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Host–Parasite relationships and co-infection of nasal mites of *Chrysomus ruficapillus* (Passeriformes: Icteridae) in southern Brazil

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ABSTRACT. One hundred twenty-two *Chrysomus ruficapillus* were examined in southern Brazil, in order to research the presence of nasal mites and the parasite-host relationships. Nasal mite infections were analyzed for: presence of Ereynetidae and Rhinonyssidae considering the total number of hosts examined; Sexual maturity of males (juveniles and adults); Periods of bird collection and presence of co-infections. Were identified five *taxa*, four belongs to Rhinonyssidae (*Sternostoma strandtmanni*, *Ptilonyssus sairae*, *P. icteridius* and *Ptilonyssus* sp.) and one to Ereynetidae (*Boydaia agelaii*). Adult males were parasitized for one *taxa* more than juvenile males. Co-infections occurred in 22 hosts, between two, three and four *taxa*, belonging to Ereynetidae and Rhinonyssidae.The co-infections were more prevalent in austral autumn / winter. The host-parasite relations and co-infections by nasal mites in *C. ruficapillus* were reported for the first time, contributing to the knowledge about nasal mites in Brazil.

KEYWORDS. Chestnut-capped blackbird, *Boydaia*, *Sternostoma*, *Ptilonyssus.*

RESUMO. Relações parasito-hospedeiro e co-infecção de ácaros nasais de *Chrysomus ruficapillus* (Passeriformes: Icteridae) no sul do Brasil. Cento e vinte e dois *Chrysomus ruficapillus* foram examinados no extremo sul do Brasil, a fim de pesquisar a presença de ácaros nasais e as relações hospedeiro-parasito. As infecções por ácaros nasais foram analisadas quanto a: presença de Ereynetidae e Rhinonyssidae considerando o total dos hospedeiros examinados; a maturidade sexual dos machos (juvenis e adultos); períodos de coleta das aves e presença de co-infecções. Foram identificados cinco *taxa,* quatro pertencentes à Rhinonyssidae (*Sternostoma strandtmanni*, *Ptilonyssus sairae*, *P. icteridius* and *Ptilonyssus* sp.) e um à Ereynetidae (*Boydaia agelaii*). Machos adultos foram parasitados por um *taxa* a mais do que os machos juvenis. Co-infecções ocorreram em 22 hospedeiros, entre dois, três e quatro *taxa*, pertencentes à Ereynetidae e Rhinonyssidae. As co-infecções foram mais prevalentes no outono/inverno austral. As relações hospedeiro-parasito e co-infecções por ácaros nasais em *C. ruficapillus* foram relatadas pela primeira vez, contribuindo para o conhecimento do hospedeiro e ampliando as informações sobre ácaros nasais no Brasil.

PALAVRAS-CHAVE. Garibaldi, *Boydaia*, *Sternostoma*, *Ptilonyssus.*

Mites (Arachnida: Acari) represent a very diversified group, with at least 2,500 described species allocated into 40 families (Proctor & Owens, 2000). According to Skoracki *et al*. (2012) it is estimated that the Prostigmata (Trombidiformes) bird parasites could be represented by 5,000 species, of which only 10% are described. These mites occupy different microhabitats in the host body, such as skin, feathers, intracutaneous layers and respiratory tract (Skoracki *et al*., 2012). The group includes the families Cheyletidae, Harpirhynchidae, Syringophilidae, Cloacaridae, and Ereynetidae (Skoracki *et al.*, 2012).

Mesostigmata includes Dermanyssidae, Laelapidae, Macronyssidae (parasites of nests, skin of the host or predators), Ascidae (phoretic mites, which are in hummingbird nostrils of Apodiformes: Trochilidae), and Rhinonyssidae (parasite nostrils and trachea) (Proctor & Owens, 2000). There are records of nasal mites for the most modern birds (Neoaves) in every continent (Dimov, 2012). According to Hyland (1979), the evolution of mites generally follows the one of their hosts.

Rhinonyssidae and Ereynetidae are parasites that inhabit the respiratory system of birds, besides being bloodsucking and consumers of tissue, respectively. Ereynetidae species are located in the innermost portion of the nasal cavity (drier environment) and are very agile because of the presence of setae in the body (Hyland, 1979). Species of Rhinonyssidae are found embedded in the secretions of the cavity (higher humidity), they move slowly in the mucous membranes and cavities (Furman, 1957).

