FALKLAND ISLANDS DEPENDENCIES SURVEY

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CONTENTS

I. INTRODUCTION

AN essential requirement in studies of vertebrate populations is a reliable method of age determination. Ideally this should be simple to perform and applicable to animals of all ages.

In fish the seasonal rings present in scales and otoliths, opercular and other bones, and fin rays, have been used by various workers in determining age. Menon (1950) gives a review of existing methods making use of bones rather than otoliths, and there is an extensive literature on the subject.

Much time and thought have been devoted to attempts to find reliable methods for estimating the age of mammals. Such widely different characters as coat colour, size, skull size and suture closure, ossification of bones, corpora lutea, etc., have been used, and it is often possible by a consideration of some or all of these characters to arrive at a reasonable estimate of the age; but it is only an estimate. Because of their economic value, whales have received more attention from this point of view than any other wild mammal, except possibly the Northern Fur Seal (*Callorhinus ursinus*). Even so, no reliable method was available until 1940, when Rudd (1950) initiated a method of determining the age of Fin whales by making use of the incremental ridges on the baleen plates.

Plehanoff (1933) has used the bands on the claws of the fore-flipper for estimating the age of the Bearded Seal (*Erignathus barbatus*) up to thirteen years. Similar growth rings are found on the claws of some other seals, but as the animal grows. attrition leads to the destruction of the first formed bands, so that in seals of most species, over two to three years of age, the claws are of no value in estimating age. The annulations on the horns of certain ungulates can be used with some success in estimating age (Chamois, *R. rupicapra* up to 18 years (Couturier, 1938)).

Doutt (1942), in an admirable survey of existing methods of age determination in pinnipeds, drew attention to the use of radiographs of the teeth to measure the degree of dentine deposition and from this to estimate the age of the animal.

In the course of two summers' field work, on the Elephant Seals (*Mirounga leonina*) of Signy Island in the South Orkney Islands, particular attention has been paid to this problem. The yearly cycle of this seal is remarkable in that there are two periods of complete or partial fasting. It is conceivable that these fasts may be correlated with changes in the general metabolism, and accordingly the solid structures of the body, such as bones and teeth, in this and other seals, were examined, to see if they retain traces of cyclical variation in rate and manner of calcification. These studies led to the development of a new method for determining the age of pinnipeds.

Independently and approximately contemporaneously with this work on the Elephant Seal, Scheffer (1950) formulated a method based on the similar structure of the teeth of the Northern Fur Seal (*Callorhinus ursinus*), of the Pribilof Islands in the Bering Sea. Since the method developed and conclusions reached from work on the Elephant Seal and other seals differ from those outlined by Scheffer, it is proposed to present them here in full, and to make a brief preliminary survey of their application to pinnipeds in general and to other vertebrates.

II. METHODS OF PREPARATION AND EXAMINATION

THE sex was recorded, and a series of measurements were taken, as part of the routine examination of every seal killed. The only measurement with which we are here concerned is the standard length, measured to the nearest inch along the curve of the back from the snout to the tip of the tail. In addition to the fixed material, collected for work on the reproductive cycle, the skull and (in males) the *os penis* were taken. In the early stages of the work, the skulls were roughly cleaned of flesh, boiled until the remaining flesh could be easily removed, and finally dried. Large skulls prepared in this way are impregnated with oil, however, and later skulls were cleaned through the intermediary of marine amphipods. The skulls, after preliminary cleaning, were attached to strong wire, and allowed to lie on the sea floor, just offshore, for about a week; they were then dried.

Canine teeth were chosen for examination because of their greater size, and because they are the only teeth in the Elephant Seal which grow throughout life. They were taken from the lower jaw so as to detract less from the value of the skulls as museum specimens. The canines from some skulls which had been smashed in killing were removed entire, but as this involved destruction of the mandible, the majority of the canines were sawn off at the level of the alveolar bone, using a medium grade hacksaw blade.

The teeth were prepared for examination by filing the cross-section face, sandpapering, and finally polishing on a piece of ground glass with water as a lubricant. They were then placed in spirit, which improves the definition of the zones, and examined by reflected light under a dissecting microscope. In several teeth taken from cows discolouration by a fatty substance impaired the definition of the rings and this had to be dissolved out in benzene before examination. Attempts to improve the definition of the zones by employing various stains, including violet ink, picro-carmine and eosin, were unsuccessful because there is no selective absorption of the dye by the different zones. Drawings to show the sequence and thickness of the rings were made for each tooth.

Thin ground sections (330–360 μ), both transverse and longitudinal, were prepared for microscopic examination by standard petrological methods, using crocus paper and ground glass instead of carborundum powder.

All microscopic measurements were made with an eyepiece micrometer.

III. MACROSCOPIC APPEARANCE OF THE TEETH

THE milk dentition is poorly developed in the pinnipeds; the milk teeth persist for a short time after birth in the Eared Seals and in the Walrus, but in the true seals they are re-absorbed during gestation. The Elephant Seal is born with some of the permanent teeth erupting.

