

INVESTIGATIONS ON THE MATTER AND ENERGY FLOW¹ OF GREAT BUSTARD CHICKS AGED 1-21 DAYS

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ABSTARCT

FARAGÓ, S.: INVESTIGATIONS ON THE MATTER AND ENERGY FLOW OF GREAT BUSTARD CHICKS AGED 1-21 DAYS. The matter and energy flow of great bustard (*Otis tarda* L.) chicks aged 3-31 days has been investigated at the Great Bustard Rescue Station of the Dévaványa Landscape Preservation Area (Hungary). On the basis of data obtained by measuring food consumption and body mass production as well as excreta (feces+urine) continuously, matter and energy flow could be calculated. Crude protein, crude fat, crude fiber and nitrogen-free extract flow has been determined too. By reason of the results obtained, the author presents recommendations for performing modifications in feeding technology and in formulary being applied.

1. INTRODUCTION

In course of captive rearing, a task of basic importance is to provide for the appropriate quantity and quality of food necessary for the normal development of each species being reared. Meeting the requirements mentioned above is of special significance for species like the great bustard, in case of which the success of rearing serves as a pledge of survival. The efficiency of feeding can be determined by analysing the matter and energy flow of the respective animals. As for the great bustard, studies carried out previously have proved the successfulness of rearing, and data on body mass gain are available. (FODOR, 1966;

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GEWALT and GEWALT, 1966; LITZBARSKY and LITZBARSKI, 1985; GORIUP, 1985; OSBORNE, 1985; HUTTERER, 1977.). However, no studies have been reported referring to the matter and energy flow of great bustards, although data of this kind might be useful for confirming results obtained in course of investigations carried out previously, or for improving their accuracy.

Results of comparative studies on the matter and energy flow of birds are reported in the standard works of GERE (1982, 1983, 1984) but they supply data acceptable as possessing general validity mainly on birds belonging to *Passeriformes*. However, it has been revealed by investigations in the field of production biology that the metabolism of bird species belonging to the group of *Non-Passerines* shows patterns differing to some extent from those of *Passeriformes*. The latter finding was proved by GERE and ANDRIKOVICS (1986) in course of their studies on cormorants (*Phalacrocorax carbo*). In addition, it has been reported by RUTSCHKE (1983) that the daily energy need of a greylag goose (*Anser anser*) weighing 3 kg and performing an average quantity of physical exercise amounts to 2.094 Joule.

For the great bustard, data on winter food quantity and energy requirements were published by STERBETZ (1980). According to his calculations, 0.3 kg of green fodder or – on the average – net energy needs of 4.18 MJ can be estimated per bird.

Our matter and energy flow trials are of significant importance not only in the scope of applied research but in that of basic investigations as well. Knowledge on trophic conditions constituting a fundamental system will render it possible to improve theoretical methods of great bustard feeding.

2. MATERIAL AND METHODS

I carried out my trials at the Great Bustard Rescue Station of the Dévaványa Landscape Preservation Area, from 11th to 19th July 1986. The cage to be used for the trials was divided into three compartments and set up in the airconditioned rearing room of the Rescue Station. Each compartment had a ground-space of 40×40 cm.

At the beginning of the trial period, ages of chicks housed in the respective compartments were the following:

Compartment 1 : 2 birds aged 3 days (Age group 1)

Compartment 2 : 3 birds aged 10 days (Age group 2)

Compartment 3 : 3 birds aged 14 days (Age group 3)

The birds were kept in an environment with a temperature of 32 °C and a relative humidity of 80%. Prior to starting the trial, one day's time was inserted to allow chicks to get adapted to their new environment. As great bustard chicks do not get any food on the first day after hatching, the trial was started on the third day of their life. (The one-day period of adaptation being counted in.)

It was difficult to provide birds of appropriate age in the number needed for my trials; this is why a three day overlapping developed between age group 2 and 3 in course of the trial period. According to this lap, the results refer to the following periods of life:

Age group 1: chicks aged 3-10 days

Age group 2: chicks aged 10-17 days

Age group 3: chicks aged 14-21 days.

The reasons for performing the trials on chicks belonging to the afore-mentioned age groups were the following: Firstly, in the course of rearing the respective age groups constitute the most critical period with highest mortality rates. Secondly, in this period of life great bustards can be kept in cages without being hurt, whereas with older individuals this kind of confinement would hardly be possible without causing injuries.

I had to perform my experiments with maximal respect for the requirements of nature conservancy. Each individual of the species dealt with being of very high value, it was inadmissible to subject a great number of birds to trials with uncertain outcome.

Great bustards are extremely sensitive birds. Therefore, instead of carrying out a permanent 3 week trial on the same individuals, I decided to perform a one-week investigation simultaneously on each of the three age groups. Owing to the limited number of birds available for each age group, it was impossible to take the sex ratio into consideration. However, the latter aspect did not seem to be of great importance in respect of the objectives of my investigations.

In spite of all limiting factors, it can be stated that the trials reported in the present paper have supplied valuable information on the matter and energy flow of a species not yet studied in this respect formerly, and the results obtained are suitable to render some useful proof for our practical work as well.

2.1. Food administered to the chicks

Up to now, the range of materials used for feeding great bustard chicks, and the mixing ratio of food ingredients have been developed in course of rearing practice. One of the

objectives of my investigations was to examine the matter and energy flow of great bustards from the afore mentioned point of view as well.

The ingredients of diet of the chicks were the following: lettuce, curd (heat-treated against *Coli* bacteria), boiled eggs, a mixture of semolina and corn grits and Kafocit M premix. For each feeding the fodder norm was 16.5 g per chicks, calculated for wet mass. According to this norm, ingredients were weighed by means of an analytical balance with an accuracy of 0.01 g before each feeding, and fodder mixture was composed in the rations listed in **Table 1**. Each bird was given the same diet.

We had the nutriment components of fodder ingredients determined in the Central Laboratory of the Faculty of Zootechnics at the University for Agricultural Sciences (Kaposvár). Values were calculated for dry matter. (**Table 2.**) **In my present paper values are given exclusively in dry matter (DM).** Wherever values refer to wet mass, this circumstance will be pointed out in each case.

In the laboratory mentioned above, energy values were determined by means of an I.K.A. calorimeter. Energy values of the fodder mixture, its individual components, respectively, the bustard body and the excreta listed in **Table 3-4.** (In 10^3 Joule). They relate to dry matter.

2.2. Feedings

According to the technological prescriptions applied at the Dévaványa Bustard Station, the timetable of feedings was fixed as follows:

Age group 1 : 4 feedings per day, at 6, 10, 14, 18 hrs.

Age group 2 and 3 : 3 feedings per day, at 6, 12, 18 hrs.

In course of each feeding, birds were given as much food as they accepted (ad libitum).

