Full Article

Rev. Bras. Parasitol. Vet., Jaboticabal, v. 20, n. 4, p. 325-330, out.-dez. 2011
ISSN 0103-846X (impresso) / ISSN 1984-2961 (eletrônico)

Reinfestation of Streblidae ectoparasites (Diptera) in *Carollia perspicillata* (Linnaeus, 1758) (Chiroptera)

Reinfestação de ectoparasitas Streblidae (Diptera) em *Carollia perspicillata* (Linnaeus, 1758) (Mammalia: Chiroptera)

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Received April 12, 2011
Accepted July 13, 2011

Abstract

The mark-recapture method allows analysis on the variation in the abundance of bat ectoparasites at consecutive captures. The objectives of this study were to compare the pattern of Streblidae parasitism between capture and recapture of *C. perspicillata*; ascertain whether the abundance of Streblidae varied with time after removal of ectoparasites at capture and analyze whether the intensity of parasitism remained the same in each individual at capture and recapture. Using bats netted in the State of Rio de Janeiro, 42 individuals of *C. perspicillata* parasitized by two Streblidae species, *Trichobius joblingi* Wenzel, 1966 and *Strebla guajiro* (Garcia & Casal, 1965), were selected. The pattern of parasitism observed at capture was similar at recapture. No relationship was observed between the capture-recapture time interval and the abundance of ectoparasites. There was no relationship between the abundances of ectoparasites at capture and recapture of each individual.

Keywords: Host-parasite interaction, mark-recapture, *Strebla guajiro*, *Trichobius joblingi*.

Resumo

A utilização da técnica de marcação-recaptura de morcegos permite a análise da variação na abundância de ectoparasitas de morcegos em capturas consecutivas. Os objetivos deste trabalho foram comparar o padrão de parasitismo de Streblidae entre captura e recaptura de *Carollia perspicillata*; verificar se a abundância de Streblidae varia com o tempo após a remoção dos ectoparasitas na captura e analisar se a intensidade de parasitismo permanece similar em cada indivíduo na captura e recaptura. Por meio de coletas com redes de neblina, no Estado do Rio de Janeiro, foram encontrados 42 indivíduos de *C. perspicillata* parasitados por duas espécies de Streblidae, *Trichobius joblingi* Wenzel, 1966 e *Strebla guajiro* (Garcia & Casal, 1965). O padrão de parasitismo observado durante a captura foi semelhante na recaptura. Não foi observada relação do tempo entre a captura e recaptura com a abundância de ectoparasitas. Não houve relação entre a abundância de ectoparasitas na captura e recaptura de cada indivíduo.

Palavras-chave: Interação hospedeiro-parasita, marcação-recaptura, *Strebla guajiro*, *Trichobius joblingi.*

Introduction

The abundance of ectoparasites in their host can vary depending on environmental factors and factors intrinsic to the host. Differences relating to the host's sex, age and body size are the parameters most analyzed regarding variations in the abundance of ectoparasites on bats (KOMENO; LINHARES, 1999; PRESLEY, 2007; PRESLEY; WILLIG, 2008; PATTERSON et al., 2008a,b). Other biological characteristics such as type of refuge, social behavior, reproductive condition and home range can also influence the abundance of ectoparasites (MOURA et al., 2003; TER HOFSTEDE; FENTON, 2005; RECKARDT; KERTH, 2006; LOURENÇO; PALMEIRIM, 2007; PATTERSON et al., 2007; BORDES et al., 2008; McCOY, 2009).