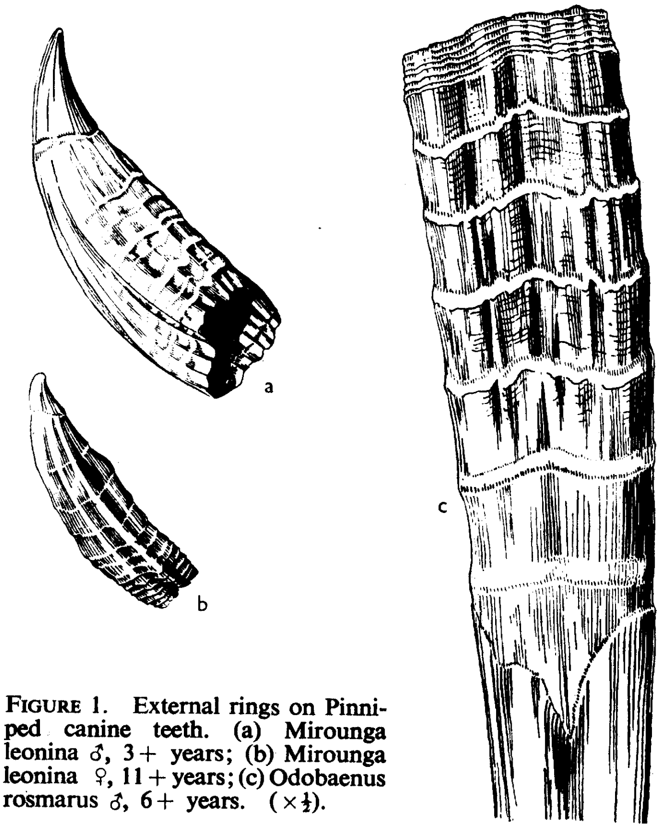

FIGURE 1. External rings on Pinniped canine teeth. (a) Mirounga leonina ♂, 3+ years; (b) Mirounga leonina ♀, 11+ years; (c) Odobaenus rosmarus ♂, 6+ years. (×½).

The permanent dentition of the Elephant Seal is I. $\frac{2-2}{2-2}$, C. $\frac{1-1}{1-1}$, PC. $\frac{5-5}{5-5}$, but there is much variation in the number of the post canines, and an adult male taken had only one lower canine. The incisors are small and the post canines reduced to mere pegs.

The pinnipeds as a group exhibit marked adaptive radiation in the form of the teeth correlated with the diversity of feeding habits, but in all species except the Walrus the form of the canine is a simple conoid. The canine teeth of the Elephant Seal are no exception; in the female they are used mainly for feeding and to a negligible extent in defence. They have four longitudinal grooves which give the teeth in cross-section a shape approximating to a diamond. A lower canine from a thirteen-year-old* female has an enamel crown 11–13 mm. long (there has been some attrition), and the rest of the tooth is 59–62 mm. in length, measured in a straight line. The mean diameter of this tooth at the level of the alveolar bone is 15 mm.

Correlated with their use during the breeding season for fighting with other males, the canines of the male are larger and better developed than in the female. A well-worn canine from a fourteen-year-old* male has an enamel crown of 13–19 mm., and a root measuring 104–115 mm. The mean diameter at the level of the alveolar bone is 32 mm. Figure 1, a and b, shows the gross appearance of canine teeth from male and female Elephant Seals.

IV. DENTINE DEPOSITION; MICROSCOPIC AND MACROSCOPIC APPEARANCE OF SECTIONS OF THE TEETH; ANNULAR RIDGES AND ANNUAL INCREMENTS

THE canine teeth of the Elephant Seal grow continuously throughout life; the pulp cavity remains open and attrition is negligible. The other teeth cease to grow, probably in the second year.

The mechanism of dentine deposition is fairly well understood and does not vary in principle throughout

* Age determined by means of growth rings in the teeth.

the mammals. The odontoblasts are responsible for the deposition of the tissue matrix, and calcification rapidly follows. It is probably achieved by a "physico-chemical precipitation of calcium salts in a protein medium (the tissue matrix) with resultant calcospherite formation and Leisegang phenomena" (Schour and Massler, 1942). The calcospherites are formed at deposition centres in the tissue matrix. They enlarge and interglobular (non-spheritic) dentine is laid down between them to form the so-called "marbled" dentine. Usually the next stage in the process is the fusion of the calcospherites in a dense layer, here referred to as "columnar" dentine. In the normal growth of seal dentine, deposition follows this pattern, but "columnar" dentine only occurs in certain layers and the remainder of the dentine is "marbled". The difference is best observed under a polarising microscope.

From an examination of ground sections it is evident that during growth a series of light and dark layers of dentine, varying in thickness from 5 to 12 μ are laid down. Schour and Steadman (1935), working with laboratory rats, have made use of periodic injections of Alizarin Red S to determine the normal daily increment in dentine in the incisor, but it is not possible to make use of a technique of this kind with a wild population of Elephant Seals. It seems not to be possible to determine the age of Elephant Seal by counting these layers as in the rat, because the ages of a number of Elephant Seals determined by counting these layers, assuming that they represent the normal daily increment, are well below the minimum ages determined by other methods (length, skull size and suture closure, and *os penis* development).

