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Skull measurements as a field tool for sex determination in muskoxen (*Ovibos moschatus*) from East Greenland

Key words: Ovibos, East Greenland, cranial measures, sex determination

Introduction

Recently the muskox (*Ovibos moschatus*) occurs naturally in the subarctic regions of Canada and Greenland. During the past century several introductions have been undertaken to rescue and stabilise muskox populations (SMIT & WIJNGAARDEN 1981, GRAY & GRZIMEK 1988, NOWAK 1991). In East Greenland, the muskox reaches its southernmost range limit at the Scoresby Sund area, where it is presently the only large herbivorous mammal since it became abundant after the reindeer (*Rangifer tarandus*) vanished at begin of the 20th century due to unsuitable climatic periods (SMIT & WIJNGAARDEN 1981). The Jameson Land (fig. 1) is considered to bear the largest population of muskoxen along the eastern coast of Greenland, with about 3000 to 3600 individuals in 1990 (BOERTMANN et al. 1991). Data on ecological features like density estimates, observations on behavioural and biological parameters are available from Jameson Land area (HALL 1964, FERNS 1977, THING et al. 1987; BORN et al. 1995). However, the western part of the Hurry Fjord was never closer investigated, neither by surveys from the air or ships nor by walks. Because the Hurry Fjord can be reached in a few hours by boat, it is an easy accessible hunting area for the residents of Ittoqqortoormiitt. The muskox is an important game species for the natives, even if the official guidelines do restrict the number and sex ratio free for hunting.

During an expedition to the Hurry-Fjord from July to August 1999, skulls and carcasses of muskoxen were found in the valleys at the western side of the fjord. Some skulls have been found mostly clustered together. Native hunters told, that such cluster typically indicate places where shot animals have been slaughtered. Some studies reported large fluctuations in calf production and mortality of calves and yearlings occur among years. Thus, counts of animals from only one season seem hardly reliable. Because skull-data do summarise kills of several years, fluctuations of age class distribution are assumed equalized. As predation by polar

bears is nearly absent, only death caused by hard winters, senescence and of course hunting activities are determining population trends.

This study aims on:

i) providing morphometric data and search for reliable field-tools for sex discrimination even on skull fragments

ii) comparing age and sex-classes derived from skull analyses with literature

Material and Methods

The geological basement of the western coast of the Hurry Fjord (Scoresby Sund / East Greenland; 70° 45'N; 22° 40'W; fig.1) consists of marine sediments. Those soils have a high water content and provide effective temperature buffer systems, leading to a suitable substrate for plant growth. The east side of the fjord is bordered by Liverpool Land built up by granite-mountains, which do not offer suitable habitats for persistent muskox populations.

In July 1999, I collected data from 95 skulls from the valleys along the Hurry Fjord. With an accuracy of 1 mm I took the skull measures: total length (tip of pre-maxillary to protuberantia occipitalis), skull width (postorbital constriction), width of occipitals (outermost points), horn width (largest distance at the base in the median direction) and the teeth row length of the upper jaw (maxillary). The measurement error was estimated by taking twice a total of 38 measurements on 20 animals (N=20, n=76). Because skulls were mostly found in clusters, mandibles could not assigned to distinct skulls. Thus, the eruption pattern of maxillary tooth as published by HENRICHSEN & GRUE (1980) was used for ageing the animals at the time of their death.

Complete data sets were available for 33 skulls. Those were subjected to a principal component analysis (PCA) to separate variables, which do explain most of the variance (Statistica 5.5). The PCA was done on the variance-covariance matrix (SOKAHL & ROHLF 1995). Only skulls of animals aged 4 years and older were considered to avoid data overlaps caused by growth.

Results

Measurement error, estimated by the mean coefficient of variation, was low (ranging from 0 to ± 7.47 %; CV = 0.89 %, SD = 1.58, n = 76).

