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Source: Systematic and Applied Acarology, 17(3) : 243-250

Published By: Systematic and Applied Acarology Society

URL: https://doi.org/10.11158/saa.17.3.3

Systematic & Applied Acarology 17(3): 243–250. ISSN 1362-1971

Article

Ticks (Acari: Ixodidae) parasitizing endemic and exotic wild mammals in the Esteros del Iberá wetlands, Argentina

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Abstract

Five species of ticks belonging to the genera *Amblyomma*, *Haemaphysalis* and *Rhipicephalus* were recorded from endemic and exotic wild mammals in the Esteros del Iberá wetlands, Argentina. Adults and immature stages of *Amblyomma dubitatum* were found on *Hydrochoerus hydrochaeris*, *Sus scrofa*, *Axis axis* and *Myrmecophaga tridactyla*. Larvae and nymphs of *A. dubitatum* were collected on *Bubalus bubalis*, *Lepus europaeus*, *Monodelphis dimidiata* and on the rodents *Cavia aperea*, *Scapteromys aquaticus*, *Oligoryzomys flavescens* and *Akodon azarae*. One male of *Amblyomma nodosum* was associated with *M. tridactyla*; specimens of *Haemaphysalis juxtakochi* were found on *A. axis*, *S. scrofa* and *Mazama gouazoubira*; and *Rhipicephalus* (*Boophilus*) *microplus* was detected on *Blastocerus dichotomus*. Adults of *Amblyomma triste* were collected on *B. dichotomus*, *S. scrofa* and *H. hydrochaeris*, while immatures of this tick were recorded on *M. dimidiata*, *A. azarae*, *S. aquaticus*, *O. flavescens* and *H. hydrochaeris*. In addition to elucidating tick-host associations, the findings of this survey are biomedically important. Although the tick fauna of Esteros del Iberá is limited, some species, such as *A. triste* and *R.* (*B.*) *microplus*, are recognized vectors of pathogenic agents infecting humans and animals. Also, a large number of the Esteros del Iberá collection records were for ticks from exotic (*S. scrofa*, *A. axis*, *B. bubalis*, *L. europaeus*) or reintroduced (*M. tridactyla*) mammals, suggesting that the introduction of these mammals may result in the amplification of tick populations in the study area, with potential deleterious effects on the endemic fauna.

Key words: ticks, Ixodidae, wild mammals, Esteros del Iberá, Argentina

Introduction

Taxonomic knowledge of the parasitic arthropods associated with a particular host community is fundamental to studies of the influence of these parasites on host ecology and to attempts to evaluate their potential as vectors of infectious diseases. From a biomedical standpoint, ticks are among the most important parasitic arthropods (Hoogstraal 1985; Jongejan & Uilenberg 2004)—they are hematophagous ectoparasites of terrestrial tetrapods whose role as vectors of animal and human pathogens is widely recognized (Sonenshine and Mather 1994; Jongejan and Uilenberg 2004). About 198 species of ticks belonging to the families Argasidae (soft ticks) and Ixodidae (hard ticks) occur in the Neotropical Zoogeographic Region (Guglielmone *et al.* 2003; Nava *et al.* 2009, 2010b), and many of these are potential vectors of pathogens to mammals (Guglielmone *et al.* 2003).

The Esteros del Iberá is a large wetland complex spanning over 13,000 km^2 in the Argentinean province of Corrientes (Canziani *et al.* 2003). This macrosystem is one of the most important

wetlands in South America, and it is a multiple-use protected area (Loiselle *et al.* 2002; Canziani *et al.* 2003). More than 40 endemic mammal species (some at risk of extinction) and nine exotic species of mammals have been recorded in the Esteros del Iberá (Fabri *et al.* 2003). However, studies of ticks associated with the mammals of the Esteros del Iberá have been few (Ivancovich & Luciani 1992; Nava *et al.* 2010a, 2011). Consequently, the objective of this research was to produce an inventory of the ticks that infest endemic and exotic wild mammals in the Esteros del Iberá wetlands, in order to provide baseline information on tick-host specificity and the potential risk of tick-borne diseases in this area.

Materials and methods

Esteros del Iberá is located in Corrientes Province, Argentina (Fig. 1). This area comprises a complex of ecosystems, chief among them swamps and marshlands that connect an extensive system of shallow lakes (Neiff & Poi de Neiff 2006). Water inputs to the Esteros del Iberá are primarily through rainfall, the historic mean total being 1500 mm, with summer rains somewhat greater (600–700 mm) than during the rest of the year (Neiff & Poi de Neiff 2006). Masses of floating vegetation, known locally as "embalsados," are common throughout the lagoons, where *Schoenoplectus californicus* (C.A. Meyer) Soják, *Thypha* spp., *Fuirena robusta* Kunth and *Cyperus giganteus* Vahl are the dominant wetland plants (Neiff *et al.* 2011). Terrestrial habitats are principally characterized by shrubland forests and temporarily flooded grasslands.

