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RESEARCH ARTICLE

Bat fly (Diptera: Streblidae) and common vampire bat (Chiroptera: Phyllostomidae) association in Honduras: prevalence, mean intensity, infracommunities and influence of the biological characteristics of the host

Wilson Gómez-Corea[1], Farlem G. España[2], David Mejía-Quintanilla[3], Martín R. del Valle Alvarez[4]

[1]*Programa de Pós-Graduação em Zoologia, Universidade Estadual de Santa Cruz. Campus Soane Nazaré de Andrade, Rodovia Jorge Amado, km 16, Salobrinho, 45662-900 Ilhéus, BA, Brazil.*
[2]*Mesoamerican Development Institute. Lowell, Massachusetts 01854-0255, USA.*
[3]*Fundación en Ciencias para el Estudio y Conservación de la Biodiversidad. Residencial Plaza, Primera entrada, Bloque16 Casa 4606, Tegucigalpa, Francisco Morazán, Honduras.*
[4]*Coleção de Mamíferos "Alexandre Rodrigues Ferreira", Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz. Campus Soane Nazaré de Andrade, Rodovia Jorge Amado, km 16, Salobrinho, 45662-900 Ilhéus, BA, Brazil.*
Corresponding author: Wilson Gómez-Corea (wilsongomezcorea@gmail.com)

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ABSTRACT. Bat species present a series of attributes that makes them prone to being parasitized. Bat flies (Streblidae) are hematophagous ectoparasites exclusive to bats. Our study aimed to investigate the association of bat flies with the Common vampire bat, *Desmodus rotundus* (É. Geoffroy, 1810), in Honduras. We analyzed the effect of sex and age of the host on parasitism. Eight localities belonging to six departments were sampled in an altitudinal range between 50 and 995 m. Field data were obtained between May 2018 to November 2019 and 80 individuals were captured, from which 395 bat flies were extracted. Four species of bat flies were registered: *Strebla wiedemanni* Kolenati, 1856, *Trichobius parasiticus* Gervais, 1844, *T. joblingi* Wenzel, 1966 and *T. caecus* Edwards, 1948. *Trichobius parasiticus* presented the highest prevalence and mean intensity, followed by *S. wiedemanni*. *Trichobius joblingi* and *T. caecus* are new records of parasitism on *D. rotundus* for Honduras, although we consider as an accidental association. We recorded six types of infracommunities that parasitized 85% of the hosts. The prevalence and mean intensity was not affected by age and sex of the host for any bat fly species.

KEY WORDS. Bats, Central America, *Desmodus rotundus*, Phyllostomidae, *Strebla*, Streblidae, *Trichobius*.

INTRODUCTION

In the Neotropical region, bat flies (Nycteribiidae and Streblidae) are the most conspicuous and well studied ectoparasites of bats (Haelewaters et al. 2018). They are obligate ectoparasites exclusively associated with bats that live in the fur and on the membranes of their hosts, where they feed on blood (Dick et al. 2016). They only leave their bat host to deposit a 3rd instar larvae, which develops within its mother's oviduct and pupates directly on a surface in the bat's roost (Hagan 1951, Hart 1992). Streblidae is cosmopolitan, occurring mainly in tropical areas and comprising 33 genera and about 239 species. Five subfamilies have been recognized, three of them exclusive to America: Trichobiinae, Strebliinae and Nycterophiliinae (Dick and Miller 2010, Dick and Graciolli 2013). In Honduras, 48 species, 17 genera of Streblidae are known (Dick 2013, Miller 2014, Graciolli et al. 2021).

Many bat fly species are strictly associated to a single bat species, while their bat hosts in turn can be associated with a small number of different bat flies (Wenzel et al. 1966, Wenzel 1976, Dick and Gettinger 2005). While host body condition in part limits parasite burden, competition for nutrients as well as resistance from host's immune response have led to the evolution of highly diverse parasite communities (Haelewaters et al. 2018). Morphological adaptations of ectoparasites have often led to the division of resources, allowing the coexistence of several species of parasites in a single host; each host individual forms the living environment for its associated parasites (Marshall 1982, Mouillot et al. 2003, Haelewaters et al. 2018). Bat fly species prefer particular areas on the host's body (Roos 1961, Wenzel et al. 1966, Linhares and Komeno 2000, ter Hofstede et al. 2004, Hiller et al. 2018).

