The ticks (Acari: Ixodida: Argasidae, Ixodidae) of Paraguay

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The ticks reported in Paraguay, which are here reviewed, can be categorized as ‘endemic or established’ (Argas persicus or a sibling species, Ornithodoros hasei, O. rostratus, O. rudis, O. talaje/O. puertoricensis, Amblyomma aureolatum, Am. auricularium, Am. brasilense, Am. cajennense, Am. coelebs, Am. dissimile, Am. dubitatum, Am. incisum, Am. longirostre, Am. nodosum, Am. ovale, Am. pacae, Am. parvum, Am. pseudoconcolor, Am. rotundatum, Am. scutatum, Am. tigrinum, Am. triste, Dermacentor nitens, Haemaphysalis justakochi, H. leporispalustris, Ixodes loricatus, Rhipicephalus microplus, and Rh. sanguineus), ‘probably endemic or established’ (Ar. miniatus, Ar. monachus, Am. argentinae, Am. cajennense, Am. pacae, Am. parvum, Am. pseudoparvum, I. aragaoi/I. paracuniculus, I. auritulus, I. luciae), or ‘erroneously reported from Paraguay’ (O. coriaceus, Am. americanum and Am. maculatum). Most Paraguayan tick collections have been made in the Chaco phyto–geographical domain, in the central part of the country. Argas persicus or a related species, Am. cajennense, D. nitens, Rh. microplus and Rh. sanguineus are important parasites of domestic animals. Ornithodoros rudis, Am. aureolatum, Am. brasilense, Am. cajennense, Am. coelebs, Am. incisum, Am. ovale and Am. tigrinum have all been collected from humans. In terms of public health, the collections of Am. cajennense and Am. triste from humans may be particularly significant, as these species are potential vectors of Rickettsia rickettsii and Ri. parkeri, respectively.

Ticks (suborder Ixodida, superfAMILY Ixodoidea) are large, obligately haematophagous mites that, in some or all of their post-embryonic stages, are ectoparasites, infesting all classes of vertebrates except fish. Several species are vectors of agents that may cause disease in, or even kill, their hosts, and even uninfected ticks may cause dermatoses, envenomization, exsanguination or paralysis. Most research on Neotropical ticks has been focused on those species of importance to livestock, especially the cattle tick Rhipicephalus (formerly Boophilus) microplus (Canestrini). Recent outbreaks of tick-transmitted human rickettsiosis in Argentina (Ripoll et al., 1999), Brazil (Silva and Galvão, 2004) and Uruguay (Venzal et al., 2004) have, however, generated renewed interest in the importance of ticks as vectors of human pathogens, and ticks are also excellent subjects for studies of regional biodiversity (Estrada-Peña et al., 2005; Labruna et al., 2005).

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### TABLE 1. The tick collection sites in each department of Paraguay, with their geographical co-ordinates

<table>
<thead>
<tr>
<th>Department and collection site</th>
<th>Co-ordinates</th>
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<tr>
<td><strong>ALTO PARAGUAY</strong></td>
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</tr>
<tr>
<td>Cerro León</td>
<td>20°20′S, 60°20′W</td>
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<tr>
<td>Parque Defensores del Chaco</td>
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<td>Colonia Neuland</td>
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<td>Filadelfia East</td>
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<td>Río Pirapó area</td>
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<td>San Juan Bautista</td>
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<td><strong>NEEMBUCU</strong></td>
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<td>General Díaz</td>
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<td>Yacaré</td>
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**TABLE 1. Continued**

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<th>Department and collection site</th>
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<td><strong>PRESIDENTE HAYES</strong></td>
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<td>San Salvador</td>
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<tr>
<td>San Pedro</td>
<td>24°07′S, 56°59′W</td>
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</table>

Given that animal husbandry is so vital to the economy of Paraguay (Payne and Osorio, 1990), a land-locked area with a diverse autochthonous fauna, it is surprising that this country’s ticks remain little known, the only comprehensive review being that of Massi Pallarés and Benítez Usher (1982). In recent years, the examination of extant collections of Paraguayan ticks and the collection of additional specimens from various sites have permitted the present, critical review of the country’s tick fauna. New information on hosts, distribution and ecology, that should prove useful in assessing the impact of these ectoparasites on human and ‘animal’ health, is presented below.

**MATERIALS AND METHODS**

The phylogenies followed for the present review were those of Barker and Murrell (2002) for the family Ixodidae, and of Hoogstraal (1985) for the Argasidae. Although there has been a more recent review of the taxonomy of argasid ticks (Klompen and Oliver, 1993), this was based...
almost entirely on morphological characters, with minimal consideration of biology, hosts, distribution, and molecular systematics (Guglielmone et al., 2005), and is not followed here.

The present review is based on: (1) recent collections of ticks — currently deposited in the United States National Tick Collection (USNTC; Georgia Southern University, Statesboro, GA) or the tick collection of the Instituto Nacional de Tecnologia Agropecuaria (INTA) at Rafaela, Argentina — from several hosts and localities in Paraguay; (2) the examination of unidentified Paraguayan specimens deposited in the tick collection of the Departamento de Entomología (TCDE) of the Museo de La Plata (Universidad de La Plata, La Plata, Argentina); (3) the unpublished records of Paraguayan ticks already in the USNTC; and (4) a thorough appraisal of the relevant scientific literature. Whenever appropriate, the recorded names of mammalian hosts have been changed to accord with those used by Wilson and Reeder (1993).

