Chewing lice (Insecta, Phthiraptera) and ticks (Arachnida, Ixodida) associated with birds in highland marshes of the Brazilian semiarid

Article *in* Studies on Neotropical Fauna and Environment · January 2024

DOI: 10.1080/01650521.2024.2307076

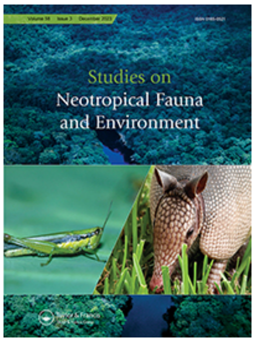
8 authors, including:

R. M. Lyra-Neves
Universidade Federal Rural de Pernambuco
12 PUBLICATIONS **7** CITATIONS

Latifa Pelage
Universidade Federal Rural de Pernambuco
19 PUBLICATIONS **138** CITATIONS

Williams Oliveira-Silva
Universidade Federal do Rio Grande do Norte
18 PUBLICATIONS **1** CITATION

Wallace Rodrigues Telino Júnior
Universidade Federal do Agreste de Pernambuco
70 PUBLICATIONS **841** CITATIONS



Taylor & Francis
Taylor & Francis Group

Studies on Neotropical Fauna and Environment

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/nnfe20

Chewing lice (Insecta, Phthiraptera) and ticks (Arachnida, Ixodida) associated with birds in highland marshes of the Brazilian semiarid

Vanessa Campelo Souza, Jaqueline Bianque de Oliveira, Rachel Maria de Lyra-Neves, Latifa Pelage, Allan Jefferson da Silva Oliveira, Williams Oliveira-Silva, Leandro da Silva Cabral & Wallace Rodrigues Telino-Júnior

STUDIES ON NEOTROPICAL FAUNA AND ENVIRONMENT
https://doi.org/10.1080/01650521.2024.2307076

Taylor & Francis
Taylor & Francis Group

Check for updates

Chewing lice (Insecta, Phthiraptera) and ticks (Arachnida, Ixodida) associated with birds in highland marshes of the Brazilian semiarid

Vanessa Campelo Souza [a,b], Jaqueline Bianque de Oliveira [a,c,d], Rachel Maria de Lyra-Neves [a,b,e], Latifa Pelage [f], Allan Jefferson da Silva Oliveira [a,b], Williams Oliveira-Silva [a,b], Leandro da Silva Cabral [a,b] and Wallace Rodrigues Telino-Júnior [a,b,e]

[a]Programa de Pós-Graduação em Biodiversidade, Universidade Federal Rural de Pernambuco, Recife, Brasil; [b]Laboratório de Ensino de Zologia, Universidade Federal do Agreste de Pernambuco, Garanhuns, Brasil; [c]Laboratório de Parasitologia, Universidade Federal Rural de Pernambuco, Recife, Brasil; [d]Programa de Pós-Graduação em Biociência Animal, Universidade Federal Rural de Pernambuco, Recife, Brasil; [e]Programa de Pós-Graduação em Ciências Ambientais, Universidade Federal do Agreste de Pernambuco, Garanhuns, Brasil; [f]Departamento de Pesca e Aquicultura, Universidade Federal Rural de Pernambuco, Recife, Brasil

ABSTRACT

In Brazilian semiarid, highland marshes are home to a great diversity of species; still, these ecosystems suffer constant impacts due to agriculture, logging, and livestock. Here we describe a community of birds and their ectoparasites in anthropized remnants of a highland marsh ecosystem, located in Northeast of Brazil. From August/2018 to July/2019, mist nets were used to capture birds, and their ectoparasites were then collected. A total of 78 bird species from 18 families were captured, of which 25 species and 12 families were parasitized by lice, while 13 species from 8 families were parasitized by ticks. Of the 546 birds captured, 11.9% were infested by 747 lice belonging to 12 taxa, and 4.2% by 27 ticks. Only seven individuals were infested by both lice and ticks. Both lice and ticks showed preference for topographic sites on their host bodies.

ARTICLE HISTORY
Received 24 April 2023
Accepted 15 January 2024

KEYWORDS
Avian; insects; arthropods; parasite–host interactions

Introduction

In northeast of Brazil, the highland marshes have been suffering intense anthropization mainly due to agriculture, logging and livestock, major causes of global biodiversity loss (McKinney 2002; Marzluff 2005; Rodrigues et al. 2008; Laurance & Vasconcelos 2009; Haddad et al. 2015; França et al. 2023). These ecosystems are important as they consist of Atlantic Forest 'islands' surrounded by semiarid regions and vegetation characteristic of the Caatinga biome and present conditions conducive to plant development, favoring fauna diversity in relation to surrounding areas, thus being potential refuges for endemic and threatened species, especially during dry seasons (Tabarelli & Santos 2004; Medeiros & Cestaro 2019; Almeida & Souza 2023).

Birds are parasitized by several arthropods species, such as diptera, fleas, lice, ticks, blood-sucking mites (Arzua & Valim 2010; Amaral et al. 2013; Kotti 2015; Cerutti et al. 2018; Goodman et al. 2020; Quiroga et al. 2020; Chagas et al. 2021; Flores et al. 2023). These ectoparasites have been the subject of studies that prove their effects on the reproductive success and survival of bird hosts, as well as impaired immunocompetence and disease transmission, which makes it essential to have a better understanding of the parasite–host interaction for the conservation of avifauna (Owen et al. 2010; López-Arrabé et al. 2014; Hicks et al. 2018; Lamarre et al. 2018; Dube et al. 2018; Rodríguez-Estrella & Rivera-Rodríguez 2019; Dudek et al. 2021; Garrido-Bautista et al. 2022).

Here we describe a community of birds and their louse and tick ectoparasite species in anthropized remnants of a rainforest ecosystem known as a highland marsh.

Materials and methods

Study area

The study was carried out in an highland marsh, an ecosystem formed by 'islands' of Atlantic Forest in semiarid regions surrounded by Caatinga vegetation, and which vegetation is known as semideciduous montane forest (IBGE 1985; de Melo & Rodal 2003; Tabarelli & Santos 2004). A determining factor for the existence of these environments is the occurrence of plateaus with

CONTACT Wallace Rodrigues Telino-Júnior wallace.telinojr@ufape.edu.br

Published online 31 Jan 2024

altitudes ranging from 500 to 1100 m, where precipitation levels can reach 1200 mm/year due to orographic rain (Andrade-Lima 1961, 2007).

The research was executed in a private property called Fojos farm, located in the municipality of Garanhuns, in Pernambuco Agreste mesoregion, northeast of Brazil (Figure 1). The climate in the municipality of Garanhuns is classified as tropical rainy with dry summer and the average annual temperature is 20°C (IBGE 1977; JCF et al. 2012).

The farm houses fragments of highland marshes in different ecological succession levels (Oliveira & Silva-Júnior 2008). Three of them were sampled: (1) *Camapuã* Fragment (8 ° 54'S – 36 ° 33'W) comprises 22.65 ha, with altitudes varying between 920 and 960 meters and flat landform. The vegetation is predominantly Montane Semideciduous Seasonal Forest (IBGE 2012). The fragment is surrounded by a pasture matrix and is connected to a second larger fragment, of a property next to Fojos Farm, with which adds up to a total of 150 ha.

(1) *Mata do Macaco* fragment (8 ° 53'S – 36 ° 32'W) with 19.43 ha and altitudes varying between 850 and 920 meters, presents steep landform. The dominant vegetation is classified as Montane Semideciduous Seasonal Forest (IBGE, 2012). The fragment also has small enclaves of savanna vegetation in areas with rugged landform. The surrounding matrix is made up of pasture for livestock.
(2) *Mata do S* fragment (8 ° 52'S – 36 ° 32W) with 16.79 ha, altitudes varying between 870 and 940 meters and a mostly irregular landform. It has mainly savanna vegetation in a state of regeneration, classified as Steppic Savanna (IBGE, 2012). The fragment is surrounded by a matrix of cattle pasture.

