Bats used as hosts by *Amblyomma sculptum* (Acari: Ixodidae) in Northeastern Brazil and its implications on tick-borne diseases

Roberto Leonan M. Novaes¹, Fernanda M. Alves², Renan F. Souza³, Rafael S. Laurindo⁴, Ricardo Moratelli⁵

¹Universidade Federal do Rio de Janeiro, Programa de Pós-Graduação em Biodiversidade e Biologia Evolutiva. 21941-902 Rio de Janeiro, RJ, Brazil.
²Fundação Oswaldo Cruz, Laboratório de Biologia de Tripanossomatídeos. 21040-360, Rio de Janeiro, RJ, Brazil.
³Centro Universitário Salgado de Oliveira, Programa de Pós-Graduação em Zoologia, Manejo e Preservação da Vida Silvestre. 24456-570 São Gonçalo, RJ, Brazil.
⁴Universidade Federal de Lavras, Departamento de Biologia. 37200-900 Lavras, MG, Brazil.
⁵Fundação Oswaldo Cruz, Fiocruz Mata Atlântica, 22713-560, Rio de Janeiro, Brazil.

Corresponding author: Roberto Leonan M. Novaes (robertoleonan@gmail.com)

http://zoobank.org/C90EBC01-23EA-45C0-8EA9-BC3717FDAEB4

ABSTRACT. *Amblyomma* Koch, 1844 is distributed worldwide, with ca. 130 species currently recognized. These ticks are vectors of pathogens to animals and humans, including the causative agent of the New World Rocky Mountain spotted fever. Species of the *Amblyomma* parasitize a wide range of organisms, especially medium and large terrestrial mammals. Here we report for the first time the association of *Myotis lavali* Moratelli, Peracchi, Dias & Oliveira, 2011, *Noctilio albiventris* Desmarest, 1818 and *Noctilio leporinus* (Linnaeus, 1758) as hosts for *Amblyomma sculptum* Berlese, 1888. The ticks were originally identified as *Amblyomma cajennense* (Fabricius, 1787), in 2011. However, a later taxonomic review indicated that the species of the *A. cajennense* complex occurring in the Caatinga is *A. sculptum*. We also discuss the ecoepidemiological implications of this association.

KEY WORDS. Caatinga, Chiroptera, hard ticks, neotropics, parasitism.

Ticks are vectors of pathogens to humans and animals, being of public health importance (Jongejan and Uilenberg 2004). Hard ticks of *Amblyomma* Koch, 1844 are the main vectors of *Rickettsia rickettsii*, the causative agent of Rocky Mountain Spotted Fever in humans, and other bacteria that cause anaplasmosis and ehrlichiosis, among others (Sangioni et al. 2005, Schulze et al. 2005, Labruna 2009, Witter et al. 2016).

*Amblyomma* is one of the most common hard tick genera, with ca. 130 species, of which more than half are endemic to the New World (Guglielmone et al. 2010). *Amblyomma sculptum* Berlese, 1888, member of the *A. cajennense* complex, occurs in the central and eastern portions of South America, including northern Argentina, Bolivia, Paraguay, and Brazil (Nava et al. 2014, Martins et al. 2016). Horses and capybaras are the primary hosts for these ticks (Sangioni et al. 2005, Labruna 2009). However, *A. sculptum* also feeds on many domestic and wild terrestrial mammals (Garcia et al. 2013, Brites-Neto et al. 2015, Martins et al. 2016).

Although there are many studies reporting the association between ectoparasites and bats (e.g., Christie et al. 2003, Dick and Patterson 2006, Franck et al. 2013, Muñoz-Leal et al. 2016), bats rarely have been reported as hosts for the New World *Amblyomma* species. New findings on host/parasite interactions are crucial for the understanding of evolutionary processes of species diversification and habitat occupation, providing additional insights on the epidemiology of emerging infectious diseases. Herein we describe new records of New World bats parasitized by hard tick *A. sculptum*.

Between October 2010 and October 2012, we performed thirty nights of bat sampling in São João do Piauí (08°19’43"S; 42°21’17"W, elevation of 270 m), state of Piauí, Northeastern Brazil. The study area comprises remnants of caatinga’s xerophytic vegetation, pastures and agricultural fields for cassava, maize, palm and cashew production. See Novaes et al. (2015) for a detailed description of the study site. Bat samplings were carried out using 10 ground level mist-nests (Zootech®, 9 x 3 m, 30 mm
mesh) placed in trails, natural clearings, and along riverbanks. Mist-nets were opened from six hours after dusk (ca. 6:00 pm). Bats were identified in the field, and their associated ectoparasites were collected with tweezers. Collected ticks were identified per morphological characters proposed by Barros-Battesti et al. (2006).