The Paraguayan tick fauna is here discussed under three headings: ‘endemic or established species’, ‘species probably endemic or established’, and ‘species erroneously reported as present in Paraguay’. No summary remarks on tick families and genera are included here because these have recently been published (González Acuña and Guglielmone, 2005). Unless otherwise noted, the known world distribution of each species is that described by Guglielmone et al. (2003a).

The collection localities for each tick species are listed in the text and the Table. Figure 1 shows the administrative divisions of Paraguay, and Figure 2 depicts the broad phyto–geographical divisions of the country.
Paraguay’s phyto–geography comprises the Amazonic and Chaco domains. The Amazonic domain is represented by the Cerrado phyto–geographical province (CePP) in the north–east and by the Paranaense phyto–geographical province (PaPP) in the east (Fig. 2). The CePP, which covers the northern part of Amambay department and the easternmost parts of Concepción department (Fig. 1), is characterised by an annual rainfall of 1200–2000 mm (most of which falls in October–April), mean annual temperatures between 21°C and 25°C, and a landscape of open forest, with trees rarely taller than 12 m. The PaPP, which covers the entire departments of Canindeyú, Alto Paraná, Itapúa, Caazapá, the east–central parts of the departments of Misiones, Guairá and Caaguazú, and the eastern part of the San Pedro department, is characterised by a yearly rainfall of 1500–2000 mm (most of which falls in November–March), mean annual temperatures between 16°C and 22°C, and a mountainous terrain, with subtropical rainforests as the dominant vegetation. The Chaco domain is only represented by one phyto–geographical province, known as the Chaco phyto–geographical province (ChPP), but this covers all of central and western Paraguay (Fig. 2). The ChPP is chiefly distinguished by its generally flat terrain and a continental climate, with mean annual temperatures varying between 20°C and 23°C and annual rainfall increasing from west (500–800 mm, concentrated in the summer months of November–March) to east (800–1200 mm, with no seasonal peak). Trees of the genera *Schinopsis*, *Aspidosperma* and *Caesalpinia* are common in the ChPP.
RESULTS

**Endemic or Established Tick Species**

**ARGASIDAE Canestrini**

*Argas* Latreille; *Argas persicus* (Oken). Kohls *et al.* (1970) found females, nymphs and larvae of this tick species in a chicken house in Filadelfia, located in the ChPP. *Argas persicus* is a Palearctic species but specimens indistinguishable from this taxon have also been found in Argentina, Brazil and Cuba. It is possible that these Neotropical ‘*Ar. persicus*’ actually represent a sibling species.

*Ornithodoros* Koch; *Ornithodoros hasei* (Schulze). The USNTC contains specimens identified as *Orn. hasei* under accession numbers RML 064769 (three larvae, ex *Noctilio leporinus*, Fortín Juan de Zalazar, 25 September 1973, collector (coll.) R. L. Martin), and RML 064770 (two larvae, ex *Noctilio leporinus*, Fortín Juan de Zalazar, 27 September 1973, coll. R. L. Martin). These are the first Paraguayan records of *Orn. hasei* (the collection locality lies within the ChPP), a species that ranges from southern Mexico to Uruguay and the Caribbean islands. Jones *et al.* (1972) observed morphological variation among specimens from different localities and concluded that more than one species may be represented in material currently classified as *Orn. hasei*.

*Ornithodoros rostratus* Aragão. Massi Pallarés and Benítez Usher (1982) recorded this species from *Panthera onca* at Mariscal Estigarribia, and Keirans (1985) mentions males and a female from an unknown host in San Salvador. The USNTC contains RML 105928 (two males, host unknown, Filadelfia, June 1975, coll. K. Colin). The collection localities are all within the ChPP. *Ornithodoros rostratus* is also known from Argentina, Bolivia and Brazil.

*Ornithodoros rudis* Karsch. Massi Pallarés and Benítez Usher (1982) found this species on the ground at Colonia Fernheim. There are three collections in the USNTC: RML 015480 (six males and 13 females, host and locality unknown, October 1928, coll. E. Brumpt), RML 032661 (one male and one female, Asunción, host, date and collector unknown), and RML 065652 (13 nymphs identified as ‘probably *Orn. rudis*', human, Loma Plata, 10 March 1975, coll. R. G. Unruh). Colonia Fernheim, Asunción and Loma Plata all lie within the ChPP. *Ornithodoros rudis* is also known from Brazil, Colombia, Ecuador, Panama, Peru and Venezuela.

