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Tick fauna from two locations in the Brazilian savannah

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Abstract The Cerrado is Brazil's tropical savannah, which is arguably under greater threat than the Amazon rainforest. The Cerrado Biome of tropical South America covers about 2 million km^2 and is considered a biodiversity hot spot which means that it is especially rich in endemic species and particularly threatened by human activities. The Cerrado is increasingly exposed to agricultural activities which enhance the likelihood of mixing parasites from rural, urban and wildlife areas. Information about ticks from the Cerrado biome is scarce. In this report tick species free-living, on domestic animals and on a few wild animals in two farms in the Cerrado biome (Nova Crixás and Araguapaz municipalities, Goiás State, Brazil) are described. *Amblyomma cajennense* was the first and *Amblyomma parvum* the second host-seeking tick species found. Only two other tick species were found free-living: one *Amblyomma nodosum* and three *Amblyomma naponense* nymphs. Cattle were infested with *Boophilus microplus* and *A. cajennense*. Buffalos were infested with *B. microplus* and *A. parvum*. Dogs were infested with *A. cajennense*, *Amblyomma ovale*, *A. parvum* and *Rhipicephalus sanguineus* ticks. *Anocentor nitens*, *B. microplus*, *A. cajennense*, and *A. parvum* were found on horses. *Amblyomma auricularium* were found attached to nine-banded armadillos and *Amblyomma rotundatum* to red-footed tortoise, cururu toads and a rattlesnake. The latter was also infested with an adult *A. cajennense*. No tick was found on a goat, a tropical rat snake and a yellow armadillo. Among the observations the infestation of several domestic animals with *A. parvum* seems be the main feature. It suggests that this species might become a pest. However, the life cycle of *A. parvum* in nature, as well as its disease vectoring capacity, are largely unknown. It would be important to determine if it is a species expanding its geographic range by adaptation to new hosts or if it has been maintained in high numbers at definite locations by specific and still undetermined conditions. A higher prevalence of *A. cajennense* in most Brazilian biomes, with the exception of rainforests, was already shown before. Thus this species is favored by deforestation and is an important research target as it is the most common vector associated with the Brazilian spotted fever.

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Introduction

The Cerrado is Brazil's tropical savannah, which is arguably under greater threat than the Amazon rainforest (Marris 2005). Such biome is considered a biodiversity hot spot which means that it is especially rich in endemic species and particularly threatened by human activities (Cincotta 2000). The Cerrado Biome of tropical South America covers about 2 million km^2, an area approximately the same as that of Western Europe, representing ca. 22% of the land surface of Brazil, plus small areas in eastern Bolivia and northwestern Paraguay (Oliveira-Filho and Ratter 2002). The Cerrado is increasingly exposed to agricultural activities which enhance the likelihood of mixing parasites from rural, urban and wildlife areas. At the same time, although knowledge of human tick-borne diseases in South America is still limited, several tick-borne pathogenic agents such as *Rickettsia parkeri* (Venzal et al. 2004; Silveira et al. 2005) and *Ehrlichia chafeensis* (Machado et al. 2006) were recently described in the continent. It is thus possible to suppose that human tick-borne diseases in this part of the world are not properly diagnosed, are emerging or both. Thus describing vector life cycle, host preferences and tick species distribution of South American ticks becomes an important issue. Information of ticks from the Cerrado biome is scarce if one considers its vastness; apart from a few reports (Knight et al. 1992; Campos Pereira et al. 2000; Bechara et al. 2002) no systematic study was undertaken. In this report tick species free-living in two locations of the Cerrado biome and on a few wild animals are described. Ticks affecting domestic animals in this biome are also reported so as to evaluate the possible exposure and adaptation of wildlife ticks to these hosts.