However, despite these studies, little is known about the pattern of how ectoparasites choose their hosts, especially regarding whether there is any individual predisposition to parasitism. Studies that analyze reinfestation can clarify this pattern of choice. In relation to bats, the studies by Esbérard et al. (2005) and Dick and Dick (2006) demonstrated the behavior of ectoparasites in laboratory experiments. Esbérard et al. (2005) showed that the Streblidae species *Megistopoda aranea* (Coquillet, 1899), *Megistopoda proxima*

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(Séguy, 1926), and *Strebla guajiro* (Garcia & Casal, 1965) search for their hosts by species: *Artibeus lituratus* (Olfers, 1818), *Sturnira lilium* (E. Geoffroy, 1810) and *Carollia perspicillata* (Linnaeus, 1758), respectively. Dick and Dick (2006) analyzed the behavior of *Trichobius joblingi* Wenzel, 1966 regarding the choice of host and observed that these flies prefer individuals of *C. perspicillata* that do not present infestation by other individuals of *T. joblingi.* However, there was no preference between hosts without ectoparasites and with *Speiseria ambigua* Kessel, 1925, another ectoparasite found in *C. perspicillata. Carollia perspicillata* is the species of Neotropical bats that is most often recaptured (MELLO et al., 2004; BIANCONI et al., 2006), and it presents prevalence of Streblidae of around 50% (KOMENO; LINHARES, 1999; BERTOLA et al., 2005). Therefore, *C. perspicillata* is one of the most appropriate species for studies on reinfestation of ectoparasites.

This study aimed to test the following hypotheses relating to Streblidae parasitism in *C. perspicillata*: 1) Removal of ectoparasites has an effect on Streblidae parasitism, thus demonstrating differences in the pattern of parasitism between capture and recapture; 2) Individuals recaptured within very short times have lower abundances of ectoparasites, thereby demonstrating that reinfestation is dependent on the time for which the individual is at risk of being parasitized; 3) When individuals from which ectoparasites are removed at the time of capture become reinfested, they reach the same patterns of ectoparasite abundance as seen at the time of capture, with an individual pattern of Streblidae infestation in *C. perspicillata*.

Methodology

Sampling was done from August 1999 to September 2009, in 38 areas at elevations ranging from sea level to 640 m in the state of Rio de Janeiro. The samples were collected by a team from the Bat Diversity Laboratory of the Federal Rural University of Rio de Janeiro. The bats were captured and recaptured in mist nets (7 × 3 m or 9 × 3 m), weighed on a digital balance (accurate to the nearest 1 g), tagged with plastic collars for individual identification (ESBÉRARD; DAEMON, 1999) and released at the same place no more than three hours after capture. Ectoparasites were removed from the bats with the aid of fine-point tweezers and were placed in vials containing a batch of 95 °GL alcohol, for each bat at each collection time. The ectoparasites collected were deposited in the reference collection of the Bat Diversity Laboratory of the Federal Rural University of Rio de Janeiro. For analysis purposes, the first recapture of each individual of *C. perspicillata* was used, and any recaptures that occurred on the same day as the first capture were ignored. Only the capture-recapture sets in which Streblidae were present, either at capture or at recapture, were taken into consideration. The dates of capture and recapture, body mass and Streblidae ectoparasites found at the times of capture and recapture were analyzed. Ectoparasites were identified with the aid of a stereomicroscope, using identification keys (WENZEL, 1976; GRACIOLLI; CARVALHO, 2001). For each species of ectoparasite, the prevalence, mean abundance of infestation and mean intensity of infestation at the times of capture and recapture were calculated, following the definitions of Bush et al. (1997). Since body size is a factor that can influence the intensity of infestation (PRESLEY; WILLIG, 2008; PATTERSON et al., 2008a), possible differences in body mass between individuals at the times of capture and recapture were checked using the chi-square test. This test was also used to analyze the abundances of Streblidae found in individuals at the times of capture and recapture, and between the proportions of individuals that presented more than one species of Streblidae concurrently, at the times of capture and recapture.

The data were converted into logarithmic form [ln (x + 1)] to carry out the analyses. Pearson's correlation was used between the abundances of pairs of ectoparasite species, in order to check for possible interference of the abundance of one species on another, at capture and recapture. It was also used between the abundance of Streblidae at recapture and the time that elapsed between capture and recapture. Because of wide variations in time between capture and recapture, it was not possible to carry out further analysis on this parameter. Pearson's correlation was performed between the abundances of each species of Streblidae at capture and recapture, to ascertain patterns of abundance per individual. Student's *t*-test was performed between the total abundance of each species of Streblidae at capture and the total for Streblidae at recapture, and analysis of variance was used between the intensities of ectoparasites at the times of capture and recapture.