2.3. Measuring methods

Simultaneously with each feeding, weighing were performed in order to determine changes in body mass, quantity of ingested food and that of excreta (FU). Before being fed at 6 hrs, each chick was weighed for the purpose of registering daily gains in body mass. The quantity of ingested food was also determined by weighing each individual before and after feeding. By subtracting the body mass registered before feeding from the result achieved after

Table 1: Dry matter content of food compound

Food ingredients (norm per bird)	Wet mass (g)		DM content (%)		DM mass (g)		DM mass (%)	
	DM	%	DM	%	DM	%	DM	%
Lettuce	8.0		8.25		0.660		12.79	
Curd	3.0		43.26		1.298		25.15	
Hen s egg	3.0		31.70		0.951		18.42	
Semolina + corn	2.0		88.20		1.764		34.17	
Grits								
Kafocit M	0.5		97.86		0.489		9.47	
Total	16.5		-		5.162		100.00	
in 1 g wet mass	1.0		-		0.313		-	

Table 2: Dry matter content of food compound, calculated for each ingredient

Food ingredients DM %	Crude protein		Crude fat		Crude fiber		N-free extract		Crude ash		Total	
	DM	%	DM	%	DM	%	DM	%	DM	%	DM	%
Lettuce	16.1	0.106	10.0	0.066	10.2	0.067	44.7	0.295	19.0	0.126	100.0	0.660
Curd	68.6	0.890	23.2	0.301	-	-	2.2	0.029	6.0	0.078	100.0	1.298
Hen s egg	46.7	0.444	43.2	0.411	-	-	-	-	10.1	0.096	100.0	0.951
Semolina + Corn grits	13.3	0.235	2.8	0.049	2.7	0.048	79.5	1.402	1.7	0.030	100.0	1.764
Kafocit M	2.5	0.012	0.8	0.004	0.5	0.002	11.3	0.055	84.9	0.416	100.0	0.489
Total g	-	1.687	-	0.831	-	0.117	-	1.781	-	0.746	-	5.162
Total %		32.68		16.10		2.27%		34.50		14.45		100.00
In 1 g wet mass		0.102g		0.050g		0.007g		0.108g		0.046g		0.313g

Table 3: Energy contained in 1 g dry matter of food compound (10^3 J)

Food ingredients	DM mass (g)	Energy value 10^3 J/g	Energy value
Lettuce	0.660	17.396	11.481
Curd	1.298	27.200	35.306
Hen s egg	0.951	30.469	28.976
Semolina + corn grits	1.764	18.785	33.137
Kafocit M	0.489	2.994	1.464
Total in 1 g DM	5.162	-	110.364
	-	-	21.380

Table 4: Energy contained in 1 g of bustard body mass and feces, respectively

Substance	Energy content 10^3 J/g DM
Bustard body	20.813
Excreta during the first week of trial	16.195
Excreta during 2 nd week of trial	16.768
Excreta during 3 rd week of trial	16.509

food ingestion, I got the quantity of food intake for each individual and each feeding. In this way, total food consumption as well as its extreme and average values could be calculated for each day and each age group, respectively.

2.4. Determination of the quantity of FU

Excreta were permanently collected from each compartment of the cage, some crinkled paper had been placed on the bottom of the cage, and it has been covered with thin plastic foil. In this way, chicks were not hindered in moving about (they did not slip up), and at the same time we were able to collect excreta without any loss and determine their quantity with an accuracy of 0.01 g.

Excreta were collected simultaneously with feeding the chicks, and the mass of FU was determined after excreta had been desiccated to absolute dry state. The total amount of FU was registered, and the average quantity per bird was calculated too. We had the quantity of substances present in FU and their energy content determined in the laboratory mentioned above.

2.5. Calculation of matter and energy flow

In course of data processing, I applied the same terms and the equation given by GERE (1983):

$$C = P + FU + R$$

where C = consumption (quantity of ingested food)

P = production (gain in body weight by means of building up body tissue)

FU = substances sorted out by the organism: feces, urine and waste products

R = respiration; oxydated matter and degraded energy.

Matter flow was determined as follows:

From C (quantity of food ingested by the chicks) I subtracted the quantity of P (production) and FU (substances sorted out by the organism); this I got the quantity of R (respiration). The same calculation can be performed concerning the nutriment components of food and their energy content as well.

In the second part of the trial period, one of the three birds belonging to age group 2 fell ill with gastrointestinal obstruction. In regard of production and consumption – where individual measuring were performed data pertinent to the latter chick could be separated, so

in **Table 14.** and **15.** I was able to indicate the respective group values referred exclusively to the two healthy birds. (Listed below the data pertinent to all three members of the group.)

Separation of FU was impossible because the sick bird was kept together with the healthy ones, therefore in this respect I had to use the value calculated proportionally to the production of the respective bird. (**Table 16.**)

Knowledge of nutriment component values allowed me to set up matter flow equations for each age group in regard of crude protein, crude fat, crude fiber and N-free extract. (**Table 5-6.**)

3. RESULTS OF INVESTIGATIONS ON MATTER FLOW

3.1. Food intake (Consumption = C)

Measurements being performed regularly, we were able to observe the pattern of food intake in the various sections of the day and during periods of several days, respectively.

It can generally be stated that – in spite of the fact that prior to starting our trials we had inserted one day's time in order to allow chicks to become adapted to their new environment – on the first day of the trial period consumption of each bird was found to be considerably below the average. However, on the second day, every chick consumed quantities above the average as if it had aimed at compensating the poor food ingestion of the previous day. This phenomenon seemed to be almost regular.

In age group 1 daily food intake varied between 25.335 and 35.760 g per bird, averaging 29.830 g. (**Table 7.**) The largest quantities (8.047 g averagely) were ingested in course of the 10 o'clock feeding, whereas the smallest ones were taken in the evening, at 18 hrs (On the average 6.33 g). Early in the morning and in the afternoon, consumption was between the above-mentioned values, averaging 7.771 and 7.680 g, respectively. From among the extreme values observed in course of a particular feeding time, those registered in the morning showed the largest deviations from the mean: between the maximal and minimal value there was a difference of 14.58 g. At 14 hrs consumption proved to be more balanced; the difference between the maximal and minimal quantity of ingested food was found to be only 4.92 g. (**Table 10.**)

In age group 2 daily food intake ranged from 15.043 to 34.093 g per bird. (On the average 26.206 g). (**Table 8.**) The largest quantities of food were ingested at noontime (9.291 g), whereas minimal consumption was registered in course of the evening feeding (8.365 g). Quantities taken in the morning (8.550 g) exceeded the minimal evening consumption only

Table 13: Changes in body mass of bustard chicks involved in our trials

J u l y	Age group 1				Age group 2				Age group 3							
	No	No	Mean	No	No	No	Mean	No	No	No	No	Mean	No	No	Mean	
	205♀	199♂		171♀	170♂	186♀		145♀	178♂	179♂						
12	79.05	83.45	81.250	90.55	103.85	95.93	96.777	130.75	144.40	143.30	139.483					
13	80.74	89.09	54.915	93.98	102.33	92.19	96.167	117.89	142.11	140.15	133.388					
14	85.73	95.57	90.650	106.17	117.27	92.20	105.213	137.67	154.98	154.36	149.003					
15	87.87	100.56	94.215	114.80	121.81	90.15	108.920	137.81	161.56	157.47	152.280					
16	97.58	109.71	103.645	121.47	127.00	94.77	114.413	142.46	171.83	173.95	162.747					
17	104.77	124.46	114.615	127.51	133.96	98.39	119.953	149.62	179.59	183.19	170.800					
18	115.86	125.51	120.685	135.48	141.28	98.68	125.147	159.71	185.21	184.98	176.633					
19	129.12	140.21	134.665	145.28	160.67	112.59	139.513	174.97	201.93	200.98	192.627					
Body mass increase %	+59.07	+56.76	+53.415	+54.73	+56.82	+16.66	+42.736	+44.22	+57.53	+57.68	+53.144					
	+63.34 %	+68.02 %	+65.74 %	+60.44 %	+54.71 %	+17.37 %	+44.16 %	+33.82 %	+39.84 %	+40.25 %	+38.10 %					
Gross body mass increase in the respective age group	106.83 gram				128.21 gram				159.43 gram							

