ASPECTS OF THE BIOLOGY OF THE CARACAL (*FELIS CARACAL* SCHREBER, 1776) IN THE CAPE PROVINCE, SOUTH AFRICA

by

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Submitted in partial fulfilment
of the requirements for the degree of
Master of Science
in the
Department of Zoology
University of Natal
1982

Pietermaritzburg

1982

The whole thesis, unless specifically indicated to the contrary in the text, is my own original work.

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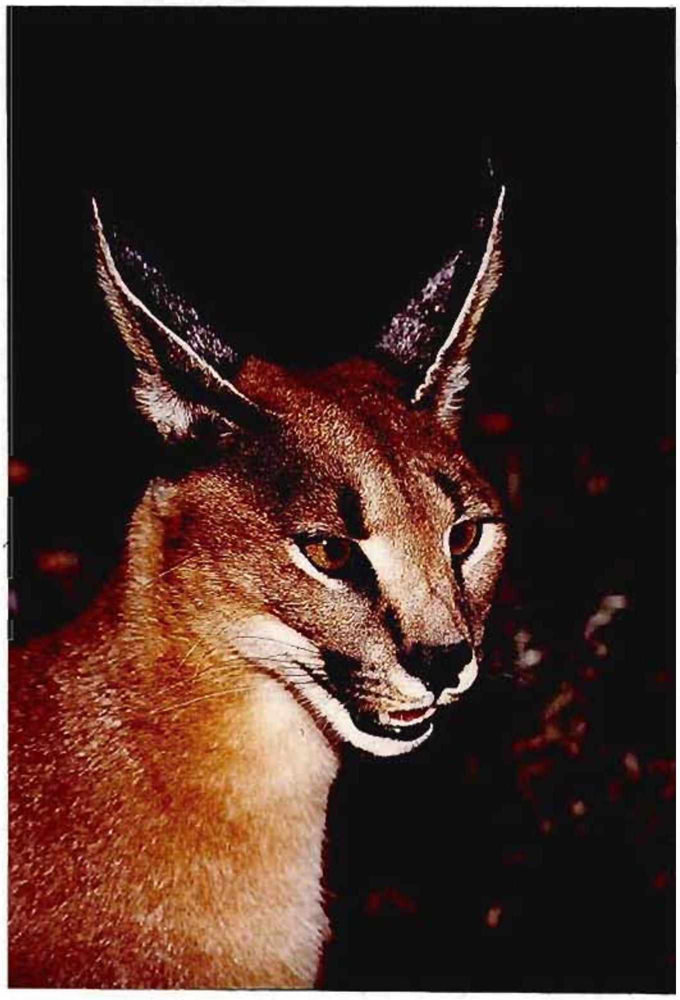

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ADDENDA

ACKNOWLEDGEMENTS

I would like to thank the following people for assisting with the project, giving advice, or simply by showing enthusiasm for the work.

Sincere thanks to G. Hickman for supervision and advice during the course of the project, and to I.G. Gaigher, J.C. Greig and C. Loedolff for the opportunity to successfully complete the study.

The Director of the Cape Department of Nature and Environmental Conservation provided funding and equipment for the project, which is greatly appreciated. The Director of the Albany Museum is thanked for allowing me to complete the final writing up whilst employed by that institution.

Many individuals contributed material and facilities, without which the project would have taken much longer to complete: P. Barnard, G.W. Dyer, W.C.N. Esterhuizen, B. Hansen, T.J.E. Heinecken, P.M. Norton, S.V. Phillips, P.J. Kershoff, J.W.A. Kleinhans, D.C. Lourens, C.P. Prins and M. Smith. In particular V. Pringle supplied a large sample of well preserved and documented caracal material from the Bedford area of the Eastern Cape.

Without the field and laboratory assistance of Miss Penny Meakin, B.M. Munnik and J. Adendorf, the project would not have been conducted as smoothly. Miss Meakin also assisted with the art work. P.M. Norton and Brett Lawson kept records on one of the radio-tagged caracal (Good Buddy); P.M. Norton also piloted the aircraft whenever needed. Mrs. J. Schickerling of the State Pathology Laboratory in Cape Town prepared the histological sections.

A special word of thanks is due to I. Bell and A. Fry of "Groothagelkraal" who showed keen interest in the project and allowed unlimited access to their farm.

The constructive criticism of Paul Skelton, of the Albany Museum, during the write-up phase is much appreciated.

My apologies to anyone who may have been inadvertently omitted from the acknowledgements.

My wife, Pat, provided assistance and support, and undertook the task of typing the manuscript. This thesis is dedicated to my wife, Pat, and my children, Kyle and Leigh, who had to put up with so much.

ABSTRACT

Felis caracal, despite heavy hunting pressure, is common and widespread throughout the Cape Province. Caracal are considered to be the principal wild predator of domestic livestock (goats and sheep) by most farmers and hunt clubs.

Scat and stomach content analysis, as well as observations, indicate that *F. caracal* prey primarily on small to medium-sized mammals. The feeding habits of caracal in different areas varied, according to abundance and occurrence of prey species. Captive animals required an average of 586g of meat each day. Killing techniques varied for different sized prey items.

Physical and behavioural ontogeny are described for captive born animals. A technique for determining age of *F. caracal* was developed from study of known-age captive caracal.

Examination of females killed in the wild, captive births, and births which were back-dated indicated that although young were born throughout the year, there was a definite birth peak between October and February with the lowest point being in May/June. Caracal were distinctly sexually dimorphic in size.

Six *F. caracal* (four females and two males) were trapped, fitted with radio-transmitters, and released at the capture sites. Animals were cumulatively tracked for a total of 164 weeks. The mean range was 24,16km^2.

A young adult male covered approximately 138km before settling in a 48km^2 area.

Recommendations are presented for reducing losses of domestic stock by the caracal, based on the principal of removing the problem individual rather than blanket control.

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selective, easy to use, and comparatively cheap. More tests need to be undertaken with the collar on extensive small stock ranges. 148

CHAPTER 1

INTRODUCTION

The caracal is one of twenty eight species of carnivore occurring in the Cape Province, seven of which are felids. This cat is in the strange position of being rare and endangered in the non-African sector of its range, with one subspecies (Felis caracal michaëlis Heptner, 1945) appearing in the I.U.C.N. Red Data Book (Anon 1969). However, in the southernmost extremity of Africa the caracal is classified as a problem species and considered a major threat to the small-stock farming industry (Stuart 1981). Despite these circumstances of rarity and problem species status, both of which require in-depth investigation, almost no research has been undertaken on this cat.

The caracal is the largest of the "small" cats occurring in the Cape Province. This predator is robustly built (Fig. 1) with long legs (hind limbs being longer than the front limbs), and is adapted to crouch and short attack and not for long distance chases. The tail is short, the pelage is thick, but short, and soft. The hair colour is variable but is usually reddish-fawn to brick red-brown, with the ventral areas being off-white with faint indications of spots. One of the most obvious characteristics of this cat are the long, pointed ears, which have a black outer surface and long black tufts of hair at the tip. The face is prominantly marked with white and black (See Frontispiece).

Figure 1. Profile photograph of Felis caracal showing principle features: short tail; hind legs longer than front legs; ear tuft; black behind ears; faint spotting on inner legs and belly.

Aspects of *F. caracal* feeding ecology have been examined by Grobler (1981), Pringle and Pringle (1979) and Skinner (1980) in the Cape Province. Sapozhenkov (1962) dealt briefly with aspects of the ecology of the caracal in Turkmenia (U.S.S.R.). Other references are of a brief and general nature and are referred to in the relevant sections of this thesis. The lack of knowledge and the adverse role of the caracal in the livestock industry of the Cape Province prompted the initiation of this study.

This study on *F. caracal*, is the second phase of a larger study of the carnivores of the Cape Province (Stuart 1981, and in preparation). The first phase consisted of a general base survey of all species known to occur within the Cape Province, in order to establish a list of research priorities. Identified problems were divided into two groups: 1) those species requiring investigation because of their rare or endangered status, and 2) those that were coming into conflict with agricultural interests. Of the latter group, the caracal was considered to be of primary importance. The main objective was to understand more fully the ecology of the caracal and secondly, to use this knowledge to formulate a more acceptable approach to problem caracal management and damage control.

Reproduction, growth and feeding strategies were identified as the most important aspects to be studied in the greatest detail, but others were also examined, notably home range and movement.

The final section of the thesis deals with the role of the caracal as a predator of domestic stock, and suggests a new approach to the problem which is intended as an aid to the current predator control programmes undertaken by official, quasi-official and private organizations.

Wherever relevant reference is made to other principal, competing, predators occurring in the Cape Province. Of these, the black-backed jackal (*Canis mesomelas*) is the most important.

CHAPTER 2

EVOLUTION, TAXONOMY AND DISTRIBUTION

Evolution

The carnivora may be divided into two superfamilies (Ewer 1973), the Canoidea (Arctoidea) which includes the Canidae, Ursidae, Procyonidae and the Mustelidae, and the Feloidea. The Feloidea arose from feloid stock derived from the Miacidae, prior to the origin of the canid stock (Wurster and Benirschke 1968) during the Eocene. Hemmer (1978) has dealt with the evolutionary systematics of the Felidae in some detail. Figure 2 presents a diagramatic representation of the phylogeny of some small to medium-sized Felidae.

The affinities of *Felis caracal* within the family Felidae are largely disputed. Werdelin (1981) studied the intra and interspecific variation of recent and fossil felid species belonging to, or morphologically related to the genus *Lynx*. The genus *Lynx* was considered to be of African origin, with the earliest occurrence in early or mid-Pliocene.

Werdeling (1981) concluded that the caracal differs significantly (based on cranial characters) from other members of the lynx-group, considering these differences to be sufficient to warrant generic distinction with no evidence for phylogenetic affinities between the lynx-group. Hendey (1974) suggested that *Caracal* (*Felis*) *caracal* is related to the extinct *Felis obscura*, implying

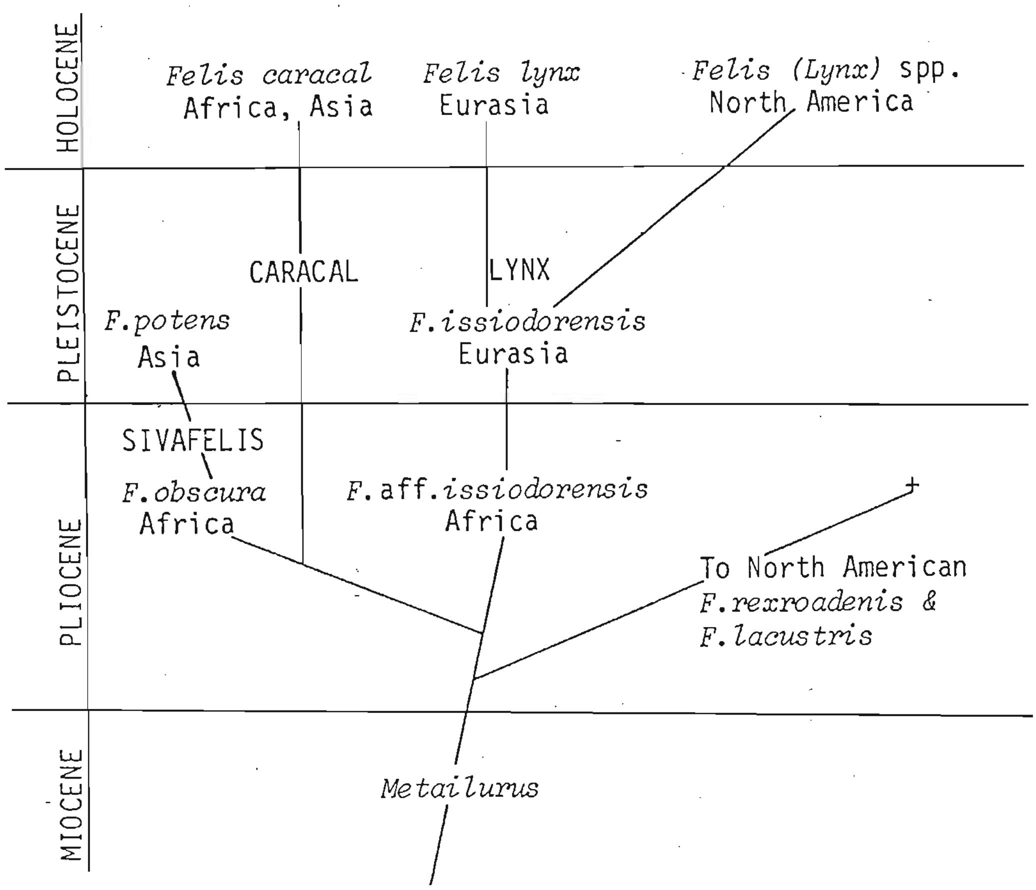

Figure 2. Tentative phylogeny of some small to medium-sized Felidae (after Hendey 1974).

the phylogenetic relationships between C. caracal and "true" lynxes may be very distant. Although the caracal is often included in the genus Lynx, Ewer (1973) favours placing it in its own genus, namely Caracal. Hemmer (1978) suggests the genus Caracal Gray, 1843, for the species caracal (Schreber, 1776).

Leyhausen (1973) united the caracal with the golden cats (Profelis spp.) and the puma (Puma concolor) in one genus, giving no reasons for this arrangement. In the opinion of Hemmer (1978) and others, the lumping of Caracal with Puma and Profelis is not acceptable. Amongst other reasons, the banding pattern of the chromosomes shows that Lynx, Puma and Profelis belong to a different group (Wurster 1973; Wurster and Gray 1973) from the caracal and wild cat (and, therefore also with the lynx) phylogenetic line. Hsu and Arrighi (1966) have given a karyotypic analysis of Felis caracal.

In plesiomorphic cranial characters, the caracal approaches the puma and golden cats, and resembles the lynxes less (Lonnberg 1926). The caracal tends to have a longer gestation period than true lynxes and the wild cat group, though not reaching the upper level of relative gestation in felids (Hemmer 1976; Kawata, Bailey and Siminski 1975).

A synthesis of all available data suggests a divergence of the wild cat/lynx line earlier than the radiation to the wild cat group, including Pallas's cat (Otocolobus manul) and the lynxes (Hemmer 1978). Therefore, the caracal would have a closer common origin with the puma and golden cat evolutionary lines (Hemmer 1978).

Taxonomy

Felis caracal Schreber, 1776, was originally described from Table Mountain, South West Cape Province. Common names include caracal, caracal lynx, lynx, red cat and rooikat. Specimens in recognised collections are few and material collected in the present study forms the largest body of material, of this species, available for research.

The caracal has been placed variously in three genera, namely *Felis* Schreber, 1776; *Caracal* Gray, 1843 and *Lynx* Roberts, 1926. For the purpose of this thesis *Felis* is used throughout.

The validity of the nine sub-species of *Felis caracal* recognised at the present time is questionable. Smithers (1971) recognised seven sub-species of the caracal in Africa (Fig.3).

F. c. algirus A. Wagner, 1841.

North Africa from Morocco east to Libya. This sub-species includes *berberorum* Matschie, 1892; *spatzi* Matschie, 1912; *medjerdae* Matschie, 1912 and *corylinus* Matschie, 1912.

F. c. caracal Schreber, 1776.

South Africa, excluding the north-western Cape Province west of c. 26°E. Absent from most of Natal and Zululand. This sub-species includes *melanotis* Gray, 1867, *roothi*

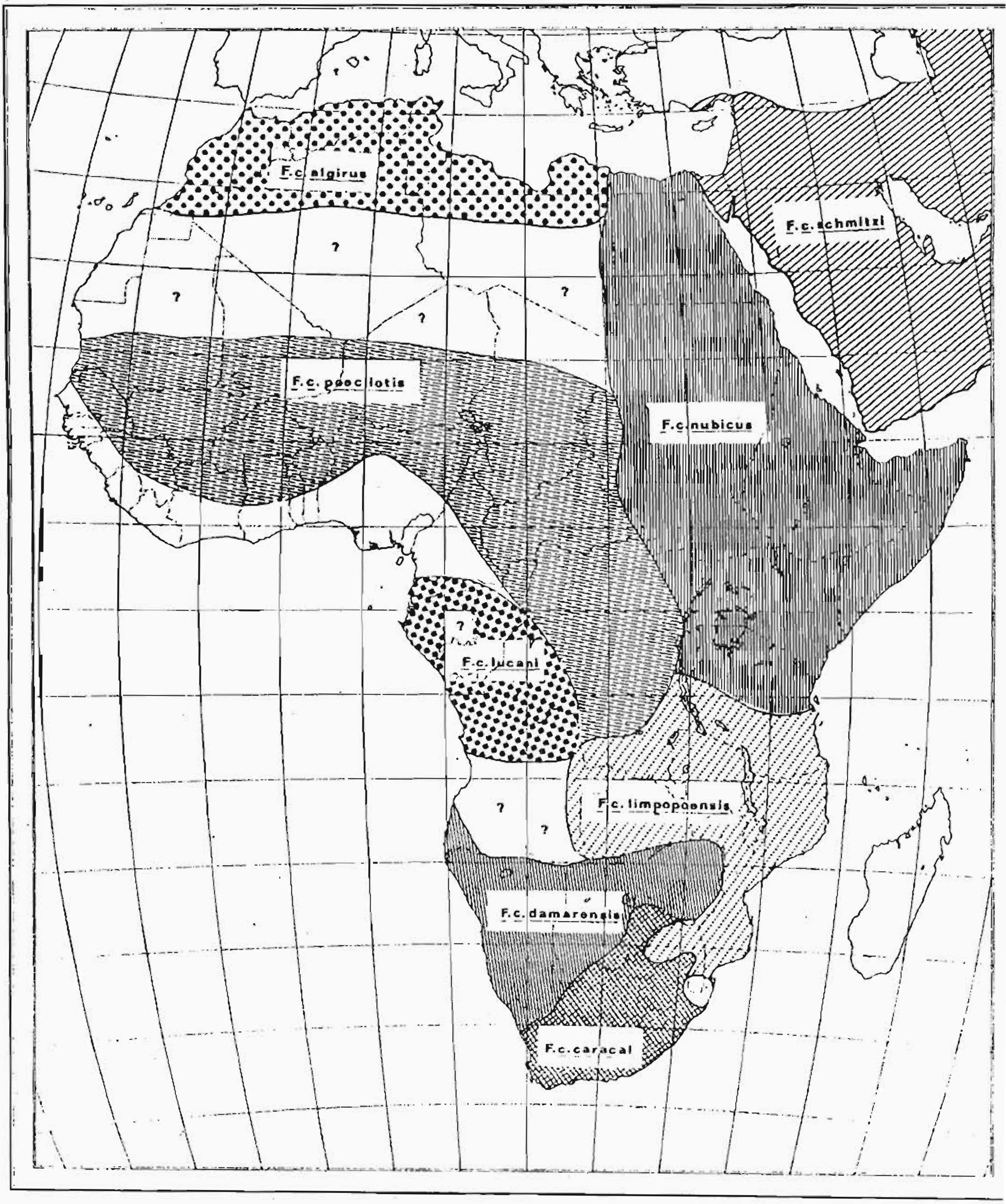

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Figure 3. Approximate distribution of currently recognised sub-species of Felis caracal in Africa and the Middle East.

Roberts, 1926 and *coloniae* Thomas, 1926.

F. c. damarensis (Roberts, 1926).

Southern coastal Angola, South West Africa, Botswana (excluding the eastern sector), western and north-western Zimbabwe, extreme northern Cape Province, South Africa west of c. 26°E.

F. c. limpopoensis (Roberts, 1926).

Northern and western Transvaal, Mocambique, southern Tanzania, Malawi, Zambia, southern Zaire and eastern Angola.

F. c. lucani (Rochelrune, 1885).

Gabon, northern Angola, south-western and western Zaire.

F. c. nubicus J.B. Fischer, 1829.

Egypt, Sudan, Ethiopia, Somalia, Uganda, Kenya and northern Tanzania.

F. c. poecilatis (Thomas and Hinton, 1921).

Southern Mauritania, northern Niger, northern Senegal, eastward in Sudan savanna and Sahelian zone to the western borders of Sudan.

Harrison (1968) is of the opinion, and in this he follows Ellerman and Morrison-Scott (1951), that the Indian and the south-western Asiatic race be called *Felis caracal schmitzi* Matschie, 1912. Pocock (1939) places all Asian races of the caracal under the nominate race, *Felis* caracal caracal, which absorbs bengalensis Fischer, 1829; schmitzi Matschie, 1912 and aharonii Matschie, 1912. Felis c. michaëlis Heptner, 1945, is the northern most form of the caracal.

Distribution

Felis caracal is widely distributed in Africa (Fig.4), around the margins of the Sahara Desert in North Africa, from Morocco east to Egypt, Sudan, Ethiopia, central and southern Somalia, and in the west to Mauritania and northern Niger. It occurs throughout the rest of Africa, to the south of the Sahara, excluding the tropical forests of West Africa and Zaire, and most of Natal and Zululand in the south-eastern sector of South Africa. The total range of F. caracal (Fig.5) also includes from Eastern Turkey, Israel, Arabian Peninsula, Syria, Iraq, Iran, the deserts of Turkmenia (USSR) and in the vicinity of the Sea of Aral, Afghanistan, Baluchistan (Pakistan), to the northern and central areas of India (Smithers 1971).

Asia

Seshadri (1969) notes that F. caracal once ranged widely over the Indian sub-continent but is now thought to have disappeared from most of its former range. P.K. Gosh (personal communication) considers F. caracal a threatened species on the Indian sub-continent. However, Prater (1965) believes the caracal is still common in the north and north-west hills of Cutch, and probably still occurs in Rajhastan and Uttar Pradesh (Prater 1965).

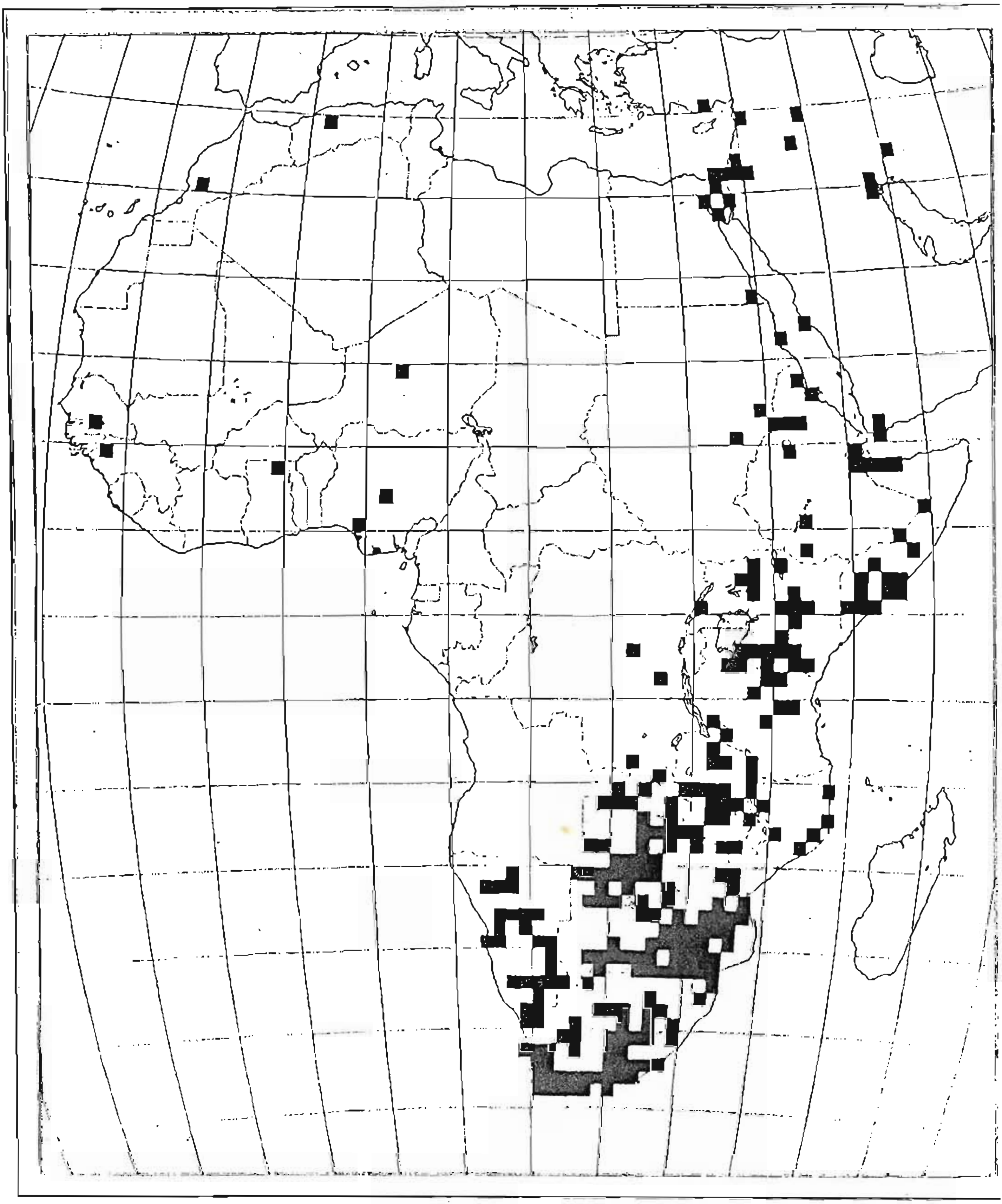

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Figure 4. Distribution (1^{o} Square) of Felis caracal in Africa based on specimen and literature records.

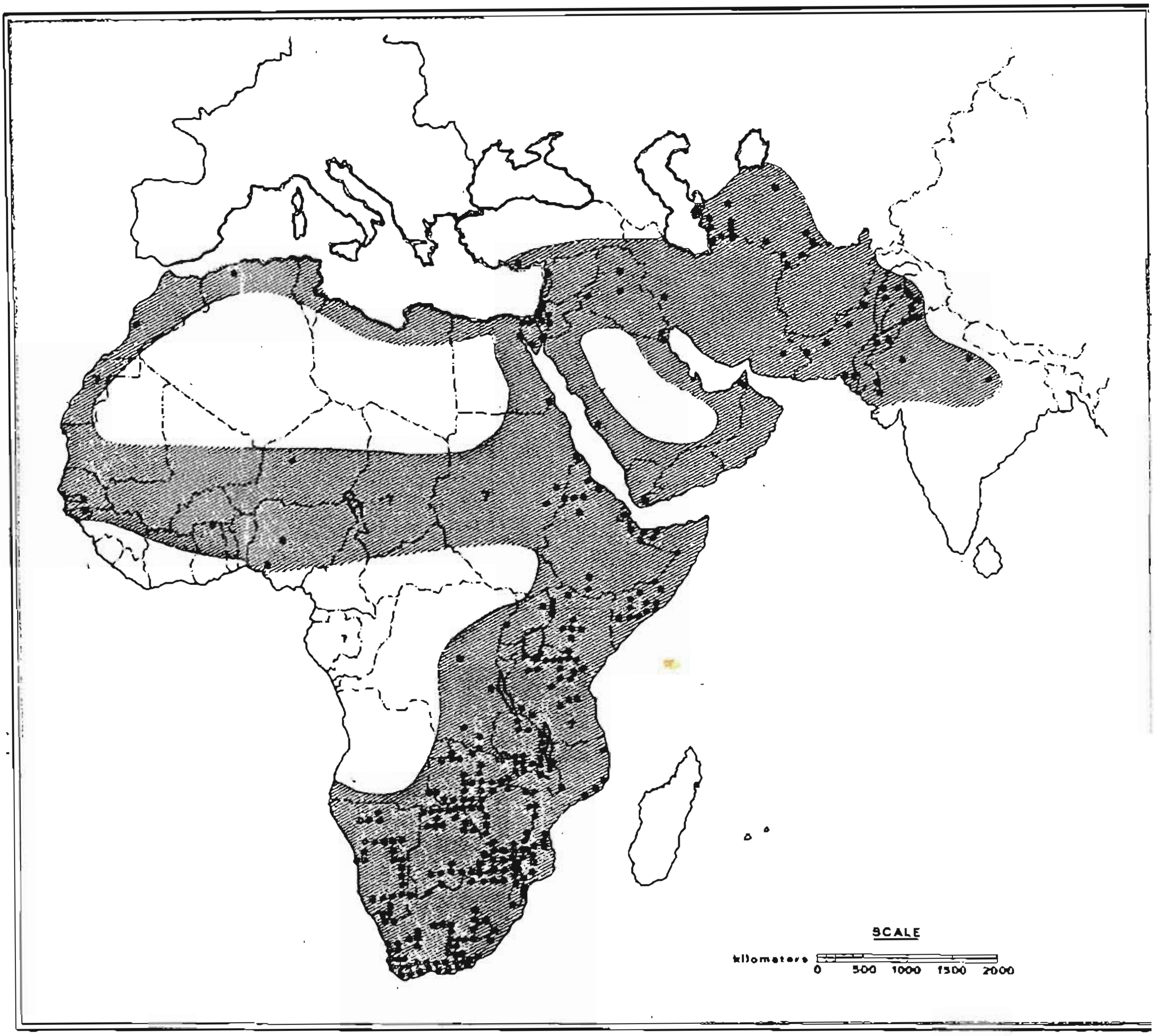

Figure 5. Total distribution of *Felis caracal*.

Roberts (1977) has dealt with the distribution of F. caracal in Pakistan in some detail, and considers it to be rare and associated with arid sub-tropical scrub forest in northern Baluchistan and tropical thorn forest in the eastern desert border regions. Although apparently found in Afghanistan (Harrison 1968; Smithers 1971), no specimen records have been traced. Harrison (1968), Novikov (1962), Ognev (1935), Sapozhenkov (1962) and others have noted F. caracal distribution in Turkmenia (USSR). Harrison (1968) also mentions the presence of caracal from the vicinity of the Sea of Aral in Uzbekistan, to the north of Turkmenistan. Much of Iran would appear to have suitable caracal habitat, but little is known about distribution in that country. Specimens of caracal have been taken in the south-east and south-west (Pocock 1939).

Middle East

Records from Turkey are few, but according to Harrison (1968), F. caracal is known from the south-east. There is a specimen in the Alexander Koenig Museum (Bonn) collected in Turkey with no details. Corkhill (1930) has recorded caracal in Iraq. The caracal is known to occur in Kuwait and Oman (Harrison 1968); the same author is of the opinion that F. caracal in Saudi Arabia probably occurs throughout the mountain ranges and hilly steppes, but considers it unlikely that it penetrates into the great sand deserts of the interior. Morrison-Scott (1939), Yerbury and Thomas (1895) and Thomas (1900) have recorded caracal as being present in Saudi Arabia. Matschie (1912) and Harrison (1968) give locality records for Syria.

Harrison (1968) concludes that _F. caracal_ is not uncommon in the Dead Sea area of Israel and Jordan, while Bodenheimer (1958), Aharoni (1930) and Pocock (1939) present records from several localities within this region. Skinner (1979) recorded caracal at an artificial feeding site at Sde Boqer in Israel.

Africa

North

Rosevear (1974) considers the occurrence of _F. caracal_ to be unusual in Morocco, Algeria and other North African countries. The Paris Museum of Natural History has specimens from Essaouira (Mogador) in Morocco and one specimen from Ouarsénis in Algeria. The Museum of Zoology (Firenze, Italy) has one specimen from Morocco. The Moroccon specimens were taken in 1915 and 1977, and the Algerian specimen in 1954. Harrison (1968) records caracal in Egypt, Libya, Algeria and Morocco.

West

Rosevear (1974) believes that _F. caracal_ manages to retain a foothold in West Africa but in many areas it is very rare. There are specimens in the British Museum (London) from the Gambia, Lake Chad, Ghana and Nigeria. In this region, the caracal is primarily restricted to the Sudan, Sahel and sub-desert regions. Two records are from the vicinity of high forest, the Gambia (Doka zone) and Nigeria (Ado Ekiti) (Anon 1970). Deforestation (Rosevear 1974) has turned the Ado Ekiti area primarily into open woodland.

Central

Although absent from much of west and central Africa, specimens of caracal are known from the Katanga area of Zaire (D. Meirte, personal communication) and one specimen from Kigali, Ruanda.

Ansell (1978) notes *F. caracal* as being uncommon, but distributed throughout most of Zambia.

Hill and Carter (1941) mention caracal in Angola. Huntley (1973) records the presence of this felid in the south-western Angolan provinces of Iona and Mocâmedes. J. Crawford-Cabral (personal communication) has confirmed the occurrence of caracal in the same area. Caracal distribution in adjacent areas of Zambia and South West Africa would seem to indicate the possibility of caracal in Angolan border areas.

East

Felis caracal is probably widely distributed in the Sudan (Harrison 1968; J. Roche, personal communication) and Ethiopia (Harrison 1968; J. Roche, R.I.M. Dunbar and M.L. Azzaroli, personal communication). Azzaroli and Simonetta (1966) have documented caracal distribution in former Italian Somaliland from 16 localities, primarily concentrated in the south. Records for northern Somaliland are given by Harrison (1968). Kingdon (1977) has given the most detailed distributional picture for caracal occurring in Kenya, Uganda and Tanzania. In Uganda it is restricted to the drier areas north of the Victoria Nile (Kingdon 1977), and Williams (1978) states that it is most frequently recorded from Karamoja. There appear to be no locality records for southern and western Tanzania (Kingdon 1977).

In Mocambique Smithers and Tello (1976) show that *F. caracal* occurs widely, although it may be absent from the north-central area and in the vicinity of the lower Zambezi River. Although Travassos Diaz (1968) states that caracal are rare in Moćambique, Smithers and Tello (1976) believe that this cat is probably not as uncommon as the few records might indicate.

Records from Malawi (Ansell 1978; Smithers and Tello 1976; Sweeney 1959) suggest that caracal could occur widely in that country.

South

Present records indicate that caracal are widespread in South West Africa/Namibia (Joubert and Mostert 1974; Lensing and Joubert 1977; Shortridge 1934; Stuart 1975). *F. caracal* is classified as a problem species in this territory, particularly in the south.

Roberts (1935), Silberbauer (1965) and Smithers (1971) have given records for Botswana, where the distribution is widespread but discontinuous. Smithers (1979) suggests

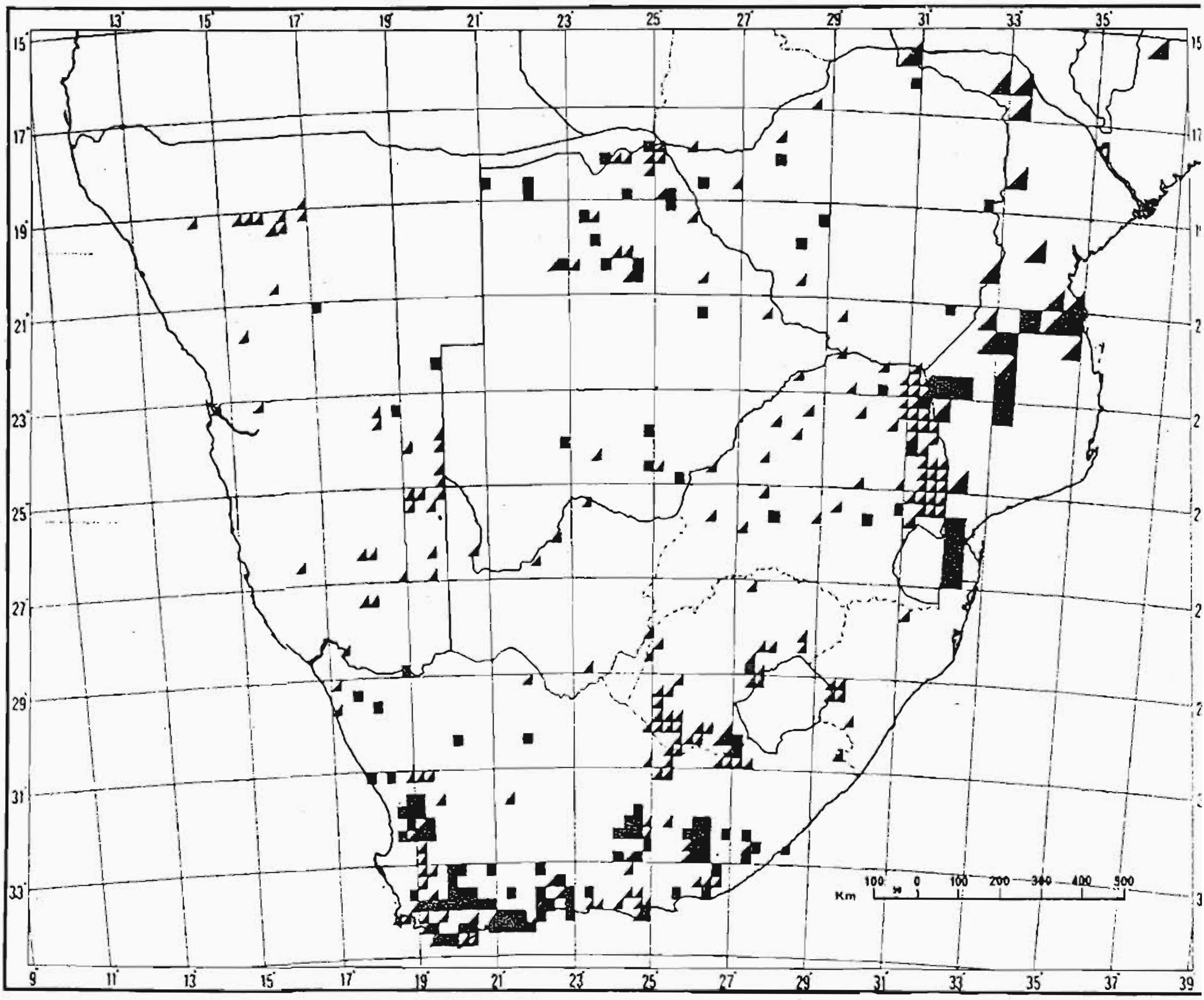

Figure 6. Distribution of Felis caracal in Southern Africa. ■ - specimen records; ◢ - literature records and sightings.

that the caracal is widely distributed in Zimbabwe. Rautenbach (1978) found the caracal to be widespread in the Transvaal, South Africa. Lynch (1975) recorded *F. caracal* as widespread in the Orange Free State. In Natal, caracal are apparently restricted to the foothills of the Drakensberg (south-west) and the Itala Game Reserve (Rowe-Rowe 1978).