Results

Forty-two individuals of *C. perspicillata* were found to present Streblidae at capture and/or recapture, thereby totaling 16.0% of 263 recapture events. Of the 38 areas analyzed, only 23 showed recaptures of *C. perspicillata* and only 12 showed *C. perspicillata* with Streblidae at capture and/or recapture (Table 1). The total sample comprised 21 males and 21 females of *C. perspicillata*, and all of them were adults. The interval in days between capture and recapture ranged from 1 to 1411 days (mean of 198.0 ± 262.9; median of 151 days). Body mass ranged from 9.0 to 27.0 g for captures (mean: 16.3 ± 2.9) and from 12.0 to 19.0 g for recaptures (mean: 15.6 ± 1.9). There was no statistical difference in individuals' body mass between capture and recapture ($\chi^2 < 3.841$; df = 1; $p > 0.05$).

At captures 51 specimens of *Trichobius joblingi* (variation 0-5, mean 1.2 ± 1.4, median 1.2) and 28 of *Strebla guajiro* (variation 0-18, mean 0.7 ± 2.9, median 0.7) were found. At recaptures 46 specimens of *T. joblingi* (variation 0-12, mean 1.1 ± 2.1, median 1.1) and 18 of *S. guajiro* (variation 0-4, mean 0.4 ± 0.9, median 0.4) were found. There was no difference in the mean abundance of *T. joblingi* ($t = 0.683$, $n = 42$, $p = 0.499$) or *S. guajiro* ($t = 0.826$, $n = 42$, $p = 0.413$); or in the mean intensity of *T. joblingi* ($n_{capture} = 24$, $n_{recapture} = 21$, $F = 0.841$, $p = 0.364$) or *S. guajiro* ($n_{capture} = 6$, $n_{recapture} = 10$, $F = 1.758$, $p = 0.206$), between capture and recapture (Table 2).

In 11.1% of the captures presenting Streblidae (n = 3), the two species were found to coexist, while in recaptures this value was 24.0% (n = 6), without any significant difference ($\chi^2 = 0.5$, df = 1, $p = 0.479$). There was no correlation between the abundances

Table 1. Total number of individuals of *Carollia perspicillata* recaptured and the capture-recapture sets with presence of Streblidae in the State of Rio de Janeiro.

Cities and localities	Coordinates	Total recaptures	Captures and/or recaptures with Streblidae
Varre Sai			
São Mateus	21° 05' 04.0" S and 41° 56' 23.0" W	1	-
Miracema			
Paraíso do Tobias	21° 24' 16.2" S and 42° 04' 03.6" W	11	1
Cambuci			
Monte Verde	21° 49' 36.9" S and 41° 87' 15.1" W	2	-
Santa Maria Madalena			
Parque Estadual do Desengano	21° 45' 00.0" S and 41° 41' 05.0" W	1	-
Quissamã			
PN Restinga Jurubatiba	22° 23' 33.0" S and 41° 45' 24.0" W	1	-
Casimiro de Abreu			
RB União	22° 27' 54.6" S and 42° 02' 32.0" W	4	-
Morro de São João	22° 29' 96.0" S and 41° 58' 92.3" W	21	2
Guapimirim			
Estação Ecológica Paraíso	22° 29' 46.5" S and 42° 54' 31.7" W	4	-
Cachoeira de Macacu			
Reserva Ecológica de Guapiaçú	22° 30' 52.0" S and 42° 58' 37.0" W	5	1
Rio de Janeiro			
Rua Jequitibá	22° 58' 26.6" S and 43° 13' 48.7" W	6	-
Parque Laje	22° 57' 37.5" S and 43° 12' 41.8" W	1	-
Parque do Penhasco Dois Irmãos	23° 59' 02.8" S and 43° 14" 07.3" W	2	-
PN da Tijuca	22° 57' 40.6" S and 43° 17' 61.0" W	5	-
Valença			
Serra da Concórdia	22° 22' 18.0" S and 43° 47' 23.0" W	4	-
Paracambi			
Ponte Coberta	22° 39' 26.7" S and 43° 48' 09.7" W	6	1
Itaguaí			
Coroa Grande	22° 53' 03.8" S and 43° 51' 03.9" W	2	1
Mangaratiba			
Ilha de Itacuruçá	22° 55' 39.5" S and 43° 53' 04.8" W	78	18
Ilha de Jaguanum	22° 59' 31.5" S and 43° 55' 22.4" W	2	2
Ilha da Marambaia	23° 04' 03.0" S and 43° 53' 14.0" W	47	5
Sahy	22° 55' 57.8" S and 44° 00' 43.6" W	8	2
Hotel Portobello	22° 54' 12.0" S and 44° 04' 11.2" W	4	2
RB Rio das Pedras	22° 59' 39.4" S and 44° 06' 17.3" W	14	1
Angra dos Reis			
Ilha da Gipóia	23° 02' 49.9" S and 44° 21' 42.4" W	34	6
Total		263	42

