Age determination in the european badger, *Meles meles* L.

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Introduction

The need for reliable age determination methods in studies of mammal population dynamics has long been well recognized and many papers on the subject have been published in the last twenty years, many of them concerning absolute age determination from increment lines in teeth and bone. Klevezal and Kleinenberg (1967) and Morris (1972) have published good reviews on the subject.

This paper is a report of different age determination methods, applied to the european badger during an investigation of reproduction and population dynamics of the species in Sweden.

Material

The material studied consists of about 950 badgers killed in Sweden during the years 1971 to 1974. The animals have as a rule been killed by local hunters but also road-killed animals have been investigated. The material collected from each animal consists of reproductive organs, skull, the tibia and from males also the baculum. Whole carcasses were only in a few cases accessible for study as the material generally was dissected out and sent in by the hunters.

Methods

Skeleton material was boiled in water for about six hours, cleaned and then air-dried. Bacula were measured across the greatest length and width and weighed to the nearest .01 g.

Teeth were freeze-sectioned using the following procedure:

The teeth, either canines or incisors were originally decalcified in 6.5 % HNO_3, which was later during the investigation replaced by a special preparation for histological use known as RDO. (Du Page Kinetic Laboratories Inc. P.O. Box 416, Downers Grove, Illinois 60515, USA). For tedails see Wu and Michaelis (1969). The rinsing time could then be reduced considerably and usually rinsing for about five minutes in running water was sufficient, whereas with HNO_3, rinsing for about 12 hours was necessary. Incisors were regularly decalcified in 12 hours while canines needed about 6 hours longer. The process was hastened if the tooth was sawn off and the crown discarded. After rinsing the tooth was sectioned transverseley on a freezing microtome at 20—30 microns. The sections were stained prior to mounting, using Mayers haemalun. Chloral hydrate and citric acid was excluded on the advice of Englund (1970 and pers. comm.) When staining was sufficient as judged by inspection, the sections were rinsed in tap water for a few minutes. Sections showing clear annulations were then placed on a glass slide, blotted and mounted in Paragon mounting medium for frozen sections. This method permits a choice of the best sections before mounting. Care was taken to select sections from different levels in the tooth, thus combining the advantages of transverse sectioning with those of longitudinal sectioning. The sections were studied in transmitted light at 12—200 times magnification.

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Results

a. Fusion of epiphyses

The degree of epiphyseal junction has long been used as an indication of age in mammals, particulary in Lagomorphs but also in other groups. On the advice of Englund, the tibia was chosen for study in this investigation. Englund (pers. comm.) has found that the epiphyses of this bone are among the last to close in the red fox, and preliminary observations had also indicated that the tibia matures rather late in the badger as well. Among the animals killed in the fall, roughly three groups of tibial development could be observed; 1. those on which both the distal and proximal epiphyses were open, in which case they often off during cleaning operations. 2. those with the distal end fully closed but with the proximal end still open and 3. tibiae with both ends closed (Fig. 1). Detailed analysis of tibia from animals killed during different parts of the year has led to the following conclusions concerning the sequence of events: during the first summer of life the tibia has open epiphyses in both ends is moreover characterized by a rough surface. The distal epiphysis is closed during the first winter, at about 10 months of age. The proximal junction is open during the second summer and starts to close in the fall and winter. The recently closed epiphysis is still discernible in the following spring at an age of about 24—28 months as a notch on the anterior part of the bone and a line on each side. The variation between individuals is appearently rather small which makes the method reasonably safe.

Fig. 1. Tibiae from badgers of different age. Age of the animals from left to right: c. 6 months, c. 18 months and c. 70 months

b. Tooth sections

Originally canines were chosen due to their large size and to the fact that many authors have found this the most suitable tooth when working with carnivores. (e. g. Sauer et al. 1966; Linhart and Knowlton 1967; Jensen and Nielsen 1968; Englund 1970; Crowe 1972 to mention a few). The zones in the cementum were, however, often difficult to read due to the fact that the lines were thick and that double lines often occured. It was soon observed that obvious annulations were often present in the dentine. When the cementum lines were easy to read, it was seen that the number of dentinal layers often equalled the number of cementum lines less one. Because of this a closer study was undertaken to evaluate the usefulness of these structures. Dentinal layers have been used as an indication of age in certain mammals in particular Pinnipedia (Laws 1960, 1962) and Cetacea. Results from terrestrial mammals however, have often been negative and most authors agree that cementum lines give more consistent readings. Van Bree et al. (1974) have used the dentine-line method as described by Stirling (1969) when aging badgers and red foxes without comment on the validity of the method.

The dentinal layers are formed when secondary dentine is deposited at a varying rate on the inside of the pulp cavity.

This deposition is of course interrupted if the crown of the tooth is fractured or otherwise injured, leading to the intrusion of sand etc. into the pulp cavity. This type of injuries are common on the canines of older badgers and hence another tooth had to be chosen.