Table 14: Total consumption, calculated for dry matter

Age group	Wet mass (g)	DM (g) in 1 g wet mass	DM _n (g)	DM ₁ (g)
Age group 1 (n = 2)	417.62	0.313	130.715	65.376
Age group 2 (n = 3)	550.33	0.313	172.253	57.418
Age group 3 (n = 3)	652.69	0.313	204.292	68.097
^x Age group 2 (n = 2)	408.53	0.313	127.870	63.935

DM_n = for all individuals DM₁ = for 1 individual ^x = without the chick that had fallen ill

Table 15: Total production, calculated for dry matter

Age group	Wet mass (g)	DM (g) in 1 g wet mass	DM _n (g)	DM _i (g)
Age group 1 (n = 2)	106.83		39.848	19.924
Age group 2 (n = 3)	128.21	0.373	47.822	15.941
Age group 3 (n = 3)	159.43		59.467	19.823
^x				
Age group 2 (n = 2)	111.55	0.373	41.608	20.804

DM_n = for all individuals DM_i = for 1 individual ^x = without the chick that had fallen ill

Table 16: Total quantity of FU, calculated in dry matter

Age group	DM _n (g)	DM _i (g)
Age group 1 (n = 2)	33.18	16.590
Age group 2 (n = 3)	50.64	16.881
Age group 3 (n = 3)	54.60	18.200
^x		
Age group 2 (n = 2)	29.37	14.686

^x without the chick that had fallen ill; calculated in proportion to P.

Table 5: Nutrient component values of elements participating in matter flow

Substance	DM Content %	Crude Protein %	Crude Fat %	Crude Fiber %	N-free Extract %	Crude Ash %
Lettuce	8.25	16.1	10.0	10.2	44.7	19.0
Curd	43.26	68.6	23.2	-	2.2	6.0
Hens egg	31.70	46.7	43.2	-	-	9.8
Semolina + corn grits	88.20	13.3	2.8	2.7	79.5	1.7
Bustard chick	37.30	71.3	10.3	-	4.7	13.7
FU in age group 1	100 ^x	35.2	9.4	5.8	28.4	21.2
FU in age group 2	100 ^x	43.2	10.6	6.2	18.2	21.5
FU in age group 3	100 ^x	43.1	8.9	6.7	18.8	22.5

^x Methodics of our trials did not allow measuring wet mass

Table 6: Nutrient component values in 1 g wet mass of elements participating in matter flow

Substance	Nutrient component value in 1 g mass /g					
	Crude protein	Crude fat	Crude fiber	N-free extract	Crude ash	DM content of 1 g wet mass (g)
Lettuce	0.013	0.008	0.008	0.037	0.016	0.082
Curd	0.297	0.100	-	0.010	0.026	0.433
Hens egg	0.149	0.137	-	-	0.031	0.317
Semolina + corn grits	0.117	0.025	0.024	0.701	0.015	0.882
Bustard chick	0.266	0.038	-	0.018	0.051	0.373
FU in age group 1	0.352	0.094	0.058	0.284	0.212	1.000 ^x
FU in age group 2	0.432	0.106	0.062	0.185	0.215	1.000 ^x
FU in age group 3	0.431	0.089	0.067	0.188	0.225	1.000 ^x

^x Methodics of our trials did not allow measuring wet mass

Table 7: Consumption of bustard chicks in course of daily feedings: Age group 1

Age group 1	J u l y								Total	Mean	Min.	Max.
	12.	13.	14.	15.	16.	17.	18.					
N ^o 205	4.40	10.83	6.90	7.04	9.99	8.90	5.93	53.99	7.713	4.40	10.83	
	6.39	11.34	3.63	6.34	3.15	9.67	8.96	49.48	7.069	3.15	11.34	
	7.04	8.17	8.08	7.00	8.48	7.75	7.97	54.49	7.784	7.00	8.48	
	5.13	4.92	4.66	3.07	7.52	3.96	9.38	38.64	5.520	3.07	9.38	
Total	22.96	35.26	23.37	23.45	29.14	30.28	32.24	196.60	28.086	22.96	35.26	
N ^o 199	0.68	5.57	9.58	8.86	15.26	7.80	7.06	54.81	7.830	0.68	15.26	
	9.13	12.72	4.90	7.11	4.39	13.20	11.73	63.18	9.026	4.39	13.20	
	9.33	8.89	9.28	5.62	5.55	4.72	9.64	53.03	7.576	4.72	9.64	
	10.83	9.08	4.75	5.63	9.51	3.06	7.14	50.00	7.143	3.06	10.83	
Total	29.97	36.26	28.51	27.22	34.71	28.78	35.57	221.02	31.574	27.22	36.26	
All together	52.93	71.52	51.78	50.67	63.85	59.06	67.81	417.62	59.660	50.67	71.52	
Mean	26.465	35.760	25.890	25.335	31.925	29.530	33.905	208.81	29.830	25.335	35.760	

Table 10: Daily consumption of bustard chicks in each age group (total, mean and extreme values)

Age group	Time of feeding	Total	Mean	Min.	Max.
Age group 1 (n = 2)	6 ⁰⁰	108.80	7.771	0.68	15.26
	10 ⁰⁰	112.66	8.047	3.15	13.20
	14 ⁰⁰	107.52	7.680	4.72	9.64
	18 ⁰⁰	88.64	6.331	3.06	10.83
	Total	417.62	59.660	22.96	36.26
Age group 2 (n = 3)	6 ⁰⁰	179.55	8.550	2.02	15.14
	12 ⁰⁰	195.12	9.291	0.07	15.28
	18 ⁰⁰	175.66	8.365	3.91	16.53
	Total	550.33	78.619	8.85	40.92
Age group 3 (n = 3)	6 ⁰⁰	251.13	11.959	0.40	25.96
	12 ⁰⁰	189.48	9.023	1.54	13.93
	18 ⁰⁰	212.08	10.099	1.54	20.17
	Total	652.69	93.242	6.10	55.78

Table 11: Mean quantity of FU (g) per bustard chicks in each age group, calculated for dry matter

Age group	J u l y								Total	Mean
	12.	13.	14.	15.	16.	17.	18.			
Age group 1	1.395	1.355	1.735	2.460	3.185	3.965	2.495	16.590	2.370	
Age group 2	2.110	2.423	2.337	2.447	2.337	2.727	2.500	16.881	2.412	
Age group 3	1.653	2.770	2.470	3.080	2.977	3.133	2.117	18.200	2.600	