PN: National Park; RB: Biological Reserve.

of *T. joblingi* (n = 42, r = 0.144, F = 0.845, p = 0.363) and *S. guajiro* (n = 41, r = 0.011, F = 0.05, p = 0.945) at captures and recaptures.

There was no correlation between the abundance of *T. joblingi* (n = 42, r = 0.038, F = 0.058, p = 0.811) or of *S. guajiro* (n = 42, r = 0.000, F = 0.302, p = 0.586) at the time of recapture and the time interval in days that elapsed between capture and recapture.

The abundances of *T. joblingi* (n = 42, r = 0.199, F = 1.650, p = 0.206) and *S. guajiro* (n = 42, r = 0.096, F = 0.369, p = 0.547) did not show any relationship between the time of capture and the time of recapture. Individuals that had more ectoparasites at the time of capture did not have more Streblidae at the time of recapture.

Two individuals presented significant differences in abundance of Streblidae between capture and recapture. One of them had a high intensity of *S. guajiro* at the time of capture, but no presence of Streblidae at recapture (χ^2 = 9.0, df = 1, p = 0.003), which occurred three days after capture. The other had a high intensity of *T. joblingi* on recapture, 342 days after the initial capture, but had not shown any Streblidae at capture (χ^2 = 6.0, df = 1, p = 0.014) (Table 2).

Table 2. Abundance of Streblidae among 42 individuals of *Carollia perspicillata* at captures and recaptures, prevalence, mean intensity, mean abundance and total abundance of Streblidae. Interval at 95% confidence between parentheses.

