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Ectoparasites associated with sigmodontine rodents from northeastern Argentina

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Usually sigmodontine rodents (Cricetidae) are associated with a variety of ectoparasites. However, the studies in northeastern Argentina are scarce. Herein we analyze the ectoparasite component communities associated with four species of sigmodontines in the south of the Province of Misiones. In total, 835 ectoparasites were collected from the 97 rodents examined: 782 mites (Acari, Mesostigmata; S = 7; P = 78.35 %; MA = 8.06), 50 fleas (Hexapoda, Siphonaptera; S = 2; P = 21.65 %; MA = 0.53), and two ticks (Acari, Ixodida; S = 1; P = 2.06 %; MA = 0.02, $P < 0.005$). The following five species are mentioned for the first time for the northeastern: *Androlaelaps rotundus*, *Gigantolaelaps wolffsohni*, *Laelaps manguinhosi*, *L. paulistanensis*, and *Polygenis* (*P.*) *tripus*, increasing the biodiversity known for the area. A tendency toward host aggregation was observed for most of the ectoparasites. Out of 10 ectoparasite species identified in the present study, five were collected from a unique host species, and so, species richness varied between three and four in every component community. Since some of the ectoparasites identified may play a role as vectors of pathogens, the obtained results contribute to a better understanding of the ectoparasite-host relationship, which may have epidemiological implications.

Por lo general, los roedores sigmodontinos (Cricetidae) están asociados con una variedad de ectoparásitos. Sin embargo, los estudios en el noreste argentino son escasos. Aquí analizamos las comunidades componentes de ectoparásitos asociados con sigmodontinos en el sur de la Provincia de Misiones. En total, se recolectaron 835 ectoparásitos de los 97 roedores examinados: 782 ácaros (Acari, Mesostigmata; S = 7; P = 78.35 %; MA = 8.06), 50 pulgas (Hexapoda, Siphonaptera; S = 2; P = 21.65 %; MA = 0.53), y dos garrapatas (Acari, Ixodida; S = 1; P = 2.06 %; MA = 0.02, $P < 0.005$). Las cinco especies siguientes se mencionan por primera vez para el noreste: *Androlaelaps rotundus*, *Gigantolaelaps wolffsohni*, *Laelaps manguinhosi*, *L. paulistanensis* y *Polygenis* (*P.*) *tripus*, y aumentan el conocimiento sobre la biodiversidad del área. Se observó una tendencia hacia la agregación para la mayoría de los ectoparásitos. De las 10 especies de ectoparásitos identificadas en el presente estudio, cinco se recolectaron de una especie hospedadora única, por lo que la riqueza específica varió entre tres y cuatro en cada comunidad componente. Dado que algunos de los ectoparásitos identificados pueden jugar un rol en la transmisión de patógenos, los resultados obtenidos contribuyen a una mejor comprensión de la relación ectoparásito-hospedador, que puede tener implicaciones epidemiológicas.

Key words: Argentina; cricetids; ectoparasites; fleas; mites; rodents; sigmodontines; ticks.

Introduction

Sigmodontine rodents (Cricetidae) are a fundamental component of the fauna of South America, representing about 20 % of the species of mammals inhabiting the subcontinent. Seven families of rodents are represented within the Misiones Province, situated in the far northeast of Argentina, limiting with Paraguay and Brazil (Patton *et al.* 2015; Lanzone *et al.* 2018). An analysis of the species richness considering only the rodents of the family Cricetidae (Sigmodontinae), indicates that spatially the greatest values are concentrated towards the central-southern part of the province, in a region where the Bosque Atlántico Interior overlap with the ecoregion of the Fields and Malezales. The high richness in the area may be related to the occurrence of a greater environmental heterogeneity with the presence of forest-dwelling rodents and others adapted to pasture environments. In addition, out of the four endemic species of rodents reported for the province of Misiones, one (*Akodon philipmyersi* Pardiñas, D' Elía, Cirignoli and Suárez) is reported for the ecoregion of the Fields and Malezales (Galliari and Goin 1993; Pardiñas *et al.* 2005; Patton *et al.* 2015; Lanzone *et al.* 2018).

