INVESTIGATION ON PRODUCTIVITY OF THE BLACKBIRD (TURDUS MERULA L.)

by

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The investigation on matter and energy turnover in different animals nowadays became a very important task. We may traverse the role of the single organisms within the biocenosis only in knowledge of such fundamental questions, get acquainted their load-bearing capacity, evaluate the phenomena from the point of view of the protection of nature and enwironment as well. Many valuable contributions were already published on the productivity of the birds. The data are but far not sufficient in order to gain a comprehensive view in every aspect on the production-biological role of this group. The evaluation of the literature is encumbered by the fact that the authors often carry on their investigations with different methods and under different circumstances. Thus the comparison of the results is not or only just possible. For that very reason I laid stress upon assuring the possibility of comparison.

Within the (non-domesticated) birds the literature deals with the productivity of the passerines and among them mainly of the granivorous ones. Our knowledge concerning the insectivorous ("soft-food-eaters") groups is essentially less. By this occasion I want to submit data for closer fact-finding on the matter and energy turnover even of the latter. For purpose of the investigation – proceeding from the mentioned environmental protectional view too – I selected the blackbird *(Turdus merula* L.) adapting to the urbanized conditions excellently.

Method and markings

I placed the birds one by one into metall cages of 44 by 24 centimeters groundspace. In order to prevent the scattering of the food or excrement particles I surrounded every side with glass plates.

Four of the experimental animals were fed with magre beef meat cut into small pieces, whilst further four birds with the granulated dog cake "Protecan". (Protecan contains around 38% protein, nearly half of it is of animal, the other half of vegetal origin. The vegetal substance is shorts.) I daily fed the food in defined quantity at the same time in the morning hours. I stated the weight of the food on a separated sample – having dried on 104 centigrades to weigth-balance. After 24 hours past – preceeding the next feeding – I collected quantitatively the food of the birds and the excrement-urine matters accumulated in the meantime, then in absolutely dry state I weighted them again. Thus I established the quanritative relations of the matter turnover.

The experiment with the single birds lasted 10–12 days but preceding the experiment I assured the experimental food and environment to the bird during three days. The experimental temperature was 22–24 centigrades, the illumination period lasted 12 hours daily.

In order to avoid eventual error-possibilities I elaborated and adapted a so-called "Ash controll" a controlling investigational method. Proceeding from the consideration that the matters taken in the food could reach only into two directions (namely P and FU – find explanation later on) but in present case – since the weight of the birds and presumably their body composition practically did not alter during the experiment, – they could reach only in the direction of the excrement-urine matters, I established the complex procentual ash content of the excrement-urine secreted during the experiment. Later on knowing this and the data of the measured quantitative matter turnover I calculated the quantitative relations of the ash matter turnover. The experiment is then justified if the calculated quantity of the ash matter taken in the food is equal to the calculated quantity of ash got into the (body and) ash of the animal.

The determination of the energy content (combustion heat) of the samples was carried out in the Berthelot–Mahler calorimeter-bomb. I established the published average mean values on the basis of 6–10 parallel measurings. The demonstration of the ash content was carried out by heating on 560 centigrades.

In order to facilitate a subsequent comparison of the productivity of the birds and arthropods – I designate the single production-biological elements and symbols on a way which is in the ornithology less but in publications on arthropods better accepted (Phillipson 1960a, 1960b, Petrusewicz 1967, Petrusewicz and Macfayden 1970 etc.).

The matter (energy) taken in the food, the consumption is C.

One part of the consumed matter (energy) leaves in form of excrement and urine (as the consequence of the nitrogen metabolism). These together are called the eliminated matter (energy), or matters of excremental character. Faeces + urine = FU.

The remaining part of the food is the assimilated matter (energy) = A.

Consequently C = A + FU.

The assimilated matter (energy) serves partly as the matter (energy) constructing the tissues of the body and the reproductive products which we call production = P and it provides the matter (energy) necessary to maintain the life processes. This is the respiration = R.

Thus A = P+R.

