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Variation in Weights of Body and Internal Organs of the Field Mouse in a Gradient of Urban Habitats

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Comparison was made of the absolute and relative weights of internal organs and body of the field mouse *Apodemus agrarius* (Pallas, 1771), living in areas differing as to their degree of urbanization: a park in the city centre, a suburban wooded park and woodland outside the suburbs. When data from the two study years (1975 and 1976) were compared similar tendencies in variations of the indices examined were found within the ranges of individual variation, sex dimorphism and also variation in indices depending on changes in body weight. The ranges of variation and mean values of the indices show that there is a distinct morpho-physiological difference between the population living in the city centre and population of the suburban area and the wooded land beyond the suburbs. This difference is manifested, *inter alia*, by the park population being characterized by greater body weight and dimensions, lower indices for the organs in autumn and more rapid ageing processes, with simultaneous better survival of winter. This would seem to indicate that the general physiological condition of field mice is better in the city centre.

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1. INTRODUCTION

The urban environment has recently become the object of ecological interest in Poland on account of the need for establishing ecological principles for its formation. This involves the necessity for obtaining a knowledge of ecological processes taking place within a city (Andrzejewski, 1976).

The great majority of studies on rodents in urbanized areas applies to synanthropic species, e.g. the migrant rat and the house mouse. Non-synanthropic species of rodents may also occur in a city, particularly with the contemporary type of building, which includes a high proportion of green spaces. Literature on rodent communities in urbanized areas is scanty and is of a primarily faunistic character. Judging by the existent papers on the subject it may be said that the dominant species in typical urban green areas in Poland is the field mouse (Sumiński, 1922, Chudoba *et al.*, 1961, Babińska-Werka *et al.*, 1979).

Other rodents and insectivores may also occur in addition to field mice (Haitlinger, 1965). In the literature available there is no analysis of variations in species composition, numbers and structure of different populations which could form the expression of their adaptation to ecosystems transformed as the result of urbanization. Complex studies have therefore been undertaken, intended to trace such variations in a system of urban and suburban habitats, used for recreational purposes to different extents and at varying distances from the city centre (Warsaw), which have already been described in great detail (Andrzejewski *et al.*, 1978; Babińska-Werka, 1981, Sikorski 1982 and others).

An attempt has also been made at estimating the physiological condition of field mice inhabiting the city, as conditioned by the effect of intrapopulation factors and the influence of external habitat conditions. Adaptation to rapidly changing habitat conditions consists primarily in the capacity for variation in the intensity of physiological processes, the expression of which may be the weights of internal organs and their variations. Values for the weight of internal organs have been treated as the indicators of their metabolical function. The existence of this relation has been demonstrated in papers by Schwarz (1949, 1958, 1975). Relative weights of internal organs have been termed by Schwarz (1960) "morphophysiological indices" and are characterized by: (1) the fact that they apply to organs carrying out important functions in the organism's life, (2) clearly react to changes in the external habitat, (3) give a reliable representation of the animal's physiological condition.

As the result of later studies it was found that the correlation between metabolic level and relative weight of internal organs is not exact (Schwarz, 1960; Hart, 1971), which modified the original assumptions. It is now considered (Bashenina, 1977) that relative weights of internal organs reflect the degree of metabolic burden on the organ, primarily by its basic function. It is for this reason that they may constitute criteria of the animals' physiological condition. This does not mean, however, that the relative weights of kidneys and heart form a measure of the general level of metabolism.

Populations of the same species developing in similar habitat conditions do not usually exhibit differences between the values of the indices compared. On this basis it is possible to define the "morphophysiological standard" for each population, understood by Schwarz (1968, 1975) as the dynamic reflection of regular age and seasonal changes in various indices. Deviations from this state point to changes in the population's energy balance due to the adaptation of individuals to, e.g., unfavourable changes in external habitat conditions. According to Schwarz (1975), the morphophysiological characteristics of a population form an important indicator of population processes.

The purpose of the present paper was to make a morphophysiological description of field mice from urban and suburban habitats and to define differences between these populations in an urbanization gradient.

2. STUDY AREAS, MATERIAL AND METHODS

The studies were made in three areas within the limits of Greater Warsaw: in the Młociny Wood (MW); Bielany Grove (BG) and the Botanical Gardens together with the adjoining part of the Łazienki Park (ŁP). The BG and MW wooded land, which is of a park-woodland and woodland character, are situated in the northern part of the city in its suburban zone and immediately outside it. The ŁP area is situated in the centre of Warsaw and forms a large city centre park area (Andrzejewski *et al.*, 1978).

Two trapping series of the rodents there were carried out in 1975 and 1976: spring (8th May — 20th June 1975, 5th May — 25th May 1976) and autumn (4th September — 18th October 1975, 21st September — 16th October 1976). Live-traps were used, set out in a line every 15 metres. In the MW and BG woods the number of traps varied from 50—70 depending on the season. A total of 1986 animals belonging to 6 rodent species, 1273 of which were field mice, were caught over the course of the two study years.

The animals were taken to the laboratory and anesthetized with ether. Male field mice were exsanguinated in order to estimate blood indices, which form the subject of a separate study (Rewkiewicz-Dziarska *et al.*, 1977). After measuring body length together with the head the animals were dissected and sex and sexual activity determined (females — state of uterus, number and size of embryos, placental scars; males — dimensions of the testes and their position).

