Paper 44

Cranial Variation in Polar Bears

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INTRODUCTION

Various attempts at understanding geographic variation in Polar bears have been made since Knotterus-Meyer (1908) began to confuse the issue by recognizing seven forms of what had previously been considered a monotypic circumpolar species. The most recent and noteworthy contribution was by Manning (1971), who outlined the earlier work.

Briefly summarized, Manning demonstrated a cline of increasing size from East Greenland across Canada to the Bering Strait. He suggested that the population of largest bears, from the Bering Strait area and southward, could be considered subspecifically distinct, but left it unnamed pending further investigation.

The present study was initiated in order to examine more closely the extent and kind of geographic variation in Alaskan polar bears. A variety of multivariate analyses were conducted on Manning's data, and on additional specimens obtained since the completion of Manning's work.

MATERIALS AND METHODS

A total of 295 skulls of Alaskan polar bears was examined. The seventeen skull measurements used and described by Manning (1971) were taken with calipers. The measurements were: (1) Condylobasal length (CBL); (2) Molar-premaxilla length (MPL); (3) Mastoid breadth (MB); (4) Zygomatic breadth (ZB); (5) Supra-orbital breadth (SB); (6) Cranial length (CL); (7) Facial length (FL); (8) Maxilla-supraorbital height (MSH); (9) Least cranial breadth (LCB); (10) Interorbital breadth (IB); (11) Breadth at canines (BC); (12) Palatal breadth (PB); (13) Length P4 to M2 (LP4-M2); (14) Crown length of M2 (LM2); (15) Crown length of M1 (LM1); (16) Coronoid height (CH); (17) Condylopalatal length (CPL).

Basic statistical analyses were performed with a univariate program (D-STST) in use at the Smithsonian Institution Information Systems Division. Ratio diagrams modified from Simpson (1941), as used by Anderson (1972), were used as a graphic method of comparing measurements and proportions between groups of specimens. The data were also analysed with subroutines contained in the Numerical Taxonomy System of Multivariate Statistical Programs (NTSYS), developed by F. J. Rohlf and associates of the State University of New York at Stony Brook.

Although the original analyses utilized individual specimens, many of the results presented here are based on group means generated by the earlier computer runs. Limitations on sample sizes owing to variation in age and sex, as well as incomplete specimen data, necessitated this approach. Only the results of analyses, on adult animals are reported here.

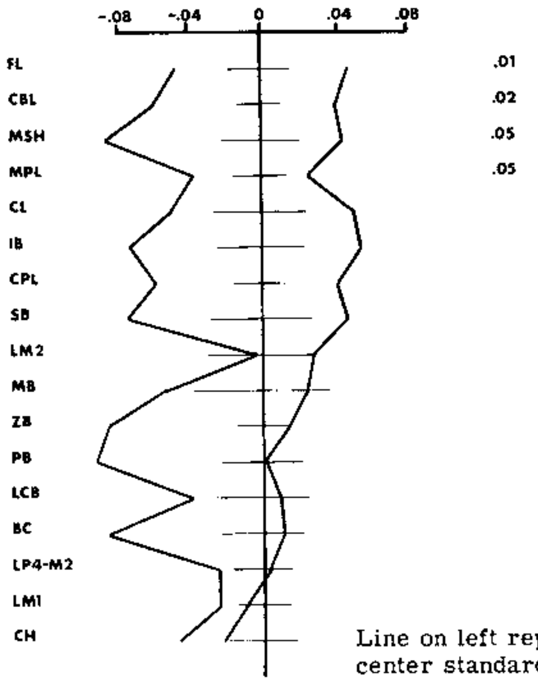

Fig. 1. Ratio diagram for males.

Line on left represents East Greenland; center standard Alaska North; line on right Alaska South. Numbers on right show significance level of T-test differences between the two Alaska populations. Scale across top represents units of difference in common logarithms among the two sample means (East Greenland and Alaska South) and that of the reference sample (Alaska North). Horizontal bars on reference sample represent confidence limits of two standard errors on either side of the reference sample mean.

