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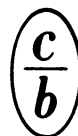
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INTERNAL CHARACTERISTICS OF BIRCH MICE (MAMMALIA, ZAPODIDAE)
OF THE USSR

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Morphophysiological indicators of forest, steppe, Altai, Tien Shan, and Caucasus birch mice during the active period were studied. All species were characterized by similar high values of relative weight of the heart, kidneys, and liver, and a relatively short intestine and cecum. Geographical differences with respect to these indicators in the widely distributed species (forest and steppe birch mice), as well as differences according to months during the active period of life in the forest, steppe, and Altai birch mice were absent or expressed weakly.

In ecology the method of morphophysiological indicators, validated and developed in detail by S. S. Shvarts, has become one of the most important methods of investigation of vertebrate animals in natural conditions (Shvarts, 1958; Shvarts et al., 1968). Its essence "is that on the basis of separate morphological or physiological characters one can judge the biological uniqueness of investigated populations" (Shvarts et al., 1968, p. 5). Utilization of this method has made it possible to demonstrate the close interconnection between the concrete conditions of existence of animals, the ecological characteristics of species and populations, and the development of the most important internal organs.

It should be stressed that the study of the internal indicators of animals on the one hand permits demonstration of populational responses to change in environmental conditions and, on the other, establishment of the species specifics of such responses. The method of morphophysiological indicators has found very wide application in ecological investigations both in our country and abroad.

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TABLE 1. Internal Indicators of Steppe Birch Mouse in Orenburg Oblast (adult individuals)

Characters	June		July				August	
	males, n=2	females, n=7		males, n=5		females, n=3		
		M	M±m	C _v	M±m	C _v	M±m	C _v
Body weight, g	10,0	11,55±0,81 (8,82—14,67)	18,62	9,11±0,23 (9,02—9,50)	5,12	9,89±0,56 (8,97—10,38)	8,13	
Body length, mm	66	64,75±1,85 (55—71)	7,59	61,80±0,89 (59—63)	2,89	68,33±2,04 (65—70)	4,22	
Index, ‰:								
heart	11,8	8,89±0,67 (6,96—11,99)	18,54	11,92±0,74 (11,08—13,10)	8,84	8,63±0,77 (7,51—9,69)	12,65	
kidney	9,15	9,34±0,76 (5,72—11,01)	19,96	10,63±0,62 (9,97—11,62)	8,19	9,62±0,45 (8,98—10,25)	6,60	
liver	68,8	70,81±4,32 (52,47—83,16)	14,93	66,12±11,28 (48,55—79,70)	24,13	—	—	
Relative length, %:								
intestine	459,6	581,0±3,24 (493,6—754,5)	15,77	514,2±37,02 (442,8—600)	12,81	516,8	—	
cecum	8,86	13,6±1,29 (8,6—18,9)	27,05	10,8±0,63 (9,2—11,6)	10,10	12,5	—	

In the present paper data are presented on the internal indicators of a little studied rodent group in the fauna of the USSR, birch mice (genus *Sicista*). Within our country there are six species of birch mice. Three of them, the forest (*S. betulina* Pall.), steppe (*S. subtilis* Pall.), and long-tailed (*S. caudata* Thom.) birch mice are of wide distribution, and three, the Caucasus birch mouse (*S. caucasica* Vinogr.), endemic to the Caucasus, the Tien Shan birch mouse (*S. tianschanica* Salensky), endemic to the Tien Shan, and the Altai birch mouse (*S. napaeva* Hob), endemic to the Altai, are of narrow distribution.

The scarcity of these animals in the collections of zoologists, especially the endemic forms, makes practically impossible their comparison according to a series of indicators by a single investigator; therefore it is necessary to pool the efforts of a number of zoologists conducting a study of the animals according to a single method. This is what we have done for demonstration of the internal characteristics of birch mice. V. N. Bol'shakov possesses collections of forest and steppe birch mice from a series of points in Sverdlovsk and Chelyabinsk Oblasts, Tien Shan birch mice (Terskei Ala-Tau Range), and Caucasus birch mice (Terberda Reserve). A. A. Tsvetkova conducted investigations of the forest and steppe birch mice in Orenburg Oblast (region of Kuvandyk). É. V. Ivanter studied the forest birch mouse in Southern Karelia (Pyatkyarantskii Raion, Karelian ASSR), while N. G. Suchkova investigated Altai birch mice in the region of Charyshskoe village in Altai Territory and forest birch mice in the region of Tomsk. Thus, all species of birch mice, except the long-tailed, were investigated. The internal characters of the animals were studied according to the general methods (Shvarts et al., 1968). The quantity of investigated material is presented in the tables.

