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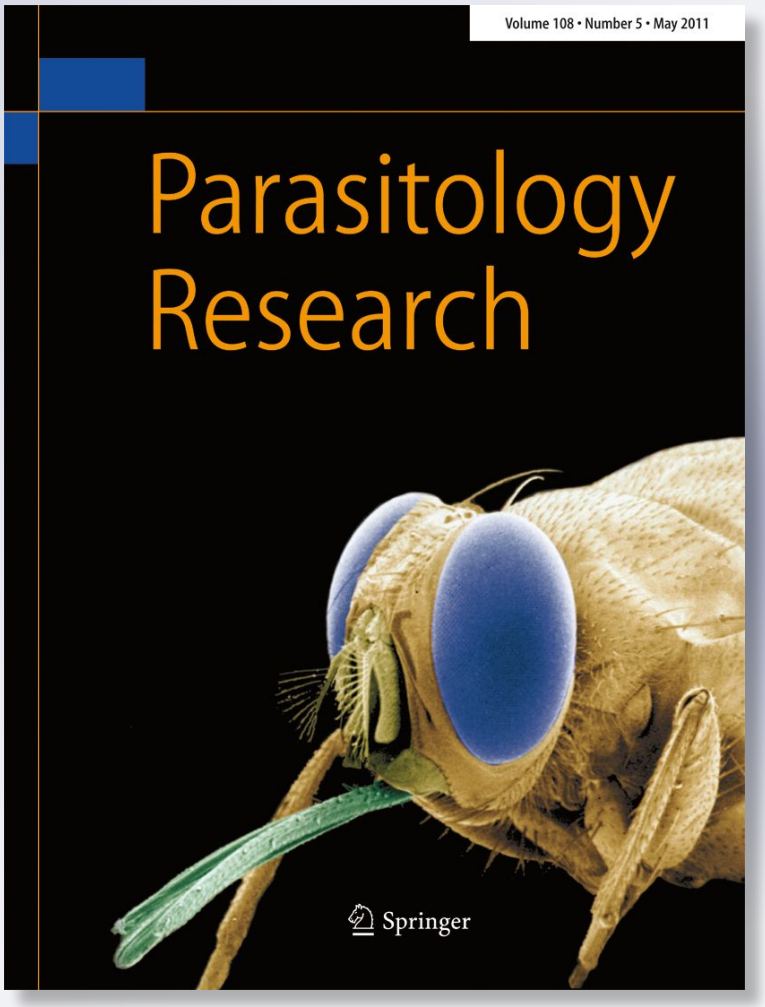

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ORIGINAL PAPER

Gastrointestinal parasites in Chinstrap Penguins from Deception Island, South Shetlands, Antarctica

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Abstract Knowledge about parasites of Antarctic birds is fragmented and scarce. The aim of this work is to contribute to the knowledge of gastrointestinal parasites of the Chinstrap Penguin (*Pygoscelis antarctica*) from Deception Island (South Shetlands, Antarctica). Gastrointestinal tracts of 64 fresh dead individuals (61 chicks and three adults) were collected from December 2006 to February 2009 and examined for macroparasites. Three adult parasite species were found: two *Cestoda* species (*Parorchites zederi* and *Tetrabothrius pauliani*) and one *Nematoda* species (*Stegophorus macronectes*). Also, immature acanthocephalans (*Corynosoma* sp.) were found in one penguin. The low parasite richness observed could be related to the stenophagic and pelagic diet of the host species. False negatives were found in coprological studies.

Introduction

Information available about helminths of Antarctic birds is fragmented and usually restricted to a single parasite species. For instance, there are published data about gastrointestinal parasites from only 21 out of 46 species of Antarctic birds, and little attention has been paid to ecological consequences of parasites on these host populations in Antarctica (Barbosa and Palacios 2009). Information about the parasitic fauna of Antarctic species can provide a baseline to understand modifications in a changing world. Climate change is one of the likely factors affecting the distribution of parasites (Sutherst 2001). Since gastrointestinal parasitic infections depend largely on foraging habits (Hoberg 1996), modifications in the hosts' diet due to climate change or fishing overexploitation could alter the range of parasites found in Antarctic penguins.