Bats have several attributes that make them prone to being parasitized: gregarious behavior, grooming, body size, age, sex, individual genetic aspects, nutritional status, areas of activity (see Poulin and Morand 2004). Compared to mammals of similar size, their life expectancy is very high (Seim et al. 2013, Garbino et al. 2021). Bats use a variety of roost structures, including foliage, tree cavities, abandoned buildings, and large cave systems (Patterson et al. 2007). Male and female bats often behave differently and exhibit sexual segregation, particularly pronounced during the maternity season when females congregate to give birth and raise offspring (Fleming 1988, McCracken and Wilkinson 2000, Kunz and Lumsden 2003, Chaverri et al. 2007). In contrast, many males frequently roost singly or in low numbers away from females, especially during the nursing season (McCracken and Wilkinson 2000, Altringham 2011) and can display lower roost fidelity than females (e.g., Morrison 1979). Some males, however, roost with groups of females in harems year round (McCracken and Wilkinson 2000). Grooming is one of the major causes of parasite mortality (Marshall 1982), during breeding, females can reduce the intensity of this behavior and in juvenile individuals it is not very marked (Berlota et al. 2005, Bezerra and Bocchiglieri 2018). Such ecological variation may cause bat species to differ in their susceptibility to the prevalence and intensity of parasitism, parameters directly related to the degree of exposure of hosts to parasites (Bush et al. 1997).

The Common vampire bat *Desmodus rotundus* (É. Geoffroy, 1810) (Chiroptera: Phyllostomidae) has a wide geographical distribution in America, occurring from México to Argentina (Greenhall et al. 1983, Koopman 1988). For this reason, the species has been relatively well-studied regarding its ectoparasitic fauna. Studies have recorded the presence of different bat fly species, the most frequent being those of *Trichobius* and *Strebla* (Wenzel et al. 1966, Guerrero 1997). In this context, our aim was to describe and analyse the association of bat flies with *D. rotundus* in Honduras, through different parasitic indices. We also identified infracommunities and tested the influence of the sex and age of the host on parasitism of bat flies.

MATERIAL AND METHODS

This study was conducted in Honduras, a Central America country with an area of 112,492 km² that is divided into 18 departments. Characterized by elevations ranging from 0 to 2870 m.a.s.l. Honduras has a diverse topography and wide variety of tropical habitats. Some portions of the country have a dry climate with little rain, whereas other areas receive regular heavy rainfall; the annual average rainfall is 1000 to 2500 mm (Zúñiga 1990). The average annual temperature is 16 °C in the mountainous areas of the central and western region, and up to 24 °C in the inland valleys and the Atlantic coast (Zúñiga 1990, Navarro-Racines et al. 2018). Field samplings were carried out in eight localities, in an altitudinal range between 50 and 995 m (Table 1). We used a Garmin eTrex 10 Global Positioning System, we obtained geographical coordinates (WGS 84) and elevation, and mapped them using QGIS version 3.14 (Fig. 1).

The field data were obtained between May 2018 and November 2019. We used mist nets with the lengths of 12 m and 9 m long x 3 m high (38 mm mesh) set at ground-level (~0.5–4.0 m height). We surveyed three nights at each site with an operating time of 05:00 pm to 10:00 pm, with nets checked for captured bats at 15 minutes intervals. The mist nets were placed, considering the characteristics of the sampled locations, trails, glades, near streams, caves, and shelters (Kunz et al. 2009) and avoiding the days close to the full moon (Saldaña-Vázquez and Munguía-Rosas 2013). For taxonomic identification of the bats, we used the publications of Timm et al. (1999), Medellín et al. (2008) and Medina-Fitoria (2014). Each individual bat captured was classified according to the sex class (males and females), age (adults and juveniles), determined by the degree of ossification of the epiphysis of the phalanges (Brunet-Rossini and Wilkinson 2009). Bats were captured and handled in the field following guidelines approved by the American Society of Mammalogists (Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016). The research and collection of the specimens were carried out with the permission granted by ICF (Instituto Nacional de Desarrollo y Conservación Forestal, Áreas Protegidas y Vida Silvestre), resolution DE-MP-067-2018.

