Research Note

Circadian Activity Patterns of Canada Lynx in Western Montana

JAY A. KOLBE,[1] *Montana Department of Fish, Wildlife, and Parks, Seeley Lake, MT 59868, USA.*

JOHN R. SQUIRES, *United States Forest Service, Rocky Mountain Research Station, Box 8089, Missoula, MT 59807, USA.*

ABSTRACT We recorded activity data for 6 male and 5 female lynx in winter and 3 male and 6 female lynx during summer in western Montana, USA, using motion-sensitive radiocollars. Lynx diel activity appeared to vary by sex, season, and reproductive status. During summer, male lynx exhibited a crepuscular activity pattern, whereas females with kittens remained active throughout the photoperiod. During winter, lynx of both sexes were most active during the afternoon and early evening. Although we observed no evidence that predation risk drove lynx activity patterns, such patterns may be a function of kitten-rearing activity, thermoregulatory strategies, and foraging behavior. (JOURNAL OF WILDLIFE MANAGEMENT 71(5):1607–1611; 2007)

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The United States Fish and Wildlife Service listed lynx (*Lynx canadensis*) as Threatened under the United States Endangered Species Act in 2000 (U.S. Fish and Wildlife Service 2000). The associated United States interagency Lynx Conservation Assessment and Strategy (2000) stated that an understanding of lynx activity patterns is necessary to mitigate the effects of human disturbances within lynx habitat, such as snowmobiling, developed recreation sites, and transportation corridors, during times when lynx are more active and presumably less secure.

Lynx activity patterns are not well documented in the literature. Parker et al. (1983) tracked the daily activity of 3 lynx (1 ad M, 1 ad F, 1 juv F) in Nova Scotia, Canada, and found that those lynx traveled most in afternoon and early evening during the winter, but their results during summer were inconclusive.

Lynx forage extensively, and at times almost exclusively, on snowshoe hares (*Lepus americanus*) throughout the species' range (Aubry et al. 2000, Mowat et al. 2000, Squires and Ruggiero 2007), and hares are primarily nocturnal with peak activity during crepuscular hours (Mech et al. 1966, Figala et al. 1984, Theau and Ferron 2001). Because prey behavior often strongly affects the activity patterns of top-level carnivores (Curio 1976, Zielinski et al. 1983, Ferguson et al. 1988), researchers speculated that lynx activity may be synchronous with the activity patterns of snowshoe hares (Saunders 1963, Brand et al. 1976).

In addition to prey behavior, other factors may influence a predator's diel activity. These factors include weather (Garshelis and Pelton 1980, Tester 1987), photoperiod (Daan and Aschoff 1975), ambient temperature (Nielsen 1984, Beltran and Delibes 1994), human disturbance and predation risk (Dorrance 1975, Lariviere et al. 1994), and reproductive status (Schmidt 1999).

We describe the circadian activity of Canada lynx in western Montana, USA, by sex, season, and reproductive status. We then evaluate how lynx activity patterns correlate with ambient temperature in our study area and with snowshoe hare activity patterns as reported in the literature.

[1] *E-mail: jkolbe@mt.gov*

STUDY AREA

We studied lynx behavior in the Clearwater River drainage, near the town of Seeley Lake, Montana. This area was about 1,800 km^2 and included state, federal, and private lands that supported intensive commercial forestry. An extensive road network and a high snow pack attracted private and commercial snowmobile operators during winter. The Bob Marshall and Mission Mountain Wilderness areas flanked the east and west sides of the study area, respectively.

Elevations ranged from 1,200 m to 2,100 m. Warm and dry forests at lower elevations were dominated by Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*) on south to west aspects, usually as mixed forests (U.S. Forest Service 1997). Low-elevation sites were usually $<35\%$ slope.

Mid-elevations supported primarily cool–moist to dry conifer forests. Dominant tree species included seral Douglas-fir, western larch, and lodgepole pine in mixed to single-species stands. Slopes at mid-elevations were often $>35\%$.

Upper-elevation forests consisted of subalpine fir (*Abies lasiocarpa*), whitebark pine (*Pinus albicaulis*), and Engelmann spruce (*Picea engelmannii*), with lesser components of lodgepole pine, Douglas-fir, and western larch. Subalpine forests were multistoried and multiaged, often with a dense shrub understory.