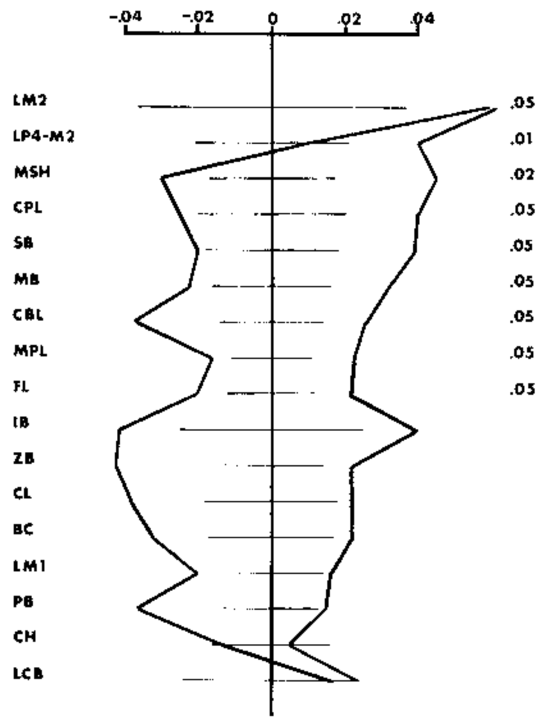

Fig. 2. Ratio diagram for females.

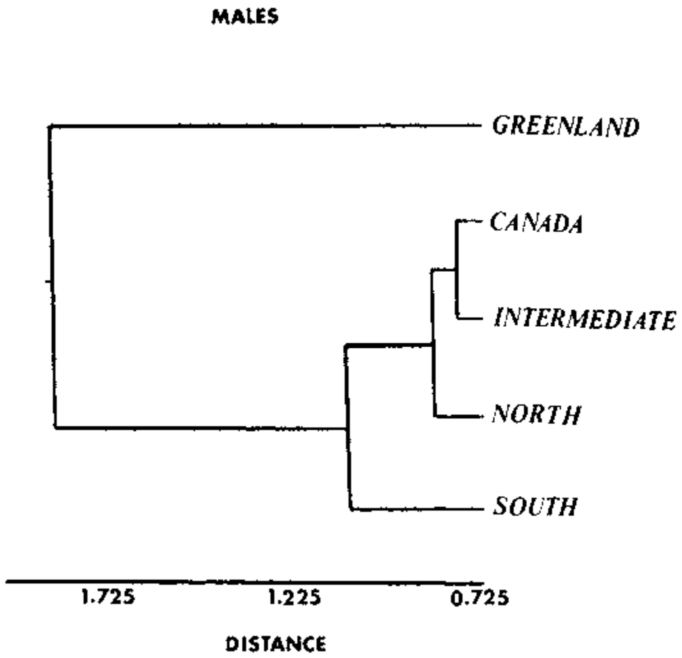

Fig. 3. Distance phenogram for males. The cophenetic correlation coefficient is 0.907.

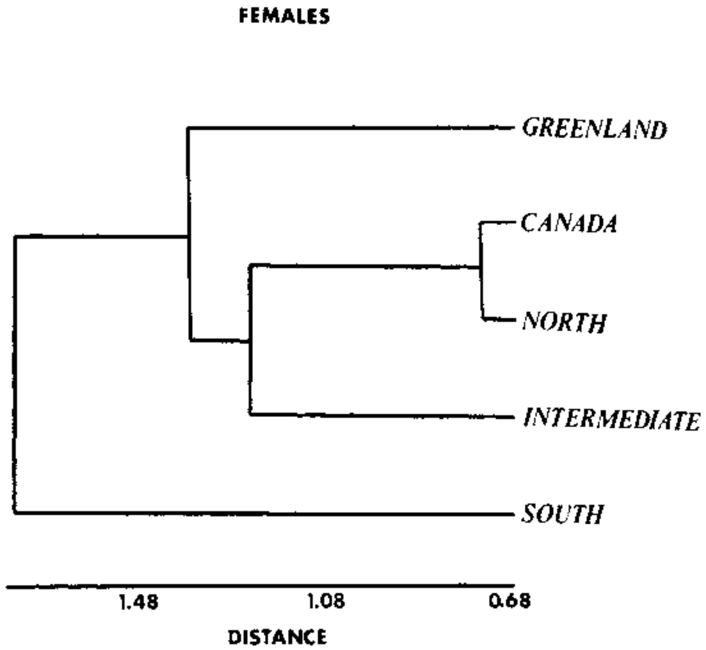

Fig. 4 Distance phenogram for females. The cophenetic correlation coefficient is 0.770.

