Exp Appl Acarol (2014) 62:91–104
DOI 10.1007/s10493-013-9725-3

Amblyomma parvitarsum (Acari: Ixodidae): localities, hosts and host-parasite ecology

Sebastián Muñoz-Leal · Daniel González-Acuña · L. Fabián Beltrán-Saavedra · Juan M. Limachi · Alberto A. Guglielmone

Received: 19 July 2013 / Accepted: 10 August 2013 / Published online: 24 August 2013

Abstract Only a few aspects of the biology of *Amblyomma parvitarsum* Neumann are known. Adults of this hard tick species are parasites of South American camelids in the Andean plateau of Argentina, Bolivia, Peru and Chile and also in the Argentine Patagonia, but they have been also rarely found on other artyodactils and two species of birds. The larva has been collected from reptiles in northern Chile, whereas the hosts for the nymph remain unknown. On nine localities included within Altitude Tropical and Perarid Mediterranean ecoregions in northern Chile, we analyzed 237 reptiles, 285 birds, 624 rodents and 52 camelids for infestation with *A. parvitarsum* to calculate seasonal prevalence of this tick. We also reviewed the literature of this tick and three entomological collections for obtaining and summarizing all the information to date about this tick. None of the analyzed birds and rodents were parasitized with *A. parvitarsum*; however, seven over a total of ten reptile species that we caught were infested with the larva. In the camelid species *Lama glama* and *Vicugna pacos* we collected adult specimens of this tick. Larval prevalence was higher during fall (75 %) in *Liolaemus pleopholis* in the Altitude Tropical ecoregion. We also collected adult specimens of *A. parvitarsum* from camelid manure heaps during summer in Salar de Surire and Llullaillaco localities. Additionally, we also reviewed the literature of this tick and examined specimens in three entomological collections for obtaining and summarizing all the information to date about this tick. By this study, nine localities and seven new hosts are added for *A. parvitarsum* and we confirm reptiles as specific hosts of this tick larva.

S. Muñoz-Leal · D. González-Acuña (✉)
Departamento de Ciencias Pecuarias, Facultad de Ciencias Veterinarias, Universidad de Concepción, Av. Vicente Méndez 595, CP 3780000 Chillán (Biobío), Chile
e-mail: danigonz@udec.cl

L. F. Beltrán-Saavedra · J. M. Limachi
Sección de Invertebrados, Colección Boliviana de Fauna, Museo Nacional de Historia Natural-Universidad Mayor de San Andrés, Casilla 8706, La Paz, Bolivia

A. A. Guglielmone
Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Rafaela, CC 22, CP 2300 Rafaela, Santa Fe, Argentina

Keywords *Amblyomma parvitarsum* · Hard ticks · Distribution · Host-parasite relationship · Ecology

Introduction

In the neotropical region, the genus *Amblyomma* Koch, 1844 (Ixodidae) is represented by 45 species (Guglielmone et al. 2004). In a recent review of these species Voltzit (2007) confuses *A. neumanni* Ribaga 1902 with *A. parvitarsum* Neumann 1901 (Nava et al. 2009). These two species are included within the *A. maculatum* Koch, 1844 tick group in the *Anastosiella* subgenera (Camicas et al. 1998), however genetic analysis proved that *A. neumanni* and *A. parvitarsum* belong to a different subgenera more related to the *A. ovale* Koch, 1844 tick group (Estrada-Peña et al. 2005). In the Neotropics, at least 21 *Amblyomma* species use reptiles as hosts, five species parasitize birds and artiodactyls and seven species are parasites of rodents for at least one of their life stages (Guglielmone et al. 2004).

Hard ticks of the genus *Amblyomma* have a three-host life cycle (Oliver 1989) and are vectors of several pathogens of zoonotic potential (Labruna et al. 2004; Venzal et al. 2004; Nava et al. 2008). The complete life cycle of *A. parvitarsum* is still unknown (Aguirre et al. 1997). Dios (1917) tried to feed females of this tick on goats, sheep and swine but he did not obtain positive results. Later, Aguirre et al. (1997) attempted to replicate the biological cycle under laboratory conditions, however he failed because he used incorrect hosts (camelids) for feeding the larva. Recently, Estrada-Peña et al. (2005) describe the larva but the nymph still remains unknown (Guglielmone et al. 2004).

Adults of this tick have been isolated from cattle and sheep in provinces of north and south Argentina (Boero 1954; Estrada-Peña et al. 2005), and Ivancovich and Luciani (1992) describe its finding in cattle and horses in non-Andean environments in central and northwestern Argentina, however the latter records are considered doubtful (Guglielmone and Nava 2006). Need et al. (1991) stated that the larva and nymph of *A. parvitarsum* may feed in reptiles and probably in little birds. In fact, González-Acuña et al. (2004) found the larva to be a parasite of the lizard *Liolaemus jamesi* Boulanger 1981 (Squamata: Liolaemidae) in Salar de Surire (18°50′S 69°06′O) in the Chilean Altiplano, which is to date the only documented record of a reptile host for this tick. Moreover, the Food and Agriculture Organization (FAO 1988) suggested that, besides reptiles and birds, immature stages of *A. parvitarsum* could be found on moles and vizcachas (*Lagidium* spp.), but to date there is no information to validate this assertion. Adults of this tick have been reported in only two birds species, *Pterocnemia pennata* Sibley and Monroe 1993 (Boero 1957) and *Spheniscus magellanicus* Forster 1781 (Becker et al. 1997), nonetheless these both hosts are considered accidental (Estrada-Peña et al. 2005).

The species *A. parvitarsum* was described by Neumann (1901) from female ticks collected in Bolivia and in the Argentinean Patagonia, without specifying the host. Years later, Dios (1917) gave a wrong diagnosis and identified the species *A. altiplanum* from male and female specimens of *A. parvitarsum* collected from *Lama glama* Linnaeus 1785 on the Andean plateau of Argentina and Bolivia. Later, most of the published information about this tick has consisted of findings in different localities and hosts, which are included in lists of ticks of Argentina (Aragão 1935, 1938; Boero 1944, 1954, 1957, 1959; Guglielmone and Nava 2006; Ortiz et al. 2011), Peru (Need et al. 1991) and also in reports in the Patagonean Andean region (Peralta et al. 1994; González-Acuña et al. 2004; Beltrán-Saavedra et al. 2011).

