ENERGY CONSERVING AND HEAT DISSIPATING MECHANISMS OF THE TURKEY VULTURE

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THE Turkey Vulture (*Cathartes aura*) is noted for its ability to thrive in a wide variety of climates (Bent, 1937). It nests successfully in arid deserts of the southwestern United States, in warm swamps of the southeast, and in the more moderate climate of New England. It winters as far north as Pennsylvania, where it is exposed to severe winter weather. During some winters a few Turkey Vultures are found well north of the usual winter range (Cooke, 1888; Jackson, 1903; Norton, 1911; Walkinshaw, 1930; Bent, 1937; Bagg and Parker, 1951, 1953; Talmadge, 1954).

It might be expected that Turkey Vultures, living and breeding in such varied environmental situations, would have unusual thermoregulatory mechanisms: those that permit them to maintain a low body temperature in hot humid areas where the effectiveness of evaporative cooling would be reduced by the high humidity; those that enable them to keep the body temperature low and at the same time conserve body water in desert areas where free water is rare; and those that enable the vultures to conserve body heat when exposed to the severe winter weather in the northern parts of their winter range.

Some recent literature leads one to think that vultures may conserve energy by lowering their body temperatures (Heath, 1962), by wintering in caves (Broadfoot, 1946), and by evaporative cooling through excreting on their legs (Kahl, 1963).

This investigation was undertaken to determine the heat loss mechanisms of Turkey Vultures, to measure the effectiveness of urohidrosis (Kahl, 1963) in dissipating heat, and to study the likelihood of Turkey Vultures conserving energy by lowering their body temperature or by wintering in caves.

METHODS AND MATERIALS

To determine the migratory tendencies of central Missouri's summer resident Turkey Vultures, I kept four roosts in Boone County, Missouri, under observation. Three had been used by 50 to 150 vultures every night during the last three summers. Leach (1929) reported that traditional roosts like these were used year after year. From the autumn of 1963 to the spring of 1965 I recorded the dates the vultures abandoned the roosts for the winter and returned to them for the summer. I also recorded weather conditions for these dates. Throughout the winters of 1963–64 and 1964–65 I watched the roosts to see if the vultures that occasionally appeared during intervals of warm winter weather used them.

I searched 10 caves and numerous small crevices in Boone, Texas, Dent, and Dallas counties, Missouri, for evidence that Turkey Vultures occasionally winter in caves.

Vultures had previously used six of the caves for nesting and were reported entering another during the winter of 1962. I made both day and night searches of the caves during midwinter and during mild and inclement days when Turkey Vultures were migrating.

Laboratory studies were made with five Turkey Vultures of the subspecies *C. a. septentrionalis* taken from their nests as young and reared in captivity. I captured the oldest bird in 1962, three others in 1963, and one in 1964. I housed them in groups of two and three in 10×10-foot chicken houses and maintained them on a diet of animal carcasses. Drinking water was denied part of the colony throughout each year.

Body temperatures of all captive vultures were measured by implanting copper-constantan thermocouples into the peritoneal cavity about ½ inch behind the rib case. To keep the bird from pulling the thermocouple out I tied the wire around a rib. Temperatures were recorded at 3-minute intervals on Leeds and Northrup and Brown recording potentiometers, accurate to within 0.1°C.

I measured the subcutaneous temperature of one adult over a period of 3 days with a telemetry device transmitting readings accurate to within 0.1°C. The transmitter was mounted on the bird's back until the bird destroyed it on the third day. Funds did not permit further use of telemetry.

To measure daily temperature fluctuations I housed the birds in a 3×3×3-foot box with one screened side. When transferred from the chicken house a bird was given at least 3 days to adjust to the confines of the box and to the general atmosphere of the laboratory. The following variables were included in the study of daily temperature fluctuation.

Season.—Diel rhythms in body temperature were measured in January, March, July, August, October, and December to learn the effects of seasonal adaptation.

Photoperiod.—The normal photoperiod for all of the above months was used. I kept adult V-3 in an air-conditioned chamber in complete darkness for 8 days in order to simulate conditions a vulture might find if he retreated deep into a cave.