*Ornithodoros talaje* (Guérin-Méneville)/ *Ornithodoros puertoricensis* Fox. Cordero *et al.* (1928) found adults of *Orn. talaje* in a chicken house in Asunción, and Keirans (1985) identified males, females and nymphs, from an unknown host, at the same locality. The USNTC contains RML 105921 (two larvae, ex *Oryzomys* sp., Transchaco Road km 580–620, 3 February 1978, coll. T.W. Nelson). The TCDE (accession GR038) contains a single nymph, collected in a chicken house in Villarica (date and collector unknown). All collection localities for this species lie within the ChPP. Although Capriles and Gaud (1977) reported *Orn. puertoricensis* from Paraguay, this record requires confirmation because only the larvae of *Orn. talaje* and *Orn. puertoricensis* are readily separable by morphology (Kohls *et al.*, 1965). *Ornithodoros talaje* has also been reported from Argentina, Brazil, Ecuador (Galapagos Islands), Guatemala, Uruguay and the Nearctic Region, while there are records of *Orn. puertoricensis* from southern Mexico, Nicaragua, Surinam and the islands of the Greater and Lesser Antilles. Both species have been found in Colombia, Panama and Venezuela.

**IXODIDAE Murray**

*Amblyomma* Koch; *Amblyomma aureolatum* (Pallas). Keirans (1985) confirmed the presence of *Am. aureolatum* (under the name *Am. striatum*) on cattle and humans in San
Pedro (ChPP). This species, whose adults chiefly infest Carnivora, has also been found in Argentina, Brazil, French Guiana, Surinam and Uruguay (Guglielmone et al., 2003c).

Amblyomma auricularium (Conil). Massi Pallarés and Benítez Usher (1982) reported this tick from the armadillos Dasypus novemcinctus in Caaguazu, Euphractus sexcinctus in General Díaz and Puerto Rico Negro, Dasypus septemcinctus in Presidente Hayes, and Tolypeutes mataco in an unknown site. The known distribution of Am. auricularium in Paraguay thus includes both the PaPP and the ChPP. This tick ranges from northern Patagonia (Argentina) northward throughout the Neotropics and into the (Nearctic) southern U.S.A. (Guglielmone et al., 2003b). It may be difficult to distinguish the males of Am. auricularium and Am. pseudoconcolor because, in the latter species, the scutal ornamentation (a crucial diagnostic character) is often indistinct (Jones et al., 1972).

Amblyomma brasiilense Aragão. Dios and Knopoff (1930) reported this species from undetermined hosts in Asunción, whereas Keirans (1985) recorded it from humans and cattle in San Pedro (ChPP). Outside Paraguay, Am. brasiilense is also known from Argentina and Brazil.

from northern Argentina northward throughout the Neotropics to the southern U.S.A. (Nearctic).

*Amblyomma calcaratum* Neumann. Neumann (1899) recorded *Am. calcaratum* from Paraguay, but without host or locality data. This species is known from Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Panama, Surinam, Trinidad and Tobago, and Venezuela, where it is a common parasite of the giant anteater (*Myrmecophaga tridacyla*) and collared anteater (*Tamandua tetradactyla*).

*Amblyomma coelebs* Neumann. Keirans (1985) reported this species from San Pedro, although it is not clear whether the specimens were removed from a dog, human or cow or from vegetation. The TCDE contains just one accession: GR043 (one male and two females, ex human, Villarica, October 1945, coll. unknown). Both known collection sites are in the ChPP. Adults of *Am. coelebs* are chiefly found on Perissodactyla, in most countries from northern Argentina to Mexico.

*Amblyomma dissimile* Koch. Dios and Knopoff (1930) identified this tick from snakes (*Lachesis sp.*) in Asunción, whereas Massi Pallarés and Benítez Usher (1982) reported it from both Asunción and Villarica, on reptiles and amphibians. These localities all lie within the ChPP. *Amblyomma dissimile* is a common parasite of reptiles and true toads of the genus *Bufo*, from Argentina northward to southern Mexico, the Caribbean islands and the southern Nearctic (Florida).

*Amblyomma dubitatum* Neumann. Robinson (1926) reported this species (as *Am. cooperi*) from Puerto Cooper, whereas Massi Pallarés and Benítez Usher (1982) recorded it (again as *Am. cooperi*) on capybara (*Hydrochaeris hydrochaeris*) from San Juan Bautista, Estancia San Rafael and Santa Medarda. The USNTC (RML 034690) contains just one male and one female, collected from *H. hydrochaeris* at ‘Rio South of Descalvadez’ (another site that could not be re-located for the present review), date and collector unknown. All confirmed localities for Paraguayan *Am. dubitatum* are situated in the ChPP. This tick has also been found on capybara in Argentina, Bolivia, Brazil and Uruguay.

*Amblyomma incisum* Neumann. The USNTC (RML 056844) contains a female tick identified as ‘probably *Am. incisum*’ but without additional data. Under accession GR047, the TCDE has a female identified as this species (ex human, Villarica, October 1945, collector unknown) which comes from within the ChPP. Labruna et al. (2005) showed, however, that, on several occasions, *Am. incisum* has been confused with *Amblyomma latepunctatum* Tonelli-Rondelli or *Amblyomma sculpturatum* Neumann. The known range of *Am. incisum* includes Argentina, Bolivia, Brazil and Peru; its presence in Ecuador, French Guiana, Guyana, and Venezuela is uncertain. *Tapirus terrestris* is this species’ principal host.

