Radiant Surface Temperatures and Hair Depths of a Black Bear, *Ursus americanus*

AARON N. MOEN[1] and LYNN ROGERS[2]

[1]Department of Natural Resources, Cornell University, Ithaca, New York l4853
[2]North Central Forest Experiment Station. USDA — Forest Service, 1992 Folwell Avenue, St. Paul, Minnesota 55108

Moen, Aaron N.,and Lynn Rogers. 1985. Radiant surface temperatures and hair depths of a Black Bear, *Ursus americanus.* Canadian Field-Naturalist 99(1): 47-50.

Radiant surface temperatures of a Black Bear (*Ursus americanus*) vary with ambient temperature; four linear regression equations are used to predict radiant temperatures on the head, neck, belly, and trunk. The trunk, with the greatest hair depth. is the coldest; predicted radiant temperature is about -2° C when air temperature is -10° C. Head temperatures are highest, and more variable than trunk and neck temperatures. A curled-up bear minimizes surface area while exposing deep trunk hair to ambient conditions.

Key Words: Black Bear, *Ursus americanus.* Radiant temperature, temperature isopleths, hair depth isopleths.

The radiant temperature of an animal's surface is a function of the ambient energy load, metabolic heat production, and the effectiveness of the pelage as thermal insulation. In cold weather, well-insulated mammals have low, and poorly-insulated animals have high, radiant temperatures as metabolic heat is dissipated. Radiant temperatures are reflections of the overall insulation of the pelage, and of differences in both insulation per unit depth and total depth of the hair.

Every animal is constantly exchanging radiant heat energy with its surroundings. Calculated energy budgets should include radiant energy estimates, cither as part of a summation procedure or as an integral part of an overall heat transfer coefficient. This paper includes predictive equations for the relationships between ambient temperature and radiant temperatures of the body, neck, and head of a Black Bear (*Ursus americanus*), with additional data on measured hair depths of the bear.

Methods

Radiant temperatures we re measured with a Barnes Instatherm hand-held radiant thermometer on the head, neck. body and belly of a 132 kg wild-trapped male black bear in a 5 x 5 m pen from 4 November-5 December 1981. Ambient temperatures ranged from + 15 to -15C. with little or no wind. The bear had been removed from its den and caged on 28 October. Temperature measurements were made when the bear was sleeping, resting but awake, and moving about the cage. An audible seeker assisted in determining the highest radiant temperature reading for a body pan. Radiant temperatures analyzed by regression included only those recorded when the bear was in diffuse light and infrared radiation. A few measurements made on sunlit hair arc discussed separately.

The bear was immobilized on 5 December and a detailed radiant temperature profile made by scanning the entire body at close range. During these measurements, ambient temperature ranged from -3° to -4° C, and there was no wind. Hair depths were also measured by reading a small ruler where hair densities occluded the mm graduations, which was about 10 mm from the tips of the longest guard hairs and about I mm from the tips of the short hairs on the feet and muzzle.

Results and Discussion

Linear regression equations were derived for X = ambient temperature (T^a) and Y = radiant temperature (T^r) of the head, neck, trunk, and belly. The data were first analyzed separately for active, resting, and sleeping readings, but the slopes of the lines for all activities were statistically similar (t test, 0.05 level) so the data for these activities were combined.

The equations for the radiant temperature; air temperature relationships (Figure l) are:

Head: $T^r = 14.41 + 0.50T^a$; $R^2 = 0.55$, N=56
Neck: $T^r = 9.86 + 0.55\ T^a$; $R^2 = 0.96$, N = 9
Belly: $T^r = 12.15 + 0.69\ T^a$; $R^2 = 0.78$, N=6
Trunk: $T^r = 6.09 + 0.77\ T^a$; $R^2 = 0.96$, N = 60

The low R^2 values for the head indicate differences in radiant temperatures of the nose, mouth, eyes, muzzle and hair-covered parts of the head. The high R^2 values for the neck and trunk indicate uniformity in the radiant temperatures of these large target areas.