The distances between these forest remnants are the following: 1.64 km between *Mata do Macaco* and *Camapuã*; 0.97 km between *Mata do Macaco* and *Mata do S*, and 2.60 km between *Mata do S* and *Camapuã*.

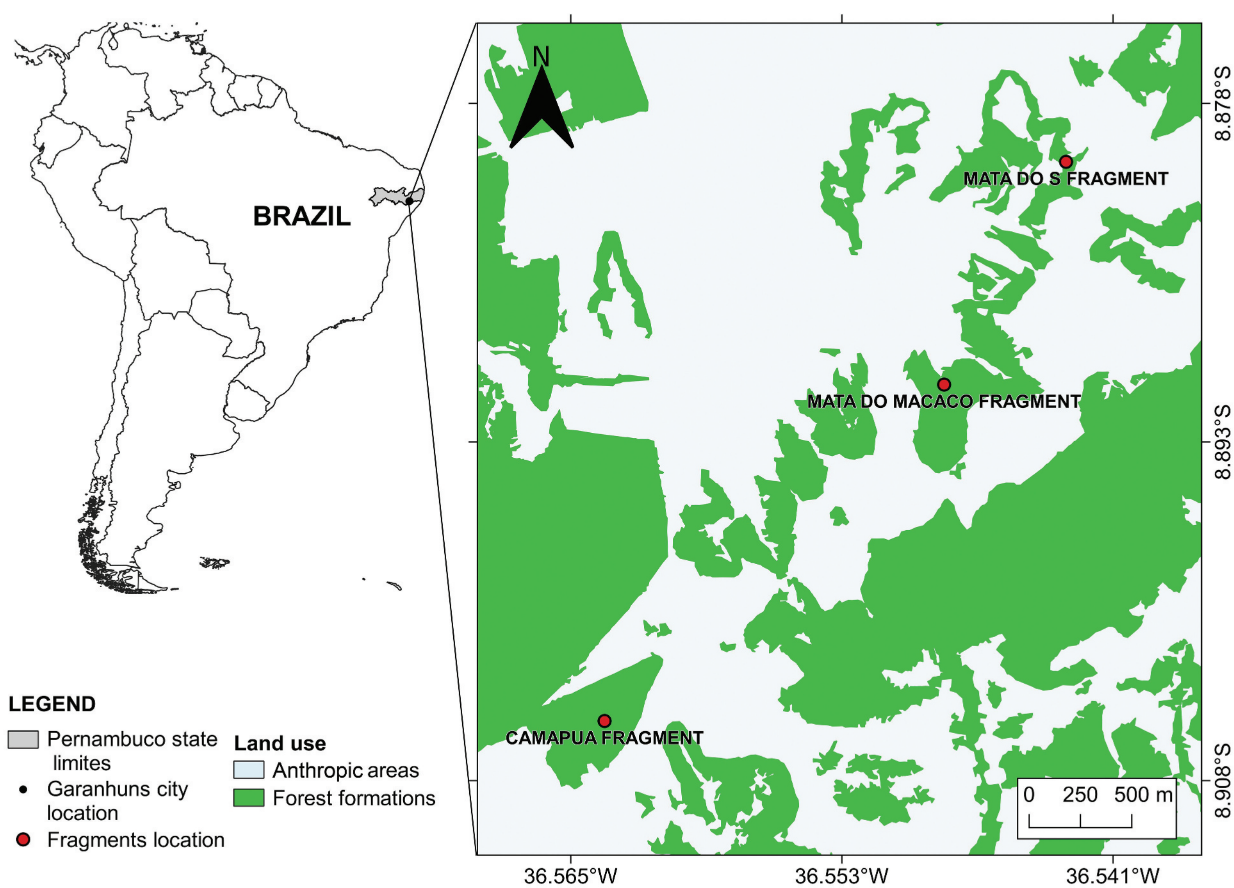


Figure 1. Map of the study area located at Fojos Farm in the municipality of Garanhuns, Pernambuco agreste mesoregion, northeast of Brazil.

Bird capture and ectoparasite collection

Birds were captured using a total of 18 mist nets of 2.5 m × 12 m and 36 mm mesh in each fragment, which were checked every 40 minutes. Each forest fragment had three linear transects, where the nets were assembled (six in each transect) and were sampled for two consecutive days per month, for 12 months (August 2018 to July 2019). Captured birds were placed in individual cotton bags, identified according to ornithological guides (Mata et al. 2006; Ridgely & Tudor 2009; Sigrist 2009; Silva 2014) and marked with metallic rings provided by the Research Center for Conservation of Wild Birds (CEMAVE). The project was submitted to the CEUA (010/2019) and also to SISBio (39887–4) and SNA (National Ringing System) Platforms of CEMAVE, guaranteeing authorization for capturing and ringing.

Ectoparasites collection, processing and identification

As for the ectoparasites, visual search and collection with the aid of tweezers were performed. In order not to compromise the health of the birds, no chemicals were used in the collection of ectoparasites. After being collected, ectoparasites were deposited in eppendorfs containing 70% ethanol. Lice were counted and photographed using an estereomicroscope. The arthropods were immersed in a 20% KOH solution for 12 hours for clarification and subsequently were kept in distilled water for 24 hours to remove clarifier excess. Then they were dehydrated in an ascending solution of 50%, 70%, 90% and 100% ethanol, staying 5 to 10 minutes in each solution. Eugenol was used for the diaphanization process, which took 1 hour; soon after, the lice were mounted on slides with synthetic Canadian balm (Palma 1978; González-Acuña et al. 2009). After a maximum time of three weeks under incubation at 50–60°C, the specimens were identified at the genus level with the aid of a stereomicroscope and a taxonomic key by Carriker and Melbourne (1966), Price et al. (2003) and Valim (2006).

Ticks were identified with the aid of a stereomicroscope and the taxonomic keys of Onofrio et al. (2006) and Martins et al. (2010).

Data analysis

In order to analyze parasitological parameters, the following indexes by Bush et al. (1997) were used: prevalence (the number of infested hosts divided by the number of examined hosts x 100); mean infestation intensity (total number of parasites divided by the number of infested hosts), and mean infestation abundance (total number of individuals of a given species of parasite divided by the total number of hosts examined, infested and non-infested). These indexes were calculated using the Quantitative Parasitology 3.0 software.

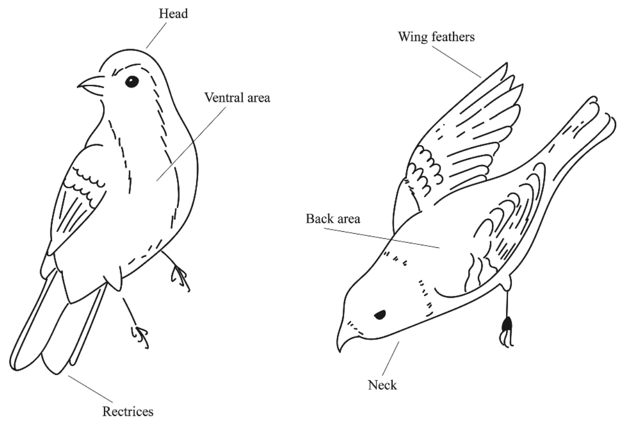


Figure 2. Topographic sites on bird hosts' bodies from where the ectoparasites were collected.

To test the preference of ectoparasites for specific host body sites (such as the head, neck, ventral area, back area, wing feathers and retrices) (Figure 2), the Kruskal-Wallis test was applied, and significance was accepted when $p \leq 0.05$. The back was considered as the dorsal area from the end of the neck to the beginning of the rectrices feathers, and the same for the ventral area on the opposite side of the bird. An 'indeterminate' category was created for cases when the parasite was collected in the cotton bag where the bird was, and it was not possible to know which region of the host it previously occupied. These analyses were performed using the R statistical package program version 3.5.2 (R Core Team 2019).

