


Parasites of the Neotropic cormorant *Nannopterum (Phalacrocorax) brasilianus* (Aves, Phalacrocoracidae) in Chile

Parasitos da biguá *Nannopterum (Phalacrocorax) brasilianus* (Aves, Phalacrocoracidae) do Chile

Daniel González-Acuña^{1*} ; Sebastián Llanos-Soto^{1,2}; Pablo Oyarzún-Ruiz¹ ; John Mike Kinsella³; Carlos Barrientos⁴; Richard Thomas¹; Armando Cicchino⁵; Lucila Moreno⁶

¹Laboratorio de Parásitos y Enfermedades de Fauna Silvestre, Departamento de Ciencia Animal, Facultad de Medicina Veterinaria, Universidad de Concepción, Chillán, Chile

²Laboratorio de Vida Silvestre, Departamento de Ciencia Animal, Facultad de Medicina Veterinaria, Universidad de Concepción, Chillán, Chile

³Helm West Lab, Missoula, MT, USA

⁴Escuela de Medicina Veterinaria, Universidad Santo Tomás, Concepción, Chile

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

⁶Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile

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Abstract

The Neotropic cormorant *Nannopterum (Phalacrocorax) brasilianus* (Suliformes: Phalacrocoracidae) is widely distributed in Central and South America. In Chile, information about parasites for this species is limited to helminths and nematodes, and little is known about other parasite groups. This study documents the parasitic fauna present in 80 Neotropic cormorants' carcasses collected from 2001 to 2008 in Antofagasta, Biobío, and Ñuble regions. Birds were externally inspected for ectoparasites and necropsies were performed to examine digestive and respiratory organs in search of endoparasites. Ectoparasites collected were cleared and mounted for identification under a microscope. Fecal samples were also evaluated to determine the presence of protozoan parasites employing a flotation technique. A total of 44 (42.5%) of birds were infested with at least one ectoparasite species, while 77 (96.25%) were carrying endoparasites. No protozoan forms were found after examination. Most prevalent endoparasite species found were *Contracaecum rudolphii* s. l. (72/80, 90%), followed by *Pectinopygus gyroceras* (33/80, 41.25%), and *Profilicollis altmani* (26/80, 32.5%). This is the first report of *P. altmani*, *Baruscaphyllaria carbonis*, *Avioseperis* sp., *Cyathostoma (Cyathostoma) phenisci*, and *Eidmaniella pelucida* in the Neotropic cormorant. These findings also expand the distributional range of *Andracantha phalacrocoracis*, *Paradilepis caballeroi*, *Hysteromorpha triloba*, and *P. gyroceras* to Chile.

Keywords: Helminths, ectoparasites, endoparasites, birds, lice.

Resumo

O Biguá *Nannopterum (Phalacrocorax) brasilianus* (Suliformes: Phalacrocoracidae) é amplamente distribuído na América Central e na do Sul. No Chile, as informações sobre parasitos para essa espécie são limitadas a helmintos e nematoides, e pouco se sabe sobre outros grupos de parasitos. Este estudo documenta a fauna parasitária presente em 80 biguás coletados de 2001 a 2008, nas regiões de Antofagasta, Biobío e Ñuble. As aves foram inspecionadas externamente em busca de ectoparasitas; adicionalmente, foram realizadas necropsias para examinar os órgãos digestivos e respiratórios em busca de endoparasitos. Os ectoparasitos coletados foram limpos e montados para identificação ao microscópio. As amostras de fezes também foram avaliadas para determinar a presença de parasitos protozoários, empregando-se uma técnica de flutuação. Um total de 44 (42,5%) aves estavam infectadas com pelo menos um ectoparasito, enquanto 77 (96,25%) estavam portando endoparasito. Nenhuma forma de protozoário foi encontrada após o exame. As espécies de endoparasitos mais prevalentes encontradas foram *Contracaecum rudolphii* (72/80, 90%), *Pectinopygus gyroceras* (33/80, 41.25%) e *Profilicollis altmani* (26/80, 32.5%). Este

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*Corresponding author: Daniel González-Acuña. E-mail: danigonz@udec.cl



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é o primeiro registro de *P. altmani*, *Baruscapillaria carbonis*, *Aviosepens* sp., *Cyathostoma* (*Cyathostoma*) *phenisci* e *Eidmanniella pelucida* no biguá. Esses resultados também expandem a distribuição de *Andracantha phalacrocoracis*, *Paradilepis caballeroi*, *Ascocotyle felippeii*, *Hysteromorpha triloba* e *P. gyroceras* no Chile.

Palavras-chave: Helmintos, parasitas externos, parasitas internos, pássaro, piolhos.

Introduction

The Neotropic cormorant *Nannopterum* (*Phalacrocorax*) *brasilianus* (Suliformes: Phalacrocoracidae) is a widely distributed bird of Central and South America, reaching Mexico and the southern areas of the United States (Kennedy & Spencer, 2014; IUCN, 2017). It feeds on crustaceans, small fish, amphibians, and insects in different aquatic habitats with fresh, brackish, or saltwater (IUCN, 2017). In Chile, the Neotropic cormorant is distributed in marine coasts, lakes, and rivers from Arica (18°28'30"S, 70°18'52"W) to Tierra del Fuego (53°36'00"S, 69°23'00"W). It comprises two subspecies *N. (P.) b. brasilianus* and *N. (P.) b. hornensis*, with the latter being distributed along the Beagle Channel and Cape Horn in southern Chile (Chester, 2008). As established by the Chilean Hunting Law N° 19.473, the Neotropic cormorant is a pest bird in some regions of northern Chile (SAG, 2018).

Currently, the Neotropic cormorant does not face conservation issues, having an increasing population of more than 2 million individuals and a large distributional range (IUCN, 2017). However, it is still important to elucidate parasite species that might be affecting the health of Neotropic cormorants, particularly younglings, which are more susceptible to develop disease due to parasitism (Kuiken et al., 1999; Torres et al., 2005). Most surveys of the parasitic fauna of the Neotropic cormorant have been performed in Brazil, Argentina, Mexico, and the United States (Vicente et al., 1996; Fedynich et al., 1997; Drago et al., 2011; Monteiro et al., 2011). Information about its parasites in Chile is restricted to studies performed by Torres et al. (1982, 1991, 1992, 1993, 2000, 2005) and Garbin et al. (2011).

Previous studies of endoparasites in the Neotropic cormorant indicate the presence of Nematoda from genera *Eucoelus*, *Ornithocapillaria*, *Capillaria*, *Contraecaecum*, *Baruscapillaria*, *Syncuaria*, *Porrocaecum*, *Anisakis*, *Pseudoterranova*, *Eustrongylides*, *Syngamus*, and *Tetrameres* (Lamont, 1920; Vicente et al., 1995, 1996; Torres et al., 1991, 2005; Monteiro et al., 2006b, 2011; Garbin et al., 2011; Violante-González et al., 2011); four Acanthocephala species from genera *Andracantha*, *Corynosoma*, and *Southwellina* (Torres et al., 1992; Hinojosa-Sáez & González-Acuña, 2005; Monteiro et al., 2006a, 2011; Violante-González et al., 2011); 28 species of Trematoda from genera *Strigea*, *Tylodelphys*, *Neodiplostomum*, *Austrodiplostomum*, *Hysteromorpha*, *Euhaplorchis*, *Mehrastomum*, *Ribeiroia*, *Odhneria*, *Drepanocephalus*, *Ascocotyle*, *Maritrema*, *Phocitrema*, *Pseudopsilostoma*, *Echinochasmus*, *Prosthogonimus*, *Clinostomatopsis*, *Clinostomum*, *Diplostomum*, *Ignavia*, and *Paryphostomum* (Fedynich et al. 1997; Lunaschi & Drago, 2005; Monteiro et al., 2007, 2011; Drago et al., 2011; Violante-González et al., 2011); and two Cestoda from genera *Paradilepis* and *Tetrabothrius* sp. (Fedynich et al., 1997; Hinojosa-Sáez & González-Acuña, 2005; Monteiro et al., 2011; Violante-González et al., 2011).

There are few descriptions of ectoparasites in the Neotropic cormorant. For instance, lice *Piagetiella vigua* Eichler, 1943, *Eidmanniella eurygaster* Nitzsch, 1866, *Pectinopygus faralloni* Kellogg, 1896, *Pectinopygus gyrocera* Nitzsch, 1866, *Pectinopygus depressus* Rudow, 1869, *Colpocephalum commune* Rudow, 1869, and *Laemobothrion brasiliense* Rudow, 1869 (Malcomson, 1960; Price, 1970); fleas *Ceratophyllus titicacensis* Smit, 1978 (Hastriter, 2001); mites *Scutomegninia microfalcifera* Mironov, 1990, *Plicatalloptes* sp. Dubinin, 1955, *Michaelia neotropica* Mironov & Hernandez, 2016, *Frehelectes gaudi* Fain, 1984, *Neottialges evansi* Fain, 1966, *Dinalloptes chelionatus* Atyeo e Peterson, 1966, and *Allopsoroptoides galli* Mironov, 2013 (Pence et al., 1997; Mironov, 2000; Barreto et al., 2012; Mironov, 2013; Tucci et al., 2014; Pedroso & Hernandez, 2016; Hernandez et al., 2016); and hippoboscids *Olfersia sordida* Bigot, 1885 (Santos et al., 2014).

There are no reports of protozoa parasites in the Neotropic cormorants or any other cormorant species in Chile. However, there are records of *Toxoplasma gondii*, *Cryptosporidium* sp., *Giardia* sp., *Entamoeba* sp., *Eimeria* sp., and Sporozoa (Apicomplexa) oocyst in the great (*Phalacrocorax carbo*) and flightless cormorants (*Phalacrocorax harrisi*) (Medema, 1999; Plutzer & Tomor, 2009; Deem et al., 2010; Carrera-Jativa et al., 2014; Víchová et al., 2016; Rzymiski et al., 2017). Certain fish species act as reservoirs of *Cryptosporidium* sp. (Gabor et al., 2011), and *Giardia* sp. (Ghoneim et al., 2012), underlining the role that cormorants might play as reservoirs of protozoan parasites due to their elevated fish consumption (Carss, 1997). Nonetheless, the importance that the Neotropic cormorant has in the maintenance of parasites in terrestrial and aquatic environments remains to be determined.

In South America, studies of the parasitic fauna of the Neotropic cormorant have been mainly carried out in Brazil (Vicente et al., 1996; Monteiro et al., 2011) and Argentina (Drago et al., 2011). In Chile, information about parasites for this bird is restricted to studies performed by Torres et al. (1982, 1991, 1992, 1993, 2000, 2005) and

Garbin et al. (2011), in which only the presence of nematodes and other helminths was reported. Due the current lack of knowledge about the parasitic fauna of Neotropic cormorants in Chile, this study aimed to document new records of the ecto-, endoparasites, and protozoa of this widely distributed bird in the country. Additionally, most cormorants included in this study were residents of Talcahuano and San Vicente Bay, both areas characterized by the presence of estuarine wetlands and marshes, which are usually visited by resident and migratory birds to rest and feed (León & Benítez-Mora, 2005; García-Walther et al., 2017). Encounters among diverse bird species in these areas provide opportunities for the transmission of different parasite groups (Bjoersdorff et al., 2001), highlighting the importance of determining parasitic organisms in these birds to better understand parasite-host interactions in the established ecological communities.