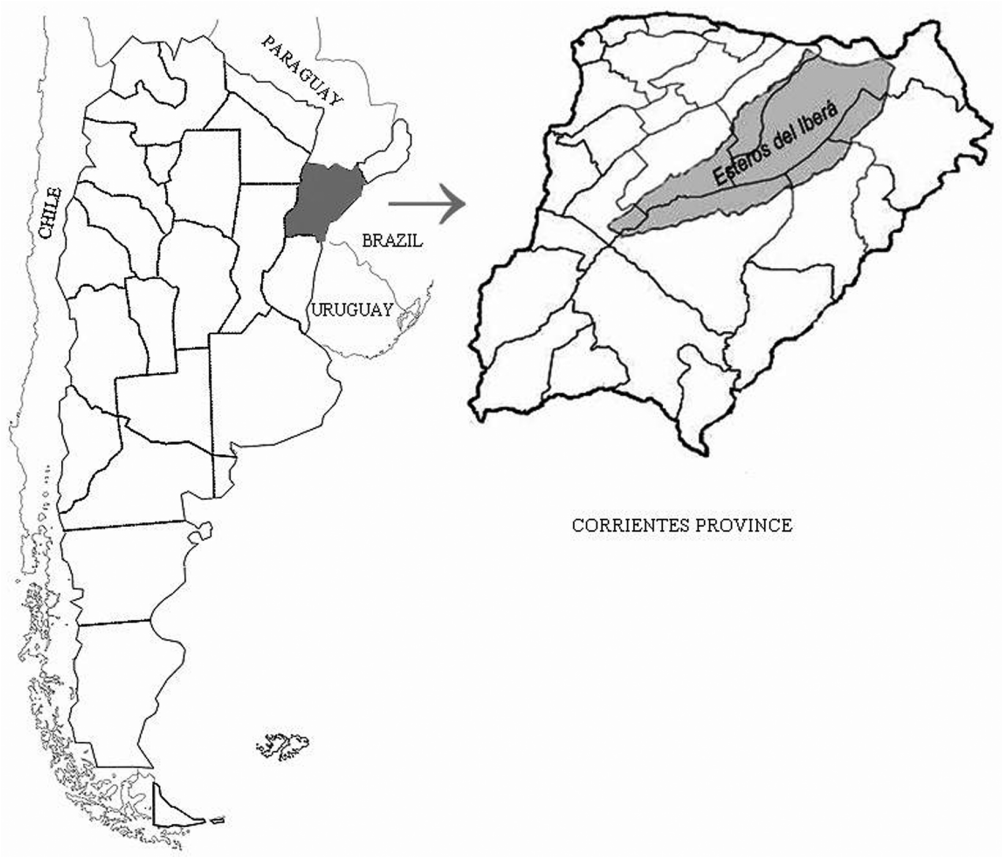

FIGURE 1. Location of Esteros del Iberá, Corrientes Province, Argentina.

Information on tick-host associations for Esteros del Iberá was obtained from the serial scientific literature, from unpublished records of ticks deposited in the tick collection of INTA Rafaela, and by sampling endemic and exotic mammals in the study area. Mammals belonging to the orders Artiodactyla, Cingulata, Didelphimorphia, Lagomorpha, Pilosa and Rodentia were examined for ticks. Rodents of the subfamilies Sigmodontinae (Cricetidae) and Caviinae (Caviidae) and small marsupials (Didelphimorphia: Didelphidae) were captured using four linear grids, each equipped with 50 Sherman live traps (24 cm long, 9 cm high, 8 cm wide) set at 5-m intervals baited with food pellets and seeds, and one linear trapping grid equipped with 50 Tomahawk live traps (32 cm long, 10 cm high, 10 cm wide) set at 5-m intervals baited with carrots. Rodents and marsupials were processed according to the methodology described by Nava *et al.* (2006), and sigmodontines were determined with the collaboration of U.F.J. Pardiñas (Centro Nacional Patagónico, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Puerto Madryn, Argentina). Large mammals, such as *Hydrochoerus hydrochaeris* (Linnaeus, 1766) (Rodentia: Caviidae), *Axis axis* (Erxleben, 1777) (Artiodactyla: Cervidae), *Sus scrofa* Linnaeus, 1758 (Artiodactyla: Suidae) and *Lepus europaeus* Pallas, 1778 (Lagomorpha: Leporidae), were taken by shotgun. Specimens of *A. axis*, *S. scrofa* and *L. europaeus* were sacrificed in the context of a control program for exotic species, while specimens of *H. hydrochaeris* were captured with permission of the Dirección de Recursos Naturales of Corrientes Province during a program to limit overpopulation. Ticks were collected on specimens of *Myrmecophaga tridactyla* Linnaeus, 1758 (Pilosa: Myrmecophagidae) and *Blastocerus dichotomus* (Illiger, 1815) (Artiodactyla: Cervidae) during health examination of these mammals. Specimens of Cingulata (Dasypodidae) were captured by hand, checked for ticks, and released. Ticks attached to road-killed animals were also included in the analysis. Tick determinations were based on Joan (1930), Guglielmone and Viñabal (1994), Estrada-Peña *et al.* (2005), Barros-Battesti *et al.* (2006) and Martins *et al.* (2010), and by comparison of field-collected ticks with known laboratory-reared material housed in the tick collection of INTA Rafaela.

