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Host range and geographical distribution of *Ixodes sigelos* (Acari: Ixodidae)

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Abstract Larvae, nymphs and females of *Ixodes sigelos* Keirans, Clifford and Corwin (Ixodidae) were collected in 13 localities of the Patagonian region of Argentina parasitizing eight species of sigmodontine rodents. We report for the first time adults of *I. sigelos* for Argentina. Besides, we extend the southern limit of its geographical distribution, and six species of sigmodontines are added as new host species of *I. sigelos* (*Phyllotis xanthopygus*, *Euneomys chinchilloides*, *Calomys musculinus*, *Reithrodon auritus*, *Loxodontomys micropus* and *Eligmodontia morgani*). The presence of larvae, nymphs and females on sigmodontines, as well as more than 50% of the individuals engorged, indicate that *I. sigelos* can develop the complete parasitic phase of its life cycle on these small mammals. The geographical distribution of *I. sigelos* is restricted to the biogeographical Andean Region in Argentina and Chile.

Keywords *Ixodes sigelos* · Sigmodontinae · Ticks · Patagonia · Argentina · Rodents

Introduction

Ixodes Latreille (Acari: Ixodida: Ixodidae) is the major tick genus of the world, with 242 described species (Nava et al. 2009). Thirty-six species of this genus have been mentioned

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from South America, and 23 of them are exclusive of this area (Barros-Battesti et al. 2003; Guglielmone et al. 2003). In Argentina, *Ixodes* is represented by nine species, and five of them (*Ixodes longiscutatus* Boero, *Ixodes loricatus* Neumann, *Ixodes luciae* Sènevet, *Ixodes pararicinus* Keirans and Clifford and *Ixodes sigelos* Keirans, Clifford and Corwin) have been mentioned associated with sigmodontine rodents (Cricetidae) (Guglielmone and Nava 2005).

Ixodes sigelos was described from females, nymphs and larvae (male is unknown) collected in Chile on rodents of the families Octodontidae, Abrocomidae and Cricetidae (Keirans et al. 1976). Phylogenetically, this tick is closely related to *Ixodes neuquenensis* Ringuelet and *Ixodes stilesi* Neumann, forming a group of South American species characterized by immature stages (the larva of *I. stilesi* is unknown) with anterior and posterior processes on palpal article I (Guglielmone et al. 2006). The geographical distribution of *I. sigelos* is currently restricted to Chile and Argentina (Guglielmone et al. 2005). In the first country, all parasitic stages of this tick were mentioned in association with the rodents *Aconaemys fuscus* (Waterhouse), *Phyllotis* sp., *Abrocoma bennetti* Waterhouse and *Octodon degus* (Molina). Nymphs and larvae were also reported parasitizing the sigmodontines *Abrothrix longipilis* (Waterhouse), *Abrothrix olivaceus* (Waterhouse), *Oligoryzomys longicaudatus* (Bennett), and the Muridae *Rattus norvegicus* Berkenhout (González Acuña and Guglielmone 2005). No adults and larvae of *I. sigelos* were recorded in Argentina. The only nymph collected was on *Akodon spegazzinii* Thomas in Hualinchay (26°20′S, 65°39′W, Tucumán Province) (Guglielmone et al. 2005).

In order to contribute to the knowledge of ecological aspects of *I. sigelos*, the host range and geographical distribution of this tick are analyzed o the basis of new records from the Patagonian region of Argentina. Besides, information of DNA sequences of the mitochondrial 16S rDNA gene is included.