Age was estimated in two ways: (1) on the basis of dry eye lens weight (Adamczewska-Andrzejewska, 1971) and (2) on the basis of wear of the grinding surfaces of tooth crowns (Adamczewska-Andrzejewska, 1973).

In view of the differing food contents the bodies of the animals examined were weighed without intestines and stomach (nett weight) with accuracy to 0.1 g. After excising the internal organs (kidneys, heart, liver) they were cleaned of fat and washed in a physiological saline solution, after which they were dried on filter paper and, weighed on a torsion balance with accuracy to 0.001 g.

In analyzing the absolute and relative weights (in % of nett body weight) of internal organs division into seven age classes was used (each class=2 months of life, class VII being over 12 months old). This formed the basis for finally distinguishing 3 groups: (1) juveniles (age class I — up to 2 months), sexually immature animals; (2) adults (age classes II and III, 3—6 months), sexually mature animals born in the given calendar year or during the winter of the preceding year; old adults (age classes from IV to VII, over 7 months),sexually mature animals born during the previous calendar year. The division accepted took into consideration generations of rodents trapped in spring and autumn, since they might have differed in respect of many properties, such as growth and development indices, rapidity of sexual maturation and also weight of internal organs (Schwarz *et al.*, 1965; Adamczewska-Andrzejewska, 1973).

Variations in the above indices were described by: arithmetical mean ($\bar{x}$), standard error (S.E.), coefficient of variation (CV), while correlation was estimated by the correlation coefficient (r), and significance of differences by the Student *t* test ($P<0.05$).

Table 1

Mean body weight and length (±S.E.) of field mice from three populations within the boundaries of Greater Warsaw. n — number of individuals.

Age class, month	Sex	Młociny Wood			Bielany Grove			Łazienki Park		
		n	Body weight, g	Body length, mm	n	Body weight, g	Body length, mm	n	Body weight, g	Body length, mm
Juv., May	M	10	10.39±0.94	76.5	13	13.62±1.00	82.9	40	11.70±0.73	80.3
	F	—	—	—	11	11.33±1.28	79.1	39	10.18±0.43	76.4
Ad., May	M	13	20.79±0.95	94.2	30	19.73±0.55	96.8	34	21.97±0.58	100.1
	F	13	20.28±0.83	92.3	25	18.02±0.77	91.7	21	20.77±0.71	95.7
Old ad., May	M	38	23.07±0.32	99.8	69	22.92±0.32	100.0	54	24.63±0.38	102.8
	F	25	21.99±0.48	97.1	21	21.00±0.53	97.3	20	22.30±0.52	98.3
Juv., Sept.	M	11	10.37±0.91	71.6	39	9.03±0.36	74.5	19	10.74±0.46	78.2
	F	16	10.80±0.56	76.4	30	9.33±0.38	71.7	15	10.92±0.42	77.5
Ad., Sept.	M	99	14.68±0.25	87.5	89	14.38±0.37	88.2	49	17.80±0.60	95.0
	F	96	14.63±0.33	84.5	89	14.78±0.43	85.7	20	17.13±0.72	90.6

3. RESULTS

3.1. Body Weight and Length

Variations in the nett body weight of field mice were compared from three populations: MW, BG and ŁP over the yearly cycle, taking into account the trapping season and the animals' sex. The results were considered jointly for the two study years since it was established that adult individuals, which form a considerable percentage of the rodents trapped (MW — 88.5%, BG — 77.7%, ŁP — 63.7%) exhibit similar tendencies in their variations in body weight in successive years.

Sex dimorphism of body weight was manifested in animals caught in spring, when males have a higher mean body weight, despite the fact that only males were exsanguinated, which reduced their weight by an average of 1 g. Males also have greater mean body length than females (Table 1).

Sexually mature rodents caught in spring in each of the three habitats have statistically significantly greated mean body weight than those caught in autumn. The greatest significant differences occurred between adult individuals from MW, e.g.: in atuumn males have 29.3% lower body weight and females 27.3% lower than in spring. The greatest mean weights were attained by old adults in May.

An estimate was next made of differences in mean body weights of animals from corresponding classes from the study populations. In adult rodents (ad.) greatest body weights were found in the population from ŁP. Rodents from the BG population have the lowest body weights (on an average 15.4% less than in ŁP, differences statistically significant). The distribution of mean values of body length differs from the distribution of weight values in the various age classes. In general field mice from the city centre have the greatest dimensions, the BG population intermediate and the MW population the lowest.

3.2. Individual Variation in Samples

The qualitative measure of individual variation is the coefficient of variation (CV). Variations in internal organs are due to their different role in the organism, the lesser the dependence of a given organ on changes in external habitat conditions and quality of food, the lesser its variations (Schwarz *et al.*, 1968).

The total range of coefficients of variation for adult animals from the habitats compared is similar (Table 2). When comparing variations in different organs expressed by the coefficient of variation CV, it is clear that it is lowest in the case of the heart, i.e., 7—18%, with relatively low variation of 10—23% for the kidneys and 8—21% for the

Table 2

Mean values of absolute weights of internal organs (in g.) and coefficients of variation (CV) for field mouse samples from the three study populations.

