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TEMPERATURE REGULATION AND CLIMATIC ADAPTATION IN BLACK-BILLED AND YELLOW-BILLED MAGPIES

ANITA M. HAYWORTH
AND
WESLEY W. WEATHERS

ABSTRACT.—The Yellow-billed Magpie (*Pica nuttalli*) and Black-billed Magpie (*P. pica*) are closely related and morphologically similar species. Yet because of their allopatric distributions, they experience different climatic regimes. We sought evidence of climatic adaptation in the thermoregulatory responses of these species by measuring their body temperature, oxygen consumption, and evaporative water loss at stable air temperatures between −10 and 40°C. At temperatures below the thermoneutral zone (TNZ), both species had similar metabolic rates, thermal conductances, and body temperatures. Within the TNZ, metabolism of Black-billed Magpies averaged 7.52 mW g^{-1}, which is 22% lower than that of Yellow-billed Magpies and 18% lower than that predicted allometrically for a 159-g passerine. Above the TNZ, Yellow-billed Magpies lost significantly more heat by nonevaporative pathways, became more hyperthermic, exhibited a smaller increase in oxygen consumption with increasing temperature, and were more heat tolerant than their congeners. Our data suggest that climate acts directly to restrict Black-billed Magpies to the Cold Type Steppe Dry Climate, rather than ecologically through a secondary effect on food availability.

Climate may influence a species' range directly (i.e., physiologically) through its impact on thermoregulatory processes, and/or indirectly (i.e., ecologically) through its influence on vegetation and food availability. Because birds are highly mobile endotherms, climate is generally believed to affect their distribution through its ecological consequences. Recent studies indicate, however, that climate's physiological consequences can be major, even dominant, determinants of distribution for some species (e.g., Weathers and van Riper 1982). Generalizations concerning the relationship between distribution and physiological capacity are lacking, however, and additional studies, especially of closely related species from different climates, are needed to resolve this issue.

North America's two magpie species are ideal subjects for such a study. Although their affinities and evolutionary histories are uncertain, the yellow-billed species probably evolved from the black-billed form (a mutant of the European Magpie, *Pica pica pica,* occurs that has a yellow bill and yellow skin on the bottoms of its feet [Linsdale 1937]). These species occupy similar niches, but because of their allopatric distributions (Fig. 1) are exposed to quite different climates.

Black-billed Magpies (*P. p. hudsonia*) occur in sparsely wooded areas of western North America from northwestern Alaska southward to northern Arizona, New Mexico, and western Texas. Their range so closely overlaps that of the Cold Type Steppe Dry Climate (Linsdale 1937) that their distribution and abundance are clearly limited by high temperature and humidity (Bock and Lepthien 1975). Whether these climatic factors exert their effect directly or indirectly through their impact on food availability is uncertain.

The range of the Yellow-billed Magpie (*P. nuttalli*) is limited to the Sacramento and San Joaquin valleys and to coastal valleys south of the San Francisco Bay in California. In the Sacramento Valley, its range is characterized by Hot Summer Mediterranean Type Climate (Linsdale 1937).

MATERIALS AND METHODS

ANIMALS

The nine adult (six male, three female) Black-billed Magpies used in this study were collected near Pocatello, Bannock Co., Idaho, in summer, 1978. The twelve adult (seven male, five female) Yellow-billed Magpies were captured near Davis, Yolo Co., California, in summer, 1979. All of the birds were housed in individual cages (0.5 × 0.5 × 0.5 m) located in a temperature- (25 ± 2°C) and light- (12L:12D) controlled windowless room. Both canned and dry, small kibble dogfood and water were provided ad libitum. The birds were allowed one month to adjust to captivity before any gas-exchange measurements were made.

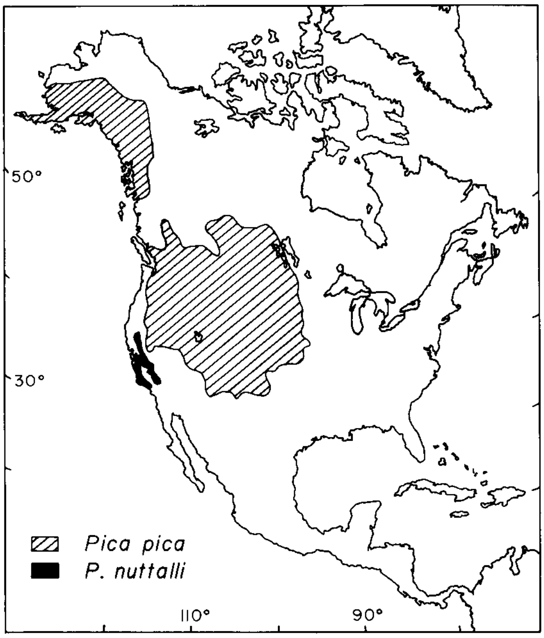

FIGURE 1. Ranges of the Black-billed (*P. pica*) and Yellow-billed (*P. nuttalli*) magpies in North America (based on data of Linsdale 1937).

