

# ENERGY REQUIREMENTS OF MOLT IN COWBIRDS

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THAT avian metabolic rates increase during molt has long been known (Koch and deBont, 1944; Perek and Sulman, 1945). Sturkie (1954) has suggested that the increase in heat production during the molt is a compensation for increased heat loss during this period of reduced insulation. Another hypothesis is that the increased metabolism during molt is due to the increased energy requirements for feather formation. After noting a seasonal modification of metabolism associated with molt in the Brown-headed Cowbird (*Molothrus ater obscurus*), I undertook a more thorough investigation of this phenomenon. Where previous studies have considered the metabolism of molting and nonmolting birds at only one ambient temperature, the present study compares molting and nonmolting cowbirds over a temperature range of 5–40°C, thus allowing one to distinguish between the energy required for feather formation and the energy required for thermal regulation in thermal neutrality (35–40°C).

## METHOD AND MATERIAL

Experimental birds were captured throughout the year, the molting birds during the late summer of 1968. All birds were caught in circular funnel traps baited with bird seed, or by mist nets at Pierce College in Woodland Hills, Los Angeles County, California. After capture the birds were taken immediately to the University of California at Los Angeles and placed in individual cages (27 × 25.5 × 25.5 cm). The mean weight at the time of capture of the nonmolting birds was 36.2 g, that of the molting birds 37.9 g. All birds were fed parakeet seed and supplied with water *ad libitum*. The birds were housed in a windowless air-conditioned room where they were kept on a 12-hour photoperiod (09:00–21:00) regulated by an automatic timer. The air temperature in the room ranged from 22–25°C. The relative humidity ranged from 40–60 per cent. All birds were allowed at least 2 weeks to adjust to laboratory conditions before being used in any experiments.

The oxygen consumption of premolting and molting cowbirds was measured with an open circuit system connected to a Beckman G-2 paramagnetic oxygen analyzer used in conjunction with a Honeywell potentiometer. The respiration chambers were made from 4-liter jars with airtight lids having an air intake, air outlet, and opening for a thermocouple, and a fitting for the sensor of an Aminco electric hygrometer. The concentrations of O<sub>2</sub> were determined in a manner described by Depocas and Hart (1957) for an open circuit system (CO<sub>2</sub> was not absorbed). The chambers were placed in a temperature control box that maintained temperature within ± 0.5°C at any level between 0.0 and 50.0°C. All measurements of oxygen consumption were obtained from cowbirds that had not eaten for at least 4 hours and during normal daylight hours in a darkened chamber.

All birds were allowed to adjust to the respirometer chamber for at least 30 minutes prior to any measurements. The value used for calculating metabolic rate was that obtained after the bird had reached and maintained steady state oxygen consumption