Age class, month	Population [1]	MALES						FEMALES					
		Kidneys		Heart		Liver		Kidneys		Heart		Liver	
		g	CV	g	CV	g	CV	g	CV	g	CV	g	CV
Juv., May	MW	0.226	13	0.106	9	0.789	12	—	—	—	—	—	—
	BG	0.257	20	0.129	16	0.995	17	0.266	19	0.121	12	0.915	21
	ŁP	0.248	19	0.128	14	0.970	14	0.252	20	0.116	18	0.878	21
Ad., May	MW	0.377	14	0.106	9	1.551	12	—	—	—	—	—	—
	BG	0.364	17	0.179	10	1.434	14	0.362	16	0.165	10	1.600	18
	ŁP	0.417	18	0.196	9	1.663	17	0.410	12	0.191	10	1.888	16
Old ad., May	MW	0.394	16	0.221	9	1.629	14	0.397	12	0.207	7	2.024	13
	BG	0.407	14	0.210	11	1.614	16	0.378	12	0.199	9	1.820	13
	ŁP	0.438	10	0.220	11	1.720	15	0.427	16	0.200	16	2.154	21
Juv., Sept.	MW	0.242	20	0.121	13	0.871	12	0.242	23	0.121	12	0.871	16
	BG	0.205	15	0.100	13	0.722	16	0.221	18	0.096	15	0.757	18
	ŁP	0.208	13	0.112	15	0.924	13	0.212	25	0.109	12	0.907	11
Ad., Sept.	MW	0.289	18	0.142	14	1.078	14	0.316	17	0.140	12	1.253	19
	BG	0.304	19	0.134	11	1.124	19	0.360	23	0.134	15	1.124	20
	ŁP	0.306	17	0.160	13	1.368	8	0.334	13	0.152	13	1.607	15

[1] MW — Młodciny Wood, BG — Bielany Grove, ŁP — Łazienki Park.

liver. Similar data have been obtained for different species of small mammals (Pucek, 1965; Schwarz *et al.*, 1968).

3.3. Correlation of Weights of Internal Organs with Body Weight

The values of the coefficients of correlation reflecting the degree of correlation between weights of internal organs and body weight are

Table 3

Values of correlation coefficients (r) of body weight (Bw — body weight) and weights of internal organs (K — kidneys, L — liver, H — heart) of field mice from three study populations (ŁP — Łazienki Park, BG — Bielany Grove, MW — Młociny Wood).

X×Y	Population	Juv., May	Ad., May	Old. ad., May	Juv., Sept.	Ad., Sept.
			MALES			
Bw×K	ŁP	.886 [1]	.487 [1]	.609 [1]	.689 [1]	.754 [1]
	BG	.877 [1]	.465 [1]	.539 [1]	.790 [1]	.714 [1]
	MW	.902 [1]	.293	.489 [1]	.870 [1]	.520 [1]
Bw×H	ŁP	.956 [1]	.791 [1]	.644 [1]	.731 [1]	.874 [1]
	BG	.900 [1]	.806 [1]	.626 [1]	.873 [1]	.885 [1]
	MW	.306	.913 [1]	.475 [1]	.936 [1]	.651 [1]
Bw×L	ŁP	.892 [1]	.440 [1]	.686 [1]	.763 [1]	.938 [1]
	BG	.899 [1]	.634 [1]	.674 [1]	.789 [1]	.757 [1]
	MW	.951 [1]	.682 [1]	.566 [1]	.945 [1]	.726 [1]
K×H	ŁP	.735 [1]	.387 [2]	.320 [2]	.542 [2]	.400 [2]
	BG	.683 [2]	.490 [1]	.402 [1]	.325 [2]	.292 [1]
	MW	.478	—	—.081	.500	.391 [1]
K×L	ŁP	.374	.204	.395 [1]	.166	.026 [1]
	BG	.360	.532 [1]	.213	—.289	.636 [1]
	MW	—	.721 [1]	.355 [2]	.188	.523 [1]
H×L	ŁP	.449 [1]	.406 [2]	.169	.160	.435 [1]
	BG	.157	.312	.231	.328 [2]	.084
	MW	—.026	—.191	—.057	.115	.523 [1]
			FEMALES			
Bw×K	ŁP	.758 [1]	.750 [1]	.517 [2]	.548 [2]	.855 [1]
	BG	.804 [1]	.718 [1]	.634 [1]	.692 [1]	.762 [1]
	MW	—	.716 [2]	.644 [1]	.642 [1]	.692 [1]
Bw×H	ŁP	.836 [1]	.773 [1]	.513 [2]	.713 [1]	.836 [1]
	BG	.964 [1]	.881 [1]	.698 [1]	.793 [1]	.886 [1]
	MW	—	.847 [1]	.719 [1]	.840 [1]	.785 [1]
Bw×L	ŁP	.678 [1]	.701 [1]	.912 [1]	.829 [1]	.573 [1]
	BG	.861 [1]	.871 [1]	.823 [1]	.767 [1]	.862 [1]
	MW	—	.940 [1]	.773 [1]	.767 [1]	.890 [1]
K×H	ŁP	.021	.750 [1]	.205	.733 [1]	.431 [1]
	BG	.135	.073	.325	.568 [1]	.580 [1]
	MW	—	—	—.143	.691 [1]	.463 [1]
K×L	ŁP	.492 [1]	.489 [2]	.487 [2]	.332	—.105
	BG	.492 [2]	.056	.343	.410 [2]	.338 [1]
	MW	—	.033	—.353	.396	—.095
H×L	ŁP	.419 [1]	.411	—.005	.346	—.201
	BG	.131	—.547 [1]	.321	.718 [1]	.338 [1]
	MW	—	.033	—.353	.396	—.095

[1] $P=0.001$, [2] $P=0.005$.

given in table 3. Calculations were made separately for the two sexes and five age classes within each of the study populations of mice.

