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Serosurvey for *Toxoplasma gondii* in arctic foxes and possible sources of infection in the high Arctic of Svalbard

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Abstract

Samples (blood or tissue fluid) from 594 arctic foxes (*Alopex lagopus*), 390 Svalbard reindeer (*Rangifer tarandus platyrhynchus*), 361 sibling voles (*Microtus rossiaemeridionalis*), 17 walruses (*Odobenus rosmarus*), 149 barnacle geese (*Branta leucopsis*), 58 kittiwakes (*Rissa tridactyla*), and 27 glaucous gulls (*Larus hyperboreus*) from Svalbard and nearby waters were assayed for antibodies against *Toxoplasma gondii* using a direct agglutination test. The proportion of seropositive animals was 43% in arctic foxes, 7% in barnacle geese, and 6% (1 of 17) in walruses. There were no seropositive Svalbard reindeer, sibling voles, glaucous gulls, or kittiwakes. The prevalence in the arctic fox was relatively high compared to previous reports from canid populations. There are no wild felids in Svalbard and domestic cats are prohibited, and the absence of antibodies against *T. gondii* among the herbivorous Svalbard reindeer and voles indicates that transmission of the parasite by oocysts is not likely to be an important mechanism in the Svalbard ecosystem. Our results suggest that migratory birds, such as the barnacle goose, may be the most important vectors bringing the parasite to Svalbard. In addition to transmission through infected prey and carrion, the age-seroprevalence profile in the fox population suggests that their infection levels are enhanced by vertical transmission.

Keywords: *Alopex lagopus*; *Branta leucopsis*; *Larus hyperboreus*; *Microtus rossiaemeridionalis*; *Odobenus rosmarus*; *Rangifer tarandus*; *Rissa tridactyla*; Svalbard; *Toxoplasma gondii*

1. Introduction

Toxoplasma gondii is a coccidian protozoan of the phylum Apicomplexa that has a global distribution. Definitive hosts are the domestic cat (*Felis catus*) and other felids, which harbour the sexual stages of the parasite in the intestines and shed infective oocysts with their faeces (Frenkel et al., 1970). A wide range of mammals and birds can serve as intermediate hosts, in which asexual reproduction and tissue cyst formation occur (Dubey and Beattie, 1988). Intermediate hosts can be infected by ingestion of oocysts

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or tissue cysts, or via vertical transmission (Dubey and Beattie, 1988).

Svalbard is a high arctic archipelago (78–81°N, 10–30°E) located midway between the Norwegian mainland and the North Pole. No wild felids are present on Svalbard, and domestic cats are prohibited. Nevertheless, some cats are found in the mining settlement Barentsburg. The arctic fox (*Alopex lagopus*) is a top predator, preying on birds and seal pups, and scavenging on any food item available (Eide et al., 2005). This also includes cannibalism (Prestrud, 1992). The polar bear (*Ursus maritimus*) is the top of the marine food chain. The Svalbard reindeer (*Rangifer tarandus platyrhynchus*) is widespread, whereas the sibling vole (*Microtus rossiaemeridionalis*) has a very restricted distribution around the former mining station at Grumant (78°11′N, 15°09′E) (Henttonen et al., 2001). The glaucous gull (*Larus hyperboreus*) is an avian top predator and scavenger, and is top of its food chain in the Arctic. All bird species on Svalbard, except the Svalbard rock ptarmigan (*Lagopus muta hyperborea*), are migratory, leaving the islands in the autumn (Strøm, 2006).

Three arctic foxes found dead on Svalbard in 2000 had disseminated toxoplasmosis (Sørensen et al., 2005), suggesting a possible role for *T. gondii* as a mortality factor in this species. In the present study, we analysed a large number of arctic fox samples from Svalbard for antibodies against *T. gondii*, and looked for evidence of negative effects of *T. gondii* infection on the physical condition of the hosts. We also analysed samples from several other species to evaluate the most likely transmission routes of *T. gondii* in this arctic ecosystem. Even though felids are nearly non-existent in the ecosystem, we evaluated the potential for oocyst transmission using terrestrial herbivores, the sibling vole and Svalbard reindeer, as indicators. We evaluated the potential importance of migratory birds as a source of infection by testing barnacle geese (*Branta leucopsis*), and tested walruses (*Odobenus rosmarus*), glaucous gulls, and kittiwakes (*Rissa tridactyla*) to obtain information on the potential occurrence of *T. gondii* in the marine food chain. We also fitted simple models of the transmission dynamics of *T. gondii* to data from the fox population to evaluate the potential importance of vertical transmission.

2. Materials and methods

2.1. Animals and samples

The samples of blood (serum or plasma) and tissue fluids included in this study were from arctic foxes ($n = 594$), Svalbard reindeer ($n = 390$), sibling voles ($n = 361$), walruses ($n = 17$), kittiwakes ($n = 58$), barnacle geese ($n = 149$), and glaucous gulls ($n = 27$) from Svalbard. All live animals sampled for this study were cared for in accordance with the current regulations of the Norwegian Animal Welfare Act, and with the permission of the Norwegian Animal Research Authority and the Governor of Svalbard.

2.2. Arctic fox

Foxes were caught by fur trappers using baited traps between 1 November and 15 March 1996–1997 ($n = 11$), 1997–1998 ($n = 103$), 1998–1999 ($n = 107$), 1999–2000 ($n = 74$), 2000–2001 ($n = 25$), 2001–2002 ($n = 116$), 2002–2003 ($n = 84$), and 2003–2004 ($n = 74$). Following trapping, the carcasses were usually stored outdoors under varying conditions, exposed to freezing and thawing, which often resulted in poor carcass quality. The zoonotic cestode *Echinococcus multilocularis* is present within the Svalbard fox population (Henttonen et al., 2001), and to kill the eggs of this parasite, the carcasses were frozen at −80 °C for a minimum of 7 days (Veit et al., 1995). Later storage was at −20 °C until necropsy, when blood and tissue fluids were collected from the heart chambers, larger vessels, or thoracic cavity. After centrifugation (1000 × *g*, 10 min), the supernatant was collected and stored at −20 °C for later analysis, and all samples, which were usually extensively haemolysed,

Table 1
Proportion (%) of *Toxoplasma gondii* seropositive arctic foxes (with 95% CI) by age group and geographic area

Age group (years)	*n*	Nordenskiöld Land, East of Isfjorden, Kapp Wijk, Farmhamna, Kongsfjorden, and Mushamna	*n*	Austfjordnes
<1	215	43 (36–49)	42	17 (8–31)
1	102	36 (28–46)	9	56 (27–81)
2	40	60 (44–74)	8	13 (1–47)
≥3	66	67 (55–77)	9	56 (27–81)

n = sample size.