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IXODID FAUNA OF EDENTATA (MAMMALIA, XENARTHRA) IN BRAZIL

IXODOFAUNA DE EDENTATA (MAMMALIA: XENARTHRA) NO BRASIL

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ABSTRACT: Systematic identification of parasites in wild animals contributes valuable information for managing captive or free-living populations. Between 1994 and 2011, 6,180 ixodids were gathered from 13 different species of Xenarthra within Brazilian territory. Through examination under a stereomicroscope at the National Reference Laboratory for Rickettsiosis Vectors, Oswaldo Cruz Foundation, Rio de Janeiro, the ticks were identified as 21 species, of which 18 were in the genus *Amblyomma: A. aureolatum, A. auricularium, A. brasiliensis, A. cajennense, A. calcaratum, A. coelebs, A. dubitatum, A. geayi, A. goeldi, A. longirostre, A. multipictum, A. naponense, A. nodosum, A. parvum, A. scutatum, A. scalptutarum, A. rotundatum, A. varium* and one unidentified species (*Amblyomma* sp.). The other species identified were *Anocentor nitens, Boophilus microplus* and *Rhipicephalus sanguineus.*

Key words*:* Ixodidae; anteater; armadillo; sloth; tick.

RESUMO: De animais silvestres livres na natureza, e mantidos em recintos em zoológico, foram identificadas as espécies de carrapatos em parasitismo no período entre 1994 e 2011. Foram recolhidos 6.180 carrapatos de 13 diferentes espécies de Xenarthra no espaço geopolítico do Brasil, e identificados por estereomicroscopia no Laboratório de Referência Nacional em Vetores das Riquetsioses, Instituto Oswaldo Cruz/Fiocruz, Rio de Janeiro. Das 21 espécies encontradas, 18 eram do gênero *Amblyomma*: *A. aureolatum, A. auricularium, A. brasiliensis, A. cajennense, A. calcaratum, A. coelebs, A. dubitatum, A. geayi, A. goeldi, A. longirostre, A. multipictum, A. naponense, A. nodosum, A. parvum, A. scutatum, A. scalptutarum, A. rotundatum, A. varium,* e um só reconhecido ao

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nível do gênero *Amblyomma*. As outras espécies identificadas eram *Anocentor nitens, Boophilus microplus* e *Rhipicephalus sanguineus.*

Palavras-chave: Ixodidae; carrapato duro; tamanduá; preguiça; tatu.

INTRODUCTION

Anteaters, armadillos and sloths form a group of primitive placental mammals that are only found in the New World, with distribution from the south of North America to the south of South America. They are members of the order *Xenarthra* or Edentata, which include 17 genera and more than 30 species[1]. Despite the name Edentata, only the giant anteater really does not have any dentition. The other members of the order have teeth, although they are mostly small and/or vestigial.

The family *Myrmecophagidae* has three genera and four species. The most prominent among these is the giant anteater (*Myrmecophaga tridactyla* L.), which is one of the largest mammals of the *Cerrado* (savanna region) and today is among the species listed as "threatened with extinction"**,** in the list of species of Brazilian fauna published by the Ministry of the Environment on May 27, 2003, and as "Vulnerable" in the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (2004). The southern *tamandua* (*Tamandua tetradactyla* L.) is not yet on the official Brazilian list of animals threatened with extinction, but according to the IUCN list, it is in the "Vulnerable" category. The silky anteater (*Cyclopes didactylus* L., 1758) is the smallest of the four species of anteaters, with tree-living characteristics and enormous knowledge gaps regarding its biology.

In the family *Bradypodidae*, there are two genera and five species, and the most prominent member is the brown-throated three-toed sloth (*Bradypus variegatus* Scinz, 1825), with known distribution covering the southeastern and central-western regions of Brazil.

Armadillos are grouped in the family Dasypodidae. They are animals with nocturnal habits and greatly varying feeding characteristics. The giant armadillo [*Periodontes maximus* (Kerr, 1792)] is the largest representative of this family living today. It is rarely seen and is now included in the list of species of Brazilian fauna threatened with extinction.