Bats captured in the mist nets were individually placed in cloth bags to prevent contamination of ectoparasite samples. The entire body of each bat was systematically examined with entomological forceps until no additional bat flies were found. The bat flies extracted were placed in Eppendorf tubes (assigning an individual registration code, for each bat), with 70% ethanol, 5% glycerin and 25% distilled water (Whitaker et al. 2009). All the collected individuals were counted and identified using stereoscopic microscope, in the installations of the Entomology Museum of the Universidad Nacional Autonoma de Honduras (UNAH). We used the reference literature for taxonomic identification, Wenzel et al. (1966), Wenzel (1976), Guerrero (1994, 1995). Voucher specimens were deposited in the entomology collection of the Natural History Museum of the Universidad Nacional Autonoma de Honduras in the Valle de Sula: UNAH–VS: UVS–I–1189, UVS–I–1190, UVS–I–1191, UVS–I–1192.

To analyse the parasite-host association, we consider three parasitological parameters: prevalence, mean abundance, mean intensity (Bush et al. 1997). The prevalence (P) is the proportion of hosts infested with a particular ectoparasite species divided by the total number of hosts examined (Bush et al. 1997). Mean abundance (MA) is the total number of individuals of an ectoparasite species in a sample of a host species divided by the total

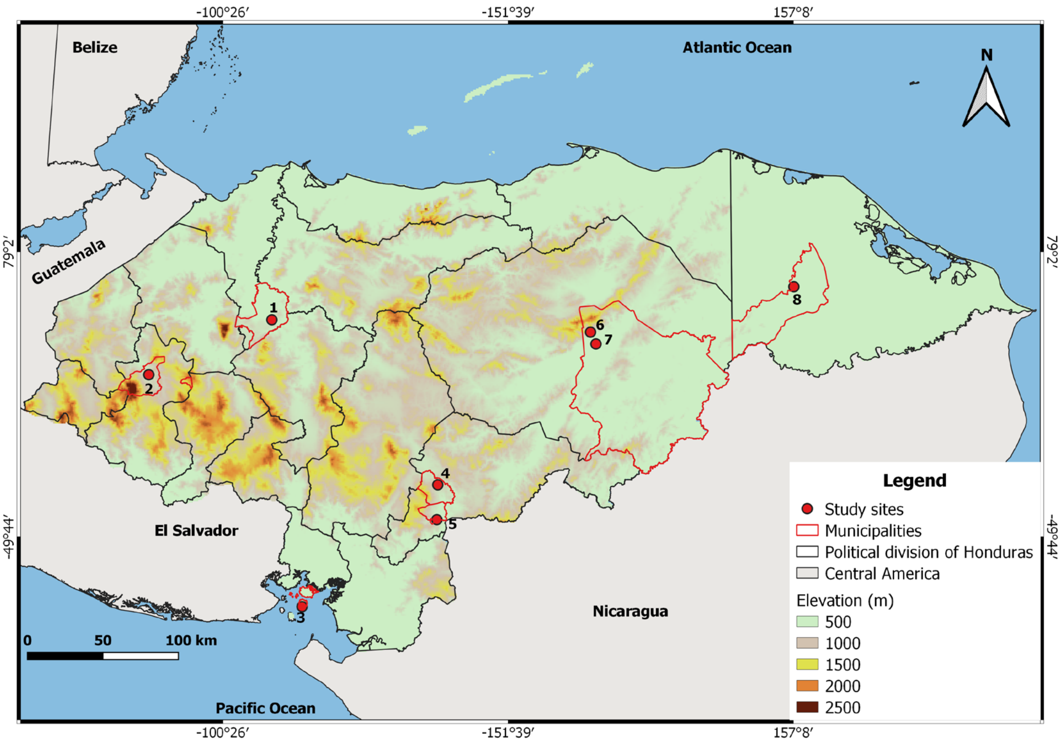

Figure 1. Geographic location of the study sites in Honduras: 1) Joya Grande, 2) Río Arcagual, 3) Los Ochales, 4) Lainez, 5) El Hizopo, 6) Cuevas de Talgua, 7) UNAG, 8 Kurpha. See Table 1 for details.