Environmental temperature.—By opening the windows of the laboratory, I maintained normally fluctuating outside temperatures during the tests (warmest day, 25.3–30.0°C; coldest day, 0.5–9.5°C). The bird exposed to simulated cave conditions was maintained at a relatively constant environmental temperature (6–9°C) for 8 days.

Age.—I measured temperature fluctuations on birds as young as 2 months and as old as 2½ years of age.

Size.—The birds weighed from 1,530 g to 2,590 g.

Food.—During temperature fluctuation tests I fed the vultures about 200 g of flesh per day except for three tests in which V-3, V-1, and V-2 were fasted for 8, 11, and 20 days respectively. The purpose of fasting was to see if the birds might lower their body temperature to conserve energy during periods when they could not obtain food.

Water.—Three of the test vultures had been maintained 3 to 6 months without drinking water and two had continuous access to drinking water.

I shot five wild birds to determine afternoon and morning body temperatures. The birds died instantly. Temperatures were measured by inserting a mercury thermometer (calibrated to the nearest 0.1°C) 120 mm into the large intestine. Wetmore (1921) used this method successfully on both large and small birds. The dead vultures maintained a constant intestinal temperature for at least 30 minutes after being shot.

I conducted two types of experiments to determine the effects of environmental temperature on the frequency and manner of excreting and to test the effectiveness of evaporative cooling of the legs. Body temperatures of the five captive vultures were measured as previously described. Leg temperatures were measured by taping the thermocouple to the leg surface of the vulture in the middle of the tarsometatarsus. I then insulated the thermocouple with styrofoam.

To observe the frequency and manner of excreting I placed the five vultures, one at a time, into a 3×3×3-foot wooden box designed to allow the test subject freedom to walk about. This box had exchangeable glass and screen-wire doors and was lined with copper tubing through which hot water (55°C) could be run.

I made tests during 6 different months to detect any adaptation to hot or cold weather. The birds were exposed to temperatures of about 22°C during the 1st hour in the chamber, about 33°C the 2nd hour, about 23°C the 3rd hour, and about 35°C the 4th hour. I watched the birds through the glass front, noted their behavior in response to the temperature changes, and counted the number of excretions per 30-minute period. The relative humidity of the chamber was measured before and after the 4-hour tests with a Bendix model 566-2 psychrometer. I made a total of eight tests, one of which involved a single 2½-hour period of rising temperature.

To test the effectiveness of evaporative cooling of the legs I placed four of the birds, one at a time, into a 20×27×16-inch cardboard box heated by one 300-watt light bulb. The front of the box was covered with clear plastic so that I could observe the bird and determine its respiratory rate. Vultures were strapped to the floor of the box with their legs hanging down through two holes, each 1 cm square. The chamber was held at a temperature of 45–50°C. Each test consisted of six consecutive 20-minute periods during which the legs were treated as follows: (I) no treatment, legs hanging in 26°C air, (II) electric fan on dry legs, (III) electric fan on legs plus ¼ cc water applied to alternate legs every 2 minutes, (IV) fan turned off, but water applied as in period III, (V) legs insulated with ½ inch of cotton, and (VI) insulation removed, electric fan on legs, plus ¼ cc water applied to alternate legs every 2 minutes. Body and leg temperatures were recorded throughout the 120 minutes and the respiratory rate determined. If long periods of struggling occurred I considered the data invalid. Five of these tests were successful.

Results

Behavior of wild vultures in autumn and winter.—Turkey Vultures using the four traditional roosts left them for the winter in late October of both autumns. Cold fronts passed through central Missouri, followed by strong northerly winds, on the days the flocks abandoned the roosts. Within a few days after the birds left their roosts for the winter I searched the selected caves and rock crevices in Boone County and found no vultures in them. Between 29 October 1963 and 1 March 1964 and between 18 October 1964 and 28 February 1965 I found no vultures at any of the four roosts or in any of the caves, and therefore concluded that the summer residents did not remain in the Boone County area. I saw a few vultures in Boone County later in the fall but none used the traditional summer roosts, suggesting that they were only passing through in southward migration.