In addition, Rhinonyssidae is considered the most diverse *taxon,* distributed in eight genera. Species vary in its degree of host specificity, and, many are restricted to a single family of birds and others occur in hosts of different orders (Pence, 1973a; 1975; Skoracki *et al*., 2012).

Ereynetidae apparently are little pathogenic, as well as Rhinonyssidae, when in low intensities of infection (Knee & Proctor, 2010). About the biology and mode of transmission of nasal mites there is not much information in the literature, Brooks & Strandtmann (1960) suggested that the transmission of Rhinonyssidae occurs quickly in the moment of feeding the juvenile birds or during the cohort when the two birds are closely associated, which would hinder the interspecific transmission.

Chrysomus ruficapillus (Vieillot, 1819) occurs in French Guiana, Brazil, Bolivia, Paraguay, Argentina and Uruguay (Narosky & Yzurieta 2003; IUCN, 2016). It is a swamp species of Brazilian Pampa with gregarious habit and can be found in flocks ranging from a few birds until thousands, and is considered one of the most abundant birds of Rio Grande do Sul state (Belton, 1994), being and closely linked to rice cultivation (*Oryza* spp.) (Silva, 2004).

The nasal mites previously registered at *C. ruficapillus* were *Boydaia agelaii* Fain & Aitken, 1968 (Ereynetidae) from states of São Paulo and Rio Grande do Sul, Brazil (Amaral & Rebouças, 1974a; Bernardon *et al*., 2015), and the Rhinonyssidae: *Ptilonyssus icteridius* (Strandtmann & Furman, 1956) in São Paulo (Amaral & Rebouças, 1974a), and *Sternostoma strandtmanni* Furman, 1957, *Ptilonyssus sairae* Castro, 1948, *Ptilonyssus* sp. and *P. icteridius* in Rio Grande do Sul (Bernardon *et al*., 2017).

The study of host-parasite relationships is essential to assist and understand the biology of both groups in these interactions. In this context, the parasitological indexes of the infections by Ereynetidae and Rhinonyssidae of *C. ruficapillus* in southern of Brazil are compared according to the periods of collect of hosts, the sexual maturity of the males, and the occurrence of co-infections.

MATERIAL AND METHODS

Collection of hosts. One hundred twenty-two hosts (20 females, 102 males: 46 adults and 56 juveniles) of Brazilian Pampa were examined from the municipality of Rio Grande, state of Rio Grande do Sul, Brazil (32°14'S; 52°29'W). The capture was performed in a farm (rice plantation) in "Granjas 4 Irmãos S. A.", where the trap (one cube with sized 2.5 m^3 with metal edges, covered with screen and top opening, which allows the entry of birds but not their exit) was installed containing potable water and bird food *ad libitum*. The samples were collected in the months of December 2013, January, February, May, June and July 2014 (were collect 20 birds in each month and other two were added in the last sample).

The identification of birds was performed according to Belton (1994). The capture, euthanasia, and transport of birds were licensed by "Instituto Chico Mendes de Conservação da Biodiversidade" (ICMBio/41095-3) and approved by "Comissão de Ética em Experimentação Animal, Universidade Federal de Pelotas – UFPel" (CEEA/UFPel/1477). After euthanasia, the hosts were packed individually in plastic bags and transported to the "Laboratório de Parasitologia de Animais Silvestres" (LAPASIL/UFPel), Departamento de Microbiologia e Parasitologia, Instituto de Biologia, UFPel and frozen until processing.

Collecting, preparing and identification of nasal mites. For mites collection, a cut was made in one nostril reaching (on the same side) to the external orifice of the ear, and then repeating the process on the opposite side. In order to form a right angle to the inferior portion, the turbinates were sectioned lengthwise, and then returned back to the top of the head (Fain, 1956). Later on, the cavity was washed with water jet in a sieve opened mesh (150 µm). The resulting content, the cavity and the respiratory tract were examined in stereomicroscope (Olympus ®SZ 61). Mites were preserved in alcohol 70%, mounted between slides and coverslip with Hoyer's, photographed under an Olympus ®BX 41 microscope with an attached camera system. Morphological identification was performed according to the dichotomous key of Pence (1975). Vouchers were deposited in the "Coleção de Artrópodes do Laboratório de Parasitologia de Animais Silvestres" – CALAPASIL/UFPel (478 at 488 and 522 at 525) Departamento de Microbiologia e Parasitologia, Instituto de Biologia, UFPel.

