

RESPIRATORY METABOLISM OF THE RED-WINGED BLACKBIRD IN RELATION TO AMBIENT TEMPERATURE

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Oxygen consumption as a function of air temperature commonly falls into three relatively distinct phases in homeotherms, including (1) a thermoneutral zone, delimited by so-called critical temperatures, in which metabolic rate is not affected by air temperature, (2) a zone below the lower critical temperature in which metabolic rate commonly increases as a linear or shallow curvilinear function of air temperature, and (3) a zone above the upper critical temperature in which metabolic rate increases rapidly or exponentially in relation to air temperature. The critical temperatures have frequently been defined as the intersections of the functions just described.

The physiological basis of these zones in birds has been analyzed by King and Farner (1961), but recent reports (e.g., King 1964) have emphasized the shortcomings of this scheme for displaying empirical data in some cases. The three zones in fact are probably segments of a continuous function. Thus there seem to be gradual transitions from predominantly physical thermoregulation to predominantly chemical thermoregulation at the lower critical temperature and to evaporative heat transfer at the upper critical temperature (Dawson and Tordoff 1964).

Evidence from this report examines further the metabolic response of birds (Red-winged Blackbirds, *Agelaius phoeniceus*) acclimatized to an outdoor environment and then tested in constant and rapidly changing temperature conditions. A design in which temperature was accurately controlled at constant levels for lengthy periods or changed at a constant rate over a wide temperature range enabled

us to compare the metabolic response of red-wings to steady and changing temperature conditions. By changing the ambient temperature at rates approximating those experienced in natural surroundings we were also able to avoid the effects of acclimation that potentially trouble longer term constant temperature programs.

MATERIALS AND METHODS

Red-winged Blackbirds were collected from marshes near the mouth of Thames River on the southeast side of Lake St. Clair in Kent County, Ontario. All the birds used in this experiment were captured in June 1965 and were held at the University of Guelph in two outside cages measuring 3 × 3 × 6 m. They were fed a mixture of 18 per cent protein chick-starter and cracked corn with a mineral and vitamin supplement.

The birds were acclimatized to outside temperatures during the month of December, which, in 1965 ranged from -16.7° to 12.2°C. The mean temperature for the month was -1.6°C, with a mean minimum of -4.6°C and a mean maximum of 1.4°C. During this month the body weights of 36 male redwings ranged from 78.84 to 57.31 g with a mean (\pm se) of 70.27 ± 0.76 g, while the weights of 15 females ranged from 59.02 to 36.92 g with a mean weight of 46.50 ± 0.81 g.

Metabolism tests were conducted in an insulated cabinet equipped with a refrigeration unit, heating coil, fan for air circulation, and thermostatic control (fig. 1). Six metabolism chambers were constructed from four-liter glass jars with metal screw lids. The lids were fitted with inlets and outlets for gas exchange and were sealed with rubber gaskets.

Gas analyses were conducted with a Beckman Model LB-1 infrared carbon dioxide analyzer connected in parallel with a Beckman Model F-3 paramagnetic oxygen analyzer. The carbon dioxide analyzer was calibrated with atmospheric CO₂ (0.03 per cent) and with three commercially mixed gases containing 0.186 per cent, 0.53 per cent, and 0.73 per cent CO₂ by volume. The oxygen analyzer was calibrated by using dry atmospheric air (20.93

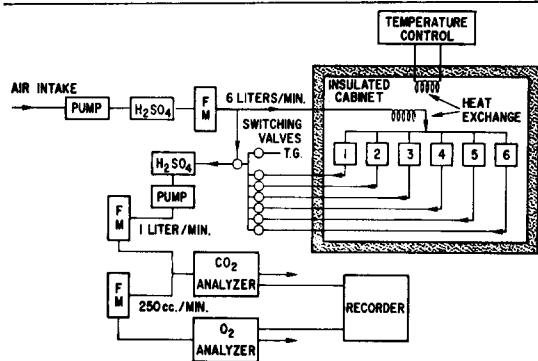


FIGURE 1. Block diagram of experimental equipment design. FM = flow meter, T.G. = test gas.

per cent O_2) and a commercial gas mixture of 18.8 per cent O_2 . The output data of the analyzers were recorded on separate channels of a Beckman Type R Dynograph.

