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# Transect width and missed observations in counting muskoxen *(Ovibos moschatus)* from fixed-wing aircraft

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*Abstract:* While conductioning muskox-censuses *(Ovibos moschatus)* in winter in Jameson Land, NE Greenland, from a fixed-wing aircraft, we examined the width of transects covered. We used a laser range-finder binocular for measuring the distance to observed groups. We found that 1000 m was a reasonable limit for observing a high proportion of the muskoxen present even though it was possible to observe muskoxen from 4000 m or even more. Using two observers on the right side of the aircraft each speaking into a tape recorder with an automatic time signal, we recorded observations and performed a double-observer experiment. By matching the group sizes and perpendicular distances with times of observation we could compare observations of the two observers. We found that both observers missed up to 25 % of muskoxen within a 2000 m transect width. The main reasons for missing animals is difficulty in obtaining reference points in snow covered landscape and fatigue of the observers.
Calibration of estimated distances using read-outs from the laser-range finder is an adequate method of obtaining distance data for line transect calculations. Our double-observer experiment demonstrated that even groups close to the transect are easily missed.

**Key words:** muskox, census techniques

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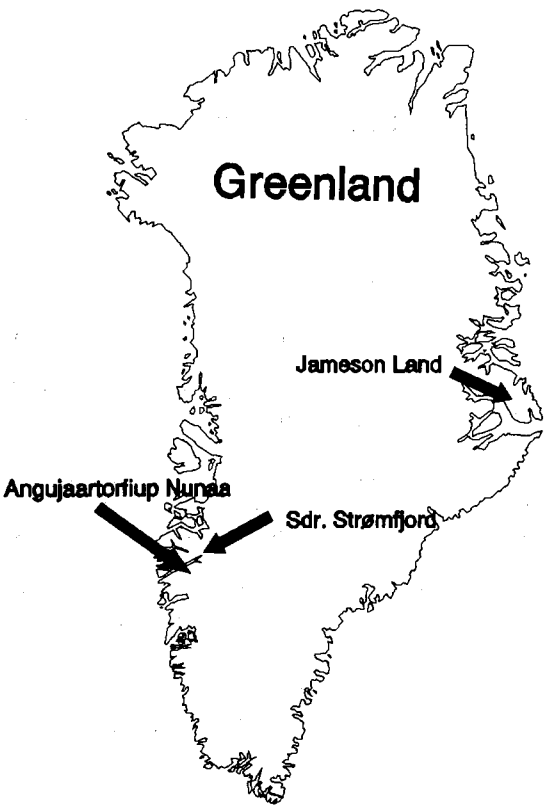
## Introduction

A population of 3000-4000 muskoxen *(Ovibos moschatus)* was monitored in Jameson Land, northeast Greenland, from 1981 to 1990. Each winter the population was strip-censused from fixed-winged aircraft and it was assumed that the observation distance allowed total coverage of the area. There is, however, a lack of distance data to evaluate this assumption. Several authors, Burnham *et al.*, 1980, Burnham and Anderson, 1984, Burnham *et al.*, 1985, Caughley *et al.*, 1976) have emphasized the need for accurate distance data in aerial survey. None of these authors, however, have described a method to obtain accurate distance data in hilly or mountainous areas with slopes, where inclinometers and wing-markers cannot be used.

In 1988 we began to record the distance from our aircraft to the observed groups using a laser range-finder and conducted a double-observer test to estimate the proportion of muskoxen missed. The incentive for this was our wish to delimit the strip and correct for missed muskoxen. Furthermore our data can be used as the basis for calculation of population size according to line-transect theory.

The objectives of our study were:

(1) to test the observer's capability to estimate distance after practicing with a range-finder;
(2) to investigate the relationship between observation rate and (I) group size and (II) observation distance;
(3) to determine whether these results can be used to estimate population size;




## Study area

Jameson Land comprises about 11.000 km² in northeast Greenland (70°30'N to 72°N). The eastern part of Jameson Land is mountainous with high slopes and deep valleys offering good opportunities of muskox foraging (Thing *et al.*, 1987, Thing, 1984). The western and southern part of Jameson Land is a plateau ranging from sea level in the west up to 5–600 m a.s.l. This area is rather level or moderately sloped and intersected by numerous rivers. The census methods used were adapted to the different kinds of landscape.

## Materials and methods

In the valleys of the northern and northeastern parts of Jameson Land census routes followed the bottom of valleys. We recorded time of observation and the number of muskoxen in each group. Flight routes over flat country were laid out in an east-west direction with a distance of 7,5 km between transects. We recorded the time of observation, the number of muskoxen in each group and the perpendicular distance from the aircraft to each group.