Parasitological analyzes. The term "assembly" was used in this study according to the concept of Fauth *et al.* (1996), because it represents the universe of species (taxonomic limits) and limits of distribution (geographic) according to the objectives of the study. This differs from the classic non-operational concept of community.

The assembly of nasal mites *C. ruficapillus* was analyzed using the following parameters: prevalence (P%), mean abundance of infection (MA), and mean intensity of infection (MII), according to Bush *et al.* (1997) and range of infection (R) according to Bush *et al.* (2001). Statistical analysis were performed using the "Quantitative Parasitology 3.0 Version 2.0" program (Rózsa *et al.*, 2000), for comparisons between the P% ($p < 0.05$), using the Chi-square test (X^2) and MI confidence interval for the "bootstrap" (BCα $p < 0.05$).

The infections by nasal mites were analyzed as: (a) the presence of Ereynetidae (E) and Rhinonyssidae (R) mites, when considering the total hosts examined (n=122) to assess whether there are differences in the infections between the two groups of mites. Similarly, infections were compared only between species Rhinonyssidae and the total sample of host; (b) maturity sexual of males: juvenile males (JM) (n=56) and adult males (AM) (n=46), in order to check if there is any difference between infections nasal mites (E+R), nasal mites Ereynetidae (E) and Rhinonyssidae mites (R). The females were collected in minor number (n = 20 birds) and have not been defined as the stage of development (adult or juvenile). Therefore, it was excluded for this analysis; (c) the collect periods: Collection period-I (CP-I, n=60 birds): December, January and February = summer in the southern hemisphere; Collection period-II (CP-II, n=62 birds): May, June and July = autumn / winter in the southern hemisphere. With the aim of cheking for differences in infections nasal mites (E+R) between periods; (d) the presence of co-infections (one host

parasitized by at least two species of nasal mites) being a species of Ereynetidae and Rhinonyssidae (ExR) or species Rhinonyssidae (RxR) considering the total hosts (n = 122). In this context, it analyzed the P% of co-infections to check for differences between the sampling periods (CP-I and CP-II).