Outside air was supplied to each metabolism chamber at a flow rate of approximately one liter per minute through tygon and glass tubing. A manifold around the temperature control unit kept the air supply at cabinet temperature. Air from the metabolism chambers passed to the outside of the cabinet for sampling and analysis. A water manometer was used to determine the pressure in the circuit, i.e., the variation from exterior air pressure. A by-pass in the incoming circuit allowed sampling of the air supply to the chamber. Samples were drawn off at a flow rate of one liter per minute and analyzed for oxygen and carbon dioxide in per cent by volume. Outside-air samples, metabolism-chamber samples, and test-gases were passed through sulfuric acid to remove water vapor before analysis. Flow meters, calibrated for standard pressure and temperature, were used to regulate the rate of airflow through the system.

Air temperatures of the cabinet and of the air passing into and out of the metabolism chambers were measured with a YSI thermistor and were recorded on a third channel of the strip chart. The temperature of the air leaving the metabolism chambers was assumed to be the same as the environmental temperature of the birds.

In the period of 30 November-30 December 1965 42 constant temperature metabolism tests of three hours duration were made using 24 male and 11 female birds. These tests were made at 0.0, 5.0, 15.5, 27.5, 29.0, 36.5, and 39.5°C. For the tests at 39.5°C it was necessary to place the birds in the chambers prior to establishing the desired test temperature. The birds were weighed and placed in the metabolism chambers with water but without food. They remained in the chambers for one hour before air samples were taken. The six chambers were sampled consecutively at 4-min intervals for the duration of the test. Both gas analyzers were recalibrated periodically during each test to maintain a check on the base line.

Additional tests were conducted on 21 males and 7 female redwings through a temperature range of 0.0° to 45.0°C. The birds were treated the same as the above group prior to the start of the test program. After testing began, the temperature was increased

at an average rate of 4° per hour. The metabolic response of the birds again was sampled consecutively at 4-min intervals and the results were grouped into 1° intervals.

All nighttime tests were conducted in changing temperature conditions between 0.5° and 42.5°. Only a part of the range was covered on any one night. The testing program started at approximately 01:00 with an average length of 7 hr.

Data on carbon dioxide production and oxygen consumption were determined concurrently for 18 constant-temperature tests and for 18 daytime changing-temperature tests. In the remaining experiments only oxygen consumption was measured. The quantities of both respiratory gases were determined by multiplying the average strip chart level recorded over the 4-min sample period by a constant obtained from the calibration curves. Since an accurate flow rate was known, these values measuring gas concentration change from the base level were used to solve the amount of CO_2 produced and the amount of O_2 consumed per unit of body weight per unit of time. Tests having both CO_2 and O_2 measurements were used to determine respiratory quotients (RQ).

The method of least squares was used to fit equations of oxygen consumption data, measured in milliliters per gram weight of bird per hour of testing ($ml/[g \times hr]$), plotted against temperature (°C) as an index of metabolism (Brody 1945). The data were segregated and plotted according to period of day and sex of the birds (figs. 2, 3, 4, 5). The daytime values followed a curvilinear relationship, and the equation $Y = (a + bX + cX^2)^{-1}$ (Ezekiel and Fox 1963) was used to describe these relationships. The nighttime data for males and females were described as linear function according to the equation $Y = a + bX$ (Alder and Roessler 1960).