RESULTS AND DISCUSSION

The Alaskan material was grouped into three samples based on the earlier results of Manning (1971). The Alaska North sample includes animals mainly from areas to the east of Wainwright, expecially Pt. Barrow, Colville and Barter Island. The Intermediate sample was drawn from Pt. Lay, Wainwright, Icy Cape and Franklin Point. Animals from Cape Lisburne south were included in the Alaska South sample.

In the ratio diagrams, the animals from the Intermediate sample were allocated to the Alaska North and South populations by using Pt. Lay as the dividing line. Figure 1 is a ratio diagram comparing means of males of the East Greenland and Alaska South samples to those of Alaska North. As can be seen, there are four characters which show significant differences between the two Alaska populations. These characters (FL, CBL, MSH, MPL) reflect the greater skull length and height of male bears from the Alaska South population. Figure 2, for females, shows nine significant differences between the two Alaska populations. That the Alaska South population averages large in all 17 characters in both males and females is obvious from Figures 1 and 2.

Results of a cluster analysis on a matrix of Euclidean distance coefficients support the above results. Phenograms in Figures 3 and 4 illustrate the clinal nature of the variation across North America with the small Greenland animals at the top of the phenograms and larger animals at the bottom. The phenogram for males (Fig. 3) shows the close relationship of the Canada, Alaska North and Alaska Intermediate populations; whereas the phenogram for females (Fig. 4) appears to stress the distinctiveness of the Alaska South population, as in the ratio diagrams.

The results of the principal components analyses on character correlation matrices are shown in Figures 5 and 6. In both cases, component number one accounts for much of the variation (77% in males, 69% in females). For males, the three characters contributing most to component number one are zygomatic breadth, supraorbital breadth and interorbital breadth. For females, the correspondingly important characters are breadth at canines, condylobasal length and supraorbital breadth. The second principal component for males which accounts for an additional 12 percent of the variation, is heavily loaded for the three toothrow measurements: length of M1, length of P4-M2, and length of M2. The second principal component for females, which accounts for 19 percent of the variation, is heavily loaded for interorbital breadth, cranial length and palatal breadth. Not unexpectedly these results indicate the major source of variation in these bears to be size, with more subtle shape variations as shown by Operational Taxonomic Units (OTU) coordinates on the second Principal Component.

To more clearly define the relationships among the various populations three dimensional plots of the results from Kruskal's nonmetric multidimensional scaling (MDSCAL) are presented (Figures 7 and 8). While not greatly different from the Principal Components Analyses, the MDSCAL plots may be a better representation of the relative phenetic differences between populations (Rohlf, 1972). The results of MDSCAL confirm the distinctiveness of the Alaska South population, and also show the phenetic similarities among the northern or interior groups of bears.

The patterns suggested here agree well with current and ice flow patterns in the Arctic region. The East Greenland population occurs mainly in the south flowing Greenland current. The Alaska South population is found mainly in the northward moving currents from the Bering Strait. The interior populations