RESULTS

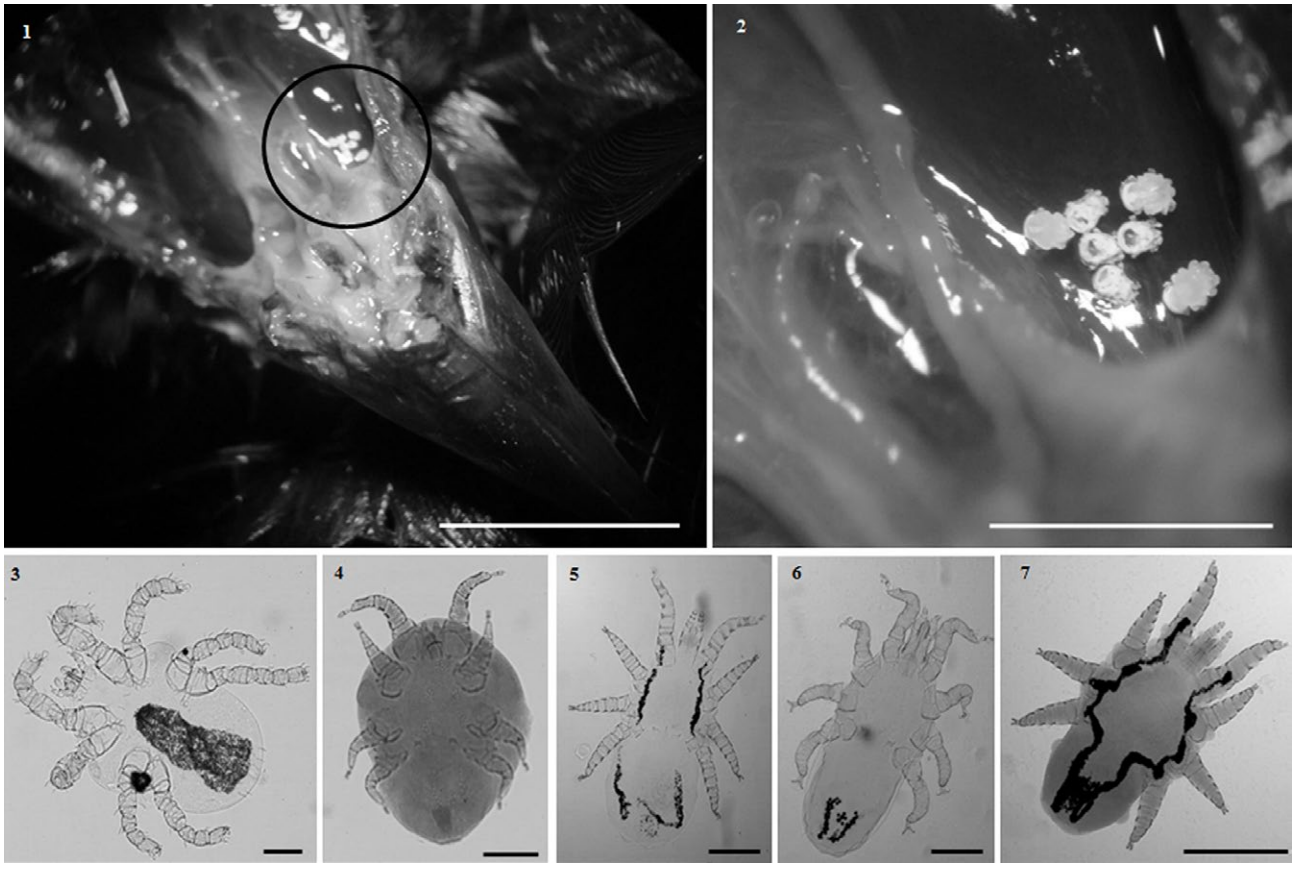
From the 122 *Chrysomus ruficapillus* examined, 62.2% (76/122) were positive for nasal mites, 47.5% (58/122) for Ereynetidae (Prostigmata), and 27.9% (34/122) for Rhinonyssidae (Mesostigmata). The assembly was composed by: *Boydaia agelaii* (Ereynetidae) (188 females and 33 larvae), *Sternostoma strandtmanni* (80 females, 1 male and 2 larvae), *Ptilonyssus sairae* (45 females), *Ptilonyssus icteridius* (54 females and 1 male), and *Ptilonyssus* sp. (2 females) morphologically distinct from the other two (Rhinonyssidae) (Figs 3-7). All mites were found in the nostril cavity (Figs 1, 2). However, pathological features were not evaluated.

The parasitological indexes P%, MA, MII and R, the total number of infected birds and host's gender are presented in Tab. I.

Boydaia agelaii was the nasal mite with the highest values of prevalence and abundance of infection (P%=47.5; MA=1.8) (Tab. I). While the highest value of intensity of infection was from *S. strandtmanni* (MII=5.5) and the range was from *P. icteridius* (R=1-21) (Tab. I). Ereynetidae even represented by only one species, had the highest value of prevalence (P%=47.5) ($p<0.05$) when compared with Rhinonyssidae (Tab. II). Comparisons of P% and MII between the *taxa* of Rhinonyssidae did not show differences (Tab. II). *Boydaia agelaii*, *S. strandtmanni*, *P. sairae* and *P. icteridius* were found in *C. ruficapillus* female, and males: adult and juveniles, however, *Ptilonyssus* sp. occurred only in male adults (Tab. I). The hosts male adults were parasitized by five *taxa*, while male juveniles by four (Tab. I). However, have not difference statistic (interfamily) in relation to P% and MII of nasal mites between hosts adults and juveniles (Tab. III).

Regarding periods of host collection, the prevalence of nasal mites (E+R) was higher ($p<0.05$) in CP-II (n=62) (P%=72.6), when compared to CP-I (n=60) which was equal to P%= 50. There was no significant difference in the mean intensity of infection of mites, in CP-I (MII=4.3) and in CP-II (MII=5.9).

The occurrence of more than one species of mites in the same host (co-infection), was observed in 22 birds (3 females, 19 males: 4 adult and 15 juveniles) (P%=18.0). Between ExR (29 times) and among RxR (21 times). The most frequent infection involving ExR was *B. agelaii* with *P. sairae*, and between RxR the most frequent relationship was



Figs 1-7. Nasal mites parasites of *Chrysomus ruficapillus* (Vieillot, 1819) (Passeriformes: Icteridae) from southern of Brazil: 1, cavity nasal parasitized, circle highlights the location of mites in the nasal turbinates (Bar = 80 mm); 2, specimens of Ereynetidae and Rhinonyssidae (Bar =30 mm); 3; *Boydaia agelaii* Fain & Aitken, 1967 (Bar = 0.09 mm); 4, *Sternostoma strandtmanni* Furman, 1957 (Bar = 0.12 mm); 5, *Ptilonyssus icteridius* (Strandtmann & Furman, 1956) (Bar = 0.14 mm); 6, *Ptilonyssus sairae* Castro, 1948 (Bar = 0.15 mm); 7, *Ptilonyssus* sp (Bar = 0.2 mm).

