The Metabolism of the Tree Sparrow as the Type of Granivorous Passerines

By

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Abstract. The daily consumption of tree sparrows fed with millet seeds at 22–24 °C in cage was 3.42 g dry matter, which is 17.82% of their live weight. The birds assimilated 85.68% of the quantity of food. The caloric value of the food was 4.869, that of the feces 4.036 kcal. g(abs. dry weight)$^{-1}$. The daily energy requirement for the existence of one bird was 14. 453 kcal. The energy requirement, expressed in bird/g live weight was 0.768 kcal.

Under identical experimental conditions, the measure of food consumption (especially referred to body surface) and the food assimilation coefficient of seven bird species belonging with the family of Estrildidae *(Lonchura striata, Taeniopygia guttata, Erythrura p. prasina, E. trichroa cyanofrons, E. trichroa sigillifera, E. psittacea* and *Chloebia gouldiae)* were rather similar to that shown by the tree sparrows This allows the conclusion that on the basis of their similar metabolism the various granivorous passerine birds may be grouped into one type. The existence of such types could be demonstrated in other groups of animals, too. These types make the material and energetic changes taking place in the ecosystem easier to survey.

The daily food assimilation of an ill sparrow calculated for weight units was only 55.6% of the quantity assimilated by healthy specimens. Thus it seems that in case of certain illnesses the bird is capable of moderateing its metabolism in a significant degree.

Introduction

The study of the metabolism of various animals belongs to the important biological tasks of our days. The principal aim is to obtain knowledge about animal production and its role in the ecosystem as far as the exchange of matter and energy is concerned. Passerine birds have been extensively studied in this respect; among these studies numerous contributions have been published on the species of *Passer*. Nevertheless, it seemed desirable to carry out the subsequent investigation of the tree sparrow *(Passer m. montanus)* partly for the reason that we accumulate as much information as possible on its symbiological role, and in particular, to elucidate the mode of its metabolism and to compare it with that of other passerine species. Such comparisons, as carried out among others by KENDEIGH (1970 *a)*, are indispensable in ecology. (I shall come back to this question later.) On the other hand, the huge mass of data available in the literature is

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almost unsuitable for purposes of comparison, since the individual authors applied special methods when carrying out the investigations under different environmental conditions. Bearing this in mind, my research on the tree sparrow was conducted under exactly the same conditions as on other species of the genus.

One specimen of the experimental animals fell ill. This circumstance gave an opportunity also to study the metabolism of the animal in a bad state of health.

Examination methods

The experimental tree sparrows were from the environs of Budapest. All of them were adults, past the moulting and incubation periods. The birds were placed singly, in cages of a 45×24 cm surface. In order to prevent the scattering of food, glass plates were put around the cages.

During the three days prior to the examination and during the investigation proper the birds were fed with millet-seeds only. Feedign took place in the forenoon every day. The millet-seeds were air-dry when fed to the birds, but their water-content, in order to establish dry matter consumption, was determined at 104 °C drying to weight-balance. Next day the surplus food was collected and directly weighed in absolute dry state. The excreta were weighed each day, similarly in absolute dry state. Drinking water was supplied to the birds in unlimited quantity.

The temperature during the investigation was about 22–24 °C, and the light period was daily 12 hours. The measurement of energy-content was performed in a Berthelot-Mahler bomb calorimeter.

Results and conclusions

Food (energy) requirements and the efficiency of utilization in the tree sparrow

The food requirement and utilization of nine tree sparrows are tabulated below (Table 1). Sparrows No. 1–5 were males, the rest were females. The data give the extreme values and averages of a series of measurements lasting for ten days. It is readily conceivable from the table that the average weight of the tree sparrows at the beginning of the experiment was 19.20 g. (According to Seel [1970] it was somewhat higher: 21.96 g in Romford between April and August; while Bauer [1975] found, for the nestleaving nestlings, a value fluctuating between 19.8 and 21.4 g in different years.)

The average quantity of the daily consumption was 3.42 g, corresponding to 17.82% of the live-weight. The daily excreta (feces and urine) came up to 0.49 g as an average value, thus the assimilation coefficient of the food materials was 85.68%.

