

The use of breeding dens and kitten development in the Iberian lynx (*Lynx pardinus*)

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(Accepted 1 August 2001)

Abstract

The use of breeding dens and the early kitten development was studied in a free-ranging population of Iberian lynx *Lynx pardinus*. Radio-tracking of female lynx allowed intensive monitoring of three litters during 1997, and additional data to be obtained from nine other litters in the previous 4 years. Females gave birth a maximum of one litter per year in spring; nine of the 10 births were recorded between the last 2 weeks of March and the first days of April. Kittens were born semi-altricial and reared for nearly 20 days in secluded hollow trunks. Afterwards, they were moved between different bushes, which served as auxiliary dens, where they began to develop walking and senses. Kittens first consumed meat at the age of 4 weeks, although they were not fully weaned until they were at least 10 weeks old. At the age of 2 months, kittens began to leave the dens, accompanying their mothers on outings. It is suggested that the pattern of den use was related to the stage of kitten development, to fulfil the kittens' need for both protection and space as they grew. Data on kitten denning and development should be accounted for in *in-situ* and *ex-situ* conservation programmes for this endangered felid.

Key words: *Lynx pardinus*, breeding, kitten development, radio-tracking, Felidae

INTRODUCTION

Little is known about the breeding ecology in felid species, especially about the pattern of breeding den use and kitten development during denning in free-ranging animals. However, this knowledge is relevant for the implementation of both *in-situ* and *ex-situ* conservation strategies for endangered species (Laurenson, 1993; Wielebnowski, 1998). In general, felid kittens are known to be born semi-altricial in natural, secluded structures. Kittens have poor thermoregulatory control and are vulnerable to predation (Kitchener, 1991). In the Iberian lynx *Lynx pardinus*, the most endangered felid species in the world (Nowell & Jackson, 1996), females are known to give birth in hollow trunks (natal dens) once per year, usually having three kittens (Aldama, 1993; Fernández & Palomares, 2000). They later move litters to bushes and thickets (auxiliary dens) to rear them, and use several of these during the early development of the kittens. The denning period ends when the kittens emerge from these structures. Both types of dens seem to play an important role in the protection of kittens against temperature fluctuations and potential enemies (Fernández & Palomares, 2000).

The aim of this paper is to describe the pattern of breeding den use in free ranging Iberian lynxes, and some aspects of early kitten development during the denning period.

STUDY AREA AND METHODS

The study was conducted in the area of Coto del Rey in the north of Doñana National Park, south-western Spain. This region's climate is Mediterranean sub-humid, with mild and wet winters and hot, dry summers. The dominant vegetation type is Mediterranean shrubland (see Fernández-Delgado, 1997 for further readings on Doñana). European rabbits, the main prey for the Iberian lynx (Delibes, 1980), reach their greatest density in Coto del Rey within Doñana, and three stable Iberian lynx breeding territories are present in an area of 6 km² (Palomares *et al.*, 2001).

Four adult, resident Iberian lynx females were captured, radio-tagged and monitored in Coto del Rey since 1993 (Palomares *et al.*, 1995; Palomares *et al.*, 2000). Location data were routinely collected 4 times per week. Lynx litters were searched for and captured and marked inside their natal dens by homing in on their mothers (Mech, 1983). This provided the opportunity to record data on the development of kittens and den use patterns.

During the 1997 breeding season, radio-location routines of the 3 resident females (LHA43, LHA53 and LHA73) living in the area were intensified to obtain more precise data on their denning ecology (Fernández & Palomares, 2000). All these females were > 6 years old and had reproduced before. Females were located

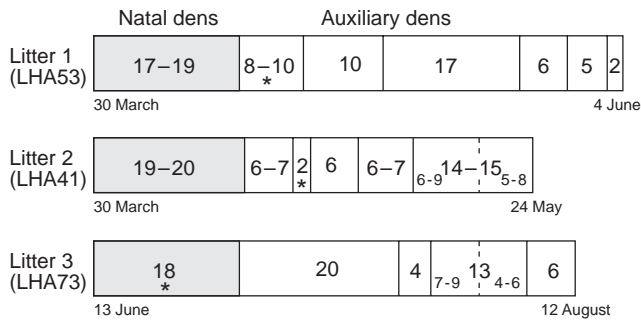


Fig. 1. Time of use of each den by litters of Iberian lynx *Lynx pardinus*. Boxes, number of days of use; dates of parturition and end of denning are indicated on the lower corners of each diagram; asterisks, kittens were marked in that den.

at least once per day, while resting during the hottest hours, by short triangulation (<300 m from the animal). When necessary, they were approached by homing in on them to find their dens. In this way, litters were located in their natal dens, the date of birth recorded, and the periods of natal and auxiliary den use monitored. UTM co-ordinates were taken for each den with a GPS.

