Experimental and Applied Acarology (2005) 36: 149–163
DOI 10.1007/s10493-005-2563-1

Ticks (Acari: Ixodida) on wild carnivores in Brazil

MARCELO B. LABRUNA[1,*], RODRIGO S.P. JORGE[1], DÊNIS A. SANA[2], ANAH TEREZA A. JÁCOMO[2], CYNTIA K. KASHIVAKURA[2], MARIANA M. FURTADO[2], CLAUDIA FERRO[2], SAMUEL A. PEREZ[2], LEANDRO SILVEIRA[2], TARCÍSIO S. SANTOS JR[3], SAMUEL R. MARQUES[3], RONALDO G. MORATO[2], ALESSANDRA NAVA[4], CRISTINA H. ADANIA[5], RODRIGO H.F. TEIXEIRA[6], ALBÉRIO A.B. GOMES[7], VALÉRIA A. CONFORTI[2], FERNANDO C.C. AZEVEDO[2], CRISTIANA S. PRADA[2], JEAN C.R. SILVA[1], ADRIANA F. BATISTA[8], MARIA FERNANDA V. MARVULO[1], ROSE L.G. MORATO[3], CLEBER J.R. ALHO[9], ADRIANO PINTER[1], PATRÍCIA M. FERREIRA[1], FERNADO FERREIRA[1] and DARCI M. BARROS-BATTESTI[10]

[1]*Departamento de Medicina Veterinária Preventiva e Saúde Animal, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, SP, Brazil 05508-000;* [2]*Associação para a Conservação dos Carnívoros Neotropicais - Pró-Carnívoros, Atibaia, SP, Brazil;* [3]*Universidade Federal de São Carlos, São Carlos, SP, Brazil;* [4]*Institutos de Pesquisas Ecológicas, Base Pontal, Teodoro Sampaio, SP, Brazil;* [5]*Associação Mata Ciliar, Jundiaí, SP, Brazil;* [6]*Parque Zoológico Municipal 'Quinzinho de Barros', Sorocaba, SP, Brazil;* [7]*Universidade Federal de Campina Grande, Patos, PB, Brazil;* [8]*Floresteca Agroflorestal Ltda, Jangada, MT, Brazil;* [9]*Universidade para o Desenvolvimento do Estado e da Região do Pantanal, Campo Grande, MS, Brazil;* [10]*Laboratório de Parasitologia, Instituto Butantan, São Paulo, SP, Brazil; *Author for correspondence (e-mail: labruna@usp.br; phone: +55-11-3091-1394; fax: +55-11-3091 7928)*

Received 19 August 2004; accepted in revised form 12 February 2005

Key words: Brazil, Carnivora, Ixodida, Ticks

Abstract. The present study reports field data of ticks infesting wild carnivores captured from July 1998 to September 2004 in Brazil. Additional data were obtained from one tick collection and from previous published data of ticks on carnivores in Brazil. During field work, a total of 3437 ticks were collected from 89 *Cerdocyon thous* (crab-eating fox), 58 *Chrysocyon brachyurus* (maned wolf), 30 *Puma concolor* (puma), 26 *Panthera onca* (jaguar), 12 *Procyon cancrivorus* (crab-eating raccoon), 4 *Speothos venaticus* (bush dog), 6 *Pseudalopex vetulus* (hoary fox), 6 *Nasua nasua* (coati), 6 *Leopardus pardalis* (ocelot), 2 *Leopardus tigrinus* (oncilla), 1 *Leopardus wiedii* (margay), 1 *Herpailurus yagouaroundi* (jaguarundi), 1 *Oncifelis colocolo* (pampas cat), 1 *Eira barbara* (tayara), 1 *Galictis vittata* (grison), 1 *Lontra longicaudis* (neotropical otter), and 1 *Potus flavus* (kinkajou). Data obtained from the Acari Collection IBSP included a total of 381 tick specimens collected on 13 *C. thous*, 8 *C. brachyurus*, 3 *P. concolor*, 10 *P. onca*, 3 *P. cancrivorus*, 4 *N. nasua*, 1 *L. pardalis*, 1 *L. wiedii*, 4 *H. yagouaroundi*, 1 *Galictis cuja* (lesser grison), and 1 *L. longicaudis*. The only tick-infested carnivore species previously reported in Brazil, for which we do not present any field data are *Pseudalopex gymnocercus* (pampas fox), *Conepatus chinga* (Molina's hog-nosed skunk), and *Conepatus semistriatus* (striped hog-nosed skunk). We report the first tick records in Brazil on two Felidae species (*O. colocolo*, *H. yagouaroundi*), two Canidae species (*P. vetulus*, *S. venaticus*), one Procyonidae species (*P. flavus*) and one Mustelidae species (*E. barbara*). Tick infestation remains