Changes to natural habitats caused by human activity are one of the biggest threats to the survival of the Xenarthra, along with predatory hunting in the specific case of armadillos. In some rural communities, in Brazil, armadillos are reared within the domestic environment and serve as an important source of animal protein, thus resulting in a close relationship with humans. The most visible ways in which habitats are altered is through direct removal of part of the biomass, caused by burning to create pasture land and highways and, more recently, through construction of hydroelectric power plants.

Ticks are arthropods that feed on the blood of mammals, birds, reptiles and amphibians, with widespread geographical distribution. More than 885 valid species have already been described[2]. Among this group, nine genera and 61 species are known in Brazil[3].

Ixodids that attach to hosts are dispersed, but seek their preferential hosts because they have a strong physiological dependence. Thus, there is a high chance that they will transmit infectious agents to their hosts, or serve as reservoirs of these agents. Infectious agents can be transmitted among ticks between stages (larva to nymph or nymph to adult) or through the eggs, i.e. from one generation to another. Studies proving the presence of ticks in Xenarthra are scarce in the worldwide literature, and this is related to the great difficulty in catching or even observing the hosts in their natural environment.

In Brazil had contributed information on the ixodid fauna of Brazilian cervids[4]; on Chelonia[5]; on the ixodid parasites on wild fauna in the region of Foz de Iguaçu[6]; and on the ixodid fauna of wild animals in the Pantanal region[7]. In Rio de Janeiro[8], Maranhão[9], Pernambuco[10] and Amazonas[11] undertook successive surveys on the situation of parasitism among free-living animals in forested and jungle areas of Brazil.

MATERIALS AND METHODS

The design of this study was characterized as individualized, since it only took into consideration Xenarthra vertebrates; observational, since no intervention actions on parasitic relationships caused by ticks were implemented during the study; and cross-sectional, because of the need to establish an equivalent investigation time covering 17 years. With these characteristics, the study was classified as a survey[12]. The ixodids were collected between 1994 and 2011, from animals that were caught alive in the SESC-Pantanal Private Natural Heritage Reserve, located in the municipalities of Poconé and Barão de Melgaço, state of Mato Grosso; the Caiman Ecological Reserve, in the municipality of Miranda, state of Mato Grosso; and the Baía Bonita Ecological Reserve, which is located 7 km from the municipality of Bonito, state of Mato Grosso do Sul. Specimens were also collected from Xenarthra that had been found alive in the municipalities of Itapetininga, Tatuí, Pilar do Sul, Piedade, Araçoiaba da Serra and Sorocaba, state of São Paulo, and had been sent to the Municipal Zoo Quinzinho de Barros Park (PZMQB), in Sorocaba. During routine examinations, some of these individuals were found to have ticks attached to their bodies, and these were removed for examination and identification. The sample was completed with specimens sent to the National Reference Laboratory for Rickettsiosis Vectors (LIRN), Oswaldo Cruz Institute (IOC), Fiocruz, from different federal states (Amazonas, Federal District, Goiás, Pará, Pernambuco, Piauí, Rio de Janeiro, Santa Catarina and Tocantins), for identification and inclusion in the Collection of Wingless Vector Arthropods of Community Health Interest (CAVAISC), IOC.

The hosts were identified by veterinarians and biologists from zoos, while the ixodids were

identified at LIRN-IOC/FIOCRUZ, in Rio de Janeiro.

The tick collection teams were trained to follow identical procedures, and the sampling was done according to convenience, taking into consideration the management defined for the animals at each location to which they were sent. Through this, the selection and measurement bias was reduced. The ticks found on their hosts (Fig. 1) were removed and preserved with ethanol (70° GL) in vials that were labeled to indicate the origin of the material, the host (scientific name and common name), collection date and name of the person responsible for collecting the material. Engorged females (Fig. 2), metalarvae and metanymphs were packed alive in nontoxic plastic vials with a pressure cap containing a central opening in the cap. These were labeled and transported to LIRN. At the laboratory, the ticks were examined under a stereomicroscope and were identified in accordance with the studies and dichotomous keys[13,14,15,16,17] and the descriptions[18,19,20,21].