	Days between capture and recapture	Captures			Recaptures			Chi-square	
		T. joblingi	*S. guajiro*	Total	*T. joblingi*	*S. guajiro*	Total	*T. joblingi*	*S. guajiro*
F1	1	2	-	2	-	-	-	1	-
F2	1	2	-	2	-	-	-	1	-
F3	1	-	-	-	-	1	1	-	0.5
F4	2	-	-	-	-	2	2	-	1
F5	3	-	18	18	-	-	-	-	9*
F6	4	1	-	1	1	-	1	-	-
F7	20	3	-	3	-	-	-	1.5	-
F8	21	-	-	-	1	2	3	0.5	1
F9	21	-	-	-	-	1	1	-	0.5
F10	30	-	1	1	1	-	1	0.5	0.5
F11	35	1	-	1	-	-	-	0.5	-
F12	70	3	-	3	-	-	-	1.5	-
F13	147	-	-	-	1	-	1	0.5	-
F14	160	1	-	1	-	-	-	0.5	-
F15	161	1	-	1	1	-	1	-	-
F16	177	4	5	9	-	-	-	2	2.5
F17	328	4	-	4	1	-	1	0.9	-
F18	490	-	-	-	3	1	4	1.5	0.5
F19	530	-	-	-	1	-	1	0.5	-
F20	601	2	-	2	2	-	2	-	-
F21	809	-	1	1	-	-	-	-	0.5
M1	1	-	-	-	1	4	5	0.5	2
M2	28	3	-	3	-	-	-	1.5	-
M3	28	-	-	-	1	1	2	0.5	0.5
M4	85	1	-	1	-	-	-	0.5	-
M5	94	4	-	4	-	-	-	2	-
M6	106	-	-	-	1	1	2	0.5	0.5
M7	110	1	-	1	-	2	2	0.5	1
M8	135	2	1	3	1	-	1	0.2	0.5
M9	155	1	-	1	-	-	-	0.5	-
M10	160	1	-	1	6	-	6	1.8	-
M11	161	2	2	4	1	-	1	0.2	1
M12	163	3	-	3	-	-	-	1.5	-
M13	188	-	-	-	2	-	2	1	-
M14	192	5	-	5	-	-	-	2.5	-
M15	192	1	-	1	-	-	-	0.5	-
M16	209	-	-	-	2	-	2	1	-
M17	267	-	-	-	-	1	1	-	0.5
M18	328	1	-	1	5	-	5	1.3	-
M19	342	-	-	-	12	3	15	6**	1.5
M20	350	2	-	2	-	-	-	1	-
M21	1411	-	-	-	1	-	1	0.5	-
Prevalence (%)		57.1	14.3	64.3	50.0	23.8	59.5	-	-
Mean abundance		1.2 (1.6-0.8)	0.7 (1.5-0.0)	2.9 (2.3-0.7)	1.1 (1.7-0.4)	0.4 (0.7-0.2)	2.6 (2.8-0.9)	-	-
Mean intensity		2.1 (2.6-1.6)	4.7 (11.7-0.0)	1.9 (4.3-1.5)	2.2 (3.5-1.0)	1.8 (2.4-1.0)	1.5 (3.8-1.3)	-	-
Abundance total		51	28	79	45	19	64	-	-

*Significant with p = 0.003; **p = 0.014.

Discussion

The two Streblidae species considered in this analysis, *T. joblingi* and *S. guajiro*, are species commonly found in *C. perspicillata* (WENZEL, 1976; KOMENO; LINHARES, 1999; BERTOLA et al., 2005; GRACIOLLI et al., 2006; DICK; GETTINGER, 2005; DICK et al., 2007), and they may coexist in the same host (BERTOLA et al., 2005; SANTOS et al., 2009). Removal of ectoparasites may result in different proportions of ectoparasite species when reinfestation occurs, since individuals without ectoparasites may attract infestation by new species (WENZEL; TIPTON, 1966; DICK; DICK, 2006; TELLO et al., 2008). However, this result is consistent with the study by Tello et al. (2008), who studied the relationship between these two species and showed that there was no interference between the abundances of one species and the other. The speed of the infestation (or reinfestation) process depends on the duration of contact between infested and uninfested individuals, the kind of shelter, the number of individuals in the colony, the parasite population size and the average duration of grooming, among other things (JOHNSON et al., 2004; PRESLEY; WILLIG, 2008; McCOY, 2009). Higher bat densities in their shelters result in increased contact between colony members and thus may increase the chance of infestation (MOURA et al., 2003; JOHNSON et al., 2004; TER HOFSTEDE; FENTON, 2005; PATTERSON et al., 2007). Studies have shown that the shelters used by *C. perspicillata*, which mainly consist of caves and hollows (TUTTLE, 1976), may have greater abundance of ectoparasites than is observed in open shelters (MOURA et al., 2003; TER HOFSTEDE; FENTON, 2005; PATTERSON et al., 2007). The high loyalty to the shelter and the social stability shown by *C. perspicillata* (FLEMING, 1988) may contribute towards a population of parasites with constant intensity of parasitism, since the parasite load present in a shelter tends to be balanced between individuals (JOHNSON et al., 2004). The occurrences of reinfestation of individuals in which there was only one day between the removal of ectoparasites and recapture demonstrate that reinfestation can be rapid and can occur within the first hour of contact. A host or social group in a shelter can be considered to be a habitat for Streblidae (TELLO et al., 2008). If we consider each host to be a habitat, it might be expected that some hosts would be better than others, but this could not be demonstrated in the present study. In the case of the individual that had a high intensity of Streblidae at the time of capture but did not show a high intensity at the time of recapture, this recapture occurred three days after the capture, which could explain the difference. Many of the individuals had similar intensities between capture and recapture. Even individuals in the same group may have different intensities of parasitism without any pattern recognition regarding body mass, reproductive condition, sex or age (OVERAL, 1980; PRESLEY; WILLIG, 2008; BERTOLA et al., 2005; DICK; DICK, 2006). Since infestation of bats by Streblidae may occur in shelters through direct contact between hosts or between the shelter and the host (DICK; PATTERSON, 2006), it is possible that the characteristics of the bats' positions during the daytime are more important in relation to infestation and intensity of parasitism. Streblidae can stay in the shelter and use its walls and substrate for larviposition and formation of the puparium, the adult will seek its host after eclosion (DICK; PATTERSON, 2006). The factors that contributed towards the differences in abundance found for these two species of Streblidae are unclear, as are the negative effects of high intensity of parasitism in bats. The low number of samples found at a single collection point, even with a large number of possible hosts, and the large variation in time between capture and recapture demonstrate the difficulties in dealing with reinfestation. Other studies using mark-recapture of hosts and experimental reinfestation should be conducted to obtain a better understanding of the behavior of these ectoparasites and their relationships with specific individuals.