Tab. I. Prevalence (P%), mean abundance of infection (MA), mean intensity of infection (MII), and range (R) of nasal mites belonging to Ereynetidae and Rhinonyssidae of *Chrysomus ruficapillus* (Vieillot, 1819) (n=122) from southern of Brazil. Prevalence of nasal mites in female (F), adults male (AM) and juvenile male (JM). (NI= number of infected birds).

Taxa Acari	All hosts				Host' gender		
	F+AM+JM (n=122)				F (n=20)	AM (n=46)	JM (n=56)
	P% (NI)	MA	MII	R	P% (NI)	P% (NI)	P% (NI)
EREYNETIDAE + RHINONYSSIDAE	62.2 (76)	-	-	-	-	-	-
EREYNETIDAE	47.5 (58)	-	-	-	-	-	-
Boydaia agelaii	47.5 (58)	1.8	3.8	1 - 17	7.4 (9)	16.4 (20)	23.8 (29)
RHINONYSSIDAE	27.9 (34)	-	-	-	-	-	-
Sternostoma strandtmanni	12.2 (15)	0.6	5.5	1 - 20	3.3 (4)	2.4 (3)	6.5 (8)
Ptilonyssus sairae	14.7 (18)	0.3	2.5	1 - 7	2.4 (3)	1.6 (2)	10.6 (13)
Ptilonyssus icteridius	13.9 (17)	0.4	3.2	1 - 21	1.6 (2)	4.1 (5)	8.2 (10)
Ptilonyssus sp.	1.6 (2)	0.01	1	1	0	1.6 (2)	0

Tab. II. Comparasion of Prevalence (P%) and mean intensity of infection (MII) between Ereynetidae X Rhinonyssidae, between *Ptilonyssus* spp. X *Sternostoma strandtmann* and between the species of Rhinonyssidae parasites of *Chrysomus ruficapillus* (Vieillot, 1819) (n= 122) from southern of Brazil. Different letter indicate significant differences ($p<0.05$); NI= number of infected birds.

Taxa Acari	Parasitological indexes	
	P% (NI)	MII (NI)
EREYNETIDAE	47.5[a] (58)	3.8
RHINONYSSIDAE	27.9[b] (34)	5.4
RHINONYSSIDAE		
Ptilonyssus spp.	19.7 (24)	4.2
Sternostoma strandtmanni	12.3 (15)	5.5
Ptilonyssus saire	14.8 (18)	2.5
Ptilonyssus icteridius	13.9 (17)	3.2
Sternostoma strandtmanni	12.3 (15)	5.5
Ptilonyssus sp.	1.6 (2)	1

Tab. III. Comparasion of indexes parasitological (P%) and mean infensity of infection (MII) of nasal mites Ereynetidae (E) and Rhinonyssidae (R) in adult males (AM) and juvenil males (JM) of *Chrysomus ruficapillus* (Vieillot, 1819) (n=122) from southern of Brazil (NI= number of infected birds).

Taxa Acari	Sexual maturity of males			
	AM (n=46)		JM (n=56)	
	P% (NI)	MII	P% (NI)	MII
EREYNETIDAE + RHINONYSSIDAE	56.5 (26)	6.0	62.5 (35)	4.2
EREYNETIDAE	43.5 (20)	4.0	51.8 (20)	3.4
RHINONYSSIDAE	19.1 (9)	3.4	32.1 (18)	6.1

between *P. icteridius* and *P. sairae.* Co-infections involving *taxa* exclusively ExR were observed in 7 hosts (1 female, 6 males: 1 adult and 5 juveniles), while *taxa* exclusively Rhinonyssidae in 5 hosts (1 female, 4 males: 2 adult and 2 juveniles) (Tab. IV). These co-infections (ExR or RxR) occurred between two *taxa* of mites (11 hosts), between three *taxa* (9 hosts), and between four *taxa* (2 hosts) (Tab. IV).