Table 1. Sampling locations in Honduras between May 2018 to November 2019 with their respective geographic information and distribution by department of bat flies. Code in map (CM), Altitude (A).

CM	Location	Municipalities/Departments	Latitude N	Longitude W	A (m)	Species
1	Joya Grande	Santa Cruz de Yojoa/Cortés	14°58′18″	87°50′6″	680	*S. wiedemanni*, *T. joblingi*, *T. parasiticus*
2	Río Arcagual	Gracias/Lempira	14°38′18″	88°35′28″	590	*S. wiedemanni*, *T. parasiticus*, *T. caecus*
3	Los Ochales	Amapala/Valle	13°15′9″	87°38′37″	50	
4	Lainez	Yuscarán/El Paraíso	13°59′11″	86°48′23″	995	
5	El Hisopo	Oropolí/El Paraíso	13°46′30″	86°49′9″	415	
6	Cuevas de Talgua	Catacamas/Olancho	14°53′49″	85°52′18″	480	*S. wiedemanni*, *T. joblingi*, *T. parasiticus*
7	Universidad Nacional de Agricultura	Catacamas/Olancho	14°49′11″	85°50′7″	350	*S. wiedemanni*, *T. joblingi*, *T. parasiticus*
8	Kurpha	Wampusirpi/Gracias a Dios	15°7′53″	84°38′11″	55	

number of hosts examined (Bush et al. 1997). Mean intensity (MI) represents the total number of individuals of an ectoparasite species in a sample of a host species divided by the total number of hosts infested (Bush et al. 1997). We estimated the confidence intervals (at 95%) for these parameters and were calculated using Quantitative Parasitology software 3.0 (Reiczigel et al. 2019).

To determine if the intrinsic attributes (sex: male-female, age: juvenile-adult) of the Common vampire bat are conditioning factors of the different bat fly species, we performed analysis for three species of bat flies. We used Fisher's exact Test to compare prevalence and a Bootstrap two-sample t test to compare both mean intensity (Reiczigel et al. 2019). *Trichobius caecus* was excluded from statistical analysis, due to their low abundance in our sample size. Infracommunities (community of parasite infrapopulations in a single host, sensu Bush et al. 1997) are represented through their relative frequency in percentage. A Spearman rank correlation test (r_s) was performed between the associations of primary and accidental bat flies in the same host. The complementary analysis were carried out using the PAST version 4.03 (Hammer et al. 2001), with the significant level at $p < 0.05$. The capture effort was calculated according to Straube and Bianconi (2002).

RESULTS

With a sampling effort of 19.017 m^2/h, a total of 80 bats were captured and reviewed, of which 68 were infected with at least one bat fly species (Fig. 2). A total of 395 bat flies were collected, belonging to four species, two genera in two subfamilies. The most abundant was Trichobiinae (n = 315; 79.75%) with three species and Streblinae (n = 80; 20.25%) only with one species. *Trichobius parasiticus* Gervais, 1844 and *Strebla wiedemanni* Kolenati, 1856 have a primary association with this host, whereas *Trichobius joblingi* Wenzel, 1966 and *Trichobius caecus* Edwards, 1948 are considered non-primary species.

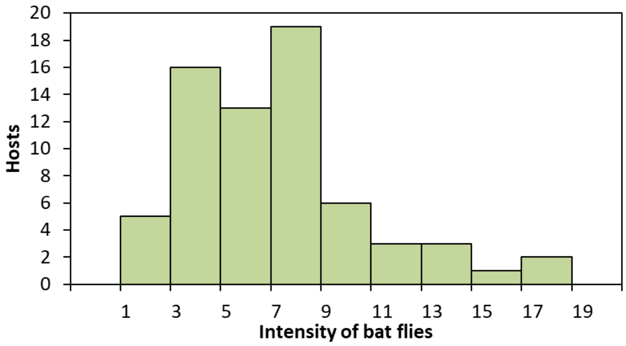

Figure 2. Infestation intensity of *Strebla wiedemanni*, *Trichobius joblingi*, *T. parasiticus* and *T. caecus*, collected on *Desmodus rotundus* between May 2018 to November 2019 in Honduras.

