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# THERMAL CHARACTERISTICS OF MOUNTAIN LION DENS

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ABSTRACT.—We used radiotelemetry and searched with a trained hound to locate the dens of 3 recently parturient mountain lions (*Felis concolor*). These dens were located in dense riparian vegetation along the same stream in the bottom of a steep canyon. We monitored the circadian temperatures of 2 dens at 1-h intervals and compared them to ambient temperatures recorded simultaneously. We found mountain lion dens to effectively moderate high ambient temperatures, but these dens failed to provide a thermal advantage at the lowest ambient temperatures recorded in this investigation. We conclude that mountain lion dens provide effective protection from thermal maxima for young, immobile kittens.

*Key words:* Felis concolor, *mountain lion, temperature, California, den, behavior.*

Female mountain lions (*Felis concolor*) select protected locations in which to bear young (Shaw 1989:7, Beier et al. 1995), but little information is available on den site characteristics for this elusive felid. Here, we describe some characteristics of 3 dens used by different females and their litters and quantify the thermal characteristics of 2 of those dens.

## DESCRIPTION OF STUDY AREA

Our study area is located in Mono Co., California, approximately 35 km NW of Bishop (118°25′W, 37°20′N), Inyo Co., California. This area is on the western edge of the Great Basin, immediately east of the crest of the Sierra Nevada. The dominant vegetation type in the general area is sagebrush (*Artemisia tridentata*) scrub with pinyon pine (*Pinus monophylla*) forest at higher elevations. Dense vegetation, dominated by willows (*Salix* spp.) and wild rose (*Rosa* spp.), occurs along the major water courses.

## METHODS

During August and September 1994 and 1995, telemetry indicated that several adult females in our investigation of mountain lion ecology had restricted their daily movements. These females returned repeatedly to the same locations, suggesting that they had established natal dens (Beier et al. 1995). We searched these 3 areas and, after detecting vocalizations of neonatal mountain lions, we used a trained hound (Bruce 1918) to locate the dens and kittens. We estimated the ages of these kittens according to criteria summarized by Anderson (1983:43) and Currier (1983).

We examined the thermal characteristics of the dens by placing a recording thermograph (model RTM, Ryan Instruments, Inc., Kirkland, WA) on the floor of each den and an identical instrument on the ground ≤ 100 m away, on a north exposure supporting sagebrush and pinyon pine. Because of the shrubs and trees present on these north-facing slopes, thermographs were not exposed directly to the sun for most of each day. Hourly temperatures were recorded at den 2 from 4 September to 4 October 1994, and at den 3 from 11 August to 16 September 1995; we did not have access to thermographs during the period that den 1 was active. We made ocular estimates of tree height and canopy closure, as well as horizontal cover, at each den.

We used analysis of variance and analysis of covariance to explore the effects of day and time on temperature, simple linear regression to examine the relationship between day of the study and daily temperature, and *t* tests to compare den temperatures with ambient temperatures (Zar 1984).

## RESULTS

Three dens containing kittens were located along the Owens River: den 1 contained 1 male and 1 female; den 2 contained 3 males and 1 female; den 3 contained 2 males and 1 female.

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We estimated the kittens at dens 1 and 3 to be ≤ 20 days of age, and those at den 2 to be ≤ 10 days old.

All 3 dens were located in dense groves of willows that ranged in height to approximately 4 m. Wild rose was abundant at all 3 sites, and each den was located ≤ 50 m from the river. Canopy closure at each den was nearly 100%, and direct sunlight did not reach the substrate during any of our midday visits ($n$ = 2, den 1; $n$ = 5, den 2; $n$ = 3, den 3). Horizontal cover at each location was sufficiently dense that, even while standing, we were totally obscured from each other's view at ≤ 3 m. The substrate of all 3 dens was littered with deciduous leaves as well as tree trunks, branches, twigs, and bark. We were able to reach the kittens only by crawling into the dense vegetation present at each site.

