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Age Determination and Development of Foetal and Juvenile *Felis caracal* Schreber, 1776

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Age determination criteria were established for foetal and juvenile *Felis caracal*. Twenty nine foetuses (16 litters) were collected, and 27 known-age animals were monitored and culled at selected ages. Ten foetal age groups were recognised from the thirty third day after conception, and spanning a period of forty seven days. Tooth eruption and replacement were the primary criteria used in the case of juvenile age determination, to one year.

Kittens were weaned between 15 and 24 weeks after birth, with first solid food being taken at three and a half to eight weeks. Full permanent dentition is developed at ten months of age. First captive breeding took place after the first year.

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1. Introduction

Accurate determination of the age of animals is an essential prerequisite for determining rates of growth, sexual maturity, longevity, and numerous other features of life history.

In South Africa, LOMBAARD (1971) has developed post-partum age determination criteria for black-backed jackal *(Canis mesomelas)* and SMUTS, ANDERSON & AUSTIN (1978) have done similar studies on the lion *(Panthera leo)*. Foetal age-determination has not been undertaken on any felid occurring in the subcontinent. One of the primary reasons for the lack of age-determination data is the shortage of known-age animals which can be used to form a comparative reference series.

The principal goals of this paper are to present practical means of determining the age of *Felis caracal* foetuses, juveniles and sub-adults.

2. Methods and materials

2.1 Foetal development

A total of 29 foetuses from 16 litters were collected during the course of the project (STUART 1983). Foetuses were preserved in 10% formalin, after mass, crown/rump, hind foot and ear measurements were recorded. Total length was taken after preservation. Foetal ages were determined using the HUGGETT & WIDDAS (1951) equation (see Appendix).

Having aged the foetuses, ten representatives were selected, spanning a period of 47 days. The external morphology of each foetus was examined in detail for changes in the development of eyes, hair, colouration, ears and claws.

2.2 Juvenile development

Known-age animals (12 males and 15 females) were culled at selected ages during the course of a captive breeding programme which was specifically aimed at producing known-age animals. Captive animals were measured and weighed at regular intervals.

The eruption sequence of the deciduous and permanent teeth of both the upper and lower jaws was determined for wild-killed caracal by comparing with the known-age material.

Table 1. Tooth eruption sequence and approximate chronological age of the caracal.

	Live Specimens		Skulls	
Age	Sample Size	Characteristics	Sample Size	Characteristics
Birth	18	No teeth visible	4	Tips of i_1, i_2, i_3; i^1 i^2 i^3 visible; also tips of c^u.
10 days	14	All incisors visible. Tips of c^u can be felt, also p_4	3	Tips of c^u clearly visible, also p_4. Tips of p_3 visible
50 days	12	c^u and c_1 emerged; also $p^3 + p^4$ and $p_3 + p_4$	2	Full deciduous dentition
113 days	1	Tips of C^u C_1 cannot be felt through gum	3	Deciduous dentition complete. Tips of C^u C_1 visible. M_1 just visible in alveolus.
4–5 months	2	C^u C_1 just through gum line. M^1 just breaking through.	2	Deciduous incisors in place but been forced out by emerging permanent incisors.
5–6 months	1	Permanent incisors emerging; deciduous incisors displaced.	2	1^1 1_1; 1^2 1_2 replace i^1 i_1; i^2 i_2.
6 months	3	1^3 and 1_3 just visible. C^u displacing c^u P^4 visible and p^4 displaced.	3	1^3, 1_3 replace i^3, i_3 C^u approx. 25 % emerged. P^4 and M_1 partially emerged.
		P_3 P_4 partly emerged. M_1 visible and well developed.	1	C_1 also visible. p_3 being replaced.
7–8 months	2	All incisors fully emerged. C^u well emerged but not completely.	3	M^1 well emerged. p_3 and p_4 almost displaced.
10 months	3	Dentition complete, P^2 absent. (1 spec. had P^2 on one side only).	3	Canines fully emerged. P^3 P^4 fully emerged as are P_3 P^4 and M_1.
1 yr 3 months	1	Complete in all respects	1	P^2 present and fully emerged.

N. B. In a random sample of 50 adult female and 50 adult male caracal skulls P^2 was present in only eight skulls.

Age at which the apical foramen to the pulp cavity closed in the canines was also recorded. Eye lens masses were recorded for 20 known-age caracal. The lenses were preserved in 10% formalin and after eight months were oven dried at 80° C until no further decrease in mass was noticed. When a constant mass was attained, the lenses were placed in dessicators to cool for 10 minutes before dry mass was measured.

Behavioural development for captive, known-age kittens from birth to adulthood (+ 1 year) was recorded.

