

Rhinonyssidae (Acari) in the house sparrows, *Passer domesticus* (Linnaeus, 1758) (Passeriformes: Passeridae), from southern Brazil

Ácaros nasais Rhinonyssidae parasitos de *Passer domesticus* (Linnaeus, 1758) (Passeriformes: Passeridae) no extremo sul do Brasil

Luciana Siqueira Silveira dos Santos^{1*}; Carolina Silveira Mascarenhas²; Paulo Roberto Silveira dos Santos³; Nara Amélia da Rosa Farias¹

¹ Laboratório de Parasitologia, Departamento de Microbiologia e Parasitologia, Instituto de Biologia, Universidade Federal de Pelotas – UFPel, Capão do Leão, RS, Brasil

² Laboratório de Parasitologia de Animais Silvestres, Departamento de Microbiologia e Parasitologia, Instituto de Biologia, Universidade Federal de Pelotas – UFPel, Capão do Leão, RS, Brasil

³ Centro Nacional de Pesquisa para a Conservação das Aves Silvestres – CEMAVE, Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio, Pelotas, RS, Brasil

Received March 29, 2018

Accepted August 7, 2018

Abstract

We report the occurrence and infection parameters of two species of nasal mites in *Passer domesticus* (Linnaeus, 1758) (house sparrow). Nasal passages, trachea, lungs, and air sacs of 100 house sparrows captured in an urban area at the city of Pelotas, State of Rio Grande do Sul, southern Brazil, were examined with a stereomicroscope. The mite, *Sternostoma tracheacolum* Lawrence, 1948 was present in the trachea and/or lungs (or both) of 13 birds (13%) at a mean intensity of 6.7 mites/infected host. *Ptilonyssus hirsti* (Castro & Pereira, 1947) was found in the nasal cavity of 1 sparrow (1%); coinfection was not observed in this bird. There was no significant difference in the prevalence and mean intensity of infection of *S. tracheacolum* between male and female birds. To our knowledge, this is the first study reporting the occurrence of *S. tracheacolum* in *P. domesticus* in Brazil and the presence of *P. hirsti* in *P. domesticus* from Rio Grande do Sul, Brazil. This is the first survey to provide the infection parameters of each of these mites in house sparrows.

Keywords: House sparrows, respiratory endoparasites, Acari, *Sternostoma*, *Ptilonyssus*, parasitological indices.

Resumo

O objetivo deste estudo foi relatar duas espécies de ácaros nasais parasitos do sistema respiratório de *Passer domesticus* (Linnaeus, 1758) (pardal) e seus respectivos índices parasitológicos. Para isso, foram examinados ao estereomicroscópio, cavidade nasal, traqueia, pulmão e sacos aéreos de 100 pardais capturados na área urbana de Pelotas, Rio Grande do Sul, Brasil. *Sternostoma tracheacolum* Lawrence, 1948 ocorreu na traqueia e/ou pulmão de 13 aves (13%) com intensidade média de 6,7 ácaros/hospedeiro infectado e *Ptilonyssus hirsti* (Castro & Pereira, 1947) na cavidade nasal de um único pardal (1%), não havendo coinfeção. A prevalência e intensidade média de infecção por *S. tracheacolum* entre hospedeiros machos e fêmeas não apresentou diferença significativa. Este relato caracteriza o primeiro registro de *S. tracheacolum* parasitando *P. domesticus* no Brasil e de *P. hirsti* em pardais no RS, Brasil, e seus respectivos índices de infecção.

Palavras-chave: Pardais, endoparasitos respiratórios, Acari, *Sternostoma*, *Ptilonyssus*, índices parasitológicos.

Introduction

Passer domesticus (Linnaeus, 1758) (Passeriformes: Passeridae) is a bird from Eurasia and North Africa, which was intentionally introduced into the Americas (GISD, 2018). In Brazil, this species

was introduced by Antônio B. Ribeiro in 1906 for biological control of insect pests (SICK, 1997). The house sparrow is now widely distributed throughout Brazil. It is a non-migratory, terrestrial bird that quickly and easily adapts to urban, suburban, and rural environments. These birds benefit from the anthropogenic changes in rural and urban environments. They adjust successfully to cities using buildings as shelter and nesting areas (MAJOR et al., 2004).

*Corresponding author: Luciana Siqueira Silveira dos Santos. Laboratório de Parasitologia, Departamento de Microbiologia e Parasitologia, Instituto de Biologia, Universidade Federal de Pelotas – UFPel, Campus Universitário, s/n, CEP 96160-000, Capão do Leão, RS, Brasil. e-mail: sssiluciana@yahoo.com.br



Despite their small size, house sparrows can be quite aggressive and capable of expelling native bird species from their nest sites, and compete with them for food (GISD, 2018).