Material and methods

Study sites

Six tick collections were performed in two farms located, approximately 200 km apart in the Cerrado in Goiás State, central west Brazil. The initial three collections occurred in the Moenda do Lago farm (13° 42′ 55″ S; 50° 46′ 52″ W; 236 m of altitude at the seat of the farm) in Nova Crixás Municipality, São José dos Bandeirantes district. This farm has 875 hectares in which, approximately 60% of the natural vegetation is preserved. It roughly corresponds to ecological unit 5 according to a recent classification of the environmental and ecological diversity of the Cerrado region of Brazil (Silva et al. 2006) (Fig. 1). In this unit poorly-drained flatlands dominate the landscape (70–250 m altitude), with flooding savannas as the dominant vegetation, although in some areas they form mosaics with open forests and small plots of better-drained savanna. Water seasonality is very strong, with large areas being flooded during the rainy season and then becoming very dry during the dry season. The main economic activity of the farm was the commercial breeding of the giant South American turtle (*Podocnemis expansa*). But it also had 400 bovines, 25 water buffalos, 15 horses, 2 goats and eight mongrel dogs. The farm was sold and most of the animals were not at available during the last tick collection.

Additional three tick collections were performed at the Moenda da Serra farm (15° 04′ 18″ S; 50° 25′ 03″ W; 336 m of altitude at the seat of the farm), in the Araguapaz Municipality. This farm has 960 hectares and also has 60% of its area preserved. It roughly corre-

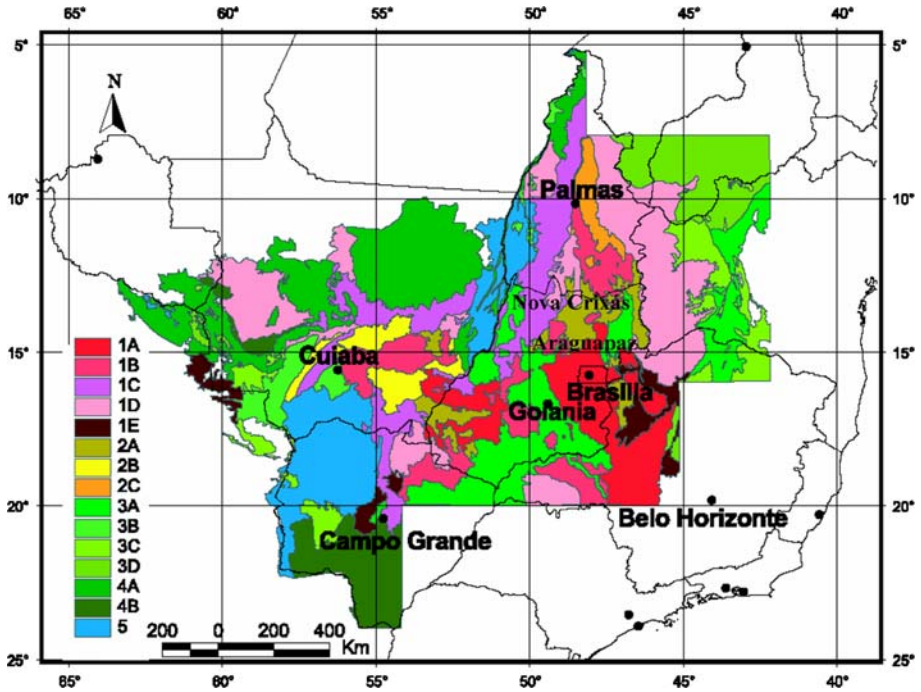

Fig. 1 Spatial heterogeneity, land use and conservation in the Cerrado region of Brazil according to Silva et al. (2006)

sponds to ecological unit 2A according to the aforementioned classification of the Cerrado region of Brazil (Fig. 1). This unit is a mosaic of rolling terrains, plains and hills in the west. The dominant native vegetation is a dense savanna, sometimes forming mosaics with open savanna and native grasslands. The main economic activity of the farm is the commercial breeding of giant South American turtle as well. But it also had 250 cattle, 9 water buffalos, 8 horses, and a non-determined number of mongrel dogs during the study period.