DISCUSSION

Most studies of nasal mites has taxonomic character and consist in descriptions and re-descriptions species, construction of identification keys and researches of nasal mites in wildlife largely realized in North America (PENCE, 1973a,b, 1975; SPICER, 1987; KNEE & PROCTOR, 2006, 2010; KNEE *et al*., 2008). Others were realized in Cuba (CERNY & DUSBABEK, 1970), Australia (DOMROW, 1978; PROCTOR & OWENS, 2000), Russia (DIMOV & MASCARENHAS, 2012), and Brazil (AMARAL & REBOUÇAS, 1974a; MASCARENHAS *et al*., 2009, 2011; COIMBRA *et al*., 2012; BERNARDON *et al*., 2013, 2015, 2017; MENDES *et al*., 2014 and SINKOC *et al*., 2016. In recent decades, complementary studies on phylogenetic relationships that use molecular techniques have been developed (ROJAS *et al*., 2001, 2002; MORELLI & SPICER, 2007) while studies that analyze the infections by nasal mites in the host, such as the one performed in this study with Passeriformes, are little discussed.

Researches available with species of Rhinonyssidae generally reported high diversity of hosts and small sample size of the same species of bird (PENCE, 1973b; DOMROW, 1978; AMARAL & REBOUÇAS, 1974a; SPICER, 1987) reflecting, possibly, the low prevalence rates (P%) recorded by the authors. In North America, to examine 1,927 birds, SPICER (1987) recorded P%=17.3 examined 502 hosts, and KNEE *et al.* (2008) reported P%=15 when analyzed 450 birds. On the other hand, in the present work the prevalence values of nasal mites in *C. ruficapillus* were higher (P% = 62.3) (76/122) (Ereynetidae + Rhinonyssidae) and P% = 27.9 (34/122) (Rhinonyssidae) than those presented by PENCE (1973b), SPICER (1987) and KNEE *et al.* (2008), when analized 122 birds of the same species and locality, possibly reflecting in the results of P%.

Studies relating differences in the assembly composition of nasal mites, and on the development stage of the birds were approached by PORTER & STRANDTMANN (1952), TERBUSH (1963) and AMERSON (1967), without statistical tests.

PORTER & STRANDTMANN (1952) found higher prevalence values in adult birds (P% = 70) compared to the juveniles (P% = 40) when examining *Passer domesticus* (Linnaeus, 1758) (Passeriformes: Passeridae) parasitized by *Ptilonyssus* spp. In the same way, TERBUSH (1963) identified *Larinyssus orbicularis* Strandtmann, 1948 (Rhinonyssidae) in *Larus argentatus* Pontoppidan, 1763 (Charadriiformes: Laridae) found higher prevalence values in adults (P% = 55)

Tab. IV. Co-infection of nasal mites *Boydaia agelaii* Fain & Aitken, 1967 (Ereynetidae), *Sternostoma strandtmanni* Furman, 1957, *Ptilonyssus sairae* Castro, 1948, *Ptilonyssus icteridius* (Strandtmann & Furman, 1956) and *Ptilonyssus* sp. (Rhinonyssidae). Between two *taxa* of nasal mites (total 11), three *taxa* (total 9) and four *taxa* (total 2) according to individual of *Chrysomus ruficapillus* (Vieillot, 1819) (n= 122) from southern of Brazil [CR, *C. ruficapillus*; HG, host' s gender; F, female; AM, adult male; JM, juvenile male; n, number of specimens of mites].