The test data of males were analyzed in an attempt to establish a measure of thermoneutrality. This analysis was conducted with the assumption that the oxygen consumption points could be converted to caloric measure of direct calorimetry according to the correlative RQ at each particular point (Hawk et al. 1947:659; King 1957). Oxygen values collected without corresponding CO_2 measurements were converted to caloric equivalents by using mean RQ values of the other tests. In this way, the results, measured by empirical values of oxygen consumption, were described by a conventional energy flow expression ($cal/[g \times hr]$). The values $cal/(g \times hr)$ were determined for three straight lines: the line below thermoneutrality with a negative slope, the line through thermoneutrality with zero slope, and the line above thermoneutrality with a positive slope. The points between 0.0° and 27.5°C showed a negative slope and those between 40.0° and 45.0°C showed a positive slope. The remaining points (those between 27.5° and 40.0°C) were analyzed as a line with a slope of zero (fig. 6).

Data for the daytime tests on males were grouped into constant temperature and changing temperature classes. The values at each temperature were fitted to curves and compared statistically (fig. 2).

RESULTS

METABOLIC STUDIES

Male response (day and night). The metabolic response of the male birds in the day-

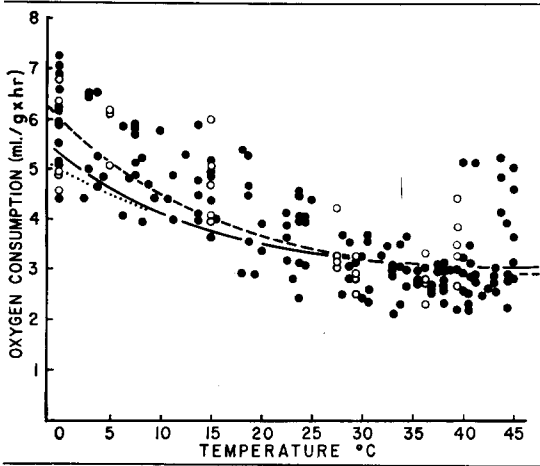


FIGURE 2. Metabolic response of male Red-winged Blackbirds to temperature during the day. Dotted line and closed circles represent changing-temperature test data; dashed line and open circles, constant-temperature test data; solid line, combined data.

time tests ranged from an individual minimum value of 2.09 ml O₂/(g × hr) at 33.5°C to individual maxima of 7.25 and 5.24 ml O₂/(g × hr) at 0.0° and 44.0°C respectively. The regression curve for the grouped data (constant- and changing-temperature tests) was $Y = (0.1863 + 0.0061X - 0.000065X^2)^{-1}$ (table 1). The mean minimum value was 3.04 ml O₂/(g × hr) at temperatures between 43.0° and 45.0°C and the mean maximum was 5.38 ml O₂/(g × hr) at 0.0°C (fig. 2).

The nighttime tests of the males showed a range from an individual minimum value of 1.75 ml O₂/(g × hr) between 28.0° and 30.5°C to a maximum of 6.25 ml O₂/(g × hr) at 0.5°C. The regression line for the males at night was

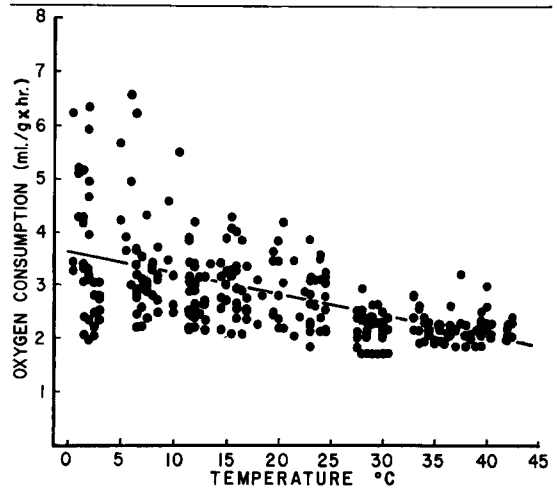


FIGURE 3. Metabolic response of male Red-winged Blackbirds to temperature during the night.