Preliminary studies indicated that I^3 would be suitable for the purpose; both cementum and dentine showed clear annulations and the tooth was as a rule undamaged even in very old animals. As no known-age material was available for study, the teeth were studied from a number of animals judged by the degree of tibial development to be young of the year, one year old and two years old respectively. The deciduous teeth of the badger are shed early; animals killed in the middle of July generally have their permanent dentition complete. In the fall the teeth of juvenile animals are characterized by a thin cementum layer with no dark zones and a large pulp cavity (Fig. 2)[1].

Animals killed during their second summer of life have a greatly reduced pulp cavity and a diffuse zone in the dentine, appearently formed during the winter, while the cementum usually shows one dark line (Fig. 3). In teeth from two-year old animals there are two lines present in the dentine; the diffuse line mentioned before and one very distinct line. In the cementum two zones are usually visible (Fig. 4). In older animals there is an increasing number of dark, distinct zones in the dentine with a corresponding number in the cementum and it seems reasonable to assume that these are formed annually.

Fig. 2—5 (from left to right). Cross-section of the third incisor of a badger about 7 months old (Mag. c. 25×). — Cross-section of the third incisor of a badger about 16 months old (Mag. c. 25×). — Cross-section of the third incisor of a badger about 30 months old (Mag. c. 25×). — Cross-section of the third incisor of a badger 11 years old (Mag. c. 25×)

[1] „dark zone" refers to dense zones in dentine and cementum which take up stain more intensively than intervening portions and therefore look dark when studied in transmitted light.

It has been argued (Morris 1972), that since the pulp cavity only permits a limited growth of dentine, the dentine-line method would be unreliable for older animals. In no case, however, has the pulp cavity been quite occluded by dentine, not even in very old animals, (Fig. 5), and it is assumed that the method is applicable throughout the life of this species. In evaluating age determination methods founded on increment lines, knowledge of the period of formation is essential. Grue and Jensen (1973) have discussed this problem which requires that date of death of the animal is known and preferrably also date of birth.

In the present investigation date of death was known, while date of birth had to be calculated. The information is rather sparse, but observations of foetuses of different age, placental scars and small young (Ahnlund, unpubl.), seem to indicate that the majority of badgers in middle Sweden (about 59° N) are born during the month of March.

A number of animals approaching, and just above two years of age were selected in order to determine when the first distinct line is formed in the dentine. The animals were aged on the basis of the tibial development, (see above) and sections of the third incisor were studied.

One problem which inevitably arises, whether working with cementum or dentine lines, is to settle objectively if a new dense line is just being formed in the periphery of the tooth or if the darker edges is an artifact caused by the more intense contact with the staining medium. Grue and Jensen (1973) recommends the use of several sections from each tooth in order to minimize the problems and in the present investigation usually about 30 sections from different levels of each tooth were studied.

The sections were classified into three categories according to the development of dentine layers as follows:

I. No dark line under formation in the dentine.
II. A dark line under formation just at the inner limit of the dentine.
III. A dark line clearly separated from the pulp cavity by a light zone.

Sections of type II are of course the most difficult to classify objectively and could perhaps be treated as type I.

In the Table the results of this analysis are presented in relation to time of death (week number). The material is rather small but the general picture indicates that the dark line is formed during a comparatively short time, the formation starting in February and in most cases being complete in May.

In older animals the process is assumed to follow the same pattern but this has not been possible to check due to the lack of known-age animals. In distinct speci-

Stage of dentine line development among two years old badgers according to date of death

For explanation of the different stages, see text

Weeknumber	Stage	I	II	III	Total
1— 4	Dec.—Jan.	1	0	0	1
5— 8	Jan.—Feb.	3	2	1	6
9—12	Feb.—March	2	4	2	8
13—16	March—April	3	5	3	11
17—20	April—May	0	2	4	6
21—24	May—June	1	0	8	9
25—28	June—July	—	—	—	—
29—32	July-August	0	0	2	2
					43

mens, however, the picture seemed to be the same, i. e. a dark line in the periphery of the dentine during early spring and a thin layer of translucent dentine separating the dark line from the pulp cavity and progressively getting thicker later in the spring and summer. If the period of formation is the same for all ages, one year should be added to the calculated age of animals killed in the spring, from January until about April—May. As can be seen from the table there is some variation; one animal killed in February had already formed the dentine line, while it was absent from one animal even in the end of May. Some uncertainity is thus inescapable but in some cases the cementum lines can give added information during the critical time.

c. Bacula

Weight, size and general appearance of the baculum have been used as age criteria in a number of mammals, mainly carnivores. In the majority of cases separation has been possible only between young of the year and adult animals (Walton 1968; Elder 1961; Rausch and Pearson 1972).