Table 2. Skull measurements of 27 known-age caracals sacrified at different ages. TL – Total length; ZW – Zygomatic width; N – Nasal length; IOC – Interorbital constriction; POC – Postorbital constriction; OH – Orbital height; CW – Cranial width; BW – Width at Bullae; WM – Maxilla width at canine base; VCL – Upper canine length; UC – Upper canine diameter; JL – Jaw length; WMC – Width of mandibular condyle.

No.	Sex	Age	TL	ZW	N	IOC	POC	OH	CW	BW	WM	VCL	UC	JL	WMC
2156	MALE	Birth	48,9	–	8,0	10,0	–	6,6	28,9	–	–	–	–	31,4	–
3150	MALE	3 months 23 days	–	62,2	21,0	15,3	34,7	23,0	50,7	42,5	15,3	9,7	4,5	59,2	14,0
3151	MALE	3 months 23 days	94,0	62,5	20,2	15,2	34,7	23,7	50,2	43,2	16,8	9,7	4,0	59,8	14,6
3152	MALE	3 months 23 days	88,3	60,5	20,0	14,5	36,2	22,9	51,0	43,0	14,6	10,0	4,9	56,7	12,9
3431	MALE	4 months 7 days	103,0	71,0	24,0	19,0	35,0	24,0	52,0	47,0	16,0	9,0	5,0	67,0	15,0
2716	MALE	5 months	98,0	–	22,4	17,5	35,0	26,2	49,0	44,5	15,4	10,7	4,4	60,5	–
2500	MALE	5 months 11 days	–	72,3	–	17,4	31,3	26,7	50,2	48,2	18,2	13,0	4,4	70,3	14,0
3320	MALE	7 months 15 days	116,0	81,0	25,0	20,0	30,4	30,0	54,2	54,0	19,2	14,0	6,4	79,0	17,0
2865	MALE	10 months 4 days	–	87,0	29,0	22,7	32,2	34,0	56,5	58,0	20,6	18,3	8,0	84,0	17,6
3223	MALE	1 year 3 months	127,0	91,0	28,8	24,7	35,0	34,6	56,3	55,0	21,6	15,6	7,3	86,0	20,7
3193	MALE	2 years 3 months	144,0	102,0	33,0	28,8	38,4	38,3	57,0	57,3	22,6	–	8,5	99,0	22,7
3383	MALE	4 years 4 months	138,0	103,0	32,0	27,7	32,7	35,2	57,3	57,5	23,7	–	8,0	96,0	23,0
2155	FEMALE	Birth	49,3	29,0	8,5	10,0	–	11,8	28,7	–	–	–	–	–	–
2102	FEMALE	Birth	46,4	27,2	7,6	9,6	–	11,7	26,0	–	–	–	–	–	–
726	FEMALE	Birth	46,7	–	8,2	9,7	–	10,7	25,4	–	–	–	–	–	–
1665 a	FEMALE	10 days	–	–	10,8	12,0	–	12,5	–	–	–	–	–	–	–
1665 b	FEMALE	10 days	47,8	–	9,3	12,0	–	12,0	32,4	–	–	–	–	–	–
1454	FEMALE	10 days	59,0	39,7	11,6	11,2	–	13,8	35,6	30,0	8,0	–	–	36,0	6,3
2862	FEMALE	1 months 20 days	–	–	15,0	12,6	31,7	–	–	–	–	8,4	4,0	46,5	9,0
2863	FEMALE	1 months 20 days	–	–	–	–	–	–	–	–	–	9,4	4,0	47,3	10,3
3430	FEMALE	4 months 7 days	105,0	73,5	23,0	18,5	35,0	25,5	52,5	49,0	17,0	10,0	5,0	67,0	15,0
2277	FEMALE	6 months	–	73,0	–	18,7	35,6	–	52,7	48,4	–	–	–	73,0	14,7
2492	FEMALE	6 months	100,0	70,0	23,5	16,0	35,0	26,7	52,0	47,6	17,0	11,5	4,6	67,0	12,7
3321	FEMALE	7 months 15 days	107,0	75,0	22,2	18,3	31,4	28,0	51,4	50,7	17,5	14,0	6,0	72,0	17,5
3322	FEMALE	8 months	110,0	78,0	25,2	19,3	32,7	30,7	–	50,5	18,0	14,8	7,0	76,0	17,4
2864	FEMALE	10 months	116,0	79,0	24,0	20,3	31,3	30,0	53,0	51,0	20,0	15,4	6,8	77,0	16,2
2196	FEMALE	10 months	113,0	77,0	26,4	18,0	31,0	29,3	51,7	49,7	18,0	16,0	6,7	76,0	–

Table 3. External measurements (mm; g) of the sixteen litters, presented as means per litter, of *Felis caracal*.

