POLISH POLAR RESEARCH
vol. 32, no. 3, pp. 263–268, 2011 doi: 10.2478/v10183-011-0018-4

Coccidian parasites (Apicomplexa) of penguins (*Pygoscelis* ssp.) from Livingston Island and King George Island, the Antarctic

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Abstract: The results of investigations on the coccidian parasites of three species of penguins (*Pygoscelis antarctica*, *P. papua* and *P. adeliae*), nesting at Livingston and King George Island (South Shetland Islands, the Antarctic) are presented. Three coccidian parasites: *Eimeria pygosceli* Golemansky, 2003, *Eimeria* sp. and *Isospora* sp. were identified in faecal samples from 360 examined birds. The total prevalence of coccidian parasites was high: about 35% in all of examined penguins. No host specificity was observed. It is attributed due to the close phylogenetic relations, common habitats and nesting territories, similar feeding and reproductive biology of the three penguin species. In more than 20 specimens of investigated penguins a high intensity of oocysts in their guano was observed (80–220 oocysts in one microscopic field at magnification of 150×) an indirect indication of the negative role of the coccidian infections on penguin populations.

Key words: Antarctic, Eucoccidiida, South Shetland Islands, coccidia, penguins.

Introduction

The dominant penguin populations on Livingston and King George Islands (South Shetland Islands, the Antarctic) consist of three species in the genus *Pygoscelis* (Sphenisciformes): *P. papua* (Forster, 1781), *P. adeliae* (Hombron *et* Jacquinot, 1841) and *P. antarctica* (Forster, 1781). *P. adeliae* and *P. antarctica* have a circumpolar distribution while *P. papua* is a widely distributed Subantarctic inhabitant (Del Hoyo *et al.* 1992).

The information on the coccidian parasites (Apicomplexa: Eucoccidiida) and coccidian diseases of penguins as a limiting factor of their biodiversity and population density is scarce and fragmented. Some generalized data on the coccidian infection and their pathogenic effect on penguin populations are given in the overview by Clarke and Kerry (1993), but they concern mainly penguins from the Australian Subantarctic and were based mainly on the papers by Obendorf and McCool (1980), Ippen *et al.*, (1981), Harrigan (1991), Mason *et al.* (1991) and

Kerry *et al.* (1999). More recent data on the coccidian parasites from South Shetland penguins of the genus *Pygoscelis* were published by Golemansky (2002, 2003, 2008), Fredes *et al.* (2007), Barbosa and Palacios (2009).

Research on the eucoccidian parasites of the penguins from South Shetland Islands started in 1994 within Bulgarian expeditions to Livingston Island (1994–2006) and Polish expeditions to King George Island (2008–2010). In a preliminary publication on the coccidian parasites of the penguins from Livingston Island Golemansky (2002) reported the presence of three unidentified species of Eucoccidiida (two *Eimeria* and one *Isospora* spp.), observed in *Pygoscelis papua, P. antarctica* and *P. adeliae.* A year later, in a fresh material from Livingston Island, a new species – *Eimeria pygosceli* was described from the type host *P. antarctica.* It was also found in two other species of penguins (Golemansky, 2003). Brief information on the diversity and prevalence of the coccidian parasites of the dominant gentoo penguin (*P. papua*) from King George Island was also published by Golemansky (2008).

The aim of the present study is to summarize the results of investigations on the eucoccidian parasites of penguins from South Shetlands Islands and to present new data on their distribution and prevalence in the studied hosts. Detailed descriptions of the oocysts of the observed coccidians were published in earlier papers by Golemansky (2002, 2003, 2008), so in the present overview only few morphometric data for the different species are presented.

Material and methods

Fresh faecal samples from living birds were collected through six years (1994–2010) from December to March. A total of 360 faecal samples from all three species of penguins were studied. The years of the studies and the number of investigated and infected penguin species from Livingston and King George Islands are presented in Table 1. The samples were collected from nesting and free birds from the vicinities of the Bulgarian and Spanish Antarctic stations at Livingston Island (62°40'09" S, 60°24'08" W) and the Polish Antarctic station at King George Island (62°16'67" S, 58°46'67" W).