Results

Males (MM), females (FF), nymphs (NN) and larvae (LL) of five tick species belonging to the genera *Amblyomma*, *Haemaphysalis* and *Rhipicephalus* were found parasitizing wild mammals in Esteros del Iberá. Ticks were collected from specimens of the orders Artiodactyla, Didelphimorphia, Lagomorpha, Pilosa and Rodentia, but not from Cingulata (*Dasypus novemcinctus* Linnaeus, 1758 and *Euphractus sexcinctus* (Linnaeus, 1758)). Results are as follows:

1) *Amblyomma dubitatum* Neumann, 1899
Estancia “Ayuí” (28º37´S 57º32´W) 38MM 67FF 56NN ex *H. hydrochaeris* (Ivancovich & Luciani 1992)[1]; Estancia “Juan Ángel” (28º41´S 57º08´W) 20MM 8FF 1N ex *H. hydrochaeris* (Ivancovich & Luciani 1992); Estancia “Palmita” (28º46´S 57º48´W) 8MM 3FF 15NN ex *H. hydrochaeris* (Ivancovich & Luciani 1992); Laguna del Iberá (28º32´S 57º10´W) 20MM 37FF 5NN ex *H. hydrochaeris* (Ivancovich & Luciani 1992); 30 km SW of Colonia Carlos Pellegrini (28°40´S 57°26´W) MM FF NN LL (Number undetermined (NU)) ex *H. hydrochaeris* (Nava *et al.* 2010a); Estancia "Rincón del Socorro" (28°42´S 57°29´W) 4 NN ex *S. scrofa*, MM FF (NU) ex *S. scrofa* (Nava *et al.* 2010a). **New records:** Reserva Provincial Iberá (28º30´S 58º00´W) 1N ex *Bubalus*

1. *Amblyomma dubitatum* is cited by Ivancovich & Luciani (1992) as *Amblyomma cooperi*. Currently, the name *A. cooperi* is considered a synonym of *A. dubitatum* (Nava *et al.* 2010a).