Examination of thin ground sections of Elephant Seal canines showed that there is not only a microscopic stratification of alternate light and dark bands but a macroscopic stratification of alternating zones of "columnar" and "marbled" dentine. The columnar zones are more dense than the marbled zones and are visible macroscopically in cross-sections of the teeth as light coloured rings. While the succession of light and dark rings 5–12 μ apart may be a Leisegang phenomenon (D'Arcy Thompson 1942), it seems probable that the gross macroscopic alternation of marbled and columnar dentine reflects changes in the calcium metabolism of the animal. The macroscopic examination of sections of the teeth shows that the zones of marbled and columnar dentine vary in thickness and are arranged in a definite pattern. The simplest pattern consists of an outer, first formed, light ring, then a narrow region of darker dentine, followed by a ring of light dentine. The average thickness of these zones, measured in a thin ground section from a male canine, are 330 μ, 200 μ, and 168 μ respectively. They are separated from the next set by a zone of marbled dentine about 312 μ thick. It is suggested that these three rings correspond to the breeding season, a period at sea and the moult respectively. In the next section evidence will be presented that collectively they represent one summer's growth, using the term "summer" as opposed to winter, to cover a period of about six months. They are separated from the following summer's rings by a wide dark ring representing the winter at sea. Figure 3 shows diagrammatically the appearance of these rings in cross-section, and Plate 1, figures 2–4 are photographs of the teeth in cross-section.

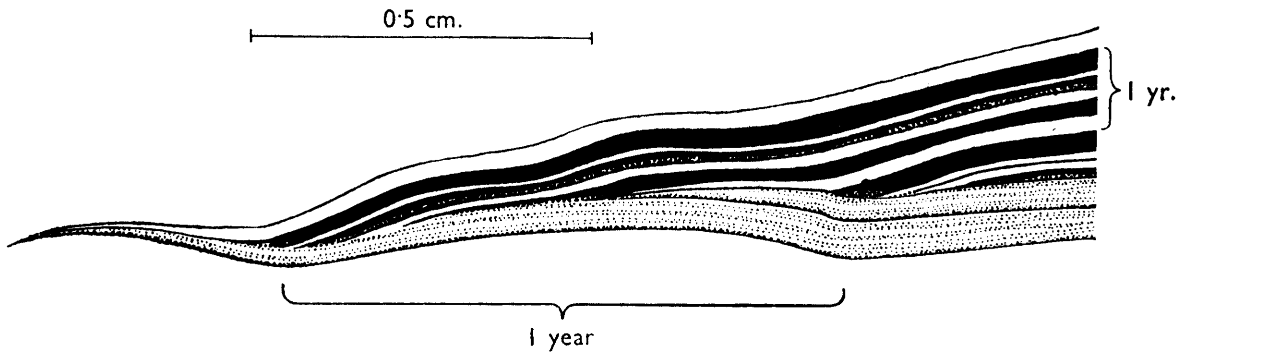

FIGURE 2. Diagrammatic longitudinal section of elephant seal canine tooth, showing method of formation of the annuli at base of the tooth. Cementum stippled.

The tooth grows in length as well as in thickness. Each year's increment of dentine approximates to a hollow cone in shape. A number of such cones superimposed would result in the formation of a number of ridges corresponding to the number of cones, that is to the number of years of age. The ridges would only be formed if there is a discontinuity or change in growth. Reference to figure 2 shows that the discontinuity occurs with the ring representing the breeding season (on the hypothesis presented above), when there is apparently a more rapid growth in length. This figure also shows that the deposition of the cementum will lead to the smoothing out of the ridges (not because of absorption or addition of *dentine* as suggested by Scheffer (1950)), so that they disappear at an early age in most species of seals. In the Hooded Seal (*Cystophora cristata*), for instance, there is a thick layer of cementum because the growth in length of the root stops, or is greatly slowed down, at an early age. In this species the cement layer may measure over half the total diameter of the tooth and incremental zones in the cementum can be used to check the age arrived at from examination of the dentine.

V. VALIDITY OF METHOD

D'ARCY THOMPSON has pointed out that "... we have no right to *assume*, without proof and confirmation, that rhythm and periodicity in structure and growth are necessarily bound up with, and indubitably brought about by, a periodic or seasonal recurrence of particular *external* conditions". (1942, p. 666).

Several tests of the value of zones of growth in the hard structures of fish, as measures of age, have been suggested. These are equally applicable to the growth zones in seal teeth, and it is proposed to examine the validity of the method under three headings. The Petersen test (Graham 1929), is based on the approximation of modes in a graph of size analysis, to the lengths calculated by the method to be tested. It requires a large sample, representative of all age groups, and cannot therefore be applied in this case.

1. *Positive correlation of the growth of the animal with the growth of the teeth*

If the body length be plotted against the number of supposedly annual growth zones, and the average curve drawn, it has the shape of the upper part of a sigmoid curve. This has been shown to be the type of growth curve which obtains for all vertebrates (D'Arcy Thompson, 1942; Rudd, 1950). In figure 3 the growth curves (standard length/age in months, derived from the growth zones) from nought to six years of age, are given for both sexes of the Elephant Seal. The range of size variation is 19 inches at one year of age (22% of the mean) and 31 inches at six years of age (21% of the mean). A variation of this magnitude is to be expected (Rudd, 1950, p. 38). Less extensive data are available for the Hooded Seal (*Cystophora cristata*) and the Harp Seal (*Phoca groenlandica*) but again the curves have the shape expected.

