

Spatio-temporal ecology of the
yellow mongoose *Cynictis penicillata*
in the Great Fish River Reserve
(Eastern Cape, South Africa)

By

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Supervisor: Dr Emmanuel Do Linh San



DECLARATION

1. This is to declare that this dissertation entitled “**Spatio-temporal ecology of the yellow mongoose *Cynictis penicillata* in the Great Fish River Reserve (Eastern Cape, South Africa)**” is my own work and has not been previously submitted to another institute.
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SUPERVISOR'S FOREWORD

This Master's dissertation is part of larger project aimed at investigating niche differentiation in an assemblage of small African carnivores: small grey mongooses, yellow mongooses, large- and small-spotted genets, and to a lesser extent water mongooses and meerkats. The project started in September 2005 and the field work was completed in August 2011. Overall, it incorporated data collection and analysis by the project leader and 5 Honours and 2 MSc students.

Although the MSc candidate, Mr Owen Akhona Mbatyoti, did collect about 50% of the data analysed in the current dissertation, his contribution to the overall project was twice larger. Mr Mbatyoti indeed spent over 150 full days or nights in the field, between May 2010 and August 2011. Field work included trapping and continuous radio-tracking sessions of most of the above-mentioned species. Mr Mbatyoti is therefore to appear as co-author on some of the related scientific outputs (conference presentations and papers).

The format of this dissertation (general introduction, abstract, two independent papers, general conclusion) has been chosen with two purposes in mind: first, to train the MSc candidate to the writing of scientific papers, and second, to secure and allow for a quicker dissemination of the scientific knowledge. Consequently, the present work does not include extensive reviews on the study species or on the main field techniques used (trapping and radio-tracking), as is sometimes the case in MSc dissertations. In order to avoid repetitions, information on the study area has been placed in a separate chapter.

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Kuwe Makhulu, Bazali, booMakazi nooMalume, bantakwethu, bodade wethu, kwizihlobo nakubahlali ndiyانبulela ngenkxaso nengqeqesho yenu. Ndicela nindixolele torho nibaninzi ndingathatha imini yonke ndinibala ngamagama niyazi ningobani. Andibalibelanga nabo badlala inkxaxheba ebomini bam kodwa sele basandulela enkosi kakhulu. Andazi ngendiyintoni ngaphandle kwenu nonke. Kunamaxesha nam endithi xa ndijonga ngasemva ndingawukholelwa umgama esele ndiwuhambile.

ABSTRACT

Very little is known about the spatio-temporal ecology of the yellow mongoose *Cynictis penicillata*, despite this small carnivore being widely distributed in the southern African subregion. Until the present study, activity patterns and daily movement distances had only been investigated over a single season, and information on home range sizes was only available from a few populations. Here, I aimed at determining the activity patterns and the space use of yellow mongooses over the different seasons of the year in the Great Fish River Reserve (Eastern Cape, South Africa). In addition, I tested some predictions related to environmental factors (variations in photoperiod, climatic conditions and food availability over the year), as well as life cycle (reproduction) and morphological and physiological characteristics (sexual dimorphism and thermoregulatory aspects associated to the possession of an elongated body).

From September 2005 to August 2011, spatio-temporal data were collected through 102 continuous tracking sessions (84 during the day and 18 during the night) of 12 adult individuals (seven males and five females) fitted with motion-sensor radio-collars. Additional data were obtained through semi-continuous tracking sessions and random locations. Yellow mongooses were essentially diurnal and crepuscular. Activity levels averaged 57% during the day ($n = 11,807$ fixes) and only 11% at night ($n = 3,623$ fixes). Yellow mongooses emerged from their burrows on average (\pm SD) 85 ± 62 min after sunrise (range: -11 to $+369$ min) and returned 21 ± 84 min before sunset (range: -518 to $+225$ min). The duration of the daily activity period varied between 12 min and 15 h 36 min, with a mean of 9 h 28 min. Both sexes exhibited some overground activity after sunset, but this was most pronounced in males than in females. Nocturnal activity outside the activity period was generally restricted to short underground bouts of activity occurring at anytime of the night. Diurnal resting, with up to 11 bouts per activity period, occurred in 98.8% of activity periods. Overall, yellow mongooses were active during $68 \pm 17\%$ of the time spent outside the burrow. Photoperiod acted as a *zeitgeber* and activity was negatively affected by adverse climatic conditions (very hot or conversely low temperatures, rain, wet soil) and probably low terrestrial arthropod activity/availability. No intersexual difference in activity levels was found, although the higher body mass of males (on average 16%) implies higher metabolic demands.

The total home range size (MCP 100%) averaged $0.55 \pm 0.65 \text{ km}^2$ (range: 0.10–2.36 km^2) and the related total perimeter measured on average $2.80 \pm 1.71 \text{ km}$ (range: 1.17–7.36 km). Male home ranges were on average more than twice large than those of females, but this difference did not reach statistical significance. However, males had larger daily home ranges ($0.13 \pm 0.15 \text{ km}^2$) than females ($0.05 \pm 0.05 \text{ km}^2$). In addition, daily movement distances of males were longer ($1.99 \pm 1.07 \text{ km}$) than those of females ($1.29 \pm 0.66 \text{ km}$). Males also travelled at a faster speed ($0.29 \pm 0.13 \text{ km/h}$) than females ($0.18 \pm 0.07 \text{ km/h}$). Overall, sex clearly appeared to play a role in the spatial ecology of yellow mongooses, but the underlying explanation does not seem to be linked to sexual dimorphism (body mass) or reproductive activity. Whilst the role of food availability on the space use of yellow mongooses is unclear, it is likely that low temperatures negatively affect yellow mongoose movements, as they do for their activity levels.

Key words: yellow mongoose, *Cynictis penicillata*, activity patterns, diurnal, home range size, daily range, daily movement distance, body mass, breeding season, photoperiod, food availability, climatic conditions.

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Chapter 1

The yellow mongoose *Cynictis penicillata*

1.1 Taxonomy and status

The yellow mongoose *Cynictis penicillata* is a small carnivore (order Carnivora) that belongs to the family Herpestidae and to the subfamily Herpestinae (Gilchrist *et al.*, 2009). *Cynictis p. penicillata* is the subspecies that possesses the largest distribution. Other subspecies are *C. p. bradfieldi*, *C. p. coombsii* and *C. p. natalensis* (Skinner & Chimimba, 2005). The IUCN assessment conducted in 2008 listed the yellow mongoose in the Least Concern category (IUCN, 2011). Even though the use of agricultural pesticides may impact negatively on the populations of *C. penicillata*, no detailed work has been undertaken on this aspect (Mills & Hes, 1997). The yellow mongoose is considered to be a chief contributor in the incidence and spread of rabies in South Africa (Mills & Hes, 1997).

1.2 Description

The yellow mongoose varies geographically from reddish-yellow to tawny-yellow in colour (Taylor & Meester, 1993). Males (body length: 563 ± 28 mm; tail length: 230 ± 15 mm) and females (body length: 554 ± 31 mm; tail length: 228 ± 21 mm) are similar in size (Lynch, 1983). However, there is a slight sexual dimorphism when it comes to body mass, with males (790 ± 132 g) being about 7–8% heavier than females (734 ± 120 g; Lynch, 1983). Both sexes have anal glands that function in scent marking of home ranges and in allomarking between colony members (Earlé, 1981). Objects may also be marked by means of the cheek glands (Balmforth, 2004).

1.3 Distribution and habitat preference

Cynictis penicillata is endemic to the southern African region, including Zimbabwe, Namibia, Botswana, Angola and South Africa (Taylor & Meester, 1993; Fig. 1). In the latter country, the species is found in all the provinces extending to the eastern Lesotho (Skinner & Chimimba, 2005). It has a wide range of habitat tolerance (Mills & Hes, 1997), although it seems to prefer open and low vegetation habitats, semi-arid areas, deserts (e.g. Kalahari), short grasslands and cultivated croplands (Mills & Hes, 1997; Larivière & Calzada, 2001; Skinner & Chimimba, 2005). It is generally not found in woodlands, mountains and thick bushes (Gilchrist *et al.*, 2009).

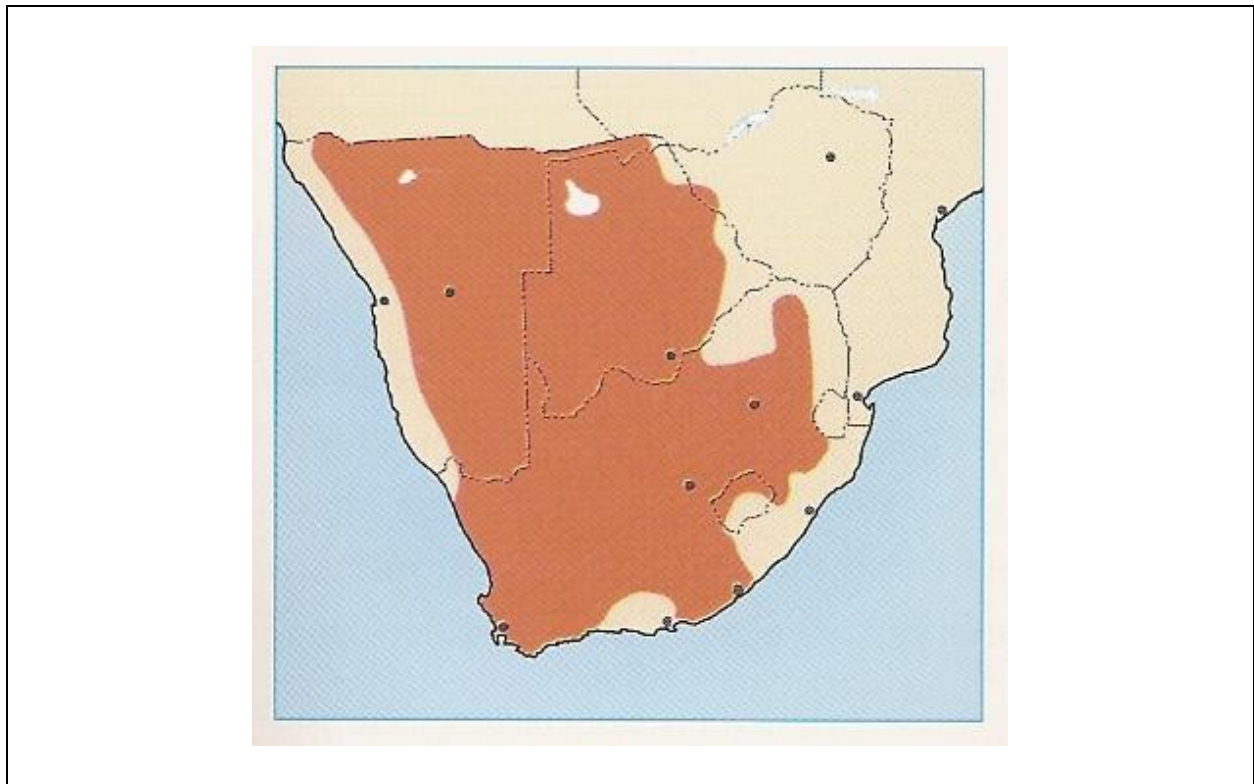


Figure 1. The distribution of the yellow mongoose *Cynictis penicillata* in southern Africa (from Mills & Hes, 1997). The black dots on the map represent major cities in southern African countries.

1.4 Reproduction

The seasonal dioestrus mating begins from the first week of July (Earlé, 1981; Skinner & Chimimba, 2005). The female's gravid period varies from 60 to 62 days and litter size ranges from two to five pups (Rasa *et al.*, 1992; Mills & Hes, 1997). The offspring are born from August extending up to March (Balmforth, 2004; Skinner & Chimimba, 2005). The young are weaned on the eighth week after their birth, even though they may occasionally suckle when aged four to five months (Rasa *et al.*, 1992). The pups start accompanying foraging adults when two months old and are nutritionally independent at 16 to 18 weeks (Rasa *et al.*, 1992).

1.5 Social and feeding behaviour

Cynictis penicillata is a solitary foraging animal, although it generally lives in groups of 2-13 individuals (Balmforth 2004; Gilchrist *et al.*, 2009). The colony occupies a den that consists of tunnels with multiple entrances (Estes, 1991). The dens are positioned on rising soil that these mongooses dig themselves, although they may adjust holes made by other animals (Estes, 1991). Yellow mongooses have been observed sharing burrows with other species, mostly Cape ground squirrels (*Xerus inauris*) and meerkats (*Suricata suricatta*) (Do Linh San & Somers, 2006; Waterman & Roth, 2007). *Cynictis penicillata* essentially feeds on arthropods (65%) (particularly termites, beetles and grasshoppers), with rodents (27.5%), birds (5%) and reptiles (7%) contributing less to its diet (Avenant & Nel, 1992). Similarly, vegetation and fruit are consumed in small quantities (Taylor & Meester, 1993). According to Avenant & Nel (1992), sight plays a major role in prey detection.

Chapter 2

Study site

2.1 The Great Fish River Reserve

The present study was conducted in the Great Fish River reserve complex (GFRR; Fig. 2). This conservation area is situated in the Eastern Cape Province, South Africa, between $32^{\circ} 55' S$, $26^{\circ} 37' E$ and $33^{\circ} 08' S$, $26^{\circ} 58' E$. The name GFRR is derived from the river that flows through the reserve. The complex incorporates the Andries Vosloo Kudu Nature Reserve (6 500 ha), the Sam Knott Nature Reserve (15 500 ha) and the Double Drift Game Reserve (23 500 ha) (Fabricius *et al.*, 2002). Its approximate total size is 445 km^2 .

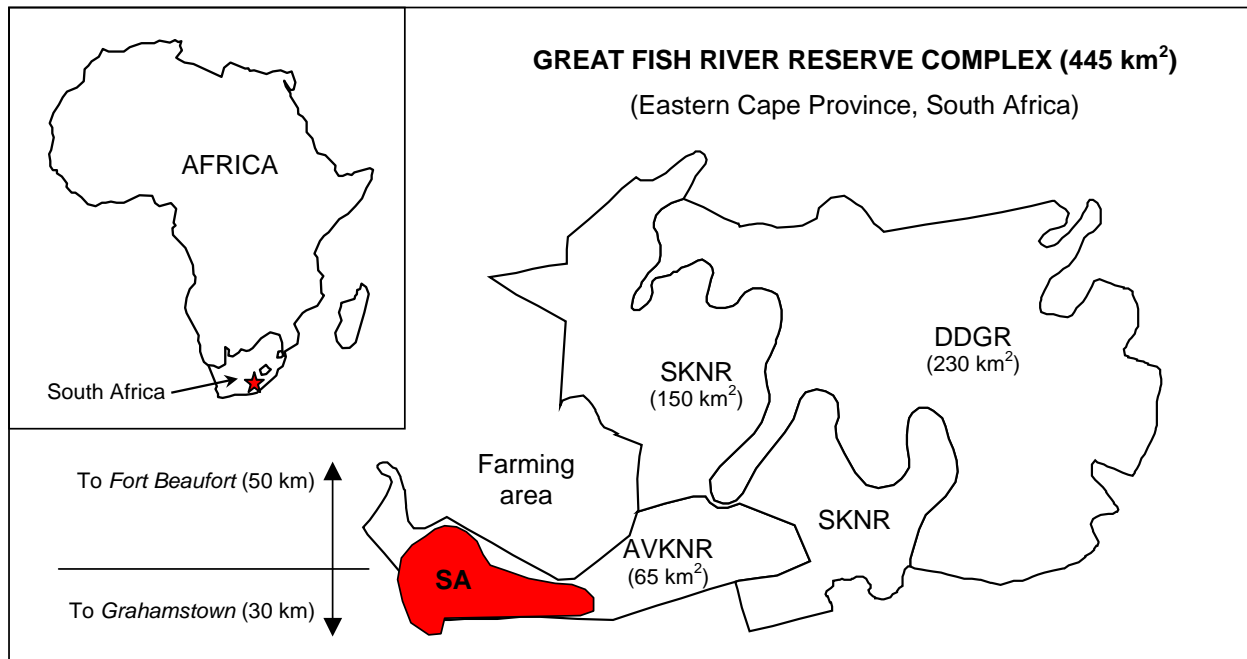


Figure 2. Map of the Great Fish River Reserve (GFRR), South Africa. The location of the reserve in South Africa is indicated by a red star. SA: Study Area (red area); AVKNR: Andries Vosloo Kudu Nature Reserve; SKNR: Sam Knott Nature Reserve; DDGR: Double Drift Game Reserve (after Do Linh San *et al.*, 2009).

2.2 Geology, climate and vegetation

The area is mostly red and grey sandstone and mudstone of the Middleton structure, with sandstone dominating the formation. Steep slopes are common due to the large range in elevation from 170 m at the banks of the Great Fish River to 800 m at the ridges. Precipitation ranges from 250 mm to over 650 mm from year to year (Birch *et al.*, 1999). There is usually a peak of rain in October and March and winters are moderately dry (Tshabalala, 2008). The slopes facing south and sites on higher elevation have a higher mean annual rainfall and a lower mean temperature (Evans *et al.*, 1997). The temperature ranges greatly with maxima exceeding 40 °C in summer and minima reaching less than 0 °C in winter (Tshabalala, 2008).

The GFRR falls within the Albany Thicket Biome and the Great Fish Thicket is the dominant vegetation type (Hoare *et al.*, 2006). Originally it was classified as Valley Bushveld vegetation (Acocks, 1988), but was later on reclassified as Xeric Succulent Thicket (La Cock *et al.*, 1990). The dominant plants are evergreen sclerophyllous shrubs, semi-succulents of karroid affinity and thorny shrubs averaging 2 m in tallness. Historical land use practices throughout the reserve resulted in the vegetation not being consistent (*i.e.* patches that resulted from land being used for planting crops for subsistence) (Tshabalala, 2008).

