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Changes in the Caloric Value of the Body During the Postnatal Development of White Mice*)

[With 7 Figs. & 1 Table]

Investigations were made of the calorificity, and water and ash contents of the body in 135 white mice from 1 to 365 days old. The caloric equivalent of 1 g of biomass of the mice depends primarily on the amount of water in the body. Newborn mice are characterised by high water content of the tissues, and in consequence by their low calorificity. The indices examined do not change between the 10th and 30th day of life. Later increase in the caloric value of fresh tissue in white mice is due on the one hand to continued reduction of the water content, and on the other to the gradual accumulation of fat by the animals. The caloric value of 1 g of dry mass without ash and the amount of ash in the body do not alter during the postnatal development of mice.

I. INTRODUCTION

A knowledge of the caloric value of animals' bodies is essential in order to describe the energy flow through populations of species examined, and also in order to establish the production of these populations. A considerable amount of information on calorimetric measurements of the body of small mammals can be found in ecological literature. In the majority of cases these are, however, only incidental data obtained from buring a small number of individuals, without taking into account the changes connected with age and sex of the animals, or the time at which the investigations were made (Golley, 1961; Slobodkin & Richman, 1961; Slobodkin, 1962; Davis & Golley, 1963). The study by Górecki (1965) presents accurate data obtained over the full year's cycle for four species of rodents — *Clethrionomys glareolus* (Schreber, 1790), *Apodemus flavicollis* (Mel-

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chior, 1834), *A. agrarius* (Pallas, 1771) and *Microtus arvalis* (Pallas, 1779) — and one representative of *Insectivora* — *Sorex araneus* Linnaeus, 1758. From the data published by the above authors it can be seen that the caloric equivalent of the body in different species of small mammals is very similar. On this account Davis & Golley (1963) propose accepting for calculations a constant simplified caloric value of 1.4 kcal/g per 1 g of biomass for the adult individuals of all species of rodent, but Górecki (1965) raises this index to 1.5 kcal/g on the basis of his more accurate studies.

There is no information in the studies referred to above on variations in the caloric value of the body of mammals during their postnatal development, and it was therefore decided to trace the course taken by this process in the white mouse. This species was chosen for two reasons. The studies by Golley (1961), Davis & Golley (1963) and Górecki (1965) showed that the bodies of adult representatives of separate species of rodents have very similar caloric values, and it may therefore be expected that these indices will be similar in young individuals of different species of small mammals also. White mice, which are easy to obtain, could therefore form a convenient model animal in these studies. On the other hand intensive research is carried out in the Institute of Ecology, Polish Academy of Sciences, on experimental populations of this species and it is essential to obtain information on its bioenergy indices in order to trace the energy flow through these populations.

II. MATERIAL AND METHODS

A total number of 135 white mice aged from 1—365 days old were examined. All individuals were obtained from the six-year old culture initiated in 1961 by the Institute of Ecology, Polish Academy of Sciences, from four pairs of animals. The mice were anaesthetized with ether and weighed, then dried in a vacuum oven at a temperature of 45°C in the presence of CaCl₂.

Water content was calculated from the difference in weight before and after drying. The dried material was minced in an electric mincer, thoroughly mixed and burnt in a K1—3 calorimeter. As samples of about 1 g in size can be burnt in this calorimeter it was necessary to use from 2—3 young of the same age mice to form a sample for burning, in the case of mice from 1—9 days old. In the case of older animals over 30 days old it was possible to take several samples from each individual. Calculations were made of the amount of ash in the dry material, weighing the dried crucible again after each burning in the calorimeter.

The caloric value of 1 g of dry mass (*Wg*), caloric value of 1 g of dry mass without ash (*WgA—F*) and caloric equivalent of 1 biomass of the animals examined were calculated for each sample.

The results are presented in diagrams on which the relation of the various indices to the age of the white mice is shown by means of the regression lines.