METHODS

We trapped (Kolbe et al. 2003), anesthetized, and fitted lynx with radiocollars that included a motion-sensitive switch and a microprocessor that recorded the number of switch activations per hour (Advanced Telemetry Systems, Isanti, MN). Collars transmitted activity data (as activity index values ranging from 10 to 90) from the previous 24-hour period twice daily. We used a hand-held ATS™ DC II

Table 1. Summary of lynx activity data sampling, Seeley Lake, Montana, USA, 2001. The presented sampling intensity data are the mean number of 24-hour periods sampled per animal.

	No. of lynx	Sampling intensity	SD	24-hr periods sampled
Summer				
M	3	6.67	3.09	20
F with young	5	17.60	5.20	88
F without young	1	4		4
Winter				
M	6	5.89	2.28	33
F	5	7.16	0.90	43

data-logging telemetry receiver to remotely record the hourly activity values. We centered activity data on the mean activity value for each sex by season for graphical presentation.

Motion-sensitive radiocollars have been used extensively to study mammalian activity patterns (Beltran and Delibes 1994, Lariviere et al. 1994, Schmidt 1999). Although the data these collars record do not reliably allow the differentiation of travel from other movements, we directly observed collared lynx in the field for several years and noted that the collars' pulse rates (which were both transmitted and recorded by the collars) were fastest when an animal was traveling and slowest when an animal was resting. Therefore, we believe the hourly counts serve as an informative index of the animals' daily activity patterns.

We sampled lynx in sequential order to maintain a minimum of 48 hours between sampling periods and to distribute the sampling effort throughout the summer (1 May–30 Aug) and winter (1 Jan–31 Mar) sampling periods. We divided females into reproductive (those with kittens) and nonreproductive (those without kittens) classes during summer. We considered the animal as the sampling unit for analysis and graphical presentation. We grouped activity data for each animal by hour and computed a mean hourly value for each animal for both summer and winter. We then analyzed these mean activity values by sex and season to describe general lynx activity patterns.

We computed Pearson's correlation coefficients to assess the relationship between lynx hourly activity index values and ambient temperature (Zar 1999). A Remote Automated Weather Station (RAWS) located at the United States Forest Service Seeley Lake Ranger District (near the center of the study area) recorded temperature data hourly. We constructed a composite daily temperature profile for both the summer and winter season by averaging hourly values across all days of the seasonal sampling periods. We reported time as Mountain Standard Time.

RESULTS

We recorded activity data for 6 male and 5 female lynx in winter (20 Jan to 21 Mar 2001). We sampled 3 male and 6 female lynx during summer (7 May to 20 Aug 2001). In total, we sampled 184 24-hour activity periods; 76 in winter and 108 during the summer (Table 1). Five of 6 females denned and reared kittens during summer.

During winter, both males and reproductive females exhibited a unimodal activity pattern. Activity index values were highest near sunset and dropped dramatically to only 50% of those peak levels 2–4 hours later (Fig. 1). Lynx winter activity was positively correlated with temperature for both males ($r = 0.62$, $n = 24$ hr, $P < 0.01$) and females ($r = 0.69$, $n = 24$ hr, $P < 0.01$).

In summer, females with kittens were active throughout the photoperiod (Fig. 1). These females demonstrated a low amplitude unimodal pattern with its peak in late afternoon. During the middle of the night, when temperatures were lowest, reproductive females' activity dropped to <70% of afternoon highs. In contrast, males' summer activity peaked during the crepuscular periods preceding dawn and dusk but dropped by >50% during midday when ambient temperatures were highest ($r = -0.49$, $n = 24$, $P < 0.02$; Fig. 1). One female lynx did not successfully den and was not rearing kittens during the summer sampling period. Her summer activity appeared to differ from that of the reproductive females and closely resembled that of male lynx (Fig. 2).

DISCUSSION

Our data do not support the hypothesis (Saunders 1963, Brand et al. 1976) that lynx on our study area are primarily nocturnal. Lynx activity patterns appeared to vary by sex, season, and reproductive status. During summer, male lynx exhibited a crepuscular activity pattern, whereas females with kittens were active throughout the photoperiod. During winter, lynx of both sexes were most active during the afternoon and early evening. This general pattern of winter activity is consistent with Parker (1983).

Thermoregulation may influence lynx activity during both seasons. Casey et al. (1979) found that Canada lynx are thermoneutral to <−10° C; however, lynx are more sensitive to high summer temperatures (McNab 1970, Beltran and Delibes 1994). We found that male activity patterns were negatively correlated with summer temperatures. During summer, we often observed male lynx using cool, moist locations as resting cover during midday. In winter, male and female lynx were most active during late afternoon when ambient temperatures were highest.

