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ECTOPARASITES OF THE COMMON VAMPIRE BAT (*Desmodus rotundus*) IN COSTA RICA: PARASITISM RATES AND BIOGEOGRAPHIC TRENDS

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ABSTRACT: A descriptive study was carried out to determine the ectoparasitic fauna of the common vampire bat *Desmodus rotundus* (Chiroptera: Phyllostomidae) from twelve locations and eight different life zones in Costa Rica. The biogeographic trends of ectoparasites were described using Geographical Information Systems. A total of sixty seven bats were collected using mist nets and submitted for necropsy. Two species of batflies (Diptera: Streblidae) were identified: *Trichobius parasiticus* (82.14%) and *Strebla wiedemanni* (4.05%), as well as two species of mites: *Radfordiella desmodi* (13.57%) (Acarina: Macronyssidae) and *Periglischrus herrerai* (0.24%) (Acarina: Spinturnicidae). The highest percentages of infestation were given by *T. parasiticus* (91.04%) and *R. desmodi* (19.40%), with an intensity of infestation of 5.65 and 4.38 per bat, respectively. *T. parasiticus* was the species which was most frequently found infesting vampire bats in their natural habitat; it seems to be the ectoparasite with the widest geographic and ecologic distribution. Additionally new geographical distribution for *T. parasiticus* and *S. wiedemanni* are proposed. Humidity, altitude, and average environmental temperature could be factors that influenced the biogeography of the ectoparasitic species found. The finding of *Radfordiella desmodi* and *Periglischrus herrerai* are the first reports of these mites for Costa Rica.

RESUMEN: Ectoparásitos del vampiro común (*Desmodus rotundus*) en Costa Rica: tasas de parasitismo y tendencias biogeográficas. Se realizó un estudio descriptivo sobre la fauna ectoparasitaria del murciélago vampiro *Desmodus rotundus* (Chiroptera: Phyllostomidae) en Costa Rica. Asimismo, se describieron las tendencias ecogeográficas de los ectoparásitos obtenidos, utilizando Sistemas de Información Geográfica. Un total de 67 animales fueron capturados, lográndose obtener un total de 420 ectoparásitos de los cuales el 82.14% correspondieron a dípteros de la especie *Trichobius parasiticus*, y el 4.05% a la especie *Strebla wiedemanni*; mientras que el 13.57% estuvo representado por el ácaro *Radfordiella desmodi*; y *Periglischrus herrerai* correspondió a un 1.5%. Los mayores porcentajes de infestación estuvieron dados por *T. parasiticus* (91.04%) y *R. desmodi* (19.40%), con una intensidad de infestación de 5.65 y 4.38 por murciélago, respectivamente. *Trichobius parasiticus* fue la especie más frecuentemente hallada infestando al murciélago vampiro en su hábitat natural, y al mismo tiempo parece ser el ectoparásito con la mayor distribución geográfica y ecológica en Costa Rica. Adicionalmente se proponen nuevos ámbitos geográficos para *T. parasiticus* y *S. wiedemanni*. La humedad, la altura y la

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temperatura ambiental promedio, parecen ser factores que influyen en la ecogeografía de los especimenes hallados. Los hallazgos de *Radfordiella desmodi* y *Periglischrus herrerai*, son los primeros registros para Costa Rica de ambas especies.

Key words. Costa Rica. Ecological patterns. Ectoparasites. Vampire bats.

Palabras clave. Costa Rica. Ectoparásitos. Murciélagos hematófagos. Tendencias ecológicas.

INTRODUCTION

Costa Rica has 9 families and 110 species of bats which represents more than 11% of all species of chiropterans currently known. *Desmodus rotundus*, *Diaemus youngi* and *Diphylla ecaudata* are the haematophagous species which have been reported in this country (La Val and Rodríguez, 2002).

Prior studies on the ectoparasitic fauna of *D. rotundus*, which have been carried out in South America (Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Surinam and Venezuela), Central America (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama) and North America (Mexico), report a great diversity of species (Wenzel et al., 1966; Guerrero, 1997; Autino and Claps, 2001; Graciolli et al., 2001; Dick and Gettinger, 2005). Among the ectoparasites identified in these countries are batflies from the Streblidae and Nycteribiidae families (Guerrero, 1996). Additionally, mites belonging the Trombiculidae, Myobiidae, Sarcoptidae, Spinturnicidae and Macronyssidae families have also been reported (Webb and Loomis, 1977). Finally, ticks of the genera *Ornithodorus* spp. (Webb and Loomis, 1977) and fleas of the species *Hormopsylla fosteri* have also been cited (Rodríguez et al., 1999).

