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Authors: Cattet, Marc R. L., Duignan, Pádraig J., House, Carol A., and St. Aubin, David J.

Source: Journal of Wildlife Diseases, 40(2) : 338-342

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-40.2.338

Journal of Wildlife Diseases, 40(2), 2004, pp. 338–342

Antibodies to Canine Distemper and Phocine Distemper Viruses in Polar Bears from the Canadian Arctic

Marc R. L. Cattet,[1,6] **Pádraig J. Duignan,**[2] **Carol A. House,**[3] **and David J. St. Aubin**[4,5] [1] Canadian Cooperative Wildlife Health Centre, Department of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Drive, Saskatoon, Saskatchewan, Canada S7N 5B4; [2] New Zealand Wildlife Health Centre, Institute of Veterinary, Animal, and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand; [3] National Veterinary Services Laboratories, Foreign Animal Disease Diagnostic Laboratory, Greenport, New York 11944, USA; [4] Mystic Aquarium, 55 Coogan Boulevard, Mystic, Connecticut 06355, USA; [5] Deceased; [6] Corresponding author (email: marc.cattet@usask.ca)

ABSTRACT: Serum samples collected from 200 polar bears (*Ursus maritimus*) from two populations in the Canadian arctic, the western Hudson Bay and Lancaster Sound populations, between 1989 and 1996, were tested for antibodies to canine distemper (CDV) and phocine distemper viruses (PDV) using virus neutralization. Antibodies to CDV and PDV were detected in 48 and six polar bears, respectively. All six bears that tested positive for PDV also tested positive for CDV; in only one case did the antibody titer for PDV exceed that of CDV. Differences in antibody prevalence to CDV were detected between populations and age classes but not sex or year of sampling.

Key words: Antibody, canine distemper virus, morbillivirus, phocine distemper virus, polar bear, prevalence, serology, *Ursus maritimus*.

As a predator of arctic seals, the polar bear (*Ursus maritimus*) may be susceptible to morbillivirus infection from seals, it may be a potential source of morbillivirus infection to seals, or transmission of morbillivirus may occur back and forth between prey and predator. Antibody to morbillivirus was identified in polar bears from western Alaska (USA) and eastern Russia (Follmann et al., 1996). However, the results of differential serum neutralization assays showed this antibody to be more specific to canine distemper virus (CDV) than to phocine distemper virus (PDV), dolphin morbillivirus (DMV), or porpoise morbillivirus (PMV) (Garner et al., 2000), and CDV-neutralizing antibodies have not been found in serum samples collected from pinnipeds inhabiting the same areas (Osterhaus et al., 1988). These data suggest that, although polar bears from western Alaska and eastern Russia (described as the Chukchi Sea population in Derocher et al., 1998) may become infected by morbillivirus, transmission of the virus between seals and bears is unlikely to occur.

The prevalence of antibody to morbillivirus in polar bears in the Canadian arctic is unknown. However, neutralizing antibody to PDV and CDV has been found in various pinniped and cetacean species inhabiting the Canadian arctic (Ross et al., 1992; Duignan et al., 1997; Nielsen et al., 2000). Most importantly, Duignan et al. (1997) found antibody to PDV prevalent in ringed seals (*Phoca hispida*), the primary prey of polar bears, throughout their range in Canada. Although there has been no evidence of morbillivirus disease outbreak in ringed seals or polar bears of the Canadian arctic, the widespread prevalence of antibody to PDV in the primary prey of polar bears suggests the possibility that both prey and predator may play important roles in the ecology of morbillivirus in this geographic region. The present article reports findings from a serologic analysis conducted to determine the prevalence of antibody to morbillivirus (CDV and PDV) in two polar bear populations inhabiting areas of the Canadian arctic, where antibody to morbillivirus similar or identical to PDV is known to be prevalent in ringed seals.

Seven hundred polar bears were captured at two locations in Canada between 1989 and 1996 as part of a long-term investigation of the physiologic ecology of polar bears (Fig. 1). Details regarding methods of capture, handling, and blood collection have been described elsewhere (Cattet et al., 1997; Cattet, 2000). Serum

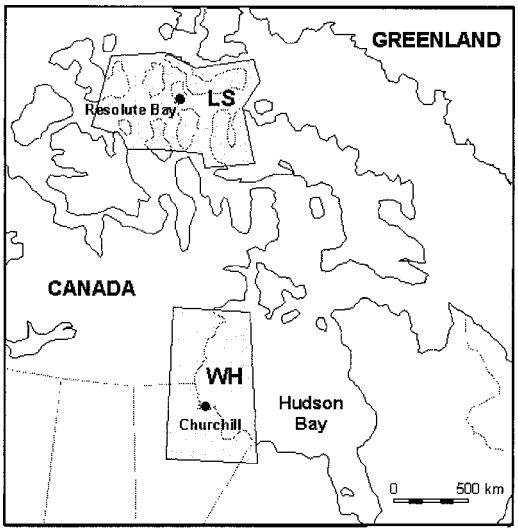

FIGURE 1. Areas of the Canadian arctic where blood samples were collected from polar bears during 1989–96. LS, Lancaster Sound population; WH, western Hudson Bay population.

