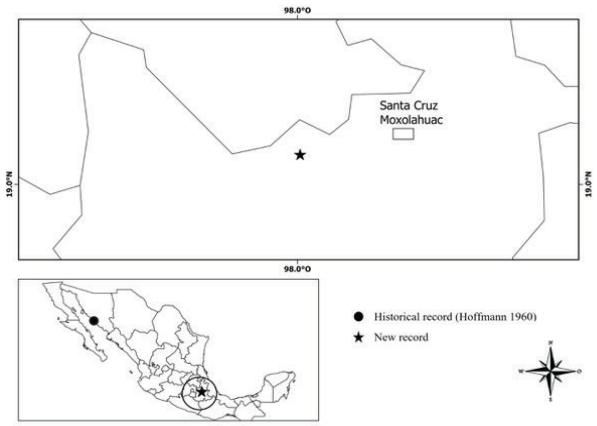

Fig. 1 - Records of *W. sonorensis* in Mexico.

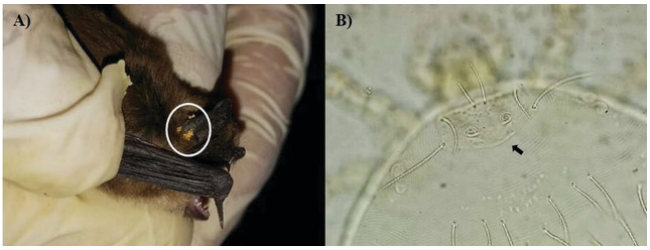

Fig. 2 - *W. sonorensis* **A)** Larvae (white circle) parasitizing the ear of *M. volans*, **B)** dorsal view of idiosoma showing the prodorsal sclerite (black arrow).

dorsal tibial silk of the palpus, the presence of a trifurcated tibial nail of the pedipalp, and a semi-quadrangular dorsal sclerite with a slightly sinuous anterior edge. While, the lateral edges diverge backward, and the posterior edge is uniformly convex. On the other hand, the species exhibits six plumose setae, with the two anteromedian ones longer than the anterolateral ones. In addition, it has a fine and smooth sensillas that is considerably longer than the other silks. The record of this species is based on the original description. However, its distribution is restricted to the type locality (Hoffmann 1960, Hoffmann & López-Campos 2000, Nielsen et al. 2021).

DISCUSSION

In this study, we report the first record of the parasitic interaction between the chigger mite *W. sonorensis* and the bat *M. volans*. The holotype is deposited in the Colección Nacional de Ácaros of the Instituto de Biología from the Universidad Nacional Autónoma de México (catalog number 000141, IBUNAM: CNAC: 141). Therefore, this is the second formal documentation of *W. sonorensis* in Mexico, expanding the mite's geographic range from the northwest to central Mexico (~ 2,000 km apart from holotype site; Fig. 1) (Hoffmann 1960, Hoffmann & López-Campos 2000, Whitaker & Morales-Malacara 2005). The genus *Whartonia* comprises 41 nominal species distributed worldwide in tropical and subtropical regions, 15 of them are confined in America (Takahashi et al. 2006, Da Silveira et al. 2015, Bassini-Silva et al. 2022). In Mexico, seven species of the genus have been recorded parasitizing 17 species of bats from 13 genera belonging to four families (Table 1), representing 14.6 % of the chigger species known worldwide and 40 % documented

Table 1 - Reports of species of the genus *Whartonia* parasitizing bats in Mexico.