Usually sigmodontine rodents are associated with a variety of ectoparasites, such as mites, ticks and fleas. A parasite component community represents all of the parasites associated with some subset of a host species, such as a population (Bush *et al.* 1997). Host-parasite associations are the result of evolutionary and ecological processes, since individuals in a rodent community or population vary in ways that may affect their interactions with their parasites. For example, host specimens may vary in their sex, age, physiology, morphology, ethology, ecology, etc., and all these features may influence their ectoparasite populations (Marshall 1981; Kim 1985; Morand *et al.* 2006; Krasnov 2008). In addition, some ectoparasites are epidemiologically important because they are involved in the transmission of pathogens that cause diseases in humans and domestic and wild animals, and whose reservoirs are rodent hosts.

Studies on component communities of ectoparasites of sigmodotines are not abundant worldwide, and Latin America is not an exception. Most of the studies were conducted in Brazil and Argentina, and in the last country, researches were concentrated in Buenos Aires Province (Linardi *et al.* 1991; Barros-Battesti *et al.* 1998; Lareschi *et al.* 2007; Lareschi and Krasnov 2010; Sponchiado *et al.* 2015; Liljesthröm and Lareschi 2018). Despite the biological relevance of northeastern Argentina, only a few ectoparasite species have been reported associated with sigmodontines, and there are not ecological analyses characterizing ectoparasite component communities (Lareschi 2010, 2011; Lareschi *et al.* 2016; Pardiñas *et al.* 2016). Thus, the aim of our study is focused on the ecological study of the communities of ectoparasites of rodents of the subfamily Sigmodontinae in southern Misiones Province in northeastern Argentina.

Materials and Methods

Study area. The study was conducted in the south of the Misiones Province. We selected two localities situated in the southern limit of the Fields and Malezales ecoregion (Burkart *et al.* 1999), very close to the the Bosque Atlántico Interior, and about less than 20 km far from Posadas City (Figure 1). Samples were taken in Estancia Santa Inés (-27° 31´ S; -55° 52´ W) during April-2007 and May-2009 and 2018, and in the Estación Experimental del Instituto Nacional de Tecnología Agropecuaria (EEA INTA) Villa Miguel Lanús

Figure 1. Sites of collection of ectoparasites. Locality 1: Estación Experimental del Instituto Nacional de Tecnología Agropecuaria (EEA INTA) Villa Miguel Lanús (27°25'S; 55°53'W). Locality 2: Estancia Santa Inés (-27° 31´ S; -55° 52´ W). Grey indicates the ecoregion Fields y Malezales.

(-27° 25' S; -55° 53' W) in April, 2007. The traps were placed in dirty (not carpid) fields of yerba mate, in fields invaded by chilcas (*Baccharis* sp.), in *Andropogon* sp. grasslands, in grasslands of cuttings in low areas and in forests implanted with native species located in the surroundings of the hull of the stay.

Rodents. Ninety-seven rodents (Cricetidae: Sigmodontinae) captured alive by using Sherman traps baited with oats were examined for ectoparasites. Ulyses F. J. Pardiñas (IDEAus Centro Nacional Patagónico, Puerto Madryn, Chubut, Argentina) and Carlos Galliari (Centro de Estudios Parasitológicos y de Vectores, La Plata, Argentina) taxonomically identified the rodents as: Cricetidae, Sigmodontinae, Akodontini: *Necromys lasiurus* (Lund) (*n* = 61), *A. philipmyersi* (*n* = 13), and *Oxymycterus rufus* Fischer (*n* = 1); Phyllotini: *Calomys* sp. (*n* = 10); Oryzomyini: *Oligoryzomys flavescens* (Waterhouse) (*n* = 7) and *O. nigripes* Desmarest (*n* = 5). Representative individuals of each species of rodents were deposited at the Colección de Mamíferos del Centro Nacional Patagónico (CNP; Puerto Madryn, Chubut Province, Argentina), some of them still have the field number: CNP742, CNP3041, CNP6007, CNP6020, CNP5705, and CNP4950.

