

Parasitic fauna of the invasive house sparrow (*Passer domesticus*) from Ñuble region, Chile: an example of co-introduced parasites

Fauna parasítica do pardal invasor (*Passer domesticus*) da região de Ñuble, Chile: um exemplo de parasitas co-introduzidos

Pablo Oyarzún-Ruiz^{1,2} ; Guissel Cárdenas¹; María Carolina Silva-de la Fuente³ ; Nicolás Martín¹; Sergey Mironov⁴ ; Armando Cicchino⁵; John Mike Kinsella⁶; Lucila Moreno^{7*} ; Daniel González-Acuña^{1†} 

¹ Laboratorio de Parásitos y Enfermedades en Fauna Silvestre, Facultad de Ciencias Veterinarias, Universidad de Concepción, Chillán, Chile

² Becario ANID Programa de Doctorado en Ciencias Veterinarias, Facultad de Ciencias Veterinarias, Universidad de Concepción, Chillán, Chile

³ Instituto de Medicina Preventiva Veterinaria, Universidad Austral de Chile, Valdivia, Chile

⁴ Zoological Institute, Russian Academy of Sciences, Universitetskaya Embankment 1, Saint Petersburg, Russia

⁵ Universidad Nacional de Mar del Plata, Mar del Plata, Argentina

⁶ Helm West Lab, Missoula, MT, USA

⁷ Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Barrio Universitario, Concepción, Chile

† In memoriam

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Abstract

Invasive species impact native wildlife in several ways, as they compete for resources and may transmit their specific pathogens. However, the potential consequences of co-introduced parasites are not fully understood. While the house sparrow (*Passer domesticus*) was introduced in Chile about a century ago, no data are available regarding its parasites. Thus, the aim of the present study was to determine the parasitic fauna of this avian invader and to determine whether there are co-introduced/co-invasive parasites shared with native birds. One hundred and eight birds were collected from three different localities in the Ñuble region of Chile, and a complete parasitic necropsy was performed in the laboratory. Twenty-three (21.3%) were parasitized by six arthropod species and four (3.7%) were parasitized by two helminth species. Four out of eight taxa are reported for the first time in Chile; among them, three arthropod parasites and the tapeworm, *Anchotaenia globata*, are considered as co-introduced parasites. Only *A. globata* is a potential co-invasive parasite given its low degree specificity in terms of its definitive hosts. Future research should examine whether additional co-introduced/co-invasive parasites have been brought by the house sparrow, and what their potential consequences might be on the health of native birds in Chile.

Keywords: Acari, Phthiraptera, Cestoda, Acanthocephala, co-introduced parasites, co-invasive parasites.

Resumo

As espécies invasoras de vertebrados competem com espécies nativas no uso de recursos e transmitem patógenos. Contudo as consequências da co-introdução de parasitos permanecem pouco estudadas. O pardal (*Passer domesticus*) foi introduzido há um século no Chile, porém não existem dados sobre seus parasitos. O objetivo do estudo foi investigar a fauna parasitária e avaliar se existem espécies co-introduzidas/co-invasivas compartilhadas com as espécies de aves nativas do Chile. Um total de 108 aves foram coletadas em diferentes localidades da região de Ñuble. Seis espécies de artrópodes parasitos foram coletadas de 23 (21,3%) aves. Quatro aves (3,7%) estavam parasitadas por duas espécies de helmintos. Quatro de um total de oito espécies de parasitos correspondem aos primeiros relatos para o Chile. Três

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*Corresponding author: Lucila Moreno. E-mail: lumoreno@udec.cl



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artrópodes parasitos e o helminto *Annochotaenia globata* são considerados parasitos co-introduzidos no país. Apenas *A. globata* possui potencial para ser considerada uma espécie co-invasiva, pois pode parasitar Passeriformes em geral. Pesquisas futuras devem investigar se os demais parasitos identificados neste estudo correspondem a espécies co-introduzidas ou co-invasoras e avaliar as possíveis consequências na saúde das aves nativas do país.

Palavras-chave: Acari, Phthiraptera, Cestoda, Acanthocephala, parasitas co-introduzidos, parasitas co-invasivos.

Introduction

Invasive species can pose a major threat causing the loss of biodiversity. They can have direct impacts on native species, as they may compete for resources or engage in predation; they sometimes also indirectly modify habitats and transmit pathogens (Lymbery et al., 2014). A species may invade a new area as a result of anthropic modifications to ecosystems and/or deliberate releases in new areas (Taraschewski, 2006; Lymbery et al., 2014). However, an introduced species will become invasive only when it overcomes the following barriers: it invades a new location, survives, reproduces, and ultimately spreads (Lymbery et al., 2014).

According to the definitions by Lymbery et al. (2014), a co-introduced parasite is a species that enters a new area together with the introduced host; meanwhile, a co-invasive parasite is one that has been co-introduced and switched from its original host to a native host that is followed by the potential emergence of new infections/infestations. That being said, the barriers described for the introduced hosts should also be overcome by the parasites, as they may then be able to parasitize native hosts in the new area, thus becoming an invasive parasite.

The parasites brought by introduced hosts may play an important role, as they may affect the success in establishment of their hosts in new areas. When some component of this parasitic fauna is lost in the process of introduction, probability establishment of the introduced host may be enhanced as supported by the enemy-release hypothesis (Torchin et al., 2003; Taraschewski, 2006; Poulin, 2017).

Also, parasites with complex life cycles requiring at least two different hosts would be suppressed in the new territory, if there are no compatible intermediate hosts. Further, if there is an important bottleneck for the introduced host population, this also could impact the dynamics of parasites, thus preventing transmission between individuals (Torchin et al., 2003; Taraschewski, 2006; MacLeod et al., 2010). Once these parasites have successfully established, they could infect competent native hosts in their life cycle, with potential negative effects given the absence of the co-evolutionary adaptation in to native hosts (Taraschewski, 2006; Lymbery et al., 2014). Conversely, the introduced host could be parasitized by native parasites, i.e., the case of a spillback, which could have consequences for the dynamics of these parasites with potentially deleterious results over native hosts (Taraschewski, 2006; Lymbery et al., 2014; Poulin, 2017).

