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Recent observations of intraspecific predation and cannibalism among polar bears in the southern Beaufort Sea

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Abstract Intraspecific killing has been reported among polar bears (*Ursus maritimus*), brown bears (*U. arctos*), and black bears (*U. americanus*). Although cannibalism is one motivation for such killings, the ecological factors mediating such events are poorly understood. Between 24 January and 10 April 2004, we confirmed three instances of intraspecific predation and cannibalism in the Beaufort Sea. One of these, the first of this type ever reported for polar bears, was a parturient female killed at her maternal den. The predating bear was hunting in a known maternal denning area and apparently discovered the den by scent. A second predation event involved an adult female and cub recently emerged from their den, and the third involved a yearling male. During 24 years of research on polar bears in the southern Beaufort Sea region of northern Alaska and 34 years in northwestern Canada, we have not seen other incidents of polar bears stalking, killing, and eating other polar bears. We hypothesize that nutritional stresses related to the longer ice-free seasons that have occurred in the Beaufort Sea in recent years may have led to the cannibalism incidents we observed in 2004.

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Introduction

Factors that motivate intraspecific predation in polar bears (*Ursus maritimus*), brown bears (*U. arctos*), and black bears (*U. americanus*) may include population regulation (Bunnell and Tait 1981; McCullough 1981; Young and Ruff 1982), dominance disputes or intraspecific aggression (Taylor et al. 1985; Amstrup 2003), and reproductive advantage (Swenson et al. 1997). The spatial distribution of female polar bears with cubs and subadults into habitats where they may be able to reduce contact with adult males, and thus reduce the threat of possible predation (Derocher and Stirling 1990; Stirling et al. 1993), and the location of many terrestrial maternity dens inland from areas frequented by non-denning polar bears (Harington 1968), appear to corroborate these hypotheses. Predation for the purposes of securing nutrition is another motivation for intraspecific killings (Taylor et al. 1985; Derocher and Wiig 1999), but the ecological factors mediating such events are poorly understood.

Here, we report the killing and consumption, between 24 January and 10 April 2004, of two adult female polar bears (one in her den and one just after leaving the den) and one yearling male. During 24 prior years of Alaskan research and 34 prior years of Canadian research in the Beaufort Sea we have not seen other evidence of polar bears stalking, killing, and eating other polar bears. We hypothesize that these events may be related to nutritional stresses accompanying the longer ice-free seasons that have predominated in this region in recent years.

Methods

Den site predation

On 24 January 2004, we searched for polar bear maternity dens in an area of previously identified denning habitat (Durner et al. 2001, 2003). Using a

helicopter-supported infrared unit (Amstrup et al. 2004), we discovered an opened maternal den on the north shore of Pingok Island, northwest of Prudhoe Bay, Alaska (Fig. 1). A blood trail led away from the den to the unfrozen carcass of a female polar bear. We photographed the carcass and blood trail, but helicopter scheduling conflicts prevented us from fully exploring the site at that time. On 5 March 2004 we returned to the site by snow-mobile and documented den structure, stratigraphy of snow at the entrance, footprints of bears, blood trail, and related details. The carcass was examined and re-photographed. A pre-molar tooth was collected (US Fish and Wildlife Service Permit #690038) for age determination (Calvert and Ramsay 1998). The skull was collected for further examination in the lab.

Predation on the sea ice

On April 7, 2004 while following polar bear footprints on the sea ice near Herschel Island, Yukon Territory, Canada (Fig. 1) as part of ongoing polar bear population studies (Stirling et al. 1993), we discovered the frozen remains of an adult female polar bear that had been accompanied by a cub of the year. On 10 April, we discovered the carcass of a yearling male polar bear. Both bears had been killed and partially consumed by other polar bears. We examined the tracks to determine the sequence of events, documented the amount and parts of the bear that were consumed, recorded evidence of scavengers, and photographed the carcasses. The heads were collected for later

examination in the laboratory and teeth were removed for age determination.

