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Age Determination in the Polar Bear

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Age Determination in the POLAR BEAR *Ursus maritimus* Phipps

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ABSTRACT

Skull criteria are given for aging of Polar Bears up to six years, by which time they are considered fully grown. Most characters develop earlier in females than in males. Sexual maturity is probably reached by males early in their fourth year, and by females possibly early in their third. Weights of 13 bacula are given.

RÉSUMÉ

L'auteur expose ici les caractéristiques du crâne de l'ours polaire, de la naissance à la sixième année, alors qu'il atteint la taille adulte. La plupart des caractéristiques se développent plus tôt chez la femelle que chez le mâle. Le mâle atteint probablement sa maturité sexuelle au début de la quatrième année, tandis que la femelle atteint la sienne vers le début de la troisième. L'auteur donne également les poids de 13 os péniens.

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AGE DETERMINATION IN THE POLAR BEAR, *URSUS MARITIMUS* PHIPPS.

As a preliminary to a taxonomic study of the polar bear, 487 skulls were measured. They were divided into four age classes. In the youngest class three groups of sutures were open: 1) that between the basisphenoid and basioccipital 2) that between the maxillae and premaxillae 3) surrounding the nasals. In the second class the basisphenoid and basioccipital bones were fused. In the third, the maxillae and premaxillae were also fused. In those considered fully grown, all three groups of bones were fused. Only two or three skulls were seen in which the basisphenoid and basioccipital were semi-fused; in the remainder there was no difficulty in deciding at once whether the skull should be in class one or class two. Evidently once fusion begins it proceeds rapidly until the suture is entirely obliterated. It cannot be reopened by over-boiling or other maltreatment during cleaning. Fusion of the bones which form the other two sutures used as age criteria appeared to be less rapid, less complete, and more irregular. The maxillae-premaxillae sutures always started to fuse before those between and around the nasals, but they were seldom, if ever, obliterated before the latter were well on the way to fusing; indeed, it is possible that remnants of both groups of sutures may persist in some individuals well into old age. Judgment must therefore occasionally be used to place a skull in its correct age class. However, as in the basisphenoid-basioccipital sutures, there is definite bone fusion and not a mere tightening of the suture, so that variations in the cleaning process have no appreciable effect.

For taxonomic purposes, physiological age as evinced by a phenomenon such as bone fusion is more important than chronological age. Nevertheless, it is clearly desirable to know the average chronological age at which such phenomena take place. I therefore attempted to separate the specimens in class one by years. Dated material available for this study consisted of 56 specimens from Northern Canada and ten from Alaska. In addition, notes previously made on tooth growth of 15 specimens from other regions, chiefly northeast Greenland, indicated that these had not passed their second winter, the first winter being that in which they were born. Fortunately, most of the Canadian and Alaskan specimens had been taken in February, March, and April, so that the preliminary grouping could be done without adjustment for the season at which the specimen was taken. The males fell easily into three groups as follows: *Second winter*: obviously small; canines usually not fully erupted; milk teeth occasionally persisting until February. (However, there is considerable variation in tooth development, and dates on some of the specimens are suspect.) Parietals sloping downward steeply with only slight lambdoidal and sagittal crests. *Third winter*: Distinctly larger than second winter skulls; enamel line on canines visible on the posterior and often on the lingual side of the tooth, but usually below or only just level with the bone; distance between cingula of molars and bone comparatively small, particularly at the heel of M2; epiphysis on occipital condyle usually unfused; mastoid comparatively short and lacking epiphysis; basisphenoid and basioccipital usually flat at suture. *Fourth winter*: enamel line on canines well above bone level on all sides; distance between cingula of molars and bone greater than in third winter; occipital condyles smooth and rounded, with epiphyseal suture barely visible; mastoid more developed and usually covered, or partly covered, by epiphysis; basisphenoid and basioccipital usually hummocked at the centre of the suture.

Three specimens dated March, August, and December respectively, remained over. All were distinctly larger than fourth winter males, and had the typical adult male appearance, with well developed sagittal and lambdoidal crests. It seems reasonable to suppose that the August specimen was in its fourth summer, the other two in their fifth winter. The basisphenoid-basioccipital suture of the March specimen was just starting to fuse, and as this left only one fifth winter specimen with no sign of fusion, it appears that in males fusion normally occurs during the fourth summer or fifth winter, that is to say, between the age of 3½ and 4½ years.

