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AN EVALUATION OF SEVERAL TECHNIQUES FOR DETERMINING THE AGE OF BOBCATS (Lynx Rufus) IN THE SOUTHEAST [1]

By RICHARD H. CONLEY and JAMES H. JENKINS

Tennessee Game and Fish Commission, Tellico Plains, Tennessee and School of Forest Resources, University of Georgia Athens, Georgia

ABSTRACT

A total of 57 of 75 bobcats (*Lynx rufus*) available were utilized in an evaluation for determining age in this species. Pelage characteristics, body measurements, frozen eye lens weight, and epiphyseal closure of the forelegs and humeri were of little value in determining age. Skull measurements were used in determining three age classes: (1) kittens (0-12 months); (2) young adults (13-24 months); and (3) adults (over 25 months). Skull morphology was also useful in defining these classes. The number of cementum annuli in the upper canine *was correlated* with age and allowed a more accurate age to be assigned to each animal than the other methods evaluated. Comparing the cementum annuli with the skull measurements indicated that the tooth sectioning technique was far better. In general, by skull examination, bobcat ages were consistently underestimated. Of 19 specimens placed in the young adult age class (13-24 months) by skull characters, 10 of these were actually over two years old as shown by cementum annuli. We saw no evidence that false annuli are formed in bobcats at least in Georgia and South Carolina.

INTRODUCTION

Reliable methods of age determination are essential for successful management of any wildlife species. Age distribution is a population characteristic which influences natality and mortality; reproduction being limited to certain age classes and mortality usually being prominent in other age classes. Therefore, age ratios are important indicators of future population trends and developments. The bobcat formerly ranged over much of southern Canada, the United States, and Mexico (Young, 1958). Previously, age classes assigned to this interesting predator have been based on general appearance, body weight, fur wear, and other morphological characters which are highly subjective.

MATERIALS AND METHODS

A total of 57 to 75 bobcats available were utilized in this study. The majority of the specimens were obtained during other studies at the Savannah River Project of the U. S. Atomic Energy Commission at Aiken, South Carolina. Additional specimens were collected in Georgia and in one county in north Florida. All animals were frozen until they could be processed.

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Pelts were dried and preserved from the 57 animals and examined for differences which might be used to indicate age. Body and skull measurements and weights were taken on all specimens by methods recommended by Hall (1946). Measurements were taken with a steel tape calibrated in millimeters and weights were recorded in kilograms. Skulls were cleaned by hand. They were examined for characteristics that could be related to age as proposed by Saunders (1961) for the lynx (*Lynx canadensis*). Emphasis was placed on skull size, approximation of temporal ridges, development of the sagittal crest and lambdoidal ridge. Using these criteria, the skulls could be grouped roughly into three age classes with some difficulties. The skulls were also arranged in order of the smallest to the largest by condylobasal length and by widths of the zygomatic breadth. Skull measurements were taken with steel vernier calipers and recorded to the nearest 0.1 millimeter.

Eye lenses from 40 specimens were removed for age determination by weight. Each pair of lenses was fixed in Mossman's AFA for one month. The lenses were examined for appearance and then dried in a forced air oven at 80°C for six days (Lord, 1963). Because dried lenses are hygroscopic, they were immediately placed in a dessicator until they could be weighed on an analytical balance. Weights were recorded to the nearest 0.1 mg.

The right humerus of each bobcat was collected and cleaned by hand. The bone, with remaining tissue, was placed in boiling water for 30 minutes. Ossification of the proximal epiphyseal groove was studied. Radiographs of the right foreleg showing the distal epiphysis of the ulna and radius from 30 specimens were taken. Condition of the epiphyseal grooves of the bones was studied for closure.

The upper canine teeth were removed from all specimens, with the exception of those kittens which had not shed their deciduous teeth. After canines were removed by boiling, they were decalcified in a solution of 1 part formalin, 5 parts formic acid, and 20 parts water for seven to ten days and stored in 70% alcohol (Linhart and Knowlton 1967). One canine was cut transversely at the alveolar border and the other was cut longitudinally with a razor blade. The transverse and longitudinal sections were prepared for embedding and sectioning in an auto-technicon. The teeth were sectioned at 15 microns by a rotary microtome and stained with hematoxylin and eosin. These sections were examined through a compound microscope at 100X magnification.