The faecal samples were collected *in situ* immediately after defecation and preserved in a 2.5% solution of Potassium dichromate ($K_2Cr_20_7$). Before the transportation and laboratory investigation they were kept in both Antarctic stations at room temperature (20–23°C) for 2–4 mounts. The laboratory investigation was accomplished at the Institute of Zoology (Sofia). The Fülleborn flotation method was used for detection of coccidian oocysts. To study the sporulation process portions of the positive faecal samples were placed in Petri dishes with moist filter paper at room temperature (22–25°C). Microscopical studies were accomplished at a

Table 1

Examined materials of *Pygoscelis* faeces

Years	*P. antarctica*		*P. papua*		*P. adeliae*		Localities	Collectors
	observed	infected	observed	infected	observed	infected		
1994/5	4	1	2	2	1	1	Livingston I.	N. Chipev
1995/6	3	–	–	–	–	–	Livingston I.	N. Chipev
1996/7	2	–	2	–	–	–	Livingston I.	N. Chipev
1997/8	8	3	11	4	–	–	Livingston I.	I. Pandurski
1998/9	17	5	9	2	4	2	Livingston I.	I. Pandurski
1999/0	10	5	14	5	–	–	Livingston I.	R. Mecheva
2000/1	20	6	22	5	–	–	Livingston I.	A.Kovachev
2001/2	9	5	16	7	–	–	Livingston I.	R. Mecheva
2002/3	4	–	12	2	4	3	Livingston I.	R. Mecheva
2005/6	5	3	4	1	–	–	Livingston I.	E. Trakiiska
2005/6	5	2	50	14	–	–	Livingston I.	R. Mecheva
2006/7	5	3	59	20	–	–	Livingston I.	I. Yankov
2006/7	–	–	38	22	–	–	King George I.	I. Yankov, R. Mecheva
2009/10	–	–	4	1	20	4	King George I.	K. Dimitrov
Total	**92**	**33 (25.8%)**	**239**	**84 (35.1%)**	**29**	**10 (34.5%)**		

NU-2 microscope (Zeiss, Jena) and the photomicrographs were made with an OLYMPUS E-500 digital camera.

It is important to note that the sporulation process in laboratory conditions after the transportation of the collected samples from the Antarctic to Europe was insignificant. The large majority of the oocysts had remained unchanged on Petri dishes in the laboratory and only in few oocysts had sporulation started, but the number of completely sporulated oocysts was very low. Some of the oocysts achieved first division of the protoplast and stopped at the two sporoblast phase. Few oocysts finished their sporulation completely, these allowing a precise identification. Obendorf and McCool (1980) reported the same problem with the sporulation of coccidian oocysts isolated from *Eudyptula minor* in Australia. A similar problem with disturbed oocyst sporulation of *Caryospora undulata* from Arctic puffins *(Fratercula arctica*) was observed also by S. J. Upton (1998, personal communication).

Results and discussion

As a result of the earlier and recent studies a total of 360 adult and subadult penguins of three species were investigated: *P. papua* – 239 specimens, *P. antarctica* – 92 and *P. adeliae* – 29. The total prevalence of the coccidian infection was high – about 35% (Table 1). This is attributed to the fact that the studied pen-

guins nest colonially on relatively limited sites and the possibilities for mutual infection are high. For the examined three species of penguins the total prevalence of coccidian infection was very similar: *P. antarctica* – 35.8%, *P. papua* – 35.1% and *P. adeliae* – 34.5%. I presume that the high and similar prevalence of the coccidian infection of the examined penguins is mainly due to the close phylogenetic relationship of the three species, which belong to the same genus, as well similar feeding and reproductive biology, and the fact that they inhabit the same localities, where they can come into contact easily. Although *P. adeliae* occurs in smaller populations on both Livingston and King George Islands it is in close contact with the dominant *P. antarctica* and *P. papua* and exchange of their parasites is thus possible. The investigations to date did not show any species-preference or host specificity of the observed coccidian parasites.

To date, three species of coccidian parasites have been observed in the three species of the genus *Pygoscelis* studied from South Shetland Islands: *Eimeria pygosceli*, *Eimeria* sp. and *Isospora* sp. (Golemansky 2002, 2003, 2008). Their brief morphological characteristics, hosts and distribution are presented in Table 2 and Fig. 1.

E. pygosceli Golemansky, 2003 (Fig. 1a) was a common intestinal parasite of all studied penguins. The type host of this parasite was *Pygoscelis antarctica* from Livingston Island, but it was also observed in *P. papua* and *P. adeliae* from Livingston and King George Islands (Golemansky 2003, 2008). The total prevalence of *E. pygosceli* in the three examined penguin species from both islands was 24% (86 infected of 360 studied birds). For the three examined penguins its prevalence varied from 14.5% for *P. adeliae*, 21% for *P. papua* to 28% for *P. antarctica*.