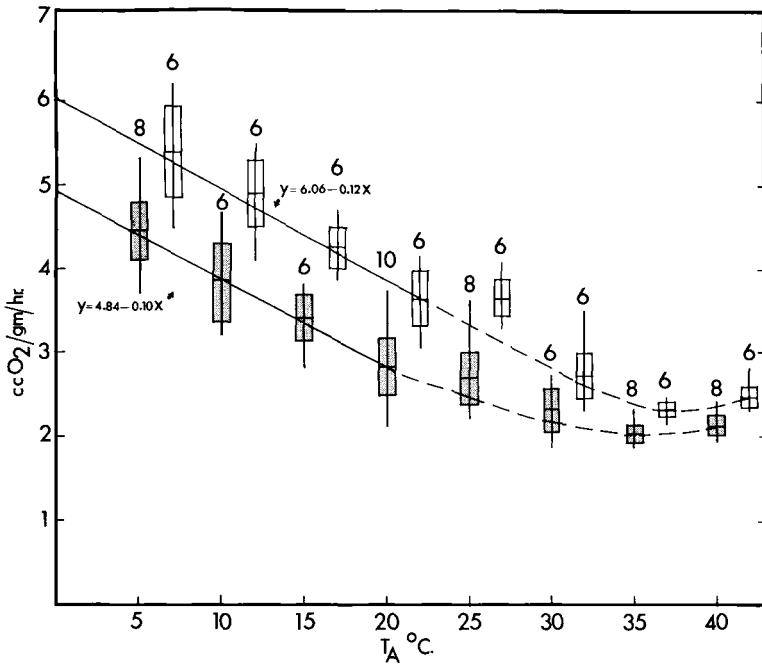


Figure 1. The mean standard oxygen consumption rates of premolting (shaded boxes) and molting (unshaded boxes) cowbirds in relation to ambient temperature. Vertical lines represent the range, horizontal lines the mean and boxes represent the 95 per cent confidence limits ("t" × SEM). The numerals show the number of birds measured at each temperature. The comparative measurements were taken at 5° intervals starting with 5°C but were displaced for graphic purposes. The solid diagonal lines were fitted to the data between 5 and 20°C by the method of least squares; the dashed line is eye fitted.

for 20–30 minutes. Birds were weighed to the nearest 0.1 g before each run and all calculations were based on this weight.

Cloacal temperatures were measured with a quick-acting mercury thermometer or a Yellow Springs telethermometer immediately after each oxygen consumption run.

Thermal conductance was calculated from Scholander et al. (1950) implied adaptation of Newton's law of cooling:

$$C = \frac{MR}{T_B - T_A}$$

where C = thermal conductance, cc O<sub>2</sub>/gm/hr/°C

T<sub>A</sub> = ambient temperature, °C

T<sub>B</sub> = body temperature, °C

MR = metabolic rate, cc O<sub>2</sub>/gm/hr.

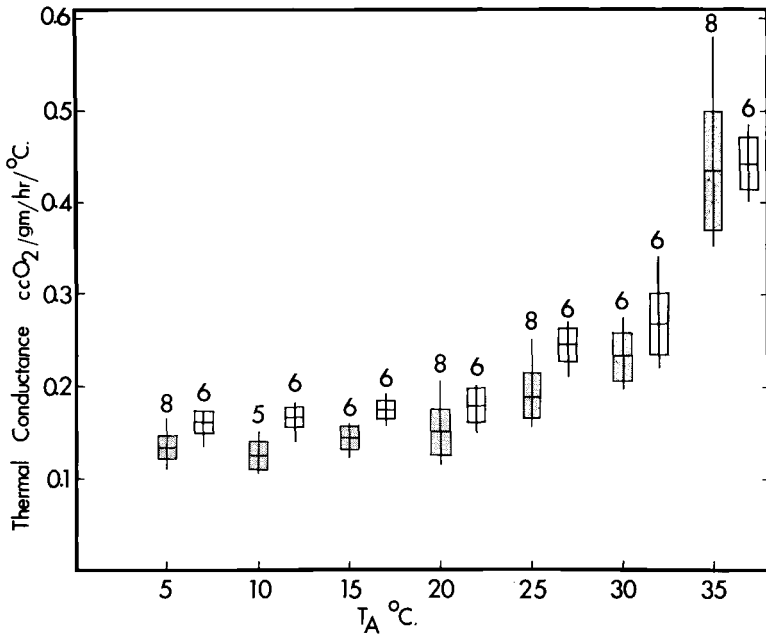


Figure 2. The relation of thermal conductance to ambient temperature in molting cowbirds (unshaded boxes) and nonmolting cowbirds (shaded boxes). The comparative measurements were taken at 5° intervals starting with 5°C, but were displaced for graphic purposes (symbols as in Figure 1).

## RESULTS

*Oxygen consumption.*—Molting cowbirds had a significantly higher oxygen consumption rate than nonmolting cowbirds at all ambient temperatures between 5 and 40°C (Figure 1). *P* is less than 0.05 at all ambient temperatures except 30°C where *P* is less than 0.1. As seen from Figure 1, the deviation in oxygen consumption between molting and nonmolting cowbirds was minimal (13 per cent) in thermoneutrality (35°C) and increased to a maximum of approximately 24 per cent at 25°C. Below 20° the regression line relating oxygen consumption to ambient temperature in the molting cowbirds ( $y = 6.06 - 0.12x$ ) nearly parallels that of the nonmolting birds ( $y = 4.84 - 0.10x$ ), the molting birds having a 24 per cent higher oxygen consumption than the nonmolting birds.