The magpies were collected under California and Federal Fish and Wildlife permits issued to Weathers and a Federal Fish and Wildlife Permit issued to Charles H. Trost.

METABOLIC RATES

Rates of oxygen consumption ($\dot{V}O_2$) and evaporative water loss ($\dot{m}_{we}$) were determined simultaneously on fasted birds between 19:00 and 23:00, i.e., during the normal rest phase of their daily cycle. Measurements were made during fall and winter so the birds were not reproductively active or molting. During measurements, the birds were housed in individual 5.7-l metabolic chambers, which contained a mineral oil trap for excrement. Oxygen consumption was measured by open-circuit respirometry with an Applied Electrochemistry model S-3A analyzer. Evaporative water loss was measured either with an E G & G model 992 dew-point hygrometer or by gravimetry. Details of the methods, apparatus, and calibration procedures used in the metabolism studies were presented by Weathers et al. (1980).

Rates of metabolic heat production ($\dot{H}_m$) were calculated by assuming 20.08 kJ of heat are produced per liter of O_2 consumed. Rates of evaporative heat loss ($\dot{H}_e$) were calculated assuming 2.43 J of heat are required to vaporize 1 mg of water. Each bird was weighed before and after each metabolic determination, and its mean mass was used in all calculations. The birds remained at a stable ambient (chamber) temperature (T_a) for 2 h before any measurements were made, ensuring that each bird was quiescent and that T_a had stabilized within the chamber. Gas exchange was determined over a period of 0.25 h, and the lowest stable value used to calculate the bird's metabolic rate. Measurements were made at only one temperature on a given day to avoid the influence of the previous temperature on metabolic rate. Each bird was allowed to recover for at least 24 h before being used again. A total of nine measurements was made per individual, one at each temperature, except for those individuals who either died or were in poor plumage condition during the study.

Laboratory studies of thermoregulatory capacity at high air temperatures are strongly influenced by the chamber humidity (Lasiewski et al. 1966). To permit effective thermoregulation, the rate at which air flows through a metabolic chamber must be increased at high T_as to prevent the buildup of water vapor. Accordingly, we used a flow rate of 2.00 l min^{-1} (STPD) at T_as below 40°C, and 2.75 l min^{-1} at 40°C. At the latter temperature, water vapor pressure in the chamber averaged 1.60 kPa, which is low enough so that evaporative heat loss was not impaired (Lasiewski et al. 1966).

BODY TEMPERATURE

Body temperature (T_b) was measured immediately after the metabolic determinations by quickly removing the birds from the chamber and inserting a Cu-Cn thermocouple through the vent into the large intestine. Thermocouples were calibrated against a National Bureau of Standards thermometer.

STATISTICAL ANALYSES

Basal metabolic rates (BMR) were compared using Student's *t*-tests. Changes in metabolic rate as a function of T_a were analyzed by least squares regression analysis, and slopes of the regression lines were compared with *t*-tests (Steel and Torrie 1960). Because there were no significant differences in gas exchange values of males and females of either species, results for the two sexes were combined. The level of statistical significance used throughout the analysis was $P < 0.05$. Values are presented as mean ± 1 SE, unless indicated otherwise.

RESULTS

METABOLIC RATES

The thermoneutral zone (TNZ) of the Black-billed Magpie extended from 21.0 to 32.5°C (Fig. 2). Within this zone, $\dot{H}_m$ averaged 7.52 ± 0.13 mW g^{-1}. Below the TNZ, $\dot{H}_m$ correlated negatively with T_a [slope = −0.313