The house sparrow (*Passer domesticus* Linnaeus, 1758) (Passeriformes: Passeridae) is a gregarious and mostly granivorous bird. It is considered a synanthropic animal because it is strongly associated with human settlements (Martínez & González, 2017). This Eurasian bird has been introduced all over the world, with the exception of the polar regions (Anderson, 2006). In South America, this bird was intentionally introduced in 1872 and 1873 in Buenos Aires, Argentina, and then in several other countries, including Peru, Brazil, and Uruguay. These populations have expanded to neighboring countries (Anderson, 2006). Meanwhile, it was introduced to Chile from Europe in 1904 (Anderson, 2006; Martínez & González, 2017). Currently, this allochthonous species is distributed from Arica to Navarino island, including Juan Fernández Archipelago and Easter Island, thus, establishing itself in almost every region of the country (Martínez & González, 2017).

Most records of parasites of the house sparrow come from its original range in Asia and Europe (e.g., Brown & Wilson, 1975; Ozmen et al., 2013; Holand et al., 2013; Abdelmageed et al., 2018). Over 60 species of arthropod parasites have been reported from the house sparrow in Europe, while only half of these taxa have been found in North America (Brown & Wilson, 1975). A similar situation has been observed for endoparasites, as approximately 16 species have been reported in Europe (Martínez et al., 1977; Illescas-Gómez & López-Roman, 1980), while in the invaded countries, only a small part of this richness has been recorded, such as the 5–9 species recorded in Brazil (Brasil & Amato, 1992; Calegario-Marques & Amato, 2010). Thus, in South America, there are noticeably fewer species of ecto- and endoparasites than have been reported from the house sparrow in its primary range, although these data came mostly from Brazil (e.g., Brasil & Amato, 1992; Calegario-Marques & Amato, 2010; Santos et al., 2018, 2020a, b). In Chile, there are scarce reports about the parasite fauna of alien hosts, with some examples noted for the monk parakeet (*Myopsitta monachus* (Boddaert, 1783) (Psittacidae), rock pigeon (*Columba livia* Gmelin, 1789) (Columbidae), and California quail (*Callipepla californica* (Shaw, 1798) (Odontophoridae) (Briceño et al., 2017, 2021; Oyarzún-Ruiz & González-Acuña, 2021). Although the house sparrow was introduced to Chile about a century

ago (Anderson, 2006), there are no thorough investigations of its parasites. We present for first time, the result of investigations of the arthropods and helminths parasites associated with this invasive species and discuss the potential implications of co-introduced parasites.

Materials and Methods

Host collection

Considering that the house sparrow is catalogued as an avian pest in Chile, its capture and hunting is allowed with no limitations, as stipulated in the Hunting Law of the State (Chile, 2017). Thus, a total of 108 house sparrows (96 adult and 12 juvenile birds) were collected from the Ñuble region, Chile, in 2019. Among these, 76 birds from the Chillán campus, Universidad de Concepción, Chillán (S36°35'52.746" W72°4'53.554"), were captured using a mist-net. These birds were euthanized through cervical dislocation, which is considered as an appropriate euthanasia method for birds weighting <3 kg (Charbonneau et al., 2010). Twenty-six birds from Las Mariposas (S36°37'51.533" W72°2'27.262") were shot using a 5.5 mm air rifle, and six birds from Chillán Viejo (S36°37'25.647" W72°7'57.514") were found dead and collected by students, who delivered them to us for examination. Each collected bird was individually placed in a hermetic plastic bag to avoid the loss of arthropod parasites. All birds were transported for parasitological examination at Laboratorio de Parásitos y Enfermedades de Fauna Silvestre, Facultad de Ciencias Veterinarias, Universidad de Concepción, Chillán, Chile. The sex of each bird was determined according to its sexual dichromatism (Martínez & González, 2017), and then subsequently confirmed through the inspection of its gonads. Age was also determined according to the presence/absence of the bursa of Fabricius, both on necropsy.

Collection, preparation, and identification of arthropods

For the collection of arthropods, the feathers of the head, body, wings, and rectrices were first inspected under a stereomicroscope. Then, the "dust-ruffling" technique described by Walther & Clayton (1997) was used to collect the lice and feather mites, which were not collected during visible inspection. Once the organs were removed for helminthological inspection, the body of every bird (the head was not immersed in the solution) was washed in 1 L of tap water with 10 mL of liquid soap (Galloway, 2005). Then, after several repetitive washings, the sediment was examined under a stereomicroscope to collect ectoparasites. The nasal cavity washing technique was performed after washing the birds' bodies. Nasal mites were initially collected following the modified Yunker's method described by Wilson (1964), using nasal flushing with a tap water-soap solution. Then, the skin of the head was pulled back and the skull disarticulated, so nasal sinuses, nasal turbinates, orbital cavities, and nares were exposed and inspected under a stereomicroscope to collect these mites (Fain, 1957). All collected arthropods were washed using a water-soap solution and rinsed with tap water for about 20 minutes to remove the soap before preservation. All collected arthropods were stored in 70% ethanol.

Feather mites were cleared in Nesbit solution and in a thermal bath (Dry Bath Incubator MK2000-1) at 70°C for 10 minutes. Nasal mites were cleared in 10% KOH and in a thermal bath at 80°C for 15 minutes. Then, all mites were mounted onto slides containing Berlese' medium (Krantz & Walter, 2009). Lice were cleared with 20% KOH, then dehydrated in a series of alcohol concentrations (40%, 80%, and 100%), cleared in clove oil for 24 hours, and mounted onto slides with Canada balsam (Palma, 1978; Price et al., 2003). Feather mites were classified according to the descriptions of Atyeo & Braasch (1966), Domrow (1987), and Horn et al. (2018); nasal mites were classified according to Fain (1957) and Pence (1975), and lice were classified according to the methods of Giebel (1874), Piaget (1880), Price (1975), Eichler (1954), Price et al. (2003) and Gustafsson et al. (2019).