2.3 Other small carnivores present and predators of the yellow mongoose

Other small carnivores present in the GFRR are Cape grey mongooses (*Galerella pulverulenta*), water mongooses (*Atilax paludinosus*), meerkats (*Suricata suricatta*), large- (*Genetta tigrina*) and small-spotted genets (*G. genetta felina*), zorillas (*Ictonyx striatus*), striped weasels (*Poecilogale albinucha*) and possibly large grey mongooses (*Herpestes ichneumon*). The potential predators of yellow mongooses are black-backed jackals (*Canis mesomelas*), caracals (*Caracal caracal*), leopards (*Panthera pardas*) and several species of large birds of prey and snakes.

Chapter 3

Activity patterns of the yellow mongoose

3.1 Introduction

Activity patterns are part of basic natural history information (Van Schaik & Griffiths, 1996) and represent a fundamental aspect of animal behaviour (Nielsen, 1983). Influence of environmental conditions on activities of birds (Blem & Shelor, 1986), amphibians (Banks & Beebe, 1986) and other small mammals (Veiga, 1986) are well documented. However, the research focused mostly on prey species (*e.g.* Alkon & Saltz, 1988). In the case of carnivores (order Carnivora), the majority of research conducted so far concerned the relation between predator and prey activity patterns (Kowalczyk *et al.*, 2003). In small carnivores similar studies are often tricky to carry out (Emmons *et al.*, 1989). Indeed, it necessitates the use radio-tracking in order to deal with the low densities, proportionally large ranges and sometimes nocturnal (secretive) habits of these predators (Beltrán & Delibes, 1994).

Mammalian carnivores' activity can be influenced by a number of factors, including environmental conditions (*e.g.* light and temperature, which act as external synchronizers (*Zeitgeber*) for certain activity patterns; Manfredi *et al.*, 2010), social behaviour, interference from competitors (*i.e.* food and sexual competition; Feldhamer *et al.*, 2004), thermoregulation (Beltrán & Delibes, 1994), and in some cases human activities (Phelan & Sliwa, 2006). However, the circadian cycles of availability and vulnerability of prey could be considered as one of the main influences on predators' activity (Lodé, 1995).

In his extensive work on the ecology of yellow mongooses, Lynch (1980) stated that *Cynictis* is “diurnal, crepuscular and marginally nocturnal”. The author did not mention how this type of information was gathered, although it is likely that this was done through a series of haphazard field observations and a compilation of information from the literature. So far, only Cavallini (1993a) investigated the activity patterns of yellow mongooses by means of radio-tracking. The research confirmed that yellow mongooses are essentially diurnal, with the times of onset and

cessation of activity correlating with sunrise and sunset times, respectively. During daytime, activities are ceased around midday, as this time coincides with maximum temperatures, and resumed in the afternoon once temperature had dropped (Cavallini, 1993a). No activity was recorded both on rainy and misty periods, as these conditions negatively affect the availability of terrestrial insects, the main food source of *Cynictis penicillata* (MacDonald & Nel, 1986; Avenant & Nel, 1992; Cavallini & Nel, 1995). This suggests that activity patterns of yellow mongooses are significantly influenced by weather conditions and food availability. However, the above study was only conducted during autumn, in a population from the Western Cape Province (South Africa) characterised by its Fynbos vegetation and Mediterranean climate. Considering that a species' activity patterns may vary inter-regionally due to variations in habitat types (and therefore climatic conditions, food availability, vegetation cover and/or predation pressure), it is unclear whether the above-mentioned results can be generalised to the whole year and to the species as a whole.

3.2 Aim, objectives and predictions

The aim of this project was to investigate the activity patterns of the yellow mongoose across a full seasonal cycle in the GFRR and its related biome, the Albany Thicket Biome, dominated by sclerophyllous, semi-succulent and thorny shrub vegetation (La Cock *et al.*, 1990).

More specifically, I wanted to determine the following: a) the duration of the activity period, b) the occurrence and duration of resting bouts during the activity period, c) the daily activity profile, d) possible intersexual and seasonal variations in both activity and time budgets, and e) the possible influence of photoperiod and weather conditions on yellow mongoose activity.

The predictions for this study were:

1. Due to the probable role of photoperiod as a *zeitgeber* (time giver), the onset and offset of the activity periods of yellow mongooses will be correlated to the sunrise and sunset times, respectively (*i.e.* yellow mongooses will be active overground for longer periods during longer days).

2. Assuming that yellow mongooses are predominantly insectivorous in the GFRR as well, activity levels will be higher in spring and winter due to the lower availability of insects and other terrestrial arthropods during that period (Fig. 3). This is because yellow mongooses are expected to compensate for the lower availability of their main prey by spending more time in search of food.
3. Similarly, yellow mongooses will be less active during rainy weather, as such conditions are not favourable to the activity of terrestrial arthropods – even though some arthropods swarm (*e.g.* ants and termites) when the soil is wet (Pielou, 1948).
4. Yellow mongooses will be less active during cold and hot weather conditions, due to their elongated bodies that lead to higher than average surface to volume ratio and therefore higher heat loss and overheating risk (Zalewski, 2004).
5. Since males are slightly, but significantly heavier than females, their daily activity levels will be higher due to their related higher energy expenditure and requirements (McNab, 1989).

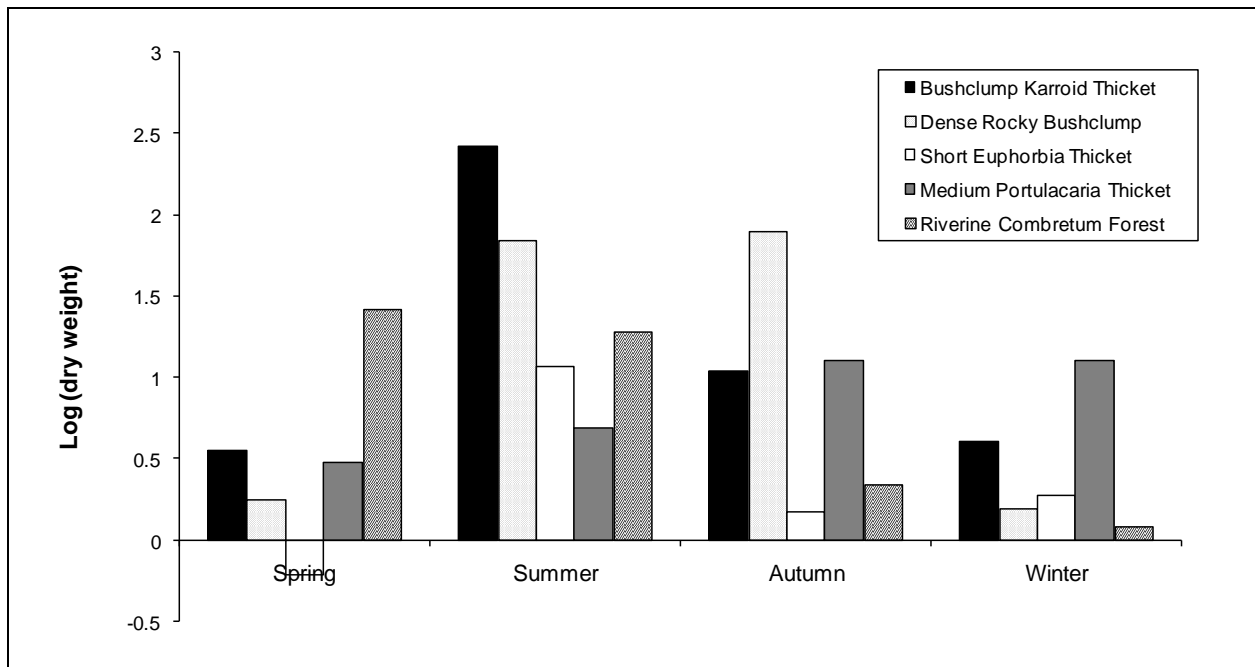


Figure 3. Seasonal availability of terrestrial arthropods in five habitat types of the Great Fish River Reserve as assessed through the log of the total dry weight (g) of individuals collected in four plots of six pitfall traps per habitat type (Do Linh San *et al.*, unpublished data).

3.3 Materials and methods

3.3.1 Trapping and radio-tracking

Yellow mongooses were trapped using 10 single-door wire mesh traps (90 x 30 x 30 cm). The traps were placed on a flat even surface and covered with vegetation to camouflage them (Fig. 4a). Warthog (*Phacochoerus africanus*) meat soaked in water was used as bait. The traps were then checked twice a day, in the morning and in the early evening. Each time when checking the traps, the water from the bait was sprinkled around the trap to lure the animals that were passing around that specific area. Rebaiting was done only if the meat had dried out or had been eaten by an animal and the trap did not close. Animals that were not targeted (mostly passerine birds and monitor lizards) were released on the spot and the trap rebaited and reactivated.

Caught *C. penicillata* were transferred to the research house (“Grasslands”) with the trap being covered with a dark nylon cloth to avoid putting the animal under stress. At the research house, before removing them from the trap, yellow mongooses were immobilized with ketamine hydrochloride (Ketalar, Parke-Davis) at doses of about 20 mg/kg (0.2 ml). An interval of 7-10 minutes after dosage was allowed for the animals to be fully anaesthetized (Fig. 4b) before processing them. Animals were then weighed, sexed and their body measurements recorded. Tooth wear patterns were investigated in order to determine the age of the animals (juveniles, subadults, one-year old animals, older adults).

All the captured mongooses were equipped with motion-sensor radio-collars (Model M1820, Advanced Telemetry Systems, Isanti, MN, USA; Fig. 4b). Complete weight of the radio-collar on the animals was 27–34 g, which represents less than 3–5% of the mongoose’s body weight. Radio-collared mongooses were monitored overnight to assess any discomfort that the animals might have experienced. They were then released at the site on which they were captured (Fig. 4c) early in the morning on the following day.

Continuous tracking sessions were carried out from before sunrise to after sunset, or from before sunset to after sunrise, so as to cover the whole 24-h daily period. As it was apparent that yellow mongooses were essentially diurnal, more diurnal than nocturnal radio-tracking sessions were conducted. Before starting a radio-tracking session, animals were first located in the burrow that they were occupying, using a hand-held, three-element antenna (Wildlife Materials Inc.,

Murphysboro, IL, USA). Variations in radio-signal pulse rate were used to determine whether yellow mongooses were moving (active) or not (inactive). Activity was monitored continuously from a car with a roof whip antenna and a TR-4 VHF-receiver (Telonics, Mesa, AZ, USA). Only one animal was tracked per day. To avoid influencing the behaviour of the studied animals, but to ensure a sufficient accuracy, tracking was generally done from a distance of 50–200 m from the collared animal (Fig. 4d).

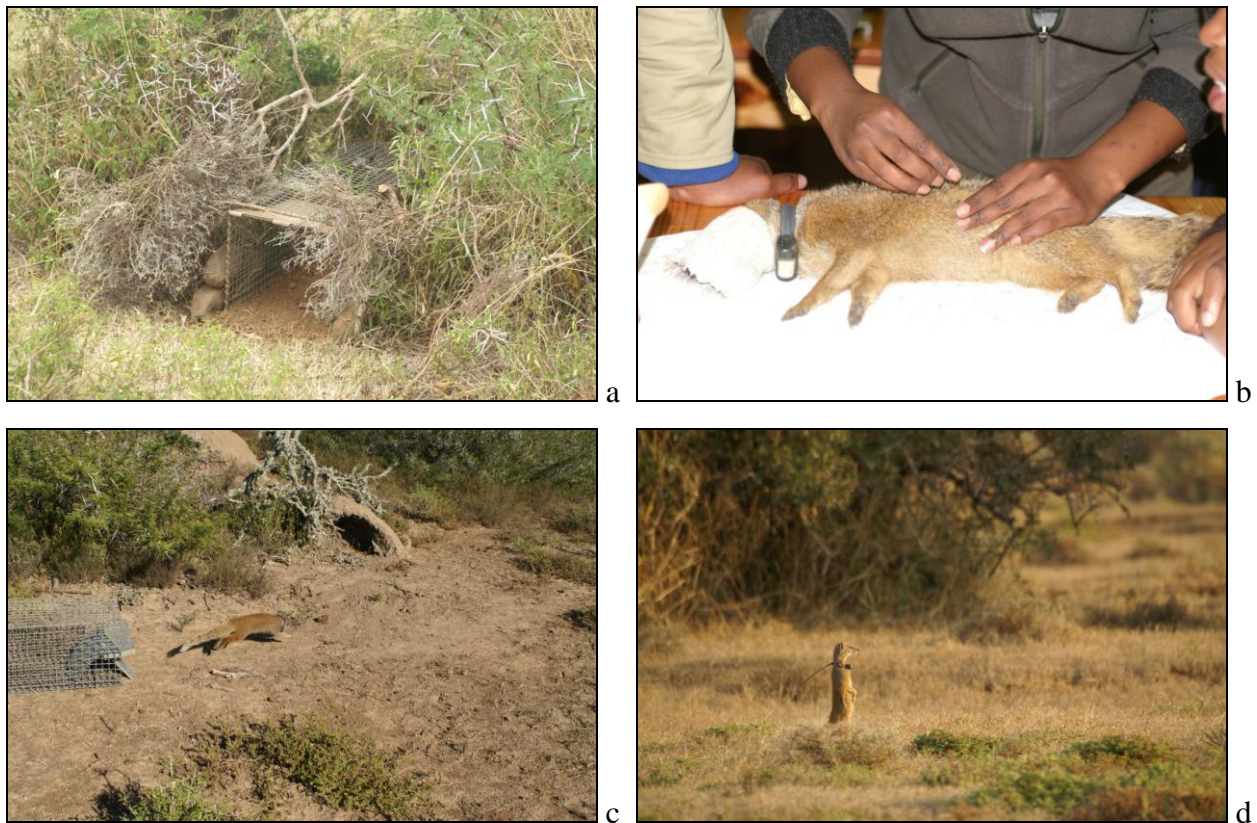


Figure 4. a) Wire mesh trap used to catch yellow mongooses, b) Sedated animal fitted with a radio-transmitter, c) Mongoosee released next to the trapping location, d) Radio-collared animal on the lookout for predators (all photographs provided by E. Do Linh San).

3.3.2 Expression of results and data analysis

The activity period (AP) was defined as the span of time between the first emergence from, and the final return to, a nocturnal shelter. The studied parameters were: 1) the onset and 2) the offset time of the AP, 3) the duration of the AP, as well as 4) the number and 5) the duration of resting bouts during the AP. The following categories were compared: males vs females, and the four seasons of the year. Seasons were defined following a meteorological subdivision of the year (autumn: March–May; winter: June–August; spring: September–November; summer: December–February).

All statistical analyses were conducted with the software IBM SPSS Statistics 19.0 (SPSS Inc.). Normality of data was evaluated with a Kolmogorov-Smirnov test ($p > 0.05$). Student's *t*-tests, one-way ANOVAs and *post hoc* LSD *t*-tests were used to investigate potential significant differences between normally distributed samples. Non-parametric tests (Mann-Whitney and Kruskal-Wallis tests) were used otherwise. Sequential Bonferroni corrections were applied to counteract the problem of multiple comparisons (Rice, 1989). However, the use of Bonferroni procedures has been criticised (Nakagawa, 2004), because they increase Type II errors (*i.e.* the improper rejection of genuine effects) to unacceptable levels. For this reason, when relevant, significance levels are presented both with and without taking Bonferroni corrections into account. A possible correlation between the duration of the activity period and day-length, as well as between the onset/offset of activity and sunrise/sunset times, was investigated with a Spearman rank correlation test.

In order to investigate the possible influence of sex, season and weather conditions on the activity (dependent binary variable) of yellow mongooses, a generalized linear model (GzLM) was generated, using a binomial distribution and a logit link function (Norušis, 2008). Since yellow mongooses were essentially diurnal (see Chapter 3.4), only valid diurnal fixes ($n = 11,783$) were taken into account. Here, activity was evaluated by classifying 5-min blocks as either active (dependent variable = 1) or inactive (dependent variable = 0). Following Do Linh San *et al.* (2007a), four meteorological variables (soil conditions, wind strength, general weather and temperature at the shade) were collected at 30-min (temperature) or 5-min intervals (all other variables). The first three meteorological variables were divided into numerical categories for the purpose of the analysis and in order to facilitate the interpretation of the results. The numbering

was done according to a progressive deterioration of external conditions (see Table 6). The possible effects of these six independent variables were evaluated with a Type III test, which does not depend on the entry order of variables (Norušis, 2008). Only main effects were considered in this analysis. As suggested by Norušis, (2008), the scale parameter (see Table 6) was estimated by dividing the deviance by its degree of freedom.

3.4 Results

From September 2005 to August 2011, 15,430 activity fixes were collected from 12 radio-collared adult yellow mongooses (seven males and five females; Tables 1, 2 and A1). These data were obtained in the framework of 84 continuous tracking sessions during the day (11,016 fixes) and 18 sessions at night (3,417 fixes). In addition, 791 daytime and 206 nocturnal fixes were obtained through semi-continuous tracking sessions and random locations.

Table 1. Number of activity fixes collected for male, female and all yellow mongooses during the day and the night in the Great Fish River Reserve (2005–2011). Semi-continuous tracking and random locations fixes are shown by *.

| Sex | Day | Night | Total |
|------------|--------------|--------------|--------------|
| Males | 6,204 + 292* | 1,410 + 84* | 7,990 |
| Females | 4,812 + 499* | 2,007 + 122* | 7,440 |
| Total | 11,807 | 3,623 | 15,430 |

Table 2. Average, standard deviation (SD), minimum and maximum number of activity fixes collected per hourly period (from 0:00 to 23:59) from seven male and five female yellow mongooses in the Great Fish River Reserve (2005–2011).

| Sex | Average | SD | Minimum | Maximum |
|------------|----------------|-----------|----------------|----------------|
| Male | 362 | 256 | 74 | 652 |
| Female | 317 | 137 | 158 | 486 |
| Total | 683 | 393 | 233 | 1,130 |

Yellow mongooses were essentially diurnal and crepuscular (Figs 5a–e, Table 3). Activity levels averaged 57% during the day ($n = 11,807$ fixes) and only 11% at night ($n = 3,623$ fixes). Out of the 84 tracking days (Table A3), only in one case was no overground activity recorded. Yellow mongooses emerged from their burrows on average (\pm SD) 85 ± 62 min after sunrise (range: -11 to $+369$ min) and returned 21 ± 84 min before sunset (range: -518 to $+225$ min). The duration of the daily activity period varied between 12 min and 15 h 36 min, with a mean of 9 h 28 min (Table A2). Both sexes exhibited some overground activity after sunset, but this was more pronounced in males than in females (Table 3). Nocturnal activity outside the activity period was generally restricted to short underground activity bouts occurring at anytime of the night. Presumably these activities were related to social interactions or comfort activities, not to trophic activities. Diurnal resting, with up to 11 bouts per activity period, occurred in 98.8% of activity periods. The longest resting periods occurred early in the morning (sunbathing), late afternoon (sunbathing) and at midday, at the shade, during the hottest period of the day. Overall, yellow mongooses were active during $68 \pm 17\%$ of the time spent outside the burrow.