Females with kittens were active throughout the photoperiod during the summer, an activity pattern very different than that of male lynx. Schmidt (1999) observed that Eurasian lynx (*Lynx lynx*) females rearing young were significantly more active in summer than females without kittens. Similarly, Garshelis and Pelton (1980) found that female black bears (*Ursus americanus*) caring for the young of the year were generally more active than females without cubs. Thus, the increased need by reproductive females to forage and care for young may explain the high diurnal activity of lynx during the summer. This hypothesis is consistent with our observation that during summer a single female without kittens appeared to be less active during

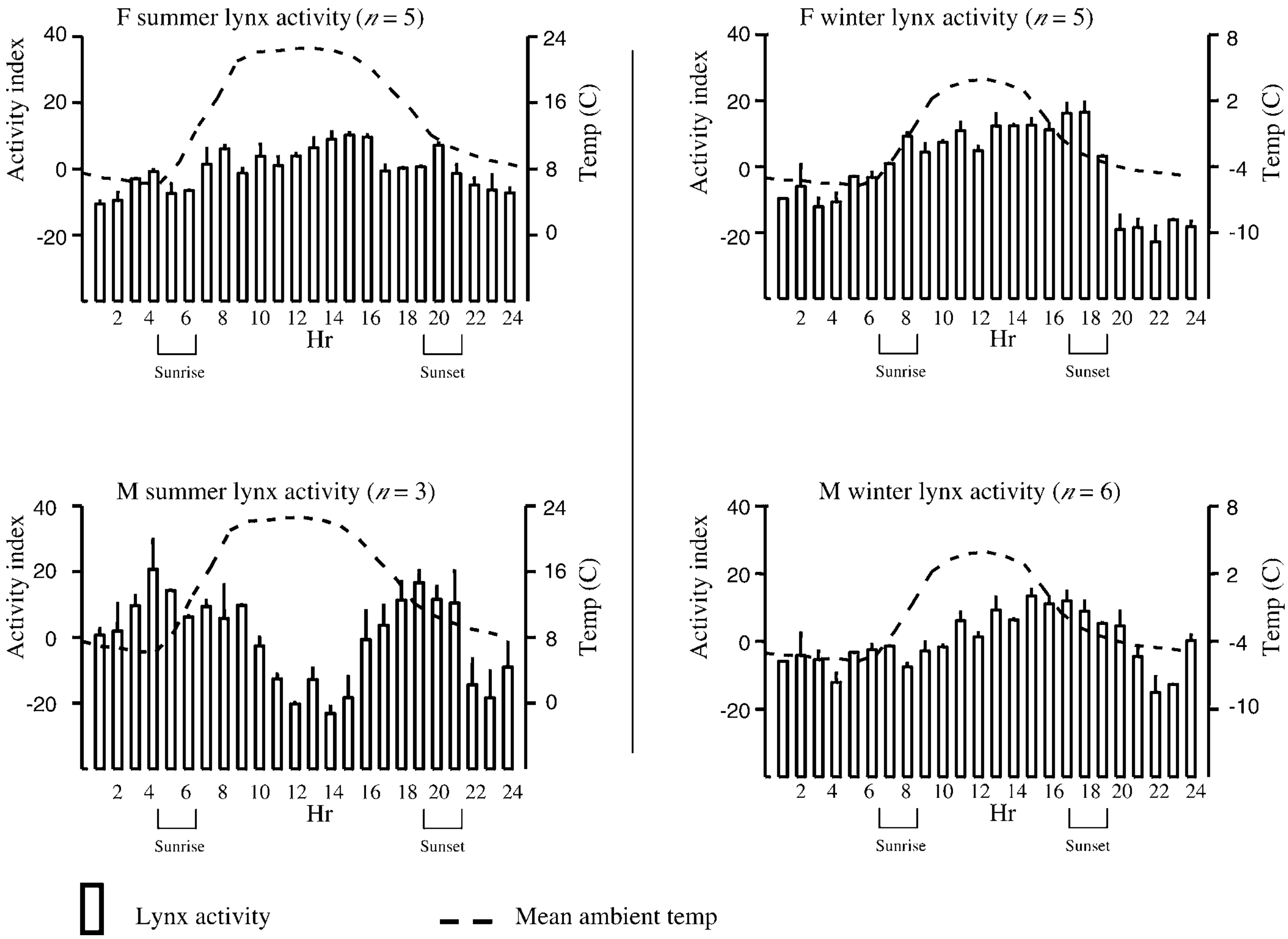

Figure 1. Activity patterns of Canada lynx and ambient temperature, Seeley Lake, Montana, USA, 2001. Each bar represents the average of the animals' mean activity values for that hour. Error bars represent the standard error of the animals' mean hourly activity values. All females were rearing young during the summer season.

midday and exhibited an activity pattern very similar to that of males (Fig. 2).