The characters given above for separation of male age classes develop earlier in the females, as is shown by the following description. *Second winter*: the same as males. *Third winter*: enamel line visible all around canines, but usually not as far above the bone as in fourth year males; occipital condyles round and smooth, with epiphyseal suture indistinct. Mastoids often partly covered by small epiphyses; sagittal and lambdoidal crests rather better developed than in third winter males; basisphenoid and basioccipital often hummocked at suture. *Fourth winter*: size and shape of skull similar to adult female; enamel line well above the bone, usually at least 2 mm.; mastoid larger than in third winter skulls and nearly fully capped by epiphysis; basisphenoid and basioccipital hummocked at suture except in a very few skulls which may never develop this feature.

Perhaps as a consequence of their earlier development, third and fourth winter females cannot be as easily separated as can males of these ages. A lower canine from each of six female skulls was therefore cut longitudinally. The polished section showed a number of lines in the dentine, obviously not annual, and a less well marked concentration of these lines which might be an annual phenomenon. However, the most obvious difference between the teeth of third and fourth winter specimens was the marked reduction in diameter of the pulp cavity. At the bone level this measured about 8 mm. in third winter, and only 3 mm. or less in fourth winter specimens. Closer to the root the difference was even more striking. Closure of the pulp cavity appears to occur about the same time in the males. Thus its width at the bone line was about 4 mm. in the two fourth winter males examined. Weight of the extracted canine, or weight/volume ratio would probably give an excellent estimate of age up to the fourth winter.

In two of the fourth winter females, taken in March and April, the basisphenoid and basioccipital sutures were commencing to close, and as no fourth summer or fifth winter specimens have been seen with this suture unfused, it is probable that fusion usually takes place between 3¼ and 3¾ years, and sometimes, perhaps, before the third year is completed.

Coronoid height and interorbital breadth increase rapidly with age (Table 1). Figure 1 shows histograms of these two measurements and

TABLE 1

	♂♂				♀♀			
	N	Mean	SD	CV	N	Mean	SD	CV
				Condylobasal length				
A	8	251.6±3.2	9.1	3.6±0.9	17	249.2±4.0	16.7	6.7±1.1
B	7	311.9±7.0	18.5	5.9±1.6	12	300.8±4.5	15.5	5.1±1.1
C	12	349.4±3.3	11.3	3.2±0.7	11	326.8±4.5	15.0	4.6±1.0
D	15	378.7±4.0	15.7	4.2±0.8	13	329.0±2.6	9.4	2.9±0.6
E	17	390.6±3.0	12.3	3.2±0.5	17	335.3±2.2	9.1	2.7±0.5
F	90	386.7±1.6	14.9	3.8±0.3	51	335.4±1.4	9.9	2.9±0.3
				Interorbital breadth				
A	7	57.9±1.8	4.88	8.4±2.3	18	56.3±1.0	4.42	7.8±1.3
B	8	67.0±1.6	4.60	6.9±1.7	13	67.0±0.8	2.92	4.4±0.9
C	13	78.9±0.9	3.25	4.1±0.8	12	76.4±1.5	5.30	6.9±1.4
D	15	94.1±1.4	5.23	5.6±1.0	13	76.4±1.1	3.82	5.0±1.0
E	17	95.9±1.4	5.86	6.1±1.1	15	80.0±0.8	3.23	4.0±0.7
F	90	99.7±0.7	6.88	6.9±0.5	50	80.9±0.6	4.45	5.5±0.6
				Coronoid height				
A	7	65.7±0.6	1.58	2.4±0.6	16	65.4±1.1	4.59	7.0±1.2
B	6	84.0±1.6	4.00	4.8±1.4	14	79.6±1.1	4.03	5.1±1.0
C	13	95.6±1.0	3.48	3.6±0.7	12	90.8±1.4	4.71	5.2±1.1
D	14	107.6±1.1	3.97	3.7±0.7	12	90.9±0.9	3.06	3.7±0.7
E	11	113.2±1.5	4.96	4.4±0.9	16	92.5±0.7	2.97	3.2±0.6
F	76	111.2±0.5	4.46	4.0±0.3	48	91.6±0.3	2.85	3.1±0.3

Statistics for the three measurements discussed. Before calculating, those for second, third, and fourth winter specimens were adjusted to estimated February values (*see* text). A = second winter, B = third winter, C = fourth winter, D = basisphenoid and basioccipital fused, E = maxillae and premaxillae fused, F = nasals fused.

