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MUROID RODENTS OF THE LOWLAND PART OF TRANSCARPATHIA: STATE OF POPULATIONS AND MORPHOPHYSIOLOGY

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Muroid Rodents of the Lowland Part of Transcarpathia: State of Populations and Morphophysiology. — **Barkasi, Z.** — The present paper deals with the results of investigation of muroid rodent populations inhabiting on the Transcarpathian lowland. The field works to collect materials were held in three types of biotopes within the Berehove raion. The paper contains information on the most common species of muroid rodents within the studied area, which is a typical lowland region of Transcarpathia. The relative abundance and tendencies in the sex and age structure of populations are analyzed. The lengths of the body, tail, foot and auricle were measured to investigate the age- and sex-related variability of morphological features. The relative weight of physiologically important organs such as heart, liver, kidneys and adrenal glands were defined with the aim to study the patterns of variability of morphophysiological indexes. All data were subjected to statistical analysis to obtain information on the variability of those parameters in different intrapopulation groups. In some species there were analyzed the age-related and seasonal variability of morphophysiological indicators in different intrapopulation groups, and also the interspecific variability of these parameters in order to study the effect of the environmental factors on the organism's physiology.

Key words: Muroidea, Transcarpathia, abundance, sex and age structure, morphophysiology.

Гризуні надродини Muroidea рівнинного Закарпаття: стан популяцій та морфологія. — **Баркасі, З.** — Праця присвячена результатам досліджень рівнинних популяцій мишуватих гризунів на Закарпатті. Польові роботи зі збору матеріалів проведено у трьох типових біотопах у межах Березівського району. У праці подано відомості про найбільш поширені види мишуватих гризунів в межах району як типового рівнинного регіону Закарпаття. Проаналізовано відносну чисельність цих видів, а також тенденції у статеві-віковій структурі популяцій. Для дослідження вікової і статевої мінливості морфологічних ознак проведено проміри довжини тіла, хвоста, стопи і вушної раковини. З метою вивчення мінливості морфологічних показників тіла визначено відносну масу фізіологічно важливих органів, зокрема серця, печінки, нирок і наднирників. Всі дані були статистично оброблені з метою аналізу мінливості цих параметрів у різних внутрішньопопуляційних груп, а також міжвидової мінливості цих показників з метою вивчення впливу факторів середовища на фізіологію організму.

Ключові слова: Muroidea, Закарпаття, чисельність, статево-вікова структура, морфологія.

Introduction

The Ukrainian Carpathians are located in the northeastern part of the Carpathian Basin. Systematic research on the fauna of this part of the Carpathian Mountains and adjacent lowland areas started in the middle of the 20th century (Янушевич, 1947; Колюшев, 1953, 1956, 1957; Татаринів, 1956; Турянин, 1959; Корчинський, 1975, 1980, 1988). In those times, zoologists concentrated their attention on issues of the species composition and distribution in different types of habitats. To the investigation of rodents within the region has been given a leading role from the very beginning — from 1947 to 1959 there were published over 50 papers concerning different aspects (e.g. dispersal, population density, ecology, systematics) of the rodent fauna's biology (Корчинський, 1988). From the 1970s works have been appeared on research in small mammals' ecology (particularly, rodents and bats) with using the method of morphophysiological indicators (Крочко, 1970; Корчинський 1997, 1999, 2003). However, during the last decade such investigations were not performed.

The present research was carried out in three types of biotopes within the Berehove raion, which is located in the SW part of the Transcarpathian region (W Ukraine). The mentioned area is opened and low-lying, however in the NW is quiet hilly. Territories covered by woodlands are not too much (Географія..., 2014).

The rodent fauna of the studied area was studied insufficiently during the last decade. This is one of the main reasons to investigate the quantitative and qualitative composition of muroid populations in the territory, alongside with the variability of morphological and morphophysiological parameters as indicators of changes in habitats.

Material and methods

The material used in the analysis was collected from 2012 until 2014 in different types of biotopes within the Berehove raion.

The Berehove raion is a lowland area of Transcarpathia. Its territory is 65 437 000 ha. The average height above the sea level is 115–130 m. The structure of land resources is the following: agricultural lands (45 961 000 ha, including 33 945 000 ha of arable lands and 9 284 000 ha of woodlands), built-up lands (4 233 000 ha), lands of water resources (2 890 000 ha) and other kinds of lands (Паспорт, 2014).