Cape Province

This is the region in which information on the caracal was collected for the thesis. *Felis caracal* is widespread and common in the Cape Province, and although records are sparse in the interior, it is known to occur throughout this area (Stuart 1981). The highest densities are reached in the southern and western Cape, particularly along the coastal belt, the coastal mountain zone and the adjacent interior. In 82% of the Cape Divisional Council districts, caracal are considered by farmers to be the principal wild predator of domestic small-stock (Unpublished records, Cape Department Nature and Environmental Conservation). *Felis caracal* occurs in all the principal habitat types in this Province (Fig. 6).

CHAPTER 3

STUDY AREA

Cape Province

The Cape Province is the largest of four South African provinces, covering approximately 60% or 700 000km^2 of the total area of the country. Principal regions and places mentioned in the text are indicated in Fig. 7. Most of the Cape Province is arid or semi-arid, with the exception of the narrow coastal strip in the south and the adjacent coastal mountain chain. Altitudes range from sea-level to over 3000m in the southern extension of the Drakensberg. Inland from the Cape Fold Belt, the interior plateau consists of flat or undulating plains.

Annual rainfall ranges from 1500mm or more in the Drakensberg and the Jonkershoek Valley, South West Cape, to less than 120mm in the north-western part of Namaqualand. The major part of Cape Province lies in a zone of summer rainfall, but the South West Cape receives most rain during winter months. Forests of the Southern Cape lie in the transition zone between the winter and summer rainfall regions and receive year-round rain. Rainfall decreases in quantity and dependability from east to west (with the exception of the South West Cape) and droughts of varying severity occur at irregular intervals.

Although the vegetation of the Cape Province can be divided into many zones, Fig. 8 shows the classification

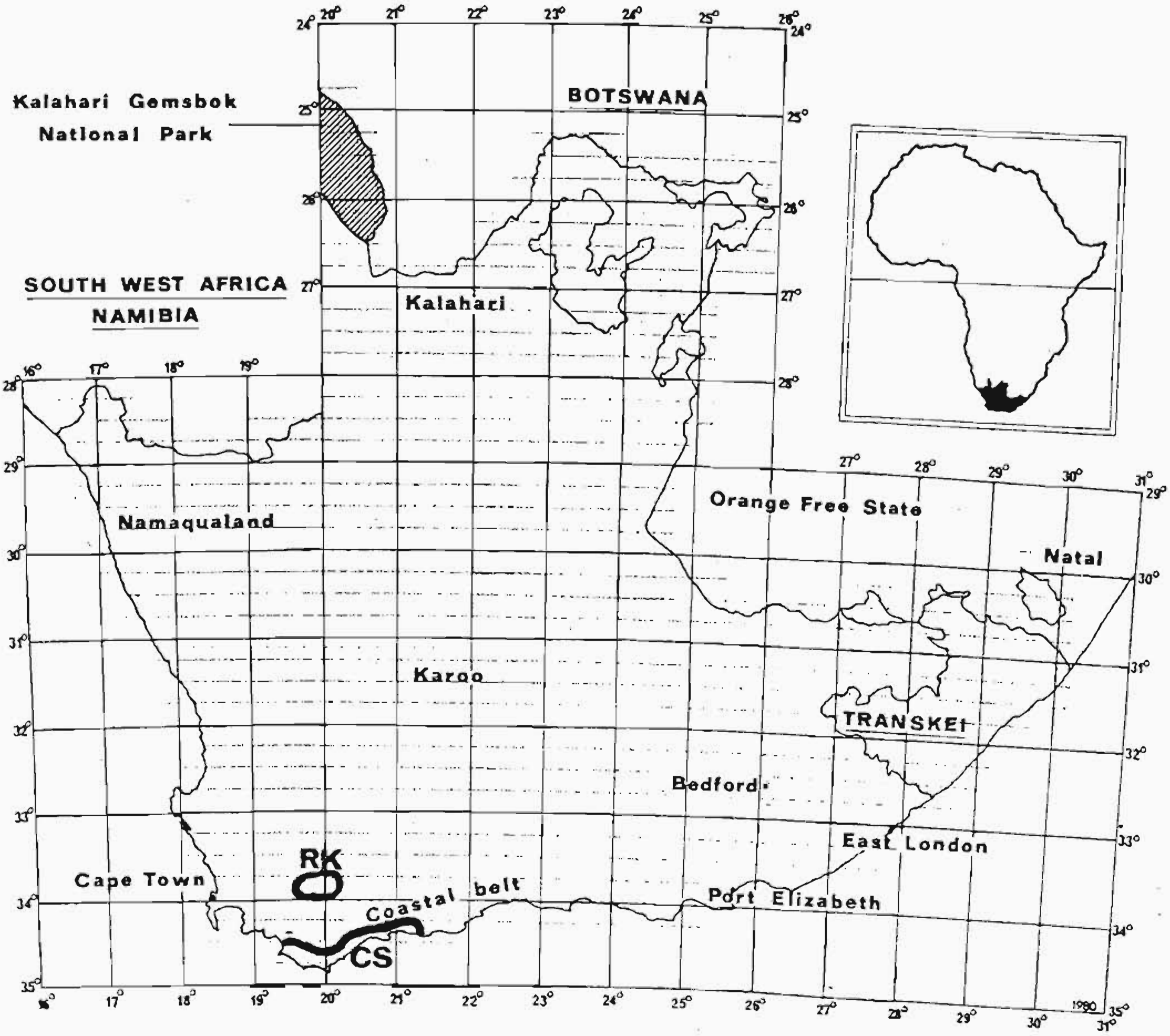

Figure 7. Principal areas, including the Robertson Karoo (RK) and the Coastal Sandveld (CS), of the Cape Province in relation to the rest of Africa.

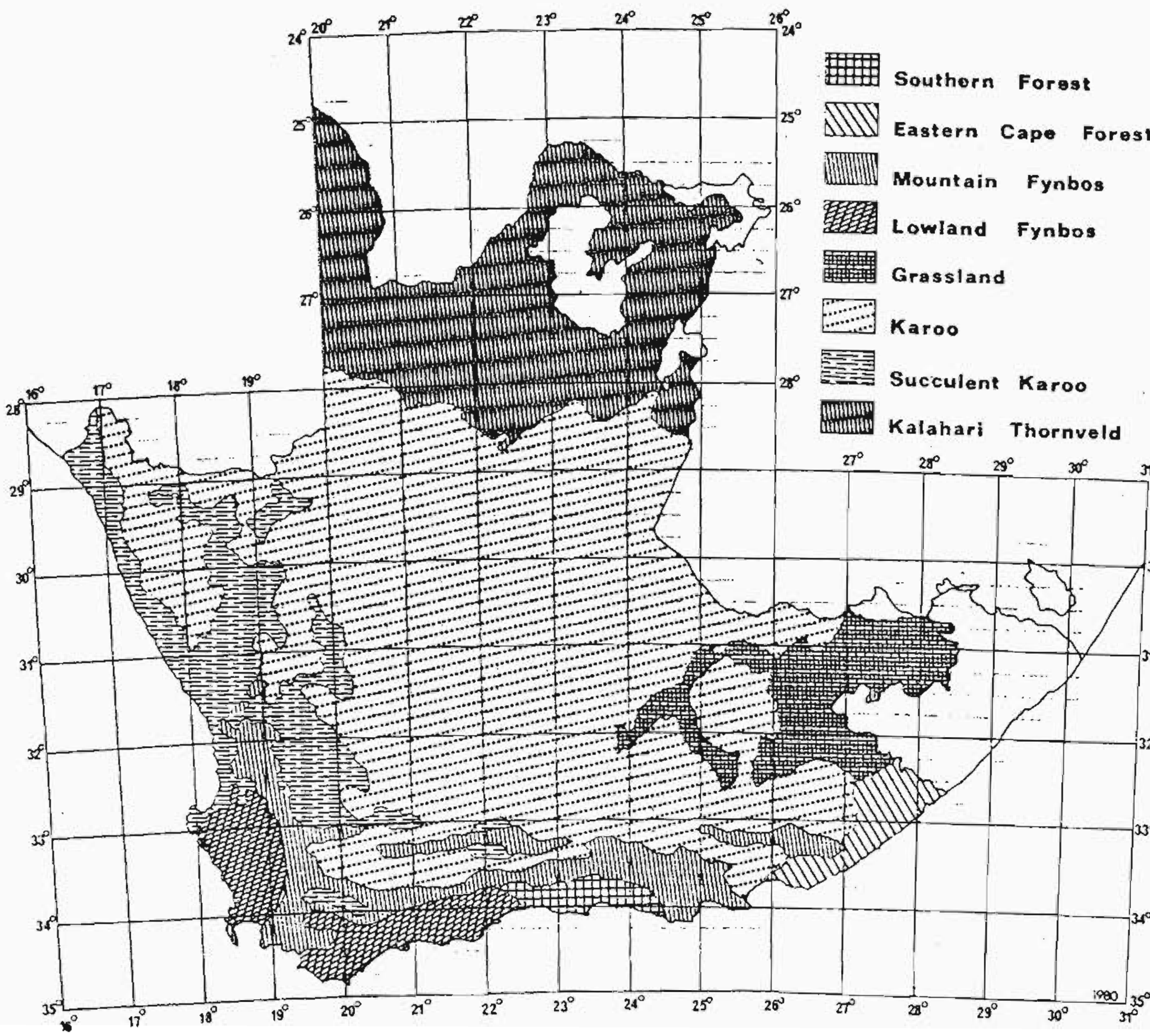

Figure 8. Major vegetation groups of the Cape Province (after Stirton 1978).

followed by Stirton (1978), who defined eight major vegetation groups.

Data for this thesis was collected in areas scattered throughout the Cape Province, but for overall purposes, brief descriptions are given only for 1) Eastern Robertson Karoo, 2) Coastal Sandveld, 3) Jonkershoek Valley and 4) Bedford.

Eastern Robertson Karoo

The Robertson Karoo is bounded by the Langeberg Mountain range in the north and east, and in the south by the Riviersonderend Mountains (Fig. 9). The Breede River provides drainage to the region. Rainfall (Fig. 10) is relatively low (mean annual precipitation = 237mm recorded at the Vrolijkheid Nature Conservation Station, Robertson, between 1968-1981) with the main precipitation in autumn and winter (March-August). The vegetation is of the Karroid broken veld type (Acocks 1975), known locally as the "Robertson Karoo". Robertson Karoo vegetation is distinguishable from that of the other Karoo areas by larger numbers of shrubs, low bushes and succulents (Joubert 1968). Vertebrates are numerous in both species and numbers; mammals recorded from this area are listed in Appendix 1. Figures11 and 12 illustrate typical areas within this region.

Coastal Sandveld

Coastal Sandveld stretches from the Uilenkraals River in

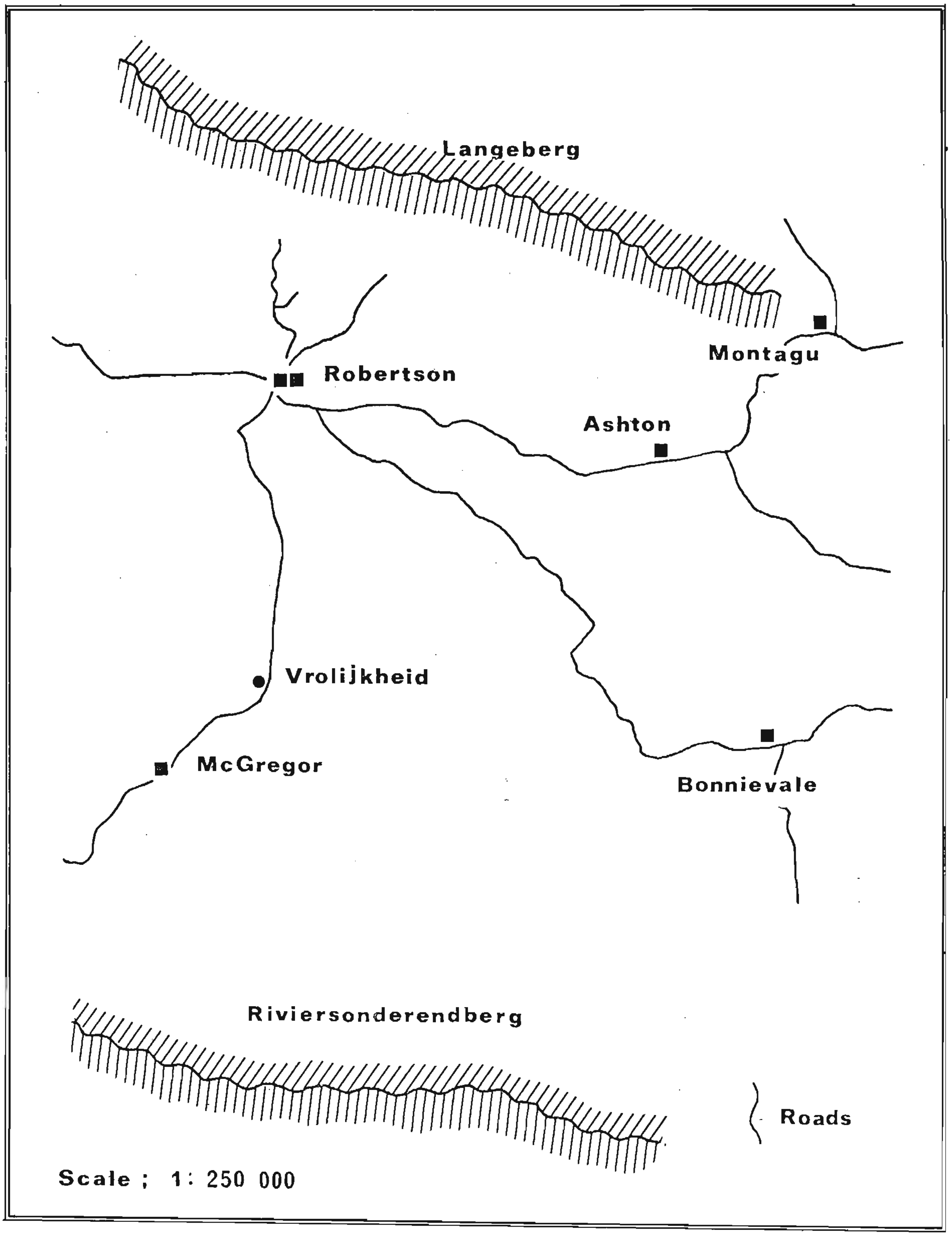

Figure 9 . The Eastern Robertson Karoo (refer to Fig. 7 for orientation to the rest of the Cape Province).

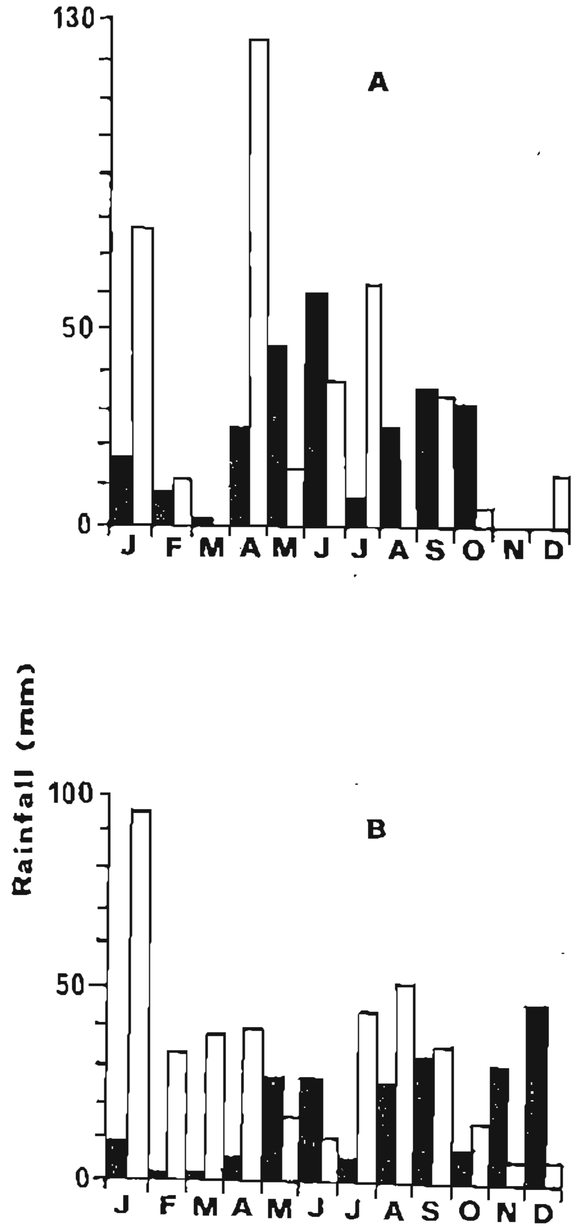

Figure 10. Rainfall for Cape Agulhas (A) and Vrolijkheid Nature Conservation Station (B) during 1980 (black) and 1981 (white).

Figure 11. Typical terrain in the Eastern Robertson Karoo, showing erosion gullies and the sparse bush cover.

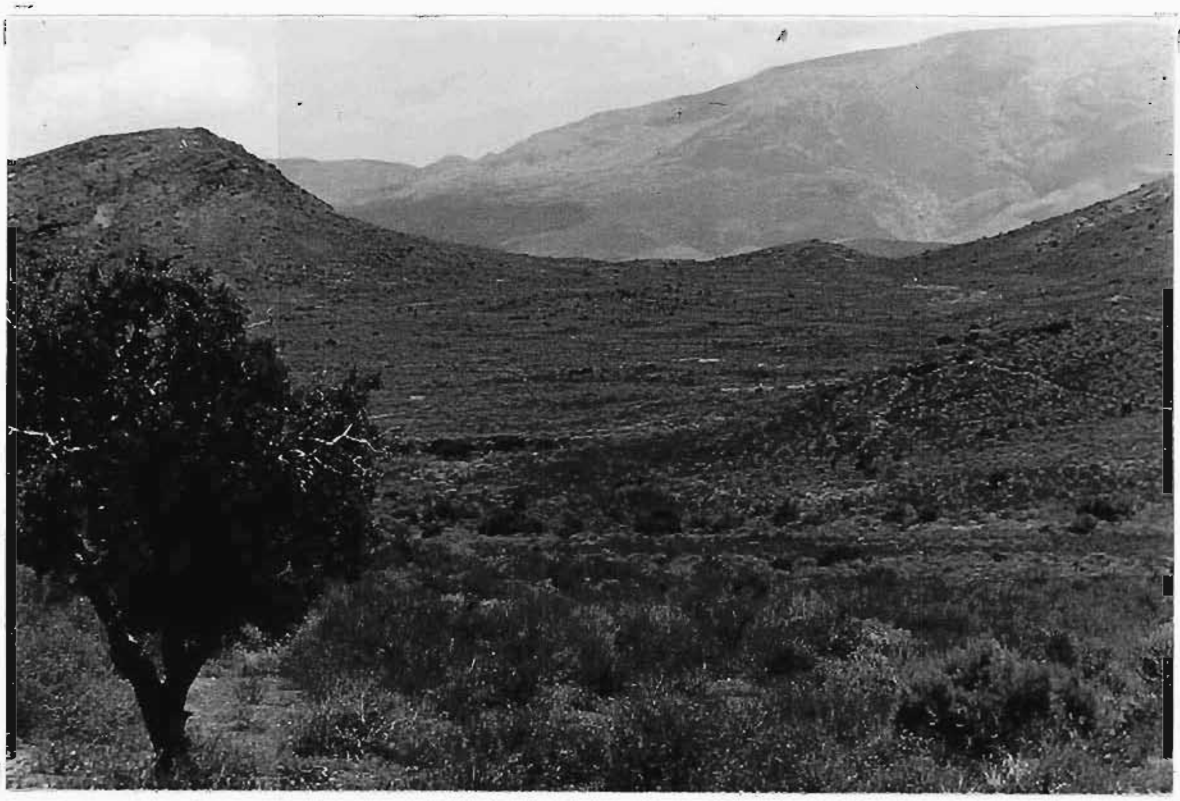

Figure 12. The terrain in the vicinity of the Vrolijkheid Nature Reserve, showing the low hills.

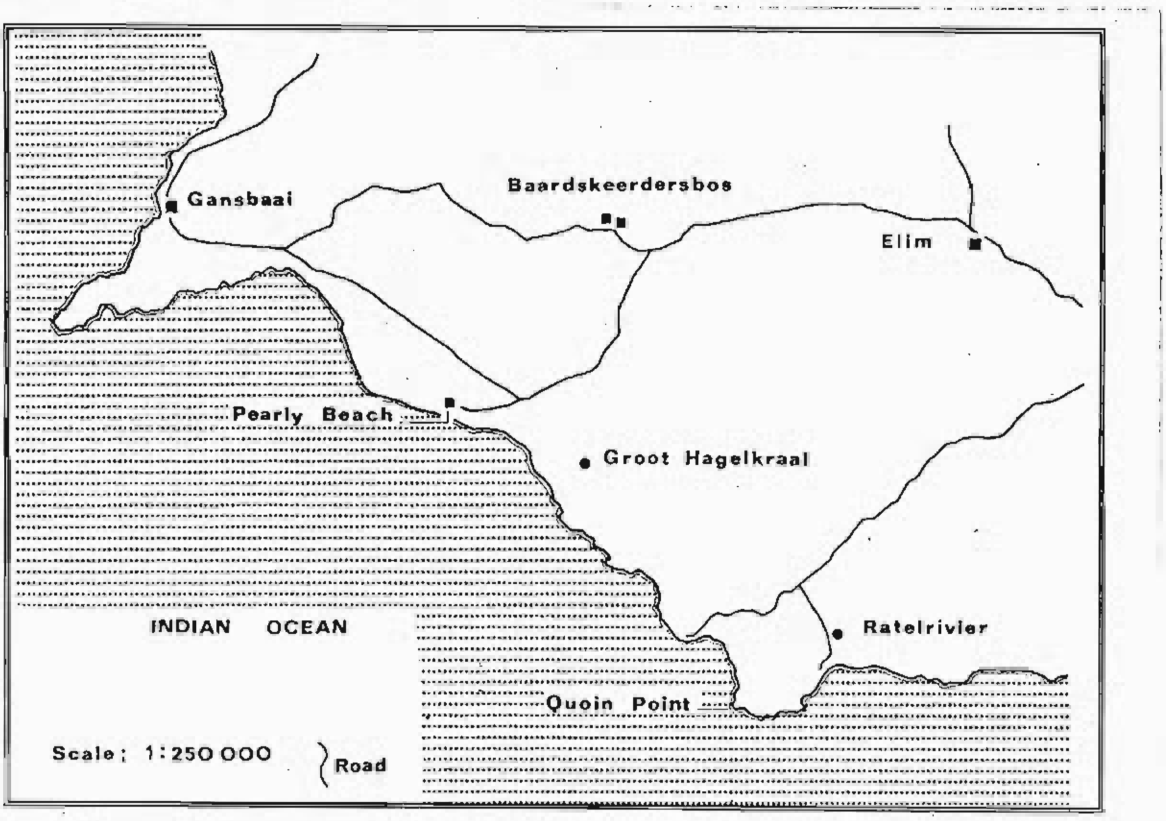

Figure 13. Coastal Sandveld study area.

the west to the Gouritz River in the east, varying in width from 10-30km. The two principal areas of study were in the region of the Breede River estuary, and the area between the Uilenkraals River and the Ratel River (Fig. 13). Vegetated and unvegetated dunes are characteristic of the coastal belt. Beyond the dunes are areas of low hills and valleys of fixed sand, intersected by rocky ridges and outcrops of dune limestone. Rain falls in the western areas primarily in the winter months, but in the east tends to be spread more evenly throughout the year. The annual mean precipitation at Cape Agulhas and Mossel Bay (Fig. 10) is approximately 430mm (Cole 1966). Acocks (1975) refers to the vegetation of this area as Macchia; more generally known as Lowland Fynbos. The vegetation between the "recent" dunes and the limestone hills increases in height towards the hills from 50cm to 1m in height, with scattered clumps of large bushes. Some reed-fringed vleis occur in the western area. Vegetation on the hill slopes include tall fynbos (Proteaceae, etc.), short scrub and isolated pockets of coastal forest. Infestations of the exotics *Acacia cyclops* and *Acacia saligna* are numerous and in some cases terminal. Figure 14 shows typical Sandveld habitat. The mammal fauna is listed in Appendix 1.

Other Areas

Two other areas deserve brief mention, Jonkershoek/Caledon in the South West Cape and Bedford in the Eastern Cape.

The Jonkershoek/Caledon area is characterized by high

Figure 14. Dune zone of the Coastal Sandveld with dense, low, vegetation.

mountains, winter rainfall (in excess of 2000mm at the upper end of the Jonkershoek Valley) and vegetation, classified as Mountain Fynbos (Kruger 1979).

The Bedford area is primarily hill country, although the southern sector consists of fairly level plains. Most precipitation is recorded in the summer months. The vegetation is classified by Acocks (1975) as Bushveld/ Scrubby mixed grassveld/Karoo.

The locations of Jonkershoek/Caledon and Bedford are indicated in Fig. 7. A list of mammals known to occur in both areas is presented in Appendix 1.

CHAPTER 4

FEEDING

Introduction

Little has been published on the diet or feeding behaviour of *Felis caracal*. General references to diet of *F. caracal* appear in Azzaroli and Simonetta (1966), Bothma (1965), Rautenbach (1978), Skinner (1979), Smithers and Wilson (1979), Stuart (1981), and Viljoen and Davis (1973). The only papers found with any detailed information on diet include Grobler (1981) for the Mountain Zebra National Park (Cradock, Eastern Cape Province), Pringle and Pringle (1979) for the Bedford region (Eastern Cape Province), Smithers (1971) for Botswana and Sapozhenkov (1962) for Turkmenia (U.S.S.R.). Dietary items identified in these and other publications are summarized in Appendix 2. Grobler (1981) is the only author to have commented on food quantity requirements of the caracal.

Leyhausen (1956; 1979) discusses killing technique of *F. caracal*; Smithers (1971) records this behaviour in a captive animal.

Principal objectives of this chapter are to establish types and quantities of animals preyed upon, and the method of food capture by adult caracal.

Methods

Diet of caracal was determined in three ways: stomach content, scat analysis, and examination of kills.

Collection of material

Carcases of *Felis caracal* were primarily obtained from predator control programmes, sponsored by provincial and local authorities and private hunters. Figure 15 shows those sites from where specimens of caracal were obtained. The principal methods used to capture caracal were hounds, and cage and gin traps. Hunters were provided with 200l drums of 10% formaldehyde solution for placing carcases (the ventral surface was slit to facilitate preservation). Freshly killed material was collected from hunters whenever feasible.

Stomachs were preserved in 10% formaldehyde. In the laboratory stomach contents were placed in a sieve (1mm mesh size) and washed to remove preserving fluid and unwanted debris, and then placed in shallow plastic or aluminium trays with water for examination.

Items were separated into two groups: immediately identifiable fragments (eg. skull portions, teeth and feet) and those requiring closer examination (eg. hair). Hair samples were examined under a binocular microscope and compared with a reference collection of hair types representing potential prey. The reference collection consisted of whole hair mounts and gelatine scale impressions, following the techniques of Brunner and Coman (1975). Skeletal material was compared with a comprehensive reference collection in the authors

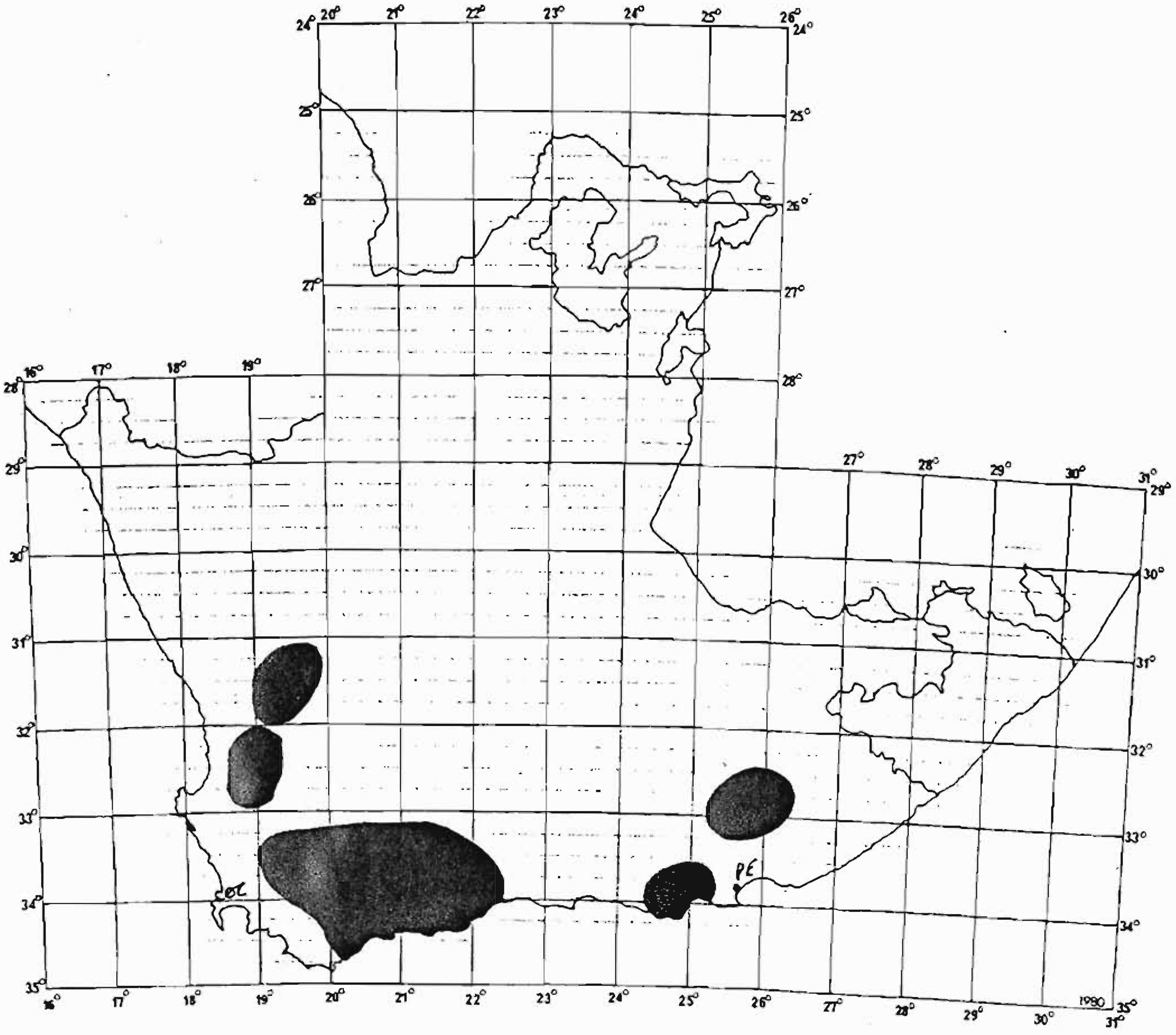

Figure 15. Principal areas from which specimens of Felis caracal were collected.

possession.

Scats were collected, mainly from the Eastern Robertson Karoo, with much smaller samples from other areas.

Caracal scats were readily recognisable (Fig. 16) from those of other carnivores, being similar in appearance to those of Felis libyca, but larger and deposited in a more random manner along roads and paths. Any scats not positively identified as to source were discarded. Individual scats were stored in plastic bags and labelled for later processing. Scats were placed in a dish of water in order to facilitate maceration, and then lightly broken up and washed for removal of soil particles. All large fragments and hair were extracted with forceps, and identified in the same manner as hair samples extracted from stomach contents. Skeletal material was also treated as for similar materials analysed from stomach contents.

Kills were located (frequently on the advice of farmers and hunters), photographed, and examined for pattern of attack, killing, and feeding.

Both wild and domestic prey items were examined. Killing and feeding behaviour, of necessity, was studied under captive conditions at the Vrolijkheid Nature Conservation Station, Robertson. Figure 17 shows the cages used for holding captive caracal. Tests were undertaken to observe the killing patterns associated with different types and size of prey. Live prey was introduced into a

Figure 16. Typical caracal scat showing average length and the segmented structure.

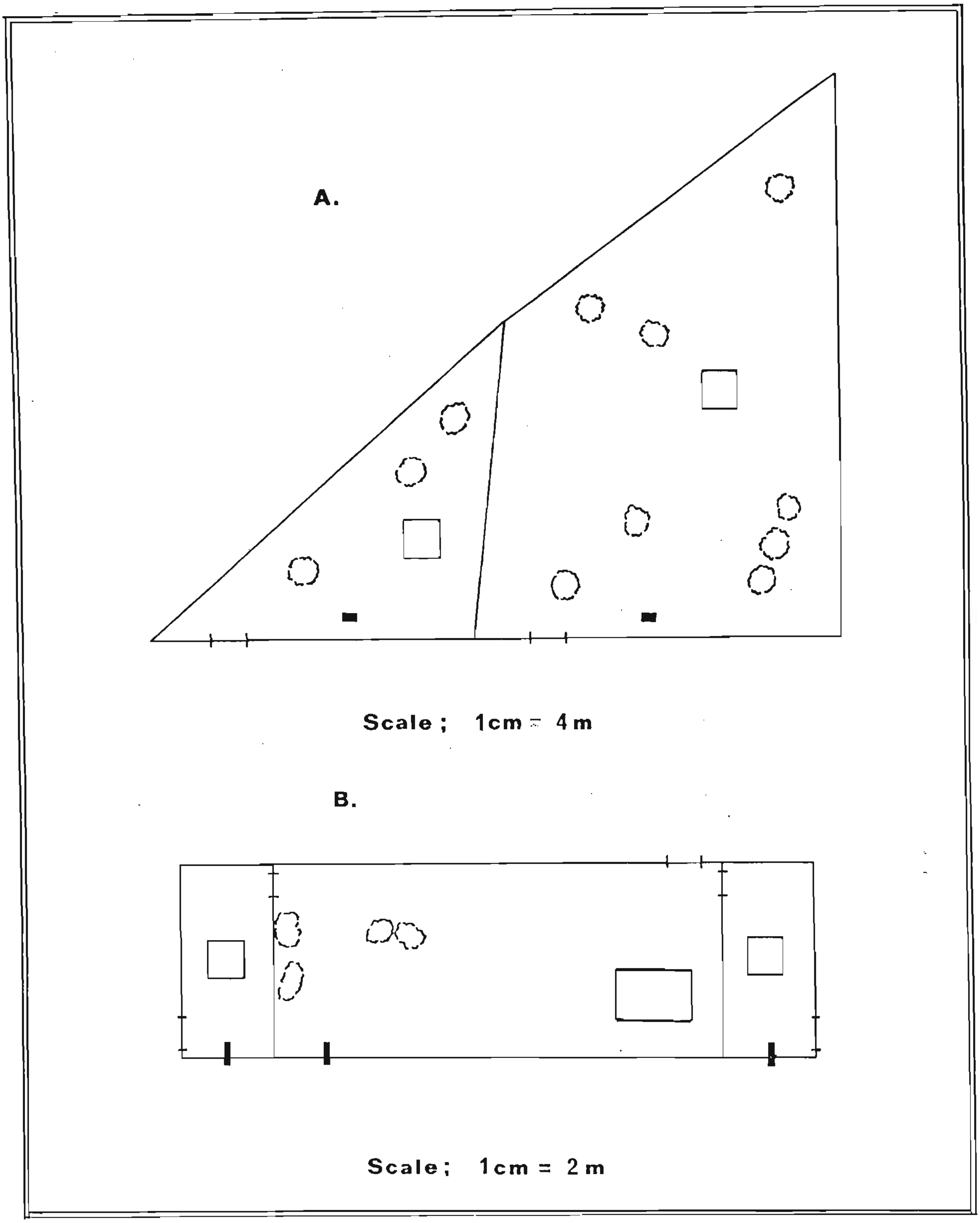

Figure 17. Holding cages used during the course of the present study for breeding and behaviour observations. The small inner squares are dens constructed of bricks. Cuter lines represent cage boundaries constructed of diamond wire mesh. Dotted lines are bushes, and solid blocks water troughs. A- upper camps; B- lower camps.

cage at the usual feeding times and observations made from an observation hide (Fig. 17 A) and an adjacent building (Fig. 17 B). Feeding behaviour was also determined by examination of abandoned kills.

Food requirements were determined by keeping individual caracal in separate cages for varying lengths of time. Food consisting primarily of horse-meat, hens, rabbits and occas ionally hyrax (*Procavia capensis*), was weighed and the amount eaten determined each day.

Results and Discussion

Stomach Contents

A total of 394 stomachs were examined, of which 148 (37%) were found to be empty. The high incidence of empty stomachs can be partly explained by the fact that caracal taken in traps were sometimes not sacrificed until 24 hours or more after capture.

Table 1 summarizes the range of prey items found in analysed stomachs, their occurrence, frequency and the regions from which prey items were taken. Adult mass of a prey item also include non-adult individuals. Wherever possible, the mean mass given is based on the personal records of the author.