In the present study, it could not be shown that host capture and ectoparasite removal resulted in greater reinfestation in the individual, but the patterns of parasitism by Streblidae at capture were similar to the patterns at recapture. The most highly infested individuals at capture were not necessarily the most highly infested individuals at recapture, thus indicating that there was no individual predisposition or no greater or lesser resistance to parasites.

Acknowledgements

To Costa, L.M; Luz, J.L; Gomes, L.A.C., Carvalho, W.D. and Freitas, L.N. – the team of the Bat Diversity Laboratory – for reviewing the text and assisting with specimen collection. To Dr. Alejos, J.L.F.L. for assistance with parasitological data.

References

BERTOLA, P. B. et al. Bat flies (Diptera: Streblidae, Nycteribiidae) parasitic on bats (Mammalia: Chiroptera) at Parque Estadual da Cantareira, São Paulo, Brazil: parasitism rates and host-parasite associations. **Memórias Instituto Oswaldo Cruz**, v. 100, n. 1, p. 25-32, 2005.

BIANCONI, G. V.; MIKICH, S. B.; PEDRO, W. A. Movements of bats (Mammalia, Chiroptera) in Atlantic Forest remnants in southern Brazil. **Revista Brasileira de Zoologia**, v. 23, n. 4, p. 1199-1206, 2006. http://dx.doi.org/10.1590/S0101-81752006000400030

BORDES, F.; MORAND, S.; RICARDO, G. Bat fly species richness in Neotropical bats: correlations with host ecology and host brain. **Oecologia**, v. 158, n.1, p. 109-116, 2008. PMid:18679724. http://dx.doi.org/10.1007/s00442-008-1115-x

BUSH, A. O. et al. Parasitology meets ecology on its own terms: Margolis et al. revisited. **Journal of Parasitology**, v. 83, n.4, p. 575-583, 1997. PMid:9267395. http://dx.doi.org/10.2307/3284227

DICK C. W.; PATTERSON, B. D. Bat flies-obligate ectoparasites of bats. In: MORAND, S., KRASNOV. B.; POULIN, R. (Ed.). **Micromammals and macroparasites: from evolutionary ecology to management.** Tokyo: Springer, 2006. p. 179-194.