Non-invasive observations of kittens and/or their activities could be performed in 1997 for 2 denning periods. During natal den occupancy, kittens were observed on some occasions while the mother was away. Care was taken to avoid disturbing the kittens. During the auxiliary den occupancy period, each auxiliary den was carefully examined after the lynx family had left, searching for signs of the kittens' activity. On 1 occasion per litter (Fig. 1), kittens were captured inside a den, measured and tagged with transponders. The intervention to capture and mark kittens led lynx females to move the litters, so the duration of use for these dens was not taken into account for assessing the denning chronology. Denning was considered to end at the moment in which kittens emerged from dens and began to walk outside bushes.

RESULTS

Den use

Between 1993 and 1996, nine new litters were identified within the study area. Seven of them were encountered inside their natal dens. Every litter was born between the last 2 weeks of March and the first days of April. During intensive monitoring of females in 1997, the three females living in the study area bred successfully. All were located close to the birthing location at least 1 week before parturition. LHA53 stayed inside a hollow cork-oak trunk during the night from 29 to 30 March, the suspected date for the birth of her litter (Fig. 1). Three days later, three kittens were observed lying crowded inside the trunk. LHA41 also occupied a

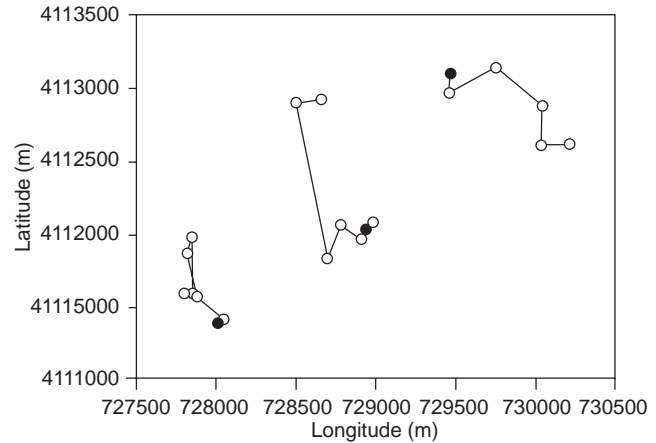


Fig. 2. Denning paths of Iberian lynx *Lynx pardinus*. Closed circles, natal dens; open circles, auxiliary dens; lines connect consecutively used dens; longitude and latitude represented in the UTM system (spindle 29S).

cork oak hollow tree and gave birth to three kittens on 30 March. LHA73 was located inside a hollow ash trunk from 27 March and, like other females (see below), spent most daylight hours inside it for 7 days. Later, she abandoned the hollow and no kitten was encountered inside. After this episode, the lynx ranged outside the trunk area and showed no manifestations of breeding activity until 60 days later. On 13 June she occupied the same hollow trunk and gave birth to four kittens.

Two (LHA53 and LHA41) of the three litters born in 1997 were maintained for 17–20 days inside their natal dens (Fig. 1), and the females were usually located inside the dens or beside them while resting (76% of non-active locations during the day; $n = 114$). The litter of LHA73 was captured and marked in its natal den when the kittens were 18 days old. Afterwards, females moved their litters into auxiliary dens to continue rearing the kittens. The mean residence time for one single auxiliary den was 7.7 ± 1.2 days ($n = 15$). The maximum residence time was 20 days, and the minimum was 2 days. The later dens were generally used for shorter periods than the earlier ones (Fig. 1).

The denning periods ended after 66, 56 and 61 days after birth of the litters of females LHA53, LHA41 and LHA73, respectively. After these dates, females did not show den fidelity, and the kittens' footprints were observed in firebreaks and tracks beside adult ones. A total of six to seven dens (one natal and five to six auxiliary ones) were used by each litter (Fig. 1).

The first auxiliary den was always within 135 m of the natal den. Distances between consecutively used auxiliary dens averaged 256 ± 58 m ($n = 17$; Fig. 2), with a maximum of 1080 m (between the fourth and fifth dens of LHA41). Distances between consecutively used auxiliary dens did not differ between females (one-way ANOVA: $F_{2,14} = 0.31$, $P = 0.74$).