The assimilated energy quantity determined in the experiment – which is called (after K e n d e i g h 1970) also metabolized energy – includes above the energy quantity needed in the state of rest and the value of the "specific dynamic action" as well, also that energy quantity which the bird needs in the cage even for its comparatively small moving activity.

The proportion of the consumption in 24 hours and given as dry matter expressed in % of the living body-weight of the animal is the consumption intensity $= \frac{C \cdot 100}{G}$.

The proportion of the assimilation expressed in % of consumption is the assimilated ratio $= \frac{A \cdot 100}{C}$.

In the same manner I name the proportion of the production, the eliminated matters (or energies) and the respiration expressed in % of the consumption, the productional, eliminational and respirational ratio.

I use the productivity only as a general concept which considers the general character of the matter and energy paths produced in the metabolic processes respectively their proportion compared to each other, „the productional performance" of the animal.

Results of the investigation

The quantitative relations of matter turnover of the blackbirds fed with meat and the different matter turnover proportions are illustrated in Table I, the corresponding data of blackbirds fed with Protecan in Table II.

The ash content of the samples can be seen in Table III. According to the calculation carried out on basis of the ash-controll investigation, the elimination-ratio of the blackbird consuming meat is 45.21%, that of the bird consuming Protecan is 60.90%. These values coincide acceptably with the elimination-ratio shown in Table I and II.

On basis of the data we may establish in first line that the birds consumed from the Protecan essentially more than from the meat, at the same time the quantity of excrements emitted were in the first case also more than in the latter. It is remarkable that the matter quantity respired – which in present case corresponds also with the matter quantity assimilated since the weight of the birds did not change practically during the experiment, – remained the same in both kinds of food. Thus the blackbirds can utilize the pure meat with better efficiency than the mixture of vegetal matters and animal proteins. They have to consume from the mixture more in order to be able to assure the nutrient matter necessary to their life functions.

Table I

Quantitative relations of the matter turnover in blackbirds fed with meat and matter turnover rations. (Data indicate the limit values and average values, preceding in brackets.)

Serial number	Period of experiment (day)	Live mass (g)	Daily consumption (g)	Faeces + urine (g)	Respiration (g)	$\frac{FU \cdot 100}{C}$	$\frac{R \cdot 100}{C}$
1.♂	10	(77.72 – 79.34) 78.42	(7.25 – 8.46) 7.98	3.34	4.64	(41.09 – 42.52) 41.85	(57.48 – 58.91) 58.15
2.♀	10	(80.15 – 80.96) 80.76	(8.47 – 9.72) 9.10	3.92	5.18	(41.04 – 43.85) 43.05	(56.15 – 58.96) 56.95
3.♀	12	(77.90 – 79.13) 78.22	(7.57 – 8.46) 8.17	3.57	4.60	(40.85 – 44.10) 43.70	(55.90 – 59.15) 56.30
4.♂	12	(80.87 – 81.30) 81.19	(7.23 – 7.72) 7.32	3.09	4.23	(41.63 – 42.73) 42.16	(57.27 – 58.37) 57.84
Mean		79.65	8.14	3.48	4.66	42.69	57.31

Table II

Quantitative relations of the matter turnover in blackbirds fed with Protecan and matter turnover rations. (Data indicate the limit values and average values, preceding in brackets.)

Serial number	Period of experiment (day)	Live mass (g)	Daily consumption (g)	Faeces + urine (g)	Respiration (g)	$\frac{FU \cdot 100}{C}$	$\frac{R \cdot 100}{C}$
1.♂	10	(78.60 – 79.05) 78.83	(9.59 – 12.49) 11.38	6.79	4.59	(59.40 – 61.22) 59.70	(38.78 – 40.60) 40.30
2.♀	10	(78.50 – 78.95) 78.73	(9.08 – 12.51) 11.64	7.17	4.47	(60.75 – 61.85) 61.56	(38.15 – 39.25) 38.44
3.♀	12	(77.12 – 78.05) 77.60	(10.67 – 12.26) 11.81	7.24	4.57	(58.84 – 62.52) 61.32	(37.48 – 41.16) 38.68
4.♂	12	(81.10 – 81.93) 81.42	(10.67 – 12.15) 11.46	7.23	4.23	(61.17 – 63.79) 63.10	(36.21 – 38.83) 36.90
Mean		79.15	11.57	7.11	4.46	61.42	38.58

Table III

Ash content of food and excrements of blackbirds on basis of 4—4 parallel measurements.