Ectoparasites. The fur of the hosts was searched for ectoparasites with the use of combs, tooth brushes and forceps. The ectoparasites were preserved in 96 % ethanol. For taxonomic identification, mites were cleared in lactophenol and individually mounted in Hoyer´s medium; fleas were cleared by using KOH and mounted in Canadian balsam; ticks were identified directly under stereoscopic microscope. Ectoparasites were identified in accordance with the keys, drawings and descriptions given by Furman (1972), Smit (1987) and Martins *et al.* (2014). Representative specimens of ectoparasites of each species were deposited at the Colección del Departamento de Entomología, Museo de La Plata (MLP; La Plata, Argentina). The catalogue number consists of the number of the host followed by a script and the number corresponding to the individual ectoparasite; some specimens still have field numbers: MLP-CNP742-3, MLP-CNP3041-1, MLP-CNP6007-1, MLP-CNP6020-1, MLP-CNP5705-1, MLP-LTU697-1/2, MLP-LTU709-1/2, and MLP-LTU717-1.

Data analyses. Since only 12 individuals of *N. lasiurus* were captured at EEA INTA, and both sites of collection are close and similar in their vegetation, data from both localities was analyzed together. Indices and parameters were calculated as follow: Ectoparasite specific richness (S = number of species), Shannon specific diversity index [$H = -\sum (pi \ln pi)$], equitability index ($J = H/\ln S$), mean abundance (MA = total number of individuals of a particular parasite species in a sample of a particular host species/total number of hosts of that species, including both infected and non-infected hosts) and prevalence [P = (number of hosts infected with one or more individuals of a particular parasite species/the number of hosts examined for that parasite species) x 100] (Begon *et al.* 1988; Bush *et al.* 1997). We tested significance (*P*) of differences between mean abundances and prevalences using Fisher's exact test and Student´s t-test, respectively. The variance to mean ratio (V/M) was also calculated to examine the distribution of every ectoparasite within each host species. Analyses were calculated using parasitology software Quantitative Parasitology 3.0 (Rózsa *et al.* 2000). Species accumulation curves were made with PAST Program (Hammer and Harper 2001), which implements the analytical solution known as "Mao's tau", with 95 percent confidence intervals. We use a matrix of presence-absence data. Species richness of ectoparasites is estimated as a function of number of samples or hosts (number of rodent individuals of the same species).

Results

A total of 834 ectoparasites were collected from the 97 rodents examined. Out of them, 782 specimens were mites (Acari, Mesostigmata), 50 were fleas (Hexapoda, Siphonaptera), and two were ticks (Acari, Ixodida). Total species richness was S = 10; and diversity was H = 0.68. In comparison, mites were highly significant more prevalent and abundant (S = 7; P = 78.35 %; MA = 8.06) than fleas (S = 2; P = 21.65 %; MA = 0.53) and ticks (S = 1; P = 2.06 %; MA = 0.02, $P < 0.005$).

The collected ectoparasites were identified as: Acari, Mesostigmata, Laelapidae, Laelapinae: *Androlaelaps fahrenholzi* (Berlese; *n* = 94), *A. rotundus* (Fonseca; *n* = 366), *A. ulysespardinasi* Lareschi (*n* = 204), *Gigantolaelaps wolffsohni* Oudemansi (*n* = 21), *Laelaps manguinhosi* Fonseca (*n* = 6), *L. paulistanensis* Fonseca (*n* = 56), *Mysolaelaps parvispinosus* Fonseca (*n* = 35); Acari, Ixodida, Ixodidae: *Amblyomma ovale* Koch (*n* = 2, nymphs); Hexapoda, Siphonaptera, Rhopalopsyllidae, Rohopalopsyllinae: *Polygenis* (*Polygenis*) *tripus* (Jordan; *n* = 48), *Polygenis* sp. (*n* = 2).