Eimeria sp. (Fig. 1b) was also often observed in the penguins studied. It is characterized by smaller oocyst dimensions (Table 2). *Eimeria* sp. was observed in mixed infection with *E. pygosceli*, as well as in independent infection, or mixed with *Isospora* sp. The taxonomic identification of this species was impossible because of the lack of fully sporulated oocysts. The total prevalence of *Eimeria* sp. in three penguin species from Livingston and King George Islands was 18% (65/360

Table 2

Coccidian parasites of *Pygoscelis* ssp. from South Shetland Islands (the Antarctic)

Coccidian parasites	Hosts	Shape of oocysts	Size of oocysts (in µm)	Oocyst wall	Micro-pyle	Polar granules	Oocyst residuum	Localities
Eimeria pygosceli	*P. antarctica* *P. papua* *P. adeliae*	round, subspherical	21.0–32.0	double, smooth, rugged	–	1–3	+	Livingston I. King George I.
Eimeria sp.	*P. papua* *P. adeliae*	round, subspherical	16.2–21.0	double, smooth	–	1–2	+	Livingston I. King George I.
Isospora sp.	*P. papua* *P. antarctica*	round, subspherical	30.2–40.6	double, smooth	–	1–4	+	Livingston I. King George I.

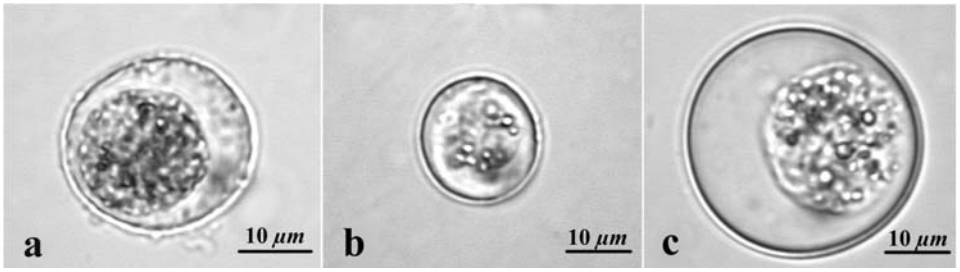

Fig. 1. Coccidian parasites from the penguins of *Pygoscelis* ssp. a, *Eimeria pygosceli* Golemansky, 2003, unsporulated oocyst; b, *Eimeria* sp., unsporulated oocyst; c, *Isospora* sp., unsporulated oocyst.

birds). The maximum prevalence of *Eimeria* sp. (24%, 9 from 37 examined birds) was observed in *P. papua* from Livingston Island (Golemansky 2008).

Isospora sp. (Fig. 1c) was also a common coccidian parasite of the *Pygoscelis* ssp. studied from both islands. Because of its large oocyst dimensions (30–40 µm) it was easily visible in the studied samples. *Isospora* sp. was often present in mixed infection with *E. pygosceli* and *Eimeria* sp. The highest prevalence of *Isospora sp*. was 15% (54/360 birds). Highest prevalence of *Isospora* sp. – 39.5% – was observed in gentoo penguin (*P. papua*) from Livingston Island in March, 2007 (15/38 birds) (Golemansky 2008). More precise taxonomic identification of the species was also impossible because of the lack of completely sporulated oocysts in laboratory conditions. In previous papers the taxonomical status of *Isospora* sp. from the observed penguins was considered as problematic, "because its unsporulated oocysts are similar to those of other coccidians like *Cyclospora* and *Caryospora*" (Golemansky 2003). But in our last observations I succeeded in obtaining some sporulated oocysts with two sporoblasts, considered to be a confirmation of the presence of *Isospora* sp. and not of *Cyclospora* sp., which is characterized by one sporoblast and one sporocyst only.

The problem of pathogenesis from the coccidian infection in the *Pygoscelis* species studied from Livingston and King George Islands could not be definitively proved because of the lack of autopsied intestinal material from ailing birds. I surmise that the high number of coccidian oocysts, observed in more than 20 specimens of all three penguin species from both islands, might be an indirect indicator of the pathogenic role of the coccidians on the natural populations of the penguins examined. During previous investigations (Golemansky 2003) and the present study we have observed in some birds a very high number of coccidian oocysts (80–220) in one microscopical field with a magnification about 150× (objective 10× and ocular 12.5×).

Some studies on serious coccidian diseases on different penguin species were published by Ratcliff and Worth (1951), Obendorf and McCool (1980), Mason *et al.* (1991), Harrigan (1991), Duignan (2001), Rose (2005) and Fredes *et al.* (2007). They have reported intestinal and renal coccidiosis in penguins from different

parts of Australia and the Antarctic; some of them with lethal effect. Further research on the coccidians of penguins is needed for more precise assessment of their negative impact on the natural populations of their hosts.

Aknowledgements. — I would like to thank all my colleagues: R. Mecheva, N. Chipev, I. Pandourski, K. Dimitrov, E Trakiiska, I.Yankov and A. Kovachev from the Bulgarian Academy of Sciences, for the precise collection of the examined samples of the studied penguins from Livingston and King George Islands during their participation in the Bulgarian and Polish Antarctic expeditions. Dr. Roger Bamber (ARTOO) has kindly improved English through the manuscript. The study was supported by the Bulgarian National Science Fund (Grant B-1516/2005).

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Received 4 March 2011
Accepted 20 July 2011