In all cases calculation was also made of the correlation coefficients. The mean values of the indices were calculated for the four age groups, then these groups were described by the confidence intervals based on variable t . The mean values of these same indices were compared with each other by means of the t — Student test for difference in mean values for two independent groups.

III. DISCUSSION OF RESULTS

The curve of growth rate of the white mice investigated (Fig. 1) is very similar to the growth curve for mice drawn by Brody (1945). In the initial period, up to about the 20th day of life, the animals grow evenly and increase in weight daily by about 0.30 g, that is, by 21% of the body weight of newborn mice.

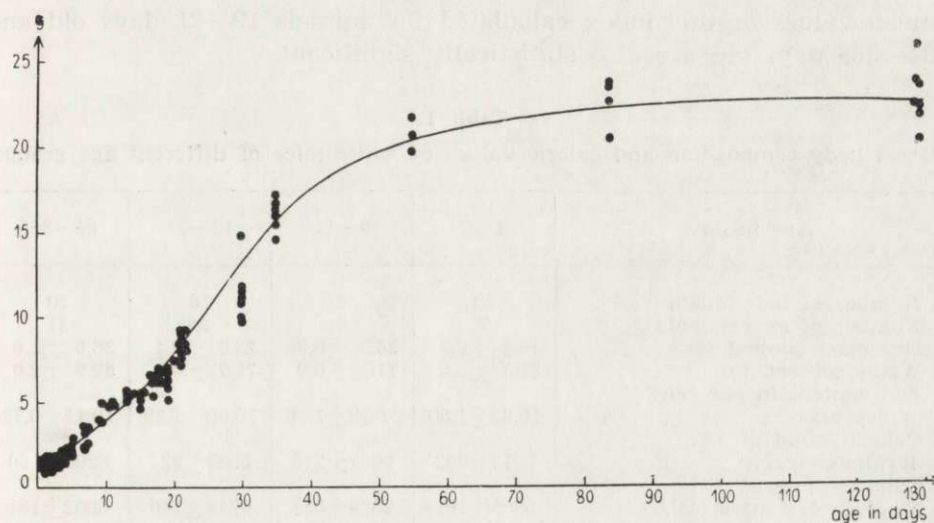


Fig. 1. Growth curve of white mice examined.

Growth rate stated: 1—20 days — 0.30 g (= 21.0%/day)
 20—35 days — 0.58 g (= 9.3%/day)
 36—85 days — 0.19 g (= 1.2%/day)

Between the 20th and 40th day of life the growth rate of white mice continues to be very intensive. During this period the body weight increased daily by an average of 0.58 g, that is, 9.3% of the weight of 20-day old animals. The period between the 40th and 85th day of life is characterized by a considerable decrease in the growth rate of the mice. The animals' increase in weight is only about 0.18 during the day, which forms only 1.0% of their weight at 40 days old. The body weight of the white mice examined does not usually alter after the 85th day.

The results presented in table 1 and fig. 2 indicate that the water content in the body of white mice changes very intensively during postnatal development. The maximum percentage of water is observed in the body of newborn mice. During the first 10 days of life the relative amount of water in the mouse's body decreases by over 10% (statistically significant difference). The value of the correlation coefficient calculated for this period is -0.69 and is statistically significant, which forms evidence of the close relation between the water content of the animals' body and their age. During the next 20 days the amount of water in the body of white mice is maintained on a uniform level, then slowly decreases to reach about 63% in individuals one year old. The correlation coefficient calculated for animals from 35 to 365 days old ($r = -0.24$) is statistically significant. The differences between the mean values of this index calculated for animals 19—21 days old and 84—365 days old are also statistically significant.

Table 1.