unreported for 5 of the 26 Carnivora species native in Brazil: *Oncifelis geoffroyi* (Geoffroy's cat), *Atelocynus microtis* (short-eared dog), *Pteronura brasiliensis* (giant otter), *Mustela africana* (Amazon weasel), and *Bassaricyon gabbii* (olingo). Our field data comprise 16 tick species represented by the genera *Amblyomma* (12 species), *Ixodes* (1 species), *Dermacentor* (1 species), *Rhipicephalus* (1 species), and *Boophilus* (1 species). Additional 5 tick species (3 *Amblyomma* species and 1 species from each of the genera *Ixodes* and *Ornithodoros*) were reported in the literature. The most common ticks on Carnivora hosts were *Amblyomma ovale* (found on 14 host species), *Amblyomma cajennense* (10 species), *Amblyomma aureolatum* (10 species), *Amblyomma tigrinum* (7 species), *Amblyomma parvum* (7 species), and *Boophilus microplus* (7 species).

Introduction

Ticks are ectoparasites of terrestrial, flying and semi-aquatic vertebrate animals on all continents of the world. In general, ticks have a unique life cycle with each post embryonic life stage feeding for several days on a vertebrate host. Ticks generally spend more than 90% of their lifetime in off-host conditions, making them very vulnerable to environment modifications. In nature, some vertebrate species are more continually exposed to ticks than others. The longer a tick and a host taxon have coevolved, the more they are likely to coexist in a given area. In this context, a successful coevolution process means that a tick species usually depends on the presence of one or more vertebrate host species for its establishment within a specific ecosystem; in this case, the vertebrate animal is the primary host for that tick species. However, solely the presence of primary host is not sufficient for the establishment of a given tick species. Abiotic factors (latitude, altitude, and vegetation type) are crucial to determine tick survival and development in the environment and also the availability of primary hosts. For this reason, environmental changes can affect populations of both vertebrates and their natural parasites. Although these changes can result in the extinction of some parasites, which participate in the natural dynamics of host populations, it can also make the vertebrate more vulnerable to parasites, which it has never experienced in its life before. The surveillance of parasites on wildlife is always useful to detect any new host–parasite interaction that has emerged. Thus, the study of the ectoparasite fauna of terrestrial wildlife can be indicative of environment changes in a temporal scale.

In general, carnivores are adapted to find, catch, and kill animal prey, although they have other ecological roles that are all beneficial and important in the ecosystems (Emmons 1997). Predator carnivores usually have a large home range, and are frequently in close contact with several other vertebrate species (the prey). In addition, a larger proportion of the prey of carnivore tend to be the weakest individuals within a specific prey population, which tend to have high tick burdens (Samish and Rehacek 1999). These factors could increase the exposure of carnivores to different tick species.

The native Brazilian wildlife encompasses four Carnivora families: Felidae (8 species), Canidae (6 species), Mustelidae (8 species), and Procyonidae (4 species) (Brasil 2004). The present study reports field data of naturally

tick-infested carnivores from different regions of Brazil. Additional data were obtained from one tick collection and from previous published data of ticks on carnivores in Brazil. The results were grouped to form a database of ticks on carnivores in Brazil. Possible tick–primary host interactions or new tick–host associations are inferred.

Material and methods

From July 1998 to September 2004, ticks were collected from field-captured wild carnivores in different regions of Brazil, as part of different projects sponsored by several institutions (see Acknowledgments). The collected ticks were transported alive or preserved in 70% alcohol to the laboratory for taxonomic identification. When possible, live immature specimens of the genus *Amblyomma* were reared to the adult stage in the laboratory for identification of the tick species (Labruna et al. 2002a). The collected ticks were deposited in the tick collection Coleção Nacional de Carrapatos (CNC) of the Faculty of Veterinary Medicine of the University of São Paulo, São Paulo, SP. Additional data of ticks on carnivores in Brazil were obtained from the Acari Collection of the Instituto Butantan (IBSP). Published records of ticks on carnivores in Brazil were extracted from the literature and presented according to the location, when available.