The sample contains 99 specimens of six species of the Muroidea superfamily (tab. 1). The systematics and species nomenclature agreed with the “Field key to small mammals of Ukraine” (Загороднюк, 2002) and the “Taxonomy and nomenclature of mammals of Ukraine” (Загороднюк, Ємельянов, 2012).

The animals were collected by Hero traps, according to the method of small mammals census on trap-lines (Межжерин и др., 1991; Константинов и др., 2000; Загороднюк, 2002; Нумеров и др., 2010). The obtained materials were processed according to the method of morphophysiological indicators (Шварц и др., 1968). The species' relative abundance assessed in the number of individuals per 100 trap-days separately for all types of investigated biotopes. The age of mice was determined by the degree of the tooth crown surface's wear, and the age of voles was determined by the degree of development of the molar teeth's root (Варшавский, 1948; Тупикова, 1964). In some cases, we also paid attention to the body and tail length as well as the skull's sculptural relief. Four age groups were distinguished (age is in months): I — 1–2, II — 2–4, III — 4–8, IV — 8 and more.

Results and their discussion

Relative abundance, sex and age structure of populations of some muroid species

There are 19 species of the Muroidea superfamily in the region of the Ukrainian Carpathians (Загороднюк та ін., 1997). We found six species of this superfamily in the examined biotopes. As it turned out, specimens of *A. agrarius* have the largest fraction in the sample, which is a typical lowland species in the region of the Ukrainian Carpathians. It is also a common species of fields and shrubs. There are three subdominant species: *S. tauricus* and *M. glareolus* in the forested areas, and *M. arvalis* on the fields (fig. 1).

The counts of the relative abundance showed that in summertime the most abundant species are the following: *A. agrarius* (14 examples/100 tap-days) and *M. arvalis* (8 ex/100 tap-days) on the fields, *A. agrarius* and *M. glareolus* (5.5 ex/100 tap-days for each) in shrubs. As it turned out, in the region, the most active species in the cold period of year is the striped field mouse, *A. agrarius* (10 ex/100 tap-days). In addition, the low abundance of the species is uncommon for them biotopes was also confirmed, for instance, the low abundance of the stripped field mouse in forests and also the abundance of the yellow-necked wood mouse on fields (1 ex/100 tap-days for each).

Based on the available data, we tried to identify the trends in the populations' sex and age structure in some species. Thus, the populations of mice are characterized by a tendency of predomination the examples of the III and IV age groups which are actively reproducing (fig. 2–3). In the *S. tauricus* population, we observed a tendency of predomination the pubescent males, although the

number of females is larger among the older examples (IV age group). Due to larger number of specimens of *A. agrarius* we can judge about the population structure of this species with more certainty. Thus, almost the same proportion of different sex individuals characterizes it. However, there is a slight predominance of males in all age groups (fig. 3).

In the *M. glareolus* population, we can observe a tendency to depression at current stage of the population dynamics (fig. 4). The small number of individuals taking part in reproduction is an evidence for this conclusion. Furthermore, there were not found females with traces of pregnancy: neither uterine spots nor visible embryos. On the other hand, the population is characterized by predominance of juvenile males (II age group), although they do not participate in the population's reproduction yet (according to the size of testicles and seminal vesicles).

Judgments about the population's structure of *M. arvalis* are less reliable because of the small number of collected examples. Despite this, we have general ideas about the state of this species population — it is characterized by a tendency for female's predominance in all age groups. Uterine spots were found in most of the females that proves their participation in the reproduction (fig. 5). There are fractions of males only in the I and II age groups.

Morphophysiological indexes of some muroid species

During the second half of the 20th century, the method of the morphophysiological indicators was widely used in investigations concerning the ecology of vertebrate populations. The method implies the use of a set of indirect signs that allows estimating the physiological peculiarities of the animals in field, in the process of their vital functions' seasonal cyclicality. By using a certain set of indicators it is possible to fix the very first stages of violations of the normal course of intrapopulation processes (Шварц и др., 1968).