Quantification of body condition

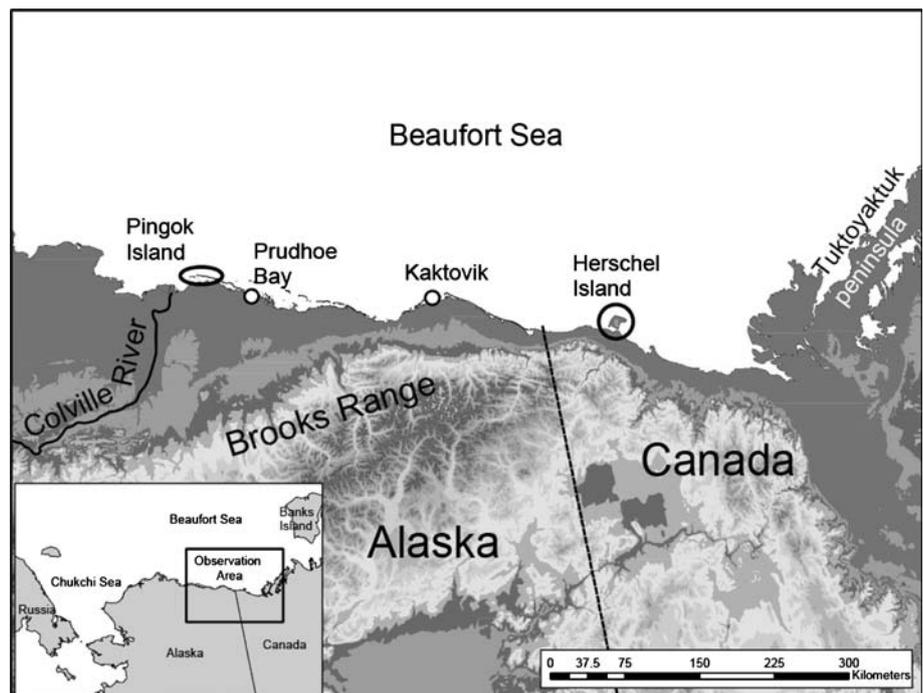
During polar bear capture efforts in Alaska and Canada (Schweinsburg et al. 1982; Stirling et al. 1989, 1993) we have recorded a subjective index of body condition for each bear. This body condition index is based on such factors as the relative amount of fat deposited over the rump area or the body as a whole, visibility of the spinal ridge, and feel of hip bones. The index is expressed as a qualitative rating from 1, the leanest, to 5, the most obese of bears we see. Although subjective, we have been using this index for over 30 years and have found remarkable consistency between individual biologists when blind comparisons are done in the field over both short and long time periods. We used a chi-square contingency table test to compare the frequencies of condition index rankings for bears > 2 years old which we captured as independent individuals in spring 2004, near Barrow Alaska, Banks Island Canada and in the easterly portions of the southern Beaufort Sea.

Results

Den site predation

Before landing the helicopter at the opened maternal den on the north shore of Pingok Island (70°33.39'N, 149°28.44'W, Fig. 1), our infrared sensor detected a

Fig. 1 Locations of intraspecific polar bear killings during late winter and spring 2004 in the eastern portion of the southern Beaufort Sea



strong residual heat signal from the open den. Upon landing, we found a largely unfrozen female's carcass. Given that the ambient temperature was -29°C , it was apparent the predation event had occurred within 12 h of discovery. Ground inspection of the den site revealed arterial blood sprayed across the exposed back wall of the den opening, deep impact impressions from large paws and claws, and much snow and ice rubble that had been pushed from the surface into the den opening when it collapsed. The female's carcass, lying at the end of a 74 m long drag trail, was partly devoured and surrounded by large paw prints and copious blood (Fig. ESM 1a). There were multiple bite wounds to her neck and head, and evidence of heavy arterial bleeding. Examination of her skull revealed canine tooth penetration through the right parietal bone and an associated massive hematoma on the right side of the brain (Fig. ESM 2a). Her right hind quarter and portions of the belly, including mammarys, had been partially consumed, for an estimated total consumption of 10% of total body weight. The residual heat of the carcass and the absence of extensive feeding suggest the survey helicopter may have displaced the predatory bear from the kill site before observers detected it.

Little snow had fallen or drifted between the time we first located the dead female (24 January) and our return visit (5 March). The den opening had partially filled with drifted snow, yet the original tracks and blood were unobscured. The female's carcass, however, was largely consumed. Footprints from arctic foxes (*Alopex lagopus*) and wolverines (*Gulo gulo*), as well as polar bears surrounded the scene.