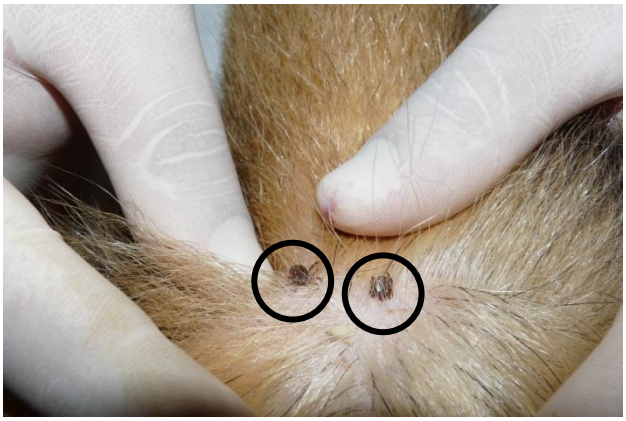

Figure 1. *Record of finding of two male hard ticks (Amblyomma nodosum) attached to the host's body, during routine inspection on a giant anteater (Tamandua tridactyla) at Sorocaba Zoo, state of São Paulo, in 2005.*

The data were analyzed statistically by means of Sørensen's similarity coefficient. The coefficient values found were compared with the data in the modified version of Rugg's table[22], and the safety of the affirmation was proven through the t test, with the significance level set at 5% ($\alpha = 5\%$), for the diversity of the tick species among the host species. The parasitological indicators of prevalence coefficient, dominance coefficient, abundance index and the mean intensity of parasitism were calculated[22]. Considering that the variable under analysis was discontinuous and finite, the results relating to the numbers of ticks were presented as integers for mean intensity of parasitism but as values fractioned in hundredths for the abundance index. The dominance coefficient and prevalence coefficient were relative numbers presented as percentages.

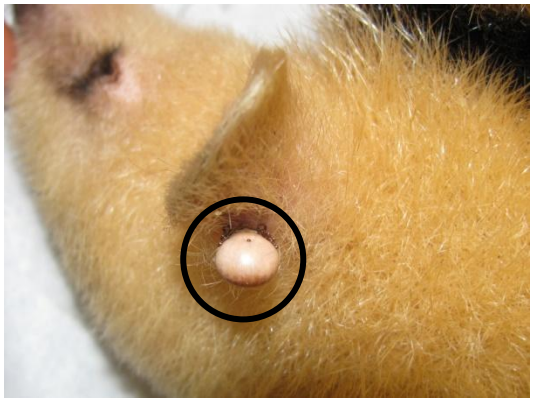

Figure 2: *Engorged female of Amblyomma nodosum at the end of the engorgement, attached to the posterior face of the pinna of an individual of Tamandua tridactyla that was received at the Municipal Zoo Quinzinho de Barros Park, Sorocaba, SP, in 2006.*

RESULTS

Among the 564 Xenarthra examined, tick species parasitized 178 hosts, which were identified as: *Myrmecophaga tridactyla* (giant anteater), *Tamandua tetradactyla* (southern tamandua), *Cyclopes didactylus* (silky anteater), *Bradypus variegatus* (brown-throated three-toed sloth), *Bradypus tridactylus* (pale-throated three-toed sloth), *Choloepus didactylus* (Linnaeus's two-toed sloth), *Choloepus hoffmanni* (Hoffman's two-toed sloth), *Choloepus* sp. (two-toed sloth), *Dasypus kappleri* (great long-nosed armadillo), *Dasypus novemcinctus* (nine-banded armadillo), *Dasypus* sp. (armadillo), *Euphractus sexcinctus* (six-banded armadillo) and *Priodontes maximus* (giant armadillo) (Tab. 1). Parasitism due to hard ticks on the Xenarthra specimens corresponded to a prevalence coefficient of 31.56%, with a mean intensity of parasitism of approximately 35 ticks/host.