Table 1. The number of collected species from the studied biotopes of the Berehove raion

Таблиця 1. Кількість здобутих видів у досліджених біотопах Берегівського району

Species	Biotope						Total	
	Shrubs		Oak forest		Field			
	n	%	n	%	n	%	n	%
<i>Apodemus agrarius</i> (Pallas, 1771)	21	47	1	12	28	61	50	51
<i>Sylvaemus tauricus</i> (Pallas, 1811)	7	15	7	88	2	4	16	16
<i>Myodes glareolus</i> (Schreber, 1780)	16	36	–	–	–	–	16	16
<i>Microtus arvalis</i> (Pallas, 1779)	–	–	–	–	13	28	13	13
<i>Terricola subterraneus</i> (Selys-Longchamps, 1836)	1	2	–	–	–	–	1	1
<i>Mus musculus</i> Linnaeus, 1758	–	–	–	–	3	7	3	3
Number of specimens, N	45		8		46		99	
Number of species, S	4		2		4		6	
Number of trap-days	400		100		400		900	

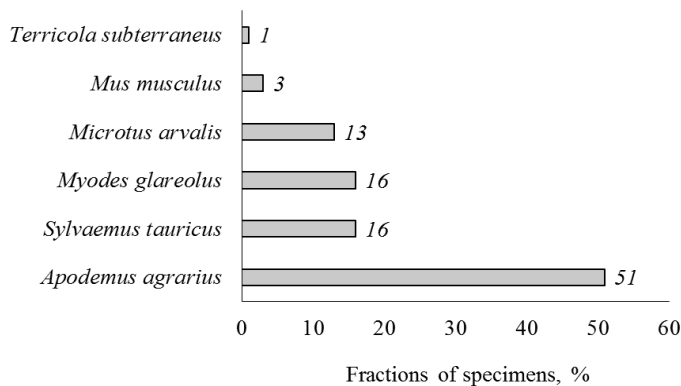


Fig. 1. Fractions of different muroid species in the sample.

Рис. 1. Частки різних видів мишуватих у вибірці.

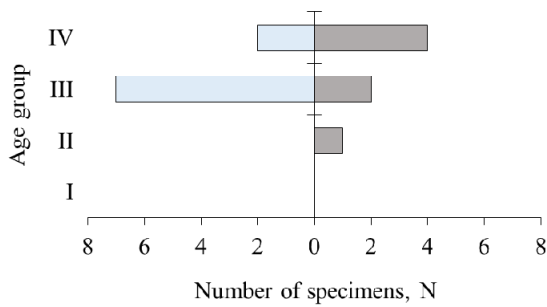


Fig. 2. Sex and age structure of the *Sylvaemus tauricus* population (M | F).

Рис. 2. Статеві-вікова структура популяції *Sylvaemus tauricus*.

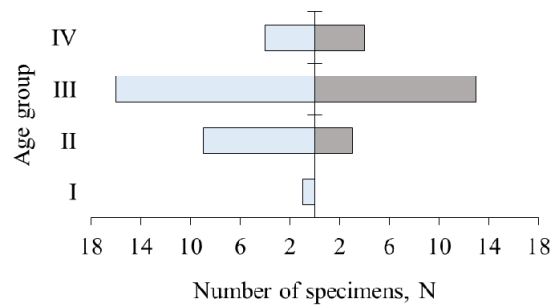


Fig. 3. Sex and age structure of the *Apodemus agrarius* population (M | F).

Рис. 3. Статеві-вікова структура популяції *Apodemus agrarius*.

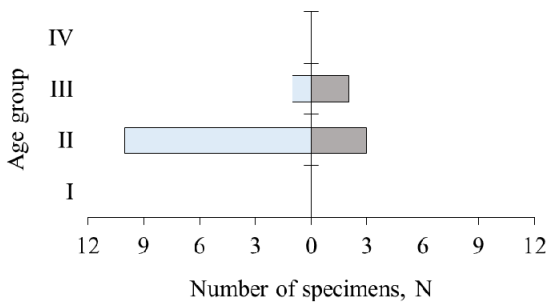


Fig. 4. Sex and age structure of the *Myodes glareolus* population (M | F).

Рис. 4. Статеві-вікова структура популяції *Myodes glareolus*.

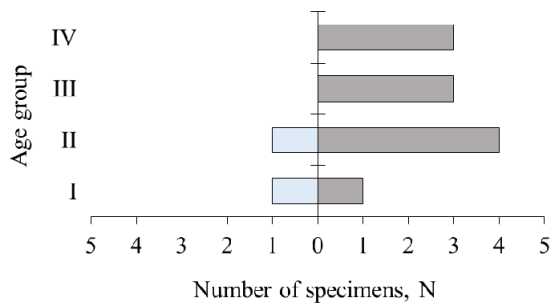


Fig. 5. Sex and age structure of the *Microtus arvalis* population (M | F).