Collection, preparation, and identification of helminths

Parasitic necropsy was performed following the methods of Lutz et al. (2017). The eyes, esophagus, gastrointestinal tract, tracheae, lungs, heart, liver, gallbladder, kidneys, bursa of Fabricius, subcutaneous tissue, and articulations were examined under a stereomicroscope. Every organ was gently crushed in citrated saline, then placed in a closed container and shaken vigorously, followed by repetitive sedimentations. Once all organs were removed, the coelomic cavity was washed using citrated saline. The sediment of every organ and cavity was examined using a stereomicroscope. All collected helminths were relaxed in saline and preserved in 80% ethanol according to the methods of Lutz et al. (2017), and Oyarzún-Ruiz & González-Acuña (2020).

Regarding the helminth preparation, acanthocephalans were cleared in a temporary preparation with glycerin alcohol for at least 24 hours. Meanwhile, tapeworms were stained using Alum carmine stain, dehydrated in a series of alcohol concentrations (70%, 80%, 96%, and 100%), cleared in clove oil, and mounted onto slides using Canada balsam (Lutz et al., 2017; Oyarzún-Ruiz & González-Acuña, 2020). Acanthocephalans were identified according to the approaches detailed by Petrochenko (1958), Yamaguti (1963), and Amin & Dailey (1998). Tapeworms were classified according to Rausch & Morgan (1947), Yamaguti (1959), Mariaux (1991), and Khalil et al. (1994).

Furthermore, feces were collected from the cloaca and preserved in 80% ethanol for posterior coprological analysis. A simple flotation technique was performed using saturated saline solution to detect parasite oocysts and eggs (Dryden et al., 2005).

Data analysis

Prevalence (P), intensity (I), range (R), mean intensity (\bar{I}_M), and mean abundance (\bar{M}_A) were calculated and interpreted according to Bush et al. (1997). Furthermore, the sex ratio, and stage of development ratio were estimated for lice and mites. Sex ratio was expressed as proportion of males, i.e., males/(males + females), and the stages of development ratio was expressed as proportion of adult, i.e. adults/(adults + nymphs). Under the term nymph, we mean all preimaginal instars for mites (tritonymphs, protonymphs and larvae) and lice (all three nymphal stages).

Arthropod parasites and helminths were observed and photographed using optic (Leica DM1000) and scanning electron microscopes (Hitachi SU3500). All parasites are deposited in the parasitological collection of the Laboratorio de Parásitos y Enfermedades de Fauna Silvestre, Universidad de Concepción.

Results

Twenty-three of 108 birds (21.3%) were infested by arthropods. Of these, 12 birds (11.11%) were parasitized by mites of the following species: a nasal mite, *Rhinonyssidae* gen. sp. (1.85%), was collected from nasal cavities after nasal flushing; the feather mite, *Proctophyllodes troncatus* Robin, 1877 (Proctophyllodidae) (10.19%), was collected from wing feathers; the mesostigmatid mite, *Ornithonyssus bursa* Berlese, 1888 (Macronyssidae) (0.93%), was collected from the body surface. Also, 13 birds (12.04%) were parasitized by three species of chewing lice isolated from the flight and body feathers: *Brueelia cyclothorax* (Burmeister, 1838) (Phloptoridae) (10.19%), *Myrsidea quadrifasciata* (Piaget, 1880) (Menoponidae) (0.93%), and *Menacanthus eurysternus* Burmeister, 1838 (Menoponidae) (5.56%) (Table 1) (Figures 1-5).

Four birds (3.7%) were parasitized by helminths. Two species were reported: *Mediorhynchus papillosus* Van Cleave, 1916 (Acanthocephala: Giganthorhynchidae) (1.85%), and *Anonchotaenia globata* (von Linstow, 1879) (Cestoda: Paruterinidae) (1.85%), both from the duodenum (Table 1, Figure 6). No protozoa parasites were detected during the coprological analyses. The sex ratio, and stage of development ratio of mites and lice are shown in Table 2.

Discussion

A total of eight taxa were collected: six arthropods and two helminths, of which four were recorded for first time in Chile (see Table 1). Furthermore, in terms of prevalence, the arthropods were the dominant group of parasites in the present study (21.3%), that contrasts with helminths (3.7%).

Proctophyllodes is considered the most speciose among all feather mite genera, with over 170 species infesting 35 families of birds belonging to the order Passeriformes (Atyeo & Braasch, 1966; Mironov, 2012). *Proctophyllodes troncatus* was originally described from two species of sparrows, *P. domesticus* and *Passer montanus*, in Europe (Robin & Mégnin, 1877). The first detailed review of world distribution of *Pr. troncatus* on sparrows was carried out by Gaud & Atyeo (1976), who reported these mites on the house sparrow in its native range (Europe, Northern Africa, Middle East, Iran, and Kashmir), and in countries where it was introduced (Argentina, Brazil, USA, and Australia), including such islands as Bermuda and Hawaii. Further, it was reported from this host in many European and Asian countries (Mironov, 1996, 1997; Kolarova & Mitov, 2008; Gürler et al., 2013, Moodi et al., 2014), in Azores archipelago (Rodrigues et al., 2015), Brazil (Hernandes & Flechtmann, 2020), USA and Canada (Brown & Wilson, 1975; Byers & Proctor, 2013). Additionally, *Pr. troncatus* was recorded on related species of sparrows, *Passer hispaniolensis*, *P. montanus*, and *Passer rutilans* from their corresponding ranges in Europe, Asia, and Northern Africa (Atyeo & Braasch, 1966; Gaud & Atyeo, 1976; Mironov, 1996; Kolarova & Mitov, 2008; Gürler et al., 2013). Thus *Pr. troncatus* appears to be restricted the bird genus *Passer*, although it is interesting to note that on *P. domesticus*

Table 1. Parasitological descriptors and sites of collection for arthropods and helminths recorded from 108 house sparrows (*Passer domesticus*) collected in Ñuble region, Chile.