$Y = 3.633 - 0.0386X$ (table 1) with a mean minimum value of 7.98 ml O₂/(g × hr) at 42.5°C and a mean maximum value of 3.61 ml O₂/(g × hr) at 0.5°C (fig. 3).

Female response (day and night). The metabolic response of the female birds in the daytime tests showed a range from an individual minimum value of 2.64 ml O₂/(g × hr) at 36.5° and 40.0°C to an individual maximum of 8.86 ml O₂/(g × hr) at 0.0°C. The regression curve of the daytime data was $Y = (0.1056 + 0.0062X - 0.00003X^2)^{-1}$ (table 1). The mean minimum value was 3.05 ml O₂/(g × hr) at 45.0°C and the mean maximum value was 9.52 ml O₂/(g × hr) at 0.0°C (fig. 4).

The nighttime tests of females showed individual ranges from 2.15 ml O₂/(g × hr) at 33.5° and 36.5°C to 4.02 ml O₂/(g × hr) at

TABLE 1. Results of metabolism tests.

Sex	Test Period	Test Type	N	Regression equation ^a	SE of Estimate ^c
Males	Day	Changing-temperature	148	$Y = (0.2001 + 0.0047X - 0.000039X^2)^{-1}$	0.892
Males	Day	Constant-temperature	31	$Y = (0.1653 + 0.0062X - 0.000049X^2)^{-1}$	0.793
Males	Day	Combined	179	$Y = (0.1863 + 0.0061X - 0.000065X^2)^{-1}$	0.847
Males	Night	Changing-temperature	279	$Y = 3.633 - 0.0386X$	0.591
Males	Day	Combined ^b			
		0.0–27.5°C	114	$Y = 27.12 - 0.456X \text{ cal}/(g \times \text{hr})$	3.503
		27.5–40.0°C	55	$Y = 14.44 \text{ cal}/(g \times \text{hr})$	1.816
		40.0–45.0°C	60	$Y = -6.526 + 0.525X \text{ cal}/(g \times \text{hr})$	3.659
Females	Day	Changing-temperature	69	$Y = (0.1056 + 0.0062X - 0.00003X^2)^{-1}$	1.103
Females	Night	Changing-temperature	58	$Y = 3.26 - 0.0188X$	0.313

^a For oxygen consumption data: Y = metabolic rate, ml O₂/(g × hr) (STP); X = air temperature, °C.

^b Analyzed for three zones shown in figure 6: slope below thermoneutrality, thermoneutrality, and slope above thermoneutrality.

^c Standard error of estimate = $S_{y.x}$ for linear equations; $S_{y.f(x)}$ for curvilinear equations.

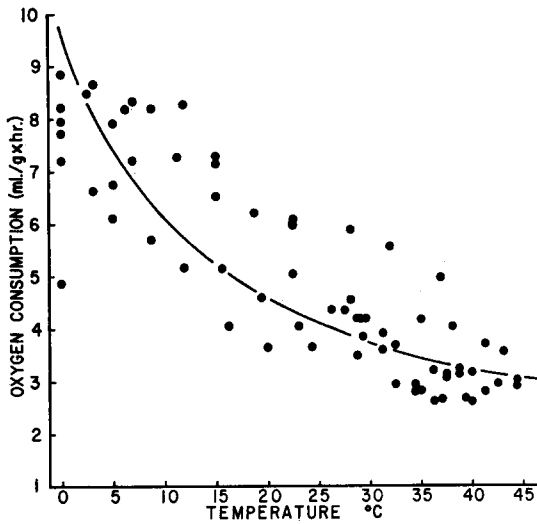


FIGURE 4. Metabolic response of female Red-winged Blackbirds to temperature during the day.

15.5°C. The regression line for the females at night was $Y = 3.26 - 0.0188X$ (table 1) with a mean minimum value of 2.47 ml $O_2/(g \times hr)$ at 42.5°C and a mean maximum value of 3.23 ml $O_2/(g \times hr)$ at 2.0° (fig. 5).