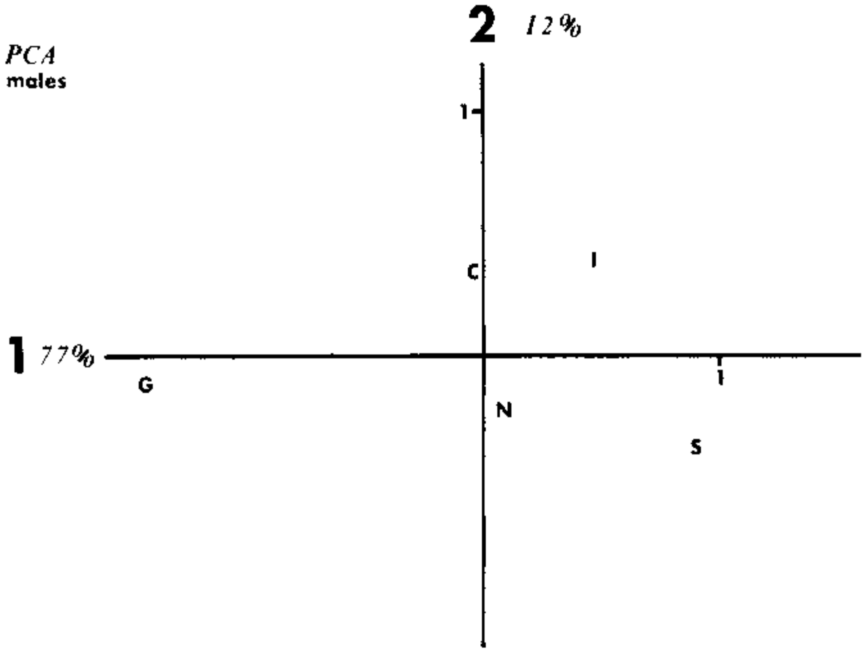

Fig. 5 Principal components analysis for males. G—Greenland; C—Canada; N—Alaska North; I—Intermediate; S—Alaska South.

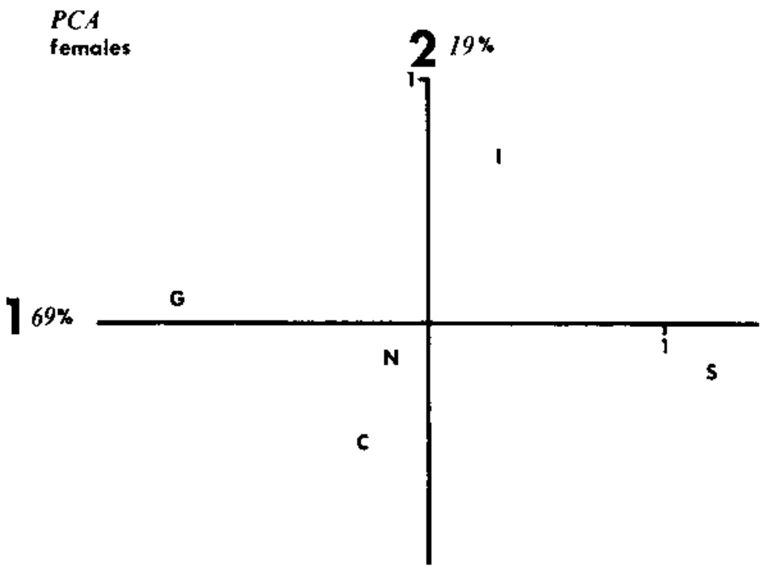

Fig. 6. Principal components analysis for females. Abbreviations as in Fig. 5.