Age (days)	Mass (g)	Crown/Rump length (mm)	Total length (mm)
33	0,9	20,5	54,0
34	1,3	22,0	–
36	2,7	34,0	74,0
40	5,4	45,0	–
42	8,2	53,7	95,0
43	9,2	52,0	–
48	18,6	70,7	131,0
52	31,1	82,0	160,0
60	63,9	84,0	–
64	89,2	111,0	222,7
65	90,6	116,5	–
67	106,5	109,0	215,0
71	138,8	119,5	278,0
74	171,5	111,5	264,5
80	234,6	151,5	305,5
81	256,8	155,0	–

3. Results

3.1 Dentition

No teeth are visible during the foetal period. Dentition of the caracal follows the characteristic pattern for the Felidae. At birth no teeth are visible, although in the cleaned skull the tips of all incisors and the upper canines can be seen. The full deciduous dentition has emerged 50 days after birth. At four to five months the permanent canines have begun to emerge, and between the fifth and sixth month they have displaced the deciduous canines. By the tenth month the permanent dentition has replaced the deciduous teeth, with all teeth fully emerged. In a sample of 100 adult skulls, P^2 was present in only eight. Tooth eruption sequence and approximate chronological age of caracal is given in Table 1.

The closure rate of the apical foramen of the pulp cavity was checked against age and the findings were as follows:

a) With complete emergence of permanent, upper canines (ca. 10 months), the apical foramen had a greatest diameter of 3,4 mm (n = 4).
b) At one year and three months the apical foramen had a greatest diameter of 1,65 mm (n = 2).
c) At two years of age the apical foramen is completely closed (n = 2).

Although the sample examined was small (n = 8), it would appear that the apical foramen of the canine pulp cavity closes at between one year and three months, and two years of age. If the closure rate is taken as being constant, it can be expected that first closure takes place at approximately one year and eight months of age.

3.2 Skull development

Thirteen skull measurements were taken of each known-age animal (Table 2) and 16 of these are graphically compared in Figure 1.

3.3 Eyelens mass

Paired eyelens mass of seventeen known age caracal are presented in figure 2. The use of eyelens mass in *F. caracal* age determination is useful in the first year following birth.

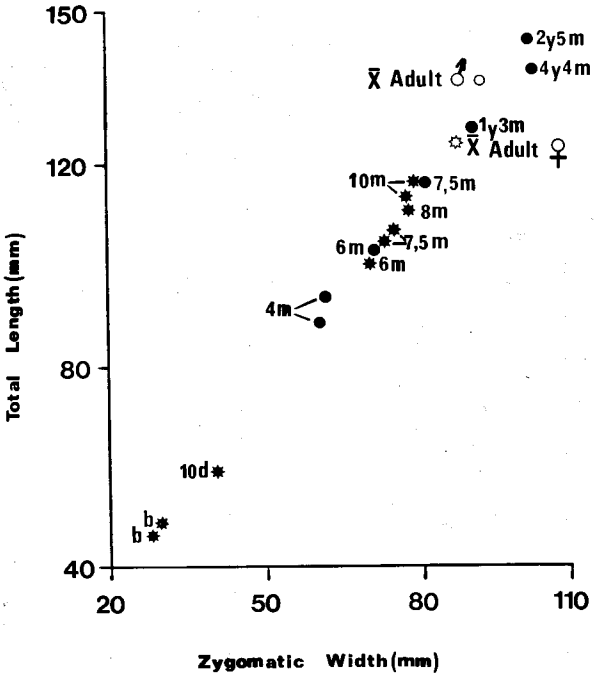

Figure 1. The growth of skulls of known-age *Felis caracal* (Total length/Zygomatic width). ★-female; ●-male. The mean, adult skull sizes are given for comparative purposes.

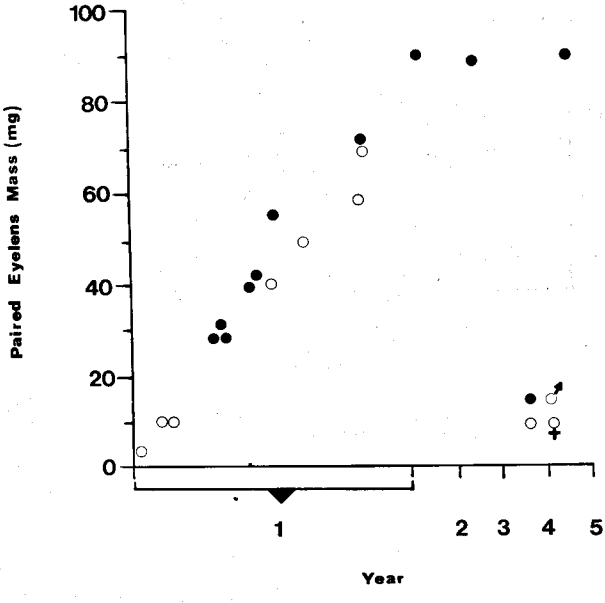

Figure 2. Paired eye lens mass plotted against age of known-age *Felis caracal*. Note the positive relationship between lens mass and age during the first year, and thereafter a cessation of lens growth.