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The Chinstrap Penguin *Pygoscelis antarctica* (Forster 1781) is one of the five penguin species living in Antarctica. It inhabits the Scotia Sea region where most penguins are gathered to breed on South Sandwich, South Orkney, South Shetland Islands, and the Antarctic Peninsula north to 65° S. Occasionally, they breed on South Georgia, Bouvetoya, Balleny, and Peter I Islands (Woehler and Poncet 1993). Several authors have published information on gastrointestinal parasites of this species (Zdzitowiecki and Drózdz 1980; Ippen et al. 1981; Andersen and Lysfjord 1982; Hoberg 1986; Zdzitowiecki 1991; Cielecka et al. 1992; Dimitrova et al. 1996; Georgiev et al. 1996) dealing with both identification and description of pathogens but providing little information about prevalences, intensities, life cycles, or any data related to the host and its environment.

In this paper, we report the gastrointestinal parasitic community of the Chinstrap Penguin (*P. antarctica*) from Deception Island (South Shetlands, Antarctica) with reference to some ecological issues such as prevalence, mean intensities, and transmission.

Material and methods

Sixty-four gastrointestinal tracts (61 chicks and three adults) from naturally and freshly dead Chinstrap Penguins were analyzed. Chicks were more than 20 days old as calculated from the mean hatching date in the breeding rookery (22 December; range, 19–28 December; Barbosa, unpublished data).

Individuals were collected from the Vapour Col breeding colony (63°00′ S; 60°44′ W) on Deception Island where about 12,000 pairs breed (Barbosa unpublished data). Collections were carried out during austral summers (January–February) from 2006 to 2009.

Gastrointestinal tracts were removed, placed in plastic bags, and frozen at −20°C until examination. Necropsies were performed by analyzing different sections of the digestive tract separately: esophagus, stomach (glandular proventriculus and muscular gizzard), small intestine, caeca, colon, and cloaca. The mucosa was examined under a stereoscopic microscope for parasites and lesions. Gastrointestinal contents were placed in sedimentation cups and, after three washes and decantations, were examined using a stereoscopic microscope. Parasites were isolated and stored in 70% ethanol (Pritchard and Kruse 1982).

Feces were collected from the last third of the gastrointestinal tract (end of the small intestine, caeca, colon, and cloaca), mixed, and separated in portions for coprological studies by two concentration techniques: flotation and sedimentation (Ministry of Agriculture, Fisheries and Food 1989). The gastric content of 30 penguins (27 chicks and three adults) was analyzed in this way. Coprological flotation techniques were performed using three different solutions: Sheather's sugar solution (d=1.27), zinc sulfate solution (d=1.38), and sodium nitrate solution (d=1.36), and examined using three McMaster's chambers for each sample and another additional one including the edges. In the case of sedimentation, nine preparations per sample were observed by light microscopy.

Parasite identification was based on morphometric features. Nematodes were cleared in Amman's lactophenol or 25% glycerine ethanol, and cestodes were stained with Semichon's acetocarmine and mounted in either DPX or Canada balsam. Acanthocephalans were observed cleared in Amman lactophenol. Some specimens were observed under a scanning electron microscope (JEOL-6100®) after previous drying by the critical point method (Bray 2000), and photographed for a more accurate observation of diagnostic structures. Parasite identification was carried out using dichotomous keys (Delymure 1955; Yamaguti 1959, 1961; Chabaud 1974; Bona 1994; Hoberg 1994) and specific bibliography (Johnston and Mawson 1945; Petter 1959; Cielecka et al. 1992). Specimens were deposited in the Helminthological Collection of Museo de La Plata; La Plata, Argentina; and in the Museo Nacional de Ciencias Naturales, Madrid, Spain. Measurements are given in micrometers unless otherwise indicated.

Prevalence (P) and mean intensity (MI) were calculated according to Bush et al. (1997). Prevalence is the percentage of infected animals of the total animals examined. Mean intensity is the number of individuals of a parasite species divided by the total number of infected animals.

Results

Forty-seven out of 64 examined penguins were parasitized (87.5%), and three species of adult gastrointestinal parasites were identified: two cestodes, *Tetrabothrius pauliani* Joyeux and Baer, 1954 and *Parorchites zederi* Baird, 1853, and one nematode, *Stegophorus macronectes* Johnston and Mawson, 1942. Also, some immature specimens of *Corynosoma* sp. (Acanthocephala) were found in only one penguin.

