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Geographic variation in ectoparasitic mites diversity in *Tadarida brasiliensis* (Chiroptera, Molossidae)

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ABSTRACT. *Tadarida brasiliensis* (Geoffroy, 1824), the Brazilian free-tailed bat, is an insectivorous bat that occurs from southern United States of America to southern South America. In this study we present the first data on diversity of ectoparasitic mites of *T. brasiliensis* in Brazil. A compilation and analysis of the studies of mite diversity conducted in different points the geographic distribution this bat species are provided. The mites were collected from March 2010 to November 2011 on 160 *T. brasiliensis* adult bats captured in southern Brazil. Four species of mites have been found: *Chiroptonyssus robustipes* (Ewing, 1925), *Ewingana longa* (Ewing, 1938), *Ewingana inaequalis* (Radford, 1948), and specimens of Cheyletidae. *Chiroptonyssus robustipes* was the most prevalent species (100%), followed by *E. longa* (20%), *E. inaequalis* (10%), and specimens of Cheyletidae (1.25%). The data currently available show that *C. robustipes* parasitizes *T. brasiliensis* throughout its region of occurrence, and this mite is highly prevalent and abundant. The two species of *Ewingana* accompany the geographical distribution of *T. brasiliensis*, but with much lower prevalence and abundance.

KEYWORDS. Brazilian free-tailed bat, Acari, Macronyssidae, Myobiidae, Cheyletidae.

RESUMO. Variação geográfica na diversidade de ácaros ectoparasitos em *Tadarida brasiliensis* (Chiroptera, Molossidae). *Tadarida brasiliensis* (Geoffroy, 1824) é um morcego insetívoro que ocorre desde o sul dos Estados Unidos até o sul da América do Sul. Neste estudo são apresentados os primeiros dados sobre diversidade de ácaros ectoparasitos de *T. brasiliensis* no Brasil e é disponibilizada uma compilação e análise dos estudos de diversidade de ácaros realizados nos diferentes pontos da distribuição geográfica desta espécie de morcego. Os ácaros foram coletados de 160 espécimes adultos de *T. brasiliensis* capturados no extremo sul do Brasil, entre março de 2010 e novembro de 2011. Quatro espécies de ácaros foram coletadas: *Chiroptonyssus robustipes* (Ewing, 1925), *Ewingana longa* (Ewing, 1938), *Ewingana inaequalis* (Radford, 1948) e espécimes de Cheyletidae. *Chiroptonyssus robustipes* foi a espécie mais prevalente (100%), seguido de *E. longa* (20%), *E. inaequalis* (10%) e exemplares de Cheyletidae (1,25%). Os dados disponíveis atualmente demonstram que *C. robustipes* parasita *T. brasiliensis* em toda sua região de ocorrência e que este ácaro é altamente prevalente e abundante. As duas espécies de *Ewingana* acompanham a distribuição geográfica de *T. brasiliensis*, porém com prevalências e abundâncias muito menores.

PALAVRAS-CHAVE. Morcego brasileiro da cauda livre, Acari, Macronyssidae, Myobiidae, Cheyletidae.

Tadarida brasiliensis (Geoffroy, 1824), the Brazilian free-tailed bat, is an insectivorous bat of the family Molossidae with a wide geographic distribution, occurring from Southern United States of America (USA), through Mexico, Central America, and western South America to about 45°S including Brazil, Uruguay, Chile, and Argentina. It also occurs in the Small and Great Antilles in the Caribbean (Wilkins, 1989; Simmons, 2005). In Brazil, it occurs mainly in the southeast and south regions, where the temperatures are lower. *Tadarida brasiliensis* form colonies in several kinds of shelters including caves, sewers, attics, bridges, and tree hollows (Wilkins, 1989).