Considering yearly data, a peak of overground activity (unimodal pattern) was noted between 13:00 and 16:00, and this in both males and females (Fig. 5a). However, clear seasonal variations in activity patterns were observed, as well as sexual differences during specific seasons (Figs 5b–e). Whilst the winter pattern (Fig. 5e) was similar to the yearly one, both sexes exhibited a clear reduction of activity between 11:00 and 13:00 during summer (bimodal pattern; Fig. 5c). In spring (Fig. 5b), males showed a peak of activity around midday, which fully contrasted with the activity reduction observed in females. A somewhat opposite scenario was recorded in autumn, with a clear midday peak observed in females, and two depressions being registered in the daily activity profile of males (trimodal pattern). During each season, an additional, albeit smaller, peak of activity could be observed in late afternoon–early evening.

There was a significant correlation between the onset of activity and sunrise ($r_s = 0.53$, $p < 0.001$, $n = 83$) and the offset of activity and sunset ($r_s = 0.44$, $p < 0.001$). Similar results were obtained when data were analysed by sex, but no correlation was found when data were analysed seasonally. Expectedly, the duration of the activity period of yellow mongooses was correlated to day length ($r_s = 0.62$, $p < 0.001$, $n = 83$). The same trend was found for the effective activity duration ($r_s = 0.38$, $p < 0.001$), but not for the percentage of time spent active during the activity period ($r_s = -0.081$, $p = 0.468$).

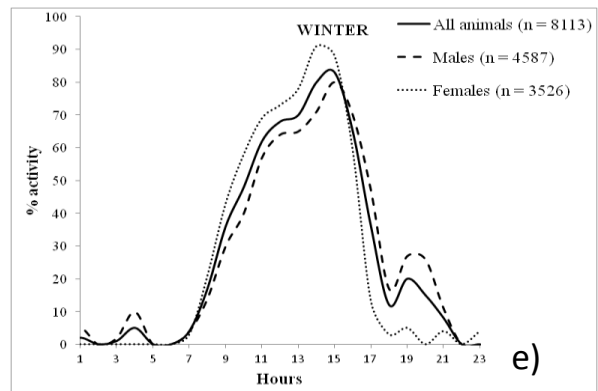
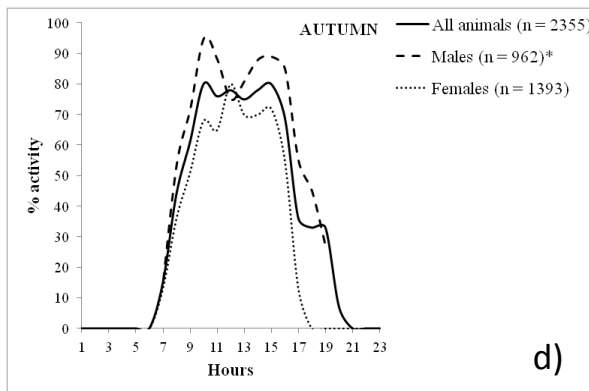
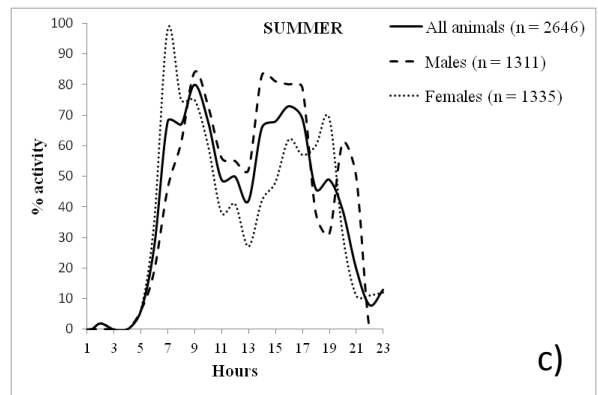
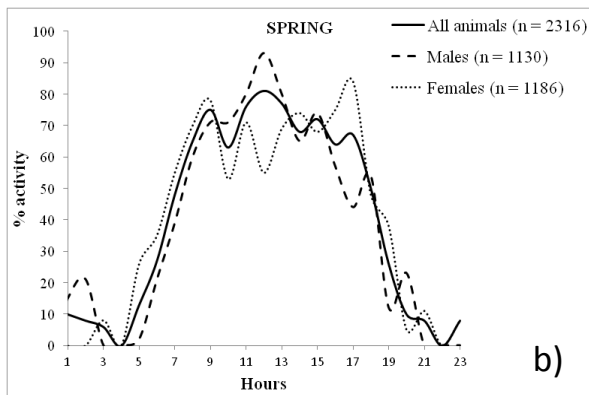
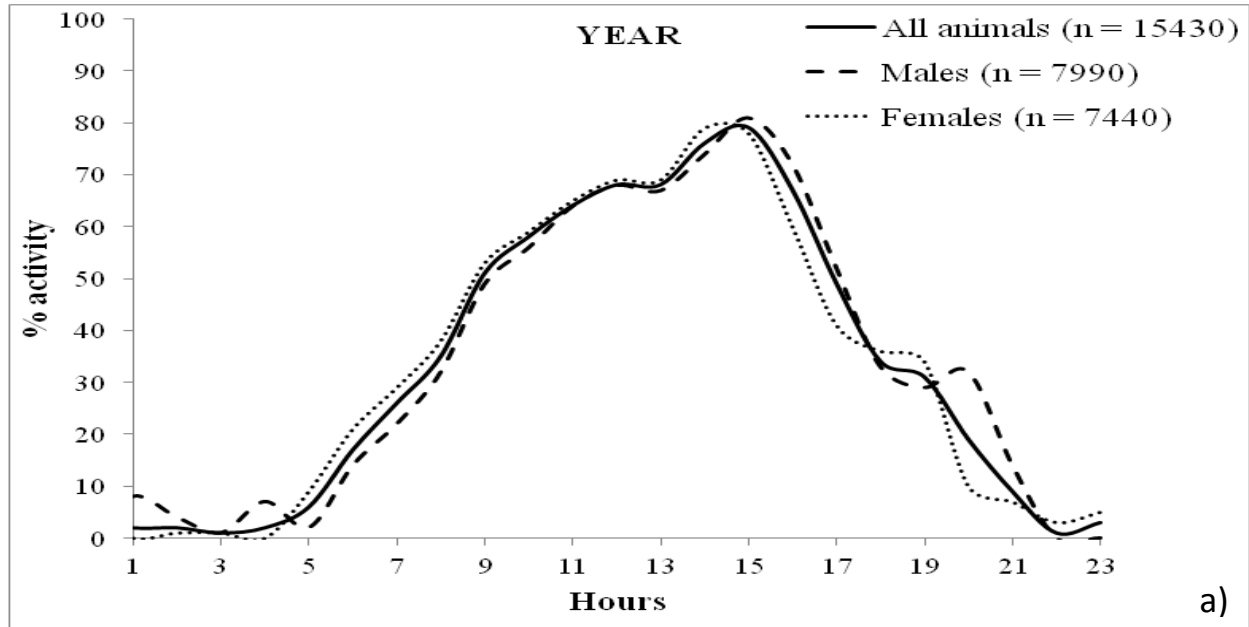


Figure 5. Diel activity profiles of yellow mongooses from the Great Fish River Reserve expressed as the percentage of activity per hour; a) yearly, b) spring, c) summer, d) autumn, e) winter activity profiles. n = number of activity fixes; * no night-tracking sessions were conducted during the autumn period.

Although the weight of radio-tracked mongooses of both sexes did not differ statistically (t -test, $t = 1.22$, $df = 10$, $p = 0.25$; Table 7 in Chapter 4), males were on average 16% heavier than females. There were no significant differences between the sexes as regards the different activity parameters recorded, except for the offset of activity (M later than F) and therefore the difference between the offset of activity and sunset time. However, significant differences were recorded in the number of resting bouts (more in M than in F), the resting duration (M longer than F), the minimum duration of resting bouts (F longer than M) and the duration of the activity period (longer in M than in F) when sequential Bonferroni corrections were not applied (Table 3).

Table 3. Average \pm SD and sexual differences for 12 activity parameters of yellow mongooses (seven males and five females) tracked in the Great Fish River Reserve (2005–2011). M = Males ($n = 50$ tracking days) and F = Females ($n = 33$ tracking days). * indicates parameters for which significant differences were obtained with a Mann-Whitney U -test, ** indicates parameters for which statistical significance was still obtained after sequential Bonferroni corrections.

| Activity parameters | Sex | Average \pm SD | Mann-Whitney U -test |
|---|-----|------------------|--------------------------------|
| Number of resting bouts | M | 5.18 \pm 2.38 | $U = 603.5$, $p = 0.038^*$ |
| | F | 4.15 \pm 2.12 | |
| Resting duration (min) | M | 192 \pm 103 | $U = 605.5$, $p = 0.041^*$ |
| | F | 149 \pm 79 | |
| Mean duration of resting bouts (min) | M | 40 \pm 31 | $U = 910.5$, $p = 0.426$ |
| | F | 46 \pm 34 | |
| Minimum duration of resting bouts (min) | M | 11 \pm 14 | $U = 1,047.5$, $p = 0.037^*$ |
| | F | 20 \pm 30 | |
| Maximum duration of resting bouts (min) | M | 94 \pm 61 | $U = 722.5$, $p = 0.340$ |
| | F | 83 \pm 53 | |
| Activity period (min) | M | 584 \pm 150 | $U = 555.5$, $p = 0.012^*$ |
| | F | 544 \pm 117 | |
| Effective activity (min) | M | 378 \pm 149 | $U = 805.0$, $p = 0.852$ |
| | F | 392 \pm 102 | |
| Percentage activity (%) | M | 66 \pm 19 | $U = 1,014.0$, $p = 0.079$ |
| | F | 72 \pm 15 | |
| Onset of activity (decimal time) | M | 7.96 \pm 1.24 | $U = 923.0$, $p = 0.362$ |
| | F | 8.03 \pm 1.00 | |
| Offset of activity (decimal time) | M | 17.72 \pm 1.73 | $U = 463.0$, $p = 0.001^{**}$ |
| | F | 17.06 \pm 1.16 | |
| Difference onset-sunrise (decimal time) | M | 1.38 \pm 1.05 | $U = 959.0$, $p = 0.212$ |
| | F | 1.46 \pm 1.02 | |
| Difference offset-sunset (decimal time) | M | -0.15 \pm 1.62 | $U = 485.5$, $p = 0.002^{**}$ |
| | F | -0.67 \pm 0.90 | |

Several significant seasonal variations were recorded in the different activity parameters (Table 4). Yellow mongoose activity periods were interspersed with significantly more resting bouts in spring and summer than during the rest of the year, but only in summer were longer resting durations and resting bout durations recorded (Table 4). Longer activity periods were observed in spring and summer, and shorter ones in autumn and winter. However, only in winter was the effective activity shorter than during the rest of the year. The percentage of activity during the activity period did not vary significantly over the year as a whole. Expectedly, due to the above-mentioned correlation with photoperiod, onset and offset times of activity varied significantly through the seasons, but not the difference with the sunrise and sunset times.

Table 4. Average \pm SD and seasonal variations in behavioural variables of *C. penicillata* (n = 12) in the Great Fish River Reserve. Values followed by the same letter do not differ significantly at the 0.05 level of significance according to *post hoc* LSD *t*-tests. n = number of seasonal tracking days. * indicates parameters for which significant differences were obtained with a one-way ANOVA, ** indicates parameters for which statistical significance was still obtained after sequential Bonferroni corrections.

| Activity parameters | Spring (n = 8) | Summer (n = 11) | Autumn (n = 15) | Winter (n = 49) | ANOVAs |
|-----------------------------|---------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------------------|
| Number of resting bouts | 6.25 \pm 2.44 ^a | 6.00 \pm 2.32 ^a | 5.27 \pm 1.94 ^{ab} | 4.11 \pm 2.21 ^b | $F = 4.107, df = 3, p = 0.009^*$ |
| Resting duration (min) | 181 \pm 94 ^a | 282 \pm 81 ^b | 147 \pm 77 ^a | 158 \pm 92 ^a | $F = 6.516, df = 3, p = 0.001^{**}$ |
| Mean resting bout duration | 29 \pm 14 ^{ab} | 56 \pm 35 ^a | 28 \pm 14 ^b | 46 \pm 35 ^{ab} | $F = 2.386, df = 3, p = 0.075$ |
| Min. resting bout duration | 8 \pm 6 ^a | 10 \pm 10 ^a | 8 \pm 5 ^a | 19 \pm 27 ^a | $F = 1.502, df = 3, p = 0.22$ |
| Max. resting bout duration | 76 \pm 59 ^a | 143 \pm 64 ^b | 59 \pm 30 ^a | 89 \pm 56 ^a | $F = 5.396, df = 3, p = 0.002^{**}$ |
| Activity period (min) | 663 \pm 131 ^a | 761 \pm 93 ^a | 564 \pm 63 ^b | 510 \pm 118 ^b | $F = 18.215, df = 3, p < 0.001^{**}$ |
| Effective activity (min) | 478 \pm 108 ^a | 481 \pm 94 ^a | 415 \pm 105 ^a | 344 \pm 122 ^b | $F = 6.675, df = 3, p < 0.001^{**}$ |
| Percentage activity | 73 \pm 12 ^a | 63 \pm 10 ^a | 73 \pm 15 ^a | 67 \pm 20 ^a | $F = 0.924, df = 3, p = 0.433$ |
| Onset decimal | 7.07 \pm 1.44 ^a | 6.29 \pm 0.48 ^b | 7.87 \pm 0.37 ^c | 8.55 \pm 0.84 ^d | $F = 26.80, df = 3, p < 0.001^{**}$ |
| Offset decimal | 18.12 \pm 1.24 ^{abc} | 18.98 \pm 1.19 ^a | 17.27 \pm 0.96 ^b | 17.06 \pm 1.60 ^{bc} | $F = 6.112, df = 3, p = 0.001^{**}$ |
| Diff. onset-sunrise decimal | 1.91 \pm 1.51 ^a | 1.08 \pm 0.66 ^{ab} | 1.02 \pm 0.35 ^b | 1.52 \pm 1.11 ^{ab} | $F = 2.017, df = 3, p = 0.125$ |
| Diff. offset-sunset decimal | -0.68 \pm 1.15 ^a | -0.32 \pm 1.15 ^a | -0.14 \pm 0.99 ^a | -0.37 \pm 1.60 ^a | $F = 0.524, df = 3, p = 0.854$ |

The results of the GzLM clearly indicate that sex, season and weather – with exception of wind – all affected the activity of yellow mongooses (Table 5). For sex, the parameter estimates suggest that overall males were significantly less active than females (Table 6). On a seasonal scale, activity levels differed significantly between all seasonal dyads ($p < 0.001$), with higher and lower activity levels observed in winter and summer, respectively. Yellow mongooses were less active when the soil was humid or wet than when it was dry. Similarly, animals were less active by misty or rainy weather than when clear and cloudy skies were recorded. Temperature was positively correlated with higher activity levels.

Table 5. Effects of sex, season and four meteorological variables on the diurnal activity of yellow mongooses ($n = 11,783$ diurnal activity fixes included) according to the results of a GzLM procedure (Type III test). Significant effects ($p < 0.05$) are indicated in bold.

| Parameters | Wald Chi-Square | <i>df</i> | <i>p</i> |
|-------------------|------------------------|------------------|-----------------|
| (Intercept) | 886.175 | 1 | < 0.001 |
| Sex | 4.231 | 1 | 0.040 |
| Season | 286.688 | 3 | < 0.001 |
| Soil | 12.337 | 2 | 0.002 |
| Wind | 2.931 | 3 | 0.402 |
| Weather | 143.608 | 5 | < 0.001 |
| Temperature | 707.639 | 1 | < 0.001 |

Table 6. Parameter estimates of a GzLM procedure aiming at testing the effects of weather conditions on the diurnal activity of yellow mongooses (n = 11,783 diurnal activity fixes). Season₁ = spring, Season₂ = summer, Season₃ = autumn, Season₄ = winter; Soil₀ = dry soil, Soil₁ = humid soil, Soil₂ = wet up to sodden soil; Wind₀ = no wind, Wind₁ = slight wind, Wind₂ = medium wind, Wind₃ = strong up to very strong wind; Weather₀ = clear up to 30% cloud cover, Weather₁ = 40% up to 60% cloud cover, Weather₂ = 70% cloud cover up to overcast, Weather₃ = mist, Weather₄ = light rain, Weather₅ = medium up to heavy rain. Significant effects (p < 0.05) are indicated in bold.

| Parameters | B | Std. Error | Chi-square | df | p |
|----------------------|--------------------|------------|------------|----|----------------|
| (Intercept) | -2.098 | 0.116 | 326.739 | 1 | < 0.001 |
| Sex _M | -0.085 | 0.041 | 4.231 | 1 | 0.040 |
| Sex _F | 0 ^a | – | – | – | – |
| Season ₄ | 0.613 | 0.064 | 92.536 | 1 | < 0.001 |
| Season ₃ | 0.400 | 0.074 | 29.438 | 1 | < 0.001 |
| Season ₂ | -0.474 | 0.074 | 41.106 | 1 | < 0.001 |
| Season ₁ | 0 ^a | – | – | – | – |
| Soil ₂ | -0.341 | 0.097 | 11.061 | 1 | 0.001 |
| Soil ₁ | -0.104 | 0.053 | 3.870 | 1 | 0.049 |
| Soil ₀ | 0 ^a | – | – | – | – |
| Wind ₃ | -0.008 | 0.076 | 0.011 | 1 | 0.918 |
| Wind ₂ | 0.056 | 0.067 | 0.719 | 1 | 0.397 |
| Wind ₁ | 0.079 | 0.060 | 1.709 | 1 | 0.191 |
| Wind ₀ | 0 ^a | – | – | – | – |
| Weather ₅ | -1.596 | 0.247 | 41.716 | 1 | < 0.001 |
| Weather ₄ | -1.021 | 0.140 | 53.049 | 1 | < 0.001 |
| Weather ₃ | -0.812 | 0.181 | 20.103 | 1 | < 0.001 |
| Weather ₂ | 0.173 | 0.047 | 13.459 | 1 | < 0.001 |
| Weather ₁ | 0.014 | 0.064 | 0.047 | 1 | 0.828 |
| Weather ₀ | 0 ^a | – | – | – | – |
| Temperature | 0.114 | 0.004 | 707.639 | 1 | < 0.001 |
| Scale | 4.839 ^b | | | | |

^aSet to zero because this parameter is redundant.