Ectoparasite component communities are compared in Tables 1 and 2. *Oxymycterus rufus* and *Calomys* sp. were not included, since *O. rufus* was not parasitized, and only one specimen of *Calomys* sp. was associated with a single flea (*P.* (*P.*) *tripus*). *Akodon philipmyersi* shows the lowest values of S, H and J (Table1), with a remarkable dominance of *A. ulysespardinasi* (92 %; Table 2).

Table 1. Comparison of component communities of ectoparasites associated with every host species. S = specific richness; H = Shannon specific diversity; J = equitability index.

	Necromys lasiurus	*Akodon philipmyersi*	*Oligoryzomys flavescens*	*Oligoryzomys nigripes*
S	4	3	4	4
H	0.76	0.31	1.34	1.02
J	0.55	0.28	0.97	0.74

Species accumulation curves considering species richness of ectoparasites as a function of number of individual hosts of each species are shown in Figures 2 a-d. Although the number of host specimens of some species is low, the curve seems to stabilize for most of the species. The number of specimens of every ectoparasite species, as well as the values of mean abundance, prevalence and their distribution are shown in Table 2.

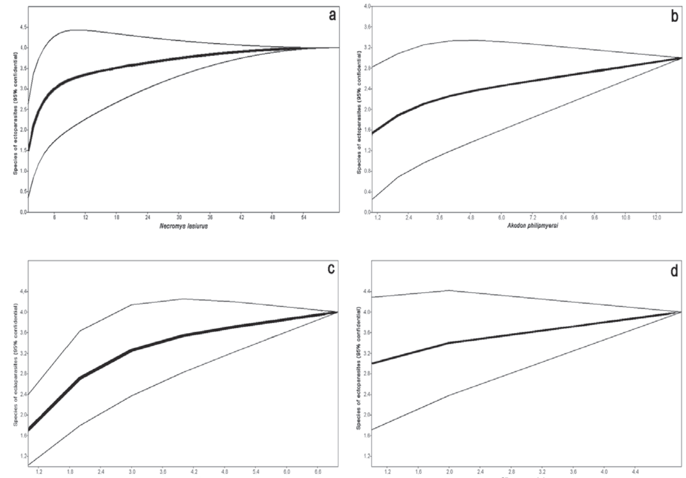

Figure 2. (a-d). Species accumulation curves considering species richness of ectoparasites as a function of number of individual hosts of each species.

Ectoparasite component communities associated with *A. philipmyersi* showed the highest MA (17.08), which was significantly different from the remaining ones ($P < 0.05$). On the contrary, component communities of *O. flavescens* showed the lowest MA (4.86), which differed from those of *A. philipmyersi* and *O. nigripes* ($P < 0.005$), but not from *N. lasiurus* ($P > 0.05$). Differences among total prevalences did not show significance ($P > 0.05$). *Akodon philipmyersi* shows the higher value of dominance (92 %, *A. ulysespardinasi*), and *O. nigripes* the lowest one (35 %, *M. parvispinosus*). Considering those ectoparasite species associated with two or more host species (Table 2), only *G. wolffsohni* was significantly more abundant in *O. nigripes* (3.00) than in *O. flavescens* (0.86; $P < 0.05$).

When comparing ectoparasite species within every component community (Table 2), the differences observed between prevalences and mean abundances of *A. fahrenholzi* and *A. rotundus* associated with *N. lasiurus*; and *A. fahrenholzi* and *A. ulysespardinasi* parasitizing *A. philipmyersi* were highly significant ($P < 0.005$). Considering high taxa of ectoparasites, differences in prevalences and mean abundances between mites (*P* = 85.2; MA = 7.3) and fleas associated with *N. lasiurus*, were highly significant ($P < 0.005$).

