Acta Theriologica 50 (4): 505–514, 2005.
PL ISSN 0001–7051

Reproductive life history of ocelots *Leopardus pardalis* in southern Texas

Linda L. LAACK, Michael E. TEWES,
Aaron M. HAINES and John H. RAPPOLE

Laack L. L., Tewes M. E., Haines A. M. and Rappole J. H. 2005. Reproductive life history of ocelots *Leopardus pardalis* in southern Texas. Acta Theriologica 50: 505–514.

The ocelot *Leopardus pardalis* Linnaeus, 1758 is an endangered felid in the United States currently restricted to southern Texas. The objectives of our study were to obtain data on ocelot parturition dates, fecundity, sex ratios, den characteristics, and first year survival, all of which are critical in development of population viability models. Sixteen parturition events were recorded ranging from mid-April to late December for 12 wild ocelots. Cumulatively, litters consisted of 1 or 2 kittens ($\bar{x}$ = 1.2 ± 0.44 SD). Cumulative sex ratio was 1:2.5 (male:female); however, there was no significant difference between the observed sex ratio and a 1:1 sex ratio. Ten den sites were in close proximity (10 m) to dense thornshrub. Adult female ocelots used 2 to 4 den sites for each litter with distance between consecutively occupied dens ranging from 110 to 280 m ($\bar{x}$ = 158 m ± 93 SD). An estimated annual survival for ocelots 0 to 1 year of age was 0.68. Evidence suggests that ocelots in the wild may breed more frequently than had been previously hypothesized.

Laguna Atascosa National Wildlife Refuge, 22817 Ocelot Rd., Los Fresnos, TX 78566, USA, e-mail: Linda_Laack@fws.gov (LLL); Feline Research Program, Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, 700 University Boulevard, MSC 218. Kingsville, TX 78363-8202, USA (MET, AMH); Smithsonian's National Zoological Park, Conservation & Research Center 1500 Remount Road, Front Royal, VA 22630, USA (JHR)

Key words: *Leopardus pardalis*, den sites, fecundity, ocelot, reproduction, southern Texas

Introduction

The ocelot *Leopardus pardalis* (Linnaeus 1758) is listed as an endangered species in the United States (U.S.) (U.S. Fish and Wildlife Service 1982). Its population, now restricted to southern Texas, is estimated at 80 to 120 individuals (Tewes and Everett 1986). Information on reproductive characteristics of North American ocelots (eg fecundity, kitten survival) is lacking and needed to develop models of population viability. However, the low density of ocelots, as well as their nocturnal habits and preference for dense cover (Tewes 1986, Laack 1991) make reproductive information difficult to obtain. Most information on ocelot

reproduction is from captive individuals (Cisin 1967, Eaton 1977, Fagen and Wiley 1978, Mellen 1989). Captive ocelots have small litters, long gestation periods, and slow growth rates compared to other felids of similar size. Reproductive information on wild ocelots is based on circumstantial data provided by Emmons (1988). A review of ocelot reproductive life history is provided by Sunquist and Sunquist (2002).

The results of our study provide further information about wild ocelot reproductive life history in the U.S. We report on parturition dates, breeding dates, fecundity, sex ratios, den characteristics, and first year-survival of ocelots in southern Texas. These results were part of on-going broader ecological study of the ocelot in southern Texas that began in the early 1980s (Tewes 1986).

Study area

Laguna Atascosa National Wildlife Refuge (LANWR) in Cameron County is located within the Lower Rio Grande Valley (LRGV) of southern Texas, U.S. (26°24'–26°09'N, 97°23'–97°17'W). The subtropical, semiarid climate is characterized by hot summers and mild winters (Thornthwaite 1948, Lonard and Judd 1985). Mean length of the frost-free period is 330 days with winters frequently occurring without freezing temperatures. Mean annual temperature and rainfall were 23°C and 68 cm, respectively, although rainfall fluctuates widely during and among years (Norwine and Bingham 1985, Lonard *et al*. 1991).

The LRGV supports a variety of plants, wildlife, and habitats as part of the Tamaulipan Biotic Province (Blair 1950, Richardson 1995). Predominant woody plant species that constitute the majority of thornshrub forest in the LRGV include spiny hackberry *Celtis pallida*, Texas ebony *Pithecellobium flexicaule*, crucita *Eupatorium odoratum*, Berlandier fiddlewood *Citharexylum berlandieri*, honey mesquite *Prosopis glandulosa*, desert olive *Forestiera angustifolia*, snake-eyes *Phaulothamnus spinescens*, colima *Zanthoxylum fagara*, and brasil *Condalia hookeri* (Lonard and Judd 1993). However, > 95% of the native rangeland in the LRGV has been converted for agricultural and urban land uses (Jahrsdoerfer and Leslie 1988).