*Amblyomma longirostre* (Koch). Although Massi Pallarés and Benítez Usher (1982) reported this tick from *Sphiggurus villosus* in Caaguazú (PaPP), Wilson and Reeder (1993) state that this host only occurs in Brazil. Adults of *Am. longirostre* have also been collected in Argentina, Bolivia, Brazil, Colombia, French Guiana, Mexico, Panama, Trinidad and Tobago, and Venezuela. Nymphs infest birds that disperse beyond the range of the porcupines, of the genera *Coendou* and *Sphiggurus*, that are the principal hosts of the adult ticks.

*Amblyomma nodosum* Koch. Massi Pallarés and Benítez Usher (1982) reported a collection of *Am. nodosum* from an unidentified anteater in Garay Cué (ChPP). This tick species shares hosts with *Am. calcaratum*, and differentiating the two tick species is not
always easy. *Amblyomma nodosum* has also been found in Argentina, Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Mexico, Nicaragua, Panama, Trinidad and Tobago, and Venezuela.

*Amblyomma ovale* Koch. Berlese (1888) first reported this species (as *Am. auronitens*) from Paraguay, on the basis of unattached specimens collected at Rio Apa. Subsequently, this tick has been collected several times, from a variety of carnivores or from humans, in Coronel Oviedo, Asunción, Luque, Puerto Cooper, Villa de San Pedro, Villarica, Yacaré, San Pedro, Estancia San Rafael and Rancho Alegre — localities that are all within the ChPP (Massi Pallarés and Benítez Usher, 1982; Keirans, 1985; Guglielmone *et al.*, 2003c). The USNTC contains RML 088296 (one female, host unknown, Asunción, 1900, coll. D. Anisitis), and RML 088297 (two males and two females, ex dog, Asunción, 14 October 1904, coll. A. Vezenji). The TCDE holds GR033 (one male, 1931, no further data), GR037 (two males and two females, ex dog, Villarica, 14 September 1946, coll. unknown), and GR041 (one male, ex human, Villarica, 9 February 1947, coll. unknown). *Amblyomma ovale* ranges from north-central Argentina northward throughout the Neotropical Region to Nearctic Mexico; there are also a few records from the U.S.A. (Guglielmone *et al.*, 2003c).

*Amblyomma paca* Aragão. Robinson (1911) reported a collection of *Am. paca* from an unknown host in San Bernardino (ChPP). The range of this tick, which commonly infests *Agouti paca*, also encompasses Belize, Brazil, Colombia, Guyana, Panama, Surinam and Venezuela.

*Amblyomma parvum* Aragão. An infestation with *Am. parvum* of cattle in Filadelfia was described by Quinlan *et al.* (1980), while Whitaker and Abrell (1987) found this tick on the carnivores *Cerdocyon thous* and *Nasua nasua* as well as the armadillo *Tolypeutes mataco* (localities unknown). The following Paraguayan collections are in the USNTC: RML 118132 (one female, ex *Ca. wagneri*, Filadelfia, 18 September 1985, coll. K. Benirschke), RML 119161 (one female, ex *Ca. wagneri*, Toledo, 1988, coll. K. Benirschke), and RML 119709 (five females, ex *Ca. wagneri*, Toledo, 1988, coll. K. Benirschke). Also in the USNTC are many, more recent collections of adult *Am. parvum* from carnivores in Paraguay, all collected by M. Cunningham — RML 123653 (27 males and two females, ex *Pu. concolor*, 22 June 2002), RML 123654 (two males and two females, ex *Pu. concolor*, 22 June 2002), RML 123655 (one male and two females, ex *Pu. concolor*, 26 June 2002), RML 123656 (two males, ex *Pu. concolor*, 3 June 2002), RML 123657 (one male and two females, ex *Pu. concolor*, 4 July 2003), RML 123658 (one male and four females, ex *Pu. concolor*, 17 June 2002) and RML 123659 (three males and one female, ex *Pa. onca*, 21 June 2002) all came from Boquerón, Estancia Faro Moro, whereas RML 123660 (one male, ex *Pa. onca*, 3 June 2002) came from Filadelfia, RML 123663 (four males, ex *Oncifelis geoffroyi*, 16 June 2002), RML 123665 (one male, ex ‘fox’, 22 June 2002) and RML 123666 (one female, ex *Pu. concolor*, July 2004) from Estancia Faro Moro, and RML 123667 (one male and four females, ex *Pa. onca*, 26 June 2004) and RML 123668 (three males and seven females, ex *Pa. onca*, 27 June 2004) from Parque Nacional Defensores del Chaco. All known collection sites for Paraguayan *Am. parvum* lie in the ChPP. This tick, which infests a variety of hosts, is also known from Argentina, Bolivia, Brazil, Costa Rica, El Salvador, French Guiana, Mexico, Nicaragua, Panama and Venezuela.