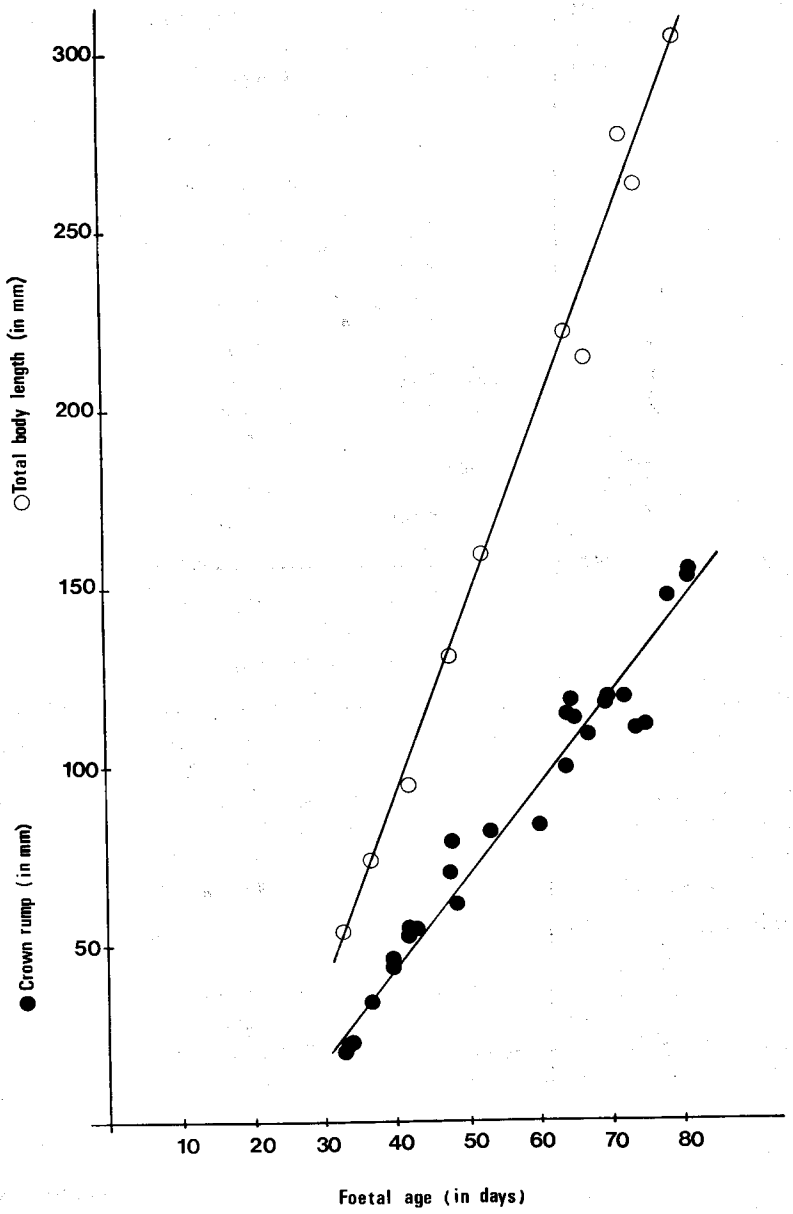

Figure 3. Graph showing increase in crown/rump and total body length with foetal age of *Felis caracal*.
For crown/rump: $Y = 2{,}55 \times - 57{,}89$ ($r = 0{,}985$) $p < 0{,}001$
For total length: $Y = 5{,}35 \times - 123{,}23$ ($r = 0{,}995$) $p < 0{,}001$.