Gross body composition and caloric values of white mice of different age groups.

| Age in days | 1—2 | 9—11 | 12—21 | 84—365 |
|--|------------------|-----------------|------------------|------------------|
| Number of individuals | 28 | 6 | 16 | 20 |
| Number of experiments | 7 | 6 | 20 | 31 |
| Dry mass content (%) | 18.4 \pm 0.9 | 28.9 \pm 0.9 | 28.3 \pm 0.4 | 36.5 \pm 1.9 |
| Water content (%) | 81.5 \pm 2.5 | 71.1 \pm 0.9 | 71.7 \pm 0.5 | 62.9 \pm 2.0 |
| Ash content in per cent of dry mass | 10.03 \pm 1.50 | 8.29 \pm 1.36 | 10.00 \pm 1.29 | 10.11 \pm 0.73 |
| Caloric value of dry mass (cal/g) | 5313 \pm 202 | 6047 \pm 275 | 5559 \pm 92 | 6205 \pm 160 |
| Caloric value of ash free dry mass (cal/g) | 5905 \pm 191 | 6529 \pm 358 | 6248 \pm 140 | 6902 \pm 131 |
| Caloric value of biomass (kcal/g) | 0.96 \pm 0.26 | 1.60 \pm 0.11 | 1.56 \pm 0.01 | 2.25 \pm 0.12 |

The ash content in the dried bodies of mice did not however change with increasing age (Fig. 2). The correlation coefficient calculated for this index has a value of -0.17 and is statistically non-significant. The differences between the mean values of ash content in the body of mice of different age (Table 1) do not differ significantly.

The regression lines illustrating the relation between the caloric value of 1 g of dry mass, both with (Wg) and without ash (Wg_{A-F}), and the age of the mice (Fig. 3), follow a course similar to the curve of ash content. In both cases it is only the animals 1—2 days old which are characterised by slightly lower indices (Table 1). In principle, however, it may be said that neither of these values alters with the age of the

animals examined. The correlation coefficients calculated are not statistically significant.

The caloric equivalent of 1 g of live tissue exhibits a sharp increase (Fig. 4) during the first 10 days of life. The difference in the mean values calculated for animals aged 1—2 days and 9—11 days old is 0.64 kcal/g and, like the correlation coefficient calculated for this period ($r = 0.85$), is statistically significant (Table 1). After attaining the value

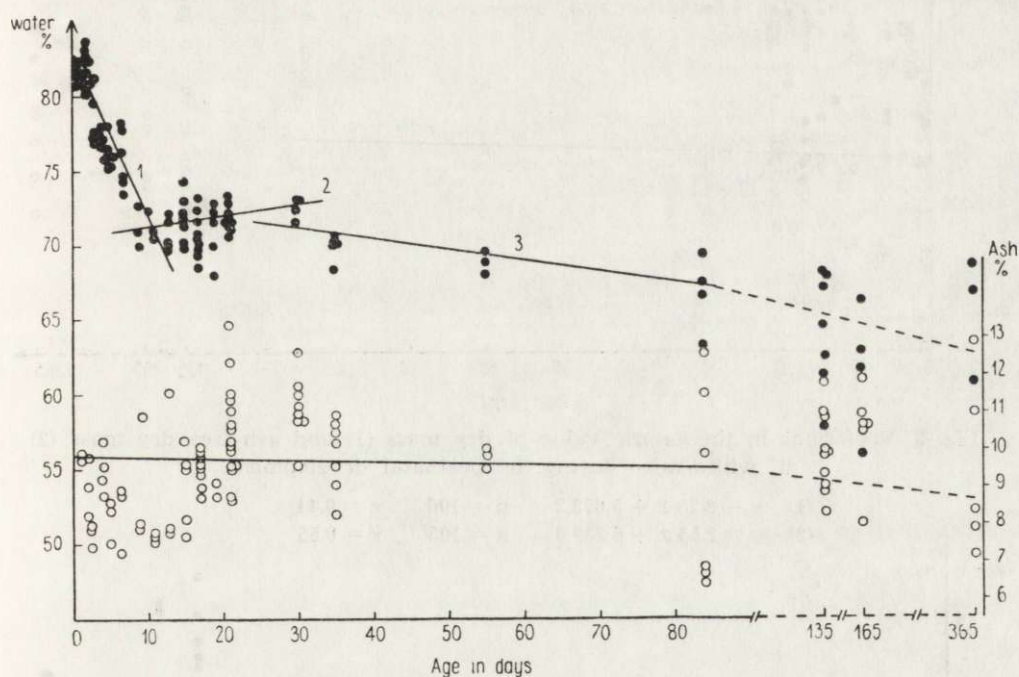


Fig. 2. Variations in percentage of water and ash content in the body of white mice depending on age.