*Amblyomma pseudoconcolor* Aragão. Robinson (1926) reported a collection of this species from an unknown host in San Bernardino (ChPP), while Whitaker and
Abrell (1987) found it on *Chaetophractus villosus* and *E. sexcinctus*, without providing locality data. The USNTC contains two accessions, both from the ChPP: RML 105927 (one male, three nymphs and five larvae, ex *Tolypeutes* sp., Cerro León, 11 July 1977, coll. K. Colin) and RML 122225 (one male, ex *To. mataco*, Toledo, 30 November 1995, coll. M. Campbell). *Amblyomma pseudoconcolor* is common on armadillos and has been found in Argentina, Bolivia, Brazil, French Guiana, Surinam and Uruguay.

*Amblyomma rotundatum* Koch. Although there have been no published reports of this reptile and amphibian ectoparasite from Paraguay, the USNTC contains six Paraguayan collections labelled *Am. rotundatum*: four taken, by an unknown collector, from *Bufo marinus* in Asunción, in September 1926 — RML 032213 (one nymph), RML 032214 (one female), RML 032219 (one female) and RML 032217 (one nymph and three larvae; labelled ‘*A. rotundatum* probable’) — and two taken, by an unknown collector, on an unknown date and at an unspecified site, from *Bu. marinus* — RML 032216 (one female and one nymph) and RML 032218 (one female and one nymph). Asunción is located in the ChPP. *Amblyomma rotundatum* ranges from Argentina northward to the Nearctic Region (Florida) and the Caribbean islands.

*Amblyomma scutatum* Neumann. Neumann (1899) reported nymphs of *Am. scutatum* from a Paraguayan bat (*Noctilio albiventris*) but provided no locality data. There are no additional Paraguayan records of *Am. scutatum*, which is an ectoparasite of reptiles in Brazil, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Venezuela.

*Amblyomma tigrinum* Koch. Massi Pallarés and Benítez Usher (1982) reported adults and immature stages of this tick from several mammals and birds in Colonia Neuland, Estancia Campo-i, Toledo, Asunción, Villeta, Rio Apa, San Bernardino, General Artigas, San Juan Bautista, San Fernando, Yacaré, Estancia Barrerito, Paraguari, Quinindy, Rancho Alegre, and Santa Medarda. The USNTC contains the following adult specimens of *Am. tigrinum* from Paraguay: RML 123657 (one female, ex *Pu. concolor*, Estancia Faro Moro, 4 July 2003, coll. M. Cunningham), RML 123659 (three females, ex *Pa. onca*, Estancia Faro Moro, 21 June 2002, coll. M. Cunningham), and RML 123660 (one male and three females, ex *Pa. onca*, Filadelfia, 3 June 2002, coll. M. Cunningham). The TCDE contains a single male (GR017) collected from a human (no further data). General Artigas is situated in the PaPP but all the other confirmed localities lie within the ChPP. Adults of *Am. tigrinum* are common parasites of wild and domestic Canidae (Guglielmone et al., 2000). Although birds appear to be the principal hosts of the larvae and nymphs (González Acuña et al., 2004), Caviidae and sigmodontine rodents in Argentina are commonly found infested with the immature stages of this tick (Nava et al., 2006). This is a South American tick, with confirmed records for Argentina, Bolivia, Brazil, Chile, French Guiana, Peru, Uruguay and Venezuela (Estrada-Pen˜a et al., 2005). *Amblyomma tigrinum* was long confused with *Am. maculatum* until these two taxa were differentiated by Kohls (1956).

*Amblyomma triste* Koch. The first Paraguayan collections of this species are in the USNTC: RML 056301 (one male and one female, ex tapir, locality unknown, 1917, coll. E. Joukowsky). The other Paraguayan specimens of *Am. triste* in the USNTC, all collected in Estancia Faro Moro by M. Cunningham, are RML 123657 (one male, ex *Pu. concolor*, 4 July 2003) and RML 123659 (three males, ex *Pa. onca*, 21 June 2002). *Amblyomma triste* has been found, on a variety of hosts, in Argentina, Brazil, Colombia, Ecuador,
Peru, Uruguay and Venezuela (Estrada-Peña et al., 2005).

*Dermacentor* Koch; *Dermacentor nitens* Neumman. This tick has been found on horses in Coronel Oviedo, Mboicyaty, Villarica, Maldonado Cú, Villasana and Paraguari, and on cattle in Estancia Surubi-y (Quinlan et al., 1980; Massi Pallarés and Benítez Usher, 1982). A recent collection (INTA 1920) was of four males, seven females and one nymph from a horse in San Pedro (19 June 2005, coll. C. Rebollo). All of the known collection sites lie in the ChPP. *Dermacentor nitens* is common on horses from northern Argentina northward through the Neotropics, including the Caribbean islands, and, occasionally, into the Nearctic Region (Florida).

*Haemaphysalis* Koch; *Haemaphysalis juxtakochi* Cooley. Massi Pallarés and Benítez Usher (1982) reported this species on deer, hare and wild pig in San Fernando, Yacaré and Rancho Alegre. There are two Paraguayan collections of *Ha. juxtakochi* in the USNTC, both collected by R. L. Martin: RML 064767 (six nymphs, ex *Sylvilagus brasiliensis*, Fortín Juan de Zalazar, 20 September 1973) and RML 064768 (two nymphs and one larva, ex *S. brasiliensis*, Río Pirapó area, 12 July 1974). These records indicate that *Ha. juxtakochi* occurs in both the PaPP and ChPP. Adults of this species are usually found on Artiodactyla, especially deer of the genus *Mazama*, in most countries of South and Central America; there are also a number of records from the Nearctic Region.