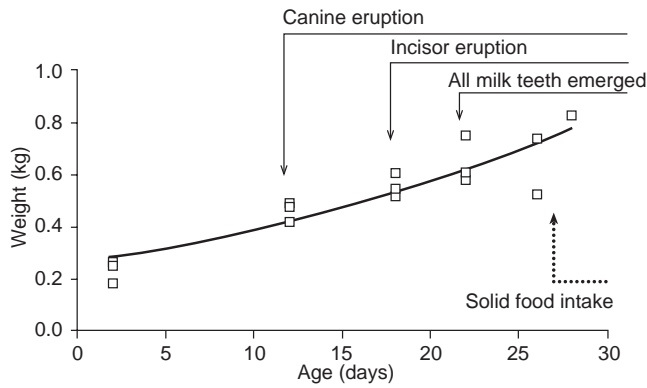


Fig. 3. Growth and teeth eruption of Iberian lynx *Lynx pardinus* kittens in relation to litter age. Growth is described by the equation $W = 0.27(\pm 0.03) * e^{0.04(\pm 0.006) T}$; where W = weight and T = age. $r^2 = 0.82$; $F = 62.7$; $P < 0.01$; $n = 15$.

Kitten development

The age of kittens could be related to their weight and sensor and motor development in the three litters born in 1997 and in three others from previous years. An exponential growth curve was adjusted to the data on age and weight instead of other curves (Zullinger *et al.*, 1984) because this gave a better fit in this early growth stage (Fig. 3). Additional data on development and teeth emergence was related to weight in the remaining four litters.

Three-day-old kittens (10 observed in three different litters, two of LHA53 and one of LHA73) showed a semi-altricial state, closed eyes, and folded ears stuck to their heads. Their bodies were covered by underfur. Kittens were motionless. Three 12-day-old kittens of LHA41 observed inside the natal den had their eyes half-open but still showed low perception capabilities, had strong cataracts and their ears were still folded but detached from the head. They were also motionless. When captured at 18 days of age inside the natal den, four kittens of LHA73 showed some mobility and attempted to walk, emitted calling vocalizations and had all their milk teeth emerging. Two kittens of LHA53 and one of LHA41 captured at the age of 27 and 28 days, respectively, inside their first and second auxiliary dens, were able to walk and escape into cork refuges and rabbit warrens. Their eyes were open and functional, and their ears were better developed although still folded. All milk teeth were erupted. These kittens emitted calling vocalizations when captured but showed no aggressive defence.

Teeth eruption patterns (obtained including all kittens captured since 1993) were as follow (Fig. 3): kittens weighing < 410 g ($n = 6$), no teeth emerging; kittens weighing between 410 and 500 g ($n = 4$), milk canines emerging; kittens weighing > 500 g ($n = 17$), milk canines and incisors or all teeth emerging.

Two faeces of lynx kittens were found during the 1997 litter tagging at the second auxiliary den of LHA41 and they contained rabbit remains. This means that kittens

began to eat prey caught by their mothers when they were younger than 28 days. In this year, nine prey carcasses eaten by kittens and many kitten scats containing rabbit remains were found in dens used by all litters from that age to the end of the denning period.

As observations of lynxes were sporadic, duration of weaning could not be well assessed. With this respect, female LHA53 and her kittens were observed in 1997 suckling on 5 June, that is, 70 days after birth and after the denning period.

During 1997, when the second auxiliary den of LHA53 was explored, one of the kittens of the litter was found dead inside the lentiscus bush. The lynx seemed to have been dead for at least 4 days, 34 days after birth. All the signs suggested that the female and her living kittens had occupied the den for at least 3 days after the kitten had died.

DISCUSSION

Most knowledge about female rearing behaviour and kitten development in felids has been compiled from captive animals (e.g. Foreman, 1997; Mansard, 1997), or from the more easily observable domestic cat (Leyhausen, 1979; Turner & Bateson, 1988). However, environmental conditions experienced by felids in the wild may be very different from those experienced in captivity, which could alter or mask certain behaviours. Unfortunately almost all cat species are secretive, nocturnal and show large ranges and, therefore, it is difficult to develop effective field observational procedures. Collecting data on the breeding biology and behaviour of felids through direct observations is usually impossible. This results in a scarcity of information about denning during breeding and kitten development, before they emerge and become some self-sufficient. In our study, a very precise, short distance positioning of free-ranging Iberian lynx females using radio-tracking allowed us to identify the exact position of several lairs and their use on a daily basis. Some observations of kittens could then be carried out in the dens without disturbing or influencing female behaviour. Data taken during capture and marking of litters, in addition to other indirect observations, allowed us to obtain information, in the wild, on some of the most important aspects of early kitten development.

Den use

Iberian lynx kittens stayed in the dens where they born for nearly 20 days, and then females spontaneously moved them to other lairs. Previous observations in the south of Doñana of two litters showed that they occupied natal dens for 36 days (one born in May 1989) and 14 days (one born in June 1988; Aldama, 1993; P. Ferreras, pers. comm.). This is a substantially shorter duration than for natal den occupancy for the bobcat *Lynx rufus* in Idaho, which has been observed

to spend between 53 and 81 days inside natal dens (Knick, 1990).