We found no evidence that predation risk affected lynx activity patterns. Although mountain lions (*Puma concolor*) have killed lynx in our study area, lions and lynx are spatially separated by deep snow during winter (J. R. Squires, United States Forest Service, unpublished data). During summer, when all documented lion predation of lynx occurred, lion activity occurs throughout the 24-hour period (Foresman 2001).

The diet of lynx during the summer is poorly understood, but may be broader in the presence of alternative prey, such as ground squirrels (*Spermophilus* spp.) and red squirrels (*Tamiasciurus hudsonicus*; Aubry et al. 2000). These species are strictly diurnal, and ground squirrels are available to lynx only during the summer months (Foresman 2001). We observed denning female lynx actively hunting ground squirrels during the day; however, we were unable to test the extent to which that behavior accounts for the difference between male and reproductive female activity patterns.

The strategies that lynx use to hunt hares in winter may also affect their activity patterns. Snowshoe hares are

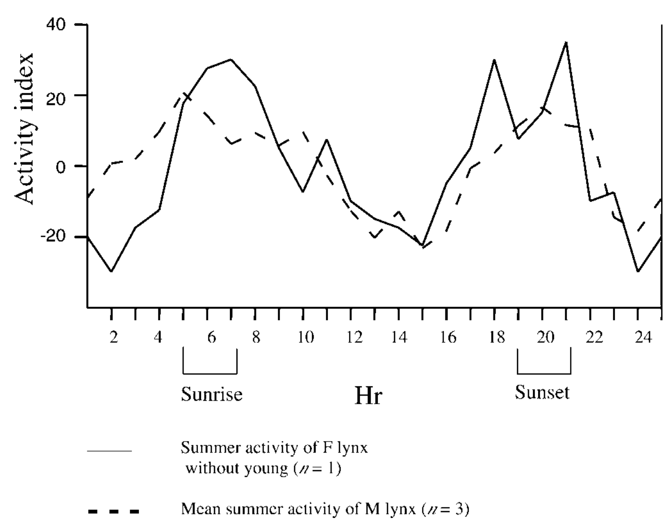

Figure 2. Summer activity of 1 female lynx without young and 3 male lynx, Seeley Lake, Montana, USA, 2001.

primarily nocturnal with peak activity during the hours just before dawn and after dusk (Figala et al. 1984, Foresman and Pearson 1999, Hodges 1999, Theau and Ferron 2001). Researchers posit that prey may be easier to detect when it is active (Curio 1976). However, our data suggest that it is unnecessary for lynx to synchronize their activity patterns with those of snowshoe hares to effectively forage. This result was particularly surprising given that hares occur at low densities in western Montana (1–2 hares/ha; Hodges 2000) relative to more northern populations and that snowshoe hares account for 97% of the winter lynx diet at Seeley Lake (Squires and Ruggiero 2007).

Lynx use 2 basic methods to hunt hares: ambushing prey from a hunting bed and actively traveling through hare habitat to spot or flush hares (Murray et al. 1995, Squires and Ruggiero 2007). Squires and Ruggiero (2007) found that roughly half of the hares killed by lynx during winter at Seeley Lake were taken from hunting beds; lynx killed the remainder while traveling. Ambushing hares from a hunting bed may be most effective at night when hares are active. During the day, when hares are generally inactive, lynx may need to move through hare habitat to flush or stalk resting hares. While backtracking lynx during winter, we often observed signs of lynx both attempting to flush hares from resting cover and using hunting beds with clear views of snowshoe hare trails. During winter, thermoregulatory stress is relatively low, and lynx kittens are able to travel with their mother. Therefore, the diurnal lynx activity patterns that we observed during winter may, in part, reflect the different strategies lynx use to capture hares.

MANAGEMENT IMPLICATIONS

Human-caused disturbances, such as motorized recreation and timber harvest, may occur concurrent with peak lynx activity periods. Although we were unable to assess whether such activities affected lynx behavior on our study area, it may be appropriate to consider potential disturbance to lynx when managing these activities.

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