Materials and methods

Study area

The Patagonian region of Argentina extends from the south of the Río Negro River (39.5°S) to 55°S (Soriano et al. 1983). This area is characterized by a climatic heterogeneity, as the result of the combined influence of the latitudinal gradient of temperature and the west-east gradient of precipitation (Barros and Rivero 1982 in Bertiller and Bisigato 1998). Biogeographically, the Patagonian region of Argentina corresponds to the Andean Region and includes three biogeographical provinces (Morrone 2001): 1. Central Patagonia Province, with climate dry and temperate-cold, high winds from the west, and annual precipitation reaching 500 mm in the west and 125 mm in the east; the dominant vegetation is shrubland, dominated by shrubs in cushion and is represented by the species *Chuquiraga avellanedae* Lorentz, *Junellia tridens* (Lagasca) Mold, *Trevoa patagonica* Spagazzini and *Colliguaya integerrima* Gillies and Hook; 2. Subandean Patagonia Province, where the amount of annual rainfall exceeds 300 mm, and characterized by the presence of steppe grasses with high coverage, and *Festuca* spp. as some of the dominant species. 3. Magallanic Forest Province, with a cold and ocean climate, high rainfall (2,000 mm), and the dominant vegetation is xeric forest, with *Nothofagus betuloides* (Mirbel) Oersterd and evergreen forests swamps grow creeping conifers *Dacrydium fonckii* (Philippi) and grasslands and peatlands (Cabrera 1976; León et al. 1998).

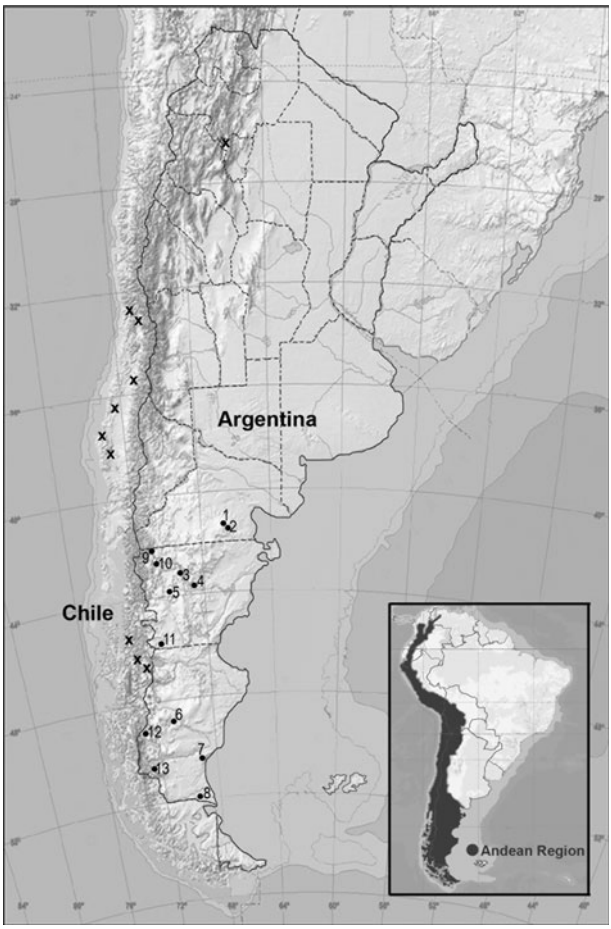

Fig. 1 Geographical distribution of *Ixodes sigelos*. Sample sites (1–13): *1* Laguna Blanca, Cerro Corona, *2* Campamento PNG Somuncura, *3* Gorro Frigio, *4* Estancia La Madrugada, *5* Estancia Quichaura, *6* Cerro Ventana, *7* Puerto Santa Cruz: 4 km W Punta Quilla s/RP 288, *8* Estancia Pali Aike: casco, *9* Estancia El Maitén, *10* Estancia Leleque, *11* 1 km E Lago Blanco, *12* Bahía Túnel (Lago Viedma), *13* Estancia Alta Vista. *X* = Previously published information: González Acuña and Guglielmone (2005) and Guglielmone et al. (2005)

The collecting localities (Fig. 1) were: Central Patagonia Province (1–8): 1. Laguna Blanca, Cerro Corona (41°25′S, 66°57′W), 2. Campamento PNG Somuncura (41°27′S, 66°53′W), 3. Gorro Frigio (43°02′S, 69°19′W), 4. Estancia La Madrugada (43°37′S, 68°57′W), 5. Estancia Quichaura (43°42′S, 70°20′W), 6. Cerro Ventana (48°59′S, 70°15′W), 7. Puerto Santa Cruz: 4 km W Punta Quilla s/RP 288 (50°06′S, 68°27′W), 8. Estancia Pali Aike: Casco (51°56′S, 69°36′W); Subandean Patagonia Province (9–11): 9. Estancia El Maitén (42°03′S, 71°09′W), 10. Estancia Leleque (42°19′S, 70°59′W), 11. Lago Blanco (45°55′S, 71°14′W); Magallanic Forest Province (12–13): 12. Bahía Tunel (Lago Viedma) (49°12′S, 72°58′W), 13. Estancia Alta Vista (50°27′S, 72°36′W). Additional distributional records of *I. sigelos* obtained from the literature (González Acuña and Guglielmone 2005; Guglielmone et al. 2005) are also added in the map (X).