Trichobius parasticus was the most abundant bat fly parasitizing *D. rotundus* in this study. Of the 395 bat flies collected, a total of 295 were *T. parasiticus* individuals, found on a total 58 bats. The highest prevalence value of the hosts was 72.50% provided by *T. parasiticus*, followed by *S. wiedemanni* with 25%. A total of 80 were *S. wiedemanni* individuals, parasitizing a total 20 bats. The mean abundance was 0.01 to 3.69 and the mean intensity of parasitic infestation ranges from 1.66 to 5.17, with an average 3.22 bat flies per host (Table 2). The greatest number of parasites collected from a single host was 18 individuals of *T. parasiticus*.

We recorded six types of infracommunities that parasitized 85% of the hosts (Fig. 3). We found higher frequencies of infracommunities with one species (frequency of occurrence = 35, n = 201) than of infracommunities with two or more species (frequency of occurrence = 20, n = 194). *Strebla wiedemanni* presented a frequency of occurrence of five, while *T. parasiticus* with 30 was the most frequent, providing the highest prevalence among the hosts, 54.55%. Among the associations of the species of the genus *Trichobius* + *Strebla*, which share the same host, one association has three species and another three have two species. *Trichobius parasiticus* + *S. wiedemanni* was the most frequent coexistence, with a frequency of occurrence of 12 (21.82%), followed by four occurrences by *T. parasiticus* + *T. joblingi*. The rest of the associations presented a frequency of occurrence the two times. *Trichobius parasiticus* and *T. joblingi* had a statistically non-significant negative correlation (r_s = -0.30, p = 0.49). The same non-significant association was found for *T. parasiticus* and *T. caecus* (r_s = -0.86, p = 0.66).

The prevalence and mean intensity of infestation of *T. parasiticus* presented similar values in each of these parameters between males and females. While in the age class, the juvenile individuals present a higher prevalence of *T. parasiticus* (94. 74) and *S wiedemanni* (36.84) (Tables 3, 4). According to the results obtained for *T. parasiticus*, *S. wiedemanni* and *T. joblingi*, the prevalence test indicates no significant difference in the classes studied. Bootstrap two-sample t test suggests that the mean intensity of infestation was not affected by age and sex of the host for any of the species analysed.

DISCUSSION

Bat fly association on *D. rotundus*

We found four species of bat flies on *D. rotundus* from different regions of Honduras. The highest values of the parasitic indices were for the two species of primary bat flies. Our data failed to support the hypothesis based, sex and age of the host, none of the bat flies studied showed preference. We found that the bat flies present different patterns of distribution and association in the hosts.

Among the bat flies *S. wiedemanni* and *T. parasiticus* representing the most common primary parasites in almost the entire distribution of *D. rotundus* (Wenzel et al. 1966, Wenzel 1976, ter Hofstede et al. 2004, Dick 2013). *Strebla wiedemanni* is a primary and characteristic parasite of *D. rotundus*, occurs in Argentina, Brazil, Bolivia, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Peru, Suriname, Trinidad and Venezuela

Table 2. Bat fly species collected on *Desmodus rotundus* between May 2018 to November 2019 in Honduras. Number of bat flies collected (N), number of infested hosts (IH), mean abundance (MA), mean intensity of infestation (MI), prevalence (P%), and maximum and minimum value (M/M), (95% CI in brackets).

Species	N	IH	MA	MI	P (%)	M/M
Strebla wiedemanni	80	20	1 (0.61–1.39)	4.00 (3.60–4.40)	25 (15.51–34.49)	6/1
*Trichobius joblingi**	15	7	0.19 (0.04–0.33)	2.14 (1.31–2.97)	8.75 (2.52–14.88)	2/1
Trichobius parasiticus	295	58	3.69 (2.81–4.57)	5.17 (4.17–6.18)	72.50 (63.27–82.73)	18/1
*Trichobius caecus**	5	3	0.01 (0.00–0.07)	1.66 (0.23–3.10)	3.75 (0.48–7.68)	3/1

* Accidental infestation.