Climate in both farms is characteristic of the Cerrado Biome region with a rainy summer and a very strong dry winter. According to the farm personnel wild fauna of the farms included, apart from several birds, reptiles, amphibians and small rodents, the following animals (nomenclature by Reis et al 2006): tapir (*Tapirus terrestris*), marsh deer *(Blastocerus diochotomus*; only in the Moenda do Lago farm), capybara (*Hydrochoerus hydrochaeris*), common rhea (*Rhea americana*), collared peccary (*Pecari tajacu*), white lipped peccary (*Tayassu pecari*), capuchin monkey (*Cebus apella*), cougar (*Puma concolor*), jaguar (*Panthera onca*), giant anteater (*Myrmecophaga tridactyla*), crab-eating fox (*Cerdocyon thous*) and armadillos, among others.

Tick sampling

Tick collections in the Moenda do Lago farm were performed from 9 to12 of October 2004 (spring), from 23 to 27 of March 2005 (autumn) and from 3 to7 of August 2005 (winter) and in the Moenda da Serra farm from 1 to 6 of November 2005 (spring), from 9 to12 of February 2006 (summer) and from 23 to 27 of May 2006 (autumn). Sampling included capture of free-living ticks, collection of ticks from domestic animals and from a few wild

Table 1 Coordinates, altitude, and phytophysiognomies of the tick sampling locations at the Moenda do Lago, Nova Crixás, and Moenda da Serra, Araguapaz, farms in the Cerrado Biome of Goiás State, 2004–2006

Locations	Coordinates	Altitude	Cerrado phytophysiognomies (Oliveira 2002)
Moenda do Lago Farm			
1	13° 43′ 22″ S 50° 47′ 11″ W	224 m	Alluvial forest[a]
2	13° 43′ 24″ S 50° 47′ 13″ W	228 m	Alluvial forest
3	13° 43′ 38″ S 50° 47′ 27″ W	221 m	Alluvial forest
4	13° 44′ 35″ S 50° 47′ 12″ W	228 m	Cerrado *sensu stricto*[b]
5*	**	**	Alluvial forest
6	13° 44′ 13″ S 50° 47′ 08″ W	231 m	Alluvial forest
7	13° 43′ 01″ S 50° 46′ 54″ W	242 m	Anthropogenic[c]
8	**	**	Floodplain grassland[d]
9	13° 42′ 55″ S 50° 46′ 52″ W	236 m	Cerrado *sensu stricto*
10	13° 42′ 57″ S 50° 46′ 41″ W	240 m	Cerrado *sensu stricto*
11	13° 44′ 54″ S 50° 49′ 10″ W	229 m	Floodplain grassland
Moenda da Serra Farm			
1	15° 03′ 50″ S 50° 24′ 02″ W	471 m	Rocky grassland[e]
2	15° 04′ 01″ S 50° 24′ 02″ W	392 m	Cerrado *sensu stricto*
3	15° 03′ 48″ S 50° 25′ 45″ W	348 m	Cerrado *sensu stricto*
4	15° 00′ 44″ S 50° 24′ 43″ W	355 m	Cerrado *sensu stricto*
5	15° 00′ 14″ S 50° 24′ 10″ W	460 m	Rocky grassland
6	**	**	Gallery forest[f]

* Adjacent to location 4

** It was not possible to obtain accurate coordinates and altitude during tick collection

[a] Forests on alluvial beds under the strong influence of the river flooding regime

[b] Vegetation dominated by trees and shrubs often 3–8 m tall and giving more than 30% crown cover but with still a fair amount of herbaceous vegetation between them

[c] Dry vegetation by a small dam

[d] Flooded areas by rivers and lakes

[e] Mostly restricted to the tops of plateaux and mountain ridges, where the soils are shallow or confined to cracks between rocks

[f] Narrow forest strips found along streams and flanked by grasslands or Cerrados

animals. Free-living ticks were captured using CO_2 traps and cloth dragging. This was done in natural areas displaying wild animal activity signs and reached by vehicle, on foot, on horseback or by boat. CO_2 traps were used as previously described (Oliveira et al. 2000). Dragging was performed as described by Rechav (1982) but slightly modified. Briefly, the drag was pulled for 30 minutes by each of two persons simultaneously in a random fashion at each sampling site. During this period the cloth was examined for ticks approximately every 50 meters of dragging.