Tadarida brasiliensis was well studied in the USA, however there is little information on this species out of North America (Wilkins, 1989). Regarding acarine ectoparasites of *T. brasiliensis*, most studies were conducted in the southern USA; however, few contain information for a significant number of individuals. Among the studies conducted with a great number of hosts include: Durden *et al*. (1992) and Ritzi *et al.* (2001), in USA, with 133 and 96 specimens, respectively; Guzmán-Cornejo *et al*. (2003), in Mexico, with 98 specimens; and Muñoz *et al.* (2011), in Chile, with 195 specimens. Few studies were conducted in South America, and only two (Muñoz *et al*., 2003, 2011) are comprehensive studies of ectoparasites of *T. brasiliensis*; however, only Muñoz *et al*. (2003) report the parasitic indexes found. The other studies are records of occurrence of Acari species (Yunker & Radovsky, 1966; Saunders, 1975; Mauri, 1982). There is no information concerning mite parasites in *T. brasiliensis* from Brazil.

The knowledge of the ectoparasite fauna of bats can provide important information on behavior and biological aspects of its host (Fritz, 1983). In this study we present the first data on mite ectoparasites of *T. brasiliensis* in Brazil, and we include data on the species richness, and parameters of prevalence, mean abundance and mean intensity. We also provide a compilation of the studies on mite ectoparasites of *T. brasiliensis* throughout its geographic distribution to discuss the existence of geographic variation in diversity, to detect gaps in knowledge on the subject, and priority approaches for future studies.

MATERIAL AND METHODS

From March 2010 to November 2011, 160 adult specimens (80 males and 80 females) of *T. brasiliensis*

from a colony housed in the attic of a one-story masonry building in the Municipality of Capão do Leão (31°48'03"S; 52°24'29"W), state of Rio Grande do Sul, Brazil, were captured in a harp trap.

Bats were anesthetized with ketamine hydrochloride by injection intramuscular (considering the weight and volume) and after euthanized in CO_2 chamber (licenced by ICMBio). Then were individually packed in plastic bags, and maintained under refrigeration for a few days in the laboratory until the time of analyses. Three different procedures were performed for collecting the ectoparasites: the body surfaces of the bats were examined under a stereomicroscope, the pelage was brushed on a tray with white background, and the bats were washed for thirty minutes in a vessel containing approximately 400 mL of water and 3 mL of detergent. The material that remained in the tray and water resulting from washing were examined under a stereomicroscope to obtain the ectoparasites. All mites were clarified in lacto phenol and mounted on slides for counting and identification. Some of these specimens were mounted on permanent slides in Hoyer's Solution.

Mite identification was made according to keys of Ewing (1938), Fonseca (1948), Dusbábek (1968), and Krantz (1978). Parameters of prevalence (frequency of parasitized hosts in a sample), mean abundance (mean of the number of individuals of a particular parasite species per host examined) and mean intensity (mean of the number of individuals of a particular parasite species per infested host in a sample) of the mites were calculated according to Bush *et al.* (1997). The specimens were deposited in the Arthropod Collection of the Laboratory of Wild Animals Parasitology, Institute of Biology, Universidade Federal de Pelotas (UFPel), Pelotas (RS), Brazil.

We performed an extensive literature review to exhaust the location of new articles. The following information was summarized: study site, number of hosts analyzed, species found, species richness, and parasitic indexes.

RESULTS AND DISCUSSION

A total of 4,837 mites of four species were collected from 160 specimens of *T. brasiliensis*: 4,751 *Chiroptonyssus robustipes* (Ewing, 1925) (Macronyssidae) (Figs 1, 2), 63 *Ewingana longa* (Ewing, 1938) (Myobiidae) (Figs 3, 4), 21 *Ewingana inaequalis* (Radford, 1948) (Myobiidae) (Fig. 5), and two specimens of Cheyletidae (Fig. 6) (Tab. I).