The geographic distribution of *A. parvitarsum* includes the Andean plateau of Argentina, Bolivia, Chile and Peru and also the Argentine Patagonia (Boero 1957) where adults are parasitic on South American camelid species of the genera *Lama* and *Vicugna* (Guglielmone et al. 2004). Nava et al. (2013) found a male *A. parvitarsum* specimen together with skeletal remains of *Vicugna vicugna* Molina, 1782 in archaeological layers of Late Holocene in a rock shelter used by hunter-gatherer groups in northern Argentina. Despite this interesting host-parasite relationship, studies of population dynamics and of the ecology of this tick in its habitat are still lacking.

The present study is a review of all the existing data about the distribution and hosts for *A. parvitarsum* including new hosts and locality reports for Argentina, Bolivia and Chile and we present unpublished data on parasite-host ecology of this tick.

Materials and methods

Literature and entomological collections review

A systematic revision of all the existent literature about *A. parvitarsum* was made and we made a table with a complete record of localities and hosts. Moreover, unpublished data of *A. parvitarsum* were obtained from a revision of specimens of the Colección Boliviana de Fauna (CBF), La Paz, Bolivia, the Colección de Zoología de la Facultad de Ciencias Veterinarias de la Universidad de Concepción (CZVUC), Chillán, Chile, and the collection of the Instituto Nacional de Tecnología Agropecuaria (INTA), Rafaela, Argentina.

Study sites

A seasonal analysis of reptiles, birds, rodents and camelids was made between December of 2011 and October of 2012 in seven localities of the Altitude Tropical (AT) ecoregion and in three localities of the Perarid Mediterranean (PM) ecoregion, both zones located in northern Chile (Fig. 1). The TA ecoregion is characterized by presenting Andean plateau (3,800–4,500 m) and tropical climate tendencies that concentrates rainfall during warm months (Di Castri 1968). To the western limits of this ecoregion, it extends to the Atacama Desert and towards southern latitudes the aridity of the environment is attenuated by the Pacific Ocean's influence, given rising to the PM ecoregion, where the dry season occurs during spring and summer and scarce rainfall in cold months (Di Castri and Hajek 1976).

Reptiles, birds, rodents and camelids capture

Over a total of 68 sampling days, reptiles were captured by noosing (Klukowski and Nelson 2001) with a capture effort of 6 h/day. Birds were captured using two mist nests (Ecotone®, Gdynia, Polonia) of 20 × 3.2 m (26 mm of mesh), with a capture effort of 128 m^2 × 10 h/day. We use 100 Sherman-like traps for capturing rodents with 100 traps × 10 h/night as capture effort. For larger rodents we also use two Tomahawk-like traps that remain active during our stay on one site. Domestic camelids were analyzed within their enclosures in the localities of Ollagüe and Enquelga (Fig. 1). All captures were authorized by the Servicio Agrícola y Ganadero and the Corporación Nacional Forestal by the resolutions n° 2012 and n° 11/2010, respectively.

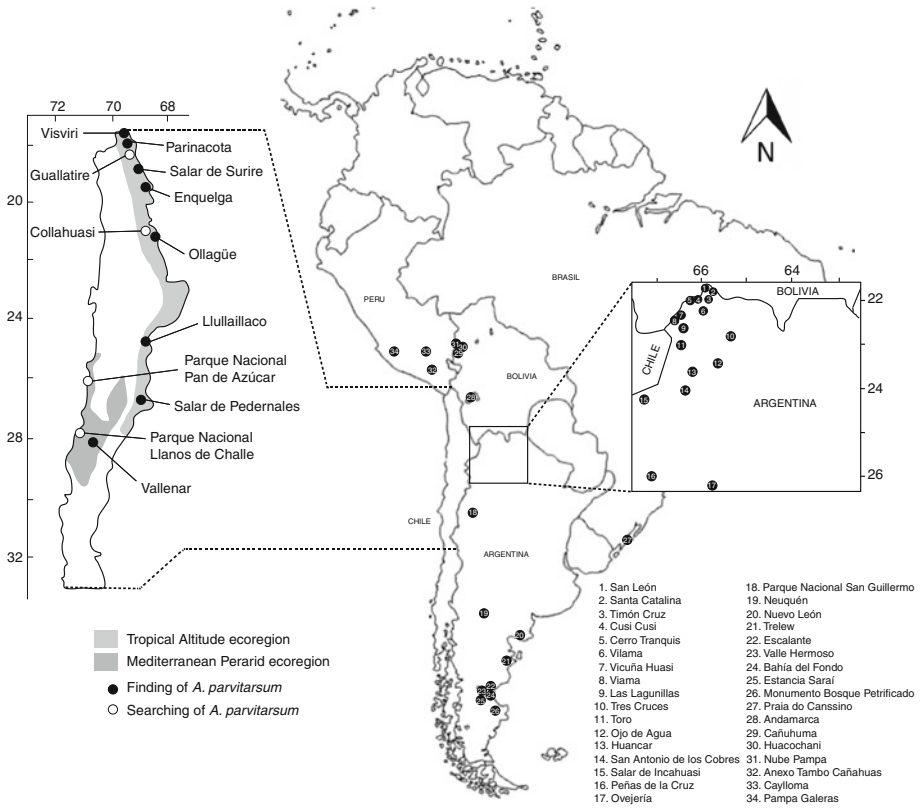

Fig. 1 South American localities where *A. parvitarsum* has been reported and study sites in chile

Tick collecting methods

Observed ticks were collected using metallic clamps and put in 70 % alcohol tubes for laboratory analysis. We registered tick's location on the host's body and calculate their prevalence. In Parinacota, Guallatire, Enquelga, Collahuasi, Ollagüe and Llullaillaco, we searched for ticks in camelid manure heaps. Larva and adult tick identification was done using the keys given by Estrada-Peña et al. (2005) and collected ticks were deposited in the CZVUC (CZVUC V204, V215, V220–V225, V238–V242, VI298, VI299, VII455, VII460, VII462–VII465, VII498, VII499, VII501, VIII231, VIII254).

