Bat flies on phyllostomid hosts in the *Cerrado* region: component community, prevalence and intensity of parasitism

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Streblidae flies are specialised parasites of bat hosts, mainly phyllostomids. There is a high richness of streblids in the savannah-like Cerrado *region; however, there is little quantitative data available in parasitological indices. Here, we describe the component community, prevalence and intensity of a streblid infestation on a phyllostomid bat assemblage in Serra da Bodoquena, a* Cerrado *region in Southwest Brazil. We conducted surveys by capturing and inspecting bat hosts during the seven-month period between October 2004-December 2005. All the ectoparasites found on the bats were collected in the field and then counted and identified in the laboratory. We captured 327 bats belonging to 13 species, of which eight species were parasitized by 17 species of streblids.* Carollia perspicillata *and* Glossophaga soricina *were infested with seven streblid species, whereas the other bat species were infested with four or fewer streblid species.* Megistopoda proxima *and* Aspidoptera falcata *flies were found on* Sturnira lilium*, and* Trichobius joblingi *was the most prevalent fly on* C. perspicillata. Megistopoda aranea *and* Aspidoptera phyllostomatis *were highly prevalent and had a high intensity of infestation on* Artibeus planirostris. *Overall comparisons of the available data suggest that the component communities of streblids vary more between the* Cerrado *and Atlantic Forest phytogeographical regions than between localities within the same phytogeographical region.*

Key words: Phyllostomidae - savannah - Serra da Bodoquena - Streblidae

Two families of Calyptratae fly species, Nycteribiidae and Streblidae, are specialised parasites of bats (Dick & Patterson 2006). Species of Streblidae are cosmopolitan, highly diverse in the New World and mainly associated with bats in the family Phyllostomidae (Dittmar et al. 2006). Seventy out of the 230 species of Streblidae have been recorded in Brazil, which likely underestimates the real number, given that there are several phytophysiognomies in the vast Brazilian territory where bat flies have been poorly studied (Dick & Graciolli 2006, Graciolli et al. 2008, Dias et al. 2009). Factors intrinsic to bat hosts, such as body size, grooming behaviour and immunological defences, are thought to affect the parasitism of streblids (ter Hofstede & Fenton 2005, Patterson et al. 2007, 2008). Furthermore, factors extrinsic to the host body, such as the different types of bat roosts and the sharing of roosting places among individual bats and among different bat species, can affect the distribution and abundance of streblids on host populations (Patterson et al. 2007).

Surveys of Streblidae species on bat hosts indicate that the richness of Streblidae is higher in the savannah-like *Cerrado* region than in the other Brazilian phytogeographical regions (Graciolli & Coelho 2001, Graciolli & Aguiar 2002, Graciolli et al. 2006a, 2008, 2010). However, there are only two studies that describe quantitative parasitological indices for the streblid communities in the *Cerrado* region (Coimbra et al. 1984, Komeno & Linhares 1999). Such studies have often been conducted in the Atlantic Forest region (Graciolli et al. 2008) and a few published surveys are available for other Brazilian regions, such as the *Caatinga* and Amazonia regions (Rios et al. 2008, Dias et al. 2009). In this paper, we describe the component community, the prevalence and the intensity of the infestation of streblid flies on a phyllostomid bat assemblage in Serra da Bodoquena, located in the southwest *Cerrado* region. We then compared these data to the results from other studies conducted in *Cerrado* and Atlantic Forest regions.

MATERIALS AND METHODS

The study was conducted in the southern part of the Serra da Bodoquena National Park, on the Campo Verde farm (21º24’48’’S, 56º46’32’’W), which is located in the municipality of Jardim, Mato Grosso do Sul (MS), Brazil. The wet summer and dry winter climate is classified as Aw using the Köppen climate classification system (Köppen 1948). Annual rainfall ranges from 1,000-1,700 mm; the average temperature during the coldest month (July) ranges from 15-20ºC (Campelo et al. 1997). The predominant vegetation is composed of savannah forests associated with karstic reliefs and rocky soils (Boggiani et al. 1999, Cunha et al. 2009).