Material and methods

Trapping and monitoring

We captured ocelots with single-door, 108 × 55 × 40 cm wire box traps (Tomahawk Trap Co., Tomahawk, WI) from September 1982 to July 1997. We attached a separate compartment containing a domestic live chicken to the trap as bait. We placed traps in shaded areas and checked each morning to reduce the risk of hyperthermia.

Ocelots were immobilized with a 9:1 ratio of ketamine hydrochloride and acepromazine maleate. We injected this mixture with a pole syringe at a dosage of 20 mg/kg body weight. We sexed, weighed, and classified ocelots as adults or subadults based on maturation of morphological development, dental wear (sharp dentition for juveniles), canine length (> 15 mm for adults), and weight (female adults >6.5 kg, male adults >8.5 kg) (Tewes 1986, Laack 1991). Ocelots were fitted with a collar--mounted radio transmitter having a frequency of 148 to 149 MHz and an activity sensor (Telonics Inc., Mesa Arizona). We located ocelots 2 3 times each week anytime between 1 hr before sunrise until 1 hr after sunset. Radio signals were monitored with a directional H-antenna connected to a model TR-2 receiver (Telonics Inc., Mesa, AZ), and we used ground stations and aerial radio telemetry to locate ocelots. Trapping and handling of ocelots were performed in a humane manner

with procedures and research methodology approved by the Texas A&M University-Kingsville Institutional Animal Care and Use Committee protocol # 1989–5–19.

Identifying breeding females and den sites

Female ocelots handled during captures were suspected of having young if they were lactating or had brown-stained fur around the teats (signifying post-lactation). In addition, parturition was suspected if radio-collared adult female ocelots were located at the same site during the daytime for 1–2 weeks. We found this pattern characteristic of denning behavior. We subsequently searched for suspected dens 2 to 5 weeks after the presumed parturition date. Dens were found by approaching a radio-collared female until it moved, then searching the area around its last known location. Once the den was found, kittens were then photographed, weighed in a bag with a scale, and measured in length with measuring tape from tip of the nose pad to the base of the tail bone. Time spent by researchers at the den was 30 min. An adult female ocelot was monitored until it returned to the den site. Some dens were not found because of the difficulty of researchers quietly approaching ocelots in dense vegetation and the concealment of the den. However, if a female displayed denning behavior for 6 weeks, parturition was presumed to have occurred. Female radio-collared ocelots with known den sites were suspected of moving den sites when denning behavior was exhibited at a different location from the initial den site. These new den site locations were estimated with triangulation. However, we only took measurements at initial den sites to reduce potential stress to ocelot females and kittens.

Parturition date was determined as the first day a female was found at the presumed site. Breeding date was determined as 80 days prior to parturition date based on a gestation length of 79 to 82 days for captive ocelots (Cisin 1967, Eaton 1977, Fagen and Wiley 1978).

After den sites were abandoned by ocelots, we recorded general characteristics of the den sites. These included den site distance to dense thornshrub cover, dimensions of den sites, and identification of plant species within den chambers. Distance to dense thornshrub cover and dimensions of den sites were measured with measuring tape.

Statistical analysis

We calculated differences between observed and expected sex ratios using a chi-square analysis. Survival rates for ocelot kittens aged 0–3 months of age were calculated using number of observation--days and number of mortalities (Trent and Rongstad 1974, Heisey and Fuller 1985a) in MICROMORT (Heisey and Fuller 1985b), a program based on the Mayfield methodology (Mayfield 1961, 1975). We assumed no ocelots died before den sites were found due to no evidence of kitten mortality at the den sites. To calculate first year survival for ocelots, we incorporated survival data from Haines *et al.* (2005), and extrapolated it with our own data. Haines *et al.* (2005) defined a resident individual as an ocelot 6 months of age that inhabited a home range or natal range for 3 months, and calculated an annual survival rate of $\hat{S} = 0.87 \pm 0.02$ SE for resident ocelots. Using the same data as Haines *et al.* (2005) we calculated an annual survival rate of $\hat{S} = 0.90 \pm 0.04$ SE for resident ocelots residing on a natal range (juvenile and subadult ocelots). Both survival rates did not significantly differ ($\chi^2_1 = 0.45$, $p = 0.50$) from each other when compared using chi-square tests in the program CONTRAST (Hines and Sauer 1989, Sauer and Williams 1989). Thus, we combined resident ocelot survival rates with our survival estimate for ocelots 0-3 months of age to calculate an estimate of ocelot first year survival.