Prey species may vary slightly from area to area, but this is possibly related to the distribution patterns of the prey and not so much to caracal preferences. Small and

Table 1. Prey species of *Felis caracal* as determined by stomach content analysis (n=246)

Prey	No. prey items	Percentage Occurrence	Prey item mass ($\bar{x}$ adult mass)	Areas of Occurrence (RK - Robertson Karoo) (CS - Coastal Sandveld) (B - Bedford) (O - Other)
ANTELOPE	102	31,4		
Raphicerus melanotis (Grysbok)	34	10,5	10,3kg (n=6)	RK; CS; O.
Unidentified	22	6,8	-	All
Sylvicapra grimmia (Grey Duiker)	21	6,5	14,0kg (n=8)	RK; CS; B; O.
Raphicerus campestris (Steenbok)	8	2,5	9,0kg (n=12)	RK; CS; B; O.
Tragelaphus scriptus (Bushbuck)	7	2,1	♀ 31,0kg (Dorst & ♂ 77,0kg (Dandelot 1970)	CS; B; O.
Redunca fulvorufula (Mountain Reedbuck)	4	1,2	22kg (Grobler 1981)	B.
Cephalophus monticola (Blue Duiker)	4	1,2	6kg (Dorst *et al* 1970)	O.
Oreotragus oreotragus (Klipspringer)	1	0,3	18kg (Dorst *et al* 1970)	RK.
Pelea capreolus (Grey Rhebok)	1	0,3	22kg (n=5)	RK.

DOMESTIC STOCK	90	27,8	–	–
Sheep	68	21,0	See text	RK; CS; B; O.
Goat	22	6,8	See text	Rk; B; O.
RODENTS	32	9,8	–	–
Unidentified	12	3,7	–	All
Rhabdomys pumilio (Four-striped mouse)	11	3,4	40g (n=100)	RK; CS; B; O.
Pedetes capensis (Springhare)	3	0,9	3,2kg (n=11)	B.
Cryptomys hottentotus (Common Mole-rat)	2	0,6	96g (n=61)	RK; CS.
Bathyergus suillus Dune Mole-rat)	2	0,6	1,1kg (n=100)	CS.
Aethomys namaquensis Namaqua Rock Rat)	1	0,3	c.100g (Own obs.)	RK.
BIRDS	24	7,4	–	–
Small (*Prinia* size)	7	2,1	–	RK; CS; O.
Medium (Pigeon size)	10	3,2	–	RK; CS; O.
Game birds	7	2,1	–	RK; CS; O.
HYRAX				
Procavia capensis (Dassie)	22	6,8	2,8kg (n=100)	RK; B; O.

LAGOMORPHS				
Lepus spp.	17	5,2	*L. capensis* *L. saxatilis* 2,4kg-2,7kg (n=30)	RK; CS; B; O.
GREEN GRASS	17	5,2	-	All. Not true food item
CARNIVORES	17	5,2	-	-
Herpestes pulverulentus (Cape Grey Mongoose)	8	2,5	768g (n=79)	RK; CS; O.
Ictonyx striatus (Polecat)	2	0,6	664g (n=29)	RK; O.
Cynictis penicillata (Yellow Mongoose)	2	0,6	935g (n=30)	RK; O.
Felis caracal (kittens) (Caracal)	3	0,9	-	RK; B; O.
Atilax paludinosus (Water Mongoose)	1	0,3	2,8g (n=27)	O.
Genetta sp.	1	0,3	1,8-2,8kg (n=70) *G. genetta* *G. tigrina*	CS.
INSECTIVORES				
Shrews (Crocidura?)	2	0,6	-	RK; CS.
Chrysochloris asiatica (Cape Golden Mole)	1	0,3	40g (n=4)	O.
FISH	1	0,3	-	CS.
CARRION	1	0,3	-	B.

medium-sized antelope were the most frequently occurring food items, followed by domestic stock. The relatively high incidence of domestic stock can be related to hunters killing caracal in areas where stock killing had taken place. This, therefore, increased the chances of stock killing predators being taken. It was difficult, and usually impossible, to determine the size of sheep and goats taken by caracal, using stomach content analysis alone. Sheep and goats were identifiable from hair sampling, and in certain cases it was possible to distinguish between some breeds of sheep.

In the case of Lagomorphs, it was not possible to distinguish Lepus even to species level.

The presence of rodent moles, (Bathyergidae) Bathyergus suillus (n=2) and Cryptomys hottentotus (n=2) is worthy of further comment. Rodent-moles sometimes move about on the surface (particularly Bathyergus suillus after heavy rain) when it would be possible for caracal to take them. Figure 18 illustrates a freshly opened B.suillus tunnel. Tracks indicated that a caracal had exposed the tunnel and then crouched below the entrance, presumably waiting for the occupant.

Carnivore remains were present in 16 (4,9%) of the stomachs, and of these, two species are diurnal (Herpestes pulverulentus, n=8; Cynictis penicillata, n=2), suggesting that Felis caracal will also hunt during the day. Remains of caracal kittens were found in stomachs of three male caracal. Cannibalism is recorded twice in the files of the Kaffrarian Museum, King Williams Town, and a report of cannibalism

Figure 18. A tunnel of Bathyergus suillus partially excavated by a caracal. Arrows indicate the position of the tracks left by the front paws.

was recorded by a hunter (V.Pringle, personal communication) for the Tarkastad district.

Only four of the birds were identified, one only to family level; two Numida meleagris; one Zosterops pallidus and one member of the Anatidae.

The single carrion sample consisted of unidentified flesh and fly (Diptera) larvae. Presumably the fish record (scales and bones) was also from a scavenged animal. Figure 19 compares the major prey groupings of the present study with those of Pringle and Pringle (1979). The diet of caracal and black-backed jackal is compared in Table 2.

Scat Contents

A total of 248 scats were collected in the Eastern Robertson Karoo. Regular routes were followed in the area during the study period and all fresh caracal scats were collected. In addition, the scats of Felis libyca, Vulpes chama and Panthera pardus were collected for comparative purposes (Table 3).

Prey items identified from Felis caracal scats are listed, with frequency of occurrence, in Table 4. The high incidence of rodents in the scats, particularly Otomys unisulcatus, coincided with an unusually large increase in the numbers of this species following the rain of September 1980 which continued into April 1981.

The relatively high incidence of domestic stock is

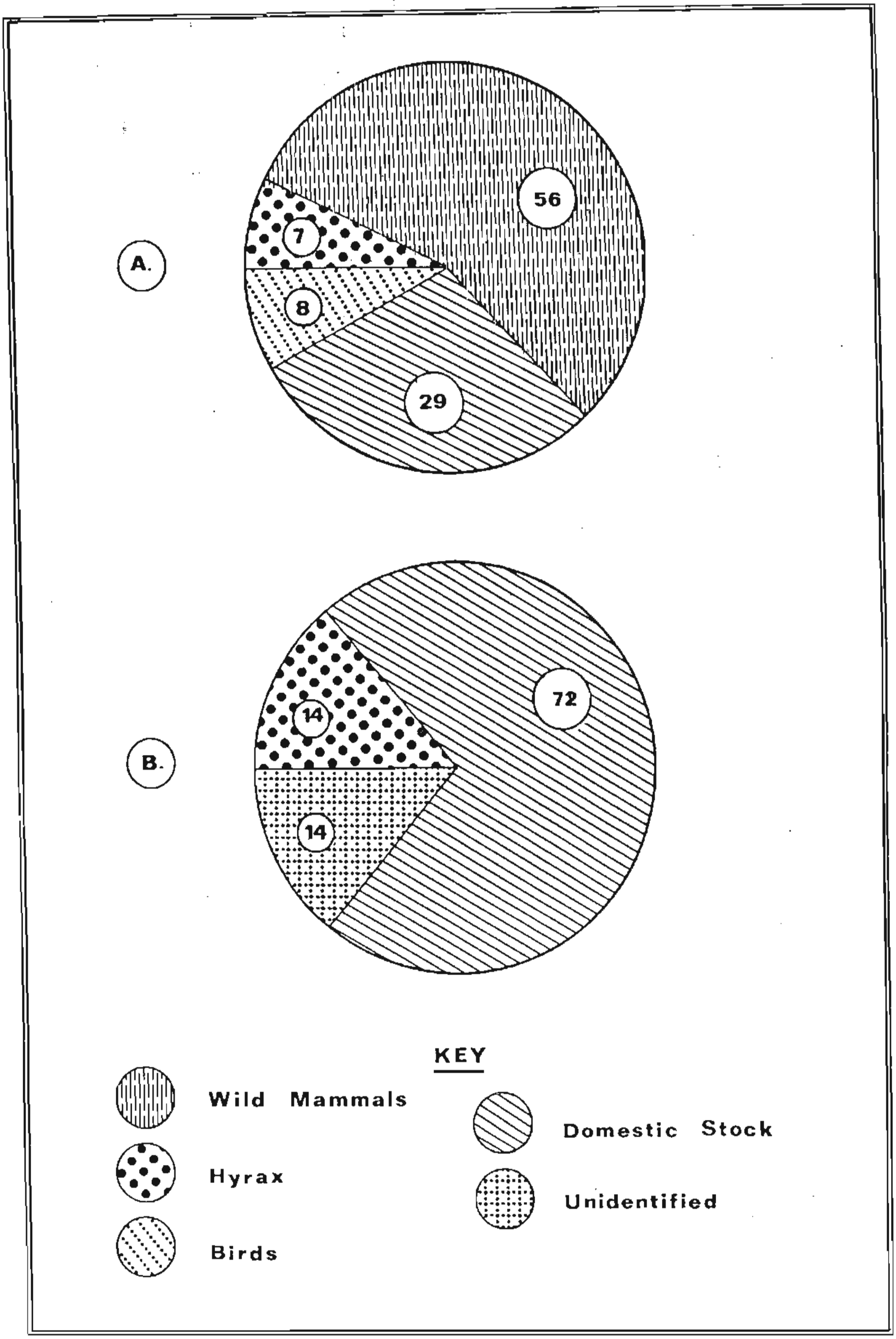

Figure 19. Stomach contents of caracal recorded from (A) the current study, and (B) that undertaken by Pringle and Pringle (1979). Numbers within circles indicate percentage occurrence.

Table 2. Comparison of black-backed jackal and caracal diet in the Cape Province based on analysis of 114 jackal and 246 caracal stomach contents collected during the current study.

Food category	Black-backed jackal % Total occurrence		Caracal % Total Occurrence	
MAMMALS	57,0		92,0	
Rodents		16,5		10,4
Domestic stock		14,9		29,2
Carrion		13,3		0,3
Antelope		3,2		33,0
Unidentified		3,2		(11,0 under rodents and antelope)
Lagomorphs		2,6		5,5
Insectivores		1,7		1,0
Carnivores		1,1		5,5
Hyrax		0,5		7,1
BIRDS	12,7		8,0	
REPTILES	2,7		-	
INVERTEBRATES	7,9		-	
PLANT FOOD	19,7		Green grass only (5,2)	

Table 3. Diet of three species of carnivore (*Vulpes chama*, *Felis libyca*, *Panthera pardus*) occurring in the Eastern Robertson Karoo based on scat analysis and expressed as percentage occurrence.

Food category	% OCCURRENCE *Vulpes chama*	*Felis libyca*	*Panthera pardus*
Mammal	74,0	96,0	100,0
Rodents	74,0	93,0	-
Insectivores	9,0	3,0	-
Lagomorphs	3,0		
Antelope	-	-	68,0
Hyrax	-	-	32,0
Unidentified	7,0	11,0	4,0
Birds	11,0	17,0	4,0
Reptiles	9,0	11,0	-
Invertebrates	68,0	30,0	-

Table 4. Prey of *Felis caracal* in the Robertson Karoo as determined from 248 scats.

Prey species	Occurrence	Relative %
RODENTS	155	50,0
Unidentified	60	19,3
Otomys unisulcatus (Karoo Rat)	57	18,4
Otomys irroratus (Vlei Rat)	16	5,2
Rhabdomys pumilio (Four-striped mouse)	17	5,5
Tatera afra (Cape Gerbil)	4	1,3
Hystrix africae-australis (Porcupine)	1	0,3
DOMESTIC STOCK	52	16,8
Sheep	28	9,0
Goats	24	7,8
ANTELOPE	34	10,9
Sylvicapra grimmia (Grey Duiker)	15	4,8
Raphicerus campestris (Steenbok)	8	2,6
Oreotragus oreotragus (Klipspringer)	7	2,3
Pelea capreolus (Grey Rhebok)	4	1,3
HYRAX		
Procavia capensis (Dassie)	28	9,0
LAGOMORPHS (*Lepus* sp.)	16	5,2
BIRDS	16	5,2
CARNIVORES	9	2,9
Atilax paludinosus (Water Mongoose)	4	1,3
Herpestes pulverulentus (Cape Grey Mongoose)	5	1,6

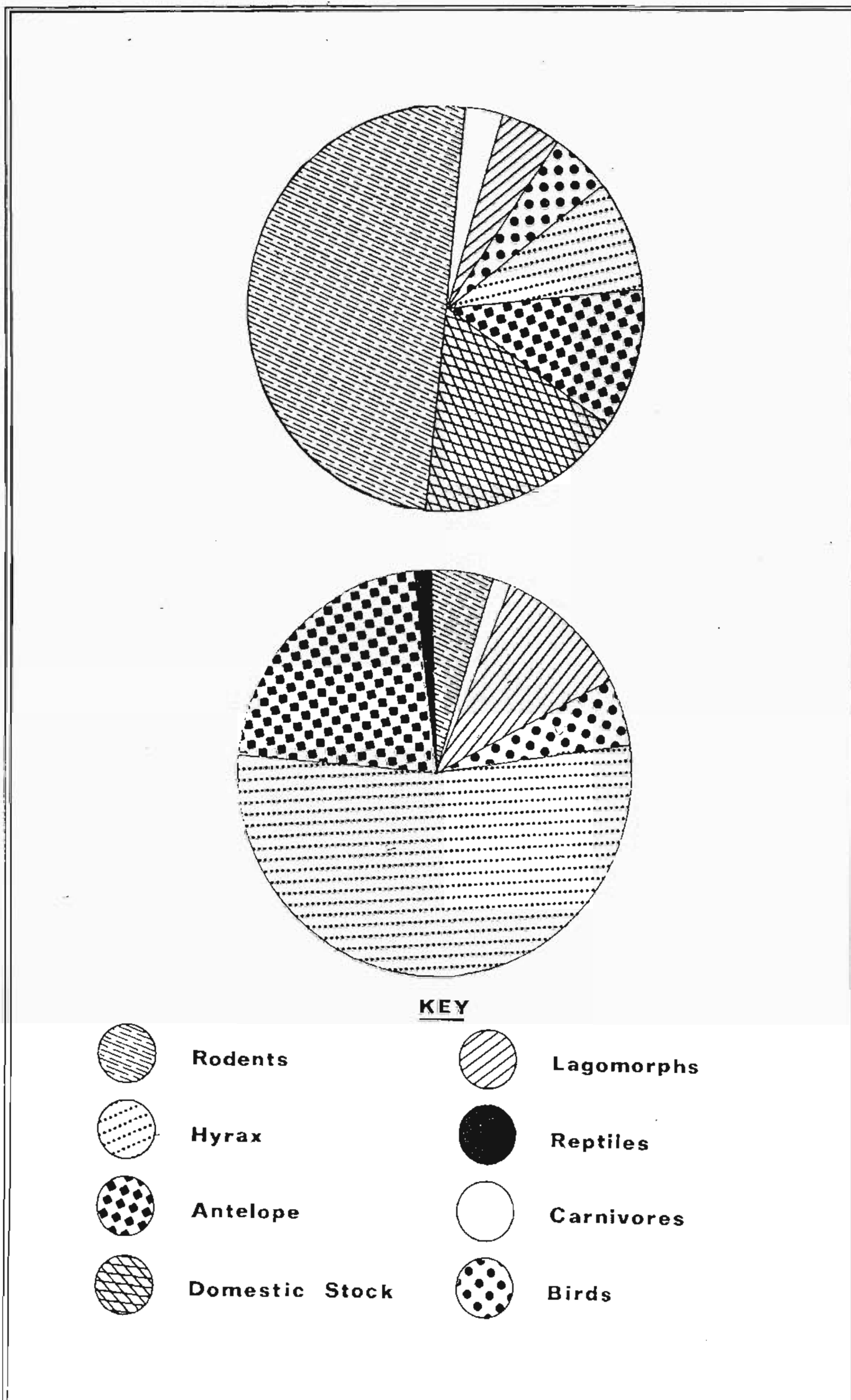

Figure 20. Composition of the scat of caracal in (A) the current study, and (B) Grobler (1981).

difficult to explain. Reports of stock losses caused by caracal were low when compared with other areas, and is probably explainable in part by lax farming practices.

Grobler (1981), the only other worker to have examined caracal scats (Mountain Zebra National Park, Cradock) in the Cape Province, concurs with the current study that the principle food, in terms of numbers, were rodents (Fig. 20). In terms of biomass, however, domestic stock and antelope made a greater contribution. Mammals represented 94,8% of the identified prey (Grobler 1981, obtained a figure of 93,8%) and birds 5,2% (Grobler 1981, 5,3%). Grobler (1981) recorded reptile prey in two scats, whereas no reptile remains were found in the present study. Bird remains in 14 cases were small to medium in size and unidentified: one was *Numida meleagris* (Crowned Guinea-fowl), and the only other specimen was tentatively identified as *Afrotis afra* (Black Korhaan).

Kills, Killing and Feeding Behaviour

A total of 30 wild prey kills were recorded (excluding domestic stock) of which 15 were examined from the Coastal Sandveld, 14 from the Robertson Karoo, and one from Bedford.

The skulls of kills were examined and individuals placed into one of three age categories, adult, subadult and juveniles. No attempt was made to sex juveniles. All the kills examined were antelope, with seven species

Table 5. Wild kills made by Felis caracal from the Coastal Sandveld and the Robertson Karoo.

Prey species	Age	Sex	Number
COASTAL SANDVELD			
Raphicerus melanotis (Grysbok)	adult	♂	3
	adult	♀	2
	juvenile	?	1
Tragelaphus scriptus (Bushbuck)	sub-adult	♂	1
	sub-adult	♀	3
	juvenile	?	2
Sylvicapra grimmia (Grey Duiker)	adult	♂	1
	adult	♀	1
	sub-adult	♀	1
ROBERTSON KAROO			
Raphicerus campestris (Steenbok)	adult	♂	1
	adult	♀	2
	juvenile	?	1
Sylvicapra grimmia (Grey Duiker)	adult	♀	3
	sub-adult	♂	1
Pelea capreolus (Grey Rhebok)	adult	♀	1
	sub-adult	♂	2
	juvenile	?	1
Raphicerus melanotis (Grysbok)	adult	♂	1
Oreotragus oreotragus (Klipspringer)	sub-adult	♂	1
			[illegible]

being involved (Table 5).

The animal taken at Bedford was a sub-adult female Redunca fulvorufula.

Smaller prey species were almost entirely consumed and difficult to locate. In several instances remains of Procavia capensis and Lepus sp. were found, but the predator could not be determined with any certainty and are not included here.

Grobler (1981) has discussed the manner of killing in some detail. Leyhausen (1956; 1979) and Pringle and Pringle (1979) found that larger prey items were dispatched by caracal biting at the nape of the neck, but findings of the present study support those of Grobler (1981) in that throat bites were most frequently associated with antelope kills and captive observations. In the case of two sub-adult ewes of Tragelaphus scriptus and one sub-adult male Pelea capreolus, tooth marks were present in the nape region as well as in the upper throat. It is presumed that the initial bite was to the nape and then shifted to the throat. Figure 21a shows an adult male caracal holding a large rabbit in a typical throat bite; Fig. 21b shows the damaged neck region of the same rabbit. A sub-adult Pelea capreolus ram showing evidence of neck bite is illustrated in Fig 21c. A Sylvicapra grimmia ewe killed by caracal and scavenged by Vulpes chama is shown in Fig. 22.

In rocky areas it was not always possible to find tracks

Figure 21(a). An adult male caracal holding a large domestic rabbit in a typical throat hold. Note the body straddle.

Figure 21(b). The rabbit showing damage to the throat and neck.

Figure 21(c). A sub-adult *Pelea capreolus* ram with neck tissue parted to show throat bite.

Figure 22. A Sylvicapra grimmia ewe killed by caracal and scavenged by Vulpes chama.

Figure 23. - Prey mutilation by Canis mesomelas.
(a) Merino x Dorper lamb killed and eaten by black-backed jackal; note the rolled back ventral skin and chewed ribs.

(b) Dorper-type lamb taken by black-backed jackal; hindquarters torn away with skin "rolled" away from the ribs.

Figure 24. Adult ewe (sheep) killed by Panthera pardus. Note lacerated throat, front limbs completely ripped away and shoulder region heavily eaten. Caracal would not inflict such heavy mutilation.

near a kill to indicate the identity of the predator. This was overcome by compiling detailed records of the method of killing and feeding used by other predators (Panthera pardus and Canis mesomelas), which differs markedly from Felis caracal. (Figs 23a, 23b, 24).

In the case of domestic stock (primarily sheep) of which 17 sheep and four goats were examined, six sheep were killed with throat bite only while nine were bitten in both the nape and throat. Scavenging by other predators made determination of method of killing in two cases impossible. The four goats (Boerbok) were all sub-adult; each had been killed with a throat bite. A case of combined nape and throat bite is illustrated in Fig. 25.

All the antelope and domestic stock examined, excepting juvenile antelope where considerably larger portions were devoured, were eaten around the anal and medial areas of the hind legs (Figs 26a, 26b). In only four cases was part of the shoulder area consumed (two sheep, one duiker and one steenbok).

On four occasions goat kids (Boerbok - c. 5kg) were given live to captive male (two trials) and female (two trials) caracal. The Boerbok were all taken by an immediate throat bite after they had been thrown on their side by the front paws, in a tripping motion and held by the throat with one of the front paws across the shoulder region for several minutes (three to eight minutes) until they had ceased to move.

Figure 25. A Merino ewe taken by a caracal. In this case both nape and throat bites were applied.

Figure 26. Typical caracal feeding pattern.
(a) A Dorper ewe showing typical decimation to the inner thighs and buttocks.

(b) *Pelea capreolus* killed by caracal, showing typical feeding on inner thighs. Note the cleaned bone. This kill was revisited at least once.

Adult live dassies (Procavia capensis) were also presented to caracal on four occasions. The prey was firstly thrown off balance with a front paw placed on the back, and in the same action, the throat was grasped in the jaws. The caracal then fell onto their side (three to the left and one to the right) and proceeded to rip at the dassies ventrum with the hind claws. Once the dassie had ceased moving, the cat would get to its feet quickly, still gripping the throat, and move to a spot in the cage to begin feeding.

Leyhausen (1979) described the sequence of a caracal killing a guineapig as, i) throat grip, side fall and hind claw raking, ii) maintains throat grip whilst crouching, with front paw on back - cervical spine being bent over, iii) spine broken, cat then stands and moves off with prey. Four guineapigs fed to caracal during the present study were dealt with in a similar manner. The spinal-break technique was absent when the dassies were taken, presumably because of the sturdier spinal column and neck muscles. Of 18 domestic rabbits (+ 1,5kg) fed to adult caracal, 11 had severe damage to the cervical spine.

Of all the animals fed to captive caracal, only one was able to inflict any injury to its captor: a large buck rabbit that raked its hind claws across the face of the caracal, drawing blood.

Dead hens were partially plucked by the caracal before they were eaten. Leyhausen (1979) has discussed plucking of hens by caracal in some detail, and no differences were noted during the current study.

On three occasions, Cape weavers (*Ploceus capensis*) entering cages housing caracal were caught. The weavers were feeding on seed placed in the cages to attract birds. Although a number of birds were feeding on each occasion (seven, three, three), the caracal only succeeded in taking one bird each time. In each case the caracal rushed from cover and "batted" at the birds in a sideways motion, immediately grasping the downed birds.

A tame caracal (Inksie) started hunting mice (*Rhabdomys pumilio*) at three and a half months of age and captured the first free-flying bird (Turtle dove, *Streptopelia capicola*) at five and a half months. The stalk and kill was observed on a number of occasions, and did not differ from the descriptions given by Leyhausen (1979) and Smithers (1971). Burying of prey by the caracal has been disputed by Pringle and Pringle (1979), but captive animals during the present study were observed on several occasions to bury unfinished food (rabbits,dassies,hens and horsemeat).

Pringle and Pringle (1979) found no evidence that *F.caracal* return to a kill or feed on carrion, but in the present study there was definite evidence that kills are sometimes revisited. Grobler (1981) found proof that caracal frequently return to kills, and also records a caracal caching a springhare (*Pedetes capensis*)in a tree in the

Gemsbok National Park. Skinner (1980) has observed caracal feeding on a donkey carcase in Israel. In the present study caracal were known to have returned to seven kills, but as Grobler (1981) pointed out, the level of hunting pressure in farming areas could result in a lower rate of return to kills.

Prey caching in trees, as recorded by Grobler (1981) and Miller (1972), could be related to the level of medium to large predator competition. Occasionally captive caracal would leap onto beams, 1,8 metres from the cage floor, whilst holding food.

Scavenging from a Cape fur-seal (Arctocephalus pusillus), in the vicinity of Groothagelkraal, was recorded. Caracal tracks were frequently encountered along the high water mark and it would seem likely that scavenging on marine carrion could play a role in the lives of caracal living in the Coastal Sandveld and other coastal areas.

Food Requirements

Grobler (1981) found that a tame caracal at eight months of age consumed 796g of food daily. In the current project a record was kept of the food consumed by eight captive animals. Horse meat and hen carcases formed the majority of food, although bone meal, liver, rabbit, guineapigs, goat kids and dassies were offered from time to time. Records were kept over periods ranging from 91 to 365 days. Mean daily consumption and the expected annual total were calculated (Table 6).

In the current tests, the mean daily food intake was 586g in contrast to Grobler (1981) who estimated wild, adult caracal, daily food intake at approximately 1kg, and juveniles at 500g.

Table 6. Record of daily food intake and calculated annual total for eight captive, adult caracal.

Animal Number	Sex	Mass (kg)	Recorded period (Days)	x̄Daily intake (g)	Annual total (kg)
1	♀	9,6	365	485	177
2	♀	10,1	365	490	179
3	♀	12,0	365	470	171
4	♀	10,0	91	566	206
5	♂	14,2	123	835	305
6	♂	13,7	272	696	254
7	♂	10,4	334	593	216
8	♂	12,0	120	554	202
				$\bar{x}$ 586	$\bar{x}$ 214

As reported by other authors previously mentioned in this chapter and in the current study, mammals are by far the most important food group. The size range is great (shrews - Soricidae weighing 15g to medium-sized antelope weighing upto 50kg) and the method of killing certain prey (antelope and domestic stock)would seem to vary, as does the habit of returning to a kill. Bester (1982) in an appendix to his study of the Cape fox (Vulpes chama) gives the contents of 109 caracal stomachs collected in the Orange Free State during predator control operations. The same author found that 43% of all stomachs contained domestic stock remains, 48% wild mammals, birds occurred in 8% and reptiles 1%. The rodent remains were dominated by the Springhare (Pedetes capensis) (76%) and the antelope remains by the Mountain Reedbuck (Redunca fulvorufula) at 82%.

Pringle and Pringle (1979) found that caracal kill large prey animals by biting the nape of the neck, whereas Grobler (1981) found that the throat bite was dominant in his study. Examination of carcases and observation of captive animals in the present study indicates that throat bites predominate, but nape bites were recorded; occasionally with a shift of bite from nape to throat, but never throat to nape. There may be regional differences in killing technique for caracal, as was found for Panthera leo (Eloff 1964).

The high incidence of domestic stock in stomachs, scats, and observed kills is primarily the result of material being collected in livestock farming areas, and follow up

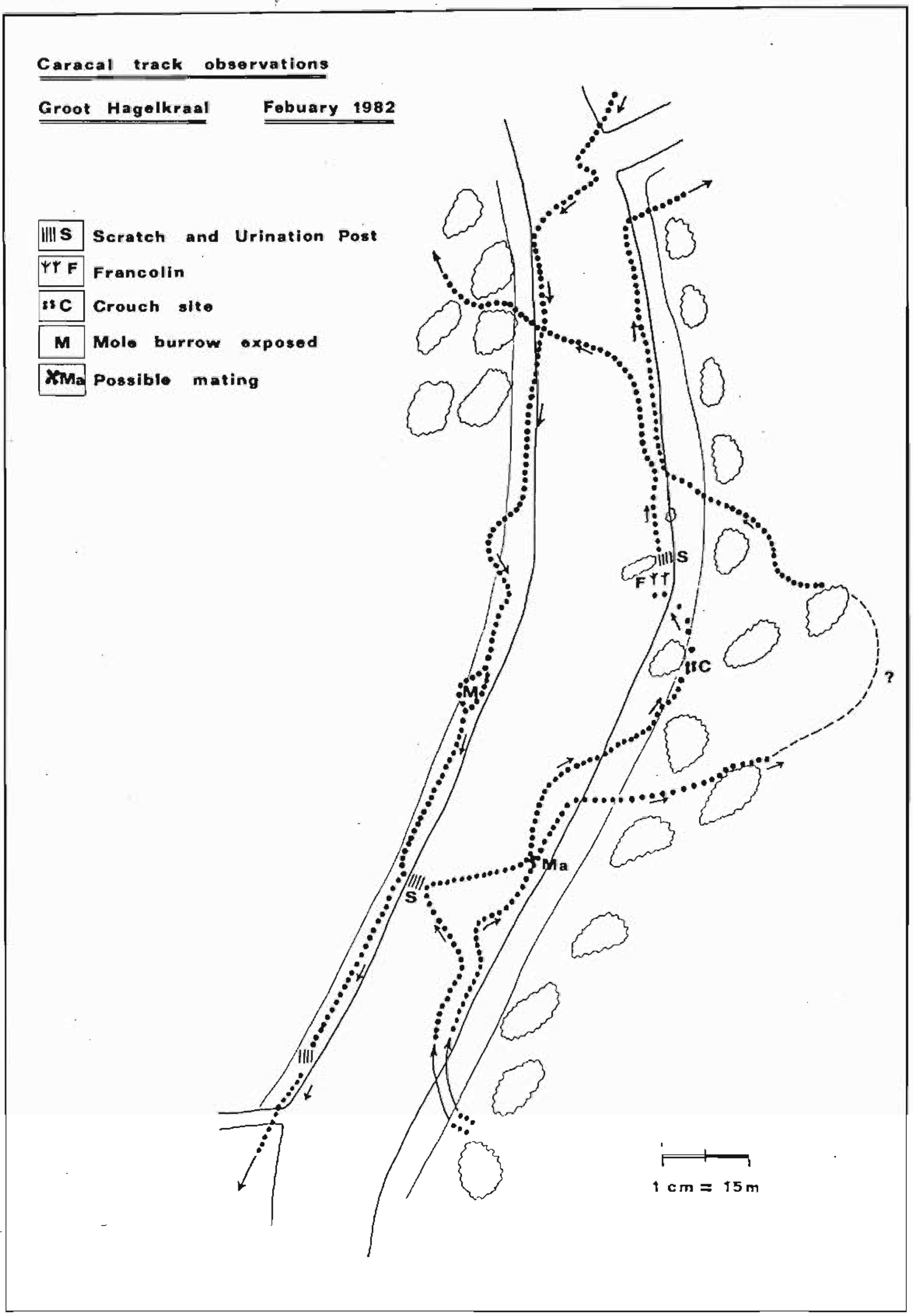

Figure 27. Observations of caracal tracks along a firebreak (Coastal Sandveld).

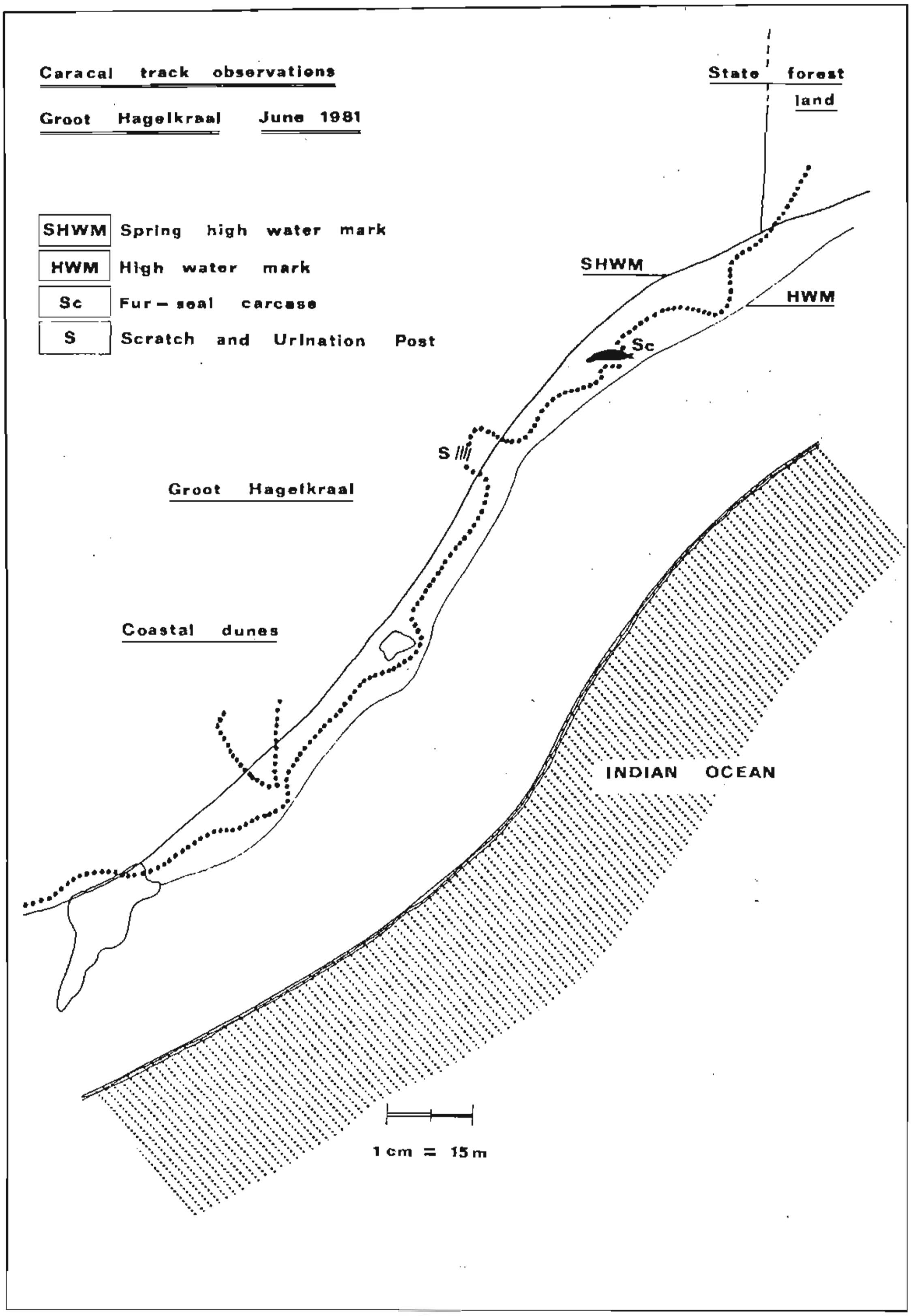

Figure 28. Observations of caracal tracks along the high water mark (Coastal Sandveld).

operations of stock losses by hunters and farmers.

In the Coastal Sandveld where footprint tracking was possible on occasion, note was kept of cat behaviour as judged from the trail (Fig. 27 and 28).

Pringle and Pringle (1979) are of the opinion that caracal do not return to kills, whereas Grobler (1981) found that most larger kills are revisited in the Mountain Zebra National Park. Some kill returns were recorded in the current study. Where hunting pressure is great, or farm management efficient, it appears that caracal rarely return to kills. However, in protected areas where caracal are not under hunting pressure, the cats can and do return safely to kills.

After the caracal, *Canis mesomelas* (black-backed jackal) is the most important wild predator of domestic small-stock in the Cape Province. In the lower size levels of prey (eg: small rodents, hares) caracal compete with a wide range of small carnivores, (eg: wild cat, Cape fox) but medium-sized prey (small antelope and domestic stock) is taken primarily by caracal, to a lesser extent by black-backed jackal, and locally by leopard (*Panthera pardus*).

CHAPTER 5

BREEDING

Introduction

As with most aspects of the biology of *Felis caracal*, few data has been recorded on reproduction. Pringle and Pringle (1979) have noted pregnant caracal from the Bedford district. Brand (1963), Cade (1968), Gowda (1967) and Kralik (1967) have recorded captive breeding, and Fairall (1968) recorded sightings of kittens in the Kruger National Park. Aspects of breeding biology were examined from caracal taken from the wild, as well as from observations of captive animals at the Vrolijkheid Nature Conservation Station, Robertson.

Methods

Reproductive material was collected from 337 caracal (180 males and 157 females) destroyed during predator control programmes, primarily in the southern sector of Cape Province.

Testes from male caracal were dissected out (the epididymus removed) and weighed to the nearest 0,1g. Specimens for histological examination were taken from one testicle, fixed in 10% buffered formaldehyde, and processed to 5μm, following standard histological techniques (Culling 1974). Sections were stained with Harris's haematoxylin and aqueous eosin, and then permanently mounted for later reference.

Mean seminiferous tubule diameters were obtained using a micrometer eyepiece,where autolysis was avoided.

Female caracal reproductive tracts, including ovaries and foetal material, were preserved in 10% formaldehyde. Embryos and foetuses were weighed, standard measurements taken, and where possible, position and sex were ascertained. Females were also examined for lactation.

Courtship behaviour and copulation were observed under captive conditions. Gestation was determined from known copulations of captive animals.