Reconnaissance of the surrounding area revealed a single set of polar bear footprints, originally seen from the air in January, weaving a westerly path along the top of the northern bank of Pingok Island (Fig. ESM 3). The width of the footprints (22 cm compared to ~ 16 cm for an adult female) confirmed the tracks were from a large adult male polar bear. The tracks passed above and within 6 m of the den site, and continued west for approximately 50 m. They then abruptly reversed direction, and descended to the sea ice below the bluff. Once on the sea ice, the tracks led directly to the den. A meandering trail followed by a straight and direct path ending at a subnivalian lair is typical of hunting patterns frequently observed for polar bears hunting ringed seals (*Phoca hispida*) by scent (S.C. Amstrup and I. Stirling unpublished observations). In the face of the den's outer wall were deep impressions of where the predatory bear had pounded its forepaws to collapse the den roof, just as polar bears collapse the snow over ringed seal lairs (Stirling and Latour 1978). From the tracks, it appeared that the predatory bear broke through the roof of the den, held the female in place while inflicting multiple bites to the head and neck. When the den collapsed, two cubs (Fig. ESM 4) were buried, and suffocated, in the snow rubble. One cub weighed 1.14 kg, the other 1.36 kg. The analysis of cementum annuli of an extracted

premolar tooth indicated that the female was 6 years old.

Predation on the sea ice

Adult female with one cub-of-year

On 7 April 2004, about 1 km north of Herschel Island, YT ($69^{\circ}37.02'\text{N}$, $138^{\circ}48.46'\text{W}$), we followed the footprints of an adult female polar bear with one cub that had just departed a maternal den on the island. Their tracks led to a pit on a pressure ridge, where she had slept and nursed her cub. Not far beyond we found her dead on the ice. Tracks confirmed she was killed by a much larger bear. The dead animal was a 15 year old female (based on premolar tooth analysis), originally captured as a cub-of-the-year in Alaska and tattooed 6838. We saw no sign of the cub, whose tracks headed NW then were lost. There was no evidence that the attacking bear attempted to follow the cub after killing the female. The carcass of the female was frozen solid (Fig. ESM 1b). Strong winds prevailed for several days prior to 5 April, so the female and cub did not likely depart their den until after the weather turned milder. Because her carcass was close to Herschel Island, she was likely not on the sea ice for more than a day before being killed. If she had been killed on 5 April there was adequate time for her remains to freeze solidly as the ambient temperature was -20°C . Track patterns indicated that an adult male had charged the female and cub in an open area roughly 150×200 m. Subsequent activity masked details of the predatory event. Tracks of at least one or more smaller bears, which we interpreted as scavengers, were also present.

The female likely died quickly due to bites to the cranium that penetrated the brain case from both the left and right sides (Fig. ESM 2b). Her hide was removed from the neck and back and all subcutaneous fat had been eaten along with most of the meat from the hind legs, back, ribs, and shoulders down to the elbows (Fig. ESM 1b). Approximately two-thirds of the left thigh, half of the right thigh, and half of the rib cage were consumed. Her intestines had been devoured, but the liver, lungs, and the chest cavity were mostly intact. While it is difficult to say with certainty how much of the female was consumed by the attacker and how much by scavengers, the extensive damage to the hide and the short time the carcass was on the ice prior to its discovery suggests substantial consumption by the predatory animal.

Subadult male

On 10 April 2004, approximately 125 km NNW of Herschel Island ($70^{\circ}38.9'\text{N}$, $139^{\circ}52.8'\text{W}$), we spotted an adult male (tattooed X32261) feeding on a dead yearling male polar bear (Fig. ESM 1c). Footprints

indicated the dead bear had been lying in a snow pit on a pressure ridge which provided a view of the surrounding area, a common resting location for females with young, and that the predatory bear had stalked it in its bed and overwhelmed it there. The yearling was killed by bites to its head, resulting in its relatively small brain case being totally crushed (Fig. ESM 2c). After being killed, the carcass was dragged about 75 m away before being consumed beside a large pit in the snow. Only the head, neck, and a small amount of the upper torso remained and those were all frozen (Fig. ESM 1c). The sex of the dead bear (male) was confirmed by DNA (Amstrup et al. 1993), and its age determined from tooth cementum annuli analysis. The weather had been clear and cold for several days previously so it was not possible to determine precisely when the bear had been killed. There were tracks of an unknown number of bears (possibly as many as 3–4) in the vicinity of the kill. Polar bears in this region typically remain with their mother until approximately 2.3 years of age and footprints might have belonged to family (mother and sibling) of the dead bear or scavenging bears. The profusion of footprints in the snow prevented following those of the predatory male beyond the carcass. However, the tracks leading to the kill site provided clear evidence that a larger bear had stalked and attacked the smaller bear in its bed.

