EKOLOGIA POLSKA (Ekol. pol.)	32	1	125–139	1984

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CHANGES OF BODY WEIGHT, CHEMICAL COMPOSITION AND ENERGETIC VALUE IN THE NESTLINGS OF THE JACKDAW, *CORVUS MONEDULA* L., DURING THEIR DEVELOPMENT IN THE NEST

ABSTRACT: Changes were followed of body weight, chemical composition and energetic value in the jackdaw (*Corvus monedula*) during a 35 days' development in the nest. Body weight was found to increase during this period, and drop towards its end to about 220 g. Relative water content dropped from 85.04 to 66.91%. Protein content showed a growth tendency, increasing from 6.81 to 20.15%. Fat content increased only in the first 3 days of nestlings' life, from 4.41 to 9.02%, whereas about 10th day of their life it decreases. Energetic value of 1 g of dry weight changed from 18.97 to 25.18 kJ, and of 1 g of biomass from 3.00 to 7.64 kJ.

KEY WORDS: Birds, *Corvus monedula*, nestling development, chemical composition, energetic values.

Contents

1. INTRODUCTION

Related to the growth kinetics are changes in body weight and in the proportions of its main components: water, proteins, fats and ash (Bailey, Kitts and Wood 1960, Laird 1965). Changes in the amount of these components indicate that the energetic value of one gramme of body weight also changes during the development.

Studies on changes in the weight, chemical composition and energetic value of birds during their growth in the nest concern different ecological types of birds. Papers dealing with this problem in the family Corvidae are few in number and limited to reporting some data on the moulting process and changes in body weight of some species during the nestlings' stay in the nest (Pitelka 1945, Parmalee 1952, Mewaldt 1956, Rustamov and Mustafaev 1958, Crossin 1967, Bateman and Balda 1973, Tomek 1975).

The aim of the present study was to follow changes in the weight, chemical composition and energetic value of the body of the jackdaw (*C. monedula*) during its 35 days' development in the nest. Changes were studied of biomass, dry body weight and fat-free dry weight. Chemical analyses were carried out for changes in the content of water, proteins, fats and ash. It was also tried to determine the course of the relationship between these parameters during the development in the nest.

2. MATERIAL AND METHODS

The investigations were carried out in a jackdaw colony consisting of about 200 nests built in hollows in the trunks of old willow-trees lining a road across flood meadows of the river Narew, 15 km south-west of Białystok. In the period from April 28 to June 12 1981, that is, during the breeding season of the jackdaw a total of 108 nestlings aged 1–35 days were examined. The nestlings were taken out of the nests, about noon, weighed, anaesthetized in chloroform, dried to a constant weight and thoroughly minced in an electric mincer. The content of water in the body was calculated from the difference between a nestling's weight before drying and that after drying. Protein content was determined by Kjeldahl's method, and the amount of fats by the gravimetric method. Samples of about 1 g in size were subjected to a double extraction at first with a mixture of chloroform and methanol (2:1) at 60°C, and then after the evaporation of the solvents the raw specimen was treated with a mixture of chloroform and petroleum ether (light, boiling temperature 40–60°C) in the proportions 1:1 at room temperature. After evaporation at 50°C and evacuation of air the samples were dried to a constant weight. The difference between the weights represented the amount of fats extracted from a sample.

In order to determine the energetic value of nestlings' bodies, from each individual 3 samples, each of 0.5–1.5 g, were taken and burned in the Berthelott KL – 5 calorimeter. This made it possible to determine the indices of the energetic value of the nestlings examined, as well as the content of ash in the samples burned. As the per cent content of water in the body was known, it was possible to calculate the energetic value of 1 g of dry weight without ash, and of 1 g of biomass. The amount of ash in the body was determined on the basis of the weight difference of a sample before and after its burning in the calorimeter.

3. RESULTS

3.1. NESTLINGS' GROWTH

Young jackdaws remain in the nest for about 35 days. The difference in the hatching time of the nestlings of a brood amounts to 6 days. Chicks that were the last to hatch are usually smaller and weaker, and they often die before the flight from the nest.

Body weight growth during the development of the jackdaw nestlings in the nest is presented in Table I. On the basis of the weighing of the nestlings in the period between their hatching and flight out of the nest a growth curve has been plotted and described by means of Gompertz's equation (Fig. 1).