For captive females information was kept on parturition, foetal presence, and back-dated births by using cranial and dental characters of known-age animals. Ageing is discussed in Chapter 6. Similar information on reproduction in the black-backed jackal *Canis mesomelas*, was collected for comparative purposes; the emphasis was placed on mating and parturition. Sexual maturity was determined by observations of the first successful copulation in captivity of known-age animals.

Results and Discussion

Mating and Copulation

Eaton (1978) and Leyhausen (1979) have discussed copulation in a number of felids, but make no mention of *Felis caracal*. During the present study, semi-tame, captive animals were used in a breeding programme with the principle aim of obtaining known-age animals. A male was kept with a female until the male no longer showed interest in the female and copulations ceased. The period over which copulations were observed ranged from one to three days ($\bar{x}$ 1,8 days) for seven specific mating periods.

Cade (1968) recorded a mating sequence over a period of two days, and Gowda (1967) noted copulation for one day; however, it was not clear whether this was an isolated observation or the total sequence of copulation.

In the current study a total of 12 "successful" copulations were observed, ranging from one and a half to eight minutes ($\bar{x}$ 3,8 minutes) in duration. Gowda (1967) observed one copulation which lasted approximately 10 minutes. The prelude to coitus followed a set pattern in all observed cases. The oestrus period appeared to last from three to six days, with an oestrus cycle of about 14 days.

One indication of oestrus is urine squirting which was observed on several occasions in captive animals. A prominant point in the cage was used repeatedly, over a period of two to four days. Urination was always brief and accompanied by a slight trembling of the hind quarters and erect tail. Urine squirting behaviour has been described for wild cat (Felis silvestris) females (Leyhausen 1979). When a male caracal was first introduced to a cage holding a receptive female, the first action was to sniff the one or more female spray urination sites before approaching the female.

Actual mating and copulation are very similar to description of such behaviour for domestic cat (Felis catus) (Leyhausen 1979). After copulation, the caracal male disengages rapidly and moves away from the female. On two occasions the female turned on the male aggressively, but without contact. In most cases the male proceeded to lick his genital area, while the female lay on her side or occassionally rolled. Although no sounds were noted during copulation, Gowda (167) reported a low groaning noise by the female.

On three occassions, male caracal were introduced into cages holding non-receptive females (one female was approximately 30 days pregnant). In all cases the male was greeted with a low growl, followed immediately by a growl/bark. Males did not attempt to approach the females, and invariably gave way to an approaching female.

Kralik (1967) recorded a male and a female caracal in the Brno Zoo, kept in adjacent cages, communicating with peculiar barking signals which was never observed in the current study.

Pregnancy and Gestation

The shortest recorded gestation period in a captive female caracal for the current study, was 78 days; the longest was 81 days (a mean of 79,4 days for the five cases of gestation recorded). Gestation is considered accurate to within two days in each case. Cessation of observed copulation was considered as the onset of pregnancy while birth was recorded within at least 12 hours of the event. Eight presumed pregnancies were monitored, of which five were successful.

Gowda (1967) recorded two gestation periods for caracal in the Mysore Zoo, India, both lasting 69 days; the kittens may have been one week premature, for one of the pregnancies which indicates normal birth would have been achieved at 76 days. Cade (168) recorded a gestation period of 78 days in one case from Nairobi Zoo, Kenya. Kingdon (1977) gives a gestation range of 69-78 days without giving specific examples or localities. Gestation periods of 78-81 days would appear to be more usual, with records of 69 days for caracal from Mysore Zoo (Gowda 1967) being unusually short. J.R.K. Green (personal communication) has found that gestation ranges from 69-78 days in zoo animals.

First indications of pregnancy were evident within 30-40 days when the nipples became prominant, and the female more intensively licked and cleaned the mammary area, as parturition approached. Cade (1968) observed an increase in nipple size at about one month.

The birth of a kitten was observed at Vrolijkheid Nature Conservation Station from a very tame three year old female. The pregnant cat became very restless, licking her genital and mammary areas repeatedly, scratching at the earth floor, and constantly moving from a lying to a sitting position, for approximately 35 minutes. Her body then started to alternatively contract and relax, with her head and chest slightly raised, and the hindquarters lying on the left side. The kitten then emerged head first, followed shortly after by the placenta. The mother turned, and began licking the kitten, and eating the membrane and placenta before lying on her side and allowing the kitten to suckle. The entire parturition from visible contractions to suckling lasted approximately 110 minutes. Kralik (1967) notes a captive female caracal making a nest from the hair and feathers of its food shortly before giving birth. Hair and feathers, as well as other potential "nesting" debris, were always available to close to term females, but nesting was never observed during the current study.

Actual pregnancies noted in the Cape Province are recorded in Fig. 29 A . The mass of pregnant females averaged 10,43kg (n = 20, range - 7,0 - 13,6kg).

Birth Season

Pringle and Pringle (1979) are the only workers to have published pregnancy records for wild killed caracal in the Cape Province; pregnant animals were recorded in April, September, October and November.

Fairall (1968) reported sightings of kittens between November and May in the Kruger National Park, Transvaal. Unfortunately, no indication of size is given which would allow estimation of birth dates. Shortridge (1934) recorded a pregnancy in September for South West Africa.

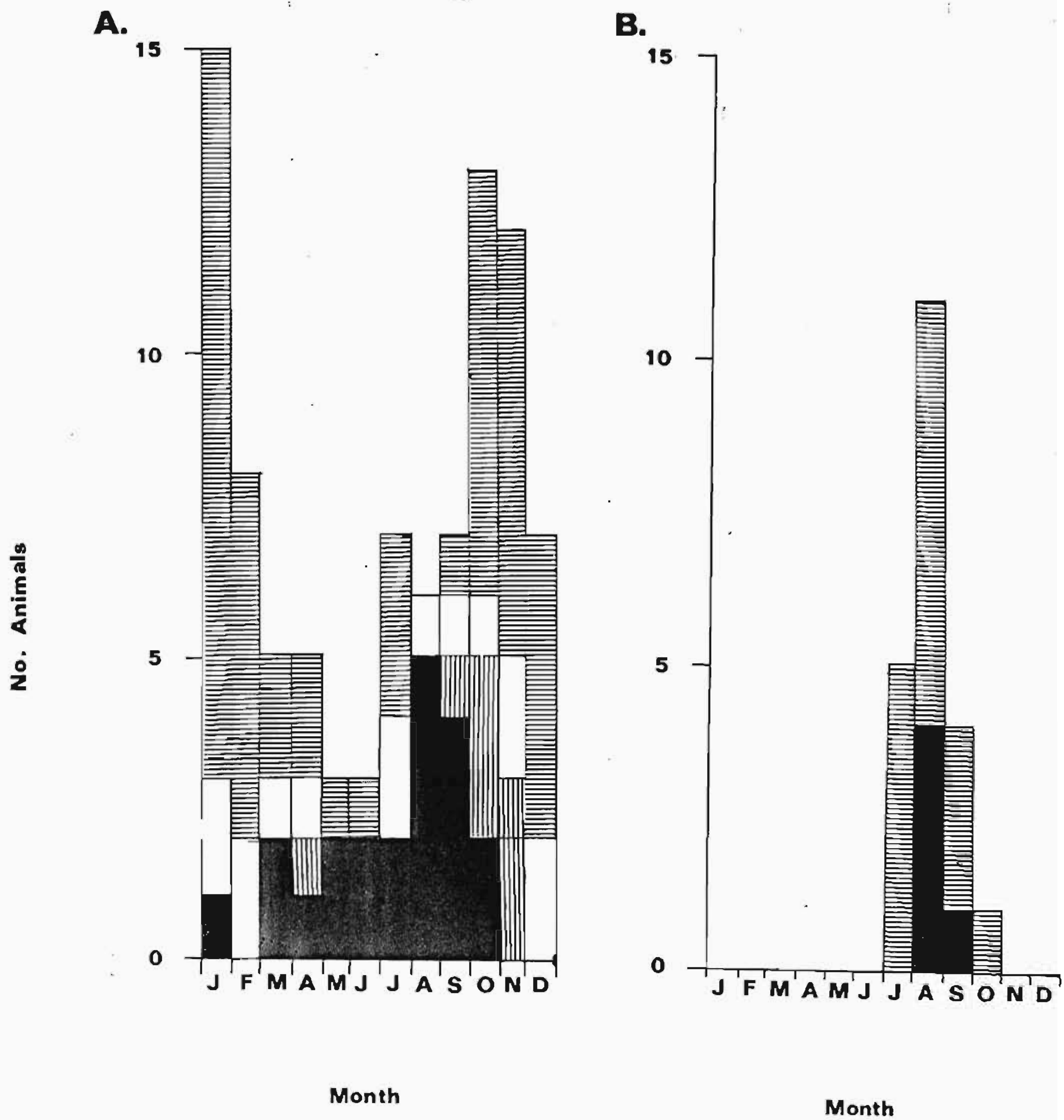

Figure 29. Breeding patterns for two medium-sized carnivores in the Cape Province. (A) Pregnancies and births of Felis caracal, and (B) Pregnancies and back-dated births of Canis mesomelas.
Key: Black- pregnant, wild killed females; vertical hatching- pregnancy records (Pringle and Pringle 1979); white- captive births; horizontal hatching- back-dated births.

Ansell (1960) recorded a pregnant female in September and juveniles during November and January from Zambia. Smithers (1971) states that in Rhodesia (Zimbabwe), young are born in September to December. The National Zoological Gardens (Pretoria) have recorded births in January, February, April, May and November (Brand 1963). In the present study, wild births (including records based on back-dated cub material) took place in every month except August, although a captive birth took place in that month. Pregnant animals killed in the wild were recorded in January, and from March to November. The highest number of births were recorded in January and October-November. Close to term foetuses (based on weights of newly born, captive animals) were recorded in March (captive), July (wild), September (wild) and October (wild).

Back-dated births were based on the comparison of wild killed juvenile/sub-adult animals (not older than six months) to known-age animals born in captivity (Chapter 6).

Figure 29 a summarizes pregnancies, captive births, and back-dated births for Felis caracal in Cape Province. Although pregnant females and newly born kittens can be expected during any month of the year, reproductive activity is increased during spring and summer. A similar presentation (Fig. 29B) is given for Canis mesomelas, which by way of contrast, has a distinctly seasonal breeding regime.

Litter size may be variable. Kralik (1967) has recorded as many as six kittens in a single litter at the Brno Zoo, although none were reared by the mother. Gowda (1967) recorded two, single kitten births at the Mysore Zoo, India and Cade (1968) noted the birth of a two kitten litter at the Nairobi Zoo, Kenya. J.R.K.Green (personal communication) also recorded a two kitten litter at the Chester Zoo, England. Pringle and Pringle (1979) recorded a pre-parturition litter size of one to four kittens (seven pregnant females) for the Bedford district, Cape Province. Other authors that have recorded litter sizes from Africa are: Brand (1963) one to three at the Pretoria Zoo; Roberts (1951) two to four (sometimes five) for South Africa and Shortridge (1934) two to four for South West Africa.

In the present study, pre-parturition litters ranged from one to three kittens (22 litters) with a mean of 2,2 kittens per litter. Captive births ranged from one to four (15 litters) with a mean of 2,2. Following unusually heavy rains in the Robertson Karoo (January/ February 1981), two adult caracal (presumably females) each accompanied by two and three small kittens; all approximately six to eight weeks old; respectively were seen within a distance of seven kilometres. The first sighting was close to a road culvert, and the second to a completely flooded earth and rock erosion gulley.

Only three litters consisting of small kittens were recorded in their natural environment. One litter was collected under a small, but dense, stand of bush

(c. 0,8m) between two wheatfields (Coastal Sandveld); the second litter was taken in a collapsed antbear burrow within one metre of the surface (Robertson Karoo); the third litter was found in a large pile of cut *Acacia cyclops* branches (Coastal Sandveld).

Lactation

No published record was found for caracal of the number of teats present. During the current study 50 females were examined: 48 had two pairs of teats, and two had three pairs (All three pairs of teats appeared to be equally developed).

During the current study, lactating females were caught in the wild during March (two), August (one), October (one) and November (one).

Reproductive Development

Cade (1968) appears to be the only author to have given ages of first mating in caracal. In this particular case, a 14 month old male was placed with an 18 month old female, culminating in parturition after a gestation period of 78 days. Kingdon (1977) stated that *Felis caracal* can reach sexual maturity between six months and two years, although no specific cases are given and the six month sexual maturity estimate would appear to be far too short.

In the current study, first succesful mating for known-age caracal were established; two males successfully impregnated females culminating in births at 12,5 and 14 months of age. Two known-age females were successfully mated at 14 and 15 months. Although this sample is small, it would appear that animals rarely, if ever, reach sexual maturity before 12 months of age.

The relationship between total body mass and testes mass are presented in Fig. 30. Photomicrographs showing testicle development are presented in Figs 32 to 35.

Based on the occurrence of spermatogenesis in the testes sections examined from known-age animals, sexual maturity would appear to be reached at between 12 and 16 months.

Mean seminiferous tubule diameters for adult male caracal examined in the current study are similar no matter the season when animals were killed. Since tubule changes little after a combined testes mass of 2g is reached (Fig. 31), it would appear that tubule diameter does not vary seasonally to any extent. Although two captive male caracal in the current study successfully mated at 12,5 and 14 months, it would seem likely that successful matings in the wild take place at a later age, due to such factors as increased competition for oestrus females by more experienced, older males. Competition does not play a role under captive conditions, so that the age of successful matings in captivity should be viewed with caution.

Although direct comparisons with lion (social) and

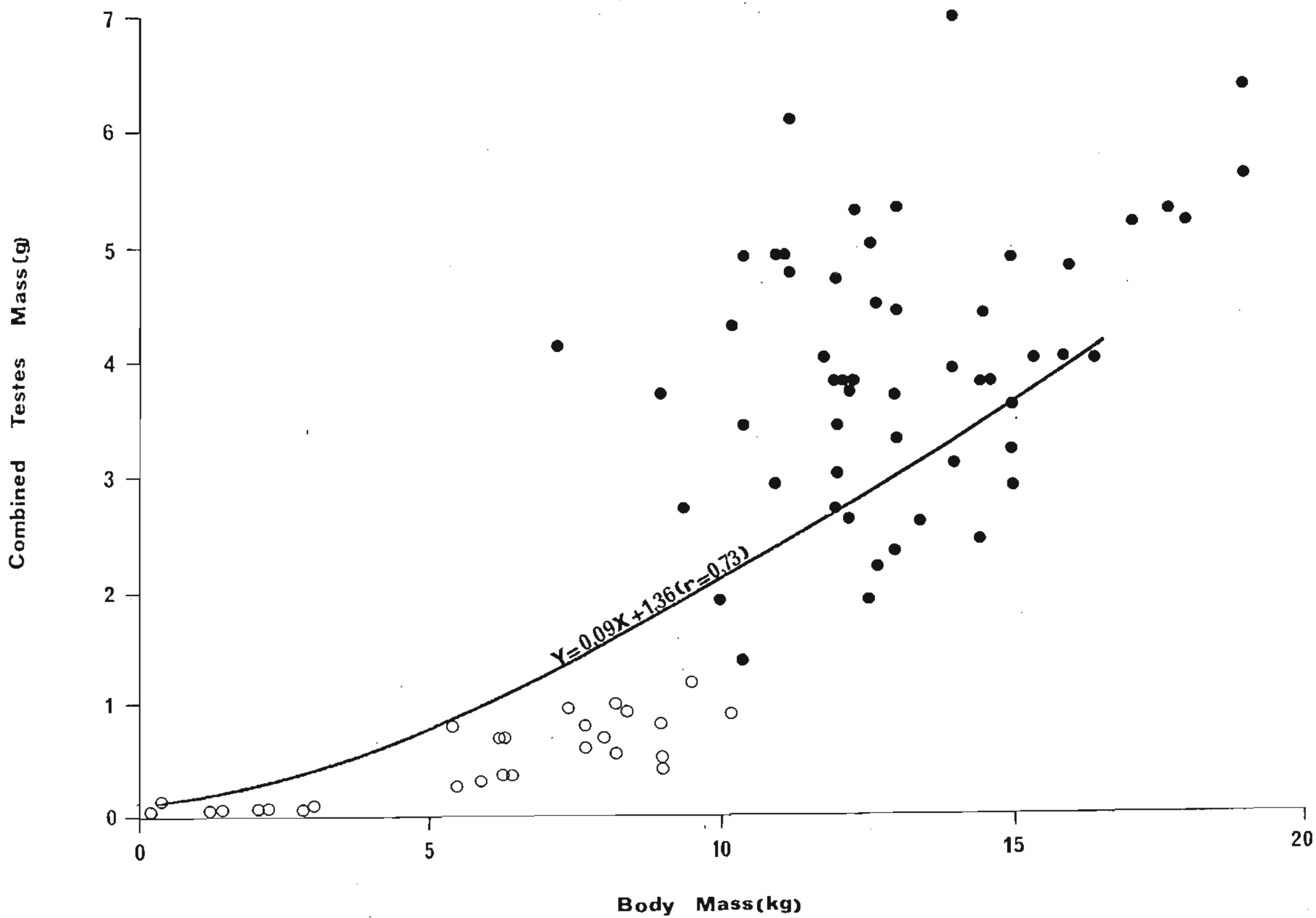

Figure 30. Relationship between testes mass (g) and body mass (kg) for immature (○), and pubertal and sexually mature (●) caracal.

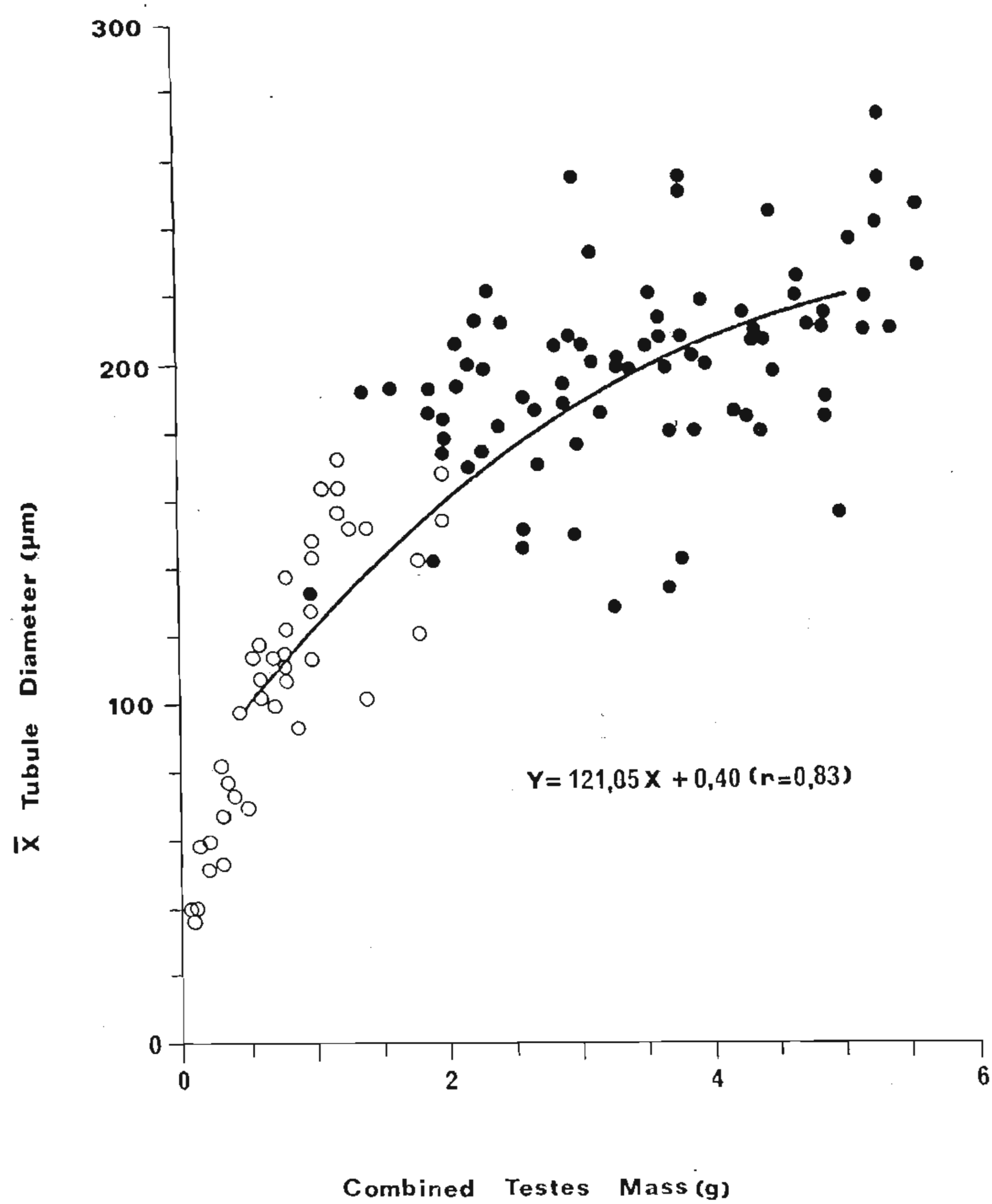

Figure 31. Relationship between testes mass (g) and seminiferous tubule diameter (µm). Ten tubule diameters were measured for each section, and the mean of each sample plotted. Immature (○), and pubertal and sexually mature (●) caracal.

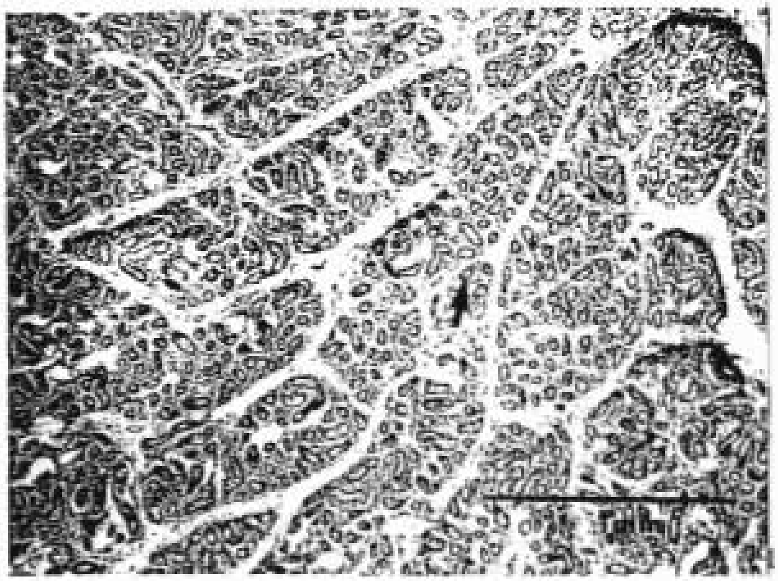

Figure 32. Histological section (5μm) of the teste of a three month old caracal. Note small size of the seminiferous tubules.

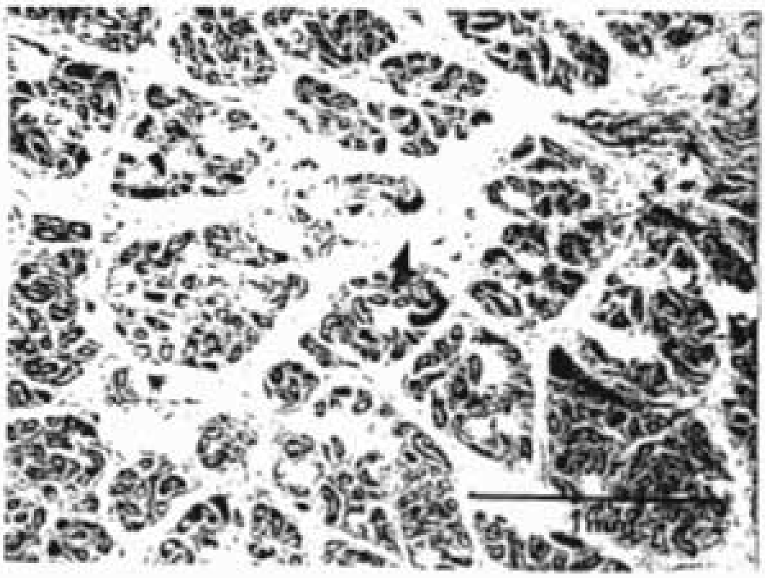

Figure 33. Section (5μm) of the teste of a five month old caracal. Note increase in development of interstitial tissue.

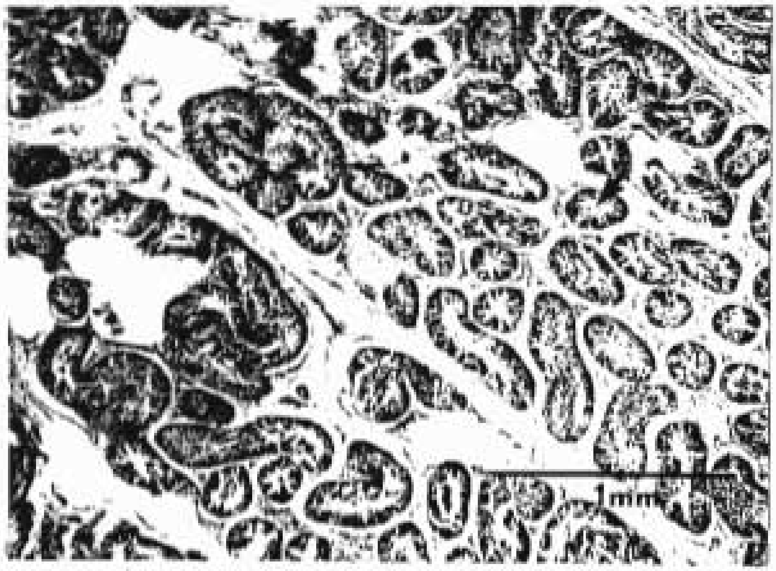

Figure 34. Section (5µm) of the teste of a ten month old caracal. Note considerable enlargement of seminiferous tubules, although no spermatogenesis has occurred.

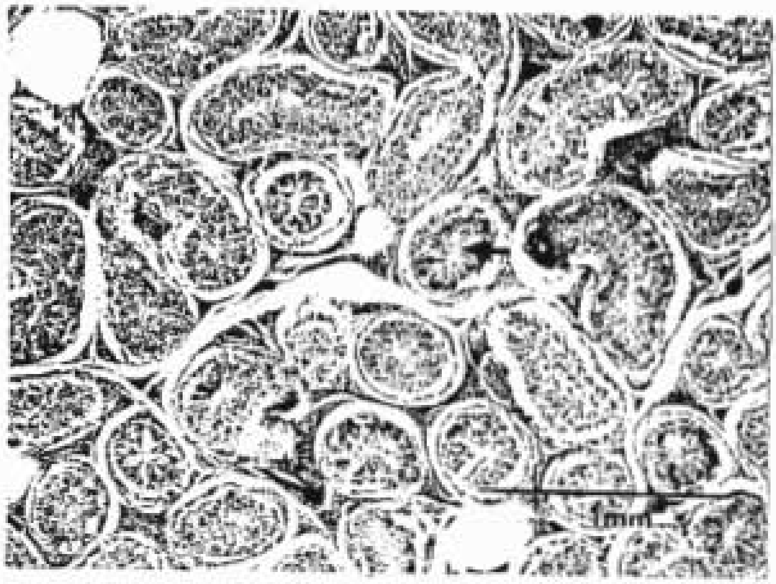

Figure 35. Section (5µm) of the teste of a two and a half year old caracal, with large seminiferous tubules in which spermatogenesis was taking place.

caracal (solitary) first breedings should not be made with any parity, there is a distinction between age of reaching sexual maturity and age at first successful mating which should be emphasized. Smuts, Hanks and Whyte (1978) for example found that although male lions were sexually mature at between 26 and 34 months of age, they only became pride (breeding) animals at 6,5 years (five to nine years). Smuts _et al_ (1978) are of the opinion that captive lionesses usually breed well before lionesses in the wild, due to a more consistant level of nutrition.

Age of first pregnancy in captive caracal females recorded in the present study was 14 and 15 months. Figure 36 illustrates the relationship between total female body mass and paired ovarian mass. Figures 37 to 40 illustrate ovarian development of female caracal.

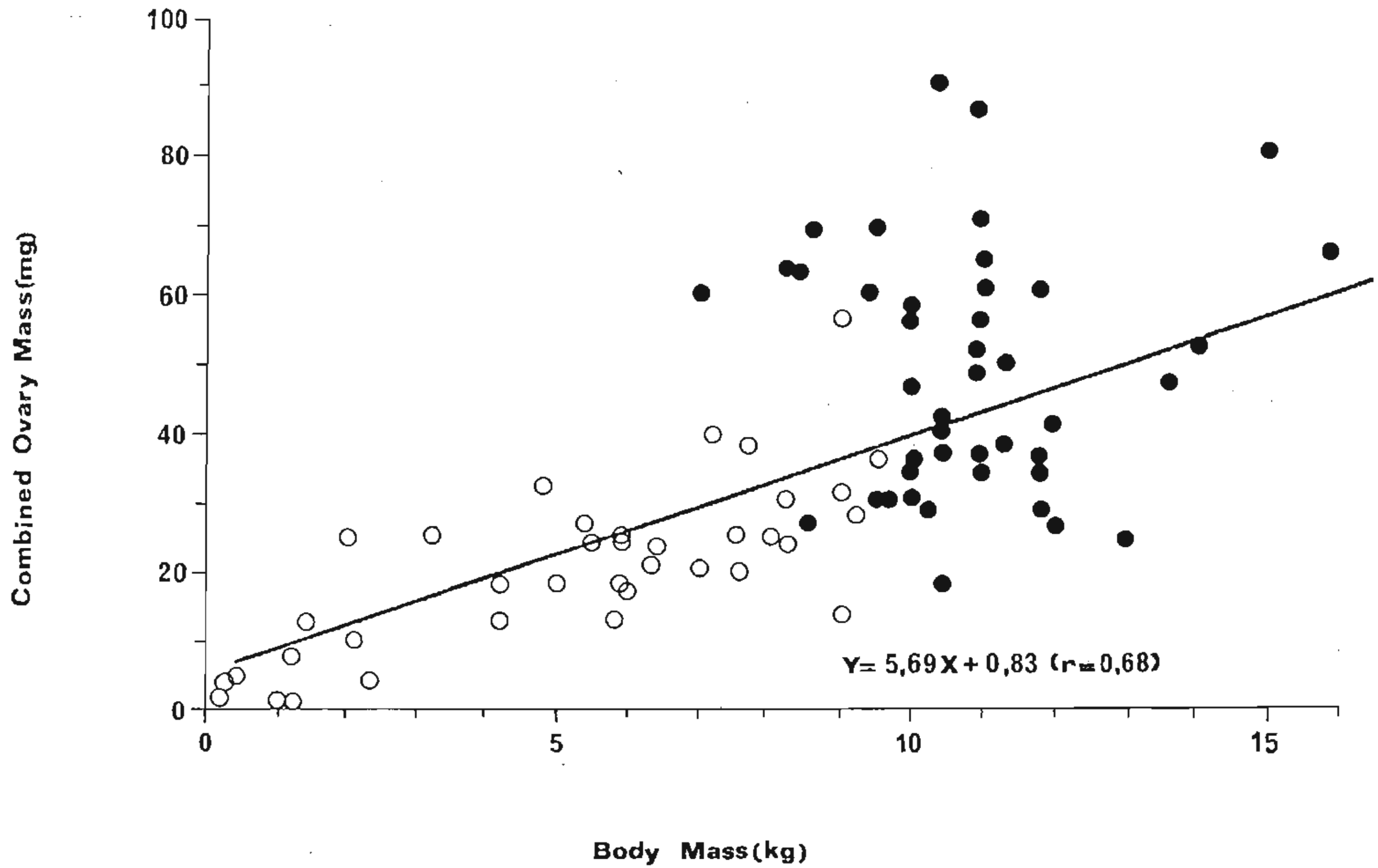

Figure 36. Relationship between paired ovary mass and body mass for immature (○), and adult (●) caracal.

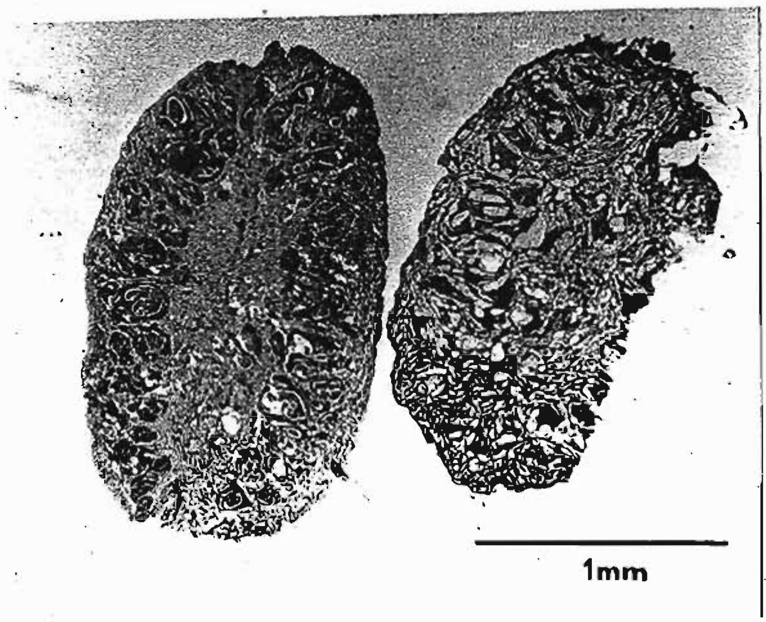

Figure 37. Histological section (5μm) of the ovary of a one and a half month old caracal.

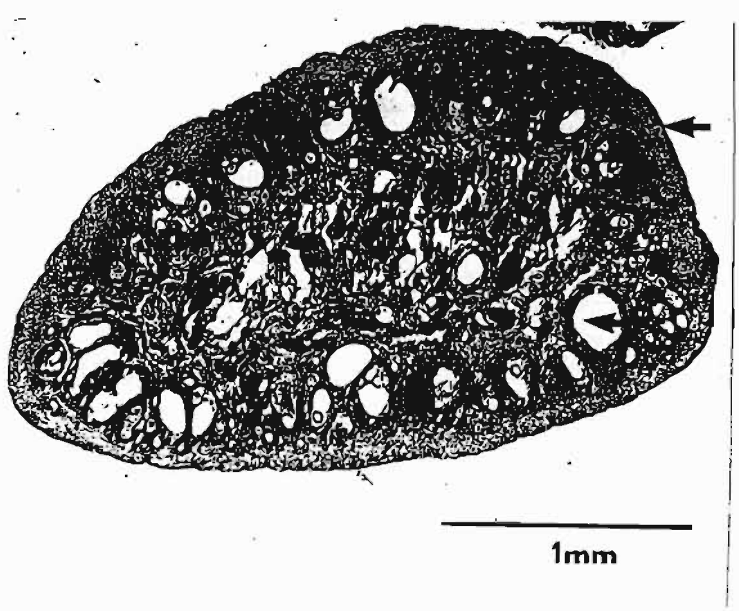

Figure 38. Section (5μm) of the ovary of a six month old caracal showing initial follicle development. Outer arrow indicates Germinal epithelium; large arrow marks a Graafian follicle.

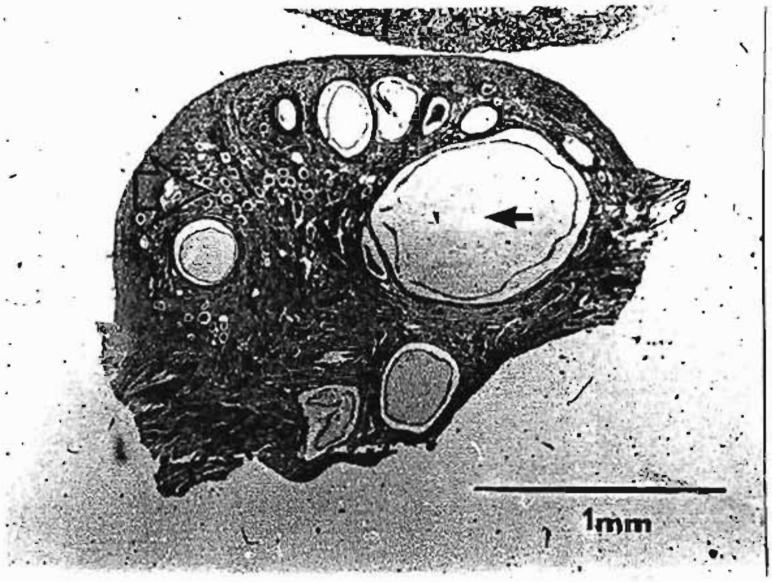

Figure 39. Section (5μm) of the ovary of a ten month old caracal showing primary follicles(large arrow); small arrow indicates Corpus luteum.

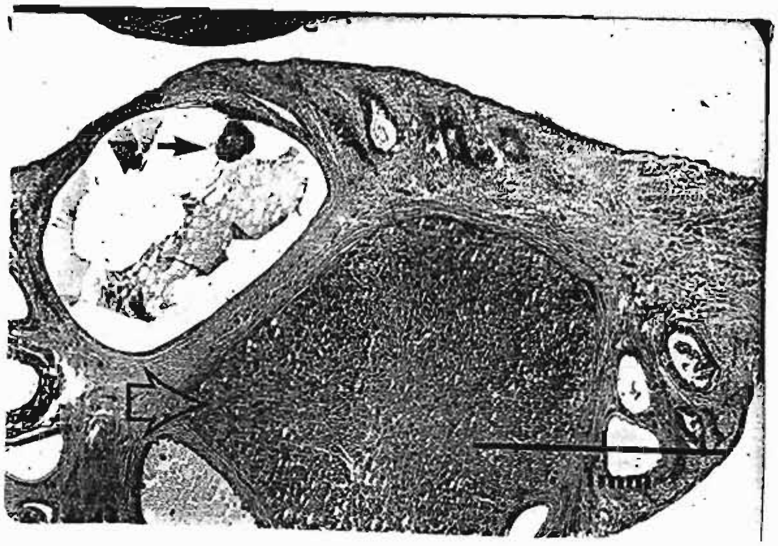

Figure 40. Section (5μm) of the ovary of an adult, pregnant caracal showing a large Corpus luteum (large arrow).