T. pauliani (Cestoda, Tetrabothriidae) had a prevalence (P)=13% in chicks and P=100% in adults, and a mean intensity (MI)=1.2±0.49 (standard deviation (SD)) in chicks and MI=1,668±1,525 in adults. This parasite was found weakly adhered to the intestinal mucosa surface as well as free in the intestinal contents. Immature individuals with scolex and few proglottids were found in chicks. Mature individuals with gravid proglottids were observed in adult penguins although the tapeworms had a brittle appearance and were small (no more than 4 mm).

P. zederi (Cestoda, Dilepididae) was found either free in the intestinal content or deeply embedded in the intestinal

mucosa forming nodular lesions with a distinct appearance. The prevalence was 26% in chicks and 100% in adults, and mean intensity=4.7±3.05 in chicks and 68±74.65 in adults. Mature specimens were observed in both adults and chicks. The presence of *P. zederi* was associated with lesions which began as small, yellow, and inflammatory nodules (3 mm in diameter). Parasites penetrated into the intestinal mucosa in a sinuous trajectory generating large nodules reaching the intestinal serosa. From one to three specimens were observed protruding through a single opening with scoleces and pseudoscoleces deeply inserted in the mucosa.

S. macronectes (Nematoda, Acuariidae), found in the stomach, was the only nematode collected. Most nematodes were mature females. This species showed the highest prevalences and mean intensity in chicks (P=72%, MI=24.25± 28.92). Prevalence and mean intensity in adults is 67% and 39.5±43.89 respectively.

Seven immature *Corynosoma* sp. (Acanthocephala, Polymorphidae) individuals were found in a single host. Specific identification was not possible since all specimens were immature.

More than 67% of infections were monospecific with *S. macronectes* the most prevalent parasite (53.5%). In multiple infections, 26.8% of penguins were parasitized by two different species with the most frequent combination *S. macronectes* and *P. zederi* (14.3%), followed by *S. macronectes*, and *T. pauliani* (8.9%). Only three penguins (5.4%) were infected by all three species.

All coprological analyses performed in chicks were negative despite the presence of gravide females of *S. macronectes*. Most of the coprological examinations in adults were negative as well except one adult in which *P. zederi* eggs were found: 810.8 eggs per gram with sodium nitrate solution, 119 eggs per gram with zinc sulfate solution, and 129.2 eggs per gram with Sheather's sugar solution; sedimentation technique was always negative. Tiny strobila were also found in one adult.

Discussion

The gastrointestinal parasitic fauna found in the Chinstrap Penguin from Deception Island (South Shetlands Islands) included three helminth species: *T. pauliani*, *P. zederi*, and *S. macronectes*. Only one species previously recorded in this host was not found in the present study, *Tetrabothrius joubini* Railliet and Henry, 1912 (Barbosa and Palacios 2009, and references therein). Predictably, the parasite species number observed in this study was low, probably due to a combination of different factors such as both a stenophagic diet and a pelagic foraging habit of the host (Hoberg 1996). Hoberg (1996) postulated that the core components of the parasite fauna from pelagic birds are cestodes, and primarily tetrabothriidean species. *P. zederi* is the only cyclophyllidean of pelagic systems found in penguins (Hoberg 1996). These associations are apparently a consequence of broad oceanic distributions for macrozooplankton such as euphausiids, cephalopods, and fishes which serve as suitable intermediate hosts in pelagic environments. In contrast, many larids, grebes and loons, which exploit a broader range of invertebrates and fishes in near shore areas, support specious faunas (Hoberg 2005). Many other studies have recorded a high richness of helminth communities of birds with a euryphagic or generalist diet which feed near shores [e.g., 18 species parasitizing *Larus dominicanus* in Argentina (Diaz et al. 2011), 21 species in *Arenaria interpres* from Alaska (Canaris and Kinsella 2007), 17 species in *Limosa haemastica* from North America (Kinsella et al. 2007)] in contrast with stenophagic birds feeding far away from coasts [five species in *Spheniscus magellanicus* from South Atlantic Sea (Diaz et al. 2010)]. Chinstrap Penguins feed mainly on krill (*Euphausia superba*), a small crustacean which is the basis of the Antarctic ecosystem food chain although they can also feed on amphipods, fishes, and cephalopods (Williams 1995). The number of gastrointestinal parasite species found in the present paper is very similar to that recorded from the Adélie penguin (Barbosa and Palacios 2009 and references therein), which is also a krill specialist.