Scientific name	**Common name**	**Absolute frequencies (Nº)**	**Dominance coefficients (%)**
Cyclopes didactylus	silky anteater	1	0,56
Myrmecophaga tridactyla	giant anteater	59	33,16
Tamandua tetradactyla	southern tamandua	39	21,91
Choloepus sp.	two-toed sloth	1	0,56
Choloepus didactylus	Linnaeus's two-toed sloth	6	3,37
Choloepus hoffmanni	Hoffman's two-toed sloth	1	0,56
Bradypus tridactylus	pale-throated three-toed sloth	20	11,24
Bradypus variegatus	brown-throated three-toed sloth	36	20,22

Dasypus kappleri	great long-nosed armadillo	1	0,56
Dasypus novemcinctus	nine-banded armadillo	6	3,37
Dasypus sp.	armadillo	1	0,56
Euphractus sexcinctus	six-banded armadillo	6	3,37
Priodontes maximus	giant armadillo	1	0,56

Table 1*. Absolute frequencies and dominance coefficients of the species of the 178 vertebrate hosts of the order Xenarthra that were found to be parasitized by ticks, among the 564 individuals examined in different federal states of Brazil between 1994 and 2011.*

Over the study period, 6180 tick specimens were collected. These were identified as *Anocentor nitens* (Neumann, 1897), *Boophilus microplus* (Canestrini, 1887), *Rhipicephalus sanguineus* (Latreille, 1806), an unidentified species in the genus *Amblyomma* (*Amblyomma* sp.) and a further 18 identified *Amblyomma* species: *Amblyomma aureolatum* (Pallas, 1772), *A. auricularium* Conil, 1878, *A. brasiliensis* Aragão, 1908, *A. cajennense* (Fabricius, 1787), *A. calcaratum* (Neumann, 1899), *A. coelebs* Neumann, 1899, *A. dubitatum* Neumann, 1899, *A. geayi* Neumann, 1899, *A. goeldi* Neumann, 1899, *A. longirostre* Koch, 1844, *A. multipictum* Neumann, 1906, *A. naponense* Packard, 1869, *A. nodosum* Neumann, 1899, *A. parvum* Aragão, 1908, *A. rotundatum* Koch, 1844, *A. scalpturatum* Neumann, 1906, *A. scutatum* Neumann, 1899 and *A. varium* Koch, 1844 (Table 2).

For the four genera of Ixodidae that parasitize Xenarthra within Brazilian territory, the parasitism indicators showed that *Amblyomma* sp. had the highest mean intensity of parasitism, with 244 specimens/host, of which the great majority were juvenile specimens. Among the species with adult specimens, the one with the highest dominance coefficient (DC) was *A. nodosum* (DC = 8.96), followed by *A. cajennense* (DC = 5.97), which was also the species found in the greatest number of hosts (Table 2).

Ticks species	**Ticks (nº)**	**PH (nº)**	**PC (%)**	**MIP (nº)**	**DC (%)**	**AI (nº)**
Amblyomma aureolatum	9	3	0,53	3	0,15	0,02
A. auricularium	4	3	0,53	1	0,06	0,01
A. brasiliense	2	1	0,18	2	0,03	0,00
A. cajennense	**355**	**50**	**8,87**	7	**5,74**	**0,63**
A. calcaratum	310	16	2,84	**19**	**5,02**	**0,55**
A. coelebs	12	2	0,35	6	0,19	0,02

A. dubitatum	18	4	0,71	5	0,29	0,03
A. geayi	26	16	2,84	2	0,42	0,05
A. goeldi	16	2	0,35	**8**	0,26	0,03
A. longirostre	2	2	0,35	1	0,03	0,00
A. multipictum	1	1	0,18	1	0,02	0,00
A. naponense	1	1	0,18	1	0,02	0,56
A. nodosum	**561**	**46**	**8,16**	**12**	**9,08**	**1,00**
A. parvum	20	6	1,06	3	0,32	0,04
A. rotundatum	4	3	0,53	1	0,06	0,01
A. scalpturatum	3	2	0,35	2	0,05	0,01
A. scutatum	3	1	0,18	3	0,05	0,01
Amblyomma sp.	**4.667**	20	3,55	**233**	**75,52**	**8,27**
A. varium	128	**42**	**7,45**	3	**2,07**	0,23
Anocentor nitens	1	1	0,18	1	0,02	0,00
Boophilus microplus	14	3	0,53	5	0,23	0,02
Rhipicephalus sanguineus	23	3	0,53	**8**	0,37	0,04