Results

We captured and monitored 15 resident adult females in their established breeding ranges. Eleven produced young or exhibited denning during this time. Sixteen parturition events were determined for 12 ocelots (Table 1). Failure to

Table 1. Breeding dates, birth dates, litter size, and sex ratio of ocelot (*Leopardus pardalis*) litters found at Laguna Atascosa National Wildlife Refuge in Cameron County, Texas, USA 1985–1997. [a] Based on gestation of 80 days prior to date of birth (Cisin 1967, Eaton 1977, Fagen and Wiley 1978). [b] Pregnant female was killed by a vehicle; date of birth was estimated based on fetal development. [c] Based on denning patterns observed by females. [d] Heard kitten in underground den but could not see kitten without destroying the dens site. [e] Observed female crossing road with 2 kittens, sexes not identified.

Adult female ID number	Date of breeding[a]	Date of birth	Date litter observed	Observed litter size and sex ratio (M:F)
1	05/06/1985	25/08/1985	11/09/1985	0:1
2	06/09/1985	26/11/1985	19/12/1985	1:1
2	01/10/1987	20/12/1987	12/01/1988	0:1
2	26/08/1988	14/11/1988	02/12/1988	0:1
3[b]	25/08/1986	15/11/1986	26/10/1986	1:1
4	23/07/1988	13/10/1988[c]	–	
4	01/03/1989	30/05/1989[d]	–	1
5	25/02/1989	15/05/1989	25/05/1989	0:1
6	25/02/1989	15/05/1989	31/05/1989	1:0
7[b]	10/04/1989	30/06/1989	25/06/1989	1:0
8	25/01/1991	15/04/1991[c]	–	
9	25/01/1991	15/04/1991	11/05/1991	0:1
10	15/06/1992	05/09/1992[c]		
10	14/03/1997	04/06/1997	18/06/1997	0:1
11	14/03/1997	04/06/1997	10/07/1997	0:1
12	25/02/1997	15/05/1997[c]	29/09/1997	2[e]

record young or denning behavior with the other 4 resident female ocelots may have been a result of short monitoring periods. One radio-collared female (female 3) was road-killed 5 months following establishment of a breeding range, and was carrying 2 fetuses. An uncollared female with 1 fetus (female 6) was also a road-kill. In June 1989, the den site for female 4 was investigated with a kitten only being heard around the den site. Thus, the kitten was not sexed (Table 1). Ocelot litters were found from mid-April to late December, indicating a minimum range of breeding activity from late January to early October (Table 1).

Two ocelots exhibited a 1-year interbirth period following the success of a previous litter. Litters consisted of 1 or 2 kittens ($\bar{x} = 1.2$, SD = 0.44, $n = 13$) at the time they were found (Table 1). The sex ratio of ocelot kittens found in this study was 1:2.5 (4 male, 10 female) (Table 1); however, there was no significant difference ($\chi^2_1 = 2.57$, $p > 0.10$) between the observed sex ratio and a 1:1 sex ratio.

All but 1 den site either occurred within close proximity (10 m) to thornshrub cover or were located directly under dense thornshrub cover. Three dens were located in dense thornshrub brush and 1 den was located along a thornshrub

corridor with no vertical cover. Four dens were located in tussocks of alkalai sacaton grass *Sporobolus airoides* and 2 in gulf cordgrass *Spartina spartinae*. These sites were surrounded on at least 3 sides by thornshrub. Within dens, no bedding was found and the den chamber usually consisted of grass bases of the species described previously. Average dimensions of the den sites were 45 29 30 cm. Thornshrub cover consisted of woody species described within the study area.

Ten offspring of 7 resident female ocelots were monitored through daily visual observations until 3 months of age. Eight of the 10 kittens survived until 3 months of age. One kitten was killed by domestic dogs and the other died of unknown causes. After 3 months of age, only 2 kittens were monitored until maturity, whereas the other 6 kittens were not monitored beyond 3 months of age when they left their den to begin traveling with their mothers.