Materials and Methods

Eighty Neotropic cormorants were hunted in years 2001 (1), 2002 (1), 2003 (4), 2005 (1), 2006 (1), 2007 (64), and 2008 (8) from four locations of the Biobío region: Talcahuano (36°43'S, 73°06'W), Lenga (36°47'S, 73°02'W), Infiernillo (36°35'S, 72°31'W), San Vicente Bay (36°44'S, 73°07'W); two locations from the Ñuble region: Chillán (36°36'S, 72°06'W) and Santa Elena Lake (36°48'S, 72°22'W), and a single location in the Antofagasta region (23°39'S, 70°23'W) (Figure 1). Cormorants collected from Talcahuano and San Vicente (Chile) in 2007 died because of an oil spill event that occurred in the area during the same year. All other carcasses examined in this study were donated by hunters. The Chilean Hunting Law N° 19.473, Article N 5°, Supreme decree N°5, allows hunting of Neotropic cormorants along its distributional range from April to August. All carcasses were brought to the Department of Animal Science, Universidad de Concepción, Chillán, and kept stored at -40 °C for future examination.

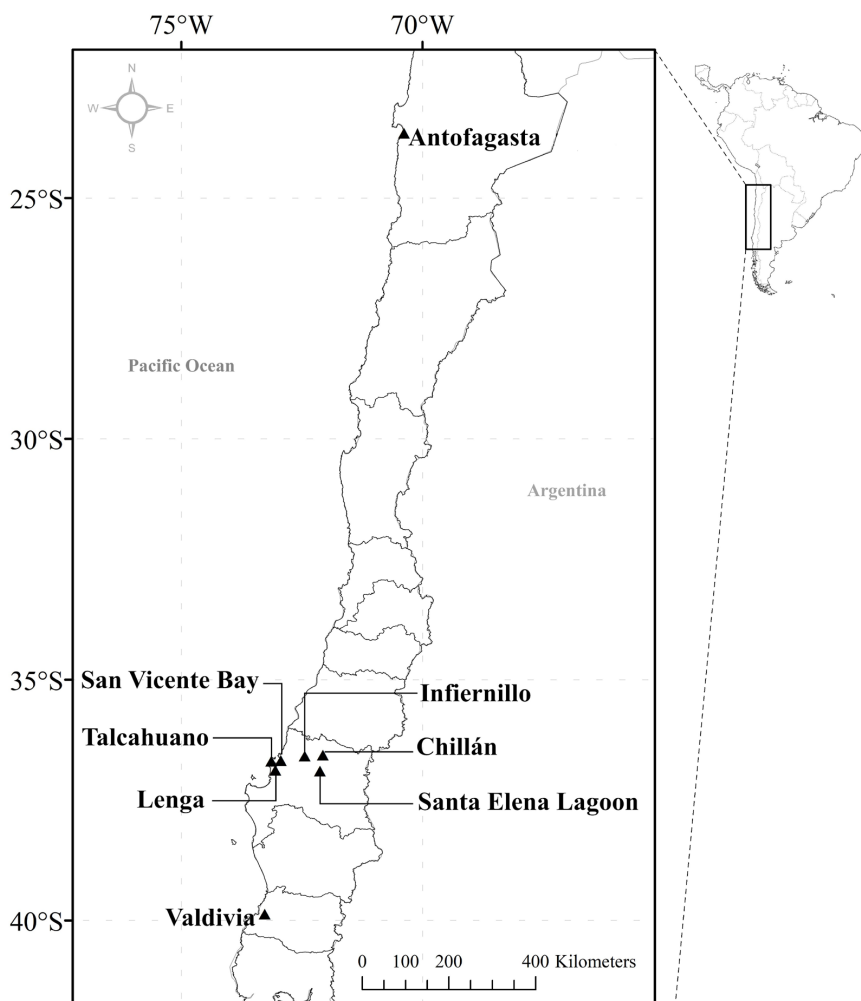


Figure 1. Map of Chile showing the sampling locations.

Cormorants were externally inspected with a magnifier in search of ectoparasites. Feathers of the wings, tail, head, neck, flanks, back, and abdomen were closely examined. As birds were dead when they were collected, it is possible that ectoparasites may have abandoned their hosts after their death. Following collection, lice were cleared using 20% KOH and ascending concentrations of ethanol solutions (40%, 70%, and 96%) and were subsequently mounted using Canada balsam, as indicated in Palma (1978) and Price et al. (2003). Ectoparasites were identified using the keys provided in Giebel (1866), Keler (1938), Ryan & Price (1969), Clay (1973), Price et al. (2003), and Kuabara & Valim (2017).

Birds were necropsied using the modified Withlock technique (Cattán & Tagle, 1974). Digestive and respiratory organs were inspected in search of endoparasites and some segments of the intestine were observed with the stereomicroscope (20x and 40x) in order to collect parasites that could have been adhered to the mucous membrane. Endoparasites were stored following methods in Pritchard & Kruse (1982). Trematoda were preserved in 70% ethyl alcohol and stained with carmine and alum carmine stains for identification. Acanthocephalans and cestodes were maintained in water for 10 min and then kept in 10% buffered formalin and a mix of 70% ethyl alcohol and 10% lactic acid, respectively. Nematoda were preserved in 70% ethyl alcohol and then fixated with glycerin in 50-100 mL flasks (Oyarzún-Ruiz & González-Acuña, 2020). Endoparasites were identified using keys and descriptions in Skrjabin et al. (1954), Skrjabin (1961, 1969), Yamaguti (1958, 1959, 1961), and Khalil et al. (1994). A fecal sample was obtained from the distal rectum of each bird in order to search for intestinal protozoa using the flotation technique described in Boch & Supperer (1982).

The terminology used to describe parasitological assemblage descriptors (prevalence, mean intensity, and mean abundance) follows that of Bush et al. (1997). 'Range' displays the minimum and maximum number of individuals of a parasite species collected from the least and most infested hosts, respectively.

Results and Discussion

Ectoparasites

Thirty-four (42.5%) birds were parasitized by at least one species of ectoparasite. *Eidmaniella pelucida* Rudow, 1869 (Figure 2a) and *Pectinopygus gyroceras* (Figure 2b) were identified as lice species in the Neotropic Cormorant. The ratios of nymph/adult and male/female for *P. gyroceras* were 0.81 and 1.67, respectively (70 females, 42 males and 91 nymphs). Only a single individual *E. pelucida* was collected. Information about population parameters for *P. gyroceras* can be found in Table 1.

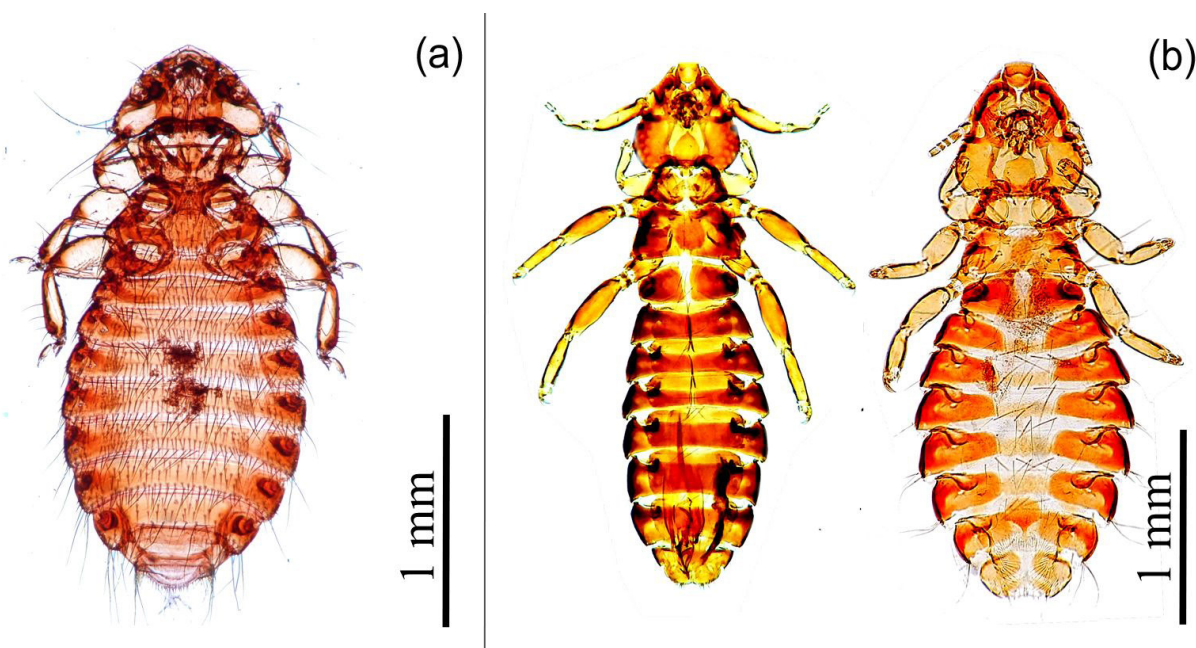


Figure 2. (a) Female specimen of *Eidmaniella pelucida* (100x magnification); (b) Male (left) and female (right) *Pectinopygus gyroceras* (100x magnification).

Table 1. Parasitological descriptors of ecto- and endoparasites collected from Neotropic cormorants (*Nannopterum (Phalacrocorax) brasiliensis*).

Species	Habitat	Positive birds	Intensity		Mean abundance	Standard deviation	Prevalence (%)	Total
			Mean	Range				
Phthiraptera								
<i>Pectinopygus gyroceras</i>	Feathers	33	6.15	1-28	2.54	34.35	41.25	203
Trematoda								
<i>Ascocotyle felippei</i>	Small and large intestines	10	52.1	1-250	6.51	35.71	12.5	521
<i>Hysteromorpha triloba</i>	Small and large intestines	2	2467	150-4784	61.68	534.9	2.5	4934
Nematoda								
<i>Anisakis</i> sp.	Stomach	1	-	-	-	-	1.25	36
<i>Avioseipens</i> sp.	Stomach	1	-	-	-	-	1.25	2
<i>Baruscaphillaria carbonis</i>	Stomach	1	-	-	-	-	1.25	1
<i>Contracaecum rudolphii</i> s. l.	Stomach	72	41	1-280	36.69	48.48	90	2935
<i>Cyathostoma (Cyathostoma) phenisci</i>	Trachea	1	-	-	-	-	1.25	1
Acanthocephala								
<i>Andracantha phalacrocoracis</i>	Small and large intestines	9	4.11	1-12	2.79	8.54	17.5	223
<i>Corynosoma arctocephali</i>	Small and large intestines	14	15.93	1-46	0.46	1.79	11.25	37
<i>Proflicollis altmani</i>	Small and large intestines	26	25.04	2-80	8.14	16.22	32.5	651
Cestoda								
<i>Paradilepis caballeroi</i>	Small intestine	3	73.33	2-183	2.75	31.77	3.75	220

Information about both ectoparasite species found in this study is extremely sparse. *Eidmaniella pelucida* was recorded in *Phalacrocorax capensis* and *P. carbo* in North America, *P. carbo* in Spain, and *Leucocarbo bougainvillii* (Phalacrocoracidae) in Peru (Emerson, 1947; Dale, 1970; Mateo, 2006). Similarly, *P. gyroceras* has been previously described in *N. (P.) brasiliensis* in the United States and Brazil (Malcomson, 1960; Kuabara & Valim, 2017). This is the first time that *E. pelucida* is described in the Neotropic cormorant and expands the distributional range of *P. gyroceras* to Chile.