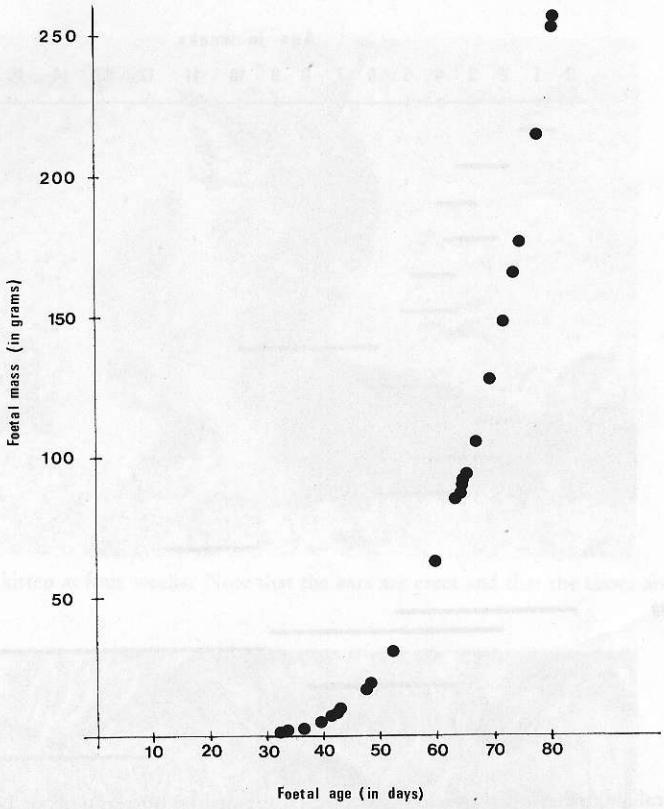

Figure 4. Graph showing the exponential relationship between mass and age of twenty four caracal foetuses, from 32 days after conception to parturition.

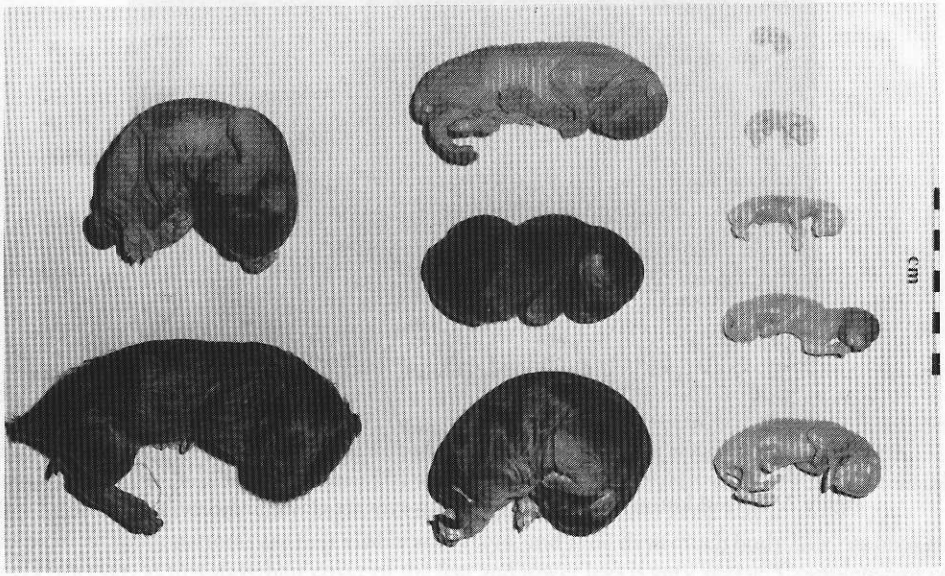

Figure 5. Foetuses of *Felis caracal,* from right to left, top to bottom, – Days – 33, 36, 42, 48, 52, 64, 67, 71, 74, 80.

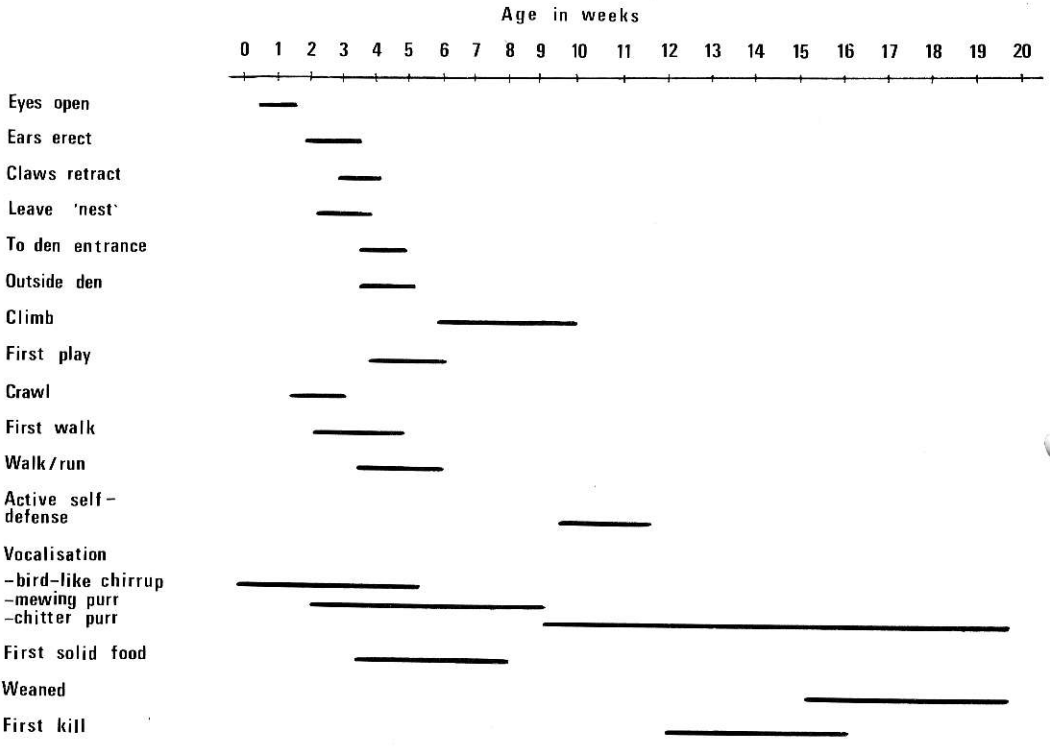

Figure 6. Physical and behavioural development of caracal based on observations of 12 captive born animals.