A highly statistically significant correlation was found between the weights of kidneys, heart and liver and body weight, which oscillated on an average on the level of $r=0.7$. The degree of the correlations referred to depends on the animals age. Sexually immature mice (chiefly males), while in the phase of postnatal development, generally have higher values for the correlation coefficients between the internal organs examined and body weight in relation to the other groups of rodents. Old adults (old ad.) are characterized by the lowest correlation coefficients of body and organ weight average ($r=0.5$), which may be due to this class covering a wide range of ages.

The correlation of the weights of internal organs in relation to each other was also estimated, in order to determine their internal proportions and functional connections. The correlation was either not statistically significant or on a low level of significance for the majority of the variants analyzed.

3.4. Age and Sex Variations in Absolute and Relative Organ Weight

In all the age classed distinguished for the animals from the three study populations MW, BG and ŁP, similar differentiation was found for absolute and relative organ weights with age and depending on sex (Table 2, Fig. 1). Sexually immature animals (juv., May and September) have lower absolute weights of internal organs than adult individuals. These weights increased as the animals grew older, but in the case of relative weights of organs, the opposite applied and was in agreement with the rule of size (Hesse, 1921). Younger rodents, when compared with older individuals with greater body dimensions, have statistically significantly higher relative weights for the organs examined. This relation for the heart, the organ least subject to variation, is generally expressed far more strongly than for other internal organs.

Sex dimorphism is usually very weakly exhibited and has the character of a periodical phenomenon, as shown in numerous studies on small mammals (Pucek, 1963; Kubik, 1965). Distinct differences in weight of internal organs in animals of both sexes appeared during the period of intensive reproduction. Gestation and lactation are connected, as is well known (Kaczmarski, 1966), with increase in the metabolic rate of females. It was found that sexually mature and reproducing females have statistically significantly higher absolute and relative weights for liver and often for kidneys than is the case with males. The appearance of sex dimorphism in the field mouse is thus intensified by reproductive processes.