DICK, C. W.; DICK, S. C. Effects of prior infestation on host choice of bat flies (Diptera: Streblidae). **Journal of Medical Entomology**, v. 43, n. 2, p. 433-436, 2006. http://dx.doi.org/10.1603/0022-2585(2006)043[0433:EOPIOH]2.0.CO;2

DICK, C. W.; GETTINGER, D. A faunal survey of streblid flies (Diptera: Streblidae) associated with bats in Paraguay. **Journal of Parasitology**, v. 91, n. 5, p. 1015-1024, 2005. PMid:16419742. http://dx.doi.org/10.1645/GE-536R.1

DICK, C. W.; GETTINGER, D.; GARDNER, S. L. Bolivian ectoparasites: A survey of bats (Mammalia Chiroptera). **Comparative Parasitology**, v. 74, n. 2, p. 372-377, 2007. http://dx.doi.org/10.1654/4264.1

ESBÉRARD, C. E. L.; DAEMON, C. Um novo método para marcação de morcegos. **Chiroptera Neotropical**, v. 5, n. 1-2, p. 116-117, 1999.

ESBÉRARD, C. E. L. et al. A method for testing the host specificity of ectoparasites: give them the opportunity to choose. **Memórias Instituto Oswaldo Cruz**, v. 100, n. 7, p. 761-764, 2005.

FLEMING, T. H. **The short-tailed fruit bat: a study in plant-animal interactions**. Chicago: University of Chicago Press, 1988. 365 p.

GRACIOLLI, G.; CARVALHO, C. J. B. Moscas ectoparasitas (Diptera, Hippoboscoidea) de morcegos (Mammalia, Chiroptera) do Estado do Paraná, Brasil. II. Streblidae: Chave pictórica para os gêneros e espécies. **Revista Brasileira de Zoologia**, v. 18, n. 3, p. 907-960, 2001. http://dx.doi.org/10.1590/S0101-81752001000300026

GRACIOLLI, G.; CÁCERES, N. C.; BORNSCHEIN, M. R. Novos registros de moscas ectoparasitas (Diptera, Streblidae e Nycteribiidae) de morcegos (Mammalia, Chiroptera) em áreas de transição cerrado-floresta estacional no Mato Grosso do Sul, Brasil. **Biota Neotropica**, v. 6, n. 2, p. 1-4, 2006. http://dx.doi.org/10.1590/S1676-06032006000200028

JOHNSON, D. D. P.; STOPKA, P.; MACDONALD, D. W. Ideal flea constraints on group living: unwanted public goods and the emergence of cooperation. **Behavioral Ecology**, v. 15, n. 1, p. 181-186, 2004. http://dx.doi.org/10.1093/beheco/arg093

KOMENO, C. A.; LINHARES, A. X. Batflies parasitic on some Phyllostomid bats in southeastern Brazil: Parasitism rates and host-parasite relationships. **Memórias Instituto Oswaldo Cruz**, v. 94, n. 2, p. 151-156, 1999.

LOURENÇO, S. I.; PALMEIRIM, J. M. Can mite parasitism affect the condition of bat hosts? Implications for the social structure of colonial bats. **Journal of Zoology**, v. 273, n. 2, p. 161-168, 2007. http://dx.doi.org/10.1111/j.1469-7998.2007.00322.x

MCCOY, K. D. Host-parasite determinants of parasite population structure: lessons from bats and mites on the importance of time. **Molecular Ecology**, v. 18, n. 17, p. 3545-3547, 2009. PMid:19703249. http://dx.doi.org/10.1111/j.1365-294X.2009.04300.x

MELLO, M. A. R. et al. A test of the effects of climate and fruiting of *Piper* species (Piperaceae) on reproductive patterns of the bat *Carollia perspicillata* (Phyllostomidae). **Acta Chiropterologica**, v. 6, n. 2, p. 309-318, 2004.

MOURA, M. O.; BORDIGNON, M. O.; GRACIOLLI, G. Host characteristics do not affect community structure of ectoparasites on the fishing bat *Noctilio leporinus* (L., 1758) (Mammalia: Chiroptera). **Memórias Instituto Oswaldo Cruz**, v. 98, n. 6, p. 811-815, 2003.

