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Spatial and temporal variation in size of polar bear (*Ursus maritimus*) sexual organs and its use in pollution and climate change studies

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Abstract

Sexual organs and their development are susceptible to atmospheric transported environmental xenoendocrine pollutants and climate change (food availability). We therefore investigated sexual organs from 55 male and 44 female East Greenland polar bears (*Ursus maritimus*) to obtain information about growth/size and sexual maturity. Then, the genitalia size was compared with those previously reported from Canadian and Svalbard polar bears. Growth models showed that East Greenland male polar bears reached sexual maturity around 7 years of age and females around 4 years of age. When comparing East Greenland and Svalbard polar bears, the size of baculum and uterus were significantly lower in the East Greenland polar bears (ANOVA: all $p<0.05$). Based on previously published baculum mean values from Canadian polar bears, a similar baculum pattern was found for East Greenland *vs.* Canadian polar bears. It is speculated whether this could be a result of the general high variation in polar bear body size, temporal distribution patterns of anthropogenic long-range transported persistent organic pollutants or climate change (decreasing food availability). The present investigation represents conservation and background data for future spatial and temporal assessments of hunting, pollution and climate change scenarios.

Keywords: Baculum; Canada; Climate change; East Greenland; Growth; Maturity; Ovary; Polar bear; Pollution; Reproductive organs; Svalbard; Testes; *Ursus maritimus*; Uterus

1. Introduction

Reproductive organs and their functionality are susceptible to environmental factors such as anthropogenic xenoendocrine disrupting chemicals, heavy metals and climatic oscillations (depleted sea ice extension and thereby food availability) (*e.g.* AMAP, 2004; Damstra et al., 2002; Derocher et al., 2004; Stirling and Parkinson, 2006). Recently, it was reported that chronic

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exposure to various OHCs (organohalogen compounds) such as PCBs and DDT may reduce the size of East Greenland polar bear (*Ursus maritimus*) genitalia due to their endocrine disrupting properties (Sonne et al., 2006 and references there-in). Furthermore, the atmospheric and anthropogenic mercury levels in East Greenland polar bears are *ca.* 93% (Dietz et al., 2006). As mercury may be a co-factor in the development of liver lesions in East Greenland polar bears (Sonne et al., 2007) and is known to induce hepatotoxic hypocholesterolemia (Goyer and Clarkson, 2001), a negative impact on the production of steroid sex hormones could be expected. Such endocrine impacts could be fatal as the reproductive rate of adult polar bears is among the lowest for terrestrial mammals (Bunnell and Tait, 1981; Ramsay and Stirling, 1988; Taylor et al., 1987; Amstrup and Durner, 1995) and the survival of the species is therefore susceptible to endocrine disruption long-range transported organic pollutants accumulated in their main prey the ringed seal (*Phoca hispida*) (AMAP, 2004; Ramsay and Stirling, 1988). Furthermore, Ferguson and Larivière (2004) have suggested that a large baculum is important for animals mating in an arctic climate, so even a relatively small reduction could be of importance for polar bear reproduction (Sonne et al., 2006).

Another important factor for the reproduction in East Greenland polar bears is the global warming (Førland et al., 2002). Future global warming with a decrease in sea ice extent may have an impact on the food availability for the East Greenland polar bear subpopulation (AMAP, 2004; Derocher et al., 2004; Førland et al., 2002; Wiig, 2005; Stirling and Parkinson, 2006). The additive effects from shrinking ice coverage and xenoendocrine disrupters (Jenssen, 2006) on reproductive success should be taken into account in future polar bear conservation strategies as the outcome in worst case could be extinction of the polar bear. The IUCN PBSG (polar bear specialist group) recently upgraded the polar bear to *vulnerable* on its red list as the polar bear populations would be reduced with *ca.* 30% over the next 45 years (www.pbsg.npolar.no).

Based on the above mentioned scenario, we decided to obtain data on polar bear sexual organs. Polar bear sexual organ growth pattern and maturity was estimated from the reproductive organs of 99 East Greenland polar bears sampled during 1999–2002. That allowed a first time spatial and temporal comparison of polar bear sexual organ size and growth including East Greenland, Svalbard and Canadian polar bear stocks. Furthermore, the information provided data necessary for future temporal assessments of the impact from global warming and pollution on polar bears.

2. Materials and methods

Testicles and/or penis ($n=55$) and ovaries and uterus ($n=44$) were obtained from East Greenland polar bears caught by subsistence hunter in the Scoresby Sound area (69°00′N to 74°00′N) during 1999–2002. All organs were taken <12 h *post mortem* and fixed in a formaldehyde/alcohol solution (3.5% formaldehyde, 86% ETOH and 10.5% H_2O, phosphate buffered). The samples were stored in Scoresby Sound and later sent to the veterinary pathobiology laboratory at the Faculty of Life Sciences in Copenhagen. The age determination was carried out by counting the cementum Growth Layer Groups (GLGs) of the lower I_3 tooth after decalcification, thin sectioning (14 μm) and staining (toluidine blue) using the method described by *e.g.* Dietz et al. (1991) and Hensel and Sorensen (1980).

2.1. Morphometrics and histology

Length (mm) and weight (g) was recorded as average of left and right testes before the tissue was trimmed, processed conventionally, embedded in paraffin, sectioned at about 4 μm and stained with Haematoxylin (Al-Haematein)-Eosin (HE) for routine diagnostics (Lyon et al., 1991). All slides were examined consecutively from seminiferous tubules to the caput of epididymis. Due to immature closure and/or suboptimal fixation, maximal diameter (μm) of five randomly chosen seminiferous and epididymal tubules was only measured in 11 and 26 individuals, respectively. The presence of elongated spermatids and spermatozoa of seminiferous tubules was recorded in the epididymal tubules (thirteen individuals were excluded from these histological examinations due to suboptimal fixation). Finally, weight (g) and length (mm) of bacula were measured. In females, dimensions of the uterine corpus (diameter, mm) and each uterine horn (diameter at mid-point and length, mm) and ovaries (length, mm; and weight, g) were measured. Data are given as the average values of the measurement of the left and right organs. The individual with enlarged clitoris reported by Sonne et al. (2005) was *not* included in the present investigation. Each ovary was sliced longitudinally in four sections. The number of follicles in four size categories (<1 mm; 1–2 mm; 2–3 mm and 3–6 mm) was counted macroscopically in each section and the presence of corpus luteum was detected. For follicle summary statistics, an average of the 4 longitudinal sections from each ovary was used.