Calegari-Marques & Amato (2010) mention that the introduction of a host species into a new environment usually results in the reduction of its parasitic fauna. Parasite diversity may decrease to half in these hosts, although they may become infected with additional species of parasites in this new environment. Such reduction may favor population growth of invasive species which have competitive advantage over endemic species. However, the house sparrow has the potential of carrying invasive species - vectors - including a number of pathogens and parasites of importance to biodiversity, economics, and public health, and may cause damage to populations of native species along their geographic range (CONABIO, 2017).

House sparrows are considered to be a natural reservoir for Newcastle disease (NDV) virus (SILVA et al., 2006) and Western equine encephalitis (WEE) virus. WEE virus affects the central nervous system of vertebrates including humans and horses. The virus is maintained in bird reservoir hosts WEE virus is transmitted by mosquitoes which are bridge vectors of this arbovirus to humans and horses (SILVA et al., 2005).

At least 500 different species of nasal mites have been reported in a large variety of birds worldwide (FAIN, 1994). Rhinonyssidae (Mesostigmata) is the most diverse and often found family of nasal mites, and consists of obligate blood-feeding endoparasites which mainly inhabit the nasal passages of birds (KNEE et al., 2008). Rhinonyssid mites move slowly, and are usually found in the nasal turbinates (PORTER & STRANDTMANN, 1952).

Most studies on parasite mites of the respiratory system of birds are taxonomic character, there being few searches that addresses the infection parameters in male and female hosts, as well as in adult and juvenile individuals. Such information may assist in understanding mite transmission processes, since direct contact during courtship or parental care are indicated as possible forms of transmission (AMERSON, 1967; BELL, 1996a). Likewise, few studies addressed the pathological aspects of infections, being *Sternostoma tracheacolum* Lawrence, 1948 the most known because can causes significant injury to the lower respiratory tract, lungs, and air sacs of bird hosts, inducing pneumonia and ultimately death (STEPHAN et al., 1950; RIFFKIN & MCCAUSLAND, 1972; BELL, 1996a; GUIMARÃES et al., 2012). Captive-reared birds severely infected by *S. tracheacolum* develop more severe disease than wild birds infected with the same mite. Captivity affects the immune system of these birds increasing disease susceptibility (FAIN & HYLAND, 1962; GUIMARÃES et al., 2012).

The following nasal mites (Rhinonyssidae) have been recorded in *P. domesticus*: *Ptilonyssus hirsti* (CASTRO & PEREIRA, 1947) which was reported in Italy, England, Portugal, Brazil, and Canada (CASTRO & PEREIRA, 1947; ČERNÝ & DUSBÁBEK, 1970; PENCE, 1975; KNEE & PROCTOR, 2010); *Ptilonyssus nudus* Berlese & Trouessart, 1889, described in Italy, France, Portugal, and Canada (CASTRO & PEREIRA, 1947; KNEE & PROCTOR, 2010); *Sternostoma cryptorhynchum* Berlese & Trouessart, 1889, reported in Europe (CASTRO & PEREIRA, 1947; PENCE, 1975); and *Sternostoma tracheacolum* described in the United States (FAIN & HYLAND, 1962; PENCE, 1975).

There are few studies on Rhinonyssidae that parasitize *P. domesticus* in Brazil, the objective of this work was to investigate the presence of mites in the respiratory system of house sparrows, and their respective parameters of infection from southern Brazil.

Materials and Methods

From March 2016 to February 2018, totaling 24 random collections, 100 house sparrows (*P. domesticus*), 40 females (2 immature), 59 males (7 immature), and 1 immature undetermined were captured in 13 different sites from an urban area of the city of Pelotas, State of Rio Grande do Sul, southern Brazil. Mist nets (30 mm mesh) were used to catch these birds in town squares, private gardens, and vacant land of the city. The capture, transport, and euthanasia of the birds were authorized by the Chico Mendes Institute of Biology and Conservation (ICMBio nº 51118-3) and approved by the Animal Experimentation Ethics Committee from the Federal University of Pelotas (CEE/UFPel nº 4915).

Captured birds were transported to our laboratory in suitable cages, euthanized humanely on arrival, and necropsied. Mites were collected at necropsy from the nasal passages, tracheae, lung, and air sacs, which were placed in Petri dishes containing distilled water and examined separately using a stereomicroscope. Mites fixed in 70 °GL ethanol were placed onto glass microscope slides, and mounted in Hoyer's medium. Slide-mounted specimens were photographed using an Olympus BX 41 microscope with attached camera, and the images were prepared using Adobe Photoshop CS5. Species identification of mites was based on morphological characters. This information was available in the taxonomic keys provided by Pence (1975). Parasitological parameters including prevalence (P%), mean abundance (MA), and mean intensity of infection (MII) were calculated according to Bush et al. (1997). The prevalence of mites in males and females hosts were compared using the Chi-square test (χ^2). The mean intensity of infection was compared using the Bootstrap confidence interval (BC_a p < 0.05) from the software Quantitative Parasitology 3.0 version 2.0 (RÓZSA et al., 2000).

