Diurnal Rhythm of Body Temperature in the Hawaiian Monk Seal (*Monachus schauinslandi*)[1]

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ABSTRACT: The diurnal variation of body temperature of an unrestrained Hawaiian monk seal, recorded by telemetry, was 1.0° C. Increased activity was the principal cause of increased body temperature in the seal. The body temperature of the animal was lowest when it was asleep on land in direct sunlight. In view of these results, an explanation is offered for the reported heat tolerance of Hawaiian monk seals in their natural habitat.

THE HAWAIIAN MONK SEAL, in its natural habitat in the Hawaiian Islands National Wildlife Refuge, has been reported to haul out onto the sand, in direct sunlight and at high air temperatures, for considerable periods of time (Kenyon and Rice, 1959). The California sea lion, another pinniped, would not be able to tolerate such conditions for more than a few hours because of its limited capacity for evaporative cooling (Whittow, Matsuura, and Lin, 1970). Monk seals have not been observed to pant (Kridler and Olsen, personal communication) and, although they possess sweat glands (Jenkinson, Kridler, Olsen, Whittow, and Szekerczes, unpublished observations), it is not known if these glands are functional. Therefore, in the absence of definite evidence for significant respiratory or cutaneous moisture loss, an increase in the body temperature of monk seals when they are out of water would appear to be obligatory. Single measurements of the rectal temperatures of five young Hawaiian monk seals on the sand in the Hawaiian Islands National Wildlife Refuge, however, did not provide any evidence that this species becomes hyperthermic (Kridler, Olsen, and Whittow, 1971). In order to obtain further information on the body temperature of the Hawaiian monk seal, we recorded, over a period of 24 hours, the deep-body temperature of the monk seal at the Waikiki Aquarium in Honolulu, the only monk seal in captivity in the world. These data are reported in this paper.

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METHODS

The Hawaiian monk seal at the Waikiki Aquarium is a 9-year-old male in excellent health. To record its deep-body temperature without having to restrain the animal and with the minimum of interference to its normal pattern of behavior, we used a telemetry technique. A temperature-sensitive "radio pill" (Fox, Goldsmith, and Wolff, 1962) was inserted in a piece of fish and fed to the animal, and the signal transmitted by the pill was detected by an antenna, held within a few feet of the seal, and a receiver. We attached the antenna to the end of a pole so that we could place it near the seal without having to approach the animal (Fig. 1). On most occasions the seal was not aware that the antenna was near. After the first few measurements, the animal, even when it did notice the antenna, was not perturbed and did not change its posture or activity. The radio pill transmitted at a frequency within the range 350 to 362 kc/sec. The sensitivity of the system was such that a change of body temperature of 0.1° C could be detected.

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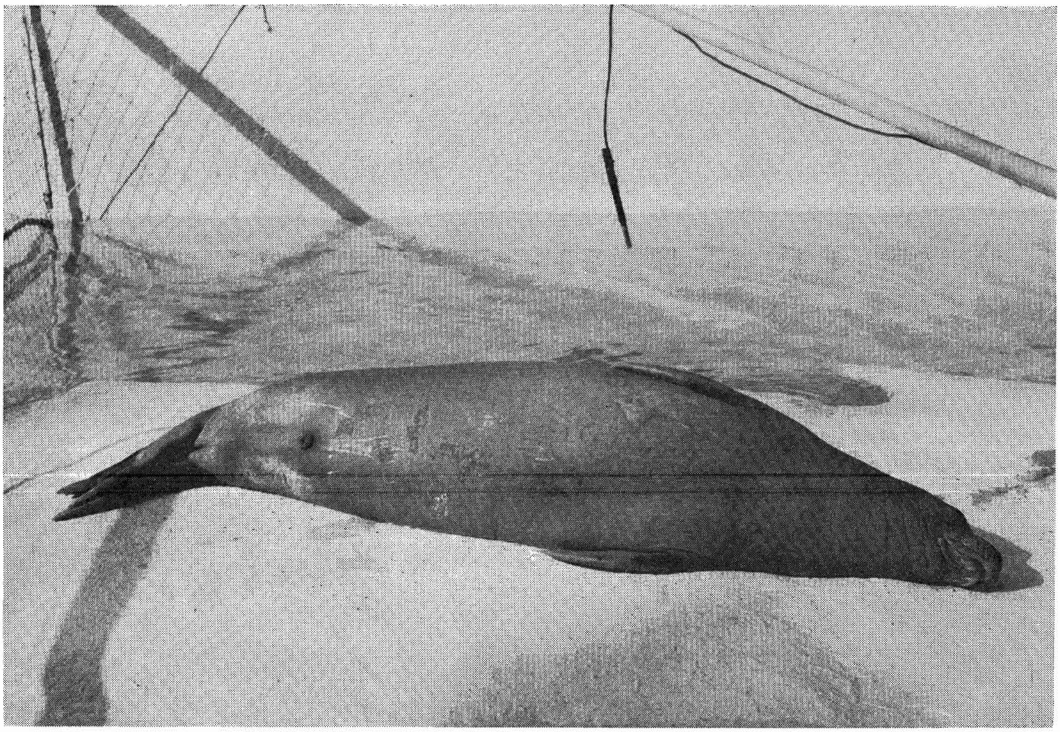