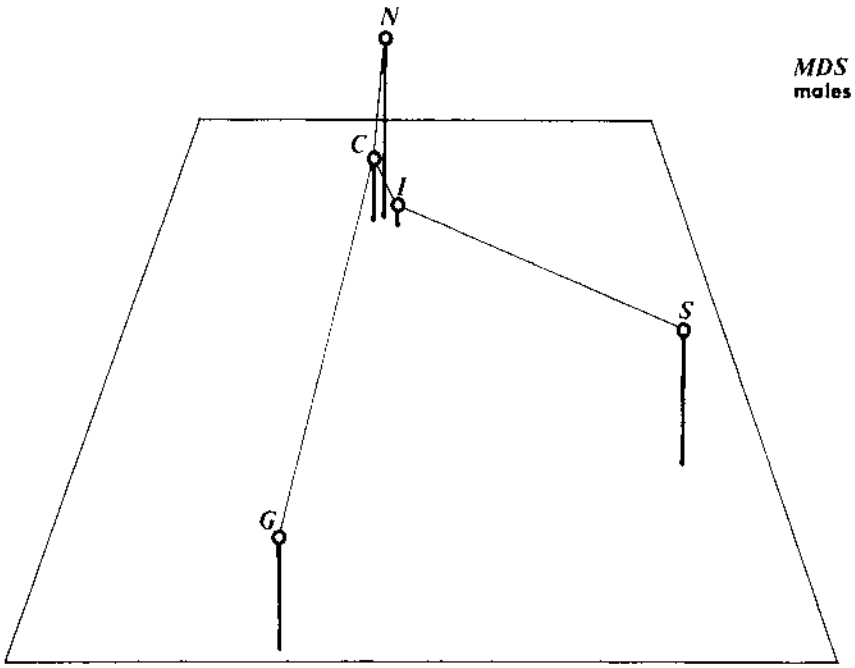

Fig. 7. Three dimensional representation of MDSCAL for males. The stress value is zero.

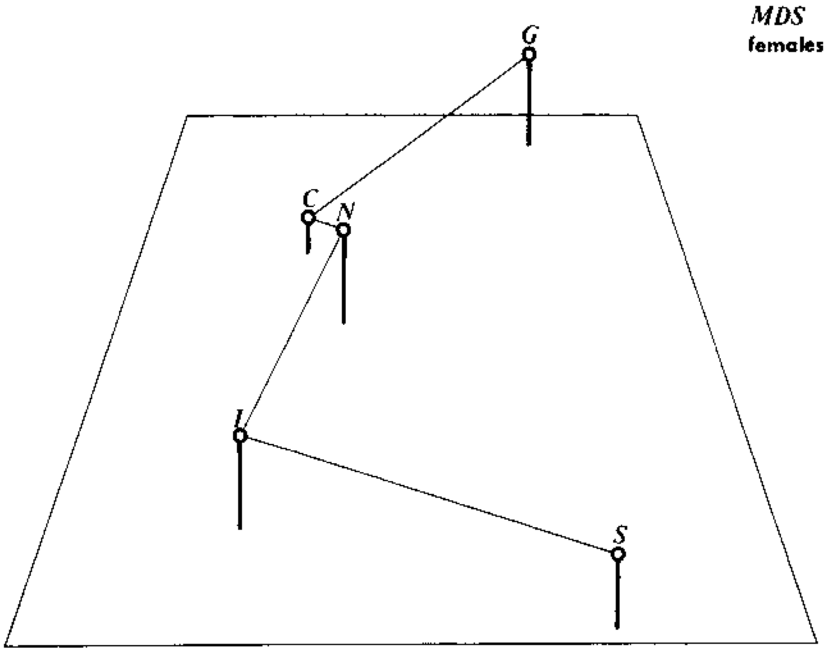

Fig. 8. Three dimensional representation of MDSCAL for females. The stress value is zero.

are affected by a variety of east or west-flowing currents across the top of North America, which may facilitate gene flow among these populations.

If subspecies were to be recognized, the East Greenland bears should be allocated to the nominate race, *Ursus maritimus maritimas* Phipps. The type locality for *U. maritimus* is Spitzbergen (Phipps, 1774). The population extending from West Greenland through Northern Alaska would take the name *U. m. labradorensis* Knotterus-Meyer. As Manning (1971) has pointed out, however, these interior Nearctic bears appear to be quite similar to the Palearctic populations which would assume the name *U. m. marinus* Pallas. In either event, there is no name currently available for the Alaska South population.

Although these results are tentative, pending the examination of a few additional specimens, I think some general conclusions are possible. The generally clinal nature of the variation originally pointed out by Manning (1971). is verified. There are definite steps in the cline at the extremes, such that the East Greenland population and the Alaska South population can be separated readily from an interior group extending from West Greenland to Pt. Lay, Alaska. Although these differences may be of sufficient magnitude to warrant subspecific recognition, I think nomenclature stability will best be served by considering *Ursus maritimus* monotypic, at least until the Old World populations have been similarly analysed.

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