Specimens were deposited in the Coleção de Artrópodes do Laboratório de Parasitologia de Animais Silvestres (CALAPASIL/UFPel) (nº 526-541) in the Departamento de Microbiologia e Parasitologia, Instituto de Biologia, Universidade Federal de Pelotas (UFPel), Pelotas, Rio Grande do Sul, Brazil.

Results

Fourteen birds (7 adult male, 5 adult females, 1 immature male, and 1 immature female) were parasitized by nasal mites Rhinonyssidae (Table 1). A total of 102 mites was collected from these birds. *Sternostoma tracheacolum* (Figure 1) was found in the tracheae or lungs (or both) of 13% of the birds. In contrast, *Ptilonyssus hirsti* (Figure 2) was present in the nasal passages of only 1 adult female (Table 1). There was no coinfection, the two species were found parasitizing different hosts.

There was no significant difference in the prevalence (P%) and mean intensity of infection (MII) with *S. tracheacolum* between male (P% = 13.6% (8/59); MII = 4.5) and

Table 1. Site of infection (SI), prevalence (P%), mean intensity of infection (MII \pm SD), mean abundance (MA \pm SD), and range (R) of parasitism by rhinonyssid mites in *Passer domesticus* (Linnaeus, 1758) (Passeriformes: Passeridae) (n = 100) from southern Brazil.

Rhinonyssidae	SI	P (%)	MII \pm SD	MA \pm SD	R
<i>Sternostoma tracheacolum</i>	Trachea and/or lungs	13	6.7 \pm 7.94	0.88 \pm 3.58	1 – 27
<i>Ptilonyssus birsi</i>	Nasal passages	1	1 \pm 1	0.14 \pm 1.4	14

SD = Standard deviation.