Table 8: Consumption of bustard chicks in course of daily feedings: Age group 2

Age group 2	J u l y								Total	Mean	Min.	Max.
	12.	13.	14.	15.	16.	17.	18.					
N ^o 186	6 ⁰⁰ 2.02	10.06	5.43	8.00	7.19	8.81	6.63	48.14	6.877	2.02	10.06	
	12 ⁰⁰ 0.07	7.28	10.24	9.69	7.88	7.65	9.30	52.11	7.444	0.07	10.24	
	18 ⁰⁰ 6.76	4.66	5.61	3.91	8.56	4.45	7.60	41.55	5.936	3.91	8.56	
Total	8.85	22.00	21.28	21.60	23.63	20.91	23.53	141.80	20.257	8.85	23.63	
N ^o 170	6 ⁰⁰ 2.29	11.56	10.52	6.50	9.03	11.52	9.64	61.06	8.723	2.29	11.56	
	12 ⁰⁰ 6.24	12.83	9.83	6.77	12.99	7.62	14.15	70.43	10.061	6.24	14.15	
	18 ⁰⁰ 6.58	16.53	7.49	7.55	11.10	8.08	11.40	68.73	9.819	6.58	16.53	
Total	15.11	40.92	27.84	20.82	33.12	27.22	35.19	200.22	28.603	15.11	40.92	
N ^o 171	6 ⁰⁰ 2.04	11.71	11.96	8.87	15.14	11.43	9.20	70.35	10.050	2.04	15.14	
	12 ⁰⁰ 10.00	15.28	10.29	10.50	7.96	9.10	9.45	72.58	10.369	7.96	15.28	
	18 ⁰⁰ 9.13	12.37	7.93	8.64	7.46	9.30	10.55	65.38	9.340	7.46	12.37	
Total	21.17	39.36	30.18	28.01	30.56	29.83	29.20	208.31	29.759	21.17	39.36	
All together	45.13	102.28	79.30	70.43	87.31	77.96	87.92	550.33	78.619	45.13	102.28	
Mean	15.043	34.093	26.433	23.477	29.103	25.987	29.307	183.443	26.206	15.043	34.093	

slightly. From among the extreme values found at a particular feeding time, the largest deviation from the mean was shown by those registered at noon, when there was a difference of 15.21 g between the maximal and minimal value. In course of the morning and evening feeding, differences were slightly smaller. (In the morning: 13.12 g, in the evening: 12.62 g). (Table 10.).

In age group 3 daily food intake varied between 13.980 and 50.017 g per chick, averaging 31.081 g. (Table 9). The largest quantity of food (11.959 g) was ingested in the morning. Minimal consumption occurred at noon (9.023) while quantities taken in the evening averaged 10.099 g. The largest difference between the maximal and minimal quantity ingested in course of one feeding was found in the morning (25.56 g). The slightest difference was registered at noon (12.39 g). (Table 10.).

It has been proved by the results of our trials that there is no relevant difference between the consumption of chicks belonging to age group 1, 2 and 3, respectively:

Age group 1: 29.830 g per chick/day

Age group 2: 26.206 g per chick/day

Age group 3: 31.081 g per chick/day

On the basis of data listed above, the first 21 days can be considered in regard of consumption as a homogeneous period in the development of great bustard chicks. In this phase of life, sexual differentiation has not yet begun to an extent necessitating increased food intake (Figure 1-3, a. and b.)

3.2. Discharge of feces and urine (FU)

In course of the trial period, daily quantities of excreta were found to reveal diverse dynamics in the various age groups. (Figure 1-3, d.)

Age group 1: During the first six days of our trials, the quantity of FU increased gradually from 1.355 g pre chick/day to 3.965 g per chick/day. The average calculated for the 7-day period amounted to 2.370 g per chick/day. The number of birds as well as the quantity of FU being small, it was not possible to perform analysis separately for each section of the day (Table 11. and 12.).

Age group 2: In course of the 7-day period, mean quantity of daily FU discharge proved to be well balanced, ranging from 2.110 to 2.727 g per chick, and averaging 2.412 g per chick/day. According to the schedule of collecting and measuring excreta, the quantity of FU discharged during nighttime and collected in the morning was the largest of all, the

Table 9: Consumption of bustard chicks in course of daily feedings: Age group 3

Age group 3	J u l y								Total	Mean	Min.	Max.
	12.	13.	14.	15.	16.	17.	18.					
N ^o 145	0.40	11.25	13.67	10.38	9.26	16.29	16.20	77.45	11.064	0.40	16.29	
	1.54	10.64	5.25	2.25	10.22	4.46	7.23	42.02	6.003	1.54	10.64	
	4.16	17.39	4.75	1.54	15.20	5.39	4.62	53.05	7.579	1.54	17.39	
Total	6.10	39.28	24.10	14.17	34.68	26.14	28.05	172.52	24.646	6.10	39.28	
N ^o 178	5.20	25.96	13.67	11.92	11.16	13.16	12.40	93.47	13.353	5.20	25.96	
	6.46	11.69	12.87	11.88	13.93	9.81	10.75	77.39	11.056	6.46	13.93	
	11.32	18.13	10.26	10.34	7.71	8.67	15.45	81.88	11.697	7.71	18.13	
Total	22.98	55.78	36.80	34.14	32.80	31.64	38.60	252.74	36.106	22.98	55.78	
N ^o 179	3.36	21.82	16.29	10.71	13.43	5.58	9.02	80.21	11.459	3.36	21.82	
	2.38	13.00	11.15	13.64	13.02	8.44	8.44	70.07	10.010	2.38	13.64	
	7.12	20.17	5.92	12.96	13.39	8.16	9.43	77.15	11.021	5.92	20.17	
Total	12.86	54.99	33.36	37.31	39.84	22.18	26.89	227.43	34.490	12.86	54.99	
All together	41.94	150.05	94.26	85.62	107.32	79.96	93.54	652.69	93.242	41.94	150.05	
Mean	13.980	50.017	31.420	28.540	35.773	26.653	31.180	217.563	31.081	13.980	50.017	

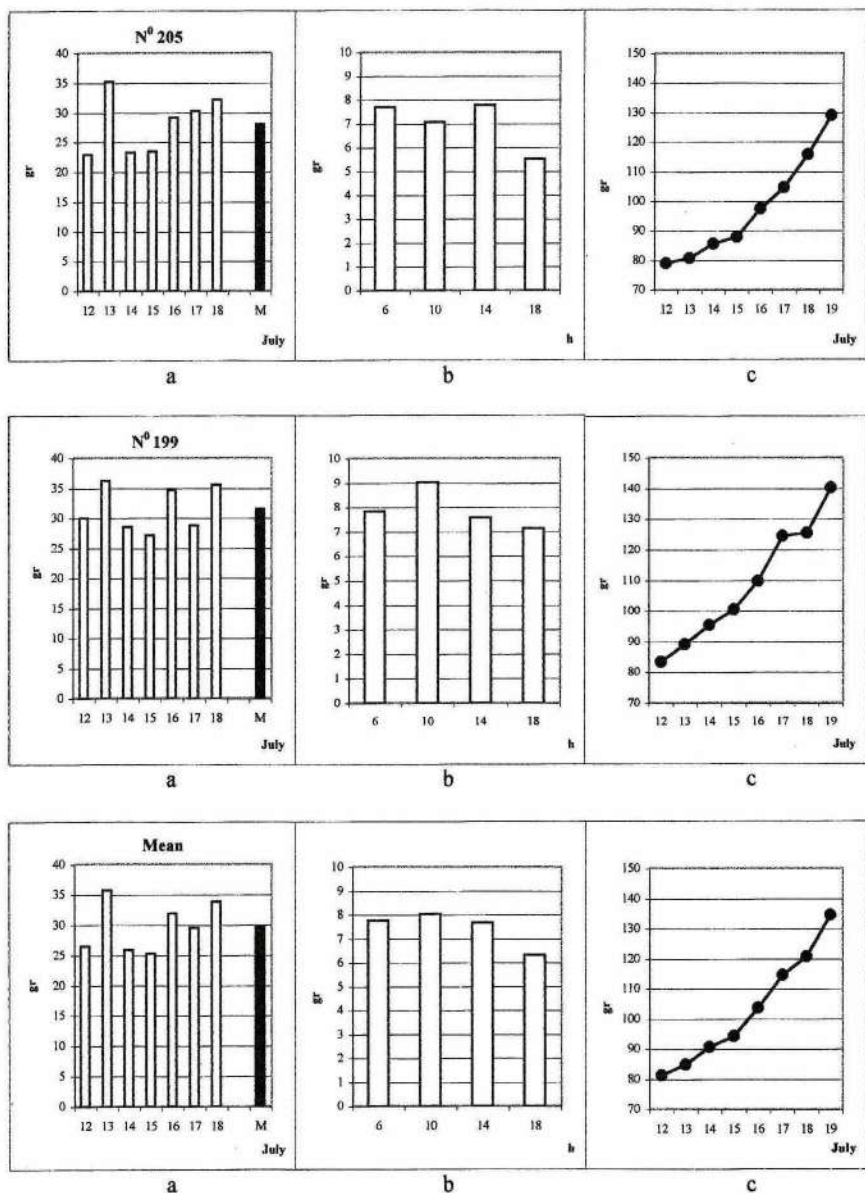


Figure 1: Pattern of consumption and production in age group 1:
(a) Pattern of daily consumption in course of the trial period; **(b) Consumption in various sections of the day;** **(c) Development of body mass in course of the trial period**