Results

Specimens of 78 bird species belonging to 18 families were captured (Table 5). Birds of 25 species and 12 families were parasitized by chewing lice of three families (Menoponidae, Philopteridae and Ricinidae) classified in 12 genus (*Brueelia* sp., *Columbicola* sp., *Formicaphagus* sp., *Furnaricola* sp., *Menacanthus* sp., *Myrsidea* sp., *Penenirmus* sp., *Psyconelloides* sp., *Ricinus* sp., *Strigiphilus* sp., *Sturnidoecus* sp., and *Tyranniphilopterus* sp.) (Table 5). Considering the entire bird community, 546 individuals were captured, of which 11.9% (65/546) were infested by 747 lice. Table 1 shows the prevalence, mean intensity and mean abundance rates of each identified lice genera in relation to the bird species host. For this table,

Table 1. Infestation data regarding each individual of infested bird.

Number of Individuals	Date	Fragment	Host species	Parasite
1	30/08/2018	Mata do Macaco	*Myiothlypis flaveola*	1 *Amblyomma* sp.
2	30/08/2018	Mata do Macaco	*Tangara fastuosa*	1 *Amblyomma* sp.
3	31/08/2018	Mata do Macaco	*Myiothlypis flaveola*	1 *Brueelia* sp.
4	31/08/2018	Mata do Macaco	*Coereba flaveola*	1 *Brueelia* sp.
5	02/09/2018	Camapuã	*Turdus amaurochalinus*	1 *Amblyomma* sp.
6	12/09/2018	Mata do Macaco	*Thlypopsis sordida*	2 *Ricinus* sp.
7	13/09/2018	Camapuã	*Turdus amaurochalinus*	21 *Brueelia* sp.
8	14/09/2018	Camapuã	*Troglodytes musculus*	7 *Penenirmus* sp.
9	15/09/2018	Mata do S	*Thamnophilus torquatus*	7 *Formicaphagus* sp.
10	16/09/2018	Mata do S	*Troglodytes musculus*	6 *Penenirmus* sp.
11	21/10/2018	Mata do S	*Arremon taciturnus*	1 *Myrsidea* sp.
12	22/10/2018	Mata do S	*Conopophaga cearae*	14 *Formicaphagus* sp.
13	23/10/2018	Mata do Macaco	*Myiothlypis flaveola*	2 *Brueelia* sp.
14	23/10/2018	Mata do Macaco	*Arremon taciturnus*	1 *Myrsidea* sp.
15	23/10/2018	Mata do Macaco	*Basileuterus culicivorus*	10 *Ricinus* sp.
16	23/10/2018	Mata do Macaco	*Tolmomyias flaviventris*	1 *Amblyomma* sp.
17	24/10/2018	Mata do Macaco	*Myiothlypis flaveola*	2 *Brueelia* sp.
18	24/10/2018	Mata do Macaco	*Camptostoma obsoletum*	4 *Myrsidea* sp.
19	16/11/2018	Camapuã	*Myiothlypis flaveola*	1 *Amblyomma* sp.
20	19/11/2018	Mata do S	*Megarynchus pitangua*	20 *Tyranniphilopterus* sp.
21	19/11/2018	Mata do S	*Tolmomyias flaviventris*	1 *Amblyomma* sp.
22	21/11/2018	Mata do Macaco	*Arremon taciturnus*	2 *Myrsidea* sp.
23	14/12/2018	Mata do Macaco	*Troglodytes musculus*	6 *Penenirmus* sp.
24	14/12/2018	Mata do Macaco	*Turdus rufiventris*	1 *Sturnidoecus* sp.
25	15/12/2018	Mata do Macaco	*Turdus rufiventris*	210 *Sturnidoecus* sp.
26	16/12/2018	Mata do S	*Taraba major*	78 *Formicaphagus* sp.
27	17/12/2018	Mata do S	*Tolmomyias flaviventris*	3 *Ricinus* sp.
28	18/12/2018	Camapuã	*Myiothlypis flaveola*	12 *Brueelia* sp., 1 *Ricinus* sp., 1 *Amblyomma* sp.
29	18/12/2018	Camapuã	*Stilpnia cayana*	1 *Ricinus* sp.
30	19/12/2018	Camapuã	*Troglodytes musculus*	2 *Penenirmus* sp.
31	19/12/2018	Camapuã	*Troglodytes musculus*	6 *Penenirmus* sp.
32	13/01/2019	Camapuã	*Troglodytes musculus*	8 *Penenirmus* sp.
33	13/01/2019	Camapuã	*Troglodytes musculus*	3 *Amblyomma* sp.
34	14/01/2019	Mata do S	*Zonotrichia capensis*	1 *Ricinus* sp.
35	14/01/2019	Mata do S	*Columbina picui*	1 *Columbicola* sp.
36	15/01/2019	Mata do S	*Taraba major*	14 *Formicaphagus* sp., 1 *Amblyomma* sp.
37	16/01/2019	Mata do Macaco	*Thlypopsis sordida*	1 *Ricinus* sp.
38	16/01/2019	Mata do Macaco	*Dendroplex picus*	1 *Amblyomma* sp.
39	17/01/2019	Mata do Macaco	*Myiothlypis flaveola*	14 *Brueelia* sp.
40	17/01/2019	Mata do Macaco	*Turdus leucomelas*	9 *Myrsidea* sp.
41	19/02/2019	Mata do Macaco	*Conopophaga cearae*	21 *Formicaphagus* sp.
42	22/02/2019	Camapuã	*Troglodytes musculus*	1 *Amblyomma* sp.
43	23/02/2019	Mata do S	*Arremon taciturnus*	3 *Myrsidea* sp.
44	23/02/2019	Mata do S	*Stilpnia cayana*	2 *Myrsidea* sp., 1 *Amblyomma* sp.
45	23/02/2019	Mata do S	*Thamnophilus torquatus*	4 *Formicaphagus* sp.
46	23/02/2019	Mata do S	*Troglodytes musculus*	1 *Penenirmus* sp.
47	23/02/2019	Mata do S	*Stilpnia cayana*	1 *Amblyomma* sp.
48	24/02/2019	Mata do S	*Thlypopsis sordida*	1 *Ricinus* sp.
49	24/02/2019	Mata do S	*Troglodytes musculus*	6 *Penenirmus* sp.
50	24/02/2019	Mata do S	*Columbina minuta*	9 *Columbicola* sp.
51	30/03/2019	Mata do S	*Thamnophilus capistratus*	4 *Formicaphagus* sp.
52	31/03/2019	Mata do S	*Synallaxis frontalis*	2 *Furnaricola* sp.
53	31/03/2019	Mata do S	*Phacellodomus rufifrons*	2 *Furnaricola* sp.
54	02/04/2019	Camapuã	*Troglodytes musculus*	2 *Penenirmus* sp.
55	03/04/2019	Mata do Macaco	*Troglodytes musculus*	18 *Penenirmus* sp.
56	04/04/2019	Mata do Macaco	*Conopophaga cearae*	2 *Formicaphagus* sp.
57	27/04/2019	Mata do Macaco	*Conopophaga cearae*	6 *Formicaphagus* sp.
58	27/04/2019	Mata do Macaco	*Megascops choliba*	1 *Strigiphilus* sp.
59	27/04/2019	Mata do Macaco	*Cantorchilus longirostris*	2 *Amblyomma* sp.
60	28/04/2019	Mata do Macaco	*Conopophaga cearae*	79 *Formicaphagus* sp., 1 *Amblyomma* sp.
61	01/05/2019	Mata do S	*Myiothlypis flaveola*	1 *Amblyomma* sp.
62	01/05/2019	Mata do S	*Herpsilochmus atricapillus*	1 *Amblyomma* sp.
63	11/05/2019	Mata do S	*Stilpnia cayana*	2 *Ricinus* sp.
64	11/05/2019	Mata do S	*Thamnophilus torquatus*	5 *Formicaphagus* sp.
65	25/05/2019	Mata do Macaco	*Myiothlypis flaveola*	15 *Brueelia* sp., 2 *Ricinus* sp.
66	25/05/2019	Mata do Macaco	*Conopophaga cearae*	1 *Formicaphagus* sp., 1 *Amblyomma* sp.
67	26/05/2019	Mata do S	*Columbina talpacoti*	26 *Columbicola* sp.
68	27/05/2019	Mata do S	*Myiothlypis flaveola*	40 *Brueelia* sp.
69	27/05/2019	Mata do S	*Columbina talpacoti*	13 *Columbicola* sp., 1 *Physconelloides eurysema* sp.
70	29/05/2019	Camapuã	*Troglodytes musculus*	2 *Penenirmus* sp.
71	03/07/2019	Camapuã	*Myiothlypis flaveola*	3 *Brueelia* sp., 4 *Ricinus* sp.