Thirteen different species, eight genera and two families (Tab. II) were identified in the 18 studies compiled on mite parasites of *T. brasiliensis*. The richness varied from one species, obtained in several studies, to nine species in the cave of Cueva de La Boca, in Mexico (Guzmán-Cornejo *et al*., 2003). Considering only the most temporally comprehensive studies and those that analyzed a number of individuals, apparently the greatest richness of mites occurs in populations of *T. brasiliensis* from southeastern USA (Foster & Mertins, 1996), and in Mexico (Guzmán-Cornejo *et al.*, 2003). However, here are no data for most species distributed in South America, including southern and southeastern Brazil, regions that should be studied. The richness of mites found in this study may be considered low, and is similar to those obtained by Durden *et al*. (1992), Spears *et al*. (1999), Ritzi *et al*. (2001), and Muñoz *et al*. (2011); however, it is lower than the richness obtained in the studies conducted by Foster & Mertins (1996) and Guzmán-Cornejo *et al.* (2003) (Tab. II).

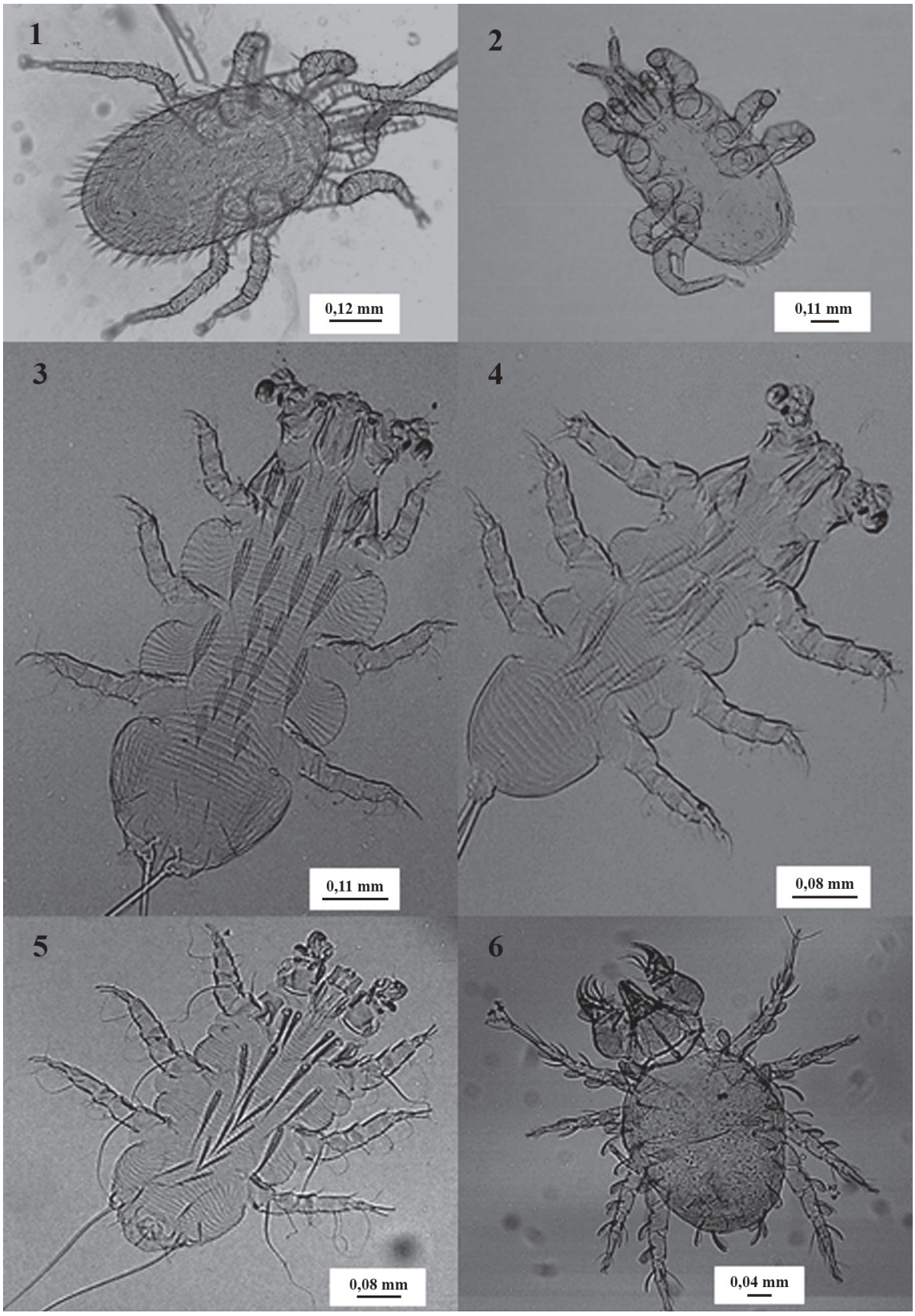
Chiroptonyssus robustipes was the most abundant and prevalent in the present study, being found in 100% of the bats (Tab. I). This result agrees with the studies in the U.S.A by Foster & Mertins (1996) and McAllister *et al*. (2006); in Chile by Muñoz *et al.* (2003); and in Mexico by Guzmán-Cornejo *et al.* (2003) who also found 100% prevalence. High prevalence was also reported by Durden *et al*. (1992) and Ritzi *et al.* (2001), USA, which obtained amounts of 86.87% and 83.33%, respectively (Tab. II).