ESTIMATES OF THERMONEUTRALITY

The thermoneutral range was found to lie between 27.5°C and 40.0°C. The metabolic value was $Y = 14.44 \text{ cal}/(g \times hr)$ (tables 1, 4; fig. 6). The metabolic data below 27.5°C gave a regression line of $Y = 27.12 - 0.456X$ and the metabolic data above 40.0°C gave a regression line of $Y = -6.526 + 0.525X$ (table 1, fig. 6).

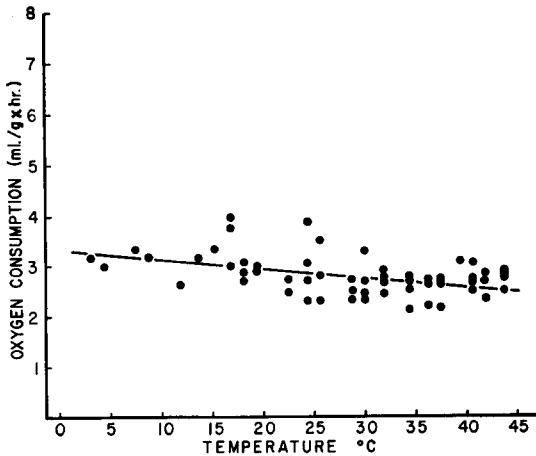


FIGURE 5. Metabolic response of female Red-winged Blackbirds to temperature during the night.

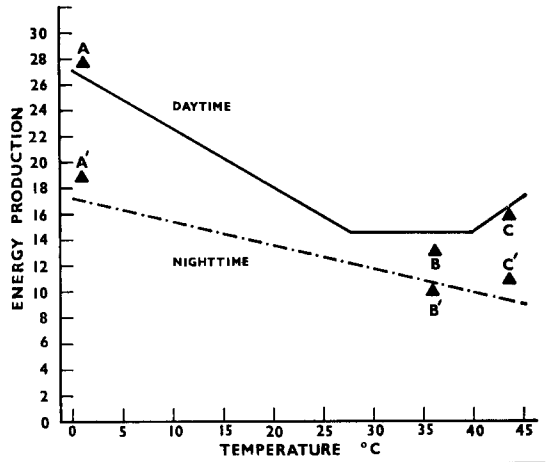


FIGURE 6. Energy expenditure, measured in cal/(g x hr), of male Red-winged Blackbirds for daytime and nighttime test conditions. The oxygen consumption data presented in figure 3 have been reworked to present a zone of thermoneutrality. An approximate method of testing differences between sets of means showed the daytime and nighttime slopes of standard metabolism to be significantly different (A, A' vs. B, B', $P < 0.001$; B, B' vs. C, C', $P < 0.05$).

COMPARISON OF TEST TYPE

The two testing programs, exposure to stable temperatures that varied from test to test and exposure to changing temperatures, showed no difference in the results (table 2, fig. 2). An adjusted analysis of variance to account for disproportionate subclass numbers and interaction (Steel and Torrie 1960:265) showed that the total variability noted was due to differences in metabolic response between temperature levels (table 2). There was no difference between the mean values obtained for the constant-temperature values and the changing-temperature values (table 2). In addition there was no evidence for interaction between the A and B components; thus the factors under consideration acted independently of one another.

TABLE 2. Comparison of results from two metabolism test types by analysis of variance.

Source of Variation	df	Mean Squares
A, Temperature ^a	7	324.13 ^d
B, Type of test ^b	1	25.19
AB, Interaction ^c	7	11.09
Error	134	9.43
Total	150	

^a The A component is environmental temperature.
^b The B component is metabolic response for the two test types: constant-temperature tests and changing-temperature tests.
^c Analysis is adjusted for unequal sub-cell number and for interaction of A and B components.
^d Significant at the 0.005 level.

TABLE 3. Respiratory quotients obtained in testing male and female Red-winged Blackbirds.