OVERAL, W. L. Host-relations of the batfly *Megistopoda aranea* (Diptera: Streblidae) in Panamá. **The University of Kansas Science Bulletin**, v. 52, p. 1-20, 1980.

PATTERSON, B. D; DICK, C. W.; DITTMAR, K. Roosting habits of bats affect their parasitism by bat flies (Diptera: Streblidae). **Journal of Tropical Ecology**, v. 23, n. 2, p. 177-189, 2007. http://dx.doi.org/10.1017/S0266467406003816

PATTERSON, B. D; DICK, C. W.; DITTMAR, K. Parasitism by bat flies (Diptera: Streblidae) on neotropical bats: effects of host body size, distribution, and abundance. **Parasitology Research**, v. 103, n. 5, p. 1091-1100, 2008a. PMid:18633645. http://dx.doi.org/10.1007/s00436-008-1097-y

PATTERSON, B. D.; DICK, C. W.; DITTMAR, K. Sex biases in parasitism of neotropical bats by bat flies (Diptera: Streblidae). **Journal of Tropical Ecology**, v. 24, n. 4, p. 387-396, 2008b. http://dx.doi.org/10.1017/S0266467408005117

PRESLEY, S. J.; WILLIG, M. R. Intraspecific patterns of ectoparasite abundances on Paraguayan bats: effects of host sex and body size. **Journal of Tropical Ecology**, v. 24, n. 1, p. 75-83, 2008. http://dx.doi.org/10.1017/S0266467407004683

PRESLEY, S. J. Streblid bat fly assemblage structure on Paraguayan *Noctilio leporinus* (Chiroptera: Noctilionidae): nestedness and species co-occurrence. **Journal of Tropical Ecology**, v. 23, n. 4, p. 409-417, 2007. http://dx.doi.org/10.1017/S0266467407004245

RECKARDT, K.; KERTH, G. The reproductive success of the parasitic bat fly *Basilia nana* (Diptera: Nycteribiidae) is affected by the low roost fidelity of its host, the Bechstein's bat (*Myotis bechsteinii*). **Parasitology Research**, v. 98, n. 3, p. 237-243, 2006. PMid:16341882. http://dx.doi.org/10.1007/s00436-005-0051-5

SANTOS, C. L. C. et al. Moscas ectoparasitas (Diptera: Streblidae) de morcegos (Mammalia: Chiroptera) do Município de São Luís, MA: Taxas de infestação e associações parasito-hospedeiro. **Neotropical Entomology**, v. 38, n. 5, p. 595-601, 2009. PMid:19943006. http://dx.doi.org/10.1590/S1519-566X2009000500006

TELLO, J. S.; STEVENS, R. D.; DICK, C. W. Patterns of species co-occurrence and density compensation: a test for interspecific competition in bat ectoparasite infracommunities. **Oikos**, v. 117, n. 5, p. 693-702, 2008. http://dx.doi.org/10.1111/j.0030-1299.2008.16212.x

TER HOFSTEDE, H. M.; FENTON, M. B. Relationships between roost preferences, ectoparasite density, and grooming behaviour of neotropical bats. **Journal of Zoology**, v. 266, n. 4, p. 333-340, 2005. http://dx.doi.org/10.1017/S095283690500693X

TUTTLE, M. D. Collecting techniques. In: BAKER, R. J.; JONES, J. K.; CARTER, D. C. (Ed.). **Biology of bats of the new world family Phyllostomidae**. Lubbock: Texas Tech Press, 1976. part 1: Special Publications Museum Texas Tech University, n. 10. p. 71-88.

WENZEL, R. L.; TIPTON, V. J. Some relationships between mammal hosts and their ectoparasites. In: WENZEL, R. L.; TIPTON, V. J. (Ed.). **Ectoparasites of Panama**. Chicago: Field Museum of Natural History, 1966. p. 677-723.

WENZEL, R. L. The Streblidae batflies of Venezuela (Diptera: Streblidae). **Brigham Young University Science Bulletin**, v. 20, p. 1-177, 1976.