samples from many bears have been stored and frozen at −20 C since the time of collection. Of these, 200 samples representing 186 individual bears were available for a survey for antibody to morbillivirus infection. Ninety-four samples were collected from polar bears of the Lancaster Sound population (LS) that were captured on the sea ice around Resolute Bay (Nunavut, Canada; 72°50′–77°00′N, 79°50′–112°50′W) during April and May 1990–92 and 1994–96. The remaining 106 samples were collected from polar bears of the western Hudson Bay population (WH), which were captured on land around Churchill (Manitoba, Canada; 57°00′–58°50′N, 92°25′–94°15′W) between July and November 1989–91 and 1993–96.

Serologic testing was carried out at the Foreign Animal Disease Diagnostic Laboratory (FADDL, Plum Island, New York, USA), using a differential microneutralization test against CDV and PDV, using African green monkey (Vero) cells, as described by Duignan et al., (1994). Canine distemper virus, Onderstepoort strain was obtained from M. J. G. Appel, Cornell University, New York, and PDV was obtained from A. D. M. E. Osterhaus, National Institute of Public Health, The Netherlands. The serum titer was calculated by the Spearman-Karber (S-K) method, which gave 50% end points (Schmidt and Emmons, 1989). A serum sample was considered to have tested positive for antibody if the titer was ≥1:28 (O'Hara et al., 1998). All antibody titer calculations were based on final serum dilutions. Mean titers were calculated from detected titers only; serum samples for which no titer was detected were not included in the calculation.

All data were analyzed using SPSS 10.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Of polar bears with positive titers (≥1:28) against either virus or both viruses, geometric mean antibody titers against CDV and PDV were compared by paired Student's t-test (Zar, 1996). Frequencies of seropositive bears were compared among years within each population using the Pearson Chi-square test and between populations, sexes, and age classes (juvenile, <6 yr; adult, ≥6 yr) by Fisher's exact test. Statistical significance was assigned when the probability (P) of type I error was ≤0.05.

Positive titers (≥1:28) for antibody to CDV were detected in 48 samples. Positive titers for antibody to PDV also were detected in six of these samples but not in any of the samples where titers against CDV were negative. Among samples with positive titers, the average titer against CDV was higher than that against PDV (geometric mean±standard error, 116±30 vs. 0±3; paired t-test, t=6.1, P≤0.001, n=48). One bear, a 16-yr-old female from the LS population, had a higher positive titer against PDV than CDV (1:60 vs. 1:34), a result that was confirmed by repeated assays.

The year of sampling did not affect the frequency of seropositive samples in either population (χ^2=1.3 and P=0.93 for LS; χ^2=6.9 and P=0.33 for WH). However, the frequency of seropositive samples from

TABLE 1. Prevalence of canine distemper virus neutralizing antibodies, by year of sample collection, in polar bears from the Lancaster Sound (LS) and western Hudson Bay (WH) populations, 1989–96.

	LS		WH	
Year	Sample	Prevalence[a] (%)	Sample	Prevalence (%)
1989	0	—	15	4/15 (27)[b]
1990	9	2/9 (22)	20	3/20 (15)
1991	5	0/5 (0)	8	1/7 (14)
1992	13	2/13 (15)	0	—
1993	0	—	13	4/12 (33)
1994	7	1/6 (17)	10	2/8 (25)
1995	26	4/23 (17)	37	15/33 (45)
1996	34	6/32 (19)	3	1/3 (33)
Total	94	15/88 (17)	106	30/98 (31)

[a] Prevalence was calculated on the basis of results from blood samples collected from all bears captured once only, combined with samples collected at first capture for 14 polar bears captured ≥2 times.
[b] Number positive/number tested (% positive).

the LS population was significantly lower than that from the WH population (Table 1; Fisher's exact test, $P=0.04$). Among all samples, the frequency of seropositive samples was greater in adults than in juveniles (Table 2; Fisher's exact test, $P=0.03$) but was similar between female and male bears (Table 2; Fisher's exact test, $P=0.39$). One LS bear and two WH bears were captured twice, and they were seropositive at both captures (interval between subsequent captures, 0.1–5.9 yr). One WH bear was seropositive at first capture but not at second capture (4.75 yr), and another WH bear was seronegative at first capture but had seroconverted by second capture (5.3 yr). Nine bears were seronegative at both captures, with an interval of up to 2 yr for four bears from the LS population and up to 5 yr for five bears from the WH population.

