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# Sexual dimorphism in the skull of Arctic Foxes *Alopex lagopus* L. from Svalbard

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Sexual size dimorphism in 12 skull and mandible dimensions of Arctic Foxes *Alopex lagopus* from Svalbard was examined. Males (n = 59) were significantly larger than females (n = 51) in 11 of the measurements (average 4.0%, range 3.2—4.7%), and females were larger in one measurement (30.2%) that was negatively correlated with overall skull size. The last variable was not included in multivariate statistics since the individual variability was large.

Zygomatic breadth was the single variable with best discriminating power, classifying 68% of the specimens to correct sex. All 11 variables classified 77% of the specimens correctly. Discriminant function scores of the sexes overlapped much, but the means were significantly different. Svalbard foxes appear to be smaller than Arctic Foxes from most other populations, but sexual dimorphism was not notably smaller.

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## INTRODUCTION

Size dimorphism in the skull of Arctic Foxes *Alopex lagopus* L. has been related both to sex, age, and geographical region (Vibe 1967, Bisaillon & DeRoth 1980, Pengilly 1981), and is comparable to that of other canid species (Pengilly 1981). Sexual dimorphism in mammals is usually explained by sexual selection or different specialization in food habits between sexes (Wilson 1975, Wiig 1986). Arctic Foxes from Svalbard are smaller than foxes from most other populations (Vibe 1967). This size reduction may be directly or indirectly attributable to more limited food resources and a shorter season for growth in Svalbard, i.e. energetic constraints. This study examines sexual dimorphism in the skull of Arctic Foxes from Svalbard, and whether the amount of dimorphism is affected by overall skull size.

## MATERIALS AND METHODS

A total of 110 Arctic Fox skulls of known sex from Svalbard were examined (59 males and 51 females). The four major samples of foxes were from Museum collections and were killed in different winters: University of Copenhagen (1963—1964), University of Oslo (1964—1965, and 1972—1973), and University of Bergen (1975—1976). The exact date of captures are unknown, but the hunting season is from November to March. Thus, foxes were minimum 5 months old when killed.

Some skulls were broken, but when possible 11 measurements of the skull and lower mandible were taken by calliper and recorded to the nearest 0.1 mm (see Bisaillon & DeRoth 1980, Wiig 1986, Wiig & Andersen 1986 for descriptions and definitions of variables). Skull measurements: Maximum skull length, condylobasal length, palatal length, zygomatic breadth, postorbital breadth, molar breadth, rostrum breadth. Jaw measurements (right jaw if possible): Maximum mandible length, mandible dental length, mandibular tooth row length, mandible height. Crista sagittalis (Vibe 1967) was also measured. This measurement has been suggested to decrease with age (Vibe 1967).

Specimens were subjectively classified as either juveniles (<1 year old) or adults (>1 year old) on the appearance and wear of the canines. This method has proved reasonably reliable (Frafjord in prep.), and was also tested in a sample of 20 specimens of known age originating from farms. Three of these (15%)

Table 1. Mean, standard deviation, and sample size of 12 skull and mandible measurements of Arctic Foxes from Svalbard. The male/female ratio (R), Mahalanobis' $D^2$, and ANOVA between sexes are also given.