The censuses were performed with a fixed-wing aircraft (Partenavia P68 Observer) with glass-nose and bubble-windows in the back seasts offering optimal observing conditions forward and to both sides of the aircraft. An Omega navigational system was used for navigation and positioning with a precision within about 500 m. Flying altitude was 200 to 300 m above ground level and the speed was about 200 km/h.

We used three observers, one at the right front seat and two in the back seats. The front seat observer registered groups, measured perpendicular distances to observed groups and recorded time and locations on a map and on tape. The back seat observers counted the number of muskoxen in each group and estimated the perpendicular distance to the groups. All observations were recorded independently on tape recorders with automatic time signals (interval 1s). This made it possible to locate all observations with a reasonable accuracy afterwards and to compare observations of the two right-hand observers. The observers shifted positions 3 times during each survey.

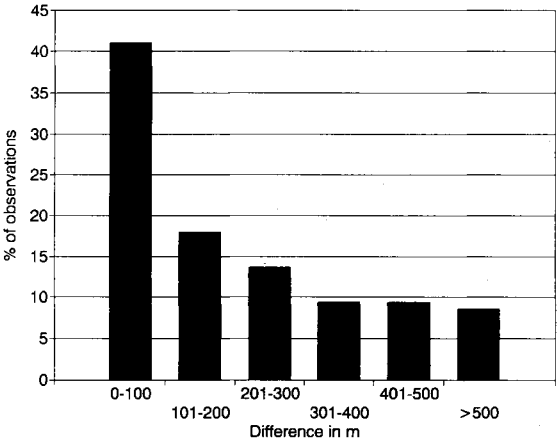



Fig. 1. Distance estimates and distance measurements to identical groups. n=117.

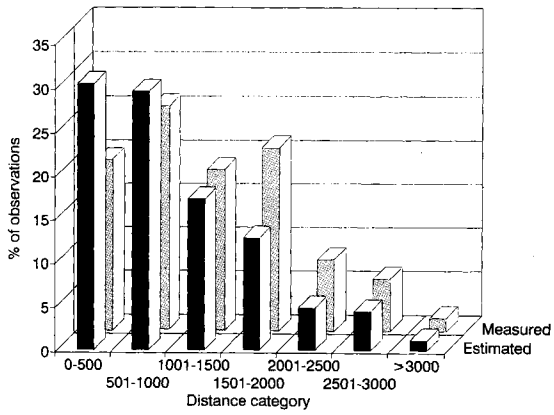



Fig. 2. Comparison of the frequency distribution of estimated and measured distances to groups. n=272 for measured groups and n=715 for estimated groups.

Distance measurements were made using a laser range-finder (Simrad LP7) with viewing capabilities like standard 7x50 binoculars and provided with a laser rangefinder offering immediate readout of distance in a separate eyepiece.

Distance measurements were made perpendicular to the flight route, directly from the aircraft to each group of muskoxen. In distances exceeding 400 m this caused a discrepancy of less than 10% relative to horizontal distance.

The proportion of muskoxen missed was calculated by comparing group sizes and the registrations of distances and the exact time of observation of two observers counting the same area.

Groups are accepted as identical if the time lapse between registrations was less than 30 seconds and the difference in number of individuals was 3 or less and the difference in observation distance was less than 300 m. At distances exceeding 2500 m groups have been accepted as identical with even greater differences than 3.

Counting conditions are not identical from the front seat and the back seats. The front seat observer has a better possibility of early awareness of muskoxen but more duties are required from this position. Back seat observers have a better view directly below the aircraft and they benefit from being able to concentrate on observing without the disturbance of other duties.

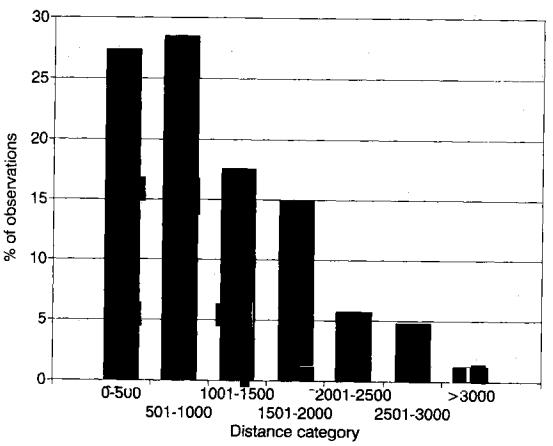



Fig. 3. Frequency distribution of distances to observed groups. n=987.