Number at water content curve means:

- | | | | |
|-----|-----------------------|-----------------------|-------------|
| (1) | 1 — 10 days, n = 62 | $y = 83.48 - 1.0955x$ | $r = -0.69$ |
| (2) | 11 — 30 days, n = 47 | $y = 0.133x + 69.31$ | $r = 0.38$ |
| (3) | 35 — 365 days, n = 25 | $y = 72.88 - 0.064x$ | $r = -0.24$ |

The regression equation for ash content for 1—365 days (n = 108) is:

$$y = -0.00331x + 9.41 \quad r = -0.17$$

of 1.60 kcal/g the caloric equivalent of 1 g of biomass is maintained on a uniform level up to the 30th day of life. The next rapid increase is observed between the 30th and 35th day, followed by a gradual slow rise in the value of this index until the level of 2.25 kcal/g is reached in animals from 3 month to 1 year old (the difference is statistically

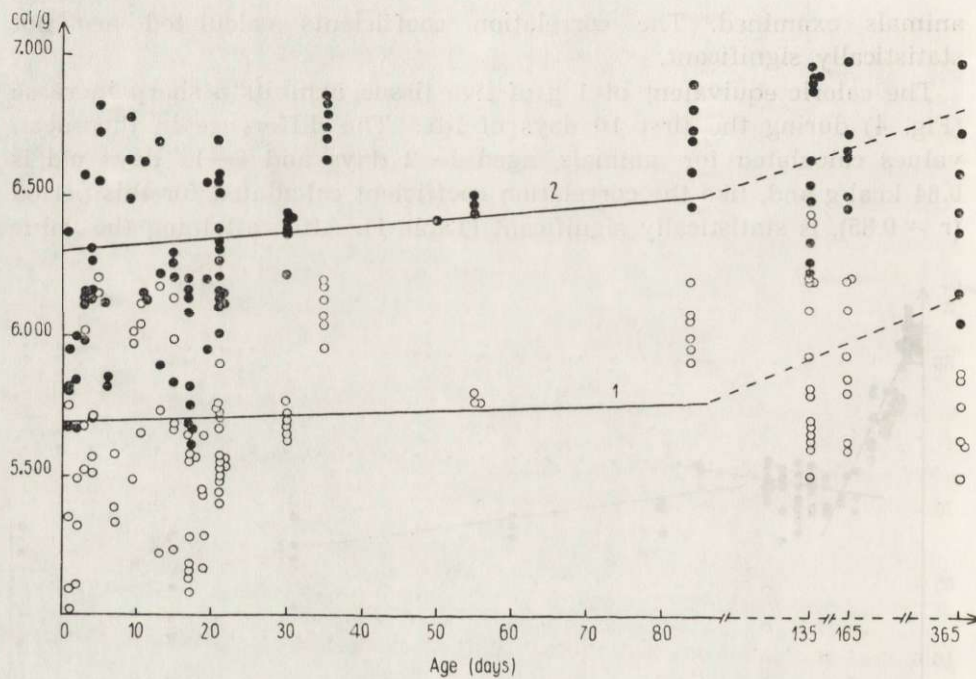


Fig. 3. Variations in the caloric value of dry mass (1) and ash-free dry mass (2) of white mice during the postnatal development.