I found no vultures in Boone County during December of either winter, but I saw single Turkey Vultures on 25 January and 5 February 1964 and two each on 1 January and 18 February 1965. None used the traditional roosts. In all four cases central Missouri had experienced above-normal temperatures and southerly winds for 3 or 4 days prior to the sightings. I found no vultures during the cold weather that followed each of these warm-weather sightings.

These sudden midwinter appearances of vultures seemed to support the idea that the birds wintered in local caves and came out in response to the warm weather. But after the cold weather resumed and the vultures disappeared, I searched the caves and rock crevices in Boone, Texas, Dent, and Dallas counties and found no vultures.

I think the most likely explanation for the midwinter appearances is that some Turkey Vultures take advantage of the warm southerly winds to drift north temporarily into Boone County, but return southward when the winds shift and temperatures drop. Maryland banding records (Stewart and Robbins, 1958: 105–106) show that Turkey Vultures make occasional erratic movements, especially in the winter months.

Turkey Vultures began returning to their traditional roosts on 1 March 1964 and 28 February 1965. They arrived during warm weather, but remained during severe ice and snowstorms on 20–26 March 1964 and 2–6 March 1965. I found them on their exposed roosts with ice on their backs, but active and able to fly. I again searched six Boone County caves and found no evidence that vultures had used them for shelter. Neither birds, feathers, casts, nor tracks were present.

Many species of mammals and birds, including hibernating Poor-wills (Jaeger, 1949) and Estella Hummingbirds (Pearson, 1953), retreat to dens, nests, and cavities in cold weather. According to Kendeigh (1961) this provides an effective means of energy conservation. But my observations indicate that Turkey Vultures either remain on the exposed roosts in cold weather and endure the storms (late February–March) or leave ahead of the approaching cold weather (October–early February).

I have interviewed more than 30 members of the Missouri Speleological Survey who enthusiastically explore caves winter and summer. None of them has seen vultures in caves except during the nesting season. Resident Missourians gave me eight verbal accounts of vultures found wintering in caves in Missouri. I located two of these caves and was unable to find vultures using them, but I think the reports are not to be completely disregarded. The facts that the vultures did not abandon their roosts during the inclement springtime weather and did not use the roosts during unseasonably warm winter weather suggest that our summer residents migrate and seldom (if ever) retreat into caves for protection from inclement conditions.

Daily temperature fluctuations.—Seventeen days of thermocouple readings and 3 days of telemetered thermometer readings showed five vultures

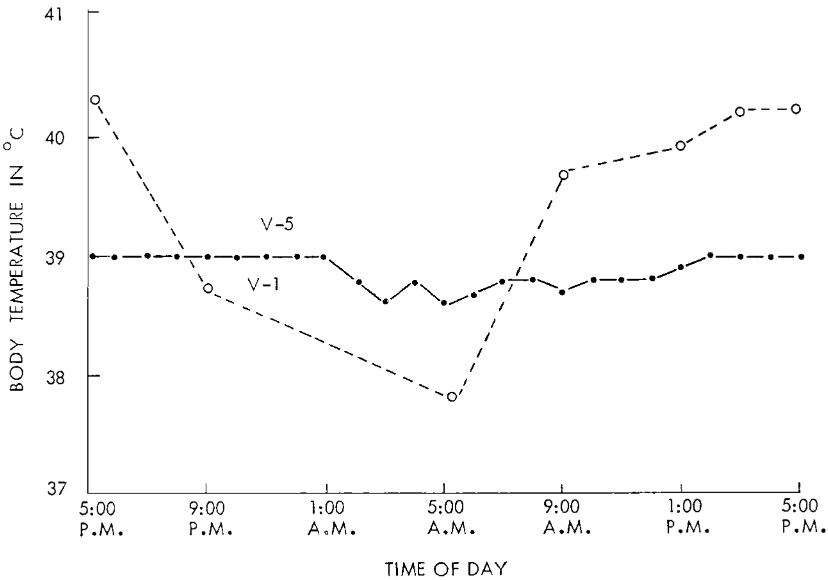

Figure 1. Body temperatures of two Turkey Vultures showing the minimum and maximum daily fluctuations.

that were fed daily underwent a 0.4–2.6°C temperature decline at night regardless of environmental temperature or length of photoperiod. The age, seasonal condition, size or weight of the bird, and the amount of drinking water available appeared to have no effect. These vultures had afternoon high temperatures of 39 or 40°C and early morning temperatures near 38°C. Figure 1 shows temperatures of birds undergoing the least and greatest daily fluctuations.