Table 2*. Species of Ixodidae ticks in mammals of the order Xenarthra that were found to be parasitized in different federal states of Brazil between 1994 and 2011, with parasitism indicators: PH = parasitized hosts; PC = prevalence coefficient; MIP = mean intensity of parasitism; DC = dominance coefficient; AI = abundance index.*

DISCUSSION

The presence of ticks on Brazilian Xenarthra species (Fig. 1 and Fig. 2) has been cited since early last century[23] and has been increasingly highlighted, even though reports in the current literature are still scarce[24,25,26,27,28,29,30]. With the large amount of material gathered through teamwork at our laboratory over the last 17 years, in the form of studies designed as surveys, it was sought here to present the current picture of ixodid fauna on some wild animals.

For this convenience sample, the giant anteater predominated among all the Xenarthra species studied. However, considering the length of the study period, the 59 giant anteaters examined are a small number, corresponding to around seven animals every two years. On the other hand, this is in line with the fact that today, the giant anteater is among the species **"**threatened with extinction**"**, on the list of species of Brazilian fauna published by the Ministry of the Environment on May 27, 2003, and as "Vulnerable", on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (2004)[31]. It should be noted that no active searches for hosts were conducted in the natural environment: the tick

samples were removed from animals that form part of the live collections at zoos and from animals seized by the Forest Guards from people without authorization to deal with these.

Species	*Myrmecophaga tridactyla*	*Tamandua tetradactyla*	*Bradypus variegatus*	*Bradypus tridactyla*	*Dasypus novemcinctus*	*Eupharctus sexcinctus*
M. tridactyla	**Strong**	**Marked**	**Acceptable**	**Weak**		
Tamandua tetradactyla	**0,53**					
B. variegatus	**0,33**	**0,38**				
B. tridactyla	**022**	**0,38**	**0,62**			
Dasypus novemcinctus	**022**	**0,29**	**0,50**	**0,40**		
Euphractus sexcinctus	**0,34**	**0,38**	**0,40**	**0,40**	**0,76**	

Note: coefficient of similarity: negligible < 0.15; weak 0.15 ≥ 0.29; acceptable 0.30 ≥ 0.49; marked 0.50 ≥ 0.74; strong ≥ 0.75

Figure 3*. Indication of the degree of similarity between tick species diversities among six Xenarthra species caught and examined in the States of Mato Grosso, Mato Grosso do Sul and São Paulo, from 1994 to 2009.*

Over the study period, 6180 hard ticks were collected from 178 hosts parasitized by 22 different species of Ixodidae, out of the total of 564 Xenarthra individuals examined (PC = 31.56%). In terms of prevalence per tick species (Table 2), the three species with greatest prevalence were *A. cajennense* (PC = 8.87%), *A. nodosum* (PC = 8.16) and *A. varium* (PC = 7.45%).

with Xenarthra hosts. This species was among the top three in all the parasitism indicators, and presented the greatest number of adult specimens in the hosts (Table 2).

A purely numerical presentation of the hosts and ticks is too simplistic to show important epizootiological data on the ecosystem and the possible human interference in the symbiotic relationships of these spaces.

The degree of similarity between the diverse species of Ixodida that were found parasitizing Xenarthra was tested among the host species, for three or more tick species found in the spaces studied. The results relating to anteaters (*M. tridactyla* and *T. tetradactyla*), sloths (*B. variegatus* and *B. tridactyla*) and armadillos (*E. sexcinctus* and *D. novemcinctus*) were compared in this

manner. It was seen that 87.51% of *Amblyomma* sp. specimens were in juvenile stages. The trophic pyramid for ixodids[20] with their endothermic hosts indicated that only 1% of the larvae reached the adult stage, and in their study the parasitism indicators were influenced by the juvenile stages. Using this reasoning, it is possible that out of the 4667 specimens (Table 2), only 46 would reach adulthood. Therefore, the dominance coefficient, mean intensity of parasitism and abundance index of the number of specimens that were not identified down to species level should not be used in making comparisons with the identified species, since such comparisons might modify the interpretation of the interspecies relationships. Although the present authors have proven experience in identifying juvenile stages of Ixodidae[19,32,33,34,35,36], it was not always possible to identify the larvae encountered. In other situations, in removing adult specimens from the hosts, part of the body was destroyed and thus the species could not be confidently identified.