Chiroptonyssus robustipes parasitizes *T. brasiliensis* throughout its geographic distribution, from the USA to southern Brazil, Argentina and Chile (Tab. II). *Tadarida brasiliensis* is the typical host and almost exclusive for *C. robustipes*, although this species of mite also occurs in other bats species such as *Myotis nigricans* (Schinz, 1821), *M. californicus* Audubon and Bachman, 1842, *Eptesicus fuscus* (Beauvois, 1796), and *Nyctinomops macrotis* (Gray, 1839), however, with lower mean intensity (Durden *et al.*, 1992; Guzmán-Cornejo *et al*., 2003). In Brazil, there are records of this mite parasitizing *N. macrotis* and other unidentified species in state of São Paulo (Fonseca, 1948); however, there are no reports of this mite infesting *T. brasiliensis* in Brazil.

Two species of *Ewingana* were found in this study. *Ewingana longa* had a prevalence of 20% (Tab. I). In USA, low prevalence in *T. brasiliensis* was reported by Durden *et al.* (1992), Foster & Mertins (1996), and Ritzi *et al*. (2001), of 1%, 3.5% and 11.46%, respectively. However, Guzmán-Cornejo *et al*. (2003), in Mexico, recorded high prevalences (42%, 50%, 63%, and 68%) (Tab. II). *Ewingana*

Tab. I. Parameter of infestation by mites in *Tadarida brasiliensis* (Geoffroy, 1824) captured from 2010 to 2011 in Rio Grande do Sul State, Brazil (n=160).

Mites	No. collected	Infestation range	Prevalence (%)	Mean Intensity ± SD	Mean Abundance ± SD
Chiroptonyssus robustipes	4751	1-204	100	29.69 ± 24.67	29.69 ± 24.67
Ewingana longa	63	0-8	20	1.96 ± 1.75	0.39 ± 1.1
Ewingana inaequalis	21	0-2	10	1.31 ± 0.47	0.13 ± 0.42
Cheyletidae	2	0-1	1.25	1	0.012 ± 0.11



Figs 1-6, ectoparasitc mites of *Tadarida brasiliensis* (Geoffroy, 1824). *Chyroptonyssus robustipes* (Ewing, 1925): 1, dorsal view; 2, ventral view. *Ewingana longa* (Ewing, 1938), dorsal view: 3, female; 4, male. 5, *Ewingana inaequalis* (Radford, 1948), dorsal view of female. 6, dorsal view of Cheyletidae.

Tab. II. Studies on mites ectoparasites of *Tadarida brasiliensis* (Geoffroy, 1824) at different regions. List of species collected and their parasitic indexes [P (%)*, prevalence; MI*, mean intensity; MA*, mean abundance; NA, not available].