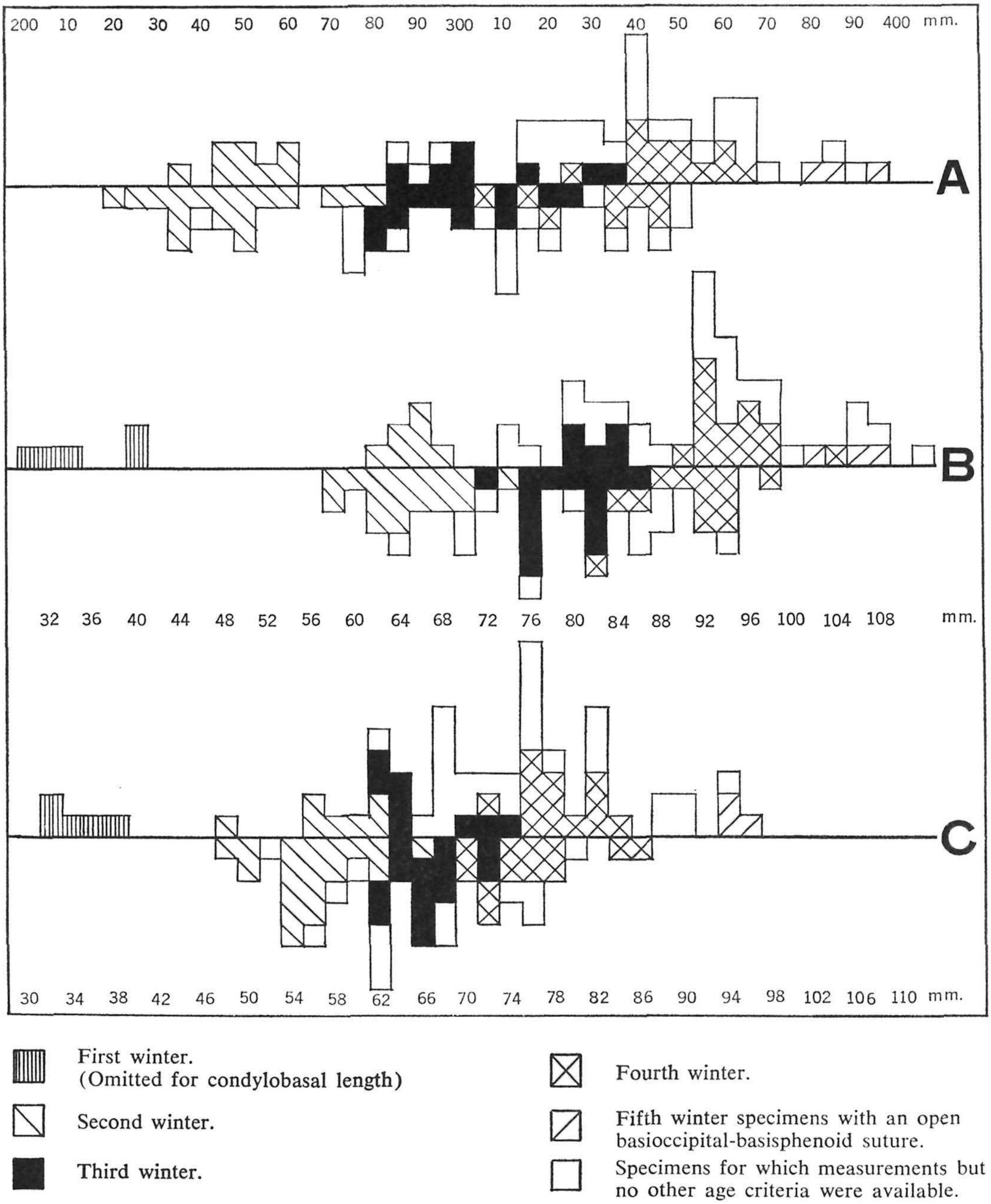

FIGURE 1. *Histograms of A) condylobasal length, B) coronoid height, C) interorbital breadth.*