Radiant temperature isopleths (Figure 2) determined from scanning at close range illustrate the differences over the surface of the bear. The close-up temperatures on the body were about 3° C higher than the temperatures predicted with the regression equations, perhaps due to excitement and muscle activity of the bear prior to immobilization, and also to the recording of the highest temperature indicated for the small close-up target area. Note the variability over the muzzle, eye, and other areas of the head; close-up

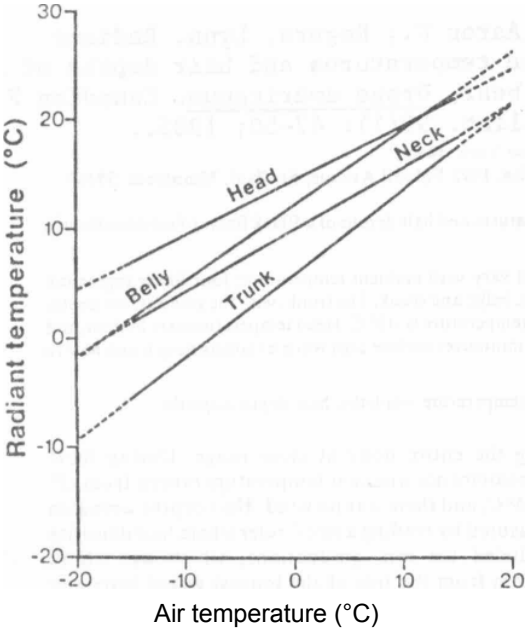

FIGURE 1. Regression lines expressing the relationships between air temperature and radiant temperature of the hair of a black bear. Equations and R^2 values are given in the text.

scanning reveals the effects of differences in hair depths and target characteristics.

Radiant temperatures of the neck and torso were quite predictable with linear regression equations. The linear relationship between T^r and T^a has been characteristic of all such measurements made by A.N.M. on a variety of mammals (Moen 1973, 1974; Moen and Jacobsen 1974; Moen 1984). The high R^2 values for the neck and trunk equations are reflections of uniformity over rather large areas. Hair depths for these parts, while variable, were also quite deep (figure 3), resulting in low variability in radiant temperature readings. The low R^2 values for the head equations are due to greater variability in hair depths and to difficulty in determining actual target areas. There was a steep temperature gradient from the thin-haired muzzle (22° C) to the thicker-haired check (8° C) when close-up measurements were made on the immobilized bear (Figures 2 and 3).

Radiant temperatures of the belly also were higher and more variable than on the trunk and neck. I he long but sparse hair (Figure 3) presented a variable target which in some cases included exposed skin, depending on the lie of the hair during temperature measurements.

A few radiant temperature measurements were made when the fur was exposed to sunlight. In one instance, with an ambient temperature of 2°, the radiant temperature of the trunk on the sunlit side was 34° C. On the shaded side it was 8°, about as predicted by the regression equation for the trunk. Other recorded radiant temperatures on sunlit fur on the trunk were 37° at T^a = 13°, and 26° at T^a = -1°C. These high radiant temperatures arc not unlike temperature patterns A.N.M. has observed on sunlit hair of black angus and on the black hair of holstein cattle; sunlit readings of over 50° occurred at summer temperatures around 25° C (unpublished data).

Morse (1937) and Svihla and Bowman (1954) observed that snow accumulated on the backs of some black bears sleeping on open ground in winter. Data for the bear measured in this study predict that a radiant temperature of0° should occur at an ambient temperature of -8°C. Ambient temperatures below -8° should result in snow accumulation on the bear. Svihla and Bowman (1954) reported a thermocouple-measured hair surface temperature of 0° when ambient temperature was about -7.8° C, very close to the radiant temperature predicted with the trunk equation.

Radiant temperatures on the belly, feet, and head are higher than on the back (see Figure 2). A curled-up sleeping bear not only minimizes surface area, but also exposes a maximum amount of well-insulated hair surface to ambient conditions.

Comparison of data for the bear with data reported for White-tailed Deer (*Odocoileus virginianus*) (Moen 1973, 1974) indicate that insulation of the bear's winter coat was superior to that of deer. At an ambient temperature of -30°, predicted T^r on the trunk of the bear is -17°, whereas on a white-tailed deer it is -12° C in no wind.