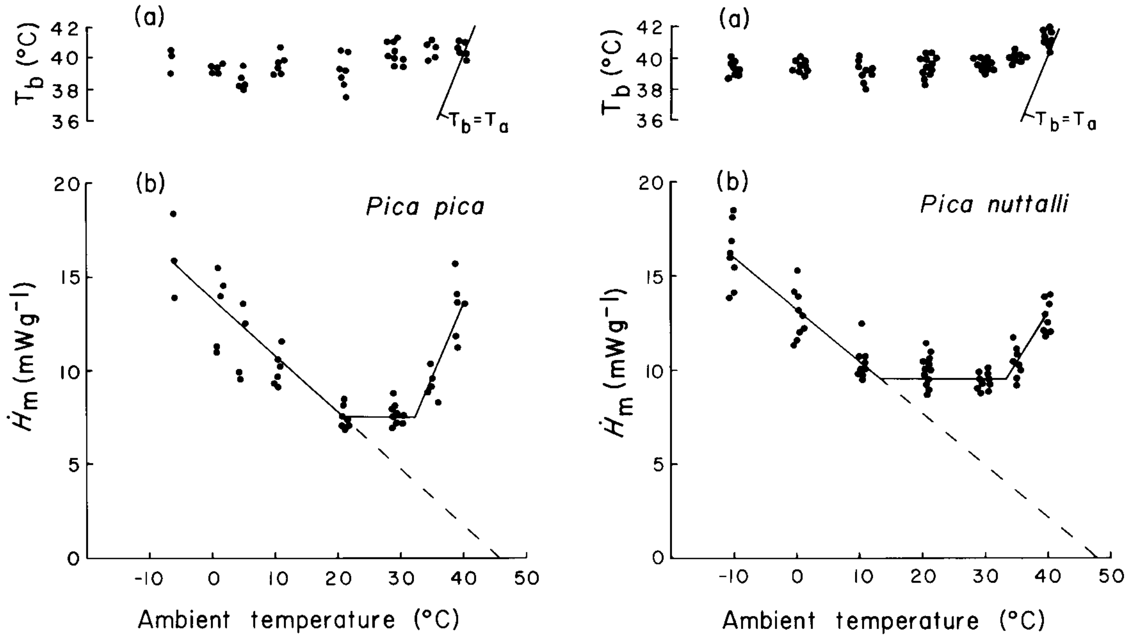

FIGURE 2. Relation of body temperature (a) and metabolism during rest phase of the circadian cycle (b) to ambient temperature in the Black-billed Magpie (left) and Yellow-billed Magpie (right). Lines fitted by method of least squares. Oblique lines in (a) indicate $T_b = T_a$ and illustrate that in most cases, the birds were not able to maintain T_b below T_a at high T_as.

mW (g°C)$^{-1}$; $r = 0.67$; 16 df, $P < 0.01$] and extrapolated to zero metabolism at approximately 45.5°C. (The slope of the line below the TNZ is a measure of the mean minimal conductance only if it extrapolates to the mean T_b; it then indicates that the animal is thermoregulating by holding conductance to a minimal and constant value and by chemically increasing heat production. The observed extrapolation is higher than the mean T_b, which indicates that the animal is responding to a decrease in T_a by a combination of increasing heat production *and* decreasing conductance. Although the mean minimal conductance would be greater than that measured by fitting a least squares regression [McNab 1980], the slope of the line is a measured response of the animal and is useful for comparing the two species.) Above 32.5°C, the $\dot{H}_m$ of this species was correlated positively with T_a ($r = 0.72$; 9 df, $P < 0.05$). The slope of the regression line fitted to the data between 35°C and 40°C was 0.816 ± 0.26 mW (g°C)$^{-1}$. Because three Black-billed Magpies died during metabolic determinations at 40°C, measurements were not made at higher temperatures.

The TNZ of the Yellow-billed Magpie extended from 13.5 to 33.5°C (Fig. 2). Within this zone, $\dot{H}_m$ averaged 9.67 ± 0.17 mW g^{-1}, which was significantly higher than that of the Black-billed Magpie. Below the TNZ, $\dot{H}_m$ increased linearly with decreasing T_a. The regression line fitted to the data below 13.5°C had a slope of -0.274 mW (g°C)$^{-1}$ ($r = 0.69$; 15 df, $P < 0.01$) and extrapolated to zero metabolism at approximately 48°C (Fig. 2). Above 33.5°, $\dot{H}_m$ increased with T_a at a rate of 0.518 ± 0.09 mW (g°C)$^{-1}$ ($r = 0.84$; 14 df, $P < 0.01$). Neither of these slopes differed significantly from those of the Black-billed Magpie. None of the Yellow-billed Magpies died during measurements of oxygen consumption at 40°C.