Surveys of the streblid species were conducted by capturing bat hosts during October and December 2004 and February, April, June, October and December 2005. In each month surveyed, bats were mist-netted during two consecutive nights at different localities. Each night,

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four mist-nets (12 x 2.8 m) were kept open during a six-hour period starting at dusk. Mist-nets were visited at 30 min intervals and the captured bats were then transferred to individual cloth bags prior to being inspected for parasites, which we conducted in the field the same night. To avoid contamination, the cloth bags were only used once during each field trip and were then carefully cleaned between expeditions. All the ectoparasites found on the bat hosts were collected and stored in 1.5-mL plastic microcentrifuge tubes containing 70% ethanol.

We identified bat hosts to the species level using Vizotto and Taddei (1973) and Anderson (1997). At least three individual bats per species were collected to confirm the identifications and were deposited as vouchers in the zoological collection at the Federal University of Mato Grosso do Sul (ZUFMS). Identification of the bat flies was performed in the laboratory using a stereomicroscope and was based on studies by Wenzel et al. (1966), Wenzel (1976) and Guerrero (1995, 1996). Streblid voucher specimens were also deposited in the ZUFMS collection. Taxonomic classifications followed Simmons (2005) for bats and Dick and Graciolli (2006) for ectoparasites. However, we used *Artibeus planirostris* instead of *Artibeus jamaicensis* Leach, 1821 (Larsen et al. 2007).

Definitions of component community (the assemblage of parasite species on a given bat species), prevalence (the percentage of bats infested by the same parasite species) and intensity of infestation (the number of parasitic flies per parasitized bat) followed Bush et al. (1997). Confidence intervals were calculated using Quantitative Parasitology 3.0 (Rózsa et al. 2000). Non-primary infestations (Dick 2007) were not considered for the comparisons with other studies.

RESULTS

We captured 327 individual bats belonging to 13 Phyllostomidae species. Eight species of bats (n = 132 individuals) were parasitized by 17 species of streblids (n = 315 individuals) (Table). *Carollia perspicillata* and *Glossophaga soricina* were infested by seven streblid species, *A. planirostris* and *Sturnira lilium* were infested by four streblids, and other bats were infested by two or fewer species. The absence of streblids on non-parasitized bat species was based on only one to four mist-netted individuals, except for *Artibeus lituratus* (n = 22), which was consistently not parasitized by streblids. Discarding accidental or transitory occurrences (Table), we recorded three streblid species on *A. planirostris*, the most abundant bat species at the study site. *Megistopoda aranea* and *Aspidoptera phyllostomatis* were the most prevalent (34.1% and 24.7%, respectively) and had the highest intensity of infestation (1.79 and 2.0, respectively) on *A. planirostris*. Two non-transitory streblid species parasitized *S. lilium*, *Megistopoda proxima* (prevalence = 33.8%; mean intensity of infestation = 2.04) and *Aspidoptera falcata* (prevalence = 21.4%; intensity of infestation = 1.35). Of the three streblid species infesting *C. perspicillata*, *Trichobius joblingi* was the most prevalent (40.5%). Three non-transitory streblid species were recorded on the bat *G. soricina*, all with prevalences lower than 10%.

DISCUSSION

Component communities - The component community of bat flies on *A. planirostris* was richer in Serra da Bodoquena National Park than in other localities in the *Cerrado* region, even when considering only non-transitory streblid species. In Minas Gerais, Komeno and Linhares (1999) only found *M. aranea*, and in Goiás, Graciolli and Aguiar (2002) found *A. phyllostomatis* and *M. aranea* streblids on the bat *A. planirostris*. These streblid species were also recorded on *A. planirostris* in two additional localities of the *Cerrado* region in MS (Graciolli et al. 2006a); *M. aranea* was also found on *A. planirostris* in the Atlantic Forest region (G Graciolli et al. 2008). Therefore, this is the first report where *Metelasmus pseudopterus* was found as an additional non-transitory streblid on *A. planirostris*. However, *M. pseudopterus* has already been reported on *Artibeus obscurus* (Bertola et al. 2005), but we recorded no streblids on this bat species in Serra da Bodoquena.

