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EFFECTS OF NASAL TUFTS AND NASAL RESPIRATION ON THERMOREGULATION AND EVAPORATIVE WATER LOSS IN THE COMMON CROW

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One feature of the family Corvidae is the presence of thick, conspicuous tufts of feathers which extend over the proximal one-third of the beak covering the external nares. Schmidt-Nielsen et al. (1970) suggested that some birds may use a temporal countercurrent air flow through the nares to reduce respiratory evaporation, but no one has investigated the possible role of nasal feather tufts in water or heat exchange in corvids or other passerine birds. Common Crows (*Corvus brachyrhynchos*) frequently winter in areas from which many passerines migrate. We have investigated the thermoregulatory ability of the Common Crow—a large passerine—and the possibility that its nasal tufts are important in thermal or water balance.

METHODS AND MATERIALS

Nine Common Crows were captured during January 1974, in Fort Collins, Larimer County, Colorado. Judging by the aging technique of Emlen (1937), all were first-year birds. The birds were kept in individual cages at 23–25°C on a 12L:12D photoperiod during the study. All birds were kept in the lab for at least two weeks before being tested. Canned dog food, dry dog meal and water were available *ad libitum*.

Oxygen consumption ($\dot{V}O_2$) was measured in an open flow system using a Beckman paramagnetic oxygen analyzer (Model F3). A metal ammunition case ($23 \times 30.5 \times 45.7$ mm) served as an air-tight respirometer. Temperature was monitored inside the respirometer with a thermocouple. Air flow through the system was maintained at 2000 cc/min with Brooks E/C flow meters calibrated with a Brooks Vol-U-Meter flow calibrator. The flow system used corresponds to condition B of Hill (1972). The birds were in a hardware cloth cage with a perch. The bottom of the respirometer had a layer of mineral oil to cover and prevent evaporation of water from cloacal discharges. The birds were maintained at a given ambient temperature (T_A) for at least one hour (although most tests necessitated two or more hours), after which oxygen consumption was calculated (corrected to STP) from the lowest values maintained for at least 15 min. Ambient temperature was maintained to within ± 0.5°C by a temperature-controlled growth chamber. All data were gathered between the hours of 17:00 and 24:00. Cloacal temperature (T_B) was measured at the beginning and end of each run by inserting a YSI thermistor probe 2.5 cm into the cloaca.

Measurements of evaporative water loss (EWL) were made simultaneously with oxygen consumption. The gravimetric technique used was the same as that described in Wunder (1970).

Following measurements of $\dot{V}O_2$, T_B and EWL at a variety of T_A's in normal birds, the nasal tufts were cut off. Then $\dot{V}O_2$, T_B, and EWL were measured in birds at both 5° and 37.5°C. Following those measurements, the nares were plugged with modelling clay and painted with layers of colloidin, and $\dot{V}O_2$, T_B, and EWL were again measured at 5° and 37.5°C for comparison.

Statistical comparisons of treatments were made using analysis of variance and paired t-test computer programs developed by the CSU Statistical Services Laboratory. Values expressed in this paper are means ± one standard deviation with sample size given in parentheses.

RESULTS

The pattern of oxygen consumption as a function of T_A in Common Crows weighing an average of 384.8 g is shown in figure 1. The animals demonstrated a thermoneutral zone extending from at least 37.5°C to 15°C. Below 15°, $\dot{V}O_2$ increased slowly with decreasing T_A. The mean of 24 $\dot{V}O_2$ measurements in thermoneutrality give an SMR of 1.53 ± 0.18 cc $O_2/(g \cdot hr)$.

Body temperature (40.2 ± 0.6°C, $n = 31$) was regulated fairly well at intermediate ambient temperature exposures. However, at 30–33°C, T_B started to rise and at 37.5°C the crows showed a definite ($P < 0.05$) regulated hyperthermia of 41.4 ± 0.8°C (9). At low T_A exposures the crows showed a much greater T_B lability (fig. 2).