	N	P(%)	I	R	_M I	_M A	Site of collection
Acari	12	11.11					
Rhinonyssidae							
Rhinonyssidae gen., sp. (n)	2	1.85	2	1	1.00	0.02	Nares
Proctophyllodidae							
<i>Proctophyllodes troncatus</i> (a, n) ^{†‡}	11	10.19	62	1-10	5.64	0.57	Wing feathers
Macronyssidae							
<i>Ornithonyssus bursa</i> (a, n)	1	0.93	298	298	298.00	2.76	Body surface
Phthiraptera	13	12.04					
Philopteridae							
<i>Brueelia cyclothorax</i> (a, n) ^{†‡}	11	10.19	95	1-23	8.64	0.88	Body feathers
Menoponidae							
<i>Myrsidea quadrifasciata</i> (a, n) ^{†‡}	1	0.93	8	8	8.00	0.07	Body feathers
<i>Menacanthus eurysternus</i> (a, n)	6	5.56	111	1-83	18.50	1.03	Body feathers
Acanthocephala	2	1.85					
Giganthorhynchidae							
<i>Mediorhynchus papillosus</i> (a)	2	1.85	9	3-6	4.50	0.08	Duodenum
Cestoda	2	1.85					
Paruterinidae							
<i>Anonchotaenia globata</i> (m) ^{†‡}	2	1.85	11	2-9	5.50	0.10	Duodenum

Abbreviations and symbols. N= number of parasitized birds; a= adult, n= nymph, m=mature worm, P= Prevalence, I= intensity of infection, R= range, _MI= Mean intensity, _MA= Mean abundance; †= first record for Chile; ‡= co-introduced parasite.

and *P. montanus* in the oriental part of Asia (India, China) and on introduced populations of the former host in South Africa and Reunion Island, this mite is replaced by another species, *Proctophyllodes orientalis* Gaud, 1953 (Gaud & Atyeo 1976).

Ornithonyssus bursa, also known as the tropical fowl mite, is a hematophagous mite distributed over tropical, subtropical, and temperate areas (Arrabal et al., 2012; Mašán et al., 2014; Lareschi et al., 2017), and is considered as a rare mite in Europe (Mašán et al., 2014). According to Mori et al. (2019), it is an introduced parasite in the Old World. This mite has been isolated from hosts of various passerine families, e.g., in Corcoracidae, Furnariidae, Hirundinidae, Icteridae, Sturnidae, Thraupidae, Troglodytidae, and Tyrannidae, in Argentina (Arrabal et al., 2012), Brazil (Mascarenhas et al., 2009; Bassini-Silva et al., 2019), and Australia (Domrow, 1987), and it has also been found on various non-passerine birds – e.g., Accipitridae, Columbidae, Cuculidae, Laridae, Phasianidae, Picidae, Psittacidae, and Strigidae (Fonseca, 1948; Domrow, 1987; Aramburú et al., 2003; Mascarenhas et al., 2009; Arrabal et al., 2012; Coimbra et al., 2012; Santillán et al., 2015; Bassini-Silva et al., 2019; Mori et al., 2019). On the house sparrow, it has been found in Australia (Domrow, 1987), Brazil (Fonseca, 1948; Santos et al., 2020b), and North America (Fonseca, 1948). In spite of *O. bursa* being considered an important parasite of chickens in the

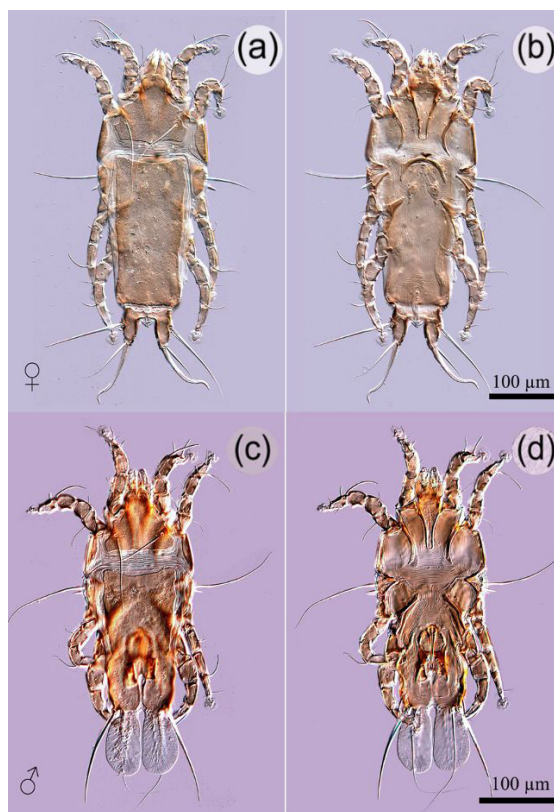


Figure 1. *Proctophyllodes truncatus* from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. Female mite, dorsal (a) and ventral (b) view. Male mite, dorsal (c) and ventral (d) view.

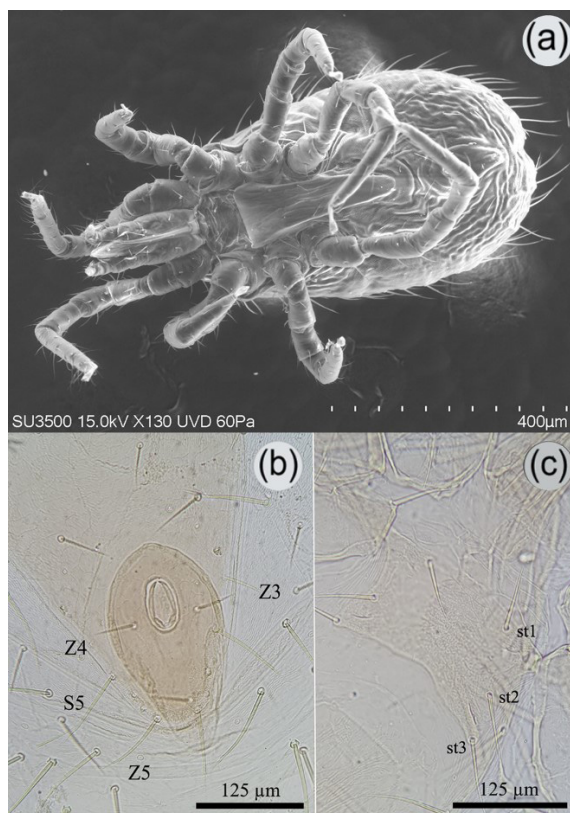


Figure 2. *Ornithonyssus bursa*, female from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. Ventral view of mite (scanning electronic image) (a); posterior end of opisthosomal plate bearing dorsal setae (Z3-Z5, S5) and anal shield visible through the transparent body cuticle (b); sternal plate with three sternal setae (st1-3) (c).