Whenever possible, sampling of free-living ticks on each farm at each expedition occurred repeatedly at the same locations and with a similar number of CO_2 traps (3 to 17) and dragging time. Free living tick sampling was not possible to perform in flooded areas during the rainy season. Details on tick sampling locations are presented on Table 1.

At each sampling expedition, a variable number of domestic animals were examined for tick infestations. Ticks were also collected from several wild animals available by chance (hunted by dogs, overrun by automobiles in the road within or leading to the farm, wandering by and easy to catch and handle).

Tick identification

Currently, it is impossible to perform a proper morphological taxonomic identification of the immature stages of the *Amblyomma* species from Brazil. Thus, the collected larvae and nymphs were brought alive to the laboratory at the Federal University of Uberlândia, where attempts to rear them until the adult stage were performed by feeding them on tick-bite naïve rabbits, as previously described (Labruna et al. 2002a). Adults obtained from the engorged nymphs were used for species identification of the former immature ticks. The voucher tick specimens collected in the present study have been deposited in the CNC-FMVZ/USP National Tick Collection, University of São Paulo, SP, Brazil (accession number: 939) and the CC-FAMEV/UFU Tick Collection, Federal University of Uberlândia (accession numbers: 1–53, 216–218, 231–236).

Results

Identification and numbers of free living ticks collected in the Moenda do Lago farm, Nova Crixás and in Moenda da Serra farm, Araguapaz, are presented in Tables 2 and 3, respectively. *Amblyomma cajennense* was the main host-seeking tick species in both farms in all expeditions and in every phytophysiognomy. Adults of this species were found all over the year but were most numerous in the Moenda da Serra farm, particularly in the spring. Nymphs of *A. cajennense* were also found in every expedition with the exception of summer of 2006. Larvae of *A. cajennense* were found only in the winter (August, 2005) and autumn (May, 2006).

The second most numerous host-seeking species was *Amblyomma parvum*. Adults of this species were found in the Cerrado *sensu stricto* in the autumn of 2005 in Nova Crixás, whereas in Araguapaz it was found in higher numbers, particularly in the summer of 2006, in every searched phytophysiognomy and in all expeditions. Nymphs of this species were found only in Nova Crixás in August 2005 in an alluvial forest and in the Cerrado *sensu stricto*.

Only two other species were found host-seeking; nymphs of *Amblyomma naponense* in an alluvial forest and in the Cerrado *sensu stricto* (autumn, 2005) and one nymph of *Amblyomma nodosum* in the Cerrado *sensu stricto* (winter 2005), both in Nova Crixás. Several nymphs and two larva clusters could not be raised until the adult stage and were retained as *Amblyomma* sp.

Information on ticks found on domestic animals in Nova Crixás and Araguapaz, is presented in Tables 4 and 5, respectively. Cattle at both farms were highly infested and only tick samples could be collected. *Boophilus microplus* and *A. cajennense* were found on this host, the latter tick species only in Araguapaz. Buffalos were infested with *B. microplus* and in Araguapaz several *A. parvum* adults were found on this host as well. Dogs were infested with *A. cajennense*, *Amblyomma ovale*, *A. parvum* and *Rhipicephalus sanguineus* ticks. *R. sanguineus* ticks were associated with higher infestations levels. They were found only in Araguapaz and on dogs that remained close to human dwellings. *A. cajennense* and *A. parvum* were found on dogs from both farms and *A. ovale* solely in Nova Crixás. All *Amblyomma* species on dogs were associated with hosts that were used to hunt and/or wander in the landscape. No tick was found on the only goat examined. *Anocentor nitens*, *B. microplus*, *A. cajennense* and *A. parvum* were the tick species found on horses. *A. nitens* was the main horse tick as it was found in every sampling and was responsible for high infestations levels particularly in the ear of the animals. All tick species were found on horses in both farms although *A. cajennense* and *A. parvum* were found in higher numbers in Araguapaz.