*Haemaphysalis leporispalustris* (Packard). Nuttall and Warburton (1915) reported *Ha. leporispalustris* from an unknown host in San Bernardino. There is a single USNTC accession: RML 031688 (one male, ex *Dasyprocta azarae*, Yhu Sommerfield village, 8 March 1959, coll. M. Hertig). These localities represent both the PaPP and ChPP. Adults infest Lagomorpha in the Neotropical Region (Argentina, Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Panama, Paraguay, Peru and Venezuela) and Nearctic.

*Ixodes* Latreille; *Ixodes loricatus* Neumann. Massi Pallarés and Benítez Usher (1982) collected *I. loricatus* on marsupials in Puerto Cooper and Sapucai (both in the ChPP), and Keirans (1982) recorded it, albeit only as ‘probable’ *I. loricatus*, from *Didelphis* sp. in Sapucai. As Massi Pallarés and Benítez Usher (1982) stated that *I. loricatus* is prevalent in eastern Paraguay, this tick may also occur in the Amazonic domain. Adults of *I. loricatus* are specific to American marsupials, in Argentina, Brazil, Guatemala, Mexico, Paraguay, Uruguay and Venezuela.

*Rhipicephalus* Koch; *Rhipicephalus microplus* (Canestrini). This tick is a wide-spread parasite of cattle in the Afrotropical, Australian, Neotropical and Oriental zoo-geographical regions. Massi Pallarés and Benítez Usher (1982) stated that, although *Rh. microplus* is most common in the Oriental Region, it is widely found on cattle in Paraguay; it is therefore probably established throughout the Amazonic and Chaco domains. Paraguay is, in fact, the type locality of *Rh. microplus*, which was described by Canestrini (1887), as *Haemaphysalis micropla*. It has been collected from cattle in Estancia Villa Ana and Río Apa, Estancia Barrerito, Estancia Naranja-y, Chaco Experimental Station and Filadelfia, and has been found on cattle and horses in Villarica and on tapir in Colonia Risso (Berlese, 1888; Tonelli Rondelli, 1931; Minning, 1934; Quinlan et al., 1980; Brizuela et al., 1996). Berlese (1888) and Minning (1934) proposed the names *Haemaphysalis micropla* and *Uroboophilus microplus* for this species, respectively. There is only a single Paraguayan collection of *Rh. microplus* in the USNTC [RML 072607 (one female, host unknown, Puerto Max, January 1957,
coll. A. Vezenyi]) and only one in the TCDE [GR056 (one female, ex Mazama sp., Villarica, November 1945, collector unknown)]. There are, however, several more recent collections at INTA, all taken from cattle by C. Rebollo: INTA 1917 (19 females, Guarambaré, 10 July 2005), INTA 1918 (one male and 20 females, Villarica, 10 June 2005), INTA 1921 (seven males, 19 females and two nymphs, San Pedro, 19 June 2005), INTA 1927 (four males, 16 females and one nymph, Sapucai, 10 June 2005), INTA 1931 (eight females, San Juan Bautista, 10 March 2005) and INTA 1934 (one male and five females, San Ignacio, 6 February 2005).

*Rhipicephalus sanguineus* (Latreille). This species was reported by Massi Pallarés and Benítez Usher (1982) on dogs in Asunción, Paraguari and San Fernando. Recent collections, all taken from dogs by C. Rebollo, are stored at INTA, as INTA 1919 (one male and 16 females, Asunción, 10 June 2005), INTA 1925 (three males and three females, San Lorenzo, 8 July 2005) and INTA 1926 (six males and 12 females, Ciudad del Este, 10 June 2005). All but one of the known localities lie within the ChPP; Ciudad del Este is in the PaPP. *Rhipicephalus sanguineus* is an African tick that has spread throughout the world, with humans and their dogs.

**Tick Species Probably Endemic or Established in Paraguay**

**ARGASIDAE Canestrini**

*Argas miniatus* Koch. This species is a common parasite of chickens in Neotropical countries. Many reports of *Ar. persicus*, a Palearctic species, on poultry in the Neotropics may actually represent misidentifications of *Ar. miniatus* or another related species (Kohls et al., 1970). Although Paraguayan specimens indistinguishable from *Ar. persicus* were examined by Kohls et al. (1970), and Aragão (1936) mentions the presence of *Ar. persicus* on domestic birds (at unspecified localities) in Paraguay, it remains possible that *Ar. miniatus* is also present in this country's chicken houses.

*Argas monachus* Keirans, Radovsky and Clifford. This tick has only been found in Argentina (Guglielmone et al., 2003a), where it is known from Formosa, a province that borders Paraguay (Ivancovich and Luciani, 1992). As this species’ known host, the parakeet *Myiopsitta monachus* can be found in Paraguay, it seems likely that *Ar. monachus* also occurs in the country.

