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Field age determination of leopards by tooth wear

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Summary

Age determination is an important tool in wildlife studies. Estimating the age of animals in the field using tooth wear criteria may be subject to error as a result of variations between individuals, habitats and populations. Data on age estimation of leopards and tooth wear characteristics are lacking. Nineteen leopards in Namibia were assessed for tooth eruption and wear. Between 1991 and 1995 leopards (induding 13 individuals of known age) were monitored at one year intervals ('28 leopard years') to record age and tooth wear. At the age of two years leopards had fully developed dentition. Wear started with the incisors and canines, and spread to the premolars and molars. A chronology of tooth eruption and wear in relation to age is presented. Above the age of three years, male leopards showed higher frequencies of enamel flaking and canine fractures than females.

Key words: Leopard, age determination, tooth wear

Resume

La determination de l'age est un outil important dans les etudes de la faune sauvage. L'estimation de l'age des aminaux sur Ie terrain en utilisant des criteres d'usure des dents peut mener a des erreurs un raison des variations entre individus, habitats et populations. Des donnees sur l'estimation de l'age chez Ie leopard et sur les caracteristiques d'usure de leurs dents font defaut. L'apparition des dents et leur usure furent etudiees chez dix-neuf leopards en Namibie. Entre 1991 et 1995, on a examine des leopards (comprenant 13 individus d'age connu) apres des intervalles d'un an ("28 leopard ans") pour enregistrer leur age er l'usure dentaire. L'usure commence avec les incisives et les canines et se poursuit avec les premolaires et les molaires. On presente une chronologie de l'eruption et de l'usure en relation avec l'age. Au-dela de l'age de trois ans, les leopards males presentaient des frequences d'ecaillage de l.email et de fractures de canines plus elevees que les femelles.

Introduction

Age determination is an important technique in understanding the ecology and behaviour of a species and in 'studies of population dynamics different generations need to be recognized (Spinage, 1973). Such information can be crucial

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when the management and conservation of species are involved (Alexander, 1958).

The age of carnivores can be estimated from the do sure rate of pulp chambers, particularly those of maxillary and mandibular canines (see Spinage, 1973). Among carnivores that live in temperate latitudes the roots of canine teeth may show distinct cementum annuli which correlate with age (Spinage, 1976; Smuts, Anderson & Austin, 1978). Field assessments of the age of live, immobilized carnivores is restricted to tooth eruption and wear. Such field assessments of age is often subject to error (Grau, Sanderson & Rogers, 1970) due to individual variation in tooth wear and differences between populations (Harris, 1978). No criteria of age determination of leopards can be found in the literature. While accepting the potential error in tooth wear dassifications (Harris, Cresswell & Cheeseman, 1992), the need for an ageing criterion, however crude, is overdue. **In** this paper a rough age determination diagram is presented which is based on eruption and tooth wear. This ageing index is not to be seen as authoritative but instead as a stepping stone to understanding the tooth wear characteristics of leopards, and as a guide to the dassification of leopards into broad age categories.

Methods

Between 1991 and 1995 leopards were studied in northeastern Namibia (S19°; E20030'). **All** data on tooth eruption and wear came from live animals that had been immobilized with a combination of Zoletil and xylazine hydrochloride (Stander & Morkel, 1991) using a traditional San bow and arrow (Stander *et al.*, 1996). Whilst immobilized the teeth of leopards were measured using vernier callipers, and body measurements were taken with a tape measure. Teeth were inspected for eruption and wear, and photographed. Body length was measured from the tip of the nose to the tip of the tail. Care was taken to ensure that leopards recovered safely from immobilization. A total of 19 leopards were assessed for age and 18 were fitted with a radio transmitter. There were 13 animals whose actual ages were known to an accuracy of ::!2 days (*N*= 3), ::!:1 month *(N=4)* and::!: 3 months *(N=6)*, respectively. Marked leopards were monitored for a total of 28 'leopard years' and individuals were immobilized, on average once a year, to assess the extent of tooth eruption and wear. Data were not normal and a non-parametric statistic (Mann-Whitney *U* test) was used to test for differences between groups. **All** tests were two-tailed. Means are given with standard errors *(x::!:*SE).