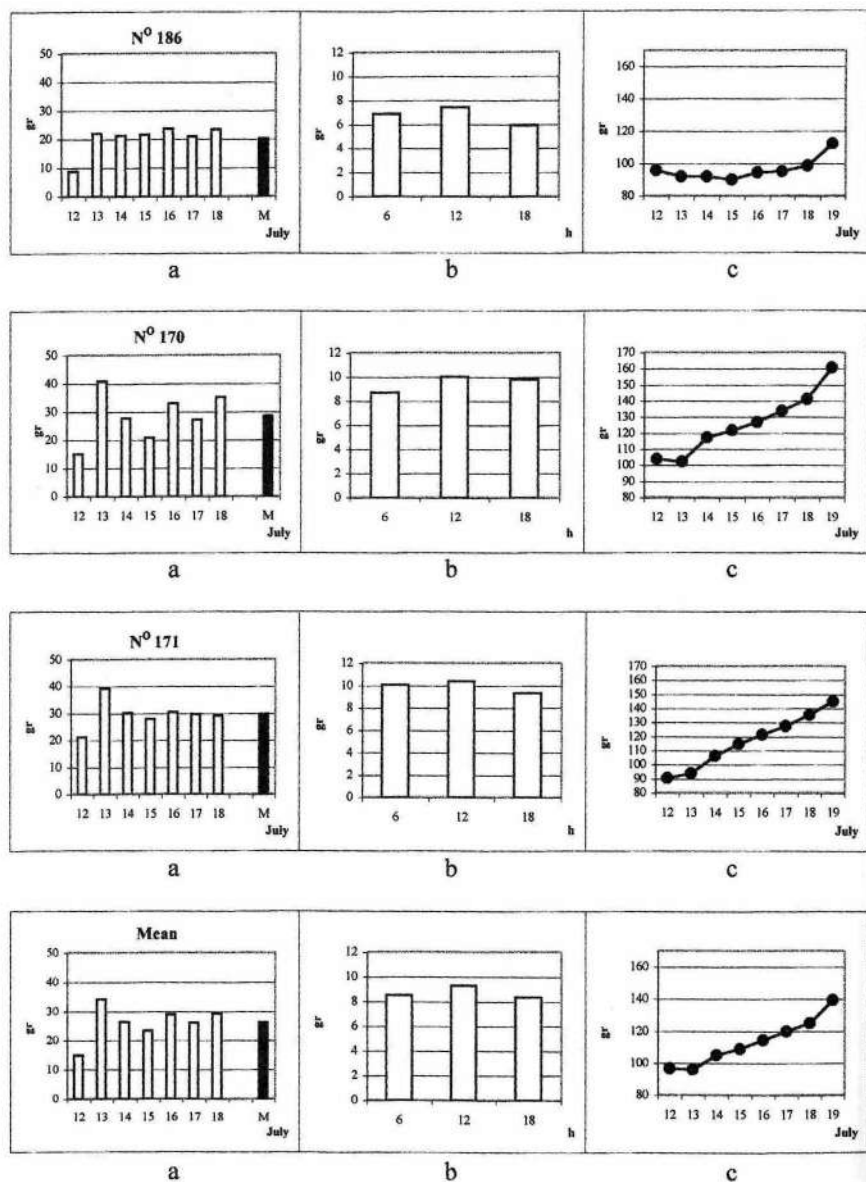


Figure 2: Pattern of consumption and production in age group 2:
(a) Pattern of daily consumption in course of the trial period; **(b) Consumption in various sections of the day;** **(c) Development of body mass in course of the trial period**

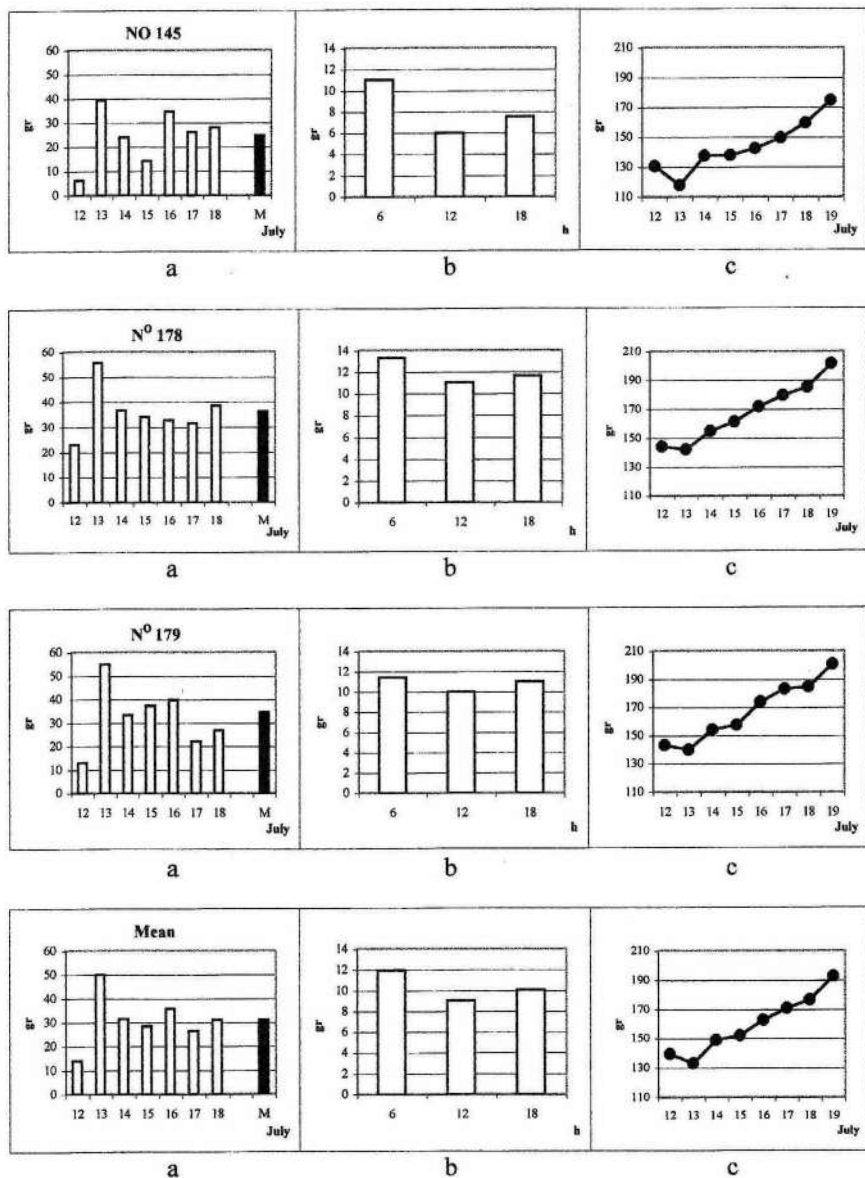


Figure 3: Pattern of consumption and production in age group 3:
(a) Pattern of daily consumption in course of the trial period; (b) Consumption in various sections of the day; (c) Development of body mass in course of the trial period