(1) $y = 2.20x + 5,672.2$ $n = 106$ $r = 0.44$
 (2) $y = 2.55x + 6,289.0$ $n = 105$ $r = 0.55$

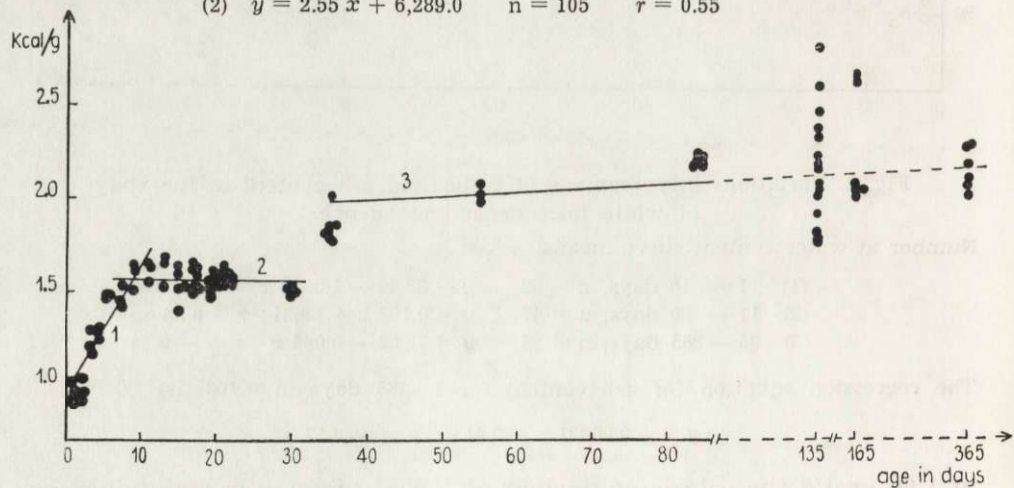


Fig. 4. Variations in caloric equivalent of 1 g of biomass of white mice during the postnatal development.

(1) 1 — 10 days, $n = 26$ $y = 0.00001x + 1.56$ $r = 0.85$
 (2) 11 — 30 days, $n = 46$ $y = 0.07055x + 0.95$ $r = -0.03$
 (3) 35 — 365 days, $n = 38$ $y = 0.00121x + 1.56$ $r = 0.22$

significant). The correlation coefficient calculated for this latter period ($r = 0.22$) is not however statistically significant.

Changes in body weight (Fig. 1) and the water content in the animals' bodies (Fig. 2) affect the shape of the curve illustrating variations in weight of dry mass of body during the postnatal development of mice (Fig. 5). As the water content decreases more sharply during the first ten days of life of white mice than their absolute weight increases, this curve takes the form of a gentle slope during the initial phase, and is more even over its whole length than the growth curve of the animals examined (Fig. 1). The graph illustrating the variations in caloric equivalent of the whole body, during the postnatal development of white mice is, however, very different in

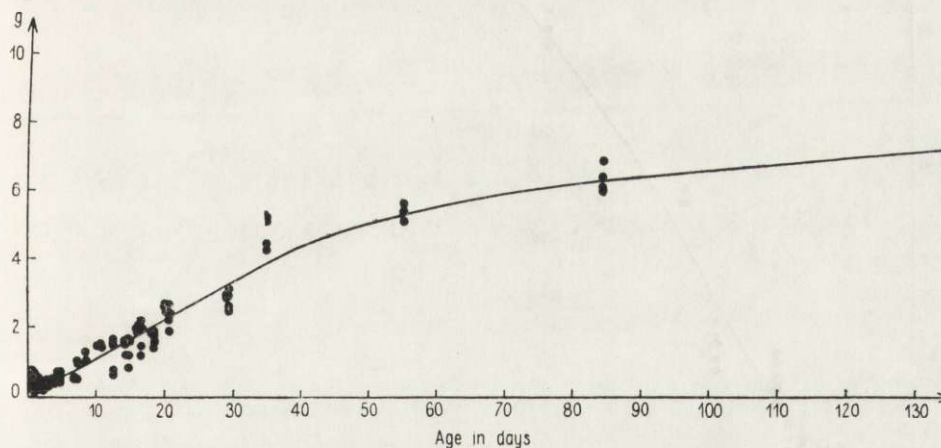


Fig. 5. Variations in the value of dry mass of individuals examined depending of their age.