^bEstimated by dividing the deviance by its degree of freedom and fixed at the displayed value.

3.5 Discussion

The results of this of this study expand on Cavallini's (1993a) radio-tracking data, as they cover the yearly cycle, and not only one season. However, due to the difficulty of trapping several yellow mongooses at the same time, and the lack of manpower (generally one, sometimes two researchers working at the same time on several small carnivore species), it was not possible to obtain all the required information over a single yearly period. Because data were collected over a 6-year span of time, some "heterogeneity" must have been added to the dataset (*e.g.* seasonal weather conditions might have slightly changed from one year to another). In addition, for reasons beyond the researchers' control (timing of trapping occurrences and duration of tracking periods), sample size was largely biased towards winter, as over half of the tracking days were conducted during the cold season alone. However, it is likely that the general trends obtained in this study would still stand, could the data have been collected more homogeneously and over a single year.

The results presented here confirm that yellow mongooses exhibit a pronounced diurnal pattern of activity. Over the year, both the onset and the offset of activity of radio-tracked individuals were correlated with sunrise and sunset times, respectively. Hence, the activity period was strongly correlated to day length. However, in my study, no significant correlations were observed when data were analysed on a seasonal scale. A combination of small sample size and clumping of observations during a specific period might likely explain these results. The yearly correlation was recorded in both sexes, confirming that photoperiod seems to act as a *zeitgeber* for the species as a whole (prediction 1). In the Western Cape, Cavallini (1993a) also noted that both sexes start their activities at the same time. Photoperiod has been shown to act, at least partly, as a synchronizer of the activity of both diurnal (*e.g.* Egyptian mongooses *Herpestes ichneumon*: Palomares & Delibes, 1992) and nocturnal carnivores (*e.g.* Eurasian badgers *Meles meles*: Kowalczyk *et al.*, 2003).

Yellow mongoose activity patterns exhibited clear seasonal variations. In summer, animals enjoyed longer activity periods than during other seasons. However, the fact that the effective activity duration was similar from spring to autumn seems to indicate that yellow mongooses do not profit from the longer daylight duration to forage for longer periods. The GzLM also clearly indicated that the summer season was associated with lower activity levels. It is likely that the

higher arthropod availability during summer (see Fig. 3) allows individuals to meet their daily energy requirements at least as rapidly as during spring and autumn. Expectedly, the activity period and effective activity duration were clearly shorter in the cold season than during the rest of the year. However, and surprisingly, the percentage of activity (63%) did not differ with other seasons, whereas yellow mongooses were expected to spend a higher proportion of their time active in search for food to compensate for the low arthropod availability that characterises this season (prediction 2). This said, a decrease in activity levels due to prey decline has been well documented in other predators (*e.g.* mink *Mustela vison*: Zielinski, 1988; culpeo foxes *Lycalopex culpaeus*: Savatori *et al.*, 1999; raccoon dogs *Nyctereutes procyonoides*: Seki & Koganezawa, 2011). Indeed, when food is limited, individuals can adjust their behaviour or physiology to maintain their energy balance and body condition (Trites & Donnelly, 2003). Small mammals *sensu lato* have a high basal metabolic rate, and this involves great energy expenditure for a variety of tasks, such as body maintenance, movement, resource acquisition and growth (McNab, 1989). Having high energy requirements during cold periods, reducing activity in such conditions (prediction 4) can provide considerable energy savings (Zielinski, 2000). Since activity increases energy expenditure, the energetic costs for *C. penicillata* to forage for long periods may be too high during the winter season, when food availability is extremely restricted. In winter, yellow mongooses would also emerge from the burrow and spend some time outside sunbathing, in order to warm their body.

The cessation of activity in this species during hot periods of the day (*i.e.* midday time from spring to autumn, though mostly in summer) was also recorded by Cavallini (1993a). These behavioural adaptations to cope with thermoregulatory constraints, including changing of activity time has been observed in other species with elongated bodies, *e.g.* weasels *Mustela nivalis* and pine martens *Martes martes* (Thompson & Colgan, 1994). Mobility in yellow mongooses seems to impose a high energetic demand, and their daily movements are therefore affected by adverse ambient conditions. It was also observed that yellow mongooses were never active during rainy days, and therefore when the soil was wet. Here too, the inactivity of this species during such conditions may be due to the difficulty of obtaining food (prediction 3), especially due to a reduced or nil activity of terrestrial arthropods.

All in all, the radio-tracked yellow mongooses exhibited a considerable variation in their activity patterns. In the case of the Cape grey mongoose *Galerella pulverulenta*, Cavallini & Nel (1990) partly showed and suggested that this variability within the species cannot only be attributed to variations in food availability and climatic factors (as suggested above for yellow mongooses too), but could possibly also result from sexual differences. In the GFRR, radio-tracked male yellow mongooses were slightly bigger than females in terms of body mass. This should imply greater energy expenditure (McNab, 1989), and therefore more time spent active in search of food than females (prediction 5). However, the opposite was observed. Indeed, my results revealed that males rested more often and for an overall longer duration than their opposite sex. Although the resulting difference in activity duration did not reach significance, it is likely that this difference would have reached significance with a larger sample size. The GzLM analysis based on 5-min activity blocks rather than continuous tracking days clearly indicated that males have lower activity levels than females. A similar intersexual pattern where females rested less than males was found by Cavallini & Nel (1990) in their study of the Cape grey mongoose. They suggested that the resulting higher levels of activity in females could be owing to the lower prey density in their home ranges, whereas the lower activity of males might have been associated with the availability of concentrated food resources in their foraging ranges (as related to the conditions prevailing in the authors' study area) and their higher efficiency in hunting than females. The basis for the latter argument is however difficult to sustain in mongooses, due to the absence of clear morphological differences between both sexes. In any case this possible difference would have to be tested under laboratory or semi-natural conditions.

Chapter 4

Spatial ecology of the yellow mongoose

4.1 Introduction

In carnivores, space use has been found to be both affected by body size (Gompper & Gittleman, 1991) and by the distribution of resources (Macdonald, 1983). Home range size increases with body mass, which is in turn correlated with an increase in metabolic requirements (Bunnell & Harestad, 1989). The Resource Dispersion Hypothesis, on the other side, predicts that territories have to encompass a minimum total area of key habitats, and the former will therefore be larger when patches of these key habitats are more dispersed (Macdonald, 1983). These two factors seem have profound consequences on the spatial ecology of male and female carnivores, and mammals in general. Indeed, home ranges of females are generally presumed to be determined by food abundance and distribution, whereas in addition to food, male home ranges are strongly influenced by mate seeking activities (Powell, 1979; Sandell, 1989; Johnson *et al.*, 2000). Consequently, home ranges of males are often expected to be larger than those of females (Goodrich & Buskirk, 1989; McLoughlin *et al.*, 1999).

Both inter- and intraspecific variations exist among the mongoose species, in the way in which individuals are spatially distributed (for recent accounts on Herpestidae species, see Gilchrist *et al.*, 2009). For example, whilst the white-tailed mongoose *Ichneumia albicauda* is generally solitary and territorial (Waser & Waser, 1985), members of the solitary foraging small Indian mongoose *Herpestes auro punctatus* occupy broadly overlapping home ranges (Rood, 1986). Other species form highly cooperative groups, *e.g.* meerkats (Clutton-Brock *et al.*, 1998; Doolan & Macdonald, 1999), banded mongooses *Mungos mungo* (Rood, 1974; Cant, 2003; Gilchrist & Russell, 2007) and dwarf mongooses *Helogale parvula* (Rasa, 1987). Such variations seem to be partly related to the species' phylogenetic history (Nel & Kok, 1999; Veron *et al.*, 2004), but also to habitat type, and therefore resource abundance/dispersion and population density (Gorman, 1979; Rood, 1986; Gilchrist & Ouali, 2002). Hence, in the white-tailed mongoose, Waser & Waser (1985) showed that the degree of range overlap between individuals increases when den

sites are limited. In another solitary species, the Egyptian mongoose *Herpestes ichneumon*, individuals can sometimes be found living in extended family groups in areas of particularly high food availability (Palomares & Delibes, 1993).

Although yellow mongooses belong to the “solitary” group of mongooses (*sensu* Veron *et al.*, 2004) and are generally regarded as solitary foragers, previous studies have revealed a great deal of variation and plasticity in the socio-spatial ecology of *Cynictis*. In a high density population (133-200 ind./km²), in Vaal Dam (Free State), Earlé (1981) initially described a structure of group territories defended by both males and females, with up to 13 group members sharing a common den. Territory limits were patrolled regularly and scent-marks and faeces deposited at border latrines. In this same population, Wenhold & Rasa (1994) demonstrated that only subordinate adults engaged in territorial defence, whereas adult males never performed any territorial marking. In contrast, in a low density population (6–7 ind./km²; West Coast National Park, WCNP), Cavallini (1993b) reported that even if females defended a group home range, males had much larger ranges (up to four times bigger) that overlapped broadly with each other and with those of males from numerous neighbouring groups. The size of social units, including offspring, varied from 1 to 7 individuals. No regular border patrolling was observed. Le Roux *et al.* (2008) studied another low-density population (4–14 ind./km²) in the Kuruman River Reserve (KRR, Northern Cape) and found that groups consisted of 2–7 animals, including offspring. They reported that only alpha males were responsible for territory defence and border scent-marking, whilst subordinates were only marking near the cores. Finally, in a medium-density population (23–26 ind./km²) living in a farmland near Heidelberg (Western Cape), yellow mongooses formed groups in which both males and females defended a common territory that was used equally by all group members (6.3 on average). Overlap between home ranges of group members was extensive, whereas the ranges of neighbouring groups overlapped little or were clearly distinct from one another (Balmforth, 2004).

The above-mentioned variations have led to the view that yellow mongooses display an intermediate level of sociality (Balmforth, 2004; Le Roux, 2007). For this reason, further research in areas with differing habitats, climate and population density could provide explanations as to which factor(s) promote(s) the transition from solitary to group-living.

4.2 Aim, objectives and predictions

This study was conducted with the aim to investigate the spatial behaviour of the yellow mongooses belonging to a formerly unstudied population (in the Great Fish River Reserve, GFRR), and compare my findings with the previous information collected on this species, when available at all. Estimations based on den distribution, observations at the den, haphazard observations when conducting field work, trapping data, and home range size suggest that the population density of yellow mongooses is low in the GFRR, with roughly 4–10 ind./km².

In particular, I aimed at determining: a) the total and daily home range sizes and perimeters of yellow mongooses, b) the daily movement distances travelled by radio-tracked individuals, c) possible intersexual and seasonal variations in the above-mentioned parameters, and d) the spatial distribution of individual home ranges.

The predictions for this study were:

1. Males will have larger total home ranges than females, and their home ranges will overlap with those of neighbouring females, because at low population density males seem to be polygynous (Cavallini, 1993b). The expected difference should go way beyond the observed body mass dimorphism and related metabolic demands (Goodrich & Buskirk, 1998).
2. If food or more generally resource abundance and distribution determine space use (Macdonald, 1993), as well as carrying capacity and population density, we should then expect yellow mongooses to have larger home ranges in the GFFR than in medium and low density populations.
3. Males' daily ranges will be larger and movement distances will be longer than those of females outside of the reproductive season (summer and autumn) due to their higher body mass and metabolic requirements (Gittleman & Harvey, 1982; Bunnell & Harestad, 1989; Gompper & Gittleman, 1991; Palomares 1994). An even higher difference should be observed during the reproductive season (see reasons below).

4. Males' daily ranges will be larger and movement distances will be longer during the reproductive season (winter and spring) than after it (summer and autumn), as males are expected to search for oestrous females and increase scent-marking and patrolling activities during the breeding period (Earlé 1981; Wenhold & Rasa, 1994; Balmforth, 2004; Zalewski *et al.*, 2004; Le Roux *et al.*, 2008).
5. Yellow mongooses will cover larger daily ranges and/or move over longer distances during winter and spring than during summer and autumn, as these first two seasons are characterised by the lowest availability of their main prey, namely terrestrial arthropods (Fig. 3, p. 8). However, since this factor might be confounded by reproductive activity (see prediction 4), the potential effect should be tested in females only.

4.3 Materials and methods

4.3.1 Trapping and radio-tracking

The trapping and tracking was carried out in a similar way as for the study on activity patterns (see Chapter 3.3.1 for details). In order to facilitate radio-telemetric work, convenient tracking points were marked along the roads using a GPS device (Model eTrex, GARMIN International, Olathe, Kansas) and also on the maps of the reserve in order to take the daily locations of the animals. Fixes for the assessment of daily home ranges and daily movement distances were taken once every 30 minutes during continuous tracking sessions. Tracking started before sunrise and ended after the focus animal entered a burrow and engaged in nocturnal rest. Animals were located by triangulation on foot using a hand-held three element antenna (Wildlife Materials Inc., Murphysboro, IL, USA). Even though the sound made by the vehicle might have influence the behaviour of yellow mongooses (*ie.* the study animal running away when hearing the sound of the car), a vehicle was also used to locate the *Cynictis penicillata* by means of a portable VHF receiver (Model TR-4, Telonics, Mesa, AZ, USA and Model R-1000, Communications Specialists Inc., Orange, CA, USA).

4.3.2 Expression of results and data analysis

The daily movement distance (DMD) was calculated as the sum of straight-line distances between consecutive locations (Kowalczyk *et al.*, 2006) taken at intervals of 30 min. Inter-locational distances were measured with a ruler on a 1:10,000 map after bearings were reported onto it. Overall, the accuracy of inter-location distance was ± 30 m. The average speed of travel was calculated by dividing the DMD by the effective duration of activity (*i.e.* resting bouts during the activity period were not taken into account). Tracking locations were entered in ArcView GIS 3.3 (ESRI, Redlands, CA, USA) and daily and total home range sizes and perimeters were calculated with Biotas 1.03 Alpha (Ecological Software Solutions LLC, Hegymagas, Hungary). Home range sizes and perimeters were evaluated with the Minimum Convex Polygon method taking 100% of the locations into account (MCP 100%). Spatial parameters were compared between males and females, and between the different seasons. Mann-Whitney *U*-tests and Kruskal-Wallis tests were used when data did not meet the assumptions of normality as revealed by a Kolmogorov test. Parametric tests (*t*-tests and ANOVAs) were used otherwise. The significance level was set at 0.05.

4.4 Results

From 2005 to 2011, 12 yellow mongooses (five males and seven females) were radio-tracked for periods varying from only a few days to over eight months (Table A1). Overall, 1,491 locations were collected from 84 full tracking days ($n = 1,349$ locations), random locations ($n = 121$) and resting sites ($n = 21$). On average (\pm SD) 122 ± 72 locations (range: 19–232) were used to calculate the total home range size and perimeter of radio-tracked individuals. The number of locations used for males and females did not differ significantly (Mann-Whitney *U*-test, $U = 21$, $p = 0.63$).

The total home range (MCP 100%) varied from 0.10 to 2.36 km² (for details, see Table A1; Fig. 8), with an average of 0.55 ± 0.65 km². Although total home ranges of males were on average more than twice larger than that of their female counterparts (Table 7), this difference did not

reach statistical significance for both MCP 100% (Mann-Whitney U -test, $U = 25$, $p = 0.22$) and MCP 95% (t -test, $t = 1.154$, $df = 10$, $p = 0.28$). However, a significant intersexual difference was recorded when daily home ranges were compared statistically ($U = 1,165$, $p < 0.003$), with males clearly exploiting larger areas ($0.13 \pm 0.15 \text{ km}^2$) than females ($0.05 \pm 0.05 \text{ km}^2$). This difference cannot be attributed to sample size discrepancy, as the total number of locations used to calculate daily ranges was similar ($U = 95$, $p = 0.32$) for males (16 ± 6) and for females (16 ± 7).

The total perimeter covered by *C. penicillata* was on average $2.80 \pm 1.71 \text{ km}$ (range: 1.17–7.36 km). Here too, no intersexual difference was found when perimeters of total home ranges were compared statistically ($U = 25$, $p = 0.22$; Table 7), but male daily ranges had larger perimeters ($1.47 \pm 0.92 \text{ km}$) than those of females ($0.96 \pm 0.51 \text{ km}$; $U = 1,154$, $p < 0.004$). The DMDs of males ($1.99 \pm 1.07 \text{ km}$) were significantly longer ($U = 466.5$, $p = 0.001$) than that travelled by females ($1.29 \pm 0.66 \text{ km}$). Males ($0.29 \pm 0.13 \text{ km/h}$) also travelled at a faster speed than females ($0.18 \pm 0.07 \text{ km/h}$) ($U = 311.0$, $p < 0.001$).