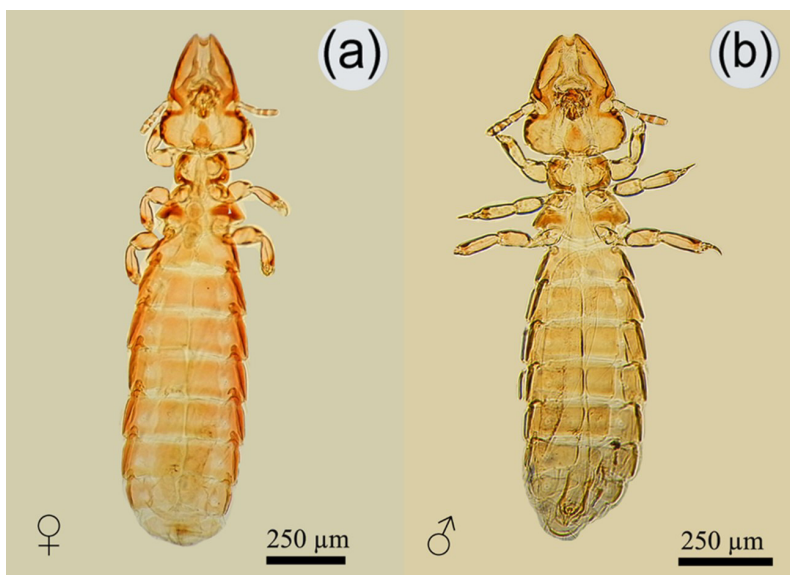


Figure 3. *Brueelia cyclothorax* from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. Female (a) and male (b).

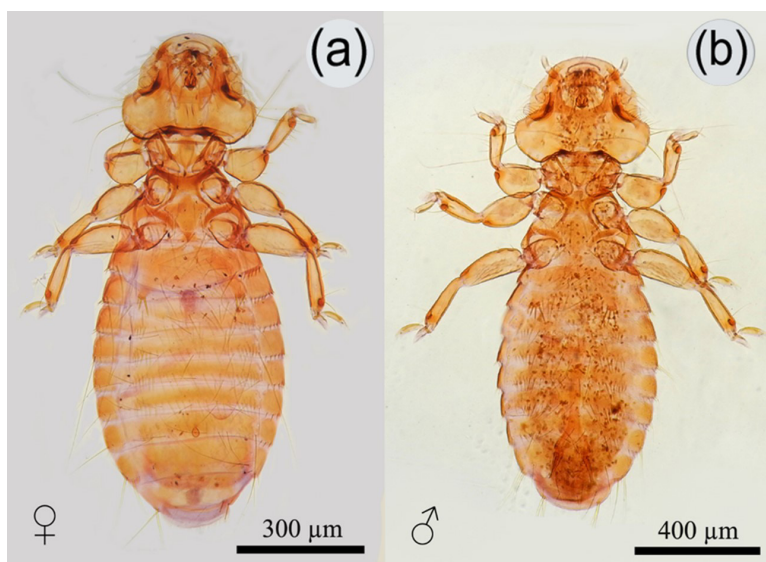


Figure 4. *Myrsidea quadrifasciata* from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. Female (a) and male (b).

Neotropics (Arrabal et al., 2012; Lareschi et al., 2017; Horn et al., 2018), there are no previous records on domestic fowl from Chile (Alcaíno & Gorman, 1999). However, it was recently recorded from the invasive monk parakeet in Central Chile (Briceño et al., 2021). Thus, the present record is the first report of this parasite on a wild passerine in Chile. Although this finding constitutes the second record in the country, it is expected to occur on other birds, considering the wide geographic distribution and host range of this mite (Mašán et al., 2014; Lareschi et al., 2017; Arce et al., 2018). Furthermore, this arthropod mostly inhabits the nests of birds and parasitizes chicks during rearing (Aramburú et al., 2003; Arrabal et al., 2012; Lareschi et al., 2017; Horn et al., 2018; Bassini-Silva et al., 2019), with lower prevalence over fledglings and adults (Arce et al., 2018; Mori et al., 2019). Keeping in mind that no chicks and nests were sampled, this biological trait would explain the low prevalence reported here (0.9%) when compared to that of other studies (~50%) (Arrabal et al., 2012; Santillán et al., 2015). Thus, future studies of this mite in Chile should consider sampling nests and chicks. Although there are no data on its role as a vector of zoonotic agents (Santillán et al., 2015; Lareschi et al., 2017), *O. bursa* has been found to parasitize humans, when infested nests are located in association with human infrastructure, or after manipulation of infested birds (Oliveira et al., 2012; Bassini-Silva et al., 2019).

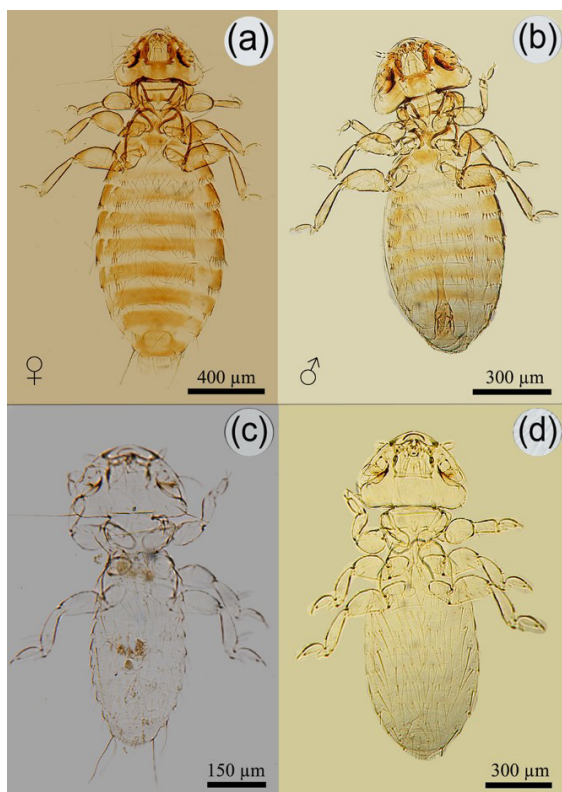


Figure 5. *Menacanthus eurysternus* from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. Adult female (a) and male (b), nymph I (c), and nymph II (d).