The 2,183-g vulture, V-3, maintained 8 days in January under simulated cave conditions predictably lost weight, but did not alter its pattern of daily temperature fluctuation. Daytime readings were near 42°C and morning readings near 39.5°C (Figure 2). Though the bird was without light for 8 days, the periods of maximum and minimum body temperatures occurred at the same time as when the bird was exposed to the normal photoperiods. By the end of the 8th day the bird had lost 18.3 per cent of its original weight.

V-1, a 2,410-g bird maintained 11 days in January without food or water, but exposed to normal January photoperiod and temperature (daily averages 4.5–10.5°C), responded similarly. This bird lost 14 per cent of its body weight, but at no time altered its pattern of daily temperature fluctuation. Both V-3 and V-1 recovered without ill effects.

V-2, a 2,166-g female kept from 8 February to 28 February under the

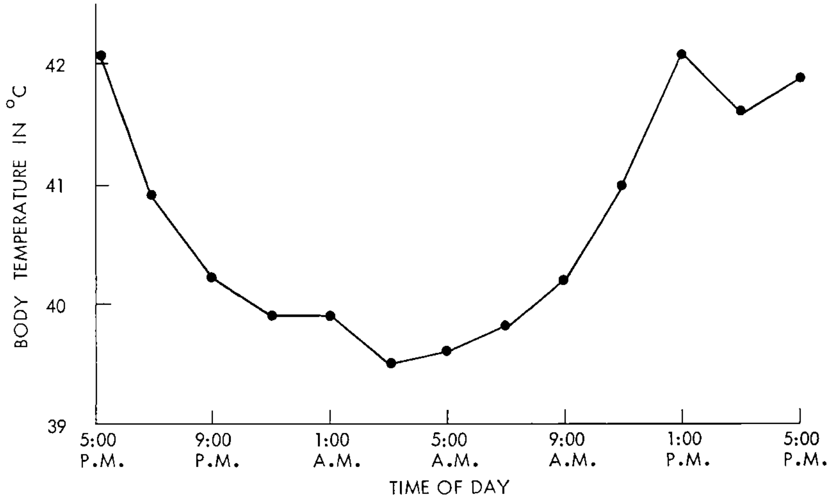

Figure 2. Diel rhythm in body temperature of experimental vulture V-3 on the 8th day of fasting in complete darkness at an environmental temperature of 6–9°C.

same experimental conditions as V-1, maintained a normal diel temperature rhythm until the 17th day of fasting and then failed to show the diurnal increase. Her body temperature remained at about 38°C from day 17 until she died on day 20. During the experiment she lost 40 per cent of her body weight.

Vultures killed in the wild showed temperature extremes similar to those of laboratory birds. Two adults, a 2,180-g male and a 2,347-g female, were shot in the late afternoons of 24 September and 1 October 1964 as they approached their roost with crops full of carrion. Both had body temperatures of 40.0°C. A helper and I shot three vultures: a 1,990-g adult female, a 2,079-g adult male, and a 2,387-g juvenile bird, from their roost at dawn 5 October 1964. Their intestinal temperatures were 38.2, 37.7, and 39.5°C, respectively. The air temperature about 40 feet below the roosting birds was 1°C.

Frequency and manner of excreting.—Vultures tested in July and August and from November through February and maintained with or without water behaved essentially as follows:

During the 1st hour temperatures rose only slightly (Figure 3). If they excreted, the vultures did so only once or twice per 30-minute period and directed the excreta to the floor or wall behind them.