CHAPTER 6

GROWTH, AGE, POPULATION STRUCTURE AND MORTALITY

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 ageing criteria for black-backed jackal (*Canis mesomelas*) and Smuts, Anderson and Austin (1978) have done similar studies on the lion (*Panthera leo*). Other than these two references, little detailed work on carnivore ageing has been undertaken. One of the primary reasons for the lack of ageing data is the shortage of known-age animals which can be used to form a comparative reference series. Criteria for age determination used in the present study are based mainly on physical external growth and morphology, tooth eruption, and skull growth. Closure rate of pulp cavities of maxillary canines and the use of incremental lines of dental cement were also investigated, but are only briefly discussed.

Methods

Known-age animals (27 caracal: 12 males and 15 females) were culled during the course of a captive breeding programme specifically aimed at obtaining known-age animals for reference. Captive animals were measured (head and body, tail, hind foot, ear) and weighed at regular intervals with some individuals sacrificed (animals were injected with Euthobarb) at specific agés for skeletal material (primarily skulls for measuring) and dental processing. A total of 754 skulls were collected (430 males and 324 females), primarily from the western and southern Cape Province.

The eruption sequence of the deciduous and permanent teeth of both the upper and lower jaws was determined with reference to known-age animals. The complete sequence of animals less than one year old was obtained by comparing skulls of caracal collected in the wild which were constructed into a series from the youngest to the oldest.

Figure 41 shows a typical adult male caracal skull; Figs 42 and 43 show the measurements which were taken with a measuring board and vernier calipres (all measurements taken in a straight line).

Age at which the apical foramen to the pulp cavity closed in the canines was also recorded. As an additional method for determining the age of caracal, longitudinal tooth sections were prepared from the entire length of the upper right canine. Sections were ground down to approximately 20µm, using several grades of water paper before being decalcified in 2,5% nitric acid for 10 minutes. Sections were neutralised in a saturated solution of lithium carbonate and 70%

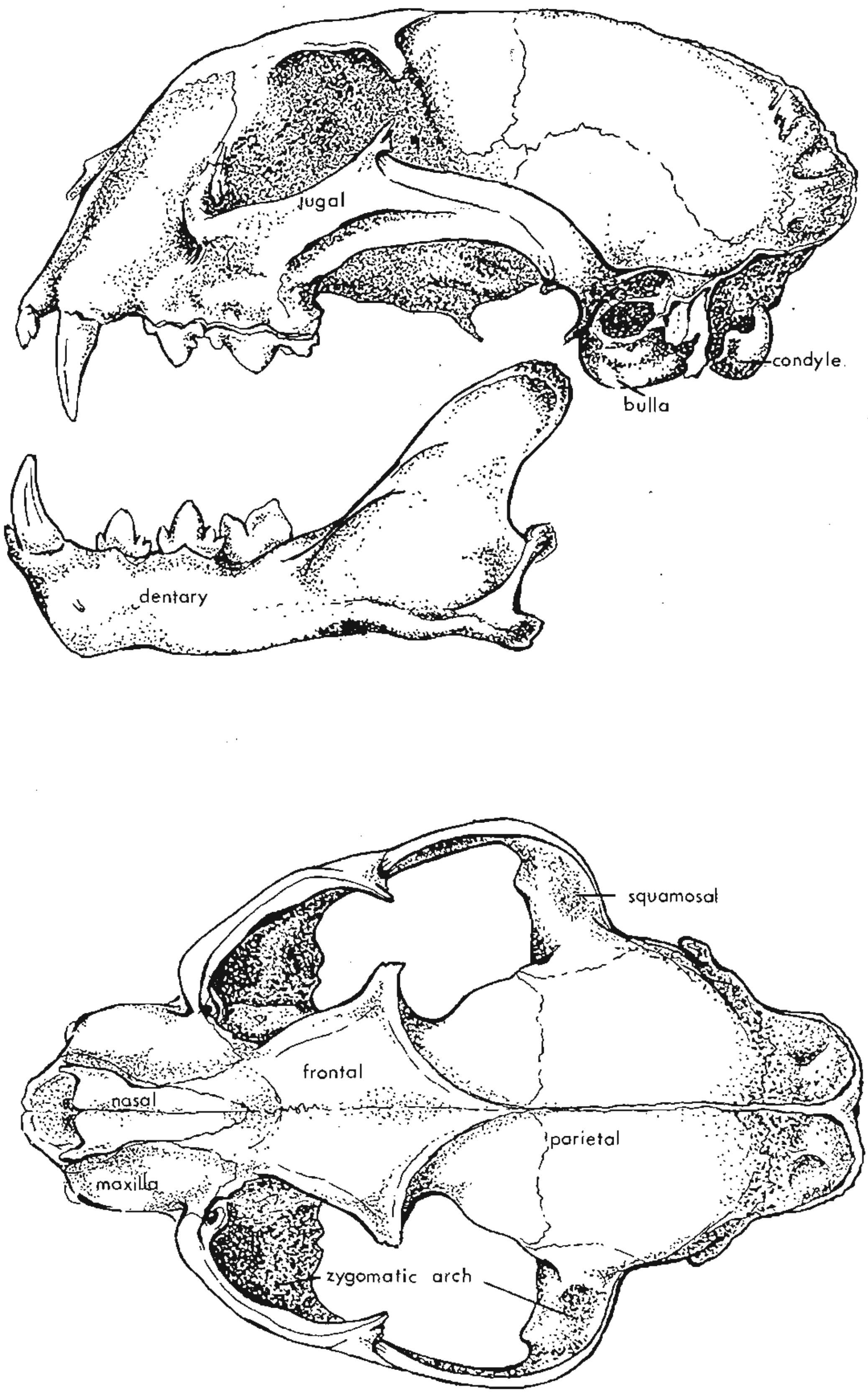

Figure 41. The skull of two year old (13kg) male <u>Felis caracal</u> from Riversdale, Southern Cape Province.

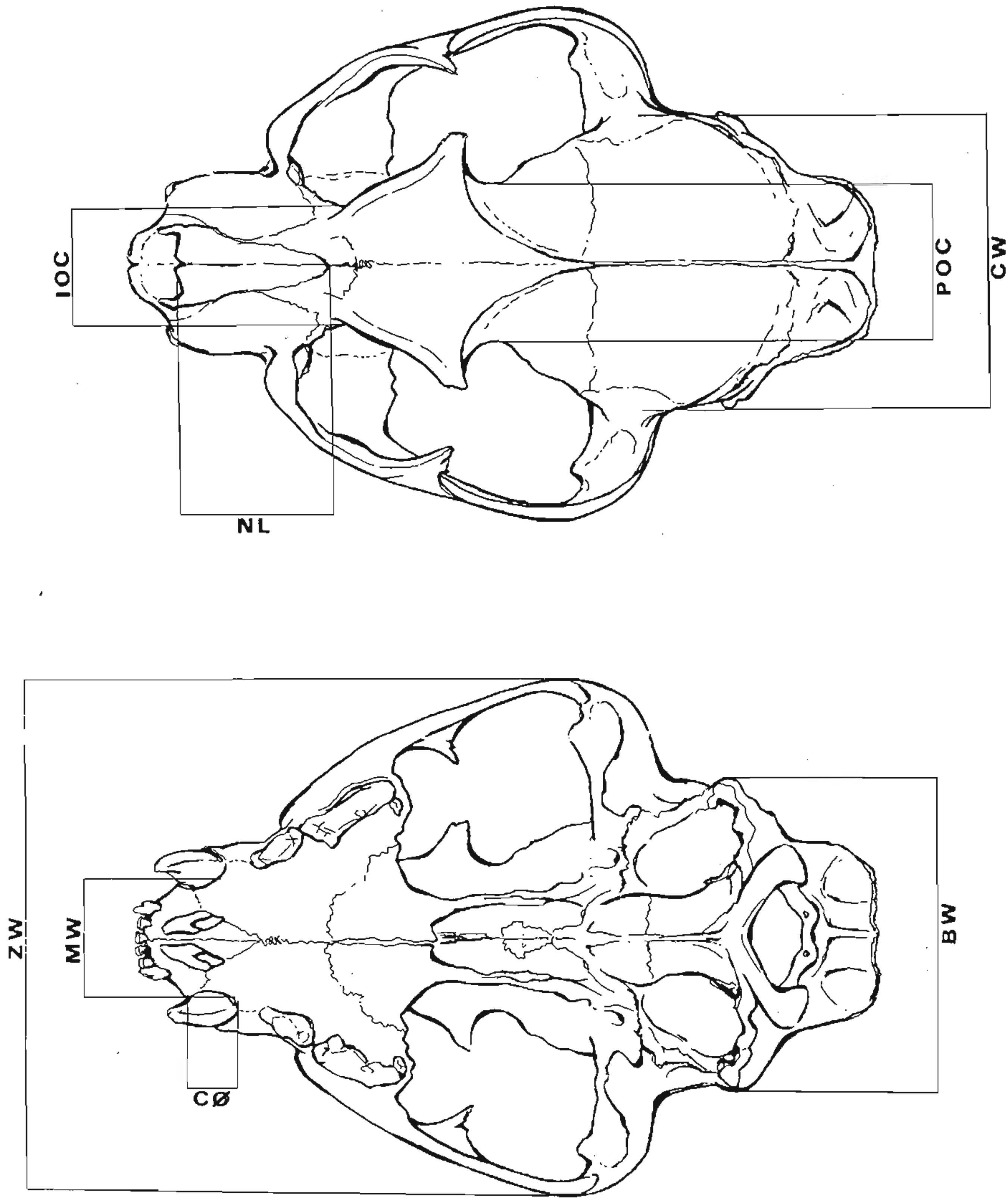

Figure 42. Cranial measurements used in establishing the sexual dimorphism of adult caracal. Key: IOC- Interorbital constriction; POC- Postorbital constriction; CW- Cranial width; NL- Nasal length; ZW- Zygomatic width; MW- Maxillary width; BW- Width at bullae.

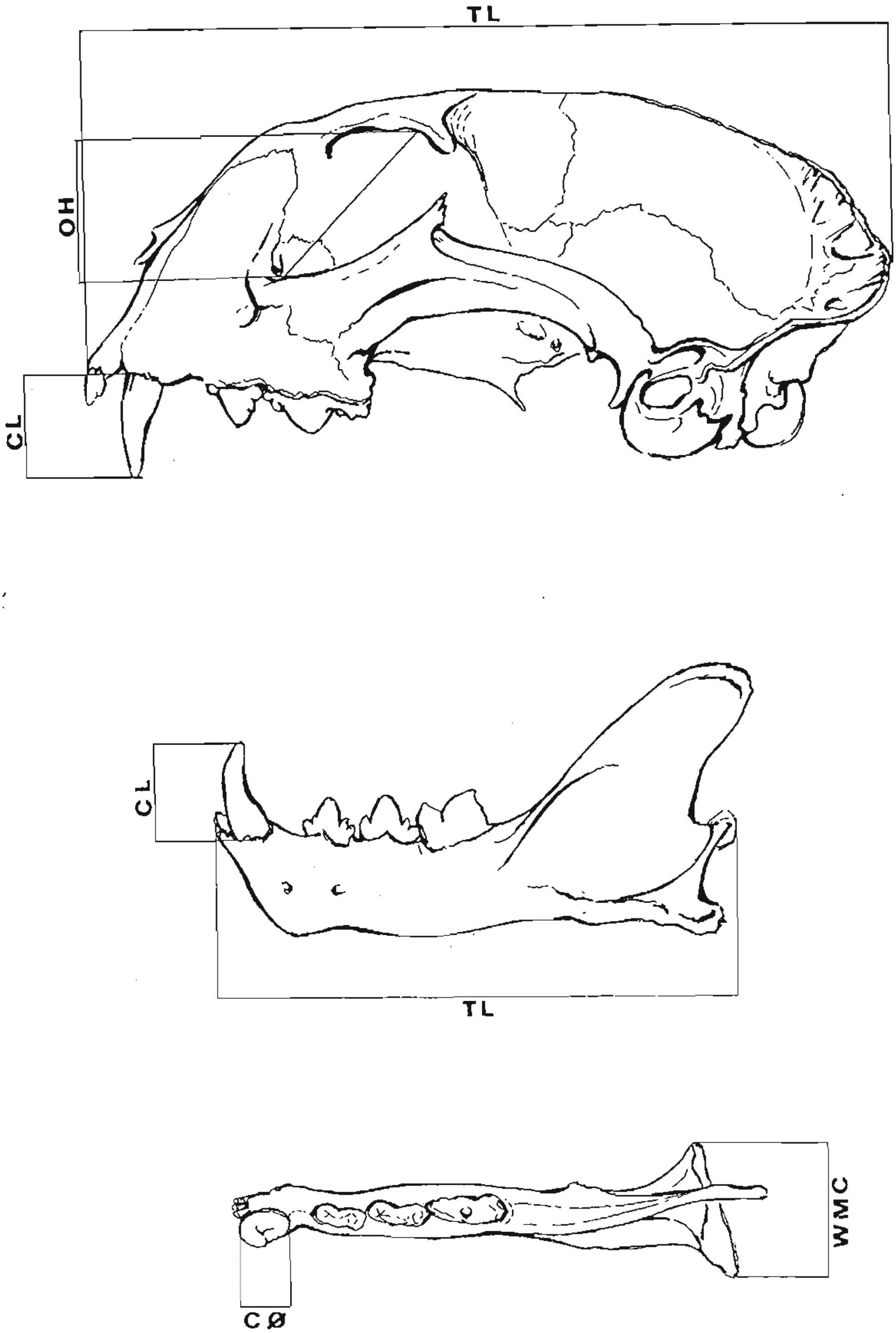

Figure 43. Cranial and mandibular measurements used in establishing the sexual dimorphism of adult caracal. <u>Key</u>: TL- Total length; OH- Orbital height; CL- Canine length; CØ- Canine greatest diameter; WMC- Width mandibular condyle.

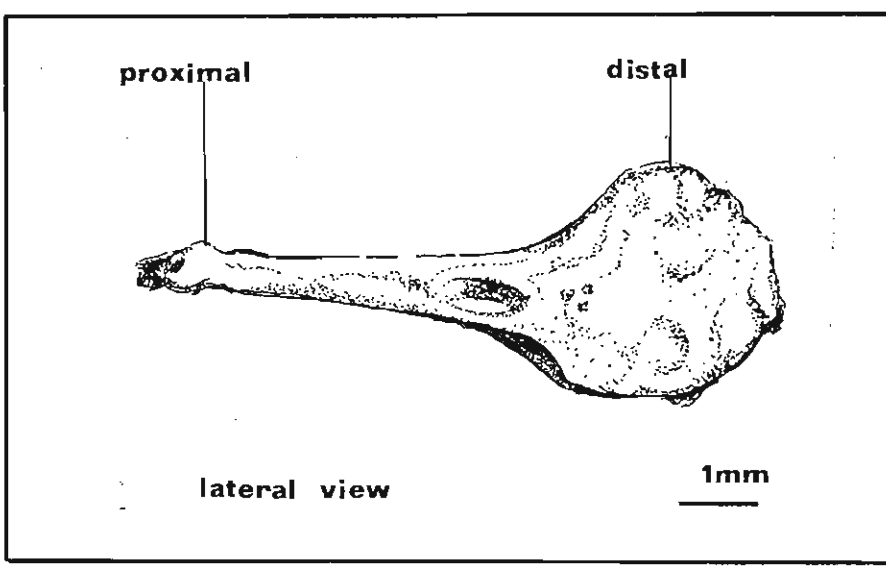

Figure 44. Baculum of a two year old male caracal.

ethanol for 30 minutes. After washing, the sections were stained for approximately 10 minutes in Meyers haemotoxylin, and blued for five minutes in Scott's water. After dehydration, the tooth sections were mounted permanently on slides with clear mountant (DPX).

Eye lens masses were recorded for 20 known-age caracal. The lens of the left eyeball was removed and the vitreous humor of the right eyeball injected with 10% formaldehyde. After eight months preservation, the eye lenses were oven dried at 80°C until no decrease in eye lens mass was noticed. When a constant mass was attained, the lenses were placed in dessicators to cool for 10 minutes before measuring mass.

Male bacula were initially removed by maceration of the penis, but the extremely small size (Fig. 44) made accurate ageing difficult. Consequently, ageing criteria utilizing bacula were not established.

Behavioural development for captive, known-age kittens from birth through into adulthood ($>$ one year) was recorded.

Results and Discussion

Growth Curves

Figures 45 (a) to 45 (e) show the mean growth of 12 (six male, six female) captive, known-age caracal from birth to the point where maximum growth was achieved. Measurements

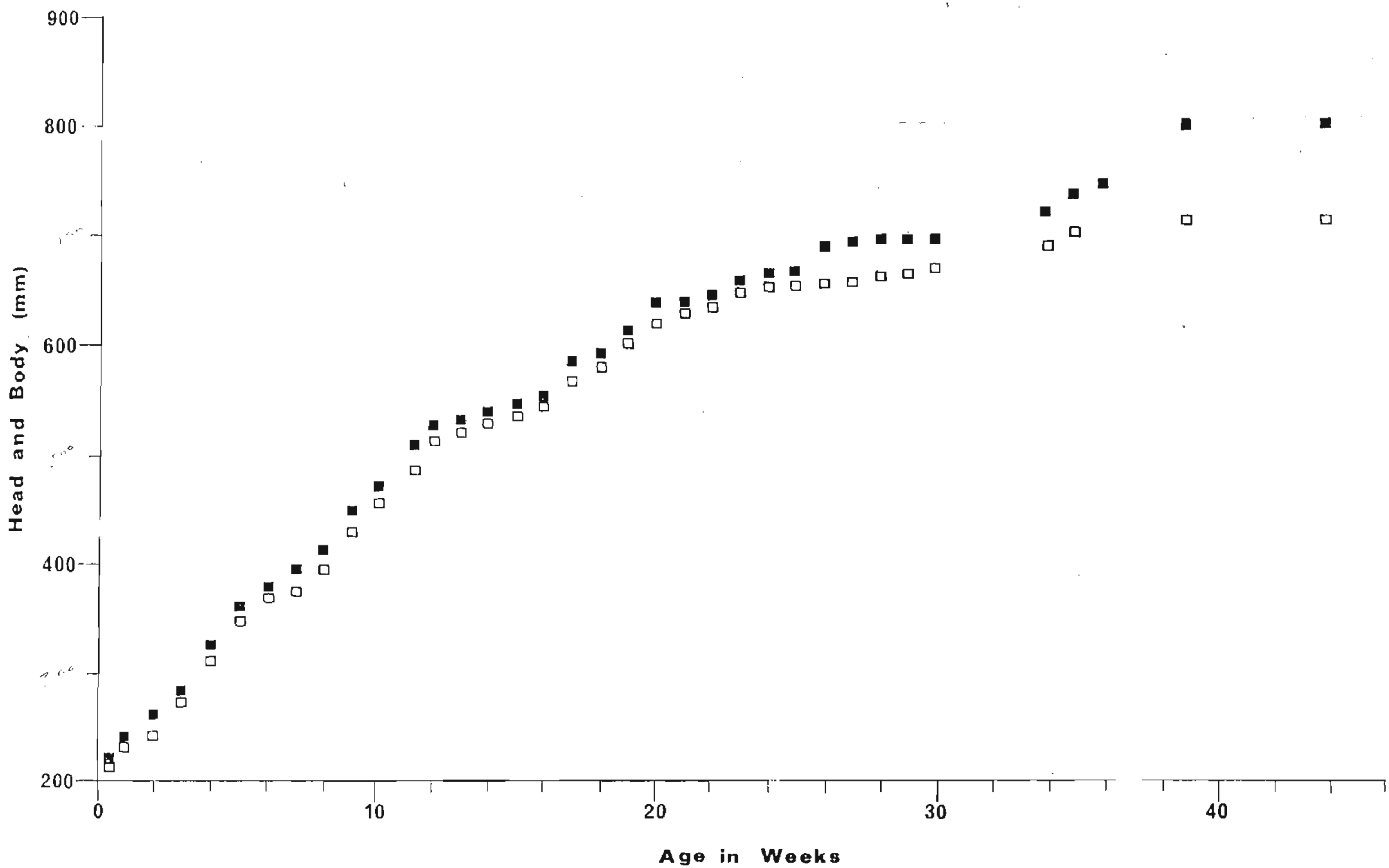

Figure 45 (a). Mean growth curves (head and body) for six male and six female caracal (■ - male; □ - female).

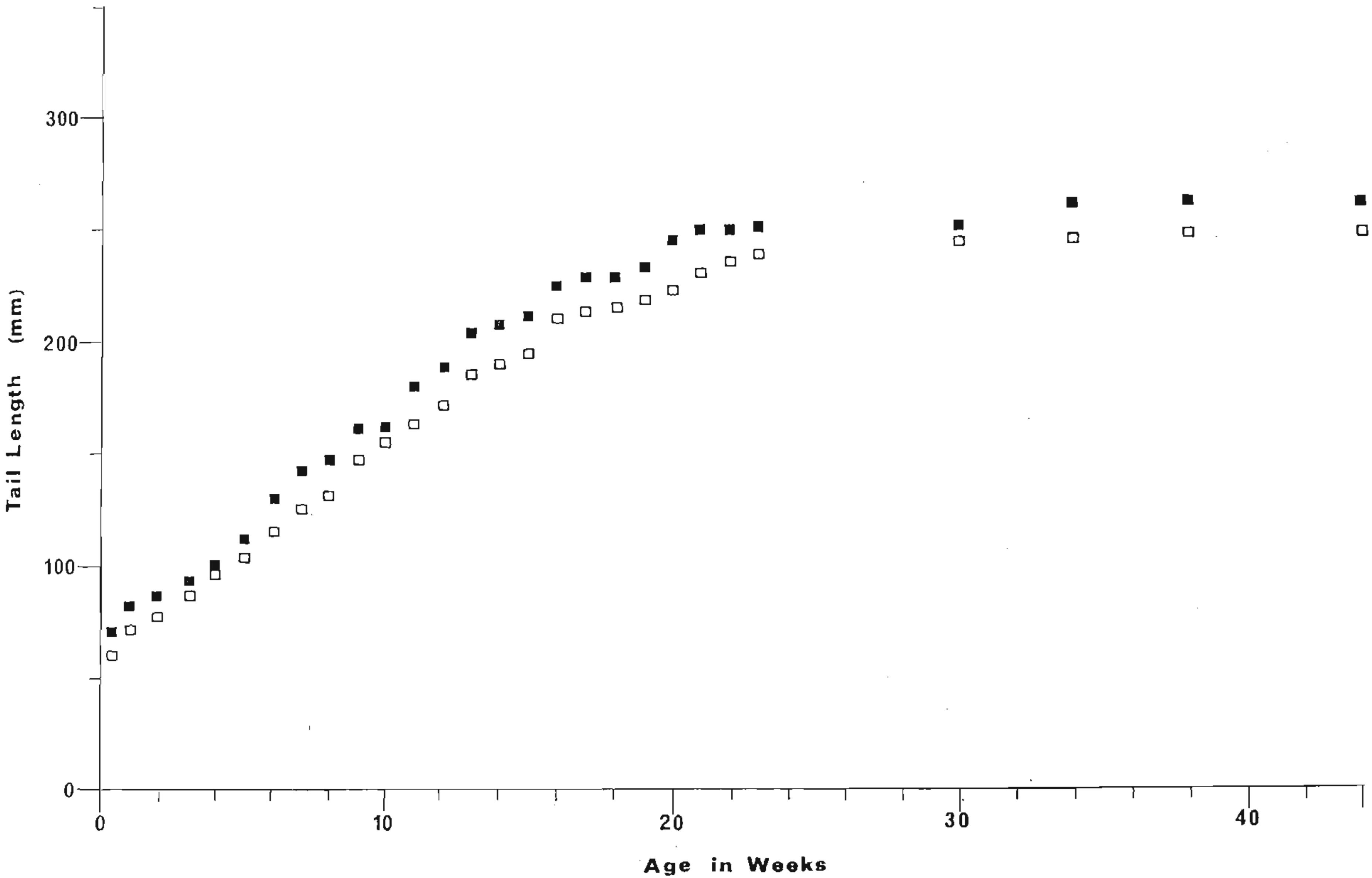

Figure 45 (b). Mean growth curves (tail) for six male and six female caracal
(■ - male; □ - female).

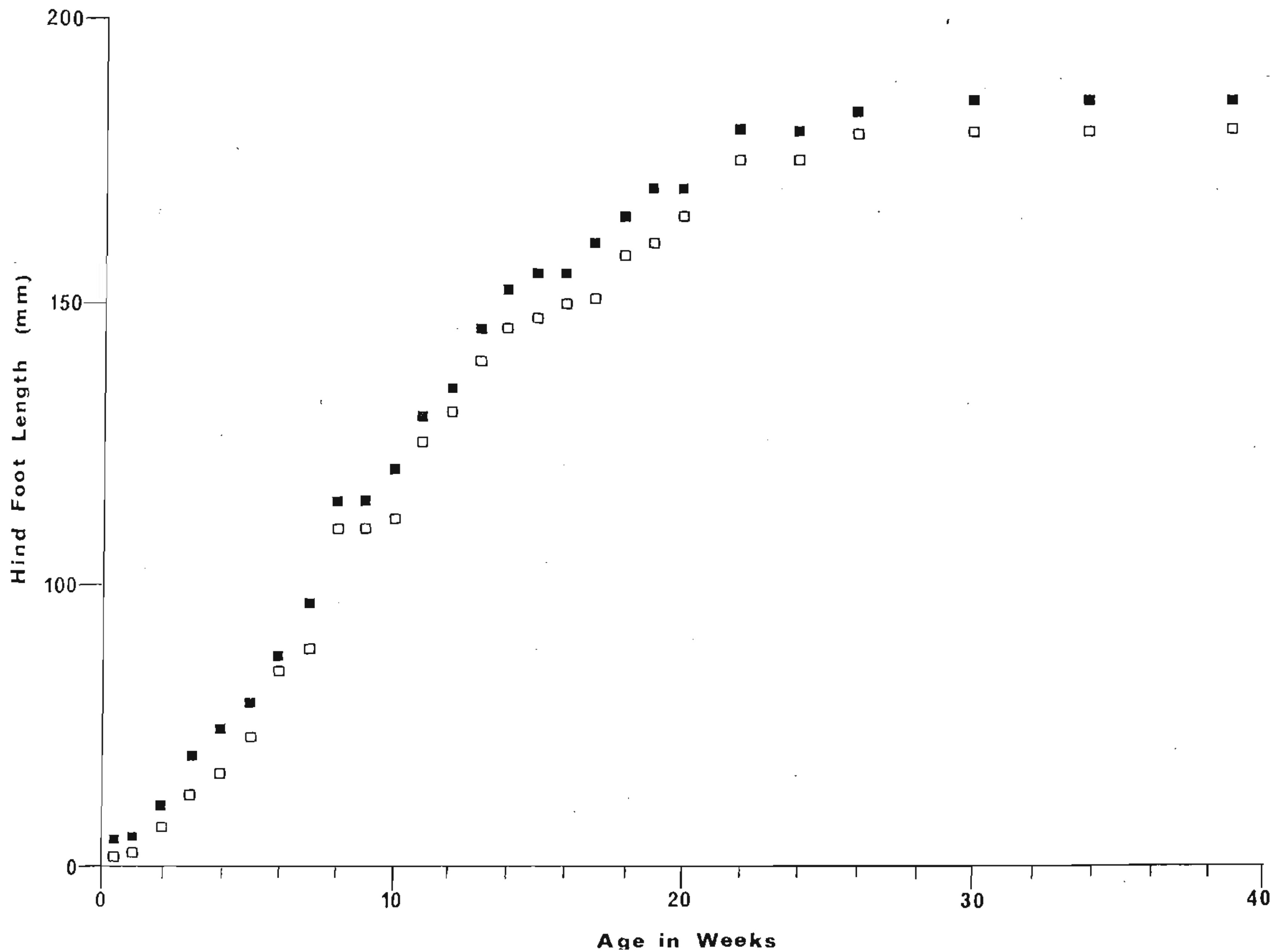

Figure 45 (c). Mean growth curves (hind foot) for six male and six female caracal (■ - male; □ - female).

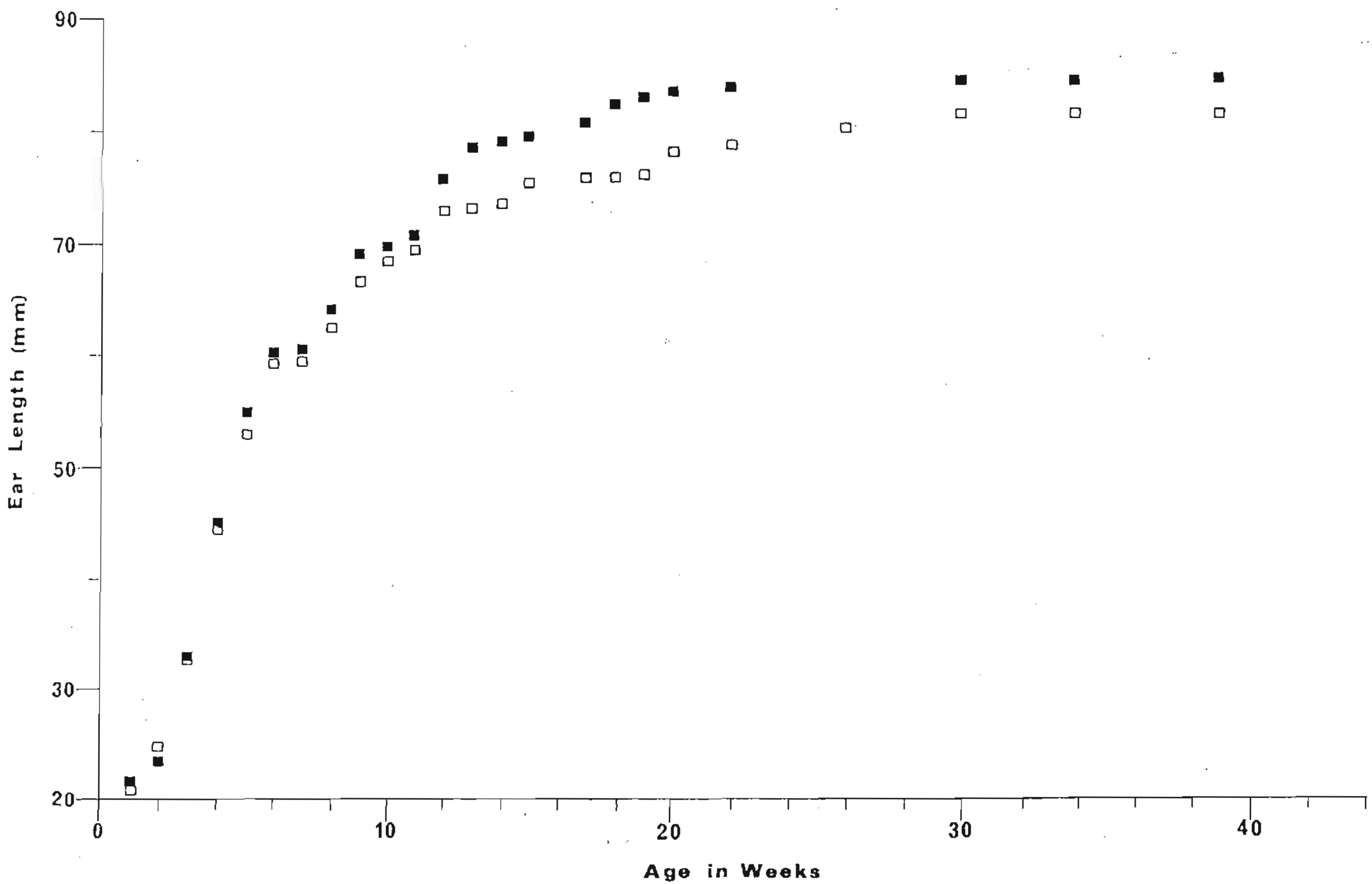

Figure 45 (d). Mean growth curves (ear) for six male and six female caracal(■ - male; □ - female).

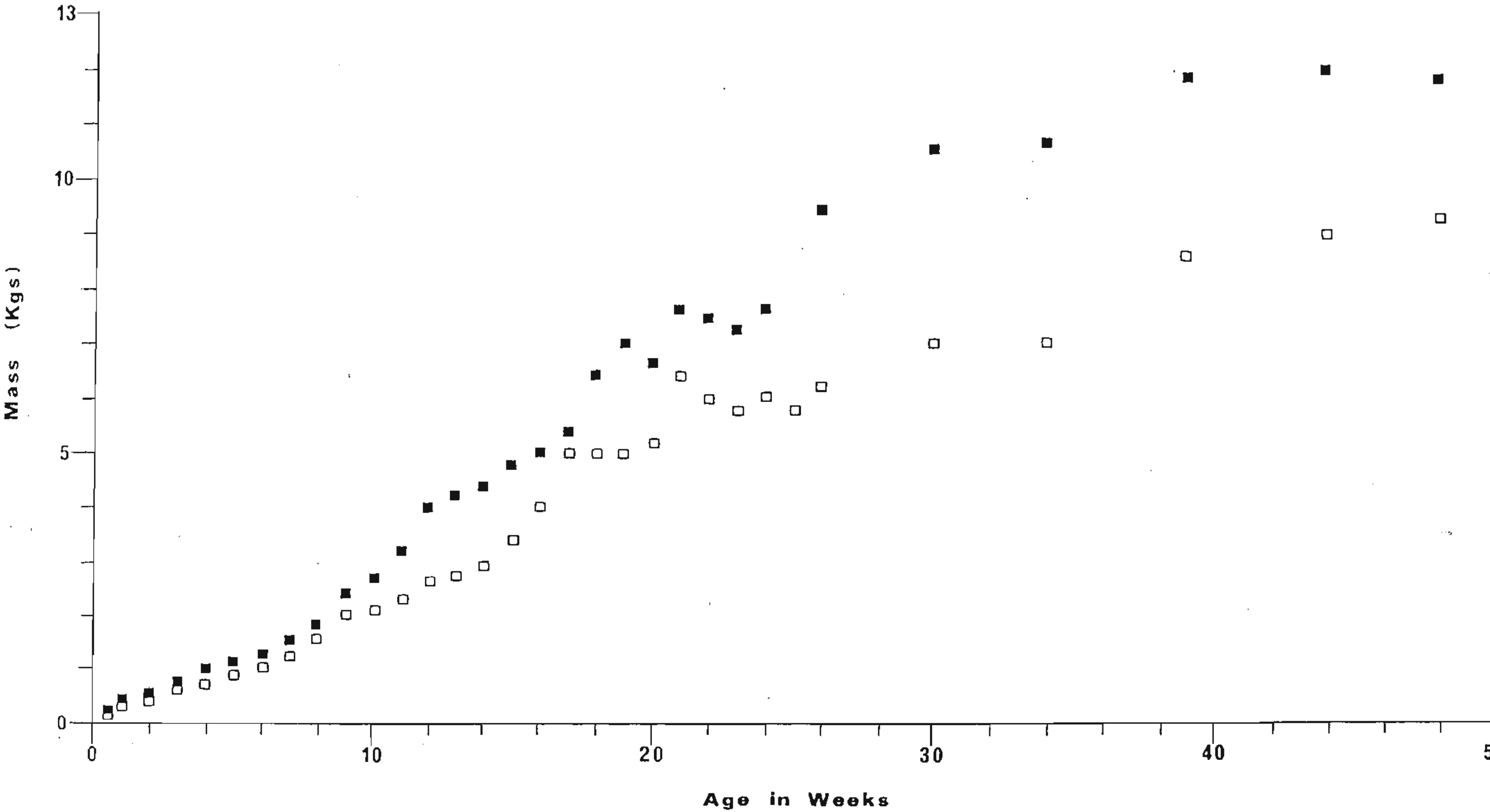

Figure 45 (e). Mean growth curves (mass) for six male and six female caracal (■ - male; □ - female).

described are 1) head and body, 2) tail, 3) hind foot, 4) ear and 5) mass.

Growth of skulls expressed as total skull length to zygomatic width, is presented in Fig. 46. Appendix 3 gives the skull measurements of all known-age material.

Development of Dentition and Ageing.

Tooth eruption and replacement were the primary ageing criteria used in this study for establishing the age of caracal less than one year of age.

The dentition of the caracal follows the characteristic pattern for the Felidae in that the deciduous and permanent tooth formulae are:

$$2 \quad I \frac{1,\ 2,\ 3}{1,\ 2,\ 3} \quad C \frac{1}{1} \quad P \frac{3,\ 4}{3,\ 4} = \text{24 for the deciduous teeth and,}$$

$$2 \quad I \frac{1,\ 2,\ 3}{1,\ 2,\ 3} \quad C \frac{1}{1} \quad P \frac{2,\ 3,\ 4}{3,\ 4} \quad M \frac{1}{1} = \text{30 for the permanent teeth}$$

In a sample of 50 skulls, P^2 was present only in eight adult skulls (16%). Teeth comprising the permanent and deciduous dentitions of the caracal are illustrated in Fig. 47.