Table 2 Free-living tick species collected at the Moenda do Lago farm, Nova Crixás municipality, Goiás, 2004–2005

Locations	Tick species		
	October 2004	March 2005	August 2005
1	*A. cajennense* 3N	Non evaluated*	Negative**
2	*A. cajennense* 1A, 4N	Non evaluated	*A. cajennense* 1N
3	*A. cajennense* 6N	*A. cajennense* 6A	*A. cajennense* 74N *A. parvum* 2N
4	*A. cajennense* 2A	Non evaluated	*A. cajennense* 6A, 4N *A. nodosum* 1N
5	Non evaluated	*A. cajennense* 18A, 1N *A. naponense* 2N	Non evaluated
6	*A. cajennense* 7N	Non evaluated	*A. cajennense* 4N
7	Negative	Non evaluated	Negative
8	*A. cajennense* 1A, 1N	Non evaluated	Non evaluated
9	*A. cajennense* 1A, 10N	*A. cajennense* 13A *A. parvum* 2A	*A. cajennense* 1A, 53N
10	Non evaluated	*A. cajennense* 4A *A. naponense* 1N	*A. cajennense* 156N, 2Lc *A. parvum* 1N
11	*A. cajennense* 11N	Non evaluated	Non evaluated
Total	*Amblyomma* sp. 1Lc, 13N *A. cajennense* 5A, 42N	*A. cajennense* 41A, 1N *A. naponense* 3N *A. parvum* 2A	*Amblyomma* sp. 1Lc, 248 N *A. cajennense* 7A, 289N, 2Lc *A. parvum* 3N *A. nodosum* 1N

* Non evaluated either because location was sampled from second expedition on or because it was inaccessible mostly by flooding

** No tick was captured by traps or dragging

A, adult; N, nymph; Lc, larva cluster

Table 3 Free-living tick species collected at the Moenda da Serra farm, Araguapaz municipality, Goiás, 2005–2006

Locations	Tick species		
	November 2005	February 2006	May 2006
1	*A. cajennense* 7A	*A. cajennense* 4A *A. parvum* 3A	*A. cajennense* 7A, 2Lc *A. parvum* 1A
2	*A. cajennense* 2A	negative**	negative
3	*A. cajennense* 98A, 30N *A. parvum* 4A	*A. cajennense* 19A *A. parvum* 9A	*A. cajennense* 31A, 3N *A. parvum* 9^{A}
4	*A. cajennense* 2N	*A. cajennense* 1A *A. parvum* 5A	*A. cajennense* 4A
5*	*A. cajennense* 1N	Non evaluated*	Non evaluated*
6	Non evaluated	*A. cajennense* 16A *A. parvum* 3A	*A. cajennense* 17A, 7N, 2Lc *A. parvum* 2^{A}
Total	*Amblyomma* sp. 25N *A. cajennense* 107A, 33N *A. parvum* 4A	*A. cajennense* 40A *A. parvum* 20A	*A. cajennense* 59A, 10N, 4Lc *A. parvum* 12A

* Substituted by new location (location 6) on February and May

** Negative—no tick was captured by traps or dragging

A, adult; N, nymph; Lc, larva cluster

Table 4 Ticks on domestic animals at the Moenda do Lago, Nova Crixás municipality, Goiás, 2004–2005. Number of examined hosts is presented between brackets

Host	Tick species		
	October 2004	March 2005	August 2005
Cattle	*B. microplus* 8A (3)	*B. microplus* 27A (7)	Host non available
Buffalo	*B. microplus* 5A (3)	Host non available	Host non available
Dog	*A. cajennense* 2A (3)	*A. parvum* 28A (3) *A. ovale* 1A	Host non available
Goat	Negative (1)	Host non available	Host non available
Horse	*A. nitens* 7A (2) *B. microplus* 1A	*A. nitens* 1A (3) *A. cajennense* 2A *A. parvum* 1A	*A. nitens* 25A (1) *B. microplus* 10A