Figure 7. Caracal kittens at two days, note that eyes are closed and claws extended.

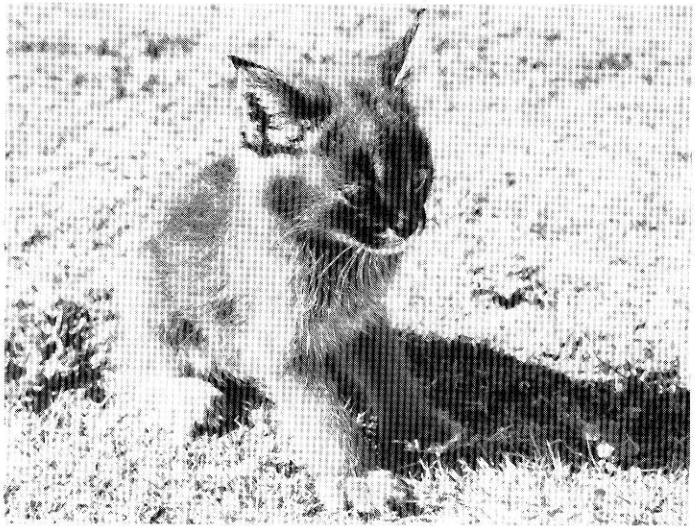

Figure 8. Caracal kitten at four weeks. Note that the ears are erect and that the claws are retracted.

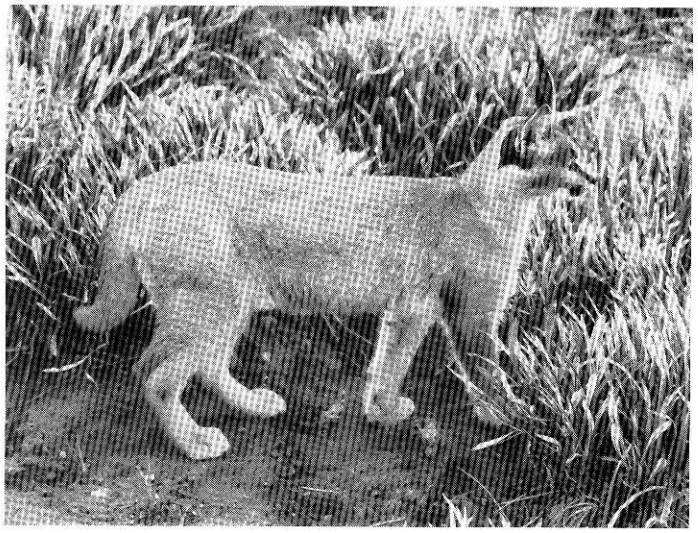

Figure 9. Caracal sub-adult at eight months.

3.4 Physical development

3.4.1 Foetuses

Claws are first visible at 36 days and remain non-retractable until three weeks after birth.

Ears remain flat against the head until $1\frac{1}{2}$ weeks after birth. The facial whiskers are first visible as whisker buds at 48 days and they begin to emerge for the first time at 52 days.

Skin pigmentation; patterns are first visible at 64 days, and at 67 days much body hair has broken the surface. However, at this stage hair cover of the feet and lower legs is very sparse. Complete hair covering and side belly spotting is only complete at near full-term. Belly spotting pigmentation is faintly vi-