The eruption sequence of each tooth and chronological age of the caracal are given in Table 7. No distinction was made between males and females, as only slight

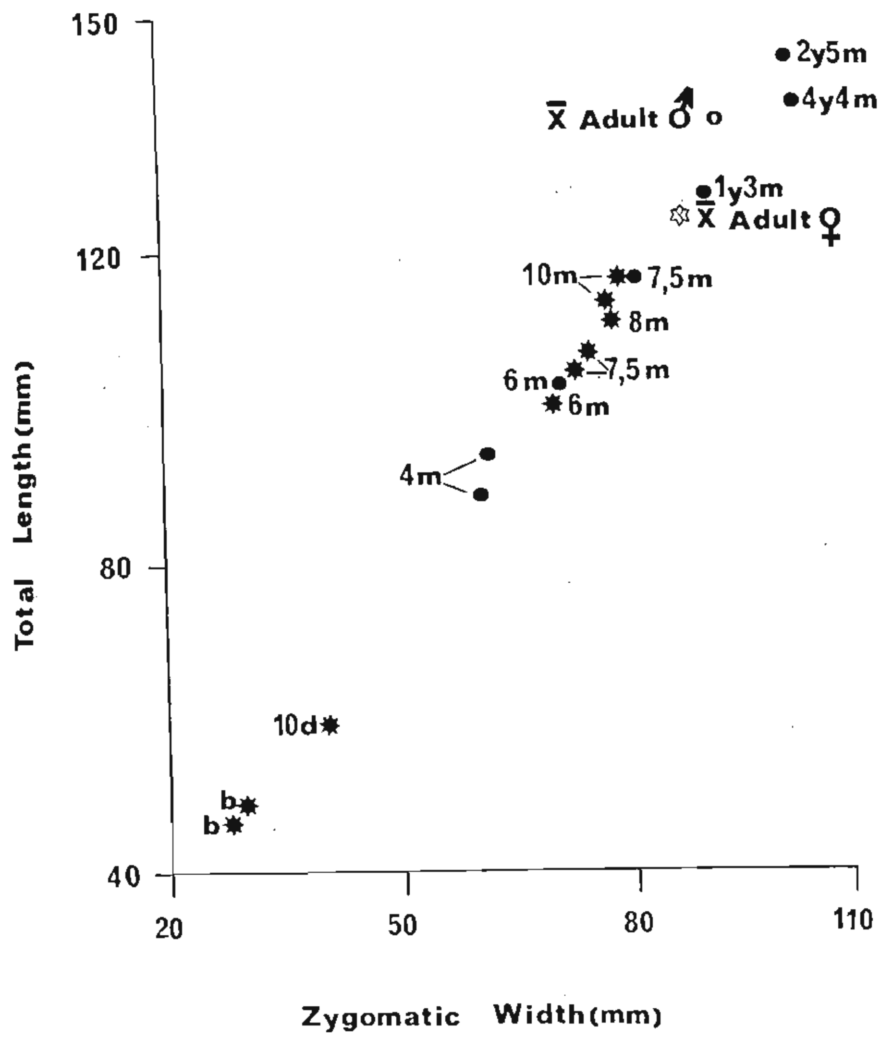

Figure 46. Growth of skulls of known-age Felis caracal (total length/zygomatic width). ✱ - female; ● - male. Mean sizes of adult skulls are given for comparative purposes.

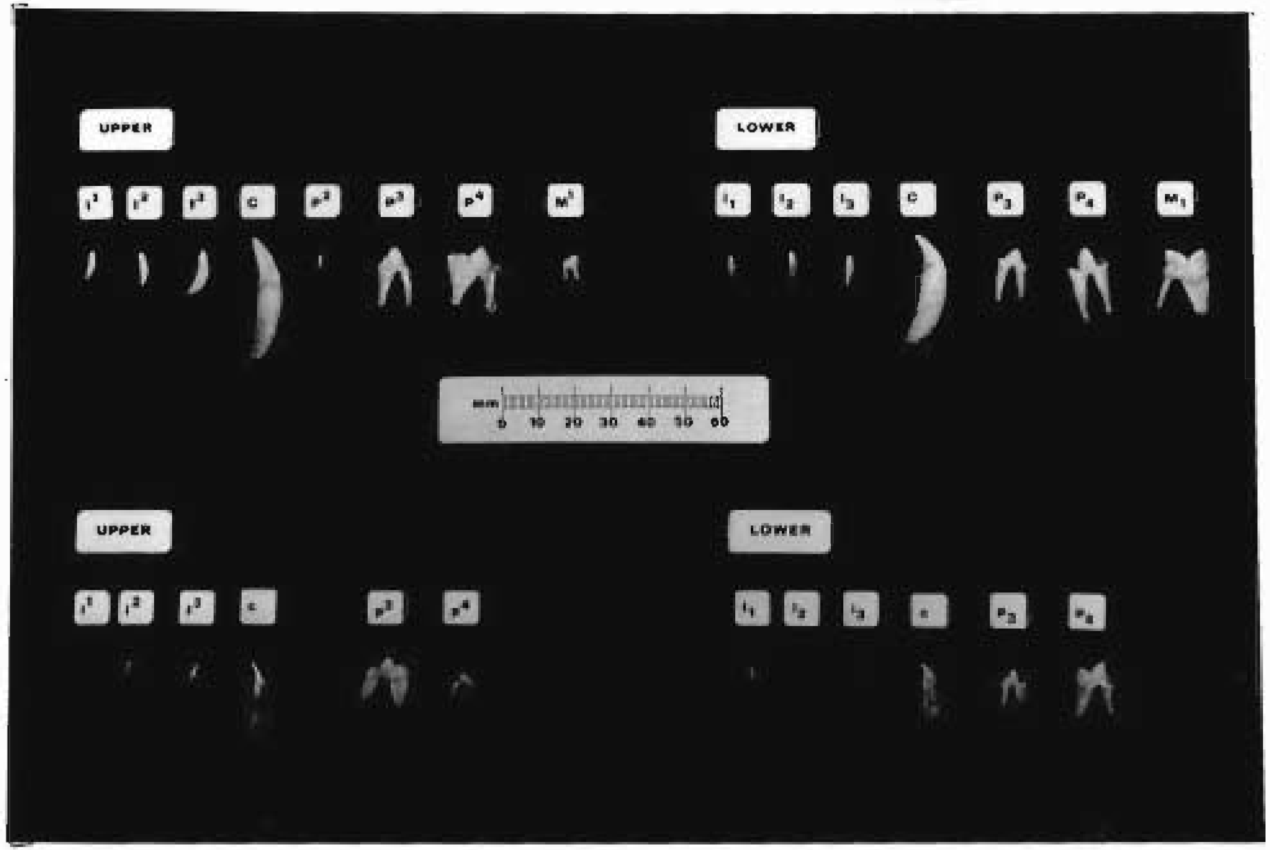

Figure 47. The permanent teeth (upper row of 15) and corresponding deciduous teeth (lower row of 12) of the caracal. Only teeth from left upper and lower quadrants are shown.

Table 7. 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, 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_1 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	I^1_2 I_1; I^2 I_2 replace i^1 i_1; i^2 i_2.
6 months	3	I^3 and I_3 just visible. C^u displacing c^u P^4 visible and p^4 displaced.	3	I^3, I_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 four skulls.

differences were apparent. Appendix 4 (1 to 8) illustrate the different stages of tooth eruption from birth to full permanent dentition, with Figs 48 and 49 illustrating levels of tooth wear.

Of all the skulls examined, only three showed gross deformities, 1) "bulldog" compression in the vicinity of the post and pre-orbital constrictions, 2) an adult male (estimated at three years) with deciduous $C\frac{1}{1}$ still in place, although other teeth fully developed and showing wear, and 3) an adult female (c. three years) with total absence of lower canines (Fig. 50). X-rays revealed no vestigal teeth.

Figure 48 a. A male caracal skull at less than two years showing very little tooth wear.

Figure 48 b. Ventral view.

Figure 49. An adult male caracal skull (> 4 years)

(a) showing wear on all teeth.

(b) ventral view of the same skull as (a); one C^u was removed for sectioning.

Figure 50. The skull of an adult (c. three year old) caracal female. C_1 were totally absent and x-rays revealed no vestige in the bone material. The animal was in good condition.

<u>Closure rate of the apical foramen</u> of the pulp cavities was checked against age; the findings were as follows:

1) complete emergence of permanent, upper canines (c. 10 months); the apical foramen had a greatest diameter of 3,4mm (n= 4).

2) At one year and three months the apical foramen had a greatest diameter of 1,65mm (n= 2).

3) At two years of age the apical foramen is completely closed (n= 2).

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

<u>Tooth sections</u> were made from three known-age animals (one year and three months, two years, and four years) and 100 caracal caught in the wild, and examined for incremental growth lines in the cementum and dentine. As Smuts <u>et al</u> (1978) found with lion, dentine lines in <u>F.caracal</u> tooth sections were difficult to interpret with a great deal of variation between individuals. Therefore, evaluation of dentine lines was not pursued further. Furthermore, the occurrence of incremental lines in the current sample was also found to be inconsistant and variable, and it was concluded that

this method of ageing was not reliable for caracal.

Eye lens mass (oven dried) of known-age caracal is presented in Fig. 51.

Physical and Behavioural Development

Physical development is summarized in Fig. 52 based on 12 captive born kittens. Cade (1968) observed that kittens (one male, one female) were able to raise their heads at two days of age; at three days were beginning to crawl round the nest box, eyes began to open at four days and were completely open by the sixth day, and at one month were able to run.

Kralik (1967) found that the eyes of caracal kittens open at nine to 10 days, and at three weeks they leave the nest and learn to chase moving prey. The same author found that kittens were taking solid food at one month and are fully weaned at six months. Kingdon (1977) noted that the eyes open at 10 days. Solid food is taken for the first time at about two months, and they are weaned at anytime between the 10th and 25th week after birth.

In the current study, kittens were weaned between 15 and 24 weeks of age with first solids being taken (meat chewed and swallowed, not just licked) between three and a half and eight weeks.

The first recorded call was a bird-like chirrup shortly

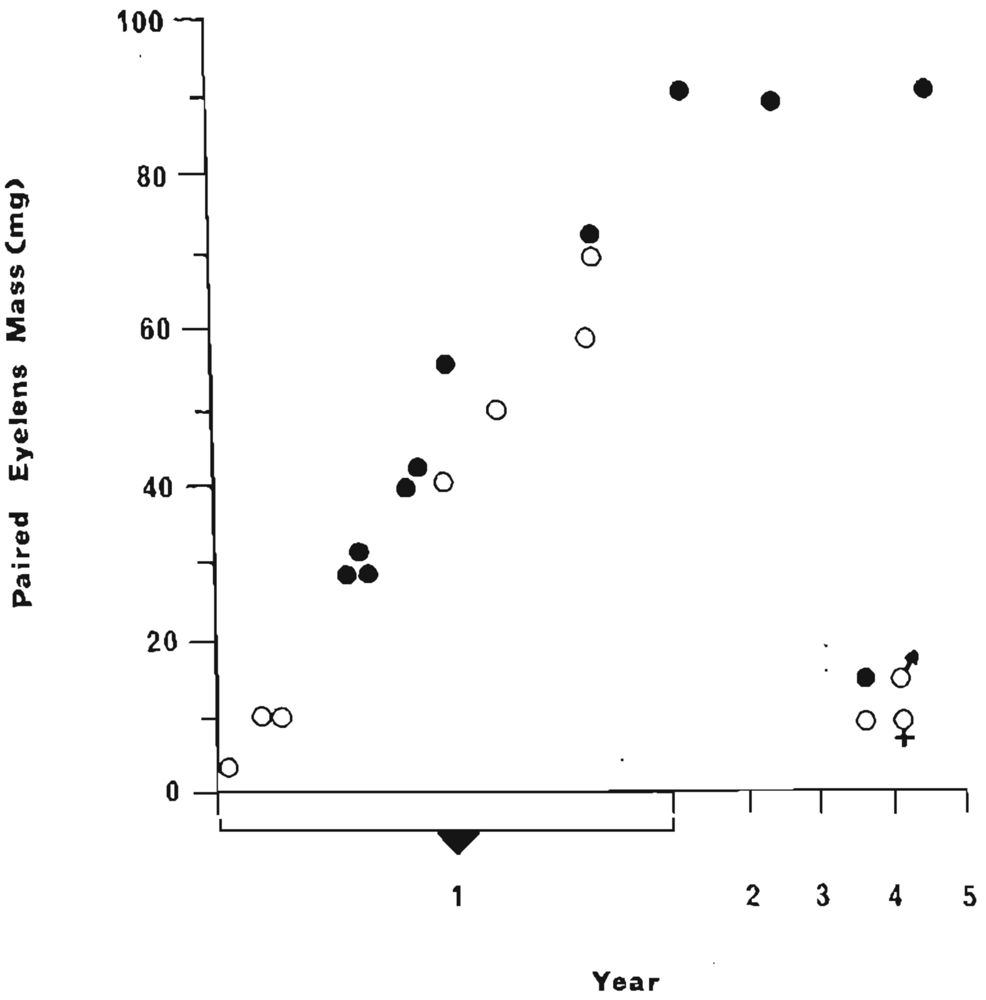

Figure 51. Paired, oven-dried, eyelens of known-age *Felis caracal*.

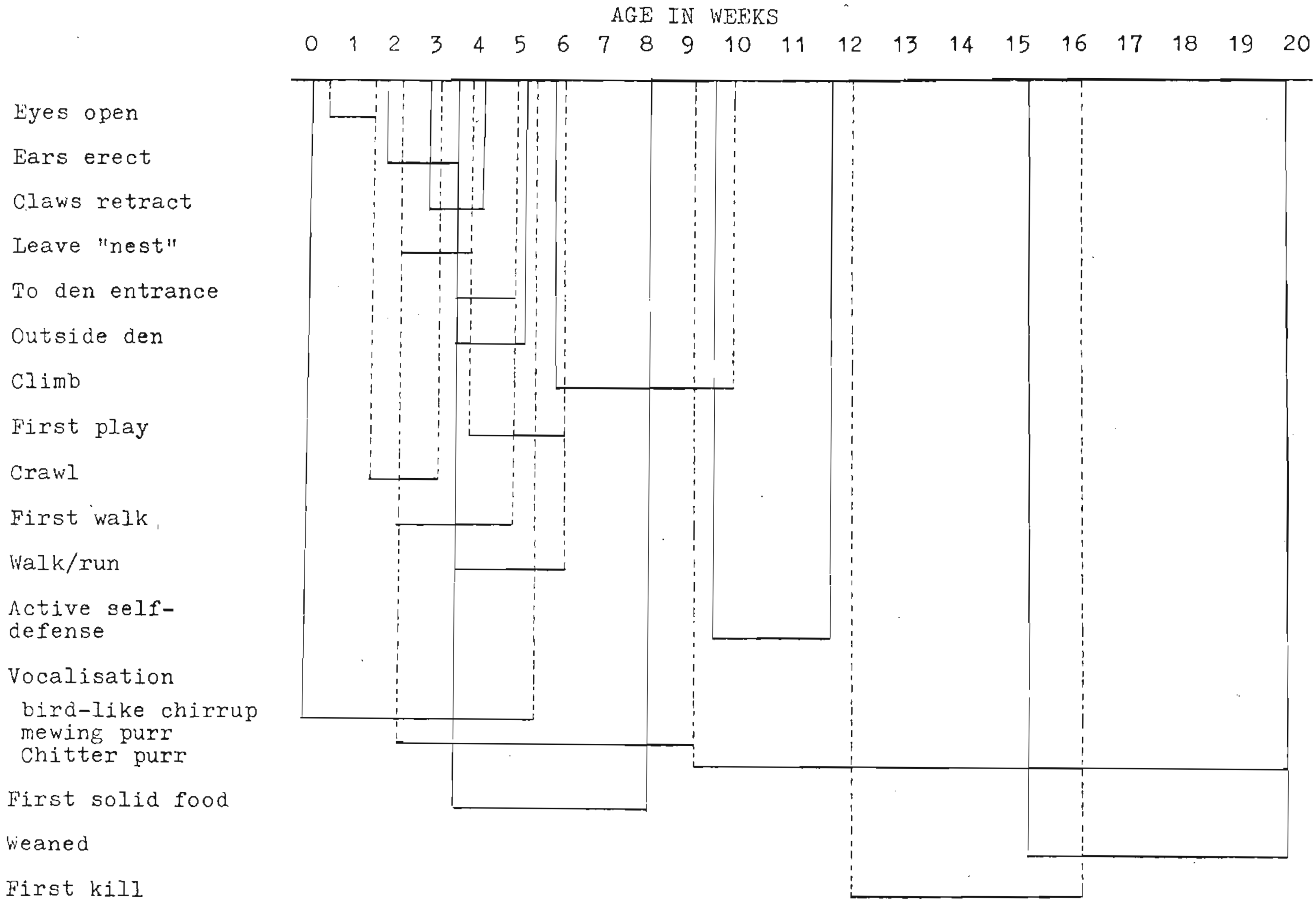

Figure 52. Physical and behavioural development of caracal kittens based on observations of 12 captive born animals.

after birth. This "chirrup" call was the only type of vocalization up until two and a half weeks of age, and persisted in a tame, house-trained caracal to the age of one year (associated with hunger). A mewing-purr entered the vocabulary at two and a half weeks, and a chitter/purr/hiss continued into adulthood from approximately nine and a half weeks.

At three and a half weeks to four weeks, the kittens began to wander around the den entrance. At five to six weeks, curiosity and playfulness were well developed. From about ten weeks, kittens were well developed and were able to defend themselves aggressively. After a mother had been removed from a cage to ease capture of young for measuring, kittens would fall on their backs, snarling and hissing, claws fully extended. From approximately 20 to 25 weeks of age, defence was from a squatting or standing position.

Figures 53 to 56 show caracal kittens at the age of two days, four weeks, two months, and eight months.

Figure 53. Caracal kittens two days after birth. Note the flattened ears, unretracted claws, and the closed eyes.

Figure 54. Caracal kitten at four weeks. Ears are erect; the claws retract, activity is much increased.

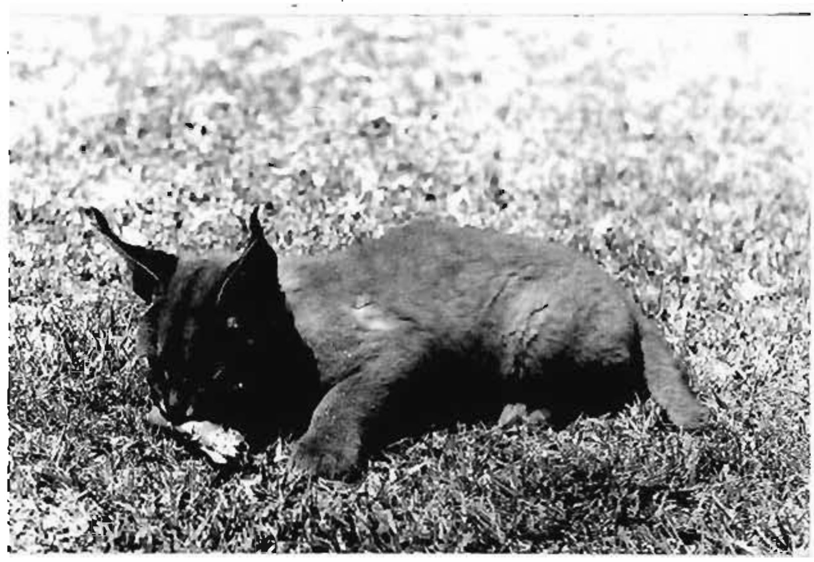

Figure 55. Caracal kitten at two months. Note the well developed ear tufts and low level aggressive posture.

Figure 56. Sub-adult caracal at eight months.

Sex ratio

Sex ratios were established for foetuses, wild caught juveniles, sub-adults and adults. The juvenile and sub-adult categories are: one to three months; four to six months, and seven months to one year (Table 8). Sex ratios of adult caracal caught in the wild from 16 Cape districts are summarized in Table 9.

The preponderance of male caracal in 13 of the 16 districts is possibly attributable to greater mobility of males. The tendency of males to cover larger areas exposes them to greater hunter pressure. An additional factor perhaps skewing towards greater male mortality is that pregnant females may spend more time closer to the cubbing site, and may therefore be less vulnerable to hunters.

Sexual Dimorphism

Male caracal are larger than the females in all respects. Mean, standard body measurements (head and body, tail, hind foot and ear) and mass are compared in Table 10, and 12 different cranial measurements are given in Table 11. A comparison of total skull length to zygomatic width shows a distinct difference between male and female caracal (Fig. 57).

Table 8. Sex ratios of foetal, juvenile, sub-adult and adult *Felis caracal* taken in the Cape Province.

Category	Actual Numbers ♂♂	♀♀	% Male	x^2
Foetuses	13	5	72,2	3,6
Kittens (1-3 months)	2	6	25,0	2,0
Juvenile (4-6 months)	31	25	55,0	0,64
Sub-adult (7-12 months)	15	18	45,4	0,28
Adult (1 year)	430	324	57,0	14,8

Table 9. Sex ratios of adult Felis caracal killed by hunters from 16 Cape districts.

District	Actual Numbers		% Male	Dominance
	Male	Female		
Riversdale	86	78	52,0	♂
Calvinia	41	28	59,0	♂
Humansdorp	15	8	65,0	♂
Piketberg	11	14	44,0	♀
Clanwilliam	45	40	53,0	♂
George	20	8	71,0	♂
Mossel Bay	24	20	55,0	♂
Ceres	30	3	91,0	♂
Caledon	29	10	74,0	♂
Robertson	12	19	39,0	♀
Namaqualand	13	11	54,0	♂
Colesberg	20	19	51,0	♂
Van Rhynsdorp	19	6	76,0	♂
Bedford	15	25	37,0	♀
Adelaide	11	8	58,0	♂
Bredasdorp	39	27	59,0	♂
TOTAL	430	324	57,0	13♂ : 3♀

Table 10. Body measurements (mm) and mass (kg; mean and range) of adult male and female caracal collected in the Cape Province.

	Males			Females		
	$\bar{x}$	n	Range	$\bar{x}$	n	Range
Head and body	868	97	750-1080	819	94	710-1029
Tail	264	99	210-340	252	101	180-315
Hind foot	193	101	170-215	180	101	160-208
Ear	80	98	65-92	76	100	60-94
Mass	12,9	77	7,2-19,0	10,0	63	7,0-15,9

Table 11. Sexual dimorphism of 12 different cranial measurements of adult *Felis caracal*.

Measurement	n	$\bar{x}$ ♂♂	range	n	$\bar{x}$ ♀♀	range
TOTAL LENGTH	424	135,0	113,0-155,0	310	124,5	110,0-144,0
ZYGOMATIC WIDTH	391	94,8	80,0-114,0	290	87,4	75,0-103,0
NASAL	417	30,4	22,2-38,0	308	28,0	18,6-34,0
INTERORBITAL CONSTRICTION	420	24,3	17,7-30,5	309	22,5	17,4-29,2
POSTORBITAL CONSTRICTION	416	30,15	24,0-36,6	305	30,0	21,7-35,5
ORBITAL HEIGHT	426	32,16	26,0-37,0	309	30,6	25,0-35,3
CRANIAL WIDTH	414	57,2	51,5-64,0	298	54,9	50,0-61,0
WIDTH AT BULLAE	406	57,2	49,0-64,5	295	53,7	47,8-61,8
MAXILLAE WIDTH AT CANINE BASE	428	20,6	13,3-29,4	308	18,8	15,0-22,7
UPPER CANINE LENGTH	335	18,0	11,0-21,6	246	16,3	13,5-20,0
UPPER CANINE DIAMETER (BASE)	427	8,2	6,4-9,7	308	7,2	6,0-9,0
JAW LENGTH	427	91,1	74,5-103,0	308	83,9	75,0-97,5

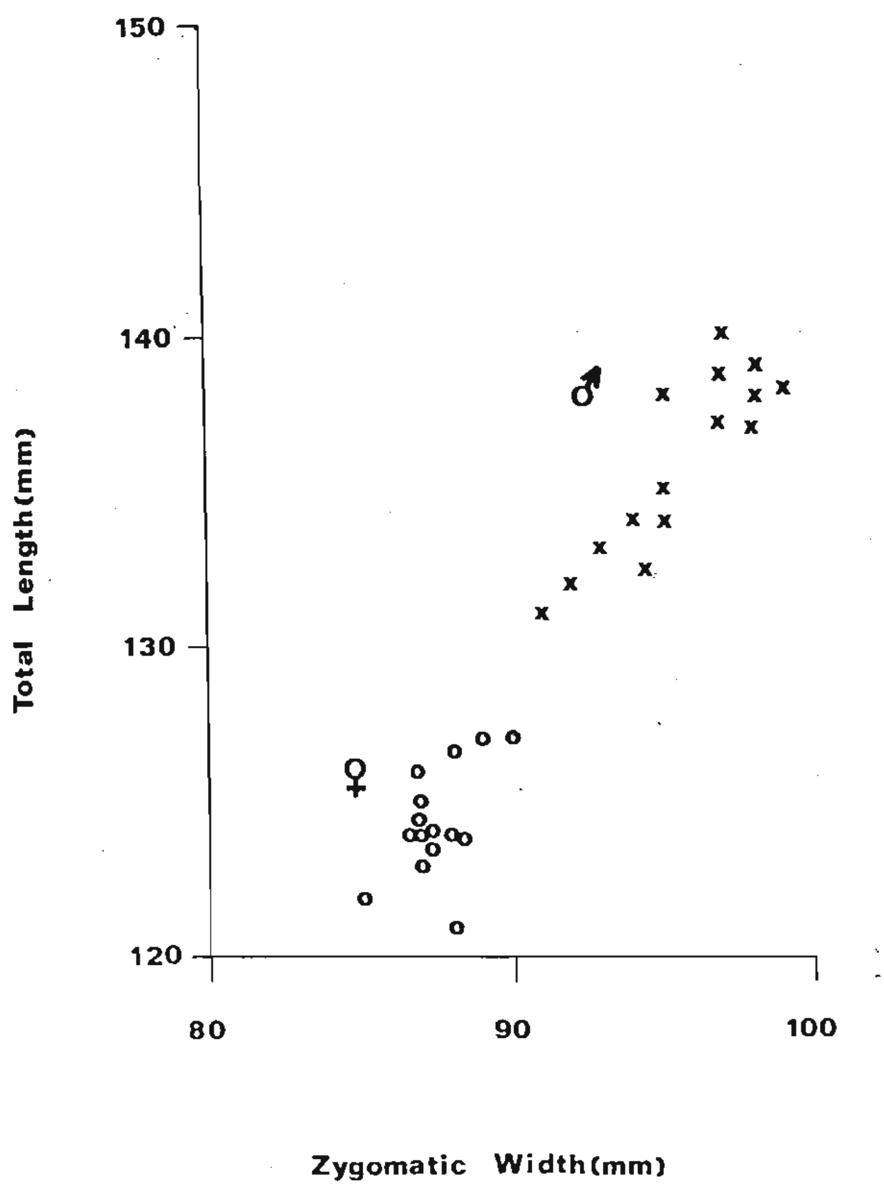

Figure 57. A comparison of mean total length/ zygomatic width in male and female Felis caracal collected from 15 Cape Province districts.

Mortality

The principal cause of mortality in *Felis caracal* in the Cape Province is undoubtedly hunting undertaken by subsidized and private hunt clubs, as well as farmers. For example, nine hunt clubs operating in sectors of the Western Cape Province between 1978 and 1981 killed 506 caracal during routine control operations. The advisability of hunting caracal at this level and the justification as a wildlife management measure is discussed in greater detail in Chapter 8.

An eight to nine month old captive female caught from the wild died from Feline pneumonitis (caused by the rickettsia-like organism *Chlamydia psittici*), also resulting in fibrinous visceral pleuritis and mild intestinal pneumonia (Dr. M.C. Williams, personal communication).

Sarcoptic mange was not noted from caracal during the present study, but it was recorded from leopard (*P. pardus*) and black-backed jackal (*C. mesomelas*) killed in areas where caracal are known to occur.

One case of extremely high tick infestation was recorded for an adult animal standing at the side of a road during the day (Major Lee, Ratel River Estates, personal communication). The cat was emaciated with a very high tick load, particularly on the head, and made no great effort to move away when approached. After being seen over a period of six days, the caracal was then shot by a local farmer. The same correspondent noted that tick numbers are so high in this area of the Coastal Sandveld that stock have to be dipped at regular intervals. The author has found grysbok (*Raphicerus melanotis*) and grey duiker (*Sylvicapra grimmia*) suffering from "draaisiekte", a tick induced blindness, in the same area. Two caracal collected in this study were found with heavy tick infestations, not only in numbers, but also in species. (Identifications, Onderstepoort Veterinary Institute).

Male (CTS 1457)	Female (CTS 1482)
Haemaphysalis l. leachi	*Haemaphysalis l. leachi*
H. zumpti	*H. zumpti*
Ixodes rubicundus	*Ixodes rubicundus*
Rhipicephalus gertrudae	*Ixodes* sp.
	Rhipicephalus sp.

All parasites recorded from caracal during this study are presented in Table 12.

The remains of one adult animal were found in a reservoir on a farm in the Robertson Karoo where it is presumed to have drowned.

Table 12. A list of parasites collected during the present study from *Felis caracal* in the Cape Province. (Identification by the Veterinary Research Institute, Onderstepoort).

ECTOPARASITES		ENDOPARASITES
INSECTA	ARACHNIDA	CESTODA
Ctenocephalides felis damarensis	*Haemaphysalis leachi*	*Taenia hydatigena*
	H. muhsamae	*Taenia* sp.
Echidnophaga gallinacea	*H. zumpti*	*Mesocestoides* sp.
	Ixodes pilosus	*Jayeuxiella* sp.
	I. rubicundus	
	Rhipicentor bicornis	
	Rhipicephalus evertsi	
	R. gertrudae	

CHAPTER 7

HOME RANGE AND MOVEMENT

Introduction

Up until the present time, nothing had been recorded about home range and movements of caracal. The only other detailed radio-telemetric studies to have been undertaken on a medium-sized carnivore in South Africa are the studies of Ferguson (1981) and Rowe-Rowe (1982) on the black-backed jackal (*Canis mesomelas*).

Methods

Caracal were captured in walk-in, box traps. The traps were of single door (Fig. 58) and double-door (Fig. 59) types. Single-door traps were set at the edge of roads or trails and well camouflaged with bush, whereas the double-door traps were set in roadways and trails without cover. The wire floors of the cages were covered with a thin layer of soil in both types of traps.

Traps were baited with scent lures (sheep or cattle blood-base; urine sand and caracal faeces collected from the cages of captive animals) and visible lures (poultry). A synthetic fermented egg formula (Bullard, Shumake, Campbell and Turkowski 1978), which has been used with success in the United States (bobcat, *Lynx rufus* and coyote, *Canis latrans*), was unsuccessful.

Captured caracal were immobilized by an intramuscular

Figure 58. A single-door cage-trap backed into a bush at the edge of a road. The arrow indicates the recepticle holding scent bait.

Figure 59. A double-door cage-trap set in a road without camouflage. The arrow indicates a trapped caracal.

injection of ketamine hydrochloride (Appendix 5) and fitted with collars to which a radio transmitter and battery pack were attached.

Telemetry equipment was obtained commercially (AVM Instrument Company, Champaign, Illinois, U.S.A.); tracking antennae were produced locally.

The LA 12 telemetry receiver was used on a frequency range of 148,714 to 148,886 MHZ, with a sensitivity of 140 dbm (0,03 mV). The construction of antennae has been discussed in detail by Ferguson (1981). The basic design is given in Fig. 60, and a single Yagi is illustrated in Fig. 61 (double Yagi antennae were also used).

The single Yagi was found to be the most practical for tracking purposes. A normal whip antennae was used until a signal was detected, and at this stage the Yagi was connected to the receiver. The antennae had 4-elements made from $\frac{3}{8}$" aluminium tubing.

The double-Yagi (working on the basis of a Null-Peak Antennae System) consisted of two 4-element single Yagis linked with a cross boom, and cables linking at a switch box. The advantage of the Null-Peak System is the allowance for homing in on a strong signal while the antennaes are in-phase, then being able to switch the antennae out of phase. The direction from the transmitter to the antennae is represented by a blank spot (null) between two peaks of less intensity than that

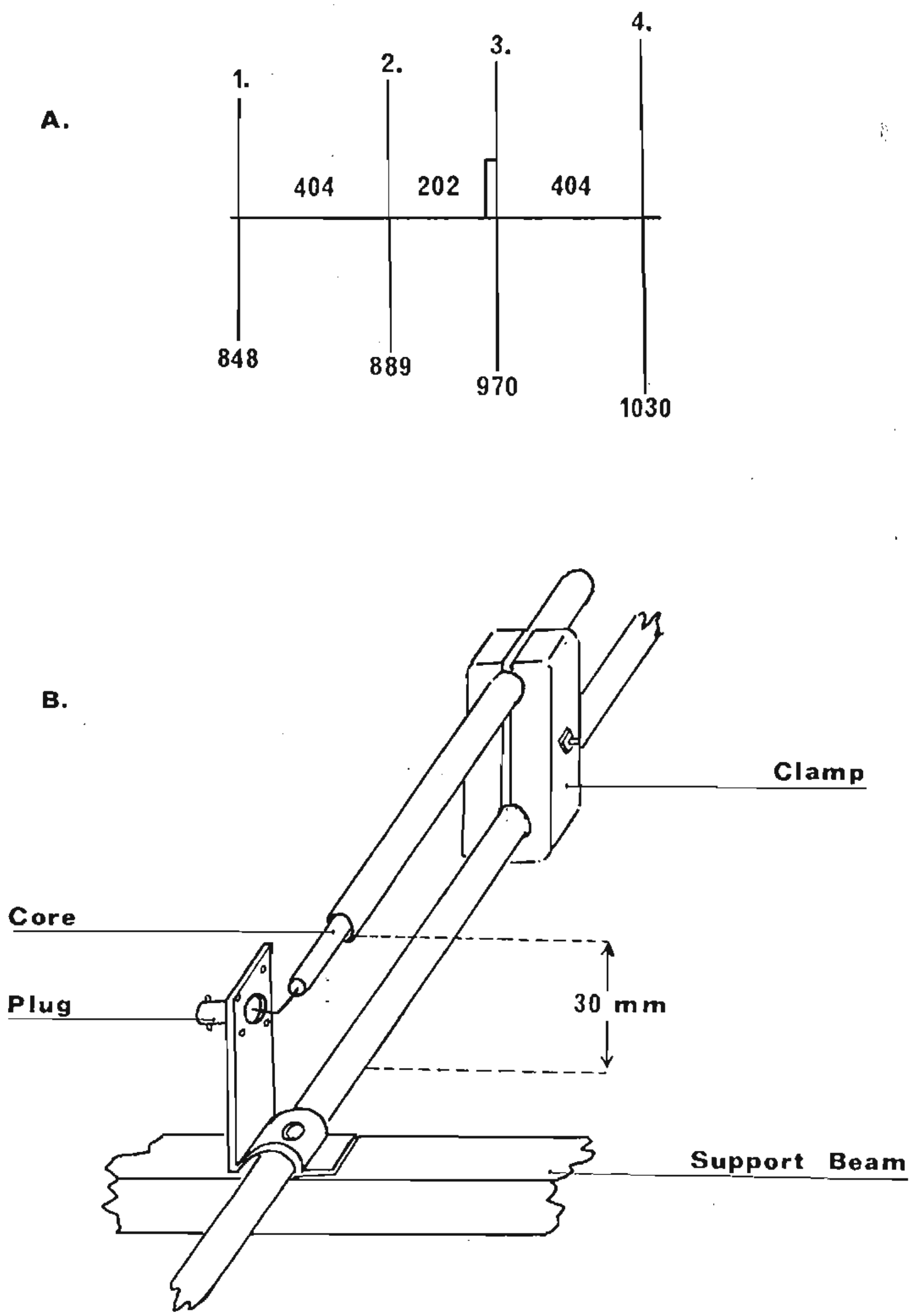

Figure 60. A. Single Yagi indicating measurements (mm) and spacing. B. Close up of aerial adaptor and plug point. (After Ferguson 1981).

Figure 61. A single, hand-held Yagi-antennae.

produced when the antennae are in the peak position, providing high directional accuracy, as the blank spot is approximately 1^{o} wide. However, the size of this system made use practical only when working from a vehicle.

The hilly nature of the Eastern Robertson Karoo and mountains in the Jonkershoek area necessitated the occassional use of aircraft. Temporary directional antennae elements were fastened to the undercarriage of the aircraft and tracking areas systematically covered until a signal was located from the air. In the Eastern Robertson Karoo, the strongest signal was pinpointed from the air and a ground search immediately implemented upon landing. Over the Jonkershoek mountains localities had to be pinpointed from the air.

The radio-transmitter collar (Fig. 62) were positioned around the necks of caracal and fastened by means of pop-rivets (Fig. 63). Collared caracal were radio-tracked either by vehicle, aircraft, or on foot. Each relocation was obtained by triangulation, based on at least two bearings. The direction of greatest signal strength was determined, and the magnetic bearing was read from a hand held prismatic compass. Bearings were plotted on 1:50 000 Cadastral maps. In order to improve accuracy and interpretation, practice sessions using collars placed at known sites were undertaken at regular intervals. These practice sessions indicated that radio-locations (n=35) were C.120 + 30m within actual location. Collared caracal, however, were frequently located in difficult terrain, and therefore

Figure 62. The transmitter package used to track caracal.

Figure 63. Fitting a collar to a drugged female caracal.

distortion of the signal was increased.

Results and Discussion

Seven caracal were captured during the study period, and information pertaining to drug reactions are summarized in Appendix 5. An average effort of 472 trap nights per capture was required. The sex ratio was skewed slightly in favour of females (four females to three males). Of the total live-capture, three females and one male were caught in the Eastern Robertson Karoo, one female in the Coastal Sandveld, and two males at Jonkershoek. Characteristics of captured animals are summarized in Table 13.