bubalis (Linnaeus, 1758); 37 km SW of Colonia Carlos Pellegrini (28°42´S 57°27´W) 37LL ex *Scapteromys aquaticus* Thomas, 1920, 3LL ex *Cavia aperea* Erxleben, 1777, 1N ex *C. aperea*, 28LL 4NN ex *C. aperea*, 1L 1N ex *C. aperea*, 30 LL 2NN ex *C. aperea*, 12 LL ex *C. aperea*, 54LL 2NN ex *C. aperea*, 21NN ex *C. aperea*, 10NN ex *C. aperea*, 2NN ex *C. aperea*, 9NN ex *C. aperea*, 1N ex *C. aperea*, 1N ex *C. aperea*, 6NN ex *C. aperea*, 7NN ex *C. aperea*; Estancia "Rincón del Socorro" (28°42´S 57°29´W) 1M 6NN 2LL ex *A. axis*, 37 NN ex *S. scrofa*, 14NN ex *S. scrofa*, 1M 2FF 18NN ex *S. scrofa*, 13 NN ex *S. scrofa*, 10NN 2LL ex *S. scrofa*, 5NN 1L ex *S. scrofa*, 8MM 7FF ex *S. scrofa*, 6NN ex *S. scrofa*, 3NN 1L ex *S. scrofa*, 1M 5FF ex *S. scrofa*, 20 NN 8LL ex *M. tridactyla*, 4NN 9LL ex *M. tridactyla*, 6NN ex *M. tridactyla*, 2MM 9NN ex *M. tridactyla*, 1M 10FF ex *M. tridactyla*, 12 NN 10 LL ex *L. europaeus*, 1M 16NN 71LL ex *H. hydrochaeris*, 7NN 9LL ex *H. hydrochaeris*, 1F 11NN 3LL ex *H. hydrochaeris*, 3MM 3FF 62NN 28LL ex *H. hydrochaeris*, 10MM 105NN 123LL ex *H. hydrochaeris*, 5MM 1F 5NN 212LL ex *H. hydrochaeris*, 24MM 18FF 59NN 61LL ex *H. hydrochaeris*, 48NN 83LL ex *H. hydrochaeris*, 5NN 30LL ex *H. hydrochaeris*, 50NN 126LL ex *H. hydrochaeris*, 23NN 6LL ex *H. hydrochaeris*, 38NN 15LL ex *H. hydrochaeris*, 2MM 2FF 80NN 2LL ex *H. hydrochaeris*, 1L ex *Akodon azarae* (J. Fischer, 1829), 1L ex *A. azarae*, 1L ex *A. azarae*, 3LL ex *A. azarae*, 7LL ex *A. azarae*, 99LL ex *A. azarae*, 9LL ex *A. azarae*, 5LL ex *A. azarae*, 5LL ex *A. azarae*, 1L ex *A. azarae*, 1N 13LL ex *A. azarae*, 3LL ex *Oligoryzomys flavescens* (Waterhouse, 1837), 1L ex *O. flavescens*,1L ex *O. flavescens*, 7LL ex *O. flavescens*, 19LL ex *O. flavescens*, 1N 9LL ex *Monodelphis dimidiata* (Wagner, 1847), 3NN 12LL ex *M. dimidiata*, 9LL ex *M. dimidiata*, 77LL ex *M. dimidiata*, 6LL ex *M. dimidiata*.

2) *Amblyomma nodosum*, Neumann 1899
New record: Estancia "Rincón del Socorro" (28°42´S 57°29´W) 1M ex *M. tridactyla*.

3) *Amblyomma triste* Koch, 1844
Laguna del Iberá (28º32´S 57º10´W) 2 FF ex *B. dichotomus* (Nava *et al.* 2011), 1M 1N ex *H. hydrochaeris* (Nava *et al.* 2011); Loreto (27º46'S 57º16'W) 1N 2LL ex *A. azarae* (Nava *et al.* 2011), 2NN 4LL ex *Calomys callosus* (Rengger, 1830) (Nava *et al.* 2011), 2NN 16LL ex *Oxymycterus rufus* (G. Fischer, 1814) (Nava *et al.* 2011), 1N ex *Oligoryzomys nigripes* (Olfers, 1818) (Nava *et al.* 2011). **New records:** 30 km SW of Colonia Carlos Pellegrini (28º40'S 57º26'W) 1M ex *H. hydrochaeris*; 37 km SW of Colonia Carlos Pellegrini (28°42´S 57°27´W) 1N ex *S. aquaticus*, 1N ex *C. aperea*; Estancia "Rincón del Socorro" (28º42'S 57º29'W) 1M 7FF ex *S. scrofa*, 1M 1 F ex *S. scrofa*, 1F ex *S. scrofa*, 2NN ex *A. azarae*, 3NN ex *A. azarae*, 4LL ex *A. azarae*, 10LL ex *A. azarae*, 3NN 9LL ex *A. azarae*, 2NN ex *O. flavescens*, 2LL ex *M. dimidiata*, 64LL 2NN ex *M. dimidiata*, 17LL ex *A. azarae*, 7LL ex *A. azarae*, 58LL 2NN ex *A. azarae*, 5LL ex *A. azarae*, 1L ex *O. flavescens*, 118LL 5NN ex *A. azarae*, 19LL 1N ex *O. flavescens*, 1L ex *A. azarae*, 46LL ex *O. flavescens*, 19LL ex *A. azarae*, 3LL ex *M. dimidiata*, 1N 57LL ex *A. azarae*, 42LL ex *A. azarae*, 1N 13LL ex *A. azarae*, 2LL ex *M. dimidiata*, 8LL ex *A. azarae*.

4) *Haemaphysalis juxtakochi* Cooley, 1946
New records: Estancia "Rincón del Socorro" (28°42´S 57°29´W) 2FF 1N ex *A. axis*, 1F ex *S. scrofa*; 100 km NW of Mercedes (28º36´S 57º16´W) 5MM 2FF ex *Mazama gouazoubira* (G. Fischer, 1814).