On October 6th, 2010, at the pond margin of an abandoned rural property, we captured an adult male of Myotis lavali Moratelli, Peracchi, Dias & Oliveira, 2011 (Chiroptera: Vespertilionidae) parasitized by a sub-adult of A. sculptum, which was adhered to the face of the bat (Fig. 1). The bat and the tick were collected and deposited in the mammal collection of Museu Nacional (MN 75191). On October 7th, 2010, at the same locality, we captured a pregnant female of Noctilio leporinus (Linnaeus, 1758) (Chiroptera: Noctilionidae) with a sub-adult A. sculptum inside the ear. The tick was removed, and the bat released in the same location. On April 2, 2012, at the same locality, we captured one adult female of Noctilio albiventris Desmarest, 1818 parasitized by some sub-adult individuals of A. sculptum, together with several soft ticks Ornithodoros sp. (Acari: Argasidae), on the top of head, and along the dorsum, wings and uropatagium (Fig. 2). The bat and ticks were deposited in the mammal collection of Museu Nacional (MN 79943).

The hard ticks were first identified as Amblyomma cajennense (Fabricius, 1787) in 2011, which was the only New World species recognized at that time. However, subsequent studies split A. cajennense into six species (see Nava et al. 2014, Martins et al. 2016), and based on geographic location, our records correspond to A. sculptum. The other species in the genus in Brazil is A. cajennense, which is restricted to the Amazon basin (Nava et al. 2014).

These are the first records of A. sculptum using bats as hosts. However, there are other records of Neotropical Myotis and Noctilio being parasitized by other tick species including the congener. Amblyomma triste Koch, 1844, which has been recorded in Myotis albofuscus (E. Geoffroy, 1806) from Paraguay (Venzal et al. 2003), and Ornithodoros hasei (Schulze, 1935) (Argasidae) recorded from N. leporinus and that was infected with Rickettsia spp. in French Guiana (Tahir et al. 2016).

There are few records of Amblyomma ticks parasitizing bats in the world (e.g., Jones et al. 1972, Barros et al. 1998, Guerra and Serra Freire 1999, Venzal et al. 2003, Ahamad et al. 2013, Alurralde and Díaz 2019). This might be partially explained by the bat behavior of social grooming (Carter and Leffer 2015), resulting in the removal of large sized ectoparasites. Bats were most frequently found infected by immature stages of soft ticks from family Argasidae (Franck et al. 2013, Munõz-Leal et al. 2016, Tahir et al. 2016), which are consistently smaller than those of the Amblyomma species. Captive observations and experiments could test this hypothesis.

Amblyomma spp. appear to not have host specificity, and the associations between ticks and their hosts seem to be more related to environmental factors than determinants inherent to the species (Nava and Guglielmone 2013). Moreover, the host preference differed between life stages, with immature ticks typically being more generalist than their adult conspecifics (Nava and Guglielmone 2013, Espinaze et al. 2015, Esser et al. 2016). As a result, in disturbed habitats without the original faunal composition, ectoparasites may infest different hosts, especially the immature ticks (McCoy et al. 2013, Esser et al. 2019, Kiene et al. 2020). Therefore, we hypothesize that the abandonment of rural property and withdrawal of livestock and domestic animals induced a new parasitic interaction between bats and A. sculptum by forcing the parasite to use different hosts.

The new records here reported extend the host range used by New World hard ticks from genus Amblyomma, which can furnish new insights about Rickettsial transmission cycle. Bats have high vagility when compared with terrestrial animals, performing seasonal migrations of thousands of kilometers and erratic movements of hundreds of kilometers (Wiederholt et al. 2020). Therefore, we hypothesize that the abandonment of rural property and withdrawal of livestock and domestic animals induced a new parasitic interaction between bats and A. sculptum by forcing the parasite to use different hosts.
2013, Arnone et al. 2016). Moreover, bats are reservoirs of *Rickettsia* spp. (D’Auria et al. 2010, Tahir et al. 2016), which makes them an important component for researches investigating pathogen dispersal and tick-borne diseases outbreaks.