It is important to highlight that pollution with hydrocarbons could have resulted in a less intense infestation with ectoparasites in cormorants from Talcahuano and San Vicente Bay. This, because hydrocarbons adhere to feathers and cause a should be disruption of the water repellent properties of birds' plumage (Jenssen, 1994), allowing polluted water to cover feathers and remove ectoparasites. Moreover, affected feathers lose their ability to provide insulation and leads to hypothermia in birds, which might have caused ectoparasites to abandon their now dead hosts before carcasses arrived at the university for inspection. Parasites could have also been washed away when cleaning birds affected by the oil. All these effects of hydrocarbons could have led to a sub-estimation of ectoparasite abundance, intensity, and prevalence.

Endoparasites

From the 80 birds examined, 77 (96.25%) were infected with at least one species of endoparasite. A total of 9566 parasites were collected in total: 5455 Trematoda (57.02%), 2979 Nematoda (31.14%), 911 Acanthocephala (9.52%), and 221 Cestoda (2.31%).

No protozoan parasites were detected in this study during faecal examination. Previously, protozoan from the genera *Giardia* and *Cryptosporidium* have been informed in feces from *P. carbo* through microscopy (Medema, 1999; Rzymiski et al., 2017) and PCR (Plutzer & Tomor, 2009). It is important to consider that the absence of protozoa oocysts and eggs observed in this study does not necessarily mean that birds were free of these parasites, but could be a result of factors associated with the low sensitivity of the flotation technique and/or low infestation rate (Zajac & Conboy, 2012). It is recommended for future studies to employ more sensitive techniques, such as molecular methods, to precisely diagnose protozoan parasite infection (Plutzer & Tomor, 2009).

Trematoda

Trematode species *Hysteromorpha triloba* (Figure 3a) and *Ascocotyle felypei* (Figure 3b) were identified and were isolated from two and ten cormorants, respectively. *Hysteromorpha triloba* was the most abundant parasite with 4784 individuals found in a single bird. Information about population parameters for Trematoda recorded in this study can be found in Table 1.

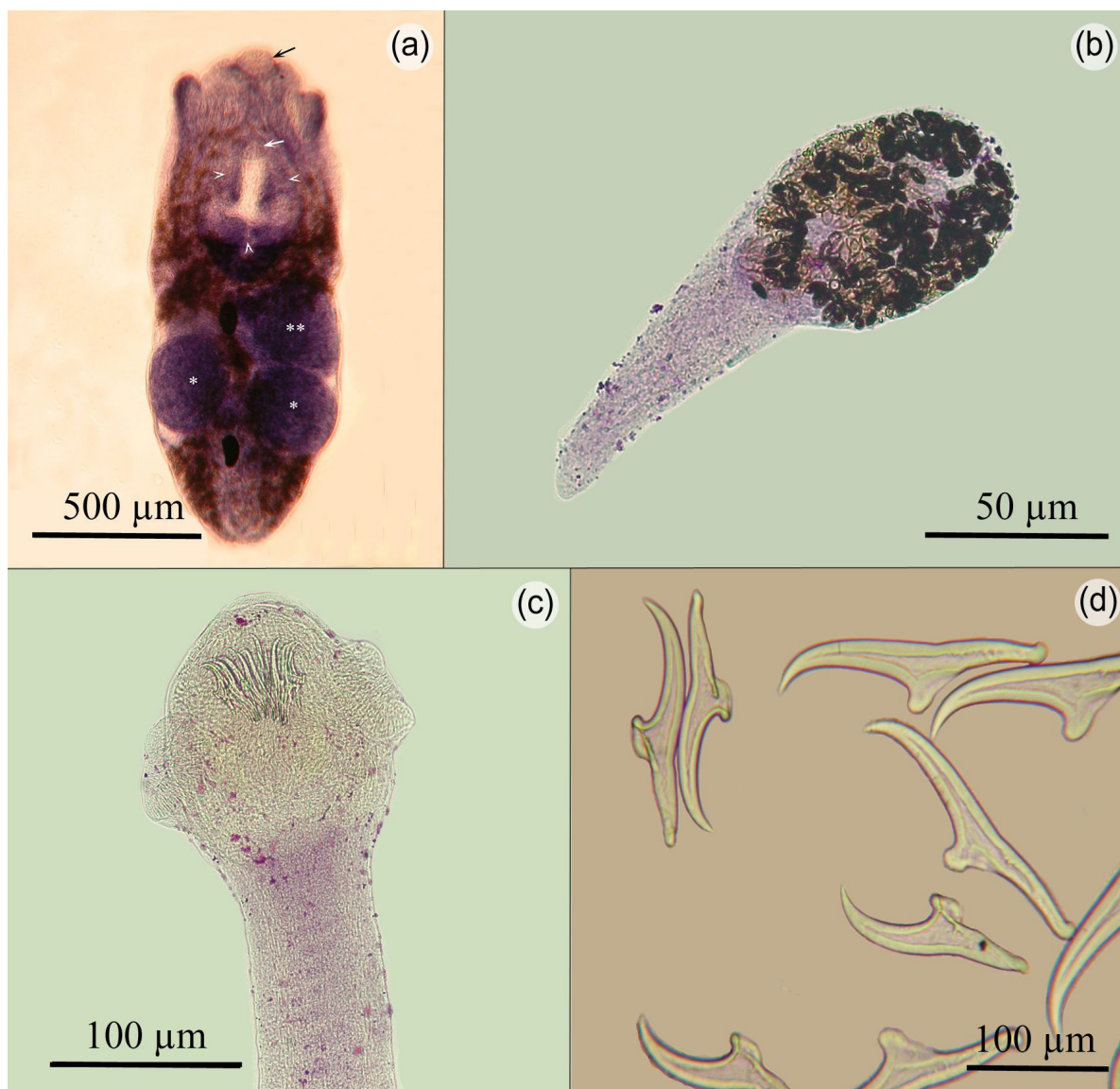


Figure 3. (a) Photomicrographs of an adult *Hysteromorpha triloba* in toto with its trilobulated forebody, small oral sucker (black arrow) and oval ventral sucker (white arrow) covered by the holdfast organ (white arrow heads). The anterior oval testis is denoted by double asterisk and the posterior bilobulated testis each by single asterisk (200x magnification); (b) *Ascocotyle felypei* mature fluke with its typical pear-shaped body and its uterus filled with eggs. Post-mortem autolytic changes account for the absence of typical cephalic spines (100x magnification); (c, d) *Paradilepis caballeroi* with its (c) scolex bearing well-developed suckers (arrows) and an invaginated rostellum (arrowhead) (40x magnification); (d) Typical hooks for this species (400x magnification).

H. triloba

Hysteromorpha triloba is a cosmopolitan parasite that infects snails and fishes as first and second intermediate hosts, respectively, reaching piscivorous birds as their definitive hosts (Huggins, 1954a, b). It is commonly found in cormorants, being described in different cormorant species and found in several countries. For instance, it has been reported in *Nannopterum (Phalacrocorax) auritus* in the United States and Canada (Chandler & Rausch, 1948), *Microcarbo melanoleucos* and *Phalacrocorax fuscescens* in Australia (Johnston, 1942), and *P. carbo* in Mongolia, Ukraine, Czech Republic, Curonian Lagoon Area (Russia and Lithuania), India, Japan, Australia, and Poland (Yamaguti, 1939; Johnston, 1942; Gupta, 1963; Našincová et al., 1993; Kanarek et al., 2003; Korniyushin, 2008; Švažas et al., 2011; Lebedeva & Chantuu, 2015). *Hysteromorpha triloba* has been previously recorded in the Neotropic cormorant in Argentina, Brazil, and the United States (Fedynich et al., 1997; Drago et al., 2011; Monteiro et al., 2011), however, this is the first time that it is reported in the Neotropic cormorant in Chile.

A. felippe

Species of the genus *Ascocotyle* infect snails and fishes as intermediate hosts and are common parasites of piscivorous birds and mammals, which serve as the definitive host (Ostrowski de Núñez, 1976). *Ascocotyle felippe* has been reported in different bird species of the American continent. For instance, it has been recorded in *Egretta caerulea*, *Egretta tricolor*, and *Botaurus lentiginosus* (Ardeidae) in the United States (Price, 1935; Leigh, 1956; Sepúlveda et al., 1996); *Himantopus melanurus* (Recurvirostridae), *Butorides striata*, *Ixobrychus involucris* (Ardeidae) *Spheniscus magellanicus* (Spheniscidae), and *Nycticorax nycticorax* (Ardeidae) in Argentina (Boero et al., 1972; Ostrowski de Núñez, 1976; Alda et al., 2011); *Ardea alba* (Ardeidae) in Mexico and the United States (Aguirre-Macedo & García-Magaña, 1994; Sepúlveda et al., 1999); *Ardea herodias* (Ardeidae) and *Buteogallus anthracinus* (Accipitridae) in Mexico (Aguirre-Macedo & García-Magaña, 1994; Scholz et al., 2001); *Ixobrychus exilis* (Ardeidae) in Brazil (Travassos et al., 1969), and *Falco sparverius* (Falconidae) in Chile (Moreno & González-Acuña, 2015). *Ascocotyle felippe* has been previously described in Neotropic cormorants in the United States and Mexico (Fedynich et al., 1997; Scholz et al., 2001) but it constitutes a new report for this species in Chile.

Cestoda

Paradilepis caballeroi (Figure 3c, d) was the only cestode isolated from cormorant carcasses. Information about population parameters for the species in this study can be found in Table 1.