**IXODIDAE Murray**

*Amblyomma argentinae* Neumann. To date, this tick has only been found in Argentina, where it is a common ectoparasite of the land tortoise *Chelonoidis chilensis* (Guglielmone et al., 2001). Since the range of this tortoise includes western Paraguay (Cei, 1993), it seems likely that *Ar. argentinae* also occurs there.

*Amblyomma humerale* Koch. This is a reptile tick that has been found on *Geochelone denticulata* in the Bolivian department of Santa Cruz, which is contiguous with northern Paraguay (Robbins et al., 2003). The range of *Am. humerale*, which covers parts of Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Surinam, Peru, Trinidad and Tobago, and Venezuela, may therefore also include Paraguay.

*Amblyomma naponense* (Packard). This species is common on peccaries (*Tayassu and Pecari* spp.), and there are records of its occurrence in areas close to Paraguay: the Bolivian department of Santa Cruz (Robbins et al., 1998) and the Brazilian state of Mato Grosso do Sul (Guimaraes et al., 2001). This tick has been found in Colombia, Costa Rica, Ecuador, French Guiana, Guyana, Panama, Peru, Surinam and Venezuela, and it seems likely that its range also includes parts of Paraguay.

*Amblyomma oblongoguttatum* Koch. This tick has been found on a variety of hosts in
several South and Central American countries. It is known from the department of Santa Cruz in Bolivia (Robbins et al., 1998) and the state of Paraná in Brazil (Ribeiro, 1966) — areas immediately to the north and east of Paraguay, respectively. It is highly likely that *Am. oblongoguttatum* occurs throughout a large part of Paraguay.

*Amblyomma pseudoparvum* Guglielmone, Mangold and Keirans. The principal host of *Am. pseudoparvum* appears to be the caviid *Dolichotis salinicola*. Both tick and host have been found in the Argentinian province of Salta, which shares a short border with Paraguay (Guglielmone et al., 1990), where *Do. salinicola* also occurs (Wilson and Reeder, 1993).

*Ixodes aragaoi* Fonseca or *Ixodes pararicinus* Keirans and Clifford. These two species are morphologically similar, and it is still unclear whether they represent distinct taxa (Guglielmone et al., 2003a); both have also long been confused with the Palearctic *Ixodes ricinus* Linnaeus. *Ixodes pararicinus* has been found on cattle in the Argentinean province of Formosa, which shares a short border with Paraguay (Guglielmone et al., 1990), whereas *I. aragaoi* has been found on an undetermined species of deer in the Brazilian state of Paraná, which borders eastern Paraguay (Ribeiro, 1966).

*Ixodes auritulus* Neumann. This tick, a parasite of birds from southern Argentina to Canada in the Americas, is known from the Brazilian state of Paraná, which is contiguous with eastern Paraguay (González-Acuña et al., 2005). Given the relative ease with which its hosts can traverse long distances, *I. auritulus* should be expected to occur in Paraguay.

*Ixodes luciae* Sénevet. Adults of this tick infest marsupials from Argentina to southern Mexico. Fonseca (1959) found *I. luciae* close to northern Paraguay, in the Bolivian state of Santa Cruz.

**Tick Species Erroneously Reported from Paraguay**

**ARGASIDAE Canestrini**

*Ornithodoros coriaceus* Koch. This argasid is found in the Nearctic Region and also in the Neotropical portion of southern Mexico. Its supposed presence in Paraguay (Rio Apa) was cited by Berlese (1888), but Tonelli Rondelli (1939) examined the nymphal specimen that was the basis for this record and found it to be an undeterminable *Ornithodoros* that was different from *Orn. coriaceus*.

**IXODIDAE Murray**

*Amblyomma americanum* (Linnaeus). This is a strictly Nearctic species. Although, according to Casanueva (2001), Bishop and Trembley (1945) reported the presence of *Am. americanum* in Paraguay, these authors did not, in fact, include Paraguay in their discussion of this species’ range.

*Amblyomma maculatum* Koch. Neumann (1899) reported males, females and nymphs of *Am. maculatum* from an unknown host and locality in Paraguay. Prior to the resurrection of *Am. tigrinum* and *Am. triste* by Kohls (1956), these species were often mis-identified as *Am. maculatum*, which does not occur in southern South America. *Amblyomma maculatum* is a Neotropical–Nearctic species, with *bona fide* records only from Belize, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Peru, the U.S.A. and Venezuela (Estrada-Peña et al., 2005).

**DISCUSSION**

The Paraguayan tick fauna is currently known to consist of 30 species but it seems likely that several other species may be present. To date, most tick records have been from the Chaco, rather than Amazonic, domain, and no specimens from Paraguay’s relatively small CePP were available for the present review. Nonetheless, the present study yielded three new records for Paraguay: *Orn. hasei, Am. rotundatum* and *Am. triste*. As expected,
collection frequency was largely a function of human-population density, most collections having been made in the populous centre of the country, especially in the area around metropolitan Asunción.