Except for first winter specimens which are not sexed, males are placed above the line, females below. The figures along the top are the condylobasal length measurements in 5 mm. groups (200–204, 205–209, etc.). The other figures on the abscissa are in 2 mm. groups (32–33, 34–35) and refer to coronoid heights and interorbital breadths.

of condylobasal length. All measurements have been reduced to an estimated February value by adding or subtracting the amount indicated by the mass-curves of growth (*see* Fig. 3). Those skulls available for age grouping by the criteria given above could be positioned on the curve by the resulting age estimate. Those previously measured but not now available had to be positioned by size. The adjustment is therefore liable to considerable error. One source of error may be variation in seasonal growth rate. This had previously been noted in the Red-backed Mouse (Manning 1956) and was suspected as a possible general phenomenon in northern mammals. It has since been recorded by Rausch (1961) in the black bear. Other errors may result from confusion of specimens or inaccuracies in the original dating, particularly as only a few of the skulls were actually taken by scientific collectors. A few specimens marked 'winter' were assumed to have been taken in February, and a few marked 'summer', in July. Unsexed specimens have been sexed by tooth size. Fortunately, until the fourth winter coronoid height and interorbital breadth are fairly independent of sex. Nonetheless, such uncertainties contribute to the overlap between age classes shown in the histograms. Another cause of overlap arises from geographical variation in size. There is some evidence that Alaskan adults average a little larger than those from Canada. Certainly northeast Greenland adults are smaller and therefore, except for second year specimens, the large series from that region which was originally measured has been omitted.

Coronoid height (Fig. 1B) gives the least overlap between age classes. Ignoring sex, a theoretical 97 percent of second and third, and 91 percent of third and fourth winter specimens are separable on this criterion alone. A slightly better separation is evidently obtained by considering coronoid height and interorbital breadth together (Fig. 2). Figure 2 also shows that in females there is little or no increase in these dimensions after the fourth winter, whereas in the males they continue to grow well into the fifth winter and perhaps into the fifth summer. Indeed, Figure 3 indicates that interorbital breadth may continue to increase after all three sets of sutures have fused. It is likely that a similar increase occurs in zygomatic and perhaps some other breadth measurements.

The probable age at which the basisphenoid and basioccipital bones fuse has been estimated above, and means for the three measurements discussed were plotted accordingly in Figure 3. Until a detailed study is made of tooth rings or some other age criteria, the average period which may elapse between the fusion of these bones and of the maxillae and premaxillae can only be estimated by extending the curves for the males in Figure 3 and by comparing the number of skulls in this condition with the number of those which are younger and older. Obviously there are more two-year-olds than three-year-olds in the natural population, but this has evidently been counter-balanced in museum collections by selection against the smaller specimens and by breakage of their more fragile skulls. Figures 1 and 2 suggest that skulls of two-year-olds are more numerous in collections than are those of one-year-olds, but that there is some fall-off in three-year-olds. With this in mind and looking at Table 2, it may be supposed that the average time which elapses between the fusion of the basisphenoid and basioccipital and that of the maxillae and premaxillae is a little under one year, or about nine months. Judging by Figure 3, this is not unreasonable. It is probably another year before the nasals fuse.