There are several records of bat parasitized by hard ticks of the genus *Ixodes*, including bat species from *Myotis* restricted to the Old World (Hassan et al. 2010, Hornok et al. 2014, Burazerović et al. 2015, Frank et al. 2015). These findings reinforce the need to continue investigating relationships between bats and ectoparasites, and their implications in public health.

**ACKNOWLEDGEMENTS**

We are grateful to Maria Lúcia Guimarães for assistance with tick identification; to Carlos Cândido for assistance in the fieldwork and in the photographic record. RLMN receives a PhD studentship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

**LITERATURE CITED**

Ahamad M, Ibrahim H, Bujang MK, Sah SA, Mohamad N, Nor SM, Ahmad AH, Ho TM (2013) A survey of acarine ectoparasites of bats (Chiroptera) in Malaysia. Journal of Medical Entomology 50: 140–146. https://doi.org/10.1603/ME11240

Alurralde SG, Díaz MM (2019) *Molossops temminckii* (Chiroptera: Molossidae). Mammalian Species 51: 34–45. https://doi.org/10.1093/mspecies/sez006

Arnone IS, Trajano E, Pulchério-Leite A, Passos FC (2016) Long-distance movement by a great fruit-eating bat, *Artibeus lituratus* (Olfers, 1818), in southeastern Brazil (Chiroptera, Phyllostomidae): evidence for migration in Neotropical bats? Biota Neotropical 16: e0026. https://doi.org/10.1590/1676-0611-BN-2015-0026

Barros SLJ, Famadas KM, Lopes LMS, Serra-Freire NM (1998) Visão sobre parasitismo de Mammalia: Chiroptera por Acari: Ixodidae, Argasidae e Nuttalliellidae (Acari: Ixodidae) do Brasil. Entomologia e Vectores 5: 123–136.

Barros-Battesti DM, Arzua M, Bechara GH (2006) Carrapatos de importância médico-veterinária da região Neotropical: um guia ilustrado para identificação de espécies. Butantan, São Paulo, 223 pp.

Brites-Neto J, Brasil J, Roncato-Duarte KM (2015) Epidemiological surveillance of capybaras and ticks on warning area for Brazilian spotted fever. Veterinary World 8: 1143–1149. https://doi.org/10.14202/vetworld.2015.1143-1149

Burazerović J, Čakić S, Mihaljica D, Sukara R, Čirović D, Tomanović S (2015) Ticks (Acari: Argasidae, Ixodidae) parasitizing bats in the central Balkans. Experimental and Applied Acarology 66: 281–291. https://doi.org/10.1007/s10493-015-9891-6

Carter G, Leffer L (2015) Social grooming in bats: are vampire bats exceptional? PLoS ONE 10: e0138430. https://doi.org/10.1371/journal.pone.0138430

Christe P, Giorgi MD, Vogel P, Arlettaz R (2003) Differential species-specific ectoparasitic mite intensities in two intimately coexisting sibling bat species: resourcemediated host attractiveness or parasite specialization? Journal of Animal Ecology 72: 866–872. https://doi.org/10.1046/j.1365-2656.2003.00759.x

D’Auria SR, Camargo MCG, Pacheco RC, Savani ESM, Dias MAG, Rosa AR, Almeida ME, Labruna MB (2010) Serologic survey for rickettsiosis in bats from São Paulo city, Brazil. Vector-borne Zoonotic Disease 10: 459–463. https://doi.org/10.1089/vbz.2009.0070

Dick CW, Patterson BD (2006) Bat flies: obligate ectoparasites of bats. In: Morand S, Krasnov BR, Poulin R (Eds) Micro-mammals and macroparasites: from evolutionary ecology to management. Springer, 179–194.

Espinaze MP, Hellard E, Horak IG, Cumming GS (2015) Analysis of large new South African dataset using two host-specificity indices shows generalism in both adult and larval ticks of mammals. Parasitology 143: 366–173. https://doi.org/10.1017/S00311820150011730

Esser HJ, Herre EA, Blüthgen N, Looizra JR, Berrmúdez SE, Jansen PA (2016) Host specificity in a diverse Neotropical tick community: an assessment using quantitative network analysis and host phylogeny. Parasites and Vectors 9: e372. https://doi.org/10.1186/s13071-016-1655-6

Esser HJ, Herre EA, Kays R, Lifting Y, Jansen PA (2019) Local host-tick coexistence in neotropical forest fragments. International Journal for Parasitology 49: 225–233. https://doi.org/10.1016/j.ijpara.2018.08.008

Franck F, Münster J, Schulze J, Liston A, Klimpel S (2013) Macroparasites of Microchiroptera: bat ectoparasites of Central and South America. In: Klimpel S, Mehlich H (Eds) Bats (Chiroptera) as vectors of diseases and parasites. Facts and Myths, 87–130.

