NOCTURNAL DECLINE IN THE TEMPERATURE OF BIRDS IN COLD WEATHER

By LAURENCE IRVING

In temperate climates many birds show a departure from strict homoiothermism in the decline of their body temperature during sleep. In order to determine whether this modification of body temperature is related to climate, I have recorded temperatures of 13 individuals of seven species of birds captured in Alaska and examined on five occasions during cold winter weather at Anchorage. I am indebted to Mrs. Mildred Monson, Mr. John Krog and Dr. Raymond Hock for their help with the measurements.

The temperature of the birds was examined at various hours during January, February and March by insertion of thermocouples through the cloaca. The couples reached deep enough into the birds' bodies to indicate the temperature of central tissues. When the cages were approached at night, the alert gulls raised a commotion and none of the birds remained undisturbed when approached. We did not catch a bird while asleep nor did we find them drowsy. The strong, vicious gulls and Snowy Owls were grasped quickly and all birds were examined before their activity exceeded the state which by day we have called resting but awake.

The following birds were examined: Black Brant, *Branta bernicla* (caught near Hooper Bay, migrates to a warm winter climate); Emperor Goose, *Philacte canagica* (caught near Hooper Bay, migrates to maritime situations with temperature little below freezing); Glaucous-winged Gull, *Larus glaucescens* (caught near Seward, migrates to shores of ice-free waters); Glaucous Gull, *Larus hyperboreus* (caught near Hooper Bay, winters near any open water, even in arctic Alaska); Snowy Owl, *Nyctea scandiaca* (caught near Barrow, where they reside winter and summer); Short-eared Owl, *Asio flammeus* (caught near Barrow, from which it migrates in autumn to mild temperate climates); and Magpie, *Pica pica* (caught near Anchorage, resident through interior subarctic Alaska).

Body temperature at Anchorage by day and night.—The temperatures in the birds' bodies showed no relation to the temperature of the air (table 1). When plotted against hour of the day, the body temperatures at night were lower than by day except for one record of the Glaucous Gull which was as warm at midnight as at midday. Since at 5 a.m. this bird was 2.5°C. cooler than by day, we consider its high temperature at midnight the result of excitement on that occasion.

Stability of the resting body temperature.—The average of daytime resting body temperature differed only a little from the averages earlier reported for those species (table 2). In the measurements of resting body temperature which we have made among birds and mammals in Alaska (Irving and Krog, 1954), the records obtained from numerous individuals of a species could usually be included in a span of about 2°C. Because many measurements were made in the field in arctic winter weather, errors easily add to the appearance of variation in the temperature of individuals. Furthermore, the state of rest in animals is defined by arbitrary judgment of the observer. In setting the variability of the resting body temperature of individuals of arctic species of birds and mammals, we have had to include errors in measurements and estimates of activity. The true natural differences of the resting body temperature of individuals of a species are probably less than the records indicate.

Nocturnal decline in body temperature of birds.—By night the body temperature of birds in temperate regions subsides, as Wetmore (1921) showed in his review of the earlier literature and as has been often recorded subsequently. Udvardy's (1953) rec-

Table 1

Depression of Body Temperature of Birds at Night in Cold Weather
(Depression = mean of day temperatures — coldest observed at night)

	Hour Temperature, degrees centigrade					
	5 a.m.	9:30 a.m.	1 p.m.	9 p.m.	12 p.m.	Depression of body temperature
Air	—20.0	—23.0	— 9.0	—22.0	—16.0	
Black Brant	41.7	41.8	42.7	41.2	41.0	1.3
Emperor Goose	41.7	42.2	42.5	41.0	41.0	2.2
Glaucous Gull	40.2	42.6	42.5	40.0	42.3	2.5
Glaucous-winged Gull	40.4	41.5	42.1	41.2	38.2	4.0
	41.1	42.1	42.2	41.4	38.6	
	41.6	42.1	42.5	41.7	40.6	
		42.1	42.7		41.6	
Snowy Owl	40.2	40.6	41.5	40.2	40.0	0.9
Short-eared Owl	38.8	39.2	42.0	39.9	39.5	2.2
	39.2	39.7	42.2	40.0	39.7	
	39.8	40.6	42.3	40.0	40.1	
	40.3			40.5	40.7	
	40.7				40.7	
Magpie		42.5	42.2	41.0	40.0	2.4

ords of recently captured birds in the laboratory in Sweden show examples of body temperatures declining during sleep and rising when awakening. In the warm climate of southern California, Dawson (1954) showed nocturnal depressions of temperature amounting to nearly 3°C. in Abert and Brown towhees (*Pipilo aberti* and *Pipilo fuscus*). His records with thermocouples implanted in the breast musculature show the steadiness and distinction of the night and day temperature levels.