EVAPORATIVE HEAT LOSS

Evaporative heat loss increased exponentially with T_a in both species (Fig. 3). Although the value was slightly higher at all T_as in the Yellow-billed Magpie, the differences were not statistically significant. The relationship of $\dot{H}_e$ to T_a is described by the polynomial regression equation $\dot{H}_e = 1.01 - 0.10\ T_a + 0.0059\ T_a^2$ for the Black-billed Magpie and $\dot{H}_e = 1.48 - 0.13\ T_a + 0.0075\ T_a^2$ for the Yellow-billed Magpie. In the TNZ, $\dot{H}_e$ averaged 1.44 ± 0.16 mW g^{-1} and 1.54 ± 0.12 mW g^{-1} in Black-billed and Yellow-billed magpies, respectively. At 40°C, $\dot{H}_e$ increased to 5.9 times the thermoneutral levels in both species.

Within the TNZ, Yellow-billed Magpies dissipated significantly less of their metabolic heat production by evaporation than did Black-billed Magpies (15.3 vs. 19.5%). This is because heat production within the TNZ was greater in Yellow-billed Magpies, but evapo-

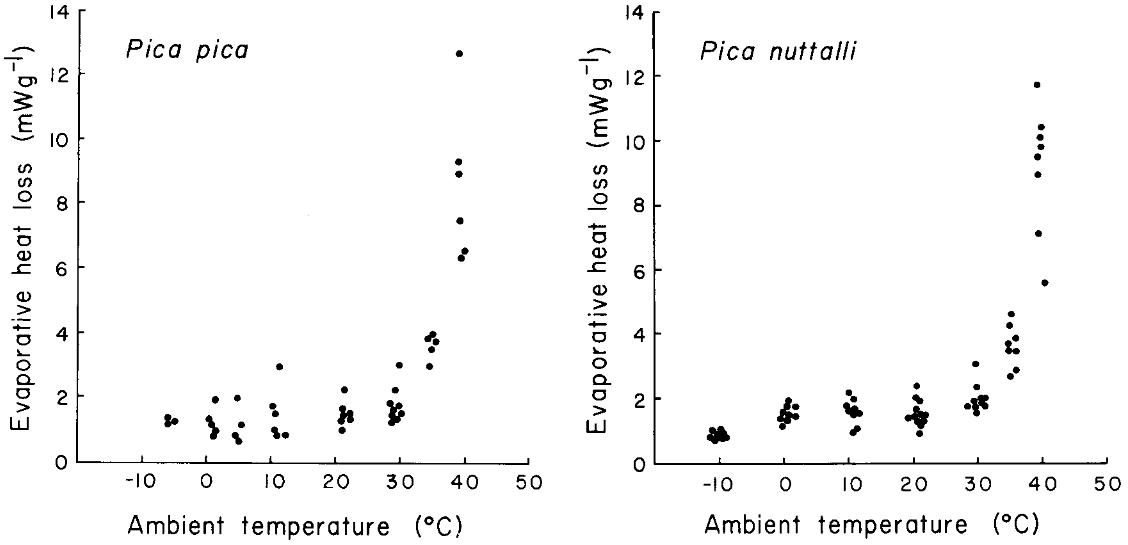

FIGURE 3. Relation of evaporative heat loss to ambient temperature for the Black-billed Magpie (left) and Yellow-billed Magpie (right).

rative heat loss was not. Under the conditions of our study, neither species was able to dissipate all of its metabolic heat production at 40°C by means of evaporative cooling. The relationship between the fraction of metabolic heat dissipated by evaporation and T_a was similar in both species (Fig. 4).

BODY TEMPERATURE

The relationship of T_b to T_a was similar in the two species (Fig. 2): T_b was independent of T_a between −10°C and 30°C, averaging 39.5 ± 0.2°C and 39.4 ± 0.1°C for Black-billed and Yellow-billed magpies, respectively. Hyperthermia developed progressively between 30 and 40°C in both species, with the T_b of Yellow-billed Magpies averaging 41.4 ± 0.2°C at 40°C, a value which is significantly higher than the 40.1 ± 0.2°C of the Black-billed Magpie.

DRY HEAT TRANSFER

The rate of dry heat transfer by radiation, conduction, and convection (Fig. 5) was calculated using the equation

$$h' = \dot{H}_m - \dot{H}_e/(T_b - T_a)$$

in which h' is the coefficient of dry heat transfer in mW $(g°C)^{-1}$. Because small errors in physiological measurements are greatly magnified when calculating h' at T_as near T_b, values of h' at $T_b - T_a = 0$ were omitted from Figure 5.