Statistical analysis

In order to obtain representative results, prevalence was seasonally compared only in hosts captured at a minimum number of 25 individuals per season (Poulin 1996; Jovani and Tella 2006). Mean numbers were obtained for infested corporal regions. Both analyses were made using the software Quantitative Parasitology 3.0 (Rózsa et al. 2000).

Results

Distribution

Considering the revision of all the existent literature, the revision of the CBF (CBF-Ixo-00008–00013 and CBF-Ixo-00030–00035), the CZVUC (CZVUC 53, CZVUC 124–132, V204, V215, V220–V225, V238–V242, VI298, VI299, VII455, VII460, VII462–VII465, VII498, VII499, VII501, VIII231, VIII254), the INTA collection (INTA 1272, 1815, 1838, 2043, 2089, 2223), and new records given by this study, *A. parvitarsum* have been described in 26 localities in Argentina (Aragão 1935, 1938; Boero 1944, 1954, 1959; Keirans 1985; Peralta et al. 1994; Aguirre et al. 1997; Arce de Hamity and Ortiz 2004; Estrada-Peña et al. 2005; Ortiz et al. 2011; Nava et al. 2013; this study), eight in Chile (González-Acuña et al. 2004; this study), four in Bolivia (Beltrán-Saavedra et al. 2011; this study), three in Peru (Dale and Venero 1977; Need et al. 1991; Guglielmone et al. 2005) and one in Brazil (Becker et al. 1997) (Table 1).

Hosts

Reptiles

In total, 237 *Liolaemus* lizards (Squamata: Liolaemidae) were captured: *L. andinus* (n = 3), *L. alticolor* (n = 3), *L. atacamensis* (n = 11), *L. bisignatus* (n = 158), *L. copiapoensis* (n = 15), *L. jamesi* (n = 7), *L. nigriceps* (n = 3), *L. ornatus* (n = 2), *L. patriciaiturrae* (n = 3) and *L. pleopholis* (n = 34). Seven of ten species were parasitized by the larva of *A. parvitarsum*, collecting a total of 101 ticks over 35 infected lizards (14.6 %). As individuals of *L. bisignatus*, *L. atacamensis* and *L. jamesi* were not parasitized, and due to the small sample obtained for *L. andinus*, *L. alticolor*, *L. nigriceps*, *L. ornatus* and *L. patriciaiturrae*, statistical analysis for prevalence was only made for *L. pleopholis.* For this lizard, prevalence was calculated in three seasons: fall (75 %), spring (28.6 %) and summer (54.6 %), however this observed variation was not significant ($p = 0.09$; $\alpha = 0.05$). Mean abundances of ticks on different corporal regions are showed in Table 2.

Birds

Birds were caught in Parinacota, Salar de Surire, Enquelga, Ollagüe, Parque Nacional Pan de Azúcar and Parque Nacional Llanos de Challe (Fig. 1). In total we analyzed 15 Columbiformes and 270 Passeriformes birds belonging to seven families, twelve genera and 19 species (*Agriornis montana*, *Asthenes humicola*, *A. modesta*, *Diuca diuca*, *Geositta cunicularia*, *G. rufipennis*, *Metriopelia aymara*, *Muscisaxicola maculirsotris*, *Leptasthenura aegitaloides*, *Passer domesticus*, *Phrygilus alaudinus*, *P atriceps*, *P. fruticeti*, *P. gayi*, *P. plebejus*, *Scelorchilus albicollis*, *Upucerthia dumetaria* and *Zonotrichia capensis*). No infestation by *A. parvitarsum* was detected. However, of the analysis of CVZUC we found one female of *A. parvitarsum* collected from a Choique (*P. pennata*) in Argentine Patagonia (Estancia Saraí, Santa Cruz) (Table 1).

Rodents

For rodents (Rodentia) we caught a total of 624 specimens belonging to four families, eight genera and 15 species (*Abrocoma cinereus*, *Abrothrix andinus*, *Abrot. longipilis*, *Abrot.*

Table 1 Localities and hosts of *Amblyomma parvitarsum* in the Neotropical region