P. caballeroi

Adults of the genus *Paradilepis* Hsü, 1935 are parasites of Pelecaniformes and, in many cases, cormorants (Presswell et al., 2012). It consists of fourteen species, *Paradilepis delachauxi* Fuhrmann, 1909, *Paradilepis diminuta* Huey & Dronen, 1981, *Paradilepis kemp* Southwell, 1921, *Paradilepis longivaginosus* Mayhew, 1925, *Paradilepis maleki* Khalil, 1961, *Paradilepis urceina* Bona, 1975, *Paradilepis phalacrocoracis* Ukoli, 1968, *Paradilepis minima* Goss, 1914, *Paradilepis patriciae* Baer & Bona, 1960, *Paradilepis rugovaginosus* Freeman, 1954, *Paradilepis scolecina* Rudolphi, 1819, *Paradilepis simoni* Rausch, 1949, *Paradilepis urceus* Wedl, 1855, and *P. caballeroi* (Presswell et al., 2012). The latter species has been found in *Pelecanus occidentalis* (Pelecanidae) and *N. (P.) auritus* in the United States (Fedynich et al., 1997; Forrester & Spalding, 2003), *N. (P.) auritus* in Canada (Robinson, 2011), *N. (P.) brasiliensis*, *P. occidentalis*, *Pelecanus erythrorhynchos* (Pelecanidae), and *Platalea ajaja* (Threskiornithidae) in Mexico (Scholz et al., 2002; Ortega-Olivares et al., 2014), *N. (P.) auritus* in Cuba (Scholz et al., 2002) and *N. (P.) brasiliensis* in Brazil (Monteiro et al., 2011). This is the first time that *P. caballeroi* has been reported in Chile.

Nematoda

Five nematode species were isolated from Neotropic cormorants' carcasses, *Anisakis* sp. (Figure 4a), *Baruscaphillaria carbonis* Dubinin & Dubinina 1940, *Avioserpens* sp. Wehr & Chitwood 1934 (Figure 4b, c), *Cyathostoma (Cyathostoma) phenisci* Baudet, 1937 (Figure 4d), and *Contraecum rudolphii* s. l. (Rudolphi, 1809) Hartwich, 1964 (Figure 4e).

Anisakis sp. and *C. rudolphii* s. l. has been previously recorded in the Neotropic cormorant and *C. (C.) phenisci* has been described for the Imperial shag in Chile (Torres et al., 1982, 2005; Oyarzún-Ruiz & Muñoz-Alvarado, 2015). This is the first report of *C. (C.) phenisci* in the Neotropic cormorant. Information about population parameters for Nematoda recorded in this study can be found in Table 1.

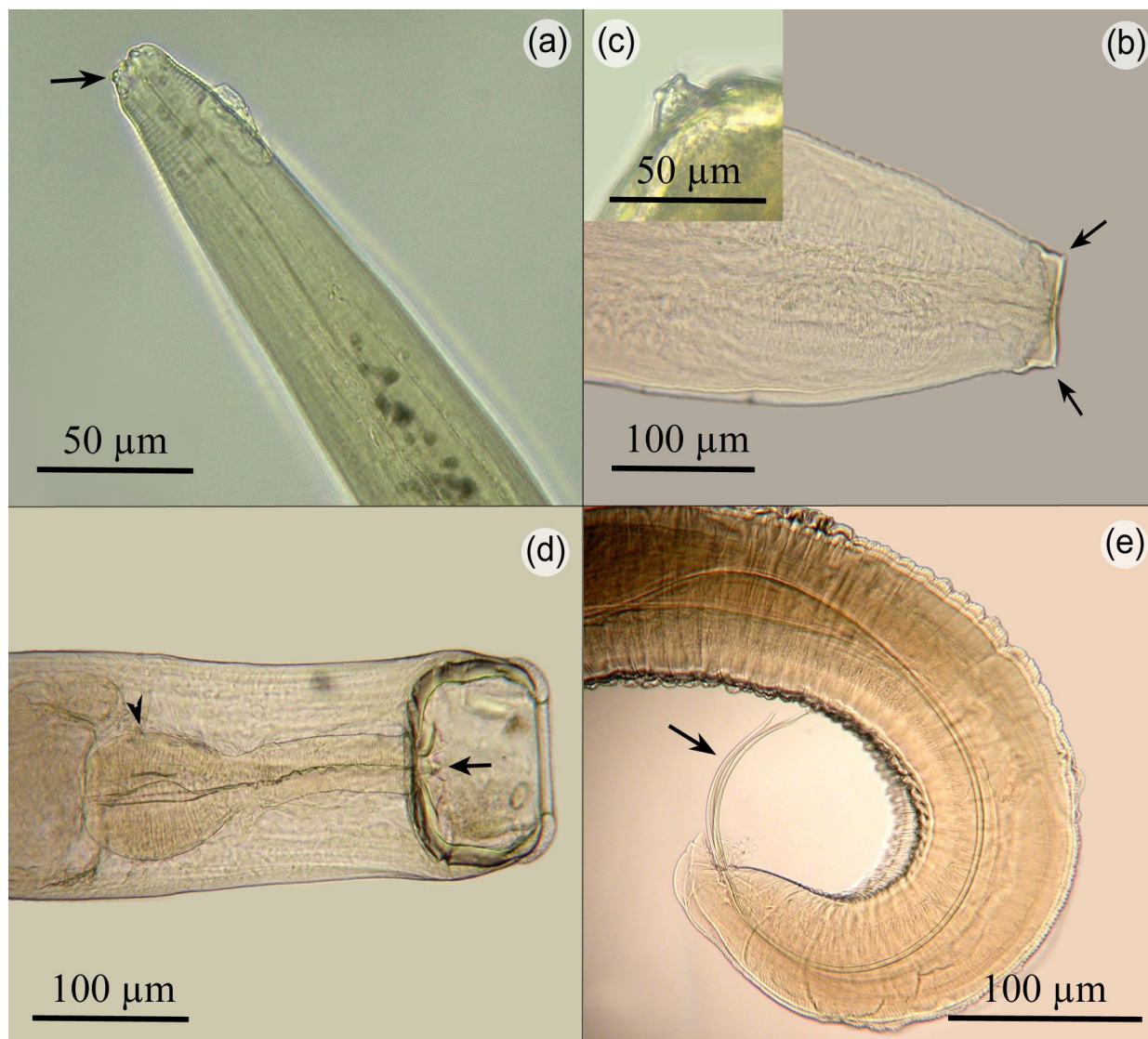


Figure 4. (a) View of anterior end of *Anisakis* sp. larva showing the presence of boring tooth (arrow) and lips forming medial bilobed process without interlabia (250x magnification); (b, c) Photomicrographs of *Avioserpens* sp. displaying the (b) anterior view end bearing two double cephalic papillae (arrows) (40x magnification); (c) and magnification of a cephalic papillae (500x magnification); (d) View of an individual from *Cyathostoma* (*Cyathostoma*) *phenisci* showing its anterior end with a wide buccal capsule bearing six teeth at its basis (arrow) and its muscular esophagus dilated at its caudal third (arrowhead) (400x magnification); (e) View of posterior end from a male *Contracaecum rudolphii* s. l. displaying its long and thin pair of subequal spicules (arrow) (400x magnification).

B. carbonis

Baruscapillaria carbonis is a specialist parasite of cormorants and it is suggested that fish may play an important role in its development and transmission (Frantová, 2001). *Baruscapillaria carbonis* has been described in *P. carbo* and *Microcarbo pygmaeus* in the European continent (Baruš & Sergeeva, 1990; Frantová, 2001; Sitko & Okulewicz, 2010; Kanarek & Zaleśny, 2014). *Baruscapillaria carbonis* has been reported in other fish-eating hosts in the Palearctic region, but those records are considered dubious as they were not properly described (Baruš et al., 1978; Moravec et al., 1994). This study is the first record of *B. carbonis* in the Neotropic cormorant.

Avioserpens sp.

Species of the *Avioserpens* genus usually occur in the subcutaneous tissue of piscivorous birds (Gibson, 1973; Wang et al., 1983). Nine species have been recognized in different domestic and wild birds, most of them in the Northern Hemisphere. For instance, *Avioserpens mosgovoyi* Supryaga, 1965 was identified in *Podiceps cristatus*,

Podiceps grisigena, *Podiceps ruficollis* (Podicipedidae), *Gavia arctica* (Gaviidae), *Anas platyrhynchos*, *Aythya ferina*, *Anser* sp. (Anatidae), and *Fulica atra* (Rallidae) in Russia and in *Alectoris rufa* (Phasianidae) in the Canary Islands (Gibson, 1973; Cordero del Campillo et al., 1994); *Avioserpens galliardi* Chabaud & Campana, 1949 in *Egretta garzetta* in France, *Ixobrychus minutus* in Italy, *Ardea cinerea* in Slovenia, *E. garzetta*, *A. cinerea*, *Ardea purpurea*, *A. alba*, *N. nycticorax*, *Botaurus stellaris* (Ardeidae), *Gavia stellata* (Gaviidae), and *Mergus merganser* (Anatidae) in the Palearctic region, and *N. nycticorax*, *I. minutus*, *A. purpurea*, and *E. garzetta* in Spain (Chabaud & Campana, 1949; Daiya, 1967; Baruš et al., 1978; Brglez, 1982; Nogueserola et al., 2002; Santoro et al., 2016); *Avioserpens denticulophasma* Wehr & Chitwood, 1934 in *A. alba*, *Anhinga anhinga* (Anhingidae), *Anas fulvigula*, and *A. platyrhynchos* (Anatidae) in the United States (Wehr, 1934; Wehr & Chitwood, 1934); *Avioserpens taiwana* Sugimoto, 1919 in *A. platyrhynchos*, *Cairina moschata domesticus* (Anatidae), and *Gallus gallus domesticus* (Phasianidae) in China and *Anas boschas* and *C. m. domesticus* in Taiwan and Vietnam (Sugimoto, 1934; Chabaud et al., 1950), *Avioserpens nana* Mawson, 1957 in *A. herodias* in Canada (Mawson, 1957); *Avioserpens multipapillosa* Singh, 1949 in *Ardeola grayii* (Ardeidae) in India (Deshmukh, 1971); *Avioserpens bifidus* Olsen, 1952 in *Bucephala islandica* (Anatidae) in the United States (Olsen, 1952) and *Avioserpens* sp. in *B. lentiginosus* in Canada, *Cygnus melancoryphus* (Anatidae) in Chile, *N. nycticorax* in Brazil, *Aechmophorus occidentalis* (Podicipedidae) in the United States, and *I. minutus* and *Plegadis falcinellus* (Threskiornithidae) in Iraq (Gibson, 1973; Arruda et al., 2001; González-Acuña et al., 2010; Al-Salim & Ali, 2010; Latas et al., 2016). This is the first time that *Avioserpens* sp. is recorded in the Neotropic cormorant.

C. (*C.*) *phenisci*

The genus *Cyathostoma* is composed of more than twenty species that parasitize sixteen different avian orders around the planet (Kanarek et al., 2013). Fish-eating birds are parasitized by the subgenus *Cyathostoma*, represented by species *Cyathostoma* (*C.*) *lari* (gulls), *C. (C.) phenisci* (penguins and cormorants), *Cyathostoma* (*C.*) *verrucosum* (pelicans and storks), *Cyathostoma* (*C.*) *trifurcatum* (*Ciconia nigra*), and *Cyathostoma* (*C.*) *microspiculum* (cormorants) (Kanarek et al., 2013; Oyarzún-Ruiz & Muñoz-Alvarado 2015). *Cyathostoma* (*C.*) *microspiculum* has been reported in *P. carbo* and *M. pygmaeus* in Asia and Europe and possibly in *N. (P.) auritus* in North America (Kanarek, 2009; Kanarek & Zalesny, 2014). *Cyathostoma* (*C.*) *phenisci* is the only species reported previously in a Chilean cormorant, *Phalacrocorax atriceps* (Oyarzún-Ruiz & Muñoz-Alvarado, 2015). This study is the first report of *C. (C.) phenisci* in the Neotropic cormorant.