Although Duignan et al. (1997) found that antibody to PDV was prevalent in ringed seals, the primary prey of polar bears, throughout their range in Canada, our results indicate the prevalence of antibody to PDV in polar bears is low. One possibility to explain this apparent discrepancy is that CDV is more immunogenic than PDV in polar bears. Another possibility is that, despite a high prevalence of antibody to PDV in ringed seals, the prevalence of infection in this species is low, so that polar bears are rarely exposed to PDV. Last, and perhaps most important, although antibodies against CDV and PDV have been detected in ringed seal blood and polar bear serum samples from the Canadian arctic, the actual virus or viruses responsible for these antibodies have not been isolated. Therefore, it remains possible that other morbilliviruses (including DMV or PMV) could have cross-reacted on the virus neutralization assays that we used. Although the morbillivirus that infected polar bears of the Chukchi Sea population was not isolated, Garner et al. (2000) used a differential serum neutralization assay for four morbilliviruses (CDV, PDV, DMV, and PMV) and found that polar bears from this population had higher serum antibody titers against CDV than they did against the three major marine morbilliviruses.

TABLE 2. Prevalence of canine distemper virus neutralizing antibodies, by age class and sex, in polar bears from the Lancaster Sound (LS) and western Hudson Bay (WH) populations, 1989–96.

	Age class[a]		Sex		
Population	Juvenile	Adult	Female	Male	Total
LS	0/13 (0)[b]	15/75 (20)	7/45 (16)	8/43 (19)	15/88 (17)
WH	1/8 (13)	29/90 (32)	13/49 (27)	17/49 (35)	30/98 (31)
Total	1/21 (5)	44/165 (27)	20/94 (21)	25/92 (27)	

[a] Juveniles <6 yr, adults ≥6 yr.
[b] Number positive/number tested (% positive) on the basis of results from blood samples collected from all bears captured once only, combined with samples collected at first capture for 14 polar bears captured ≥2 times.

Although differences in antibody prevalence were not detected among years in either population, the overall prevalence for the 8-yr period was greater in WH than in LS bears. However, with considerable variation in prevalence rates among years for each population (LS, 0–22%; WH, 14–44%) and with a relatively small number of samples collected on a per year basis (≤37 per year), the significance of a difference between populations remains questionable. Similarly, Follmann et al. (1996) found considerable year-to-year variation in the prevalence of antibody to morbillivirus in polar bears from the Chukchi Sea population (26–42%), but, again, the number of samples collected per year was generally small (≤44/yr).

The prevalence of antibody to morbillivirus was greater in adults than in juveniles but was similar between female and male polar bears. Antibody prevalence in polar bears from the Chukchi Sea population was also greater in adults than in juveniles and similar between sexes (Follmann et al., 1996), but antibody prevalence in juveniles was higher than that found in the present study (~37% vs. 5% for both Canadian populations). Although the significance of this difference is unknown, it is important to note that the number of samples available for serology from juvenile bears in the present study was small (22 out of 200 samples) and was therefore possibly too few to estimate prevalence accurately.

Antibody titers against morbillivirus may persist over the long term in polar bears, as was suggested by two seropositive samples collected from a WH bear almost 6 yr apart. Furthermore, repeated exposure seems unlikely, given that nine bears tested seronegative at first capture and remained seronegative up to 5 yr later. This persistence of antibody titers was also observed in some bears from the Chukchi Sea population over a period of 2 yr (Follmann et al., 1996). However, antibody titers may not always persist—one bear from each of the Chukchi Sea and WH populations tested seropositive at first capture but seronegative at second capture.

In conclusion, our results show that polar bears from the Canadian arctic have been infected by a morbillivirus more similar to CDV than PDV since at least 1989. However, these results are based on identifying antibody, not infection. Other studies have reported the presence of antibody to morbillivirus similar or identical to PDV in ringed seals (Duignan et al., 1977) and other marine prey of polar bears in the Canadian arctic (Nielsen et al., 2000), but, again, the causative virus or viruses have not been identified. Similarly, the type of morbillivirus infecting arctic and subarctic terrestrial mammals sympatric with polar bears across their range has not been determined (Choquette and Kuyt, 1974; Zarnke and Ballard, 1987; Bohm et al., 1989; Chomel et al., 1998). Although the results of serologic analyses have been informative, future studies should be directed toward identifying the types of morbillivirus infection present in Canadian arctic wildlife, because this information is essential to understanding the ecology of morbillivirus infection in polar bears and, more generally, in arctic marine and terrestrial mammals.

Serum samples from polar bears captured in Manitoba and the central Canadian arctic during 1989–96 were collected by J. Arnould, S. Atkinson, M. Cattet, S. Polischuk, and M. Ramsay. This collection was funded by the US National Science Foundation, the Natural Science and Engineering Research Council of Canada, the Polar Continental Shelf Project, the World Wildlife Fund (Canada), and the Western College of Veterinary Medicine Wildlife Health Fund. G. Sirpenski at the Mystic Aquarium managed the transfer of serum samples between Canada and the FADDL (Plum Island, New York, USA). A. Torres at the FADDL provided access to facilities and supplied resources that were required for the serologic analyses.

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Received for publication 20 June 2002.