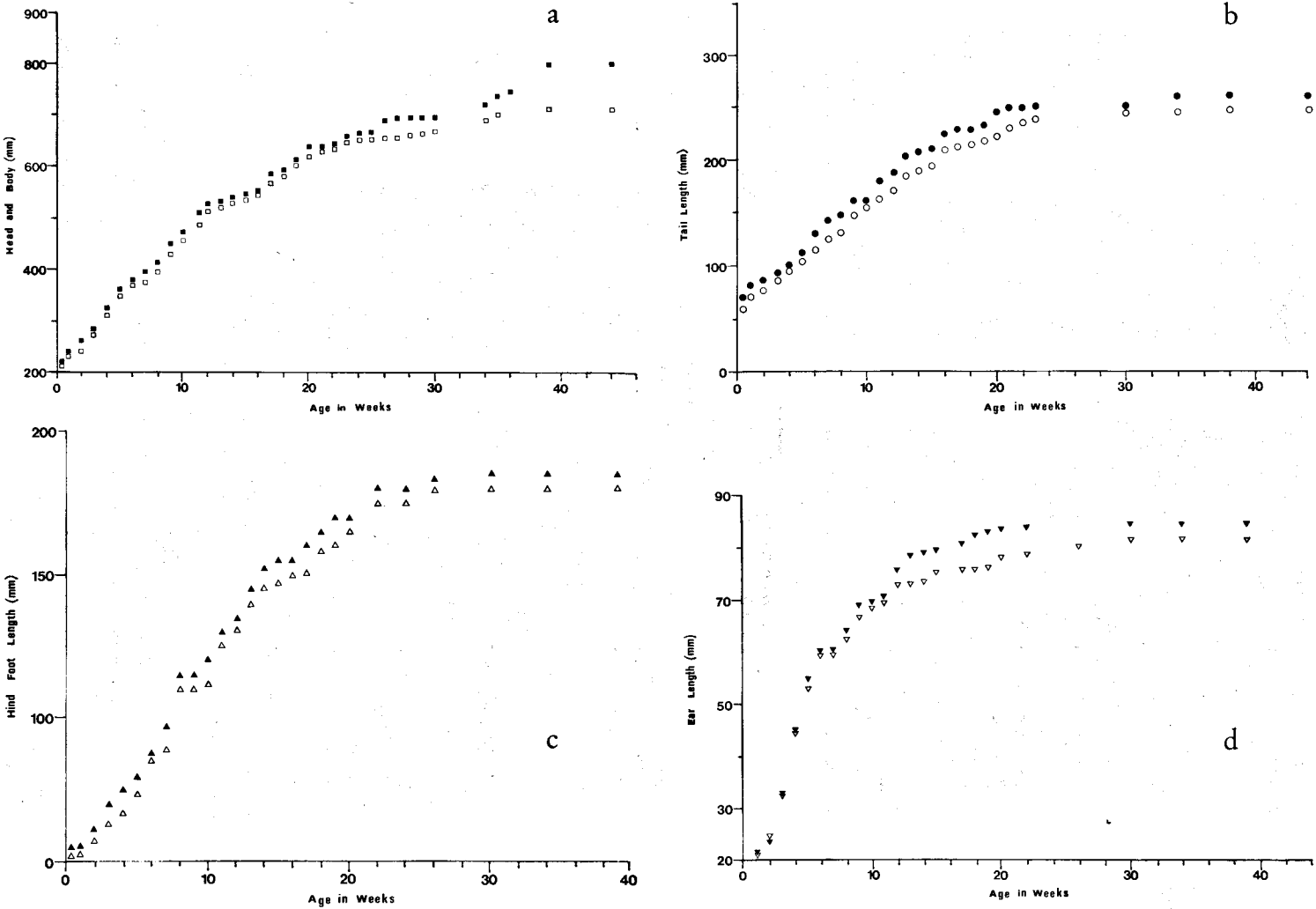

Figure 10. Mean growth curves (male n = 6; female n = 6) of *Felis caracal*, showing the relationships between age and (a) head and body length; (b) tail length; (c) hind foot length and (d) ear length. Solid symbols are for males and open symbols for females.

sible at 64 days. Colouration remains evenly flesh-coloured until 64 days, beginning to darken from this stage. Facial pattern colouration becomes visible at 67 days, and is complete close to the time of parturition.

Foetal growth and development, using crown/rump, total body length and mass are presented in Figures 3 and 4, with the ten foetal development stages being illustrated in Figure 5. The measurements of the complete foetal sample are presented in Table 3.

3.4.2 Juveniles

The eyes open within ten days after birth, but clear vision is only achieved several days after opening. At birth the ears are flattened against the head and only stand erect between the second and fourth week, but in most cases they are fully erect by the third week. The claws are non-retractable until the third week, but by the fourth week they are fully retractable. Physical development of 12 captive born kittens is summarized in Figure 6. Figures 7, 8 and 9 show caracal kittens at the ages of two days, four weeks and eight months. Growth curves (head and body; tail; hind foot; ear; mass) are illustrated in Figures 10 and 11.

3.5 Behavioural development

The first recorded call was a bird-like chirrup emitted shortly after birth. This chirrup-like call was the only vocalisation noted up to the age of two and a half weeks, and persisted in a tame, house-trained caracal to the age of one year. A mewing-purr entered the vocabulary at two and a half weeks, and a chitter/churr/hiss continued into adulthood from approximately nine and a half weeks. At three and a half to four weeks the kittens began to wander around the den entrance. At five to six weeks, curiosity and playfulness were well developed. From ten weeks kittens were robust and able to defend themselves vigorously. The kittens would fall onto their backs, snarling and hissing, claws fully extended. From approximately 20 to 25 weeks defence was executed from a squatting or standing position.

