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HIBERNATION IN CAPTIVE GOATSUCKERS

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Since the discovery of hibernation (Jaeger, 1948, 1949) in the Poor-will (*Phalaenoptilus nuttallii*) only one additional naturally hibernating bird of this species has been found. The rarity of such finds despite efforts to locate the well concealed birds may justify presentation of the following observations which, allowing for artificial conditions involved, seem to establish the capacity for hibernation in the Trilling Nighthawk (*Chordeiles acutipennis*). There are provided also very low body temperatures for live Poor-wills. I am indebted to H. Broadbooks, W. H. Brown, C. H. Lowe, Jr., and Mrs. C. V. Perrin for materials and to J. Brauner, R. J. Hock, and Dr. Lowe for helpful suggestions. Temperatures were taken with a rapid-adjusting Schultheis mercury thermometer and are presented in degrees centigrade.

TRILLING NIGHTHAWK

Mrs. Clarence V. Perrin of Tucson, Arizona, kept two young Trilling Nighthawks, which had been found each with a broken wing, from July to November, 1950, in an unused room of her home. The birds lived in a small cage and were given by hand all they wanted to eat and drink. Venetian blinds shuttered this room, which was unheated and generally unilluminated at night. Thus there was an obvious difference in light between day and night. Mrs. Perrin states that for two or three days prior to November 29, the nighthawks were drowsy and occasionally dropped asleep in the middle of their meal. They were awake and took a little food on the evening of November 28. Mrs. Perrin found them both in a dormant state about noon the next day. At 6:15 p.m., at room temperature 18.7°, I recorded their oral temperatures as 18.6° and 19.2°. Unfortunately, I attempted to warm the birds and the sudden application of heat from an electric bed-pad proved a mortal shock to both. One reached an oral temperature of 35.7° at 9:45 p.m. and died the following morning. The other reached 38.9° on November 31, became dormant at 15.7° (oral) on December 5, and died the next day. Great deposits of fat on both birds suggest that they were in good health on the 29th, although neither had been able to fly. The deposits also suggest a normal preparation for hibernation and that their torpor was probably not the result of disease.

There are a few midwinter records of this species in the southwestern United States: Phoenix, Arizona, December 27, 1897 (Bent, 1940:253); Long Beach, California, January 31, 1911 (Dawson, 1916:26); Calexico, California, January 23, 1922 (Howell, 1922:97); Menager's Dam, Papago Reservation, Arizona, January 6, 1940 (Monson and Phillips, 1941:109). At least one (Menager's Dam) pertains to a bird active in a spell of warmth during a cold winter. The record from Calexico, however, is of a bird active during a cold period, with freezing temperatures at night. Conceivably the few Trilling Nighthawks which remain here may be dormant during cold portions of the winter.

POOR-WILL

Three fully grown wild Poor-wills were captured in the fall of 1950 near Tucson, were observed during the winter, and were released in good condition the following

spring. They were kept in a shed with screen on the east side, through which the sun shone in the morning. They flew at dusk, huddled together on the ground at night, and slept side-by-side on a log during most of the day. On sunny mornings they followed the patch of sunlight along the sand floor. They never caught their own food, although I attracted hordes of moths into the shed with a light. For several weeks in October, following their capture, it was necessary to force-feed these birds. At length two of them changed to taking food voluntarily from my hand and were fed all they would take. The brown immature Poor-will continued to be force-fed through the entire experiment, with the amount taken by the others serving as a guide to quantity.