RESULTS

Pelage

Pelage characteristics were found to be of little value in determining the age of bobcats. The animal's color is brownish, in general, with the guard hairs tipped with black and white. The color appears to become less distinct with age but no features could be specifically related to age.

Skull Measurements and Morphology

The skull measurements revealed three relatively distinct size classes which were assumed to be age classes designated as kitten (0-12 months), young adults (13-24 months), and adults (25 months). Skull size, approximation of temporal ridges, development of the sagittal crest and lambdoidal ridge were useful in defining these age classes. The mean, standard deviation, standard error, and coefficient of variation of the skull measurements were calculated for each age class. The measurements for the kitten age class were statistically tested against the young adult age class and in turn the later against the adult class at the 99.9% level. All measurements were highly significant with the exception of postglenoid length (young adult-adult), postorbital construction, and length of the tooth rows (kitten-young adult).

Characteristics of the skulls in the three age classes were studied and are given as follows:

Kittens (0-12 months)

This group was assumed to include bobcats 12 months old or less. The general appearance of the skull surface was smooth. The temporal ridges were wide and indistinct, but unite in later life to the sagittal crest at the rear of the skull. The lambdoidal ridge was low and undeveloped; it becomes more prominent with increasing age and size as in beaver (Osborn, 1953).

Young adults (13-24 months)

This class presumably included specimens 13 to 24 months of age. The general appearance of the skull surface was slightly rough. The temporal ridges were more distinct and closer to the median line than in the kitten class. The sagittal crest and lambdoidal ridge had begun to develop.

Adults (25 months and above)

This class was assumed to include specimens 25 months or more in age. These skulls were generally heavier and larger than those of the preceeding classes. The temporal ridges were distinct and medial in position on the skull. The sagittal crest and lambdoidal ridges were well developed.

Body Measurements

Total length and heart girth gave an indication of two age classes, juveniles and adults. No further classification was deemed possible because of variation and overlap between these two groups. The remaining measurements were found to be of little value either.

Eye Lens Weight

This technique was found unsatisfactory in determining the age of these bobcats because the specimens were frozen. The frozen lenses prevented the formation of an eye lens growth rate curve and erratic weights were obtained as has been shown in other species (Montgomery 1963 and Pelton 1968).

Epiphyseal Closures

From the humeri and forelegs collected it could not be determined at what age the closure of the epiphyseal groove occurs. Without material from known-age specimens, aging bobcats by this method was highly subjective.

Canine Tooth Sections

Examination of the sections of canine teeth showed alternating light-staining and dark-staining bands in the cementum. A pair of alternating bands was assumed to be one annulus or an added year of age. Using a compound microscope, interpretations could be made best at magnifications of 100X with transmitted light.

The lack of known-age specimens made it difficult to establish the precise age at which the first light-staining and dark-staining band is formed. The data suggests that the light-staining band could be laid down during the second spring and/or summer of life and the dark-staining band may be formed during the second fall and/or winter or 17-23 months of age. Sauer, Free, and Browne (1966) found the first dark-staining layer is formed in the second winter of life in black bear (*Ursus americanus*). Saunders (1961) reported that permanent canines do not erupt until 5 or 6 months in the genus *Lynx*. Therefore, by counting the dark-staining bands, one year must be added to the estimate of the tooth sections. As an example, a five year-old (best estimate) bobcat killed in the spring clearly showed four annuli.

Younger animals may be separated from older ones by the opening of the canine root canal. Saunders (1961) found that the canals of Canadian lynx closed between 13 and 18 months. Six bobcats were probably about one year of age. The root canal was open and examination of the slides revealed that the pulp cavity was very large. The dentine layer was found to be relatively wide and deposition of cementum had begun.

Fifteen bobcats could not be aged by either section because the tissue did not stain adequately enough to see the cementum bands. Many teeth had to be resectioned as the sections were frequently lost in the staining procedures.

Comparison of the specimens aged by skull measurements and tooth sections indicates that the skull measurement technique may not be as dependable as the T tests would indicate. Utilizing tooth sections, an age can be assigned to the animal with greater accuracy. When estimated ages based on skull measurements were compared to the ages derived by tooth sections, results were similar for the kitten and adult age classes. However of the 19 specimens in the young adult class, 10 were determined by counting the cementum bands to be older than two years, and 2 were found to be less than 13 months of age.