(*Continued*)

Table 1. (Continued).

Number of Individuals	Date	Fragment	Host species	Parasite
72	02/08/2019	Mata do S	*Turdus amaurochalinus*	1 *Menacanthus* sp.
73	05/08/2019	Camapuã	*Myiothlypis flaveola*	2 *Brueelia* sp., 1 *Myrsidea* sp., 1 *Ricinus* sp.
74	05/08/2019	Camapuã	*Basileuterus culicivorus*	1 *Myrsidea* sp., 3 *Amblyomma* sp.
75	07/08/2019	Mata do Macaco	*Turdus leucomelas*	5 *Myrsidea* sp., 1 *Amblyomma* sp.

only parasitized bird species with at least three captured individuals were considered. Table 2 shows the division of lice ectofauna considering forest fragments and host birds.

The highest prevalences of birds infested by lice were those of *Formicaphagus* sp. infesting *Conopophaga cearae* (100%) and *Thamnophilus torquatus* (100%), followed by *Formicaphagus* sp. infesting

Table 2. Parasitological parameters of avifauna lice from three anthropized highland marsh fragments of the Brazilian semiarid.

Lice	Bird order	Family	Species	Infested/captured	Prevalence	Mean intensity	Mean abundance
Menoponidae							
Menacanthus sp.							
	Passeriformes	Turdidae	*Turdus amaurochalinus*	1/4	25%	1	0.25
Myrsidea sp.							
	Passeriformes	Passerellidae	*Arremon taciturnus*	5/27	18.5%	1.8	0.3
	Passeriformes	Parulidae	*Myiothlypis flaveola*	1/32	3.1%	1	0.03
	Passeriformes	Parulidae	*Basileuterus culicivorus*	1/12	8.3%	1	0.08
	Passeriformes	Parulidae	*Camptostoma obsoletum*	1/15	6.6%	4	0.26
	Passeriformes	Thraupidae	*Stilpnia cayana*	1/33	3%	2	0.06
	Passeriformes	Turdidae	*Turdus leucomelas*	2/8	25%	7	1.75
Ricinidae							
Ricinus sp.							
	Passeriformes	Parulidae	*Myiothlypis flaveola*	4/32	12.5%	2	0.25
	Passeriformes	Thraupidae	*Thlypopsis sordida*	2/14	14.2%	1.3	0.28
	Passeriformes	Parulidae	*Basileuterus culicivorus*	1/12	8.3%	10	0.83
	Passeriformes	Rhynchocyclidae	*Tolmomyias flaviventris*	1/19	11.1%	3	0.15
	Passeriformes	Thraupidae	*Stilpnia cayana*	2/33	6%	1.5	0.09
	Passeriformes	Passerellidae	*Zonotrichia capensis*	1/4	25%	1	0.25
Philopteridae							
Brueelia sp.							
	Passeriformes	Parulidae	*Myiothlypis flaveola*	9/32	28.1%	10.1	2.8
	Passeriformes	Thraupidae	*Coereba flaveola*	1/7	14.2%	1	0.14
	Passeriformes	Turdidae	*Turdus amaurochalinus*	1/4	25%	21	5.25
Columbicola sp.							
	Columbiformes	Columbidae	*Columbina minuta*	1/3	33.3%	9	3
	Columbiformes	Columbidae	*Columbina talpacoti*	2/6	33.3%	19.5	6.5
Formicaphagus sp.							
	Passeriformes	Thamnophilidae	*Thamnophilus torquatus*	3/3	100%	5.3	5.3
	Passeriformes	Conopophagidae	*Conopophaga cearae*	6/6	100%	20.5	20.5
	Passeriformes	Thamnophilidae	*Taraba major*	2/4	50%	46	23
Furnaricola sp.							
	Passeriformes	Furnariidae	*Synallaxis frontalis*	1/30	3.3%	2	0.06
	Passeriformes	Furnariidae	*Phacellodomus rufrifons*	1/3	33.3%	2	0.06
Penenirmus sp.							
	Passeriformes	Troglodytidae	*Troglodytes musculus*	11/26	42.3%	5.8	2.4
Physconelloides sp.							
	Columbiformes	Columbidae	*Columbina talpacoti*	1/6	16.6%	1	0.16

Table 3. Parasitological parameters of avifauna ticks from three anthropized highland marsh fragments of the Brazilian semiarid.

Bird order	Family	Species	Infested/captured	Tick species	Prevalence	Mean intensity	Mean abundance
Passeriformes	Parulidae	*Basileuterus culicivorus*	1/7	*Amblyomma* sp.	14.2%	3	0.4
Passeriformes	Troglodytidae	*Cantorchilus longirostris*	1/5	*Amblyomma* sp.	20%	2	0.4
Passeriformes	Conopophagidae	*Conopophaga cearae*	2/3	*Amblyomma* sp.	66.6%	1	0.3
Passeriformes	Thamnophilidae	*Herpsilochmus atricapillus*	1/8	*Amblyomma* sp.	12.5%	1	0.1
Passeriformes	Parulidae	*Myiothlypis flaveola*	4/32	*Amblyomma* sp.	12.5%	1	0.1
Passeriformes	Troglodytidae	*Troglodytes musculus*	4/36	*Amblyomma* sp.	11.1%	2	0.1
Passeriformes	Thraupidae	*Stilpnia cayana*	2/33	*Amblyomma* sp.	6%	1	0.06
Passeriformes	Thraupidae	*Tangara fastuosa*	1/9	*Amblyomma* sp.	11.1%	1	0.1
Passeriformes	Thamnophilidae	*Taraba major*	1/4	*Amblyomma* sp.	25%	1	0.2
Passeriformes	Rhynchocyclidae	*Tolmomyias flaviventris*	3/19	*Amblyomma* sp.	15.7%	1	0.1
Passeriformes	Turdidae	*Turdus amaurochalinus*	1/4	*Amblyomma* sp.	25%	1	0.2
Passeriformes	Turdidae	*Turdus leucomelas*	1/8	*Amblyomma* sp.	12.5%	1	0.1

Table 4. Ectofauna found in each highland marsh fragment and its bird hosts.