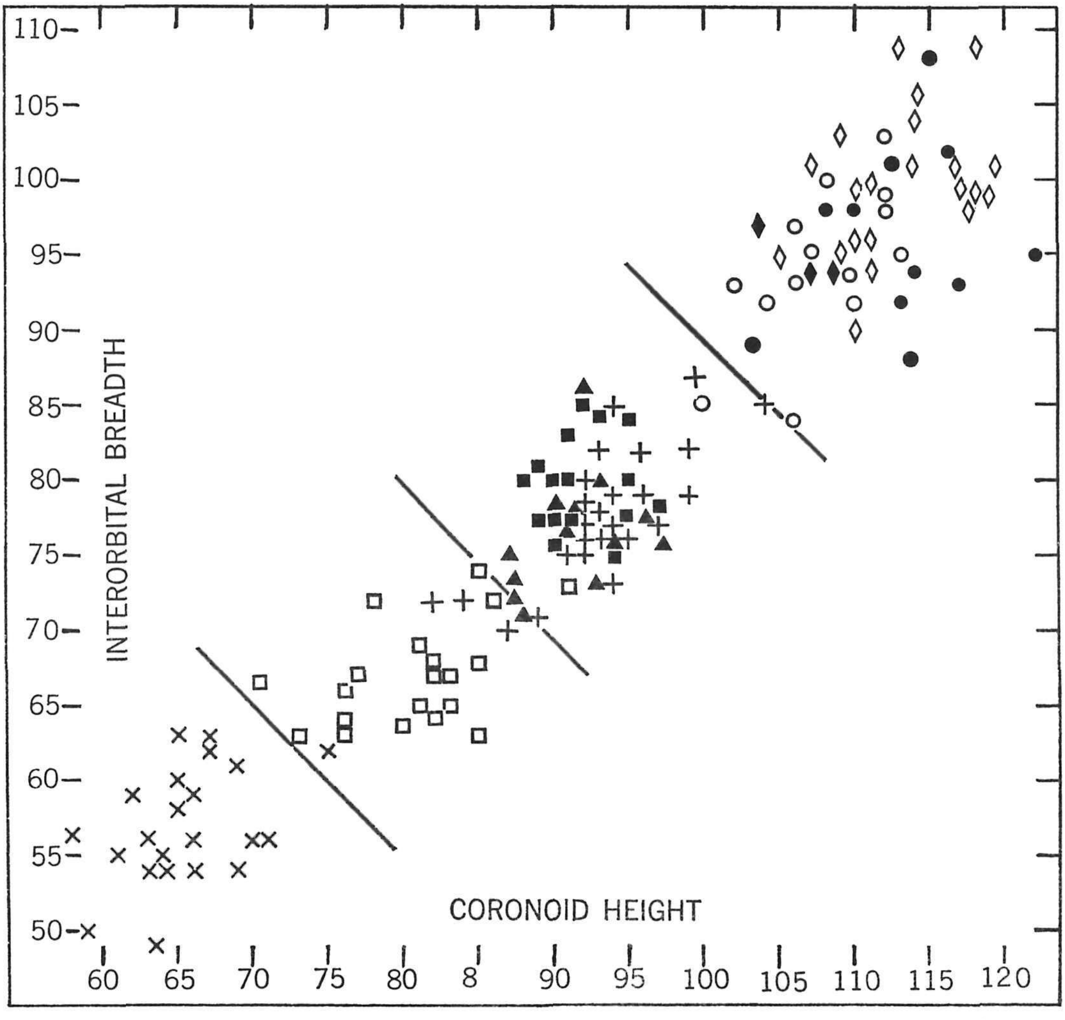

FIGURE 2. *Coronoid height plotted against interorbital breadth.* × = ♂ and ♀ second winter; □ = ♂ and ♀ third winter; + = ♂ and ♀ fourth winter; ○ = ♂ and ▲ = ♀ basioccipital-basisphenoid fused; ● = ♂ and ■ = ♀ maxillae-premaxillae fused; ♦ = ♂ fifth winter basisphenoid-basioccipital unfused; ◇ = ♂ from Barrow Strait, nasals fused. No adjustment has been made to specimens with fused basioccipital-basisphenoid sutures. The two lower sloping lines are drawn midway between the means as given in Table 1 to separate second, third, and fourth winter skulls. The upper line is two standard deviations from the means of the fourth winter skulls.