## Results

*Comparison of estimated and measured distances*

Figure 1 shows the results of comparison of estimates and measurements of distances to groups. In 41% of the observations the difference is 100 m or less and in 73% of the observations the difference is 300 m or less.

*Comparison of estimated and measured distance distribution*

Figure 2 shows the distribution of measured and estimated distances respectively in seven 500 m distance categories. The profiles are similar. The observer who measured distances, however, had a smaller proportion of observations close to the flight route and a relatively large proportion of observations at distances exceeding 1000 m. At distances exceeding 2000 m the proportion of observations in the distance categories is less than half the proportion of the distance categories close to the transect.

*Missed observations*

In the valleys the front seat observer missed 25% of the muskoxen present while the back seat observer missed 24% of the muskoxen. In transects the situation was slightly different because the front seat observer missed 25% while the back seat observer missed 30%.

*Difference in counts of groups*

Datasets including group sizes from two observers are available for 181 groups (Figure 4). About 50% of the groups were counted to the same number by the two observers. In 26% of the cases the difference in count was 1 individual, in 11% of the case the difference was 2, in 5% of the cases the difference was 3 and finally in 9% of the cases the difference was more than 3.

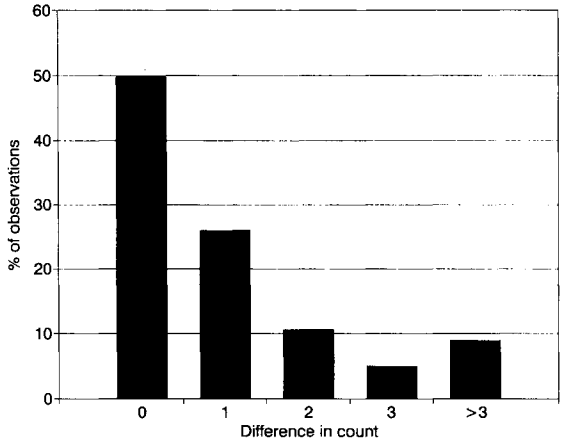



Fig. 4. Double-observer experiment. Difference in count of groups. n=181.

*Missed groups in relation to group size and observation distance*

Figure 5 shows the characteristics of groups missed by one observer in the double-observer experiment in relation to groups size and distance. Such data are available for 174 missed groups. More than one third of these groups consist of 5 or more individuals and more than half the groups were less than 1500 m away from the flight route. A relatively high proportion of the missed groups are large and relatively close to the flight route.

Within distance categories there was a tendency that larger groups were missed to a smaller extent than small groups and individuals. Within size categories there was a tendency for relatively few groups missed at larger distances. Comparing the distribution of missed groups with the distribution

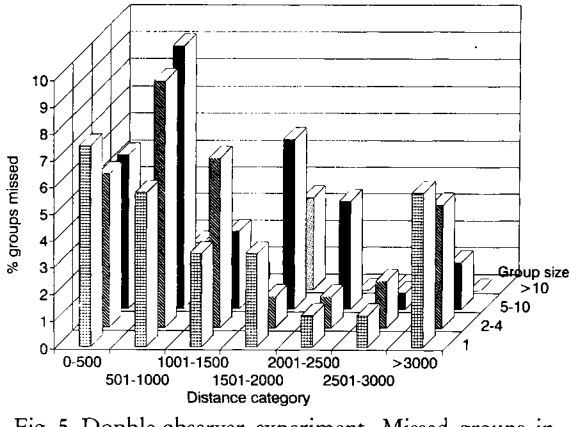



Fig. 5. Double-observer experiment. Missed groups in relation to group size and obsevation distance. n=174.

of observed groups (Figure 5 and 6) revealed that most groups were observed in the close distance categories and therefore also more groups were missed in these distance categories.

The ratio between missed and observed groups increased with distance and decreased with group size indicating that the chance of missing increases with distance and decreases with group size (Figure 7).

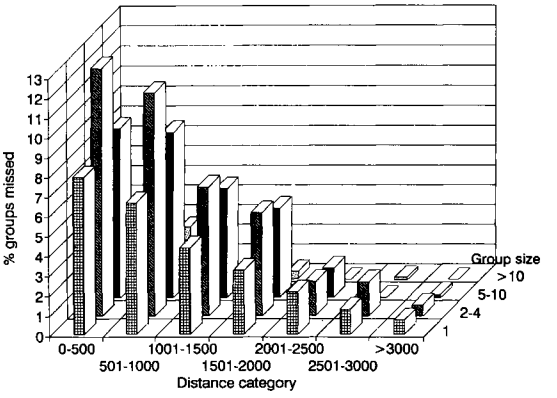



Fig. 6. Observed groups in relation to group size and observation distance. n=1288.