Ectofauna	Forest Fragment	Host bird
Ticks		
Ixodidae		
Amblyomma sp.	Camapuã	*Tolmomyias flaviventris*
		Troglodytes musculus
		Turdus amaurochalinus
		Basileuterus culicivorus
		Myiotlhypis flaveola
	Mata do Macaco	*Conopophaga cearae*
		Dendroplex picus
		Tolmomyias flaviventris
		Cantorchilus logirostris
		Turdus leucomelas
		Myiothlypis flaveola
		Tangara fastuosa
	Mata do S	*Herpsilochmus atricapillus*
		Taraba major
		Tolmomyas flaviventris
		Myiotlhypis flaveola
		Stilpnia cayana
Lice		
Menoponidae		
Menacanthus sp.	Mata do S	*Turdus amaurochalinus*
Myrsidea sp.	Camapuã	*Myiothlypis flaveola*
		Basileuterus culicivorus
	Mata do Macaco	*Turdus leucomelas*
	Mata do S	*Arremon taciturnus*
Ricinidae		
Ricinus sp.	Camapuã	*Myiothlypis flaveola*
		Stilpnia cayana
	Mata do Macaco	*Basileuterus culicivorus*
		Myiothlypis flaveola
		Thlypopsis sordida
	Mata do S	*Tolmomyias flaviventris*
		Zonotrichia capensis
		Stilpnia cayana
		Thlypopsis sordida
Philopteridae		
Columbicola sp.	Mata do S	*Columbina minuta*
		Columbina picui
		Columbina talpacoti
Psyconelloides sp.	Mata do S	*Columbina talpacoti*
Formicaphagus sp.	Mata do Macaco	*Conopophaga cearae*
	Mata do S	*Conopophaga cearae*
		Thamnophilus capistratus
		Thamnophilus torquatus
		Taraba major
Furnaricola sp.	Mata do S	*Phacellodomus rufifrons*
		Synallaxis frontalis
Penenirmus sp.	Camapuã	*Troglodytes musculus*
	Mata do Macaco	*Troglodytes musculus*
	Mata do S	*Troglodytes musculus*
Brueelia sp.	Camapuã	*Turdus amaurochalinus*
		Myiothlypis flaveola
	Mata do Macaco	*Myiothlypis flaveola*
	Mata do S	*Myiothlypis flaveola*
Strigiphilus sp.	Mata do Macaco	*Megascops choliba*
Sturnidoecus sp.	Mata do Macaco	*Turdus rufiventris*
Tyranniphilopterus sp.	Mata do S	*Megarynchus pitangua*

Taraba major (50%) and *Penenirmus* sp. infesting *Troglodytes musculus* (42.3%).

The highest mean intensities were those of *Formicaphagus* sp. infesting *Taraba major* (46), *Formicaphagus* sp. infesting *Conopophaga cearae* (20.5), *Brueelia* sp. infesting *Turdus amaurochalinus* (21) and *Columbicola* sp. infesting *Columbina talpacoti* (19.5).

In relation to the mean abundances, *Formicaphagus* sp. infesting *Taraba major* (23), *Formicaphagus* sp. infesting *Conopophaga cearae* (20.5), *Columbicola* sp. infesting *Columbina talpacoti* (6.5) and *Thamnophilus torquatus* (5.3) were the most relevant.

The highest prevalences infested by ticks were those of *Conopophaga cearae* (66.6%) *Taraba major* (25%) and *Turdus amaurochalinus* (25%).

The highest mean intensities of ticks were those of *Basileuterus culicivorus* (3), *Cantorchilus longirostris* (2) and *Troglodytes musculus* (2).

In relation to the mean abundances, *Basileuterus culicivorus* (0.4), *Cantorchilus longirostris* (0.4) and *Troglodytes musculus* (0.3) presented the highest ones.

A significant difference was observed in relation to the topographic preference of lice (Kruskal–Wallis chi-squared = 17,377; df = 6; $p = 0.007994$), with the head and neck being the preferred regions, respectively (Figure 3).

A total of 27 ticks, *Amblyomma sculptum* (Acari, Ixodidae), were collected while parasitizing 4.2% (23/546) birds of 13 species (*Basileuterus culicivorus*, *Conopophaga cearae*, *Cantorchilus longirostris*, *Dendroplex picus*, *Herpsilochmus atricapillus*, *Myiothlypis flaveola*, *Stilpnia cayana*, *Tangara fastuosa*, *Taraba major*, *Tolmomyias flaviventris*, *Troglodytes musculus*, *Turdus amaurochalinus*, and *Turdus leucomelas*) and 8 families (Parulidae, Con-opophagidae, Troglodytidae, Furnariidae, Thraupidae, Thamnophilidae, Turdidae, and Rhynchocyclidae). All 27 ticks were nymphs. In addition, 81.4% of tick-infested birds belonged to the insectivorous guild, while 11.1% had frugivorous eating habits and 7.4% omnivorous. Ticks were found in birds captured in all three fragments (Table 3).

Considering coinfestation by lice and ticks, only 1.3%, or seven individuals, of six species (*Conopophaga cearae*, *Myiotlhypis flaveola*, *Stilpnia cayana*, *Taraba major*, *Troglodytes musculus*, and *Turdus leucomelas*) and six families (Conopophagidae, Parulidae, Thraupidae, Thamnophilidae, Troglodytidae, and Turdidae) were coinfested (Table 4).

The neck of the birds was the topographic region preferred by ticks, where 72.4% of the ticks were attached, followed by the head (24.1%) and ventral area (3.4%).

Discussion

The prevalence of bird lice in rain forest ecosystems in Brazil varies greatly considering previous studies carried out in the Atlantic Forest such as those by Marini et al. (1996), Roda and Âmi de (1999) and Soares (2018). The low number of parasitized birds observed in the present study, considering both the bird

Table 5. List of birds captured during the study.

Lista de aves
COLUMBIFORMES Latham, 1790
Columbidae Leach, 1820
Columbina minuta (Linnaeus, 1766)
Columbina talpacoti (Temminck, 1810)
Columbina picui (Temminck, 1813)
Leptotila verreauxi Bonaparte, 1855
STRIGIFORMES Wagler, 1830
Strigidae Leach, 1820
Megascops choliba (Vieillot, 1817)
Aegolius harrisii (Cassin, 1849)
APODIFORMES Peters, 1940
Trochilidae Vigors, 1825
Phaethornis pretrei (Lesson & Delattre, 1839)
Eupetomena macroura (Gmelin, 1788)
Chlorostilbon lucidus (Shaw, 1812)
Chionomesa fimbriata (Gmelin, 1788)
Chrysuronia versicolor (Vieillot, 1818)
Heliomaster squamosus (Temminck, 1823)
Thalurania watertonii (Bourcier, 1847)
PICIFORMES Meyer & Wolf, 1810
Picidae Leach, 1820
Picumnus fulvescens Stager, 1961
Veniliornis passerinus (Linnaeus, 1766)
Colaptes melanochloros (Gmelin, 1788)
PASSERIFORMES Linnaeus, 1758
Thamnophilidae Swainson, 1824
Formicivora grisea (Boddaert, 1783)
Formicivora melanogaster Pelzeln, 1868
Herpsilochmus sellowi Whitney & Pacheco, 2000
Herpsilochmus atricapillus Pelzeln, 1868
Thamnophilus capistratus Lesson, 1840
Thamnophilus torquatus Swainson, 1825
Thamnophilus pelzelni Hellmayr, 1924
Thamnophilus caerulescens Vieillot, 1816
Taraba major (Vieillot, 1816)
Conopophagidae Sclater & Salvin, 1873
Conopophaga cearae Cory, 1916
Dendrocolaptidae Gray, 1840
Dendroplex picus (Gmelin, 1788)
Furnariidae Gray, 1840
Phacellodomus rufifrons (Wied, 1821)
Synallaxis infuscata Pinto, 1950
Synallaxis frontalis Pelzeln, 1859
Synallaxis albescens Temminck, 1823
Synallaxis scutata Sclater, 1859
Pipridae Rafinesque, 1815
Neopelma pallescens (Lafresnaye, 1853)
Rhynchocyclidae Berlepsch, 1907
Tolmomyias flaviventris (Wied, 1831)
Todirostrum cinereum (Linnaeus, 1766)
Poecilotriccus plumbeiceps (Lafresnaye, 1846)
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)
Hemitriccus mirandae (Snethlage, 1925)
Tyrannidae Vigors, 1825
Euscarthmus meloryphus Wied, 1831
Camptostoma obsoletum (Temminck, 1824)
Elaenia spectabilis Pelzeln, 1868
Elaenia chilensis Hellmayr, 1927
Phaeomyias murina (Spix, 1825)
Serpophaga subcristata (Vieillot, 1817)
Casiornis fuscus Sclater & Salvin, 1873
Megarynchus pitangua (Linnaeus, 1766)
Myiophobus fasciatus (Statius Muller, 1776)
Cnemotriccus fuscatus (Wied, 1831)
Lathrotriccus euleri (Cabanis, 1868)
Myiarchus ferox (Gmelin, 1789)
Vireonidae Swainson, 1837
Cyclarhis gujanensis (Gmelin, 1789)
Hylophilus amaurocephalus (Nordmann, 1835)
Vireo olivaceus (Linnaeus, 1766)
Vireo chivi (Vieillot, 1817)
Troglodytidae Swainson, 1831
Troglodytes musculus Naumann, 1823
Cantorchilus longirostris (Vieillot, 1819)
Polioptilidae Baird, 1858
Polioptila plumbea (Gmelin, 1788)
Turdidae Rafinesque, 1815
Turdus flavipes Vieillot, 1818
Turdus leucomelas Vieillot, 1818
Turdus rufiventris Vieillot, 1818
Turdus amaurochalinus Cabanis, 1850
Passerellidae Cabanis & Heine 18,505
Zonotrichia capensis (Statius Muller, 1776)
Arremon taciturnus (Hermann, 1783)
Parulidae Wetmore, Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer 1947
Setophaga pitiayumi (Vieillot, 1817)
Basileuterus culicivorus (Deppe, 1830)
Myiothlypis flaveola Baird, 1865
Thraupidae Cabanis, 1847
Tangara fastuosa (Lesson, 1831)
Tangara sayaca (Linnaeus, 1766)
Stilpnia cayana (Linnaeus, 1766)
Nemosia pileata (Boddaert, 1783)
Volatinia jacarina (Linnaeus, 1766)
Coryphospingus pileatus (Wied, 1821)
Dacnis cayana (Linnaeus, 1766)
Coereba flaveola (Linnaeus, 1758)
Sporophila nigricollis (Vieillot, 1823)
Sporophila albogularis (Spix, 1825)
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)