When comparing ectoparasite component communities between host tribes, Akodontini vs Oryzomini, differences between prevalences (*P* = 90.50 vs *P* = 91.70; $P > 1$) and mean abundances (MA = 10.66 vs MA = 10.82; *P* = 0.92), were not significant. Comparing host species included in every tribe, *O. nigripes* MA (13.4) show differences highly significant from that of *O. flavescens* (MA = 4.86; $P < 0.05$), while differences in their prevalences were not significant (*P* = 100 % vs *P* = 85 %; *P* = 1). Results are similar when comparing *N. lasiurus* vs *A. philipmyersi*: differences in their mean abundance (MA = 8.11 vs MA = 17.11, $P < 0.005$) were highly significant, while those in prevalences were not (P = 88.5 % vs P = 100; $P > 1$). Considering all ectoparasites in every component community, the distribution was aggregate (V/M > 1). The same results were observed when considering every ectoparasite species, with some exceptions

Table 2. Comparison of component communities of ectoparasites associated with every host species. N = number of specimens; MA = mean abundance; P = prevalence; V/M = aggregation index.

	***Necromys lasiurus* (*n* = 61)**				***Akodon philipmyersi* (*n* = 13)**				***Oligoryzomys flavescens* (*n* = 7)**				***Oligoryzomys nigripes* (*n* = 5)**			
Ectoparasites	N	P	MA	V/M	N	P	MA	V/M	N	P	MA	V/M	N	P	MA	V/M
Androlaelaps fahrenholzi	78	32.80	1.28	7.07	16	46.2	1.23	2.46								
Androlaelaps rotundus	366	83.61	6.00	6.22												
Androlaelaps ulysespardinasi					204	100	15.69	4.11								
Gigantolaelaps wolffsohni									6	42.9	0.86	1.33	15	100	3.0	0.67
Laelaps manguinhosi									6	14.3	0.86	6.00				
Laelaps paulistanensis									10	57.1	1.42	1.83	46	100	9.2	4.59
Mysolaelaps parvispinosus									12	57.1	1.71	2.67	23	80	4.6	2.78
Polygenis tripus	47	36.70	0.77	4.34									1	20	0.2	1.00
Polygenis sp.					2	7.7	0.15	2.00								
Amblyomma ovale	2	3.30	0.03	0.98												
Ectoparasites total (N = 385)	492	88.5	8.11	7.75	222	100	17.08	4.12	34	85	4.86	3.32	67	100	13.4	2.35

in ticks and *P. tripus* collected from *O. nigripes*. In these cases randomless distribution (V/M = 1) were shown.

Discussion

In the present study, 10 ectoparasite species were identified parasitizing four sigmondontine species in southern Misiones Province in Argentina. With the exception of *Polygenis* sp., probably a new species deserving further study, the remaining species were previously reported for Argentina. Out of them, the following five are mentioned for the first time for the northeastern: *A. rotundus*, *G. wolffsohni*, *L. manguinhosi*, *L. paulistanensis*, and *P.* (*P.*) *tripus* (Lareschi and Mauri 1998; Lareschi *et al.* 2016). Previously, the following mites and fleas have been mentioned parasitizing sigmodontines in Misiones Province: *Adoratopsylla* (*Adoratopsylla*) *antiquorum antiquorum* (Rothschild) (Ctenophthalmidae) and *Polygenis* (*Polygenis*) *rimatus* (Jordan; Rhopalopsyllidae, Rhopalopsyllinae), both from *Abrawayaomys chebezi* Pardiñas, Teta and D'Elía, *A. fahrenholzi* from *A. philipmyersi* and *A. chebezi*; *Androlaelaps misionalis* Lareschi from *Akodon montensis* Thomas, and *M. parvispinosus* from *Oligoryzomys* sp. (Lareschi 2010, 2011; Lareschi and Mauri 1998; Pardiñas *et al.* 2016). Thus, the results obtained increase to ten the biodiversity of ectoparasites associated with sigmodontines in Misiones Province.