Evaporative water loss was stable between T_A exposures of 5 to 20°C. At T_A's above 20°C, EWL increased exponentially (fig. 3). With water loss expressed as amount of heat lost by evaporation (EHL) relative to heat production (HP) (assuming consumption of 1 cc O_2 liberates 4.8 calories and

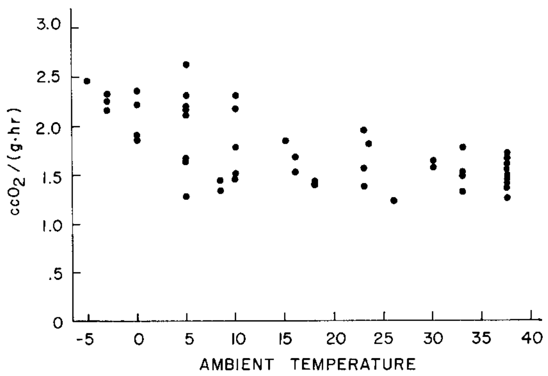

FIGURE 1. Oxygen consumption of the Common Crow as a function of ambient temperature (°C).

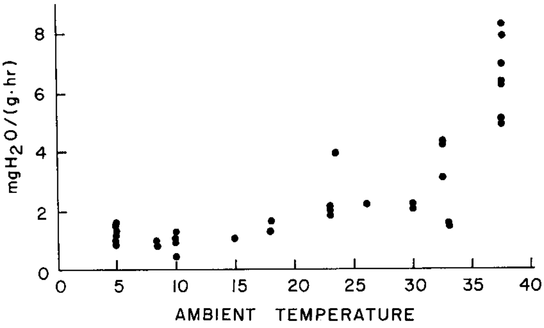

FIGURE 3. Total evaporative water loss of the Common Crow as a function of ambient temperature (°C).

evaporation of 1 g of water uses 574 calories), there was a logarithmic increase with increase in temperature (fig. 4) which can be expressed by the following least squares regression:

$$\log(\mathrm{EHL/HP} \times 100) = 0.628 + 0.0260\ T_A,$$

where $n = 37$, $s_{yx} = 0.020$, and $r = 0.91$.

The effects of removing nasal tufts alone and of subsequently plugging the nasal passages to force mouth breathing are shown in tables 1 and 2. Neither experimental treatment affected $\dot{V}O_2$ either at high or low T_A exposures. Although the mean value for EWL at 5°C of Common Crows with nasal feathers cut was larger than the controls, it was not statistically significant ($P > 0.05$). Nor did plugging the nares have an effect on rates of EWL at 5°C. At high temperature, and thus high rates of EWL, cutting nasal tufts did not affect EWL; however, plugging the nares resulted in a 15% increase in EWL ($P < 0.05$).

DISCUSSION

Within the limits of our experiments, Common Crows do not appear to demonstrate any striking physiological modifications for existing in cold regions during winter. Unlike some of the smaller passerines which show high rates of metabolism in the winter (Pohl and West 1973, Hart 1962) or Willow Ptarmigan (*Lagopus lagopus*) which lower metabolism in winter (West 1972), the oxygen consumption of Common Crows is about that expected for birds their size. Standard metabolism is within 5% of that predicted for a 385-g passerine by allometric relationships (Lasiewski and Dawson 1967) and within 15% of that predicted for a 385-g passerine during its resting period (Aschoff and Pohl 1970). Thermal conductance [0.0356 cc O_2/(g·hr·°C), calculated from $\dot{V}O_2$, T_B and T_A], which can be used as an index to insulation (Bartholomew 1972), is within 10% of the value estimated by the equation of Herreid and Kessel (1967). The lower critical temperature is between 10° and 15°C.