community and populations, may reflect the negative binomial distribution pattern, present in several parasite-host systems. The tendency is that parasite populations are diluted in those of their hosts in an agglomerated manner, causing most hosts to have few parasites and many parasites to concentrate on a few hosts (Anderson & May 1982; Wall 2007).

Lice found on birds belong to two families (Menoponidae, Ricinidae) of the suborder Amblycera, and one family (Philopteridae) of the suborder Ischnocera. They are mandatory ectoparasites,

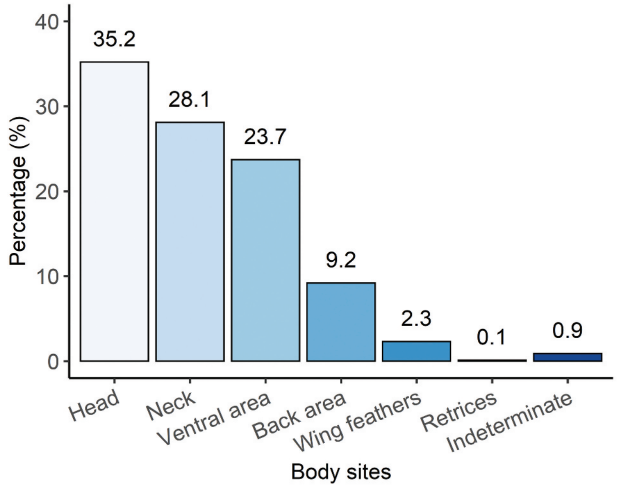


Figure 3. Topographic distribution of the avifauna lice community.

completing the entire life cycle on the host's body, and some species are host specific (Szczykutowicz et al. 2006). Their transmission happens mainly by direct contact during parental care (vertical), or during copulation (horizontal) (Galloway & Lamb 2017). In addition, although rarer, forensic behavior has also been recorded, through which Ischnocera lice use Hippoboscidae flies as a way to reach other hosts (Keirans 1975; Bartlow et al. 2016). Lice of both orders have chewing appendages, feeding mainly on the feathers of birds, although some species of Amblycera feed on dead or living parts of the skin, and on blood (Johnson & Clayton 2003; Mey et al. 2006). These ectoparasites can cause a reduction in life expectancy due to damage caused to the feathers, hindering flight performance, and causing greater mortality during migrations; increased host metabolism and reduced thermoregulation; reduced sexual attractiveness and impaired reproduction (Clayton 1990; Booth et al. 1993; Barbosa et al. 2002; Moreno-Rueda & Hoi 2012).

When considering the topographic preference of lice and ticks on the birds' bodies, the head and neck were the preferred areas. Different species of ectoparasites have adapted to the occupation of specific sites on the body of their hosts so that differential distributions are common and the preference for topographic regions on the body of birds may be related to the purpose of avoiding preening, the main defense behavior against ectoparasites, or competition for resources with other parasites (Reiczigel & Rozsa 1998; Tompkins & Clayton 1999; Touati & Samraoui 2013; Mishra et al. 2016). The birds' heads and necks are areas of difficult or impossible access during feather cleaning behavior, which may influence ectoparasite preference in these regions.

Nymphs of *Amblyomma* sp. were the only ticks found on birds. They belong to one of the six species in the *Amblyomma cajennense* (Fabricius, 1787) complex, of which only two are found in Brazil, *A. cajennense* (sensu stricto) and *A. sculptum* (Berlese, 1888). Although found in sympatry in transition localities, such as the geographic boundaries of the Amazon and Cerrado biomes, these two species present different distribution areas along Brazil. *A. cajannense* is mostly restricted to areas with equatorial climate, such as the Amazon biome, whilst *A. sculptum* is mostly found in areas with tropical climate, coinciding with the Cerrado and Atlantic forest biomes (Martins et al. 2016). The localities in the study area consist of Atlantic forest ecosystems, with tropical climate, and therefore, the collected nymphs most likely belong to *A. sculptum* species.

Regarding trophic guilds, the majority of infested birds with *A. sculptum* belong to the insectivorous guild (81.4%), followed by frugivorous birds (11.1%) and omnivorous (7.4%). The predominance of ticks in insectivorous birds captured during this research can be explained by the fact that these captured species often forage mainly on the lower strata of the forest, close to foliage and soil, facilitating contact with ticks since most arachnids look for hosts close to the ground, which limits their contact with birds that forage in the highest strata (Heller et al. 2019).

We presented data about the community of birds and their ectoparasites in a highland marsh ecosystem.

Acknowledgments

We would like to thank Iara Cohim and André Luis Vasconcelos for the support and permission to carry out the research in Fazenda Fojos.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (Capes) – Financing Code 001.

ORCID

Vanessa Campelo Souza http://orcid.org/0000-0002-0802-343X

Jaqueline Bianque de Oliveira http://orcid.org/0000-0002-6120-7895
Rachel Maria de Lyra-Neves http://orcid.org/0000-0002-6420-9271
Latifa Pelage http://orcid.org/0000-0001-8365-2001
Allan Jefferson da Silva Oliveira http://orcid.org/0000-0001-5147-9582
Williams Oliveira-Silva http://orcid.org/0000-0003-1619-0817
Leandro da Silva Cabral http://orcid.org/0000-0003-3449-5294
Wallace Rodrigues Telino-Júnior http://orcid.org/0000-0002-5570-1993

References

Almeida AM, Souza AF. 2023. Northern Atlantic Forest: conservation status and perspectives. In: Pereira-Filho G, França F, Alves R and Vasconcellos A, editors Anim Biodivers Conserv Brazil's north atl for [internet]. Cham: Springer International Publishing. pp. 7–22. doi:10.1007/978-3-031-21287-1_2

Amaral HLC, Bergmann FB, Santos PRS, Krüger RF, Graciolli G. 2013. Community of arthropod ectoparasites of two species of Turdus Linnaeus, 1758 (Passeriformes: Turdidae) in southern Rio Grande do sul, Brazil. Parasitol Res [Internet]. 112(2):621–628. doi:10.1007/s00436-012-3174-5

Anderson RM, May RM. 1982. Coevolution of hosts and parasites. Parasitology. 85(2):411–426.