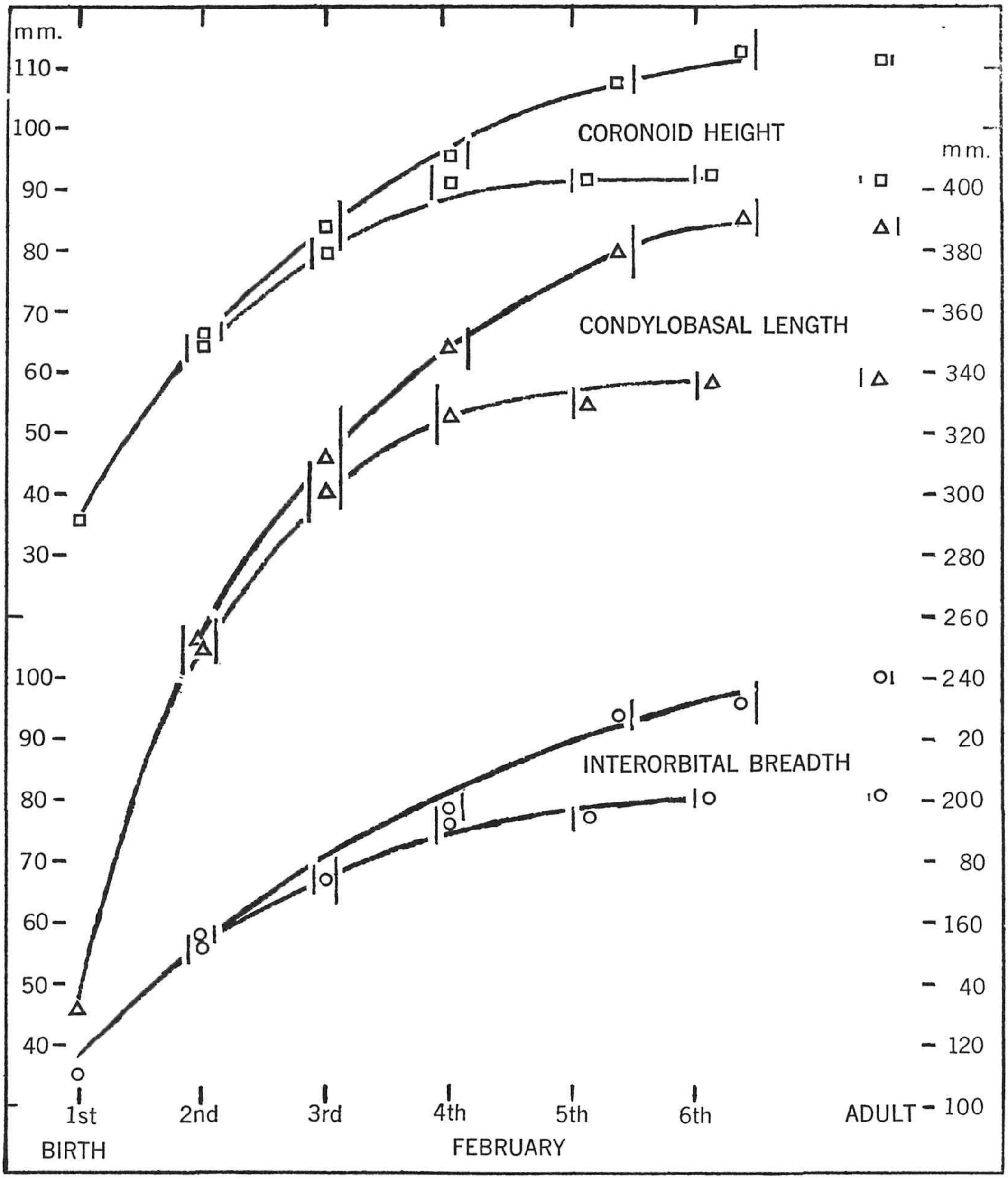

FIGURE 3. *Mass curves of growth for coronoid height* □, *condylobasal length* △, *interorbital breadth* ○. In each case the upper curve is that for males, the lower for females. Before calculating the means denoted by the symbols above the first, second, third, and fourth February, the measurements were adjusted to February values. No adjustment was made to the measurements of those specimens with fused bones, but the means have been positioned according to the age at which it is believed that the majority of such specimens would be found. This is later than the average date of fusion. The means for adults (all three sets of sutures fused) are without reference to the time scale. The vertical lines (males to right, females to left of their respective symbols) represent the 5 percent confidence limits of the means.