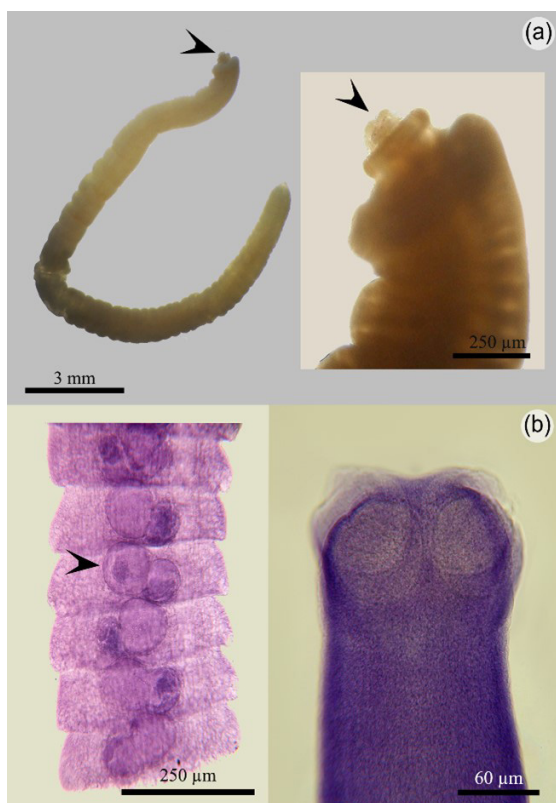


Figure 6. Helminths from the house sparrow (*Passer domesticus*) collected in Ñuble region, Chile. (a) *Mediorhynchus papillosus*. Female worm *in toto*, note its trunk lightly curved dorsally with a conical proboscis covered with hooks (insert); (b) *Anonchotaenia globata*. Scolex lacking an armed rostellum, also note the four rounded suckers. Mature proglottids with its characteristic paruterine organs in every proglottid.

Table 2. Stages of development ratio and sex ratio for lice and mites parasitizing the house sparrow (*Passer domesticus*) collected from Ñuble region in Chile.

	N	Adults (%)	Nymphs (%)	Males (%)	Females (%)	Stage of development ratio	Sex ratio
Acari							
Rhinonyssidae							
Rhinonyssidae gen., sp. (n)	2	0	2	-	-	-	-
Proctophyllodidae							
<i>Proctophyllodes truncatus</i>	62	48 (77.4)	14 (22.6)	19 (39.6)	29 (60.4)	0.8	0.4
Macronyssidae							
<i>Ornithonyssus bursa</i>	298	1 (0.3)	297 (99.7)	0	1	0.003	-
Phthiraptera							
Philopteridae							
<i>Brueelia cyclothorax</i>	95	63 (66.3)	32 (33.7)	33 (52.9)	30 (47.6)	0.7	0.5
Menoponidae							
<i>Myrsidea quadrifasciata</i>	8	3 (37.5)	5 (62.5)	1 (33.3)	2 (66.7)	0.4	0.3
<i>Menacanthus eurysternus</i>	111	44 (39.6)	67 (60.4)	10 (22.7)	34 (77.3)	0.4	0.2

Abbreviations and symbols. "-" not determined; N= number of parasitized birds; Stages of development ratio= adults/(adults + nymphs); Sex ratio= males/(males + females).

Two nasal mites of the family Rhinonyssidae found in two individuals of the house sparrow represented by nymphs were identified only to the family level. Previous records of rhinonyssid species in Chile include *Ptilonyssus certhiaticola* Fain, 1964 and *Rhinonyssus belenopteri* Fain, 1964 isolated from the nasal cavity of *Vanellus chilensis* (Molina, 1782) (cited as *Belenopterus chilensis*) originally from Chile but died in Belgium (Fain, 1964); *Sternostoma tracheacolum* Lawrence, 1948 collected from the mucosal surfaces of the air sacs, bronchi, trachea, and lung of canaries (*Serinus canaria* Linnaeus, 1758) from a private bird collection in the Metropolitan Region (González-Hein et al., 2007). To our knowledge, this is the first report of a nasal mite collected from a wild bird in Chile. The scarce records in Chile could be related to non-inspection of the organs where these mites are found (Oyarzún-Ruiz & González-Acuña, 2021). The spectrum of rhinonyssid species recorded in the house sparrow worldwide has included so far seven species from three genera, *Ptilonyssus*, *Sternostoma* and *Tinaminyssus*, the latter is a parasite of *C. livia*, its records are probably a contamination, a misidentification, or a straggler for the house sparrow (Castro & Pereira, 1947; Domrow, 1969, 1987; Pence, 1975; Knee et al., 2008; Dimov, 2018, 2020; Santos et al., 2018). Of four species of *Ptilonyssus* recorded from the house sparrow, only *Ptilonyssus degtiarevae* Dimov & Mironov, 2012 is known exclusively from this host in Europe (Dimov & Mironov, 2012) while, three others, *Ptilonyssus hirsti* (Castro & Pereira, 1947), *Ptilonyssus icteridius* (Strandtmann and Furman, 1956), and *Ptilonyssus nudus* Berlese & Trouessart, 1889, are associated with sparrows of the genus *Passer* and passerines of other families (Dimov, 2020). At present time, it is impossible to evaluate reliably the origin and parasitological importance of rhinonyssid mites found in the house sparrow in Chile; consequently, future surveys of wild birds should include the analysis of the respiratory tract, because there is a possibility that many new host-parasite associations, and very likely undescribed species, might be found in wild birds.

The chewing louse *Brueelia* Kéler, 1936 is comprised over 300 species found on birds of various avian orders, such as Passeriformes, Coraciiformes, Piciformes, Charadriiformes, and Galliformes, however, the greatest number of species is found in Passeriformes (Gustafsson & Bush, 2017). Similarly, *Myrsidea* Waterson, 1951 contains over 350 species, primarily parasitizes members of the order Passeriformes with a few records in the order Apodiformes. Both

are the most diverse genera from the order Phthiraptera (Price et al., 2003; Valim & Weckstein, 2013; Gustafsson & Bush, 2017).