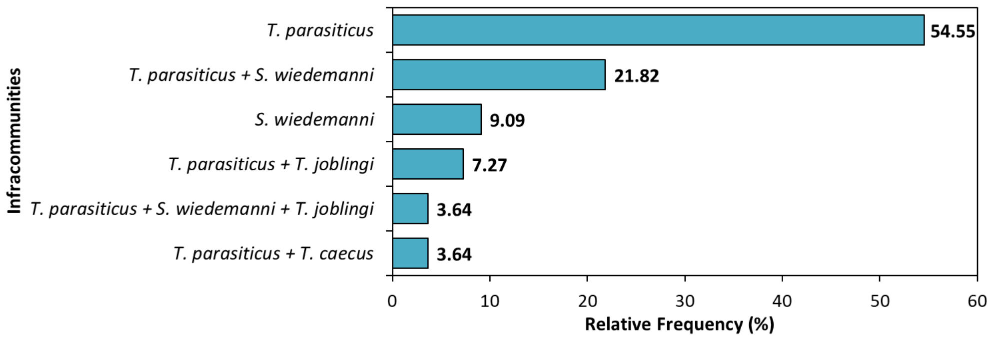

Figure 3. Infracommunities of bat flies and relative frequency, collected on *D. rotundus* between May 2018 to November 2019 in Honduras.

Table 3. Comparison of the prevalence by sex and age on *Desmodus rotundus*, considering the three bat fly species analysed. Number of infested hosts (IH), number of uninfested hosts (UH).

Species	Male			Female			Fisher's exact Test P-value
	IH	UH	P%	IH	UH	P%	
Strebla wiedemanni	17	48	26.15	3	12	20	0.75
Trichobius joblingi	6	59	9.23	1	14	6.66	1.00
Trichobius parasiticus	47	18	72.31	11	4	73.33	0.75
	Adult			Juvenil			
	IH	UH	P%	IH	UH	P%	
Strebla wiedemanni	13	48	21.31	7	12	36.84	0.22
Trichobius joblingi	4	57	6.55	3	16	15.79	0.34
Trichobius parasiticus	40	21	65.57	18	1	94.74	0.07

Table 4. Comparison of the mean intensity by sex and age on *Desmodus rotundus*, considering the three bat fly species analyzed. Number of infested hosts (IH), number of uninfested hosts (UH).

Species	Mean infestation		Bootstrap two-sample t test	P-value
	Male	Female		
Strebla wiedemanni	4.12	3.33	1.51	0.15
Trichobius joblingi	2.33	1.00	1.51	0.19
Trichobius parasiticus	5.17	5.20	0.04	0.98
	Adult	Juvenil		
Strebla wiedemanni	4.000	4.00	0.00	1.00
Trichobius joblingi	2.500	1.67	1.30	0.26
Trichobius parasiticus	4.975	5.65	0.60	0.55

(Wenzel et al. 1966, Guerrero 1996, 1997, Dick 2013). Of the genus *Trichobius*, only *T. parasiticus* is a characteristic parasite associated on *D. rotundus*, throughout its geographic distribution (Dick 2013), however *Trichobius furmani* Wenzel, 1966, seems to replace in some areas of South America (Guerrero 1995). Although *T. joblingi* and *T. caecus* are new records of parasitism for the Common vampire bat in Honduras, they are an accidental association, given the high specificity of ectoparasites (Dick 2007). *Trichobius caecus* occurs on momoorpid bats of *Pteronotus* (Wenzel 1976).