2. *Formation of the zones annually and regularly at particular seasons*

In order to establish when the dense and "marbled" zones are formed it is necessary to observe the nature of the newly formed zone, next the pulp, in seals killed at all seasons of the year. Since it is not possible to capture Elephant Seals at sea, the problem resolves itself into confirming that the dense zones are formed when the animals are on land, and determining whether there is any distinction between the layers formed during the breeding fast and those laid down during the moult. Detailed examination of the teeth supplies an affirmative answer to both questions.

In figure 3 diagrammatic cross-sections of the canine teeth of male and female Elephant Seals have been drawn. For the first three years the dense rings are variable in number and it is only in the fourth and later years that the regular pattern of two conspicuous dense rings obtains. Observations on the length, weight and specific gravity of the *os penis*, together with histological examination of the testes, show that in the male sexual maturity is reached at about three years of age* (determined by other methods than tooth rings), and it seems probable that the establishment of the regular dentine pattern in the tooth coincides with the onset of sexual maturity.

Field observations and, in particular, the weekly classified counts (based on size) carried out in the Borge Bay area on Signy Island, had also shown that the hauling-out habits of the young, sexually immature male seals were very different from those of the mature animals. They tend to remain at sea during the summer and haul out for only short periods. After the third year the males haul out at two definite periods—during the breeding season (although they do not take part until the sixth year), and during the moult. Occasionally they also haul out for a short time in the autumn.

The tooth rings of the males above three years of age, then, are in regular pairs, with occasional extra rings. The adult male during the breeding season fasts for a period of up to eight weeks or more, but when hauled out during a moulting period that increases with age from four to six weeks, they tend to remain

* As a result of further work on a larger number of specimens the age at sexual maturity is found to be four years.

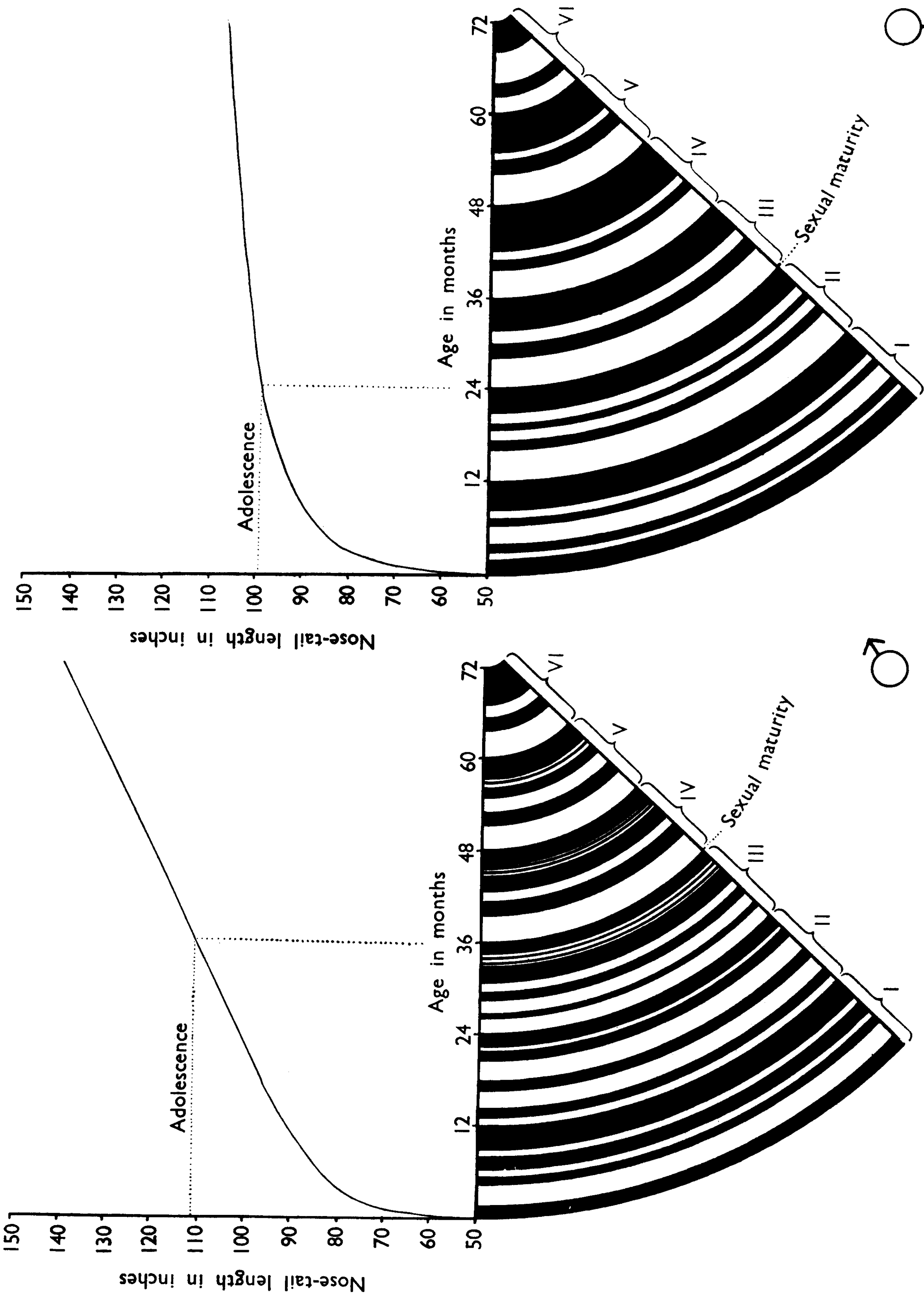

FIGURE 3. Mean growth curves (body length/age) for male and female elephant seals, calculated from tooth rings, with the age and length at sexual maturity indicated. Diagrammatic sections of the canine teeth are added to show the normal pattern of the rings.

