DAY AND NIGHT CHANGES IN BODY WEIGHT OF THE WHITE-THROATED SPARROW, *ZONOTRICHIA ALBICOLLIS*

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SEVERAL investigators (Partin, 1933; Nice, 1937; Linsdale and Sumner, 1934; Stewart, 1937; Baldwin and Kendeigh, 1938; Owen, 1954; Bartleson and Jensen, 1955; Stegeman, 1955; Lawrence, 1958; Helms and Drury, 1960) have shown that wild birds increase in weight from a low in the early morning to a maximum in the late afternoon.

This investigation was undertaken to determine how the rate of weight gain during a 10-hour photoperiod for control and exercised White-throated Sparrows, *Zonotrichia albicollis,* varied with temperature. In addition, two different groups of control birds, also on a 10-hour photoperiod, were used to follow weight gains and losses through both light and dark periods at different temperatures.

MATERIALS AND METHODS

The birds used for this investigation were captured with Japanese mist nets near Urbana, Illinois, during the spring and autumn migratory periods, 1962 through 1964. Before they were used for experimental purposes, the birds were confined in large outdoor flight cages, with food (University of Illinois baby chick mash no. 521) and water *ad libitum.*

For experimental work the birds were placed in individual cages (30.5 × 30.5 × 17.5 cm) which were equipped with an outside feeder on one end and a water cup on the other (Martin, 1967). The birds were then left outdoors for 15 to 20 days before being subjected to the experimental temperature and a photoperiod of 10 hours.

Weight changes at 2½-hour intervals during the day were followed for both control and exercised birds at temperatures of 22°, 30°, and 35°C, and for control birds only at –15°C, since exercised birds died at this temperature. Different groups of birds were used at each of the above temperatures. Exercised birds were birds that were given forced activity for 12 of the 14 hours of darkness. Activity was induced by placing the birds in a motor-driven, cylindrical cage that rotated at 1.7 rpm, starting one hour after the lights went off for the day and stopping one hour before the lights went on the next day. The birds were placed in the rotating cage after being weighed in the evening and were removed from the rotating cage and placed in the same type of cage as the control birds after they were weighed in the morning (Kontogiannis, 1967).

In order to follow the changes in weight of the control birds through the day and night, weights were taken at 2½-hour intervals at three different temperatures, except that no weights were taken during the last 6½ hours of darkness. The same group of birds was used first at –5°C and then at 22°C, while a different group was used at 30°C.

All birds were weighed daily just before the lights came on in the morning and immediately after they went off in the evening. Weights at all other intervals were obtained for all individuals at random over a series of days, but no more than one weighing was done on any single day. This was done in order not to disturb unduly the normal rhythm of feeding.

TABLE 1

TOTAL GAIN OF WEIGHT IN GRAMS AT END OF EACH INTERVAL OF THE DAY[1]

Temperature (°C)	*Group*[2]	*Number of birds*	*Initial weight*	*Number of weights*[3]	*First period*	*Second period*	*Third period*	*Number of weights*[4]	*Fourth period*
-15	C	6	27.76	24	2.30±.04	2.89±.06	3.49±.08	72	3.40±.09
22	C	7	24.73	21	1.51±.08	1.99±.07	2.34±.07	63	1.85±.05
	E	7	22.82	21	1.92±.08	2.76±.08	3.16±.08	63	2.92±.06
30	C	5	25.85	5	2.18±.33	2.83±.53	3.20±.49	15	2.69±.24
	E	5	23.57	5	3.14±.19	3.90±.32	4.08±.31	15	3.84±.15
35	C	5	22.57	5	2.55±.27	3.25±.23	3.64±.25	15	3.26±.20
	E	5	21.18	5	2.97±.25	3.75±.27	4.08±.32	15	4.29±.22

[1] Mean and Standard Error are given.

[2] C = Control, E = Exercised.

[3] For each of the first, second, and third periods.

[4] For fourth period only.