## Discussion

*Distance estimation*

The results of the direct comparison of estimated and measured distances to groups indicated a good success in estimating distances. In about 40% of the observations estimated and measured distances agreed within 100 m and in almost 75% of the observations the difference between estimated and measured distances was 300 m or less. It seems, however, important to practice estimating distances by comparing estimates with readouts from the laser range-finder. Furthermore changing of flying altitude should be avoided. Results of comparison of estimated and measured distances from a flying altitude of 500 m altitude indicate that the observer was confused after having been "calibrated" to an altitude of 200 m (unpublished data).

The distribution of distances of observations of muskoxen by the person estimating distances and the person measuring distances were quite similar. It was striking, however, that the latter seemed to miss groups close to the flight route. This was probably caused by a tendency of the observer to concentrate on groups at large distances. This was because operation of the range finder forces the

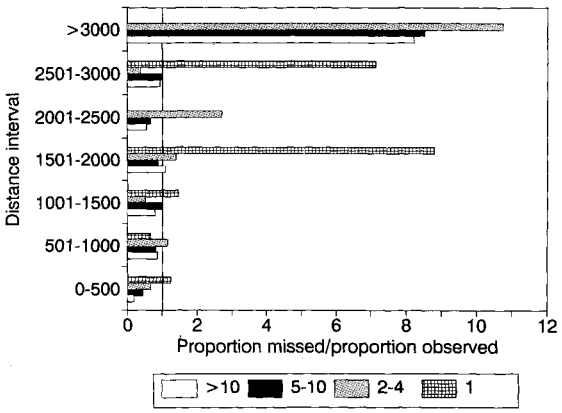



Fig. 7. Ratio between percentage of missed and observed groups in relation to group size and observation distance.

attention of the observer outwards, at least when used in an airplane like the Partenavia. The frequency of observations of muskoxen decreased with observation distance (Figure 1). The accuracy in distance estimates decreased with distance. It is evidently possible to estimate distances to observed groups with an adequate accuracy provided the observer had been given the opportunity to calibrate his estimates with exact measurements from the range finder. This is probably the only way to get good distance data in an undulating landscape where wing-markers and the like cannot be used.

*Distance profile*

The percentage of observations decreased from 25% in the distance intervals 0–500 and 500–1000 to less than 10 percent beyond a distance of 3000 m. Hence the most accurate count of the transect was obtained by concentrating on a strip of 1000 m on either side of the aircraft thus giving a total transect width of 2000 m.

*Missed individuals and groups*

The total counts of two independent observers agreed well and it appeared that the observers had seen all the muskoxen present in the area. Closer examination of the data revealed, however, that both observers missed groups, but at different times. About 25% of the groups were missed.

In the valleys there was no difference between front seat and back seat in the proportion of groups missed. The range finder was used only occasionally whereas it was in counstant use in the more or less level areas. The higher proportion of missed muskoxen from the back seat in the level areas contradicts the hypothesis that operating the range finder causes missing of groups.

In almost two thirds of the cases there was no difference between two observers in the count of identical groups and in less than 15% of the cases the difference between observers was 3 individuals or more. We conclude that missing of groups was the most important factor for underestimating of population size while underestimating of group size only is of minor importance in this respect. Generally, more groups are missed the further away they are (Figure 5) and small groups were missed more often than large groups.

Most missed muskoxen were in larger groups at distances close to the transect line. The reasons include: 1) fatigue of observers, 2) distraction because of other duties such as distance measurement, 3) moisture on the windows, 4) difficulty in focusing the eye on the ground surface in the all white landscape. On several occasions one of the observers was not able to see groups that were clearly seen and pointed out by the other observer. After forcing the eyes to focus from close to far the observer suddenly became aware of the group. This illustrates the importance of observing intensely in all directions and at all distances.

*Implications for strip transect calculations*

Our studies of transect width and missed observations have demonstrated a transect width of 7000 m is too broad for successful aerial survey of muskoxen. Furthermore we have shown, that it is neccessary to correct the counts for missed observations.

We have used a strip width of 4000 m and have added 25% to the counts. From these densities we have calculated an average density of 'neighbour' strips to calculate densities for the areas between the strips. On this basis we calculated the population size. Based on our studies we suggest that a strip width of 2000 m should be used and that the counts should be revised for missed muskoxen.

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