If we compare these data with the ones found in the literature we see at once that the experimental birds consumed only a rather small amount of food. That is why, for example, according to Kendeigh (1970 *a)* the house sparrow consumed daily 6.2 g comprising various seeds in the month of August. The weight of tree sparrows is about 78% of that of house sparrows. In establishing the weight of the latter I used the data in the papers of Barnett (1970), Weiner (1970),

Table 1. The food requirements and utilization of tree sparrows

Number	Live weight (g)	Weight decrease during the experiment (g)	Daily consumption; dry weight (g)	Daily excrement; dry wieght (g)	$\frac{C \times 100}{G}$	$\frac{FU \times 100}{C}$
1	16.15	0.46	(2.18 – 2.85) 2.65	(0.37 – 0.43) 0.40	(13.48 – 17.62) 16.43	(14.21 – 16.92) 15.21
2	19.46	0.30	(3.36 – 3.79) 3.55	(0.46 – 053.) 0.51	(17.29 – 19.48) 18.25	(13.40 – 15.15) 14.24
3	20.28	0.55	(3.47 – 4.25) 3.79	(0.51 – 0.55) 0.54	(17.11 – 20.96) 18.69	(14.02 – 14.89) 14.37
4	19.69	0.11	(2.86 – 3.55) 3.40	(0.42 – 0.50) 0.47	(14·52 – 18.03) 17.28	(12.55 – 14.73) 13.68
5	21.99	0.46	(3.36 – 4.14) 3.85	(0.50 – 0.54) 0.53	(15.27 – 18.82) 17.50	(13.28 – 14.75) 13.78
6	19.08	0.88	(3.02 – 3.75) 3.43	(0.42 – 0.52) 0.48	(15.85 – 19.64) 17.96	(13.60 – 15.11) 14.00
7	20.65	0.25	(3.44 – 3.78) 3.75	(0.52 – 0.56) 0.55	(16.67 – 18.72) 18.19	(14.30 – 14.91) 14.77
8	16.40	0.09	(2.59 – 3.14) 3.01	(0.40 – 0.47) 0.45	(15.79 – 19.13) 18.35	(14.17 – 15.69) 14.95
9	19.18	0.39	(2.87 – 3.59) 3.40	(0.46 – 0.52) 0.47	(14.98 – 18.70) 17.72	(12.88 – 14.47) 13.94
Mean value	19.20	0.39	3.42	0.49	17.82	14.32

C = daily consumption in dry weight (g); FU = feces + urine, daily quantity in dry weight (g); G = initial live weight of the bird (g); Live weight = the live weight of the bird at the beginning of the experiment.

Pinowska (1976), as well as Pinowska and Myrcha (1977). At the same time the daily consumption of the tree sparrows reached only 50.6% of that of the house sparrows in summer. It is just the decrease in body-weight that refers to the fact that the birds could not cover the entire energy demand necessary for their metabolism under the given conditions. However, the weight decrease was not really significant, which can be explained by the good assimilation efficiency of the millet-seeds. The millet-seed has namely, a high content of utilizable carbohydrates, and it seems that the granivorous passerines are able to utilize in their metabolism these carbohydrates with high efficiency as compared to fats and, especially, to proteins. This is clearly proved by our examinations carried out in *Lonchura striata* (Estrildidae; unpublished results). Of course, this fact does by no means decrease the significance of protins in bird metabolism.

The caloric value of the food was 4.869 ± 0.042 kcal. g (absolute dry weight)$^{-1}$ and the average caloric value of the excreta was 4.036 ± 0.028 kcal. g (absolute dry weight)$^{-1}$. The derived data of measurement gave me the opportunity to establish the energy balance of the sparrows. For the sake of preciseness I also considered the drop in body-weight having taken place during the examination. When calculating the energy loss due to decrease in body-weight, the caloric value of the body of the sparrows was only estimated, and taken to be 2.025 kcal. g (live weight)$^{-1}$, relying on the data of PINOWSKI and MYRCHA (1977).