TABLE 2

—	A		B		C		D		Total
	♂	♀	♂	♀	♂	♀	♂	♀	
January.........	1	2	—	—	—	—	—	1	4
February........	3	9	2	—	2	—	7	7	30
March..........	11	5	1	1	1	—	13	7	39
April............	5	6	1	1	—	—	6	3	22
May............	3	3	—	—	1	1	2	2	12
June............	2	1	—	—	—	1	1	2	7
July............	4	4	1	—	—	1	2	—	12
August..........	7	3	3	4	2	2	11	4	36
September.......	3	3	—	1	1	1	2	—	11
October.........	1	5	—	—	—	—	2	3	11
November.......	6	1	1	—	1	—	2	2	13
December.......	3	3	—	2	—	1	4	1	14
Total	49	45	9	9	8	7	52	32	211

Numbers of specimens by months and by physiological age and sex. A, basisphenoid-basioccipital suture open; B, basisphenoid and basioccipital bones fused; C, maxillae and premaxillae fused; D, nasals fused. This table includes all dated specimens examined. Most of the unsexed specimens were also undated, but those which did have dates have been sexed by tooth size or, in the case of adults (D), by other skull characters. It may be noted that although the material was obtained from many sources, the variation in the monthly totals is highly significant ($\chi^2 = 83$ with *d.f.* 11). This variation presumably reflects the interaction of the habits of the hunters and of the bears.

The baculum of a first summer animal killed 21 July weighed 0.7 gms.; those of three third-winter specimens weighed 2.9, 2.1, and 2.0 gms., respectively; and those of two fourth-winter (late March) specimens, 12.5 and 8.2 gms. The average weight of the bacula of seven fully adult bears was 20.5 (14.6-28.1) gms.

The age at which polar bears reach sexual maturity is not definitely known. Asdell (1946) gives no data. Kost'yan (1954), on the evidence of a captive pair, appeared to consider sexual maturity was not reached until five years, but Tzalkin (1936), without giving any reasons, states that females apparently become sexually mature at two years and males at three. The present study supports Tzalkin's statement. Thus, the rapid increase in baculum weight (shown by the figures in the above paragraph) between the third and fourth winter probably indicates the onset of puberty (Cf. Rausch, 1961), and three-year-old males are therefore very likely capable of mating, although it is doubtful if they would often be successful in competition with full grown animals. The shorter period required by the skulls of females to show adult characters suggests that they mature earlier and may mate in their third spring and produce young at three years, by which time they will have reached nearly adult size and their skulls taken on adult shape. The data given by Rausch (1961) for the black bears of Alaska provide an interesting comparison. In his captives which did not hibernate, the rapid increase in the weight of the bacula occurred in the third or fourth summer, but in wild bears, aged by tooth annulations, this was delayed until the fifth or sixth summer. If we are both correct in our estimates of the ages of our respective specimens, it appears that, whereas captive black bears mature at approximately the same time as wild polar bears, the wild black bears, at least in Alaska, mature later. Figure 4 suggests that there may also be a closer correspondence between the somatic growth of wild polar bears and captive black bears than there is between the former and wild Alaskan black bears. Possibly this is due to the shorter and less complete hibernation of the former.