The component community of bat flies on *S. lilium* in Serra da Bodoquena does not differ from other localities in the *Cerrado* region (Komeno & Linhares 1999, Graciolli & Aguiar 2002, Graciolli et al. 2006a), but in the Atlantic Forest region this bat is parasitized by the endemic fly *Trichobius phyllostomae* (Bertola et al. 2005, Rui & Graciolli 2005, Graciolli & Bianconi 2007), in addition to *M. proxima* and *A. falcata*, which are also found in the *Cerrado* region.

On the bat *C. perspicillata*, the component community of non-transitory streblids in Serra da Bodoquena was richer than in the other localities in the *Cerrado* region due to the added presence of *Speiseria ambigua*. Only *T. joblingi* and *Strebla guajiro* have previously been reported on *C. perspicillata* in the *Cerrado* region (Komeno & Linhares 1999, Graciolli et al. 2010). These two streblid species and *Paraeuctenodes similis* have been found on *C. perspicillata* in the Atlantic Forest region (Bertola et al. 2005, Graciolli et al. 2008).

The non-transitory streblids recorded on *G. soricina* at our study site, *Strebla curvata*, *Trichobius uniformis* and *Trichobius dugesii*, are the same species found in other localities of the *Cerrado* region (Graciolli & Coelho 2001, Graciolli et al. 2010). However, component communities of streblids on *G. soricina* differed between bat populations in the *Cerrado* and Atlantic Forest regions. *T. dugesii* is the only species that parasitizes *G. soricina* in both regions, whereas *Anastrebla caudiferae* and *Trichobius lonchophyllae* have only been reported in the Atlantic Forest region (Graciolli & Rui 2001, Azevedo & Linardi 2002, Bertola et al. 2005).

We discovered that *Trichobius angulatus* is another non-transitory streblid that parasitizes *Platyrrhinus lineatus* in Brazil. In other localities in the *Cerrado* and Atlantic Forest regions, *P. lineatus* appears to be infested only by *Paratrichobius longicrus* (Komeno & Linhares 1999, Azevedo & Linardi 2002, Bertola et al. 2005, Graciolli et al. 2010). In reality, *P. longicrus* is a species complex that is found on the bat genera *Artibeus*, *Uroderma* and *Platyrrhinus*. The “true” *P. longicrus* would be recorded on only *A. lituratus*, which is regarded as its

TABLE

Streblid species collected on phyllostomid bats in the Serra da Bodoquena National Park, Southwestern Brazil