Results

During the field work from 1998 to 2004, ticks were collected from 246 wild carnivores as follows: 89 *Cerdocyon thous* (crab-eating fox), 58 *Chrysocyon brachyurus* (maned wolf), 30 *Puma concolor* (puma), 26 *Panthera onca* (jaguar), 12 *Procyon cancrivorus* (crab-eating raccoon), 6 *Pseudalopex vetulus* (hoary fox), 6 *Nasua nasua* (coati), 6 *Leopardus pardalis* (ocelot), 4 *Speothos venaticus* (bush dog), 2 *Leopardus tigrinus* (oncilla), 1 *Leopardus wiedii* (margay), 1 *Herpailurus yagouaroundi* (jaguarundi), 1 *Oncifelis colocolo* (pampas cat), 1 *Eira barbara* (tayara), 1 *Galictis vittata* (grison), 1 *Lontra longicaudis* (neotropical otter), and 1 *Potus flavus* (kinkajou). All animals were captured in wild life except for 1 *C. brachyurus*, 1 *P. vetulus*, and 1 *L. wiedii*. A total of 3437 ticks were collected and identified.

Data obtained from the Acari Collection IBSP included a total of 381 tick specimens collected on the following host species: 13 *C. thous*, 8 *C. brachyurus*, 3 *P. concolor*, 10 *P. onca*, 3 *P. cancrivorus*, 4 *N. nasua*, 1 *L. pardalis*, 1 *L. wiedii*, 4 *H. yagouaroundi*, 1 *Galictis cuja* (lesser grison), and 1 *L. longicaudis*. The tick species found infesting each host species from our field work and the IBSP data were grouped and presented in Tables 1–3. The locations of the tick records are indicated in Table 4.

Table 1. Ticks on Felidae species from different locations in Brazil.

Ticks [a]	Host species [Number of examined individuals]						
	Puma concolor [33]	*Panthera onca* [36]	*Leopardus pardalis* [7]	*Leopardus tigrinus* [2]	*Leopardus wiedii* [2]	*Oncifelis colocolo* [1]	*Herpailurus yagouaroundi* [5]
Ixodes aragaoi							
Adult	1 (13)						
Amblyomma aureolatum							
Adult	3 (47,58,68)						2 (32,68)
A. brasiliense							
Nymph [b]		1 (70)					
A. cajennense							
Adult	3 (7,13)	8 (4,5,7,17)		1 (60)			
Nymph [b]		2 (7,70)	2 (13)				
Larva [b]	1 (7)	1 (70)	1 (13)				
A. coelebs							
Nymph [b]	1 (9)	4 (70)					
A. oblongoguttatum							
Adult		1 (34)					
A. ovale							
Adult	13 (4,7,11,13,17,27)	11 (2,5,7,20,21,34,59,70)	2 (27,61)		1 (1)		
A. parvum							
Adult	7 (3,13)	3 (2,4,59)	1 (13)				1 (18)
A. tigrinum							
Adult	3 (3,4)	4 (4,5)					
A. triste							
Adult	1 (4)	2 (4,59)					1 (18)
Larva [b]		1 (11)					
Amblyomma sp.							
Nymph	6 (7,9,11)	13 (2,4,7,11,59,70)	2 (4,13)			1 (4)	1 (4)
Larva	5 (7,11,13)	4 (7,11)	1 (4)				

Dermacentor nitens					
Adult	4 (7,66)	1 (59)	1 (69)		
Nymph		1 (59)			
Boophilus microplus					
Adult	5 (7,11,13)	6 (7,8,70)	1 (69)		1 (4)
Nymph	2 (7,11)	5 (4,7,57)			1 (4)
Rhipicephalus sanguineus					
Adult				1 (35)	

[a]Number of infested animals (location code in parentheses see Table 4).
[b]species identification were made after rearing the tick to the adult stage in the laboratory.

Table 2. Ticks on Canidae species from different locations in Brazil.