Reference	No bats examinated	Location	Mites	Parasitic Index		
				P(%)*	MI*	MA*
BRADSHAW & ROSS, 1961	NA	Arizona (EUA)	*Chiroptonyssus robustipes*	-	-	-
			Steatonyssus sp.	-	-	-
DURDEN *et al*., 1992	133	Alabama (EUA)	*Chiroptonyssus robustipes*	86.8	8.4	-
			Steatonyssus ceratognathus (Ewing, 1923)	6	1.9	-
			Steatonyssus occidentalis (Ewing, 1933)	2	1	-
			Ewingana longa	1	1	-
			Androlaelaps casalis (Berlese, 1887)	1	5	-
SPEARS *et al*., 1999	45	Georgia (EUA)	*Chiroptonyssus robustipes*	98	-	-
			Steatonyssus ceratognathus	-	-	-
			Cheletonella vespertilionis (Womersley, 1941)	-	-	-
			Teinocoptes sp.	-	-	-
			Nycteriglyphus sp.	-	-	-
MCALLISTER *et al*., 2006	10	Arkansas (EUA)	*Chiroptonyssus robustipes*	100	-	-
JAMESON, 1959	55	Texas (EUA)	*Chiroptonyssus robustipes*	-	-	-
			Ewingana longa	-	-	-
			Trombicula sp.	-	-	-
STRANDTMANN, 1962	NA	Texas (EUA)	*Nycteriglyphus bifolium* (Strandtmann, 1962)	-	-	-
WHITAKER & EASTERLA, 1975	NA	Texas (EUA)	*Chiroptonyssus robustipes*	-	-	-
			Steatonyssus occidentalis	-	-	-
RITZI *et al*., 2001	96	Texas (EUA)	*Chiroptonyssus robustipes*	83.3	-	6.75
			Ewingana longa	11.4	-	0.32
			Trombiculidae	1.04	-	0.03
FOSTER & MERTINS, 1996	45	Florida (EUA)	*Chiroptonyssus robustipes*	100	-	-
			Dentocarpus macrotrichus Dusbábek & Cruz, 1966	3.5	-	-
			Ewingana inaequalis	3.5	-	-
			Ewingana longa	3.5	-	-
			Ewingana sp.	3.5	-	-
			Notoedres sp.	3.5	-	-
			Raphignathus sp.	3.5	-	-
			Cheyletidae	3.5	-	-
DUSBÁBEK & CRUZ, 1966	NA	Camagüey (Cuba)	*Dentocarpus macrotrichus*	-	-	-
DUSBÁBEK, 1968	NA	Camagüey (Cuba)	*Ewingana inaequalis*	-	-	-
GUZMÁN-CORNEJO *et al*., 2003	31	Nombre de Díos (Mexico)	*Chiroptonyssus robustipes*	100	-	39.8
			Macronyssus unidens (Radovsky, 1967)	3.2	-	0.03
			Ewingana inaequalis	26	-	0.5
			Ewingana Longa	42	-	1.03
			Leptotrombidium mexicana Wharton & Fuller, 1952	13	-	0.5
			Whartonia (Asolentria) sp.	3.2	-	0.4
			Dentocarpus macrotrichus	3.2	-	0.03
			Notoedres lasionycteris (Boyd, 1950)	25.8	-	0.74
GUZMÁN-CORNEJO *et al*., 2003	12	Río Salado (Mexico)	*Chiroptonyssus robustipes*	100	-	95.5
			Ewingana inaequalis	58.3	-	1.6
			Ewingana longa	50	-	1.75
			Whartonia (Asolentria) sp.	41.7	-	4
			Dentocarpus macrotrichus	25	-	8.9
			Notoedres lasionycteris	58.3	-	2.91
			Olabidocarpus nyctinomus Fain, 1976	16.6	-	15
GUZMÁN-CORNEJO *et al*., 2003	27	Cueva de la Boca (Mexico)	*Chiroptonyssus robustipes*	100	-	39.1
			Ewingana inaequalis	33.3	-	1.1
			Ewingana longa	63	-	2
			Leptotrombidium mexicana	15	-	1
			Dentocarpus macrotrichus	14.8	-	0.3
			Notoedres (Notoedres) sp.	7.4	-	0.1
			Notoedres lasionycteris	51.8	-	2.5

Tab. II. Cont.