Size of Home Range

Total areas covered by five radio-collared caracal are given in diagramatic form in Fig. 64 (A,B,C).

The three females tracked in the Eastern Robertson Karoo had home ranges of 11,8km^2 (C.Lady), 22,4km^2 (E.Kloof), and 26,7km^2 (D.Fence).

C.Lady was tracked over a period of 43 weeks, ranging widely within her comparatively small range, with no easily definable core area. Habitat within her range consisted of southern hill slopes and valley bottom. On a number of occassions she was located near flocks of sheep and goats, but no stock losses were reported by the farmer throughout the entire tracking period.

Table 13. Details of caracal captured and radio-tracked in the South West Cape Province.

Locality	Caracal	Home Range	Weeks tracked	Total relocations	Remarks
Jonkershoek/Caledon	A (Good Buddy) (Male)	48,0km^2	67	62	Sub-adult/adult male (9,2kg)
Jonkershoek	B (Peter) (Male)	Too short a time to establish home range limits	4	7	Male (8,5kg)
Eastern Robertson Karoo	C (Lady) (Female)	11,8km^2	43	94	Adult female (8,5kg)
E.R.K.	D (Fence) (Female)	26,7km^2	17	67	Adult female (8,4kg)
E.R.K.	E (Kloof) (Female)	22,4km^2	12	49	Adult female (9,9kg) Pregnant
Coastal Sandveld	F (Agatha) (Female)	11,9km^2	25	37	Adult female (9,4kg)

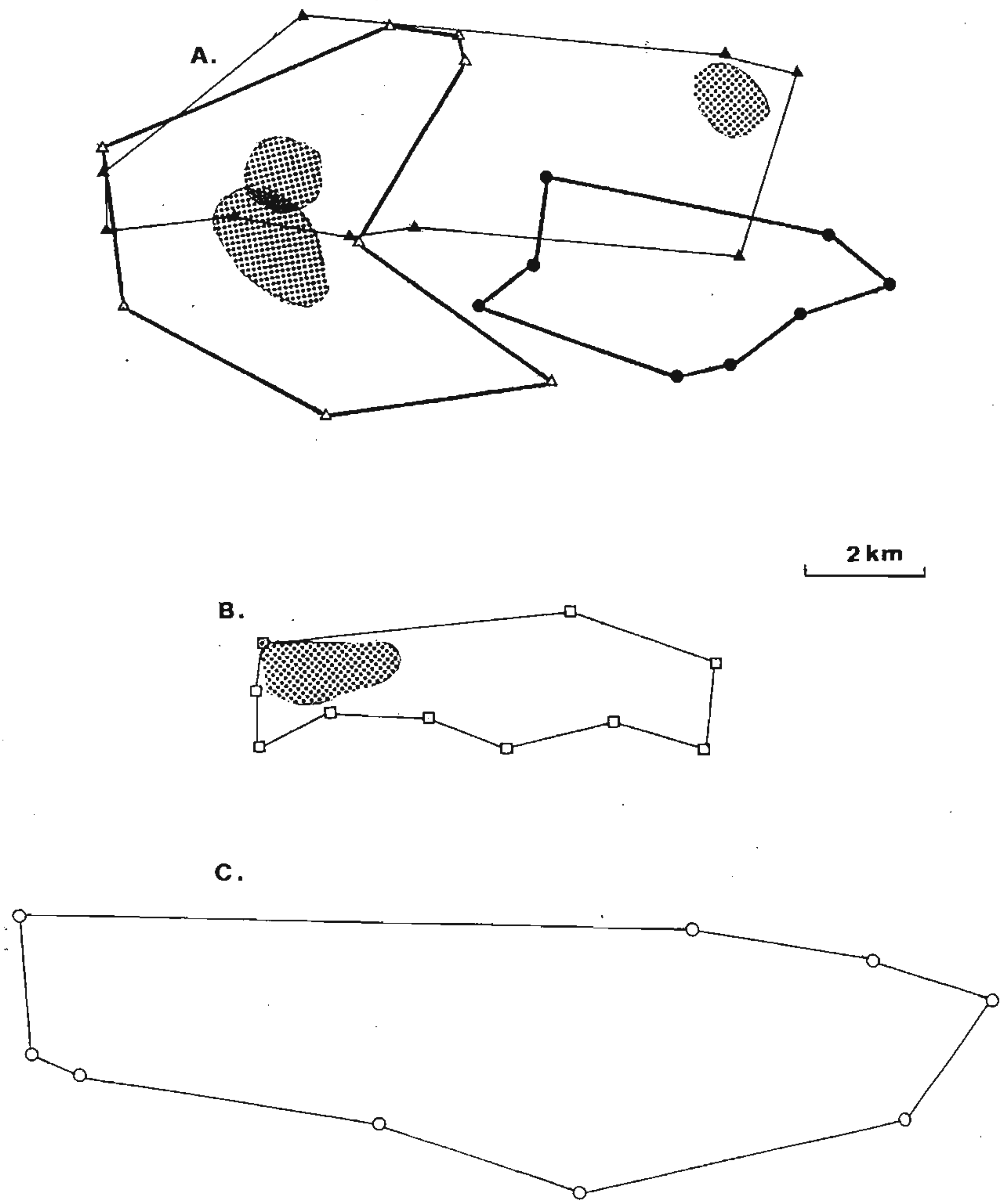

Figure 64. Home range estimates for five radio-tracked caracal. Information on individual caracal is presented in Table 13. A Eastern Robertson Karoo, ▲ - D.Fence, △ - E.Kloof, ● - C.Lady; B Coastal Sandveld, □ - F.Agatha; C Jonkershoek/Caledon, ○ - A.Good Buddy. (stippled) - Core areas.

E. Kloof (approximately two years of age), tracked for only 12 weeks, covered an area almost twice the size ($22,4km^2$) of that of C. Lady, overlapping the range of D. Fence (Fig. 64A). Although E. Kloof ranged widely within her home range, a distinct core area was discernable in the centre of the range. The range of E. Kloof consisted of north and south facing hill slopes and dry valley bottoms.

D. Fence, the only caracal tracked suspected of taking sheep (on two occasions), had a home range of $26,7km^2$ and was tracked over a 17 week period. Over this relatively short time she moved between two "core" areas (marked on Fig. 64A), one of which overlapped slightly with the core area of C. Kloof. Within the range of D. Fence were north and south facing slopes, valleys and some cultivated pastures.

Despite extensive efforts, only one caracal was trapped in the Coastal Sandveld (F. Agatha). The home range of this cat was small ($11,9km^2$) over the 25 week period she was tracked, with the southern boundary being formed by the Indian Ocean. F. Agatha had a distinct core area in the western sector of her home range, consisting primarily of exotic Acacia cyclops and low stabalized dune veld close to a holiday settlement (Pearly Beach). This core area was particularly rich in rodents (primarily Rhabdomys pumilio) and small antelope (Raphicerus melanotis, Sylvicapra grimmia).

The only male caracal tracked, A. Good Buddy, was followed over a period of 67 weeks. Originally trapped in the Jonkershoek Valley, this cat moved a distance of approximately 98km before settling temporarily for 53 days in an area of scattered plantations and river valley vegetation. Over a period of 51 days , the cat moved a distance of 40km southwards to the Highlands Forest area. A total of 22 plots over a period of 292 days were made, (an average of one plot per 13 day period), largely due to the great distance involved and the need to use an aircraft. A. Good Buddy was recorded in an area of 48,0km^2 (Fig. 64 C), consisting primarily of Lowland Fynbos in hilly country, with perennial water. Eighty two percent of recorded plots were in the eastern two thirds of the home range.

With a small sample (four females and one male) and inadequate monitoring time it can still be shown that female home ranges were large (11,8km^2 to 26,7km^2). A.Good Buddy, a young adult (P.Norton, personal communication) male with sufficient plots for calculating home range, settled in an area of some 48,0km^2 after moving considerable distances. Mean home range for animals in the South West Cape Province was 24,16km^2 (n=5).

Variations in the size of home range of carnivores in different habitats or at different times have been related to prey density (Erlinge 1978; Van Ballenberghe, Erickson and Byman 1975). Rowe-Rowe (1982) has discussed home range size relationships in black-backed jackal in some detail, as has Ferguson (1981). Potential food supply within the home ranges of radio-tracked caracal, in the current study, was considered to be highest at the coast (F. Agatha) and similar to the home range of A. Good Buddy. During the tracking period in the Eastern Robertson Karoo (C. Lady, D. Fence and E. Kloof), there was a population "explosion" of Otomys unisulcatus and other rodents within the study area, following unusually heavy rains during the first quarter of 1981.

Core areas were defined by the present study as those areas within home ranges where a number of plots were made close together over the tracking period, and areas where most scats were collected. It should be noted, however, that there was no way in which the origin of these scats could be determined.

Movement

Movement of A. Good Buddy, (Fig. 65) a young, adult male, demonstrated that a considerable distance was covered (138km) before a home range was settled. The period of 53 days spent at site B (Fig. 65) by A. Good Buddy is difficult to explain, Bailey (1974), working on bobcats, Lynx rufus, found that dispersing young cats appeared to avoid settling in areas already occupied by residents. The same author also concluded that male bobcats moved from one part of their range to another without any apparent pattern and rarely returned to previously used resting places. Although current findings are limited, the same could well apply to caracal.

A wild caught caracal male (sub-adult) was tatooed (no. 10),

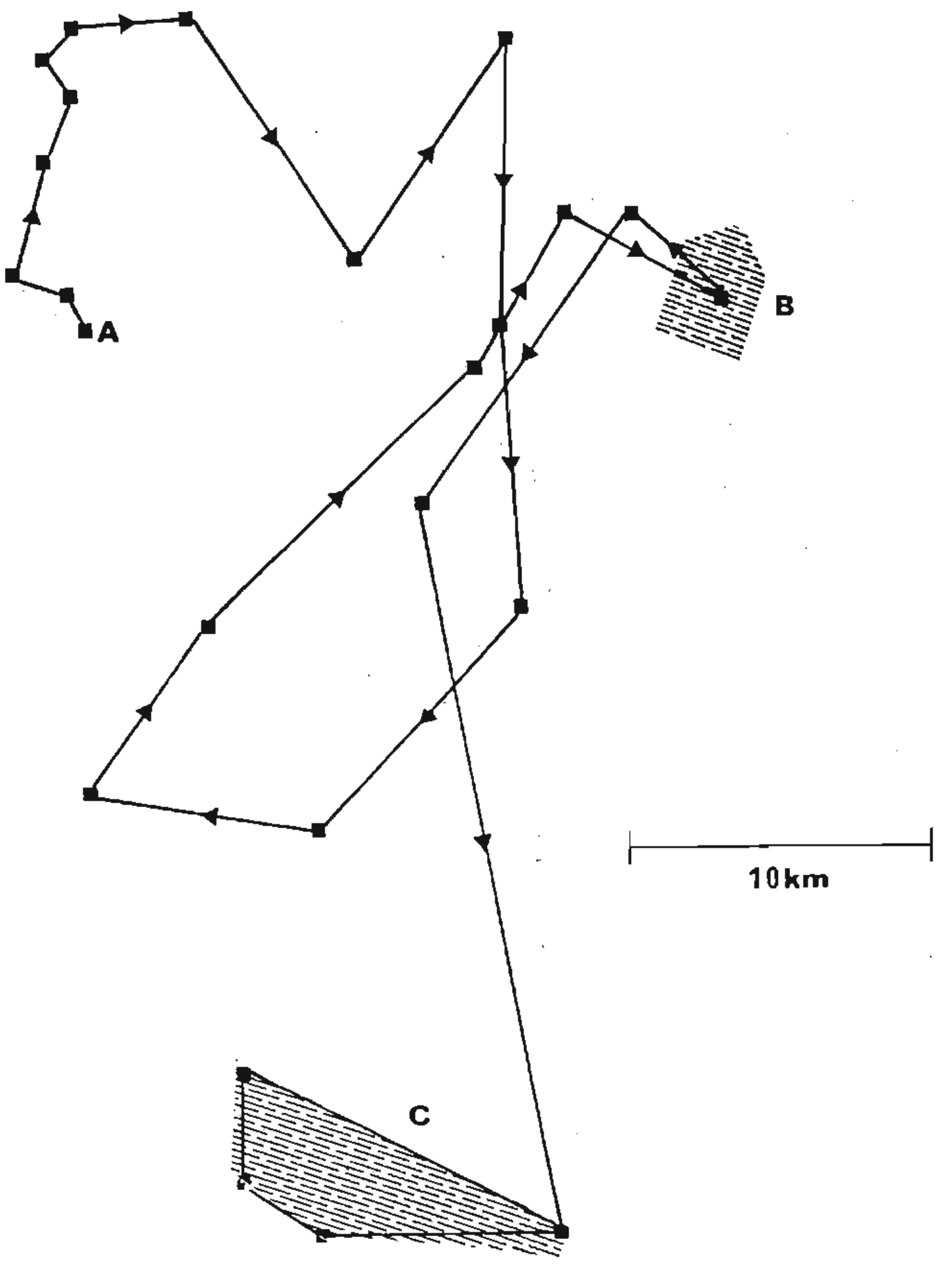

Figure 65. Movements of Good Buddy. A- Capture site, B- Temporary refuge, C- Established home range.

ear-tagged, and released at the capture site on the Vrolijkheid Nature Reserve. Twenty six days later the same animal was shot by a farmer 14km (straight line distance) from the original capture site.

Many farmers and hunters in the South West Cape Province maintain that caracal males move "long" distances on regular routes known locally as "kattrekpaaie". Traps are set along these pathways, and seven caracal recorded killed in this manner during the current study (Boesmansrivier, 3319DD Robertson) were all males.

Scent Marking

The communication value of scent marking by caracal is probably quite high. Adult caracal scent mark with scats (faeces), urine, and scrapes. On either side of the anus there are small glands which secrete a light brown fluid in minute quantities, quite possibly during defecation as an addition to the scat. Captive animals were rarely seen to cover freshly passed scats. Animals within cages deposited scats in favoured areas, but not in a midden. No midden sites were discovered during the course of the study, but occasionally several scats were found at pathway junctions. Scats were regularly distributed and conspicuously exposed along the routes followed by caracal. Unlike black-backed jackal, caracal deposit scats on the ground, and not on tufts of grass, rocks and other above-ground level sites (Ferguson 1981 and personal observations). Density of scats within the core areas of the radio-tagged Eastern

Robertson Karoo caracal appeared to be higher than outlying areas.

As discussed in the Chapter on reproduction, caracal scent mark by squirting quantities of urine on bushes and other prominant sites. Female caracal increased their tempo of urine squirting upon coming into heat. Bailey (1974) found bobcat females squirted urine at the entrance of caves in which they stayed during the breeding season. Eleven sites within the home ranges of C. Lady and E. Kloof were found where caracal had marked with urine (including tracks and distinct smell, and on three occasions dark stains). Scraping was observed for captive males, but never females. Scrapes were made after ground urination by backwards and forwards movements of the hind feet (Fig. 66).

Figures 27 and 28 show urine scrapes (with distinct urine smell) that were located during two specific tracking exercises. The animal squats on its hindquarters with the entire length of its hind feet touching the ground. Then each foot is alternately thrust backward, with the claws usually extended. Upon completion of this scuffing motion the foot is almost always lifted as it is brought forward. The tempo of the movement is moderately fast. Urination occurs for brief periods during or near the termination of the scuffing bout. The churning effect of the feet mixes urine into the soil, and distributes it along the length of the foot. These scrapes were found in softer terrain, such as firebreaks, sand tracks, dunes, and sandy riverbeds.

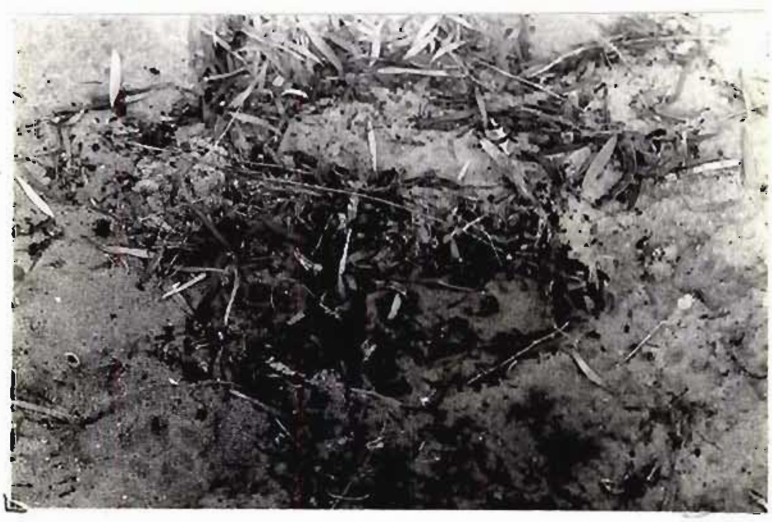

Figure 66. A caracal urine scrape with distinct grooves left by the hind feet. A single paw print appears in the lower left hand corner of the photograph.

Leopard, Panthera pardus, are known to scent mark with urine scrapes (personal observations), Bailey (1974) recorded similar behaviour in bobcat, and Wemmer and Scow (1977) mention this method of marking for tiger (Panthera tigris) and the Canada Lynx (Lynx lynx). The description of this marking behaviour given by Wemmer and Scow (1977), is almost identical to that observed in caracal.

Caracal regularly "clawed" tree trunks in their cages, and a number of sites in the study areas. Leopard were also noted as clawing and urine scraping and it is possible that this clawing behaviour has some marking function (personal observations). Clawing and urine scrapes were not noted together for caracal, but may have easily been overlooked.

Captive caracal were observed to rub the top of the head, cheeks and chin against rocks and logs in their enclosures. Wemmer and Scow (1977) were of the opinion that saliva and skin exudates were deposited in this way.

CHAPTER 8

DISCUSSION

Suggestions for Improved Management

The caracal (*Felis caracal*) has been killed regularly throughout the Cape Province because of depredations on domestic animals. Yet, after decades of destruction by a wide variety of schemes and devices, the caracal remains abundant. If anything, populations are on the increase in certain areas.

During the late nineteenth century and up until recent times, the efforts of farmers to destroy caracal were supplemented by bounties paid from public funds. Lantz (1905) in Connolly (1978), discussing coyote (*Canis latrans*) states: "Some of these bounty laws have been in operation for a score of years or even more and, except locally, no diminuation in the general numbers of the animals has resulted ..... in most sections of its range the coyote is either increasing or no substantial decrease has been observed ..... Indeed, in many parts of the West coyotes are said to be increasing in spite of a constant warfare against them." This also applies to both the caracal and black-backed jackal in South Africa at the present time. Although the bounty system was once widely applied in Cape Province (Table 14), bounties are now restricted to the Divisional Councils (Koup and Bo-Karoo) (E. Barnard, personal communication), and to individual farmers. Bounties range from a low R2,00, to R150,00 paid by

Table 14. Total bounties paid for caracal between the years 1931 to 1943, and 1952. It is of interest to note that the 1931 figure (2601) and the 1952 figure (2626) are very similar.

Year	1931	1932	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1952
Caracal Bounties	2601	2404	1253	2575	2969	1950	2175	2041	2071	1959	2102	2120	2626

certain farmers. Hey (1956) has summarized the reasons for the discontinuation of bounty payments in the Cape, emphasising bounties should play no role in the logical management of caracal in the Cape Province.

Control of predators (and other problem animals) is undertaken by the Cape Department of Nature and Environmental Conservation through its problem animal control officers, Divisional Council hunt clubs, private hunt clubs, and individual farmers. The predator control system is in theory controlled by the Vermin Extermination Ordinance No. 26 of 1957 and subsequent ammendments (Heinecken 1979).

The methods currently in use for caracal control, depend on such factors as prevailing climatic conditons, topography, vegetation, training, previous experience and, in many cases, the personal preferences of the hunters. The most commonly used methods to control caracal are packs of trained hounds, gin traps, and cage traps. A more recent development has been the use of the toxic-collar. To date, little effort has been made to: 1) evaluate currently used control measures, 2) develop a greater selectivity of current methods, or 3) establish and test new methods.

Current control activities are based largely on the "blanket" approach; selectivity aimed at the species level or the damage causing individual is rarely attained. A greater effort is needed to make existing methods more selective and the development of sophisticated non-lethal methods.

There are obvious economic needs for finding more suitable means of reducing damage to livestock by caracal. The more unselective the method, the greater will be the time/ effort (and therefore cost) required to catch the individual which kills stock.

The gin-trap is rarely 100% selective, although its selectivity can be greatly increased by such methods as off-set jaws (Fig. 67), adjustable trigger-plates (Fig. 68), attractants, and careful selection of trap sites. However, even with these precautions, gin-traps are not ideal control tools. Many thousands of these traps are currently in use in the Cape Province, and therefore, any attempt to ban or greatly limit use would meet with considerable opposition. Therefore, every effort should be made to refine gin-trap technique for more selectivity in capture.

Cage traps, although having the advantage of causing little or no damage to trapped animals, are only selective in the sense that non-target animals can be released. In practice, however, this rarely happens. Bulkiness in certain circumstances greatly limits the use of cage traps, although usage should be encouraged. Cage traps are illustrated in Figs 58 and 59 (Chapter 7).

Hound packs, if well trained and operating in optimum conditions, have a role to play. However, this type of hunting should be undertaken only when fresh scent can

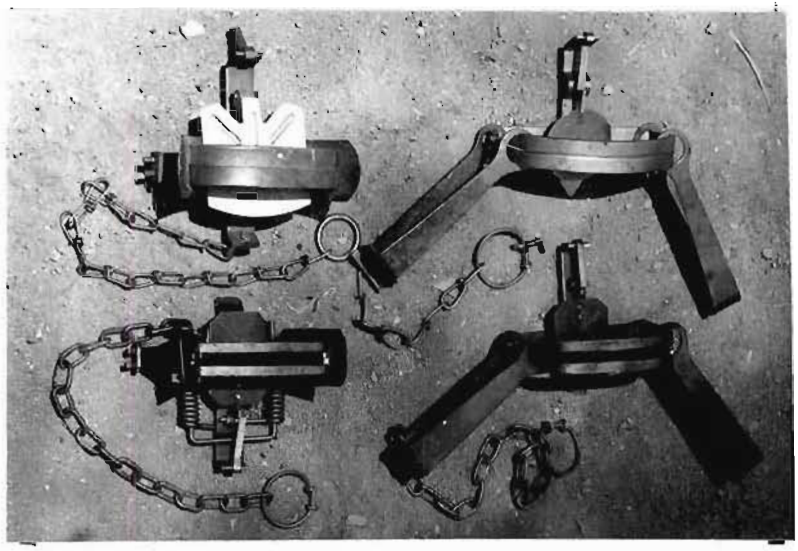

Figure 67. Coil spring and leaf spring gin traps showing the closed types (top) and the more acceptable off-set jaws (lower).

Figure 68. An off-set jaw leaf spring with a trigger plate adjustment screw. This allows for greater size selectivity.

be picked up close to a freshly killed prey carcase. Hound packs are, however, a costly method of control.

The "Coyote getter", an unselective control method used primarily against the black-backed jackal (Canis mesomelas), has no practical significance in caracal control. Caracal have been killed by this tool, but only rarely.

Although the methods so far mentioned are effective in caracal control, under certain circumstances, greater emphasis should be placed on seeking alternatives.

The toxic-collar (Fig. 69), recently put into use in South Africa, was first used in 1920 in the United States with numerous developments appearing since that date (Savarie and Sterner 1979). The principal advantage of the toxic collar is the selective removal of caracal that attack domestic small-stock (sheep and goats). Herding practices, economics, and safety considerations are aspects that may affect the use of the toxic collar. Savarie and Sterner (1979) summarized the advantages of the collar as follows: 1) specific dosing of "problem" individuals that prey upon sheep, 2) limited environmental contamination and reduced risks of secondary poisoning, 3) the method is easy to use and economical when compared to most other methods. Toxic collars would appear to have greater application in limited pasture conditions than in extensive grazing areas. Research is needed to test application of the toxic collar under local conditions and to examine problems

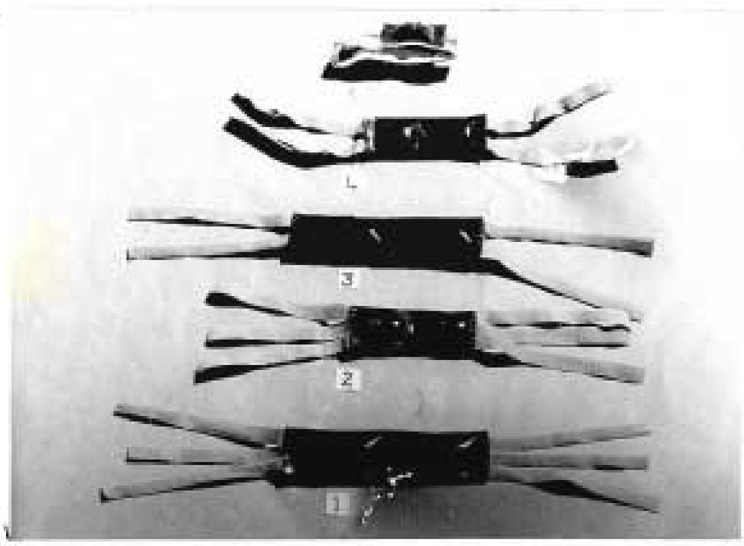

Figure 69. Five types of toxic collar. This method is 100% selective, easy to use, and comparatively cheap. More tests need to be undertaken with the collar on extensive small-stock ranges.

which arise from its use, such as punctured compartments.

Although considerable research on chemical aversive conditioning has been undertaken in the United States of America, this potential tool in damage control is unknown in the Cape Province. The use of Lithium chloride treated baits and carcases has been applied (USA) on an experimental basis as a potential means of controlling coyote predation on sheep through aversive conditioning or taste aversion. Theoretically, if the predator eats baits or prey carcases treated with a physiological illness producing drug, negative associations will be formed between the baits and subsequent gastrointestinal disorders. The dislike for the bait will then be transferred to live prey, inhibiting future attacks on that prey. A predator is truly averted to a prey or food item only if there is refusal to attack or eat the item which is readily available (Griffiths, Connolly, Burns, and Sterner 1978). The taste aversion method could be a useful tool in controlling caracal predation on domestic stock, but would require considerable research to test its application under local conditions.

Another method receiving considerable attention in the United States of America is the use of chemosterilants for reducing population densities; Stellflug, Gates and Sasser (1978) have summarized developments in this field. Reproductive inhibitors may offer a practical approach for population control of caracal, as well as the black-backed jackal. The potential for discriminately subjecting a particular species to antifertility compounds is still uncertain, but merits further investigation. Advantages of this method are:

1) Preventing animals from being born may be more practical than reducing numbers after they are partly or fully grown and established in a secure environment.

2) The compensating increase in reproduction may be overcome by suppressing reproduction, but survival may be increased in the remaining population.

3) Movement or ingress that occurs when animals are removed from a population may be lessened by the treated predators occupancy of territories.

4) Nontoxic antifertility compounds are safer to use than many toxicants.

There are also a number of problems involved, as the antifertility compound must be:

1) effective in a single, oral dose.

2) relatively stable, inexpensive, and effective in small quantities.

3) odourless and tasteless to prevent aversion.

4) relatively host specific in order to minimize the effects on non-target species.

5) effective for relatively long periods during the reproductive cycle.

6) dependant on the development of host specific delivery systems for practical application.

An additional factor raised by Stellflug et al (1978) is the difficulty in deciding on chemical castration of the male target animal, to interrupt pregnancy in the female, or a combination of both.

One other method, the use of livestock guarding dogs Green, Tueller, and Woodruff (1980), has possible application under certain conditions in the Cape Province.

Farm management practices play a pivotal role in the entire problem predator dilemma. Guidelines for the reduction of damage by improving methods should also receive attention. Amongst these suggestions are:

1) regulation of lambing and kidding seasons.

2) to bring close to term ewes and nannies into sheds or kraals.

3) to maintain regular and accurate counts of livestock.

4) avoidance of leaving stock carcases lying in the veld.

No single known method will solve all predator management problems with caracal. Different methods may need application in different areas in various seasons. Greater refinement of currently used methods is required, and investigation of methods at the experimental level should be tested under field conditions.

The guiding economic principle for all control and management programmes should be based on costs of control not outweighing costs of actual stock losses. The complete eradication of a species which is rare in most parts of the world has, however, no price tag attached.

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APPENDIX 1. Mammals (excluding Chiroptera) known to occur in the Robertson Karoo (RK), Coastal Sandveld (CS), Bedford (B) and Jonkershoek (J).

Species	RK	CS	B	J
MENOTYPHLA				
Macroscelides proboscideus			X	
Elephantulus rupestris	X		?	X
LIPOTYPHLA				
Erinaceus frontalis			X	
Myosorex varius	X	X	X	X
Suncus etruscus		X	X	
Crocidura flavescens	X	X		X
Crocidura cyaneae	X			X
Amblysomus hottentotus		X		X
Chrysochloris asiatica	X	X		X
PRIMATES				
Papio ursinus	X		X	X
Cercopithecus pygerythrus			X	
CARNIVORA				
Otocyon megalotis	X	X	X	
Vulpes chama	X	X	X	
Canis mesomelas	X	X	X	
Ictonyx striatus	X	X	X	
Poecilogale albinucha			X	
Mellivora capensis	X	X	X	X
Aonyx capensis	X	X	X	X
Genetta genetta	X	X	X	X
G. tigrina	X	X	?	X
Herpestes ichneumon	X	X	X	
Herpestes pulverulentus	X	X	X	X
Atilax paludinosus	X	X	X	X

Ichneumia albicauda			X	
Cynictis penicillata	X	X	X	
Suricata suricatta	X		X	
Proteles cristatus	X	X	X	
Felis libyca	X	X	X	X
Panthera pardus	X			X
TUBULIDENTATA				
Orycteropus afer	X	X	X	
HYRACOIDEA				
Procavia capensis	X	X	X	X
ARTIODACTYLA				
Potamochoerus porcus			X	
Sylvicapra grimmia	X	X	X	
Raphicerus campestris	X	X	X	
R. melanotis	X	X	X	X
Oreotragus oreotragus	X		X	X
Pelea capreolus	X	X	X	
Redunca fulvorufula			X	
Tragelaphus scriptus		X	X	
T. strepsiceros			X	
LAGOMORPHA				
Lepus capensis	X		X	
L. saxatilis	X	X	X	X
Pronolagus sp.	X	X	X	X
RODENTIA				
Bathyergus suillus		X		
Georhychus capensis	X	X		X
Cryptomys hottentotus	X	X	X	X
Hystrix africaeaustralis	X	X	X	X
Pedetes capensis			X	

Aethomys namaquensis	X	X		X
Praomys sp.	X	X		X
Rhabdomys pumilio	X	X	X	X
Mus minutoides	X	X		X
Otomys irroratus	X	X	X	X
O. unisulcatus	X			
Gerbillurus paeba	X	X		
Tatera afra	X	X		

Appendix 2. Prey species of *Felis caracal* as recorded in the literature.

Area	Prey Species Common Name	Scientific Name	Source
Pakistan	Chinkara	*Gazella gazella*	Roberts (1977)
	Urial	*Ovis orientalis*	
	Hares	Lagomorpha	
	Sandgrouse	*Pterocles* sp.	
	Peacocks	*Pavo cristatus*	
	Grey partridge	*Francolinus pondicerianus*(?)	
	Pigeons	(Columbidae)	
Turkemenistan (USSR)	Hares	Lagomorphs	Ognev (1935)
	Ground squirrels	Lagomorphs (Ochotonidae)	
	Pikas	Lagomorphs (Ochotonidae)	
	Tolai hares	Lagomorphs	Sapozhenkov (1962)
	Jerboa	Rodentia (Dipodidae)	
	Goitered gazelle	*Gazella subqutturosa*	Novikov (1962)
	Doves	(Columbidae)	Ognev (1935)
	Hazel hens		
	Storks	(Ciconiidae)	
East Africa	Dik-dik	Madoquinae	Kingdon (1977)
	Duiker	Cephalophinae	
	Hyraces	Procaviidae	
	Hares	Lagomorpha	
	Monkeys	Cercopithecidae	
	Ostrich	*Struthio camelus*	
	Tawny eagle	*Aquila rapax*	
	Martial eagle	*Polemaëtus bellicosus*	
	Brown parrot		
	Sandgrouse	*Pterocles* spp.	Fuente (1970)

Somalia	Phillips dik-dik	Madoqua saltiana	Azzaroli and Simonetta (1966)
	Kirk's dik-dik	Rhynchotragus kirki	
	Ground squirrel	Xerus rutilus	
		Acryllium vulturinum	
Southern Africa			
South West Africa	Springbok (adult ♀)	Antidorcas marsupialis	Shortridge (1934)
	Kudu (calf)	Tragelaphus strepsiceros	
	Hyraces	Procaviidae	
	Klipspringer	Oreotragus oreotragus	
	Steenbok	Raphicerus campestris	
	Hare	Lepus sp.	
	Ostrich	Struthio camelus	
Botswana	Gerbil	Tatera sp.	Smithers (1971)
	Namaqualand gerbil	Desmodillus auricularis	
	Pouched mouse	Saccostomus campestris	
	Dwarf mouse	Mus. sp.	
	Multimammate mouse	Praomys natalensis	
	Springhare	Pedestes capensis	
	Hare	Lepus sp.	
	Impala	Aepyceros melampus	
	Grey loerie	Crinifer concolor	
	Button quail	Turnix sylvatica	
	Red-billed francolin	Francolinus adspersus	
Zambia	Grey duiker	Sylvicapra grimmia	Wilson (1966)
Zimbabwe	Pouched mouse	Saccostomus campestris	Smithers and Wilson (1979)
	Multimammate mouse	Praomys natalensis	
	Grey duiker (adult ♀)	Sylvicapra grimmia	Grobler (1981)
	Francolin	(Phasianidae)	

South Africa			
Natal	Mountain reedbuck	_Redunca fulvorufula_	Rowe-Rowe (1978)
Transvaal	Warthog	_Phacochoerus aethiopicus_	Rautenbach (1978)
	Warthog (?)	_P. aethiopicus_	Viljoen & Davis (1973)
	Wild cat	_Felis libyca_	Pienaar (1969)
	Sharpe's grysbok	_Raphicerus sharpei_	
	Impala (lambs)	_Aepyceros melampus_	
	Steenbok	_Raphicerus campestris_	
	Grey duiker	_Sylvicapra grimmia_	
	Klipspringer	_Oreotragus oreotragus_	Pienaar, _et al_ (1980)
	Reedbuck	_Redunca arundinum_	
Cape Province			
Kalahari Gemsbok National Park (N. Cape)	Steenbok	_Raphicerus campestris_	Mills (1977)
	Springbok (3ad; 1sa; 1j)	_Antidorcas marsupialis_	
	Springhare	_Pedetes capensis_	
	B.b. jackal	_Canis mesomelas_	Grobler (1981)
	Wild cat	_Felis libyca_	
	Kori bustard	_Ardeotes kori_	
Namaqualand (N.W. Cape)	Steenbok	_Raphicerus campestris_	Skinner (1979)
Bedford (E. Cape)	Hyraxes	_Procavia capensis_	Pringle and Pringle (1979)
	Steenbok	_Raphicerus campestris_	
	Grey rhebok	_Pelea capreolus_	
	Red rock-hare	_Pronolagus_ sp.	
Mountain Zebra National Park (E. Cape)	Mountain reedbuck	_Redunca fulvorufula_	Grobler (1981)
	Springbok	_Antidorcas marsupialis_	
	Grey duiker	_Sylvicapra grimmia_	

	Steenbok	Raphicerus campestris	
	Springhare	Pedetes capensis	
	Red rock-hare	Pronolagus rupestris	
	Scrub hare	Lepus saxatilis	
	Cape grey mongoose	Herpestes pulverulentus	
	Greywing francolin	Francolinus africanus	
	Crowned guinea-fowl	Numida meleagris	
Robertson Karoo (S.W. Cape)	Striped mice	Rhabdomys pumilio	Bothma (1965)
	Grey duiker	Sylvicapra grimmia	

Appendix 3. Skull measurements of 27 known-age caracal sacrificed at different ages. TL - Total length; ZW - Zygomatic width; N - Nasal; IOC - Inter-orbital constriction; POC - Post-orbital 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.

