Issac Camargo, Evangelina Romero-Callejas, Cristian Cornejo-Latorre, Evelyn Rios and Sergio Ticul Álvarez-Castañeda*

Prevalence and intensity of flea *Tunga monositus* (Siphonaptera) in an insular population of *Peromyscus maniculatus* (Rodentia) from Northwest Mexico

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Abstract: We surveyed the status of the endemic deer mouse *Peromyscus maniculatus exiguus* from San Martin Island, Baja California, Mexico where the population is numerous. A total of 89 adult rodents of *P. m. exiguus* were caught, 51 of which were parasitized by the flea *Tunga monositus* (Siphonaptera: Pulicidae); prevalence was 57% and the mean infection intensity was 1.8 parasites per host. No significant differences in prevalence were found between both sexes and between sites. Our results showed a higher infection percentage than those reported in previous studies for the species.

Keywords: Baja California; endemic subspecies; fleas; rodents; San Martin Island.

Fleas (Insecta: Siphonaptera) are a group of highly specialized insects of great importance as vectors of pathogens worldwide (Bitam et al. 2010). The Siphonoptera are cosmopolitan and have the ability to inhabit different environments (Whiting et al. 2008). It has been estimated that flea diversity includes around 3000 species and subspecies worldwide; however, only 2575 have been described to date (Whiting et al. 2008, Acosta-Gutiérrez 2014). Male and female adult fleas are forced obligated blood-sucking ectoparasites of endothermic vertebrates (Acosta-Gutiérrez 2014). In the case of mammals, the species of the order Rodentia are the most affected group as they make approximately 74% of known hosts of fleas worldwide (Linardi and Moreira de Avelar 2014).

In Mexico there are eight families and 172 species of fleas, which account for 6.8% of flea fauna in the world (Acosta-Gutiérrez 2014). It has been reported that fleas parasitize 253 species of mammals in Mexico, mostly rodents (Whitaker and Morales-Malacara 2005). Studies for this group of parasitic insects are scarce in Mexico (Acosta-Gutiérrez 2014). Only in recent years it has been increasing its study (Hernández-Camacho et al. 2014). Many aspects of the basic biology, diversity and distributions, as well as the taxonomic identity of the hosts, are still unknown. This situation reflects the fact that most of the mammal surveys are not paying much attention to the collection of their ectoparasites. In contrast, studies of ectoparasites conducted by entomologists often lack the collaboration of mammalogists, resulting in questionable host identification on some occasions.

In semi-arid areas, such as the Baja California peninsula in Northwest Mexico, no recent efforts have been made to collect blood-sucking ectoparasites, so the lack of knowledge about Siphonaptera diversity and the flea-host interactions is higher than that for other areas of the country (Acosta-Gutiérrez 2014). *Tunga monositus* Barnes and Radovsky 1969 (Siphonaptera: Pulicidae) is a parasitic flea species that lives in the San Quintin area (30.3780° N, 116.0021° W), Baja California. Individuals from San Martin Island, located off San Quintin bay were originally reported as *T. caecata* by Banks (1964); however, they were later assigned to *T. monositus* by Barnes and Radovsky (1969). The known hosts for *T. monositus* are the rodent species

***Corresponding author: Sergio Ticul Álvarez-Castañeda,** Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional 195, Col. Playa Palo de Santa Rita, La Paz, Baja California Sur 23090, Mexico, e-mail: sticul@cibnor.mx
Issac Camargo, Cristian Cornejo-Latorre and Evelyn Rios: Centro de Investigaciones Biológicas del Noroeste, Instituto Politécnico Nacional 195, Col. Playa Palo de Santa Rita, La Paz, Baja California Sur 23090, Mexico
Evangelina Romero-Callejas: Departamento de Parasitología, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México, Coyoacán, Distrito Federal 04510, Mexico

Peromyscus maniculatus (Wagner, 1845), *P. eremicus* (Baird, 1858), *P. crinitus* (Merriam, 1891), *Neotoma lepida* (Thomas, 1893), and *Neotoma* sp. (Barnes and Radovsky 1969, Hastriter 1997, Linardi and Moreira de Avelar 2014). Since its description, no additional collections of *T. monositus* have been reported for Northwest Mexico; thus, the basic parameters (prevalence, abundance, and intensity) to characterize the parasite are unknown, as well as its potential effects on the host. The aim of this note is to report the prevalence and intensity of the flea *T. monositus* parasitizing rodent population of *Peromyscus maniculatus exiguus* (J. A. Allen, 1898) in San Martin Island, Baja California, Mexico.