Ticks [a]	Host species [number of examined individuals]			
	Cerdocyon thous [102]	*Chrysocyon brachyurus* [66]	*Pseudalopex vetulus* [6]	*Speothos venaticus* [4]
Amblyomma aureolatum				
Adult	5 (45,53,58,68)	1 (56)		
A. brasiliense				
Nymph [b]		1 (55)		
A. cajennense				
Adult	7 (13,14,29,68)	5 (4,10,13,51,69)		2 (4,13)
Nymph [b]	31 (13,14)	9 (13,65)	1 (14)	1 (13)
Larva [b]	6 (13)			
A. dubitatum				
Adult	1 (54)			
A. fuscum				
Adult	1 (50)			
A. ovale				
Adult	10 (13,14,16,29,50,52)	4 (13,15,65)		3 (4,13)
A. parvum				
Adult	6 (13,16)	3 (13,14)		
A. tigrinum				
Adult	20 (4,18)	47 (13,14,15,46,49,67)	1 (4)	
A. triste				
Adult		1 (13)	1 (4)	
Amblyomma sp.				
Nymph	67 (4,13,14,16,55)	18 (4,13)	1 (14)	3 (4)
Larva	22 (4,13,14,16,69)	2 (4)		
Dermacentor nitens				
Adult	1 (13)			
Boophilus microplus				
Adult	1 (16)			
Nymph	2 (14,16)	1 (13)		
Rhipicephalus sanguineus				
Adult		1 (55)	4 (22,24)	
Nymph	1 (65)			

[a]Number of infested animals (location code in parentheses see Table 4).
[b]species identification were made after rearing the tick to the adult stage in the laboratory.

Table 5 summarizes the literature records of the tick species that have been found on carnivores in Brazil, prior to the present study. All records refer to the tick adult stage except for one nymphal record of *Ixodes loricatus* on *N. nasua*. The only carnivore species cited in the literature (Table 5), for which we do not present any field data (Tables 1–3) are *Pseudalopex gymnocercus* (pampas fox), *Conepatus chinga* (Molina's hog-nosed skunk), and *Conepatus semistriatus* (striped hog-nosed skunk).

We report the first tick records in Brazil on two Felidae species (*O. colocolo*, *H. yagouaroundi)*, two Canidae species (*P. vetulus*, *S. venaticus*), one Procyonidae species (*P. flavus*) and one Mustelidae (*E. barbara*). Tick infestation

Table 3. Ticks on Procyonidae and Mustelidae species from different locations in Brazil.

Ticks [a]	Host species [number of examined individuals]						
	Procyon cancrivorus [15]	*Nasua nasua* [10]	*Potus flavus* [1]	*Galictis vittata* [1]	*Galictis cuja* [1]	*Lontra longicaudis* [2]	*Eira barbara* [1]
Amblyomma aureolatum							
Adult	4 (27,39,55,68)						
A. brasiliense							
Nymph[b]		1 (27)					
A. cajennense							
Adult	1 (13)						
Nymph[b]	9 (13,14,55)						
A. ovale							
Adult	4 (13,68)	7 (17,27,62,64)		1 (63)	1 (68)	2 (48,50)	1 (35)
A. rotundatum							
Adult		1 (19)					
Amblyomma sp.							
Nymph	10 (13,14,55)	4 (17,62,64)					
Larva		1 (4)					
Ornithodoros sp.							
Larva			1 (35)				

[a]Number of infested animals (location code in parentheses see Table 4).
[b]species identification were made after rearing the tick to the adult stage in the laboratory.

remains unreported for 5 of the 26 Carnivora species native to Brazil: *Oncifelis geoffroyi* (Geoffroy's cat), *Atelocynus microtis* (short-eared dog), *Pteronura brasiliensis* (giant otter), *Mustela africana* (Amazon weasel), and *Bassaricyon gabbii* (olingo).

Our field data comprise 16 tick species represented by the genera *Amblyomma* (12 species), *Ixodes* (1 species), *Dermacentor* (1 species), *Rhipicephalus* (1 species), and *Boophilus* (1 species) (Tables 1–3). Additional 5 tick species (3 *Amblyomma* species and 1 species from each of the genera *Ixodes* and *Ornithodoros*) were reported in the literature (Table 5). The distribution of the most frequent tick species found on carnivores in Brazil are presented in the Figure 1, according to the six major biomes of this country.