Table 12: Gross quantity of FU in each age group, calculated for dry matter

Age group	J u l y						7-day gross	7-day gross/bird	7-day bird/day		
	12.	13.	14.	15.	16.	17.				18.	
Age group 1	Total	2.79	2.71	3.47	4.92	6.37	7.93	4.99	33.18	16.590	2.370
Age group 2	6 ⁰⁰	2.05	1.45	1.49	2.04	1.23	1.06	1.92	11.24	3.747	0.535
	12 ⁰⁰	1.19	1.49	1.53	1.20	1.90	2.35	2.42	12.08	4.027	0.575
	18 ⁰⁰	3.09	4.33	3.99	4.10	3.88	4.77	3.16	27.32	9.107	1.302
	Total	6.33	7.27	7.01	7.34	7.01	8.18	7.50	50.64	16.881	2.412
Age group 3	6 ⁰⁰	1.40	1.81	1.72	1.86	1.35	2.05	1.94	12.13	4.043	0.578
	12 ⁰⁰	1.39	1.58	1.32	1.53	1.92	1.64	1.28	10.66	3.553	0.508
	18 ⁰⁰	2.17	4.92	4.37	5.85	5.66	5.71	3.13	31.91	10.603	1.514
	Total	4.96	8.31	7.41	9.24	8.93	9.40	6.35	54.60	18.200	2.600

respective amount having been excreted in course of 12 hours. During daytime, excreta were collected every 6 hrs, simultaneously with the food intake of the birds. The average quantities collected at noon and those gained at the time of the evening feeding were nearly equal with each other. (0.535 and 0.575 g per chick, respectively.). As for FU discharged at night, the average calculated for a period of 6 hours amounted to 0,651 g/chick, thus exceeding the afore-mentioned values significantly (Table 11. and 12.).

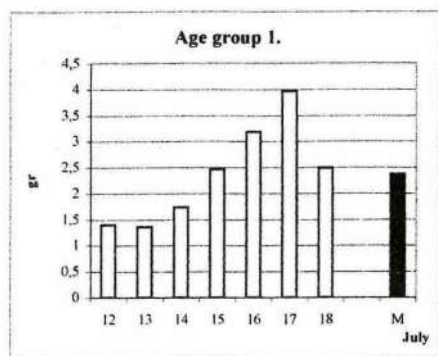
Age group 3: Average quantities of FU were less balanced than those registered in group 2. In course of the 7-day trial period, they ranged from 1.653 to 3.133 g per chick/day, averaging 2.600 g per chick/day. The mean quantity of FU collected at noon and in the evening – i.e. every 6 hrs – amounted to 0.578 and 0.508 g per chick/day, respectively. FU discharged at night – calculated for a period of 6 hrs – averaged 0.757 g per chick/day, so it proved to be considerably more than the quantities excreted during daytime. (Table 11. and 12., Figure 4.).

3.3. Production (P)

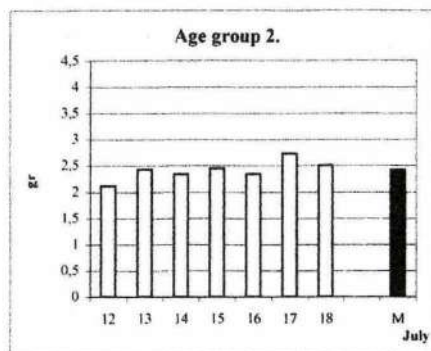
The degree of production, i.e. of body tissue building could be tracked by means of body mass weighings performed each morning. (Table 13., Figure 1-3, c.)

It can be considered as typical that in course of the 7-day trial period, gain in body weight was high in age group 1 and 2. (54.71 – 68.02 %). The only exception was the female chick that had fallen ill with gastrointestinal obstruction (No. 186) In case of the latter bird, body mass production was only 17.37%. In age group 3, body mass production ranged from 33.82 to 40.25%. With an average of 39.10%, it was more moderate than in the two younger groups. Rapid body mass building characteristic for the first two weeks of life presumably experiences a slight slackening in course of the third week. It was observed only in age group 3 that – in spite of the fact that the birds had been being adjusted to their new environment for a day's time prior to the onset of the trial, and their consumption was appropriate, after the first day of the trial period a slight loss of their body mass occurred, which became compensated on the third day.

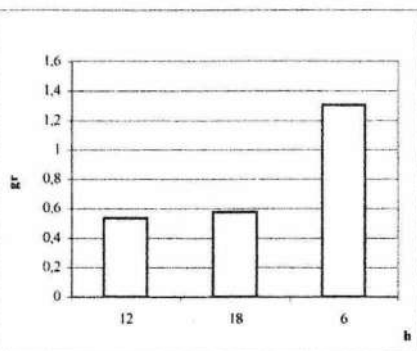
The latter phenomenon may be due to the following: Chicks drawn into the trial at the age of two weeks were much more sensitive than the younger ones (age group 1 and 2), therefore they responded to stress caused by being often touched with losses in body weight until becoming adapted to such disturbing moments.



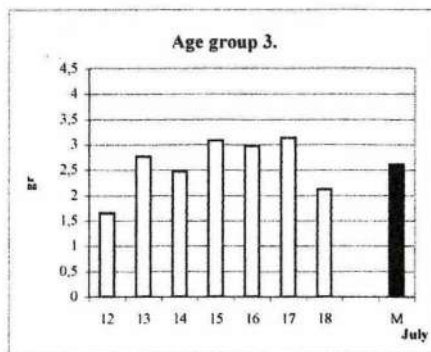
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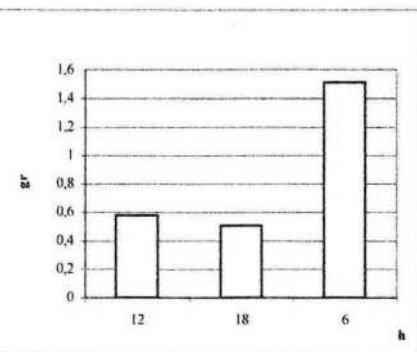
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b



a



b

Figure 4: Pattern of FU discharge in the individual age groups in course of the trial period: (a) Total quantity of FU/day; (b) Quantity of FU in various sections of the day

3.4. Matter flow model of great bustard chicks

Results listed in **Table 14-17**, reveal that there are no essential changes in the matter flow of great bustard chicks in course of the first three weeks of life. This may be principally due to the fact that the nestling age of the respective birds lasts for several months, the first three weeks covered by our trials representing only the initial stage of nestling period.

The results of our 3-week trials on great bustard chicks display significant conformity to the matter flow balance defined by GERE (1983) for 1-13-day-old song birds – as it is shown by the following comparison of data:

	<i>Lonchura striata</i> 1-13 days	<i>Otis tarda</i> 3-21 days
Production – P	20.47%	27.76-30.48%
FU	29.09%	25.38-29.40%
Respiration – R	50.44%	42.84-44.16%

By the 27th day of its life, the production of *Lonchura striata* decreases practically to 0, thus the bird approximately reaches its adult body mass by this age, while in case of great bustards, the same event will ensue some months later. Therefore it can merely be presumed that by the time of reaching their adult body mass, respiration values of great bustards would also amount to about 70-80%, i.e. the values registered for song birds. (GERE 1983, 1984).