In August 2013, we surveyed the status of mammals in San Martin Island, which has its center near 30.4879° N, 116.1133° W, about 5 km off San Quintin on the western coast of Baja California, Mexico (Figure 1). The island is approximately 1.5 km in diameter with an area of 318 ha and surrounded by cliffs up to 4.5 m, except on the northeastern side where a small sandy beach and tidal lagoon occur. San Martin Island is part of a volcanic belt, composed of Tertiary andesite and basalt, with little soil on most of the island (Cortés-Calva et al. 2001). The island is within the Upper Sonoran life zone, and the dense Californian coastal scrub vegetation (Pase and Brown 1994), including the cacti *Myrtillocactus cochal* and *Stenocereus gummosus*, lichens, shrubs, and suffrutescent perennials (*Encelia californica* and *Euphorbia misera*), as well as the conspicuous succulents *Dudleya anthonyi* and *D. cultrate* (Junak and Philbrick 1994). The only terrestrial mammals in the island are *Notiosorex crawfordi* (Coues 1877), *Neotoma martinensis* Goldman 1905 (probably extinct, Samaniego-Herrera et al. 2007), and *Peromyscus maniculatus exiguus*, an endemic deer mouse (Álvarez-Castañeda and Cortés-Calva 1999) considered by the Mexican government as threatened (SEMARNAT 2010). The island has no native terrestrial carnivores; some exotic ones – domestic cats (*Felis catus*) and dogs – have been introduced at different times; however, large grazing animals have never been introduced to the island. Only the barn owl (*Tyto alba*) and the gopher snake (*Pituophis catenifer*) are potential predators of rodents on the island.

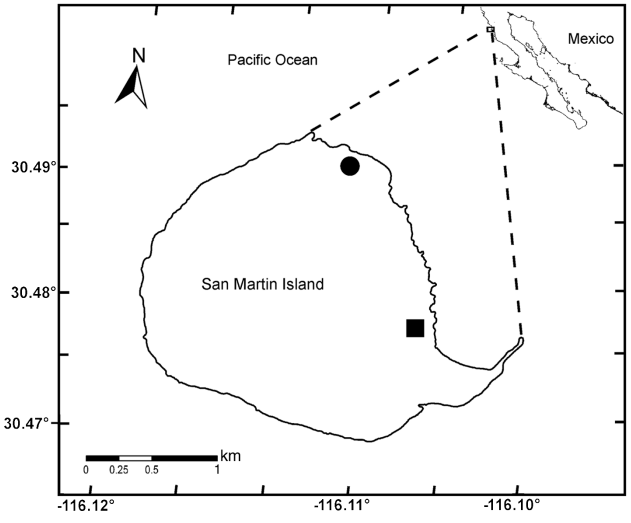

Figure 1: Location of San Martin Island in Northwest Mexico. Solid circle=North point (30.4957° N, -116.1102° W); solid square=East side (30.4869° N, -116.1054° W).

To capture rodents during 3 nights on August 20–22, we placed transects comprising 120 Sherman traps (H.B. Sherman Traps, Inc., Tallahassee, FL, USA) each in two sites spaced about 900 m from one another. The two sites were set in the island under similar vegetation conditions where the only differences between the localities were the substrate. The first one had a sandy substrate (North Point, altitude 8 m, 30.4957° N, -116.1102° W). The second a volcanic substrate (East side, altitude 4 m, 30.4869° N, -116.1054° W). Traps were placed between 18:00 to 07:00 h with a 10-m distance between traps, and baited with rolled oats. All specimens captured (*Peromyscus maniculatus exiguus*) were adults; no juvenile individuals were collected. The rodents were euthanized with chloroform and examined for the presence of fleas before the taxidermy process. Conventional somatic

Table 1: Flea infestation rates on *Peromyscus maniculatus exiguus* by *Tunga monositus* in San Martin Island.