A previous study in Honduras recorded *T. caecus* on *Phyllostomus discolor* Wagner, 1843 and *P. mesoamericanus* Smith, 1972 (cited as *P. parnellii*, see Pavan and Marroig 2016) (Dick 2013). We captured *D. rotundus* and *P. mesoamericanus*, on the same sampling night, and both species of bats were parasitized. It is possible that horizontal transfer from *P. mesoamericanus* occurred; considering the only previous registration of this association is mentioned by Wenzel et al. (1966) in Venezuela. *Trichobius joblingi* is a characteristic parasite of *Carollia* species throughout the extent of its range (Wenzel et al. 1966, Wenzel 1976, Guerrero 1994). In this study in the different sampling sites (Cortés, Lempira, El Paraiso, Gracias a Dios, Olancho and Valle); species of *Carollia* were sympatric with *D. rotundus*, mainly *C. perspicillata* (Linnaeus, 1758) and probably shared roost. Apparently, *T. joblingi* has low host specificity, since it has been registered as a parasite on *D. rotundus* in Brazil, Colombia, Mexico, Panama, Trinidad and Tobago and Venezuela (Wenzel et al. 1966, Wenzel 1976, Bertola et al. 2005, Tlapaya-Romero et al. 2015, Durán et al. 2017), is possibly the most common ectoparasitic fly in the Neotropical region (Guerrero 1995). The social structure of the Common vampire bat is complex and developed, they are generally spatially separated from other bat species that use the same shelter (Wilkinson 1985, Kunz and Lumsden 2003, Aguiar and Antonini 2011); some ectoparasitic species are more likely to show strong host preferences when alternative bat host species roost together, while less specificity has been observed when host species roost alone (e.g., the streblid *Raymondia pagodarum* Speiser, 1900 prefers *Hipposideros speoris* (Schneider, 1800) over *Rhinolophus rouxii* Temminck, 1835, when these two bat species roost together – Seneviratne et al. 2009).

We were more successful in registering *D. rotundus* parasitized by bat flies in environments close to caves, which in fact are considered favorable for parasitism, as cave-roosting bats usually carry heavier parasite loads, and host a greater diversity of ectoparasites (Kunz 1982, Patterson et al. 2007). Therefore, we would expect greater prevalence of infestation in species of bats with high roost fidelity than those with low roost fidelity (Fenton et al. 2001, Kunz and Lumsden 2003). Trajano (1996) reported that, in a karst area of Brazil, *D. rotundus* moves between caves located in a relatively small area (2–3 km radius) and shows some degree of roost fidelity for some months.

Prevalence, Mean abundance and Mean intensity

There are few studies of bat flies on *D. rotundus* in Honduras and the Central American region that calculate prevalence, mean intensity of the infestation or other parasitic indices; this lack of information makes it difficult to establish comparisons. The prevalence can be highly variable in this host (P% = 0–100%), depending on the ectoparasite species, generally *T. parasiticus* and *S. wiedemanni* show the highest values, with some exceptions for accidental bat fly species (e.g., *T. joblingi* P% = 70, Tlapaya-Romero et al. 2015). In this study, the highest prevalence was for *T. parasiticus* (P% = 72.50), followed by *S. wiedemanni* (P% = 25). Rojas et al. (2008) in Costa Rica, recorded a high prevalence of *T. parasiticus* (P% = 91.4) while that for *S. wiedemanni* was lower (P% = 11. 4). In Brazil, Aguiar and Antonini (2011, 2016), found intermediate values and the highest prevalence in *S. wiedemanni* (P% = 43.6, P% = 44) and in *T. parasiticus* was (P% = 29.5, P% = 30) values of both studies respectively. Minaya et al. (2021) report low values in Peru, *S. wiedemanni* (P% = 22.22) and *T. parasiticus* (P% = 11.11). In our study, the mean abundance and the mean intensity was higher for *T. parasiticus* (MA = 3.69, MI = 5.17), followed by *S. wiedemanni* (MA = 1, MI = 4), similar results were found by Rojas et al. (2008) for mean intensity in *T. parasiticus* (MI = 5.65) while for *S. wiedemanni* (MI = 2.12). Aguiar and Antonini (2011) found in *S. wiedemanni* (MA = 1.56, MI = 3.57) and in *T. parasiticus* (MA = 0.62, MI = 2.09). These variations in the parasitological indices may be due to climatic differences, different biogeographic regions, environmental heterogeneity, variations of the hosts between localities, as well as differences in the sampling effort (Rui and Graciolli 2005, Vinarski et al. 2007, Lourenço et al. 2016). Variations may also indicate that parasites are often unevenly distributed among hosts (Shaw and Dobson 1995, Poulin 2007).