Acanthocephala

Andracantha phalacrocoracis (Figure 5a), *Profilicollis altmani* Perry, 1942 (Figure 5b) and *Corynosoma arctocephali* (Figure 5c) were identified in cormorants' carcasses in this study. *Corynosoma arctocephali* has been previously reported in *N. (P.) brasiliensis* in Chile (Torres et al., 1993). Information about population parameters for Acanthocephala recorded in this study can be found in Table 1.

A. *phalacrocoracis*

Andracantha Schmidt, 1975 is a cosmopolitan genus that parasitizes cormorants and other piscivorous birds (Schmidt, 1975). There are seven species within the genus described to this date: *Andracantha baylisi* Zdzitowiecki, 1986, *Andracantha clavata* Goss, 1940, *Andracantha gravida* Alegret, 1941, *Andracantha mergi* Lundstrom, 1941, *Andracantha tandemtesticulata* Monteiro, 2006, *Andracantha tunitae* Weiss, 1914, and *A. phalacrocoracis* (Monteiro et al., 2006a). *Andracantha phalacrocoracis* has been described in *Urile pelagicus* (Phalacrocoracidae) in the United States and Japan, *P. carbo* in Czech Republic, *Haliaeetus leucocephalus* (Accipitridae) in the United States, and *N. (P.) brasiliensis* in Brazil (Schmidt, 1975; Našincová et al., 1993; Richardson & Cole, 1997; Aznar et al., 2006; Monteiro et al., 2006a). Findings in this study expand the distributional range of *A. phalacrocoracis* to Chile.

P. *altmani*

The genus *Profilicollis* Meyer, 1931 is composed of nine species, which use crustaceans as intermediary hosts and parasitizes seabirds as their definitive host (Rodríguez et al., 2017). *Profilicollis antarcticus* Zdzitowiecki, 1985, *Profilicollis chasmagnathi* Holcman-Spector, Mañé-Garzón and Dei-Cas, 1977, and *P. altmani* have been recorded in South America (Rodríguez et al., 2017), with the latter having a Pan-American distribution (Rodríguez & D'Elía, 2017). Along the Pacific coast of South America, *P. altmani* uses the Pacific mole crab (*Emerita analoga*) as

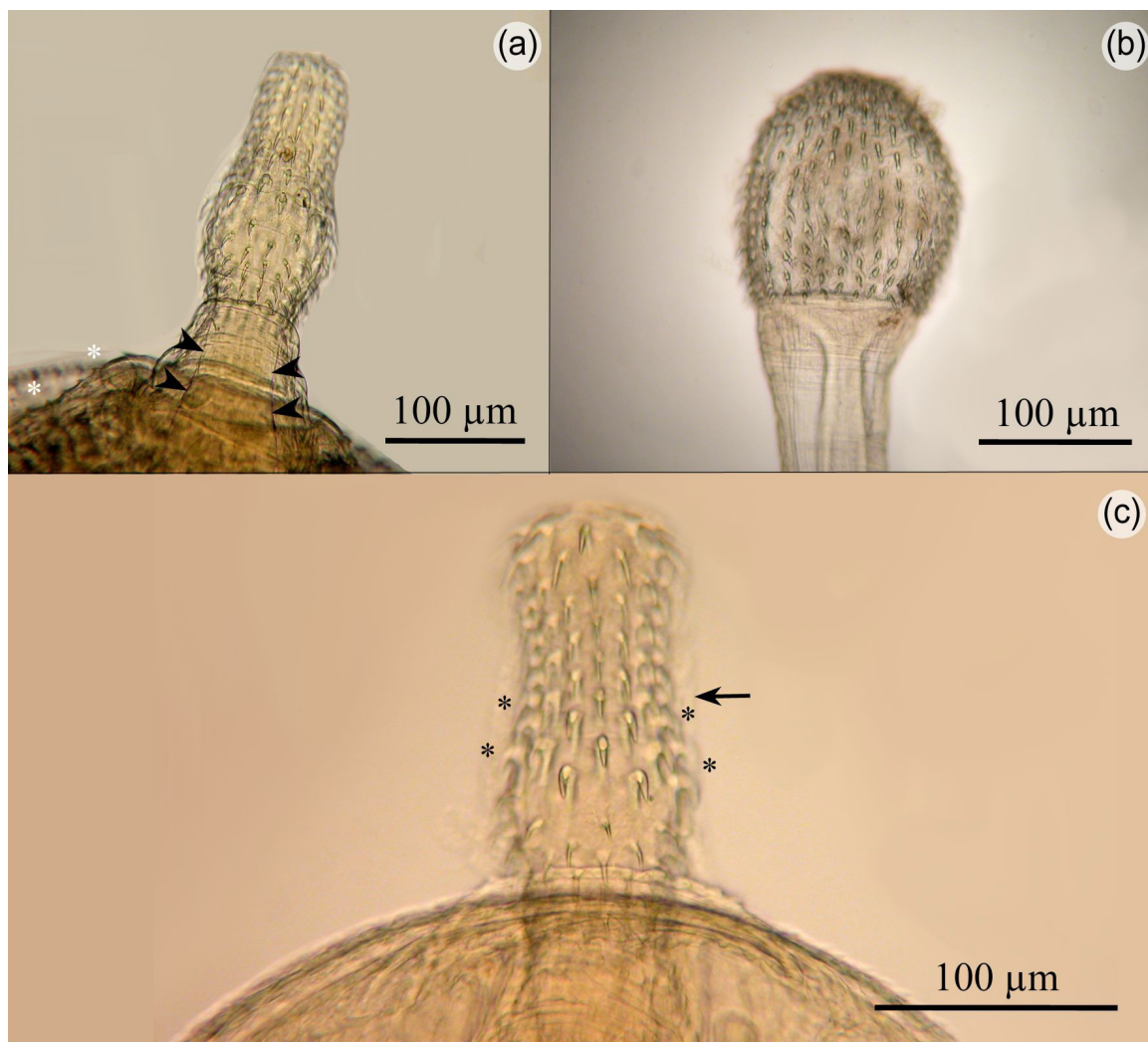


Figure 5. (a) *Andracantha phalacrocoracis* showing its cylindrical proboscis swollen at its posterior half armed with several longitudinal rows of small hooks, neck lacking hooks (arrow heads), and trunk covered with small spines (asterisks) (400x magnification); (b) *Profilicollis altmani* with its typical spherical proboscis covered with several rows of small hooks and lacking hooks in the neck (400x magnification); (c) *Corynosoma arctocephali* showing its proboscis constricted at its middle area (arrow) and armed with larger hooks (asterisks) in comparison to hooks present in the anterior and posterior areas of the proboscis (400x magnification).

intermediate host and has been described in *Larus belcheri*, *Leucophaeus modestus*, and *Larus pipixcan* (Laridae) in Peru (Tantaleán et al., 2005) and *Larus dominicanus*, *L. pipixcan* (Laridae), *Numenius phaeopus* (Scolopacidae), *Podiceps occipitalis* (Podicipedidae), and *Egretta* sp. (Ardeidae) in Chile (Riquelme et al., 2006). This study reports *P. altmani* in the Neotropic Cormorant for the first time.

This is the first report of *P. altmani*, *B. carbonis*, *Avioserpens* sp., *C. (C.) phenisci*, and *E. pelucida* in the Neotropic cormorant. In addition, these findings expand the distributional range of *A. phalacrocoracis*, *P. caballeroi*, *H. triloba*, and *P. gyroceras* to Chile.

In this study, a total of 13 parasite morphs were collected from Neotropic cormorant, 11 of which were described to the species level. Most of these descriptions are new records for Chile. Lice *P. gyroceras* and *E. pelucida*, trematodes *A. felippeii* and *H. triloba*, nematodes *C. rudolphii* s. l., *B. carbonis*, and *C. (C.) phenisci*, cestode *P. caballeroi*, and acanthocephalans *A. phalacrocoracis*, *C. arctocephali*, and *P. altmani* are, in most cases, parasite species distributed in different geographical areas of the American continent. There are some species, such as *H. triloba*, that are cosmopolitan and have been recorded in a wide range of hosts. Although this study describes their presence in Chile for the first time, it is likely that they have been present in the country since the establishment of parasite-host associations with local wildlife. Conversely, it is also possible that some of these species were introduced into the country through parasitized migratory birds that arrive seasonally to spend the summer in the Southern

Hemisphere (Martínez & González, 2017). Nonetheless, molecular studies are necessary in order to test this latter hypothesis, which will most likely involve the application of molecular tools to study parasite populations in their different distribution areas.