During the 2nd hour, as the chamber's temperature rapidly increased, the birds greatly increased their rate of excreting, and in every case directed the excreta toward one leg or the other. They excreted upon both

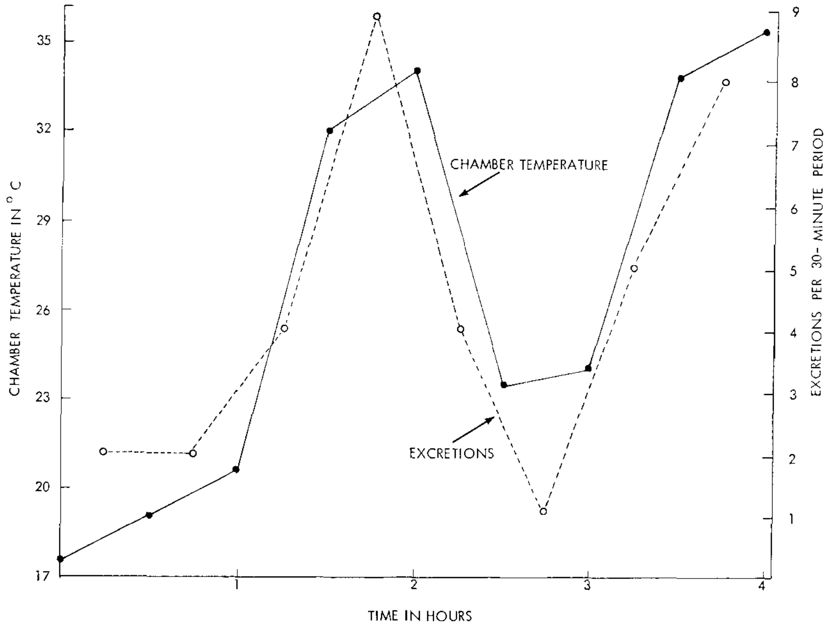

Figure 3. Excretion rate of Turkey Vulture V-1 exposed to a rising and falling environmental temperature.

legs, one at a time, but usually used one more than the other. The first few excretions consisted of 5 cc or more, but the volume gradually decreased during the hour. When excreting on their legs, the vultures assumed a different position than when regularly voiding. At lower temperatures they lowered their foreparts, raised their tails, and squirted the excreta behind them, but when reacting to a rising temperature they lifted their foreparts, lowered their tails, and directed the excreta toward the tarsus or toes.

In the 3rd hour as the ambient temperature decreased, the frequency of excreting slowed or stopped (Figure 3). Since much of the excreta had been eliminated during the previous hour, the purpose of excreting during the 3rd hour would seem to be for cooling purposes only. This concept was supported by the fact that the birds directed all 3rd-hour excretions toward the legs.

During the 4th hour as ambient temperature again increased, the birds resumed excreting on their legs. The vultures that excreted most frequently during the early part of the experiment were seldom able to eject more than a small drop of excreta later, but this did not reduce the frequency of their attempts to dampen the legs.

In 12 of the 15 periods of rapidly rising temperature the vultures began excreting on their legs before they began panting. In three of the periods the birds did not pant but frequently excreted on their legs.

Other heat dispersing mechanisms.—During the above periods of rapidly rising temperature the birds usually began panting when the body temperature rose 0.1–0.2°C above the normal daytime high. It was not unusual for birds to begin panting before there was a measurable rise in the body temperature. Environmental temperatures at the onset of panting ranged from 27.2–34.5°C. In 3 of the 15 exposures to rapidly rising temperature the birds did not pant, even though the chamber temperature rose to highs of 34.4–36.0°C. Surprisingly all three of these exposures were in midwinter when the vultures were heaviest and best insulated.

In all tests the vultures responded to high temperatures by extending the bare portion of their necks from the loose, heavily-feathered skin of the lower part of the necks. This exposed about 1 inch of bare skin that is usually covered by feathers.

Effectiveness of evaporative cooling of the legs.—Figure 4 shows the results of a typical test.

During period I the legs showed a considerably greater temperature rise than did the body, although they were exposed to a temperature some 23°C lower than was the body. In the five tests this rise ranged from 1.2–2.4°C, with a mean of 1.75°C. The mean deep body temperature rise was 0.85°C above the initial temperature, with a range of 0.3–1.6°C. The birds began panting almost immediately after being put into the heated box, and averaged 141 inhalations per minute.