The estimated survival rate of 3-month old ocelot kittens was 0.785 ± 0.13 SE. We assumed ocelots over 3 months of age had the same 3-month survival rate as resident ocelots (0.966). However, we assumed that survival of ocelot kittens between 3 and 6 months of age was still dependant on their mother. Thus, we assumed that ocelot kittens between 3 to 6-months of age had a 3-month survival rate equal to their mothers 3-month survival rate (0.966) multiplied by their own (0.966). Thus, ocelots aged 3 to 6-months of age had a survival rate of 0.933 (0.933 = 0.966 0.966). When an ocelot is 6 months of age we assumed its 3-month survival rate was 0.966, the same as a resident ocelot. Thus, we estimated that first-year survival of an ocelot was $\hat{S} = 0.68$, or the product of $\hat{S} = 0.785$ 0.933 0.966 0.966.

Discussion

Parturition dates

Eaton (1977) found that captive ocelots breed through much of the year. In addition, Eaton (1977) found that ocelots breed every year. Furthermore, captive female ocelots have short inter-parturition periods if dependant kittens die at a young age (Hatfield and Hatfield 1973, Eaton 1977). However, Emmons (1988) suggested that wild ocelots had 2-year interbirth periods based on circumstantial evidence. In this study, female 4 produced a litter 7 months following a successful litter (Table 1), suggesting that wild ocelots have the potential for shorter interbirth period than suggested by Emmons (1988). In addition, 1 wild Texas female ocelot (female A) produced 3 litters within 15 months (Tewes 1986). Unfortunately, female A was not monitored during her denning period and thus no estimates of date of birth, date of breeding, date litter observed, or observed litter size or sex ratio were estimated.

In October 1982, female A had a successful litter of at least 1 offspring (Tewes 1986). Eight months later she was recaptured and was lactating. Two months later female A was captured again with evidence of post lactation with the

offspring from the previous litter still using the maternal range (which it later used as its own breeding range). Female A was again recaptured 3 months later and was again in lactation. We believe the second litter of female A failed to survive and that estrus occurred soon afterward.

Fecundity and sex ratio

Eaton (1977) found 1 to 3 kittens ($\bar{x}$ = 1.4 kittens) in 168 captive-born litters of ocelots, with only 3 litters that contained 3 kittens. Previous observations of free-ranging ocelots included 5 litters with 1 kitten, 3 litters with 2 kittens, and 1 litter with 3 kittens (Enders 1935, Vesey-FitzGerald 1936, Hall and Dalquest 1963, Petrides *et al.* 1951). Petrides *et al.* (1951) reported a pregnant female Texas ocelot with 2 female fetuses, and the Smithsonian's National Museum of Natural History in Washington D.C. includes a pair of male kittens from a litter collected by H. E. Bridgewater in 1956 in Kleberg County, Texas, and a solitary female kitten collected by F. B. Armstrong in 1892 in Cameron County, Texas. Litters consisted of 1 to 3 kittens ($\bar{x}$ = 1.4, SD = 0.58, n = 22) when our data was combined with these historic observations.

When including all known records of litters, the cumulative sex ratio for the ocelot in southern Texas was 1:2.2 (6 male, 13 female). However, there was no significant difference (χ^2_1 = 0.33, $p > 0.50$) from a 1:1 sex ratio. Eaton (1977) reported a sex ratio of 1:0.7 (n = 168) among captive-born ocelots.

Den ecology

All ocelot dens were devoid of prey remains and scat, much like dens sites of the Florida panther *Puma concolor coryi* (Linnaeus 1771) (Maehr *et al.* 1989). However, this was unlike bobcat *Lynx rufus* (Schreber 1777) dens that contained numerous prey remains, other vegetation, and fecal marking stations (Bailey 1979).

Female ocelots usually used 2 to 4 den sites for each litter, and moved kittens 1 to 5 times. Females occupied den sites from 3 to 64 days ($\bar{x}$ = 27 ± 17 *SD* days/den site, n = 16). Distance between consecutively occupied dens ranged from 110 to 280 m ($\bar{x}$ = 158 m ± 93 SD). However, this range excludes 1 female that moved kittens 990 m. This long movement may have been in response to human disturbance that consisted of brush clearing 40 m from the den site. Lions *Panthera leo* (Linnaeus 1758), cheetahs *Acinonyx jubatus* (Schreber 1776), and leopards *Panthera pardus* (Linnaeus 1758) occasionally relocate cubs to new dens (Schaller 1972, Seidensticker 1977). Bailey (1979) suggested that female bobcats may move young up to 6.5 km into areas that contained more prey. Ocelots in our study relocated dens 0.11 to 0.28 km (excluding the female that responded to human disturbance), making it unlikely that females moved dens in response to prey availability. It is more likely that dens were moved because of the changing needs of maturing kittens, or to move kittens away from a den site with

accumulated odors and worn trails. Loss of concealment because of worn trails or odor accumulation may expose litters to threats from other carnivores such as coyotes *Canis latrans* (Say 1823), domestic dogs, bobcats, or conspecifics.