Results

Leopards resemble other felids in possessing 26 deciduous and 30 permanent teeth. Their total permanent dentition is:

$$I\frac{3}{3}-C\frac{1}{1}-P\frac{3}{2}-M\frac{1}{1}=30.$$

Most extant carnivo'res show a phylogenetic reduction of molars and premolars from primitive placental mammals (Smuts *et al.*, 1978) that had 44 permanent teeth. The dental formula of leopards is:

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Table 1. Chronology of tooth eruption and wear in relation to age, of Namibian leopards

Age	Tooth eruption and wear
8-10 months	All I replaced i; C erupting with c still in place; p3, P3,4 replacing p3, P3,4; MI erupting. all other permanent teeth present.
12 months	Full permanent eruption complete except C; c5: maxillary C::f: 18-23 cm; mandibular C 15-20 cm.
I. 5-2 years	Full C eruption; teeth white with no wear; c5: maxillary C (median) 34 mm; mandibular C 27 mm '!': maxillary C (median) 27 mm; mandibular C 23 mm.
2.5 years	Complete dentition; slight wear on tips some incisors, canines, p3 and P4; slight and irregular wear of canine ridges*.
3 years	Wear apparent on incisors, canines, and on highest cusps of p3 and P4; noticeable chipping and wear of canine ridges; slight yellowing** noticeable on premolars and molars.
4 years	Wear present on all teeth; pulp cavities may show on II and II; canine ridges worn along length of canine; yellowing of teeth, including canines, well advanced.
5-6 years	Wear obvious on all teeth; incisor wear, exposing pulp cavities, spreading to 12.3 and 12,3, one or two incisors may be absent; canine ridges worn flat; tips of p3 and P3,4 showing rounded wear; yellowing of all teeth; flaking of enamel layers and broken canine tips among males.
7-10 years	Extensive wear on all teeth; incisors worn short and flat, pulp cavities visible and some absent; canines worn down with pulp cavities visible; distal side of canines show extensive wear; p3, P3,4 worn to flat tips; extensive yellow of all teeth; c5: flaking of enamel layers on all teeth and occasional broken canine.

Note: Dentition formulae: capital letters = permanent teeth; lower case letters = deciduous teeth; 1= incisors, C=canine, P=premolar, M=molar. *Canine ridge = enamel longitudinal ridge along the distal side of canines. **Yellowing=discolouring of teeth.

$$2\left(I\ \frac{1,2,3}{1,2,3}\ C\ \frac{1}{1}\ P\ \frac{0,2,3,4}{0,0,3,4}\ M\ \frac{1,0,0}{1,0,0}\right) = 30 \text{ permanent teeth}$$

(O=phylogenetic loss of a tooth).

The eruption sequence of deciduous teeth and the sequence of permanent teeth replacing the deciduous dentition could not be recorded as only leopards eight months or older were immobilized. Full permanent dentition was present when leopards were one year of age, although canines were not fully erupted. At the age of 1.5-2 years leopards had fully developed dentition with no signs of wear. Tooth wear occurred first, at three years of age, in the incisors and canines and then spread to the premolars, and then to the molars. By the age of 7 + years the teeth of leopards showed extensive wear, discolouration and flaking of enamel layers. A chronological outlay of the age at various stages of eruption and wear is presented in Table 1, with a graphic display of the approximate extent of canine and premolar wear for different ages (Fig. 1). No data from this study were available on the longevity of leopards.

Sexual dimorphism was present in both body size and the size of teeth. Male leopards were larger and heavier than females. Both maxillary and mandibular