Host	HG	Mite (n)		Mite (n)		Mite (n)		Mite (n)
CR 05	AM	*B. agelaii* (1)	X	*P. sairae* (1)		-		-
CR 35	JM	*B. agelaii* (1)	X	*P. sairae* (2)		-		-
CR 41	AM	*P. icteridius* (13)	X	*Ptilonyssus* sp. (1)		-		-
CR 57	JM	*S. strandtmanni* (16)	X	*P. sairae* (3)		-		-
CR 76	F	*B. agelaii* (10)	X	*P. sairae* (1)		-		-
CR 82	JM	*B. agelaii* (1)	X	*P. sairae* (1)		-		-
CR 86	F	*P. icteridius* (1)	X	*P. sairae* (1)		-		-
CR 108	JM	*B. agelaii* (3)	X	*P. sairae* (6)		-		-
CR 112	JM	*B. agelaii* (17)	X	*S. strandtmanni* (3)		-		-
CR 118	AM	*P. icteridius* (2)	X	*P. sairae* (1)		-		-
CR 121	AM	*B. agelaii* (3)	X	*P. icteridius* (2)		-		-
CR 91	JM	*B. agelaii* (1)	X	*P. sairae* (1)	X	*P. icteridius* (1)		-
CR 93	JM	*B. agelaii* (2)	X	*P. sairae* (1)	X	*P. icteridius* (2)		-
CR 96	AM	*B. agelaii* (2)	X	*P. icteridius* (1)	X	*Ptilonyssus* sp. (1)		-
CR 102	JM	*P. icteridius* (3)	X	*P. sairae* (7)	X	*S. strandtmanni* (5)		-
CR 105	F	*B. agelaii* (2)	X	*P. sairae* (6)	X	*P. icteridius* (1)		-
CR 107	JM	*B. agelaii* (9)	X	*P. sairae* (2)	X	*S. strandtmanni* (6)		-
CR 115	JM	*B. agelaii* (3)	X	*P. sairae* (1)	X	*P. icteridius* (21)		-
CR 116	JM	*B. agelaii* (1)	X	*P. sairae* (5)	X	*P. icteridius* (1)		-
CR 117	JM	*B. agelaii* (2)	X	*P. sairae* (4)	X	*P. icteridius* (1)		-
CR 89	JM	*B. agelaii* (1)	X	*P. sairae* (1)	X	*P. icteridius* (2)	X	*S. strandtmanni* (9)
CR 103	JM	*B. agelaii* (2)	X	*P. sairae* (1)	X	*P. icteridius* (1)	X	*S. strandtmanni* (2)

than the immatures (P%=37), in the first (P%=1) and second year of life (P%=40). Amerson (1967) found similar results regarding *Sternostoma* and *Larinyssus* (Rhinonyssidae) infecting juveniles and adults of *Onychoprion fuscata* (=*Sterna fuscata*) Linnaeus, 1766 (Charadriformes: Laridae) (n=460). The values of prevalence were higher from the 5th month of bird life (P%=29.0) compared to the first four months (Amerson, 1967). These authors suggest, that the probability of infection is greater over on the longevity of the host, increasing the likelihood of becoming infected as a function of exposure time, as for example, through with the cohort in between male and female, which may realize along its life. On the other hand, nasal mite infections (E + R) in *C. ruficapillus* presented opposite results to those found by Porter & Strandtmann (1952), Terbush (1963) and Amerson (1967), since juveniles males present P % values higher (P% = 62.5) than adult males (P% = 56.5), even without statistical difference.

Cases of co-infection between Rhinonyssidae species are more frequently recorded than between species Ereynetidae and Rhinonyssidae. Pence (1973b) reported the presence of more than one species of Rhinonyssidae, but did not indicate frequency. Spicer (1987) analyzed 103 birds (belonging to 11 orders), found a case of *Ptilonyssus tyrannus* Brooks & Strandtmann, 1960 and *Sternostoma pencei* Spicer, 1984 in *Empidonax* Cabanis, 1855 (Passeriformes: Tyraniidae) (n = 1), considered the infrequent relation, representing 1% of the total parasitized birds and 0.2% of the birds examined. Butenko & Stanyikovich (1999) reported co-infection by Rhinonyssidae P% = 0.3 in *Anas platyrhynchos* Linnaeus, 1758 (Anseriformes: Anatidae). Knee *et al.* (2008) commented that there are rare cases in which a host is parasitized by more than one species of Rhinonyssidae and cases of two species of mites belonging to the same genus are very rare. Reported *Tinaminyssus melloi* (Castro, 1948) and *Tinaminyssus columbae* (Crossley, 1950) in *Columba livia* Gmelin, 1789 (Columbiformes: Columbidae); *Ptilonyssus morofskyi* Hyland, 1962 and *Ptilonyssus nivalis* Knee, 2008 in *Plectrophenax nivalis* (Linnaeus, 1758) (Passeriformes: Fringilidae); *Ptilonyssus callinectoides* (Brooks & Strandtmann, 1960) and *P. icteridius* in *Myiarchus crinitus* (Linnaeus, 1758) (Passeriformes: Tyraniidae), and *Sternostoma longisetosae* (Hyland, 1961) and *Ptilonyssus* sp. in *Tyrannus tyrannus* (Linnaeus, 1766) (Passeriformes: Tyraniidae), corresponding to 3.5% of 114 birds examined (Knee *et al*., 2008). Dimov & Mascarenhas (2012) reported to Brazil *Ptilonyssus* sp. and *Sternostoma* sp. in: *Lanio cucullatus* (Statius Muller, 1776) (n = 3) (one infected bird) (P% = 33.3); *Saltator aurantiirostris* Vieillot, 1817 (one infected bird) (P% = 12.5) and *Paroaria coronata* (n = 28) (one infected bird) (P% = 3.5) (Passeriformes: Thraupidae) corresponding in total to P% = 3.8 of the 39 birds examined. In Russia, they recorded *Ptilonyssus* sp. and *Sternostoma* sp. in *Parus major* Linnaeus, 1758 (Passeriformes: Paridae) (n = 46) (one infected bird) (P% = 2.17).