Andrade-Lima D. 1961. Tipos de florestas de Pernambuco. An da Assoc dos Geógrafos Bras. 12(1):68–95.

Andrade-Lima D. 2007. Estudos Fitogeográficos de Pernambuco. An da Acad Pernambucana Ciência Agronômia. 4:243–270.

Arzua M, Valim MP. 2010. Bases para o estudo qualitativo e quantitativo de ectoparasitos em aves. In: Von-Matter S, Straube F, Accordi I, Piacentini V and Cândido-Jr J, editors Ornitol e Conserv ciência Apl técnicas pesquisias e Levant. Rio de Janeiro: Technical Books. pp. 347–365.

Barbosa A, Merino S, Lope F, Møller AP, Moore F. 2002. Effects of feather lice on flight behavior of male barn swallows (*Hirundo Rustica*). The Auk [Internet]. 119 (1):213–216. doi:10.1093/auk/119.1.213

Bartlow AW, Villa SM, Thompson MW, Bush SE. 2016. Walk or ride? Phoretic behaviour of amblyceran and ischnoceran lice. Int J Parasitol [Internet]. 46(4):221–227. doi:10.1016/j.ijpara.2016.01.003

Booth DT, Clayton DH, Block BA. 1993. Experimental demonstration of the energetic cost of parasitism in free-ranging hosts. Proc R Soc B Biol Sci [Internet]. 253 (1337):125–129. doi:10.1098/rspb.1993.0091

Bush AO, Lafferty KD, Lotz JM, Shostak AW. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. J Parasitol [Internet]. 83(4):575. doi:10.2307/3284227

Carriker JR, Melbourne A A revision of the genus *Furnaricola* (Mallophaga) with descriptions of new species. Proceedings of the United States National Museum, 1966.

Cerutti F, Modesto P, Rizzo F, Cravero A, Jurman I, Costa S, Giammarino M, Mandola ML, Goria M, Radovic S, et al. 2018. The microbiota of hematophagous ectoparasites collected from migratory birds. PLoS One. 13(8):1–16. doi:10.1371/journal.pone.0202270

Chagas CRF, Harl J, Preikša V, Bukauskaitė D, Ilgūnas M, Weissenböck H, Valkiūnas G. 2021. *Lankesterella* (Apicomplexa, Lankesterellidae) blood parasites of passeriform birds: prevalence, molecular and morphological characterization, with notes on sporozoite persistence in vivo and development in vitro. Animals [Internet]. 11 (5):1451. doi:10.3390/ani11051451

Clayton DH. 1990. Mate choice in experimentally parasitized rock doves: lousy males lose. Integr Comp Biol. 30 (2):251–262.

de Melo JIM, Rodal MJN. 2003. Levantamento florístico de um trecho de floresta serrana no planalto de Garanhuns, Estado de Pernambuco. Acta Sci Biol Sci. 25(1):173–178.

Dube WC, Hund AK, Turbek SP, Safran RJ. 2018. Microclimate and host body condition influence mite population growth in a wild bird-ectoparasite system. Int J Parasitol Parasites Wildl [Internet]. 7(3):301–308. doi:10.1016/j.ijppaw.2018.07.007

Dudek BM, Henderson MT, Hudon SF, Hayden EJ, Heath JA, Cooke S. 2021. Haematophagous ectoparasites lower survival of and have detrimental physiological effects on golden eagle nestlings.Cooke S, editor. Conserv Physiol [Internet]. 9(1). doi:10.1093/conphys/coab060

Flores FS, Saracho-Bottero MN, Tarragona EL, Sebastian PS, Copa GN, Guardia L, Mangold AJ, Venzal JM, Nava S. 2023. Ticks (Acari: Ixodidae, Argasidae) associated with wild birds in Argentina. Ticks Tick Borne Dis [Internet]. 14(3):102135. doi:10.1016/j.ttbdis.2023.102135

França FGR, Vasconcellos A, Nóbrega Alves RR, Filho GAP. 2023. An introduction to the knowledge of animal diversity and conservation in the most threatened forests of Brazil. In: Filho G, França F, Alves R and Vasconcellos A, editors Anim Biodivers Conserv Brazil's north atl for [internet]. Cham: Springer International Publishing. pp. 1–5. doi:10.1007/978-3-031-21287-1_1

Galloway TD, Lamb RJ. 2017. Abundance of chewing lice (Phthiraptera: Amblycera and Ischnocera) increases with the body size of their host woodpeckers and sapsuckers (Aves: Piciformes: Picidae). Can Entomol. 149 (4):473–481.

Garrido-Bautista J, Soria A, Trenzado CE, Pérez-Jiménez A, Pintus E, Ros-Santaella JL, Bernardo N, Comas M, Kolenčík S, Moreno-Rueda G. 2022. Within-brood body size and immunological differences in blue tit (Cyanistes caeruleus) nestlings relative to ectoparasitism. Avian Res [Internet]. 13:100038. doi:10.1016/j.avrs.2022.100038

González-Acuña D, Lara J, Cicchino A. 2009. Nuevos registros de piojos (Insecta: Phthiraptera) en aves domésticas y ornamentales en Chile. Arch Med Vet. 41(2):181–184.

Goodman GB, Klingensmith MC, Bush SE, Clayton DH. 2020. The role of scratching in the control of ectoparasites on birds. The Auk [Internet]. 137(2). doi:10.1093/auk/ukaa010

Haddad NM, Brudvig LA, Clobert J, Davies KF, Gonzalez A, Holt RD, Lovejoy TE, Sexton JO, Austin MP, Collins CD, et al. 2015. Habitat fragmentation and its lasting impact on

Earth's ecosystems. Sci Adv [Internet]. 1(2). doi:10.1126/sciadv.1500052

Heller EL, Gaff HD, Brinkerhoff RJ, Walters EL. 2019. Urbanization and tick parasitism in birds of coastal southeastern Virginia. J Wildl Manage. 83(4):975–984.

Hicks O, Burthe SJ, Daunt F, Newell M, Chastel O, Parenteau C, Green JA. 2018. The role of parasitism in the energy management of a free-ranging bird. J Exp Biol [Internet]. doi:10.1242/jeb.190066

IBGE (Instituto Brasileiro de Geográfia e Estatística). 1977. Geografia do Brasil: região NordesteVol. 2. Rio de Janeiro: IBGE.

IBGE (Instituto Brasileiro de Geográfia e Estatística). 1985. Atlas nacional do Brasil: região Nordeste. Rio de Janeiro: IBGE.

Instituto Brasileiro de Geográfia e Estatística - IBGE. 2012. Manual Técnico da Vegetação Brasileira. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística - IBGE.

JCF B-J, Anjos RJ, Silva TJA, Lima JRS, Andrade CLT. 2012. Métodos de estimativa da evapotranspiração de referência diária para a microrregião de Garanhuns, PE. Rev Bras Eng Agric E Ambient. 16(4):380–390 [Internet]. doi:10.1590/S1415-43662012000400008

Johnson KP, Clayton DH. 2003. The biology, ecology, and evolution of chewing lice. In: Price R, Hellenthal R, Palma R, Johnson K and Clayton D, editors Chewing lice world Checkl Biol Overv. Champaign: Illinois Natural History Survey. pp. 449–476.

Keirans JE. 1975. A review of the phoretic relationship between Mallophaga (Phthiraptera: Onsecta) and Hippoboscidae (Diptera: Insecta). J Med Entomol. 12 (1):71–76.