When daily home ranges and perimeters were compared on a seasonal basis, no overall statistically significant difference was found (Kruskal-Wallis test, home ranges: $H = 4.59$, $df = 3$, $p = 0.20$; perimeters: $H = 4.04$, $df = 3$, $p = 0.26$; Table 8 and Fig. 6). Similarly, there were no statistically significant seasonal variations in the DMD travelled by yellow mongooses (ANOVA, $F = 4.00$, $df = 3$, $p = 0.14$; Table 8 and Fig. 7) and the speed at which they moved ($F = 0.30$, $df = 3$, $p = 0.80$; Fig. 7b).

Males covered larger daily ranges ($U = 38.0$, $p = 0.033$), perimeters ($U = 30.0$, $p = 0.012$) and distances ($U = 26.0$, $p = 0.006$) than females outside the breeding period (Table 9). The same was not observed during the breeding period, as only daily ranges were larger in males than in females ($U = 277.0$, $p = 0.039$). When comparing data between the breeding and the non-breeding season, no difference was observed for females (t -tests, $df = 31$, $p > 0.44$ in all cases; Table 9). For males, however, the perimeter of daily ranges was larger ($t = -1.879$, $df = 49$, $p = 0.032$) during the non-breeding period than when females were receptive. Differences observed for the daily ranges (t -test for unequal variances, $t = -1.879$, $df = 18.59$, $p = 0.141$) and DMDs, ($U = 381.0$, $p = 0.066$) were large (see Table 9) but not statistically significant.

Table 7. Sex, number of radio-tracked individuals (n), average body mass (g), home-range size (km²) and perimeter (km) of the studied yellow mongooses in the Great Fish River Reserve (2005–2011). Data are given as means ± SD.

| Sex | n | Body mass | Home range MCP 100% | Home range MCP 95% | Perimeter MCP 100% |
|--------|---|-----------|------------------------|-----------------------|-----------------------|
| Male | 7 | 861 ± 179 | 0.73 ± 0.80 | 0.48±0.49 | 3.28 ± 2.09 |
| Female | 5 | 743 ± 142 | 0.30 ± 0.23 | 0.22±0.12 | 2.12 ± 0.75 |

Table 8. Number of tracking days per season (n) and seasonal values of MCP 100% daily ranges (km²), related perimeters (km) and daily movement distances (DMD; km) of yellow mongooses.

| Season | n | Daily range | Perimeter | DMD |
|--------|----|-------------|-------------|-------------|
| Spring | 7 | 0.12 ± 0.05 | 1.55 ± 0.42 | 2.11 ± 0.72 |
| Summer | 11 | 0.21 ± 0.28 | 1.85 ± 1.46 | 2.27 ± 1.67 |
| Autumn | 15 | 0.09 ± 0.07 | 1.25 ± 0.69 | 1.70 ± 0.79 |
| Winter | 51 | 0.08 ± 0.08 | 1.22 ± 0.56 | 1.61 ± 0.77 |
| Year | 84 | 0.09 ± 0.13 | 1.27 ± 0.82 | 1.77 ± 0.94 |

Table 9. Number of tracking days (n), seasonal values of MCP 100% daily ranges (km²), related perimeters (km) and daily movement distances (DMD; km) of male and female yellow mongooses during and after the breeding season.

| Season | Sex | n | Daily range | Perimeter | DMD |
|--|--------------|-----------|--------------------|--------------------|--------------------|
| Winter & Spring (breeding period) | Male | 34 | 0.10 ± 0.09 | 1.27 ± 0.71 | 1.74 ± 0.95 |
| | Female | 24 | 0.05 ± 0.05 | 1.00 ± 0.51 | 1.34 ± 0.69 |
| | Total | 58 | 0.08 ± 0.08 | 1.16 ± 0.64 | 1.57 ± 0.86 |
| Summer & Autumn (non-breeding period) | Male | 17 | 0.19 ± 0.23 | 1.86 ± 1.18 | 2.37 ± 1.26 |
| | Female | 9 | 0.06 ± 0.06 | 0.85 ± 0.53 | 1.14 ± 0.58 |
| | Total | 26 | 0.14 ± 0.19 | 1.51 ± 1.10 | 1.94 ± 1.22 |

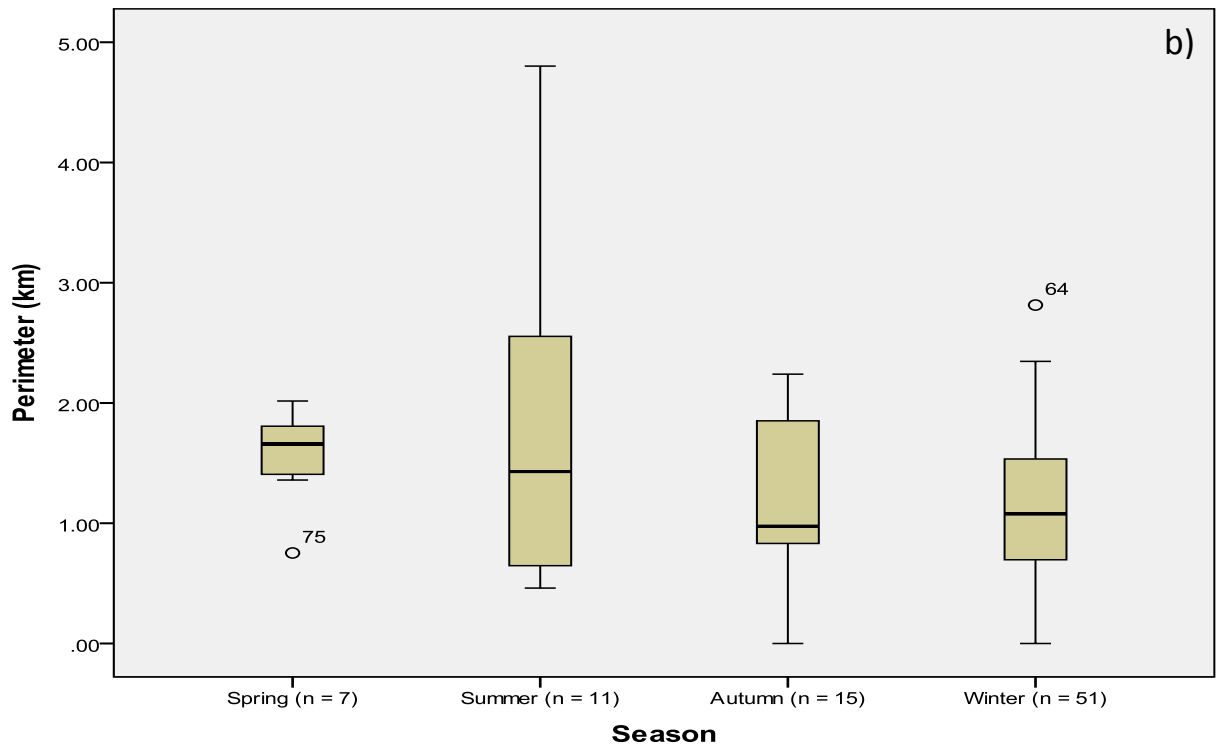
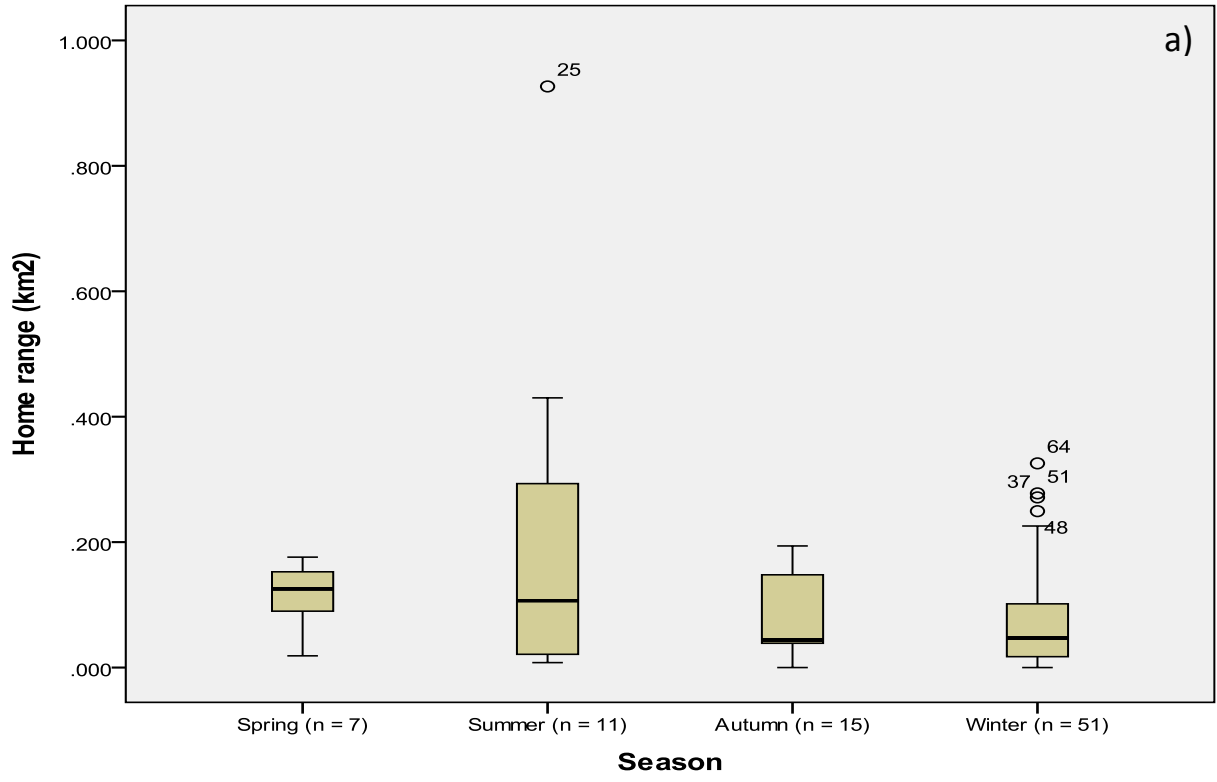


Figure 6. Seasonal variations in a) daily range size (km²) and b) daily range perimeter (km) of radio-tracked yellow mongooses (n = 12) in the Great Fish River Reserve (2005–2011).

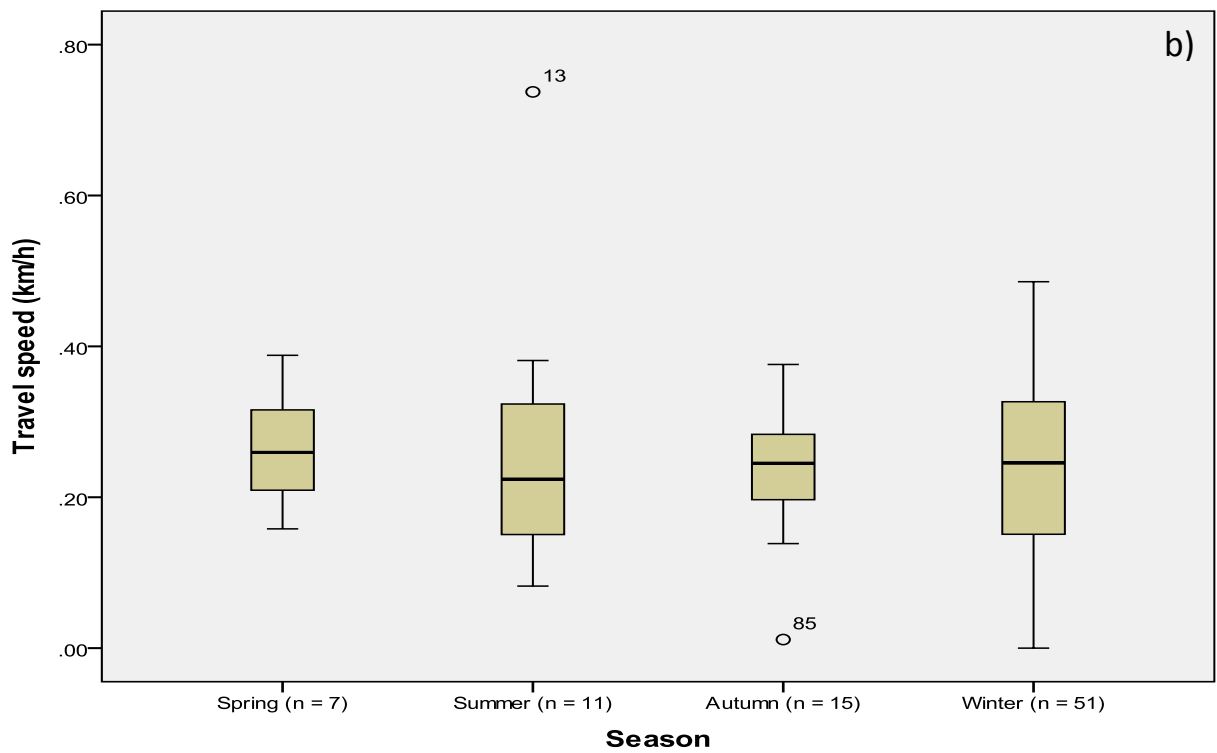
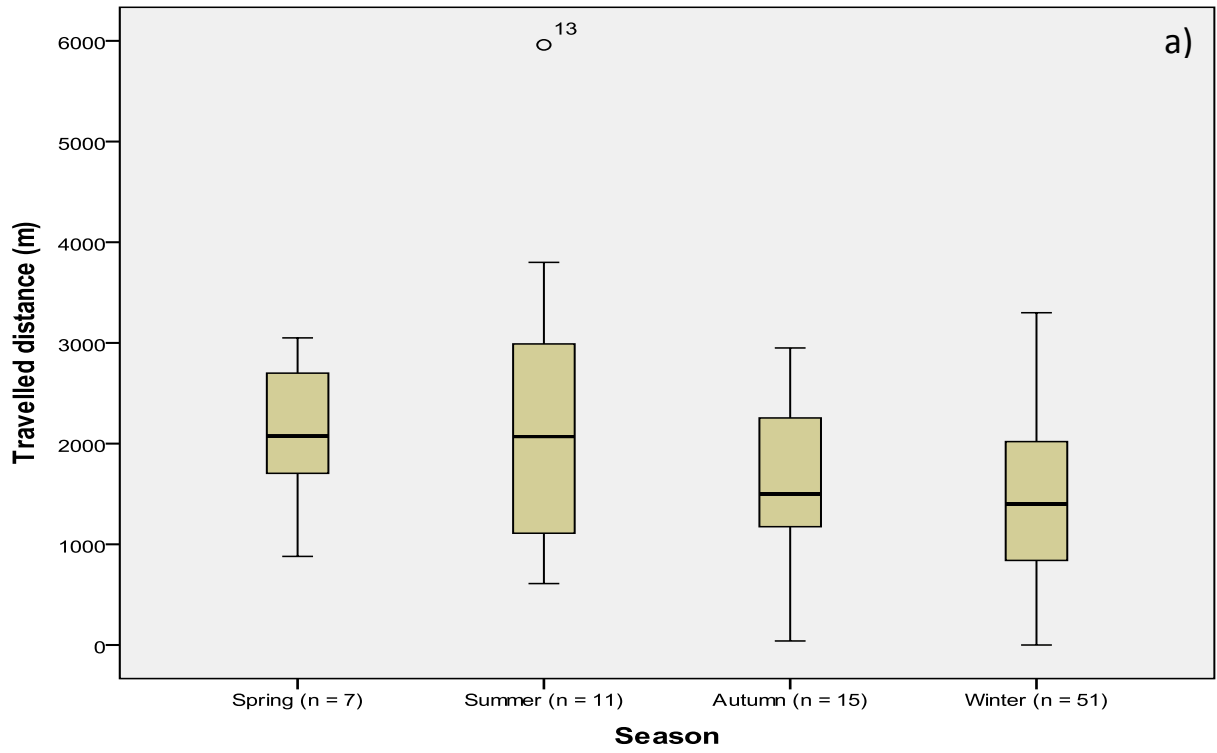


Figure 7. Seasonal variations in a) daily movement distance (m) and b) travel speed (km/h) of radio-tracked yellow mongooses (n = 12) in the Great Fish River Reserve (2005–2011).

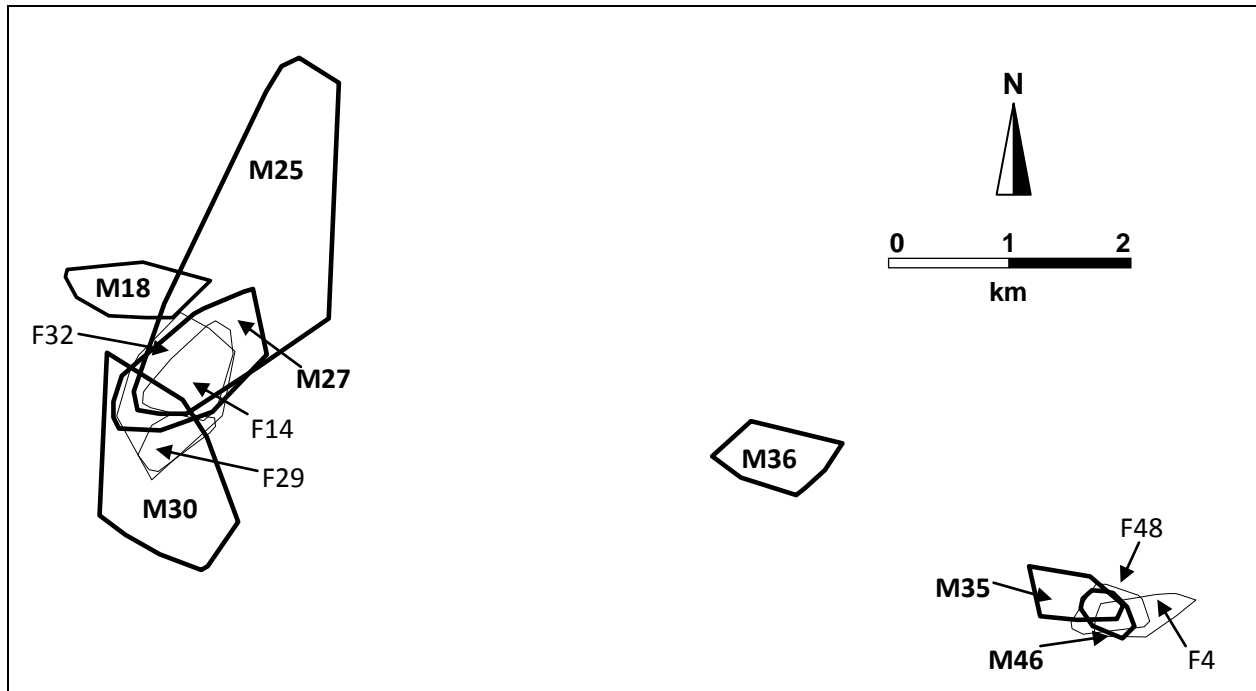


Figure 8. The distribution and shape of the total home ranges of the 12 yellow mongooses (seven males and five females) radio-tracked in the Great Fish River Reserve (2005–2011).