on the beaches, not wandering far from shore, and the fast is probably broken by one or more feeding excursions. We might expect the rings representing these two periods to be of different thickness; possibly a thick ring representing the breeding season, and a thin or discontinuous ring corresponding to the moult. This is in fact the pattern of the tooth structure observed in cross-sections of the canines of mature bulls.

In the female, from histological evidence of pregnancy, sexual maturity is reached at two years of age, and the first pup is born at three years. (The ages given here are determined by other means than tooth rings.) The teeth show a variable number of rings for the first two years, reflecting differences between the habits of virgin and adult cows, of the same kind as those of immature and mature bulls. After the second year the dense tooth rings are in pairs, thick and thin, with no supernumerary rings. From the sixth year the order is reversed and the ring representing pupping and lactation is thinner than that representing the moult. This may be correlated with the fact that the drain on the cow's reserves is greater during suckling when she is small, since there is no evidence to suggest that small cows have small pups. The fast during the breeding season is for twenty-eight days only, but in this period the pup, deriving its nourishment solely from the cow, changes from 100 pounds in weight at birth to 450 pounds at weaning. When the cow grows larger the drain, being the same absolutely, is likely to be relatively less, so that the ring representing breeding may be expected to be thinner. On the other hand the length of the moult period increases with age; the cows move inland and do not feed at all for four or five weeks. They are seen to be greatly emaciated at the end of the moult, and it is therefore understandable that with increasing age the thickness of the ring representing the moult increases.

3. *Use of seals of known age (branded) as a check*

In the absence of a long series of branded animals, it is possible to work out the age of Elephant Seals (but then only up to three or four years) independently of tooth rings, by considering size, claw bands, skull proportions and the condition of the sutures. Observations of these factors provide a useful check on the growth zones in teeth up to this age.

In the Pribilof Islands large numbers of Northern Fur Seals (*Callorhinus ursinus*) have been branded and are available as checks. Scheffer (1950) states that the annular ridges at the base of the tooth correspond with the known age of seals branded as pups; in fact it was this correlation which first drew his attention to the use of the ridges for determining age. Unfortunately, in this species, cement deposition obscures the ridges which are rarely distinct after the fourth or fifth years. The canine teeth of Fur Seals of known age have been sectioned transversely during the present study, but the rings are not well marked in section, and according to Scheffer, the pulp cavity closes at ten years of age and dentine deposition must cease. In this species, then, the structure of the canine teeth could not be expected to be of assistance in determining age after ten years at most.

VI. DETERMINATION OF AGE OF ELEPHANT SEALS

THE differential growth of Elephant Seal teeth, correlated with complete or partial fasts during the annual cycle, seems then to result in the formation of growth zones in the dentine which can be used to determine age.

Since the breeding season extends over a short period of less than two months the age of any Elephant Seal can be calculated with an accuracy of $\pm$ one month, by examination of the canine teeth. The number of growth zones are first counted, either from the external ridges, or preferably in cross-section; this gives the age in years. In order to calculate the age in months, the number of months between the median date of the pupping season and the date of killing are added to the figure for age in years (determined from teeth rings) converted to months.

In cutting cross-sections, it is essential that the cut be made between the level of the first annulus on the root, and the level above which the pulp cavity has been obliterated. Otherwise one or more annual growth rings will be missed. In practice a cut made at the level of the alveolar bone fulfils these conditions.

Using this method the maximum ages of animals taken from the wild population of Signy Island in the South Orkney Islands are: male twenty years, and female seventeen years. The rings in female teeth are small and crowded, and above thirteen years the accuracy is $\pm$ one year.

VII. APPLICATION OF THE METHOD TO OTHER PINNIPEDS

A NUMBER of other pinnipeds have been examined in order to decide whether age can be determined in this way in the group as a whole. In all that have been examined rings are present, both externally and internally. In only two genera, however, are distinct external rings visible for more than six or seven years; these are *Mirounga* and *Odobaenus* (figure 1).