In Costa Rica there are few reports concerning the parasites of vampire bats (Zeledón and Vieto, 1957; Tonn and Arnold, 1963; Ubelaker et al., 1977; Webb and Loomis, 1977; Fritz, 1983; Goff, 1988; Rojas and Guerrero, 2007). More studies are needed due to the importance of the ectoparasites in the ecology, maintenance and dissemination as biological agents among the population of those mammals (Fritz, 1983; Fonseca et al., 2005).

The aim of the present study was to further clarify the species of ectoparasites on vampire bats, their parasitism rates and biogeographic trends in Costa Rica.

MATERIALS AND METHODS

Study area

Vampire bats were collected in twelve different areas and eight life zones around Costa Rica. The geographic distribution of the sampling areas were: 1) Guanacaste, Nicoya, Quebrada Honda (10.21502 N, 85.29914 O). 2) Guanacaste, Nandayure, Bejuco (9.77530 N, 85.26066 O). 3) Guanacaste, La Cruz, La Cruz (11.15665 N, 85.63048 O). 4) Guanacaste, Tilarán, Santa Rosa (10.49166 N, 84.98541 O). 5) Guanacaste, Abangares, San Juan (10.19668 N, 84.89324 O). 6) Alajuela, San Ramón, Los Angeles (10.14582 N, 84.49910 O). 7) Alajuela, San Carlos, Venado (10.52183 N, 84.81839 O). 8) Alajuela, San Ramón, San Rafael (9.98291 N, 84.49171 O). 9) Alajuela, San Mateo, Jesús María (9.96495 N, 84.57589 O). 10) Cartago, Turrialba, Tres Equis (9.98221 N, 83.60420 O). 11) Puntarenas, Puntarenas, Cóbano (9.59506 N, 85.14223 O). 12) Puntarenas, Puntarenas, Lepanto (9.89690 N, 85.21064 O). The bioclimatic characteristics of sampling areas were taken using the Geographic Position System (**Table 1**).

Collection

Monthly samplings were realized from October 2003 to July 2005. The vampire bats were collected using mist nets placed in caves, tunnels or abandoned mines. The bats caught were manipulated with leather gloves and placed in cages of galvanized steel, in order to be transferred to the Pathology Laboratory at the School of Veterinary

Table 1

Bioclimatics characteristics of the sampling sites from *D. rotundus* in Costa Rica. Bh-T10 = Base Moist Forest, Transition to Base Dry Forest; Bh-P6 = Premontane Wet Forest, Transition to Base Wet Forest; Bh-T = Base Moist Forest; Bh-T12 = Base Moist Forest, Transition to Premontane Moist Forest; Bmh-P = Premontane Wet Forest; Bp-P = Premontane Rain Forest; Bh-T2 = Base Moist Forest, Transition to Base Rain Forest; Bmh-T12 = Base Wet Forest, Transition to Premontane Wet Forest; *According to Holdridge (1987).

Locality	Life Zone* annual precipitation (mm/year)*	Average total Evapotranspiration Ratio*	Potential Biotemperature Average (C°)*	Annual Rank (m)*	Altitudinal
1	Bh-T10	2000-4000	0.5-1	>24	0-500
2	Bh-P6	2000-4000	0.25-0.5	12-24	>500-2000
3	Bh-T	2000-4000	0.5-1	>24	0-500
4	Bh-T12	2000-4000	0.5-1	>24	0-500
5	Bh-T	2000-4000	0.5-1	>24	0-500
6	Bmh-P	2000-4000	0.25-0.5	12-24	>500-2000
7	Bp-P	4000-8000	0.125-0.25	12-24	>500-2000
8	Bmh-P	2000-4000	0.25-0.5	12-24	>500-2000
9	Bh-T2	2000-4000	0.5-1	>24	0-500
10	Bmh-T12	4000-8000	0.5-1	>24	0-500
11	Bh-T2	2000-4000	0.5-1	>24	0-500
12	Bh-T	2000-4000	0.5-1	>24	0-500

Medicine, National University of Costa Rica to be euthanatized. The animals were euthanized inside a glass container that had a paper towel impregnated with an inhalant anesthetic (chloroform) according to ACUC (1998), and maintained inside for five minutes until they died. Once the animals were dead, the collection of the ectoparasites was realized with the aid of fine tweezers.

Preservation, mounting and species identification

The ectoparasites were preserved in individual containers filled with alcohol 70%-glycerol and mounted using Hoyer's solution. The ectoparasites were identified using specific morphological keys (Machado-Allison, 1965; Wenzel et al., 1966; Radovsky, 1967; Guerrero, 1994; Guerrero, 1996). The batflies were deposited in the entomology collections of the National Institute of Biodiversity (deposit numbers 4015662-4016997), Museum of Insects at the University of Costa Rica and the Laboratory of Parasitology of the Veterinary Medicine School at the National University of Costa Rica (deposit numbers not applicable). The mites found were deposited in the entomology collection of the Museum of Insects at the University of Costa Rica (deposit numbers not applicable).