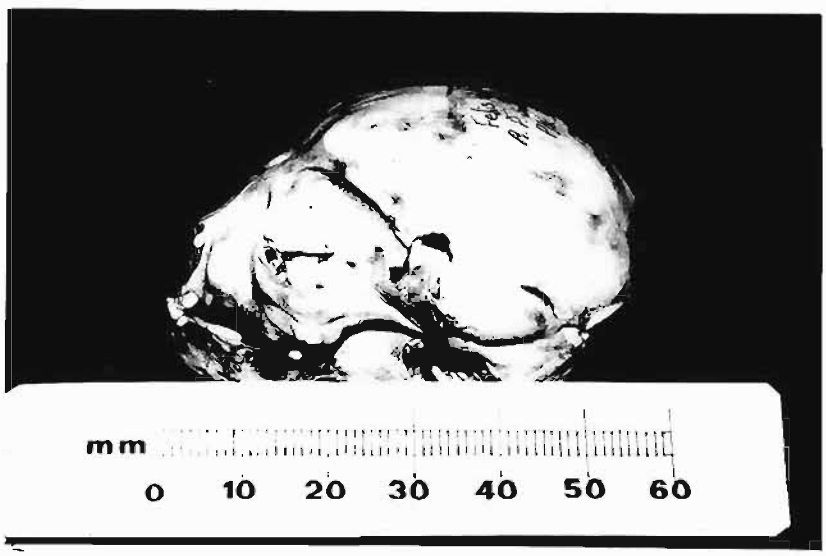
No.	Sex	Age	TL	ZW	N	IOC	POC	OH	CW	BW	WM	VCL	UC	JL	WMC
	MALE														
2156	"	Birth	48,9	-	8,0	10,0	-	6,6	28,9	-	-	-	-	31,4	-
3150	"	3 months 23 days	-	62,2	21,0	15,3	34,7	23,0	50,7	42,5	15,3	9,7	4,5	59,2	14,0
3151	"	3 months 23 days	94,0	62,5	20,2	15,2	34,7	23,7	50,2	43,2	16,8	9,7	4,0	59,8	14,6
3152	"	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	"	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	"	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	"	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	"	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	"	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
3323	"	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	"	2 years 5 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	"	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

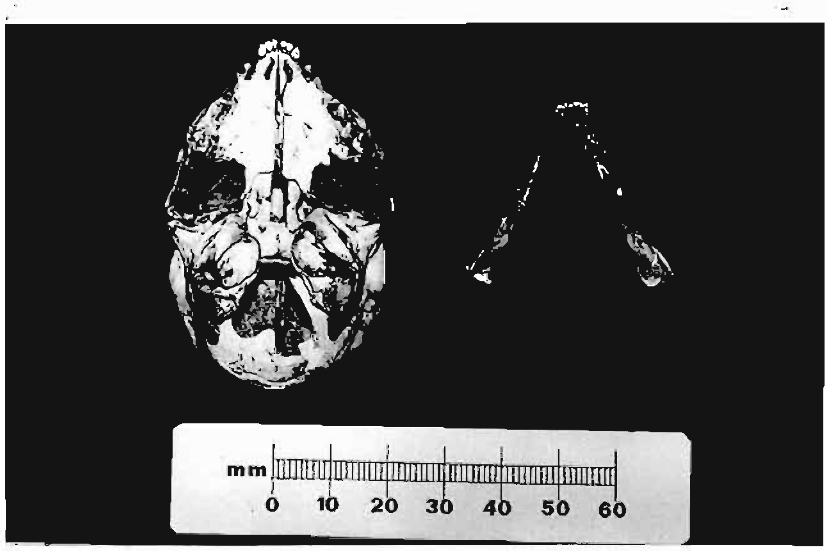
FEMALE

2155	"	Birth	49,3	29,0	8,5	10,0	-	11,8	28,7	-	-	-	-	-	-
2102	"	Birth	46,4	27,2	7,6	9,6	-	11,7	26,0	-	-	-	-	-	-
1726	"	Birth	46,7	-	8,2	9,7	-	10,7	25,4	-	-	-	-	-	-
1665a	"	10 days	-	-	10,8	12,0	-	12,5	-	-	-	-	-	-	-
1665b	"	10 days	47,8	-	9,3	12,0	-	12,0	32,4	-	-	-	-	-	-
1454	"	10 days	59,0	39,7	11,6	11,2	-	13,8	35,6	30,0	8,0	-	-	36,0	6,3
2862	"	1 month 20 days	-	-	15,0	12,6	31,7	-	-	-	-	8,4	4,0	46,5	9,0
2863	"	1 month 20 days	-	-	-	-	-	-	-	-	-	9,4	4,0	47,3	10,3
3430	"	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	"	6 months	-	73,0	-	18,7	35,6	-	52,7	48,4	-	-	-	73,0	14,7
2492	"	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	"	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	"	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	"	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	"	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	-

Appendix 4. Photographic Record of Known-age Caracal skulls, in Chronological Order.

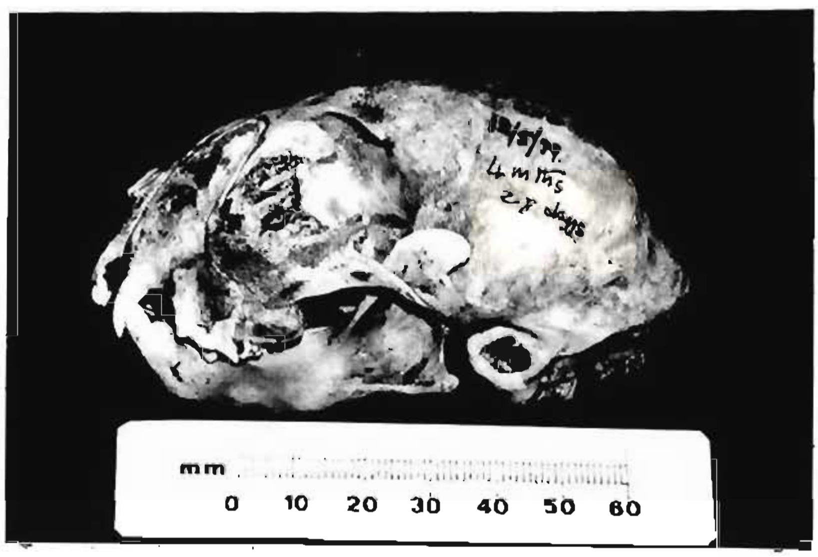
1. Newly born Caracal kitten. Note presence of incisors and tips of c^u.

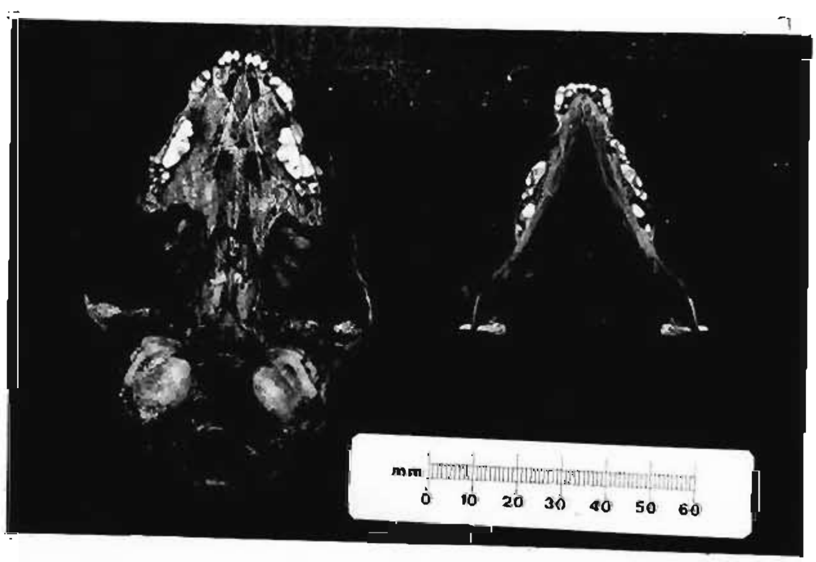




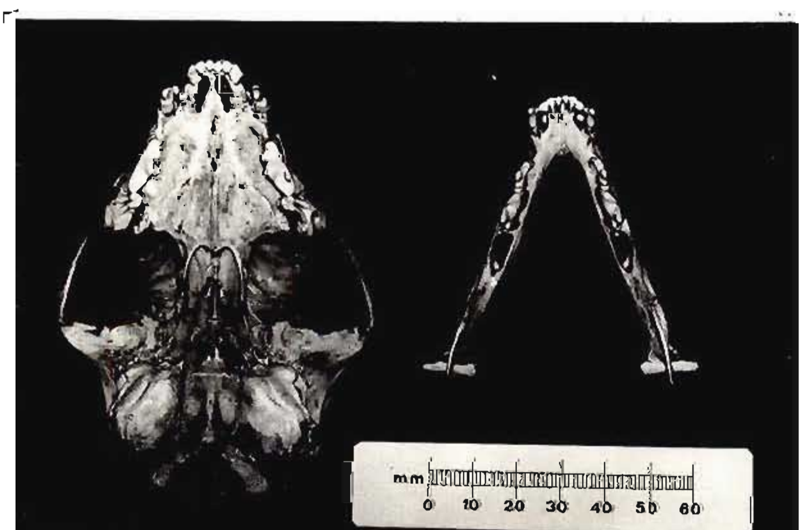
2. Skull of two month old Caracal kitten. Note that c^u and c_1 well emerged, as are upper and lower premolars.

3. Skull of five month old Caracal (four months, twenty eight days). Tips of C_1 visible; M_1 clearly visible.





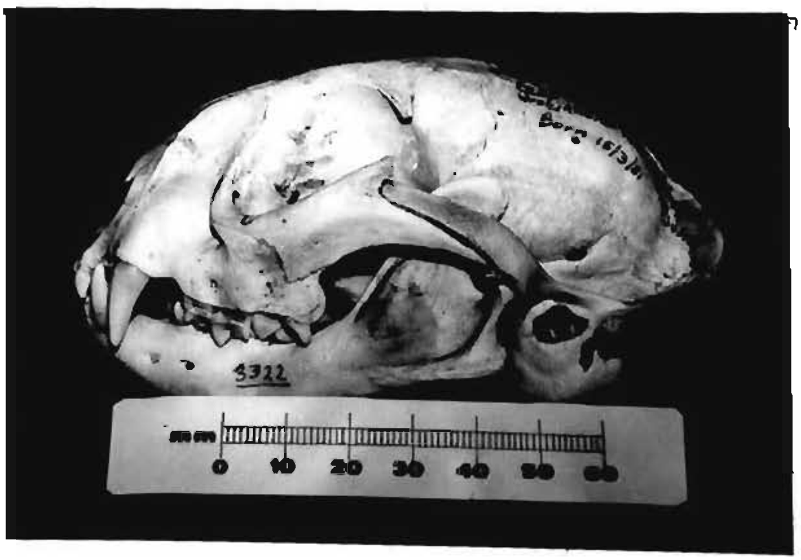
4. Skull of Caracal at six months of age. C^u and C_l clearly visible. Permanent incisors in place.

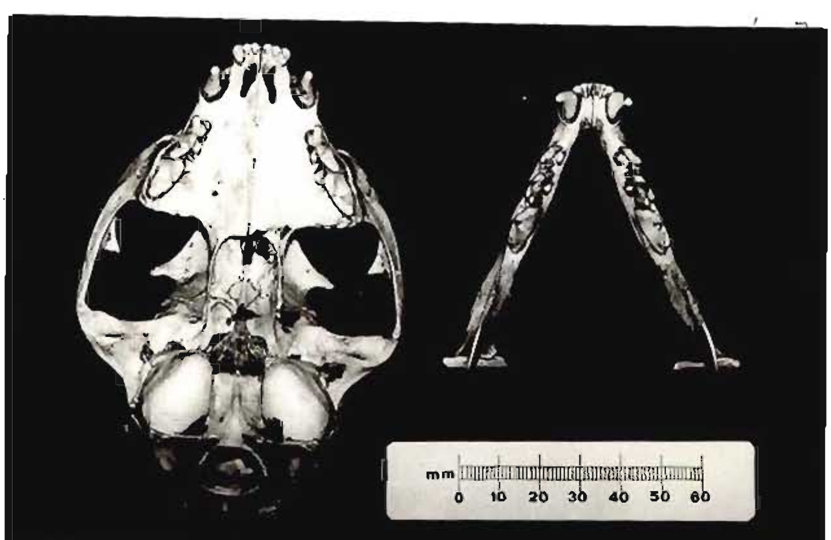


5. Skull of Caracal at seven months. C^u and C_1 well emerged and c^u and c_1 displaced. M^1 clearly visible; p_3 and p_4 almost displaced.

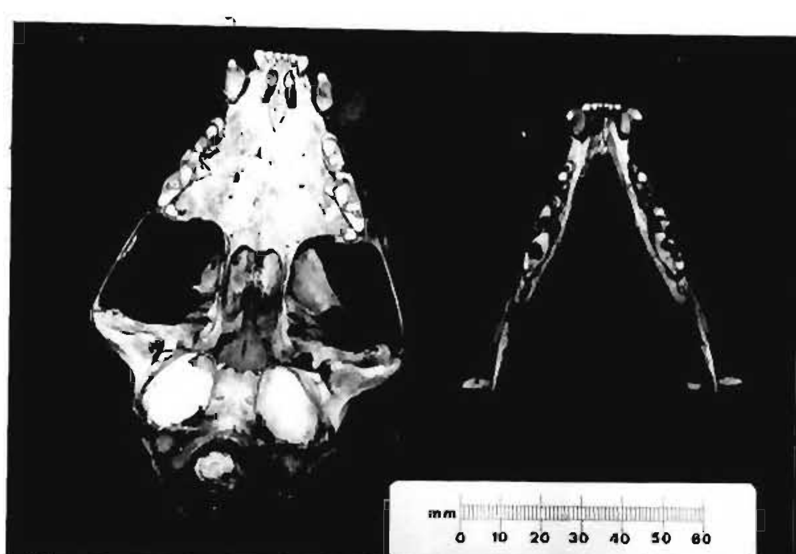
5 (continued). Close up of upper dentition of seven month old Caracal showing incomplete C^u emergence, and upper cusp of P^3.

6. Caracal skull at eight months. Note almost fully emerged canines. P^3_3 and P^4_4 and M_1 are clearly visible.

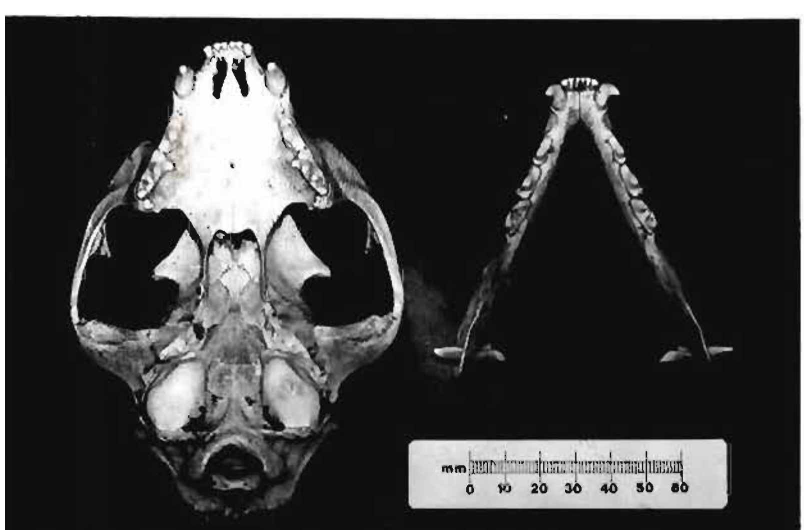




7. Skull of Caracal at ten months. All deciduous teeth absent; C^1 and C_1 fully emerged. Molars and premolars close to full emergence.



8. Skull of a Caracal at one year and three months. Complete dentition. Note presence of P^2.



Appendix 5. Dosage rates and reaction times for caracal (<u>Felis caracal</u>) immobilized with Ketamine hydrochloride (animals trapped for tracking purposes and one captive animal are included).

Animal	Sex	Age	Mass (kg)	Drug and Dosage (mg) (Ketamine hydrochloride)	Time of 1st reaction (mins)	Time when tractable (mins)	Time 1st recovery (Hrs. Mins)	Fully recovered (Hours)
"FENCE" (WILD)	♀	Adult	8,4	125	3	7	1 hour 35 mins	3 hours 30 mins
"KLOOF" (WILD)	♀	Adult	9,9	100	2 mins 30 secs	15	1 hour 04 mins	4 hours 45 mins
"LADY" (WILD)	♀	Adult	8,5	100	4 mins 2 secs	6	1 hour 55 mins	4 hours 10 mins
"GOOD BUDDY" (WILD)	♂	Sub-adult/ Adult	9,0	c.140-170	10	-	-	-
"PETER" (WILD)	♂	Sub-adult	8,5	c.215	-	40	1 hour 8 mins	?
"AGATHA" (WILD)	♀	Adult	9,4	100	5	8	2 hours 40 mins	7 hours
"TYGERBERG" (CAPTIVE)	♀	Adult	9,5	100	3 mins 20 secs	6 mins 30 secs	42 mins	2 hours 45 mins

<u>NOTE</u>: In the case of "GOOD BUDDY", an initial oral dose was administered in order to make the cat tractable enought to give an intramuscular injection. "Peter" was drugged with a blow-pipe dart, although it is suspected that the syringe malfunctioned. Captive animals were initially tested with Phencyclidine hydrochloride, but the trauma to which the animal was subjected and the long recovery time ($\bar{x}$ 21 hours, n=7) made its use unacceptable.

ADDENDUM 1. ADDITIONAL STATISTICAL ANALYSES

Table 9, page 117

Sex ratios of adult *Felis caracal* killed by hunters from 16 Cape districts.

District	Chi-square test	p
Riversdale	0,39	p >0,5
Calvinia	15,50	p <0,001
Humansdorp	1,50	p >0,2
Piketberg	0,36	p >0,5
Clanwilliam	0,29	p >0,5
George	5,14	p <0,05
Mossel Bay	0,36	p >0,5
Ceres	22,08	p <0,001
Caledon	9,26	p <0,01
Robertson	1,58	p >0,2
Namaqualand	0,17	p >0,5
Colesberg	0,026	p >0,8
Van Rhynsdorp	6,76	p <0,01
Bedford	2,50	p >0,1
Adelaide	1,69	p >0,1
Bredasdorp	2,18	p >0,05

(p- factor, expected ratio of 1 : 1. H_o : p= 0,99; df= 1)

The p- factors for the districts of Calvinia, Ceres, Caledon and Van Rhynsdorp are significant.

The chi-square value for the total sample (males 430; females 324) is 14,9 (p < 0,01).

<u>Table 10, page 118</u>

Body measurements(mm) and mass(kg; mean and range) of adult male and female caracal collected in the Cape Province.

Measurement	Standard Deviation		Standard Error	
	Male	Female	Male	Female
Head and body	77,078	61,786	7,746	6,476
Tail	29,355	29,897	2,920	3,020
Hind foot	10,606	10,003	1,050	1,010
Ear	7,324	6,855	0,736	0,692
Mass	2,849	1,823	0,318	0,231

Table 10....... continued

Student's t-test for the difference between two means.

Measurement	t-	p
Head and body	4,21	p <0,001
Tail	4,77	p <0,001
Hind foot	6,43	p <0,001
Ear	2,35	p <0,01
Mass	4,35	p <0,001

Table 11, page 119

Sexual dimorphism of 12 different cranial measurements of adult *Felis caracal* (sd- standard deviation; se- standard error).

	Male		Female	
Measurement	sd	se	sd	se
Total length	8,148	0,388	4,721	0,668
Zygomatic width	5,523	0,781	3,987	0,564
Nasal	2,818	0,394	1,315	0,186
Interorbital constriction	1,988	0,278	2,204	0,312
Postorbital constriction	1,842	0,261	1,836	0,260
Orbital height	1,745	0,247	1,542	0,218
Cranial width	1,559	0,221	1,642	0,232
Width at bullae	2,305	0,326	1,929	0,273
Maxillae width	1,597	0,226	0,992	0,140
Upper canine length	1,428	0,202	0,937	0,133
Upper canine diameter	0,498	0,071	0,397	0,056
Jaw length	4,910	0,688	3,592	0,508

Table 11 .... continued.

Student's t-test and p applied to cranial measurements.

Measurement	t-	p
Total length	4,44	p <0,001
Zygomatic width	3,57	p <0,01
Nasal	3,72	p <0,01
Interorbital constriction	3,11	p <0,01
Postorbital constriction	0,74	p <0,4
Orbital height	3,06	p <0,01
Cranial width	4,41	p <0,001
Width at bullae	4,54	p <0,001
Maxillae width	4,88	p <0,001
Upper canine length	3,65	p <0,01
Upper canine diam.	6,85	p <0,001
Jaw length	4,25	p <0,001

ADDENDUM 2. A Synthesis of the State of Current Knowledge of *Felis caracal* Biology and Management Implications

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Within the Cape Province the caracal *Felis caracal* is considered (Stuart 1981) to be the principal wild predator of small domestic stock (sheep and goats), and as such, it was necessary to undertake an investigation of caracal biology. The principle purpose of the study was to formulate a more acceptable and meaningful management plan for the caracal in the Cape Province by investigating the following factors: 1) feeding, 2) breeding, 3) growth, age determination and population structure and, 4) home range and movement.

Research on the caracal has received limited attention and only two papers have been published on research undertaken in the Cape Province. Grobler (1981) and Pringle and Pringle (1979) have examined the qualitative aspect of the diet of the caracal in two very limited geographical areas of the Eastern Cape, but the work of Grobler (1981) is the only one of significance. The food categories and analytical methods of Pringle and Pringle (1979) were of too general a nature to enable any definite conclusions to be drawn as to dietary patterns within their study area.

Although distribution of the caracal has been documented by numerous authors for limited geographical areas, the current study examined distribution over this cats entire range. The caracal is widely distributed in Africa, the Middle East and south-western Asia, but it is only in South Africa and southern South West Africa that it is considered to be a problem animal. The caracal is a classified problem animal in the Cape Province, Transvaal, Orange Free State and the southern districts of South West Africa. Problems exist in areas with both intensive and extensive small stock husbandry. Unfortunately, little has been recorded on the caracal outside South Africa, but elsewhere it is apparently uncommon to rare with the possible exception of the Somali habitats (Kingdon 1977). It does not appear to pose a significant threat to small animal husbandry in other areas, but this could be indicative of the predominantly nomadic nature of the stock farming which takes place. Findings in the current study indicate that the caracal is largely reliant on sedentary prey species, and therefore nomadic animals would not be expected to play a significant role in the overall feeding regime. No information on the caracal is available from large conserved or non-livestock areas to compare relative densities with areas stocked with domestic animals.

<u>Food</u>

The felids are specialist predators, and they are the only carnivore group capable of handling prey larger than themselves when hunting alone. This is achieved by means of a lethal, well directed nape or throat bite when dealing with prey dassie size or larger. Observations of captive caracal show that they approach prey by moving from cover to cover in a crouched position. The caracal exploits to the full all available cover in order to make the closest possible approach. The caracal will wait until the prey animal is in the most favourable position and then make a very rapid, short dash or leap. Small prey (rabbit or dassie size) is usually held by the throat and carried into cover. Larger prey such as small antelope or sheep are killed at the capture site (death usually results from suffocation) by a throat or nape bite (where the nape is bitten this is soon switched to the throat),and either eaten on site or dragged to cover.

During the current study and the examination of published work, it was determined that caracal in the Cape Province is predominantly a predator of small to medium sized mammals which are taken by active hunting in a wide range of habitats.

Mammal remains in the current study, and those of Bester (1982- Orange Free State), Grobler (1981) and Pringle and Pringle (1979), were found to occur in more than 90% of all samples examined. The extremely small information base for caracal outside South Africa makes it difficult to draw conclusions on diet for other regions,but it would seem likely that mammals will be found to form the bulk of prey taken despite Kingdon (1977) having expressed the view that birds are probably the most important food group. This conclusion lacks sound back-up in the form of stomach or scat analyses and would appear to be largely anecdotal.

In the current study, caracal stomachs were found to contain significantly more antelope remains than any other prey items, with rodents occurring in less than 10% of stomachs. The analysis of scats collected in the Robertson Karoo revealed that rodent remains were present in 50% of scats, whereas antelope remains were traced in less than 11% of scats. This considerable difference in content is probably explained by the fact that stomachs were taken from animals collected from many localities, whereas the scats were collected in the eastern Robertson Karoo. As with most carnivores, the caracal will exploit a suitable, abundant food resource when the opportunity arises.

Although not recorded for wild prey, the incidence of surplus killing of small stock by caracal appears to be not uncommon. Although not conclusive, certainly in a number of cases surplus killing involved more than one caracal. From examination of tracks it would appear that surplus killing is largely carried out by females with kittens at heel.

The incidence of stock killing by caracal is highest in the arid interior where the bulk of the small stock farming is undertaken. Although stock of all ages and sizes are taken, there is a strong bias towards the taking of younger animals. This is borne out by the fact that lambs are taken in preference to adults in mixed age flocks. Stock is taken throughout the year with a discernable peak in stock predation during the drier winter months. Although more stock losses are recorded in the winter months, this could be related to lower levels of flock supervision during this period and a lower frequency of dosing and dipping. A surprising number of farmers are unfamiliar with predator sign,and it is felt that many kills blamed on caracal were in fact not killed by this species.

Two of the difficulties in controlling stock losses in the Cape Province are the predominantly extensive nature of the livestock farming and the fact that many farmers allow sporadic breeding to take place throughout the year. Having one or two definite lambing seasons a year would allow for more effective control and supervision. The adoption of a spring mating and autumn lambing programme would help reduce losses of smaller lambs, because at this time it would fall outside the main caracal breeding peak when food requirements are at their highest. At the present time,it would seem that stock losses to caracal are not generally related to natural food availability, and this is borne out by the widespread nature of the problem in the province. The influence of the drought conditions leading up to and during the current study could also be playing a role in the reduction of natural prey in some areas. It would appear that excessive caracal predation on small stock is not always due to scarcity of natural prey. Rather, the abundant natural prey supports a larger caracal population, and some of the caracal would prey on stock at will.

Although caracal were found to show a preference for young small stock units, they would also take large, fully grown animals. The latter included adult "Boerbokke" and Merino ewes. In the case of the black-backed jackal, a far greater preference is shown for the taking of young animals, although adults are taken on occassion. Management practices to reduce stock losses to predators would be of greater value in curbing losses to black-backed jackal than to caracal.

It is of interest to note that the two principal wild predators of domestic stock in the Cape Province, the caracal and the black-backed jackal, differ in two important ways. The caracal is an active predator (primarily of mammals) with a much wider breeding season. The black-backed jackal has a much broader food base which includes a high percentage of carrion in some areas, and has a fixed, short-term breeding season.

Breeding

The caracal is a solitary animal, forming a pair bond of very short duration. Mating and copulation follow a pattern very closely allied to that of the domestic cat. Following the end of the female's oestrus, the male moves off, leaving the female to undertake all aspects of rearing the young.

The mean gestation period was found to be 79,4 days in the current study, with a range of 78 to 81 days. The lowest gestation period recorded in the literature is 69 days (Gowda 1967) and the highest 78 days (Cade 1968). As with all births of wild animals in captivity, there is always the element of doubt as to whether this is a reliable indication of the situation in the natural state. The lowest gestation period would appear to be far too short and indicates a miscalculation of time of conception. In the current study, first succesful mating was established as 12,5 and 14,0 months for two captive held males, and 14,0 and 15,0 months for two females.

Although caracal pregnancies and births were recorded throughout the year, peaks are discernable for October/ November and January, with a low from March to June. Current findings indicate that the birth rate in spring and summer is approximately double that for the winter months. The only published records for the Cape Province are those of Pringle and Pringle (1979) with records for April and September to November. The highest incidence was in October/November. In the case of the caracal which relies primarily on fixed area prey, and generally shows little population fluctuation, there is no significant benefit in having a short, fixed breeding season. Although most of the prey species have young during spring and early summer, it would mean a greater food availability during this period. An in depth study of caracal/ prey relationships in different regions would be of benefit . Unlike the black-backed jackal which is a monogamous species with a permanent pair bond (Rowe-Rowe 1982), the caracal is a polygamous breeder with a pair bond of very short duration. Although not known with certainty, it would seem likely that the reproductively active caracal male has a fairly large territory which overlaps those of several females. Once the mating cycle is complete with one female, the male then moves off leaving the female to single-handedly raise the kittens.

Growth, age determination and population structure

The current study was the first to examine growth and development of the caracal. Information was collected from 27 known-age caracal bred in captivity.

Asymtotic growth of head and body length and body mass is reached at 40 weeks of age, and it is these two measurements that are recommended for age determination up to this age. Tail, hind foot and ear maximum growth which are reached at 20 weeks are not recommended. The sequence of tooth eruption is considered to be a useful method of age determination up to the age of ten months. Eyelens mass is also considered to be a useful method of ageing. The use of dentine incremental lines is rejected as an acceptable age determination technique, but the presence of incremental lines in the cementum warrants further investigation.

A preponderance of males in 13 of the 16 Cape districts sampled (chi-square 14,9; $p < 0,01$) was attributed to the greater mobility of males and therefore greater exposure to human hunting pressure. Although more males are killed than females, it is ultimately the females that regulate population growth. Due to the lack of non-selective control in this country, it is not possible to say whether males kill more stock than females although their greater mobility would seem to indicate this possibility.

Sexual dimorphism exists in the caracal, with the males being consistently larger than the females. Once again evidence is lacking, but the greater size of males would be beneficial in the taking of larger prey and therefore larger stock units.

Movement and home range

The caracal in the South West Cape is a solitary animal and mainly nocturnal in activity. The influence of human hunting activity could, however, influence whether a population is primarily nocturnal or not. Smithers (1971) recorded primarily nocturnal activity in Botswana, although Rowe-Rowe (1978) recorded early morning and evening activity only. In stock farming areas, the nocturnal activity of caracal tend to limit the usefulness of hounds as a control measure, although a few packs (depending on the level of good breeding) find little difficulty in picking up the trail of a predating cat. If the use of the toxic collar was more widely adopted, the nocturnal activity pattern would have no influence on selective control.

The closest parallel's to caracal spatial organisation known probably exist in the smaller North American felids, notably the bobcat Felis rufus (Bailey 1974). Bailey (1974) found that mean male home range was 42,1km^2 and for females 19,3km^2. In the South West Cape the mean female caracal home range was 18,2km^2 and the range of one male was found to cover 48km^2. As considerable variation has been found in bobcat home range size (2,5km^2- Provost, Nelson and Marshall 1973; 105km^2- Marston 1942), similar variation can be expected for caracal in different environments. This is likely to be a result of reflecting differences in the abundance and availability of suitable prey. The resident caracal density is probably a function of the habitat and prey availability as was postulated for mountain lion Felis concolor by Seidensticker, Wiles and Messick (1974). The caracal prey species are primarily area restricted (eg. territorial, solitary antelope and rodents) and therefore, they are more likely to be stationary than is a predator preying on mobile or migratory prey. The generally sedentary nature of domestic stock makes them especially susceptible to caracal predation.

The female caracal must raise the family alone; therefore, reproductive success is largely female dependant. Females with small kittens must utilize smaller areas than males because of their restricted mobility. Females must bring food to kittens , which when small, are left behind while the female hunts. Most of the females time is spent protecting and providing food for her young. After the kittens become independent she is likely to mate again soon afterwards. For a succesfully reproducing female, the best strategy for exploiting the food resource at a constant rate necessary for rearing kittens is to gain familiarity with, and attachment to, the best site available. Failure to do this has far more serious results for the females reproductive fitness than for the male.

As Bailey (1974) found with bobcat and Seidensticker et al (1973) with mountain lion, the manner which resident caracal use to advertise land occupancy, and the way in which intruders respond was uncertain, but scent marking almost certainly plays an important role. Methods of scent marking identified in the caracal were urine (either direct or in conjunction with scrapes in the male); possibly faeces, as they are not buried; and in conjunction with the faeces, small quantities of secretion are given off by small glandular pockets situated on either side of the anus. Caracal probably use scent marking for a number of purposes, one function could well be related to demarcation of the home range. By demarcating special places within their home ranges, caracal may have prevented others from settling there. Urine marks and faeces could also serve to facilitate or prevent encounters. The latter is necessary in that the caracal with an established home range has a limited prey availability and therefore cannot be shared by other caracal. The fact that caracal utilise urine for marking purposes is well known to some farmers who utilize urine dampened sand in cage traps to improve trapping success. The analysis of the pheremones in caracal urine could lead to the development of artificial lures and repellents.

It would seem probable that the situation with dispersing young caracal and those of young bobcat (Bailey 1974) could be similar. Young caracal, because of the apparently territorial system, would probably avoid settling in areas already occupied by resident adults. The current "blanket" control methods undertaken in the Cape almost certainly facilitate the establishment of young caracal in territories or home ranges from which established animals have been removed.

In the Robertson Karoo study area, the three radio-collared female caracal had overlapping home ranges; but due to the lack of a collared male in the same area, it was not possible to determine home range relationships or territoriality between the sexes. As a result of the limited nature of the current study in both numbers and extent of study area, it would be wrong to assume the system could not differ given a different prey resource, a different environmental structure, and the presence of a competetive species or species for a similar food resource. The importance of undertaking similar studies in other regions cannot be over-emphasized.

Management preamble and proposals

Although documentary evidence is lacking, anecdotal evidence indicates that the caracal has only recently developed into a threat to small stock. Up until the post Second World War it was claimed that the black-backed jackal was the principal problem predator, and the caracal played only a minor role. Intensive campaigns to eradicate the jackal and then exclude them by erecting jackal proof fencing left a vacant feeding niche which could be exploited by the caracal. Ferguson (1981) found that there were aggressive interactions between jackal and other predators, including the caracal. The same author expresses the opinion that this possibly plays a role in the limiting of numbers of other carnivores. In areas where jackal are intensively controlled, it has a positive effect on other predator populations.

As has already been discussed in general, unselective control methods currently being practiced in the Cape Province are of little use, as dispersing young caracal would soon occupy suitable uninhabited terrain and vacated areas. In areas where caracal numbers are intensively controlled it can be expected that vacant areas will soon be reoccupied. The most success will generally be achieved by localised, selective control of the animal causing the damage.

The aim should be to remove animals causing damage by such selective means as the toxic-collar, but where it is considered that population levels should be reduced, the use of cage traps and careful gin trap sets (to be avoided unless as a last resort) can be used. The use of hounds for selective control is limited by meagre rainfall over much of the Cape interior. Current use of hounds is primarily aimed at non-selective control. One of the most important factors in successful control is that response to the damage should be swift and not delayed, as is usually the case.

Where general suppression of a poulation is warranted (rarely) , it would appear that removal would be most effective as dispersal of young wanes (although of limited value in the case of caracal), and immediately prior to the spring/ early summer birth peak. Reductions would then be added to natural losses and would also remove part of the incipient reproduction, hence making the effects more severe and presumably longer lasting than reduction at other times. However, the impact of such a programme would be of far more limited value than one aimed at a markedly seasonal breeder such as the black-backed jackal.

It would appear that caracal populations can endure much higher annual kill rates than are likely to be attained over broad geographical areas with the funds, manpower and principally, the methods currently in use in this province. Unfortunately stock loss costs have never been assessed in the Cape Province, and these figures are urgently needed in order to establish the cost-effectiveness and the level of control currently being exercised.

While predation is a significant problem, it is not the only one affecting stock farmers. Predation is dramatic and arouses emotions, but its magnitude is often tied to other circumstances. However, farmers feel that predation, unlike weather or economic conditions, is a problem that could be alleviated immediately if efficient and safe techniques for the control of predators were made available.

Unlike the black-backed jackal, the caracal cannot be excluded from areas by erecting fences. The development of electrified fencing has very limited application but could serve a useful function under intensive pasture conditions.

It is strongly recommended that the use of the toxic collar and its application under field conditions be encouraged by conservation authorities and organised farming associations. This is the only method which will serve to remove only those caracal killing livestock as opposed to species "blanket" control. The collar has a number of additional advantages which have been enumerated in Chapter 8 of the thesis. The recent banning of the most suitable poison (1080) is unfortunate, and it is therefore essential that efforts be made to find an efficient substitute. An added advantage of the use of this method is the fact that the farmer could deal with the majority of problems arising from predation without having to call in the assistance of professional predator hunters. The collar has value in both intensive and extensive stock farming practices.

Apart from implementing the wider use of the toxic collar, the following are also recommended:

1. An education programme aimed at the farming public and officials dealing with problem animal control, pointing out the value of predators in general. At the same time they should be encouraged to use the toxic collar and cage traps for caracal control. Where gin traps are in widespread use,

their setting should be refined and made as selective as possible. This should be undertaken by the provincial and divisional council authorities offering an adequate extension service.

2. Improved predator management measures must go hand in hand with improved farm management practices. These include measured lambing season/s, better flock supervision, possible use of livestock-guarding dogs.

3. An assessment of stock losses in areas where caracal (and other predators) are active, with a view to preventing an imbalance in cost effectiveness of control versus stock losses.

4. Control should be restricted to areas where caracal prey on domestic stock, and blanket control on surrounding areas such as State Forest land and conservation areas should be avoided.

Additional References

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ERRATA

PAGE	PARA	LINE	FOR	READ
vii	4	1	captive births	births in captivity
1	2	4	to crouch	for crouch
1	2	9	One of	The most
5	2	3	intra	intra -
23	2	1	Data .... was	Data .... were
23	3	14	;mammals	. Mammals
32	2	6-9	To read: Caracal carcases were placed in 200 ℓ drums containing 10% Formalin, by the hunters (...).	
32	3	1	10% Formaldehyde	10% Formalin (and throughout thesis)
41	1	5	Stock killing	stock-killing
60	2	11	$\pm$	approximately
63	2		To read: The mean daily food intake in the current tests was 586g. This is in contrast to Grobler (1981) who found that daily food intake of adult, wild caracal was 1kg, and that of juveniles 500g.	
69	1	2	data has	data have
69	3	4	10% buffered formaldehyde	10% buffered formalin
70	4	3	Ageing	Age determination
70	4	6	purposes; the	purposes and the
72	4	2	days; the	days and the
74	3	3	Province; pregnant	. Pregnant
76	1	12	were	was
78	5	2	were established	was established
79	2	2	are presented	is presented
88	3	2	culled	killed
89	1	1	and weighed	"delete"
89	2	3	determined with	determined from
89	3	3	vernier calipers	Vernier slide calipers
94	1	2	Meyers	Meyer's
94	2	7	dessicators	desiccators
99	Fig 45(e)		Kgs	kg
104	1	1	illustrate	illustrates
115	1	1	for foetuses	from foetuses
124	1	1	the present time	the present
124	1	4	studies of	studies by
126	2	2	;tracking	. Tracking
126	4+5		antennae	antenna
129	3	1	were positioned	was positioned