Although the number of captured specimens of some species is low, the accumulated curves suggest that the specific ectoparasite richness reported is representative of most of every component community. The purpose of the study is more descriptive than analytical and is the first study on ectoparasites of rodents from northeastern Argentina that considers usual ecological parameters in parasitology. We consider that in this sense, our results are novel.

Considering every ectoparasite high taxa, only mites were associated with the four host species. In addition, mites were dominant, and the most prevalent and specious taxa. These results are in agreement with studies from central Argentina and Brazil (*e. g.,* Linardi *et al.* 1991; Barros-Battesti *et al.* 1998; Lareschi *et al.* 2007; Lareschi and Krasnov 2010; Sponchiado *et al.* 2015; Liljeström and Lareschi 2018). On the contrary, dominance of mites was not so remarkable observed in Argentinean Chaco (Nava and Lareschi 2012), and fleas are dominant in Patagonia (Sanchez and Lareschi 2018).

A tendency toward host aggregation was observed for most of the ectoparasites. Out of 10 ectoparasite species identified in the present study, five were collected from a unique host species, and so, species richness varied between three and four in every component community. Core species, characterized by high prevalence and abundance (Bush *et al.* 1997), was detected in every community.

Every mite-host associated reported herein was previously reported for other areas. *Androlaelaps ulysespardinasi* and *A. rotundus*, belong to the *Androlaelaps rotundus* species group, which includes host specific species associated with different akodontine rodents (Lareschi and Galliari 2014; Lareschi 2018). *Laelaps manguinhosi, L. paulistanensis, Mysolaelaps* spp., and *Gigantolaelaps* spp. were reported mainly parasitizing oryzomines (Furman 1972; Lareschi and Mauri 1998). On the contrary, usually fleas and nymphs of ticks are not host specific (Linardi and Guimarães 2000; Lareschi *et al.* 2016; Nava *et al.* 2017). Among the genera of fleas included into the family Rhopalopsyllidae, *Polygenis* Jordan is the largest and most widely distributed, parasitizing mainly a broad range of sigmodontine rodents (Linardi and Guimarães 2000; Lareschi *et al.* 2016). Herein, *P.* (*P.*) *tripus* and *Polygenis* sp. were identified exclusively associated with *N. lasiurus* and *A. philipmyersi*, respectively. Further studies are necessary to understand these host-parasite associations.

In the same way, nymphs of ticks were only associated to *N. lasiurus*, although this relationship seems to be hazardous (V/M = 0.98). *Amblyomma ovale* has a wide distribution from southern United States to northern Argentina. Our findings are consistent with literature, since larvae and nymphs of *A. ovale* have the ability to parasitize a wide variety of hosts, including small rodents and birds, in order to increase the probability to reach the adult stage, which parasitize Carnivora (Nava *et al.* 2017).

In the last years for the northeast of Argentina, new species of mites and the unknown males of these species were described (Lareschi 2010, 2011, 2018). These studies suggest that the diversity of the area is underestimated and that more studies are needed to know its biodiversity.

In addition, *A. ovale* is a common parasite of dogs in rural and forested areas, and the records of *A. ovale* adults biting humans in South America are numerous. Besides, this tick species has capacity to transmit *Hepatozoon canis*, the causative agent of a serious dog disease, and it is also a potential vector of the human pathogen *Rickettsia* sp. strain Atlantic rainforest (Nava *et al.* 2017). Other ectoparasites might play an important role in epizootic diseases and their perpetuation among those rodents (Morand *et al.* 2006). Such is the case of *Polygenis* spp., (Linardi and Guimarães 2000), and *Androlaelaps* spp. (Lareschi and Mauri 1998; González *et al.* 2005; Chaisiri *et al.* 2015).

Since some of the ectoparasites identified may play a role in the transmition of pathogens, the results obtained contribute to a better understanding of the ectoparasite-host relationship, which may have epidemiological implications.

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