Acknowledgments

This work was completed at the North Central Forest Experiment Station's Kawishiwi Field Laboratory in the Superior National Forest while A.N.M. was on sabbatical leave from Cornell University, Ithaca. New York. Research on Black Bears and on the energetics of homeotherms is sponsored by the USDA — Forest Service. North Central Forest Experiment Station, hv the New York Department of Environmental Conservation through P-R project W-124-R, and the New York Stale College of Agriculture and Life Sciences, Hatch Project 406.

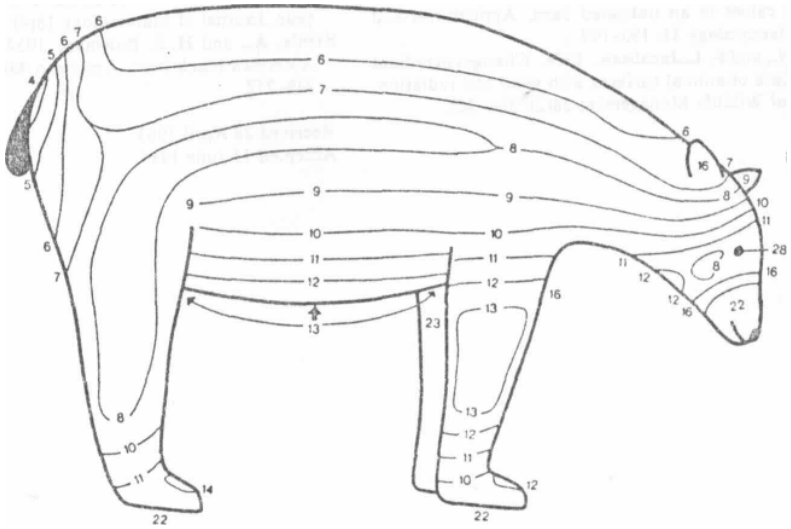

FIGURE 2. Radiant temperature isopleths based on close-up scanning of an immobilized bear exposed to an ambient temperature of -3 to -4° C.

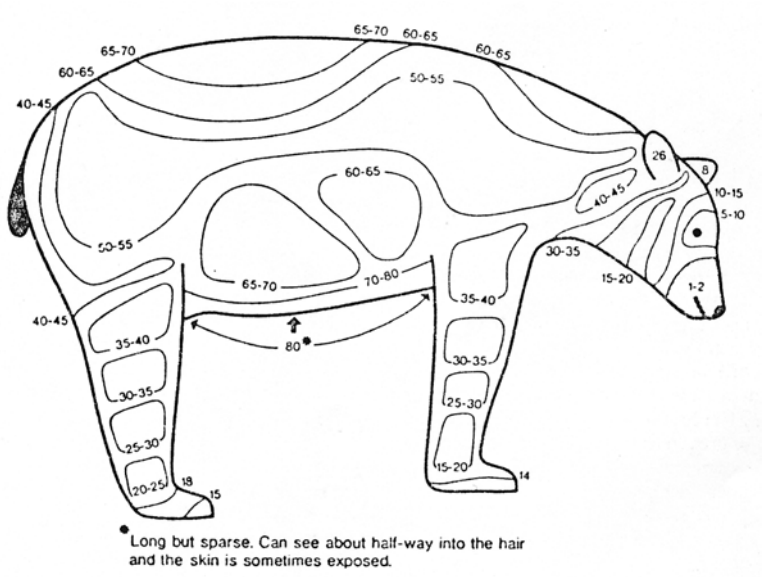

FIGURE 3. Hair depth isopleths (cm) based on measurements on an immobilized bear.

Literature Cited

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman and Company, San Francisco. 45H pp.

Moen, A. N. 1974. Radiant temperature of hair surfaces. Journal of Range Management 27(5): 401-403.

Moen, A.N. 1984. Radiant surface temperatures of Angus-Holslein calves in an unheated barn. Agricultural and Forest Meteorology 31: 193-199.

Moen, N., and F. L. Jacobsen. 1974. Changes in radiant temperature of animal surfaces with wind and radiation. Journal of Wildlife Management 38(2): 366-368.

Morse. M. A. 1937. Hibernation and breeding of the black bear. Journal of Mammalogy 18(4): 460-465.

Svitila, A., and H. S. Bowman. 1954. Hibernation in the American black bear. American Midland Naturalist 52:248-252.

Received 28 April 1983
Accepted 13 June 1984