During their first three months of captivity the Poor-wills were constantly fed, and they showed no sign of dormancy. On December 28, the first freeze of the winter, an experiment began wherein food was withheld from one or two birds at a time. The others

Fig. 1. Two Poor-wills in the shed at 10 a.m. on February 26, 1951. The dormant gray adult (right) has just been moved out of the shade to be photographed; it has already relaxed the extreme posture of hibernation; it was fully awake by 11:30 a.m. The wide-awake brown immature (left) had been plentifully fed for several days. Photograph by H. Broadbooks.

were fed and they remained active no matter how cold the weather. The unfed birds became torpid, for periods of a half-day to four days, at various times from December 29 to March 8, 1951. Because of the low body temperature (6.0° to 17.5° rectally) the term *hibernation* as defined by Hock (1951:289) may apply to these short dormant periods. Respiration was not evident. In the gradual process of waking, the birds exhibited sudden periods of slow, labored breathing of about 40 respirations per minute at body temperatures around 14° to 20°, alternating with periods when no respiration was detected. Eventually they worked into rapid, shallow breathing of 78 to 82 per minute at body temperatures of 20° to 24°. I have 9 records of rate of respiration, based upon movement of the feathers, for resting birds awake which range from 50 to 67 per minute at body temperatures from 37.2° to 40.0°. Such estimates are easily thrown off by the birds' habit of rocking from side-to-side when approached.

The brown adult Poor-will hibernated on January 14 and 15, and February 3 and 4; all periods were of a half-day. The brown immature (with the tail and most of the wing in the juvenal plumage) hiberated 13 times: December 29, probably 30, 31 to January 1, January 2, 4, 5, 6 to 7, 8 to 10, 12 to 15, 16, 21, February 3, 23. The gray adult had 10 half-day periods of torpor: February 23, 26, and every day from March 1 through 8.

The following representative observations (table 1), my most complete for a single period of hibernation, pertain to the brown adult dormant on the cold clear day of February 3 and portray the amount of activity possible at different body temperatures during its awakening due to handling. The minimum and maximum air temperatures in the shed that day were —3.5° and 22°; these air temperatures were taken a few inches above the sand floor on the shady side, as were all other air temperatures to follow. Except when not fed, this bird had previously maintained a weight of around 44 and 45 grams. It was last fed on the morning of January 31 (partly rainy, air temperatures 0° minimum to 12° maximum). On February 1 (clear, air temperatures —2° and 13°) the bird was active, and its plumage was all fluffed out at 7:45 a.m., when it weighed 39.1 grams. On February 2 (clear, air temperatures —4.5° and 16°) it was still active.

Table 1

Hibernation and Awakening of Poor-will on February 3

Time	Temperature Air	Temperature Rectal	Respirations per minute	Activity and weight
7:00 a.m.	—2.0°	6.2°	not detected	dormant; called *coo* and stretched wings when handled
7:10 a.m.		6.8	not detected	dormant
7:50 a.m.	—1.0	6.0	not detected	dormant
11:20 a.m.	14.5	13.0	not detected	dormant; squawked
11:40 a.m.			39 labored	dormant; shivered wings a little; moved head with effort at each breath; weight 36.2 gm.
12:00			not detected	dormant
12:04 p.m.			82 shallow	dormant
12:07 p.m.		23.3	78	eyes slightly open
12:35 p.m.	17.0	34.4		eyes open; hissed, grabbed and swallowed food; fell when dropped, could not fly
1:45 p.m.	19.5	37.5		ate; could fly
6:30 p.m. (dusk)	13.0	39.0	50 (seen only after struggle taking temp.)	active

Inducing hibernation.—The warmest day during the morning of which an unfed bird hibernated was March 8 (9° minimum to 28° maximum), when the gray adult was dormant and the brown immature was active and full of food. Conversely, the coldest days at which a full bird did not hibernate and a hungry bird was simultaneously dormant had such temperatures as —3° to 13° (January 1), 0° to 12.5° (January 12),

—5° to 22.5° (March 4). Low temperature, therefore, appeared not to induce torpor directly, although it helped maintain that state once it began.