We found significant differences between the dens in mean ambient temperature ($\bar{x}_{\text{den 2}} = 13.18 \pm 9.94$ [$s$]° C; $\bar{x}_{\text{den 3}} = 20.47 \pm 10.61$° C; $F = 202.584$, df = 1, 1630, $P < 0.001$), mean den temperature ($\bar{x}_{\text{den 2}} = 6.01 \pm 5.77$° C; $\bar{x}_{\text{den 3}} = 15.22 \pm 7.08$° C; $F = 807.949$, df = 1, 1630, $P < 0.001$), and mean daily temperature differential (ambient temperature – den temperature; $\bar{x}_{\text{den 2}} = 7.16 \pm 6.05$° C; $\bar{x}_{\text{den 3}} = 5.25 \pm 6.09$° C; $F = 40.224$, df = 1, 1630, $P < 0.001$). At den 2, there was a significant effect of day on ambient temperature ($F = 3.814$, df = 30, 713, $P < 0.001$), den temperature ($F = 3.191$, df = 30, 713, $P < 0.001$), and temperature differential ($F = 4.320$, df = 30, 713, $P < 0.001$). At den 3, however, there was no such effect on ambient temperature ($F = 0.421$, df = 36, 851, $P = 0.999$), den temperature ($F = 0.535$, df = 36, 851, $P = 0.989$), or temperature differential ($F = 0.488$, df = 36, 851, $P = 0.995$). As the study progressed, there was a significant decline at den 2 in ambient temperature ($r = -0.340$, $P < 0.001$), den temperature ($r = -0.112$, $P < 0.001$), and temperature differential ($r = -0.228$, $P < 0.001$); lesser declines in ambient temperature ($r = -0.100$, $P < 0.001$), den temperature ($r = -0.051$, $P = 0.001$), and temperature differential ($r = -0.048$, $P < 0.001$) occurred at den 3.

At both dens, there was significant diel variation in ambient temperature (den 2: $F = 103.382$, df = 23, 720, $P < 0.001$; den 3: $F = 618.443$, df = 23, 864) and den temperature (den 2: $F = 91.008$, df = 23, 720, $P < 0.001$; den 3: $F = 431.275$, df = 23, 864, $P < 0.001$). When date was used as a covariate to control for daily solar radiation, the mean temperature differential also varied on an hourly basis at both dens (den 2: $F = 112.271$, df = 23, 719, $P < 0.001$; den 3: $F = 329.936$, df = 23, 863, $P < 0.001$). Hourly ambient temperatures were greater than corresponding den temperatures at both locations (den 2: $t = 32.285$, df = 743, $P < 0.001$; den 3: $t = 25.662$, df = 887, $P < 0.001$); this difference was especially pronounced at high ambient temperatures (>31° C [HAT]; Fig. 1). At HAT, the temperature differential at den 2 ($\bar{x} = 21.92 \pm 4.49$° C) was >3 times that at moderate ambient temperatures (≤ 31° C [MAT]; $\bar{x} = 6.03 \pm 4.46$° C), and the temperature differential at den 3 ($\bar{x} = 13.56 \pm 8.37$° C) at HAT was nearly 5 times that at MAT ($\bar{x} = 2.87 \pm 3.50$° C). At den 2, the mean range of daily ambient temperatures ($\bar{x} = 28.96 \pm 7.81$° C) was nearly double that of daily den temperatures ($\bar{x} = 15.79 \pm 5.26$° C) ($t = 15.83$, df = 30, $P < 0.001$). Similarly, at den 3 the mean range of daily ambient temperatures ($\bar{x} = 32.54 \pm 3.71$° C) was >1.5 times that of daily den temperatures ($\bar{x} = 20.89 \pm 3.50$° C; $t = 15.24$, df = 36, $P < 0.001$). For both locations combined, den temperatures were less than ambient temperatures for all but 2 (<0.2%) of the paired hourly observations.

## DISCUSSION

These mountain lion dens effectively moderated high ambient temperatures, consistent with the hypothesis of Shaw (1989) that dens play an important role in protecting young, defenseless kittens from thermal maxima. At HAT, mean temperature differentials were 3–5 times greater than at MAT (Fig. 1). There were significant effects of time of day (both dens) and day length (den 2) on temperature differential and, hence, the moderating influence of the dens. Nevertheless, den temperatures were less variable than were ambient temperatures. We found no evidence that these dens provided a thermal advantage (i.e., den temperatures greater than ambient temperatures) at the minimum ambient temperatures we recorded; dens may, however, provide protection for kittens when temperatures fall below those that we encountered.

Few descriptions of mountain lion dens are available, but females may select caves, rocky areas, or dense thickets in which to bear young