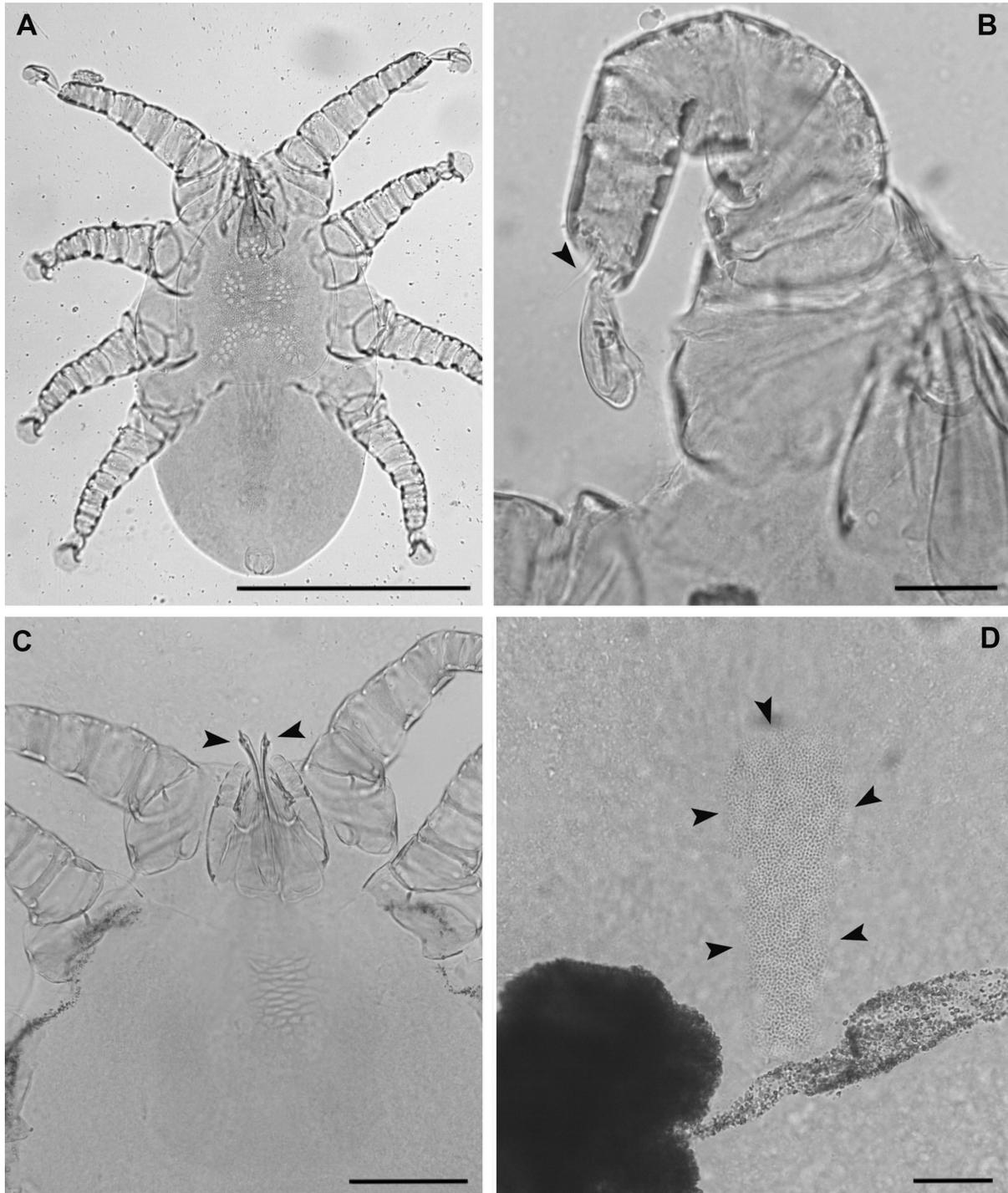


Figure 1. Female of *Sternostoma tracheacolum* Lawrence, 1948 (Rhinonyssidae) parasite of trachea and lung of *Passer domesticus* Linnaeus, 1758 (Passeriformes: Passeridae) from southern Brazil. (A) Dorsal view (bar = 300 µm); (B) Detail of the leg I, the arrow indicate the long attenuated seta in tarsus I (bar = 27.5 µm); (C) Ventral view, the arrows indicate the chelicerae (bar = 90 µm); (D) Detail of the opisthosomal shield (arrows) (bar = 30 µm).