Administrative division	Locality	Date	Geographical coordinates	Host	Ticks (M, F, L)	References
Argentina						
Jujuy	San León	Unknown	21°55′00″S; 66°14′00″O	*L. glama*, *V. vicugna*	19M, 8F	Aragão (1935, 1938), Keirans (1985)
	Santa Catalina	Unknown	21°57′20″S; 66°03′29″O	*L. glama*, *V. vicugna*	19M, 8F	Aragão (1935, 1938)
	Timón Cruz	Jan 12, 1994	22°11′19″S; 66°09′40″O	*L. glama*	5M, 3F	Ortiz et al. (2011)
	Limitayoc	Oct 21, 1999	Unknown	*L. glama*	Adults	Arce de Hamity and Ortiz (2004)
	Cerro Tranquis	Mar 2, 2000	22°19′00″S; 66°37′00″O	*L. glama*	2F	Ortiz et al. (2011)
	Cusi Cusi	Oct 21, 1999	22°20′28″S; 66°29′16″O	*L. glama*	Adults	Arce de Hamity and Ortiz (2004)
	Vilama	Jan 1, 1999	22°26′23″S; 66°09′57″O	*L. glama*	Adults	Arce de Hamity and Ortiz (2004)
	Vicuña Huasi	Nov 10, 2009	22°27′00″S; 66°47′00″O	*L. glama*	1M, 1F	Ortiz et al. (2011)
	Viama	Nov 10, 2009	22°36′00″S; 66°55′00″O	*L. glama*	4M, 3F	Ortiz et al. (2011)
	Unknown	Unknown	Unknown	*L. guanicoe*, *V. vicugna*	Unknown	Boero (1944, 1954, 1959)
	Las Lagunillas	Jan 14, 1983	22°45′00″S; 65°45′00″O	*L. glama*	3M, 6F	This study
	Tres Cruces	Unknown	22°55′17″S; 65°35′20″O	Unknown	Unknown	Boero (1959)
	Toro	Feb 2000	23°11′00″S; 66°50′00″O	*L. glama*	1M, 8F	This study
	Ojo de Agua	Apr 1995	23°28′00″S; 65°58′00″O	*L. glama*	365M, 119F	Aguirre et al. (1997)
	Huancar	Dec 1999	23°45′00″S; 66°30′00″O	*L. glama*	1F	Estrada-Peña et al. (2005)
Salta	San Antonio de los Cobres	Jan 28, 2013	24°13′00″S; 66°45′00″O	*V. vicugna*	6M, 16F	This study
	Salar de Incahuasi	Apr 26, 1985	24°15′00″S; 67°33′00″O	*V. vicugna*	1M, 1F	This study
Catamarca	Peñas de la Cruz	Unknown	26°05′00″S; 67°19′00″O	Late Holocene	1M	Nava et al. (2013)
	Ovejería	Mar 1993	26°14′16″S; 66°09′49″O	*L. glama*	2M, 12F	Peralta et al. (1994)
San Juan	Parque Nacional San Guillermo	Mar 7, 2009	29°28′00″S; 68°19′00″O	*V. vicugna* manure heap	2M, 2F	This study

Table 1 continued

Administrative division	Locality	Date	Geographical coordinates	Host	Ticks (M, F, L)	References
Neuquén	Neuquén	Unknown	38°57′42″S; 68°03′43″O	*B. taurus*	Unknown	Boero (1954)
Río Negro	Nuevo León	Unknown	40°44′45″S; 64°14′45″O	*Ovis aries*	Adults	Boero (1959)
Chubut	Escalante	Unknown	45°45′00″S; 67°45′00″O	*B. taurus*	Adults	Boero (1954, 1959)
	Valle Hermoso	Unknown	45°45′40″S; 68°29′05″O	*L. guanicoe*	Adults	Boero (1944, 1954, 1959)
	Trelew	Unknown	43°16′59″S; 65°15′19″O	*Pterocnemia pennata*	Adults	Boero (1954)
Santa Cruz	Bahía del Fondo	Unknown	46°03′17″S; 67°37′03″O	*L. guanicoe*	Adults	Boero (1944, 1954, 1959)
	Estancia Saraí	Feb 27, 2007	46°20′49″S; 68°52′07″O	*P. pennata*	1F	This study
	Monumento Bosque Petrificado	Sep 2008	47°40′00″S; 68°10′00″O	On vegetation	3M	This study
Bolivia						
La Paz	Nube Pampa	Oct 28, 2006	14°52′41″S; 69°13′25″O	*V. vicugna*	2F	Beltrán-Saavedra et al. (2011)
	Huacochani	Nov 4, 2006	14°58′38″S; 69°15′24″O	*V. vicugna*	2M	Beltrán-Saavedra et al. (2011)
	Cañuhuma	Dec 5, 2006	15°01′36″S; 69°13′02″O	*V. vicugna*	2M, 1F	Beltrán-Saavedra et al. (2011)
		Nov 6, 2007	15°01′15″S; 69°13′03″O	*V. vicugna*	1M, 5F	This study
Oruro	Andamarca	Nov 16, 2008	18°47′02″S; 67°28′55″O	*V. vicugna*	1M, 1F	This study
		Nov 16, 2008	18°47′02″S; 67°28′55″O	*L. glama*	2M, 2F	This study
Brazil						
Rio Grande do Sul	Praia do Cassino	Sep 2, 1996	32°11′04″S; 52°09′08″O	*Spheniscus magellanicus*	1F	Becker et al. (1997)
Chile						
Arica y Parinacota	Visviri	Jul 12, 2012	17°35′45″S; 69°28′56″O	*L. lama*, *V. pacos*	12M, 23F	This study
	Parinacota	Mar 21, 2012	18°09′55″S; 69°18′01″O	*Liolaemus pleopholis*	76L	This study
	Salar de Surire	Mar 1, 2003	18°50′00″S; 69°06′00″O	*L. jamesi*	3L	González-Acuña et al. (2004)
		May 28, 2011	18°51′12″S; 69°08′25″O	*L. alticolor*	1L	This study
		Mar 23, 2012	18°51′12″S; 69°08′25″O	*V. vicugna* manure heap	3M	This study

Table 1 continued

Administrative division	Locality	Date	Geographical coordinates	Host	Ticks (M, F, L)	References
Tarapacá	Enquelga	Mar 24, 2012	19°13′29″S; 68°49′08″O	*L. ornatus*	3L	This study
		Mar 24, 2012	19°13′56″S; 68°47′56″O	*V. pacos*	3M	This study
Antofagasta	Ollagüe	Mar 12, 2012	21°10′02″S; 68°20′09″O	*L. glama*	1F	This study
Atacama	Volcán Llullaillaco	Feb 15, 2005	24°42′41″S; 68°39′44″O	*L. andinus*	2L	This study
		Feb 15, 2005	24°42′41″S; 68°39′44″O	*L. nigriceps*	5L	This study
		Feb 15, 2005	24°42′41″S; 68°39′44″O	*V. vicugna* manure heap	1M	This study
	Salar de Pedernales	Nov 20, 2010	26°18′90″S; 69°14′96″O	*L. patriciaiturrae*	2L	This study
	Vallenar	Sep 15, 2005	28°12′40″S; 70°38′47″O	*L. copiapoensis*	12L	This study
Peru						
Arequipa	Caylloma	Unknown	15°11′00″S; 71°47′00″O	*L. glama*	Unknown	Need et al. (1991)
	Anexo Tambo Cañahuas Pampa Galeras	Unknown	16°01′00″S; 71°26′00″O	*V. pacos*	3M, 20F	Guglielmone et al. (2005)
Ayacucho		Jan 3, 1974	14°42′00″S; 74°25′00″O	*V. vicugna*	4M, 1F	Dale and Venero (1977)
		Oct 23, 1974	14°42′00″S; 74°25′00″O	*L. glama*	1F	Dale and Venero (1977)
		Oct 16, 1975	14°42′00″S; 74°25′00″O	*V. vicugna* manure heap	5M, 5F	Dale and Venero (1977)
		Jun 6, 1976	14°42′00″S; 74°25′00″O	*V. vicugna* manure heap	7M, 7F	Dale and Venero (1977)