In period II the increased air circulation caused a decrease of 2.1°C in the mean temperature of the leg surface (range 0.0–5.8°C). The greatest mean decrease (1.6°C) was during the first half of the period. This decrease in leg-surface temperature was accompanied by an average rise of 0.6°C in body temperature during the 1st half of the period and a 0.5°C decrease during the 2nd half. Panting continued, but the rate decreased from a mean of 141 to 117 inhalations per minute.

During period III the small amount of water caused enough evaporative cooling to decrease the leg temperature another 1.9°C (0.6–3.7°C). The deep body temperature continued to follow the leg temperature with a 0.7°C (0.2–1.2°C) decrease. This, on the average, reduced the body temperature to within 0.25°C of the beginning level. Panting stopped in three of the five tests. The average rate decreased to 76 inhalations per minute.

During period IV the reduction in convection allowed a 3.9°C (3.0–5.0°C) rise in leg-surface temperature. This rise also seems to indicate that a large amount of the body's heat is being shunted into the legs to be disposed of. Although leg temperatures rose, body temperatures re-

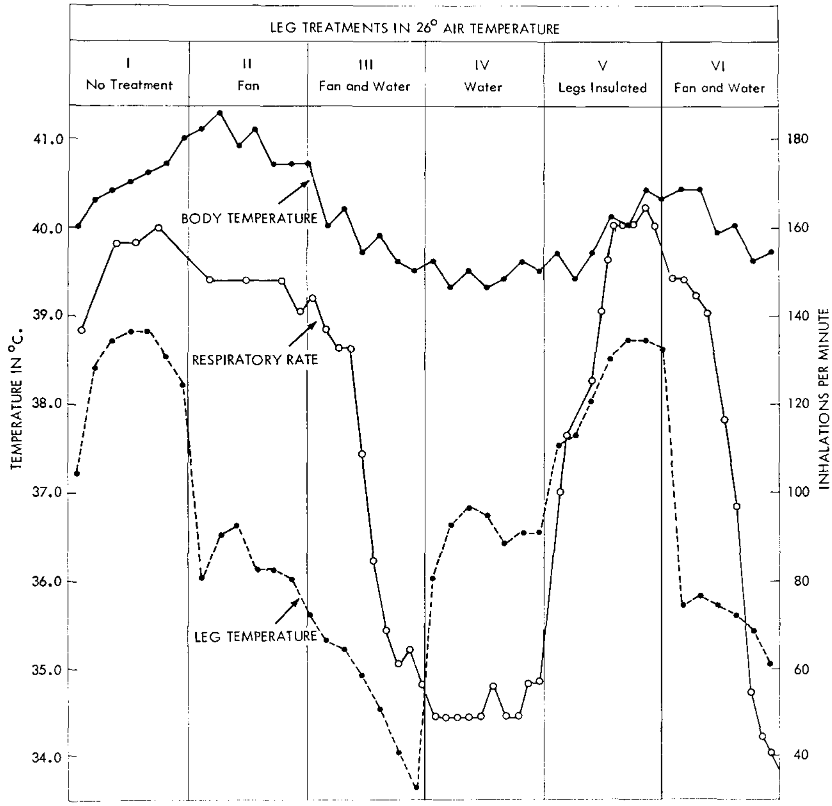

Figure 4. Body temperature, leg temperature, and respiratory rate of a captive vulture, V-5, with body exposed to a 45–50°C environmental temperature; legs in air temperature of 26°C and subjected to various treatments during six consecutive 20-minute periods.

mained constant (range from 0.2°C decrease to 0.7°C increase). As during period III there was no panting in three tests. The mean rate rose slightly to 92 inhalations per minute.

In period V insulating the legs caused a further mean rise of 2.6°C (1.5–4.0°C), but the legs did not reach the temperature of the body core. The body, unable to dispose of heat through the legs, had a mean temperature rise of 0.7°C (0.1–1.5°C). At the end of this period the mean body temperature was 41.5°C (39.7–43.9°C), 3.8°C above the mean surface temperature of the insulated legs (36.2–39.3°C). The rise in body and leg temperature was accompanied by resumed panting, reaching a mean rate of 130 inhalations per minute.