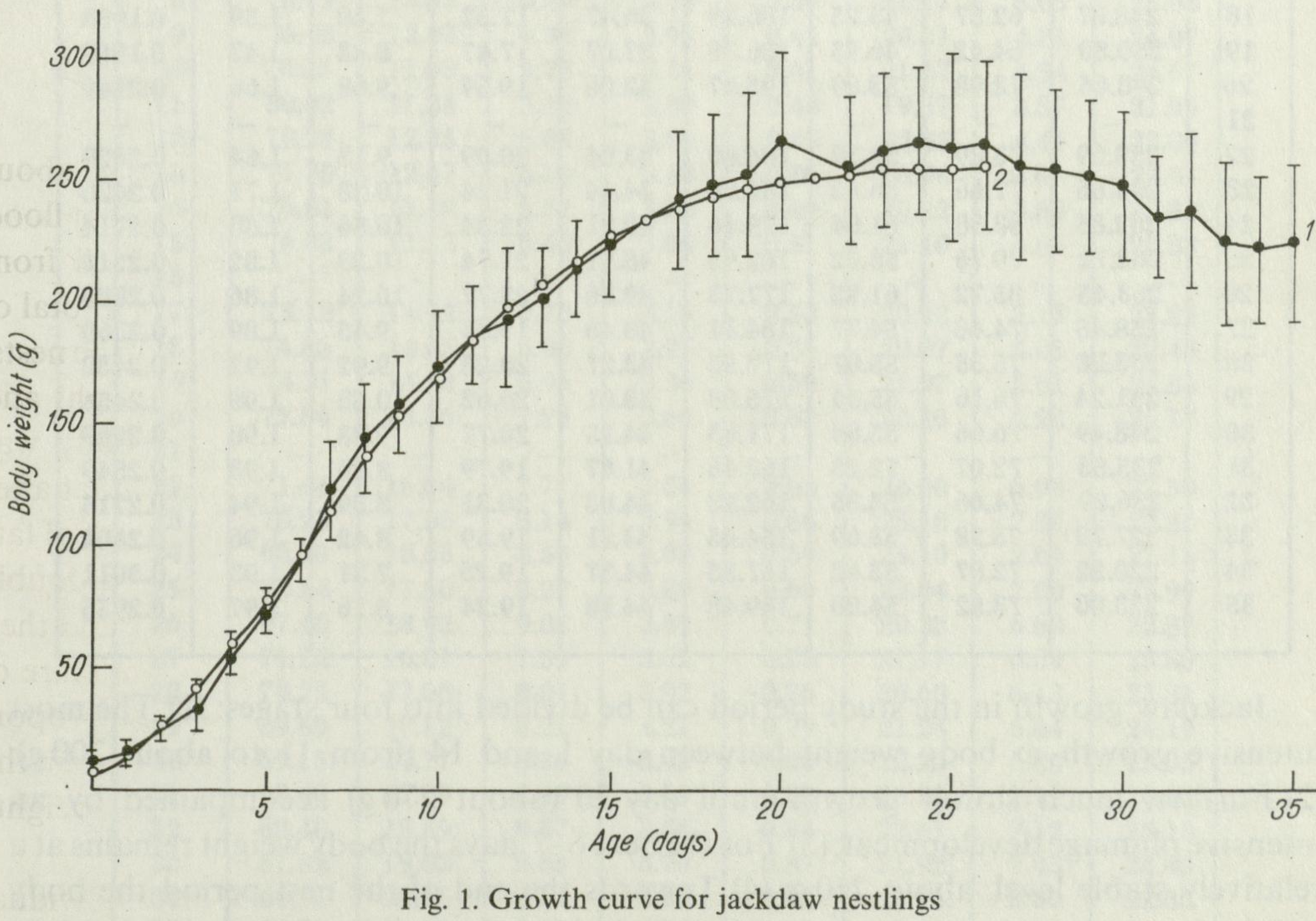

Fig. 1. Growth curve for jackdaw nestlings
1 – mean values of body weight and range of their variation, 2 – the curve obtained by using Gompertz's equation ($K_G = 0.206$, $A = 268.65$, $t_{10-90} = 14.50$)

Table I. Changes of body weight and chemical composition during the nestling development of *C. monedula*

Age (days)	Body weight (g)	Dry weight (g)	Fat-free dry weight (g)	Weight of constituents (g)					Protein : water ratio
				water	protein	fat	ash	unidentified compounds	
0	11.54	1.94	1.31	9.60	0.90	0.63	0.36	0.05	0.0937
1	16.49	2.63	1.82	13.86	1.13	0.81	0.62	0.07	0.0815
2	23.78	3.56	2.51	20.23	1.62	1.05	0.82	0.07	0.0801
3	32.70	5.18	3.67	27.51	2.47	1.51	1.11	0.10	0.0898
4	53.34	8.91	6.25	44.43	4.50	2.66	1.59	0.17	0.1010
5	71.58	12.77	8.99	58.91	6.60	3.78	2.15	0.24	0.1120
6	94.28	18.67	13.41	75.61	10.07	5.26	3.01	0.33	0.1332
7	121.44	26.31	18.89	95.13	13.91	7.42	4.54	0.45	0.1462
8	142.17	33.00	24.06	109.17	18.51	8.94	5.03	0.55	0.1695
9	158.68	37.31	27.28	121.36	20.36	10.03	6.27	0.66	0.1678
10	173.24	36.63	26.67	136.61	20.49	9.96	5.46	0.72	0.1500
11	186.63	37.29	27.18	149.34	21.17	10.11	5.22	0.81	0.1417
12	192.53	41.94	30.33	150.59	23.78	11.61	5.71	0.86	0.1579
13	201.19	44.76	32.31	156.43	25.10	12.45	6.30	0.93	0.1604
14	213.76	49.58	35.65	168.18	28.19	13.93	6.42	1.04	0.1676
15	221.82	51.28	36.97	170.54	29.11	14.31	6.75	1.12	0.1707
16	–	–	–	–	–	–	–	–	–
17	241.74	60.15	43.76	181.59	34.86	16.39	7.62	1.29	0.1920
18	248.87	62.57	45.25	186.29	36.47	17.32	7.40	1.39	0.1958
19	250.80	64.42	46.95	186.38	37.07	17.47	8.43	1.47	0.1989
20	268.65	72.98	53.39	195.67	42.06	19.59	9.68	1.66	0.2149
21	–	–	–	–	–	–	–	–	–
22	258.69	73.89	53.80	184.80	43.04	20.09	9.13	1.64	0.2329
23	260.86	77.66	56.42	183.20	44.44	21.24	10.28	1.71	0.2426
24	262.85	83.38	61.04	179.46	48.71	22.34	10.56	1.80	0.2714
25	262.72	79.76	58.02	182.95	45.97	21.74	10.23	1.82	0.2513
26	263.45	85.72	61.95	177.73	49.86	23.77	10.24	1.86	0.2805
27	258.48	74.40	54.77	184.11	43.46	19.63	9.45	1.89	0.2360
28	253.28	75.35	55.07	177.93	43.27	20.28	9.92	1.91	0.2432
29	251.24	76.16	55.54	175.08	43.01	20.62	10.58	1.98	0.2456
30	248.49	76.66	55.89	171.83	44.15	20.77	9.83	1.98	0.2569
31	235.53	72.07	52.28	163.46	41.67	19.79	8.70	1.93	0.2549
32	236.89	74.66	54.35	162.23	44.03	20.31	8.39	1.94	0.2714
33	227.73	73.28	53.69	154.45	43.31	19.59	8.42	1.96	0.2804
34	220.22	72.87	53.62	147.35	44.37	19.25	7.31	1.93	0.3011
35	223.00	73.52	54.28	149.48	44.18	19.24	8.16	1.97	0.2955