5) *Rhipicephalus* (*Boophilus*) *microplus* (Canestrini, 1888)
New records: Laguna del Iberá (28º32´S 57º10´W) 25FF ex *B. dichotomus*, 9 MM 11FF ex *B. dichotomus*; 100 km NW of Mercedes (28º36´S 57º16´W) 4MM 2FF 1N ex *B. dichotomus*.

Discussion

This is the first systematic study of ticks associated with wild mammals in the Esteros del Iberá wetlands. The apparently limited tick fauna—only five species—may be related to the unique ecological characteristics of the study area, which possibly preclude the establishment of other tick species, or it may be an artifact of sampling, since hosts belonging to the orders Carnivora and Chiroptera were not examined. Future studies should focus on ticks associated with mammalian orders that were not sampled during this investigation.

Two of the five tick species collected in Esteros del Iberá are of known medical and veterinary importance. *Amblyomma triste* has been found infected by *Rickettsia parkeri* in Argentina, Brazil and Uruguay (Venzal *et al.* 2004; Silveira *et al.* 2007; Nava *et al.* 2008), where cases of human disease attributed to this rickettsia have been diagnosed (Conti-Díaz *et al.* 2009; Moraes-Filho *et al.* 2009; Romer *et al.* 2011). In our study, adults of *A. triste* were found on *B. dichotomus*, *H. hydrochaeris* and *S. scrofa*. These results are not unexpected because Nava *et al.* (2011) determined that adult *A. triste* feed on large mammals belonging to different orders. Additionally, both *B. dichotomus* and *H. hydrochaeris* had already been recorded as key hosts for adults of *A. triste* in Argentina (Nava *et al.* 2011). Therefore, our record of *A. triste* adults on *S. scrofa*, although new, is not surprising. Similarly, most of the larvae and nymphs of this tick species collected at Esteros del Iberá were from rodents of the subfamilies Sigmodontinae and Caviinae, confirming the results of Nava *et al.* (2011) in Argentina and Venzal *et al.* (2008) in Uruguay, who established that these rodents are principal hosts for the immature stages of *A. triste*. Although Venzal *et al.* (2008) also found larvae and nymphs of *A. triste* on the marsupial *M. dimidiata*, the collection of larvae and nymphs of *A. triste* on this host in Esteros del Iberá represents the first record of this parasite-host association for Argentina and suggests that *M. dimidiata* is a suitable host for the immature stages of this tick.

The second tick species of economic relevance collected on wild mammals in Esteros del Iberá is *R.* (*B.*) *microplus*, which was found on the marsh deer, *B. dichotomus*. This tick is a major pest of cattle and the vector of *Babesia bovis* and *Babesia bigemina*, the causative agents of bovine babesiosis (Guglielmone 1992). The ability of *B. dichotomus* to serve as an alternative host for *R.* (*B.*) *microplus* is not well known. In a study of ticks associated with *B. dichotomus* in Brazil, carried out in a marsh environment with ecological characteristics similar to Esteros del Iberá, Szabó *et al.* (2003) determined that *R.* (*B.*) *microplus* was the most prevalent tick on this deer. However, these authors were not convinced that *B. dichotomus* was able to exclusively maintain populations of *R.* (*B.*) *microplus*. Additional studies should be conducted to determine the suitability of *B. dichotomus* as a host for *R.* (*B.*) *microplus* and the deleterious effects that this tick may have on marsh deer.

Amblyomma dubitatum is a South American tick associated with *H. hydrochaeris* (Nava *et al.* 2010a), and the results of our study confirm this observation, because most collections of *A. dubitatum* were made on *H. hydrochaeris*. Small marsupials and rodents of the subfamilies Caviinae and Sigmodontinae appear to be alternative hosts for larvae and nymphs, while *S. scrofa* and *A. axis* can support the entire life cycle of this tick because immature and adult stages were found feeding on these two exotic mammals. Although the numbers of *A. dubitatum* collected on *L. europaeus*, *B. bubalis* and *M. tridactyla* were lower, they were sufficient to suggest that these three species of mammals may serve as alternative hosts for *A. dubitatum*. Similarly, *H. juxtakochi* may maintain a surrogate life cycle independent of its native host (*Mazama* spp. (Szabó *et al.* 2006)) in Esteros del Iberá, because it was also found parasitizing *S. scrofa* and *A. axis*.