Reference	No bats examinated	Location	Mites	Parasitic Index		
				P(%)*	MI*	MA*
Guzmán-Cornejo *et al*., 2003	28	Concepción del Oro (Mexico)	*Olabidocarpus nyctinomus*	29.6	-	5.07
			Chiroptonyssus robustipes	100	-	186.2
			Ewingana inaequalis	57.1	-	2
			Ewingana longa	68	-	2
			Leptotrombidium mexicana	8	-	0.2
			Whartonia sp.	3.6	-	0.03
			Dentocarpus macrotrichus	3.7	-	0.5
			Notoedres lasionycteris	21.7	-	0.25
Pence *et al*., 1981	2	Antillean island (Dominica)	*Chiroptonyssus robustipes*	-	-	-
Saunders, 1975	NA	Mérida (Venezuela)	*Chiroptonyssus robustipes*	-	-	-
Yunker & Radovsky, 1966	NA	Cerro Punta (Panamá)	*Chiroptonyssus robustipes*	-	-	-
Muñoz *et al*., 2003	90	Concepción (Chile)	*Chiroptonyssus robustipes*	100	-	-
			Ewingana inaequalis	32.2	-	-
			Notoedres lasionycteris	40	-	-
Muñoz *et al*., 2011	195	Santiago (Chile)	*Chiroptonyssus robustipes*	-	-	-
			Ewingana inaequalis	-	-	-
			Notoedres lasionycteris	-	-	-
Mauri, 1982	NA	La Plata (Argentina)	*Chiroptonyssus robustipes*	-	-	-

inaequalis showed a prevalence of 10% (Tab. I), higher than that recorded by Foster & Mertins (1996) in USA (3.5%), however lower than those reported by Muñoz *et al.* (2003) in Chile (32.22%) and Guzmán-Cornejo *et al*. (2003) in Mexico (26%, 33.3%, 57.1%, and 58.3%) (Tab. II). There are no reports of occurrence of these mites in Brazil or infestation by these mites in other bat species.

Mites of Myobiidae show high specificity, and many species are specific to a single host genus (Fain, 1994). *Ewingana longa* and *E. inaequalis* probably infest *T. brasiliensis* throughout its geographic distribution (Tab. II). The compiled data indicate that *E. inaequalis* is present in *T. brasiliensis* populations, from the USA (Durden *et al*., 1992; Foster & Mertins 1996) to Chile (Muñoz *et al*., 2003; Muñoz *et al*., 2011), and in southern Brazil (this study), and *E. longa* occurs in populations from the USA (Jameson, 1959; Durden *et al.*, 1992; Foster & Mertins, 1996; Ritzi *et al*., 2001), Mexico (Guzmán-Cornejo *et al*., 2003), and southern Brazil (this study).

The low prevalence of Cheyletidae obtained (Tab. I) is similar to that reported by Foster & Mertins (1996) (3.5%) in USA (Tab. II). In this country, Spears *et al.* (1999) reported the occurrence of *Cheletonella vespertilionis* (Womersley, 1941) in *T. brasiliensis*. Most species of Cheyletidae are free-living predators preying on other arthropods, including mites; however, some species can parasitize small mammals, among them bats (Ezequiel *et al*., 2008). There is no previous report of these mites parasitizing *T. brasiliensis* in Brazil.

This review shows that there is a reasonable number of studies that report the occurrence of mite ectoparasites in *T. brasiliensis*, however, few have data of large numbers of hosts and parasitic indexes. Moreover, only four studies have data from populations in South America, and the current was the only study conducted in Brazil.

We can consider that are two major gaps in knowledge on mite parasites of *T. brasiliensis*: diversity related to geographic variation, and temporal and spatial dynamics of populations. Data currently available show that there is great specificity between *T. brasiliensis* and *C. robustipes* throughout its geographic distribution, and this mite species is highly prevalent and abundant. Both *Ewingana* species are also present along the geographic distribution of *T. brasiliensis*, however with much lower prevalence and abundance.

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