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References

- Aguirre-Macedo ML, García-Magaña L. Metacercarias de cíclidos nativos del Sureste de México; taxonomía y claves para su reconocimiento. *Univ Cienc* 1994; 11(21): 5-35. <http://dx.doi.org/10.19136/era.a11n21.612>.
- Alda P, Martorelli SR, Sarria R. Digenean Parasites in the White-Backed Stilt *Himantopus melanurus* Vieillot, 1817 (Recurvirostridae) from the Argentine Coast. *Comp Parasitol* 2011; 78(1): 217-219. <http://dx.doi.org/10.1654/4479.1>.
- Al-Salim NK, Ali AH. First record of five nematode species in some water birds from Al-Hammar marsh, south of Iraq. *Bull Iraq Nat Hist Mus* 2010; 11(2): 39-53.
- Arruda VS, Pinto RM, Muniz-Pereira LC. New host and geographical records for helminths parasites of Ardeidae (Aves, Ciconiiformes) in Brazil. *Rev Bras Zool* 2001; 18(Suppl 1): 225-232. <http://dx.doi.org/10.1590/S0101-81752001000500018>.
- Aznar FJ, Pérez-Ponce de León G, Raga JA. Status of *Corynosoma* (Acanthocephala: Polymorphidae) based on anatomical, ecological, and phylogenetic evidence, with the erection of *Pseudocorynosoma* n. gen. *J Parasitol* 2006; 92(3): 548-564. <http://dx.doi.org/10.1645/GE-715R.1>. PMID:16883999.
- Barreto M, Burbano ME, Proctor HC, Mironov SV, Wauthy G. Feather mites (Acariformes: Psoroptidia) from Colombia: Preliminary list with new records. *Zootaxa* 2012; 3516(1): 1-68. <http://dx.doi.org/10.11646/zootaxa.3516.1.1>. PMID:23847408.
- Baruš V, Sergeeva TP, Sonin MD, Ryzhikov KM. *Helminths of fish-eating birds of the Palaearctic Region. 1. Nematoda*. Prague: Springer Science; 1978. <http://dx.doi.org/10.1007/978-94-009-9972-5>.
- Baruš V, Sergeeva TP. Capillariids parasitic in birds in the Palaearctic Region 3. Genus *Baruscapillaria*. *Acta Sci Nat Brno* 1990; 24(10): 1-53.
- Bjoersdorff A, Bergstrom S, Massung RF, Haemig PD, Olsen B. *Ehrlichia*-infected ticks on migrating birds. *Emerg Infect Dis* 2001; 7(5): 877-879. <http://dx.doi.org/10.3201/eid0705.017517>. PMID:11747702.
- Boch J, Supperer R. *Parasitología en medicina veterinaria*. Buenos Aires: Hemisferio Sur; 1982.
- Boero JJ, Led JE, Brandetti E. Algunos parásitos de la avifauna argentina. *Analecta Vet* 1972; 4(1): 17-25.
- Brglez J. *Avioserpens galliardi* and *Ingliseria cirrohamata* in birds from Slovenia. *Zb Bio Fak Uni Edv Kard Ljub Vet* 1982; 19(2): 247-251.
- 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.
- Carrera-Játiva PD, Rodríguez-Hidalgo R, Sevilla C, Jiménez-Uzcátegui G. Gastrointestinal parasites in the Galápagos Penguin *Spheniscus mendiculus* and the Flightless Cormorant *Phalacrocorax harrisi* in the Galápagos Islands. *Mar Ornithol* 2014; 42: 77-80.
- Carss DN. Techniques for assessing cormorant diet and food intake: towards a consensus view. *Suppl Ric Biol Selvaggina* 1997; 26: 197-230.
- Cattán P, Tagle L. Estudio preliminar de la helmintiasis gastrointestinal en el conejo silvestre *Oryctolagus cuniculus*. *Rev Soc Med Vet Chile* 1974; 24(1): 34-42.
- Chabaud AG, Campana U, Truong-Tan-Ngoc. Note sur les dracunculides d'oiseaux. *Ann Parasitol Hum Comp* 1950; 25(4): 335-339. <http://dx.doi.org/10.1051/parasite/1950254335>. PMID:14790467.
- Chabaud AG, Campana Y. *Avioserpens galliardi* n. sp. parasite de l'aigrette *Egretta garzetta*, L. *Ann Parasitol Hum Comp* 1949; 24(1-2): 67-76. <http://dx.doi.org/10.1051/parasite/1949241067>. PMID:18131387.
- Chandler AC, Rausch R. A contribution to the study of certain avian strigeids (Trematoda). *J Parasitol* 1948; 34(3): 207-210. <http://dx.doi.org/10.2307/3273266>. PMID:18867395.

- Chester S. *A wildlife guide to Chile: Continental Chile, Chilean Antarctica, Easter Island, Juan Fernandez Archipelago*. Princeton: Princeton University Press; 2008.
- Clay T. The species groups of *Pectinopygus* (Phthiraptera: philopteridae). *Bull Br Mus Nat Hist Entomol Ser* 1973; 29(4): 203-223.
- Cordero del Campillo M, Castañón L, Reguera A. *Índice catálogo de zooparásitos ibéricos*. 2nd ed. León: Secretariado de Publicaciones Universidad de León; 1994.
- Daiya GG. Nematodes of fish-eating birds of the lower Ob. In: Ryzhikov KM, editor. *Sbornik rabot po gel'mintofaune ryb i ptits*. Moscow: Izdat Akad Nauk SSSR; 1967. p. 133-153.
- Dale W. *Mallophaga (Hexapoda) en aves de la costa y sierra centrales del Perú* [dissertation]. Lima: Universidad Nacional Agraria La Molina; 1970.
- Deem SL, Merkel J, Ballweber L, Vargas FH, Cruz MB, Parker PG. Exposure to *Toxoplasma gondii* in Galapagos Penguins (*Spheniscus mendiculus*) and Flightless Cormorants (*Phalacrocorax harrisi*) in the Galapagos Island, Ecuador. *J Wildl Dis* 2010; 46(3): 1005-1011. <http://dx.doi.org/10.7589/0090-3558-46.3.1005>. PMID:20688714.
- Deshmukh PG. On the male of *Avioserpens multipapillosa* Singh, 1949 from *Ardeola grayii*. *Riv Parassitol* 1971; 32(2): 101-103. PMID:5166875.
- Drago FB, Lunaschi LI, Schenone M. Digenean parasites of the Neotropic cormorant, *Phalacrocorax brasilianus* (Gmelin, 1789) (Aves: Phalacrocoracidae) from Argentina: Distribution extension and new host records. *Check List* 2011; 7(6): 871-875. <http://dx.doi.org/10.15560/7.6.871>.
- Emerson KC. Notes on the Menoponidae of North America. I. *Can Entomol* 1947; 79(7-8): 135-141. <http://dx.doi.org/10.4039/Ent79135-7>.
- Fedynich AM, Pence DB, Bergan JF. Helminth community structure and pattern in sympatric populations of double-crested and Neotropic cormorants. *J Helminthol Soc Wash* 1997; 64(2): 176-182.
- Forrester DJ, Spalding MG. *Parasites and diseases of wild birds in Florida*. Gainesville: University Press of Florida; 2003.
- Frantová D. Capillariid nematodes (Nematoda: Capillariidae) parasitic in the common cormorant (*Phalacrocorax carbo*), with redescription of *Baruscapillaria carbonis* (Dubinin et Dubinina, 1940). *Folia Parasitol (Praha)* 2001; 48(3): 225-230. <http://dx.doi.org/10.14411/fp.2001.037>. PMID:11699658.
- Gabor LJ, Srivastava M, Titmarsh J, Dennis M, Gabor M, Landos M. Cryptosporidiosis in intensively reared barramundi (*Lates calcarifer*). *J Vet Diagn Invest* 2011; 23(2): 383-386. <http://dx.doi.org/10.1177/104063871102300235>. PMID:21398470.
- Garbin L, Mattiucci S, Paoletti M, González-Acuña D, Nascetti G. Genetic and morphological evidences for the existence of a new species of *Contraecaecum* (Nematoda: Anisakidae) parasite of *Phalacrocorax brasilianus* (Gmelin) from Chile and its genetic relationships with congeners from fish-eating birds. *J Parasitol* 2011; 97(3): 476-492. <http://dx.doi.org/10.1645/GE-2450.1>. PMID:21506861.
- García-Walther J, Senner NR, Norambuena HV, Schmitt F. *Atlas de las aves playeras de Chile: sitios importantes para su conservación*. Santiago: Universidad Santo Tomás; 2017.
- Ghoneim NH, Abdel-Moein KA, Saeed H. Fish as a possible reservoir for zoonotic *Giardia duodenalis* assemblages. *Parasitol Res* 2012; 110(6): 2193-2196. <http://dx.doi.org/10.1007/s00436-011-2748-y>. PMID:22160281.
- Gibson GG. *Cardiofilaria pavlovskyi* Strom, 1937 and *Avioserpens* sp. (Nematoda) from Canadian ciconiiform birds. *Can J Zool* 1973; 51(8): 847-851. <http://dx.doi.org/10.1139/z73-126>. PMID:4750285.
- Giebel C. Die im zoologischen Museum der Universität Halle aufgestellten Epizoen nebst Beobachtungen über dieselben. *Zeitschrift für die Gesamten der Naturwissenschaften* 1866; 28: 353-397.
- González-Acuña D, Moreno L, Cicchino A, Mironov S, Kinsella M. Checklist of the parasites of the black-necked swan, *Cygnus melanocoryphus* (Aves: Anatidae), with new records from Chile. *Zootaxa* 2010; 2637(1): 55-68. <http://dx.doi.org/10.11646/zootaxa.2637.1.3>.
- Gupta R. On two new diplostome parasites of birds, with a note on *Hysteromorpha triloba* (Rud., 1819) Lutz, 1931 from India (Trematoda: diplostomatidae). *Rev Biol Trop* 1963; 11(1): 75-87.
- Hastriter MW. *Ceratophyllus altus* Tipton and Mendez (Siphonaptera: Ceratophyllidae) in Chile, with notes on the distribution of the genus *Ceratophyllus* Curtis 1832 in the southern hemisphere. *Proc Entomol Soc Wash* 2001; 103(3): 582-585.
- Hernandes FA, Mironov SV, Bauchan GR, Ochoa RA. A new asymmetrical feather mite of the genus *Michaelia* Trouessart, 1884 (Astigmata: Freyanidae) from the Neotropical Cormorant, *Phalacrocorax brasilianus* (Pelecaniformes). *Acarologia* 2016; 56(1): 45-61. <http://dx.doi.org/10.1051/acarologia/20162187>.