Brueelia cyclothorax and *M. quadrifasciata* have been recorded on house sparrows in Europe and North America (Brown & Wilson, 1975; Price et al., 2003; Martín-Mateo, 2006, 2009), and Asia (Saxena et al., 2007; Moodi et al., 2013). The present records reflect their close relationship with the house sparrow, as they can be found across the invaded areas, such as in South America (Hernandes & Flechtmann, 2020). Both species of lice seem to be restricted to *Passer* species (Price et al., 2003; Gustafsson & Bush, 2017); as such, in Chile, they could be considered specialist parasites for the house sparrow, acting as its only host.

Menacanthus eurysternus is a species complex which, unlike most other lice, can be found on hosts from various families of Passeriformes – e.g., Corvidae, Fringillidae, Icteridae, Prunellidae, Remizidae, Sturnidae, and Turdidae, as well as on Piciformes around the world (Price et al., 2003; Galloway, 2005; Martín-Mateo, 2006; Fairn et al., 2014; Galloway et al., 2014), with over 170 avian species counted as hosts (Price, 1975; Price et al., 2003). In terms of house sparrows, this parasite has been recorded in Europe and North America (Brown & Wilson, 1975; Price et al., 2003; Martín-Mateo, 2006; Byers & Proctor, 2013), and New Zealand (Galloway, 2005; Palma 2017). In Chile, in addition to the present record, this generalist louse has been isolated only on the austral thrush (González-Acuña et al., 2006; Llanos-Soto et al., 2019). This lower number of hosts in Chile contrasts with the wide range of hosts reported in other South American countries (Cicchino & Castro, 1998). This could be a direct consequence of a relatively small number of parasitological studies conducted examinations of passerines in Chile. Thus, there is a high probability that additional passerine species could act as hosts of this louse.

Mediorhynchus Van Cleave, 1916 is a cosmopolitan genus comprised of 46 valid species (Moya et al., 2011; Smales, 2011). *Mediorhynchus papillosus* is widely reported to parasitize mainly passerine birds from several families, such as Alaudidae, Hirundinidae, Mimidae, Motacillidae, Parulidae, Passerellidae, Sturnidae, Sylviidae, Turdidae, and Tyrannidae. They have been found in Asia, Europe, North America, and South America (Van Cleave, 1947; Petrochenko, 1958; Yamaguti, 1963; Byrd & Kellogg, 1971; Lisitsyna, 1994; Amin & Dailey, 1998). Also, there have been some reports from non-passerine birds, such as those from the orders Accipitriformes, Charadriiformes, Galliformes, Gruiformes, and Piciformes (Yamaguti, 1963; Byrd & Kellogg, 1971; Lisitsyna, 1994; Amin & Dailey, 1998). For the house sparrow, this species has been recorded from the United States (Byrd & Kellogg, 1971), Russia (Petrochenko, 1958), and Brazil (Brasil & Amato, 1992). A *Mediorhynchus* sp. has been recorded from this host in Peru and Brazil (Tantaleán et al., 2005; Santos et al., 2020a). In Chile, *M. papillosus* has been reported in the rufous-collared sparrow *Zonotrichia capensis* (Müller, 1776) (Passerellidae) (Llanos-Soto et al., 2017) and from the shiny cowbird, *Molothrus bonariensis* (Gmelin, 1789) (Icteridae) (Mena et al., 2020). This parasite has an indirect life cycle, with darkling beetles (Coleoptera: Tenebrionidae) acting as intermediate hosts (Amin & Dailey, 1998). According to these authors, the geographic distribution of these beetles in part determines the distribution of this parasite. In fact, Tenebrionidae is reported in Chile with >400 species (Elgueta & Arriagada, 1988) although, to our knowledge, there are no data available to indicate which species might act as an intermediate host. In spite of the fact that the house sparrow is mostly a granivorous bird, it also consumes insects (Martínez & González, 2017), which explains infections by this parasite. The relatively low parasite load reported here is similar to that of previous reports (e.g., Brasil & Amato, 1992) and could be related to the host's small size (Van Cleave, 1947).

The genus *Anonchotaenia* Cohn, 1900 comprises 29 species of tapeworm; its main definitive host includes passerine birds (Phillips et al., 2014). Records in other orders, e.g. Apodiformes and Ciconiiformes, among others, are considered rare or accidental (Khalil et al., 1994). *Anonchotaenia globata* (von Linstow, 1879) has been recorded in Alaudidae, Fringillidae, Hirundinidae, Icteridae, Motacillidae, Nectariniidae, Paridae, Parulidae, and Sylviidae in Africa and Europe (Rausch & Morgan, 1947; Illescas-Gómez & López-Roman, 1980; Mariaux, 1991; Okulewicz & Sitko, 2012). In house sparrows, this tapeworm has been recorded in Africa, Europe, and North America (Rausch & Morgan, 1947; Cooper & Crites, 1974; Martínez et al., 1977; Illescas-Gómez & López-Roman, 1980). This genus is poorly known from South America, with only eight species reported from Brazil, Paraguay, and Chile (Phillips et al., 2014). Three species have been previously reported in the latter country: *Anonchotaenia longiovata* (Fuhrmann, 1901) in the austral blackbird, *Curaeus curaesus* (Molina, 1782) and long-tailed meadowlark, *Leistes loyca* (Molina, 1782) (Icteridae); *Anonchotaenia (Paranonchotaenia) prolixa* Phillips, Georgiev, Waeschenbach, Mariaux, 2014 in the white-crested Elaenia, *Elaenia albiceps* (D'Orbigny & Lafresnaye, 1837) (Tyrannidae); *Anonchotaenia (Paranonchotaenia) macrocephala* Fuhrmann, 1908 in *Tachycineta leucopyga meyeri* (Canabis, 1850) (Hirundinidae) (Rausch & Morgan, 1947; Soto et al., 2013; Phillips et al., 2014); and *Anonchotaenia* sp. from *C. curaesus* (Mena et al., 2020). Thus, the present finding represents the first record for this host in Chile and the third avian host in South America, with

Sporophila caerulescens (Vieillot, 1823) (Thraupidae) and *Z. capensis* acting as the other two passerine hosts, although their localities of origin were not detailed (Rausch & Morgan, 1947). The life cycle of these tapeworms is unknown; however, considering the insectivorous diet of their avian hosts, terrestrial insects are suggested as potential intermediate hosts (Phillips et al., 2014).

