TEMPERATURE CHANGES IN CHIMNEY SWIFTS (*CHAETURA PELAGICA*) AT LOWERED ENVIRONMENTAL TEMPERATURES

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There are many references concerning torpor in the Chimney Swift (*Chaetura pelagica*). Storer (*in* Marshall 1960) stated that they can compensate for the great output of energy (required by their almost constant flight) by becoming torpid at night. McAtee (1947) gave many accounts of inactive swifts and stated that "torpidity from brief to extended periods is possible," and that "under favorable circumstances, hibernation seems a possibility." Berger (1961) stated that hibernation is known in Chimney Swifts. Lack (1956) referred to the discovery in December 1879 of a group of seven Chimney Swifts "stowed away" in an unused stove pipe in New York state.

Hypothermia and hibernation have been found in other species of swifts and in related birds. Koskimies (1948) found that European Swifts (*Apus apus*) became temporarily poikilothermic, or torpid, when deprived of food. White-throated Swifts (*Aeronautes saxatalis*) have been shown to become torpid when exposed to both cold and starvation (Bartholomew et al. 1957). Members of various genera of hummingbirds (Pearson 1950, 1953; Howell and Dawson 1954; Lasiewski 1963) and Poorwills, *Phalaenoptilus nuttallii* (Bartholomew et al. 1957; Howell and Bartholomew 1959, and references cited therein), exhibit true hibernation with hypothermia. Lesser Nighthawks, *Chordeiles acutipennis* (Marshall 1955), and colies, *Colius* (Huxley et al. 1939), apparently become torpid.

With this background of reports of torpor in the Chimney Swift and of the demonstration of hypothermia among its relatives, the present study was undertaken to determine whether the body temperature of the Chimney Swift changes during periods of lowered environmental temperatures.

METHODS AND MATERIALS

Swifts for this study were obtained after they had settled to roost for the night in a large chimney on the Oklahoma State University campus during the spring, summer and fall of 1964. A 46-oz juice can with a bale and a long cord, as described in Fischer (1958), was used to catch the birds, but most of them were obtained by making noise low in the chimney with this can and capturing the birds as they flew to the top of the chimney. The first ones were caught either in the can or by hand as they flew by. An ordinary fishing dip net proved quite successful for capturing the birds as they flew from the mouth of the chimney.

The Adult Chimney Swifts used in this investigation were held overnight in a small cage in a room away from any activity. Each bird was weighed on a platform balance and the weight recorded to the nearest 0.1 g. A band was placed on the bird for identification purposes.

During testing each bird was held immovable on a 0.5-inch mesh wire screen in a comfortable resting position by clipping the rectrices and outer primaries to the screen with an alligator clip and tying a narrow ribbon across the back of the bird twice so that it made a cross on the back of the bird. The bird could move the proximal portion of the wing and the head, but its shoulders and body were held securely against the screen. Although the test birds were restrained, and therefore under some physiological stress, their general posture was that of a resting swift, and nearly normal fluffing of feathers for heat conservation was possible. Any movement of the head or wing was visually noted and recorded during the progress of the experiments.

The birds were placed in a closed chamber equipped to supply oxygen to the bird as needed. Temperature readings were made using a thermistor inserted 10 mm into the cloaca and held in place by an alligator clip to the rectrices. Body temperatures were determined to the nearest 0.1°C using a Tele-Thermometer Model 40B124. No change in the temperature of the environment was made until the bird had been in the chamber at least 30 min.

The chamber was cooled by packing ice and salt around it. Environmental temperatures were measured with a mercury thermometer, the bulb located approximately 8 cm from the bird. The relative humidity in the chamber was controlled by the use of calcium chloride.

Observation was continuous with periodic recording of environmental temperature and bird body temperature. These readings were taken at intervals of 1–6 min, depending upon the rate of change in either reading. Readings were continued until the bird became torpid, or until it had been under observation for 12 hr without significant change.