F female, *M* male, *L* larva

Table 2 Mean numbers of the larvae of *Amblyomma parvitarsum* on *Liolaemus* lizards

Host	n	I	Corporal region									
			AO	GR	PFR	N	CLO	HL	VR	AP	FL	GR
L. alticolor	3	1						0.30				
L. andinus	3	3			0.67							
L. copiapoensis	15	5	0.33		0.27		0.20					
L. nigriceps	3	3	0.67	1								
L. ornatus	2	2	1.50									
L. patriciaiturrae	3	1				0.333						
L. pleopholis	34	20	0.41	0.29	0.05	0.34	0.47	0.02	0.29	0.23	0.05	0.05
Total	63	35	2.91	1.29	0.98	0.67	0.67	0.32	0.29	0.23	0.05	0.05

I number of infested hosts, *AO* auricular orifice, *GR* gular region, *PFR* post femoral regions, *N* neck, *CLO* cloaca, *HL* hind limbs, *VR* ventral region, *AP* arm pits, *FL* flanks, *GR* groin

olivaceus, *Akodon albiventer*, *Ak. berlepschi*, *Auliscomys sublimis*, *Eligmodontia hirtipes*, *E. puerulus*, *Eligmodontia* sp., *Lagidium viscacia*, *Oligoryzomys longicaudatus*, *Phyllotis darwini* and *P. xanthopygus*) at the same bird capture localities. No rodents were parasitized with *A. parvitarsum*.

Camelids

Amblyomma parvitarsum was observed in three domestic populations of *Vicugna pacos* and *L. glama* in different seasons: Enquelga (summer, n = 12), Ollagüe (winter, n = 15; summer, n = 5) and Visviri (summer, n = 20), locality of CZVUC analyzed ticks. In these three localities we observed a total of 39 adults of *A. parvitarsum* (24 females and 15 males). In both Visviri and Enquelga, observed prevalence was 50 % and in Ollagüe only one individual was observed in during summer (20 %).

Manure heaps

Over a total of 37 manure heaps of wild and domestic camelids (*V. vicugna* and *V. pacos* respectively), analyzed in Parinacota (n = 7), Salar de Surire (n = 8), Guallatire (n = 4), Enquelga (n = 7), Collahuasi (n = 4), Ollagüe (n = 4) and Llullaillaco (n = 3) localities, we only collected three males of *A. parvitarsum* in Salar de Surire and one male in Llullaillaco. In both cases, ticks were found hidden under the dung. No ticks were observed in manure heaps analyzed in Parinacota, Guallatire, Enquelga, Collahuasi and Ollagüe. Moreover, of the analysis of the INTA collection, we found two males and two females collected during autumn (Mar 7, 2009) in a *V. vicugna* manure heap in Parque Nacional San Guillermo (San Juan, Argentina), and three males collected on vegetation during spring (Sep 2008) in Monumento Bosque Petrificado (Santa Cruz, Argentina) (Table 1).

Discussion

The hard tick *A. parvitarsum* is described as an inhabitant of Andean and Patagonic environments and in association with populations of South American camelids (Boero 1957; Guglielmone et al. 2004). Although described for Chile, Bolivia, Peru and

Argentina, it is at the northern end of the latter country where records of adults of this tick are concentrated, which could be explained by the greater sampling effort that has existed in the area. The larva has only been reported in Chile as a parasite of lizards (González-Acuña et al. 2004) and the nymph still remains unknown, however it is probable that it also parasitizes reptiles but during a short period of time. Therefore, it would be less probable to observe it and this may be the reason why we could not find it during this study.

Hosts

Considering literature and the data obtained by this study, to date *A. parvitarsum* has eight reptiles, two bird and seven mammal species as hosts. However, the finding of adults of this tick on horses and cattle (Ivancovich and Luciani 1992) in San Pedro de Toyos (Córdoba, Argentina) and Salta (Salta, Argentina) are considered doubtful by Guglielmone and Nava (2006).

Reptiles

With the data collected in this study, we observed that, at least in Chile, hosts of *A. parvitarsum* larva correspond to lizards of *Liolaemus* genus. This reptile genus is also present in all the other countries where *A. parvitarsum* inhabits, therefore the number of reptile species hosts might be still underestimated. Seven of ten reptiles species analyzed in this study were parasitized with the larva of *A. parvitarsum*. Even when González-Acuña et al. (2004) found the larva of this tick parasitizing *L. jamesi* in Salar de Surire, none of these lizard species analyzed in the present study were infested. However, in the same locality, we found one individual of *L. alticolor* with one larva of *A. parvitarsum*, confirming its presence there.

Higher prevalence of the larva observed in *L. pleopholis* during the fall (75 %) in Parinacota, might be explained by optimum humidity and temperature conditions as a consequence of regular summer rainfall occurring in the AT ecoregion (Di Castri and Hajek 1976). However, it also might be explained by the absence of active *L. pleopholis* individuals during winter (possibly due to low temperatures), which would force the larva of *A. parvitarsum* to seek a reptile host before they take refuge underground. Moreover, at this locality there exist large groups of domestic Alpacas (*V. pacos*) and Llamas (*L. glama*) that might harbor adult stages of this tick. Higher density of these camelid groups could also explain the higher prevalence observed in *L. pleopholis* in this locality.