Test Type ^a		N	Respiratory Quotients	
Constant Air Temp. ^b	Changing Air Temp. ^c		Mean	SE
Both sexes		18	0.71	0.016
	Both sexes	171	0.76	0.005
Males		14	0.71	0.022
Females		4	0.73	
	Males	131	0.75	0.004
	Females	40	0.79	0.014

^a See text for description of test type.
^b O₂ and CO₂ values were averages of 2-hr sampling and only one RQ per test is reported (N = number of birds).
^c Each test was made up of a number of observations at different temperatures (N = number of birds × observations).

RESPIRATORY QUOTIENTS

The mean RQ for both sexes for constant-temperature tests (3-hr duration) was 0.71 with a SE of 0.016 and the 18 observations ranged between 0.61 and 0.83. The mean RQ for changing-temperature tests (7-hr average duration) was 0.76 with a SE of 0.005 and the values ranged between 0.57 and 0.98 for 171 observations (table 3).

The mean RQ for males was 0.71 (SE = 0.022, 14 observations) in constant-temperature tests and 0.75 (SE = 0.004, 131 observations) in the changing-temperature tests (table 3). A comparison of the results from the two test groups by Student's *t* test showed no difference between the two mean values ($P < 0.10, > 0.05$). The mean RQ for females was 0.73 (4 observations) in constant-temperature tests and 0.79 (SE = 0.014, 40 observations) in the changing-temperature tests (table 3). No statistical comparison could be made between the two test types.

A comparison of the results obtained for male and female data obtained in changing-temperature tests by Student's *t* showed the RQ means of 0.75 for the males and 0.79 for the females to be different ($P < 0.01$, table 3).

DISCUSSION

STANDARD METABOLISM

Two widely quoted equations, the Brody-Proctor and the King-Farner (King and Farner 1961), and a recently-reported equation

updating the previous equations (Lasiewski and Dawson 1967) were used to predict standard energy production. The results are summarized in table 4. Our results for both male and female redwings show general agreement with predicted values.

McNab and Morrison (1963) suggested that minimum values at a given temperature represented a better measure of minimal metabolism required at that temperature. Using this criterion the experimentally determined minima become, for males, 9.93 cal/(g × hr) in the day, and 8.31 cal/(g × hr) at night; and for females, 12.60 cal/(g × hr) in the day, and 10.21 cal/(g × hr) at night. The nighttime values obtained in this way more closely approximate those predicted by the King-Farner equation.

A comparison of our values with those reported by Brenner and Malin (1965) shows an overlap of the SE ranges and there is probably no statistical difference between the reports from the two studies. For nighttime values (= basal, according to Brenner and Malin) they reported 2.90 (± 2 SE = 1.108–4.692) ml O₂/(g × hr) at 24°C. Our results for the same temperature were 2.71 (± 2 SE = 1.53–3.89) ml O₂/(g × hr). For daytime resting metabolism Brenner and Malin reported a value of 6.31 (± 2 SE = 2.65–9.97) ml O₂/(g × hr) and our values are 3.41 (± 2 SE = 1.71–5.11) ml O₂/(g × hr). Since Brenner and Malin averaged results obtained over a temperature range of 24° to 30°C, the differences in analyses probably account for the variation in results since our data show the lower critical temperature to be between the ranges assumed to be thermoneutral by Brenner and Malin (1965).

Metabolism differences were noted between daytime and nighttime results but these variations fall within the accepted limits of probable error noted by Lasiewski and Dawson (1967) (table 4). As would be expected, daytime values were higher than nighttime values and showed a difference of 5.03 cal/(g × hr) for males and 2.77 cal/(g × hr) for the females. Analyzed as an energy-conserving mechanism, the levels reported during the night represent a decrease of 35 per cent

TABLE 4. Summary of metabolism estimates from three published equations, and observed metabolic rates from male and female Red-winged Blackbirds. Values are expressed in cal/(g × hr).