Discussion

The most common ticks on Carnivora hosts were *Amblyomma ovale* (found on 14 host species), *Amblyomma cajennense* (10 species), *Amblyomma aureolatum* (10 species), *Amblyomma tigrinum* (7 species), *Amblyomma parvum* (7 species), and *Boophilus microplus* (7 species). It is noteworthy that all records of *A. aureolatum*, *A. ovale*, *A. parvum* and *A. tigrinum* refer to the tick adult stage whereas most of the records of *A. cajennense* refer to the immature stages (nymphs and larvae). These findings are supported by other studies that

Table 4. Locations of the present study where ticks were collected on Carnivora.

Code	Municipality	State	Longitude	Latitude
1	Macapá	AP	−51.06	0.03
2	Brasília	DF	−47.93	−15.78
3	Chapadão do Céu	GO	−52.54	−18.40
4	Mineiros	GO	−52.75	−18.32
5	Mato Verde	MG	−42.86	−15.39
6	São Roque de Minas	MG	−46.36	−20.24
7	Anaurilândia	MS	−52.71	−22.18
8	Bataguassu	MS	−52.42	−21.71
9	Bataiporã	MS	−53.27	−22.29
10	Bonito	MS	−56.48	−21.12
11	Navirai	MS	−54.19	−23.06
12	Tula	MS	−56.76	−19.13
13	Barão de Melgaço	MT	−55.95	−16.27
14	Chap. dos Guimarães	MT	−55.75	−15.46
15	Cuiabá	MT	−56.09	−15.59
16	Jangada	MT	−56.48	−15.23
17	Poconé	MT	−56.62	−16.25
18	Rio Branco	MT	−58.11	−15.24
19	Belém	PA	−48.50	−1.45
20	Monte Alegre	PA	−54.06	−2.00
21	Santana do Araguaia	PA	−50.62	−9.50
22	São Josédo Bonfim	PB	−37.30	−7.16
23	Caracol	PI	−43.33	−9.27
24	Teresina	PI	−42.80	−5.08
25	Almirante Tamandaré	PR	−49.31	−25.32
26	Caiobá	PR	−48.54	−25.81
27	Foz do Iguaçu	PR	−54.58	−25.54
28	Guaratuba	PR	−48.57	−25.88
29	Japurá	PR	−52.55	−23.47
30	Morretes	PR	−48.83	−25.47
31	Paranaguá	PR	−48.50	−25.52
32	Piraído Sul	PR	−49.94	−24.52
33	Ponta Grossa	PR	−56.62	−16.25
34	Gov. Jorge Teixeira	RO	−62.64	−10.52
35	Monte Negro	RO	−63.32	−10.29
36	Arroio Grande	RS	−53.08	−32.23
37	Encruzilhada do Sul	RS	−52.52	−30.54
38	Guaíba	RS	−51.32	−30.11
39	Herval	RS	−53.39	−32.02
40	Jaguarão	RS	−53.37	−32.56
41	Pedro Osório	RS	−52.82	−31.86
42	São Franc. de Paula	RS	−50.58	−29.44
43	Três Passos	RS	−53.93	−27.45
44	Vacaria	RS	−50.93	−28.51
45	Rio Vermelho (?)	SC	?	?
46	Altinópolis	SP	−47.37	−21.02
47	Arujá	SP	−46.32	−23.39
48	Bertioga	SP	−46.13	−23.85
49	Brotas	SP	−48.12	−22.28

Table 4. Continued.

Code	Municipality	State	Longitude	Latitude
50	Cananéia	SP	−47.92	−25.01
51	Franca	SP	−47.40	−20.53
52	Iguape	SP	−47.55	−24.70
53	Itapecerica da Serra	SP	−46.84	−23.71
54	Jordanésia	SP	−46.87	−23.35
55	Jundiai	SP	−46.88	−23.18
56	Luís Antônio	SP	−47.70	−21.55
57	Marabá Paulista	SP	−51.96	−22.10
58	Mogi das Cruzes	SP	−46.18	−23.52
59	Paulicéia	SP	−51.83	−21.31
60	Pedreira	SP	−46.90	−22.74
61	Pereira Barreto	SP	−51.10	−20.63
62	Piedade	SP	−47.42	−23.71
63	Pirassununga	SP	−47.42	−21.99
64	Presidente Venceslau	SP	−51.84	−21.87
65	Ribeirão Preto	SP	−47.81	−21.17
66	Rosana	SP	−53.05	−22.58
67	São Carlos	SP	−47.89	−22.01
68	São Paulo	SP	−46.63	−23.54
69	Sorocaba	SP	−47.45	−23.50
70	Teodoro Sampaio	SP	−52.16	−22.53