The finding of *A. parvitarsum* in *L. copiapoensis*, a lizard that inhabits the interior zones of the PM ecoregion (Veloso and Navarro 1988), suggests that this tick does not restrict its habitat to altiplanic hosts of AT ecoregion. In fact, there are reports of adult *A. parvitarsum* in the Argentinean Patagonia (Boero 1957) where populations of *Lama guanicoe* exist (González et al. 2006). Therefore, if we consider *L. guanicoe* populations of the coastal PM ecoregion (25°–28°S) of Argentine and Chilean Patagonia and the northern portion of Tierra del Fuego island (50°–55°S) (González et al. 2006) and the existence of sympatric *Liolaemus* lizards populations, both at the PM ecoregion (Moreno et al. 2002; Vidal et al. 2009) and in the southern portion of Patagonia (Jaksic and Schwenk 1983), *A. parvitarsum* might have a larger distribution. Notwithstanding the foregoing, none of *L. bisignatus* individuals, analyzed in the coastal portion of PM (Parque Nacional Pan de Azúcar and Parque Nacional Llanos de Challe), were positive for this tick larva. Estrada-Peña (2002) suggests that the distribution of a tick species might not only depend on abiotic factors such as temperature or humidity but also on hosts occurrence and availability in a particular

habitat. In this way, low density and fragmentation of coastal *L. guanicoe* populations inhabiting visited localities at the PM ecoregion (Marín et al. 2008), also separated from populations of the AT ecoregion at the same latitudes (González et al. 2006), might be ecological reasons that prevent the development of *A. parvitarsum* life cycle. However, more prospections of sympatric lizard populations might be done within camelid species distributional range in the PM ecoregion in order to confirm the absence of this tick in this zone.

Anatomic preference of larva on its host was mainly auricular orifices. This body zone might be an ecologic niche for parasites that cannot hide under a host's scales and also constitute sites of difficult access to get rid of them (Fajfer 2012). Lizards of the genus *Liolaemus* have little thin round scales around the tympanic membrane (Donoso-Barros 1966; Pincheira-Donoso and Núñez 2005), making the adhesion and blood sucking easier for this tick larva.

Birds

Need et al. (1991) stated that in addition to reptiles, little birds may be hosts of the larva of *A. parvitarsum*. However, none of the analyzed birds was parasitized by immature stages of this tick, even when sympatric analyzed reptiles were positive to the larva. The sole records of *A. parvitarsum* parasitizing birds correspond to one female isolated on *S. magellanicus* in Brazil (Becker et al. 1997) and an adult specimen of unspecified sex collected on *P. pennata* in the Southern Patagonia of Argentina (Boero 1954). Moreover in this study we identify a female again on a Choique (*P. pennata*) in southern Argentina. This data discards little birds as hosts of this tick and suggests that no flying birds might be occasional hosts of adult stages of *A. parvitarsum* and that, at least the larva, would be a specific parasite of reptiles. Otherwise, we still consider exceptional the report of this tick on *S. magellanicus*.

Rodents

Contrary to the proposal by the FAO (1988) that immature stages of *A. parvitarsum* should parasite moles and vizcachas (*Lagidium* spp.), none of the analyzed rodents was infested with *A. parvitarsum*. This data suggests that immature stages of this tick might not use mammal hosts since rodents were captured at the same localities where analyzed reptiles were infested.

Camelids

For this study adult ticks were collected only on domestic *L. glama* and *V. pacos*, a still unreported host for *A. parvitarsum* in Chile (Donoso 1953; Tagle 1971). The four South American camelids species (*L. glama*, *L. guanicoe*, *V. pacos* and *V. vicugna*) have been described as hosts of *A. parvitarsum* in Argentina (Aragão 1935, 1938; Boero 1944, 1954, 1957, 1959; Peralta et al. 1994; Aguirre et al. 1997; Arce de Hamity and Ortiz 2004; Ortiz et al. 2011), however only *L. glama* and *V. vicugna* has been reported as hosts in Bolivia (Dios 1917; Beltrán-Saavedra et al. 2011). In Peru, the sole species still not recorded as a host of this tick is *L. guanicoe*. Although adult stages of *A. parvitarsum* have been described as specifics of South American camelids (Hoogstraal and Aeschlimann 1982), there are some reports on other herbivore mammals and on two bird species, indicating

only a moderate specificity (Estrada-Peña et al. 2005). All ticks collected from camelids were engorged in perianal and inguinal region on the host. These body regions have thin skin and would be preferred by this blood sucking parasites (Dios 1917; FAO 1988; Aguirre et al. 1997). This data is consistent with other studies (Peralta et al. 1994; Beltrán-Saavedra et al. 2011).

Ticks in the environment

Besides *A. parvitarsum* males collected during summer in *V. vicugna* manure heaps in Salar de Surire and Llullaillaco (Chile) and during fall in the Parque Nacional San Guillermo (Argentina), Dale and Venero (1977) collected adult specimens of this tick from manure heaps of the same camelid species in Pampa Galeras (Peru) during winter and spring. *A. parvitarsum* is a tick adapted to live under extreme conditions in all seasons. Other hard ticks (e.g. *Ixodes uriae* White 1852) living in similar extreme conditions have more than a 1 year life cycle (Frenot et al. 2001) and remain hidden under rocks in the environment (Benoit et al. 2008). Nevertheless, *A. parvitarsum* could occasionally be on vegetation, as suggested by the finding of one specimen in Monumento Bosque Petrificado, at Argentine Patagonia. The presence of adults of this tick during fall, winter, spring and summer, may indicate that its biological cycle requires more than a year to be accomplished.