The first principle component (PC 1) is loaded by horn width (loading 0.97), occipital width (0.87), skull width (0.87) and skull length (0.85), which explains for 92 % of total variance. Along the first axis the PCA separated the data points into two distinct groups (see insert in fig. 2). The group with the larger skulls (positive values) were assumed to be male skulls, whereas the smaller skulls (negative values) should be from females. Teeth row length loads the second axis, which summarises 6.2 % of total variance. However, data showed no groups along the second axis. These results are consistent to those of SMITH et al. (2002). The discriminant function separating these two groups along the first axis was used to assign the skulls of known sex from museum collections (B4495 and B12474; State Museum for Zoology, Dresden and number 778 and 779, Zoological Museum, Copenhagen, all collected in East Greenland) to one of these groups. A discriminant analysis supported the clear distinction between male and female skulls (fig. 2).

Based on this sex-discrimination the 33 datasets of adult muskoxen were analysed by descriptive statistics (tab. 1). Non-overlapping confidence limits among all measurements contributing to PC1 provide a reliable tool for distinguishing both skulls and fragments for their sex, with the restriction that animals were about 4 years and older at the time they died.

Applying our results, a total of 91 skulls and fragment could be aged and 65 assigned to a gender.

The mean annual crop rate is estimated on about 10 to 12 % whereas the proportion of yearlings in free ranging herds was observed to be 5.6 % up to 23.9 % (HALL 1964, FERNS et al. 1977, BORN et al. 1995). The corresponding values from the skull data are 5.5 % calves (n = 5) and 2.2 % (n = 2) yearlings. In opposite, adults represent 76.8 % (n = 69) of the skulls, what is higher than their proportion within the feral populations at the study area (50 to 61 %, HALL 1964, THING et al. 1987).

Comparing the distribution of skull demography with the official guidelines from 1999, a bias towards killed adult cows was asserted (Fishers exact test, two-tailed: $\chi 2 = 6.21$; df = 1; p = 0.02). We found 34 skulls of females and 31 of males, leading to a sex ratio (males / females) of 0.91 instead of 2.33, as it would be expected by the sex ratio free for hunting in 1999.

Discussion

Adult muskoxen show a distinct morphological dimorphism between the genders as described by previous studies (BOHLKEN 1982 and references cited therein). The general validity for the population at Jameson Land could be confirmed and underlined with field data. This is not as trivial as it might appear. VIBE (1958) reported considerable differences in skull sizes of collection material of the museums of Lund and Copenhagen collected around 1900 and 1930´s, respectively. Thus, proof for the local validity of particular characters is always desirable. This study provides some measurements, which are easily accessible in the field and can be used for sex determination on skulls even they are fragmented. Although the application is still restricted to adult animals, further studies based on material with known sex and age may lead to an extension to younger animals.

The fact that skulls were mainly found in clusters together and the skewed age distribution towards older individuals both supports their origin from hunting kills. Additionally, several skulls have been found damaged by shots. If animals had died because of starvation or natural predation, a higher proportion of calves and yearlings as well as senescent animals would be expected. But only in two out of 91 cases loss of teeth was recorded. Nevertheless, animals that died for other reasons than hunt might be included in this study.

THING et al. (1987) reported an annual harvest of 300 to 500 muskoxen in 1980´s. 200 animals per year could be hunted in 1991 outside the border of the National Park, but illegal shooting was considered as being common (BOERTMANN et al. 1991). The real number harvested might be higher. In 1999 the municipality of Scoresbysund issued 250 licenses, 175 for bulls and 75 for cows.

Satellite photographs have shown that large sections of the area west of the Hurry Fjord remain free of snow during the winter (FERNS 1977). Thus, the inner parts of Jameson Land act as an important wintering area (VIBE 1958, HALL 1964) and are therefore very important for the viability of the population. The skewed sex ratio in shot muskoxen confirms that animals, which are a highly important part of the effective (because reproductive active) population, had been removed. This must be considered as a non-sustainable management.