At low temperatures ($T_b - T_a > 20°C$), h' was constant and did not differ significantly between the two species (combined mean of $h' = 0.31 \pm 0.02$ mW $[g°C]^{-1}$). However, h' increased as T_a rose above 20°C and differences between the species appeared. Black-billed Magpies had a significantly lower heat transfer

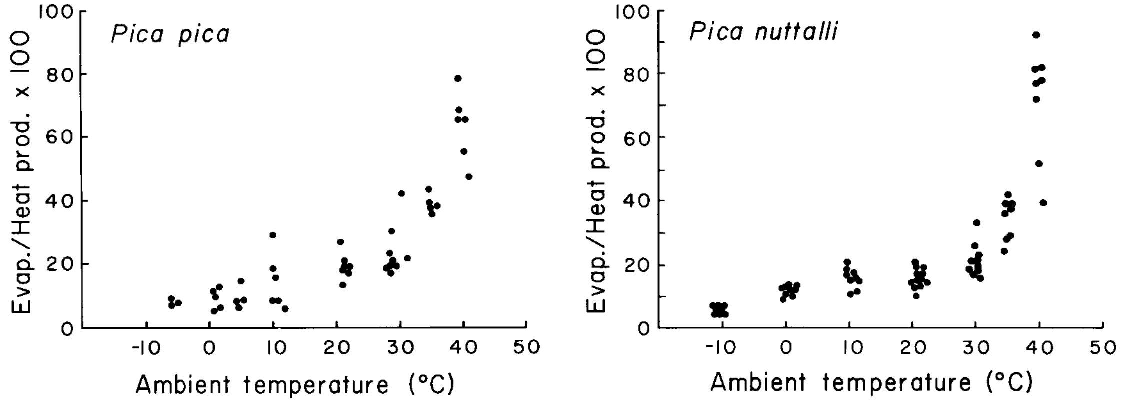

FIGURE 4. Relation of percent of metabolic heat lost by evaporation to ambient temperature in the Black-billed (left) and Yellow-billed (right) magpies.

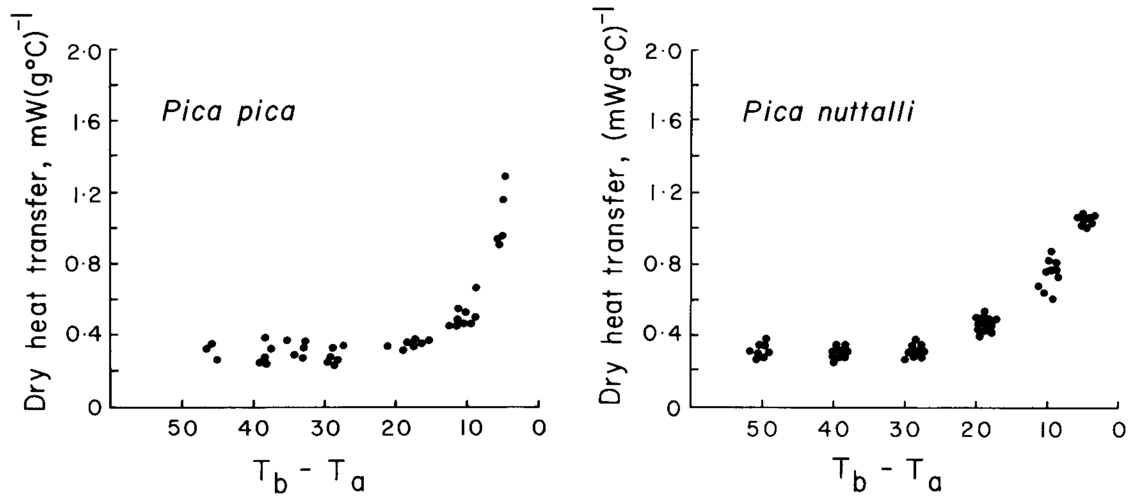

FIGURE 5. Relation of dry heat transfer to the difference between body and ambient temperature in the Black-billed (left) and Yellow-billed (right) magpies.

coefficient than Yellow-billed Magpies when ($T_b - T_a$) was 20°C or less (Fig. 5).

DISCUSSION

Temperature records for locations near our capture sites (Table 1) reveal that Yellow-billed Magpies in Sacramento encounter extreme summer temperatures that are more than 8°C hotter than those to which Black-billed Magpies are exposed in Pocatello. Conversely, Black-billed Magpies must contend with extreme winter temperatures that are more than 20°C colder than those experienced by Yellow-billed Magpies. Considering the northern limits of the species' ranges, and the mean monthly temperature data in Table 1, the major difference in their climatic regimes appears to be the much colder winters faced by the black-billed form. From a detailed study of thermal and behavioral energetics, Mugaas and King (1981) concluded that Black-billed Magpies could always avoid heat stress by retreating to shade, but could not avoid cold stress. They suggested that selection pressure should therefore have favored adaptation to cold rather than heat, and that heat stress should be more limiting to this species than cold stress.