Although the principal hosts for *A. nodosum* are mammals of the family Myrmecophagidae (Jones *et al.* 1972; Guglielmone *et al.* 2003), the finding of a male of *A. nodosum* parasitizing *M. tridactyla* in Esteros del Iberá is not easy to interpret. *Myrmecophaga tridactyla* became extinct there

30 years ago (Chebez 1999) but was successfully reintroduced recently. The previous records of *A. nodosum* in Argentina consist of two males collected on *Tamandua tetradactyla* (Linnaeus, 1758) in Chaco Province, and two males and one female collected on the same host in Formosa Province (Ivancovich 1987). It is unlikely that *A. nodosum* could have sustained itself in Esteros del Iberá prior to the reintroduction of *M. tridactyla*. We therefore speculate that the male of *A. nodosum* reported in this study was not detected on our individual of *M. tridactyla* prior to its release into the wild. If this hypothesis is valid, the entry into Esteros del Iberá of non-native ticks and their associated pathogens with mammals introduced from other ecological areas constitutes a potential threat to wildlife.

In Brazil, *A. dubitatum* has been found infected with *Rickettsia bellii* and *R. parkeri* (strain COOPERI) (Labruna *et al*. 2004), *Rickettsia rhipicephali* and *R. bellii* have been detected in *H. juxtakochi* (Labruna *et al*. 2007), and *R. bellii* (strain Pontal) and *R. parkeri* (strain NOD) have been found in *A. nodosum* (Ogrzewalska *et al*. 2009). However, the precise role of *A. dubitatum*, *H. juxtakochi* and *A. nodosum* in the transmission of pathogenic microorganisms to both humans and animals is as yet unknown.

A high proportion of the records presented in this work are associations between ticks and exotic (*S. scrofa, A. axis, B. bubalis, L. europaeus*) or reintroduced (*M. tridactyla*) mammals. Non-indigenous species may act as new hosts for native parasites, and this interrelationship can have a negative effect on native fauna due to acquisition and amplification of the native parasite by an introduced host (Kelly *et al*. 2009; Mastitsky & Veres 2010; Tompkins *et al.* 2011). Both *A. axis* and *S. scrofa* are exotic large mammals that occur throughout Esteros del Iberá. The considerable number of specimens of *A. dubitatum* and *A. triste* that were collected on *A. axis* and *S. scrofa* suggests that introduction of these mammals may result in an increase in tick populations, with potential eco-epidemiological implications. Further studies should determine whether a positive numerical response of tick populations to the presence of exotic hosts is occurring in the Esteros del Iberá wetlands.

Acknowledgements

We are grateful to INTA, Asociación Cooperadora INTA Rafaela, and CONICET for providing financial support to VND, SN and AAG. Fieldwork was conducted with the support of The Conservation Land Trust Argentina. We thank Dr. U.F.J. Pardiñas for identifying our sigmodontine rodents, and Oscar Warnke for assisting with fieldwork.

References

Barros-Battesti, D.M., Arzua, M. & Bechara, G.H. (2006) *Carrapatos de importancia médico-veterinaria da regiao Neotropical: um guia ilustrado para identificação de espécies*. Vox/ICTTD-3/Butantan, São Paulo. 223 pp.

Canziani, G., Rossi, C., Loiselle, S. & Ferrati, R. (2003) Los Esteros del Iberá. Informe del proyecto ‘‘El Manejo Sustentable de Humedales en el Mercosur.’’ Fundación Vida Silvestre Argentina, Buenos Aires, Argentina.

Chebez, J.C. (1999) *Los que se van. Especies argentinas en peligro.* Editorial Albatros, Buenos Aires, Argentina, 606 pp.

Conti-Díaz, I.A., Moraes-Filho, J., Pacheco, R.C. & Labruna, M.B. (2009) Serological evidence of *Rickettsia parkeri* as the etiological agent of rickettsiosis in Uruguay. *Revista do Instituto de Medicina Tropical de São Paulo*, 51, 337–339.

Estrada-Peña, A., Venzal, J.M., Mangold, A.J., Cafrune, M.M. & Guglielmone, A.A. (2005) The *Amblyomma maculatum* Koch, 1844 (Acari: Ixodidae: Amblyomminae) tick group: diagnostic characters, description of the larva of *A. parvitarsum* Neumann, 1901, 16S rDNA sequences, distribution and hosts. *Systematic Parasitology*, 60, 99–112.

Fabri, S., Heinonen Fortabat, S., Soria, A. & Pardiñas, U. (2003) Los mamíferos de la reserva provincial Iberá, provincia de Corrientes, Argentina. In: Alvarez, B. B. (Ed.). *Fauna del Iberá*. Editorial de la Universidad Nacional del Nordeste, Talleres Gráficos Volpe/Fox, Buenos Aires. pp. 305–342.