T. pauliani has been previously found in *P. antarctica*, *P. papua*, and *Pygoscelis adeliae* (Prudhoe 1969; Cielecka et al. 1992). There were no prominent lesions associated with these parasites, probably due to their small size and their weak attachment.

Parorchites zederi is potentially the most pathogenic parasite found here (Hoberg 1984). This species has been previously cited in *P. antarctica* and other pygoscelid penguins such as *P. papua* and *P. adeliae* (Ippen et al. 1981; Cielecka et al. 1992).

S. macronectes has been previously reported in the three pygoscelid penguin species (Mawson 1953; Zdzitowiecki and Drózdz 1980).

There are few reports of *Corynosoma* spp. in Antarctic birds (see Barbosa and Palacios 2009). These species are primary parasites of marine mammals (Hoberg 1986) and can be incidental in seabirds since most records in penguins are of immature specimens (Hoberg 1986). However, adults of *Corynosoma shackletoni*, Zdzitowiecki, 1978 have been reported in *P. papua* and *Corynosoma* sp. in *S. magellanicus* (Hoberg 1986; Diaz et al. 2010). Holloway and Bier (1967) and Hoberg (1986) reported the presence of ovarian balls in some specimens of *Corynosoma hamanni* Linstow, 1892 from Adélie penguins. Our specimens resemble *C. hamanni* in number and distribution of hooks on the proboscis, the body shape and size, and the distribution of body spines. The finding of only immature stages in a single penguin in the present study seems to indicate that this *Corynosoma* might be a parasite of marine mammals (with some

exceptions) that occurs only accidentally in avian hosts, as postulated by Hoberg (1986).

The most prevalent parasite in chicks was *S. macronectes* while cestode species were the most prevalent parasites in adults. Only *S. macronectes* showed higher prevalence in chicks than in adult birds. Its presence could be related not only to a less developed immunity in chicks but also to regurgitation of infective larvae by parents as reported for other acuarioid nematodes (Muzaffar and Jones 2004) or even the transfer of adult nematodes living in the stomach of their parents. However, prevalence in adults could have been underestimated because of the small sample size.

Acuarioids which parasitize aquatic hosts develop to the infective stage in the haemocoel of aquatic crustaceans (Anderson 2000). So, prey consumption should be the main source of infection for penguins. Since krill is the main prey item for Chinstrap Penguins, then they are likely intermediate hosts. An acuarioid nematode larva was found in the body cavity of a krill in the same study area (Diaz, personal communication). Since crustaceans are also involved in the cestode life cycles of both Dilepididae and Tetrabothriidae (Cielecka et al. 1992; Hoberg 1994), *Euphausia superba* could be the main intermediate host not only for the nematode *S. macronectes* but also for the other parasite species found in this study. However, the Chinstrap Penguin also feeds on fish or squids in low proportions (Williams 1995) so one of these two kinds of prey probably act as intermediate host for *T. pauliani.*

The absence of cestode eggs in chicks seems to be predictable since most of the worms found were immature. However, gravid females of *S. macronectes* were observed in stomachs of chicks, and no eggs were found in the feces. Despite high prevalences of cestodes and nematodes in adults, only one out the three showed cestode eggs in its feces. Therefore, coprological studies could underestimate parasitism of the Chinstrap Penguin by helminths. The young age of the hosts studied could be the most important reason for these results. However, the weakness of eggshells (not being strong enough to resist freezing and thawing) or a possible periodicity in egg liberation could also influence them. Development of molecular markers could be an additional tool for an accurate estimation of parasitism in living adult penguins.

Chinstrap Penguins from Deception Island were parasitized by only a few parasite species: two cestodes, *P. zederi* and *T. pauliani*, and one nematode, *S. macronectes*. Even though host survival did not appear to be affected, other biological parameters, such as body condition, fitness, reproductive efficiency, or immunological level should be analyzed to determine the real effect of these parasites on the penguins.

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