Matter	Ash content (%)
Beef meat	4.04 ± 28
Excrement of blackbird fed with meat	8.94 ± 19
Protecan	10.39 ± 37
Excrement of blackbird fed with Protecan	17.05 ± 25

According to a previous investigation under environmental conditions adapted in the present experiment too, the elimination-ratio of the zebra finches *(Taeniopygia guttata)* fed with millet was 14.85%, the respiration-ratio 85.15% (Gere 1973), those appropriate ratios in case of the Bengalese finch (being the domesticated form of Lonchura striata) were 14.06% respectively 85.94% (Gere 1974). Similar matter circulational ratios were found in other granivorous birds too. Comparing these with the matter turnover ratios shown in Table I and II as well, we may establish that the blackbirds assimilate with an essentially less efficiency this meat which they can better utilize in quantitative sense than the granivorous birds their proper food. It is certain that this difference arises mostly from the specific resp. ecological type character of the birds (Gere 1979), but at the same time the quality of the food has also a role in it becauese the different granivorous birds utilize the food containing also animal proteins with a better quantitative efficiency than the blackbirds but still with less degree than the finches consuming millet. The elimination-ratio of the granivorous birds concuming the chicken starter resp. the eglayer food according to the references is the following:

in *Taeniopygia guttata*	26.4	(El-Wailly 1968),
Zonotrichia albicollis	33.2	(Kontogiannis 1968),
Passer montanus	34.97	(Weiner 1970).

The energy turnover conditions show another view. Table IV illustrates the energy values of the different foods and that of the from them transformed excrements and the extent of the difference coming out in the energy values of the two. In Table V we can see the quantitative conditions and the ratios of the energy turnover. (The data concerning the zebra finch are published according to Gere 1972.) From these it emerges that in the qualitative energetical sense — in comparison to the quantitative ratios of the productivity — the blackbirds utilize their food better. The difference between the energy content of the food and excrement of the millet consuming zebra finch, the Protecan eating as well as the meat eating blackbird grows in the recited sequence. This is resulted by the fact that for example until there is a threefold difference in the matter elimination ratio of the zebra finch and the balckbird fed with meat, in the energy elimination ratio of the same is the difference only around twofold.

Table IV

Caloric value of foodstuffs and eliminated matter of blackbirds and zebra finches. (Data concerning zebra finches according to Gere 1972.)

Species	Foodstuff	Caloric value of foodstuff (kcal/g)	Caloric value of faeces + urine (kcal/g)	Caloric value of faeces + urine expressed as percentage of caloric value of foodstuff
Turdus merula	Beef meat	5.976 ± 27	3.424 ± 42	57.30
Turdus merula	Protecan	4.927 ± 56	3.165 ± 37	64.24
Taeniopygia guttata	Millet	4.869 ± 42	4.061 ± 81	83.41

Table V

Quantitative relations of energy turnover in blackbirds an zebra finches and the energy turnover ratios. (Data concerning zebra finches according to Gere 1972.)

Species	Foodstuff	Consumption (kcal/day)	Faeces + urine (kcal/day)	Respiration (kcal/day)	$\frac{FU \cdot 100}{C}$ referred to energy	$\frac{R \cdot 100}{C}$ referred to energy
Turdus merula	Beef meat	47.985	11.916	36.069	24.83	75.17
Turdus merula	Protecan	57.005	22.503	34.502	39.48	60.52
Taeniopygia guttata	Millet	12.666	1.568	11.098	12.38	87.62