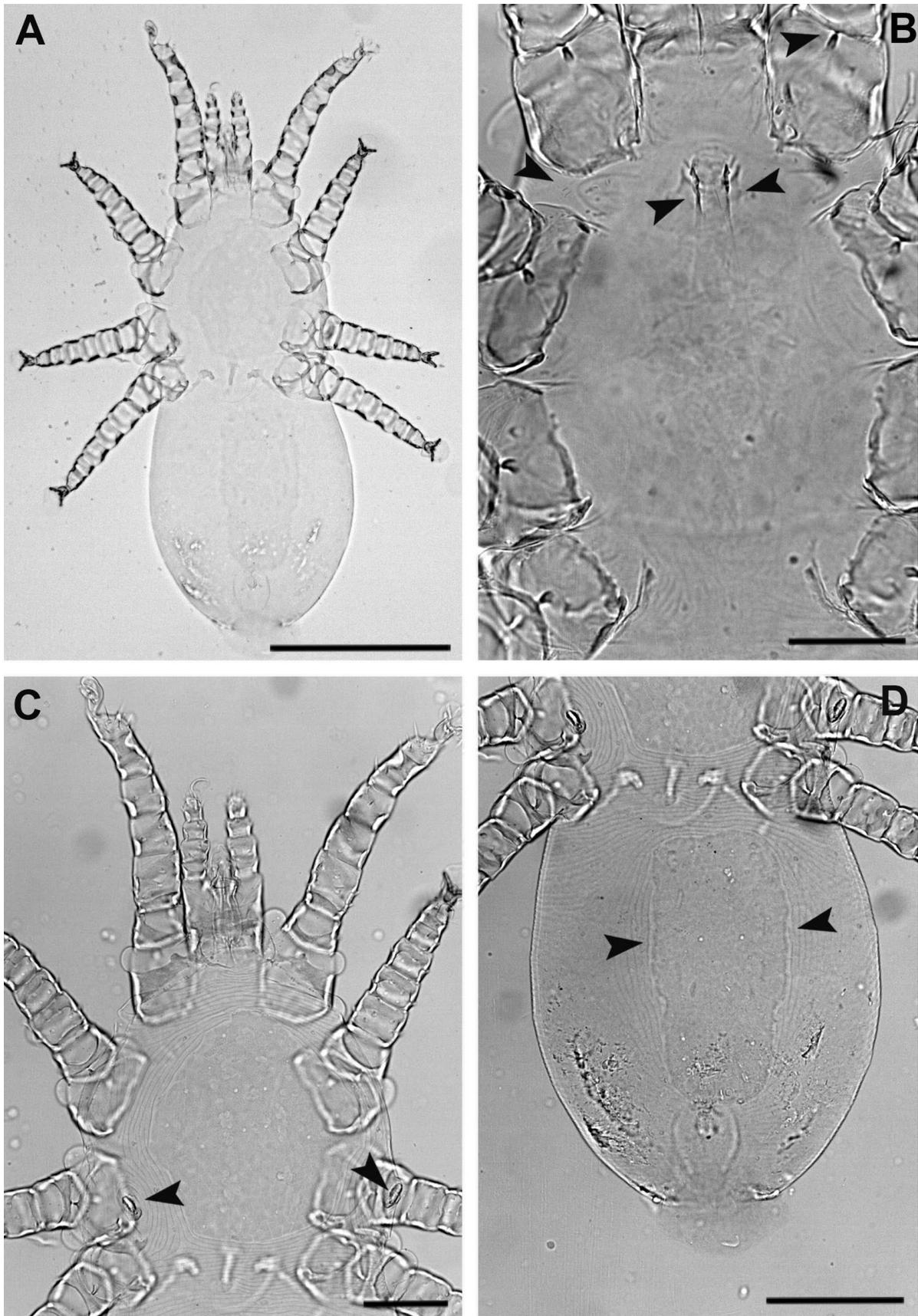


Figure 2. *Ptilonyssus hirsti* (Castro & Pereira, 1947) (Rhinonyssidae) parasite of nasal cavity of *Passer domesticus* Linnaeus, 1758 (Passeriformes: Passeridae) from southern Brazil. (A) Dorsal female view (bar = 250 μ m); (B) Detail of the male gonopore (arrows) (bar = 52.5 μ m); (C) Dorsal female view, the arrows indicate the stigma and peritreme (bar = 55 μ m); (D) Detail of the opisthosomal shield (arrows) of the female (bar = 115 μ m).

female (P% = 12.5% (5/40); MII = 10.4), independent of the maturity stage of hosts; 2 immature birds parasitized by *S. tracheacolum* had a mean intensity of infection of 1.0 mite/bird; 7 birds parasitized by *S. tracheacolum* had mites only in the tracheae, whereas in the other birds, this species of mite was found in both the tracheae and lungs affecting the same host.

Discussion

In Brazil, *S. tracheacolum* parasitized *Serinus canarius* (Linnaeus, 1758) (common canary) (Passeriformes: Fringillidae) in the State of São Paulo, *Melospittacus undulatus* (Shaw, 1805) (Psittaciformes: Psittacidae) in the State of Rio de Janeiro, and *Molothrus bonariensis* (Gmelin, 1789) (Passeriformes: Icteridae) in the State of Rio Grande do Sul (AMARAL, 1968); *S. tracheacolum* has also been reported in our country infesting *Cyanerpes cyaneus* (Linnaeus, 1766) (red-legged honeycreeper), *Dendrocincla merula* (Lichtenstein, 1829) (white-chinned woodcreeper) (Passeriformes: Dendrocolaptidae), and *Rhynchocyclus olivaceus* (Temminck, 1820) (olivaceous flatbill) (Passeriformes: Rhynchocyclidae) in the State of Pará (FAIN & AITKEN, 1968, 1971). These are taxonomic studies, and no information on infection parameters was provided.

The prevalence of nasal mite infections with was low in birds from North America where large-scale population studies were conducted (PENCE, 1973; SPICER, 1987; KNEE et al., 2008). In the United States, Pence (1973) examined a total of 1,927 birds from 193 species and determined that 16.2% of these hosts were parasitized by nasal mites. Spicer (1987) examined 502 bird hosts belonging to 103 species and found that 17% of these birds were infected with nasal mites. In Canada, Knee et al. (2008) studied a group of 450 birds from 154 species in the province of Alberta and observed that 15% of these birds were parasitized by nasal mites. These authors also examined a population formed by 2,447 birds belonging to 196 species in the province of Manitoba, and found that 16% of these hosts were infected with nasal mites. Our findings on the prevalence of nasal mites in *P. domesticus* corroborate those of previous research published by other authors in North America; however, in two previous studies carried out in Brazil (MASCARENHAS et al., 2011; BERNARDON et al., 2017), the prevalence of rhinonyssid mites in passerines was higher than the prevalence of rhinonyssid mites in *P. domesticus*. Prevalence of nasal mite infection was 55% in *Paroaria coronata* (Miller, 1776) (red-crested cardinal) (n = 40) (MASCARENHAS et al., 2011) and 27% in *Chrysomus ruficapillus* (Vieillot, 1819) (chestnut-capped blackbird) (n = 120) (BERNARDON et al., 2017). Further studies are needed in order to broaden our understanding of the relationships between rhinonyssid mites and their bird hosts. Parasitological indices are tools that help us to understand host-parasite relationships. The variation in the prevalence of nasal mite infection in birds in different works may be related to the biology of each mite species and bird species and also due to the type of bird host involved (free-living versus captive birds). Another source of variation among studies is the mite collection method. Knee & Galloway (2017), for example, washed the nasal passages of thawed birds with neutral soap and water using orthodontic

syringes; such a technique may underestimate infections by species that inhabit the tracheae and lungs.