The measurements at Anchorage were made at times of cold weather. The resting body temperatures of the birds by day conformed with earlier measurements and bore no relation to the temperature of the air. The lowest temperatures observed at night in the several species were from 0.9°C. to 4.0°C. cooler than the average temperatures during the day. These are of the order of the night depressions observed among birds in temperate regions and there is no indication that the variation between night and day temperatures is related to life in the cold winter climates of Anchorage.

The decline of body temperature at night is not obligatory upon birds in all climates, for Bartholomew and Dawson (1954) and Dawson (1954) found that during experimental exposure at 39°C. their birds failed to cool off as much at night as in cooler air. Apparently in birds body temperature may remain above customary levels by night or by day when hot weather requires all means to be used for the dissipation of heat.

Table 2

Resting Body Temperatures of Birds

	Irving and Krog, 1954		Present Series	
	Number of records	°C. records	Number of records	°C. records
Glaucous Gull	3	42.1	2	42.2
Glaucous-winged Gull	11	41.7	8	42.2
Snowy Owl	4	40.9	2	40.9
Short-eared Owl	13	41.2	6	41.0
Magpie	3	41.5	2	42.2

Diurnal rhythm of activity among arctic owls.—As I have seen them on the tundra in arctic Alaska, Snowy and Short-eared owls are active by day in summer. In winter, I have only seen Snowy Owls by daylight, when they are certainly active. In the wooded parts of arctic Alaska in summer, I have frequently seen Horned and Hawk owls active during the day. In spring and autumn the activity of Horned Owls extends into twilight later than does the activity of common diurnal birds. The captive owls, when undisturbed, were still at night and awake by day, and their temperatures ranged about as would be expected among birds which rest at night in lower latitudes. None of our birds was noticeably easier to catch at night than by day. Although most of them were distinctly cooler at night, we did not notice them to be drowsy at the depressed nocturnal temperatures.

Elevation of body temperature during activity.—We have found that wild birds killed instantly during vigorous exertion, or captive large mammals which could continue violent struggles against restraint, were sometimes 2°C. warmer than their average temperature when at rest (Irving and Krog, 1954). Wetmore (1921) remarked upon the warming of birds in a temperate climate during their vigorous exertion. The average temperatures in small petrels (*Pachyptila turtur*) returning from fishing at sea to their nesting place on an island off New Zealand was on the average 41.5°C.; when these birds were active about their nesting burrows it was 39.9°C., and when incubating, 38.6°C. (Farner, 1955). In Sweden, Udvardy (1953) showed elevations of body temperature in active birds and declines during rest after activity. These birds were comparable with ours in being species of a northern avifauna but their body temperature was not examined in relation to cold weather.

Probably the warming of active birds is comparable to that which occurs in active man, for whom the highest temperature that I have seen reported was 4°C. above the resting level in champion distance runners after a long race (Robinson, 1953). Marius Nielsen (1939) has shown that the elevation of human body temperature by activity is related to the rate of working and unrelated to variation in the temperature of the air.

Discussion.—In sleep the body temperature of man declines (Deighton, 1933) although not as much as is commonly seen among birds. In each species of warm-blooded animals there is apparently a level of body temperature which is maintained during sleep and another which is held in a wakeful state of rest, but during activity the temperature rises toward some limit set by the animal's metabolism.

Among birds the normal range in temperature from sleep to waking activity is, according to the figures quoted, some 6°C. It may be even greater in some species, and the thirsty camel in the Sahara may warm from 34°C. in the cool desert night to 41°C. during a hot day. These variations in body temperature occur normally, although with specific differences, in birds and mammals possessing effective regulation of their heat balance. It is interesting to consider these examples indicating that homoiothermous animals normally effect regulated changes in body temperature which are so large that they would be considered dangerous symptoms if they were observed during fever or as a result of exposure to cold.

SUMMARY

The body temperature in seven species of birds captured in Alaska and held in captivity at Anchorage was examined at various times of day. In winter air temperatures between −9°C. and −22°C., the body temperatures by day were about those reported for these species on warmer days. At night they were from 0.9°C. to 4°C. lower. The night-time decline in body temperature was similar to that reported to occur in tem-

perate climates. Considering that activity can elevate body temperature some 3°C. above that at rest, it is apparent that homoiothermous animals change body temperature in sleep, waking rest, and activity in cold as in temperate weather.

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