FIG. 1. Antenna positioned close to the seal to detect the signal transmitted by the radio pill which the seal has swallowed.

RESULTS

The pill was fed to the seal on 2 days, separated by an interval of 1 week. On the first occasion, the radio pill was given to the animal at 1010 hours, when the aquarium had been drained and the seal was in approximately 1 foot of water. The temperature recorded by the pill was initially low because the fish containing the pill was cold, but it increased to a maximal value of 37.6° C over the following 2.5 hrs. The pool was being filled during this time and the seal was swimming continuously. Over the next 3.25 hr, the body temperature diminished to 36.7° C. The animal was not fed on this particular day, and the pill was ejected at 1600 hours. It was not determined whether the pill was regurgitated or whether it had passed through the gastrointestinal tract.

When the pill was administered the second time, a normal pattern of activity was followed; i.e., the aquarium was not drained and the animal was fed twice. The pill was given to the animal at 1200 hours. The temperature increased as the fish, which contained the pill, warmed to body temperature. At 1300 the seal was fed approximately 5 pounds of fish. This resulted in a diminution in the temperature of the pill (Fig. 2). Thereafter, the temperature increased to 37.3° C. At 1500 the seal was fed a second time and this again resulted in a decrease in the temperature transmitted by the pill. Thirty minutes after being fed, the animal's temperature had increased to 36.7° C. At this point, the seal hauled out onto the rock formation in the aquarium and remained there for the next 2 hours. During this period, the animal slept and its coat dried out. The body temperature diminished to 36.1° C and remained at this level until the seal entered the water at 1730. Swimming was associated with a rapid increase in body temperature to a maximal value of 37.1° C. Thereafter, the seal was in the water continuously and its body temperature declined to 36.5° C at 0530. During the