The brown dog tick, *Rh. sanguineus*, is the most widely distributed tick species in the world (Keirans, 1992) and is able to complete its life-cycle indoors (Koch, 1982). This species has, surprisingly, only been recorded in a few localities in the ChPP and PaPP, and it is almost certainly much more widespread in Paraguay than these records indicate. As Oliveira et al. (2005) and Szabó et al. (2005) recently found morphological, biological and molecular evidence to support the presence of two species of the *Rh. sanguineus* tick group in Argentina and Brazil, additional studies of Paraguayan 'Rh. sanguineus' are needed, to determine whether these ticks represent *Rh. sanguineus sensu stricto*, a closely related taxon, or both.

*Amblyomma tigrinum* was found in both the Amazonic and Chaco domains, which accords with Guglielmone et al. (2000), who observed that this species is able to colonize regions with vastly different climates, including the xeric environment of Patagonia, in southernmost Argentina. The Paraguayan ranges of *Am. parvum* and *Am. cajennense* appear to be extensions of their ranges in Argentina, with *Am. parvum* restricted to dry areas of the Chaco domain and *Am. cajennense* more widespread, even in the Amazonic domain (Mangold et al., 1990; Guglielmone et al., 1990). In contrast, *Am. aureolatum*, which has only been recorded at one site in Paraguay, appears to be less abundant and significantly more restricted in distribution than the related *Am. ovale*. Additional research is needed to understand the distribution of both of these species, although it appears that, in general, the range of *Am. ovale* is more extensive than that of *Am. aureolatum* in the central and western portions of the Neotropical Region (Guglielmone et al., 2003c). Paraguay would benefit from a country-wide survey of its ticks, to delimit precisely the ranges of those tick species that are of medical or veterinary importance or that are key indicators of biodiversity.

The reptile and amphibian parasites *Am. dissimile* and *Am. rotundatum* are known to produce long-lasting wounds; they may also affect the reticulo-endothelial system of their hosts and transmit toxins (Aragão, 1936; Jakowska, 1972). *Rhipicephalus microplus* and *Rh. sanguineus* are well known for their capacity to heavily infest cattle and dogs, respectively, and to transmit disease-causing pathogens to their hosts (Guglielmone, 1995; Bool and Sutmöller, 1957). The same applies to infestations of horses with *De. nitens* (Friedhoff and Soulé, 1996) and of chickens with *Ar. persicus* or *Ar. miniatus* (Hoogstraal, 1985). *Argas miniatus* may cause paralysis in its avian hosts (Magalhães et al., 1987). Additional collections of argasids in Paraguay are needed in order to confirm the presence of *Ar. miniatus* and resolve the issue of whether *Ar. persicus* and/or a sibling species occurs in the country’s chicken houses. Recently, Petney et al. (2004) used molecular evidence to verify the presence of *Ar. persicus sensu stricto* in Australia; similar studies are needed to determine the taxonomic status of specimens hitherto identified as *Ar. persicus* in Paraguay and other Neotropical countries.

It is important to note that *Orn. rudis*, *Am. aureolatum*, *Am. brasiilense*, *Am. cajennense*, *Am. coelebs*, *Am. incisum*, *Am. ovale* and *A. tigrinum* have all been found on humans in Paraguay. Moreover, Massi Pallarés and Benítez Usher (1982) suspect that *Orn. rostratus* also attacks humans in Paraguay, as it does in Argentina (Boero, 1957). *Amblyomma parvum* and *Am. triste* appear to be frequent ectoparasites of humans in Argentina and Uruguay, respectively (Guglielmone et al., 1991; Venzal et al., 2003), and probably therefore also attack humans in Paraguay. *Ornithodoros talaje*/*Orn. puertoricensis*, *Am. calcaratum*, *Am. dissimile*, *Am. dubitatum*, *Am. longirostre*, *Am. pacae*, *Am. pseudoparvum*, *Am. rotundatum*, *De. nitens*, *Ha. juxtakochi*, *Ha. leporispalustris*, *Rh. microplus* and *Rh. sanguineus* have all been found attached to humans in several Neotropical countries (Guglielmone et al., 2003a).
Although there appear to be no published reports of ticks transmitting pathogens to humans in Paraguay, both *Am. cajennense* and *Am. triste* are known to transmit rickettsiae (*Rickettsia rickettsii* and *Ri. parkeri*, respectively) in other South American countries (Labruna, 2004; Venzal *et al*., 2004), and *Ri. rickettsii* has been isolated from *Am. aureolatum* (Salles Gomes, 1933). *Ornithodoros rostratus*, *Orn. rudis*, *Ha. leporispalustris* and *Rh. sanguineus* may play a role in the maintenance of rickettsiae of the spotted-fever group (Hoogstraal, 1985; Labruna, 2004). Bites of *Orn. rostratus* are extremely painful to humans, causing itching, inflammation and blisters (Boero, 1957), and members of the genus *Ornithodoros* are involved in the transmission of relapsing fever spirochaetes in South America (Hoogstraal, 1985). *Ehrlichia canis* or a closely related species has been isolated from humans in Venezuela (Perez *et al*., 1996), and evidence indicates that *Rh. sanguineus* is the vector (Unver *et al*., 2001). These observations indicate that, apart from their veterinary impact, a significant number of Paraguayan ticks may pose a threat to human health.

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