character (Fig. 6). Both the increase in body weight of the animals and the changes in caloric value of 1 g of their biomass influence the shape of this curve. As a result the caloric value of the whole body of the mice examined rises sharply and relatively evenly up to about the 80th day of life. The daily increase in energy contained in the animals' bodies during this period is on an average 0.62 kcal/animal. As from approximately the 80th day of postnatal development the summary caloric value of the body of white mice becomes stable and as a result of the merely negligible increase in body weight from that time and simultaneous slight decrease in water content of the body does not alter with increasing age of the animals examined.

Comparison of fig. 2 and fig. 4 leads to the conclusion that the caloric value of 1 g of biomass of the white mice examined depends primarily on the body water content. The regression lines characterising the variations in these two values with the age of the animals take a reverse course. This conclusion is confirmed by the regression line

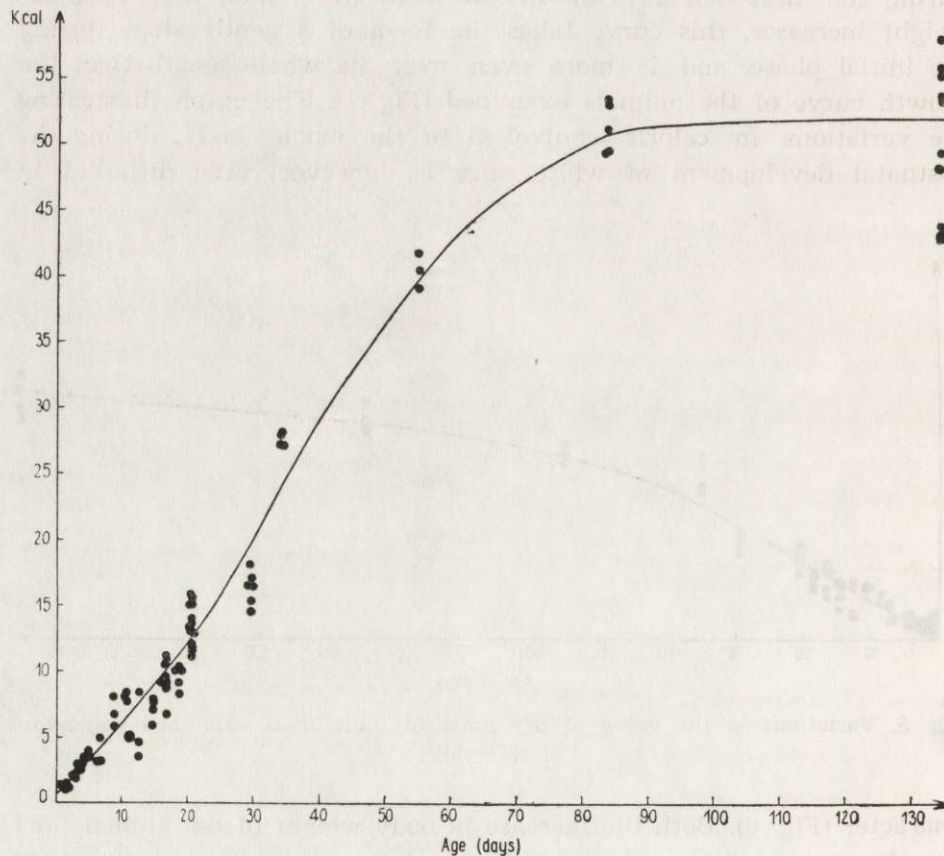


Fig. 6. Variations in caloric equivalent of biomass of white mice during their postnatal development (kcal/animal).