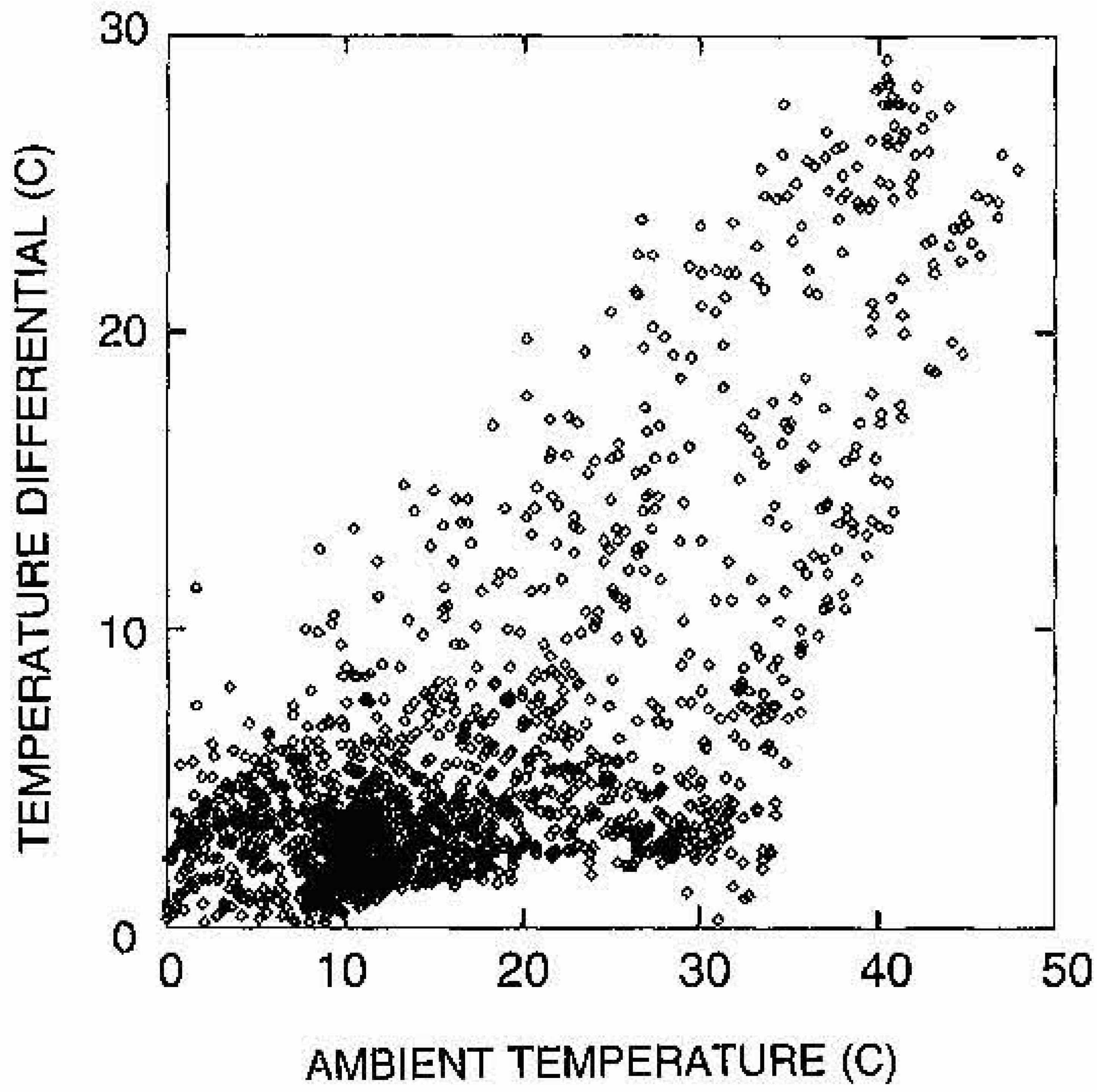


Fig. 1. Mean temperature differential (ambient – den) is more than 3 times greater at high ambient temperatures (>31° C) than at moderate ambient temperatures (≤31° C; data from dens 2 and 3 combined, $F = 1, 241.07$, df $= 1, 1630$, $P < 0.001$). Mountain lion dens in dense vegetation effectively moderate extreme high temperatures and afford young, helpless kittens protection from ambient maxima, consistent with the hypothesis of Shaw (1989).

(Bruce 1918, Young and Goldman 1946, McBride 1976, Russell 1978, Shaw 1989). We hypothesize that thermal characteristics vary among types of dens, and that mountain lions inhabiting particular environments select den sites based, in part, on the thermal advantage(s) they provide.

In an area with a warm, Mediterranean climate, Beier et al. (1995) reported 2 dens that were located in a small canyon with very heavy cover of "brush," similar to those we investigated. Dens located in thick, woody vegetation may conceal young that are vulnerable to predation, but they also provide protection for kittens from extreme temperatures associated with direct insolation. Such locations provide important thermal benefits for kittens at high ambient temperatures, and a more stable thermal environment than exists outside the den throughout the range of ambient temperatures we recorded. Movements by kittens for thermoregulatory purposes might be lessened under these circumstances. Fewer movements by kittens may decrease the probability of discovery by potential predators, thereby enhancing the survival of young, defenseless mountain lions.

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