Parasitism rates

The percentage of infestation and the intensity of infestation were determined. The percentage of infestation was defined as the total number of positive bats to ectoparasite between the total bats captured, whereas the intensity of infestation was defined as total number of ectoparasites by bat, between the total of positive bats to each ectoparasites (Muñoz et al., 2003).

Biogeographic trends

Data base in Arc View (Arc View 3,3 ESRI. Inc., 2001), was created using the Lambert comformal Conic projection, in which the following information was included: province, county and district, latitude, longitude, altitude, species of ectoparasites and life zone; in order to classify the geography and ecology of each locality sampled using the Holdridge's life zones system (Holdridge, 1987).

RESULTS

A total of 67 bats were captured (15 males and 52 females) and 420 ectoparasites were obtained. Three hundred and sixty two (86.20%) were batflies of the species *Trichobius parasiticus* and *Streblа wiedemanni*; and 58 (13.80%) corresponds to mites *R. desmodi* and *P. herrerai* (**Table 2**).

The percentage of infestation of *T. parasiticus* and *S. wiedemanni* on bats was 91.04% (61) and 11.94% (8) respectively. Additionally 13 (19.40%) bats were found positively infested by the mite *R. desmodi*. The spinturnicid mite *P. herrerai* could be only found in 1 (1.50%) bat. The infestation intensity average by ectoparasitic species was 6.27ectoparasites/bat. The intensity average by species was 5.65 *T. parasiticus*/bat, 2.12 *S. wiedemanni*/bat, 4.38 *R. desmodi*/bat and 1.00 *P. herrerai*/bat, respectively (**Table 3**).

Most of the ectoparasites collected were located in the provinces of Alajuela and Guanacaste (**Table 4**). The ecological distribution varied for each species. Of a total of 345 specimens of *T. parasiticus* collected, 27.53% (95) were found in the life zone corresponding to premontane wet forest; 22.60% (78) in base moist forest, transition to premontane moist forest; 22.00% (61) in base moist forest; 11,88% (41) in premontane rain forest, and the remain 15.28% (54) were distributed in life zones corresponding to premontane moist forest, transition to base moist forest; base moist forest, transition to base dry forest; base moist forest, transition to premontane moist forest and base moist forest, transition to base wet forest. A total of 17 specimens of *S. wiedemanni* were collected, 52.93% (9) could be found in base moist forest; 29.41% (5) in base moist forest, transition to base dry forest; 11.76% (2) was found in base moist forest, transition to premontane moist forest, and 5.88% (1) in zones corresponding to premontane wet forest. A total of 57 specimens of *R. desmodi* were obtained, of which 49.12% (28) were located in premontane rain forest; the 43.85% (25) in base moist forest; 5.26% (3) in life zones corresponding to premontane wet forest, and 1.75% (1) in base moist forest, transition to base dry forest. The only specimen of *P. herrerai* corresponds to one protonymph and was found in the life zone corresponding to base moist forest (**Table 5**).

DISCUSSION AND CONCLUSIONS

In our study only four species of ectoparasites could be found. These species correspond to *T. parasiticus* and *S. wiedemanni* (Diptera: Streblidae), *R. desmodi* (Acarina: Macronyssidae) and *P. herrerai* (Acarina: Spinturnicidae). Only *T. parasiticus* and *S. wiedemanni* were the streblids collected on *D. rotundus* in this work, findings similar to others studies carried out in Costa Rica (Tonn and Arnold, 1963; Guerrero, 1997). Wenzel et al. (1966) also reported *S. hertigi* infesting *D. rotundus* in Costa Rica; however this streblid was not found in this research which could indicate that the common vampire bat is an accidental host. The total number of ectoparasitic species found per vampire bat in this study is lowest than other previous reports (Machado-Allison, 1965). This difference could be explain by the natural history of the ectoparasite, in addition to a small sample size and ecological factors such as competence between species of parasites (Linhares and Komeno, 2000), reproductive behavior (Ter Hofstede et al., 2004; Berlota et al., 2005) and its life cycle (Whitaker et al., 2000).