On the other hand, lack of food and low body weight directly influenced the attainment of torpor. No bird became torpid without first having lost around 20 per cent of its weight through having its food withheld. This drop occurs in the 2 or 3 days between the last feeding and the attainment of torpidity. (Since the birds did not hibernate on the scales, and since they would eventually waken if moved to the scales, I could get no more than one weight per hibernation period. The expected extremely slight loss of weight in deep torpor was therefore not detected.) For instance, the brown adult's hibernation of February 3 followed a drop from about 44 gm. on January 31 (43.5 gm. on January 24) to 39.1 gm. the following day, and to 36.2 gm. on the day it was torpid. It was harder to keep the brown immature's weight up, and it would begin hibernation after only a day or two without food, since it would start from a weight lower than 44 gm. to reach 36 gm. The gray adult was last fed on January 1 when it weighed 48.3 gm. and it came down to 39.9 gm. by January 4 with no hibernation. This gentle and lovable pet, whose plumage (fig. 1) was unusually gorgeous, cried so piteously for food that I relented, and it was not until later that another attempt was made to produce dormancy in it. This bird "hibernated" every morning from March 1 through 8 after its weight had been reduced through previous withholdings of food to around 38.5 gm. (March 1). It was not awake long enough to eat enough to prevent torpor each subsequent morning, and I finally forced greater quantities upon it beginning March 6 in order to bring it out of an apparently vicious cycle.

The following summary may clarify the relation of weight to torpor:

	Brown adult	Brown immature	Gray adult
Capture in fall (fat?)	51.4 gm.	42.9	44.8
Maximum	51.4	45.2	48.3
Beginning of experiment, Dec. 28	44.4	44.0	47.2
Release in spring	44.1	44.8	42.3
Minimum without torpor	39.1	38.1	38.4
Minimum after torpor	36.2	36.0	38.5

Whether or not the birds had any fat may perhaps be deduced from these weights of fall specimens collected in Arizona by the author:

JTM 4124 ♂ ad Sabino Canyon Rd., Tucson, Sept. 28, 1950, found dead in road same time and place as brown adult captured, stomach full, no fat: 40.0 gm.

JTM 4258 ♂ Catalina Mts., 6000 ft., Oct. 12, 1951, stomach full, skin stretched tight over enormous deposits of fat, about 4 mm. thick over thighs and rump: 50.0 gm.

JTM 4265 ♀ im Guadalupe Canyon, Cochise Co., Oct. 20, 1951, moths in stomach, immense deposits of fat including body cavity: 55.7 gm.

Another, same time and place as 4265, caught alive and released later: 58.0 gm.

Time and position during dormancy.—The only record I have of inception of dormancy is for the brown immature: in a rigid posture but with its eyes still open at 2:30 a.m. December 30, oral temperature 26°, air 7°. Generally a bird in deep hibernation at dawn would have been active through the previous evening before midnight. If it was going to awake that day, it would be back to normal around noon, because of the sun shining in the shed much of the morning.

The brown adult chose no particular place for hibernation but seemed to "fall asleep" wherever it happened to be; it usually huddled against the other two in the middle of

the floor. The brown immature on the other hand definitely selected a place each time, namely, on the sand floor, either leaning against the wall of the shed or wedged between the wall and a sack of chicken feed. One night at 10 it seemed drowsy, crawled into a hole under a log, and shut its eyes. However, at 7:45 the next morning, January 16, it was hibernating in its usual place behind the sack. The posture in deep hibernation was more extreme than figure 1 indicates, for the bird shown had been disturbed and was beginning to revive. Before being moved, its head had been nearly vertical, with the bill down among the breast feathers.

Causes of awakening from torpor.—Any handling of the dormant birds, as in weighing, taking temperature, or moving to photograph, caused them to become fully awake and active within a few hours, *regardless of the environmental temperature.* Some of the hibernation periods would have been a day or two longer if the birds had not been disturbed. But they would have been wakened eventually under the conditions in the shed because of the warmth from the sun and protection from circulation of the air. Furthermore, there was no series of more than three cloudy days in a row. The brown immature Poor-will's longest period of torpor came about by a combination of cloudy days plus its retreat to the coldest part of the shed, behind the feed sack, so as to be shielded from the sun when it did shine. It "slept" right through a day's maximum of 12.5°. Another day, a maximum temperature of 19.5° was the only known cause that aroused the bird from hibernation. I suspect therefore that temperatures around 20° suffice to awaken these birds, but a Poor-will in natural surroundings would be less likely than the experimental birds to be wakened from this cause because it would be under a log or in a rock cranny, pressed against cold surfaces. Upon awakening the Poor-wills were wilder and more active than usual; perhaps this is connected with an acute need to secure food.