Sternostoma tracheacolum is the only species of mite from the family Rhinonyssidae that is capable of infecting not only the nasal passages of birds but also the tracheae, lungs and air sacs causing serious respiratory problems (STEPHAN et al., 1950; FAIN & HYLAND, 1962; TIDEMANN et al., 1992; BELL, 1996a). This species was described for the first time in captive canaries (*S. canarius*) by R. F. Lawrence in 1947 in South Africa, and published these novel findings in 1948 (STEPHAN et al., 1950). Fain & Hyland (1962) described cases of *S. tracheacolum* infection in captive canaries from Uruguay, Belgium, the United States, Brazil in the cities of Porto Alegre and Rio de Janeiro. These birds died of pneumonia and had severe inflammation in the respiratory system. These authors also reported the occurrence of this nasal mite in 20 different species of wild birds from several regions of the world, including *P. domesticus* in the Michigan, USA. *Sternostoma tracheacolum* is a generalist parasite infecting many species of hosts. This species of mite has been collected from at least 37 species, 32 genera, and 11 families of wild and captive birds inhabiting different geographic regions (FAIN & HYLAND, 1962; BELL, 1996b; KNEE & GALLOWAY, 2017). The fact that a large variety of wild birds are parasitized by *S. tracheacolum* and that these birds are highly resistant to this parasite show that wild birds are probably the natural hosts for this species of mite (FAIN & HYLAND, 1962; RIFFKIN & MCCAUSLAND, 1972; BELL, 1996b).

Tidemann et al. (1992) documented the occurrence of *S. tracheacolum* in wild passerines in Australia where the prevalence of this mite infection was 62% in the Gouldian finch, *Chloebia gouldiae* Gould, 1844 (= *Erythrura gouldiae*) (n = 26), 13% in the pictorella mannikin, *Heteromunia pectoralis* Gould, 1841 (n = 8), and <1% in the masked finch, *Poephila personata* Gould, 1842 (n = 118). Tidemann et al. (1992) reported that *C. gouldiae* had 34.1 mites/bird (1 – 102 mites); mites were found in different anatomical locations. The authors suggested that *C. gouldiae* has not been able to regain its former population status due to *S. tracheacolum* infection. According to the IUCN Red List of Threatened Species, the gouldian finch has been endangered since the 1980s (BIRDLIFE INTERNATIONAL, 2016).

Infection parameters for rhinonyssid mites found in *P. domesticus* are similar to those from previous studies published by researchers elsewhere (PENCE, 1973; SPICER, 1987; KNEE et al., 2008) except for *C. gouldiae* in Australia where more than half of the birds examined were parasitized by *S. tracheacolum* (TIDEMANN et al., 1992).

The infection parameters in male and female hosts of *P. domesticus* suggest that both can contribute in the transmission of mites, either during the cutting or feeding of the young, once the levels of infection were similar between the sex genres. These data are similar to the records in *Spheniscus magellanicus* (Forster, 1781) (Spheniscidae), in which there were not found significant differences in the prevalence and mean intensity of *Rhinonyssus sphenisci* (Fain & Mortelmans, 1959) infection in male and female hosts (GASTAL et al., 2017).

Since *S. tracheacolum* causes severe lesions in the respiratory system of a wide variety of birds and can result in death of these

avian hosts, the presence of this mite should be systematically monitored and investigated in newly introduced birds as well as in native wild birds. In addition, because of the hematophagous nature of Rhinonyssidae, that mites may serve as reservoirs/vectors of pathogenic agents should not be ruled out. The broad geographic distribution of *P. domesticus* and its adaptability to different ecosystems around the world including urban and rural areas make the house sparrow an important reservoir for a number of pathogens of interest and concern for public and animal health including zoonoses.

Castro & Pereira (1947) described infection of *P. hirsti* in nasal passages of *P. domesticus*. These house sparrows came from Portugal, Italy, England, and Brazil from the cities of São Paulo/SP and Curitiba/PR.

In the present survey, *P. domesticus* is reported as a host for *S. tracheacolum* in Brazil for the first time. To the authors' knowledge, this is the first time *P. hirsti* has been found in the State of Rio Grande do Sul, south Brazil. This is the first study in which infection parameters for rhinonyssids mites in *P. domesticus* have been reported in an urban area of southern Brazil.