Fig. 6 illustrates the changes in baculum weight from badgers in relation to age as determined by tooth sections. The age classes represent the following periods: class 0, young of the year from June to the end of the year (about 3—10 months), class 1, 11—22 months, class 2, 23—34 months and so on. Though there is a steady increase in mean weight with age, the overlap between age classes renders the method very unreliable, even for separating young of the year from one-year old animals. An attempt was made to relate the width of the distal end of the baculum to age, but the results were equally negative. The large variation in baculum size that occurs among one year old animals is probably caused by the fact that only a portion of the males reach puberty as yearlings, while other apparently do not become sexually mature until one year later.

The onset of sexual activity has been shown to coincide with a rapid growth of the baculum, due to stimulation by male sex hormones (Wright 1950), and the baculum may perhaps be useful as an indication of sexual maturity in the males (Hewer 1964). Its value for age determination is however considered to be small, especially so when, as has been shown, the tibial epiphyses separates the age classes, males as well as females, up to about two years of age.

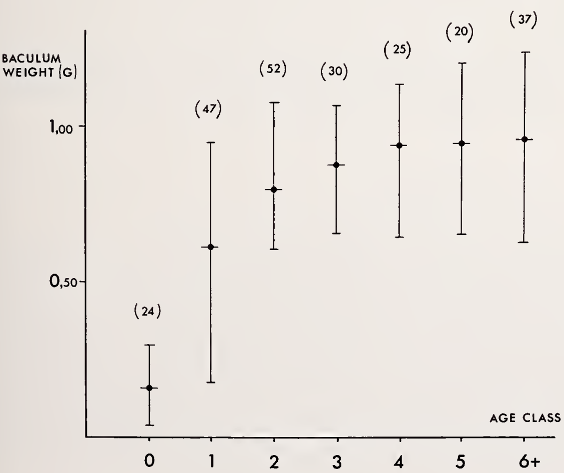

Fig. 6. Graph showing baculum weight (mean and range), in relation to age according to tooth sections

d. Other age characteristics

These include the degree of cranial fusion and the statuts of internal reproductive organs.

The skull of the badger develops rather rapidly; no systematic study has however been made of the closure of different sutures. Young of the year are easily recognized until the following spring when almost all sutures are obliterated. The jugalsquamosal suture seems to be most persistent and is still faintly visible in two-year old animals. The sagittal crest which has been used as an indication of age in certain Mustelids (Marshall 1951), is often fully developed in size in 1.5 year old animals but the surface has a spongy appearance which helps identifying this age-class. Further use of this structure seems to be fruitless as the variation between individuals is large.

The status of female reproductive organs may be used as a way to settle the minimum age of an animal. The badger ovulates and becomes regnant at a minimum age of about one year. After a period a delayed implantation, the young are born the following spring. Females with placental scars in the uterus are thus at least two years old, and if more than one set of scars is present, at least three years old.

Conclusion

The combined results of the different methods indicate that tooth sectioning in combination with study of the closure of tibial epiphyses give the most consistent results for age determination of the european badger. In the tooth both cementum and dentine lines are present but the latter are superior in clarity as well as in uniformity and thus greatly reduces errors due to difficulties in reading. In the absence of known-age material, the reliability of the dentine-line method has yet to be verified, but the circumstantial evidence strongly supports it.

Summary

Several age determination methods have been applied to badgers, *Meles meles* L., collected in Sweden. The methods include study of the epiphyses of the tibia, tooth sectioning, baculum weight and -size and, more briefly, study of the general appearance of the skull and of the female reproductive organs.

The study indicates that the best results are obtained by analysis of tibial development in combination with tooth sectioning.

The degree of epiphyseal junction in the tibia separates the age-classes until about two years of age. In the teeth, dentine annuli are considered superior to those of the cementum due to their greater clarity and uniformity, which reduces reading errors. As the canines are often injured the third incisor (I^3) is better suited for the study of dentine annuli.

Zusammenfassung

Altersbestimmung beim europäischen Dachs, Meles meles L.

Mehrere Methoden zur Altersbestimmung werden auf Dachse (*Meles meles* L.) aus Schweden angewandt. Die Merkmale an Tibia-Epiphysen und Zahnschnitten sowie Gewicht und Größe der Penisknochen (Os baculum) sind eingehender behandelt; Altersunterschiede im generellen Schädelbau und an den weiblichen Geschlechtsorganen finden zusätzlich Erwähnung.

Die Untersuchungen ergeben die besten Resultate, wenn die Analyse der Tibia-Entwicklung mit den Zahnschnitten kombiniert ausgewertet wird. Nach dem Grad der Verwachsung der Tibia-Epiphysen lassen sich Altersklassen bis zu ca. 2 Jahren trennen. Im Zahnbau werden die Dentinringe als ein besseres Bewertungsmerkmal angesehen als die Zementringe, da sie besonders klar und gleichförmig erscheinen. Ferner ist der 3. Schneidezahn (I^3) für das Studium der Dentinringe besser geeignet, da die Canini häufig beschädigt sind.

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