(Fig 7) illustrating the interdependence between the caloric equivalent of live tissue of these animals and the water content in the sample.

The correlation coefficient calculated for this relation has a value of -0.77 and is statistically significant. The sudden jump in the caloric value of 1 g of biomass between the 30th and 35th day of life and the subsequent slow rise of this index is also probably connected with increase in fat content in the bodies of these animals. The

accumulation of fat by laboratory animals soon after they begin obtaining food independently, and the considerable differences in this process depending on food and culture conditions, have already been observed by Moulton (1923). In this connection this author proposes analysing the relation between the biochemical components of animals' organisms by calculating their values in fat-free bodies.

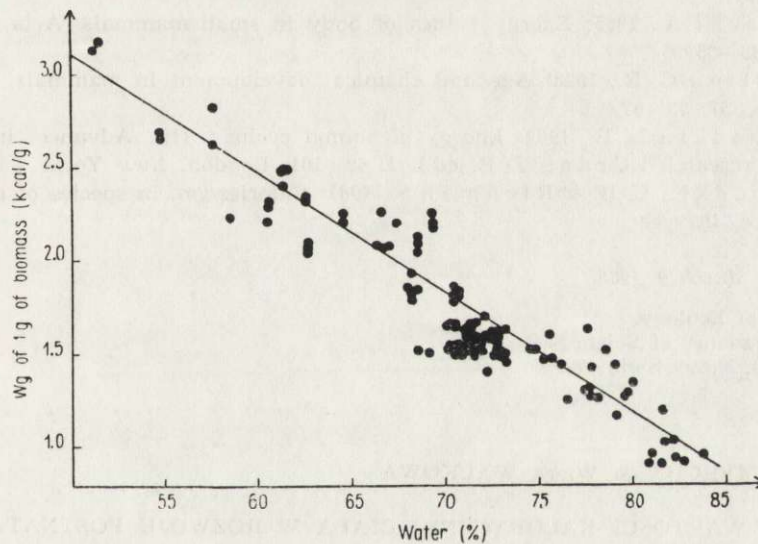


Fig. 7. Relation between caloric value of 1 g of biomass and water content in the body of white mice.

$$y = -0.0598x + 6.10 \quad r = -0.77$$

On the other hand the data given by Babineau & Page (1955) and Bailey *et al.* (1960) lead to the conclusion that a fairly distinct relation in reversely proportion occurs between the age changes in the percentages of water and fat contents in rats and mice. The fact that indices of body caloricity of adult white mice are, in comparison with corresponding data obtained by other authors for different species of rodents, relatively high is probably connected with this phenomenon. Confirmation of this supposition is provided by the similarity between the values of these indices and the values obtained for wild representatives of small mammals possessing well-developed fatty tissue, *e. g.* *A. agrarius* caught in the summer (cf. Górecki, 1965).

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ZMIANY WARTOŚCI KALORYCZNEJ CIAŁA W ROZWOJU POSTNATALNYM BIAŁYCH MYSZY

Streszczenie

Zbadano kaloryczność ciała oraz zawartość wody i popiołu u 135 białych myszy w wieku 1—365 dni życia. Ekwiwalent kaloryczny 1 g biomasy myszy zależy przede wszystkim od ilości wody w ich ciele. Nowonarodzone zwierzęta charakteryzują się dużym uwodnieniem tkanek, a tym samym bardzo niską ich kalorycznością. Pomiedzy 10 i 30 dniem życia badane wskaźniki nie ulegają zmianie. Późniejszy wzrost wartości kalorycznej świeżej tkanki białych myszy jest spowodowany z jednej strony dalszym obniżeniem się w niej ilości wody, a z drugiej stopniowym otluszczaniem się zwierząt. Wartość cieplna 1 g suchej masy bez popiołu i ilość popiołu w ciele nie zmieniają się w rozwoju postnatalnym myszy.