Through this study the presence of *A. parvitarsum* is confirmed in seven *Liolaemus* lizard species, and the sympatric distribution and possible ecologic association of this tick species with reptiles and South American camelids, in the PM and AT ecoregions in northern Chile. Apparently, regardless of the ecoregion, the existence of reptiles and the density of camelids population could be a determining factor for the prevalence of *A. parvitarsum*.

Further studies should find and describe the nymph of *A. parvitarsum* and its respective hosts, and study the life cycle and ecology of this hard tick since, besides the parasitizing wild hosts, it is a frequent parasite of domestic camelids and it may have sanitary and productive implications.

Acknowledgments The authors want to thank the Servicio Agrícola and Ganadero for giving capture authorizations for reptiles, birds and rodents and to the Corporación Nacional Forestal for graciously providing its facilities in different visited protected areas in Chile. To Atilio J. Mangold and Santiago Nava of INTA Rafaela (Argentina) and Ignacio Ruiz for providing us unpublished records of *A. parvitarsum* in Argentina. To Wilfredo Briones for providing data of parasitized reptiles in northern Chile and to Rolando Manzano who generously provided us with tick specimens. Moreover, special thanks to Pablo Olmedo, Braulio Muñoz, Iván Torres, Nicolás Fernández, Daniela Doussang, Gonzalo Torres, Cecilia Figueroa, Consuelo Manosalva, Carolina Silva, Karolina Araya, Dani Fuentes, Nicolás Martin, Karen Ardiles, Lucila Moreno and Salomón Moyano for their valuable assistance during field work. This study was funded by the FONDECYT Project No. 1100695.

References

Aguirre DH, Viñabal AE, Cafrune MM (1997) Sobre la biología de *Amblyomma parvitarsum* Neumann, 1901 (Acari: Ixodidae). Vet Arg 24(131):32–33

Aragão H (1935) Observações sobre os ixodideos da república Argentina. Mem Inst Oswaldo Cruz 30(3):519–533

Aragão H (1938) Nota sobre os ixodoideos da república Argentina. Mem Inst Oswaldo Cruz 33(2):319–327

Arce de Hamity M, Ortiz F (2004) Ectoparásitos (Insecta y Arachnida) sobre animales domésticos de la quebrada de Humahuaca y puna (Jujuy, Argentina). IDESIA 22(1):55–56

Becker GK, Silva RP, Sinkoc AL, Brum JGW (1997) *Amblyomma parvitarsum*, Neumann, 1901 (Acari: Ixodidae) in Magellanic penguins *Spheniscus magellanicus* (Spheniscidae) in Cassinos beach, Rio Grande do Sul, Brazil. Arq Inst Biol (São Paulo) 64(1):81–82

Beltrán-Saavedra LF, Limachi JM, Guglielmone AA (2011) Registro de vicuñas (*Vicugna vicugna*, Molina 1782) como hospedador de *Amblyomma parvitarsum* Neumann, 1901 (Acari: Ixodidae) en Bolivia. J Selva Andina Res Soc 2(2):40–44

Benoit JB, Lopez-Martínez G, Phillips SA, Elnitsky MA, Yoder JA, Lee RE, Denlinger DL (2008) The seabird tick, *Ixodes uriae*, uses uric acid in penguin guano as a kairomone and guanine in tick feces as an assembly pheromone on the Antarctic Peninsula. Polar Biol 31:1445–1451

Boero JJ (1944) Notas ixodológicas. II. Nueva lista de los ixodoideos argentinos y sus huéspedes. Rev Asoc Méd Arg 58:354–355

Boero JJ (1954) Los ixodoideos de la República Argentina y sus huéspedes. Rev Fac Agr y Vet (La Plata) 13:505–514

Boero JJ (1957) Las garrapatas de la República Argentina (Acarina: Ixodoidea). Universidad de Buenos Aires, Buenos Aires

Boero JJ (1959) Acarina–Ixodoidea. In: Primeras Jornadas Entoepidemiológicas Argentinas. Buenos Aires, Argentina, pp 595–596

Camicas JL, Hervy JP, Adam F, PC Morel (1998) Les tiques du monde. Nomenclature, stades décrits, hôtes, répartition (Acarida, Ixodida). Orstom, Paris

Dale WE, Venero J (1977) Insectos y ácaros ectoparásitos de la vicuña en Pampa Galeras. Ayacucho. Rev Peru Entomol 20(1):93–99

Di Castri F (1968) Esquisse écologique du Chili. In: Biologie de l'Amérique australe. Volume IV: études sur la faune du sol. Documents biogéographiques. Centre National de la Recherche Scientifique, Paris, pp 7–52

Di Castri F, Hajek ER (1976) Bioclimatología de Chile. Universidad Católica de Chile, Santiago

Dios R (1917) Sistemática y biología de los ixodídeos argentinos, contribución a su estudio. Anales de la Sociedad Rural Argentina 51:249–251

Donoso RB (1953) Ixodoidea de Chile. Rev Chilena Entomol 3:132–134

Donoso-Barros R (1966) Reptiles de Chile. Ediciones de la Universidad de Chile, Santiago

Estrada-Peña A (2002) Understanding the relationships between landscape connectivity and abundance of *Ixodes ricinus* ticks. Exp Appl Acarol 28(1–4):239–248

Estrada-Peña A, Venzal JM, Magold AJ, Cafrune MM, Guglielmone AA (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. Syst Parasitol 60:99–112

Fajfer M (2012) Acari (Chelicerata)—Parasites of reptiles. Acarina 20(2):108–129

Food and Agricultural Organization (1988) Garrapatosis. In: Manual de parasitología y parasitismo de camélidos sudamericanos. Informe técnico del programa de cooperación técnica de enfermedades de camélidos de Chile, pp 88–91

Frenot Y, de Oliveira E, Gauthier-Clerc M, Deunff J, Bellido A, Vernon P (2001) Life cycle of *Ixodes uriae* in penguin colonies: relationships with host breeding activity. Int J Parasitol 31(10):1040–1047

González BA, Palma RE, Zapata B, Marín JC (2006) Taxonomic and biogeographical status of guanaco *Lama guanicoe* (Artiodactyla, Camelidae). Mamm Rev 36(2):157–178