Host (n) Streblidae (n)	IH	P (95% CI)	MI (95% CI)
Carollia perspicillata (L., 1758) (42)			
Trichobius joblingi Wenzel 1966 (48)	17	40.5 (25.6-56.7)	2.8 (2.12-3.65)
Strebla guajiro (Garcia & Casal, 1965) (5)	4	9.5 (2.7-22.6)	1.3 (1.00-1.50)
Speiseria ambigua Kessel, 1925 (2)	2	4.8 (0.6-16.2)	1.00[b]
Aspidoptera falcata Wenzel 1976 (4)[a]	1	2.4[b]	4.00[b]
Aspidoptera phyllostomatis (Perty, 1833) (1)[a]	1	2.4[b]	1.00[b]
Megistopoda aranea (Coquillet, 1899) (3)[a]	1	2.4[b]	3.00[b]
Megistopoda proxima (Séguy, 1926) (2)[a]	1	2.4[b]	2.00[b]
Total (65)	20	47.6 (32.0-62.6)	3.3 (2.50-4.00)
Glossophaga soricina (Pallas, 1766) (42)			
Trichobius dugesii Townsend 1891 (7)	4	9.5 (2.7-22.6)	1.8 (1.00-2.50)
Strebla curvata Wenzel, 1976 (3)	2	4.8 (0.6-16.2)	1.5[b]
Trichobius uniformis Curran 1935 (5)	2	4.8 (0.6-16.2)	2.5[b]
Aspidoptera falcata (2)[a]	1	2.4[b]	2.0[b]
Megistopoda proxima (2)[a]	1	2.4[b]	2.0[b]
Speiseria ambigua (1)[a]	1	2.4[b]	1.0[b]
Trichobius sp. (1)	1	2.4[b]	1.0[b]
Total (21)	11	26.2 (13.9-42.0)	1.8 (1.27-2.45)
Artibeus planirostris Spix, 1823 (85)			
Megistopoda aranea (52)	29	34.1 (24.2-45.2)	1.8 (2.45-2.38)
Aspidoptera phyllostomatis (42)	21	24.7 (16.0-35.3)	2.0 (1.48-2.57)
Metelasmus pseudopterus Coquillet, 1907 (4)	3	3.5 (0.7-10.0)	1.3 (1.00-1.67)
Trichobius joblingi (3)[a]	2	2.4 (0.3-8.3)	1.5 (1.00-1.50)
Total (101)	43	50.6 (39.5-61.6)	2.4 (1.86-2.88)
Sturnira lilium (E. Geoffroy, 1810) (80)			
Megistopoda proxima (56)	27	33.8 (23.6-45.2)	2.0 (1.67-2.37)
Aspidoptera falcata (23)	17	21.3 (13.0-31.8)	1.4 (1.06-1.71)
Trichobius joblingi (4)[a]	2	2.5 (0.3-8.6)	2.0[b]
Trichobius uniformis (1)[a]	1	1.3 (0.03-6.8)	1.0[b]
Total (84)	39	48.8 (37.4-60.2)	2.1 (1.74-2.59)
Platyrrhinus lineatus (E. Geoffroy, 1810) (31)			
Trichobius angulatus Wenzel, 1976 (14)	7	22.6 (9.6-41.1)	2.0 (1.14-3.86)
Paratrichobius aff. *longicrus* (Miranda Ribeiro, 1907) (7)	4	12.9 (3.6-29.8)	1.8 (1.00-2.50)
Total (21)	10	32.3 (16.7-51.3)	2.1 (1.10-4.70)
Desmodus rotundus (E. Geoffroy, 1810) (10)			
Strebla wiedemanni Kolenati, 1856 (18)	6	60.0 (26.2-87.9)	3.0 (1.67-3.67)
Aspidoptera phyllostomatis (1)[a]	1	10.00[b]	1.00[b]
Total (19)	7	70.0 (34.8-93.3)	2.7 (1.57-3.43)
Anoura caudifera (E. Geoffroy, 1818) (5)			
Trichobius tiptoni Wenzel, 1976 (1)	1	20.0[b]	1.0[b]
Total (1)	1	20.0[b]	1.0[b]
Chrotopterus auritus (Peters, 1856) (2)			
Strebla chrotopteri Wenzel, 1976 (3)	1	50.0[b]	3.0[b]
Total (3)	1	50.0[b]	3.0[b]
Artibeus lituratus (Olfers, 1818) (22)	0	-	-
Artibeus obscurus (Schinz, 1821) (4)	0	-	-
Chiroderma doriae Thomas, 1891 (2)	0	-	-
Micronycteris megalotis (Gray, 1842) (1)	0	-	-
Pygoderma bilabiatum (Wagner, 1843) (1)	0	-	-

a: non-primary associations (Dick 2007); *b*: insufficient data to calculate confidence intervals (CI); IH: number of infested host individuals; MI: mean intensity of infestation; P: prevalence (%).

primary host (Wenzel et al. 1966, Wenzel 1976). However, *A. lituratus* was not parasitized by *P. longicrus* or other streblids in Serra da Bodoquena. Thus, the specimens named *P. longicrus* found on *P. lineatus* are likely a new species whose distribution may be restricted to the *Cerrado* region.