Frank R, Kuhn T, Werblow A, Liston A, Kochmann J, Klimpel S (2015) Parasite diversity of European *Myotis* species with special emphasis on *Myotis myotis* (Microchiroptera, Vespertilionidae) from a typical nursery roost. Parasites and Vectors 8: e101. https://doi.org/10.1186/s13071-015-0707-7

Garcia MV, Silva DC, Almeida RFC, Cunha RC, Matias J, Barros JC, Andreotti R, Szabó MPJ (2013) Environmentally associated ticks (Acari: Ixodidae) in Campo Grande, Mato Grosso do Sul, Brazil. Revista Brasileira de Parasitologia Veterinária 22: 124–128. https://doi.org/10.1590/S1984-2961201300100023

Guerra RMS, Serra-Freire NM (1999) *Amblyomma oblongoguttatum* Koch, 1844 (Acari: Ixodidae) in *Carollia perspicillata* (L.) (Chiroptera: Phyllostomidae): report and ecological reflexion. Entomologia e Vectores 6(1): 63–73.

Guglielmone AA, Robbins RG, Apanaskevich DA, Petney TV, Estrada-Peña A, Horak IG, Shao R, Barker SC (2010) The Argasidae, Ixodidae and Nuttallineelidae (Acari: Ixodida) of the world: a list of valid species names. Zootaxa 2528: 1–28. https://doi.org/10.11646/zootaxa.2528.1.1

Hassan V, Zakkyeh T, Mozafar S, Alireza M, Maryam K, Mojtaba T (2010) Ectoparasites of lesser mouse eared bat, *Myotis blythii* from Kermanshah Iran. Asian Pacific Journal of
Tropical Disease 3: 271–373. https://doi.org/10.1016/S1995-7645(10)60090-9

Hornok S, Kontschán J, Kováts D, Kovács R, Angyal D, Göröf T, Polacsek Z, Kalmár Z, Mihalca AD (2014) Bat ticks revisited: *Ixodes ariakensis* sp. nov. and allopatric genotypes of *I. vespertilionis* in caves of Hungary. Parasites and Vectors 7: e202. https://doi.org/10.1186/1756-3305-7-202

Jones EK, Cliford CM, Keirans JE, Kohls GM (1972) The ticks of Venezuela (Acarina: Ixodoidea) with a key to the species of *Amblyomma* in the Western Hemisphere. Brigham Young University Science Bulletin, Biological Series 17(4): 1–40.

Jongejan F, Uilenberg G (2004) The global importance of ticks. Parasites & Vectors 7: 341–348. https://doi.org/10.1186/1756-3305-7-341

Kiene F, Andriatsitohaina B, Ramsay MS, Rakotondramanana H, Rakotondravony R, Radespiel U, Stube C (2020) Forest edges affect ectoparasite infestation patterns of small mammalian hosts in fragmented forests in Madagascar. International Journal for Parasitology 50: 299–313. https://doi.org/10.1016/j.ijpara.2020.01.008

Labruna MB (2009) Ecology of rickettsia in South America. Annals of the New York Academy of Science 1166: 156–166. https://doi.org/10.1111/j.1749-6632.2009.04516.x

Martins TF, Barbieri ARM, Costa FB, Terassini FA, Camargo LM, Peterka CR, Pacheco R, Dias RA, Nunes PH, Marcili A, Scolfield A, Campos AK, Horta MC, Guil lux AG, Benatti HR, Ramirez DG, Barros-Battesti DM, Labruna MB (2016) Geographical distribution of *Amblyomma cajennense* (sensu lato) ticks (Parasitiformes: Ixodidae) in Brazil, with description of the nymph of *A. cajennense* (sensu stricto). Parasites and Vectors 9: e186. https://doi.org/10.1186/s13071-016-1460-2

McCoy KD, Léger E, Dietrich M (2013) Host specialization in ticks and transmission of tick-borne diseases: a review. Frontiers in Cellular and Infection Microbiology 3: a57. https://doi.org/10.3389/fcimb.2013.00057

