Capture Locations of Coyotes, *Canis latrans*, Bobcats, *Lynx rufus*, and Raccoons, *Procyon lotor*, Relative to Home Range Boundaries

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Gipson, Philip S., and Jan F. Kamler. 2003. Capture locations of Coyotes, *Canis latrans*, Bobcats, *Lynx rufus*, and Raccoons, *Procyon lotor*, relative to home range boundaries. Canadian Field-Naturalist 117(3): 472-474.

Previous research showed that Coyotes (*Canis latrans*) and other canids might be more vulnerable to capture near the boundary or outside of their home ranges, making the capture of specific individuals within their territories difficult. Information concerning capture vulnerability relative to home range boundaries for other carnivores is lacking. During a four-year study of carnivore ecology in Kansas, we compared capture locations of Coyotes, Bobcats (*Lynx rufus*), and Raccoons (*Procyon lotor*) to their home range boundaries to determine if they were more likely to be captured inside, or near the periphery of, their home ranges. Resident Coyotes were captured disproportionately more often ($P < 0.01$) near the periphery of their home ranges, whereas Bobcats, Raccoons, and transient Coyotes were captured equally ($P > 0.05$) in both areas of their home ranges. Differences in capture vulnerability within and between species might be related to differences in social organization and behavior.

Key Words: Bobcat, *Lynx rufus*, Coyote, *Canis latrans*, Raccoon, *Procyon lotor*, capture locations, home range boundaries.

Some canid species, such as Coyotes (*Canis latrans*) and Red Foxes (*Vulpes vulpes*), have been shown to be most vulnerable to trapping near the periphery or outside of their home ranges (Hibler 1977; Woodruff and Keller 1982; Windberg and Knowlton 1990; Travaini et al. 1993; Sacks et al. 1999), although this has been disputed (Laundré and Keller 1983). Previous research suggests that peripheral areas are unfamiliar and used less by canids; thus canids are more prone to capture in these areas (Hibler 1977; Woodruff and Keller 1982; Harris 1983). Whether other carnivore groups, such as felids or procyonids, also are more vulnerable to trapping near the periphery of their home ranges is not known.

We conducted concurrent studies of Coyotes, Bobcats (*Lynx rufus*), and Raccoons (*Procyon lotor*) in northeastern Kansas from 1995 to 1999 (Kamler 1998). Our data allowed us to compare capture locations in relation to home range boundaries among these three species. Also, because age and social status were determined for study animals, we examined intraspecific differences in trapping vulnerability. Because differences in social organization, home range sizes, and habitat use are exhibited within and between these carnivore species (Sandell 1989; Kamler 1998), differences in trapping vulnerability also might occur.

Study Area and Methods

Data used in this paper were obtained during a study of predator interactions conducted on Fort Riley Military Reservation, Kansas (39°N, 97°W). Description of the study area is detailed in Kamler and Gipson (2000). At time of capture, we classified Coyotes as adult (> 2 years), yearling (1-2 years), or juvenile (< 1 year) based on body size, reproductive condition, and tooth wear (Gier 1968; Bowen 1982). We classified Bobcats as adult or juvenile based on body size, reproductive condition, and tooth replacement (Crowe 1975). We classified Raccoons as adult or juvenile based on body size, tooth wear, and for females, size and pigmentation of teats (Kaufmann 1982). From October 1995 to March 1999, we radio-collared and monitored 19 adult Coyotes, 10 adult Bobcats, and 12 adult Raccoons for this study. All animals, except four Raccoons captured in wire box traps, were captured in padded leghold traps. Most trapping occurred annually from October to March. Our capture and handling protocol, number 1098, was approved by the Institution Animal Use and Care Committee at Kansas State University.