Jackdaw growth in the study period can be divided into four stages: (1) The most intensive growth in body weight between day 1 and 14 (from 11 to about 200 g); (2) Further, much slower growth until day 20 (about 270 g) accompanied by an intensive plumage development; (3) For the next 6–7 days the body weight remains at a relatively stable level, about 260 g; (4) Towards the end of the nest period the body weight decreases so that at the time of their flight from the nest the average weight of the jackdaws is 220 g.

3.2. CHEMICAL COMPOSITION

W a t e r. The absolute content of water in the body of the jackdaw nestlings increases until about day 25, the most intensive growth occurring in the period up to day 10 (Table I). After a 3 weeks' stay in the nest the absolute content of water decreases till the time when the individuals leave the nest.

Table II. Changes of the per cent content of chemical constituents and energetic value indicators of the body of *C. monedula* during the nestling development

Age (days)	Percentage of composition					Energy content ($kJ \cdot g^{-1}$)		
	water	protein	fat	ash	unidentified compounds	dry weight	fresh weight	ash-free dry weight
0	83.19	7.80	5.46	3.12	0.43	20.99	3.53	24.86
1	84.05	6.85	4.91	3.76	0.42	20.79	3.32	25.71
2	85.04	6.81	4.41	3.45	0.29	20.09	3.00	24.71
3	84.15	7.55	4.62	3.39	0.31	19.06	3.02	23.12
4	83.29	8.44	4.99	2.98	0.32	18.97	3.17	22.35
5	82.16	9.22	5.28	3.00	0.34	22.02	3.93	25.71
6	80.20	10.68	5.58	3.19	0.35	24.59	4.87	28.55
7	78.34	11.45	6.11	3.74	0.37	23.23	5.03	27.23
8	76.79	13.02	6.29	3.54	0.39	21.77	5.05	25.08
9	76.48	12.83	6.32	3.95	0.41	20.61	4.84	24.07
10	78.85	11.83	5.75	3.15	0.41	21.47	4.54	24.67
11	80.02	11.34	5.42	2.80	0.43	19.37	3.87	21.95
12	78.22	12.35	6.03	2.96	0.45	20.25	4.41	23.00
13	77.75	12.47	6.19	3.13	0.46	20.96	4.66	23.91
14	76.81	13.19	6.51	3.00	0.49	20.22	4.69	22.84
15	76.88	13.12	6.45	3.04	0.51	21.10	4.88	23.88
16	–	–	–	–	–	–	–	–
17	75.12	14.42	6.78	3.15	0.53	20.62	5.13	23.22
18	74.86	14.65	6.96	2.97	0.56	20.07	5.05	22.45
19	74.31	14.78	6.96	3.36	0.59	21.97	5.61	24.84
20	72.84	15.66	7.29	3.60	0.62	23.10	6.28	26.17
21	–	–	–	–	–	–	–	–
22	71.44	16.64	7.77	3.53	0.63	24.30	6.94	27.30
23	70.23	17.03	8.14	3.94	0.66	25.18	7.50	28.53
24	68.28	18.53	8.50	4.02	0.69	24.10	7.64	27.15
25	69.64	17.50	8.27	3.89	0.69	23.04	7.00	25.99
26	67.46	18.92	9.02	3.89	0.71	20.38	6.63	22.82
27	71.22	16.81	7.59	3.65	0.73	21.17	6.09	23.86
28	70.25	17.08	8.01	3.92	0.76	20.60	6.13	23.31
29	69.69	17.12	8.21	4.21	0.79	21.24	6.44	24.19
30	69.15	17.77	8.36	3.95	0.80	22.20	6.85	25.05
31	69.40	17.69	8.40	3.69	0.82	23.25	7.11	26.05
32	68.48	18.59	8.57	3.54	0.84	22.61	7.12	25.15
33	67.82	19.02	8.60	3.70	0.87	21.92	7.05	24.43
34	66.91	20.15	8.74	3.32	0.88	20.76	6.87	22.85
35	67.03	19.81	8.63	3.66	0.89	19.70	6.49	21.88

Per cent water content ($y = -0.513x + 83.81$, $r = -0.96$, $n = 34$) attains its peak during the first days of development in the nest (about 85%), whereafter it slowly drops until the end of the nestlings' stay in the nest (about 65%) – Table II.

Increase in the absolute water content in the body ($y = 4.348x + 59.10$, $r = 0.79$, $n = 34$) is slower than the body weight growth ($y = 6.757x + 68.05$, $r = 0.85$, $n = 34$). A similar relationship is found between the absolute content of water and dry body weight ($y = 2.011x + 32.16$, $r = 0.92$, $n = 34$), and between the absolute water content and biomass ($y = 0.688x + 7.16$, $r = 0.99$, $n = 34$). This is connected with a decrease in the relative water content during the development in the nest.