Among others Kendeigh (1970a) dealt with questions of the energy turnover in different birds in details. He found the energy quantity on 30 centigrades temperature utilized for "existential metabolism" of the Passeriformes birds expressable by a general equation. On basis of the calculation according to the equation the discussed zebra finch has a daily existential energy requirement on 30 centigrades temperature 7.88 kcal while that of the blackbird would be 35.82 kcal. It is worth to note to compare these values with the respiration (kcal/day) quantity as shown in Table V. In case of the zebra finch I suppose – there is a larger difference between the experimental value and the calculated value as stated above than the actual temperature difference (namely 22 – 24 centigrades to 30 C) would justify although in case of the blackbird such a difference does not exist which could be expected as an effect of the two temperatures. In spite of this the measured and calculated values are not far from each other and enforce my observation namely that not rarely the productivity of the different animals is in general or in certain sense similar and on basis of these such animals can be classified in a production-biological sense in types (G e r e 1979).

The data indicating the consumption intensity and other conditions of the matter and energy turnover in blackbirds – compared with the data concerning the corresponding ones in zebra finches – are illustrated in Table VI. The difference dealt with already above in meat and Protecan consumption and resp. in their assimilation in blackbirds is expressed of course by the consumptional intensity value and the ratio of the assimilated matter quantity related to the body weight too. It is interesting that while the blackbirds consuming Protecan take also a little bit more in energy within a time-unit than the meat consuming blackbirds, till then the quantity of the assimilated energy similarly to the assimilated matter remained nearly the same in case of the two different kinds of food indicating that the bird utilized from both foodstuffs matters of somilar caloric value in order to provide their energy requirement of life functions.

According to Table VI the relative (correlated to the body mass) matter and energy consumption and assimilation of the zebra finches are alike more than that of the blackbirds. The difference can be partly explained by the difference in body size of the two birds. As namely well-known the food consumptional quantity of birds consuming food of similar value, of different body size (but similar type in their assimilation) resp. the energy requirement of the same birds is not proportional with their body mass but it better follows the alteration in body surface which can be expressed by the 2/3 power of the body mass. In this sense the proportion of the consumptional quantity and the 2/3 power of the live body mass, namely $\frac{C_{(mg)}}{\sqrt[3]{G^2_{(mg)}}}$ is similar in both the favorable food, namely meat consuming blackbirds and also the favorable food namely millet consuming zebra finches as well and there exists an approximating similarity also in the ratio of the energy consumption expressed as above $\frac{C_{(cal)}}{\sqrt[3]{G^2_{(cal)}}}$ The proportion of the assimilated matter quantity to the body surface expressed again in similar form is already quite different in zebra finches as in blackbirds. The values express this already mentioned fact that the zebra finches utilize their food in quantitative sense better than the blackbirds. The assimilated energy quantity related to the body surface is in turn similar again in both kinds of birds. According to the results got the "soft-food-eating" blackbird and the granivorous zebra finch is of different

Table VI

Consumption intensity in blackbirds and zebra finches as well as data indicating the ratio related of the matter and energy turnover to body mass and body surface

Matter				Species	Foodstuff	Mean of live mass (g)	Energy			
$\frac{C \cdot 100}{G}$	$\frac{C\ (mg)}{\sqrt[3]{G^2}\ (mg)}$	$\frac{A_{(g)} \cdot 100}{G}$	$\frac{A\ (mg)}{\sqrt[3]{G^2}\ (mg)}$				$\frac{C\ (kcal)}{G}$	$\frac{C\ (cal)}{\sqrt[3]{G^2}\ (mg)}$	$\frac{A\ (kcal)}{G}$	$\frac{A\ (cal)}{\sqrt[3]{G^2}\ (mg)}$
10.23	4.40	5.85	2.52	*Turdus merula*	Beef meat	79.65	0.60	25.94	0.453	19.50
14.62	6.28	5.63	2.42	*Turdus merula*	Protecan	79.15	0.72	30.95	0.436	18.73
20.81	4.83	17.72	4.12	*Taeniopygia guttata*	Millet	12.50	1.01	23.53	0.887	20.62

type what it concerns the quantitative utilization of food but in view of their energy requirement they represent a similar type. It is very noteworthy that the balckbirds consuming two different kinds of food correspond both to this type what it concerns the utilized energy.