Guglielmone, A.A. (1992) The level of infestation with the vector of cattle babesiosis in Argentina. *Memórias do Instituto Oswaldo Cruz*, 87, Suppl. III, 133–137.

Guglielmone, A.A. & Viñabal, A.E. (1994) Claves morfológicas dicotómicas e información ecológica para la identificación de garrapatas del género *Amblyomma* Koch, 1844 de la Argentina. *Revista de Investigación Agropecuaria*, 25, 39–67.

Guglielmone, A.A., Estrada Peña, A., Keirans, J.E. & Robbins, R.G. (2003) *Ticks (Acari: Ixodida) of the Neotropical Zoogeographic Region*. International Consortium on Ticks and Tick-Borne Diseases (ICTTD-2), Atalanta, Houten, The Netherlands, 173 pp.

Hoogstraal, H. (1985) Argasid and nuttalliellid ticks as parasites and vectors. *Advances in Parasitology*, 24, 135–238.

Ivancovich, J.C. (1987) *Amblyomma nodosum* Neumann, 1899 (Acarina-Ixodidae), nueva especie de garrapata en Argentina. *Veterinaria Argentina*, 4, 150–153.

Ivancovich, J.C. & Luciani, C.A. (1992) *Las garrapatas de Argentina*. Buenos Aires: Asociación Argentina de Parasitología Veterinaria. 95 pp.

Joan, T. (1930) El amblyomma [sic] de Cooper y demás garrapatas de los carpinchos. *5ª Reunión de la Sociedad Argentina de Patología Regional Norte*, octubre 1929, Jujuy, Argentina 2: 1168–1179.

Jones, E.K., Clifford, C.M., Keirans, J.E. & Kohls, G.M. (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, 1–40.

Jongejan, F. & Uilenberg, G. (2004) The global importance of ticks. *Parasitology*, 129, 1–12.

Kelly, D.W., Paterson, R.A., Townsend, C.R., Poulin, R. & Tompkins, D.M. (2009) Parasite spillback: a neglected concept in invasion ecology? *Ecology*, 90, 2047–2056.

Labruna, M.B., Whitworth, T., Horta, M.C., Bouyer, D.H., McBride, J., Pinter, A., Popov, V., Gennari, S.M. & Walker, D.H. (2004) *Rickettsia* species infecting *Amblyomma cooperi* ticks from an area in the state of São Paulo, Brazil, where Brazilian spotted fever is endemic. *Journal of Clinical Microbiology*, 42, 90–98.

Labruna, M.B., Pacheco, R. C., Richtzenhain, L.J. & Szabó, M. J. P. (2007) Isolation of *Rickettsia rhipicephali* and *Rickettsia belli* from *Haemaphysalis juxtakochi* ticks in the state of São Paulo, Brazil. *Applied and Environmental Microbiology*, 73, 869–873.

Loiselle, S., Hull, V., Permingeat, E., Falucci, M. & Rossi, C. (2002) Qualitative models to predict impacts of human interventions in a wetland ecosystem. *Web Ecology*, 3, 56–69.

Martins, T.F., Onofrio, V.C., Barros-Battesti, D.M. & Labruna, M.B. (2010) Nymphs of the genus *Amblyomma* (Acari: Ixodidae) of Brazil: descriptions, redescriptions, and identification key. *Ticks and Tick-borne Diseases*, 1, 75–99.

Mastitsky, S.E. & Veres, J.K. (2010) Field evidence for a parasite spillback caused by exotic mollusc *Dreissena polymorpha* in an invaded lake. *Parasitology Research*, 106, 667–675.

Moraes-Filho, J., Pinter, A., Pacheco, R.C., Gutmann, T.B., Barbosa, S.O., Gonzáles, M.A.R.M., Muraro, M.A., Cecilio, S.R.M. & Labruna, M.B. (2009) New epidemiological data on Brazilian spotted fever in an endemic area of the state of São Paulo, Brazil. *Vector-Borne and Zoonotic Diseases*, 9, 73–78.

Nava, S., Mangold, A.J. & Guglielmone, A.A. (2006) The natural hosts for larvae and nymphs of *Amblyomma neumanni* and *Amblyomma parvum* (Acari: Ixodidae). *Experimental and Applied Acarology*, 40, 123–131.

Nava, S., Elshenawy, Y., Eremeeva, M.E., Sumner, J.W., Mastropaolo, M. & Paddock, C.D. (2008) *Rickettsia parkeri* in Argentina. *Emerging Infectious Diseases*, 14, 1894–1897.