D r y w e i g h t a n d d r y f a t-f r e e w e i g h t. The dry weight of the jackdaws' bodies varies in accordance with the following equation: $y = 2.407x + 8.95$, $r = 0.93$, $n = 34$, and it increases between days 1 and 26 after hatching, this increase being particularly intensive between days 5 and 15 (Table I), which is connected primarily with the growth at that time of the dry fat-free weight. Afterwards the dry weight decreases till the day of the jackdaws' flight out of the nest. The dry fat-free weight ($y = 1.738x + 6.97$, $r = 0.93$, $n = 34$) also grows regularly between days 1 and 26 after hatching, and then it decreases slowly till the day of the flight out of the nest (Table I). A more intensive growth in the dry fat-free weight is seen between 5th and 15th days of the nestlings' life, during the growth of the feathers. The decrease of this index after day 30 is accompanied by a partial falling of feathers. The relationships between the dry weight and wet weight ($y = 0.311x - 7.14$, $r = 0.97$, $n = 34$), and between the dry fat-free weight and wet weight ($y = 0.232x - 6.35$, $r = 0.96$, $n = 34$) are directly proportionate.

P r o t e i n s. The absolute content of proteins in the nestlings' body ($y = 1.416x + 4.77$, $r = 0.94$, $n = 34$) increases between days 1 and 24 after hatching, and then until the flight of the birds out of the nest it shows slight changes (Table I). Relative protein content varies between 6.81 and 20.15% of wet weight (Table II) with a tendency to grow with an increase in body weight ($y = 0.356x + 7.95$, $r = 0.97$, $n = 34$). Per cent protein content in the dry weight also shows a growth tendency ($y = 0.323x + 49.93$, $r = 0.81$, $n = 34$), ranging from 42.80 to 60.89%. Changes in the absolute protein content during the development in the nest are proportionate to changes in the nestlings' body weight ($y = 0.187x - 5.68$, $r = 0.96$, $n = 34$). A relationship of similar nature is found between the absolute content of proteins and dry body weight ($y = 0.592x - 0.87$, $r = 0.99$, $n = 34$).

The relationship between the absolute content of proteins and water in the body of young jackdaws is expressed by the equation: $y = 0.258x - 5.90$, $r = 0.91$, $n = 34$.

The protein content to water content ratio, being an index of the chemical maturity of the tissues, shows an over three-fold growth during the nest period (Table I). This indicates that the process of changes in the chemical composition of the body is not completed in the fledging period. The relationship between the ratio protein:water and the body weight varies in accordance with the equation: $y = 0.001x + 0.06$, $r = 0.86$, $n = 34$.

F a t. Absolute fat content in the nestlings' body ($y = 0.630x + 2.95$, $r = 0.92$, $n = 34$) increases till day 24 after hatching, the most intensive growth being observed between days 3 and 9 (Table I). From 26th day on fat content decreases and then remains at a relatively stable level of about 20 g until the flight out of the nest. The per cent content of this component in the biomass ($y = 0.123x + 4.76$, $r = 0.96$, $n = 34$), following its decrease in the first 3 days after hatching (from 5.46 to 4.41%), grows till day 9. The next growth period is between days 12 and 24, and then before the flying out of the nest (Table II). The fall in relative content of fat about day 10 (from 6.32 to 5.42%) is correlated with the growth of the plumage which starts then.

Per cent content of fat in the dry weight ($y = -0.092x + 29.39$, $r = -0.73$, $n = 34$) remains at a comparatively stable level during the first week of the nestlings' life (about 30%), and in the next days it drops to about 27%, whereas immediately before the nestlings' flight out of the nest it is 26.17%.

The relationship between the absolute content of fat and biomass weight changes in accordance with the equation: $y = 0.085x - 2.10$, $r = 0.97$, $n = 34$. A relationship of a similar nature is found between the absolute content of fat and dry weight ($y = 0.268x + 0.22$, $r = 0.99$, $n = 34$). The relationship between the per cent content of fat and water is inversely proportionate, and can be described by the equation: $y = -0.241x + 24.95$, $r = -0.99$, $n = 34$.

A s h. The absolute content of ash in the body of young jackdaws ($y = 0.267x + 1.92$, $r = 0.88$, $n = 34$) grows between day 1 and day 24, whereafter it tends to decrease (Table I). Its change is rectilinear and parallel to changes in the birds' body weight ($y = 0.037x - 0.33$, $r = 0.97$, $n = 34$). Per cent content of ash in the biomass ($y = 0.018x + 3.17$, $r = 0.49$, $n = 34$) shows a weak growing tendency during the nest period, ranging from 2.80–4.21% (Table II). The relative content of ash in the dry weight is found to change with age ($y = -0.248x + 18.77$, $r = -0.80$, $n = 34$). It shows the highest level in the first days of life (about 20%), and it slowly decreases to a value lower by half at the end of the nest period.

U n i d e n t i f i e d c o m p o u n d s. The group of unidentified compounds included primarily carbohydrates. Their content in jackdaws' body is slight, and it increases somewhat during the development in the nest (Tables I, II).