Data were collected at the same time each day (beginning near 10:30) under constant subdued lighting conditions. The birds used as controls were observed until late at night to determine whether there might be any changes due to daily cycle of oxygen uptake.

Four birds were subjected to an environmental temperature of –5°C; four were held at 0°C, five at 5°C, five at 10°C; and two served as controls and were kept at room temperature (approximately 25°C) for the duration of the experiment. One bird was subjected to successive temperatures as follows: 5°C for 1.5 hr, 0°C for 0.5 hr, and –5°C for 4 hr. Another

The Condor, 72:225–229, 1970

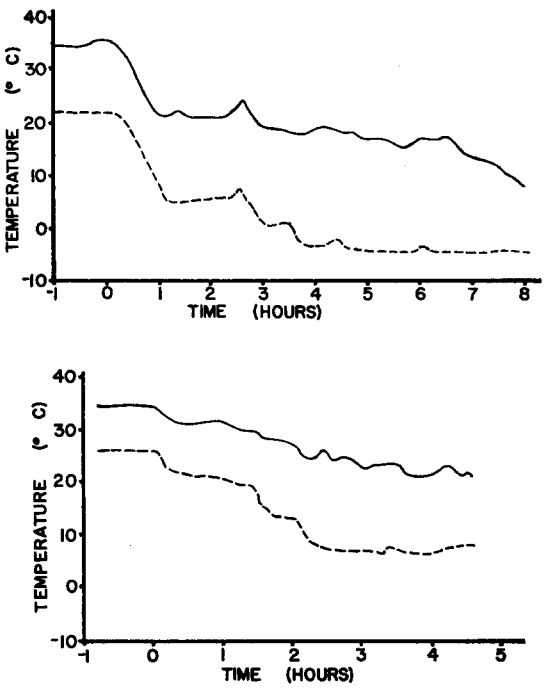

FIGURE 1. The relationship between environmental temperature change and body temperature change in two Chimney Swifts exposed to various levels of colder environments. Solid lines represent body temperature of the birds, while the broken lines represent ambient temperature. Upper graph, bird no. 028; lower, bird "N."

bird was held at 20°C for 45 min, 15°C for 0.5 hr, and 5°C for 2 hr.

Birds were released after experimentation, some after being held over night (approximately 34 hr), others approximately 17 hr after capture. Attempt was made to feed some of these birds, and five birds were held for four days in feeding trials, but they continually lost weight and died, showing no indication of torpor.

RESULTS AND DISCUSSION

Control swifts, held at room temperature (about 25°C), showed no fluctuation in body temperature (35°C) although the birds had had no food for at least 28–30 hr. Although lack of food, if continued, might cause changes to be evident, this period of time was sufficient to show that lack of food alone could not be the cause of variation in body temperature which might be noted up to 20–30 hr.

Two birds were subjected to various stages of cooling for short periods of time. The ambient temperature was slowly lowered on the first experimental bird (no. 028) to 5°C. During this slow cooling of the environment, the body temperature of the bird dropped 15°C as compared with a 17° change in environmental temperature (fig. 1). Subsequent cooling produced only slight variations in the

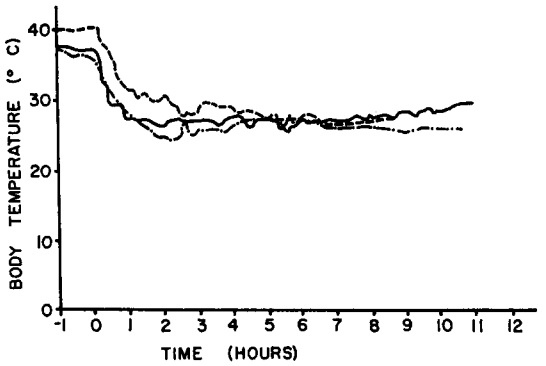

FIGURE 2. Body temperatures of three of the five Chimney Swifts exposed to 10°C ambient temperatures. Zero hr is the time at which ice was added around the chamber (broken line = bird no. 428, dash-dot line = bird no. 007, and solid line = bird no. 037).

body temperature of the bird until torpidity was reached about 8 hr after the cooling began.