appointed Carnivora to be primary hosts for the adult stages and other animal taxa (birds or small rodents) as hosts for the immature stages of *A. aureolatum*, *A. ovale*, and *A. tigrinum* (Labruna et al. 2002b; Arzua et al. 2003; Guglielmone et al. 2003; Pinter et al. 2004). On the other hand, herbivorous hosts such as tapirs, horses and capybaras are considered primary hosts for all stages of *A. cajennense* but its immature stages have shown a much broader host range than the adult stage (Lopes et al. 1998; Labruna et al. 2002a,c). Primary hosts for *A. parvum* ticks have not been appointed in the literature although this tick has been collected on hosts of several mammalian orders (including Carnivora) (Guglielmone et al. 1990). Cattle have been considered the only primary host for the tick *B. microplus* (both were introduced in Brazil during European colonization). Thus, infestation by Carnivora hosts by *B. microplus* indicate habitat sharing by these Carnivora and cattle, or even a predator–prey relation (see below). In fact, most of the individuals infested by *B. microplus* in the present study were *P. onca* or *P. concolor*, which are the main predators of cattle in Brazil (Cullen et al. 2003).

The remaining tick species shown in Tables 1–3 were less commonly recorded, each found on 1 to 4 different host species. Several different hosts species other than Carnivora are considered the main primary hosts for the adult stage of these tick species in Brazil; i.e. deer are primary hosts for adults of *Ixodes aragaoi* and *Amblyomma triste* (Barros-Battesti and Knysak 1999; Szabo et al. 2003), capybaras for *Amblyomma dubitatum* (Labruna et al. 2004),

Table 5. Literature records for ticks on wild carnivores in Brazil.

Host species	Tick species (location code in parentheses) [a]	References
Cerdocyon thous	*Amblyomma aureolatum* (26,32,36,37,38,44)	Aragão (1936), Guimarães (1945), Barros and Baggio (1992),
	A. cajennense [b]	Evans et al. (2000)
	A. longirostre [b]	
	A. tigrinum (38,44)	
Chrysocyon brachyurus	*A. ovale* [b]	Aragão (1936), Whitaker
	A. tigrinum	and Dietz (1987)
Pseudalopex gymnocercus	*A. aureolatum* (36,37)	Barros and Baggio (1992),
	A. tigrinum (33,37,40,41)	Evans et al. (2000)
Panthera onca	*A. cajennense* [b]	Aragão (1936), Sinkoc et al. (1998)
	A. ovale (27)	
	Boophilus microplus [b]	
Puma concolor	*A. aureolatum* [b]	Aragão (1936), Aragão
	A. cajennense [b]	and Fonseca (1961)
	A. ovale [b]	
Leopardus pardalis	*A. ovale* (27)	Aragão (1936), Sinkoc et al. (1998)
	B. microplus [b]	
Leopardus tigrinus	*A. longirostre* (30)	Barros and Baggio (1992)
Leopardus wiedii	*A. aureolatum* [b]	Aragão and Fonseca (1961)
Herpailurus yagouaroundi	*A. ovale* (25)	Barros and Baggio (1992)
Procyon cancrivorus	*A. aureolatum* (43)	Aragão (1936), Jones et al. (1972),
	A. calcaratum [b]	Evans et al. (2000)
	A. ovale [b]	
Nasua nasua	*A. aureolatum* [b]	Aragão (1936), Barros and
	A. cajennense (12)	Baggio (1992), Campos
	A. ovale (12,33)	Pereira et al. (2000)
	A. parvum (12)	
	A. tigrinum (12)	
	Ixodes loricatus (nymph) (33)	
Conepatus chinga	*Ornithodoros brasiliensis* (42)	Aragão (1936)
Conepatus semistriatus	*A. auricularium*(as	Aragão (1913)
	A. concolor (23)	
Galictis cuja	*A. aureolatum* (31)	Barros and Baggio (1992),
	A. ovale (27,31)	Sinkoc et al. (1998)
Galictis vittata	*A. aureolatum* [b]	Aragão and Fonseca (1961)
Lontra longicaudis	*A. ovale* (28)	Aragão and Fonseca (1961), Barros and Baggio (1992)