Two smaller corvids from northern regions show much more striking physiological adjustments for coping with cold. Blue Jays (*Cyanocitta cristata*) and Gray Jays (*Perisoreus canadensis*), which weigh between 70–80g, show thermal conductances [0.05 cc O_2/(g·hr·°C)] which are only about 50% of that expected for birds of their body size (Misch 1960, Veghte 1964). Further, the Gray Jays show a seasonal shift in lower critical temperature to lower levels in winter (Veghte 1964). Thus, it appears that two morphological and physiological features allowing Common Crows to exist in cold regions are their large body size and T_B lability at low T_A. When exposed to low T_A Common Crows can allow T_B to drop, thus saving energy. Because of their large body size, they already have lower thermal conductances (and, thus, higher insulation) than those of Blue and Gray jays during winter. One other ad-

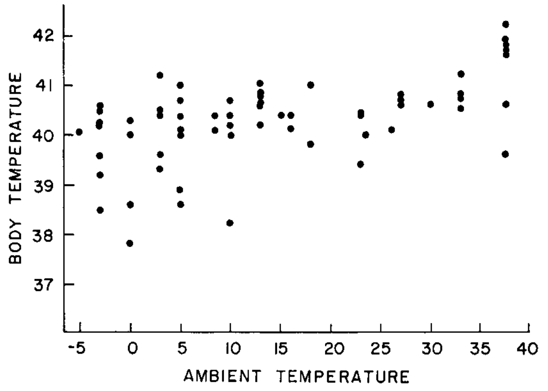

FIGURE 2. Body temperature of the Common Crow as a function of ambient temperature (°C).

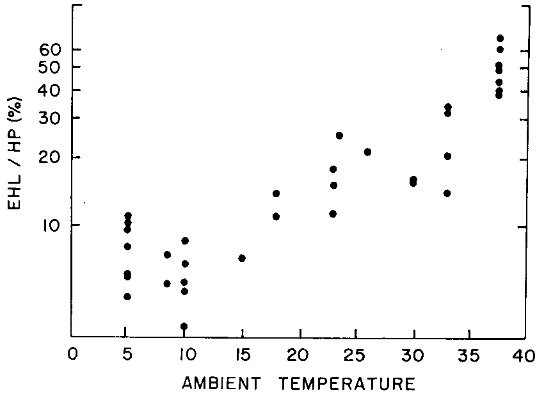

FIGURE 4. Evaporative heat loss of the Common Crow as a function of ambient temperature (°C).

TABLE 1. Oxygen consumption of the Common Crow.[a]

Ambient temperature (°C)	Treatment		
	Controls	Tufts cut	Tufts cut and nares plugged
5	1.81 ± 0.52(8)	1.81 ± 0.30(10)	1.90 ± 0.35(7)
37.5	1.34 ± 0.13(9)	1.51 ± 0.64(10)	1.31 ± 0.13(10)

[a] Values are means ± SD and sample sizes are given in parentheses. Units are cc O_2/g · hr.

vantage of size is the ability of the crows to exist without food during the long winter nights when they cannot feed. Smaller birds need to put on 50% of their body weight in fat each day in order not to starve during cold nights (Kendeigh et al. 1969).

Common Crows can dissipate at least 41% of their metabolic heat production by evaporation, but this occurs only at T_A exposures of 37.5°C (fig. 4). They may be able to dissipate a higher percentage of their metabolic heat by evaporation if tested at higher ambient temperature conditions. However, we did not test them at such temperatures since most of the birds had high T_B following T_A exposures to 37.5°C and we wished to keep them alive for subsequent treatments in our study. We were not able to measure relative humidity during the tests in the respirometer. However, using the equations of Lasiewski et al. (1967) the maximum relative humidities in the chamber at 37.5°C were less than 52%.

Crawford and Lasiewski (1968) presented allometric equations for estimating pulmocutaneous evaporation from birds at 25°C. Using these equations, Common Crows have rates of EWL which are 70% greater than those for all birds their size and 300% greater than those for passerines of their size at 25°C. There are several possible explanations for the differences between our results and these predictions. First, Crawford and Lasiewski (1968) cautioned that their equations should be considered preliminary for a number of reasons which they discussed. Second, their data are all for evaporation at 25°C. This is not a truly standard condition since rates of evaporation tend to increase exponentially with T_A for any given species of bird; thus, any small deviation in temperature will have a great effect on the rates of EWL measured. And 25°C may represent different degrees of thermal stress for different species. The great discrepancy of Common Crows from the passerine equation may be due to the fact that most passerines previously studied have been much smaller and the regression may simply represent a bias of scatter about a small weight range. When compared with actual rates of water loss from other passerines (Crawford and Lasiewski 1968, Bernstein 1971), the rates of water loss in crows do not appear high. For these reasons the equations of Crawford and Lasiewski (1968), especially for passerines, should be used only with great caution.