DISCUSSION

Pelage characteristics such as fur wear and coloration proved to be of no value in age determination. Generally, both characters were associated with climate and seasonal change. Grinnell and Dixon (1924) found color tone of bobcats, collected from mountains and valleys, varied within each habitat.

Skull measurements were useful in determining age classes. The condylobasal length and zygomatic breadth were the most important in placing the specimens into three age groups. Osborn (1953) reported that by using the total dorsal length and zygomatic breadth, three developmental groups were evident for beavers. It is recommended, however, that other skull measurements be used to further separate age classes in the bobcat. Using only one or two measurements can easily mislead the investigator.

The size of the skull, approximation of temporal ridges, development of the sagittal crest and lambdoidal crest were very useful in defining age classes but were too variable when used by themselves as an aging technique.

Body measurements could not be used to determine age classes adequately. When used with other aging criteria, they may give validity to the findings, but their usefulness as an aging technique is limited.

The effect of freezing was readily apparent on the eye lenses of bobcats. None exhibited smooth, shiny surfaces associated with properly fixed (unfrozen) lenses. Most were rough and pitted with highly irregular shapes. Montgomery (1963) demonstrated that freezing or decomposition before fixation reduces the weight of the dry lenses. Pelton (1968) discovered a significant weight difference between eye lenses of the same rabbit (*Sylvilagus floridanus*) in which one was frozen and the other not frozen.

Age could possibly be determined by this technique, if known-age specimens were available and the lenses were fixed before freezing and decomposition. Research should be directed toward developing the lens technique for bobcats.

By studying the epiphyseal groove of the ulnae, radii, and humeri, investigators may determine the ratio of younger animals in a population. Unfortunately the approximately time for ossification of the epiphyseal groove is unknown.

The age of bobcats can be determined from the development of the canine teeth and annual cementum bands. Kittens can be recognized by their deciduous dentition until permanent canines erupt during the first fall or winter. Early permanent canines generally show an open root canal, a large pulp cavity, and a narrow layer of dentine.

The tooth sectioning technique appears to more accurately reflect the age of the animal than the skull measurement classification due to the variability in the latter.

Young adults may be separated by the light-staining band that is assumed to be formed during the second spring and/or summer of the

TABLE 1. Comparison of bobcats aged by skull measurements and tooth cementum annuli.

Specimen No.	Skull Measurements	Tooth Cementum Annuli
13	Kitten (0-12 mos.)	Kitten (1 year)
30	Kitten (0-12 mos.)	Kitten (1 year)
33	Kitten (0-12 mos.)	Kitten (1 year)
56	Kitten (0-12 mos.)	Kitten (1 year)
32	Young adult (13-24 mos.)	Kitten (1 year)
44	Young adult (13-24 mos.)	Kitten (1 year)
9	Young adult (13-24 mos.)	Young adult (2 years)
11	Young adult (13-24 mos.)	Young adult (2 years)
19	Young adult (13-24 mos.)	Young adult (2 years)
48	Young adult (13-24 mos.)	Young adult (2 years)
57	Young adult (13-24 mos.)	Young adult (2 years)
61	Young adult (13-24 mos.)	Young adult (2 years)
68	Young adult (13-24 mos.)	Young adult (2 years)
5	Young adult (13-24 mos.)	Adult (3 years)
7	Young adult (13-24 mos.)	Adult (5 years)
8	Young adult (13-24 mos.)	Adult (4 years)
29	Young adult (13-24 mos.)	Adult (4 years)
31	Young adult (13-24 mos.)	Adult (3 years)
54	Young adult (13-24 mos.)	Adult (3 years)
40	Young adult (13-24 mos.)	Adult (3 years)
64	Young adult (13-24 mos.)	Adult (3 years)
69	Young adult (13-24 mos.)	Adult (5 years)
72	Young adult (13-24 mos.)	Adult (3 years)
2	Adult (25 mos.)	Adult (4 years)
4	Adult (25 mos.)	Adult (6 years)
6	Adult (25 mos.)	Adult (4 years)
26	Adult (25 mos.)	Adult (3 years)
35	Adult (25 mos.)	Adult (4 years)
36	Adult (25 mos.)	Adult (5 years)
37	Adult (25 mos.)	Adult (4 years)
49	Adult (25 mos.)	Adult (4 years)
50	Adult (25 mos.)	Adult (3 years)
53	Adult (25 mos.)	Adult (3 years)
58	Adult (25 mos.)	Adult (4 years)
62	Adult (25 mos.)	Adult (3 years)
65	Adult (25 mos.)	Adult (3 years)