During period VI the return to evaporative cooling of the legs brought a 5.0°C (3.6–7.4°C) mean reduction. The body core responded to the cooling of the legs with a 1.0°C (0.4–1.9°C) mean temperature reduction. As in period III, birds stopped panting in three of the five tests. At the end of the period the mean respiration rate had decreased to 71 (36–125) inhalations per minute.

The striking fact shown by these tests is that the deep body temperature and panting of a large bird can be regulated by the evaporation of a small amount of water from a small portion of the bird's total surface area. A Turkey Vulture weighs about 2,000 g and has a total surface area (if plucked) of about 1,050 square cm. The surface area of the bare leg and toes is approximately 52 square cm. In 20 minutes 2.5 cc of water and ample convection applied to this 52 square cm of leg surface was sufficient to cause a 1°C reduction in deep body temperature that could not be attained by panting alone. I found no difference between birds being maintained with or without water.

DISCUSSION

Tests measuring daily temperature fluctuations showed that under a variety of laboratory conditions, body temperatures fluctuated no more than 2.6°C during 60 periods of 24 hours each. The highest temperatures occurred late in the vultures' daily periods of activity and the lowest when the birds were inactive at night. Heath (1962) recorded diel fluctuations as great as 4°C and these also correlated with periods of activity and inactivity. My results show that the diel temperature range of the Turkey Vulture, at any season of the year, is of similar magnitude to that of many other large and small birds incapable of prolonged torpor (Simpson and Galbraith, 1905; Wetmore, 1921; Gardner, 1930; Irving, 1955; Bartholomew and Cade, 1957; Bartholomew and Dawson, 1958; Howell and Bartholomew, 1961; Udvardy, 1963).

Birds that conserve energy by lowering their metabolic rates—some swifts, goatsuckers, and hummingbirds—undergo temperature depressions of 20–40°C, and in some cases remain in a poikilothermic state for several days or weeks (Koskimies, 1948; Jaeger, 1949; Pearson, 1950, 1953; Lack and Lack, 1951; Marshall, 1955; Bartholomew et al., 1957). Turkey Vultures, showing no temperature decreases of this magnitude, almost certainly do not have such an energy-conserving mechanism.

It is true that Turkey Vultures may be unable to feed for periods of several days. In summer I have seen them remain on their roosts for as long as 2 days when prolonged rainy weather made soaring difficult. In winter they are sometimes seen in areas where freezing temperatures would make feeding difficult. However Turkey Vultures probably do not need a special energy-conserving mechanism to endure these cold or foodless periods. Vultures V-1 and V-3 when fasted for 11 and 8 days maintained their body temperatures and remained healthy. Vulture V-2 lived 20 days without food or water and maintained her body temperature until the 17th day. Turkey Vultures thus can easily endure short periods of unfavorable weather by simply waiting.

The species also has strong migratory tendencies, abundantly documented in the literature, and is well-known as an effortless flyer. Most vultures leave the northern part of their range in winter, but those stragglers and wanderers that are overtaken by freezing weather or severe storms can escape to warmer areas to the south with little effort. Aided by their gliding ability and by northerly winds that almost always follow winter storms, they should be able perhaps to travel southward several hundred miles before being weakened by lack of food.

Birds in general seem to possess characteristics that allow them to adapt easily to hot and arid environments (see Miller, 1963). Turkey Vultures have several of these general characteristics such as a body temperature near 40°C, a great degree of mobility, and the ability to live on a carnivorous diet without access to drinking water. My captive vultures, fed a wide variety of fresh and decayed animals, lived without drinking water and yet remained in good health. One bird was without drinking water for 1 year and four others for 6-month periods. They also showed nasal secretions while eating. Cade and Greenwald (1966) point out that nasal glands seem to enhance the water conserving ability of many falconiform birds by secreting ingested electrolytes, especially sodium. The abovementioned characteristics and the additional adaptation of evaporative cooling by excreting on the legs have, no doubt, contributed significantly to the success of the Turkey Vulture in hot and arid environments. Though I assume that subspecies of the Turkey Vulture living in the deserts could make effective use of this evaporative cooling mechanism, it should be kept in mind that I used only members of the subspecies *C. a. septentrionalis* in my experiments.