Co-infections involving Rhinonyssidae and Ereynetidae were presented by Knee *et al*. (2008) in North America and Dimov & Mascarenhas (2012) in Brazil and Russia. Knee *et al.* (2008) reported *Rhinoecius brikinboricus* Butenko, 1976 and *Neoboydaia colymbiformi* (Clark, 1964) in *Asio otus* (Linnaeus, 1758) (Strigiformes: Strigidae) (n = 3). Dimov & Mascarenhas (2012) recorded *Ptilonyssus* sp. and *Boydaia* sp. (P = 50), P. major (n = 46) (one infected bird) (P% = 6.2) and in *Passer montanus* Linnaeus, 1758 (Passeriformes: Passeridae) (n = 8) (an infected bird) (P% = 12.5) representing P% = 5.06 of the 79 birds analyzed.

Co-infections with nasal mites apparently occur at low prevalence rates, according to Spicer (1987), Butenko & Stanyikovich (1999) and Knee *et al.* (2008). However, the authors examined a great diversity of hosts (orders / families / bird species) and low sample numbers of the same species. Therefore, the sample number should be considered as an important factor in future studies aimed at evaluating this relationship, either between species of Rhinonyssidae, or between species of Rhinonyssidae and Ereynetidae that parasitize Passeriformes, and probably other groups of birds. In this sense, the co-infections observed in *C. ruficapillus* (P% = 18.03), reinforce that the sample number (same host species) may be an important factor in the results with nasal mites. It should also be pointed out that aspects related to biology of bird, and also to biology of the species of mites should be considered.

In relation to the co-infections in the collection periods, the highest prevalence found in the collection period-II (P%=81,8) (18/22 occurrences), may be related to the behavior of the bird, because this period corresponds to winter in the southern hemisphere, characterized by low temperatures 10-25° (average of the last 30 years) (Fritzsons *et al.*, 2015). This fact causes birds to pool up in the vegetation near to the field and road, which may facilitate contact between hosts, favoring so the transmission of mites. However, little is known about the biology and transmission of these species of mites and reproductive factors of mites should be studied. Therefore, additional studies on the behavior of *C. ruficapillus* should be conducted to aid in the understanding of parasite-host relationships and to evaluate possible forms of mite transmission among hosts.

In the study of host-parasite relationships, it is essential to consider the different taxonomic groups of birds, the peculiarities of behavior and evolutionary history, in addition to different geographical regions involved, both for the *taxa* of mites as of the hosts. Spicer (1987) comments that these factors are important and therefore may influence the prevalence of nasal mites. Thus, considering such factors, comparisons should be made with caution.

Boydaia agelaii was the only Ereynetidae found parasitizing *C. ruficapillus*. Cases of co-infections between Ereynetidae and Rhinonyssidae *taxa* have been reported. Adult males were parasitized for a higher rate than juvenile males. Co-infections by nasal mites were more prevalent in the collection period-II (austral autumn /winter in southern hemisphere). The most prevalent co-infection was between *B. agelaii* (Ereynetidae) and *Ptilonyssus sairae* (Rhinonyssidae). And the maximum number of taxa co-infecting *C. ruficapillus* was four species: *B. agelaii*, *P. sairae*, *P. icteridius* and *S. strandtmanni*.

The relationship of parasite-host, and co-infection by nasal mites in *Chrysomus ruficapillus* were reported for the first time, contributing to the knowledge parasitological of the host and enlarge the information about nasal mites in Brazil.

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