A, adult; N, nymph

Table 5 Ticks on domestic animals at the Moenda da Serra farm, Araguapaz municipality, Goiás, 2005–2006. Number of examined hosts is presented between brackets

Host	Tick species		
	November 2005	February 2006	May 2006
Cattle	*B. microplus* 47A, 2N (2) *A. cajennense* 3A	*B. microplus* 32A (3) *A. cajennense* 6A	*B. microplus* 54A, 1N (3) *A. cajennense* 1A
Buffalo	Host non available	*B. microplus* 30A, 5N (1) *A. parvum* 8A	*B. microplus* 37A, 2N (3)
Dog	*R. sanguineus* 4A, 1N (5) *A. parvum* 1A *A. cajennense* 7N *Amblyomma* sp. 2N	*R. sanguineus* 45A, 4N (4) *A. parvum* 1A	*R. sanguineus* 67A (10) *A. nitens* 32A (2)
Horse	*A. nitens* 70A (1) *B. microplus* 4A *A. cajennense* 76A *A. parvum* 3A *Amblyomma* sp. 3N	*A. nitens* 11A, 1N (3) *A. cajennense* 19A *A. parvum* 4A *B. microplus* 9A, 1N	*A. cajennense* 11A *A. parvum* 1A *B. microplus* 20A

A, adult; N, nymph

On wild animals two additional tick species were found (Table 6). *Amblyomma auricularium* adults were found attached to nine-banded armadillos and *Amblyomma rotundatum* was found on red-footed tortoise, on cururu toads and a rattlesnake. Two *Amblyomma* sp. nymphs were found on the cururu toads as well. The rattlesnake was also infested with an *A. cajennense* adult and two adults and one *Amblyomma* sp. nymph. These *Amblyomma* adults from this snake could not be properly identified because they were severely damaged. No tick was found on a tropical rat snake and a yellow armadillo.

Discussion

The predominance of *A. cajennense* at the study locations suggests an overall good adaptation for *A. cajennense* to the Cerrado biome. It is also a meaningful finding if one considers that this parasite is very aggressive to humans and the most common vector associated with

Table 6 Ticks on wild animals in the Cerrado Biome in Goiás Sate, 2005–2006. Number of examined hosts is indicated between brackets

Municipality	Hosts	Tick species
Nova Crixás	Nine-banded armadillo (1) (*Dasypus novemcinctus*)	*A. auricularium* 1A
Araguapaz	Nine-banded armadillo (3) (*Dasypus novemcinctus*)	*A. auricularium* 9A
Araguapaz	Red-footed tortoise (8) (*Geochelone carbonaria*)	*A. rotundatum* 2A
Araguapaz	Cururu toad (5) (*Bufo paracnemis*)	*A. rotundatum* 2A *Amblyomma* sp. 2N
Araguapaz	Rattlesnake (1) (*Crotalus durissus*)	*A. rotundatum* 4A *A. cajennense* 1M *Amblyomma* sp. 2A* *Amblyomma* sp. 1N
Araguapaz	Tropical Rat Snake (1) (*Spilotes Pullatus*)	Non infested
Araguapaz	Yellow Armadillo (1) (*Euphractus sexcinctus*)	Non infested

A, adult; N, nymph;
* unsuitable for identification

the Brazilian spotted fever, caused by the bacterium *Rickettsia rickettsii* (Guedes et al. 2005; Sangioni et al. 2005; Guglielmone et al. 2006). In fact, the prevalence of *A. cajennense* over other tick species elsewhere in Brazil, with the exception of the rainforests, has been reported before (Campos Pereira et al. 2000; Labruna et al. 2002a; Estrada Peña et al. 2004; Labruna et al. 2005a; Szabó et al. 2007).