While in torpor, this bird, like the others that became torpid, had no visually noticeable respiratory movements and gave little or no response to external stimuli. Its posture was hunched, giving the peculiar "pointed up" tilt to the head, and the eyes were closed. It gradually began to recover from this torpor after a few minutes at room temperature. The first sign of recovery was a single, slight, apparently convulsive breathing movement. These movements were repeated at closer intervals, and slight shivering movements were noted. The eyes sometimes opened during this time, but responses to stimuli were slight. Breathing movements came closer together and finally the bird appeared to be normal and flew normally when it was released.

A second bird (unbanded "N") was cooled in smaller increments of temperature change. The ambient temperature was lowered to 20°C, then to 15°C, and finally to 5°C. During this environmental change the bird exhibited similar body temperature changes, dropping a total of 13°C as compared with a drop of 20°C in environmental temperature (fig. 1).

The body temperature of birds exposed to ambient temperatures of 10°C dropped an average of 11°C. This drop in temperature was almost immediate upon the lowering of the ambient temperature, and remained relatively stable (varying a maximum of 3°C) in a 10-hr period (fig. 2).

Another group of birds was held at an environmental temperature of 5°C, and their body temperatures dropped an average of 13°C. The body temperatures fluctuated much

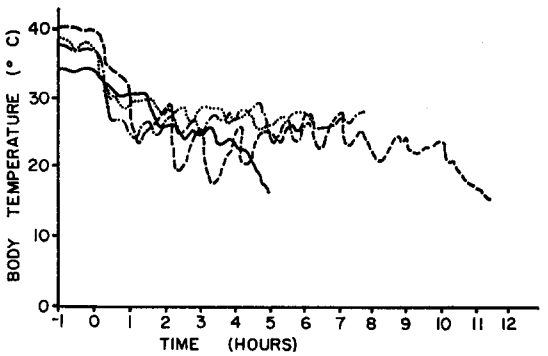

FIGURE 3. Body temperatures of four of the five Chimney Swifts exposed to 5°C ambient temperatures (broken line = bird no. 034, solid line = bird no. 001, dotted line = bird no. 010, and dash-dot line = bird no. 012).

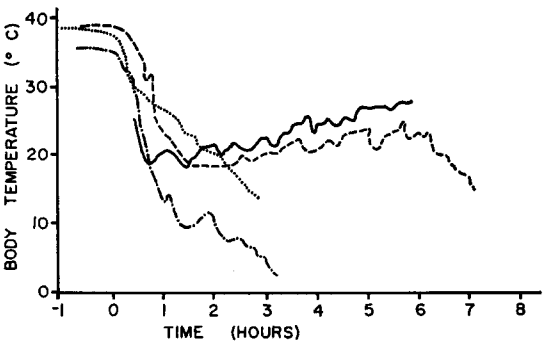

FIGURE 4. Body temperatures of the four Chimney Swifts exposed to 0°C environmental temperatures (broken line = bird no. 033, dash-dot line = bird no. 031, solid line = bird no. 023, and dotted line = bird no. 016).

more at this ambient temperature, varying as much as 12°C and ranging from 29 to 17°C during the time of low environmental temperature (fig. 3). One bird (no. 001) became torpid at this temperature, with a body temperature of 16.2°C, as compared with a body temperature of 34.5° at an environmental temperature of 21.0°C. Another bird (no. 034) also became torpid at 5°C ambient temperature with body temperature of 15.8°C, as compared with 40.3°C at 27°C ambient temperature.

Each of the birds that became torpid at an ambient temperature of 5°C was released after regaining its vitality at warmer temperatures. Each one flew normally and each was joined almost immediately by two or three other Chimney Swifts in the area, and they flew away together. Torpidity occurred after periods of exposure to this test temperature of 5 hr for no. 001 and 11 hr for no. 034. Two other test animals did not show torpidity at this temperature. These birds' temperatures dropped 8–10°C and varied around this temperature but never fell to the lower point (fig. 3).