Nava, S., Mangold, A.J., Mastropaolo, M., Venzal, J.M., Oscherov, E.B. & Guglielmone, A.A. (2009) *Amblyomma boeroi* n.sp. (Acari: Ixodidae), a parasite of the Chacoan peccary *Catagonus wagneri* (Rusconi) (Artiodactyla: Tayassuidae) in Argentina. *Systematic Parasitology*, 73, 161–174.

Nava, S., Venzal, J.M., Labruna, M.B., Mastropaolo, M., González, E.M., Mangold, A.J. & Guglielmone, A.A. (2010a) Hosts, distribution and genetic divergence (16S rDNA) of *Amblyomma dubitatum*. *Experimental and Applied Acarology*, 51, 335–351.

Nava, S., Venzal, J.M., Terassini, F.A., Mangold, A.J., Camargo, L.M.A. & Labruna, M.B. (2010b) Description

of a new argasid tick (Acari: Ixodida) from bat caves in Brazilian Amazon. *Journal of Parasitology*, 96, 1089–1101.

Nava, S., Mangold, A.J., Mastropaolo, M., Venzal, J.M., Fracassi, N. & Guglielmone, A.A. (2011) Seasonal dynamics and hosts of *Amblyomma triste* (Acari: Ixodidae) in Argentina. *Veterinary Parasitology*, 181, 301–308.

Neiff, J.J. & Poi de Neiff, A.S.G. (2006) Situación ambiental en la ecorregión Iberá. In: *La situación ambiental Argentina* (A. Brown, U. Martinez Ortiz, M. Acerbi, and J. Corcuera, eds.). Fundación Vida Silvestre Argentina, Buenos Aires, Argentina. pp. 177–184.

Neiff, J.J., Casco, S.L., Cózar Cabañas, A., Poi de Neiff, A. & Ubeda, U. (2011) Vegetation diversity in a large Neotropical wetland during two different climatic scenarios. *Biodiversity & Conservation*, 20, 2007–2025.

Ogrzewalska, M., Pacheco, R., Uezu, A., Richtzenhain, L.J., Ferreira, F. & Labruna, M.B. (2009) Rickettsial infection in *Amblyomma nodosum* ticks (Acari: Ixodidae) from Brazil. *Annals of Tropical Medicine & Parasitology*, 103, 413–425.

Romer, Y., Seijo, A.C., Crudo, F., Nicholson, W.L., Varela-Stokes, A., Lash, R.R. & Paddock, C.D. (2011) *Rickettsia parkeri* rickettsiosis, Argentina. *Emerging Infectious Diseases*, 17, 1169–1173.

Silveira, I., Pacheco, R.C., Szabó, M.P.J., Ramos, H.G.C. & Labruna, M.B. (2007) *Rickettsia parkeri* in Brazil. *Emerging Infectious Diseases*, 13, 1111–1113.

Sonenshine, D.E. & Mather, T.N. (1994) *Ecological dynamics of tick-borne zoonoses*. Oxford University Press, New York. 446 pp.

Szabó, M.P.J., Labruna, M.B., Pereira, M.C. & Duarte, J.M.B. (2003) Ticks (Acari: Ixodidae) on wild marsh-deer (*Blastocerus dichotomus*) from southeast Brazil: infestations before and after habitat loss. *Journal of Medical Entomology*, 40, 268–274.

Szabó, M.P.J., Labruna, M.B., Vogliotti, A. & Duarte, J.M.B. (2006) Ticks (Acari: Ixodidae) on small red brocket deer (*Mazama bororo* Duarte) along deer trails in the Atlantic rain forest of southeastern Brazil. *Systematic and Applied Acarology*, 11, 41–45.

Tompkins, D.M., Dunn, A.M., Smith, M.J. & Telfer, S. (2011) Wildlife diseases: from individuals to ecosystems. *Journal of Animal Ecology*, 80, 19–38.

Venzal, J.M., Portillo, A., Estrada-Peña, A., Castro, O., Cabrera, P.A. & Oteo, J.A. (2004) *Rickettsia parkeri* in *Amblyomma triste* from Uruguay. *Emerging Infectious Diseases*, 10, 1493–1495.

Venzal, J.M., Estrada-Peña, A., Castro, O., de Souza, C.G., Félix, M.L., Nava, S. & Guglielmone, A.A. (2008) *Amblyomma triste* Koch, 1844 (Acari: Ixodidae): hosts and seasonality of the vector of *Rickettsia parkeri* in Uruguay. *Veterinary Parasitology*, 155, 104–109.

Accepted by R.G. Robbins: 6 Jul. 2012; published 31 Aug. 2012