3.3. ENERGETIC VALUE

The energetic value of 1 g of dry weight of jackdaws' body shows during the nest period a weak growth tendency, varying between 18.97 and 25.18 kJ (Table II). It is expressed by the equation: $y = 0.008x + 4.99$, $r = 0.24$, $n = 34$. During the first developmental days the energetic value of 1 g of biomass ($y = 0.031x + 0.73$, $r = 0.87$, $n = 34$) is about 3.50 kJ, and it then drops to 3.00 kJ, whereafter it increases to attain more than double value by day 24 ($7.64\ kJ \cdot g^{-1}$). In the last 10-day period of the nestlings' stay in the nest the energetic value of 1 g of biomass falls to about $6.5\ kJ \cdot g^{-1}$

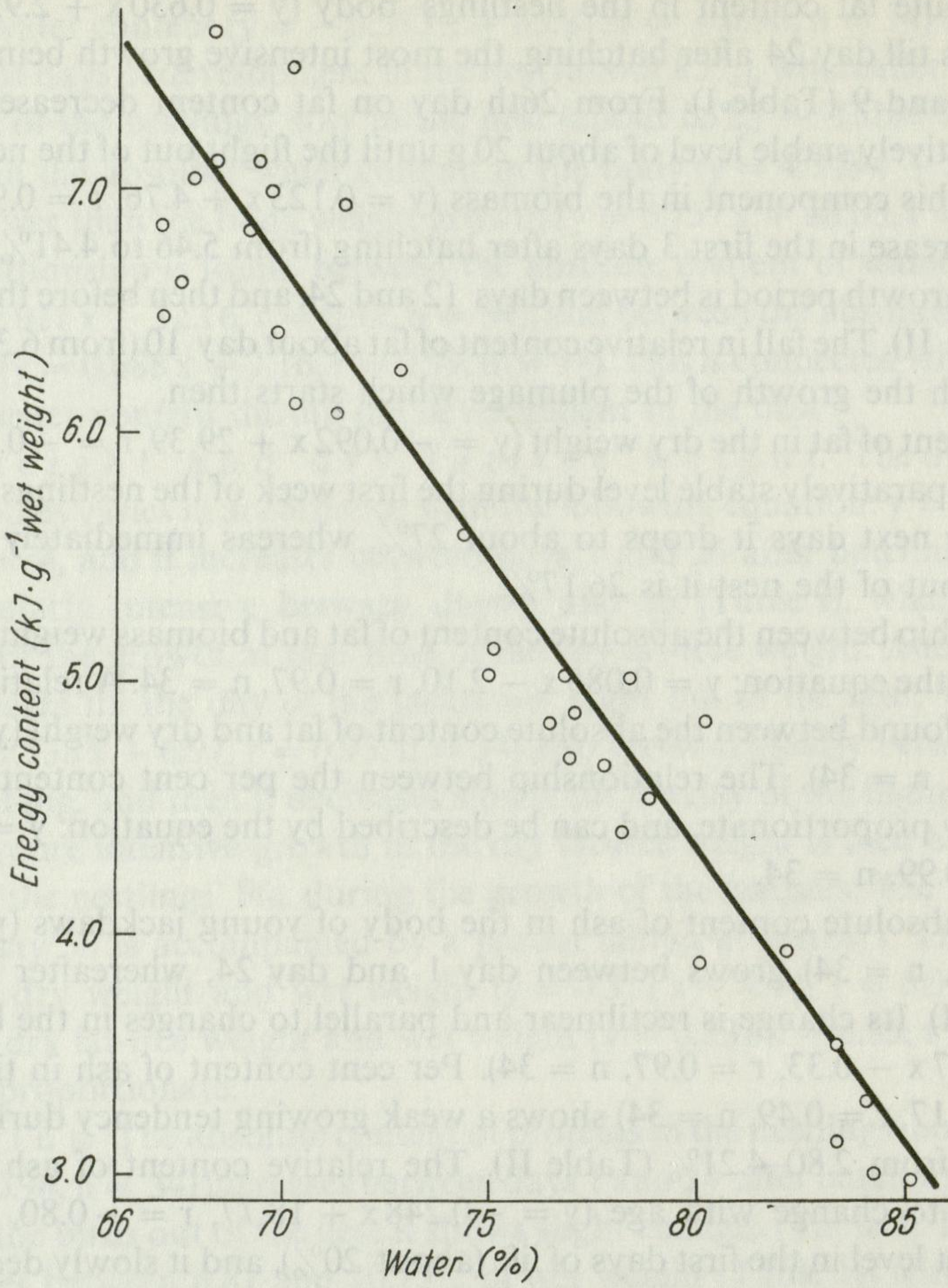

Fig. 2. Relationship between the energetic value of wet body weight (kJ · g^{-1}) and per cent content of water in the bodies of jackdaw nestlings
$y = -0.56x + 5.52$, $r = -0.951$, $n = 34$

(Table II). The value of this index depends first of all on the relative content of water in the bodies of young jackdaws (Fig. 2). It also is related to the per cent content of fat and protein, the relationships being directly proportionate (Fig. 3).

The energetic value of 1 g of dry body weight without ash ($y = 0.021x + 5.35$, $r = 0.22$, $n = 34$) changes during the jackdaws' development in the nest fairly irregularly (Table II). It is at its highest between day 5 and day 7 after hatching, and then between day 20 and day 25 (about 27 kJ), whereas in the last days of the jackdaws in the nest it decreases by about 20%.

The energetic value of entire jackdaws in the nest period ($y = 12.664x + 44.69$, $r = 0.91$, $n = 34$) varies between 40.71 and 2009.28 kJ.