References

- Amaral V. Notas sobre ácaros nasais com a descrição de duas novas espécies: *Ptilonyssus zeferinoi* n. sp. e *Sternostoma clementei* n. sp. (Acarina: Rhinonyssidae). Lista das espécies descritas no Brasil e seus hospedeiros. *Arq Inst Biol* 1968; 35(3): 107-126.
- Amerson AB Jr. Incidence and transfer of Rhinonyssidae (Acarina: Mesostigmata) in sooty terns (*Sterna fuscata*). *J Med Entomol* 1967; 4(2): 197-199. <http://dx.doi.org/10.1093/jmedent/4.2.197>. PMID:6052126.
- Bell PJ. The life history and transmission biology of *Sternostoma tracheacolum* Lawrence (Acari: Rhinonyssidae) associated with the Gouldian finch *Erythrura gouldiae*. *Exp Appl Acarol* 1996a; 20(6): 323-341. <http://dx.doi.org/10.1007/BF00052962>.
- Bell PJ. Survey of the nasal mite fauna (Rhinonyssidae and Kytoditidae) of the Gouldian finch, *Erythrura gouldiae*, and some co-occurring birds in the Northern Territory. *Wildl Res* 1996b; 23(6): 675-685. <http://dx.doi.org/10.1071/WR9960675>.
- Bernardon FF, Müller G, Mascarenhas CS. Rhinonyssidae in *Chrysomus ruficapillus* (Vieillot, 1819) (Passeriformes: Icteridae) from Southern Brazil. *Comp Parasitol* 2017; 84(1): 67-71. <http://dx.doi.org/10.1654/1525-2647-84.1.67>.
- BirdLife International. *Chloebia gouldiae*. Cambridge: IUCN; 2016. <http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22719744A94642482.en>.
- Bush AO, Lafferty KD, Lotz JM, Shostak AW. Parasitology meets ecology on its own terms: Margolis et al. revisited. *J Parasitol* 1997; 83(4): 575-583. <http://dx.doi.org/10.2307/3284227>. PMID:9267395.
- Calegari-Marques C, Amato SB. Helminths of introduced house sparrows (*Passer domesticus*) in Brazil: does population age affect parasite richness? *Iheringia Ser Zool* 2010; 100(1): 73-78. <http://dx.doi.org/10.1590/S0073-47212010000100010>.
- Castro MP, Pereira C. Ácaros nasícolas (Parasitiformes: Rhinonyssidae) do pardal – *Passer domesticus* L. *Arq Inst Biol (Sao Paulo)* 1947; 18(7): 125-133.
- Černý V, Dusbábek F. The nasal mites of Cuban birds. II. Ptilonyssidae and Rhinonyssidae (Acarina: Mesostigmata). *Acarologia* 1970; 12(3): 479-491.
- Comisión Nacional para el Conocimiento y Uso de la Biodiversidad – CONABIO. *Método de Evaluación Rápida de Invasividad (MERI) para especies exóticas en México. Passer domesticus Linnaeus, 1758. Vertebrados* [online]. México: Gobierno de la República; 2017 [cited 2018 Feb 9]. Available from: https://www.gob.mx/cms/uploads/attachment/file/222386/Passer_domesticus.pdf
- Fain A, Aitken THG. Acariens nasicoles d'oiseaux et de mammifères du Brésil. I. Rhinonyssidae de la région de Belém (Nord Brésil). *Bull Inst Roy Sci Nat Belg* 1968; 44(41): 1-28.
- Fain A, Aitken THG. Acariens nasicoles d'oiseaux et de mammifères du Brésil. V. Nouveaux Rhinonyssidae de la region de Belém (Nord Brésil). *Bull Ann Soc Roy Ent Belg* 1971; 107: 27-46.
- Fain A, Hyland KE. The mites parasitic in the lungs of birds. The variability of *Sternostoma tracheacolum* Lawrence, 1948, in domestic and wild birds. *Parasitology* 1962; 52(3-4): 401-424. <http://dx.doi.org/10.1017/S0031182000027232>.
- Fain A. Adaptation, specificity and host-parasite coevolution in mites (Acari). *Int J Parasitol* 1994; 24(8): 1273-1283. [http://dx.doi.org/10.1016/0020-7519\(94\)90194-5](http://dx.doi.org/10.1016/0020-7519(94)90194-5). PMID:7729980.
- Gastal SB, Mascarenhas CS, Vanstreels RET, Ruas JL. *Rhinonyssus sphenisci* (Acari: Rhinonyssidae) in Magellanic Penguin (*Spheniscus magellanicus*). *Polar Biol* 2017; 41(3): 487-490. <http://dx.doi.org/10.1007/s00300-017-2208-y>.
- Global Invasive Species Database – GISD. *Species profile: Passer domesticus* [online]. Invasive Species Specialist Group; 2018 [cited 2018 Feb 1]. Available from: <http://www.iucngisd.org/gisd/species.php?sc=420>
- Guimarães LLB, Wouters ATB, Casagrande RA, Rolim VM, Wouters F, Gonçalves ICM, et al. Parasitismo pelo ácaro de sistema respiratório *Sternostoma tracheacolum* em um canário belga (*Serinus canaria domestica*). *Acta Sci Vet* 2012; 40(4): 1094.
- Knee W, Galloway TD. New host and locality records for endoparasitic nasal mites (Acari: Rhinonyssidae, Turbinoptidae, and Ereyneidae) infesting birds in Manitoba, Canada. *Can Entomol* 2017; 149(1): 89-103. <http://dx.doi.org/10.4039/tce.2016.47>.
- Knee W, Proctor H, Galloway T. Survey of nasal mites (Rhinonyssidae, Ereyneidae, and Turbinoptidae) associated with birds in Alberta and Manitoba, Canada. *Can Entomol* 2008; 140(3): 364-379. <http://dx.doi.org/10.4039/n08-017>.
- Knee W, Proctor H. Interactive HTML-based Dichotomous key to female Rhinonyssidae (Mesostigmata) from birds in Canada. *Can J Arthropod Identif* 2010; 9: 1-64.
- Major I, Sales LG Jr, Castro R. *Aves da Caatinga*. Fortaleza: Edições Demócrito Rocha; 2004.
- Mascarenhas CS, Coimbra MAA, Müller G, Brum JGW. Nasal mites (Gamasida: Rhinonyssidae) of *Paroaria coronata* (Miler) (Passeriformes: Emberezidae). *Neotrop Entomol* 2011; 40(4): 507-508. <http://dx.doi.org/10.1590/S1519-566X2011000400016>. PMID:21952970.
- Pence DB. The nasal mites of birds from Louisiana. IX. Synopsis. *J Parasitol* 1973; 59(5): 881-892. <http://dx.doi.org/10.2307/3278429>.
- Pence DB. *Keys, species and host list, and bibliography for nasal mites of North American birds (Acarina: Rhinonyssidae, Turbinoptinae, Speleognathinae, and Cytoditidae)*. Lubbock: The Texas Tech Press; 1975. (Special Publications; vol. 8).