RESULTS AND DISCUSSION

The maximum rate of weight increase for control and exercised birds occurred during the first 2½ hours of light (Table 1 and Figure 1). This is a period of active feeding and drinking, refilling the alimentary tract emptied during the night. The maximum weight for the day was attained, for both groups of birds and at all temperatures, after 7½ hours, with the exception of the exercised birds at 35°C. The decrease in weight during the last 2½ hours of the day would presumably be due to decreased feeding and partial emptying of the digestive tract. A decrease in weight correlated with decrease in rate of feeding in late afternoon has also been shown for various wild birds by Baldwin and Kendeigh (1938: 428) and for the Purple Finch, *Carpodacus purpureus,* by Bartleson and Jensen (1955).

The birds at 22°C gained less weight during the day and lost less at night than did the birds at either higher or lower temperatures. This is probably the case because at lower temperatures increased metabolic processes doubtless use more of the fat reserves in the body, and at high temperatures more water should be lost for temperature regulation. Exercised birds at all temperatures gained more weight than did their corresponding control groups. This corresponds to their greater weight loss during the preceding night.

Changes in weights throughout the 24-hour day, shown graphically in Figure 2, are similar to those already discussed. Weight losses during the night were greater during the first hours of darkness and decreased after the waste material had been eliminated from the gut.

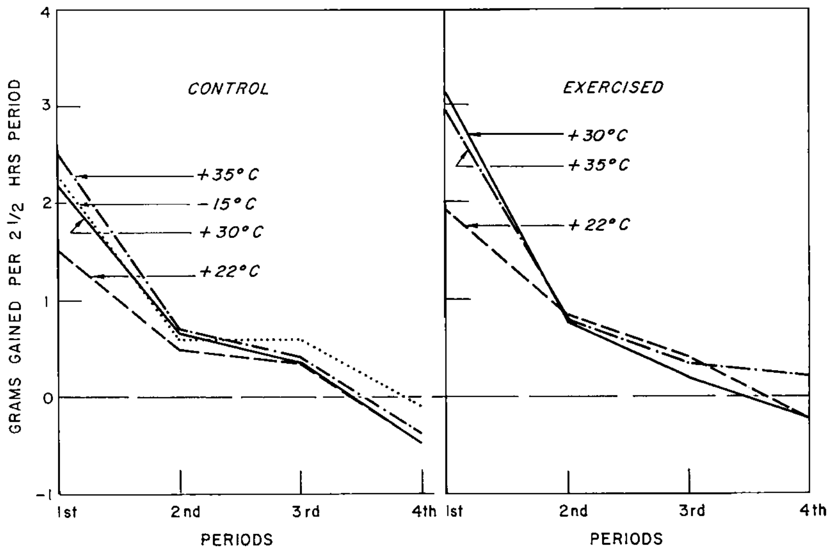

Figure 1. Rate of weight gain during daytime in each period, for control and exercised White-throated Sparrows.

Evacuation of the digestive tract appears to require at least five hours (Table 2). The continued weight loss thereafter occurs as a result of energy being used to support the basic body functions when the bird is at rest. This involves an exchange of oxygen and carbon dioxide and the loss of water and kidney wastes. Blumenthal and Dolnik (1962) referred to this loss as "expenditure for exchange at rest" or "basic exchange."

I assumed that the rate of weight loss during the last 6½ hours of darkness best represents the basic exchange and that this is the same throughout the night. On this basis, calculated weight loss due to basic exchange for the dark period of 14 hours is shown in Table 3. The difference between this and the total weight loss must represent the wastes evacuated from the gut.

It is of interest that the weight loss due to basic exchange, in rate per hour, is almost the same for −5°C and 22°C, both of which are lower than the rate at 30°C, in spite of the higher metabolic rates at the lower temperatures. However, the oxidation of fat, to release energy, produces more than its equivalent weight of water, and this is not evaporated or lost as rapidly at low temperature so that it compensates in part for the water normally lost in respiration (Nisbet *et al.*, 1963; Rogers and Odum, 1964; Odum *et al.*, 1964). On the other hand, at high temperatures, less fat is oxidized and more water is lost in evaporative cooling, hence the

TABLE 2
MEAN RATE OF WEIGHT LOSS IN GRAMS PER HOUR DURING THE NIGHT FOR CONTROL BIRDS AT VARIOUS TIME INTERVALS

Temperature (°C)	*Number of birds*	*Mean evening weight*	*Hours after dark*			
			0–2½	*2½–5*	*5–7½*	*7½–14*
–5	8	29.60	0.52	0.22	0.11	0.080
22	8	27.35	0.28	0.13	0.10	0.077
30	8	26.87	0.30	0.17	0.10	0.094

higher rate of basic exchange. Gain and loss of weight during day and night cannot, therefore, be ascribed to the deposition and ultilization of fat reserves without corrections for the changes in the water balance and in the amount of food in the alimentary tract.