Kahl (1963) found that the Wood Stork (*Mycteria americana*) and the Black Vulture (*Coragyps atratus*) will also wet their legs with urine when too hot. Kahl suggested that this phenomenon be called urohidrosis because of its functional similarity to true sweating.

The fact that Turkey Vultures excrete on their legs at an increasing rate when exposed to increasing environmental temperatures suggests that the mechanism is sufficiently developed to be of survival value and has developed for this purpose in the species' evolution. Figure 4 shows that when a vulture (V-5) was exposed to a 50°C environmental temperature it underwent a 1°C rise in body temperature in 20 minutes when the legs were hanging in 26°C air untreated or when the legs were insulated with cotton.

This rise took place even though the panting rate was about 160 inhalations per minute and the neck was extended from the feathers. But 2.5 cc of water on the legs, when accompanied by forced air currents, was sufficient not only to halt the rising body temperature, but to lower it about 1°C in 20 minutes. Thus the additional evaporation and convection were responsible for approximately a 2°C decrease in the bird's body temperature in 20 minutes and were sufficient to enable the respiratory rate to decrease and the panting to cease.

My experimental vultures, when first exposed to high temperatures, squirted about 5 cc of excreta each time they attempted to dampen their legs. After three or four excretions the amount decreased, but even after excreting 30 or 40 times in a 4-hour period the birds were able to eliminate a small drop at almost every attempt. The liquid excreted is about 95 per cent water by weight. During 8 daylight hours one captive vulture, not under heat stress, excreted at the rate of 10 cc per hour, even though maintained for 14 months without drinking water. Therefore a vulture can easily excrete more than enough water than would be necessary for urohidrosis during the warm diurnal period. I used only 7.5 cc per hour to reduce an overheated vulture's temperature 1°C.

My experiments do not clearly reveal the nature of the mechanism that stimulates the act of excreting on the legs, but they do give some general ideas about its function. The fact that vultures attempt to excrete on their legs even when the supply of excreta is low suggests that the act is probably an involuntary neural response to a rising body temperature. I have seen the captive vultures excrete on their legs on hot days or when alarmed by my presence. Therefore either high environmental temperatures or excitement can elicit the act.

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SUMMARY

The normal daytime deep body temperature of adult Turkey Vultures is about 40°C and decreases 1 or 2°C at night. Diel temperature fluctuations as great as 2.6 and 4.0°C have been recorded. Diel temperature

fluctuations of this magnitude can be attributed to change in activity and do not represent true hypothermia. Swifts, goatsuckers and hummingbirds show diel ranges of 20–40°C, which truly indicate a lowered metabolism to conserve energy.

Although Turkey Vultures commonly nest in caves, they apparently rarely enter them at other times of the year and do not depend upon caves for shelter from winter weather. The vultures of central Missouri migrate ahead of cold autumn weather but endure springtime storms sitting on their exposed traditional roosts. Because of their large size, migratory instinct, and soaring ability, Turkey Vultures may not need special energy-conserving mechanisms to endure cold or foodless periods.

Because of their high body temperature, ease of mobility, carnivorous diet, and perhaps functional salt glands, Turkey Vultures are well-adapted to life in hot environments. I kept a Turkey Vulture in good health for 1 year without drinking water. In addition to panting, Turkey Vultures attempt additional evaporative cooling by excreting on the legs. A rising environmental temperature causes the birds to excrete more frequently and to direct the excreta onto the legs.

Experimental vultures exposed to a 50°C environmental temperature underwent a 1°C rise in body temperature in 20 minutes if their legs were dry and hanging in still air at 26°C or were insulated. This rise took place even though the birds panted and bared their necks. Vultures exposed to a 50°C environmental temperature underwent a 1°C reduction in body temperature in 20 minutes when water was squirted on alternate legs and accompanied by air currents from an electric fan. This heat-dissipating mechanism, urohidrosis, apparently contributes significantly to the success of the Turkey Vulture in hot environments.

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