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Zusammenfassung

Geschlechtsbestimmung des Moschusochsen (*Ovibos moschatus*) von Ostgrönland anhand von Schädelmaßen

Während einer Expedition im Sommer 1999 an der Westküste des Hurry-Fjordes (Jameson Land, Scoresbysund, Ostgrönland, 70° 45'N; 22° 40'W) wurden aufgefundene Schädel des Moschusochsen (*Ovibos moschatus*) vermessen. Moschusochsen werden durch die einheimische Bevölkerung (Inuit) bejagt, wobei die Schädel nach der Jagd zusammen mit anderen größeren Knochen im Gelände verbleiben. Mittels Hauptkomponenten- und Diskriminanzanalyse konnte eine sichere Geschlechtsbestimmung von Schädeln adulter Tiere (> 4 Jahre) gezeigt werden. Die Altersbestimmung erfolgte anhand des Zahnstatus der Oberkiefer nach HENRICHSEN & GRUE (1980). Neben den Abmaßen der Hörner können noch die Schädellängen und –breiten sowie die Breite der Occipitalen für die Geschlechtszuordnung an Schädeln und Fragmenten im Feld angewandt werden. Das Geschlechterverhältnis der geschossenen Tiere betrug 0.91 (m:w) und wies einen starken Überhang adulter Tiere auf. Die für 1999 gültigen offiziellen Abschußvorgaben (175 Bullen, 75 Kühe; 2.33 m:w) zeigen den Versuch, die Bestände nachhaltig zu nutzen. Dies ist in den vorangegangenen Jahren im Untersuchungsgebiet nicht geschehen, wie die Alters- und Geschlechtsverteilung der Schädel zeigt.

Summary

Skull measurements as a field tool for sex determination in muskoxen (*Ovibos moschatus*) from East Greenland

During an expedition to the western coast of the Hurry inlet (Jameson Land, Scoresbysund, East Greenland, 70° 45'N; 22° 40'W) in summer 1999, skulls of muskoxen (*Ovibos*

moschatus) found in the field became measured. This species is hunted by the native inuits. Skulls and other larger bones from shot muskoxen kept left in the field. Applying principal component analysis (PCA) and discriminant analysis allowed a save sex determination of adult animals (>4 years). Ageing was done on the teeth state of the upper jaws following HENRICHSEN & GRUE (1980). Beside the horn size, also skull length and width and the width of the occipitals can be used for determining genders on skulls and even on fragments in the field. A sex ratio of 0.91 (m:f) and a strong bias towards adult animals was found in shot animals. In 1999 permits for killing 175 bulls and 75 cows (2.33; m:f) were issued, which underlines the attempt for a sustainable management of the local population. As the sex- and age distribution of analysed skulls shows, this did not happen during the years before.

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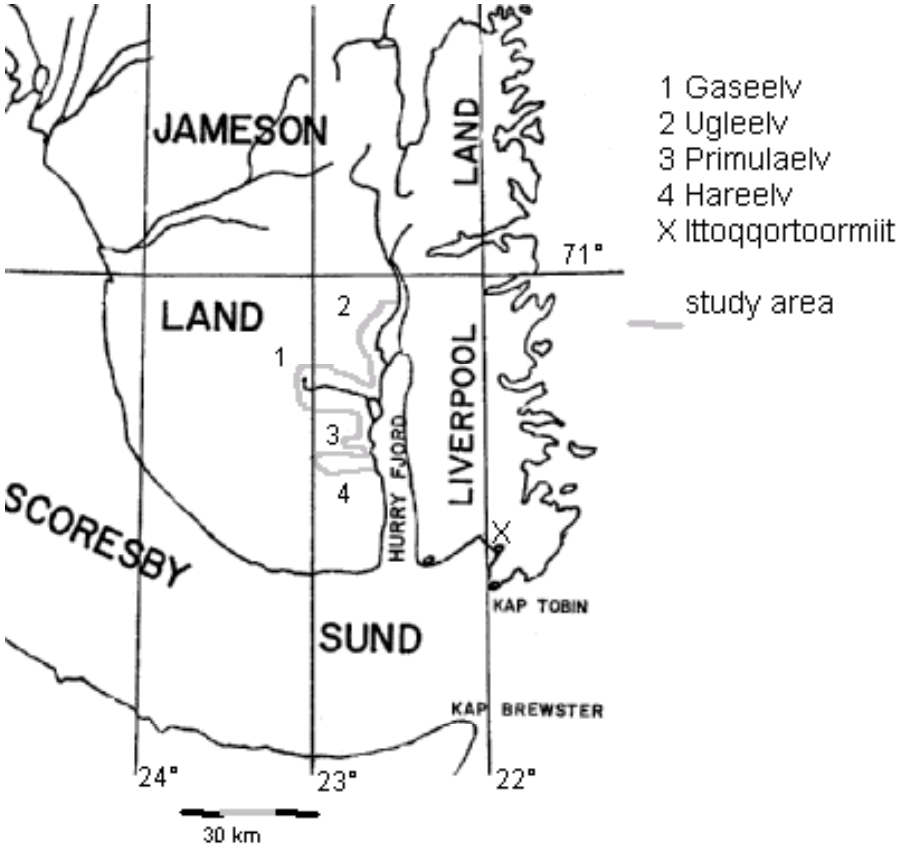