On the basis of the matter flow equation it is sure that in the age groups covered by our trials, no difference between the matter flow of song-birds and that of great bustards belonging to Non-passeres can be verified, although the existence of such differences was hypothesized previously.

3.5. Crude protein flow

It is a well-known fact that in the first weeks of life, great bustard chicks mainly feed upon food of animal origin. Animal proteins allow direct and quick production of body tissue. Their intestinal flora developing slowly, chicks only gradually become able to decompose vegetable matter. In course of analysing protein flow data of our chicks belonging to age group 1, 2 and 3, respectively (**Table 18-21.**), it was proved that approximately two thirds of

Table 17: Data on matter flow of great bustard (Otis tarda) chicks

Age (days)	Mean live body mass per chick		CONSUMPTION (g)	PRODUCTION (g) and $\frac{P \times 100}{C}$	FECES + URINE (g) and $\frac{FU \times 100}{C}$	RESPIRATION (g) and $\frac{R \times 100}{C}$
	at the beginning of phase (g)	at the end of phase (g)				
3-10	81.250	134.665	65.376	19.924 30.48%	16.590 25.38%	28.862 44.14%
10-17	96.777	139.513	57.418	15.941 27.76%	16.881 29.40%	24.596 42.84%
14-21	139.483	192.627	68.097	19.823 29.11%	18.200 26.73%	30.074 44.16%
10-17 ^x	97.200	152.975	63.935	20.804 32.54%	14.686 22.97%	28.445 44.49%

(values for age group 2, without the chick that had fallen ill)

Table 18: Crude protein content of consumption

Age group	Wet mass (g)	Protein (g) in 1 g wet mass	Protein content _n (g)	Protein content ₁ (g)
Age group 1 (n = 2)	417.62	0.102	42.597	21.299
Age group 2 (n = 3)	550.33	0.102	56.134	18.711
Age group 3 (n = 3)	652.69	0.102	66.574	22.191

Table 19: Crude protein content of production

Age group	Wet mass (g)	Crude protein (g) in 1 g wet mass	Protein content _n (g)	Protein content _i (g)
Age group 1 (n = 2)	106.83	0.266	28.417	14.209
Age group 2 (n = 3)	128.21	0.266	34.104	11.368
Age group 3 (n = 3)	159.43	0.266	42.408	14.136

Table 20: Crude protein content of FU

Age group	Total DM _n (g)	Crude protein (g) in 1 g DM	Crude protein content (g) of DM _n	Crude protein content (g) of DM _i
Age group 1 (n = 2)	33.18	0.352	11.679	5.840
Age group 2 (n = 3)	50.64	0.432	21.876	7.292
Age group 3 (n = 3)	54.60	0.431	23.533	7.844

Table 21: Data on crude protein flow of great bustard (*Ovis tarda*) chicks

Age (days)	CONSUMPTION (g)	PRODUCTION and $\frac{P \times 100}{C}$	FECES + URINE and $\frac{FU \times 100}{C}$	RESPIRATION and $\frac{R \times 100}{C}$
3-10	21.299	14.209 66.71%	5.840 27.42%	1.250 5.87%
10-17	18.711	11.368 60.76%	7.292 38.97%	0.051 0.27%
14-21	22.191	14.136 63.70%	7.844 35.35%	0.211 0.95%

ingested proteins are used for building up body mass, so this quantity serves for production. The rest is mainly discharged in FU (27.42-38.97%). During the first week of life, the quantity of protein serving for respiration is considerable (5.87%), while in the older age groups proteins are used – in a more servicable way – for building up body mass, and only 0.270, 95% will be burnt. Protein content found in FU proves that the protein component of the chicks' food is quantitatively satisfactory, some part of it being eliminated by the organism. On the worst, there may be some problem with the amino-acid composition of proteins ingested. The latter topic remains to be investigated.

3.6. Crude fat flow

Analysis on crude fat flow of the chicks (**Table 22-25.**) revealed that the major part of fat (62.78-66.55%) is used for respiration while a lesser fraction of this most important source of energy is built into the body (11.71-19.44%), or becomes eliminated in FU (14.89-19.51%). Our data also indicate the appropriate crude fat content of food administered to the chicks.

3.7. Crude fiber flow

Results of investigation on crude fiber flow (**Table 26-29.**) indicate that the preponderant percentage of crude fibers (65.80-81.54%) becomes eliminated in FU. In age group 1 approximately one third (34.20%) of crude fibers ingested is used for respiration. In the older groups this ratio decreases to 18.46-19.96%. Naturally, no raw fibers appear in body mass produced by the chicks. Crude fiber content of FU is very high in young chicks. Their intestinal flora having not yet developed, they are unable to decompose crude fibers.

3.8. Nitrogen-free extract flow

The results of our trials listed in **Table 30-33.** reveal that the above-mentioned nutriment component is also used preponderantly for energy production as its major part (74.84-81.36%) appears in respiration. Merely a relatively small percentage (3.88-4.27%) is built into body mass. 14.56-20.89% becomes discharged in FU.

Table 22: Crude fat content of consumption

Age group	Wet mass (g)	Crude fat in 1 g wet mass (g)	Crude fat content _n (g)	Crude fat content ₁ (g)
Age group 1 (n = 2)	417.62	0.050	20.881	10.441
Age group 2 (n = 3)	550.33	0.050	27.517	9.172
Age group 3 (n = 3)	652.69	0.050	32.635	10.878

Table 23: Crude fat content of production

Age group	Wet mass (g)	Crude fat in 1 g wet mass (g)	Crude fat content _n (g)	Crude fat content ₁ (g)
Age group 1 (n = 2)	106.83	0.038	4.060	2.030
Age group 2 (n = 3)	128.21	0.038	4.872	1.624
Age group 3 (n = 3)	159.43	0.038	6.058	2.019

Table 24: Crude fat content of FU

Age group	Total DM _n (g)	Crude fat in 1 g DM	Crude fat content of DM _n (g)	Crude fat content of DM ₁ (g)
Age group 1 (n = 2)	33.18	0.094	3.119	1.560
Age group 2 (n = 3)	50.64	0.106	5.368	1.789
Age group 3 (n = 3)	54.60	0.089	4.859	1.620

Table 25: Data on Crude fat matter flow of great bustard (*Otis tarda*) chicks

Age (days)	CONSUMPTION (g)	PRODUCTION and $\frac{P \times 100}{C}$	FECES + URINE and $\frac{FU \times 100}{C}$	RESPIRATION and $\frac{R \times 100}{C}$
3-10	10.441	2.030 19.44%	1.560 14.94%	6.851 65.62%
10-17	9.172	1.624 11.71%	1.789 19.51%	5.759 62.78%
14-21	10.878	2.019 18.56%	1.620 14.89%	7.239 66.55%

Table 26: Crude fiber content of consumption

Age group	Wet mass (g)	Crude fiber in 1 g wet mass (g)	Crude fiber content _n (g)	Crude fiber content ₁ (g)
Age group 1 (n = 2)	417.62	0.007	2.923	1.462
Age group 2 (n = 3)	550.33	0.007	3.852	1.284
Age group 3 (n = 3)	652.69	0.007	4.569	1.523