Coyotes have been classified according to space use as "residents" and "transients" (Messier and Barrette 1982; Andelt 1985; Gese et al. 1988; Kamler and Gipson 2000). Home range sizes of Coyotes tend to be bimodally distributed, with home ranges of residents smaller than those of transients (Andelt 1985; Gese et al. 1988; Kamler and Gipson 2000). Therefore, we classified Coyotes as resident if they had relatively small home ranges (< 10 km^2) and associated with other Coyotes in the same areas, or transient if they had relatively large home ranges (> 20 km^2) and traveled alone (Andelt 1985). A large gap in home range sizes allowed for confident classifications of residents and transients (Kamler and Gipson 2000). Resident groups consist of a breeding pair and helpers (non-dispersing offspring) (Messier and Barrette 1982; Andelt 1985; Kamler and Gipson 2000). We classified resident Coyotes as breeders if they were located with adult Coyotes of the opposite sex on most occasions, especially during the breeding season, and if females were pregnant or nursing (Andelt 1985; Kamler and Gipson 2000). We classified resident Coyotes as helpers if they were yearling females that associated with a breeding pair, and showed no evidence of pregnancy during the reproductive season (Kamler and Gipson 2000).

Radio-telemetry methods are detailed in Kamler and Gipson (2000). We determined home range sizes for study animals by use of the minimum convex polygon (MCP) method (Mohr 1947), as calculated by CALHOME (Kie et al. 1994). We removed all capture and recapture locations and calculated home ranges for study animals with > 30 locations and > 6 months of radio-tracking. Data from only 13 Coyotes, 6 Bobcats, and 12 Raccoons met these criteria and were used in analyses. Trap locations in areas beyond 80% MCP home ranges were classified as "periphery," and those in areas within 80% MCP home ranges were classified as "inside." Although this classification is arbitrary, we believe that the 20% area near the outer edge of their home ranges adequately represents periphery areas. The 80% cutoff was between the 90% (Travaini et al. 1993) and 65% (Sacks et al. 1999) cutoff chosen by previous researchers. For each species, we used Yates-corrected chi-square goodness-of-fit tests to compare capture frequencies in the periphery and within home ranges to expected frequencies (20% and 80%, respectively).

Results

Home ranges were calculated for 13 adult Coyotes (seven residents and six transients). Seven resident Coyotes, five breeders and two helpers, were captured a total of eight times (one was captured twice) in the periphery or outside their home ranges (100%), as compared with 20% expected ($\chi^2 = 6.67$, $P < 0.01$). The two resident helpers were captured three times on excursions that were 1.8, 4.4, and 5.5 km away from their home range boundaries. Five of the six transient Coyotes were captured inside their home ranges (83%), as compared with 80% expected ($\chi^2 = 0.60$, $P = 0.44$). After more than 6 months, two transient Coyotes joined separate family groups and became resident Coyotes with home ranges that were 2.0 and 3.8 km from their initial capture location (Kamler and Gipson 2000).

Home ranges were calculated for six adult Bobcats captured a total of nine times (3 were captured twice). Eight captures were inside their home ranges (89%), as compared with 80% expected ($\chi^2 = 0.00$, $P = 1.00$). Home ranges were calculated for 12 Raccoons captured a total of 19 times (5 captured twice, 1 captured three times). Seventeen captures were inside their home ranges (89%), as compared with 80% expected ($\chi^2 = 0.20$, $P = 0.66$).

Discussion

We found that resident Coyotes were more likely to be captured in the periphery or outside of their home ranges, which is consistent with results of other studies (Hibler 1977; Woodruff and Keller 1982; Windberg and Knowlton 1990; Sacks et al. 1999). However, capture vulnerability relative to home range boundaries differed between social classes of Coyotes, as transients were captured proportionately throughout their home ranges. In contrast, Windberg and Knowlton (1990) found that 9 of 12 transient Coyotes were captured outside of their delineated home ranges. However, Windberg and Knowlton (1990) stated that their results were tenuous and that transients were only located 55% of the time, suggesting that delineated home ranges were incomplete. The transient Coyotes in our study were located > 90% of the time; therefore, delineated home ranges likely were more accurate.