Kotti BK. 2015. Fleas (Siphonaptera) of mammals and birds in the Great Caucasus. Entomol Rev [Internet]. 95 (6):728–738. doi:10.1134/S0013873815060068

Lamarre V, Legagneux P, Franke A, Casajus N, Currie DC, Berteaux D, Bêty J. 2018. Precipitation and ectoparasitism reduce reproductive success in an arctic-nesting top-predator. Sci Rep [Internet]. 8(1):8530. doi:10.1038/s41598-018-26131-y

Laurance WF, Vasconcelos HL. 2009. Consequências ecológicas da fragmentação florestal na amazônia. Oecologia Bras [Internet]. 13(3):434–451. doi:10.4257/oeco.2009.1303.03

López-Arrabé J, Cantarero A, Pérez-Rodríguez L, Palma A, Moreno J, Tarvin K. 2014. Experimental pyrethroid treatment underestimates the effects of ectoparasites in cavity-nesting birds due to toxicity.Tarvin K, editor. Ibis (Lond 1859) [Internet]. 156(3):606–614. doi:10.1111/ibi.12160

Marini MÂ, Reinert BL, Bornschein MR, Pinto JC, Pichorim MA. 1996. Ecological correlates of ectoparasitism on Atlantic Forest birds, Brazil. Ararajuba. 4 (2):93–102.

Martins TF, Barbieri ARM, Costa FB, Terassini FA, Camargo LMA, Peterka CRL, De C Pacheco R, Dias RA, Nunes PH, Marcili A, et al. 2016. Geographical distribution of *Amblyomma cajennense* (sensu lato) ticks (Parasitiformes: Ixodidae) in Brazil, with description of the nymph of *A. cajennense* (sensu stricto). Parasit Vectors [Internet]. 9(1):1–14. doi:10.1186/s13071-016-1460-2

Martins TF, Onofrio VC, Barros-Battesti DM, Labruna MB. 2010. Nymphs of the genus *Amblyomma* (Acari: Ixodidae) of Brazil: descriptions, redescriptions, and identification key. Ticks Tick Borne Dis [Internet]. 1(2):75–99. doi:10.1016/j.ttbdis.2010.03.002

Marzluff JM. 2005. Island biogeography for an urbanizing world: how extinction and colonization may determine biological diversity in human-dominated landscapes. Urban Ecosyst [Internet]. 8(2):157–177. doi:10.1007/s11252-005-4378-6

Mata JRR, Erize F, Rumboll M. 2006. Birds of South America: non-passerines. Princeton: Princeton University Press.

McKinney ML. 2002. Urbanization, biodiversity, and conservation: the impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. Bioscience. 52 (10):883–890.

Medeiros JF, Cestaro LA. 2019. As diferentes abordagens utilizadas para definir Brejos de Altitude, áreas de exceção do Nordeste brasileiro. Soc e Territ [Internet]. 31(2):97–119. doi:10.21680/2177-8396.2019v31n2ID16096

Mey E, Cicchino A, González-Acuña D. 2006. Consumo de secreción ocular de aves por piojos Amblycera en Chile y Argentina. Boletín Chil Ornitol. 12(1):30–35.

Mishra S, Pednekar R, Gatne M. 2016. A comparative study of region specificity in bird louse in organized and unorganized sector of Mumbai. Int J Sci Environ Technol. 5 (5):3506–3511.

Moreno-Rueda G, Hoi H. 2012. Female house sparrows prefer big males with a large white wing bar and fewer feather holes caused by chewing lice. Behav Ecol. 23 (2):271–277.

Oliveira M, Silva-Júnior AP. 2008. Laudo técnico da Fazenda Fojos, Garanhuns - PE. Recife: Companhia Pernambucana de Meio Ambiente e Reursos Hídricos (CPRH).

Onofrio VC, Labruna MB, Pinter A, Giacomin FG, Barros-Battesti DM. 2006. Comentários e chaves para as espécies do gênero Amblyomma. In: Barros-Battesti DM, Arzua M and Bechara G, editors Carrapatos importância médico veterinária da região Neotrop um guia Ilus para identificação espécies. São Paulo: Instituto Butantã. pp. 53–113.

Owen JP, Nelson AC, Clayton DH. 2010. Ecological immunology of bird-ectoparasite systems. Trends Parasitol [Internet]. 26(11):530–539. doi:10.1016/j.pt.2010.06.005

Palma R. 1978. Slide-mounting of lice: a detailed description of the Canada balsam technique. New Zeal Entomol. 6 (4):432–436.

Price RD, Hellenthal RA, Palma RL, Johnson KP, Clayton DH. 2003. The chewing lice: world checklist and biological overview. Champaign: Illinois Natural History Survey.

Quiroga MA, Hayes TI, Hayes CD, Garrod H, Soares L, Knutie SA, Latta SC, Anderson DL. 2020. More than just nestlings: incidence of subcutaneous *Philornis* (Diptera: Muscidae) nest flies in adult birds. Parasitol Res. 119 (7):2337–2342. doi:10.1007/s00436-020-06696-2

R Core Team. 2019. R: a language and environment for statistical. R found stat comput [Internet]. [accessed 2019 Dec 12]. https://www.r-project.org/
Reiczigel J, Rozsa L. 1998. Host-mediated site segregation of ectoparasites: an individual-based simulation study. J Parasitol [Internet]. 84(3):491–498. doi:10.2307/3284711
Ridgely RS, Tudor G 2009. Field Guide to the songbirds of South America: the passerines. Austin: University of Texas Press.
Roda SA, Âmi de F. 1999. Aves silvestres infestadas por Phthiraptera (Insecta) na Zona da Mata Norte de Pernambuco, Brasil. Rev Bras Zool. 16(3):871–878.
Rodrigues PCG, Chagas MGS, Silva FBR, Pimentel RMM. 2008. Ecologia dos Brejos de Altitude do agreste pernambucano. Rev Geogr. 25(3):20–34.
Rodríguez-Estrella R, Rivera-Rodríguez LB. 2019. High prevalence of louse flies on osprey nestlings in a Baja California colony. J Raptor Res [Internet]. 53(2):142. doi:10.3356/JRR-17-59
Sigrist T. 2009. Guia de Campo Avis Brasilis - Avifauna brasileira: Panchas e Mapas (vol. 1)/Descrição das espécies (vol. 2). São Paulo: Avis Brasilis.
Silva WAG. 2014. Aves da Chapada do Araripe: guia fotográfico. Caucaia: Aquasis.
Soares SDS. 2018. Ectoparasitismo de aves em um fragmento de Mata Atlântica no Distrito de Cacaria (Piraí, RJ). Seropédica: Universidade Federal Rural do Rio de Janeiro.
Szczykutowicz A, Adamski Z, Hromada M, Tryjanowski P. 2006. Patterns in the distribution of avian lice (Phthiraptera: Amblycera, Ischnocera) living on the great grey shrike *Lanius excubitor*. Parasitol Res. 98(6):507–510.
Tabarelli M, Santos AMM. 2004. Uma breve descrição sobre a história natural dos brejos nordestinos. In: Porto K, Cabral J and Tabarelli M, editors Brejos Alt em Pernambuco e Paraíba história Nat Ecol e Conserv. Brasília: Ministério do Meio Ambiente. pp. 17–24.
Tompkins DM, Clayton DH. 1999. Host resources govern the specificity of swiftlet lice: size matters. J Anim Ecol [Internet]. 68(3):489–500. doi:10.1046/j.1365-2656.1999.00297.x
Touati L, Samraoui B. 2013. Diversity and distribution of avian lice on greater flamingo chicks (*Phoenicopterus roseus*) in Algeria. Avian Biol Res. 6(4):261–268.
Valim MP. 2006. *Tyranniphilopterus caiolukasi* sp. n. (Phthiraptera: Philopteridae) from the yellow-olive flycatcher (Aves: Tyrannidae), with observations on gut contents. Lundiana: Int J Biodivers. 7(1):55–58.
Wall R. 2007. Ectoparasites: future challenges in a changing world. Vet Parasitol [Internet]. 148(1):62–74. doi:10.1016/j.vetpar.2007.05.011