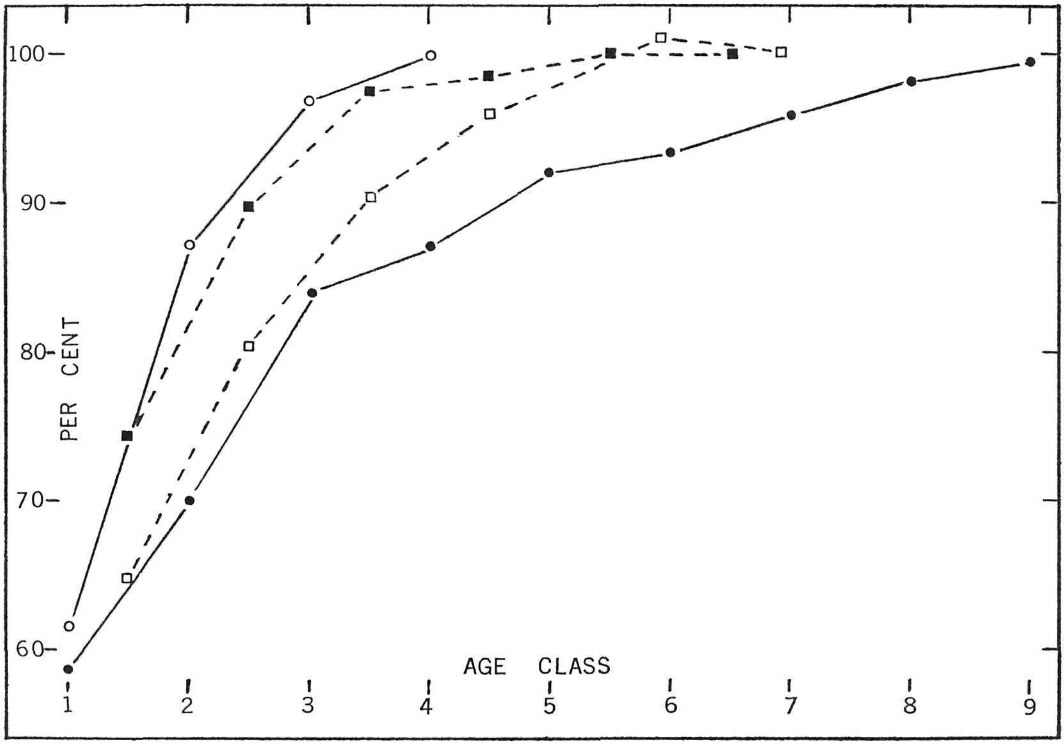

FIGURE 4. *Comparison of skull growth in Black and Polar Bears.* The data for Black Bears, ○ = captive, ● = wild, are taken from Fig. 9 of Rausch (1961); that for the Polar Bears □ = ♂, ■ = ♀ from the condylobasal length for the Polar Bears given in Table 1. The age classes are those used by Rausch. The first six correspond to years. As the dates for his specimens centre around the summer, whereas the Polar Bear measurements have been reduced to February values (Fig. 3, Table 1), the latter are plotted between the Black Bear classes. The graph indicates that there may have been some overcorrection.

Of the 66 specimens with basisphenoid and basioccipital unfused that were available for this study, ten were lent by the University of Alaska through the courtesy of Dr. Rowinski, 22 were in the temporary collection of the Canadian Wildlife Service, and the remaining 34 in the National Museum of Canada. The Wildlife Service specimens and a number of those in the National Museum were obtained chiefly from the Eskimos of Cornwallis Island through the co-operation of Mr. A. H. Macpherson. I am also indebted to those in charge of mammals at the following institutions for permission to measure specimens in their care: British Museum, University of Copenhagen Museum of Zoology, University of Oslo Museum of Zoology, National Museum of Canada, California Academy of Sciences, Chicago Natural History Museum, University of British Columbia Museum of Zoology, University of California Museum of Zoology, University of Michigan Museum of Zoology, Academy of Natural Sciences of Philadelphia, American Museum of Natural History, Carnegie Museum, Museum of Comparative Zoology, Royal Ontario Museum of Zoology, State Natural History Museum (Stockholm), United States National Museum. The original measurements were taken while holding a John Simon Guggenheim Fellowship; the remainder of the work was done under a contract from the Canadian Wildlife Service. Mr. C. R. Harington, Canadian Wildlife Service, made a number of helpful suggestions.

LITERATURE CITED

Asdell, S. A. 1946. Patterns of mammalian reproduction. 437 pp. London.

Kost'yan, E. Ya. 1954. [New data on Polar Bear reproduction.] Zoologisheskiy Zhurnal, 23:207-215. Can. Wildl. Serv. Trans. Typed.

Manning, T. H. 1956. The Northern Red-backed Mouse, *Clethrionomys rutilis* (Pallas), in Canada. Nat. Mus. Can. Bull. 144. iv + 67 pp.

Rausch, Robert L. 1961. Notes on the Black Bear, *Ursus americanus* Pallas, in Alaska, with particular reference to dentition and growth. Zeitschrift für Säugetierkunde, 26: 65-128.

Tzalkin, V. I. 1936. [On the biology of the Polar Bear of the Franz Josef Archipelago.] Bull. Soc. Nat. Moscow, 45:355–368. Bur. Animal Population, Oxford Univ. trans. 99. Typed.