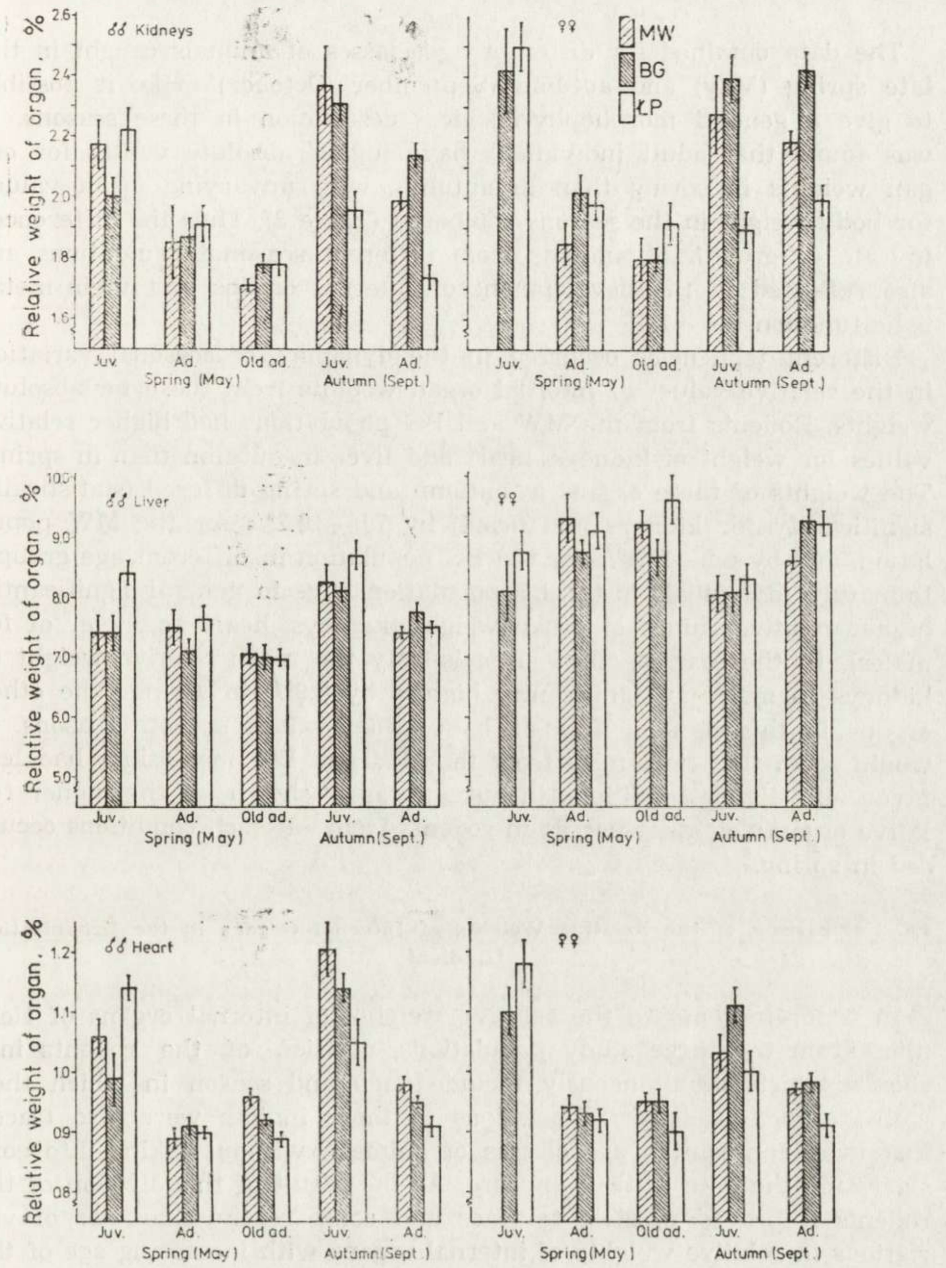

Fig. 1. Comparison of mean relative weights of internal organs of field mice from three populations; Młociny Wood (MW), Bielany Grove (BG), and Łazienki Park (ŁP).

3.5. Seasonal Variations

The data obtained for different age classes of animals caught in the late spring (May) and autumn (September, October) make it possible to give a general morphophysiological description in these seasons. It was found that adult individuals have higher absolute values for organ weights in spring than in autumn, with unvarying mean values for body weight in the seasons compared (Table 2). Thus the differences in rate of growth of animals from different seasonal generations are also reflected in the development of internal organs and their metabolic function.

Different tendencies occurred in the dynamics of seasonal variation in the relative values of internal organ weights from those for absolute weights. Rodents from the MW and BG populations had higher relative values for weight of kidneys, heart and liver in autumn than in spring. The weights of these organs in autumn and spring differed (statistically significantly for kidneys and heart) by 7.0—19.2% for the MW population, and by 4.2—13.4% for the BG population in different age groups. Immature individuals in the ŁP population have in general significantly higher relative values of organ weight (kidneys, heart and liver of females). In the case of adult animals only the mean relative weight of kidneys in males is significantly higher, by 8.9% in spring. The other organs in this class of animals have equal values in both seasons. It would seem that field mice from the MW and BG populations had less favourable living conditions in autumn, as is shown by the higher relative organ weights, whereas in rodents from ŁP such conditions occurred in spring.

3.6. Comparison of the Relative Weights of Internal Organs in the Urbanization Gradient

In order to compare the relative weights of internal organs of field mice from the three study populations, division of the rodents into classes which simultaneously included age and season in which they were trapped was used. Variations in these indices were also traced for seven consecutive age classes of animals, without taking into consideration the date of their capture. As the result of this division of the rodents it proved possible to trace and compare the character of variations in relative weights of internal organs with increasing age of the mice.

It was found that the relative weight of kidneys in animals from the populations compared differs within the class of sexually immature rodents in May (juv., May) and the classes of mice caught in autumn