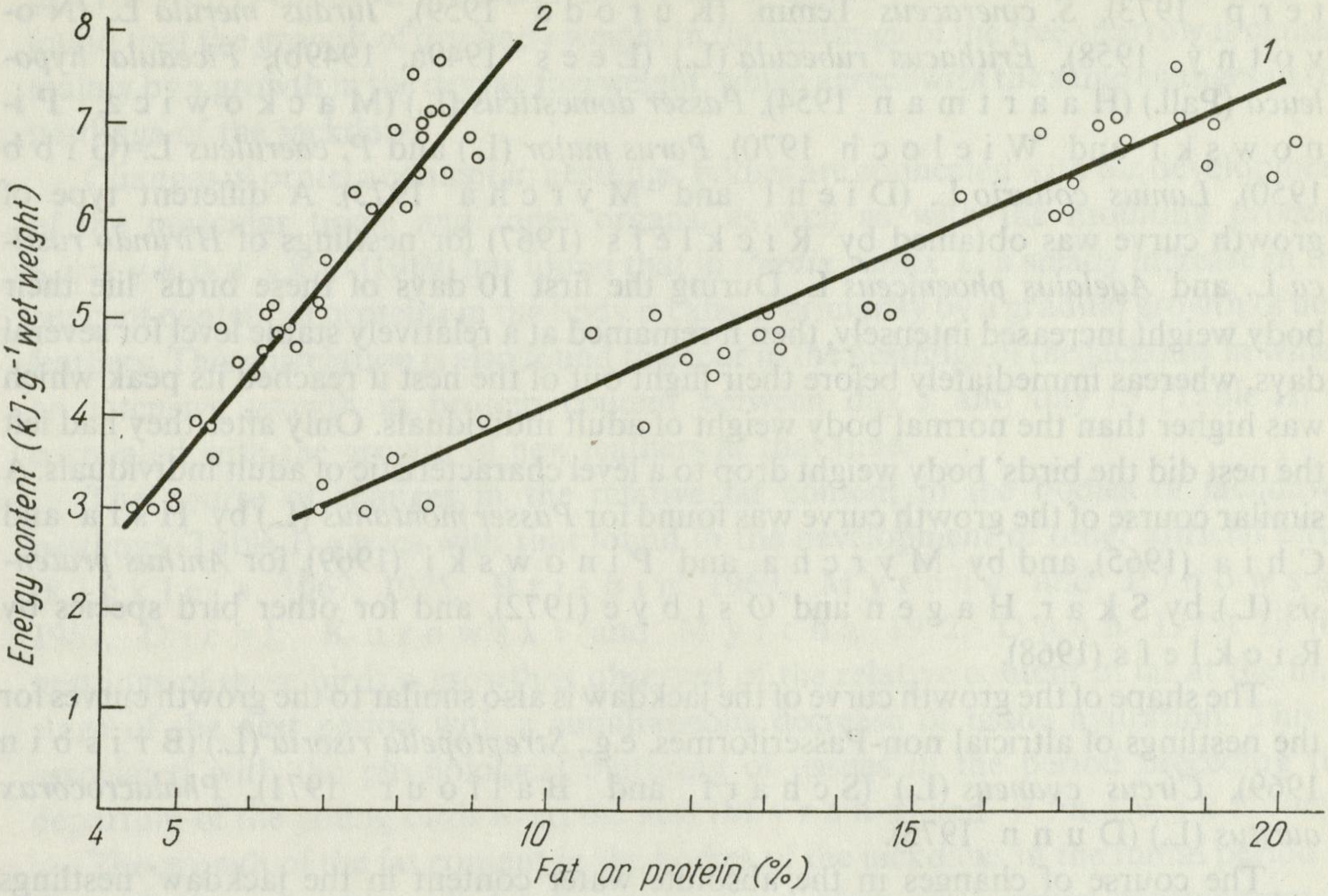

Fig. 3. Relationship between the energetic value of wet body weight (kJ · g^{-1}) and per cent content of proteins (1) an fat (2) in jackdaw nestlings

$1 - y = 0.336x + 0.68$, $r = 0.95$, $n = 34$, $2 - y = 0.968x - 1.25$, $r = 0.96$, $n = 34$

4. DISCUSSION

The intensive growth of the body weight of the jackdaws during the first dozen or so days in the nest (Table I), and the shape of their growth curve (Fig. 1) are similar to those found in other corvine birds, e.g., *Corvus frugilegus* (L.) (R u s t a m o v and M u s t a f a e v 1958, T o m e k 1975), *C. brachyrhynchos* (L.) (P a r m a l e e 1952), *Nucifraga columbiana* (L.) (M e w a l d t 1956), *Gymnorhinus cyanocephalus* (L.) (B a t e m a n and B a l d a 1973). In the jackdaws the growth was impeded about day 20 after hatching. According to D e n i s o v a (1958) this occurs during the growth of the feathers. However, this regularity has not been found to occur in the jackdaws, because their feathers began to grow about day 12.

The shape of the growth curve for the jackdaws under study is similar to the growth curves of the passerine birds, and is characterized by a fast growth in body weight during the first period after hatching, whereafter the growth rate is slowed down and a several days' stagnation follows before the drop of body weight (P o r t m a n n 1938). A similar course of the growth curves is found, e.g., for *Sturnus vulgaris* L. (H u d e c and F o l k 1961, M y r c h a, P i n o w s k i and T o m e k 1973, W e s t e rterp 1973), *S. cineraceus* Temm. (Kuroda 1959), *Turdus merula* L. (Novotný 1958), *Erithacus rubecula* (L.) (Lees 1949a, 1949b), *Ficedula hypoleuca* (Pall.) (Haartman 1954), *Passer domesticus* (L.) (Mackowicz, Pinowski and Wieloch 1970), *Parus major* (L.) and *P. caeruleus* L. (Gibb 1950), *Lanius collurio* L. (Diehl and Myrcha 1973). A different type of growth curve was obtained by Ricklefs (1967) for nestlings of *Hirundo rustica* L. and *Agelaius phoeniceus* L. During the first 10 days of these birds' life their body weight increased intensely, then it remained at a relatively stable level for several days, whereas immediately before their flight out of the nest it reached its peak which was higher than the normal body weight of adult individuals. Only after they had left the nest did the birds' body weight drop to a level characteristic of adult individuals. A similar course of the growth curve was found for *Passer montanus* (L.) by Hsia and Chia (1965), and by Myrcha and Pinowski (1969), for *Anthus pratensis* (L.) by Skar, Hagen and Østbye (1972), and for other bird species by Ricklefs (1968).