bobcat's life. Sections of teeth may show an increase in the thickening of dentine, deposition of cementum, and possibly a closing or closed root canal. Adults bobcats can be aged by the cementum annuli. The dark-staining band probably appears during the second fall and/or winter.

The decalcification solution used in this study was not completely effective. After 10 days, all teeth appeared to be decalcified. A needle was used to penetrate each tooth with relative ease. During the sectioning procedures, however, several teeth were extremely difficult to cut because they were not completely decalcified. It is believed a stronger solution would facilitate better decalcification of the teeth. A major problem of the technique was that the tissue sections would not adhere to the slides. Entire sections were often lost during staining procedures in spite of the use of egg albumen on each slide.

Some slides were of poor quality and uneven staining, lifting, and curling occurred on nearly one-half of the slides. Stoneberg and Jonkel (1966) used a mixture of 1 percent celloidin in alcohol and ether (a 1:1 mixture) to coat each slide. Probably we should have tried this. Boiling was used to remove the canine teeth from all skulls. Low and Cowan (1963) reported that boiling may alter the staining properties of the tissue. Another method of extraction should be tried.

The longitudinal sections were considered superior to the transverse sections. It is desirable to check the sections along the entire length of the cementum, since layering is more distinct in some areas than in others. The cementum is thicker at the apex of the root; thus the annuli are more easily counted. Low and Cowan (1963) and Gilbert (1966) have reported that the cementum bands were easily counted in this area. With the specimens available, we found no evidence that false annuli are formed in bobcats at least in Georgia and South Carolina

SUMMARY

An investigation of aging techniques for bobcats was undertaken from specimens collected in South Carolina, Georgia, and Florida. Pelts, skulls, eye lenses, humeri, forelegs, and canine teeth were studied for evaluation of age in bobcats Pelts and body measurements were of no value in determining age. With better preparation, eye lenses and epiphyseal characteristics could possibly be used to develop aging techniques. Skull measurements and morphology may be used to determine three age classes: kittens (0-12 months); young adults (13-24 months); and adults (25 + months). The technique is limited, however, in that variation will occur in these classes and ages may not be assigned beyond two years. Cementum annuli present in the canine teeth can be used to age bobcats accurately, but several histological problems should be resolved before the method will be widely used.

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Figure 1. Longitudinal section of the canine of a bobcat collected in the spring. Best estimate of age is 5 years by the cementum annuli. Dentine shown at A and the dentino-cemental interface (B) is a very faint line. There are four annuli but the first annuli is not formed until the second winter of life.

AN INVENTORY AND STUDY OF BEAVER IMPOUNDED WATER IN MISSISSIPPI [1]

By D. H. ARNER, J. BAKER, D. WESLEY and B. HERRING

Department of Wildlife Management
Mississippi State University

The beaver (*Castor canadensis*) and its habitat have become extremely controversial in a number of southeastern states, specifically in Alabama, Georgia, and Mississippi. The low prices paid for beaver fur during the last decade, coupled with the increased prosperity of the area, have resulted in near abandonment of beaver trapping. This reduced harvesting of beaver, combined with the moving of nuisance beaver to other areas by the various state game agencies, has created ideal conditions for the beaver populations to expand rapidly.

Beaver activity, especially the beaver-constructed impoundments, resulted in an increasing volume of complaints by land owners. Game conservation agencies became alarmed at the volume of complaints, and in Alabama and Mississippi removed the beaver from the protected category and permitted year around, unlimited killing of these animals. On the credit side of the beaver ledger, it is common knowledge among many sportsmen that beaver ponds attract ducks and provide fishing superior to that found in small streams and creeks. Wildlife biologists recognize the value of beaver ponds for nesting and brooding sites for wood ducks (Beard, 1953) (Speake, 1955) and roosting and feeding areas for migratory waterfowl. Arner (1961) demonstrated that many

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