The result of energy balance was as follows:

In food one bird consumed daily:	16.652 kcal (gross energy)
Loss in feces and urine:	1.978 kcal (excretory energy)
Daily assimilation:	14.674 kcal (metabolized energy)
One bird used daily	14.674 kcal of the food
One bird used daily	0.079 kcal of its own body (loss in body-weight)
Daily total energy utilization	14.753 kcal

This value means the subsistence energy of the bird (at a given temperature) at moderate locomotor activity. The energy utilization, expressed in bird/g of live weight is thus 0.768 kcal.

Similarly, the caloric values prove a good utilization of the food. The assimilation coefficient of food energy: $\frac{\text{gross energy} - \text{excretory energy}}{\text{gross energy}} \cdot 100 = 88.1\%$

Taeniopygia guttata (Estrildidae) similarly consuming millet-seeds showed a value of 87.6% (GERE, 1972). An approximately high value (82%) was calculated by KENDEIGH (1970 *a)* who fed house sparrows with various seeds. On the other hand, the birds fed with chick starter mash or with egg-laying mash, both very rich in proteins, could utilize the food with less efficiency. Consequently, the assimilation coefficient varied; for example, according to EL-WAILLY (1966) in *Taeniopygia guttata* it was 73.6, according to KONTOGIANNIS (1968) in *Zonotrichia albicollis* it was 66.8, while according to WEINER (1970) in *Passer domesticus* it was only 65.0%. From the investigations of MYRCHA et al. (1970) we know that the utilization coefficient of food in nestlings is dependent on age.

It is common knowledge that the energy requirements of birds are governed by numerous exterior and internal factors. From among these factors we especially mention temperature (KENDEIGH 1970b). The energy quantity used at the given temperature of our experiments by the tree sparrow is not far from, though relatively slightly more than, the values found by EL-WAILLY (1966), BLACKMORE (1969), WEINER (1970) and DOLNIK (1974) for other passerine birds in approximately similar circumstances. Therefore, we may conclude that the tree sparrow covers its energy requirements by a comparatively smaller amount of food along with a better utilization, which is possible through its physiological capacity and, of course, the quality of the food.

The type food (energy) requirements and utilization efficiency in granivorous passerines

A comparison of the literary data on the metabolism of various birds enabled KENDEIGH (1970b) to give a general equation for the value of the metabolism of passerine and non-passerine birds, and for the temperature-dependent changes of that value, respectively. The possibility of generalization clearly proves in itself that there is or may be a similarity among the various species as to the character of the metabolism, i. e. the birds can be ranged according to types of food (energy) requirement and utilization.

Results of the numerous investigations indicate that sometimes even very different animals are similar to one another either in one or in several significant characteristics, especially as regards biological production (GERE, 1956, 1965, 1978). Within ontogenesis this similarity may appear, for example, in the rate of increase of body-weight or length measurements, in the composition of substances in the body, in the consumed quantity of food, in digestion, in the qualitative features of the metabolism and in the most diverse characteristics of physiology. It may also happen that two animal species behave in some respect as identical types only under certain definite conditions, however, in case these conditions change, the said species will represent different types. Of course, it is easy to understand that identical types occur more frequently in related species; on the other hand, in numerous instances quite distantly related species may fall in the same type.

It should be stressed that as far as types are concerned, we should rather adopt the term similarity than identity. It seems, namely, quite probable that the characteristics of species are, on the whole, specific, however in the case of an identical type the differences in the feature in question are slight. I am of the opinion that in order to step forward towards a precise evaluation of the similarities and differences further research is needed. With this in mind, as I have mentioned above, I studied the material exchange of passerine species belonging in the family of Estrildidae under identical conditions, as I did in the case of tree sparrows. Table 2 gives the data of my results concerning food utilization. Under numbers 1 and 3 published data (GERE 1974, 1973) are given, while the data under 2 and 4 are unpublished ones. The last data refer to four *Erythrura* species and forms, respectively, *(Erythrura prasina prasina, E. trichroa cyanofrons, E. trichroa sigillifera, E. psittacea)*, as well as to a related species, *Chloebia gouldiae*, representing the extreme values of their material-exchange conditions. As regards comparison, the species of *Erythrura* are especially interesting, since most of them are restricted to small distribution areas, in which environment they have strictly adopted themselves to the prevailing nutritional conditions. When studying the digestive organs, ZISWILER et al. (1972) also demonstrated morphological differences corresponding with adaptation.