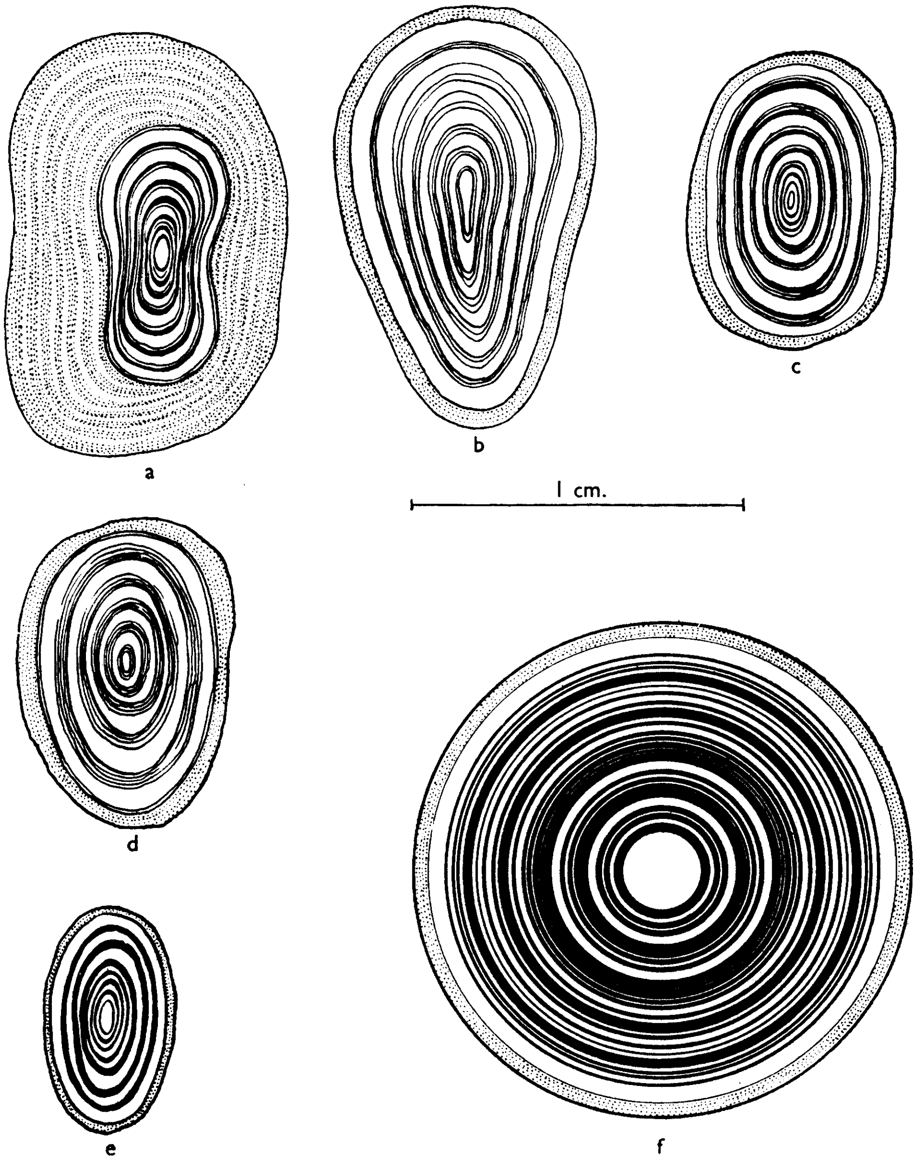

FIGURE 4. Seal canine teeth. (a) *Cystophora cristata* ♂, 6+ years; (b) *Hydrurga leptonyx* ♀, 6 years; (c) *Lobodon carcinophaga* ♂, 6 years; (d) *Halichoerus grypus* ♂, 5 years; (e) *Phoca groenlandica* ♂, 6+ years; (f) *Mirounga leonina* ♂, 5 years.

The teeth of the following species have been examined: *Eumetopias stelleri*, *Zalophus californianus*, *Arctocephalus* sp. (these three species have been examined by Scheffer), *Callorhinus ursinus*, *Phoca vitulina*, *Phoca groenlandica*, *Halichoerus grypus*, *Cystophora cristata*, *Mirounga leonina*, *Hydrurga leptonyx*, *Lobodon carcinophaga*, *Leptonychotes weddelli*, *Ommatophoca rossi*, and *Odobaenus rosmarus*. Assuming, by analogy with the Elephant Seal, that the number of rings in the teeth is a valid criterion for determining age, growth in length of the teeth ceases or becomes very slow at an age varying from two years upwards, and in most species the cavity is completely closed by ten years of age. (*Cystophora*, thirteen years; *Phoca vitulina*, three–four years.)

Concentric rings which, by analogy with the Elephant Seal, may probably be used in determining age up to the date of closure of the pulp cavity, have been observed in cross-sections of the teeth of the following species: *Cystophora cristata* and *Hydrurga leptonyx*, *Phoca vitulina*, *Phoca groenlandica*, *Halichoerus grypus*, *Lobodon carcinophaga*, *Leptonychotes weddelli*, and *Ommatophoca rossi*. The first two species have particularly clear rings. Cross-sections of the teeth of other species have not been examined. Thin ground sections of the teeth show that the rings are similar in structure to those found in the Elephant Seal. The actual pattern of the rings varies from species to species, but in all the discontinuity between the yearly groups of rings is pronounced (figure 4). Ten teeth of *P. groenlandica*, ten of *C. cristata*, and ten of *O. rossi* were available for examination, and the growth curves (body length/age determined from teeth) are as expected.

It is probable that all pinnipeds have distinct growth zones in the teeth, but detailed work is necessary before the validity of the method is proved for individual pinniped species.