The establishment of *A. cajennense* seems to rely on the presence of at least one of its primary host species for the adult stage, considered to be tapirs, capybaras, or horses in Brazil (Labruna et al. 2001) and probably peccaries (Labruna et al. 2005a). However *A. cajennense* has a very broad host range being found on several mammals and also on birds (Aragão 1936, Rojas et al. 1999; Campos Pereira et al. 2000; Labruna et al. 2002a; Guglielmone et al. 2003a). Thus infestation of domestic animals in Nova Crixás and Araguapaz must be regarded as a common feature. On the other hand infestation of a rattlesnake with an adult *A. cajennense* has not been reported before and adds to its host species range. Actually, there are only two reports of *A. cajennense* on snakes in the Neotropics, one of nymphs and larvae on an undetermined snake species in Alto Apure, Apure, Venezuela (Fiasson 1949) and the other one of an undetermined *A. cajennense* stage on a captive *Bothrops leucurus* from Ilhéus, Bahia, Brazil (Encarnação et al. 2004).

Even though it was not the aim of this research and sampling did not cover all seasons, observations of the numbers of each *Amblyomma* instar at the various sampling periods indicate a roughly similar seasonal activity to the one-year generation pattern described for *A. cajennense* ticks in southeastern Brazil (Labruna et al. 2003). Such pattern, characterized by the highest activity of larvae during the autumn, of nymphs during the winter and of adults during the spring-summer months (Oliveira et al. 2000, Labruna et al. 2002b), shows that seasonality of *A. cajennense* ticks in central west Brazil may share similarities with the southeastern part of the country. This issue, however, must be further investigated.

Amblyomma parvum, the second most prevalent tick species found, is known to be very abundant in the Brazilian Pantanal region (Cançado et al. 2006) and common in northwest Argentina (Guglielmone et al. 1990). In fact, *A. parvum* has both a broad host and geographic range within the Neotropical region (Guglielmone et al. 2003a). Although the primary hosts for this tick species are unknown, the adults are frequently associated with carnivores (Labruna et al. 2005b) and those in immature stages with Caviidae rodents

(Nava et al. 2006a). At the same time this tick species is also found on hosts as diverse as cattle (Guglielmone et al. 1990), long nosed-armadillo (Mullins et al. 2004), brown brocket deer (Campos Pereira et al. 2000), anteaters (Martins et al. 2004) and was shown to parasite humans as well (Guglielmone et al. 1991, 2006; Nava et al. 2006b). In this research such a broad host range was confirmed by the recovery of *A. parvum* from dogs, horses and buffalos but not from cattle. The infestation of bovines, however, cannot be ruled out because tick samples could only be taken from animals that were sometimes covered with several hundred or even thousands of *B. microplus* ticks.

The infestation of dogs and horses with *A. parvum* was significant since these hosts were found repeatedly infested during the survey. On one occasion in particular (March, 2005), a dog was found harboring many *A. parvum* ticks, including several engorging females. This animal had the habit of chasing small rodents in a nearby Cerrado (location 10), the probable source of the infestation. On the whole these observations indicate that dogs might be a suitable host for *A. parvum* adults.

Host-seeking *A. parvum* were found in several phytophysiognomies of the Cerrado but predominated in the drier areas since 73% of the free-living ticks of this species were found mostly in the Cerrado *sensu stricto*. These observations suggest that it is a very resistant tick species to desiccation and to high temperatures and might be favored by deforestation as is the case of *A. cajennense* (Estrada-Peña et al. 2004).

Considering the wide geographic distribution and the broad host range which includes domestic animals and man, *A. parvum* seems to have the potential to become a pest. The evaluation of such a parasitism is nevertheless complicated by the fact that *A. parvum* shares, on a gross inspection, common morphological features with unfed *R. sanguineus*; it is very tiny, brown and has a scutum that lacks ornamentation. Thus it is plausible to suppose that in Brazil dog infestations with *A. parvum* might be attributed to *R. sanguineus*. Moreover the life cycle and requirements of *A. parvum* in nature as well as its disease vectoring capacity are still poorly understood and thus this tick species deserves further research. It is chiefly important to determine if it is a species expanding its overall geographic range by adaptation to new hosts or if it is maintained in high numbers at definite locations by specific and still undetermined host and environmental conditions.