González-Acuña D, Venzal JM, Fabry M, Guglielmone AA (2004) *Liolaemus jamesi* (Boulanger, 1891) (Reptilia: Tropiduridae), a host for the larva of *Amblyomma parvitarsum* Neumann, 1901 (Acari: Ixodidae). Syst Appl Acarol 9:33–36

Guglielmone AA, Nava S (2006) Las garrapatas argentinas del género *Amblyomma* (Acari: Ixodidae): distribución y hospedadores. RIA 35(3):133–135

Guglielmone AA, Estrada-Peña A, Keirans JE, Robbins RG (2004) Las garrapatas (Acari: Ixodida) de la región zoogeográfica neotropical. Ediciones INTA, Buenos Aires

Guglielmone AA, Romero J, Venzal JM, Nava S, Mangold AJ, Villavicencio J (2005) First record of *Haemaphysalis juxtakochi* Cooley, 1946 (Acari: Ixodidae) from Peru. Syst Appl Acarol 10:33–35

Hoogstraal H, Aeschlimann A (1982) Tick-host specificity. Bull Soc Entomol Suisse 55:5–32

Ivancovich JC, Luciani CA (1992) Las garrapatas de Argentina. Monogr Asoc Arg Parasitol Vet 95

Jaksic FM, Schwenk K (1983) Natural history observations on *Liolaemus magellanicus*, the Southernmost lizard in the world. Herpetologica 39(4):457–461

Jovani R, Tella JL (2006) Parasite prevalence and sample size: misconceptions and solutions. Trends Parasitol 22(5):214–218

Keirans JE (1985) George Henry Falkiner Nuttall and the Nuttall tick catalogue. Un St Dep Agric, Agric Res Ser Misc Pub (1438) 1785 pp

Klukowski M, Nelson CE (2001) Ectoparasite loads in free-ranging northern fence lizards, *Sceloporus undulatus hyacinthinus*: effects of testosterone and sex. Behav Ecol Sociobiol 49(4):289–295

Labruna MB, Whitworth T, Bouyer DH, McBride J, Camargo LMA, Camargo E, Popov V (2004) Walker DH (2004) *Rickettsia bellii* and *Rickettsia amblyommii* in *Amblyomma* ticks from the state of Rondônia, western Amazon, Brazil. J Med Entomol 41(6):1073–1081

Marín JC, Spotorno AE, González BA, Bonacic C, Wheeler JC, Casey CS, Bruford MW, Palma RE, Poulin E (2008) Mitochondrial DNA variation and systematics of the guanaco (*Lama guanicoe*, Artiodactyla: Camelidae). J Mammal 89(2):269–281

Moreno R, Moreno J, Ortiz JC, Victoriano P, Torres-Pérez F (2002) Herpetofauna del Parque Nacional Llanos de Challe (III región, Chile). Gayana 66(1):7–10

Nava S, Elshenawy Y, Eremeeva ME, Summer JW, Mastropaolo M, Paddok CD (2008) *Rickettsia parkeri* in Argentina. Emerg Infect Dis 14(12):1894–1897

Nava S, Estrada-Peña A, Mangold AJ, Guglielmone AA (2009) Ecology of *Amblyomma neumanni* (Acari: Ixodidae). Acta Trop 111:226–236

Nava S, Martínez JG, Arreguez GA, Guglielmone AA (2013) Ticks (Acari: Argasidae, Ixodidae) from middle and pre Hispanic late Holocene associated with human activities in northwestern Argentina. Ticks Tick Borne Dis 4:167–169

Need JT, Dale WE, Keirans JE, Dasch GA (1991) Annotated list of ticks (Acari: Ixodidae, Argasiade) reported in Peru: distribution, hosts, and bibliography. J Med Entomol 28:590–597

Neumann LG (1901) Révision de la famille de ixodidés (4^{e} mémoire). Mém Soc Zool Fr 14:249–372

Oliver JH (1989) Biology and systematics of ticks (Acari:Ixodida). Annu Rev Ecol Syst 20:397–430

Ortiz F, Nava S, Guglielmone AA (2011) Análisis de una colección de garrapatas (Acari: Argasidae, Ixodidae) del norte argentino. Revista FAVE—Ciencias Veterinarias 10(1):49–55

Peralta JL, Gevarsoni S, Ferraro M, Pazo R, Viaña-Fuentes LG (1994) Hallazgo de *Amblyomma parvitarsum* Neumann en llamas (*Lama glama*) de Catamarca, Argentina. Vet Arg 11(105):327

Pincheira-Donoso D, Núñez H (2005) Las especies chilenas del género *Liolaemus* Wiegmann, 1834 (Iguania: Tropiduridae: Liolaeminae). Taxonomía, sistemática y evolución. Pub Ocas Mus Nac Hist Nat Chile 59:1–486

Poulin R (1996) Measuring parasite aggregation: defending the index of discrepancy. Int J Parasitol 26(2):227–229

Rózsa L, Reiczigel J, Majoros G (2000) Quantifying parasites in samples of hosts. J Parasitol 86:228–232

Tagle I (1971) Ixodoidea en Chile. Bol Chil Parasitol 26:46–49

Veloso A, Navarro J (1988) Lista sistemática y distribución geográfica de anfibios y reptiles de Chile. Boll Mus Reg Sci Nat Torino 6(2):481–539

Venzal JM, Portillo A, Estrada-Peña A, Castro O, Cabrera PA, Oteo JA (2004) *Rickettsia parkeri* in *Amblyomma triste* from Uruguay. Emerg Infect Dis 10(8):1493–1495

Vidal MA, Soto ER, Veloso A (2009) Biogeography of Chilean herpetofauna: distributional patterns of species richness and endemism. Amphibia-Reptilia 30(2):151–171

Voltzit OV (2007) A review of neotropical *Amblyomma* species (Acari: Ixodidae). Acarina 15(1):3–134