All records refer to the tick adult stage except when stated.
[a]see Table 3.
[b]References did not specify the location of the host species in Brazil.

reptilia for *Amblyomma fuscum* (Barros-Battesti et al. 2004), tapirs for *Amblyomma oblongoguttatum* (Labruna et al. 2000), horses for *Dermacentor nitens*, amphibia and snakes for *A. rotundatum*, porcupines for *Amblyomma longirostre*, anteater for *Amblyomma calcaratum*, armadilhos for *A. auricularium*, and small rodents for *I. loricatus* nymphs (Guimarães et al. 2001). The fact that these other animals are the primary hosts for these tick species means that

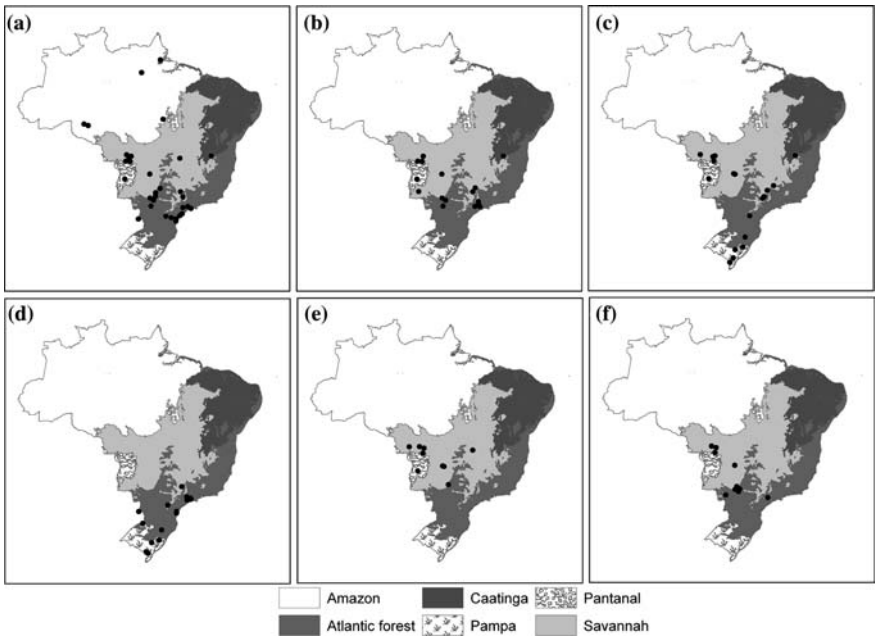

Figure 1. Collection sites (•) for the most frequent tick species found on carnivores in Brazil, according to the six major biomes. (a) *Amblyomma ovale*, (b) *Amblyomma cajennense*, (c) *Amblyomma tigrinum*, (d) *Amblyomma aureolatum*, (e) *Amblyomma parvum*, (f) *Boophilus microplus*.

the majority of their host records have been on these animal hosts and that the establishment of each of these tick species in a given area will depend on the presence of its corresponding primary host. On the other hand, these tick species tend to parasitize hosts other than their primary hosts (i.e. Carnivora) in situations of high tick burdens in the environment (Labruna et al. 2002a), when host specificity tends to decrease. In addition, the parasitism of Carnivora hosts by unusual tick species could also be a result of predatory or scavenger habits such as when a tick has its normal feeding process on a primary host (the prey) interrupted by any reason (i.e. the death of the host prey). In this case, this tick tends to lose host specificity and will reassume the feeding process on the closest available host species (i.e. the predator or scavenger Carnivora) (Hoogstraal and Aeschlimann 1982).