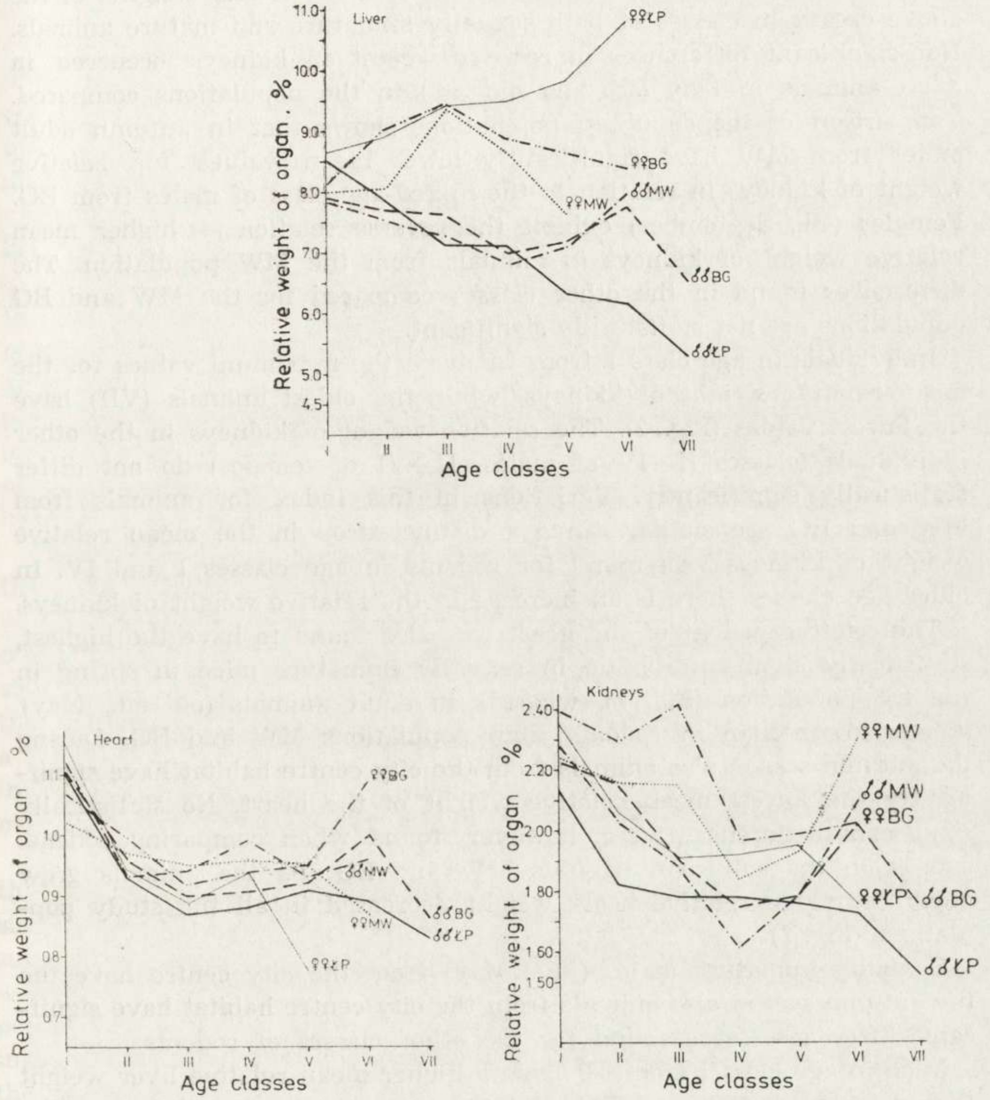

Fig. 2. Comparison of relative weights of internal organs of field mice in different age and sex classes from three study populations (MW — Młociny Wood, BG — Bielany Grove, ŁP — Łazienki Park).

(juv. and ad., September) (Fig. 1). In spring young mice from ŁP have the greatest (difference not statistically significant) mean relative weight of kidneys, but in autumn mice from this population differ significantly from rodents from MW and BG in respect of the lowest weights of the above organs in classes of both sexually immature and mature animals. Non-significant differences in relative weight of kidneys occurred in adult animals in May (ad. and old ad.) in the populations compared. Comparison of the suburban populations shows that in autumn adult males from MW have significantly lower mean values for relative weight of kidneys in relation to the mixed-age class of males from BG. Females (ad., September) exhibit the reverse relation — higher mean relative weight of kidneys in animals from the MW population. The differences found in the other classes compared for the MW and BG populations are not statistically significant.

Individuals in age class I from ŁP have the maximum values for the mean relative weight of kidneys, while the oldest animals (VII) have the lowest values (Fig. 2). The relative weight of kidneys in the other individuals (classes II—IV of males, II—VI of females) do not differ statistically significantly. Variations in this index for animals from MW and BG are similar. Thus a distinct drop in the mean relative weight of kidneys was found for rodents in age classes I and IV. In older age classes there is an increase in the relative weight of kidneys.

The relative weight of the heart was also found to have the highest, statistically significant value in sexually immature mice in spring in the ŁP population (Fig. 1), whereas in adult animals (old ad., May) it was lower than in rodents from populations MW and BG. During the autumn season also animals from the city centre habitat have significantly the lowest mean relative weight of the heart. No statistically significant differences were, however, found when comparing rodents caught in the suburban habitats MW and BG. As the animals grew older the mean relative heart weight decreased in all the study populations (Fig. 2).

Sexually immature males (juv., May) from the city centre have the the autumn season also animals from the city centre habitat have signif-cant differences were found for the other classes of rodents.

Mice in age class I from ŁP have a higher mean relative liver weight than mice from MW and BG, and the older they grow, the more the weight of this organ decreases. The oldest classes of rodents from the ŁP population have the significantly lowest value for relative liver weight, while in the older age classes (as from IV) rodents from MW and BG were found to have increased relative liver weight. The reverse tendency was manifested in the case of females. While females from population ŁP have increasingly higher values for the man relative liver weight with increasing age, females from populations MW and BG exhibit lower values.

4. DISCUSSION

Analysis of variation in the relative mass of internal organs in field mice from suburban and urban areas showed that these indices are characterized by similar tendencies in variations to those in other homoiothermal vertebrates. This was evident when comparing these indices for two successive study years, and for individual and seasonal variation. The qualitative similarity of variations in different populations are due to the specific unity of the study populations. Certain quantitative differences were, however, described, which were manifested in the mean relative values of organ and body weights, differentiated from the aspect of age, sex and season. An estimate of the greatness of differences between individual field mice from the three populations compared made it possible to define their morphophysiological specific character arising from the different ecological structure of the populations and in the different living conditions in the given habitat (Schwarz, 1975).

The heaviest and largest animals are the rodents living in ŁP in the city centre, those weighing least are from the BG suburban population. Rodents from suburban districts are more similar to each other in respect of their body weight. They are also linked by the similar character of variations in mean body weight with the age of the individuals, particularly old adults, the females of which exhibit a tendency to its decrease, and the males — to its increase. Fluctuations in the body weight of old adults of both sexes from ŁP are, however, negligible.