Host rodents

Rodents captured alive were examined for ticks. Later, they were deposited at the Colección de Mamíferos del Centro Nacional Patagónico, Puerto Madryn, Chubut, Argentina and identified following the taxonomic criteria proposed by Musser and Carlenton (2005) as (Cricetidae, Sigmodontinae) *A. olivaceus* ($n = 26$), *A. longipilis* ($n = 15$), *Phyllotis xanthopygus* (Waterhouse) ($n = 9$), *Euneomys chinchilloides* (Waterhouse) ($n = 2$), *Calomys musculinus* (Thomas) ($n = 1$), *Reithrodon auritus* G. Fischer ($n = 2$), *Loxodontomys micropus* (Waterhouse) ($n = 1$) and *Eligmodontia morgani* J. A. Allen ($n = 2$).

Ticks

Ticks were sampled in the field by brushing rodents, and stored in 96% ethyl alcohol. Identification was carried out following Keirans et al. (1976) and Guglielmone et al. (2005, 2006). Voucher specimens of *I. sigelos* are housed in the Colección del Departamento de Entomología, Museo de la Plata, Buenos Aires, Argentina, and in the tick collection of the Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria, Rafaela, Santa Fe, Argentina. Collection numbers are available under request. One female collected on *A. olivaceus* in Puerto Santa Cruz (Santa Cruz Province, Argentina) and one nymph collected on *A. longipilis* in Estancia El Maitén (Chubut Province, Argentina) were used to obtain sequences of a fragment of circa 430 bp of the mitochondrial 16S rDNA gene according to Mangold et al. (1998), and compared with the sequence of *I. sigelos* from Chile deposited in the GenBank (accession number: AF549858).

Results

In total 199 specimens of *I. sigelos* were collected from 58 sigmodontines, and more than 50% of both immature and adult specimens were engorged. The number of specimens of every stage collected on every host species and locality are shown in Table 1. Considering only host species, 14 larvae and 15 nymphs were collected on *A. longipilis*; 46 larvae, 18 nymphs and 6 females on *A. olivaceus*, 14 larvae on *E. chinchilloides*, 2 larvae on *E. morgani*, 5 nymphs on *L. micropus*, 49 larvae, 23 nymphs, and 4 females on *P. xanthopygus*, 1 nymph and 1 female on *R. auritus*, and 1 larva on *C. musculinus*. The 16S rDNA sequences of the two specimens of *I. sigelos* from Santa Cruz and Chubut were identical (GenBank accession numbers: HM014413, Chubut and HM014414, Santa Cruz), and the percentage of genetic divergence among the Argentinean ticks and *I. sigelos* from Chile was 3.7%. Concerning the geographical distribution of *I. sigelos* in the Patagonian region of Argentina (Fig. 1), 45% of the records were in the Central Patagonia Province (sites 1–8 in the map), 33.3% in the Subandean Patagonia Province (sites 9–11), and 16.7% in the Magallanic Forest Province (sites 12–13).

Discussion

The results obtained in this work support that *I. sigelos* can develop its life cycle feeding on sigmodontines, since both immature and adult specimens were collected from this host group, and more than 50% of the ticks were engorged. Moreover, *I. sigelos* have been previously reported parasitizing sigmodontines along its known distribution

Table 1 Number of larvae (L), nymphs (N) and females (F) of *Ixodes sigelos* collected in every locality and host species