In the *Cerrado* region, the component communities of bat flies on *Desmodus rotundus* is comprised of *Strebla wiedemanni*, *Trichobius furmani* and *Trichobius parasiticus* (Graciolli et al. 2008, 2010), but only *S. wiedemanni* parasitized this bat at our study site. In the Atlantic Forest region, *Trichobius dugesioides* also parasitizes *D. rotundus* (Bertola et al. 2005). The occurrence of *Trichobius tipton* on the bat *Anoura caudifer* and the occurrence of *Strebla chrotopteri* on the bat *Chrotopterus auritus* would be expected based on parasite-host associations published for other sites in the *Cerrado* and Atlantic Forest regions (Bertola et al. 2005, Graciolli et al. 2008). The absence of bat flies on *A. obscurus*, *Chiroderma doriae*, *Micronycteris megalotis* and *Pygoderma bilabiatum* may be due to our small sample size (number of captured bats) for these host species. However, even with large collections of bats, Bertola et al. (2005) also found no streblids on *P. bilabiatum* at a site in the Atlantic Forest region. Furthermore, streblids have not been recorded on *C. doriae* or *M. megalotis* in the *Cerrado* or Atlantic Forest regions.

Prevalence and intensity of infestation - The prevalence of *M. proxima* on *S. lilium* (33.8%) in Serra da Bodoquena was similar to that (34%) found at other sites in the *Cerrado* region (Komeno & Linhares 1999), but intermediate compared to sites in the Atlantic Forest region (20-60%) (Bertola et al. 2005, Graciolli et al. 2006b, Graciolli & Bianconi 2007). Thus, the prevalence of *M. proxima* on *S. lilium* appears to be more variable throughout the Atlantic Forest region than in the *Cerrado* region. However, the prevalence of *A. falcata* on *S. lilium* was variable (10-32%) in both the *Cerrado* and Atlantic Forest regions (Komeno & Linhares 1999, Graciolli et al. 2006b, Graciolli & Bianconi 2007).

The prevalence of *T. joblingi* on *C. perspicillata* in Serra da Bodoquena (40.5%) was lower than at other sites in the *Cerrado* or Atlantic Forest regions (> 60%) (Komeno & Linhares 1999, Bertola et al. 2005, Anderson & Filho 2006), except for one study in the Atlantic Forest region (10.8%) (Graciolli et al. 2006b). The prevalence of *P. longicrus* on *P. lineatus* at our study site was similar to that at another site in the *Cerrado* region (Komeno & Linhares 1999); the prevalence of streblids on *G. soricina* is usually low (Graciolli & Rui 2001, Bertola et al. 2005), such as we found in Serra da Bodoquena (< 10%).

The intensities of infestation for *M. proxima* ($2.0^{1.67-2.37}$) and *A. falcata* ($1.4^{1.06-1.71}$) on *S. lilium* in Serra da Bodoquena were similar to those found in all the other studies performed in the *Cerrado* or Atlantic Forest regions (Komeno & Linhares 1999, Rui & Graciolli 2005, Graciolli et al. 2006b, Graciolli & Bianconi 2007). These results show a similar per bat pattern of infestation on *S. lilium* between sites in the *Cerrado* and Atlantic Forest regions. Otherwise, the intensity of infestation of *T. joblingi* on *C. perspicillata* in Serra da Bodoquena ($2.82^{2.12-3.65}$) does not differ from that (2.1) of another *Cerrado* region (Komeno & Linhares 1999) but is higher than that (1.4) reported in the Atlantic Forest region (Graciolli et al. 2006b).

Overall comparisons of the available data suggest that the component community of streblids varies more between the *Cerrado* and Atlantic Forest phytogeographical regions than between sites within the same phytogeographical region. Therefore, environmental conditions likely play a role in local bat fly associations, which lead to variable component communities across a wide distribution of the host species (Wenzel et al. 1966). Prevalence patterns vary extensively between sites, but there is not an apparent pattern associated with phytogeographical domains. Local host abundance and shelter type are thought to affect the prevalence of streblids (Arneberg et al. 1998, Patterson et al. 2007). Therefore, the data available on streblids support the theory that conspecific bats use variable shelters throughout their distributional range and/or that bat species vary widely in their abundance within a phytogeographical region. However, the intensity of infestation of streblids on a host species does not vary as much between sites, even between different phytogeographical regions. Factors intrinsic to the host species, such as body mass, grooming behaviour and immunological defences, could limit the number of bat flies on host individuals (Overal 1980). Additional studies at multiple sites are needed to verify the possible patterns of bat fly associations discussed in this study.

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