| | Males | | | Females | | | | | ANOVA | |
|---|---|---|---|---|---|---|---|---|---|---|
| Measurements | $\bar{X}$ | SD | n | $\bar{X}$ | SD | n | R | $D^2$ | F | p< |
| Maximum skull length | 122.9 | 4.8 | 55 | 118.3 | 4.8 | 49 | 1.04 | 0.75 | 22.74 | 0.001 |
| Condylobasal length | 117.7 | 4.8 | 56 | 113.4 | 4.6 | 49 | 1.04 | 0.66 | 20.89 | 0.001 |
| Palatal length | 60.8 | 2.9 | 59 | 58.3 | 2.9 | 50 | 1.04 | 0.65 | 21.29 | 0.001 |
| Zygomatic breadth | 68.7 | 2.6 | 54 | 65.7 | 2.7 | 44 | 1.05 | 1.08 | 31.77 | 0.001 |
| Postorbital breadth | 31.9 | 2.3 | 56 | 30.7 | 1.9 | 47 | 1.04 | 0.29 | 8.25 | 0.005 |
| Molar breadth | 39.1 | 2.0 | 59 | 37.6 | 1.9 | 51 | 1.04 | 0.89 | 16.81 | 0.001 |
| Rostrum breadth | 23.2 | 1.3 | 59 | 22.3 | 2.0 | 51 | 1.04 | 0.34 | 8.99 | 0.005 |
| Maximum mandible l. | 88.8 | 4.0 | 59 | 84.9 | 4.1 | 51 | 1.05 | 0.71 | 25.79 | 0.001 |
| Mandible dental l. | 60.5 | 2.8 | 57 | 57.7 | 3.7 | 49 | 1.05 | 0.61 | 18.68 | 0.001 |
| Mandibular tooth row length | 50.7 | 2.6 | 58 | 49.1 | 3.3 | 51 | 1.03 | 0.15 | 7.62 | 0.01 |
| Mandible height | 33.8 | 1.7 | 59 | 32.2 | 1.7 | 51 | 1.05 | 0.57 | 24.79 | 0.001 |
| Crista sagittalis | 5.3 | 3.1 | 54 | 6.9 | 3.3 | 49 | 0.77 | - | 6.15 | 0.02 |

were erroneously classified to age group. In the Svalbard sample, age distribution was very even. Females: 26 juveniles, 25 adults. Males: 30 juveniles, 29 adults. Furthermore, Pengilly (1981) found little development in cranial measurements beyond the first winter of life, and measurements of specimens about 6 months old were about 96% of measurements of specimens four years or older. Thus, no corrections for age were made and the entire sample was used in the analysis.

Statistical analysis includes analysis of variance (ANOVA), discriminant analysis, Wilks' lambda and Mahalanobis' distance, and Pearson's product-moment correlation coefficient ($r_p$) (Norusis 1988).

## RESULTS

Males were significantly larger than females in all measurements except crista sagittalis (Table 1). When excluding crista sagittalis the male/female ratio was very constant among measurements. Males were on average 4.0% larger than females, range 3.2—4.7%. Sexual dimorphism was significant within the two age classes in most measurements (F range 4.4—18.3, $p<0.05$), except postorbital breadth, rostrum breadth, mandible tooth row length, and mandible dental length in adults ($p>0.05$).

Crista sagittalis was negatively correlated ($r_p$, $p<0.01$) with all other measurements except postorbital breadth in both males and

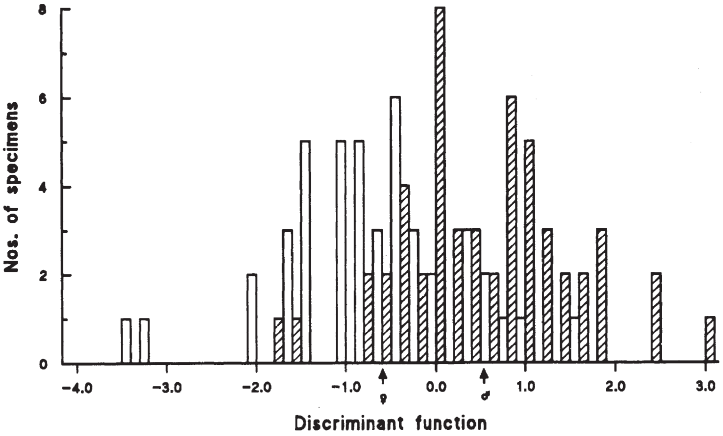

Fig. 1. Histogram of discriminant function of male (hatched) and female Arctic Foxes, based on 11 skull and mandible dimensions. The group centroids are indicated.

females, mandibular tooth row length in males, and rostrum breadth in females ($p > 0.01$). All the other 11 measurements were positively correlated with each other ($p < 0.01$), except rostrum breadth and postorbital breadth in females ($p > 0.01$). Thus, crista sagittalis was not a measure of overall skull size, and the individual variability in this measurement was large (Table 1). Consequently, it was not included in the following multivariate analysis.