Figure 1: Scoresby Sund and Jameson Land / East Greenland (redrawn from Hall 1964).

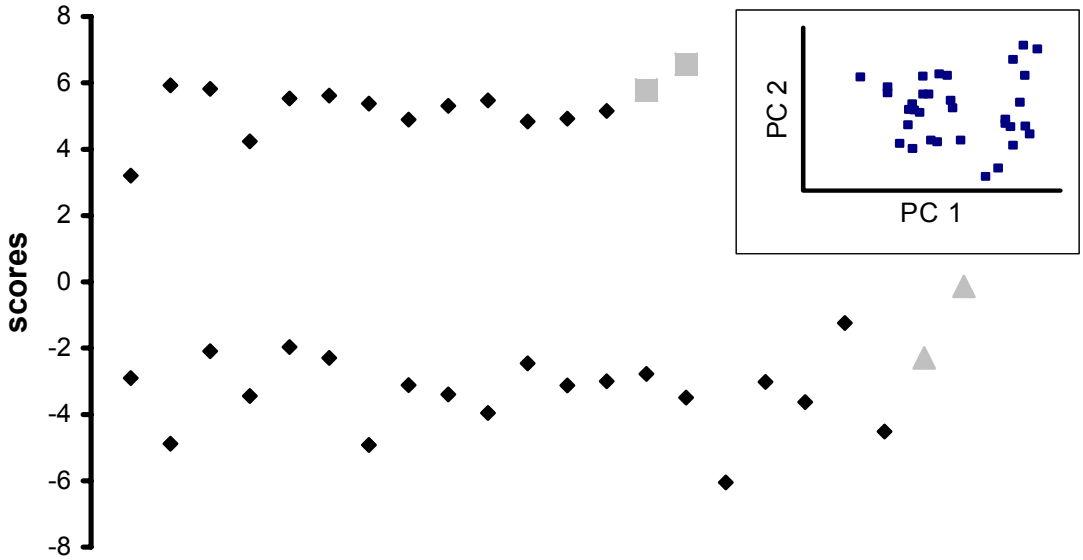

Figure 2: Scores (unstandardised) from a discriminant analysis of muskox skull data (Scoresbysund / East Greenland). Skulls from museums (Copenhagen, females, grey rectangles and Dresden, males, grey triangles) were projected on the graph by using the discriminant function of skull data. Grouping derived from PCA results are shown at the diagram in the right upper corner (first two principal components).

Table 1: Descriptive statistics of 33 sets of skull data of muskoxen from East Greenland. Each variable was tested among genders by applying a Wald-Wolfowitz-test.

variable	n	mean [mm]	95% CL lower [mm]	95% CL upper [mm]	SE	z corr.	p corr.
skull length males	20	483.6	470.6	496.5	6.17	4.54	< 0.001
skull length females	13	426.6	421.3	431.9	2.42		
skull width males	20	127.3	122.8	131.9	2.18	5.28	< 0.001
skull width females	13	102.5	101.0	104.1	0.72		
occipitals males	20	179.8	175.6	184.1	2.02	4.54	< 0.001
occipitals females	13	152.2	148.3	156.0	1.75		
horn width males	20	178.7	171.3	186.1	3.53	5.28	< 0.001
horn width females	13	79.2	75.0	83.3	1.89		
teeth row males	20	137.2	135.2	139.3	0.97	1.21	0.23
teeth row females	13	132.1	127.2	137.0	2.24		