Physiological adaptations to cold environments include reductions in thermal conductance and the lower critical temperature (T_{lc}), and/or increases in BMR (Calder and King 1974, Weathers 1979). Adaptations to hot environments include decreases in BMR and, in xeric species, lower rates of evaporative water loss (see Weathers 1977, 1979, 1981). Thus, by comparing these physiological parameters of the two magpie species (Table 2, Fig. 6) we may gain insight into their climatic adaptations.

RESPONSES TO LOW TEMPERATURES

Overall, our results indicate little difference in the physiological responses of the species to cold. Indeed, below 10°C we found no significant difference in any of their measured responses. At somewhat higher temperatures, the Black-billed Magpie had a significantly lower BMR and higher T_{lc} than the Yellow-billed Magpie (Table 2). This is contrary to what we expected, given the differences in their climatic regimes. Because the Black-billed Magpie is a large bird (the third largest passerine in North America), perhaps the colder winters it experiences are not sufficiently stressful to have required the evolution of distinct physiological adaptations. This is in contrast to the pattern observed in the much smaller House Sparrow (*Passer domesticus*; Hudson and Kimzey 1966).

The Black-billed Magpie's BMR is lower than that predicted for a passerine of its size (Table 2). This is contrary to what would be expected for a cold climate species (Weathers 1979) and suggests that ecological constraints

TABLE 1. Representative air temperatures experienced by Yellow-billed Magpies (Sacramento) and Black-billed Magpies (Pocatello).[a]

	Air temperature, °C			
	Mean daily		Mean monthly	Extreme
	Max.	Min.		
Sacramento, California				
Jan.	11.8	2.9	7.3	−5.0
Jul.	34.1	14.1	24.1	46.1
Pocatello, Idaho				
Jan.	−0.2	−10.6	−5.4	−28.3
Jul.	32.0	12.8	22.4	37.8

[a] Data for the period 1931–1960 (Ruffner and Blair 1977).

TABLE 2. Observed (Obs.) and predicted (Pred.) physiological parameters of *P. pica* and *P. nuttalli.*

	P. pica		*P. nuttalli*	
	Obs.	Pred.	Obs.	Pred.
Body mass, g	158.9*	—	151.9	—
Thermal conductance, $mW(g°C)^{-1}$	0.313	0.311[a]	0.274	0.317[a]
Heat strain coefficient, $mW(g°C)^{-1}$	0.816	0.464[b]	0.518	0.477[b]
Basal metabolism, $mW\ g^{-1}$	7.52*	9.21[c]	9.67	9.32[c]
Evaporation, g H_2O/day at 20°C	8.14	4.70[d]	8.33	4.65[d]
Lower critical temperature, °C	21.0*	9.8[e]	13.5	10.0[e]
Upper critical temperature, °C	32.5	—	33.5	—

* Significantly different from *P. nuttalli* ($P < 0.05$, *t*-test).

[a] Calculated from the relation $mW\ g^{-1} = 3.215\ g^{-0.461}$ after Aschoff (1981).

[b] Calculated from the relation $mW\ g^{-1} = 12.5\ g^{-0.65}$ from Weathers (1981).

[c] Calculated from the relation $W = 5.57\ kg^{0.726}$ after Aschoff and Pohl (1970).

[d] Calculated from the relation $gH_2O\ day^{-1} = 1.563\ g^{0.217}$ from Crawford and Lasiewski (1968); expected value at 25°C.

[e] Calculated from the relation $T_{lc} = T_b - 11.5\ g^{0.187}$ from Weathers and van Riper (1982).

are the major selective forces in this species, as they are in other species whose BMR departs from expectations based on climate. For example, the Emperor Penguin (*Aptenodytes forsteri*) does not have the elevated BMR typical of cold climate species—apparently an adaptation to its prolonged fast during the breeding season (see Weathers 1979). In four species of Hawaiian honeycreepers, BMR also departs from the usual allometric function of mass (i.e., BMR is not proportional to $mass^{3/4}$). The selective forces operating in this case were the species' social positions in an interspecific dominance hierarchy and their relative success at nectar exploitation (MacMillen 1981). The Black-billed Magpie's lower BMR is perhaps related to availability of food in the summer. If food is less predictably available during the time when the birds are in thermal neutrality, a reduced BMR could represent a substantial energy savings. Additional measurements are required in order to discern whether this reduction in BMR is correlated with food supply or due to acclimation.