Рис. 5. Статеві-вікова структура популяції *Microtus arvalis*.

In the process of studying the muroid populations the following parameters were used: *linear body dimensions* such as the body length (L), tale length (Ca), foot length (Pl) and auricle length (Au); *relative weight of the body and internal organs* such as heart (Cr), liver (Hp), kidneys (Rn) and adrenal glands (GSr) (tab. 2–3). Note that the data of samples infected by macroparasites were not taken into the statistics.

The analysis of morphological parameters of the collected specimens proves that the body weight grows with the age in all species. The value of this indicator decreases in the cold period of the year due to exhaustion of the organism caused by consumption of the body energetic reserves. Such exterior parameters as body length (L) and tail length (Ca) undergo to major changes with the age, but the value of the foot length (Pl) and auricle length (Au) are less variable, so they can be used in systematics.

Investigation of seasonal changes of the interior parameters shows that in wintertime in all examined species the indexes of the liver and kidneys are lower, but the indexes of the heart and adrenal glands are higher than of the same population samples collected during summer. Obviously, such character of seasonal changes of these organs' indexes has two reasons. On the first hand, it is the shortage of food, which means the impossibility of storing proper amount of nutrients (rather in form of glycogen) and slowing down the metabolism as a result. On the other hand, it is the organism's high energetic tension and active searching for food that also leads to the reserves' mobilization (Шварц и др., 1968).

In case of specimens of summertime samples from the populations, they are characterized by higher indexes of heart and kidneys and lower indexes of adrenal glands in the younger age groups. Such pattern of age-related changes of those indexes associated with the high energetic tension of

breeding animals. Because of this, in the case of adrenal glands the “rule of ranks” is not maintained¹. Besides, it is important to mention that among the examined species the yellow-necked wood mouse (*S. tauricus*) has the highest values of GSR index, moreover, it is discovered that the relative weight of the adrenal glands is always higher in males, which is apparently due to their higher aggressiveness.

The indexes of liver vary similarly, which are usually higher in lacting and pregnant females. This is due to storing a significant amount of nutrients as glycogen, which leads to an increase in the liver’s weight.

Statistically significant interspecific differences ($t \geq 2$) among the same-age and same-sex groups of the examined rodent species were found on most exterior parameters. As an example, *M. arvalis* significantly differs from *A. agrarius* on the following parameters: tail length, Ca ($t = 15$) and foot length, Pl ($t = 2.9$); from *S. tauricus* the species differs on three types of parameters: tail length, Ca ($t = 8.7$), foot length, Pl ($t = 11.4$) and auricle length, Au ($t = 8.6$).

Table 2. Intrapopulation and interspecific variability of linear body sizes of different rodent species from the Berehove raion of Transcarpathia (individual value / $X \pm \sigma$ / min–max)

Таблиця 2. Внутрішньопопуляційна та міжвидова мінливість лінійних розмірів тіла у різних видів гризунів з Березівського району Закарпаття (індивідуальне значення / $X \pm \sigma$ / min–max)