Trichobius parasiticus and *R. desmodi* had the highest parasitism rates. Therefore it can be hypothesized that both species are frequent ectoparasites of *D. rotundus* in its natural habitat. Our results agree with the reported for this streblids in Paraguay (Dick and Gettinger, 2005), Brazil, Mexico, Peru and Trinidad (Wenzel et al., 1966). However, our results are not in accordance with other studies that propose the same geographic distribution for *S. wiedemanni* and *D. rotundus* (Guerrero, 1996). Additionally, *P. herrerai* and *R. desmodi* have been reported as common ectoparasites of vampire bats in several countries of Latin America (Marinkelle and Groose, 1981; Whitaker and Abrell, 1987; Azevedo et al., 2002; Mendoza-Uribe and Chavez, 2003), but it is the first record of these mites infesting *D. rotundus* in Costa Rica. *Periglischrus*

Table 2

Ectoparasites collected from *D. rotundus* in Costa Rica. * Protonymph

Ectoparasite	Males	Females	Total	%
DIPTERA				
Trichobius parasiticus	197	148	345	82.14
Strebla wiedemanni	9	8	17	4.05
ACARINA				
Radfordiella desmodi	3	54	57	13.57
Periglischrus herrerai *	-	-	1	0.24
TOTAL	209	210	420	100

Table 3

Infestation percentages and intensity averages of the ectoparasites species found. (*Not calculated as there was only one specimen).

Ectoparasite	# of bats Infested	Infestation %	Infestation Intensity	Range of infection
Trichobius parasiticus	61	91.04	5.65 ± 6.1	0.00-11.75
Strebla wiedemanni	8	11.94	2.12 ± 0.76	1.36-2.88
Radfordiella desmodi	13	19.40	4.38 ± 1.73	2.65-6.11
Periglischrus herrerai	1	1.5	*	*

Table 4

Geographic distribution of the ectoparasites collected from *D. rotundus* (+Positive to ectoparasites, -Negative to ectoparasites).

Province	*Trichobius parasiticus*	*Strebla wiedemanni*	*Radfordiella desmodi*	*Periglischrus herrerai*
Guanacaste	+	+	+	+
Alajuela	+	+	+	-
Cartago	+	-	-	-
Puntarenas	+	-	+	-

Table 5

Ecological distribution of the ectoparasites obtained from *D. rotundus* in Costa Rica (+Positive to ectoparasites, -Negative to ectoparasites). *The simbology of the life zones are described in **Table 1**.

Life Zone*	*Trichobius parasiticus*	*Strebla wiedemanni*	*Radfordiella desmodi*	*Periglischrus herrerai*
Bh-T10	+	+	-	-
Bh-P6	+	-	-	-
Bh-T	+	+	+	+
Bh-T12	+	+	-	-
Bmh-P	+	+	+	-
Bp-P	+	-	+	-
Bh-T2	+	-	-	-
Bmh-T12	+	-	+	-

herrerai was distributed in few areas which may signify that the occurrence of these mites in the populations of vampire bats is low. In general, the infestations with Spinturnicidae mites are found in very few individuals (Wohland, 2000).

The finding of *T. parasiticus* in the Guanacaste, Puntarenas, Alajuela and Cartago provinces, as well as *S. wiedemanni* in the Alajuela and Guanacaste provinces, suggests new geographic ranges for them inside Costa Rica.

Previous studies about the ectoparasitic fauna of *D. rotundus* in Costa Rica are focused mainly in a geographic description in which these ectoparasites were found; without giving reference to their ecology. The results obtained according to the ecology indicate that *T. parasiticus* and *R. desmodi* seem to prefer relatively cold habitats and low humidity, where the precipitation indices are between the 2000-8000 millimeters per year, with a mean potential evapotranspiration ratio between 0.125-0.5, and environmental temperature average oscillating in the rank of 12-24°C. Due to the fact that the life zones where these two species were found corresponded mainly to altitudinal belts of premontane character, it is possible that both species might be found only in geographic areas with elevations between 500-2000 meters above sea level; results that are similar to the altitudinal ranks near to 1700 meters above sea level, that have been proposed for some streblid species (Wenzel et al., 1966). In contrast, *S. wiedemanni* and *P. herrerai* seem to prefer warmer zones of life and humidity, with an annual precipitation between 2000-4000 millimeters per year, a potential evapotranspiration ratio of 0.25-0.5, and environmental temperatures over 24°C, being frequently found in basal altitudinal belts in which the elevation average is 0-500 meters above sea level (Holdridge, 1987). These results suggest that the altitude, temperature and environmental humidity average are important factors in the ecology of these species, in accordance with previous studies which propose that seasonal temperatures may affect the reproductive and mortality rates of some bat ectoparasites (Rui and Graciolli, 2005).

Additionally, our results suggest that the ecological distribution of the ectoparasitic species found might be the same in other geographic areas of our country, as well as in other Latin American countries with similar life zones. Nevertheless more studies are needed in order to clarify more about their ecology.

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