Comparisons of condition indices

While in the field in spring 2004, more bears in the eastern portion of the Alaskan Beaufort Sea were in significantly poorer condition at the time of capture ($\chi^2 = 27.2$, $df = 6$, $P = 0.0001$), as opposed to the more westerly and northerly areas. In the area east of 150° west longitude, 70 of 148 (47%) of bears captured as independent animals (i.e., not including cubs captured with their mothers) were in the lean condition classes 1 and 2. In contrast only 6 of 36 (17%) bears captured in westerly regions (near Barrow, Alaska) and 14 of 53 (26%) bears captured in the northern Beaufort Sea, near Banks Island, Northwest Territories, were in those poorer condition classes.

Discussion

Den site predation

Female polar bears are approximately half the size of males and, when their movements are restricted within a subnivalian den, it is probably difficult for an adult female bear to successfully evade an attack from outside. In the Pingok Island case, the elevated position from which the male attacked, along with his superior strength, appear to have enabled him to hold the female in place and kill her quickly.

Despite the apparent vulnerability of bears in dens, and the ease with which predatory bears could locate dened bears, killings at den sites appear, from the dearth of reports, to be among the rarest form of intraspecific killing in bears (Reynolds et al. 1976; Tietje et al. 1986). To the best of our knowledge this is the only intraspecific killing at a den site reported for polar bears. Such incidents may be uncommon because den sites are spatially segregated from foraging areas frequented by large males (Derocher and Stirling 1990; Stirling et al. 1993; Lunn et al. 1997). Brown bears select denning locations that minimize the chances for discovery and subsequent interaction with conspecifics (Schoen et al. 1987). In Hudson Bay, pregnant female polar bears chose den sites that are isolated from the majority of male bears (Derocher and Stirling 1990; Clark and Stirling 1998; Lunn et al. 2004). In other areas, females tend to dig their maternity dens several kilometers from the coastline (Harington 1968; Van de Velde et al. 2003). Female polar bears with newborn cubs in the southeast Beaufort Sea and Amundsen Gulf appear to avoid habitats frequented by adult males (Stirling et al. 1993). Derocher and Wiig (1999) suggested that failure to achieve spatial segregation could increase the frequency of cannibalism among polar bears.

The den of this predated female was typical of those found on Alaska's North Slope (Durner et al. 2003), where most bears den on the coast or nearby islands (Amstrup and Gardner 1994; Durner et al. 2006), rather than inland. Den site selections in Alaska are largely based on availability of suitable denning habitat (Durner et al. 2001, 2003, 2006). Because males and other non-denning polar bears forage for seals in the drifting pack ice during winter, however, coastal habitats are segregated from areas frequented by other bears. Pack ice is typically found 25–40 km north of Pingok Island, where this den was located. Therefore, this den was at least 25 km from typical habitat used by adult males during the winter denning period. We have found many successful polar bear dens on Pingok Island in past years but, prior to this incident, have seen few signs of other bears (male or female) nearby, and no indication of searching or hunting activities by males.

The fresh feeding on the still unfrozen carcass and the fact that the predatory male had consumed relatively little of the carcass at the time of discovery, suggests our helicopter may have displaced the male before we observed the den. We do not know whether the predatory bear returned to the carcass after we left, and before it was visited by scavengers.