A coprological survey was performed in an attempt to collect coccidian parasites; however, there were no positive results. Previous studies have reported the intestinal protozoa, *Isoospora passeris* Levine, 1982 (Martínez et al., 1977; Levine, 1982).

In terms of the proportions of males and females recorded in this study for parasitic arthropods, the feather mite *Pr. troncatus* and the lice *M. quadrifasciata* and *M. eurysternus* were female-biased. Only *B. cyclothorax* had an equal proportion of females to males. Similar results have been reported in several parasitic arthropod species (e.g., Marshall, 1981; Clayton et al., 1992; San-Martín Órdenes et al., 2005; Surkova et al., 2018). Males are perhaps more mobile and smaller than females, and therefore more prone to detach from or be preyed upon by the host. It has also been observed that females are longer-lived than males, which could explain the higher proportion found (Marshall, 1981). Another explanation for this phenomenon is the proportion of infested hosts (prevalence), determining the degree of isolation and the size of parasite populations, which in turn determines the level of inbreeding (Marshall, 1981; Pap et al., 2013). If inbreeding levels are high, a female-biased sex ratio reduces sibling competition for mates and, by this mechanism, all adults can contribute to reproduction (local mate competition hypothesis) (Pap et al., 2013). Therefore, in parasitic species with low prevalence, female bias should be observed most often (Clayton et al., 1992; Poulin, 1997; Pap et al., 2013). In our study, the prevalence of mites and lice did not exceed 10%, this low prevalence may be an explanation for the female-bias found. In the case of *B. cyclothorax*, where a similar proportion of males and females was found, this could be explained by the higher mobility described for this louse (Pap et al., 2013), which is reflected in the higher prevalence observed compared to the other two louse species collected.

Concerning the developmental stage of the isolated arthropods, the feather mite *Pr. troncatus* and the louse *B. cyclothorax* had a higher proportion of adults than nymphs, while the opposite was true for the lice *M. quadrifasciata* and *M. eurysternus*. A higher proportion of adults could indicate that the lice population is decreasing, or these proportions are a consequence of the season of the year in which the samples were taken, coinciding with non-reproductive periods of these arthropods since the populations of parasitic arthropods present seasonal changes in the reproductive parameters, which may be particular to each species (Galloway & Lamb, 2015). To assess this, it would be convenient to sample over several seasons and evaluate the variation in population sizes and reproductive periods of these.

Our study reported low parasite richness and low prevalence for each taxon, with lice and mites being the most prevalent parasites (see Table 1). This finding supports the suggestion that co-introduced parasitic fauna has a low richness and prevalence after introduction (Torchin et al., 2003; Lymbery et al., 2014). Furthermore, the predominance of lice and mites over helminths could be explained given that these parasites are permanent, i.e., do not leave their hosts, and they are transmitted mainly by direct contact between individuals, and they do not require intermediate hosts (McGroarty & Dobson, 1974), as occurs with the reported helminths. This makes it less likely to find high prevalence in helminths. Additionally, the social behavior of these birds favors the transmission of mites and lice (MacLeod et al., 2010; Tuliozi et al., 2018). In comparison to studies in Europe, there are about 13 species of helminths and over 60 species of ectoparasites recorded in the house sparrow from the Old World (Brown & Wilson, 1975; Calegario-Marques & Amato, 2010), which starkly contrasts with the two helminths and six ectoparasites reported here. However, these results align with previous findings reported from Brazil (Brasil & Amato, 1992; Calegario-Marques & Amato, 2010; Santos et al., 2018, 2020a,b). It is thought that most of these parasites were not co-introduced with their hosts or, if they were, they failed to persist in the new environment because there was an absence of susceptible intermediate hosts, there were adverse climate conditions, or there was a small population size, among other reasons (Torchin et al., 2003; MacLeod et al., 2010). Notwithstanding the above, among the isolated parasites, six out eight taxa were recorded in Chile for the first time.

According to the definitions of Lymbery et al. (2014), *Pr. troncatus*, *B. cyclothorax*, and *M. quadrifasciata* are likely co-introduced parasites, as these ectoparasites are specific to the genus *Passer* (Price et al., 2003; Mironov, 2012; Hernandez & Flechtmann, 2020). Although *A. globata* is a nonspecific helminth (Rausch & Morgan, 1947; Mariaux, 1991), it should also be considered as a co-introduced parasite, but not co-invasive; this could change, if in the future, native hosts are found to be parasitized by this tapeworm (Lymbery et al., 2014). Additionally, whether or

not *O. bursa* was co-introduced remains doubtful, because it is as a widely distributed parasite in the Americas (Mašán et al., 2014; Lareschi et al., 2017; Arce et al., 2018; Santos et al., 2020b).

Additional research at other locations across Chile will determine if other parasites were co-introduced with the house sparrow, or if there are additional native parasites that may have parasitized this invasive passerine (e.g., Brown & Wilson, 1975; Calegario-Marques & Amato, 2010). The examination of chicks and nests is necessary to study abundance and prevalence of nest-dwelling mites (e.g., Arrabal et al., 2012; Santillán et al., 2015; Mori et al., 2019), and to collect other ectoparasites such as fleas, and ticks (Brown & Wilson, 1975; Fairn et al., 2014).

In addition to the present study, it is worth noting that among nine avian species introduced to Chile, three species (*C. californica*, *C. livia* and *M. monachus*) are infected with co-introduced parasites (Briceño et al., 2017, 2021; Oyarzún-Ruiz & González-Acuña, 2021). The discussion about invasive hosts and their co-introduced/co-invasive parasites in the country is not extensive (PNUD, 2017). There is a clear need to continue monitoring these bird species and other exotic species that are widely distributed across the country (see PNUD, 2017), including their parasitic fauna and other pathogens. The goal of future research is to understand zoonotic implications of these parasites, and their impact on native species, especially considering that for most studied cases, such consequences are unknown (Lymbery et al., 2014; Poulin, 2017).

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