Species	Age group	N, Sex	Body weight, g	Exterior parameters			
				L, mm	Ca, mm	Pl, mm	Au, mm
<i>October (2012)</i>							
<i>M. arvalis</i>	I	1 F	9.2	65.0	21.0	17.0	9.0
	II	3 F + 1 M	15.8 ± 3.8	79.3 ± 4.6	25.8 ± 4.7	14.8 ± 0.4	9.8 ± 0.4
	III	2 F	29.1–31.1	102.0–107.0	39.0–43.0	16.0–18.0	12.0
<i>February (2013, 2014)</i>							
<i>S. tauricus</i>	IV	1 F + 2 M	38.9 ± 10.9	105.7 ± 11.9	103.0 ± 10.7	24.3 ± 1.9	19.3 ± 1.3
<i>A. agrarius</i>	III	2 F + 8 M	20.3 ± 3.1	86.1 ± 7.6	70.0 ± 5.7	19.0 ± 1.8	12.1 ± 1.4
<i>M. glareolus</i>	II	4 M	15.6 ± 0.5	84.3 ± 4.3	34.5 ± 0.5	17.3 ± 2.2	13.0 ± 1.2
<i>July–August (2013, 2014)</i>							
<i>S. tauricus</i>	II	1 F	19.3	87.0	81.0	20.0	15.0
	III	1 F + 6 M	25.5 ± 4.2	94.7 ± 4.9	91.4 ± 4.5	24.7 ± 1.5	15.6 ± 1.8
	IV	4 F	37.9 ± 6.4	100.5 ± 7.4	95.3 ± 6.3	25.0 ± 0.7	19.0 ± 0.7
<i>A. agrarius</i>	I	1 M	10.5	71.0	51.0	16.0	11.0
	II	3 F	15.6 ± 1.2	83.7 ± 1.2	64.7 ± 2.4	16.7 ± 0.9	10.3 ± 0.9
	II	9 M	15.5 ± 1.3	81.7 ± 2.7	64.7 ± 3.1	18.2 ± 1.1	11.0 ± 0.5
	III	11 F	23.7 ± 4.1	91.4 ± 4.3	69.9 ± 4.1	18.3 ± 1.1	11.8 ± 0.7
	III	8 M	21.8 ± 3.4	92.1 ± 6.0	69.1 ± 2.8	19.3 ± 0.4	11.6 ± 0.9
	IV	4 F	30.5 ± 1.6	100.5 ± 3.3	75.0 ± 1.9	19.0 ± 0.7	13.0 ± 0.7
	IV	4 M	29.0 ± 1.5	105.3 ± 2.5	74.3 ± 3.0	19.0 ± 0.7	12.8 ± 0.4
	IV	4 M	29.0 ± 1.5	105.3 ± 2.5	74.3 ± 3.0	19.0 ± 0.7	12.8 ± 0.4
<i>M. glareolus</i>	II	3 F	18.2 ± 4.05	85.3 ± 7.8	37.0 ± 2.8	16.3 ± 0.5	12.0 ± 1.4
	II	5M	14.1 ± 0.6	83.8 ± 4.2	34.4 ± 1.0	16.2 ± 0.4	10.6 ± 0.8
	III	1 F + 1 M	20.3–26.1	95.0–102.0	43.0	16.0–17.0	12.0
<i>M. arvalis</i>	I	1 M	11.8	67.0	24.0	15.0	8.0
	II	1 F	22.5	92.0	31.0	16.0	10.0
	III	1 F	26.3	101.0	33.0	15.0	12.0
	IV	2 F	34.4–36.4	111.0–114.0	37.0–40.0	17.0	13.0

¹ According to the “rule of ranks,” the smaller is the relative body weight of an animal the higher are the indexes of main internal organs.

Table 3. Intrapopulation and interspecific variability of morpho-physiological parameters of different rodent species from the Berehove raion of Transcarpathia (individual value / $X \pm \sigma$ / min–max)

Таблиця 3. Внутрішньопопуляційна та міжвидова мінливість морфо-фізіологічних показників у різних видів гризунів з Березівського району Закарпаття (індивідуальне значення / $X \pm \sigma$ / min–max)