Because bears are opportunistic foragers (Amstrup 2003; Schwartz et al. 2003), that may resort to cannibalism (Taylor et al. 1985), this den predation may have been a chance encounter by a bear searching for other food sources (e.g., carrion, terrestrial animals—see Derocher and Wiig 1999). However, considering that pregnant females commonly den on Pingok Island (Amstrup 1993; Amstrup and Gardner 1994; Durner

et al. 2001, 2003); that male bears in winter normally hunt on the sea ice many miles north of the island; that the meandering trail of the male polar bear prior to his attack on this den was typical of hunting patterns by polar bears (Stirling 1974; Stirling and Latour 1978; Amstrup et al. 2000), and that there are no other predictable sources of food along the shores of Pingok Island; we suggest that this male was specifically searching for occupied dens. Three other dens within 12 km of the predation site were identified during our infrared survey in January 2004. All of these dens were abandoned in mid-winter, well before normal den emergence time. Whether those females detected the presence of the hunting male bear in time to escape, or abandoned dens for other reasons is unknown.

Predation on the sea ice

The tracks on the sea ice indicated that both the adult female and the yearling male were actively hunted down and killed. Both of these bears, and the denning female at Pingok Island, suffered bites to the top of the head and brain case penetration by the male's canines (Fig. ESM 1). Polar bears normally kill seals by bites to the cranium (Stirling 1974) and, as in predation of seals, the carcasses of the denning female and the yearling male were both dragged away from the site of the predation before feeding began. The large portions of each carcass that were eaten, and the observation, as in the case of the Pingok Island female, that the female's cub was not pursued, suggest that the motivation for the predation of these bears, as with the female at Pingok Island, was food.

Conclusion

Given the absence of observations of polar bears stalking and killing other polar bears during all prior years of polar bear study in the Beaufort Sea, it seemed unusual that we observed three such instances within a two and a half month period in 2004. In the cases we observed, the motivation for the attacks appears to have been nutritional. There are precedents that cannibalism in polar bears may accompany reduced access to food. The only other published observation similar to those reported here, of one polar bear pursuing, killing and eating another, occurred in Svalbard, Norway, where shortage of available food and density dependent nutritional stresses were hypothesized as precipitating factors (Derocher and Wiig 1999). Taylor et al. (1985), however, recorded that malnourished female polar bears sometimes even kill and consume their own cubs, and Lunn and Stenhouse (1985) observed an emaciated male consuming an adult female polar bear.

During 2004, more independent male and female polar bears captured in the area between Tuktoyaktuk, in Canada and the Colville River in Alaska, were in poor

condition than in either the northern Beaufort Sea or the western Beaufort Sea near Point Barrow. Some ecological factor driving this pattern appears to have acted more strongly in the former region than in the latter two. That factor may be greater expanses of open water in summer (Skinner et al. 1998; Comiso and Parkinson 2004). Comiso (2002) illustrated large summer retreats of sea ice in recent years; and the sea ice declines of 2002, 2003, and 2004 were significantly steeper than even the declining trend of the preceding decade (Stroeve et al. 2005). We hypothesize that the effect of the ice retreat on polar bears was greater in the southern Beaufort Sea than north near Banks Island. Southern Beaufort Sea polar bears had to spend the summer either on the ice remaining over the deep waters of the polar basin, where oceanic productivity is low (Pomeroy 1997), or on land where foraging opportunities are minimal. Northern Beaufort Sea polar bears appear to have had comparatively more summer access to ice in productive shallow water areas over the continental shelf. Similarly, bears in western Alaska, although also recently forced far offshore by retreating sea ice, may have had summer access to ice over the shallower and more productive Chukchi Sea.

The underlying causes for our cannibalism observations are not known. They simply could be chance observations of previously unobserved rare events, or even a single rogue male bear that adopted a survival strategy including cannibalism. Because we have not observed such events previously, however, we cannot overlook the possibility they may be related to the generally poorer condition we recorded for polar bears in the Southern Beaufort Sea compared to bears in adjacent areas to the north and west. Because adult male polar bears feed little during the spring when they focus on breeding; they enter summer in poor condition (Amstrup 2003). Therefore, adult males may be the first population segment to show adverse effects of the large ice retreats of recent years (Skinner et al. 1998; Comiso and Parkinson 2004; Stroeve et al. 2005), and the potentially reduced foraging opportunities it presents (Pomeroy 1997). This possibility, and recent observations of adverse effects sea ice changes have had on the lower latitude Hudson Bay polar bear population (Skinner et al. 1998; Stirling et al. 1999; Gough et al. 2004; Stirling et al. 2004), emphasizes the importance of continuing long-term studies of the Beaufort Sea ecosystem in relation to ongoing and predicted sea ice changes.

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