TABLE 2. Evaporative water loss[a] of the Common Crow.

Ambient temperature (°C)	Treatment		
	Controls	Tufts cut	Tufts cut and nares plugged
5	1.19 ± 0.23(7)	1.46 ± 0.36(9)	1.56 ± 0.74(7)
37.5	6.44 ± 1.14(9)	6.81 ± 0.84(10)	7.40 ± 0.69(10)

[a] Values are means ± 1 SD and sample sizes are given in parentheses. Units are mg H_2O/g · hr.

Stonehouse (1972) suggested that the nasal feather tufts found in Adelie Penguins (*Pygoscelis adeliae*) function to conserve heat. This does not appear to be their function in Common Crows as we found no difference in oxygen consumption at either high or low T_A and with or without feather tufts.

Schmidt-Nielsen et al. (1970) suggested that small birds and mammals may use temporal counter-current air flow in the nares to effect a savings in respiratory evaporation. We hypothesized that feather tufts, acting as a baffle to respiratory air flow, may act similarly. However, this did not appear to be the case for Common Crows, as cutting feather tufts did not significantly ($P > 0.05$) modify evaporation, although a higher mean EWL was evident in birds with feather tufts cut. However, plugging the nares and forcing mouth breathing so that counter-current air flow could not be used did effect increased EWL at high T_A. Thus, respiration under these conditions did not allow a savings in respiratory water loss. However, one assumption of our technique was that blocking the nares did not affect other sites of evaporation (e.g., cutaneous).

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GALÁPAGOS MOCKINGBIRD PECKS AT SEA LION MOUTH

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The mockingbirds of the Galápagos Islands (*Nesomimus* spp.) are well-known for their opportunistic feeding habits. Hood Island Mockingbirds (*N. macdonaldi*), in particular, use a wide variety of sources for food and water. Presumably, the extreme aridity and barrenness of their home island have precipitated such habits as egg-eating, blood-drinking, and predation on *Tropidurus* lizards and nestling sea-birds.

Bowman and Carter (Living Bird 10:243–270, 1971) tabulated feeding habits of Galápagos mockingbirds. While at Punta Suarez on Hood Island, 26 July 1973, I witnessed a behavior not recorded in their paper or elsewhere in the literature. A *N. macdonaldi* foraged along a sandy beach littered with sleeping sea lions (*Zalophus californianus*). This mockingbird spent several minutes hopping from one sea lion to another, pecking at their teeth (fig. 1). The bird appeared to obtain and swallow bits of moist food and/or droplets of saliva. The sea lions continued to sleep, showing no reaction to the mockingbird's pecks. Lack of water, a conspicuous feature of Hood Island, has fostered several unusual methods of feeding in the island's mockingbirds; pecking at sea lions' mouths seems to be an addition to this repertoire.

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FIGURE 1. Hood Island Mockingbird pecking at the mouth of a sleeping sea lion.

DOMINANCE HIERARCHIES IN WINTER SONG SPARROWS

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In many species of birds, some individuals are excluded from establishing territories in optimal habitats. Earlier we have shown that first year birds are excluded from spring territories in the Song Sparrow (*Melospiza melodia*) (Knapton and Krebs 1974). Empty territories were rapidly refilled by young birds after experimental removal of adults. In this note we report that the replacement birds were young who had been dominant in winter flocks in the study area. Odum (1942) and Dixon (1963) reported similar cases of dominant birds in winter flocks establishing territories in the spring, but their results were less detailed. Glase (1973) showed that resident pairs were most dominant in winter flocks, and Smith (1976) has reported that higher ranking individuals can obtain better quality breeding territories.