Sex	Mean weights (g) redwings	Source of estimate			SE limits	Observed red-wing values	
		Brody-Proctor	King-Farner	Lasiewski-Dawson	Lasiewski-Dawson equation	Day	Night
Male	70.27	9.647	8.250	11.183	8.621–14.510	14.44	9.41
Female	46.50	11.192	9.502	12.536	9.659–15.896	14.60	11.83

TABLE 5. The relationships of daytime and nighttime metabolism of male Red-winged Blackbirds to changing temperatures compared by analysis of variance.

Source of Variation	df	Mean Squares
A, Temperature ^a	17	327.16 ^d
B, Day vs night ^b	1	3513.32 ^d
AB, Interaction ^c	17	48.62 ^d
Error	417	8.41
Total	452	

^a The A component is environmental temperature.

^b The B component is metabolic response that is comprised of b_1 (metabolic response during the day) and b_2 (metabolic response during the night).

^c Interaction of A and B components are tested for.

^d Significant at the 0.005 level.

from daytime values for the males and 19 per cent for the females, although little reliability can be given to the amount cited for the females owing to the small sample size for the nighttime tests.

Lasiewski and Dawson (1967) could find no concrete reasons for separating their data into diurnal and nocturnal components; however, they did note one study, that by Hudson and Kimzey (1964), in which a diurnal cycle was reported. West and Hart (1966) reported a pronounced difference between day and night values and reviewed other reports showing similar cycles. In addition West and Hart (1966:181) stated that "the diurnal metabolic rhythm persists at all temperatures." Our data for the male redwings support the conclusions reached by West and Hart (1966) and Hudson and Kimzey (1964). An analysis of variance (ANOVA) was used to examine the relationship of metabolism to temperature and differences between day and night values (table 5). The ANOVA, designed to correct for unequal subclass numbers, adjust the influence of B values (metabolism) on the A component (temperatures), adjust the influence of A values on the B component, and test for AB interaction, was used to determine the relationships of the day and night redwing metabolism with all temperatures. The results showed significant relationships ($P < 0.005$) for all levels. Thus both metabolism curves showed a significant increase in slope as environmental temperatures lowered (A and AB components) and there were significant differences between day and night values (B component).

Further comparisons of the data presented in the ANOVA showed that day-night differences existed for all temperature levels, as predicted by West and Hart (1966). A t test of weighted mean differences (Steel and

Torrie 1960:271) between the highest metabolic values (A and A' at 0°C, fig. 6) and the lowest values in the thermoneutral range (B and B' at 36°C, fig. 6) demonstrated that the metabolic values were different ($P < 0.001$). Likewise a comparison of the weighted mean day-night values in the thermoneutral range (B and B', fig. 6) and the highest mean values obtained above thermoneutrality (C and C' at 43.5°C, fig. 6) showed significant differences ($P < 0.05$). Thus not only were the standard metabolic rates different in the thermoneutral range, but in addition the slopes noting rate of increase in cold and warm conditions were different. This relationship is shown in figure 6.

The equation derived by Lasiewski and Dawson (1967) encompasses daytime and nighttime values for both male and female redwings within one standard error of estimate (table 4). Since we have found significant differences between day and night values, it would seem that the confidence limits set by the Lasiewski and Dawson equation perhaps are large because the data included day and night values. Thus, it may be of academic interest to re-examine daytime and nighttime standard metabolism slopes. The conflicting evidence is particularly puzzling at this time because not all of the literature differences can be explained by differences in handling or measuring techniques. Whether these differences can be explained by species-specific behavior or physiology cannot be determined at this time. The value in continuing these investigations has been pointed out by Zar (1968) in his report on metabolism differences between orders of birds. Further analyses of day-night differences should provide additional data for understanding avian phylogeny, ecology, and behavior, the subjects noted by Zar.