It can be seen from comparison of the relative weights of organs that mice from the city centre (ŁP) represent a different morphophysiological state in spring and autumn from that of rodents from the suburban populations. In general differences in relative values for the weights of internal organs between generations from these two suburban populations consist in individuals from the more urban area (BG) having slightly greater values than the rodents from the area outside the suburbs (MW). This regularity was manifested in all the organs examined.

When comparing indices for the organs calculated for groups of animals with different mean body weight, endeavour was made to eliminate the effect of the animals' different dimensions, since the attempt to estimate the effects of the action of external habitat factors, in the form of variations in the intensity of the metabolic rate of individuals, will then, as suggested in previous discussions and also by Hart (1971), be more accurate.

The kidneys are organs directly connected with intensity of metabolism (Schwarz *et al.*, 1968). Similarly the relative heart weight is a good index of variations in metabolism and the vital activities of animals (Schwarz, 1960; Bashenina, 1968). The animals' considerable activity, or their living under unfavourable external conditions, involve energy losses which are manifested by increase in heart weight.

According to Schwarz (1960, 1968) the dimensions of the liver are defined by those physiological and ecological properties which depend on the animals' resistance to hunger. When there is a shortage of food normal functioning of the organism is ensured by the greater capacity for depositing high-energy compounds (glycogen) in the hepatic tissues, which in effect causes increase in the weight of this organ (Emielijanov & Zolotuhina, 1975). Using a large number of rodent species from different climatic zones as examples, it has been shown that variations in external conditions and an unfavourable intrapopulation situation, requiring intensification of metabolism, lead to increase in the relative weights of internal organs — kidneys, heart and liver (Schwarz, 1960; Schwarz *et al.*, 1968).

The greatest differences between relative weight values for the organs examined in this study occurred in sexually immature individuals and old adults of the oldest age classes in the three populations compared. During the spring period the morphophysiological condition of rodents from ŁP, in relation to the populations from the suburban districts, would appear to indicate, particularly in the case of sexually immature animals, greater intensity of metabolism. Mice from the city centre have higher relative values for organ weight than individuals from the other habitats. This therefore shows that the ŁP population lived under less favourable conditions in spring than animals in the suburban populations.

Rodents from the suburban areas have similar tendencies in relation to each other of variations in indices and also the values of indices for different age classes form evidence of similar intensity of metabolism during the spring season. It is only the old adults which have higher relative values for heart weight than animals from ŁP of the same age. This relation is more strongly expressed in males than in females. As the heart index is connected to a greater degree with locomotor activity than the animals' intensity of metabolism (Bashenina, 1977) the phenomenon described may be due to the greater activity of old adults from MW and BG. On the other hand, the lack of corresponding reaction of kidneys and liver points to a different interpretation, i.e. that this is the result of the difference in the animals' adaptation to the winter season. Adaptation and consequent change in the morphophysiological state of individuals take place by means of reducing metabolism, activity and chemical thermoregulation, with simultaneous increase in fat deposit (Sealender, 1951; Bashenina, 1968; Sawicka-Kapusta, 1968). Bovikov & Bovikova (1972) found that animals with a high relative heart weight survived the winter worse. The lower heart indices of old adults, and also the lower relative weight of the heart and kidneys in young animals in autumn, point to the better overwintering of young individuals in the population from the city centre than in the suburban populations (MW and BG). This phenomenon is confirmed by the results of ecological studies, which have shown that indices for winter survival of mice increase in a direction towards the city centre (Andrzejewski *et al.*, 1978).

Comparison of individuals from the city centre and suburban areas revealed different tendencies in variations of relative weight of the internal organs, which occurred in males from different age classes over 6 months of age. With increasing age of old adults from ŁP the relative weight of their internal organs abruptly decreases, whereas in old adults from MW and BG the opposite phenomenon is observed — first increase in the relative weight of organs, then decrease at ages over 10 months. According to Górecki (1969) intensity of basic metabolic rate decreases with age and the physiological properties of the organism determining its capacity for rapid reaction to unfavourable or suddenly changing living conditions decrease. It would seem that ageing processes in rodents from the city centre take place more quickly than in rodents from the other study habitats. This may be the cause of the percentage of older individuals being smaller in the ŁP population as the result of their greater mortality than in the MW and BG populations (Andrzejewski *et al.*, 1978). A similar phenomenon of variation in the relative liver weight with age was observed by Toktosumov (1973) in different populations of *Microtus gregalis* from Tien-Shan.

The tendency, opposite to that in males, of variations in the relative liver weight in females, although differences between populations are maintained, is interesting. The relative liver weight in females from ŁP constantly increases with age, and decreases in females from MW and BG.

Sex dimorphism is manifested primarily in the relative mass of the liver. The physiological capacity for synthesis and deposit of glycogen in this organ increases in sexually active and reproducing females

(Schwarz, 1960). During the development of embryos and lactation females make more rapid use than males of this high-energy compound than they accumulate it, as has been shown in the case of *Microtus socialis* (Emieljanov & Zolotuhina, 1975). In old adult females from ŁP the value of the liver index increases more intensively with age. This may be the result of reduction in intensity of reproduction processes, and this in effect causes slower use of glycogen.