Three of the four birds exposed to an ambient temperature of 0°C exhibited torpidity and one of these torpid birds died subsequently. The fourth bird, however, underwent a temperature drop of approximately 20°C almost immediately and then gradually its temperature rose from about 20°C up to 28°C over a period of about 5 hr (fig. 4).

The birds showing torpidity at 0°C (nos. 016, 031, and 033) had body temperatures at the end of the experiment of 13.2, 3.0, and 17.6°C, respectively. Corresponding data at the beginning of the experiment were 38.2, 35.3, and 38.4°C, respectively. One of these (no. 031) had a body temperature which varied between 13 and 8°C for a period of 100 min before its body temperature dropped to 3°C. At this point the bird was removed from the chamber and examined. It was alive, as shown by a slight spontaneous movement of the head in response to tapping of the bill region, but it ultimately died. The other two birds (nos. 016 and 033) became torpid after 3 and 7 hr, respectively, at the lowered temperature. These two birds, as well as the one which did not show torpidity, were released successfully.

Three birds (nos. 020, 025, and 040) placed in environments of –5°C became torpid after 1.5, 3, and 2.5 hr, respectively, at cold temperatures. They recovered and were released. Another bird (no. 027) died after about 90 min at temperatures below 0°C. The three birds that became torpid had body temperatures of 14.9, 14.8, and 10.7°C, respectively, at the end of the experiment. Similar figures at the first of the experiment were 40.4, 40.2, and 40.3°C (fig. 5).

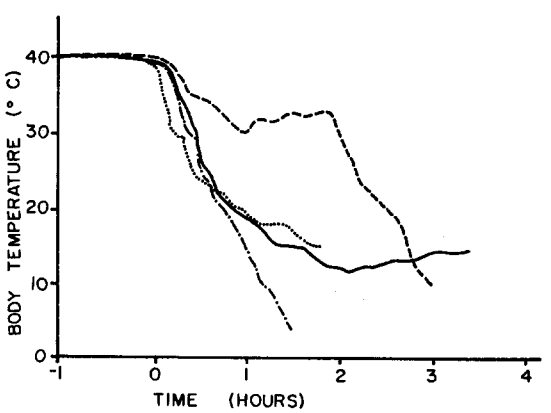

FIGURE 5. Body temperatures of the four birds exposed to –5°C ambient temperature (dotted line = bird no. 020, solid line = bird no. 025, dash-dot line = bird no. 027, and broken line = bird no. 040).

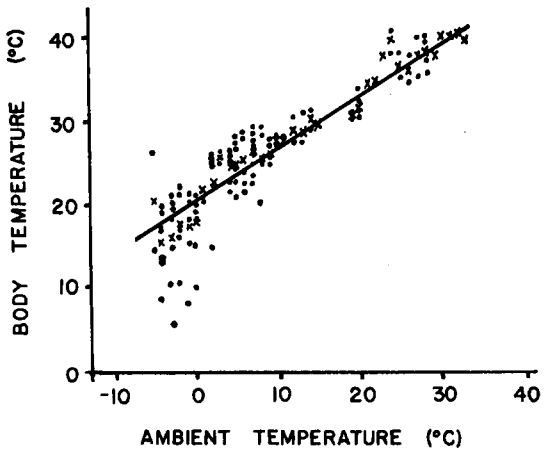

FIGURE 6. The relationship between ambient and mean body temperatures. Each dot represents the mean body temperature of one bird at that ambient temperature; each x shows the mean of all birds at that ambient temperature.

In order to determine the relationship between body and environmental temperatures, the data for each bird were examined and an individual mean body temperature was computed for each degree of ambient temperature available in that particular bird's data (no bird's temperature reading was included if the body temperature was changing markedly). From these individual means an overall mean body temperature was obtained for each degree of environmental temperature from –5 to 33°C. This relationship is presented in figure 6.