- Porter JC, Strandtmann RW. Nasal mites of the English sparrow. *Tex J Sci* 1952; 4: 393-399.
- Riffkin GG, McCausland IP. Respiratory acariasis caused by *Sternostoma tracheacolum* in aviary finches. *N Z Vet J* 1972; 20(7): 109-112. <http://dx.doi.org/10.1080/00480169.1972.34026>. PMID:4516555.
- Rózsa L, Reiczigel J, Majoros G. Quantifying parasites in samples of hosts. *J Parasitol* 2000; 86(2): 228-232. [http://dx.doi.org/10.1645/0022-3395\(2000\)086\[0228:QPISOH\]2.0.CO;2](http://dx.doi.org/10.1645/0022-3395(2000)086[0228:QPISOH]2.0.CO;2). PMID:10780537.
- Sick H. *Ornitologia brasileira*. 2. ed. Rio de Janeiro: Nova Fronteira; 1997.
- Silva HG, Ita AO, Medellín RA. *Passer domesticus domesticus* Linnaeus, 1758. In: Comissão Nacional da Biodiversidade, editor. *Vertebrados superiores exóticos en México: diversidad, distribución y efectos potenciales*. México: Instituto de Ecología, Universidad Nacional Autónoma de México; 2005.
- Silva JSA, Mota RA, Vilela SMO, Doretto Júnior L, Pinheiro Júnior JW, Silva LBG. Newcastle disease virus infection in sparrows (*Passer domesticus*, Linnaeus, 1758) captured in poultry farms of the agreste region of the state of Pernambuco. *Braz J Poultry Sci* 2006; 8(2): 125-129. <http://dx.doi.org/10.1590/S1516-635X2006000200009>.
- Spicer GS. Prevalence and host-parasite list of some nasal mites from birds (Acarina, Rhinonyssidae, Speleognathidae). *J Parasitol* 1987; 73(2): 259-264. <http://dx.doi.org/10.2307/3282076>. PMID:3585621.
- Stephan SAR, Kaschula VR, Canham AS. Respiratory acariasis of canaries. *J S Afr Vet Assoc* 1950; 21(3): 103-107.
- Tidemann SC, McOrist S, Woinarski JCZ, Freeland WJ. Parasitism of wild Gouldian finches (*Erythrura gouldiae*) by the air-sac mite *Sternostoma tracheacolum*. *J Wildl Dis* 1992; 28(1): 80-84. <http://dx.doi.org/10.7589/0090-3558-28.1.80>. PMID:1548805.