The greatest differences between individuals in the populations compared occurred in autumn, as was the case in spring, among sexually immature animals. This may be due to different phases of development and consequently to the different physiological state of the rodents, or to their greater susceptibility to the effect of external conditions (poorer thermoregulation) (cf. Bashenina, 1960, 1964). Individuals from ŁP have the lowest mean relative kidney weight, which with retention of the proportional relation of the heart index to body weight, points to reduction in metabolic level due to more favourable living conditions. This is also evidence of the good physiological condition of rodents before the onset of winter. The lower weight of the liver and higher relative weights of heart and kidneys in the suburban populations point to unfavourable living conditions and generally poorer condition of the mice. In autumn the numbers of rodents in these two habitats are similar, but higher than in the urban population (Andrzejewski *et al.*, 1978). It may be assumed that the urban population inhabits an environment with a warmer microclimate (Kossowska, 1975), devoid of competitors and natural predators (Luniak *et al.*, 1964; Goszczyński, 1979).

The morphophysiological state of the field mouse described here points to the separate character of the population living in the city centre from that of the suburban populations. Individuals from the city centre have generally lower metabolic level than animals in the other populations, due to the more favourable living conditions. The morphophysiological condition of the MW and BG populations is far more similar than would appear from the differences in their ecological structure (which changes gradually in a direction from the suburban to the urban population). In general the morphophysiological difference found in the populations compared are reflected in their different population structure, controlled in the case of ŁP mainly by intrapopulation factors, but in the suburban populations by inter-population factors (Andrzejewski *et al.*, 1978).

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ZMIENNOŚĆ MASY CIAŁA I NARZĄDÓW WEWNĘTRZNYCH MYSZY POLNEJ W GRADIENCIE ŚRODOWISK MIEJSKICH

Streszczenie

Celem pracy było zbadanie morfofizjologicznej zmienności osobników myszy polnej *Apodemus agrarius* (Pallas, 1771) z populacji miejskich i podmiejskich oraz określenie różnic pomiędzy tymi populacjami. Zastosowano metodę „wskaźników morfofizjologicznych" Schwarza, która pozwala ocenić kondycję fizjologiczną zwierząt stałocieplnych. Badania przeprowadzono w latach 1975 i 1976 na terenach parkowych w obrębie Warszawy: Park Łazienkowski i Ogród Botaniczny (ŁP) — centrum miasta, Lasek Bielański (BG) — rejon przedmiejski, Lasek Młociński (MW) — podmiejski. Odłowy gryzoni przeprowadzano wiosną i jesienią w linię pułapek żywołownych. Ogółem odłowiono 1273 myszy. Określano: płeć i aktyw-

ność płciową, wiek, masę ciała, absolutną i względną masę nerek, serca i wątroby każdego osobnika. Analizę absolutnych i względnych mas narządów wewnętrznych oraz masy ciała przeprowadzono dla obu lat badań uwzględniając zmienność indywidualną, dymorfizm płciowy, zmienność sezonową. Przeanalizowano tendencje zmian względnych mas narządów wewnętrznych i różnice morfologicznej specyfiki porównywanych populacji myszy polnej. Stwierdzono, iż dojrzałe gryzonie mają jesienią niższe masy ciała oraz absolutne masy narządów niż wiosną (Tabela 1, 2). Zakres zmienności badanych wskaźników jest podobny w porównywanych populacjach, przy czym masy narządów wykazują małą zmienność indywidualną (7—21%) (Tabela 2). Dymorfizm płciowy przejawia się w podobny sposób u wszystkich porównywanych serii osobników z trzech środowisk. Samice mają wyższe absolutne i względne masy wątroby, samce — wyższe masy ciała. Zależność zmian masy narządów od zmian masy ciała wykazuje wysoką istotną statystycznie korelację dla większości wyróżnionych klas gryzoni (Tabela 3). Gryzonie ze środowiska miejskiego (ŁP) mają większe masy i rozmiary ciała niż osobniki ze środowisk podmiejskich (MW, BG) (Tabela 1). Na wiosnę, gryzonie z centrum miasta (szczególnie niedojrzałe płciowo) mają wyższe wartości względnych mas narządów (nerek, serca i wątroby) w stosunku do równowiekowych osobników z pozostałych środowisk (Ryc. 1). Jesienią, gryzonie z ŁP mają niższe wskaźniki narządów w stosunku do populacji podmiejskich, co wskazuje na korzystniejsze warunki bytowania myszy w centrum miasta. Największe różnice między względnymi masami narządów i masą ciała osobników z populacji miejskich i podmiejskich wystąpiły w najmłodszych klasach gryzoni i u przezimków (Ryc. 2). Procesy starzenia się przezimków z ŁP zachodzą szybciej niż u przezimków z MW i BG, przy równocześnie lepszej ich przeżywalności zimowej.

Z porównania populacji myszy polnej z miejskich i podmiejskich środowisk wynika, że istnieje wyraźna odrębność morfofizjologiczna populacji bytującej w ŁP od populacji z MW i BG. Osobniki z centrum miasta mają ogólnie lepszą kondycję fizjologiczną, wynikającą z korzystniejszych warunków życia.