Table 27: Crude fiber content of production

Age group	Wet mass (g)	Crude fiber in 1 g wet mass (g)	Crude fiber content _n (g)	Crude fiber content ₁ (g)
Age group 1 (n = 2)	106.83	0.000	-	-
Age group 2 (n = 3)	128.21	0.000	-	-
Age group 3 (n = 3)	159.43	0.000	-	-

Table 28: Crude fiber content of FU

Age group	Total DM _n (g)	Crude fiber content in 1 g DM (g)	Crude fiber content of DM ₁ (g)	Crude fiber content of CM ₁ (g)
Age group 1 (n = 2)	33.18	0.058	1.924	0.962
Age group 2 (n = 3)	50.64	0.062	3.140	1.047
Age group 3 (n = 3)	54.60	0.067	3.658	1.219

Table 29: Data on crude fiber matter flow of great bustard (*Otis tarda*) chicks

Age (days)	CONSUMPTION (g)	PRODUCTION and $\frac{P \times 100}{C}$	FECES + URINE and $\frac{FU \times 100}{C}$	RESPIRATION and $\frac{R \times 100}{C}$
3-10	1.462	- 0.00%	0.962 65.80%	0.500 34.20%
10-17	1.284	- 0.00%	1.047 81.54%	0.237 18.46%
14-21	1.523	- 0.00%	1.219 80.04%	0.304 19.96%

Table 30: N-free extract content of consumption

Age group	Wet mass (g)	N-free extract (g) in 1 g wet mass	N-free extract content _n (g)	N-free extract content ₁ (g)
Age group 1 (n = 2)	417.62	0.108	45.103	22.551
Age group 2 (n = 3)	550.33	0.108	59.436	19.812
Age group 3 (n = 3)	652.69	0.108	70.491	23.497

Table 31: N-free extract content of production

Age group	Wet mass (g)	N-free extract (g) in 1 g wet mass	N-free extract content _n (g)	N-free extract content ₁ (g)
Age group 1 (n = 2)	106.83	0.018	1.923	0.962
Age group 2 (n = 3)	128.21	0.018	2.308	0.769
Age group 3 (n = 3)	159.43	0.018	2.870	0.957

Table 32: Data on N-free extract matter flow of great bustard (*Otis tarda*) chicks

Age group	Total DM _n (g)	N-free extract content of 1 g DM	N-free extract content of DM _n (g)	N-free extract content of DM ₁ (g)
Age group 1 (n = 2)	33.18	0.284	9.423	4.712
Age group 2 (n = 3)	50.64	0.185	9.368	3.123
Age group 3 (n = 3)	64.60	0.188	10.265	3.422

Table 33: Data on N-free extract matter flow of great bustard (*Otis tarda*) chicks

Age (days)	CONSUMPTION (g)	PRODUCTION and $\frac{P \times 100}{C}$	FECES + URINE and $\frac{FU \times 100}{C}$	RESPIRATION and $\frac{R \times 100}{C}$
3-10	22.551	0.962 4.27%	4.712 20.89%	16.877 74.84%
10-17	19.812	0.769 3.88%	3.123 15.76%	15.920 80.36%
14-21	23.497	0.957 4.08%	3.422 14.56%	19.118 81.36%

3.9. Results of our investigations on energy flow

3.9.1. Model of energy flow

The results of investigations on matter flow, and knowledge on energy values of food components have enabled us to formulate energy flow equations for each age group of great bustard chicks. Results listed in **Table 34**, indicate that no differences exist between the groups in respect of energy flow pattern.

As in the work of GERE (1983) referred to above, energy flow of *Lonchura striata* is not given separately for the first 13 days of the birds' life, our results can be compared only with GERE's summarized data calculated for the period lasting until the onset of flying, i.e. the 27th day of life.

	<i>Lonchura striata</i>	<i>Otis tarda</i>
	1-27 days	3-21 days
Production - P	10.3%	28.62-31.42%

As GERE has pointed out that in course of the last five days before becoming fledged, a significant percentage of nutrients and energy contained in the food ingested by *Lonchura striata* is used for respiration, it can be inferred that an average production as high as 10,3% is only possible mathematically if in the first period of life body mass production is considerably higher, approaching the value obtained for bustard chicks in course of our trials.

Summarizing the results of our investigations, it can be laid down that in respect of the period covered by our trials, the type of production biology established by GERE (1983) for birds in general, applies for great bustards as well. Clearing the question how the above-mentioned type deviates during the subsequent stages of great bustards life in the direction hypothesized for *Non-passeres* remains the task of further investigations. However, technical implementation of the latter will be extremely difficult.

4. CONCLUSIONS AND RECOMMENDATIONS

Among investigations performed under artificial circumstances, our trials were the first ones to supply comprehensive data on the matter and energy flow of great bustard chicks.

Table 34: Data on energy flow of great bustard chicks (10^3 J and % respectively)

Age (days)	CONSUMPTION (10^3 J)	PRODUCTION and $\frac{P \times 100}{C}$	FECES + URINE and $\frac{FU \times 100}{C}$	RESPIRATION and $\frac{R \times 100}{C}$
3-10	1.397.739	414.678 29.67%	268.675 19.22%	714.386 51.11%
10-17	1.227.597	331.780 27.03%	283.061 23.06%	612.756 49.91%
14-21	1.455.914	412.576 28.34%	300.464 20.64%	742.874 51.02%
10-17	1.366.930	432.994 31.67%	246.255 18.02%	687.681 50.31%

The results of our trials indicate that daily consumption (expressed in dry matter) averages approximately 30g when chicks are fed according to the methods applied at the DÉVAVÁNYA RESCUE STATION. By converting the quantity given in dry matter into wet mass, it can be laid down that great bustard chicks of the respective age require circa 100g of food daily.

During the first three weeks of life, 28-30% of consumption was used for building up body mass, 43-45% served for respiration, and 25-30% became eliminated in FU. From the point of view of energetics, the share of production amounts similarly to 28-30%, whereas 50-51% of energy serves for respiration, and only 18-21% will be eliminated.

We were able to establish that protein flow serves mainly (60-67%) for building up body tissue while the rest becomes eliminated. The bulk of crude fat (63-67%) as well as the majority of nitrogen-free extracts (75-82%) is used for respiration. A lesser percentage of these substances participates in production, and the rest is eliminated. Crude fibers do not play any part in production; the amount used for respiration does not exceed 18-34%, thus the majority of this food component becomes eliminated in FU.

On the basis of results reported above, it can be stated that compound feed applied at the DÉVAVÁNYA RESCUE STATION does not contain insufficient quantities of any physiologically important component. Crude fiber content of the diet is to be considered as too high. The majority of it becomes eliminated in FU in undigested state, due to the natural characteristics of bustard chicks nutrition biology. Therefore, the ratio of vegetable matter in the diet has to be reduced considerably. Applying semolina and corn grits as food ingredients seems to be superfluous. Their present share (calculated for dry matter) amounts to 34.17 mass %, and their crude content is as high as 2.7%.

The present quantity of young lettuce fed to the chicks (12.79 mass % of food, with a crude fiber content of 10.2%) seems to be sufficient, or it may be even slightly reduced.

Simultaneously with the reduction of ingredients containing a high percentage of crude fiber, animal protein content of crude fiber, animal protein content of the diet (meat, insects, etc.) has to be provided for. These changes would be of great importance because in the present formulary amino-acid composition of proteins is surely poorer than the one which could be accomplished by applying meat as diet ingredient. More complex amino-acid composition of food would have advantageous consequences in regard of nutrition physiology, somatic development and hygiene of bustard chicks.

In the future we intend to make use of the results of our investigations for optimizing the composition of food applied in Hungarian great bustard rearing.

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