Site	No. individuals	Infested (prevalence)	Mean intensity (±SEM)
North point	42	28 (67%)	1.1904 (±0.1874)
Female	26	15 (58%)	
Male	16	13 (81%)	
East side	47	23 (49%)	0.8723 (±0.1682)
Female	23	9 (39%)	
Male	24	14 (58%)	
	Total 89	51 (57%)	

SEM, Standard error of the mean.

Table 2: Intensity of infection of *Tunga monositus* by sex of *Peromyscus maniculatus exiguus*.

Fleas by host	*Peromyscus maniculatus exiguus*	
	Males	Females
4	4	2
3	1	4
2	7	5
1	15	13
Mean intensity	1.81	1.79

Number of individuals in each case.

measures were taken. For each parasitized rodent, fleas were collected and placed in vials with 75% alcohol. The number of fleas found on each host was counted, and the following data of the host was recorded: locality, sex, and number of fleas (Tables 1–2). The taxonomic identification of the fleas was conducted by a flea expert at the Departamento de Parasitología, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México. The parasitism of *Tunga monositus* was characterized based on ecological parameters such as prevalence which is the percentage of hosts infected with one or more individuals of a species of ectoparasites in particular, divided by the total number of hosts that are examined for the parasite species (Bush et al. 1997) and intensity, which is the number of individuals of a particular species of ectoparasites found infecting a single host species (Bush et al. 1997).

We captured a total of 89 rodents (49 females, 40 males), 51 of which were infested with the flea *Tunga monositus* (24 females, 27 males), which translates into a prevalence of 57% (Table 1). More infested rodents (67%) were found in the north point than in the east side (49%); however, no significant differences were found between both sites (X^2=2.850, *d.f.*=1, p>0.05). Infection intensity ranged from 1 to 4 fleas per host, with a mean intensity of 1.8 (Table 2). The total number of fleas found on the rodents was 91. The ratio of female/male captured rodents was 1.2:1. Prevalence of fleas in females was 49%, and males 67%; no significant differences were found between both sexes (X^2=3.087, *d.f.*=1, p>0.05). Additionally, during our fieldwork five shrews (*Notiosorex crawfordi*) were also captured; however, we found no evidence that these organisms were parasitized by *T. monositus*. No specimens of *Neotoma martinensis* were collected. Separately, during a mammalian survey in the Baja California mainland, we observed minimum parasitism of fleas on rodents, and we found only one parasitized *Peromyscus maniculatus* by *T. monositus* per 100 individuals captured. We found *P. fraterculus* (Miller, 1892) specimens to be more frequently infested with *T. monositus*.

Peromyscus maniculatus and *Tunga monositus* are highly numerous on San Martin Island. In April 1963, Banks (1964) reported a 50% success in capturing the rodents on the island, and he found that nearly one third of the rodents caught were infested with fleas at the base of one or both ears. Our findings 50 years later are similar. Rodents were observed running everywhere after sunset, seemingly unaffected by human presence. Comparing our obtained success to capture rodents on the mainland (6.6%), the success on the island was greater (42.3%) and 57% of the rodents captured on San Martin Island were infested with *T. monositus*. The characterization of the infection based on prevalence provides key information on the parasite-host relationship (Linardi and Moreira de Avelar 2014). Prevalence for *T. monositus* in *P. maniculatus* from San Martin Island was higher than those reported in previous studies for the species (29%, Hastriter 1997). The high parasitism prevalence found here may be due to the fact that *P. m. exiguus* is the only host available for the flea *T. monositus* in the island studied, as the other potential host (*Neotoma martinensis*) is probably extinct; moreover, because of its high density, in relation to the trapping success in relation to mainland, there is greater contact between them, so parasite transmission is easier. The "dilution effect" (Civitello et al. 2015) is also a possible explanation for the high prevalence values of *T. monositus*. This phenomenon generally implies that the abundance of hosts that can potentially be infected by an infectious agent decreases as the species diversity increases. In contrast, the increase in prevalence of various pathogens in some communities, as in the case of *P. maniculatus* (a species highly opportunistic with a broad habitat preferences and wide geographical distribution) on the San Martin Island, can be related to the increase in the abundance of generalist species (Suzán et al. 2009, Ostfeld and Keesing 2012). The numerous population of *P. m. exiguus* on the island suggests that the population dynamics of this endemic rodent has not been significantly affected by *T. monositus*.

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