Summary

The publication deals with the matter and energy turnover of adult blackbirds *(Turdus merula* L.*)* on basis of laboratory investigations. One group of the blackbirds was fed with magre beef meat while the another group with "Protecan" (containing approximatively 38% animal and vegetal proteins mixedly) dog-cake. The experimental birds assimilated 57.31% of the meat but only 38.58% of Protecan. In quantitative sense they did not utilize neither food with a good efficiency as this is done by granivorous passeriforms. (According to a previous investigation the food assimilation of the zebra finch selected as modell of the latter type was 85.15% when fed with millet.) The energy of the foodstuff was in turn better utilized by the blackbirds in contrary to the zebra finches. The ratios can be expressed by the proportion of the caloric value of the excrements related to that of the consumed food too. This value is 57.30% in case of the meat consuming blackbird, 64.24% in case of the Protecan consuming blackbird, finally 83.41% in case of the millet consuming zebra finch.

The blackbirds consuming Protecan eat essentially more than those fed with meat and the quantity of the energy taken with the food is a bit more in the first case than in the latter. The quantity of the assimilated matter and the assimilated energy was in turn nearly similar when feeding with the two kinds of food.

The blackbirds related to their body mass consumed less from both foodstuffs than the zebra finches of smaller body size. But the consumption related to their body surface of the meat-eating blackbird and the granivorous zebra finch was similar. The assimilated energy quantity as related to the body surface was found similar in blackbird consuming the two kinds of food and in zebra finch which shows that these birds what it concerns their energy requirement (in sense of the so-called surface law) are of similar type.

REFERENCES

El-Wailly, A. J. 1966. Energy requirements for egg-laying and incubation in the zebra finch, *Taeniopygia castanitis*. Condor **68**: 582–594.

Gere, G. 1972. Water economy of the zebra finch *(Taeniopygia guttata* Vieill.) under conditions of watering and thirst. Acta Biol. Acad. Sci. Hung. **23**: 201–206.

Gere, G. 1973. Die quantitativen Verhältnisse des Wasserhaushaltes und des Gesamtstoffumsatzes des Zebrafinken *(Taeniopygia guttata* Vieill.). Opusc. Zool. Budapest, **13**: 53–60.

Gere, G. 1974. Die quantitativen Verhältnisse des Wasserhaushaltes und des Gesamtstoffwechsels beim japänischen Mövchen (domestizierte Form von *Lonchura striata* L.). Ann. Univ. Sci. Budapest de R. Eötvös nominatae, Sect. Biol. **16**: 163–176.

Gere, G. 1979. Ökologisch- produktionsiologische Typen in der Tierwelt. Opusc. Zool. Budapest, **16**: 77–85.

Kendeigh, S. C. 1970. Energy requirements for existence in relation to size of bird. Condor **72**: 60–65.

Kontogiannis, J. E. 1968. Effect of temperature and exercise on energy intake and body weight of the whitethroated sparrow *Zonotrichia albicollis*. Physiol. Zool. **41**: 54–64.

Petrusewicz, K. (ed.) 1967. Secondary productivity of terrestrial ecosystems. (Principles and methods.) I+II. Panstwowe Wydawnictvo Naukowe, Warszawa–Kraków.

Petrusewicz, K. – Macfayden, A. 1970. Productivity of terrestrial animals. Principles and methods. (IBP Handbook No. 13.) Burgess and Son (Abingdon) Ltd. Abingdon, Berkshire.

Phillipson, J. 1960a. A contribution to the feeding biology of *Mitopus morio* (F.) (Phalangida). J. Anim. Ecol. **29**: 35–43.

Phillipson, J. 1960b. The food consumption of different instars of *Mitopus morio* (F.) (Phalangida) under natural conditions. J. Anim. Ecol. **29**: 299–307.

Weiner, J. 1970. Energy requirements of house sparrow in Southern Poland. Internat. Stud. Sparrows **4**: 39–41.