Body temperature.—Whether the Poor-wills' temperatures were 37° to 38° or around 40° seemed to depend merely on what recent exercise they had, regardless of the time of day. On the morning of March 22 two birds had temperatures of about 37½° while inactive. But after five minutes of continuous flight both were 40.5°. They subsided to 38° and 39° during 25 minutes of rest. Series of temperature readings over 24-hour periods therefore showed a peak at dusk, for the birds voluntarily flew at that time. This was in the first part of February. By later February and March they had become so dependent upon hand feeding that they gave up even the activity at dusk, and the 24-hour temperature record showed no peaks. (One might wonder how they fared when released. Apparently they reverted to former habits, for they became very wild and intolerant of my approach immediately upon finding themselves in the foothills again.) The temperature records of Brauner (1952:fig. 3) and of Miller (1950) could be interpreted on this basis, which allows us to expect the two peaks of elevated temperature at dawn and dusk of dark nights just as the bats (*Myotis*) studied by Pearson (1947:135) have their highest metabolism at those times. But additionally we should obtain high temperatures for Poor-wills active through moonlit nights. Thus specimen no. 4258, mentioned earlier, collected at midnight, full moon, had been foraging constantly as indicated by the direction of its frequent *quup* calls. It had a temperature of 40.8°, with the air temperature at 13.5°. But the *live* bird mentioned in the same tabulation was 38.6° rectal (air 19.0°) at 11:50 p.m. when it was caught. It had been just sitting for hours in a wash on this dark night. Its temperature might have been lower had it not flown 100 yards after being missed with the first sweep of my butterfly net.

In the early part of the experiment the wakeful birds appeared to maintain tem-

peratures at least in the high 30's, regardless of ambient temperature, as noted by Brauner (*op. cit.*:155). Therefore the regular daily (or nightly) loss of control of body temperature shown by bats (Hock, *op. cit.*) and by hummingbirds (Pearson, 1950) was not evident. But later a few records around 33° and 34° were obtained, at various air temperatures. This is insufficient to prove metabolic affinity to the hummingbirds, which were more aptly studied by measuring oxygen consumption (Pearson, *op. cit.*). But such affinity seems demanded by Miller's (*op. cit.*:42) observation of a wild Poor-will (able to fly) roosting on a fairly warm but rainy day at the astonishing temperature of 34.0°. Of course ambient temperature influenced the depth to which body temperature of torpid birds could descend, as shown by the minima I happened to obtain for the three captive birds, respectively: 6.0° rectal at —1° air temperature, 8.5 rectal at 7° air, and 10.2° rectal at 5° air.

DISCUSSION

Of the two species of captive goatsuckers studied, the nighthawks, in my opinion, approach closer to conditions which might be expected in nature, for they were fat and their dormancy was synchronized as if part of a prescribed annual cycle. Since change in day-length was sensible to the birds, perhaps it governed entry into this stage. It was timed for a period when nighthawks outdoors might find little food. This cyclic interpretation of the supposed hibernation is further strengthened by its taking precedence over the continued food supply and mild temperatures.

One may speculate that the Poor-wills lost or failed to accumulate their fat during the weeks of forced feeding. Thus they might have operated upon slim margins of fuel in the hibernation experiment, a view supported at least by the low weight at which they hibernated. The unfed birds, with too little fuel to support activity on cold mornings, became dormant. Warmth later in the day roused them. They awoke in a snarling and voracious condition, as if forced to heightened activity to prevent starvation.

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