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The Use of the Skull in Age Determination of the Brown Bear

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To understand many aspects of the biology of bears, it is necessary to establish age of animals. Without this ability, it is impossible to determine the age structure of the population, rate of growth, onset of sexual maturity, lifespan, etc. Accurate age of bears after one year may be determined by the number of layers in dental root cement. The first work on this technique was reported by Smirnov (1960) ... 'in the bear, the layer of cement is most exact and one can consider that each layer signifies one year of life.' Rausch (1961) studied American bears of known age and established that there is an annual layer of dentine and cement and also a yearly outgrowth on the root of the tooth; according to the number of annual layers in the length of the tooth, one can distinguish ten age classes. Mundy and Fuller (1964) determined the age of grizzlies (*Ursus arctos*) by the cement layers of the third molar. Because the third molar of the lower jaw cuts through in the bear in the second year of life, its age can be determined by the number of cement layers plus one year. Manning (1964) took as significant the degree of concretion of skull sutures, the thickness of enamel on teeth, and the form of the skull outgrowths as a technique in the determination of the age of the polar bear. By these criteria he identified four age classes and determined the ages of the bears to the sixth year. Sauer, Fry and Brown (1966) determined the ages of black bears (*Ursus americanus*) according to the lengths of the incisors to a thickness of 250 microns in sequential sections of 25 microns. They discovered that wild bears did not differ from bears living in captivity. They showed that sequential layers of cement did not always correlate with age or were sometimes completely absent, and in wild bears of known age each cement layer corresponded to one year in the life of the bear. Ushivtsev (1972) used the same criteria for determining the age of the brown bear (*Ursus arctos*) of Sakhalin Oblast and came to the same conclusion. Inukai Masaaki (1972) discovered that the age of the brown bears of Hokkaido, according to sections of the incisors, up to a year old cannot be determined by this method because there were no definite layers of dental cement, but in older bears they are in annual layers.

Thus all researchers attempting to determine the ages of bears came to the same conclusion: that the number of layers of tooth cement corresponds to a year in the life of the bear.

This position was taken for the basis of our studies and thus accurate growth of bears of the Turykhan population was determined according to the number of cement layers at the root of the tooth. As the basis of our research on the skulls of brown bears in the Borogov State Agricultural Enterprise, located in the middle Yenesey region (33, 040 sq. km.), forty-three skulls were collected between 1967 and 1973 from bears in a comparatively small region. Therefore, errors connected with geographical variability of the species can be excluded.

The analysis of the collected material was conducted according to the method of Klevezal and Kleynenberg (1967) on microtome sections of roots of bear teeth. To select the most suitable tooth from several skulls of the collection,

we sliced all teeth, sections of jaws, and different parts of each tooth. It was shown that the number of layers in the cement were the same whatever portion of the tooth was studied aside from the third molar of the lower jaw, where the number of layers on one side was less than in the remaining teeth. Therefore, in the majority of samples collected, age was determined according to the first section of the lower jaw, as being the easiest for treatment and the least expensive for collection.

The teeth were decalcified in a 7% solution of nitric acid to the point that the tooth could be pierced with a needle. Sections were made at 3, 4, 5 and 6 days. After decalcification, the tooth was fixed in a 5% solution of potash alum for 20 to 24 hours and rinsed in distilled water; then the root of the tooth was sectioned on a freezing microtome. The most defined cement layer was visible in the upper third of the root. From one tooth, we made about 100 sections varying in thickness from 30 to 60 to 90 microns. The cement layer was clearly visible under the microscope even in unstained sections. After staining the sections with hematoxylin for one hour, we studied the most successful slides under the microscope. The selected samples were differentiated in 96% alcohol to a reddish color, then mixed in slightly alkaline water until slightly bluish. Samples were then transferred to glycerine (25, 50 and 75% for 1, 1. 5 and 2 hours respectively), prepared in gelatine or canada balsam, and photographed. Such a method was used to determine the age of all the specimens in the collection.

This method determined age with sufficient accuracy; however, it requires laboratory conditions, specialized equipment, chemicals, and a lot of time. In field conditions, when it is not always convenient to transport skulls, or there is no suitable laboratory, we worked out a more simple and rapid method of determining the age of bears according to a complex of craniological and morphometric indicators.

The skull of the brown bear grows and changes structure in the course of the entire life of the animal. In the bear cub the skull is nearly circular in form, predominant according to the size above the facila portion of the skull with weak development of the mandibular arch. During growth, the skull lengthens and, with the attainment of sexual maturity of the individual (females, 3 to 4 years; males, 4 to 5 years), the skull has the characteristic form for the species. A mix of juvenile and adult teeth begins at age 5 to 6 months, depending on conditions of development for the cub, and ends at 1. 5 years. Towards the first autumn, in sequence, there are changes in the incisors, the first upper molars, the first and second upper molars. Incisors and molars grow quickly and toward the fourth year reach their maximum size.

Canines grow more slowly. In the first year of life, they are about 5 to 8 mm long; in the second they grow to 20 mm, and finish their growth by the 8th to 10th year. The wearing down of the teeth begins with the incisors from the internal side, then the molar teeth of the upper jaw and the lower molars and finally the canines.