VIII. APPLICATION OF THE METHOD TO OTHER VERTEBRATES

A SUPERFICIAL examination of material in the Zoology Museum and the Sedgwick Museum of Geology, in Cambridge, indicates that a number of other vertebrates, living and fossil, have growth zones in the teeth, which by analogy with those found in seals may be used for determining age.

Except for a single tooth of the Sperm Whale (*Physeter cathodon*) no teeth have been sectioned as yet. Table 1 shows those species which have distinct ridges on the root of the tooth.

The whale teeth examined do not have distinct ridges on the root, but a tooth of the Sperm Whale (*Physeter cathodon*) when sectioned showed groups of rings. Teeth of other Odontoceti, examined *in situ* in museum specimens, often have the crowns of the teeth worn down, thus exposing rings in the dentine.

TABLE I

Species	Living	Fossil	Teeth showing clearest ridges
Mammals:			
Hyaena spp.	+	+	Canine
Felis leo	+	+	Canine
Ursus spelaeus		+	Canine
Thalarctos maritimus	+		Canine
Mastodon americanus		+	Incisor (Tusk)
Elephas indicus	+		Incisor (Tusk)
Rhinoceros sp.		+	Molar
Sus spp.	+	+	Canine
Hippopotamus amphibius	+	+	Canine, incisor
Bison spp.	+	+	Molar
Reptiles:			
Ichthyosaurus		+	All teeth
Pliosaurus		+	All teeth
Mosasaurus		+	All teeth
Dacosaurus		+	All teeth

IX. DISCUSSION

IT IS known that in the rat there is a normal daily 16 μ increment of dentine in the incisor. Schour and Steadman (1935) demonstrated a succession of light and dark layers; they suggest that the former, well calcified, were laid down in the daytime, and the latter, poorly calcified, at night. This may be a reflection of the feeding habits of the rat. Owing to the rapid attrition of the rat incisor only the preceding fifty days are represented in this tooth; the molars, which also show these rings, cease growing after 150 days. As has been stated above it is not possible to determine the age of Elephant Seals from similar layers, because it is not known what period each of these layers represents. In view of the variation in thickness of the layers in the Elephant Seal (from 5 to 12 μ) it is likely that the feeding rhythm is not regular, it is certainly not daily. Bertram (1940), discussing the feeding of the Weddell Seal (*Leptonychotes weddelli*), says "... one would judge that probably they do not fill their stomachs ... more than once in every two or three days". The pattern may in fact be a Liesegang phenomenon.

In laboratory rats measurements of the growth rate of the incisor are possible by making use of injections of Alizarin Red S, which stains the layer of dentine laid down at the time of the injection. It has been shown by these methods that, in spite of the severe drain upon the calcium "reservoir" of the animal, caused by repeated pregnancies and lactations, no calcium withdrawal occurs from the enamel and dentine. It is reasonable to suppose that this holds for other mammals, and the pattern found in the tooth can be taken as reflecting the metabolism of the animal at the time it was laid down.

Work has been carried out on the causes of disturbances in the calcification of the rat incisor. The effects of vitamin excess and deficiency, fasting, removal of endocrine organs, etc., are all known in some detail. Dentine formation is not completed when Vitamin D is deficient; instead "marbled" dentine forms. The parathyroids have an important function in regulating the blood calcium level, and therefore an effect on the calcification of the teeth. The effects of high doses of Vitamin D are the same as those produced by injection of parathyroid extract.

Further work on variations in the histology of the parathyroids of the Elephant Seal, throughout the year, is to be undertaken with a view to ascertaining whether these glands cause the disturbances in the calcium metabolism of this species.

Cephalopods, which comprise the main food taken by the Elephant Seal, are probably rich in Vitamin D. On the other hand it is known that the effect of sunlight on sterols is to produce Vitamin D, so that when seals are hauled out for breeding or moulting it is possible that more Vitamin D is produced by irradiation than is obtained normally in the food. The assumption is then that the basal diet of the seals has Vitamin D in amounts suboptimal for dentine formation and fully calcified dentine is only laid down when the animal is on land.

Several causative factors for the growth zones in the scales and bones of fishes have been suggested. Changes in temperature of the environment, variations in feeding habits, and "physiological stress" associated with breeding, have all been advanced as causes of differential growth. Scheffer (1950) suggests that growth layers in pinniped teeth result from seasonal temperature changes.

"Physiological stress" associated with breeding may be ruled out as a factor causing the formation of columnar dentine, for this dentine is also formed when the seals are hauled out for moulting. It is possible that it is due to a temperature variation, for moulting bull Elephant Seals are exposed to a range of air temperatures of from 0°F to 50°F, while the temperature of sea water cannot fall below 28°F, and in the latitudes frequented by the seals seldom rises above 34°F. But seals are mammals and therefore homoiothermic.

We are thus left with either fasting, or variation in Vitamin D, or changes in Parathyroid activity, as probable causative factors. It is possible that all three may be interdependent, and the problem can only be solved by a detailed investigation of the physiology of the Elephant Seal.

X. SUMMARY

1. Growth layers occurring in the teeth of the Elephant Seal (*Mirounga leonina*) are described, and the validity of these layers as indicators of age discussed.