The shape of the growth curve of the jackdaw is also similar to the growth curves for the nestlings of altricial non-Passeriformes, e.g., *Streptopelia risoria* (L.) (Brisbin 1969), *Circus cyaneus* (L.) (Scharf and Balfour 1971), *Phalacrocorax auritus* (L.) (Dunn 1975).

The course of changes in the absolute water content in the jackdaw' nestlings (Table I) is similar to that of changes in this index in the nestlings of *P. montanus* (Myrcha and Pinowski 1969), *S. vulgaris* (Myrcha, Pinowski and Tomek 1973) and *C. frugilegus* (Tomek 1975). In *L. collurio* (Diehl, Kurowski and Myrcha 1972) and *A. pratensis* (Skar, Hagen and Østbye 1972) the absolute water content was found to increase during the development in the nest.

A reduction of the absolute water content at the final stage of the development in the nest causes a decrease in body weight in the nestlings of species characterized by a particularly well-developed flying capability (Ricklefs 1968). This has also been documented in studies of the nest period development of *H. rustica* (Ricklefs 1967) and *P. montanus* (Myrcha and Pinowski 1969).

The course of changes in the relative water content in the nestlings of the jackdaw does not differ from the course of this process in the nestlings of a number of other bird species. The highest level of relative water content in their bodies is found in the first days of their life when the growth is most intensive (Ricklefs 1967, Myrcha and Pinowski 1969, Diehl, Kurowski and Myrcha 1972, Myrcha, Pinowski and Tomek 1972, 1973 Skar, Hagen and Østbye 1972, Westerterp 1973, Dunn 1975, Tomek 1975).

The intensive growth of the dry fat-free weight between day 5 and day 15 agrees with the data reported by Myrcha and Pinowski (1970) who found that in *P. montanus* a considerable growth in the dry fat-free weight was connected with the growth of new feathers. Similar regularities have been recorded by Farrar (1966) and Helms et al. (1967) for *Junco hyemalis* (L.), and by Skar, Hagen and

Ø s t b y e (1972) for *A. pratensis*. M y r c h a and P i n o w s k i (1970) also have found that the growth of dry body weight in the nestlings of the tree sparrow is caused mainly by a growth in the dry fat-free weight, which agrees with the same changes in the nestlings of the jackdaw.

Changes in protein content in nestlings' bodies are connected with the development of the muscular tissue and inner organs, as well as with the moulting process. S z w y k o w s k a (1969) has found that in *Perdix perdix* L. a steady increase in the per cent content of proteins in the body is caused primarily by a gradual growth of new feathers. This correlation is also found to occur in the nestlings of the jackdaw in which an intensive growth in protein content between day 5 and day 15 (Table II) is correlated with the growth of new feathers at that time.

The course of changes in the relative fat content in the bodies of jackdaw's nestlings (Table I) agrees with that found in the development of other altricial birds (R i c k l e f s 1967, 1975, B r i s b i n 1969, M y r c h a and P i n o w s k i 1969, D i e h l, K u r o w s k i and M y r c h a 1972, D u n n 1975). In the nestlings of these birds a growth is observed of the relative content of fat at the final stage of the nest period with a simultaneous decrease of tissue hydration. This is associated with the physiological maturing of tissues in the period preceding the departure of the young birds from the nest (M y r c h a and P i n o w s k i 1969).

The growth of the fat content in the bodies of the jackdaws in the initial period of their life, from hatching till day 9, is terminated when an intensive development of plumage starts. A similar phenomenon has also been reported from other passerine birds, e.g., *Spiza americana* (L.) (Z i m m e r m a n 1965), *Fringilla coelebs* L. (D o l n i k and B l y u m e n t a l 1967), *P. montanus* (M y r c h a and P i n o w s k i 1970) in which an increase in the content of fat was found prior to fledging, and its lowest level during this process.

The relative content of ash in the bodies of the jackdaw's nestlings slightly increases during the nest period (Table II). Also in most other altricial bird species studied the amount of mineral substances is most often the lowest in the youngest nestlings and then increases during the nest period. This is true of, e.g., *H. rustica* (R i c k l e f s 1967), *P. montanus* (M y r c h a and P i n o w s k i 1969), *A. pratensis* (S k a r, H a g e n and Ø s t b y e 1972) and *S. vulgaris* (M y r c h a, P i n o w s k i and T o m e k 1973).

The energetic value of 1 g of dry body weight of the jackdaws in the nest period (Table II) is similar to the energetic value of 1 g of dry body weight of the nestlings of *P. montanus* (M y r c h a and P i n o w s k i 1969), *P. domesticus* (M y r c h a, P i n o w s k i and T o m e k 1972), *L. collurio* (D i e h l, K u r o w s k i and M y r c h a 1972), *S. vulgaris* (M y r c h a, P i n o w s k i and T o m e k 1973, W e s t e r t e r p 1973) and *C. frugilegus* (T o m e k 1975). As in those species, it does not show any significant variations during the nest period. In other bird species a slight growth was most often observed of the energetic value of 1 g of dry body weight during the development of nestlings (S k a r, H a g e n and Ø s t b y e 1972, D u n n 1975).

The course of changes in the energetic value of 1 g of the biomass of young jackdaws' bodies (Table II) is similar to that observed in the nestlings of other altricial bird species studied, regardless of their size (R i c k l e f s 1967, M y r c h a and P i n o w s k i 1969, M y r c h a, P i n o w s k i and T o m e k 1972, 1973, D i e h l, K u r o w s k i and M y r c h a 1972, S k a r, H a g e n and Ø s t b y e 1972, W e s t e r t e r p 1973, D u n n 1975, T o m e k 1975). The absolute values of this indicator, too, are similar to the respective values in the nestlings of these species.