It is noteworthy our findings of *Rhipicephalus sanguineus* on the Canidae species *P. vetulus* (4 individuals), *C. brachyurus* (1), *C. thous* (1) and on the Felidae *L. wiedii* (1). The domestic dog is considered the single primary host for *R. sanguineus* in the New World, although the tick has occasionally been reported on domestic cats and rabbits in Brazil (Aragão 1936; Evans et al. 2000). The strong tick–host interaction between *R. sanguineus* and dogs is reflected by the absence of an effective immune response of dogs against repeated infestations by this tick (Szabó et al. 1995). Interestingly, similar

immune responses were observed for *C. thous* against experimental infestations by *R. sanguineus* (Ferreira and Bechara 1995). Furthermore, our records of this tick on *C. brachyurus*, *L. wiedii*, and one *P. vetulus* individual were on captive animals. Indeed, the captive environment is very similar to the ideal conditions for the establishment of *R. sanguineus* in restrained dogs in the cities (Labruna and Pereira 2001). The other three records on *P. vetulus* were on free-living animals that had close contact with domestic dogs in the rural area of the state of Paraíba. The possibility of Brazilian native Carnivora (especially Canidae) to act as primary hosts for *R. sanguineus* requires further investigations.

Our findings of *A. triste* larvae on *P. onca* (5 ticks on a host), *A. brasiliense* nymphs on *P. onca, C. brachyurus*, and *N. nasua* (1 nymph on each host), *A. coelebs* nymphs on *P. concolor* and *P. onca* (1 to 2 nymphs per host), and *I. aragaoi* adults (1 male and 1 female) on a *P. concolor* deserve special consideration because host associations of these tick species have been scarcely reported, especially for immature stages.

The Brazilian land is basically composed by six major biomes (Figure 1): 1 – Amazon forest, in the north. 2 – Atlantic rain forest, throughout the east cost entering the land towards the southeast. 3 – Savannah, in the central. 4 – Caatinga (semi-desert), in the northeast between the Atlantic rain forest and the Savannah. 5 – Pantanal, a smaller biome located in the central-western area surrounded by the Savannah in the east. 6 – Pampa, a small biome in the extreme south of the country (Ab'Saber 1977). The fauna composition tends to be distinct between these biomes although some Carnivora species are present in two or more biomes (Emmons 1997). Similarly, some tick species are restricted to a single biome whereas others are established among different biomes. In this regard, the present study allowed us to conclude that the tick species *A. ovale* and *A. oblongoguttatum* are the main species infesting Carnivora in the Amazon; *A. cajennense*, *A. ovale*, *A. tigrinum*, and *A. parvum* were the dominant species in the Savannah and Pantanal; *A. aureolatum*, *A. ovale*, and *A. tigrinum* predominate in the Atlantic rain forest; and *A. aureolatum* and *A. tigrinum* predominate in the Pampa. The Atlantic rain forest biome has been massively degraded and the secondary biome that has formed (resembling the Savannah) has turned a highly suitable area for *A. cajennense*. The species *D. nitens* and *B. microplus* are primarily associated with horses and cattle, respectively, and were found on Carnivora from different biomes in areas where cultured pastures have replaced the original biome vegetation. Generally, the tick species found on Carnivora in these different biomes follow the known geographic distribution of these tick species in Brazil (Aragão 1936; Guimarães et al. 2001; Guglielmone et al. 2003). The only tick species found on Carnivora from the Caatinga were *R. sanguineus* and *A. auricularium*. However, this is a poorly studied biome and it is possible that other tick species would have major importance on Carnivora from that area.

In the present study, we considered the foxes captured in the state of Paraíba (Caatinga biome) as belonging to the species *P. vetulus*. We are aware that the taxonomic status of the Caatinga fox has been a controversial subject. As long

as this taxonomic problem remains unsolved, we are adopting the species name *P. vetulus*.

Finally, even that we evaluated a limited number of host records for some biomes, it was possible to conclude that the ticks infesting wild Carnivora in Brazil are the result of the main tick species established in each area, as a result of particular faunal and environmental characteristics.

Acknowledgements

Field work of the present study was sponsored by the following institutions (office location in parentheses): Associação para a Conservação dos Carnívoros Neotropicais – Pro-Carnívoros (Atibaia, SP), Companhia Energética de São Paulo CESP (São Paulo, SP), Reserva Particular de Patrimônio Natural SESC Pantanal (Cuiabá, MT), Furnas Centrais Elétricas S.A (Chapada dos Guimarães, MT), Floresteca Agroflorestal Ltda (Jangada, MT), Associação Mata Ciliar (Jundiaí, SP), and Parque Zoológico Municipal 'Quinzinho de Barros'. All captures of wild animals were previously approved by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA).

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