METABOLISM-TEMPERATURE RELATIONSHIPS

The data obtained in this study for male and female redwings add to the listing of studies noting discrepancies between empirical results and the theoretical Newtonian model used to explain heat transfer processes in homeotherms (see King 1964:21-22 for review). The daytime curvilinear results noted for both redwing sexes point out the complex physiological and behavioral activities that are not accounted for in the model put forward by Scholander et al. (1950). Birkebak (1966) has stated that it is not because the Newtonian model is inadequate that biologists have had difficulty in fitting empirical data to theory, but rather that the

incorrect theoretical model type has been used. King (1964) implied this in his discussion. Thus most, if not all, experimental designs have dealt with "un-steady state" heat transfer situations for which Newton's Law of Cooling is not strictly appropriate (Birkebak 1966). Furthermore, Birkebak (1966) has shown that heat transfer processes are not solely a function of conduction-heat-transfer of a sphere and thus vary directly with the geometrical shape assumed by the animal. By accounting for unsteady-state conditions instead of a steady state, geometrical configuration of the animal at different ambient temperatures, and evaporative heat transfer mechanisms, the role of changing metabolic rates in passerine species subjected to different environmental conditions will be more meaningful. The heuristic value of such an approach has already been demonstrated for sub-species investigations on the Canada Goose, *Branta canadensis* (LeFebvre and Raveling 1967).

COMPARISON OF TEST TYPE

The results obtained from the ANOVA (table 2) showing no difference between constant-temperature and changing-temperature test types at ambient temperatures to 0°C are noteworthy. The fact that there was no difference in the results tends to justify the technique of measuring oxygen consumption in changing-temperature conditions. There are several advantages in using this technique. Birds can be tested over a wide temperature range with maximum efficiency as far as handling technique is concerned. In addition there is less opportunity for the bird to become acclimated to the test temperature when the emphasis of the experiment is to test individual birds in a wide temperature range after they have been acclimated to a selected temperature condition. A major feature is the ability to program the data collecting system to sample in intervals so that statistical techniques can be applied to the data. This is particularly important when attempting to compare various slopes of oxygen consumption data against ambient temperatures. This technique will be less useful for studies on weight loss due to temperature stress. However, for comparative purposes, weight losses can be expressed in terms of loss per unit time per degree temperature change as long as the test conditions are comparable.

It is worthwhile noting that the two curves began to depart from one another rather drastically at 0°C. Despite the fact that no

statistical differences were found between the two curve types for the ambient range reported here, programs at lower temperatures or with other species could have different results.

RESPIRATORY QUOTIENTS

Mean respiratory quotients of 0.75 (males) and 0.79 (females) determined in this series of experiments are in agreement with work reported previously. Kendeigh (1944) reviewed a number of papers in his study of the House Sparrow (*Passer domesticus*) and reported RQ values as low as 0.70 and as high as 0.86. From his own data he recorded an RQ of 0.73 with a range of 0.65 to 0.81. Brenner and Malin (1965) reported an average RQ of 0.722 for redwings.

The fact that there was no difference in the RQ values of males tested in the constant-temperature and changing-temperature environments lends support to the conclusion reached from the oxygen consumption results that there was no difference in the metabolic response in the two test situations. However, the differences between male and female mean RQ values are not understood at this time. If the RQ data are critical enough, the results suggest that the metabolic substrates were somewhat different between the two sexes at this time of year. We feel that the validity of this observation must await further investigation.

SUMMARY

The effect of ambient temperature on the respiratory metabolism of Red-winged Blackbirds was studied during December 1965. Tests were conducted on the birds in constant and changing air temperatures. No difference was found between the two test conditions. A curvilinear relationship between metabolism and ambient temperature was found for daytime conditions but the nighttime results showed a linear relationship. In addition, significant differences were found between daytime and nighttime standard metabolic rates.

RQ values were lower for males than for females. This difference suggests that there was a slightly different metabolic substrate being utilized by the two sexes.

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