In the current study kittens were weaned between the ages of 15 and 24 weeks, with the first solid food being taken at three and a half to eight weeks.

4. Discussion

No previous worker has examined foetal development of the caracal, although several authors have recorded juvenile development, but not in detail (CADE 1968; KINGDON 1977; KROLIK 1967).

The length of the gestation period is generally similar to that previously recorded, with the exception of the findings of GOWDA (1967). This author gave a gestation period of one litter as 69 days, ten days shorter than the recognised gestation period.

Current findings suggest that male caracal can successfully impregnate females from the age of just over one year (two males – 12,5 and 14 months respectively) and females are receptive from their fourteenth month. KINGDON (1977) states that caracal can reach sexual maturity as early as six months, although no specific cases are cited.

When determining foetal age for caracal the use of total length, crown/rump and mass was applied. In the case of total length and crown/rump length the relationship between length and age is highly significant ($p<0,001$) and therefore perfectly acceptable for age determination.

Tooth eruption and replacement were the primary criteria used in this study for establishing the age of caracal less than one year. Eye lens mass and skull measurements can also be used with some accuracy but are not practical for fieldwork.

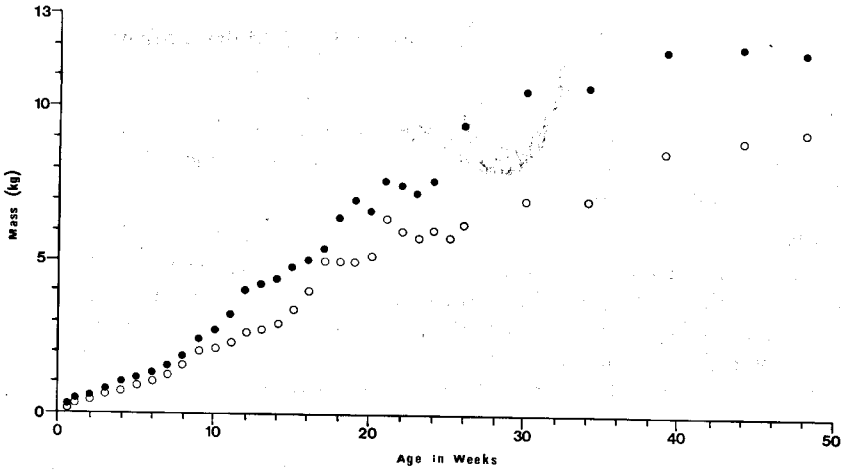

Figure 11. Mean mass increase of six male and six female *Felis caracal.*

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References

CADE, C. E. (1968): A note on the breeding of the caracal lynx at Nairobi Zoo. Int. Zoo Yb. 8: 45.

GOWDA, C. D. K. (1967): A note on the birth of caracal lynx, *Felis caracal* at Mysore Zoo. Int. Zoo Yb. 7: 133.

HUGGETT, A. StG. and Widdas, W. F. (1951): The relationship between mammalian foetal weight and conception age. J. Physiol., Lond. 114: 306–317.

KINGDON, J. (1977): East African Mammals. Vol. 3A. Carnivores. Academic Press, London.

KROLIK, S. (1967): Breeding the caracal lynx *Felis caracal* at Brno Zoo. Int. Zoo Yb. 7: 132.

LOMBAARD, L. J. (1971): Age determination and growth curves in the black-backed jackal, *Canis mesomelas* Schreber, 1775, (Carnivora, Canidae). Ann. Transv. Mus. 27: 135–169.

SMUTS, G. L.; J. L. ANDERSON & J. C. AUSTIN (1978): Age determination of the African lion *(Panthera leo).* J. Zool., Lond. 185: 115–146.

STUART, C. T. (1983): Aspects of the biology of the caracal *(Felis caracal* Schreber, 1776) in the Cape Province, South Africa. M. Sc. Thesis, University of Natal, Pietermaritzburg.

Appendix

HUGGETT & WIDDAS (1951) equation for foetal age determination as used in this paper:

$$\sqrt[3]{w} = a\,(t - t_o)$$

(where w represents foetal mass in grammes)

a = the specific foetal growth velocity

t = the foetal age in days

t_o = a numerical estimate derived from the expression $t = f \times$ gestation period ($f = 0{,}3$ for animals with a gestation length of 50–100 days).

Specific foetal growth velocities were calculated using a mean birth mass of 224,5 g and a mean gestation period of 79 days. These means were calculated using data from the current study (Stuart 1983).

The equation reads as follows:

$$a = \frac{\sqrt[3]{\bar{w}}}{t - t_o}$$

$$a = 0{,}11$$

(where w = mean birth mass
t = mean gestation period)