Moving litters from the natal den to auxiliary dens, as observed in our study, is a common behaviour in most cat species for which denning is known in the wild (e.g. Schaller, 1972; Seidensticker, 1977; Bailey, 1981; leRoux & Skinner, 1989). In the Iberian lynx, this change seems to be related to the kittens' need for space to develop motor skills. Lynx births occur inside hollow trunks with dimensions of *c.* 0.4 m² (Fernández & Palomares, 2000). The litters are confined and tightly grouped there for some weeks with no opportunity for expansion. Although this may provide a thermoregulatory advantage, these structures seem to be inadequate when kittens become mobile. The time of change from the natal to the big bush dens, at *c.* 20 days after birth, coincides with the timing of first rudimentary walks of the kittens observed in this study and also in studies on other cat species (McCord & Cardoza, 1982; Martin & Bateson, 1988; Stahl, Artois & Aubert, 1988; Foreman, 1997).

Moving litters between auxiliary dens also seems to be a shared pattern with other felid species (Bailey, 1981; Wassmer, Guenter & Layne, 1988; Laurenson, 1993; Schmidt, 1998). Lynx families in our study used up to six auxiliary dens during the denning period. Some hypotheses have been proposed regarding the causes of moving litters during this period. Disturbance (of various types) has been identified as one factor that induces den changes for both free-ranging and captive felines (Lembeck, 1982; Laurenson, 1993), and this was true in our study when we disrupted the den to capture and mark kittens. However, other biological and/or behavioural determinants securely motivate these changes in the absence of human disturbance. Den use for long periods would favour the growth of ectoparasites (McCord & Cardoza, 1982; Butler & Roper, 1996) and also increase the danger of attracting predators through odour and other signals. Also, den changes may be a response to the need of the mother for improved access to areas of high prey density (Laurenson, 1993), although in our area, den selection does not seem to be influenced by this factor at any stage (Fernández & Palomares, 2000). The denning period ends *c.* 2 months after birth, an age when, like in other felids, Iberian lynx kittens show complex motor capabilities and begin to accompany their mothers on some excursions (Turner & Bateson, 1988; Laurenson, 1993; pers. obs.).

Kitten development

Parturition dates for the Iberian lynx were usually at least 1.5 months earlier than described for the more northern lynx species (Crowe, 1975; Novak *et al.*, 1987; Schmidt, 1998; Mowat, Poole & O'Donoghue, 1999). Later births that were observed in this study and a previous one (Pablo Ferreras, pers. comm.) seemed to be related to a recent reproductive failure. The semi-altricial state of kittens at birth and the timing of

developmental events showed in the Iberian lynx (such as eyes opening, teeth eruption, first walking, weaning and solid ingest) is similar throughout the Felidae (Kunc, 1970; Schaller, 1972; McCord & Cardoza, 1982; Martin, 1986; Martin & Bateson, 1988; Stahl & Leger, 1992; among others).

Many indirect observations indicate that the loss of any member of the litter before 8 months of age is common in the Iberian lynx, but the date of death has never been registered. In the present study, the death of a female Iberian lynx was registered for the first time when it was *c.* 1 month old. Kitten death in felid litters of similar age has been attributed to infanticide by male siblings (Sokolov, Nidenko & Serbenyuk, 1994), starvation, predation, bad weather (Laurenson, 1994), or disease. Although in this study the cause of the death could not be determined, the carcass did not show any sign of predation or other trauma. After this study, in April 2001, another dead kitten was found, this time inside the natal den. This 1-week-old kitten had not suckled since birth and died of starvation.

In summary, the pattern of denning seems to be tightly linked with kitten development at each stage, owing to the necessity of combining protection and the requirements of the kittens for space as they grow larger and more mobile. The denning period seems to be critical for the survival of the kittens, and probably encompasses the time when individuals are more vulnerable to illness and predation. Soon after leaving the den, the kittens may be able to survive by themselves, as shown in 1997 by one whose mother (LHA53) died when it was 3 months old, and its survival was confirmed to the age of 11 months.

Given the vulnerability of the kittens in the dens, our findings on the chronology of denning should be taken into account in the management of public access in areas where this endangered species could be breeding. Activities such as hunting, tourism and forest practices should be restricted during this period. Additionally, the interaction between kitten development and the pattern of use of dens should be meticulously accounted for in *ex-situ* conservation programmes for the species.

Acknowledgements

This research was funded by the Dirección General de Investigación Científica y Técnica (projects PB94-0480 and PB97-1163), and sponsored by Rover España, SA. NF was supported by a pre-doctoral grant of the Spanish Ministry of Science and Technology. J. Calzada, J. M. Fedriani and E. Revilla helped with data collection. E. Grossmann kindly review the English.

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