- Hinojosa-Sáez A, González-Acuña D. Estado actual del conocimiento de helmintos en aves silvestres de Chile. *Gayana* 2005; 69(2): 241-253. <http://dx.doi.org/10.4067/S0717-65382005000200004>.
- Hughhins EJ. Life history of a strigeid trematode, *Hysteromorpha triloba* (Rudolphi, 1819) Lutz, 1931. I. Egg and miracidium. *Trans Am Microsc Soc* 1954a; 73(1): 1-15. <http://dx.doi.org/10.2307/3224180>.
- Hughhins EJ. Life history of a strigeid trematode, *Hysteromorpha triloba* (Rudolphi, 1819) Lutz, 1931. II. Sporocyst through adult. *Trans Am Microsc Soc* 1954b; 73(3): 221-236. <http://dx.doi.org/10.2307/3224061>.
- International Union for Conservation of Nature and Natural Resources – IUCN. *Phalacrocorax brasilianus*. In International Union for Conservation of Nature and Natural Resources – IUCN. *The IUCN Red List of Threatened Species* [online]. Cambridge: IUCN; 2017. <http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22696773A93585558.en>.
- Jenssen BM. Review article: effects of oil pollution, chemically treated oil, and cleaning on thermal balance of birds. *Environ Pollut* 1994; 86(2): 207-215. [http://dx.doi.org/10.1016/0269-7491\(94\)90192-9](http://dx.doi.org/10.1016/0269-7491(94)90192-9). PMID:15091638.
- Johnston TH. Trematodes from Australian birds. I. Cormorants and darters. *Trans R Soc S Aust* 1942; 65(2): 226-242.
- Kanarek G, Horne EC, Zaleśny G. *Cyathostoma* (*Cyathostoma*) *phenisci* Baudet, 1937 (Nematoda: Syngamidae), a parasite of respiratory tract of African penguin *Spheniscus demersus*: Morphological and molecular characterisation with some ecological and veterinary notes. *Parasitol Int* 2013; 62(5): 416-422. <http://dx.doi.org/10.1016/j.parint.2013.05.002>. PMID:23684707.
- Kanarek G, Sitko J, Rolbiecki L, Rokicki J. Digenean fauna of the great cormorant *Phalacrocorax carbo sinensis* (Blumenbach, 1798) in the brackish waters of the Vistula Lagoon and the Gulf of Gdańsk (Poland). *Wiad Parazytol* 2003; 49(3): 293-299. PMID:16889033.
- Kanarek G, Zaleśny G. Extrinsic-and intrinsic-dependent variation in component communities and patterns of aggregations in helminth parasites of great cormorant (*Phalacrocorax carbo*) from N.E. Poland. *Parasitol Res* 2014; 113(3): 837-850. <http://dx.doi.org/10.1007/s00436-013-3714-7>. PMID:24297694.
- Kanarek G. The occurrence of *Cyathostoma* (*Cyathostoma*) *microspiculum* (Skrjabin, 1915) (Nematoda: Syngamidae) in the great cormorant [*Phalacrocorax carbo* (L., 1758)] in north-eastern Poland. *J Helminthol* 2009; 83(4): 391-398. <http://dx.doi.org/10.1017/S0022149X09990307>. PMID:19531273.
- Keler S. Über eine neue gattung von Mallophagen, *Eidmaniella* n. gen. *Ann Mus Zool Pol* 1938; 13: 81-87.
- Kennedy M, Spencer HG. Classification of the cormorants of the world. *Mol Phylogenet Evol* 2014; 79: 249-257. <http://dx.doi.org/10.1016/j.ympev.2014.06.020>. PMID:24994028.
- Khalil LF, Jones A, Bray RA. *Keys to the cestode parasites of vertebrates*. Wallingford: CAB International; 1994.
- Kornyushin VV. Cormorant (*Phalacrocorax carbo* L.) as a potential source of the helminthosis spreading in fish, game-birds and fowls. *Branta* 2008; 11: 200-203.
- Kuabara KM, Valim MP. New records of chewing lice (Insecta, Phthiraptera) from Brazilian birds (Aves) collected by Helmut Sick (1910–1991). *Rev Bras Entomol* 2017; 61(2): 146-161. <http://dx.doi.org/10.1016/j.rbe.2016.12.006>.
- Kuiken T, Leighton FA, Wobeser G, Wagner B. Causes of morbidity and mortality and their effect on reproductive success in double-crested cormorants from Saskatchewan. *J Wildl Dis* 1999; 35(2): 331-346. <http://dx.doi.org/10.7589/0090-3558-35.2.331>. PMID:10231760.
- Lamont MA. A new species of *Clinostomum*. *Ocass Pap Mus Zool* 1920; 83: 1-5.
- Latas PJ, Stockdale Walden HD, Bates L, Marshall S, Rohr T, Whitehead LR. *Avioserpens* in the Western Grebe (*Aechmophorus occidentalis*): A new Host and Geographic Record for a Dracunculoid Nematode and Implications of Migration and Climate Change. *J Wildl Dis* 2016; 52(1): 189-192. <http://dx.doi.org/10.7589/2015-06-169>. PMID:26555111.
- Lebedeva DI, Chantuu K. New data on bird helminths in Mongolia. *Parazitologija* 2015; 49(4): 304-308. PMID:26827489.
- Leigh WH. Observations on life-histories of members of the genus *Ascocotyle* Looss (Heterophyidae). *J Parasitol* 1956; 42(4): 39.
- León C, Benítez-Mora A. *Guía de campo avifauna presente en el sector adyacente al Canal El Morro, Humedal Rocuant-Andalién, Octava Región, Chile*. Talcahuano: Dirección de Medio Ambiente; 2005.
- Lunaschi L, Drago F. Primer registro de *Neodiplostomum travassosi* (Digenea: Diplostomidae) en Argentina. *Rev Mex Biodivers* 2005; 76(1): 97-100. <http://dx.doi.org/10.22201/ib.20078706e.2005.001.353>.
- Malcomson RO. Mallophaga from birds of North America. *Wilson Bull* 1960; 72(2): 182-197.
- Martínez DE, González GE. *Aves de Chile: guía de campo y breve historia natural*. Santiago, Chile: Ediciones del Naturalista; 2017.
- Mateo MM. Diversidad y distribución de las especies de Mallophaga (Insecta) en aves y mamíferos de la comunidad de Madrid. *Graellsia* 2006; 62(Extra): 21-32. <http://dx.doi.org/10.3989/graeellsia.2006.v62.iExtra.108>.
- Mawson PM. Filariid nematodes from Canadian birds. *Can J Zool* 1957; 35(2): 213-219. <http://dx.doi.org/10.1139/z57-018>.

- Medema GJ. *Cryptosporidium and Giardia: new challenges to the water industry* [dissertation]. Utrecht: University of Utrecht; 1999.
- Mironov SV. A review of the feather mite genus *Scutomegninia* Dubinin, 1951 (Acarina: Analgoidea: Avenzoariidae). *Acarina* 2000; 8(1): 9-58.
- Mironov SV. *Allopsoroptoides galli* n. g., n. sp., a new genus and species of feather mites (Acari: Analgoidea: Psoroptoididae) causing mange in commercially raised domestic chicken in Brazil. *Syst Parasitol* 2013; 85(3): 201-212. <http://dx.doi.org/10.1007/s11230-013-9422-y>. PMID:23793494.
- Monteiro C, Amato J, Amato S. A new species of *Andracantha* Schmidt (Acanthocephala, Polymorphidae) parasite of Neotropical cormorants, *Phalacrocorax brasilianus* (Gmelin) (Aves, Phalacrocoracidae) from southern Brazil. *Rev Bras Zool* 2006a; 23(3): 807-812. <http://dx.doi.org/10.1590/S0101-81752006000300027>.
- Monteiro C, Amato J, Amato S. Helminth parasitism in the Neotropical cormorant, *Phalacrocorax brasilianus*, in Southern Brazil: effect of host size, weight, sex, and maturity state. *Parasitol Res* 2011; 109(3): 849-855. <http://dx.doi.org/10.1007/s00436-011-2311-x>. PMID:21431903.
- Monteiro C, Amato J, Amato S. Primeiro registro de *Syncuaria squamata* (Linstow) (Nematoda, Acuariidae) em biguás, *Phalacrocorax brasilianus* (Gmelin) (Aves, Phalacrocoracidae) no Brasil. *Rev Bras Zool* 2006b; 23(4): 1268-1272. <http://dx.doi.org/10.1590/S0101-81752006000400041>.
- Monteiro C, Amato J, Amato S. *Prosthogonimus ovatus* (Rudolphi) (Digenea, Prosthogonimidae) em três espécies de aves aquáticas da Região Sul do Brasil. *Rev Bras Zool* 2007; 24(1): 253-257. <http://dx.doi.org/10.1590/S0101-81752007000100035>.
- Moravec F, Scholz T, Našincová V. The systematic status of *Trichosoma carbonis* Rudolphi, 1819 and a description of *Baruscaphillaria rudolphii* n. sp. (Nematoda: Capillariidae), an intestinal parasite of cormorants. *Syst Parasitol* 1994; 28(2): 153-158. <http://dx.doi.org/10.1007/BF00009593>.
- Moreno L, González-Acuña D. Los parásitos de las aves rapaces de Chile: una revisión. *Bol Chil Ornitol* 2015; 21(1-2): 93-102.
- Našincová V, Moravec F, Scholz T. Trematodes of the common cormorant (*Phalacrocorax carbo*) in Czech Republic. *Acta Soc Zool Bohem* 1993; 57(1): 31-46.
- Nogueserola ML, Navarro P, Lluç J. Helminths parasites of Ardeidae in Valencia (España). *An Biol* 2002; 24: 139-144.
- Olsen OW. *Avioserpens bifidus*, a new species of nematode (Dracunculidae) from ducks. *Trans Am Microsc Soc* 1952; 71(2): 150-153. <http://dx.doi.org/10.2307/3223075>.
- Ortega-Olivares MP, Garcia-Prieto L, Garcia-Varela M. Gryporhynchidae (Cestoda: Cyclophyllidea) in Mexico: species list, hosts, distribution and new records. *Zootaxa* 2014; 3795(2): 101-125. <http://dx.doi.org/10.11646/zootaxa.3795.2.1>. PMID:24870465.
- Ostrowski de Núñez M. Fauna de agua dulce en la República Argentina. VI. Las cercarias de *Ascocotyle* (A.) *tenuicollis* Price 1935 y de *Pygidiopsis pindoramensis* Travassos 1929 (Trematoda, Heterophyidae). *Physis, Secc B* 1976; 35(90): 51-57.
- Oyarzún-Ruiz P, González-Acuña D. Colecta, preparación e identificación de parásitos. *Parasitol Latinoam* 2020; 69(1): 12-29.
- Oyarzún-Ruiz P, Muñoz-Alvarado P. Cormorán imperial, *Phalacrocorax atriceps* (Aves, Phalacrocoracidae): Nuevo hospedero para un parásito respiratorio, *Cyathostoma* (*Cyathostoma*) *phenisci* (Nematoda, Syngamidae). *Rev Biol Mar Oceanogr* 2015; 50(2): 353-358. <http://dx.doi.org/10.4067/S0718-19572015000300013>.
- Palma R. Slide-mounting of lice: a detailed description of the Canada balsam technique. *N Z Entomol* 1978; 6(4): 432-436. <http://dx.doi.org/10.1080/00779962.1978.9722313>.
- Pedroso LGA, Hernandez FA. New records of feather mites (Acariformes: Astigmata) from non-passerine birds (Aves) in Brazil. *Check List* 2016; 12(6): 1-25. <http://dx.doi.org/10.15560/12.6.2000>.
- Pence DB, Spalding MG, Bergan JF, Cole RA, Newman S, Gray PN. New records of subcutaneous mites (Acari: Hypoderatidae) in birds, with examples of potential host colonization events. *J Med Entomol* 1997; 34(4): 411-416. <http://dx.doi.org/10.1093/jmedent/34.4.411>. PMID:9220674.
- Plutzer J, Tomor B. The role of aquatic birds in the environmental dissemination of human pathogenic *Giardia duodenalis* cysts and *Cryptosporidium* oocysts in Hungary. *Parasitol Int* 2009; 58(3): 227-231. <http://dx.doi.org/10.1016/j.parint.2009.05.004>. PMID:19446039.
- Presswell B, Poulin R, Randhawa HS. First report of a gryporhynchid tapeworm (Cestoda: Cyclophyllidea) from New Zealand and from an eleotrid fish, described from metacestodes and *in vitro*-grown worms. *J Helminthol* 2012; 86(4): 453-464. <http://dx.doi.org/10.1017/S0022149X11000691>. PMID:22152219.
- Price EW. Description of some heterophyid trematodes of the subfamily Centrocestinae. *Proc Helminthol Soc Wash* 1935; 2(2): 70-73.
- Price RD, Hellenthal RA, Palma RL, Johnson KP, Clayton DH. *The chewing lice: world checklist and biological overview*. Champaign: Illinois Natural History Survey; 2003.

