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

Parasitos da biguá *Nannopterum (Phalacrocorax) brasilianus* (Aves, Phalacrocoracidae) do 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 Nuble 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*, *Baruscapillaria carbonis*, *Avioserpens* 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 Nuble. As aves foram fiscalizadas 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%).
Introduction

The Neotropic cormorant *Nannopterus (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 No. 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 *Eucoleus*, *Ornithocapillaria*, *Capillaria*, *Contracaecum*, *Baruscapillaria*, *Syncerca*, *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, 1993, 1999, 2000, 2005; Monteiro et al., 2006a, 2011; Violante-González et al., 2011); 28 species of Trematoda from genera *Strigea*, *Tylodelphys*, *Neodiplostomum*, *Austrodiplostomum*, *Hysteromorpha*, *Euhaplorchis*, *Mehrarostomum*, *Ribeiroia*, *Odheria*, *Drepanocephalus*, *Ascoscyte*, *Maritrema*, *Phocireniaides*, *Pseudopilostoma*, *Echinochasmus*, *Prothoagonimus*, *Clnostomatopsis*, *Clnostomum*, *Diplodistomum*, *Ignavia*, and *Paryphostomum* (Fedyech 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. (Fedyech et al., 1997; Hinojosa-Sáez & González-Acuña, 2005; Monteiro et al., 2006a, 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 gyroceras* 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, *Picotallolopes* sp. Dubinin, 1955, *Michaella neotropica* Mironov & Hernandes, 2016, *Frehelectes gaudi* Fain, 1964, *Neottialges evansi* Fain, 1966, *Dinalloloptes chelionatus* Atyeo e Peterson, 1966, and *Alloposoroptoides galli* Mironov, 2013 (Pence et al., 1997; Mironov, 2000; Barreto et al., 2012; Mironov, 2013; Tucci et al., 2014; Pedroso & Hernandes, 2016; Hernandes 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; Plutzner & Tomor, 2009; Deem et al., 2010; Carrera-Jativa et al., 2014; Vichová et al., 2016; Rzymski et al., 2017). Certain fish species act as reservoirs of *Cryptosporidium* sp. (Gabor et al., 2011), and *Giardia* sp. (Ghneim 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 comorant 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 to 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](image-url). (a) Female specimen of *Eidmaniella pelucida* (100x magnification); (b) Male (left) and female (right) *Pectinopygus gyroceras* (100x magnification).
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.) brasilianus* 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.

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

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

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### 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; Rzymski et al., 2017) and PCR (Plutzer & Tomor, 2009). It is important to consider that the absence of protozoan 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 felippei* (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.](image)

(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 felippei* 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 fuscens 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; Kornyushin, 2008; Svažas 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. felippei

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 felippei 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), Batorides striata, Ixobrychus involucris (Ardeidae) Spheniscus magellanicus 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 sparrowius (Falconidae) in Chile (Moreno & González-Acuña, 2015). Ascocotyle felippei 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 kempi 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.) brasilianus, 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.) brasilianus 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), Baruscapillaria carbonis Dubinin & Dubinina 1940, Avioserpen sp. Wehr & Chitwood 1934 (Figure 4b, c), Cyathostoma (Cyathostoma) phenisci Baudet, 1937 (Figure 4d), and Contracaecum 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.
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,

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).
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*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. ncticorax, Botaurus stellaris* (Ardeidae), *Gavia stellata* (Gaviidae), and *Mergus merganser* (Anatidae) in the Palearctic region, and *N. ncticorax, I. minutus, A. purpurea*, and *E. garzetta* in Spain (Chabaud & Campana, 1949; Daiya, 1967; Baruš et al., 1978; Brgelz, 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 multispillolosa* Singh, 1949 in *Ardeola grayii* (Ardeidae) in India (Deshmukh, 1971); *Avioserpens bifidus* Olsen, 1952 in *Bucephala islandica* (Anatidae) 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-Ruíz & 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 & Zalešny, 2014). *Cyathostoma* (C.) *phenisci* is the only species reported previously in a Chilean cormorant, *Phalacrocorax atriceps* (Oyarzún-Ruíz & Muñoz-Alvarado, 2015). This study is the first report of C. (C.) *phenisci* in the Neotropic cormorant.

**Acanthocephala**

*Andracantha phalacroracoris* (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.) brasilianus* in Chile (Torres et al., 1993). Information about population parameters for Acanthocephala recorded in this study can be found in Table 1.

**A. phalacroracoris**

*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. phalacroracoris* (Monteiro et al., 2006a). *Andracantha phalacroracoris* has been described in *Urile pelagicus* (Phalacrocoracidae) in the United States and Japan, *P. carbo* in Czech Republic, *Halieaeetus leucocephalus* (Accipitriformes) in the United States, and *N. (P.) brasilianus* 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. phalacroracoris* 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* Holcmann-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
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. pellucida, trematodes A. felippei and H. triloba, nematodes C. rudolphi 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

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).
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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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