The growth of skull sutures begins in females at the age of 3 or 4 years, in males at 4 or 5 years. The growth of the basic skull sutures ends in females at 8 or 9 years, but the sites of suture growth at that age are still well marked; later it smoothes down and in old animals is completely unnoticeable. Latest of all, by the 15th to 18th year, the bones of the lower jaw and skull knit. The character of the knitting of skull sutures of bears is complex and requires further study.

On the basis of analysis of age changes in the form of the skull, the characteris-

tic changes and wearing of the teeth and sequence of knitting of skull sutures, other indicators include the measurement and weight indicators of the animal. All skull collections, independent of determination of growth by cement layers, were distributed in 11 age classes.

1. Cubs to 5 months of age

Live weight (LW) to 8 kg. Condyle-basal length (CBL) of the skull to 150 mm. Weight of skull without lower jaw (WS) to 80 g. These three changes will lead to a shortening of the corresponding LW, CBL and WS. The teeth of the young bear: canines to 15 mm in length. In the lower and upper jaw the first molar tooth is visible; the others are still beneath the jawline.

2. Cubs from 5 months to one year

LW: 23 - 25 kg; CBL: 190 - 200 mm; WS: 315 - 328. In the lower jaw the second molars have appeared, the third are still in the bone; in the upper jaw, the opening beneath the second molar has opened. The milk teeth have fallen out: the canines have changed to permanent or they both appear together.

3. Yearlings (from 1 to 1.5 years)

LW: 30 - 49; CBL: 224 - 240; WS: 300 - 430. Molars of the upper jaw appear full, but the rear part of the second molar is still level with the jaw bone. The first part of the third molar appears in the lower jaw, the rear part is still beneath the jaw surface. The tooth surface is very irregular and rugose. The tooth capsule of the second upper molar is separated and protrudes from its socket by 2.5 to 3 cm.

4. Immature Bears (from 1.5 to 2.5 years)

LW: 50 - 70; CBL: 234 - 260; WS: 300 - 530. The process of closure of the skull sutures has not begun. The last molars of both jaws are almost emerged, and the capsule of the second upper has diminished to 1-1.5 cm; its rear end from the circular form gradually takes on the form of a point. The semi-circular lines are almost parallel.

5. Immature Bears (from 2.5 to 3 years)

LW: 62; CBL: 254 - 285; WS: 530 - 610. The semicircular lines go out to 3 - 4 cm from the occipital bone where growth of the sagittal crest begins and where closure begins in an almost lamellar suture. Closure begins from the lower part of the coronal suture.

6. Females from 4 to 6 years

LW: 103 - 105; CBL: 283 - 304; WS: 560 - 870. The suture between the upper jaw and the cheek bones begins to close. The rear edge of the upper incisor starts to wear off. The length of the sagittal crest is up to 3 cm and its height is 1.5 cm.

7. Females from 6 to 10 years

LW: to 125. Coronal and basal sutures closed. Internal and external surfaces of the upper median tooth worn evenly, the outermost only on the internal side. External parts of some of the molar teeth higher than internal by 2 - 5 cm.

8. Males from 6 to 9 years

LW: 130 - 184; CBL: 313 - 323; WS: 950 - 1100. Frontal suture closing or closed. Length of sagittal crest 9 - 11 cm, height 1.5 - 2 cm. Boundaries of the teeth of the upper jaw 5 - 6 mm higher than the middle. Rugosity of the molar series still well marked. All edges of canines sharp.

9. Males from 12 to 14 years

LW: 170 - 230; CBL: 223 - 247; WS: 1100 - 1340. Height of sagittal crest 2.5 - 2.7 cm. Internal crown of upper canine is worn. Intermediate molars appear grooved, outer edges worn almost to the level of the middle. Upper fissures nearly closed, including those between the frontal bones and the upper jaw.

10. Males 15 to 18 years

LW: 165 - 264; CBL: 333 - 349; WS: 1130 - 1500. The external surface of the upper canines is worn—little pits are formed. There are grooved depressions in a series of upper molars. The outside edges of both jaws are worn down to the level of the centers. The zygomatic suture is closed.

11. Both sexes—older than 18 years

The zygomatic arch and bones of the lower jaw are joined. On the skull there is no evidence of former sutures visible. The molars in the majority of cases are cariose; the upper molars are almost all filled with cavities. The upper row of molars is worn evenly. The outerpart of the molar is about 8 - 10 mm higher than the internal and is sharp in form. Some teeth are absent and canines often broken.

Thus, according to external signs, the sequence of joining of the skull sutures, the type of wearing of the teeth, weight, and linear indicators can determine the approximate age of the brown bear under field conditions with the aid of measurements of length and weight. No recourse to complex laboratory techniques is needed. With this method, accuracy of age determination to the 4th year is within 1 - 2 months, and from the 4th to the 18th year, to within 2 - 3 years. According to the accumulation of collected materials, the given method will be made more accurate and the number of age classes will increase.

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