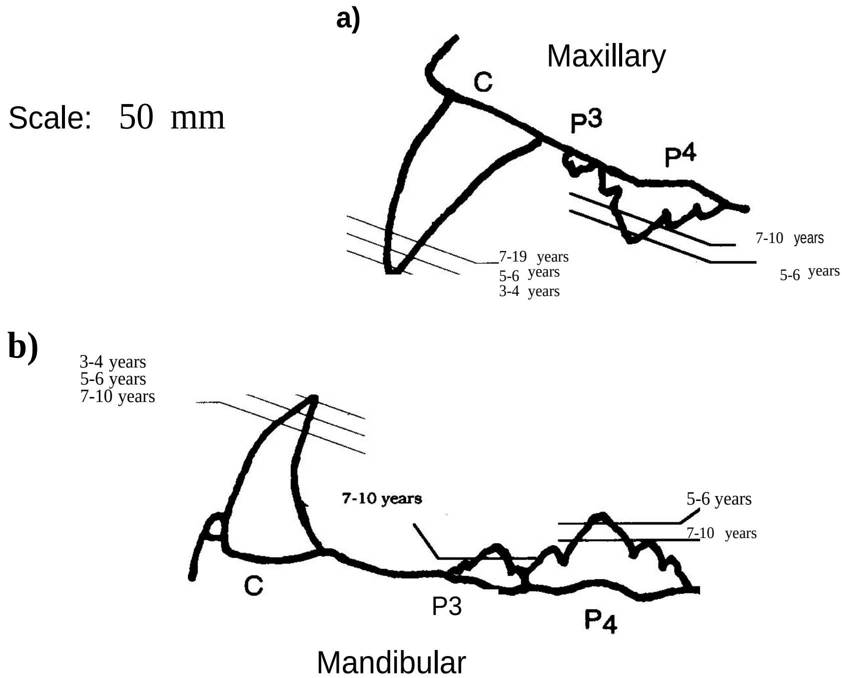

Fig. 1. Lateral views of the (a) maxillary and (b) mandibular of a leopard, aged two years, displaying the left canine and first two premolars. Approximate extent of wear at various ages is indicated.

Table 2. Sexual dimorphism in Namibian leopards as measured by (a) body mass, (b) body length and (c) canine length. Eight male and six female leopards, at the estimated age of two years, were assessed

					Canine length (mm)			
	Mass (kg)		Body length (cm)		Maxillary		Mandibular	
	Males	Females	Males	Females	Males	Females	Males	Females
Mean	45	25	228	207	33.2	27.2	26.1	22'5
SE	0,53	2.24	3.18	0,76	1-0I	0,65	0,56	0.61
Range	42-46.5	20---29	215-242	205-210	28'7-36,5	25.0---29.0	23.0---27.5	20.5-24'0
N	8	6	8	6	8	6	8	6
U	48'0; P<O'OOI		48'0; P<O'OOI		39'0; P<O'OI		38'0, P<O'OI	

Note: U=Mann-Whitney *U* test.

canines in males were longer than in females (Table 2). The extent of tooth deterioration after the age of four years was also different between the sexes. Although females showed similar tooth wear and discolouration to males, their teeth were less prone to flaking of enamel layers and to broken canines. At an estimated age of four years, five out of seven males had one broken canine, and by the estimated age of five to eight years, all four males had at least one broken canine. Females appeared less prone to tooth breakage as only one out of six females between the estimated ages of two to seven years, had a broken canine tip.

Discussion

The leopards in Namibia showed a similar sequence of tooth eruption to lions (Smuts *et al.*, 1978), and tooth wear followed patterns that have been recorded for lions, spotted hyaenas (Kruuk, 1972) and some canids (Harris, 1978). Incisors and canines were the first teeth to show wear. This is supported by recent observations of carnivores, and especially felids, using incisors and canines as a unit in well over half their feeding activities (Van Valkenburgh, 1996). There are, however, considerable variations in tooth eruption and wear. Tooth eruption and growth vary significantly between the sexes (Smuts *et al.*, 1978) and between populations (Harris, 1978). Individual variation and especially differences between habitats have effects on the extent of tooth wear (Smuts *et al.*, 1978).

Tooth breakage, especially of canine teeth, is commonc in extant carnivores (Van Val ken burgh, 1988) but has been recorded at a much higher frequency among Pleistocene carnivores (Van Valkenburgh & Hertel, 1993). There is a 25% likelihood of extant carnivores breaking a tooth during their life, and it is a function of age, increased feeding pressure, and eating meat that indudes bones (Van Valkenburgh, 1988). Male leopards in Namibia showed a higher frequency of broken canines than females. Both sexes had the same feeding habits in terms of prey species, but males consumed more food than females (unpublished data). The discrepancy in fractured canines may be explained by the fact that the smaller females with smaller teeth, compared to males, exhibit greater precision when feeding and are less prone to injurious contact with bones (see Van Valkenburgh, 1996). The fact that enamel flaking is more common in males supports the suggestion of repeated contact between anterior teeth and bone. Decay of enamel layers may weaken teeth (Rensberger, 1995) and augment fractures.

Ageing criterion is an important tool in wildlife studies and management, but the level of error in most systems for estimating age needs to be considered (Erickson *et al.*, 1970; Harris *et al.*, 1992). The age estimating technique for leopards presented in this paper will be useful in studies where high levels of accuracy (doseness to actual age) and precision (repeatability; Erickson *et al.*, 1970) are' not required.

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