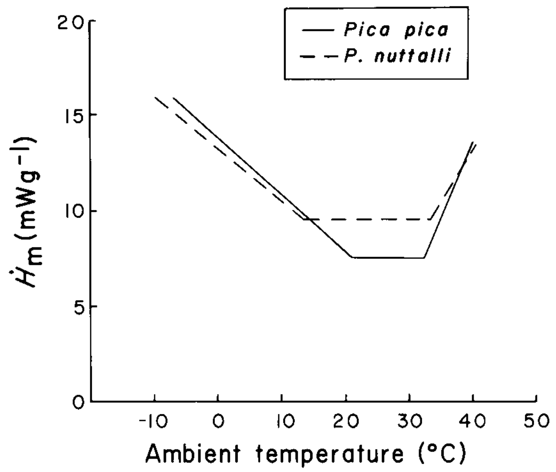

FIGURE 6. Relation of metabolism to ambient temperature in both Black-billed and Yellow-billed magpies, illustrating the effect of a lower basal metabolism on the shape of the graph.

ACCLIMATION EFFECTS

Our study was based on the assumption that genetic differences between related species can be revealed by determining their BMRs after acclimating individuals to a neutral temperature. An acclimation period is required because BMR depends upon the bird's previous thermal history (see Chaffee and Roberts 1971, Weathers and Caccamise 1978). Therefore, we kept magpies of both species at 25 ± 2°C for one month before measuring their metabolism. In retrospect, this may have been an inappropriately high acclimation temperature. It exceeds the mean July air temperature to which our magpies are normally exposed (Table 1), and may have elicited different responses in the two species: the Black-billed Magpie responding as if in a hot environment, the Yellow-billed Magpie responding as if in a neutral environment. If so, our results may reflect acclimation effects rather than genetic adaptation. Stevenson's (1971) data support this suggestion. He found that the BMR of Black-billed Magpies acclimatized out-of-doors in Montana varied seasonally from an April low of 7.65 $mW\ g^{-1}$ to a December high of 11.05 $mW\ g^{-1}$. The BMR value we obtained is essentially the same as Stevenson's April value (Table 2), which suggests that had we acclimated our Black-billed Magpies to a lower temperature, their BMR might have been higher. What acclimation temperature we should have chosen is uncertain. The mean annual temperature for the range of each species, however, would probably have been more appropriate than the single, fairly high temperature that we used.

Stevenson's (1971) data suggest another possible pattern for climatic adaptation by the Black-billed Magpie: namely, a much larger seasonal change in BMR than expected for a bird of its size (see Weathers and Caccamise

1978). Assuming that the body mass of the magpies used in Stevenson's study was similar to that of our birds (i.e., 159 g), the April BMR is 83% of that predicted by the equation of Aschoff and Pohl (1970), whereas the December BMR is 120% of the predicted value. Thus, through seasonal acclimatization, Black-billed Magpies are able to achieve BMRs characteristic of cold-adapted birds in winter and heat-adapted birds in summer. Although such seasonal variations in BMR appear to be more typical of small than large passerines (see Weathers and Caccamise 1978), additional studies are needed to clarify its size dependency.

HIGH TEMPERATURE TOLERANCE

Despite their higher BMR, Yellow-billed Magpies are better adapted to high temperatures than are Black-billed Magpies. Above the upper critical temperature (T_{uc}), they became more hyperthermic—permitting them to lose significantly more heat by nonevaporative pathways, exhibiting a smaller increase in $\dot{V}_{O_2}$ as a function of T_a, and surviving better than did Black-billed Magpies. Although birds adapted to hot environments often have lower BMRs than would be predicted allometrically (see Calder and King 1974), our data indicate that a low BMR does not necessarily signify greater heat tolerance.

Why the Black-billed Magpie's heat tolerance is so low is unclear. Its heat strain coefficient (slope of the temperature metabolism line above the T_{uc}) is much higher than that of the Yellow-billed Magpie (Fig. 6); indeed, the coefficient is 76% greater than that predicted for a bird of its size (Table 2). Accordingly, its metabolic heat production increases very rapidly above the T_{uc}, much more so than the Yellow-billed Magpie, whose heat strain coefficient, in contrast, is only 8.6% greater than that predicted for a bird its size (Table 2). Regardless of the mechanisms underlying these species' differences, natural selection has clearly resulted in greater heat tolerance in the Yellow-billed Magpie, a fact well correlated with the higher temperatures to which it is exposed.