Species	Age group	N, Sex	Body weight, g	Interior parameters			
				Cr, ‰	Hp, ‰	Rn, ‰	GSr, ‰
<i>October (2012)</i>							
<i>M. arvalis</i>	I	1 F	9.2	6.96	40.98	13.70	0.22
	II	3 F + 1 M	15.6 ± 3.8	5.59 ± 1.19	50.52 ± 9.63	10.39 ± 1.54	0.46 ± 0.14
	III	2 F	29.1–31.1	4.51–4.86	49.16–52.45	9.54–12.70	0.61–0.99
<i>February (2013, 2014)</i>							
<i>S. tauricus</i>	IV	1 F + 2 M	38.9 ± 10.9	5.89 ± 0.79	35.67 ± 3.37	8.05 ± 0.67	0.50 ± 0.32
<i>A. agrarius</i>	III	2 F + 8 M	20.3 ± 3.1	6.85 ± 0.75	50.74 ± 9.38	10.81 ± 1.88	0.21 ± 0.15
<i>M. glareolus</i>	II	4 M	15.6 ± 0.5	7.3 ± 1.4	45.48 ± 4.4	11.07 ± 2.4	0.16 ± 0.04
<i>July–August (2013, 2014)</i>							
<i>S. tauricus</i>	II	1 F	19.3	8.57	105.30	18.70	0.42
	III	1 F + 6 M	25.5 ± 4.2	6.18 ± 0.98	54.52 ± 6.07	11.89 ± 1.79	0.30 ± 0.09
	IV	4 F	37.9 ± 6.4	5.09 ± 0.36	53.03 ± 9.87	10.56 ± 1.65	0.23 ± 0.09
<i>A. agrarius</i>	I	1 M	10.5	12.49	60.82	18.30	0.57
	II	3 F	15.6 ± 1.2	8.04 ± 0.68	47.54 ± 8.23	14.35 ± 0.47	0.30 ± 0.04
	II	9 M	15.5 ± 1.3	7.99 ± 0.93	53.07 ± 10.07	15.64 ± 1.42	0.36 ± 0.09
	III	11 F	23.7 ± 4.1	7.23 ± 1.00	70.34 ± 9.73	14.45 ± 2.57	0.45 ± 0.19
	III	8 M	21.8 ± 3.4	7.42 ± 1.12	58.86 ± 9.95	13.78 ± 1.66	0.36 ± 0.09
	IV	4 F	30.5 ± 1.6	6.53 ± 1.04	81.00 ± 18.68	15.11 ± 2.16	0.43 ± 0.09
	IV	4 M	29.0 ± 1.5	7.29 ± 0.26	65.84 ± 4.80	14.36 ± 2.38	0.46 ± 0.07
<i>M. glareolus</i>	II	3 F	18.2 ± 4.1	6.54 ± 1.06	50.74 ± 2.63	12.39 ± 2.00	0.29 ± 0.18
	II	5 M	14.1 ± 0.6	6.77 ± 0.45	49.07 ± 3.59	12.55 ± 1.81	0.16 ± 0.03
	III	1 F + 1 M	20.3–26.1	5.66–6.96	49.88–49.89	12.85–12.89	0.15–0.27
<i>M. arvalis</i>	I	1 M	11.8	6.33	61.57	15.79	0.34
	II	1 F	22.5	5.51	81.13	17.67	0.53
	III	1 F	26.9	4.26	63.93	12.75	0.57
	IV	2 F	34.4–36.4	4.77–5.17	56.81–64.43	12.08	0.64

The striped field mouse *A. agrarius* significantly differs from the yellow-necked wood mouse *S. tauricus* also on three exterior parameters: Ca ($t = 3.1$), Pl ($t = 6$) and Au ($t = 6$).

According to the data we have, the bank vole *M. glareolus* differs from *A. agrarius* only on the tail length Ca ($t = 9.3$), but from *S. tauricus* the species significantly differs on three exterior parameters such as Ca ($t = 10.8$), Pl ($t = 5.2$) and Au ($t = 2$).

Considering the statistically significant differences among the species on most of exterior parameters those morphological features can be used in taxonomy and during the species identification as well.

Significant interspecific differences on the indexes of internal organs were revealed only on the index of adrenal glands (GSr) in two cases. Thus, on the index of this organ the common vole *M. arvalis* differs from the yellow-necked wood mouse *S. tauricus* ($t = 3.7$) and the bank vole *M. glareolus* differs from the striped field mouse *A. agrarius* ($t = 2$). This phenomenon is obviously due to different levels of metabolic processes and higher activity and aggressiveness of mice (the latter can be proved by higher indexes of heart (Cr) in the mice).

Conclusions

Among the muroid rodents, according to our data, on the lowland part of Transcarpathia the dominant species is the striped field mouse *A. agrarius*. Such species as *M. arvalis*, *S. tauricus* and *M. glareolus* are subdominants. Obviously, such distribution is related to the features of landscapes and habitat types.

The analysis of the sex and age structure of populations of the most abundant species showed the tendency of predomination of mature individuals, especially males in mice populations. Mature females are the most numerous in the common vole's population. The bank vole population at the current stage of its dynamics is in depressive state.

The investigation of morphological and morphophysiological indicators showed that such linear body parameters as body length (L) and tail length (Ca) essentially change with the age, although the foot length (Pl) and the auricle length (Au) are less variable. The indexes of the liver (Hp) and kidneys (Rn) are clearly lower in winter, which is related to peculiarities of the metabolism in the cold period of the year, namely with running out the reserves of nutrients and slowing down the metabolic processes. The indexes of the heart (Cr) and kidneys (Rn) in summertime samples are higher in the young age groups, but the indexes of the adrenal glands (GSr) are lower. The latter is related to higher activity and higher level of metabolism in young animals. The index of the adrenal glands (Gsr) are usually higher in mature individuals that take part in reproduction.

Significant interspecific differences were revealed on most of the linear parameters, which is important for the taxonomy and the species identification as well.

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