Without taking into consideration these three indicators of parasitism for *Amblyomma* sp., the most dominant species (in descending order) were *A. nodosum*, *A. cajennense* and *A. calcaratum* (Table 2), which were also the most abundant species, in the same order. *A. nodosum* had previously only been indicated as a parasite of anteaters[23,37], although there was one reference to sloths as a host[26], but *A. nodosum* has now been confirmed to be a parasite of the species *Bradypus variegatus*.

The mean intensity of parasitism (MIP), without taking *Amblyomma* sp. into consideration, was greatest in *A. calcaratum*, followed by *A. nodosum* and, in equal third place, by *A. goeldi* and *R. sanguineus*. It is surprising that, of the three species of Ixodidae with greatest MIP among the Xenarthra, one species was characteristically from both urban and rural environments (Table 2), which may be indicating the existence of closer contact between the fauna of forests, fields and urban areas. This was also highlighted[38], in studying human parasitism due to ticks in the Pedra Branca State Park.

The parasitism indicators enable the perception that among the species encountered, *A. nodosum* had the best trophic interaction

Calculation of the coefficients of similarity between the parasitic tick diversities in the Xenarthra species made it very clear that, among the armadillos, there was a strong, real and significant identicality among the common tick species (Fig. 3). The results also demonstrated marked identicality (60%) among the common tick species that were parasitizing sloths and among those parasitizing anteaters. Between anteaters and sloths, the identicality of ticks was acceptable (Fig. 3), and likewise, between anteaters and armadillos, the similarity of parasitic tick spectra was acceptable, real and significant. However, between anteaters and armadillos, the similarity of the common tick species was weak ($p < 0.05$). The number of tick species in the anteaters was always more than twice the number in sloths, and the number of tick

species in the latter was greater than or equal to the number in armadillos. These data show that anteaters are much more sensitive to and tolerant of parasitism caused by ticks, perhaps as a result of the ethological differences between these hosts.

A. varium was found on all the species of sloth, thus confirming the assertions[39,40]. It is unusual for *A. rotundatum* to parasitize endothermic animals[33,41], as observed in the case of sloths (Table 1), and this may be an accidental phenomenon favored by the natural hypothermia of sloths, whose body temperature ranges from 24 to 33 degrees centigrade.

Attention was drawn greatly to the fact that *A. cajennense* and *Amblyomma* sp. were the only tick species always present on *M. tridactyla*, *T. tetradactyla*, *B. variegatus*, *C. didactylus*, *E. sexcinctus* and *D. novemcinctus* when parasitized with more than two tick species. Moreover, *A. cajennense* was the only species found parasitizing giant armadillos. This tick species is polyxenous, nonspecific and heteroxenous[42,43], but is taken to be a tick of field environments. It is now invading anthropomorphized urban environments, but with presence on lowland tapirs (*Tapirus terrestris*) that visit transitional areas between forests and fields. The data may indicate that there is a great density of *A. cajennense* at the periphery of forested areas, or that incursions of sloths, armadillos and anteaters into field areas are occurring more frequently. Thus, there is a need for better assessment of these possibilities because of the risks coming from vector-borne activity of pathogenic agents, bacteria, viruses, rickettsia and protozoa, caused by this tick species.

Contrary who[44] found high prevalence of *A. auricularium*, this species was only found in one armadillo and one giant anteater over these 17 years of surveys.

A. parvum has already been found in several species of armadillo[11,45] and in anteaters[29]. It has now been conformed in giant anteaters, six-banded armadillos, nine-banded armadillos and great long-nose armadillos. This study has indicated that *B. microplus* and *R. sanguineus* are present on *E. sexcinctus*: the primary hosts of these ticks are cattle and dogs[45], which suggests that in the areas studied, there is circulation between domestic and wild animals within the same space. This was the first record of six-banded armadillos (*E. sexcinctus*) as hosts for these two species of hard ticks.

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