4.4 Discussion

Spatial data presented in this chapter were collected over a 6-year period. For this reason and because the research team could never trap and radio-tag at the same time more than one individual from a specific burrow, it made it impossible to appropriately study home range overlaps among members of the same “social unit”. In this study, traps were only checked twice a day, in the morning and in the late hours of the afternoon. It is possible that more frequent checks (so as to be able to remove the trapped animal within minutes from the capture) would have allowed to avoid potential trap avoidance by other group members following a successful trapping event.

In addition, an evaluation of home range overlaps between individuals of different units was seriously compromised by the fact that some of the denning sites actively used by yellow mongooses – or at least where trapping was successful – were separated by distances of several kilometres (see Fig. 8).

In spite of the above-mentioned limitations, trapping and radio-tracking data, as well as observations made while conducting field work suggest that yellow mongooses live in pairs or in small groups consisting of a pair and one or two additional adults – probably offspring that did not disperse (yet?) from the natal burrow –, as well as the possible young of the year. This type of social organization seems to be characteristic of low density populations, as was already described by Cavallini (1993b) and Le Roux *et al.* (2008). In addition to the role played by habitat characteristics (food abundance, number of favourable den sites), the observed low density might result from the important predation pressure exerted by medium carnivores. Indeed, during the study period, no less than eight out of the 12 radio-collared individuals were killed. The radio-collars that were recovered from the field showed teeth bites' signs, probably of black-backed jackals (see Table A1). It is hard to believe that such fatalities would solely be linked to the possible disturbance created by radio-collars (added weight, increased fatigue, lower vigilance), as some fatalities were only recorded after several months and other animals had at least survived until the collar failed (see Table A1).

The home ranges of yellow mongooses in the GFRR ($0.55 \pm 0.65 \text{ km}^2$, $n = 12$, MCP 100%) were similar to those obtained by Cavallini (1993b) during autumn in the WCNP ($0.59 \pm 0.46 \text{ km}^2$, $n = 7$, MCP 100%). Data collected for males in the GFRR ($0.73 \pm 0.80 \text{ km}^2$, $n = 7$, MCP 100%) also corresponded to those found in the WCNP ($1.02 \pm 0.32 \text{ km}^2$, $n = 7$, MCP 100%) and by Le Roux *et al.* (2008) in the KRR ($0.76 \pm 0.21 \text{ km}^2$, $n = 6$, Kernel 95%). Females' home ranges were also similar in the GFRR ($0.30 \pm 0.28 \text{ km}^2$, $n = 5$, MCP 100%) and in the WCNP ($0.27 \pm 0.17 \text{ km}^2$, $n = 3$, MCP 100%). Only one adult (dominant) female was tracked in Le Roux *et al.*'s (2008) study, and her home range was 0.20 km^2 in size. Concordantly with prediction 2, individual home range sizes recorded by Balmforth (2004) in her medium density population were two to three times smaller ($0.26 \pm 0.06 \text{ km}^2$, $n = 11$, MCP 100%) than in low density populations, whereas at very high density, Earlé (1981) recorded home range sizes of only $0.05\text{-}0.06 \text{ km}^2$. The latter value, however, was most probably an underestimate, because data were not obtained with radio-tracking, but through visual observations. In the WCNP, yellow mongooses were reported to travel an average distance of $3.23 \pm 1.14 \text{ km}$ per day (Cavallini & Nel, 1995), which is almost twice longer as the values obtained in this study ($1.77 \pm 0.94 \text{ km}$). Locations were collected every 15 min in the WCNP, as opposed to every 30 min in the GFRR, what might explain this

important discrepancy. This consideration, however, does not invalidate the inter-sexual differences obtained in my study (see below).

In the GFRR, radio-tracked yellow mongooses demonstrated a considerable variation in their ranging behaviour. Besides the potential differences related to the duration and timing of radio-tracking periods, part of this variation, as already suggested above, could be ascribed to sex. Indeed, the total home ranges of male yellow mongooses were about 2.4 times larger than those of females, which is way above the average ratio (1.16) recorded for body mass difference (prediction 1). Although the range size difference was not statistically significant, it is believed that this result was largely due to small sample size and the fact that most individuals could not be tracked for long enough periods. The large home range size difference, together with the distribution (overlap) of some male and female home ranges (on the left side of Fig. 8), suggest that male yellow mongooses show a potential or tendency for polygyny (prediction 1). The same pattern was observed by Cavallini (1993b) in the low density population he studied in WCNP. Interestingly such spatial patterns were recorded in autumn, *i.e.* outside of the reproductive period. Similar variations in home range size attributed to sex have been reported in other small to medium carnivore species such as the Cape grey mongoose *Galerella pulverulenta* (Cavallini & Nel, 1990, 1995), the pine marten *Martes martes* (Zalewski *et al.*, 2004) and the honey badger *Mellivora capensis* (Begg *et al.*, 2005).

Another source of variation in home range size and other spatial parameters can be attributed to temporal changes in food availability and climatic conditions (*e.g.* in stoats *Mustela erminea*: Erlinge & Sandell, 1986; and Eurasian badgers *Meles meles*: Do Linh san *et al.*, 2007b), as well as changes in the reproductive status of individuals (*e.g.* in common genets *Genetta genetta*: Camps Munuera & Llimona Llobet, 2004). In the present study, sample sizes were too small to calculate seasonal home ranges and investigate possible variations thereof. However, daily spatial parameters could be tested statistically, and no significant seasonal differences were recorded. In Poland, Zalewski *et al.* (1995) showed that the daily ranges of martens increased with decreasing density of prey. In the case of yellow mongooses, and contrarily to prediction 4, female spatial ecology was apparently not affected by food availability. Indeed, daily ranges and movement distances were not larger and longer, respectively, when terrestrial arthropods were less abundant (winter–spring). It is possible that the nursing activities of both mothers and

female helpers (Balmforth, 2004), which take place during the lean period, constrain them to forage near to the burrow. Indeed, contrarily to other mongoose species (*e.g.* meerkats), pups only start accompanying foraging adults at a very late stage, when aged about two months (Rasa *et al.*, 1992). Another, possibly overarching reason, is that low temperatures might constitute the principal factor contributing to the decrease in home range size during winter. As suggested by Pereira (2010), small carnivores may intentionally restrict their movements as a strategy to minimize their energy expenditure when temperatures are low. This would also explain why, contrarily to what was expected (prediction 5), males tended to travel longer distances and roam over larger daily ranges during the non-breeding period (= hot rainy season) than when females were receptive (= cold dry season). Finally, a current study on the dietary habits of the yellow mongoose in the GFRR (Bizani, in prep.) might indicate whether *Cynictis* feeds on alternative, more abundant and profitable food resources (*e.g.* rodents) during winter and spring. This could possibly allow both males and females to quickly meet their energy requirements and therefore restrict their activity (see Chapter 3) and movements. However, we cannot exclude that the reduction in ranging behaviour shown by males might be more reminiscent of mate guarding than coherent with polygyny, as was also observed in red foxes (Cavallini, 1998).

Gittleman & Harvey (1982) and Lindstedt *et al.* (1986), amongst others, showed that differences in body mass/size can also affect the spatial ecology of carnivores and mammals in general. In this study, males covered larger daily ranges and longer perimeters and distances than females outside of the reproductive season (prediction 3). However, the ratios recorded (2.1-3.2) were well above the intersexual body mass ratio. These two observations suggest that besides temperature and possibly reproductive activity, other, unknown factors play a role in the spatial differences registered, and this would be worth investigating in a future study. This could also help understanding why male home ranges are still disproportionately larger than that of females outside of the breeding period, as reported by Cavallini (1993b) and Le Roux *et al.* (2008) in other low density populations.

CONCLUSION

In this dissertation, I presented for the first time information on the activity patterns and spatial ecology of the yellow mongoose across a full seasonal cycle in the Albany Thicket Biome. I essentially provided data on a) the duration of the activity period, b) the occurrence and duration of resting bouts during the activity period, c) the daily activity profile, d) the total and daily home range size and perimeter, e) the daily movement distance travelled by radio-tracked individuals, and f) intersexual and seasonal variations in the above-mentioned parameters.

At the beginning of the study, I formulated predictions related to environmental factors (photoperiod, climatic conditions, food availability), as well as life cycle (reproduction) and morphological and physiological characteristics (sexual dimorphism and thermoregulatory aspects). The following was found:

1. Photoperiod acted as the *zeitgeber* (timegiver), as the onset and offset of the activity period of yellow mongooses were correlated to the sunrise and sunset times; **prediction fully met.**
2. The availability of terrestrial arthropods was lower in spring and winter than in summer and autumn. In winter, yellow mongooses exhibited low activity levels, whereas they were expected to compensate for the low food availability by spending more time active during the day. This suggests that low temperatures affect yellow mongoose activity budget more than low food availability (see point 4 below). In contrast, activity levels were the highest in spring, but it is unclear whether this was due to a) the low food availability and facilitated by the higher daily temperatures (as compared to winter), b) the increased activity during the reproductive season or 3) an artefact linked to small sample size; **prediction not or only partially met.**
3. Low terrestrial arthropod activity probably affected the activity levels of yellow mongooses during rainy weather and/or when the soil was wet, as radio-tracked individuals were less active during such conditions; **prediction fully met.**
4. Yellow mongooses were less active during cold and hot weather conditions, presumably due to their elongated bodies that lead to higher than average surface to volume ratio, and therefore higher heat loss and overheating risk; **prediction fully met.**

5. No intersexual difference in activity levels was found. Females were therefore proportionally (with regard to body mass) more active than males, which is exactly the opposite of what was expected; **prediction not met**. It would be interesting to further explore whether this lower activity of males might be associated with the availability of concentrated food resources in their foraging ranges and/or their higher hunting efficiency as compared to females.
6. Males had larger total home ranges than females, because at low population density (as was the case in the GFRR) males seem to be polygynous and their home ranges overlap with those of several females; **prediction fully met**.
7. Yellow mongooses have larger home ranges in the GFRR than in medium and low density populations, probably because resource abundance and distribution determine space use and consequently carrying capacity and population density; **prediction fully met**.
8. Males' daily ranges were larger and movement distances were longer than those of females outside of the reproductive season (summer and autumn). However, the observed difference was well above the intersexual body mass ratio; **prediction met**, but (an) other overarching factor(s) probably affect male spatial behaviour outside of the breeding season.
9. Males' daily ranges were smaller and movement distances shorter during the reproductive season (winter and spring) than after it. The opposite was expected, as males are to search for oestrous females and increase scent-marking and patrolling activities during the breeding period; **prediction not met**. It is possible that, like other small carnivore species, male yellow mongooses intentionally restrict their movements as a strategy to minimize their energy expenditure when temperatures are low. The consumption of alternative prey (*e.g.* rodents) might also help males to quickly meet their energy requirements and therefore restrict their activity (see point 2 above) and movements. The possible role of mate-guarding would be worth investigating.
10. Females' daily ranges were smaller and movement distances shorter during winter and spring (low arthropod availability) than during summer and autumn (high arthropod availability). The opposite was expected; **prediction not met**. Here too, cold conditions and the consumption of alternative prey might explain the observed pattern. It is also possible that

the nursing activities of both mothers and female helpers constrain them to forage near to the burrow.

The above-mentioned conclusions must of course be put into perspective with the characteristics of the samples used for the analyses, and must therefore be considered with some caution. Indeed, spatio-temporal data presented and analysed in this dissertation were collected over a 6-year period and were largely biased towards the winter season. For this reason, and because the research team could never trap and simultaneously radio-track more than one individual from a specific burrow, an evaluation of home range overlaps was seriously compromised.

In spite of the such limitations, trapping and radio-tracking data, as well as observations suggest that in the GFRR yellow mongooses live in pairs or in small groups consisting of a pair, one or two additional adults, as well as the young of the year. This type of social organization seems to be representative of low density populations (4–10 ind./km² in the GFRR). In addition to the role played by key resources (food, den sites), the observed low density might result from the important predation pressure exerted by mesocarnivores, particularly black-backed jackals.

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APPENDICES

Table A1. Code (ID), sex, body mass at capture, area of capture, tracking period, number of tracking days and nights (continuous sessions), home range size (as determined by the MCP 100% method) and perimeter of individual yellow mongooses in the Great Fish River Reserve (2005–2011).

| ID | Sex | Weight (g) | Group/Burrow | Tracking period | Tracking days | Tracking nights^a | Home range (km²) | Perimeter (km) |
|------------------|------------|-------------------|---------------------|------------------------|----------------------|------------------------------------|------------------------------------|-----------------------|
| F4 ^c | Female | 815 | Grasslands | 08.09.2005–23.10.2005 | 1 | 0 | 0.18 | 1.79 |
| F14 ^c | Female | 740 | Kentucky | 15.06.2006–23.11.2006 | 4 | 0 | 0.32 | 2.33 |
| M18 ^c | Male | 890 | Kentuckykop | 24.11.2006–26.11.2006 | 3 | 0 | 0.33 | 2.43 |
| M25 ^c | Male | 740 | Kentucky | 01.08.2007–30.01.2008 | 10 | 0 | 2.36 | 7.36 |
| M27 | Male | 980 | Kentucky | 14.05.2008–09.12.2008 | 10 | 0 | 0.74 | 3.63 |
| F29 ^c | Female | 580 | Village-Gate | 21.06.2008–23.06.2008 | 3 | 0 | 0.15 | 1.58 |
| M30 ^b | Male | 980 | Village-Gate | 03.07.2008–07.08.2011 | 17 | 2 | 1.12 | 4.35 |
| F32 | Female | 940 | Kentucky | 17.06.2010–11.12.2010 | 11 | 6 | 0.69 | 3.35 |
| M35 ^c | Male | 1060 | Grasslands | 24.06.2010–12.08.2010 | 4 | 3 | 0.21 | 1.87 |
| M36 ^c | Male | 850 | Junction 10 | 28.06.2010–07.07.2010 | 4 | 1 | 0.29 | 2.18 |
| M46 ^c | Male | 530 | Grasslands | 18.04.2011–20.04.2011 | 3 | 0 | 0.10 | 1.17 |
| F48 | Female | 640 | Grasslands | 14.05.2011–04.08.2011 | 14 | 6 | 0.16 | 1.56 |

^aFor most animals tracked between June 2006 and January 2009, nocturnal activity data were obtained through semi-continuous tracking sessions and random locations.

^bThis animal was last tracked on 19.01.2009 and retrapped and fitted with a new radio-transmitter on 15.06.2011.

^cAnimals that were killed by predators (probably only jackals).

Table A2. Mean, standard deviation (SD), minimum and maximum of behavioural parameters of the yellow mongoose in the Albany Thicket Biome of South Africa, based on 84 diurnal continuous radio-tracking sessions (2005–2011).

| Behavioural parameter | n* | Mean | SD | Min | Max |
|---|-----------|-------------|-----------|------------|------------|
| Number of resting bouts | 83 | 4.77 | 2.32 | 0 | 11 |
| Resting duration (min) | 83 | 175 | 96 | 0 | 382 |
| Mean duration of resting bouts (min) | 83 | 42 | 32 | 0 | 187 |
| Minimum duration of resting bouts (min) | 83 | 15 | 22 | 0 | 151 |
| Maximum duration of resting bouts (min) | 83 | 89 | 58 | 0 | 310 |
| Travelled distance (m) | 84 | 1688 | 994 | 0 | 5960 |
| Travel speed (m/min) | 83 | 4.18 | 2.02 | 0.00 | 12.29 |
| Travel speed (km/h) | 83 | 0.25 | 0.12 | 0.00 | 0.74 |
| Mean distance (m) travelled in 30 min | 83 | 86 | 45 | 0 | 248 |
| Max distance (m) travelled in 30 min | 83 | 307 | 157 | 0 | 890 |
| Activity period (min) | 83 | 568 | 139 | 12 | 936 |
| Effective activity (min) | 84 | 383 | 132 | 0 | 627 |
| Percentage time active (%) | 83 | 68.4 | 17.3 | 16.3 | 100 |
| Onset of activity (decimal time) | 83 | 7.99 | 1.14 | 5.62 | 11.13 |
| Offset of activity (decimal time) | 83 | 17.46 | 1.56 | 9.98 | 21.62 |
| Difference onset-sunrise (decimal time) | 83 | 1.41 | 1.03 | -0.18 | 6.15 |
| Difference offset-sunset (decimal time) | 83 | -0.35 | 1.40 | -7.63 | 3.76 |
| Difference onset-sunrise (hour) | 83 | 01H25 | 01H02 | -00H11 | 06H09 |
| Difference offset-sunset (hour) | 83 | -00H21 | 01H24 | -07H38 | 03H45 |

*No emergence was recorded on one tracking day, reason why sample size is reduced to n = 83 for some parameters.