The high amount of alimentary wastes (Table 3) of the birds kept at –5°C, which is double that of birds at higher temperatures, is a reflection of the greater rate of feeding and metabolism of the birds at lower temperatures.

Since the weight of birds progressively increases during the first two-thirds of the day and then decreases, and since the rates of increase and decrease vary with temperature, it is recommended, if comparable data are desirable, that the weighings of birds be made in the early morning, just before the birds start feeding for the day. The early morning weight of the bird may be considered as the "basic weight" since only at this time is the alimentary tract free of food and wastes, and all birds are in a comparable stage in the daily rhythm.

If early morning weighings are impossible, comparable data may be obtained at other times if experimental conditions are constant and the weights are always taken at the same time. Under natural conditions, however, since the number of daylight hours changes with the season, weighing the birds at the same time of day throughout the year will not give comparable data, because of the different times at which the birds begin to feed. Thus, the time of weighing should be changed to maintain a constant relation to the time of sunrise or the beginning of feeding.

TABLE 3
ANALYSIS OF WEIGHT LOSSES IN GRAMS AT NIGHT IN CONTROL BIRDS

Temperature (°C)	*Basic exchange*	*Gut wastes*
–5	1.12	1.50
22	1.08	0.70
30	1.32	0.72

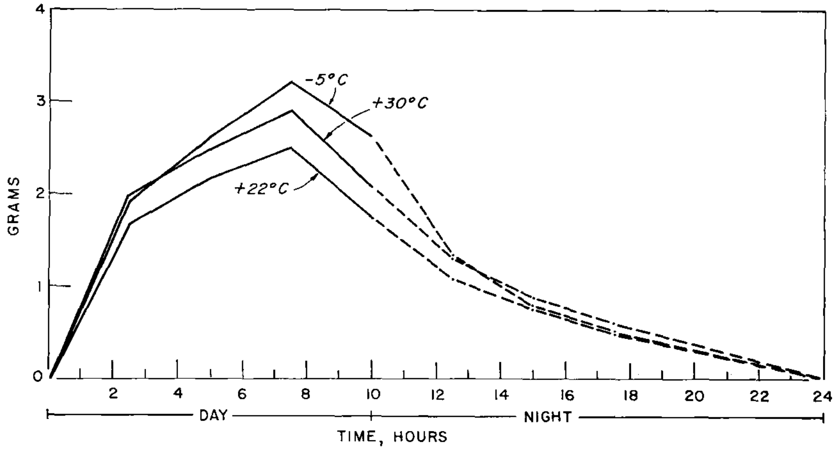

Figure 2. Weight gain and loss by control birds during the 24-hour period.

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SUMMARY

Weight changes, at 2½-hour intervals during a 10-hour photoperiod, were followed for control White-throated Sparrows and birds given forced exercise during 12 of the 14 hours of darkness, for both groups at temperatures of 22°, 30°, and 35°C, and for controls at –15°C. Weight changes throughout the 24-hour day were recorded for other, unexercised birds at –5°, 22°, and 30°C.

Both control and exercised birds showed a maximum rate of weight increase during the first 2½ hours of light. The maximum daily weight for both groups of birds and at all temperatures was reached 7½ hours after the lights came on.

Exercised birds made greater gains during the day, correlated with their greater losses during the night, at all temperatures, than did their corresponding control groups.

Weight loss at night was greater during the first hours of darkness, because of the evacuation of the gut. The continued weight loss after that was the result of fat utilization for the maintenance of basic body functions and of evaporative water loss for temperature regulation. The smallest change of weight during the day occurred at 22°C.

To obtain comparable data from day to day, or season to season, birds should be weighed at the same stage in the daily cycle.

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