Localities	Hosts	Ticks
Laguna Blanca, Cerro Corona	*Phyllotis xanthopygus*[a] ($n = 1$)	7L, 2N
Campamento PNG Somuncura	*Abrothrix longipilis* ($n = 2$)	3L
	Phyllotis xanthopygus ($n = 1$)	7L
Gorro Frigio	*Eligmodontia morgani*[a] ($n = 1$)	1L
Estancia La Madrugada	*Calomys musculinus*[a] ($n = 1$)	1L
Estancia Quichaura	*Reithrodon auritus*[a] ($n = 1$)	1F
Cerro Ventana	*Phyllotis xanthopygus* ($n = 1$)	2N
	Reithrodon auritus ($n = 1$)	1N
	Abrothrix olivaceus ($n = 2$)	3L
	Eligmodontia morgani ($n = 1$)	1L
Estancia Pali Aike: casco	*Abrothrix olivaceus* ($n = 4$)	6N, 1F
Puerto Santa Cruz: 4 km W Punta Quilla s/RP 288	*Abrothrix olivaceus* ($n = 11$)	1L, 10N, 5F
Estancia El Maitén	*Abrothrix longipilis* ($n = 2$)	1L, 7N
	Loxodontomys micropus[a] ($n = 1$)	5N
Estancia Leleque	*Abrothrix longipilis* ($n = 7$)	9L, 2N
	Abrothrix olivaceus ($n = 3$)	19L
	Phyllotis xanthopygus ($n = 1$)	2L, 2N
	Euneomys chinchilloides[a] ($n = 2$)	14L
1 km E Lago Blanco	*Phyllotis xanthopygus* ($n = 3$)	2L, 15N, 4F
	Abrothrix longipilis ($n = 3$)	9N
Estancia Alta Vista	*Abrothrix olivaceus* ($n = 2$)	17L
	Abrothrix longipilis ($n = 1$)	1L
Bahía Túnel (Lago Viedma)	*Phyllotis xanthopygus* ($n = 2$)	31L,1N
	Abrothrix olivaceus ($n = 4$)	4L, 2N

n Number of hosts parasitized

[a] New host records

(Keirans et al. 1976; González Acuña and Guglielmone 2005; Guglielmone et al. 2005). Consequently, sigmodontines appear to be a key host for the three parasitic stages of *I. sigelos*. The participation of this rodent group in the life cycle of Southamerican *Ixodes* species is a common event, since they have been cited as hosts of other species such as *Ixodes amarali* Fonseca (Barros-Battesti and Knysak 1999), *Ixodes andinus* Kohls (Kohls 1956), *Ixodes jonesae* Kohls (Kohls et al. 1969), *I. longiscutatus* (Venzal et al. 2008), *I. loricatus* (Nava et al. 2004), *I. luciae* (Díaz et al. 2007), *I. pararicinus* (Venzal et al. 2005) and *Ixodes venezuelensis* Kohls (Durden and Keirans 1994). In the present study, *P. xanthopygus*, *E. chinchilloides*, *C. musculinus*, *R. auritus*, *L. micropus* and *E. morgani* are mentioned for first time associated with *I. sigelos*, and the finding of female specimens of *I. sigelos* represent the first record of adults of this tick species in Argentina.

The results on the geographical distribution of *I. sigelos* (Fig. 1) support that this tick species is restricted to an area of the South Cone of South America, in the biogeographical provinces of the Andean Region in Argentina and Chile. The record of Hualinchay (26°20′S, 65°39′W, Prepuna Biogeographical Province) represents the northernmost locality of *I. sigelos* distribution, while Estancia Pali Aike in the present study (51°56′S; 69°36′W, Central Patagonia Biogeographical Province) constitutes the southern limit. On the other hand, surveys of ticks carried out by the authors in a large part of Argentine territory (biogeographical provinces Pampa, Chaco, Monte and Yungas) fail to found

I. sigelos specimens, supporting the idea that its geographical distribution is restricted to the biogeographical Andean Region. Considering that the distribution of sigmodontines exceeds largely those of *I. sigelos*, it is evident that environmental variables rather than hosts determine the distributional range of this tick.

Although the sequences obtained from specimens of *I. sigelos* collected in Argentina were identical, the genetic divergence between Argentinean and Chilean *I. sigelos* ticks is considerably high for an intraspecific level of variation. Differences bigger than 3.0% in 16 rDNA sequences of *Ixodes* ticks can indicate a restrictive gene flow among the analyzed populations. On this matter, future works should carry out an extensive study on the genetic population of *I. sigelos*, including several populations that represent its distribution, to determine the presence-absence of morphologically cryptic species.

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