Infracommunities

In this study, the higher frequencies of infracommunities with one species than with two or more species indicate a possible pattern of association (Barbier and Graciolli 2016). The maximum number of parasites per host individual was 18 bat flies, Aguiar and Antonini (2011) in Brazil registered 25 and Tlapaya-Romero et al. (2015) in Mexico 26. *Trichobius parasiticus* + *S. wiedemanni* presented a higher frequency between the associations of different bat fly species; this infracommunity is widely registered in this host (e.g., Aguiar and Antonini 2011, 2016, Hiller et al. 2018, Graciolli et al. 2019, Barbier et al. 2021). Teixeira and Ferreira (2010) record *S. wiedemanni* and *T. furmani*, considering that the second species replaces *T. parasiticus* in some regions of South America (Bertola et al. 2005, Guerrero 1995). We also register infracommunities that include accidental species mainly *T. joblingi*, while (Soares et al. 2017) report associations formed only by accidental species (i.e., *T. joblingi* + *Speiseria ambigua* Kessel, 1925, *Aspidoptera falcata* Wenzel, 1976 + *Megistopoda proxima* (Séguy, 1926)). The coexistence of these infracommunities can be explained by the fact that they are made up of species of different genera, which may result in less competition between bat flies (Krasnov et al. 2014), since they present different morphologies and exploit various body niches in the hosts (Marshall 1982, Presley 2011, Hiller et al. 2018). Species of the Streblinae subfamily have a preference for hair-covered body surfaces, while species of the Trichobiinae subfamily tend to be found more frequently on wing membranes (ter Hofstede et al. 2004). Associations of species of the same genus, such as the one recorded here (*T. parasiticus* + *T. joblingi*) are considered less frequent due to the existence of competition for the host body between more closely related species (Ingram and Shurin 2009, Krasnov et al. 2014, Hiller et al. 2018).

Age and sex of the host

Sex and age of the host did not influence on the prevalence and intensity of infection of the bat flies. This may be due to the ecology of the species involved, the roosting behaviour, the social organization (Greenhall et al. 1983, Wilkinson 1985), variability of the sampled localities, and mainly because of the size of the sample of bats and bat fly species. Tlapaya-Romero et al. (2015) found on *D. rotundus* that females had a higher prevalence of *T. joblingi*. Other studies show that the influence of host sex does not show a significant relationship for different species of bats and bat flies (e.g., Moura et al. 2003, Rui and Graciolli 2005, Graciolli and Bianconi 2007, Ramalho et al. 2018). However, it has been documented that female and juvenile bats should be infested with bat fly species more often and in higher intensities as they roost predominantly in year-round stable groups together with their offspring (Christe et al. 2000, Bertola et al. 2005, Dick and Patterson 2007, Patterson et al. 2008, Presley and Willig 2008, Webber and Willis 2016). Some studies have also shown that males harbor more ectoparasites than female bats (Komeno and Linhares 1999, Zhang et al. 2010).

Overall, this study provides significant information of ectoparasites studied in relation to age and sex of the host, aggregate distribution of bat flies on *D. rotundus*, occurrence in Honduras and reveals the need for new studies in the country. Since biotic and abiotic factors play an important role in the host specificity, prevalence and parasitic intensity (Marshall 1982, Poulin and Morand 2004, Haelewaters et al. 2018). It is necessary to evaluate different regions, ecosystems, host species and variables (e.g., microclime, infracommunities, self-grooming, bat age, body mass, bat hormones, immune system, specialization, predators and parasites, community ecology of bat flies – Ross 1961, Overal 1980, Christe et al. 2000, Moura et al. 2003, Tlapaya-Romero et al. 2015, Warburton et al. 2016, Hiller et al. 2018, Barbier et al. 2021). Furthermore, *D. rotundus* and bat fly species can play an important role in the transmission and maintenance of different pathogenic microorganisms (Brandão et al. 2008, Schneider et al. 2009, Bai et al. 2011, Morse et al. 2012, Lima et al. 2013, Abundes-Gallegos et al. 2018, Ballados-González et al. 2018, Bergner et al. 2021), therefore new studies may increase the understanding of this interaction.

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Authors Contributions

WNGC design and implementation of the investigation. WNGC, FGE and DJMQ carried out the fieldwork and taxonomic identifications. WNGC formal analysis, writing-original draft. WNGC, MRVA, FGE and DJMQ contributed to the analysis of the results, reviewed and approved the preliminary version of the paper.

Competing Interest

The authors have declared that no competing interests exist.

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