- Price RD. The *Piagetiella* (Mallophaga: Menoponidae) of the Pelecaniformes. *Can Entomol* 1970; 102(4): 389-404. <http://dx.doi.org/10.4039/Ent102389-4>.
- Pritchard MH, Kruse GOW. *The collection and preservation of animal parasites*. Lincoln: University of Nebraska Press; 1982.
- Richardson DJ, Cole RA. Acanthocephala of the bald eagle (*Haliaeetus leucocephalus*) in North America. *J Parasitol* 1997; 83(3): 540-541. <http://dx.doi.org/10.2307/3284428>. PMID:9194845.
- Riquelme C, George-Nascimento M, Balboa L. Morfometría y fecundidad de *Profilicollis bullocki* Mateo, Córdova & Guzmán 1982 (Acanthocephala: Polymorphidae) en especies simpátricas de aves costeras de Chile. *Rev Chil Hist Nat* 2006; 79(4): 465-474. <http://dx.doi.org/10.4067/S0716-078X2006000400005>.
- Robinson SA. *Parasitism and contaminants: relationships and underlying mechanisms for a model endohelminth-bird association* [dissertação]. Ottawa: Carleton University; 2011.
- Rodríguez SM, D'Elía G. Pan-American marine coastal distribution of the acanthocephalan *Profilicollis altmani* based on morphometric and phylogenetic analyses of cystacanths from the mole crab *Emerita brasiliensis*. *J Helminthol* 2017; 91(3): 371-375. <http://dx.doi.org/10.1017/S0022149X16000237>. PMID:27126405.
- Rodríguez SM, Diaz JI, D'Elía G. Morphological and molecular evidence on the existence of a single estuarine and rocky intertidal acanthocephalan species of *Profilicollis* Meyer, 1931 (Acanthocephala: Polymorphidae) along the Atlantic and Pacific coasts of southern South America. *Syst Parasitol* 2017; 94(4): 527-533. <http://dx.doi.org/10.1007/s11230-017-9716-6>. PMID:28337681.
- Ryan S, Price RD. A review of the genus *Eidmanniella* (Mallophaga: Menoponidae) from the Pelecaniformes. *Ann Entomol Soc Am* 1969; 62(4): 815-823. <http://dx.doi.org/10.1093/aesa/62.4.815>.
- Rzyski P, Slodkiewicz-Kowalska A, Klimaszuk P, Solarczyk P, Poniedziałek B. Screening of protozoan and microsporidian parasites in feces of great cormorant (*Phalacrocorax carbo*). *Environ Sci Pollut Res Int* 2017; 24(10): 9813-9819. <http://dx.doi.org/10.1007/s11356-017-8652-y>. PMID:28255818.
- Santoro M, D'Alessio N, Di Prisco F, Veneziano V, Galiero G, Cerrone A, et al. Helminth communities of herons (Aves: Ardeidae) in southern Italy. *Parasitol Int* 2016; 65(4): 340-346. <http://dx.doi.org/10.1016/j.parint.2016.04.002>. PMID:27091547.
- Santos A, López OG, Miller M. Hippoboscidae (Insecta: Diptera). Ectoparásitos en aves de Panamá, claves de identificación, hospederos y distribución. *Scientia* 2014; 24(1): 49-68.
- Schmidt GD. *Andracantha*, a new genus of Acanthocephala (Polymorphidae) from fish-eating birds, with descriptions of three species. *J Parasitol* 1975; 61(4): 615-620. <http://dx.doi.org/10.2307/3279453>. PMID:1165545.
- Scholz T, Aguirre-Macedo ML, Salgado-Maldonado G. Trematodes of the family Heterophyidae (Digenea) in Mexico: a review of species and new host and geographical records. *J Nat Hist* 2001; 35(12): 1733-1772. <http://dx.doi.org/10.1080/00222930152667087>.
- Scholz T, Kuchta R, Salgado-Madonado G. Cestodes of the family Dilepididae (Cestoda: Cyclophyllidae) from fish-eating birds in Mexico: a survey of species. *Syst Parasitol* 2002; 52(3): 171-182. <http://dx.doi.org/10.1023/A:1015700801579>. PMID:12143788.
- Sepúlveda MS, Spalding MG, Kinsella JM, Forrester DJ. Parasites of the great egret (*Ardea albus*) in Florida and a review of the helminths reported for the species. *J Helminthol Soc Wash* 1999; 66(1): 7-13.
- Sepúlveda MS, Spalding MG, Kinsella JM, Forrester DJ. Parasitic helminths of the little blue heron, *Egretta caerulea*, in southern Florida. *J Helminthol Soc Wash* 1996; 63(1): 136-140.
- Servicio Agrícola y Ganadero – SAG. *La ley de caza y su reglamento* [online]. Chile; 2018 [cited 2020 May 19]. Available from: https://www.sag.gob.cl/sites/default/files/ley_de_caza_2018.pdf
- Sitko J, Okulewicz A. *Checklist of the nematodes in birds in the Czech Republic and the Slovak Republic*. Přerov: Comenius Museum; 2010.
- Skrjabin KI, Shikobalova NP, Schulz RS. *Essentials of nematology*. Moscow: USSR Academy of Sciences Press; 1954. (vol. III, Trichostrongylids of animals and man).
- Skrjabin KI. *Key to parasitic nematodes*. Washington: National Science Foundation, Israel Program for Scientific Translations; 1961. (vol. III, Strongylata).
- Skrjabin KI. *Key to parasitic nematodes*. Jerusalem: Israel Program for Scientific Translations; 1969. (vol. I, Spirurata and filariata).
- Sugimoto M. On the filaria from the Formosan domesticated birds. *J Jap Soc Vet Sci* 1934; 13(4): 261-266. <http://dx.doi.org/10.1292/jvms1922.13.261>.
- Švažas S, Chukalova N, Grishanov G, Pūtys Ž, Sruoga A, Butkauskas D, et al. The role of Great cormorant (*Phalacrocorax carbo sinensis*) for fish stock and dispersal of helminthes parasites in the Curonian Lagoon Area. *Vet Med Zoot* 2011; 55(77): 79-85.
- Tantaleán M, Sánchez L, Gómez L, Huiza A. Acantocéfalos del Perú. *Rev Peru Biol* 2005; 12(1): 83-92.

- Torres P, Contreras A, Cubillos V, Gesche W, Montefusco A, Rebolledo C, et al. Parasitismo en peces, aves piscívoras y comunidades humanas ribereñas de los lagos Yelcho y Tagua-Tagua, X Región de Chile. *Arch Med Vet* 1992; 24(1): 77-92.
- Torres P, Figueroa L, Saldivia A, Barrientos J. Gastrointestinal helminths of fish-eating birds from the Valdivia River, Chile. *J Parasitol* 1982; 68(6): 1157. <http://dx.doi.org/10.2307/3281111>.
- Torres P, Ortega J, Schlatter R. Nematode parasites of the digestive tract in Neotropic cormorant chicks (*Phalacrocorax brasilianus*) from the River Cruces Ramsar site in southern Chile. *Parasitol Res* 2005; 97(2): 103-107. <http://dx.doi.org/10.1007/s00436-005-1372-0>. PMID:15986255.
- Torres P, Ruíz E, Gesche W, Montefusco A. Gastrointestinal helminths of fish-eating birds from Chiloe Island, Chile. *J Wildl Dis* 1991; 27(1): 178-179. <http://dx.doi.org/10.7589/0090-3558-27.1.178>. PMID:2023322.
- Torres P, Schlatter R, Montefusco A, Gesche W, Ruiz E, Contreras A. Helminth parasites of piscivorous birds from lakes in the south of Chile. *Mem Inst Oswaldo Cruz* 1993; 88(2): 341-343. <http://dx.doi.org/10.1590/S0074-02761993000200028>. PMID:8107596.
- Torres P, Valdivieso J, Schlatter R, Montefusco A, Revenga J, Marín F, et al. Infection by *Contraecaecum rudolphii* (Nematoda: Anisakidae) in the Neotropic cormorant *Phalacrocorax brasilianus*, and fishes from the estuary of the Valdivia river, Chile. *Stud Neotrop Fauna Environ* 2000; 35(2): 101-108. [http://dx.doi.org/10.1076/0165-0521\(200008\)35:2;1-9;FT101](http://dx.doi.org/10.1076/0165-0521(200008)35:2;1-9;FT101).
- Travassos L, Teixeira de Freitas JF, Kohn A. Trematódeos do Brasil. *Mem Inst Oswaldo Cruz* 1969; 67(1): 1-886. PMID:5397756.
- Tucci EC, Soares NM, Faccini JLH, Vilas Boas D. Additional information about a mange outbreak by *Allopsoroptoides galli* (Acari: Psoroptoididae) in commercial laying hens in the state of São Paulo, Brazil. *Pesq Vet Bras* 2014; 34(8): 760-762. <http://dx.doi.org/10.1590/S0100-736X2014000800009>.
- Vicente JJ, Pinto RM, Noronha D, Carvalho PGD. Nematode parasites of Brazilian Pelecaniformes and Trogoniformes birds: a general survey with new records for the species. *Rev Bras Zool* 1996; 13(4): 891-901. <http://dx.doi.org/10.1590/S0101-81751996000400011>.
- Vicente JJ, Rodrigues HD, Gomes DC, Pinto RM. Nematóides do Brasil. Parte IV. Nematóides de aves. *Rev Bras Zool* 1995; 12(1 Suppl 1): 1-273. <http://dx.doi.org/10.1590/S0101-81751995000500001>.
- Víchová B, Reiterová K, Špilovská S, Blaňarová L, Hurníková Z, Turčeková L. Molecular screening for bacteria and protozoa in great cormorants (*Phalacrocorax carbo sinensis*) nesting in Slovakia, central Europe. *Acta Parasitol* 2016; 61(3): 585-589. <http://dx.doi.org/10.1515/ap-2016-0078>. PMID:27447224.
- Violante-González J, Monks S, Gil-Guerrero S, Rojas-Herrera A, Flores-Garza R, Larumbe-Morán E. Parasite communities of the neotropical cormorant *Phalacrocorax brasilianus* (Gmelin) (Aves, Phalacrocoracidae) from two coastal lagoons in Guerrero state, Mexico. *Parasitol Res* 2011; 109(5): 1303-1309. <http://dx.doi.org/10.1007/s00436-011-2377-5>. PMID:21503640.
- Wang PQ, Sun YL, Zhao YR. Studies on the life history and epidemiology of *Avioserpens taiwana* (Sugimoto, 1919) of the domestic duck in Fujian. *Dong Wu Xue Bao* 1983; 29: 350-357.
- Wehr EE, Chitwood BG. A new nematode from buds. *Proc Helminthol Soc Wash* 1934; 1: 10-11.
- Wehr EE. A new host for the bird darcunculid (sic) *Avioserpens denticulophasma*. *Proc Helminthol Soc Wash* 1934; 1: 11.
- Yamaguti S. Studies on the helminth fauna of Japan. 25. Trematodes of birds IV. *Jap J Zool* 1939; 8: 129-210.
- Yamaguti S. *Systema Helminthum*. New York: Interscience; 1958. (vol. I, The Digenetic Trematodes of Vertebrates. Part I and II).
- Yamaguti S. *Systema Helminthum*. New York: Interscience; 1959. (vol. II, The Cestodes of Vertebrates. Part I and II).
- Yamaguti S. *Systema helminthum: the nematodes of vertebrates*. New York: Interscience Publisher; 1961. (vol. 3).
- Zajac AM, Conboy GA. *Veterinary clinical parasitology*. 8th ed. Ames: Wiley-BlackWell; 2012.