During the first four days after hatching the energetic index values for the jackdaws examined were found to decrease (Table II). This is probably connected with the presence of some yolk supply in the bodies of newly hatched nestlings. A similar phenomenon was also recorded for some other altricial birds (R i c k l e f s 1967, D i e h l, K u r o w s k i and M y r c h a 1972, M y r c h a, P i n o w s k i and T o m e k 1972, D u n n 1975).

In the nestlings of the species under study changes in the energetic value of the biomass depended first of all on changes in the content of water (Fig. 2) and fat (Fig. 3). It is a phenomenon commonly occurring in both altricial and precocial birds.

As a result of all these processes, the energetic value of 1 g of the biomass of young jackdaws, assessed immediately before their departure from the nest, is higher by 85% than on the first day of their life. During the nest period there occurs an over 35-fold increase in the total energy contained in a nestling's body, from about 41 kJ to nearly 1450 kJ.

5. SUMMARY

Changes were followed of body weight, chemical composition and energetic value during a 35 days' nest period of the jackdaw (*Corvus monedula*). The investigations were carried out in a jackdaws' colony of nests in hollows in the trunks of old willow trees between flood meadows of the Narew river, about 15 km to the south-west of Białystok. Between April and June 1981 a total of 108 jackdaw nestlings were examined. The content of water in their bodies was determined by drying to a constant weight. Protein content was determined by Kjeldahl's method, and the amount of fat by the gravimetric method. The energetic value was found by burning samples in the Berthelott System KL – 5 calorimeter.

The growth of nestlings can be divided into 4 stages (Fig. 1, Table I): the most intensive growth between day 1 and day 14 after hatching (from 11 up to about 200 g), further growth in weight until 20th day (about 270 g), a week's stagnation (about 260 g) and a slight decrease in body weight in the last days of the nest period (to about 220 g).

The highest relative water content in the body is found during the first days of development in the nest (about 85%), whereafter it decreases steadily till the time of the nestlings' departure from the nest (about 65%) – Table II. Dry weight and dry fat-free weight increase from day 1 until day 26 after hatching (Table I). Relative protein content changed from 6.81 to 20.15% of the biomass, showing a tendency to increase (Table II), due to which the ratio of protein content to water shows an over 3-fold growth during the nest period (Table I). The per cent content of fat decreases in the first days of life, whereafter it grows from 4.62 to 8.74% (Table II). Per cent content of ash in the biomass showed a slight growth tendency during the nest period, changing from 2.80 to 4.21% (Table II).

The energetic value of 1 g of dry weight varies between 18.97 and 25.18 kJ, while the energetic value of 1 g of biomass increases during the nest period from 3.00 to 7.64 kJ (Table II). The energetic value of the biomass depends on the relative content of water (Fig. 2) and fat (Fig. 3) in the bodies of the nestlings.

6. POLISH SUMMARY

Prześledzono zmiany ciężaru, składu chemicznego i wartości energetycznej ciała kawki (*Corvus monedula*) w okresie 35 dni rozwoju gniazdowego. Badania prowadzono na terenie kolonii kawek gnieżdżącej się w dziuplach wierzb między łąkami rozlewiskowymi rzeki Narwi, ok. 15 km na południowy zachód od Białegostoku. W okresie od kwietnia do czerwca 1981 r. przebadano 108 piskląt kawki. W ich ciałach określono zawartość wody poprzez suszenie do stałego ciężaru. Zawartość białek oznaczono metodą Kjeldahla, a ilość tłuszczu metodą grawimetryczną. Wartość energetyczną wyznaczono przez spalanie prób w kalorymetrze KL – 5, systemu Berthelotta.

Wzrost piskląt można podzielić na 4 stadia (rys. 1, tab. I): najintensywniejszy przyrost między 1 i 14 dniem życia (od 11 do ok. 200 g), dalszy wzrost ciężaru do 20 dnia (ok. 270 g), tygodniowa stagnacja (ok. 260 g) i lekki spadek ciężaru ciała w ostatnich dniach rozwoju gniazdowego (do ok. 220 g).

Względna zawartość wody w ciele jest największa w pierwszych dniach rozwoju gniazdowego (ok. 85%), po czym maleje równomiernie do końca pobytu piskląt w gnieździe (ok. 65%) – tab. II. Sucha masa i sucha masa beztłuszczowa wzrasta of 1 do 26 dnia życia (tab. I). Względna zawartość białek zmienia się w zakresie 6,81–20,15% biomasy wykazując tendencję wzrostową (tab. II), co powoduje, że stosunek zawartości białek do wody wzrasta w rozwoju gniazdowym ponad 3-krotnie (tab. I). Procentowa zawartość tłuszczu obniża się w ciągu pierwszych dni życia, po czym wzrasta od 4,62 do 8,74% (tab. II). Procentowa zawartość popiołu w biomasie wykazuje w rozwoju gniazdowym słabą tendencję wzrostową i zmienia się w zakresie 2,80–4,21% (tab. II).

Wartość energetyczna 1 g suchej masy ciała kształtuje się w granicach 18,97–25,18 kJ, zaś wartość energetyczna 1 g biomasy wzrasta w czasie pobytu piskląt w gnieździe od 3,00 do 7,64 kJ (tab. II). Wartość energetyczna biomasy zależy od względnej zawartości wody (rys. 2) i tłuszczu (rys. 3) w ciele piskląt.

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