Researchers have suggested that resident Coyotes were more vulnerable to capture in the periphery or outside of their home ranges because of less familiarity with those areas (Hibler 1977; Woodruff and Keller 1982; Harris 1983). However, because transient Coyotes, Bobcats, and Raccoons were not more likely to be captured near their home range boundaries, we believe that capture vulnerability of resident Coyotes might be more related to social behavior that results in greater inspection and marking of home range boundaries.

Social behavior of resident Coyotes includes group hunting, pair bonding, male care of young, and a high degree of territoriality with mutually exclusive home ranges among family groups (Kleiman and Eisenberg 1973; Andelt 1985; Windberg and Knowlton 1988). Transient Coyotes are solitary, non-reproducing, and have nomadic movement patterns that result in home ranges that are not well defined, non-territorial, and overlapping (Messier and Barrette 1982; Andelt 1985; Gese et al. 1988; Kamler and Gipson 2000). Social behavior of both Bobcats and Raccoons includes a solitary existence (except mother-young social units) and a low degree of territoriality with overlapping home ranges within and among sexes (Kleiman and Eisenberg 1973; Kaufmann 1982; Sandell 1989).

Group-living carnivores, such as resident Coyotes, maintain mutually exclusive family groups to ensure reproduction and rearing of young; thus regular inspection and marking of home range boundaries is necessary. Wells and Bekoff (1981) found that marking rates of resident male Coyotes were greatest in areas of high intrusion near home range boundaries, as opposed to denning areas and areas in which non-group members infrequently trespassed. Thus, Coyotes may expect to find new sign (such as trap sets) more in peripheral areas, as these areas are shared with neighboring family groups that might be attempting to encroach on their home ranges. However, new sign within core areas of Coyote family groups might be viewed as more unusual because these areas are not shared with other Coyotes, which could result in Coyotes being more wary of the new sign. Interestingly, Laundré and Keller (1981) showed that peripheral areas of Coyote home ranges could be high areas of use.

Inspection of new sign and marking in solitary carnivores, such as Bobcats and Raccoons, might occur equally in all parts of their home ranges because they

share most parts of their home range with other solitary individuals of the same species. Similar to resident Coyotes, some resident Bobcats and Raccoons in this study used the same areas for 3 years, thus were likely more familiar with areas within their home ranges than near the periphery. However, unlike resident Coyotes, Bobcats and Raccoons were not more likely to be captured in the periphery of their home ranges. Because transient Coyotes also had overlapping and non-territorial home ranges, they might inspect new sign and mark in a similar manner as solitary carnivore species. Because four Raccoons were captured in box traps baited with food, their captures might have been related to food acquisition and not necessarily inspection of new sign.

Resident Coyotes inspect new sign more intensely, and consequently might be more vulnerable to trapping, in peripheral areas because close inspection and marking are necessary to maintain territorial boundaries. We believe this is a more reasonable explanation for greater vulnerability of Coyotes near their territorial boundary, than lack of familiarity as suggested by others (Hibler 1977; Woodruff and Keller 1982; Harris 1983). Solitary carnivores, which do not have mutually exclusive home ranges and are not as territorial as resident Coyotes, might inspect new sign and mark equally throughout all areas of their home ranges. Thus, solitary carnivores might be equally vulnerable to trapping throughout their home ranges.

Acknowledgments

This project was funded by U.S. Department of Defense, in cooperation with Kansas Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, and Division of Biology at Kansas State University. Comments by G. Batcheller, R. Belden, and M. Chamberlain helped improve this manuscript. We thank D. Jones, H. Abel, M. Pont, C. Richardson and other personnel at the Conservation Division on Fort Riley for their assistance. We also thank J. Beckman, B. Bowman, J. Goheen, D. Hogan, B. Kamler, C. Perchellet, T. Snyder, C. Richardson, and G. Truan for assistance with field work and other aspects of the project.

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Received 5 July 2001
Accepted 24 March 2004