Wilks' lambda was large (0.74, $\chi^2 = 23.2$, d.f. = 11, p = 0.02) and separation between the sexes was not complete (Fig. 1). When measurements were entered stepwise in a discriminant analysis which maximized Mahalanobis' distance between sexes, zygomatic breadth, mandibular tooth row length, and maximum mandible length had most discriminating power (Table 2). Thus, these three measurements significantly discriminated between sexes, and the inclusion of further measurements did not add much to this discriminating ability. About 75% of the specimens were correctly classified to sex in a model using these three variables, while about 77% were correctly classified using all 11 variables (Table 2). Zygomatic breadth alone classified 68% of the specimens correctly to sex (Table 2).

Table 2. Specimens correctly classified to sex by step in a discriminant analysis (%). ZB = zygomatic breadth, MTRL = mandibular tooth row length, MML = maximum mandible length.

| Variables included | Males | Females | Total |
|---|---|---|---|
| ZB | 66.7 | 70.5 | 68.4 |
| ZB, MTRL | 66.7 | 70.5 | 68.4 |
| ZB, MTRL, MML | 73.6 | 77.3 | 75.3 |
| All 11 (of Table 1) | 73.6 | 79.5 | 76.6 |

## DISCUSSION

Cranial dimensions of Svalbard foxes appear to be smaller than those of Arctic Foxes from most other populations from which data is available (Vibe 1967, Bisaillon & DeRoth 1980, Pengilly 1981). Pengilly (1981) found that males in Alaska and Canada averaged 2—8% larger than females in cranial measurements, which is somewhat more than I found in foxes from Svalbard. In another study of Canadian foxes, the range in male to female ratio was 1.00—1.06 (calculated from Bisaillon & DeRoth 1980), similar to that found in the present study. Thus, sexual dimorphism in the skull of Svalbard foxes does not appear to be notably smaller than in Arctic Foxes elsewhere.

Sexual dimorphism in the Arctic Fox is less than in the Red Fox *Vulpes vulpes* (Huson & Page 1979). This dimorphism may be associated with sexual selection, i.e. male competition for mate, territory, etc., as arguments for different specialization in food habits between sexes are hard to find in the Arctic Fox. Both Arctic and Red Foxes are monogamous (Bekoff et al. 1981), and the smaller dimorphism in the Arctic Fox might be due to greater energetic constraints on body size than in the Red Fox. The number of specimens correctly classified to sex by discriminant analysis was higher in the Red Fox than in the Arctic Fox, 80—88% (Huson & Page 1979) and 77%, respectively. This may also indicate a higher within-sex variability in the Arctic Fox.

Zygomatic breadth was the single measurement that best discriminated between sexes in the Arctic Fox, but the ratio of breadth to length was not greater in males than in females ($F = 0.18$, $p > 0.05$). Crista sagittalis was the only measurement in which females were larger than males, and sexual dimorphism was greatest in this variable (30.2%). Pengilly (1981) concluded that the high variability in crista sagittalis made this measurement unreliable for sex determination, and consequently it was not included in the present multivariate analysis. The width of crista sagittalis is probably negatively correlated with several factors, like age, growth, health, and general condition of the fox.

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## SAMMENDRAG

### Kjønnsdimorfisme i kranier av fjellrev fra Svalbard

Kjønnsdimorfisme i 12 forskjellige mål ble undersøkt i kranier og kjever av fjellrev *Alopex lagopus* fra Svalbard. Hanner (n = 59) var større i alle 11 mål som var relatert til størrelse (gjennomsnittlig 4.0%), mens hunner (n = 51) var større i ett ikke-størrelsesrelatert mål. De 11 størrelsesrelaterte målene klassifiserte 77% av kraniene til riktig kjønn i en diskriminant analyse, mens maksimal skallebredde alene klassifiserte 68% av kraniene riktig. Overlappet mellom kjønnene i størrelsen av skallen var relativt stort, men kjønnsdimorfisme hos fjellrev fra Svalbard ser ikke ut til å være særlig mindre enn hos fjellrev fra andre områder.

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