Muñoz-Leal S, Eriksson A, Santos CF, Fischer E, Almeida JC, Luz HR, Labruna MB (2016) Ticks infesting bats (Mammalia: Chiroptera) in the Brazilian Pantanal. Experimental and Applied Acarology 69: 73–85. https://doi.org/10.1007/s10493-016-0026-5

Nava S, Guglielmone AA (2013) A meta-analysis of host specificity in Neotropical hard ticks (Acarina: Ixodidae). Bulletin of Entomological Research 103: 216–224. https://doi.org/10.1017/S0007485312000557

Nava S, Beati L, Labruna MB, Cáceres AG, Mangold AJ, Guglielmone AA (2014) Reassessment of the taxonomic status of *Amblyomma cajennense* (Fabricius, 1787) with the description of three new species, *Amblyomma tonelliae* n. sp., *Amblyomma interandinum* n. sp. and *Amblyomma patinoi* n. sp., and reinstatement of *Amblyomma mixtum* Koch, 1844, and *Amblyomma sculptum* Berlese, 1888 (Ixodida: Ixodidae). Ticks Tick-borne Diseases 5: 252–276. https://doi.org/10.1016/j.ttbdis.2013.11.004

Novaes RLM, Laurindo RS, Souza RF (2015) Structure and natural history of an assemblage of bats from a xerophytic area in the Caatinga of Northeastern Brazil. Studies on Neotropical Fauna and Environment 50: 40–51. https://doi.org/10.1890/10050521.2015.1006478

Sangioni LA, Horta MC, Vianna MC, Gennari SM, Soares RM, Galvão MA, Schumaker TT, Ferreira F, Vidotto O, Labruna MB (2005) Rickettsial infection in animals and Brazilian spotted fever endemicity. Emerging Infections Diseases 11: 265–270. https://doi.org/10.3201/eid1102.040656

Schulze TL, Jordan RA, Schulze CJ, Mixton T, Papero M (2005) Relative encounter frequencies and prevalence of selected Borrelia, Ehrlichia, and Anaplasma infections in *Amblyomma americanum* and *Ixodes scapularis* (Acari: Ixodidae) Ticks from Central New Jersey. Journal of Medical Entomology 42: 450–456. https://doi.org/10.1093/jmedent/42.3.450

Tahir D, Socolovaschi C, Marié JL, Ganay G, Berenger JM, Bobpar JM, Blanchet D, Cheuret M, Mediannikov O, Raoult D, Davoust B, Parola P (2016) New *Rickettsia* species in soft ticks *Ornithodoros hasei* collected from bats in French Guiana.Ticks Tick-borne Diseases 7: 1089–1096. https://doi.org/10.1016/j.ttbdis.2016.09.004

Venzal JM, González EM, Capellino D, Estrada Peña A, Guglielmone AA (2003) First record of *Amblyomma triste* Koch, 1844 (Acari: Ixodidae) and new records of *Ornithodoros mimon* Koch, Clifford & Jones, 1969 (Acari: Argasidae) from Neotropical bats. Systematics and Applied Acarology 8: 93–96. https://doi.org/10.11158/saa.8.1.11

Wiederholt R, López-Hoffman L, Cline J, Medellin RA, Cryan P, Russel A, McCracken G, Diffendorfer J, Semmens D (2013) Moving across the border: modeling migratory bat populations. Ecosphere 4: e114. https://doi.org/10.1890/ES13-00023.1

Witter R, Martins TF, Campos A, Melo AL, Corrêa SH, Morgado TO, Wolf RW, May-Júnior JA, Sinkoc AL, Strüssmann C, Aguiar DM, Rossi RV, Semedo TB, Campos Z, Desbiéz AL, Labruna MB, Pacheco RC (2016) Rickettsial infection in ticks (Acari: Ixodidae) of wild animals in midwestern Brazil. Ticks Tick-borne Diseases 7: 415–423. https://doi.org/10.1016/j.ttbdis.2015.12.019

Submitted: July 22, 2020
Accepted: September 30, 2020
Available online: November 2, 2020
Editorial responsibility: Valéria da Cunha Tavares

Author Contributions: RLMN and RSL conducted the fieldwork and data collecting; RLMN, FMA, RFS, RSL and RM analyzed the data and wrote the paper.

Competing interests: The authors have declared that no competing interests exist.

© 2020 Sociedade Brasileira de Zoologia. Published by Pensoft Publishers at https://zoologia.pensoft.net