Table A3. Activity parameters of yellow mongooses investigated through 84 diurnal continuous tracking sessions conducted in the Albany Thicket Biome of South Africa (2005–2011). ID = identity of animal, NRB = number of resting bouts, RD = resting duration, MEAN DRB = mean duration of resting bouts, MIN DRB = minimum duration of resting bouts, MAX DRB = maximum duration of resting bouts, START = onset of activity, STOP = offset of activity, AP = duration of the activity period, EA = effective activity, %A = percentage activity, DL = day length, DIFF ONSET-SUNRISE = difference between onset of activity and sunrise time, DIFF OFFSET-SUNSET = difference between offset of activity and sunset time, – = no overground activity recorded during the tracking day.

| ID | DATE | TRACK DAY | N RB | RD | MEAN DRB | MIN DRB | MAX DRB | START | STOP | AP | EA | %A | SUNRISE | SUNSET | DL | DIFF ONSET-SUNRISE | DIFF OFFSET-SUNSET |
|-----|------------|-----------|------|-----|----------|---------|---------|-------|-------|-------|-----|----|---------|--------|-------|--------------------|--------------------|
| F4 | 23.10.2005 | 1 | 7 | 65 | 9 | 5 | 20 | 06H45 | 18H05 | 11H20 | 585 | 86 | 05H23 | 18H32 | 13H09 | 01H22 | –00H27 |
| F14 | 15.06.2006 | 1 | 6 | 51 | 9 | 3 | 24 | 08H26 | 17H03 | 08H37 | 468 | 91 | 07H14 | 17H12 | 09H58 | 01H12 | –00H09 |
| F14 | 18.06.2006 | 2 | 3 | 134 | 45 | 4 | 120 | 09H00 | 17H35 | 08H35 | 381 | 74 | 07H15 | 17H13 | 09H58 | 01H45 | 00H22 |
| F14 | 23.11.2006 | 3 | 7 | 252 | 36 | 5 | 88 | 05H38 | 20H05 | 14H27 | 615 | 71 | 04H59 | 19H00 | 14H01 | 00H46 | 01H05 |
| F14 | 18.01.2007 | 4 | 6 | 361 | 60 | 8 | 185 | 05H44 | 21H20 | 15H36 | 575 | 61 | 05H22 | 19H24 | 14H02 | 00H22 | 01H56 |
| M18 | 24.11.2006 | 1 | 7 | 294 | 42 | 4 | 200 | 08H03 | 19H08 | 11H05 | 371 | 56 | 04H59 | 19H01 | 14H02 | 03H04 | 00H10 |
| M18 | 25.11.2006 | 2 | 2 | 29 | 15 | 14 | 15 | 10H07 | 17H00 | 06H53 | 384 | 93 | 04H58 | 19H02 | 14H04 | 05H09 | –02H02 |
| M18 | 26.11.2006 | 3 | 9 | 224 | 25 | 5 | 94 | 06H43 | 19H07 | 12H24 | 520 | 70 | 04H59 | 19H03 | 14H04 | 01H45 | 00H04 |
| M25 | 01.08.2007 | 1 | 4 | 77 | 19 | 3 | 62 | 07H55 | 20H34 | 12H39 | 613 | 81 | 07H04 | 17H34 | 10H30 | 00H51 | 03H00 |
| M25 | 16.08.2007 | 2 | 5 | 153 | 31 | 19 | 91 | 07H55 | 17H55 | 09H30 | 396 | 70 | 06H50 | 17H45 | 10H55 | 01H50 | –00H20 |
| M25 | 21.08.2007 | 3 | 6 | 125 | 21 | 3 | 57 | 08H00 | 18H03 | 10H03 | 474 | 79 | 06H45 | 17H48 | 11H03 | 01H15 | 00H15 |
| M25 | 22.08.2007 | 4 | 4 | 203 | 51 | 21 | 81 | 10H09 | 21H37 | 11H28 | 422 | 62 | 06H43 | 17H49 | 11H06 | 03H26 | 03H45 |
| M25 | 23.08.2007 | 5 | 6 | 308 | 51 | 3 | 142 | 08H35 | 15H47 | 07H12 | 125 | 29 | 06H42 | 17H49 | 11H07 | 01H53 | –02H47 |
| M25 | 25.10.2007 | 6 | 4 | 157 | 39 | 20 | 52 | 06H00 | 18H02 | 12H02 | 565 | 78 | 05H21 | 18H33 | 13H12 | 00H39 | –00H31 |
| M25 | 10.01.2008 | 7 | 5 | 151 | 30 | 5 | 58 | 06H00 | 18H58 | 12H58 | 627 | 81 | 05H14 | 19H26 | 14H12 | 00H46 | –00H28 |
| M25 | 28.01.2008 | 8 | 8 | 382 | 48 | 4 | 198 | 05H33 | 19H11 | 13H18 | 424 | 53 | 05H31 | 19H20 | 13H49 | 00H22 | –00H09 |
| M25 | 28.01.2008 | 8 | 8 | 382 | 48 | 4 | 198 | 05H33 | 19H11 | 13H18 | 424 | 53 | 05H31 | 19H20 | 13H49 | 00H22 | –00H09 |

Table A3. (CONTINUED)

| ID | DATE | TRACK DAY | N RB | RD | MEAN DRB | MIN DRB | MAX DRB | START | STOP | AP | EA | %A | SUNRISE | SUNSET | DL | DIFF ONSET-SUNRISE | DIFF OFFSET-SUNSET |
|-----|------------|-----------|------|-----|----------|---------|---------|-------|-------|-------|-----|----|---------|--------|-------|--------------------|--------------------|
| M25 | 29.01.2008 | 9 | 7 | 261 | 37 | 5 | 143 | 06H33 | 19H45 | 13H12 | 531 | 67 | 05H32 | 19H19 | 13H47 | 01H01 | 00H26 |
| M25 | 30.01.2008 | 10 | 7 | 303 | 43 | 14 | 75 | 06H19 | 19H20 | 13H01 | 485 | 62 | 05H33 | 19H18 | 13H45 | 00H46 | 00H02 |
| M27 | 14.05.2008 | 1 | 6 | 117 | 20 | 4 | 57 | 07H31 | 16H57 | 09H26 | 445 | 79 | 06H56 | 17H22 | 10H26 | 01H35 | -00H25 |
| M27 | 16.05.2008 | 2 | 6 | 42 | 7 | 3 | 19 | 07H49 | 17H43 | 09H54 | 555 | 93 | 06H57 | 17H21 | 10H24 | 00H52 | 00H22 |
| M27 | 20.05.2008 | 3 | 5 | 133 | 27 | 4 | 60 | 08H00 | 20H11 | 12H11 | 597 | 82 | 07H00 | 17H18 | 10H18 | 01H00 | 02H53 |
| M27 | 23.05.2008 | 4 | 2 | 46 | 23 | 8 | 38 | 08H37 | 17H15 | 08H38 | 470 | 91 | 07H02 | 17H17 | 10H15 | 01H35 | -00H02 |
| M27 | 26.05.2008 | 5 | 2 | 15 | 8 | 3 | 12 | 08H10 | 17H30 | 09H20 | 534 | 95 | 07H04 | 17H15 | 10H11 | 01H06 | 00H15 |
| M27 | 27.05.2008 | 6 | 6 | 198 | 33 | 15 | 67 | 07H48 | 17H30 | 09H42 | 381 | 65 | 07H05 | 17H15 | 10H10 | 00H43 | 00H15 |
| M27 | 29.05.2008 | 7 | 5 | 146 | 29 | 5 | 72 | 07H36 | 17H26 | 09H50 | 442 | 75 | 07H06 | 17H14 | 10H08 | 00H30 | 00H12 |
| M27 | 28.08.2008 | 8 | 2 | 264 | 132 | 3 | 193 | 07H40 | 17H07 | 09H27 | 290 | 51 | 06H35 | 17H53 | 11H18 | 01H05 | -00H46 |
| M27 | 29.08.2008 | 9 | 4 | 99 | 25 | 4 | 77 | 07H55 | 20H34 | 12H39 | 493 | 65 | 06H34 | 17H54 | 11H20 | 01H21 | 02H40 |
| M27 | 09.12.2008 | 10 | 6 | 345 | 58 | 11 | 115 | 06H46 | 19H01 | 12H15 | 390 | 53 | 04H57 | 19H14 | 14H17 | 01H49 | 00H13 |
| F29 | 21.06.2008 | 1 | 7 | 69 | 10 | 5 | 25 | 08H35 | 17H03 | 08H28 | 440 | 87 | 07H16 | 17H14 | 09H58 | 01H19 | -00H11 |
| F29 | 22.06.2008 | 2 | 5 | 119 | 24 | 3 | 63 | 08H23 | 17H47 | 09H24 | 444 | 79 | 07H16 | 17H14 | 09H58 | 01H07 | 00H33 |
| F29 | 23.06.2008 | 3 | 4 | 61 | 15 | 3 | 35 | 09H23 | 17H00 | 07H37 | 393 | 86 | 07H16 | 17H14 | 09H58 | 02H07 | -00H14 |
| M30 | 03.07.2008 | 1 | 8 | 274 | 34 | 5 | 171 | 08H00 | 18H08 | 10H02 | 336 | 56 | 07H17 | 17H18 | 10H01 | -00H11 | 01H00 |
| M30 | 09.07.2008 | 2 | 6 | 221 | 37 | 3 | 131 | 08H48 | 17H10 | 08H22 | 279 | 56 | 07H16 | 17H21 | 10H05 | 01H32 | -00H11 |
| M30 | 11.07.2008 | 3 | 6 | 311 | 52 | 10 | 180 | 08H05 | 17H10 | 09H05 | 234 | 43 | 07H15 | 17H22 | 10H07 | 00H50 | -00H12 |
| M30 | 16.08.2008 | 4 | 7 | 189 | 27 | 4 | 111 | 08H09 | 17H30 | 09H21 | 362 | 65 | 07H13 | 17H25 | 10H12 | 00H56 | 00H05 |
| M30 | 21.08.2008 | 5 | 3 | 127 | 42 | 4 | 82 | 08H30 | 17H28 | 08H58 | 410 | 76 | 07H11 | 17H28 | 10H17 | 01H19 | 00H00 |

Table A3. (CONTINUED)

| ID | DATE | TRACK DAY | N RB | RD | MEAN DRB | MIN DRB | MAX DRB | START | STOP | AP | EA | %A | SUNRISE | SUNSET | DL | DIFF ONSET-SUNRISE | DIFF OFFSET-SUNSET |
|-----|------------|-----------|------|-----|----------|---------|---------|-------|-------|-------|-----|-----|---------|--------|-------|--------------------|--------------------|
| M30 | 24.08.2008 | 6 | 7 | 293 | 42 | 4 | 150 | 08H04 | 18H19 | 10H15 | 326 | 53 | 07H10 | 17H28 | 10H18 | 00H54 | 00H51 |
| M30 | 18.11.2008 | 7 | 8 | 347 | 43 | 3 | 97 | 08H41 | 16H10 | 07H29 | 104 | 23 | 07H09 | 17H30 | 10H21 | 01H32 | -01H20 |
| M30 | 11.12.2008 | 8 | 9 | 180 | 20 | 3 | 44 | 06H08 | 16H40 | 10H32 | 446 | 71 | 05H01 | 18H56 | 13H55 | 01H07 | -02H16 |
| M30 | 19.01.2009 | 9 | 11 | 212 | 19 | 4 | 65 | 06H01 | 19H33 | 13H32 | 598 | 74 | 04H57 | 19H15 | 13H18 | 01H04 | 00H18 |
| M30 | 17.06.2011 | 10 | 5 | 364 | 73 | 4 | 197 | 05H37 | 19H07 | 13H30 | 445 | 55 | 05H23 | 19H24 | 14H01 | 00H14 | -00H17 |
| M30 | 17.06.2011 | 11 | 1 | 58 | 58 | 58 | 58 | 10H37 | 16H31 | 05H54 | 296 | 84 | 07H15 | 17H13 | 09H58 | 03H22 | 00H42 |
| M30 | 18.06.2011 | 12 | 3 | 223 | 74 | 51 | 102 | 08H37 | 17H01 | 08H24 | 281 | 56 | 07H15 | 17H13 | 09H58 | 01H22 | -00H12 |
| M30 | 19.06.2011 | 13 | 4 | 146 | 37 | 20 | 93 | 08H46 | 17H07 | 08H21 | 355 | 71 | 07H15 | 17H13 | 09H58 | 01H31 | -00H06 |
| M30 | 25.07.2011 | 14 | 0 | 0 | 0 | 0 | 0 | - | - | - | 0 | 0 | 07H09 | 17H30 | 10H21 | -07H09 | -17H30 |
| M30 | 05.08.2011 | 15 | 0 | 0 | 0 | 0 | 0 | 09H47 | 09H59 | 00H12 | 12 | 100 | 07H01 | 17H37 | 10H36 | 02H46 | -07H38 |
| M30 | 06.08.2011 | 16 | 2 | 149 | 75 | 40 | 109 | 11H08 | 14H21 | 03H13 | 45 | 23 | 07H00 | 17H38 | 10H38 | 04H08 | -03H17 |
| M30 | 07.08.2011 | 17 | 1 | 12 | 12 | 12 | 12 | 10H35 | 17H54 | 07H19 | 427 | 97 | 06H59 | 17H39 | 10H40 | 03H36 | 02H15 |
| F32 | 17.06.2010 | 1 | 10 | 161 | 16 | 3 | 42 | 08H21 | 16H51 | 08H30 | 354 | 69 | 07H15 | 17H13 | 09H58 | 01H06 | 00H22 |
| F32 | 08.07.2010 | 2 | 2 | 135 | 68 | 10 | 125 | 09H01 | 16H11 | 07H10 | 300 | 70 | 07H16 | 17H20 | 10H04 | 01H45 | 01H09 |
| F32 | 09.07.2010 | 3 | 4 | 142 | 36 | 5 | 69 | 08H40 | 17H05 | 08H25 | 363 | 72 | 07H16 | 17H20 | 10H04 | 01H24 | -00H15 |
| F32 | 10.07.2010 | 4 | 2 | 165 | 83 | 54 | 111 | 08H37 | 16H45 | 09H08 | 322 | 59 | 07H16 | 17H21 | 10H05 | 01H21 | 00H36 |
| F32 | 05.08.2010 | 5 | 1 | 51 | 151 | 151 | 151 | 09H30 | 17H07 | 07H37 | 306 | 67 | 07H01 | 17H37 | 10H36 | 02H29 | -00H30 |
| F32 | 06.08.2010 | 6 | 2 | 134 | 67 | 5 | 129 | 07H52 | 17H32 | 09H40 | 446 | 77 | 07H00 | 17H38 | 10H38 | 00H52 | 00H06 |
| F32 | 11.08.2010 | 7 | 4 | 100 | 25 | 5 | 48 | 08H05 | 16H59 | 08H54 | 432 | 81 | 06H55 | 17H41 | 10H46 | 01H10 | -00H42 |
| F32 | 04.10.2010 | 8 | 5 | 249 | 50 | 6 | 92 | 07H09 | 16H52 | 09H43 | 334 | 57 | 05H46 | 18H17 | 12H31 | 01H23 | -01H25 |

Table A3. (CONTINUED)

| ID | DATE | TRACK DAY | N RB | RD | MEAN DRB | MIN DRB | MAX DRB | START | STOP | AP | EA | %A | SUNRISE | SUNSET | DL | DIFF ONSET-SUNRISE | DIFF OFFSET-SUNSET |
|-----|------------|-----------|------|-----|----------|---------|---------|-------|-------|-------|-----|----|---------|--------|-------|--------------------|--------------------|
| F32 | 09.12.2010 | 9 | 2 | 306 | 153 | 41 | 265 | 07H07 | 17H32 | 10H25 | 319 | 51 | 04H57 | 19H14 | 14H17 | 02H10 | -01.42 |
| F32 | 10.12.2010 | 10 | 5 | 247 | 49 | 8 | 143 | 06H33 | 18H15 | 11H42 | 455 | 65 | 04H57 | 19H14 | 14H17 | 01H36 | 00H59 |
| F32 | 11.12.2010 | 11 | 4 | 167 | 42 | 8 | 126 | 06H43 | 16H47 | 10H04 | 437 | 72 | 04H57 | 19H15 | 14H18 | 01H46 | 02H28 |
| M35 | 24.06.2010 | 1 | 5 | 304 | 61 | 3 | 141 | 07H51 | 17H23 | 09H32 | 261 | 46 | 07H16 | 17H14 | 09H58 | 00H35 | 00H09 |
| M35 | 25.06.2010 | 2 | 7 | 238 | 34 | 10 | 77 | 08H02 | 17H35 | 09H33 | 340 | 59 | 07H16 | 17H14 | 09H58 | 00H46 | 00H21 |
| M35 | 26.06.2010 | 3 | 5 | 271 | 54 | 3 | 130 | 08H12 | 17H09 | 08H51 | 261 | 49 | 07H19 | 17H15 | 09H56 | 00H57 | -00H09 |
| M35 | 06.07.2010 | 4 | 2 | 374 | 187 | 64 | 310 | 08H36 | 17H48 | 09H12 | 179 | 32 | 07H16 | 17H19 | 10H03 | 01H20 | 00H29 |
| M36 | 28.06.2010 | 1 | 6 | 105 | 18 | 5 | 42 | 07H45 | 17H20 | 09H35 | 470 | 82 | 07H17 | 17H15 | 09H58 | 00H28 | 00H05 |
| M36 | 29.06.2010 | 2 | 4 | 199 | 50 | 22 | 81 | 08H03 | 17H58 | 09H55 | 395 | 66 | 07H16 | 17H16 | 10H00 | 00H46 | 00H42 |
| M36 | 30.06.2010 | 3 | 4 | 186 | 47 | 6 | 80 | 07H54 | 16H27 | 08H33 | 327 | 64 | 07H16 | 17H16 | 10H00 | 00H37 | -00H49 |
| M36 | 07.07.2010 | 4 | 4 | 52 | 13 | 5 | 21 | 08H18 | 17H06 | 08H48 | 481 | 91 | 07H16 | 17H19 | 10H03 | 01H02 | -00H13 |
| M46 | 18.04.2011 | 1 | 7 | 217 | 31 | 5 | 84 | 07H44 | 17H22 | 09H38 | 351 | 61 | 06H37 | 17H48 | 11H11 | 01H07 | -00H26 |
| M46 | 19.04.2011 | 2 | 9 | 169 | 19 | 7 | 41 | 07H14 | 17H31 | 10H17 | 449 | 73 | 06H37 | 17H46 | 11H09 | 00H37 | -00H12 |
| M46 | 20.04.2011 | 3 | 7 | 286 | 41 | 6 | 100 | 07H36 | 16H48 | 09H12 | 265 | 48 | 06H38 | 17H45 | 11H07 | 00H58 | -00H57 |
| F48 | 14.05.2011 | 1 | 4 | 117 | 29 | 10 | 50 | 08H18 | 16H34 | 08H16 | 379 | 76 | 06H55 | 17H23 | 10H28 | 01H23 | -00H49 |
| F48 | 15.05.2011 | 2 | 5 | 138 | 28 | 4 | 51 | 07H43 | 17H27 | 09H44 | 446 | 76 | 06H56 | 17H22 | 10H26 | 00H47 | 00H05 |
| F48 | 16.05.2011 | 3 | 5 | 265 | 53 | 16 | 86 | 08H16 | 16H12 | 07H56 | 211 | 44 | 06H57 | 17H21 | 10H24 | 01H19 | -01H08 |
| F48 | 17.05.2011 | 4 | 7 | 149 | 21 | 15 | 33 | 08H11 | 16H23 | 08H12 | 343 | 70 | 06H58 | 17H21 | 10H23 | 01H13 | -00H04 |
| F48 | 17.05.2011 | 5 | 3 | 169 | 56 | 12 | 119 | 07H31 | 16H12 | 08H41 | 352 | 68 | 06H58 | 17H20 | 10H22 | 00H33 | -00H36 |
| F48 | 14.06.2011 | 6 | 3 | 103 | 34 | 6 | 50 | 08H04 | 17H08 | 09H04 | 441 | 81 | 07H14 | 17H12 | 09H58 | 00H50 | -01H07 |