Nonetheless, compared with most other passerines, Yellow-billed and Black-billed magpies are heat intolerant. Both species have very low T_{uc}s and limited capacities for evaporative cooling at high temperatures. Black-billed Magpies are especially heat sensitive as indicated by the death of three birds at 40°C. The death of several Black-billed Magpies during metabolic measurements at 39°C led Stevenson (1971) to suggest that high temperatures and humidities in the midwestern United States restrict Black-billed Magpies to regions west of 100°W longitude. Our data support this postulate and indicate that climate probably acts *directly* to restrict Black-billed Magpies to the Cold Type Steppe Dry Climate, rather than ecologically through a secondary effect on food availability.

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RECENT PUBLICATIONS

A Guide to Field Identification/Birds of North America. Revised edition.—Chandler S. Robbins, Bertel Bruun, and Herbert S. Zim; illustrated by Arthur Singer. 1983. Golden Press, New York; Western Publishing Co., Racine, WI. 360 p. Hard cover $10.95, soft cover $7.95. Here is an enlarged and completely revised edition of a popular field guide, first published in 1966. The format, features, and style are the same as before, but more species, pages, and illustrations are included. Nomenclature and taxonomy have been brought up-to-date, and the text has been revised so as to add new information or improve the writing. All of the range maps have been redrawn and modernized. "Art revisions range from small color improvements and helpful additional details . . . to entirely new plates and many more paintings of individual birds." The new typography is more legible than before, while the color printing tends to be softer and more accurate. Even the binding has been improved in the soft-cover edition. If you're in the market for a North American field guide, compare this one with its new competitors, noted below.

Field Guide to the Birds of North America.—National Geographic Society. 1983. 464 p. Paper cover. $13.95 plus $3.00 for postage and handling. Source: National Geographic Society, Dept. 100, Washington, DC 20036. This new entry among field guides was produced by the NGS staff with the aid of four birding/ornithological consultants and thirteen artists. In one volume it includes not only the North American breeding birds, but also those that only winter here or pass through on migration, occasional visitors, and introduced species that are now either established breeders or at least commonly seen as escapees from captivity—for a total of over 800 species. The species accounts (3–5 per page) and range maps are placed on the left-hand pages with the color plates facing. The entries describe appearance, habits, habitat, and voice insofar as is helpful for identification, paying attention to duller plumages, geographic variation, and similar species. The illustrations have naturalistic touches and present the birds in different poses so as best to show the field marks. They vary from reasonably good to excellent according to the artist responsible. This guide invites comparison with others, particularly the revised edition of that by Robbins et al. (Golden Guide), because it too is a single volume and uses the same format. Detailed comparison is not possible here but a few points can be noted. The NGS guide includes more species and the texts are more informative than those of the Golden Guide; its maps tend to be smaller and less detailed, while the illustrations tend to be larger and better printed. Physically, the NGS volume is a little larger (i.e., less pocketable) and considerably heavier. Including postage, the NGS book costs more than twice as much as the Golden. Before deciding between them, however, be sure to see the Peterson standbys and the new Audubon set (noticed below).

The Audubon Society Master Guide to Birding.—Edited by John Farrand, Jr. 1983. Alfred A. Knopf, New York. 3 volumes (447, 398, 399 p.). Stiff paper and cloth cover. $13.95 per volume. Recent decades have seen reciprocal interactions between birders and field guides: improvements in the one have led to improvements in the other. The latest round in this escalation is marked by this work, subtitled "an advanced field handbook." That it occupies three volumes, each larger than any single-volume guide, indicates the depth of treatment. Volume 1 goes from loons through sandpipers, volume 2, from gulls through the Dipper, and volume 3, from Old World warblers through the *Passer* sparrows. The 835 species are arranged according to the latest *A.O.U. Check-list,* except for accidentals, which are listed at the end of each volume. They have been written up by one or another of 61 authors. The text is on the left-hand pages, faced by the illustrations. Each account (⅓ to 1 page per species) provides a characterization of the species, descriptions of appearance and voice, comparison with similar species, and a statement of the range (supplemented with a small map). Aside from its size, the most distinctive feature of this set is the illustrations. Every species, except for the accidentals, is presented individually, not in combination plates, with one or two (rarely more) added to show sexually dimorphic or immature plumages. Most of the illustrations are color photographs, with color paintings used where suitable photographs were unavailable. The editor and the authors have done an amazing job of unearthing so many good photographs, especially of unglamorous species and plumages. Field marks are pointed out in small monochrome copies of the color pictures and in marginal drawings. Also included are several short but informative articles about birds and birding. A glossary, mostly of terms pertaining to external morphology, is provided in each volume. Indexed. This work is the most ambitious guide to North American birds, but despite its advantages it is not in all ways the "best." It deserves close comparison with other new or newly revised guides on the basis of accuracy, usefulness for identification—particularly in tricky cases—and practicality in the field.