Table 2. The food requirements and utilization of various granivorous passerines (Estrildidae)

Number	Species	Live weight (g)	$\frac{C \times 100}{G}$	$\frac{C}{\sqrt[3]{G_{dry}^2}}$ *	$\frac{FU \times 100}{C}$
1	*Lonchura striata*	14.4	21.68	10.82	14.06
2	*Lonchura striata*	15.2	19.77	11.87	15.75
3	*Taeniopygia guttata*	12.5	20.81	10.87	14.85
4	*Erythrura* spp. and *Chloebia gouldiae*	12.53 – 16.75	17.62 – 22.73	10.67 – 11.92	12.94 – 15.42

G_{dry} = dry weight of bird; * = mg; other symbols as in Table 1.

It is well-known that birds of different sizes, otherwise under the same conditions, rather consume food in proportion to the change of the surface of their body than according to that of body-weight (KENDEIGH 1970*b)*. Changes in surface area may best be expressed as the 2/3 power value of body-weight (in this case: of dry body weight). Consequently, the quotient of daily consumption and of the latter value expresses the intensity of food consumption as compared to body surface area. (This formula was first used by BORNEBUSCH [1930] in soil zoology.) This quotient is also to be found in Table 2.

From the table it appears that the quantity of the consumed food of the birds in question as compared to their live body-weight, as it follows from the above, is somewhat divergent in relation to the body-size. The fluctuation of consumption as compared to body surface is, however, comparatively small. In the case of the tree sparrow, the respective value is 10.74, which thus fits in well with the rest of the values in the table. A repeated series of experiments with *Lonchura striata* (numbers 1 and 2) shows that, in the quantity of the consumed food the differences may be greater within one species than the ones existing in certain instances between two species, indicating great individual variability. As to be seen, also the differences in the ratio of assimilated food and of wasted matter are rather small. Even in this respect the tree sparrow may readily be placed among the other birds.

The great similarity of the metabolic symbols definitely supports our assumption that the examined bird species, and most likely several other granivorous passerines, too, belong into a clearly delimitable type. Their basic character is not fundamentally changed even by their adaptation to various types of food. The type is well represented by the tree sparrow. The existence of such types is most important especially in respect of the ecological investigations of extensive character, since they permit to characterize with fair alexactness the materi and energetic changes taking place in the ecosystem, and closely related to the metabolism of the living organism, not broken down to the activity of species-populations, but grouping them by types. This makes the extremely complicated processes of biological production fairly clear.

The food requirement and utilization of an ill tree sparrow

The data of the food requirement and -utilization of an ill tree sparrow are given in Table 3. The symptoms of the illness (ruffled plumage, somnolence) culminated on the third day, yet the bird did not entirely recover even in 10 days. As the illness became graver also the quantity of the consumed food decreased, simultaneously with the measure of used food, as it is easy to determine from the changes in the proporion of wasted materials. The quantity of the assimilated food per day was 1.66 g on an average during the 10 days period. Since the initial weight of the sparrow was 19.46 g, the daily assimilation calculated for g of live weight was 0.085 g. This value is merely 55.6% of the quantity assimilated by healthy sparrows in one day. On the other hand, in the period of 10 days the bird lost only 0.77 g of its body-weight. The decrease of food consumption is much greater than the one in the energy requirements owing to a decrease locomotory activity would account for. Thus, we may conclude that in case of certain diseases the bird is capable of moderating the rate of its netire metabolism in a significant degree.

Table 3. Daily pattern of the food requirement and utilization of an ill tree sparrow. (Symbols as in Table 1)

Daily consumption; dry weight (g)	Daily excrement; dry weight (g)	$\frac{C \times 100}{G}$	$\frac{FU \times 100}{C}$
2.11	0.42	10.84	19.91
2.11	0.40	10.84	18.96
1.29	0.40	6.63	31.01
1.92	0.42	9.87	21.86
1.76	0.38	9.04	21.52
2.28	0.43	11.72	18.86
2.21	0.39	11.36	17.65
2.17	0.41	11.15	18.89
2.59	0.49	13.31	18.92
2.40	0.47	12.33	19.58
Mean value: 2.08	0.42	10.69	20.19

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