Female ocelots did not move kittens 3 days after the den was visited by researchers, and females returned to their kittens 2 h after researchers exited the den. Thus, human disturbance by researchers did not appear to cause den abandonment or relocation.

Survival of young ocelots

This first year survival rate is comparable to first year survival rates calculated by Hemker *et al.* (1986) $\hat{S} = 0.67$ and Logan and Sweanor (2001) $\hat{S} = 0.64$ for 0 to 1 year old mountain lion kittens in an unexploited population within arid and semi-arid environments. Survival of 3-month old ocelot kittens did not differ significantly ($\chi^2_1 = 2.07, p = 0.15$) from a 3-month survival rate of resident ocelots. Logan and Sweanor (2001) found that mountain lion kittens 3 months of age had a higher rate of mortality than older cubs. Logan and Sweanor (2001) attributed this higher mortality to the ability of predators able to detect trails made by maternal mountain lions traveling in and out of the den to care for the young.

Ocelot reproductive adaptation and future research

The ocelot is primarily a tropical felid that breeds through the year (Eaton 1977, Mondolfi 1986, Nowell and Jackson 1996). Although the similarly-sized bobcat residing in the southern portion of its range may breed year-round, it still exhibits major parturition periods in late winter to early spring (Blankenship and Swank 1979, Fritts and Sealander 1978, Winegarner and Winegarner 1982, Wassmer *et al.* 1988).

Emmons (1988) believed that low fecundity, long gestation, and slow growth periods in ocelots were adaptations to low expected rates of energy acquisition. In addition, these characteristics typify other small to medium-sized Neotropical cats such as the oncilla *Leopardus tigrinus* (Schreber, 1775) (Fagan and Wiley 1974, Quillen 1981, Widholzer *et al.* 1981) and margay *Leopardus wiedii* (Schinz, 1821) (Fagan and Wiley 1974, Eaton 1984, Mellen 1993). However, in southern Texas, ocelots have the potential for 1- year interbirth periods while evidence suggests that ocelots in the tropics have 2 year inter-birth periods (Emmons 1988). This may be the result of ocelots within southern Texas having higher rates of energy acquisition compared to ocelots in the Neotropics. However, this has yet to be analyzed.

We believe these findings contribute to an understanding of ocelot reproductive ecology and provide the best available estimates of fecundity and first-year survival that can be used in population modeling. However, more research is needed to obtain estimates of ocelot kitten survival, juvenile survival, and sources of mortality. In addition, we recommend more research on interbirth

periods and any possible relation to energy acquisition. Furthermore, the majority of these data are over 10 years old, and the LANWR population is small and isolated. Thus, current research is needed to analyze potential negative effects of inbreeding or habitat fragmentation on ocelot reproductive life history.

Acknowledgements: This project was funded by the Rob and Bessie Welder Wildlife Foundation, U.S. Fish and Wildlife Service, the James R. Dougherty Foundation, the Ben and Rachael Vaughen Foundation, the Boone and Crocket Club, G. Hixon, and B. Vaughan, III. We thank personnel from the LANWR for granting permission to use the land. We also thank L. Drawe, D. Everett, M. Fernandez, E. Haines, J. Janecka, S. Jojola, J. Mays, S. Miller, and B. Tewes for their help in the field, data collection, and support of the project. Other personnel with the U.S. Fish and Wildlife Service instrumental in the success of this study were G. Burke, C. Carley, T. Jasikoff, S. Rice, R. Rauch, and S. Thompson. We thank M. Hornocker and the Wildlife Research Institute of the University of Idaho for their support facilities, and S. Henke and W. Kuvlesky for reviewing this manuscript. This is publication #04-119 of the Caesar Kleberg Wildlife Research Institute and Contribution #637 of the Rob and Bessie Welder Wildlife Foundation.

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Received 28 October 2004, accepted 14 April 2005.

Associate Editor was Joseph F. Merritt.