Ectoparasite species	Bat Host	References
W. carpenteri Brennan 1962	*Lasiurus borealis*	Brennan 1962
	Balantiopteryx plicata	Hoffmann 1990, Hoffmann & López-Campos 2000, Whitaker & Morales-Malacara 2005
W. glenni Brennan 1962	*Balantiopteryx plicata*	Brennan 1962
	Corynorhinus mexicanus	Vercammen-Grandjean et al. 1965
	Choeronycteris mexicana	Webb & Loomis 1977
	Macrotus californicus	Palacios-Vargas & Morales-Malacara 1983, Morales-Malacara & López-Wilchis 1990, Whitaker & Morales-Malacara 2005
W. guerrerensis Hoffmann 1960	*Mormoops megalophylla*	Hoffmann 1960, Loomis 1969, Reed & Brennan 1975, Whitaker & Morales-Malacara 2005
W. nudosetosa Wharthon 1938	*Lasiurus borealis* *Carollia perspicillata* *Mimon cozumelae* *Peropteryx macrotis* *Glossophaga soricine* *Artibeus jamaicensis* *Desmodus rotundus* *Carollia subrufa* *Balantiopterix plicata*	Hoffmann 1990, Hoffmann & López-Campos 2000, Whitaker & Morales-Malacara 2005
W. sonorensis Hoffmann 1960	*Myotis vivesi*	Hoffmann 1960, Hoffmann & López-Campos 2000, Whitaker & Morales-Malacara 2005
	Myotis volans	This study
Whartonia (*Asolentria*) sp.	*Myotis thysanodes*	Bassols-Batalla et al. 1996
	Tadarida brasiliensis	Hoffmann & López-Campos 2000, Guzmán-Cornejo et al. (2003)
Whartonia sp.	*Tadarida brasiliensis*	Guzmán-Cornejo et al. (2003)

in the American continent. In addition to bats, some species of the genus *Whartonia*, such as *W. sonorensis*, have been recorded parasitizing five species of rodents (Gould 1956, Loomis & Crossley Jr 1963).

The understanding of the relationship between chigger mites and their hosts is limited, due to the lack of accurate records and the incorrect identification of these species. On the other hand, limited information suggests that chigger mites may be limited to a particular animal's order (Zajkowska et al. 2018). According to Takahashi et al. (2006) within the genus *Whartonia*, it has been documented that 20 out of the 41 described species have been exclusively collected from a single host (*Plecotus auritus*), while others have been reported as parasites of various bat species belonging to the families Hipposideridae, Vespertilionidae, Phyllostomidae, Emballonuridae, Pteropodidae, and Rhinolophidae, on substrates inside caves, such as guano, and from six rodent species of the genera *Neotoma*, *Baiomys*, *Perognathus*, and *Peromyscus*. This suggests that while some species may be specific to a host, others may exhibit a more generalist selection.

In this context, *W. sonorensis* has currently only been collected from two individuals belonging to two species of bats of the genus *Myotis*: *M. vivesi* and *M. volans* (Hoffmann 1960, Hoffmann & López-Campos 2000, and the report made here). In this scenario, some mite species may tend to parasitize hosts with very specific biological or ecological characteristics (Oconnor 1982). This specialization allows mite species to avoid direct competition when multiple species parasitize the same host (Michalska et al. 2010). This may result in a more limited geographic distribution, as mites depend on the presence of their specific hosts, restricting their range to areas where these hosts are found (Govindarajan et al. 2021, Peng et al. 2018). In contrast, other mite species could develop generalist interactions due to the greater availability of hosts, facilitated by social behaviors such as shelter sharing or living in groups, which ease infestation (Lourenço et al. 2016). In conclusion, this new report on the relationship between *W. sonorensis* and *M. volans* provides evidence of possible host specificity. Additionally, techniques such as sequencing the genes of these parasites could provide valuable insights into the co-evolutionary processes between *W. sonorensis* and *M. volans*, allowing for a deeper understanding of host-parasite dynamics. In future studies, these genetic data could inform parasite adaptation, host immune responses, and the potential for cryptic species within the parasite lineage.

ACKNOWLEDGEMENTS

Special thanks to the Ejido Moxolahuac in the state of Puebla for kindly giving us access to the study site. To M.

Medina, A. Arellanes, and O. Juárez for participating in the capture of the bats, A. Campos Rubio for reviewing the English version of the manuscript, A. Aragon and H. Medina for the elaboration and edition of the map, J.M. Arana for the edition of the photography, and J. B. Morales-Malacara for providing valuable information for the preparation of the manuscript. The research was financed by the National Council for Science and Technology of Mexico (SEP-CONACyT 2017-2018, No. A1-S-39572).

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