*Thermal conductance.*—The thermal conductance (Figure 2) of the molting birds is higher than the thermal conductance of the nonmolting birds over the temperature range 5–30°C; in thermal neutrality (35°C) there was no significant difference in thermal conductance between molting

and nonmolting birds. As the ambient temperature ( $40^{\circ}\text{C}$ ) approximates the body temperature ( $40.8^{\circ}\text{C}$  for molting birds and  $40.4$  for nonmolting birds) the thermal conductance becomes vertically asymptotic. One should note that both the molting and nonmolting birds show three thermal zones: a zone of thermal neutrality ( $35\text{--}40^{\circ}\text{C}$ ) where the bird regulates body temperature by physical means, a zone below  $20^{\circ}\text{C}$  where thermal conductance remains relatively constant indicating that the bird is regulating its body temperature strictly by increased thermogenesis, and a zone between  $20$  and  $35^{\circ}\text{C}$  intermediate between the previous two where body temperature is regulated by both increased metabolism and physical regulation. The relative humidity at the high ambient temperature was maintained below 40 per cent as humidity is known to affect metabolic rate at high temperatures.

#### DISCUSSION

The fact that within the zone of thermal neutrality ( $35^{\circ}\text{C}$ ), molting cowbirds increased their oxygen consumption 13 per cent over that of nonmolting controls while maintaining the same thermal conductance, suggests that the 13 per cent increase is due to the energy required in feather formation. The increasing deviation (13–24 per cent) in oxygen consumption between molting and nonmolting birds between  $35$  and  $25^{\circ}\text{C}$  (intermediate zone) along with the increased thermal conductance in the molting birds over this same temperature range suggests an increased energy expenditure for thermoregulation over and above that required for feather formation. That there is a gradual transition from regulation of body temperature primarily through control of insulative changes to regulation primarily through thermogenesis has also been suggested by Dawson and Tordoff (1959), West (1962, 1965), and Veghte (1964).

In the zone of thermogenesis (below  $20^{\circ}\text{C}$ ) the increase in oxygen consumption of the molting birds over the nonmolting birds remains relatively constant at 24 per cent. Assuming a 13 per cent increase with feather formation as in thermal neutrality, one could say that approximately 50 per cent of increased oxygen consumption below  $25^{\circ}\text{C}$  was due to feather formation and 50 per cent was due to increased thermogenesis. These results indicate that at all temperatures below  $35^{\circ}\text{C}$  an additive effect exists between the energy required for feather formation and that required for thermal regulation in the cowbird.

#### ACKNOWLEDGMENTS

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## LITERATURE CITED

- DAWSON, W. R., AND H. B. TORDOFF. 1959. Relation of oxygen consumption to temperature in the Evening Grosbeak. *Condor*, 61: 388-396.
- DEPOCAS, F., AND J. S. HART. 1957. Use of the Pauling oxygen analyzer for measurement of oxygen consumption of animals in open-circuit systems and in short-leg closed-circuit apparatus. *J. Appl. Physiol.*, 10: 388-392.
- KOCH, H. J., AND A. F. DEBONT. 1944. Influence de la mue sur l'intensite de metabolisme chez le pinson, *Fringilla coelebs coelebs*. *L. Ann Soc. Zool. Belg.*, 75: 81-186.
- PEREK, M., AND F. SULMAN. 1945. The BMR in molting and laying hens. *Endocrinology*, 36: 240-243.
- SCHOLANDER, P. F., R. HOCK, V. WALTER, F. JOHNSON, AND L. IRVING. 1950. Heat regulation in some arctic and tropical mammals and birds. *Biol. Bull.*, 99: 237-258.
- STURKIE, P. D. 1954. *Avian Physiology*. Ithaca, New York, Comstock.
- VEGHE, J. H. 1964. Thermal and metabolic responses of the Gray Jay to cold stress. *Physiol. Zool.*, 37: 316-328.
- WEST, G. C. 1962. Responses and adaptations of wild birds to environmental temperatures. Pp. 291-321 in *Comparative physiology of temperature regulation*, part 3 (J. P. Hannon and E. Viereck, Eds.). Arctic Acromedical Lab.
- WEST, G. C. 1965. Shivering and heat production in wild birds. *Physiol. Zool.*, 38: 111-119.

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