The other two free-living tick species, *A. naponense* and *A. nodosum* were found in very low numbers. *A. naponense* have been recorded chiefly on peccaries (*P. tajacu* and *T. pecari*), which are incriminated as the primary hosts (Labruna et al. 2005a). Peccaries are widespread in Brazil and it is possible to suppose that these were the local hosts for *A. naponense*. *A. nodosum* has been reported almost exclusively in anteaters (Guimarães et al. 2001) a host species that is also widely distributed in Brazil, particularly in the Cerrado region.

Several other tick species were found on animals. Those found on domestic animals were mostly the usual ones in Brazil. *B. microplus* is the cattle tick in the Neotropical region (Guglielmone et al. 2004) although other domestic and wild animals can be parasitized if sharing highly infested pastures (Labruna et al. 2002a, 2002b; Szabó et al. 2003). *A. nitens* and *A. cajennense* are the most frequent species infesting horses on farms of the state of São Paulo (Labruna et al. 2001, 2002b). *Rhipicephalus sanguineus* is the most common dog tick particularly in an urban environment and in rural areas it is responsible for high infestations if the animals are kept in kennels or restricted to human dwellings (Szabó et al. 2001; Labruna et al. 2005a). It must be emphasized, however, that the recent description of dissimilar populations of *R. sanguineus* ticks within South America (Szabó et al. 2005) has raised doubts regarding the biosystematic status of Neotropical *R. sanguineus* ticks and a reliable characterization of this species in the Neotropics is dependent on a more compre-

hensive study with samples from several locations of the region. *Amblyomma ovale* found on one dog is a very common tick of wild carnivores in Brazil (Labruna et al. 2005b) but it frequently parasitizes dogs from rural regions (Szabó et al. 2001; Labruna et al. 2005a) and has also been recorded on humans (Guglielmone et al. 2006; Szabó et al. 2006). *Amblyomma ovale* is not known to be a vector of any disease (Guglielmone et al. 2006).

Amblyomma auricularium and *A. rotundatum* collected on wild animals confirmed earlier observations. *Amblyomma auricularium* found on armadillos, its usual host (Guglielmone et al. 2003b), is a tick described in several South and Central American countries (Guglielmone et al. 2003a) but also in the United States (Lord and Day 2000). *Amblyomma rotundatum* found on tortoise and a snake is known to parasitize Amphibia and Reptilia and is widely distributed throughout the Neotropics as well (Guglielmone et al. 2003a).

An important feature of the results herein described is the partial dissociation observed between ticks species found on animals and those host-seeking in natural areas. Only *A. cajennense* and *A. parvum* were found on both animals and in the environment, whereas *A. auricularium* and *A. rotundatum* were found solely on wild animals. These hosts, however, were known to live in the areas sampled for free-living ticks. Such an observation indicates that the methods used for sampling free-living ticks had a bias and that several other tick species may be present in the studied area. Ticks might not have been attracted to the CO_2 traps or were not host-seeking on the vegetation during dragging. Some of the species might also be nidicolous and should be found at particular sites such as burrows, and nests. Considering the difficulties to sample every possible ecological niche, the capture of wild animals is still the best option for a proper tick fauna sampling. However this is a laborious and difficult task due to the rich host fauna of the Cerrado and the necessity of many different capture methods.

Overall results from this work reassured existing information but also displayed worrying information on ticks from the Cerrado. The permissibility of this biome to ticks with such a broad host range as *A. cajennense* and *A. parvum* and coexistence at the same locations of wild and domestic hosts is above all a matter of concern. Considering the vastness of the Cerrado and the changes imposed by civilization, ticks as vectors should be closely monitored.

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