2. Similar growth zones occur in the teeth of all other pinnipeds which have been examined.

3. A brief survey of material in museums suggest that these annual growth layers are not confined to the pinnipeds, nor to aquatic animals only, and that they also occur in reptiles.
4. The factors causing these growth layers are briefly discussed.

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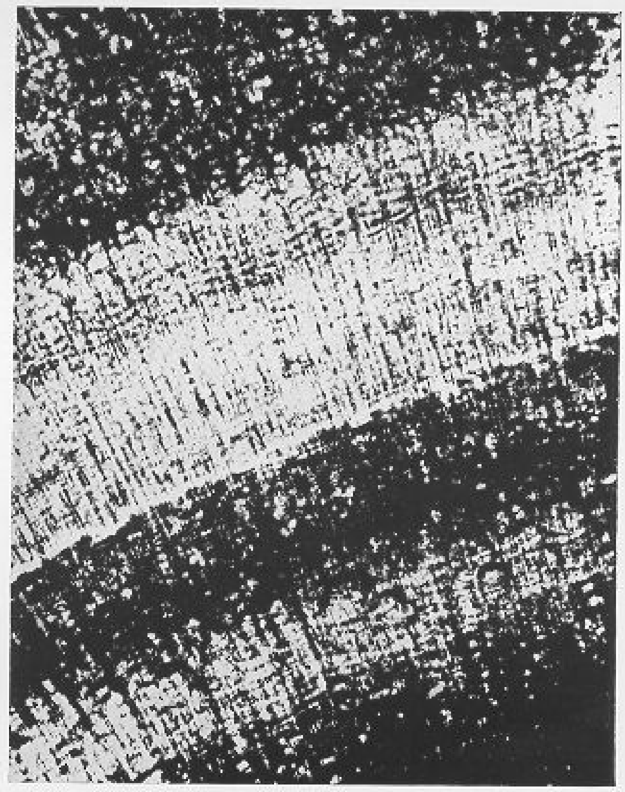

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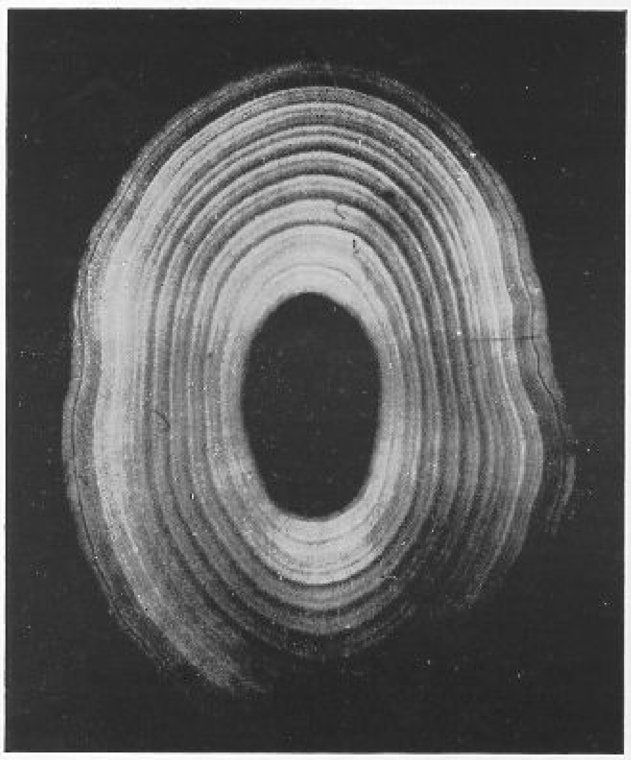

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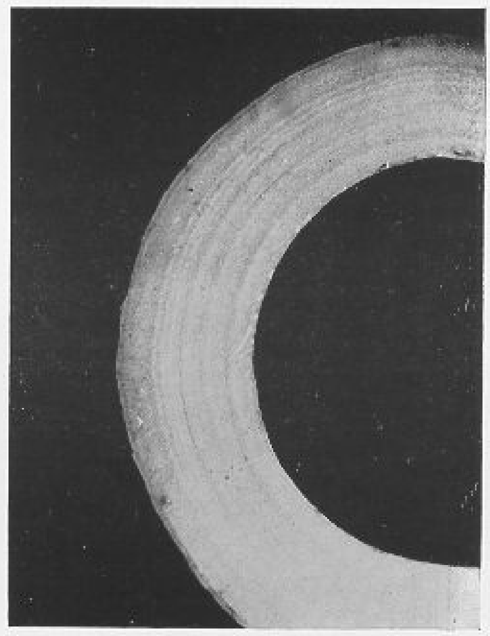

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PLATE I

FIGURE 1. Canine tooth of male Elephant Seal H 133 in longitudinal section, age seven months. Note ridges of denser material at base of root, and rings in section. (× 2)

FIGURE 2. Microscopic appearance in thin ground section of a pair of rings from the canine tooth of a male Elephant Seal (H 354). (× 100)

FIGURE 3. Cross-section of canine tooth of male Elephant Seal H 354, age 98 months. (× 3)

FIGURE 4. Cross-section of canine tooth of male Elephant Seal H 129, age 43 months. (× 12)