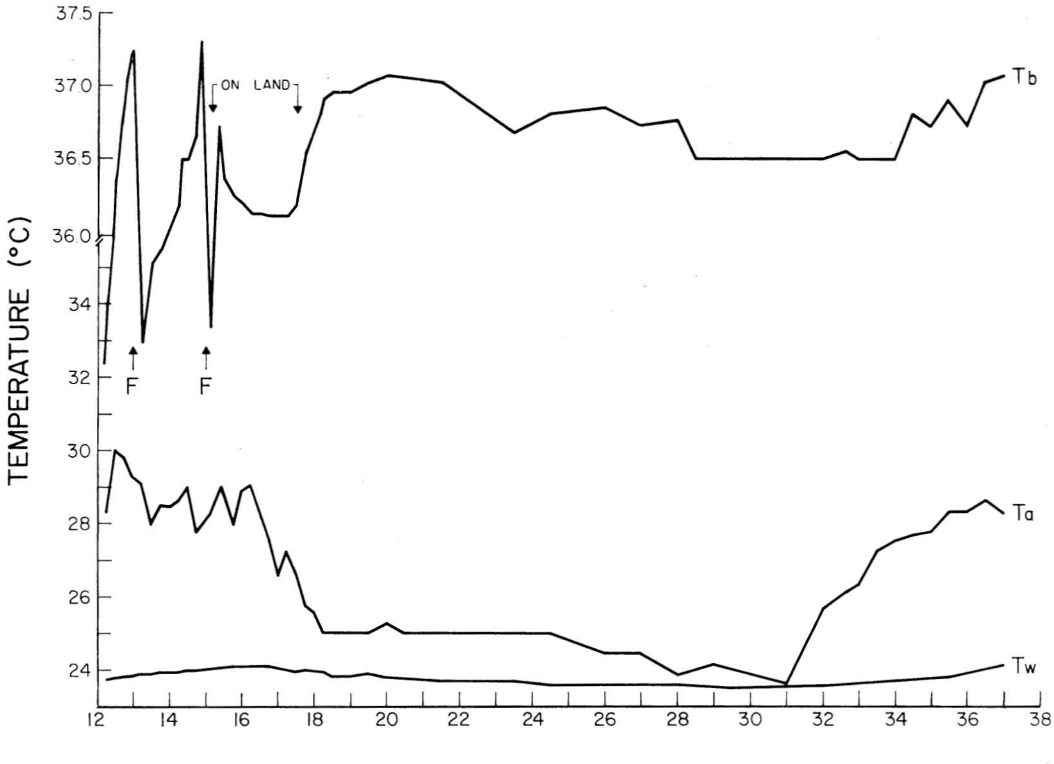

FIG. 2. Body temperature (Tb) of an adult male Hawaiian monk seal in relation to air (Ta) and water (Tw) temperature. F = periods when the seal was fed approximately 5 pounds of fish; "on land" indicates the time when the seal hauled out on a rock. The temperature-sensitive radio pill was fed to the seal at 1200 hours and the time was recorded continuously thereafter.

night the seal appeared to sleep, for periods, in the water. At 0730 the water level in the aquarium began to diminish as the pool was drained, and at 0930 the aquarium was dry. During this time the seal was wet but relatively inactive and its body temperature remained constant at 36.5° C. When the pool began to fill again at 1030, the seal became more active. By 1300 its body temperature had increased to 37.1° C. At this time the experiment was terminated. The pill was recovered from the pool on the following day.

DISCUSSION

The results of this study permit several conclusions to be made. In the first place, the deep-body temperature of an unrestrained adult Hawaiian monk seal (36.8° C) was similar to that of restrained young seals in their natural habitat on land (Kridler, Olsen, and Whittow, 1971). No evidence was obtained in either investigation that Hawaiian monk seals become hyperthermic. The deep-body temperature of the Hawaiian monk seal is similar to that of the California sea lion (Whittow, Matsuura, and Lin, 1970; Whittow, Ohata, and Matsuura, 1971) and the harbor seal, higher than the value reported for the northern elephant seal, but lower than the deep-body temperatures of either Steller's sea lion pups or northern fur seals (McGinnis, 1968; Hubbard, 1968).

Secondly, the diurnal variation of deep-body temperature in the unrestrained seal was 1.0° C. The California sea lion has a similar diurnal range of deep-body temperature (Whittow, Ohata, and Matsuura, 1971). On the other hand, wide variations have been reported in the body temperature of the northern elephant seal (Bartholomew, 1954; McGinnis and Southworth, 1967), while the Steller's sea lion and harbor seal show a considerably smaller diurnal temperature rhythm (McGinnis, 1968).

The third conclusion is that the major cause of variation in deep-body temperature in the Hawaiian monk seal is activity. Similar conclusions were made with regard to the northern elephant seal (McGinnis and Southworth, 1967) and the California sea lion (Whittow, Ohata, and Matsuura, 1971). It is apparent from Fig. 2 that the body temperature of the seal, being more closely related to the animal's activity, could vary independently of the air temperature. The deep-body temperature of the monk seal was highest when the animal was swimming in water and it was lowest when the seal was resting on land, even in direct sunlight. The seal was wet when it initially hauled out on land, and the decrease in its temperature presumably may be attributed to evaporation of water from the skin surface and possibly to a decrease in heat production. However, it is of great interest that even after the seal's skin and hair coat had dried out, its body temperature remained constant until it reentered the water. This raises the possibility that, when the seal was asleep, its heat production was reduced so that the body temperature remained constant in the face of a solar heat load. This may explain why Hawaiian monk seals are able to lie out on the sand in the Hawaiian Islands National Wildlife Refuge for long periods of time in direct sunlight (Kenyon and Rice, 1959). The increased body temperature which occurred when the animal entered the water and swam, in spite of the greatly increased cooling power of the water, suggests either that the energy cost of activity is high or, as seems more likely, that the level at which the body temperature is regulated is higher during exercise.

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