Table A3. (CONTINUED)

| ID | DATE | TRACK DAY | N RB | RD | MEAN DRB | MIN DRB | MAX DRB | START | STOP | AP | EA | %A | SUNRISE | SUNSET | DL | DIFF ONSET- SUNRISE | DIFF OFFSET- SUNSET |
|-----------|-------------|----------------------|-----------------|-----------|---------------------|--------------------|--------------------|--------------|-------------|-----------|-----------|-----------|----------------|---------------|-----------|------------------------------------|------------------------------------|
| F48 | 15.06.2011 | 7 | 5 | 122 | 24 | 7 | 59 | 07H48 | 16H36 | 08H48 | 406 | 77 | 07H14 | 17H12 | 09H58 | 00H34 | -01H21 |
| F48 | 22.06.2011 | 8 | 2 | 40 | 20 | 16 | 24 | 08H25 | 16H07 | 07H48 | 422 | 90 | 07H16 | 17H14 | 09H58 | 06H09 | -00H39 |
| F48 | 22.07.2011 | 9 | 3 | 90 | 30 | 24 | 66 | 08H29 | 16H08 | 07H39 | 369 | 80 | 07H11 | 17H29 | 10H18 | 01H18 | -01H40 |
| F48 | 23.07.2011 | 10 | 6 | 172 | 29 | 6 | 57 | 08H08 | 16H50 | 08H42 | 350 | 67 | 07H10 | 17H29 | 10H19 | 00H58 | -00H39 |
| F48 | 24.07.2011 | 11 | 4 | 272 | 68 | 47 | 103 | 10H18 | 15H49 | 05H31 | 54 | 16 | 07H10 | 17H29 | 10H19 | 03H08 | -01H40 |
| F48 | 03.08.2011 | 13 | 2 | 99 | 50 | 48 | 51 | 08H06 | 16H11 | 08H05 | 386 | 80 | 07H03 | 17H36 | 10H33 | 01H03 | -01H25 |
| F48 | 04.08.2011 | 14 | 1 | 66 | 66 | 66 | 66 | 07H51 | 15H25 | 07H34 | 388 | 85 | 07H02 | 17H37 | 10H35 | 00H49 | -02H12 |

Table A4. Behavioural parameters of yellow mongooses investigated through 84 diurnal continuous tracking sessions in the Albany Thicket Biome of South Africa (2005–2011). ID = identity of animal, n = number of locations, DMD = daily movement distance, MEAN D and MAX D = mean and maximum distances travelled between two consecutive locations (collected every 30 min), respectively, TS = travelling speed. Daily range sizes and perimeters were determined by means of the MCP 100% method.

| ID | DATE | TRACKING DAY | n | DMD | MEAN D | MAX D | TS (m/min) | TS (km/h) | DAILY RANGE (km ²) | PERIMETER (km) |
|-----|------------|--------------|----|------|--------|-------|------------|-----------|--------------------------------|----------------|
| F4 | 23.10.2005 | 1 | 19 | 3000 | 130 | 400 | 5.13 | 0.31 | 0.18 | 1.79 |
| F14 | 15.06.2006 | 1 | 35 | 1820 | 107 | 270 | 3.89 | 0.23 | 0.12 | 1.75 |
| F14 | 18.06.2006 | 2 | 25 | 1210 | 61 | 450 | 3.18 | 0.19 | 0.05 | 1.14 |
| F14 | 23.11.2006 | 3 | 29 | 2210 | 74 | 430 | 3.59 | 0.22 | 0.1 | 1.59 |
| F14 | 18.01.2007 | 4 | 35 | 2070 | 61 | 300 | 3.6 | 0.22 | 0.21 | 1.83 |
| M18 | 24.11.2006 | 1 | 24 | 2400 | 104 | 600 | 6.47 | 0.39 | 0.16 | 2.04 |
| M18 | 25.11.2006 | 2 | 14 | 1650 | 118 | 230 | 4.3 | 0.26 | 0.13 | 1.36 |
| M18 | 26.11.2006 | 3 | 21 | 1760 | 70 | 420 | 3.38 | 0.2 | 0.07 | 1.45 |
| M25 | 01.08.2007 | 1 | 24 | 2860 | 110 | 510 | 4.67 | 0.28 | 0.08 | 1.44 |
| M25 | 16.08.2007 | 2 | 19 | 1780 | 94 | 340 | 4.49 | 0.27 | 0.05 | 0.88 |
| M25 | 21.08.2007 | 3 | 20 | 2010 | 101 | 330 | 4.24 | 0.25 | 0.04 | 0.87 |
| M25 | 22.08.2007 | 4 | 23 | 2070 | 86 | 230 | 4.91 | 0.29 | 0.04 | 1.01 |
| M25 | 23.08.2007 | 5 | 5 | 590 | 39 | 250 | 4.72 | 0.28 | 0.01 | 0.49 |
| M25 | 25.10.2007 | 6 | 23 | 3050 | 127 | 370 | 5.4 | 0.32 | 0.23 | 1.98 |
| M25 | 10.01.2008 | 7 | 22 | 3290 | 127 | 510 | 5.25 | 0.31 | 0.38 | 2.76 |
| M25 | 28.01.2008 | 8 | 17 | 870 | 33 | 220 | 2.05 | 0.12 | 0.01 | 0.59 |
| M25 | 29.01.2008 | 9 | 25 | 2960 | 100 | 580 | 5.07 | 0.3 | 0.21 | 2.34 |
| M25 | 30.01.2008 | 10 | 25 | 5960 | 248 | 890 | 12.29 | 0.74 | 0.92 | 4.8 |
| M27 | 14.05.2008 | 1 | 17 | 2270 | 119 | 240 | 5.1 | 0.3 | 0.16 | 1.52 |

Table A.4. (CONTINUED)

| ID | DATE | TRACKING DAY | n | DMD | MEAN (D) | MAX (D) | TS (m/min) | TS (km/h) | DAILY RANGE (km ²) | PERIMETER (km) |
|-----|------------|--------------|----|------|----------|---------|------------|-----------|--------------------------------|----------------|
| M27 | 16.05.2008 | 2 | 21 | 2950 | 134 | 440 | 5.31 | 0.31 | 0.18 | 2.23 |
| M27 | 20.05.2008 | 3 | 17 | 2470 | 99 | 290 | 4.1 | 0.25 | 0.11 | 1.54 |
| M27 | 23.05.2008 | 4 | 19 | 2090 | 116 | 350 | 4.45 | 0.27 | 0.19 | 2.15 |
| M27 | 26.05.2008 | 5 | 18 | 2180 | 115 | 270 | 4.08 | 0.24 | 0.18 | 2.19 |
| M27 | 27.05.2008 | 6 | 18 | 2240 | 112 | 350 | 5.88 | 0.35 | 0.14 | 1.77 |
| M27 | 29.05.2008 | 7 | 18 | 2770 | 139 | 460 | 6.27 | 0.38 | 0.13 | 1.96 |
| M27 | 28.08.2008 | 8 | 11 | 2060 | 103 | 390 | 7.1 | 0.43 | 0.15 | 1.66 |
| M27 | 29.08.2008 | 9 | 21 | 3300 | 150 | 390 | 6.69 | 0.4 | 0.27 | 2.35 |
| M27 | 09.12.2008 | 10 | 10 | 2160 | 86 | 300 | 5.54 | 0.33 | 0.04 | 1.05 |
| F29 | 21.06.2008 | 1 | 16 | 2350 | 138 | 390 | 5.34 | 0.32 | 0.05 | 1.25 |
| F29 | 22.06.2008 | 2 | 14 | 1900 | 100 | 360 | 4.28 | 0.26 | 0.09 | 1.34 |
| F29 | 23.06.2008 | 3 | 17 | 1940 | 129 | 420 | 4.94 | 0.3 | 0.01 | 1.53 |
| M30 | 03.07.2008 | 1 | 15 | 2720 | 130 | 400 | 8.1 | 0.49 | 0.25 | 2.19 |
| M30 | 09.07.2008 | 2 | 14 | 1120 | 66 | 470 | 4.01 | 0.24 | 0.04 | 1.63 |
| M30 | 11.07.2008 | 3 | 12 | 1830 | 61 | 420 | 3.93 | 0.24 | 0.15 | 1.62 |
| M30 | 16.08.2008 | 4 | 14 | 2650 | 156 | 500 | 7.32 | 0.44 | 0.28 | 2.17 |
| M30 | 21.08.2008 | 5 | 18 | 840 | 44 | 160 | 2.05 | 0.12 | 0.01 | 0.5 |
| M30 | 22.08.2008 | 6 | 9 | 1280 | 61 | 420 | 3.93 | 0.24 | 0.02 | 0.98 |
| M30 | 24.08.2008 | 7 | 1 | 0 | – | – | – | – | 0.00 | 0.00 |
| M30 | 18.11.2008 | 8 | 18 | 1940 | 88 | 420 | 4.35 | 0.26 | 0.14 | 1.82 |
| M30 | 11.12.2008 | 9 | 22 | 3800 | 141 | 660 | 6.35 | 0.38 | 0.43 | 3.84 |

Table A.4. (CONTINUED)

| ID | DATE | TRACKING DAY | n | DMD | MEAN (D) | MAX (D) | TS (m/min) | TS (km/h) | DAILY RANGE (km ²) | PERIMETER (km) |
|-----|------------|--------------|----|------|----------|---------|------------|-----------|--------------------------------|----------------|
| M30 | 19.01.2009 | 10 | 16 | 610 | 23 | 100 | 1.37 | 0.08 | 0.01 | 0.48 |
| M30 | 17.06.2011 | 11 | 10 | 1230 | 103 | 290 | 4.16 | 0.25 | 0.06 | 1.09 |
| M30 | 18.06.2011 | 12 | 12 | 1030 | 61 | 190 | 3.67 | 0.22 | 0.03 | 0.81 |
| M30 | 19.06.2011 | 13 | 12 | 2070 | 115 | 420 | 5.63 | 0.25 | 0.13 | 1.53 |
| M30 | 25.07.2011 | 14 | 2 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| M30 | 05.08.2011 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| M30 | 06.08.2011 | 16 | 2 | 30 | 4 | 30 | 0.67 | 0.04 | 0.00 | 0.00 |
| M30 | 07.08.2011 | 17 | 15 | 3230 | 215 | 460 | 7.56 | 0.45 | 0.33 | 2.81 |
| F32 | 17.06.2010 | 1 | 16 | 780 | 46 | 120 | 2.2 | 0.13 | 0.01 | 0.31 |
| F32 | 08.07.2010 | 2 | 11 | 1210 | 101 | 360 | 4.03 | 0.24 | 0.03 | 0.97 |
| F32 | 09.07.2010 | 3 | 15 | 980 | 54 | 145 | 2.7 | 0.16 | 0.01 | 0.45 |
| F32 | 10.07.2010 | 4 | 18 | 810 | 48 | 140 | 2.52 | 0.15 | 0.01 | 0.45 |
| F32 | 05.08.2010 | 5 | 17 | 660 | 44 | 230 | 2.16 | 0.13 | 0.22 | 1.01 |
| F32 | 06.08.2010 | 6 | 15 | 1680 | 84 | 380 | 3.77 | 0.23 | 0.09 | 1.58 |
| F32 | 11.08.2010 | 7 | 13 | 2290 | 127 | 370 | 5.3 | 0.32 | 0.17 | 1.81 |
| F32 | 04.10.2010 | 8 | 15 | 880 | 44 | 200 | 2.63 | 0.16 | 0.02 | 0.75 |
| F32 | 09.12.2010 | 9 | 21 | 620 | 30 | 110 | 1.94 | 0.12 | 0.01 | 0.46 |
| F32 | 10.12.2010 | 10 | 22 | 1350 | 56 | 160 | 2.97 | 0.18 | 0.03 | 0.7 |
| F32 | 11.12.2010 | 11 | 22 | 1630 | 71 | 170 | 3.73 | 0.22 | 0.11 | 1.43 |
| M35 | 24.06.2010 | 1 | 17 | 1700 | 81 | 450 | 6.51 | 0.39 | 0.1 | 1.46 |
| M35 | 25.06.2010 | 2 | 17 | 1960 | 103 | 400 | 5.76 | 0.35 | 0.09 | 1.46 |

Table A.4 (CONTINUED)

| ID | DATE | TRACKING DAY | n | DMD | MEAN (D) | MAX (D) | TS (m/min) | TS (km/h) | DAILY RANGE (km ²) | PERIMETER (km) |
|-----|------------|--------------|----|------|----------|---------|------------|-----------|--------------------------------|----------------|
| M35 | 26.06.2010 | 3 | 13 | 1490 | 83 | 320 | 5.71 | 0.34 | 0.07 | 1.21 |
| M35 | 06.07.2010 | 4 | 16 | 790 | 42 | 240 | 4.41 | 0.26 | 0.03 | 0.72 |
| M36 | 28.06.2010 | 1 | 19 | 2960 | 148 | 460 | 6.3 | 0.38 | 0.21 | 2 |
| M36 | 29.06.2010 | 2 | 17 | 2020 | 101 | 380 | 5.11 | 0.31 | 0.08 | 1.26 |
| M36 | 30.06.2010 | 3 | 15 | 1780 | 99 | 300 | 5.44 | 0.33 | 0.12 | 1.38 |
| M36 | 07.07.2010 | 4 | 19 | 2830 | 149 | 350 | 5.88 | 0.35 | 0.08 | 1.11 |
| M46 | 18.04.2011 | 1 | 18 | 1290 | 65 | 190 | 3.68 | 0.22 | 0.04 | 0.85 |
| M46 | 20.04.2011 | 3 | 18 | 1130 | 59 | 160 | 4.26 | 0.26 | 0.01 | 0.47 |
| M46 | 20.04.2011 | 3 | 19 | 1130 | 59 | 160 | 4.26 | 0.26 | 0.01 | 0.47 |
| F48 | 14.05.2011 | 1 | 13 | 1220 | 72 | 200 | 3.22 | 0.19 | 0.04 | 0.83 |
| F48 | 15.05.2011 | 2 | 16 | 1030 | 52 | 230 | 2.31 | 0.14 | 0.04 | 0.83 |
| F48 | 16.05.2011 | 3 | 11 | 40 | 2 | 20 | 0.19 | 0.01 | 0.00 | 0.00 |
| F48 | 17.05.2011 | 4 | 12 | 970 | 57 | 230 | 2.83 | 0.17 | 0.03 | 0.73 |
| F48 | 17.05.2011 | 5 | 12 | 1340 | 74 | 300 | 3.81 | 0.23 | 0.04 | 0.83 |
| F48 | 14.06.2011 | 6 | 14 | 1450 | 81 | 200 | 3.29 | 0.2 | 0.06 | 1 |
| F48 | 15.06.2011 | 7 | 14 | 1250 | 69 | 230 | 3.08 | 0.18 | 0.03 | 0.89 |
| F48 | 22.06.2011 | 8 | 15 | 730 | 46 | 150 | 1.73 | 0.1 | 0.02 | 0.5 |
| F48 | 22.07.2011 | 9 | 13 | 1350 | 84 | 190 | 3.66 | 0.22 | 0.04 | 0.76 |
| F48 | 23.07.2011 | 10 | 12 | 710 | 46 | 150 | 2.03 | 0.12 | 0.01 | 0.51 |
| F48 | 24.07.2011 | 11 | 1 | 0 | 84 | 190 | 0 | 0 | 0.00 | 0.00 |
| F48 | 02.08.2011 | 12 | 12 | 1240 | 39 | 200 | 3.05 | 0.18 | 0.06 | 1.08 |

Table A.4 (CONTINUED)

| ID | DATE | TRACKING DAY | n | DMD | MEAN (D) | MAX (D) | TS (m/min) | TS (km/h) | DAILY RANGE (km²) | PERIMETER (km) |
|-----------|-------------|---------------------|----------|------------|-----------------|----------------|-------------------|------------------|-------------------------------------|-----------------------|
| F48 | 03.08.2011 | 13 | 11 | 910 | 0 | 0 | 2.36 | 0.14 | 0.03 | 0.78 |
| F48 | 04.08.2011 | 14 | 12 | 870 | 78 | 210 | 2.24 | 0.13 | 0.02 | 0.67 |