The line drawn in this figure was obtained by the method of least squares, and the equation of this simple linear regression line is:

$$T_B = b_1 T_A + b_o,$$

where $b_o = 20.4$ and $b_1 = 0.64$. These values of slope and intercept were obtained using the Abbreviated Doolittle Method as outlined by Ostle (1963). The birds' body temperatures drop with decreasing ambient temperature; but not as rapidly as the environmental temperature. The slope of the line is therefore less than one.

Variations in the body temperatures of birds have been reported, but these variations are relatively small. Simpson and Galbraith (1905) observed that diurnal variations of the temperatures of small birds were greater than those for large birds (ducks varied 0.92°C, while thrushes varied 4.27°C during a day's time). Doves were exposed to environmental temperatures of 5, 23, and 39°C, and 24-hr records of body temperatures were obtained by Bartholomew and Dawson (1954); daytime temperatures approximated 41.5°C and nighttime temperatures were about 2° lower. Udvardy (1955) and Irving (1955) reported studies of bird temperature variations in the Arctic and in Alaska. Irving reported on seven species of birds and found that at ambient temperatures of –9 and –22°C the daytime body temperatures were about the same as those reported for these species on warmer days; at night they were from 0.9 to 4.0°C lower. Dawson and Tordoff (1964) reported that the body temperature of crossbills ranged between 38.5 and 40°C, even though the ambient temperature was –15 to 28°C. The body temperature of the Common Nighthawk (*Chordeiles minor*) was reported by Lasiewski and Dawson (1964) to vary only 6°C even though the environmental temperature varied from 2 to 35°C.

The Chimney Swift showed a much greater variation in body temperature than did any of these other species. Considering only birds that survived, body temperatures ranged from 41 to 10.5°C in the swifts.

The rate of warming of the torpid bird was approximately 0.6°C/min when exposed to room temperature. This value may be compared with a rate of about 0.4°C/min for the White-throated Swift (*Aeronautes saxatalis*) reported by Bartholomew et al. (1957).

SUMMARY AND CONCLUSIONS

Chimney Swifts were placed in a chamber where cloacal temperatures were recorded for environmental temperatures of –5, 0, 5, 10, and 25°C. The birds were held so that movement inside the chamber was impossible.

Chimney Swifts were found to exhibit a condition which is far from homeothermous. The body temperature of these birds changed almost immediately with lowered ambient temperature, and a direct relationship existed between environmental and body temperatures. The slope of the line representing this relationship was 0.64. Body temperatures in this investigation ranged from 41.0 to 10.7°C. At ambient temperature of 30°C, the mean body temperature was near 40°C, while at 0°C ambient temperature, the average body temperature dropped to 20.5°C.

When these birds were subjected to cold, their body temperatures dropped, and eventually a state of torpor was evident. No movement was noticed, and no response to ordinary stimuli could be noted. After a few minutes at room temperatures, however, the birds began to breathe slowly, and gradually returned to a lively condition. In recovery from torpor, the rate of warming was approximately 0.6°C per min.

ACKNOWLEDGMENTS

I wish to thank F. M. Baumgartner for his guidance and suggestions throughout the course of the project. His positive attitude and encouragement have been greatly appreciated. The author is especially grateful to W. S. Newcomer for his suggestions and help in designing the equipment used and for advice during the experimentation. Appreciation is expressed to G. A. Moore, B. P. Glass, and T. C. Dorris for their help in obtaining equipment. An expression of gratitude goes to R. A. Hultquist who aided in the analysis of data, and to those who helped in the preparation and editing of the manuscript: F. M. Baumgartner, A. M. Stebler, B. P. Glass, and W. S. Newcomer. Finally, I wish to thank my wife and family for their patience and help throughout the course of the project.

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Accepted for publication 24 March 1969.