The ecology of the birch mouse fauna of the USSR is still extremely inadequately studied. More complete data are available in the literature on the forest birch mouse (Blagosklonov, 1948; Dal' and Chugunov, 1956; Popov, 1960; Tupikova, 1960; Sorokin and Sokolov, 1960; Kulik et al., 1968; Ivanter, 1975; Tsvetkova and Stadukhin, 1976; and others). R. P. Zimina and M. A. Merkova (1960) studied the ecology of the Tien Shan birch mouse in the Northern Tien Shan; the data on the other species are fragmentary and scattered. A series of observations on the ecology of birch mice was conducted by the authors of the present article.

All birch mouse species are characterized by a comparatively short active period (in the forest birch mouse it comprises in various regions of the distribution range 4-6 months), winter hibernation, the ability during decline in temperature to go into torpor, the predominance of animal food (primarily insects) in the nutrition, and a number of other peculiarities, all of which distinguish them from other small mammals. The ecology of the species in considerable degree determines also the morphophysiological characteristics of the birch mice. Data on the internal characters of birch mice are presented in Tables 1-5. To avoid

TABLE 2. Internal Indicators of Forest Birch Mice from Various Regions of the Distribution Range (adult individuals)

Characters	Southern Karelia				Sverdlovsk Oblast		Region of Tomsk	
	males, n=45		females, n=27		males, n=16	females, n=7	males, n=6	
	$M \pm m$	C_V	$M \pm m$	C_V	$M \pm m$	$M \pm m$	$M \pm m$	C_V
Body weight, g	8,45±0,14 (6,5—10,6)	10,9	9,02±0,27 (6,0—12,9)	15,7	9,0±0,30 (7,9—11,8)	9,9±0,15 (7,1—11,6)	9,20±0,50 (7,8—10,8)	10,25
Body length, mm	66,23±0,73 (53,1—73,0)	7,4	64,37±1,11 (53,5—73,0)	9,0	68,4±1,54 (59—73)	69,0±1,20 (58—71)	— —	—
Index, ‰: heart	11,76±0,23 (8,4—14,2)	13,1	9,93±0,27 (7,2—14,6)	13,9	8,8±0,34 (7,0—12,3)	8,9±0,40 (7,1—12,7)	9,70±0,44 (8,4—11,2)	13,4
kidney	10,54±0,14 (9,1—14,0)	9,0	10,5±0,25 (8,4—13,1)	12,3	10,9±0,80 (7,9—12,6)	10,2±0,36 (7,7—11,9)	9,80±0,59 (8,4—12,3)	14,75
liver	69,55±1,34 (51,2—88,4)	14,1	72,37±2,23 (49,0—91,6)	15,0	70,0±1,52 (50,3—82,5)	71,3±2,25 (49,0—83,6)	72,08±4,86 (55,6—84,2)	15,38
Relative length, %: intestine	474±8,6 (404—608)	11,5 n=40	509±12,1 (358—595)	11,2 n=22	496±10,4 (410—600)	515±9,0 (418—550)	—	—
cecum	13,19±0,37 (10,0—17,4)	17,3 n=33	12,9±0,61 (8,6—18,0)	21,4 n=20	12,3±0,40 (8,9—15,5)	11,9±0,52 (9,2—14,8)	—	—

TABLE 3. Internal Indicators of Forest Birch Mouse in Orenburg Oblast (adult individuals)

Characters	June	July				August			
	females, n=2	females, n=6		males, n=8		females, n=4		males, n=8	
	M	M±m	C _V	M±m	C _V	M±m	C _V	M±m	C _V
Body weight, g	14,27	10,95±0,79 (9,53—13,55)	16,27	9,05±0,38 (8,32—11,50)	11,12	12,93±1,20 (10,32—15,20)	16,16	10,19±0,78 (8,83—15,20)	20,30
Body length, mm	68,5	65,92±2,22 (60,5—72,0)	7,53	66,19±1,88 (56—71)	7,51	70,25±1,79 (66—72)	4,41	66,13±1,64 (60—71)	6,54
Index, ‰: heart	8,48	8,09±0,40 (7,65—8,93)	10,02	11,02±0,74 (9,13—12,01)	13,78	7,69±0,93 (6,21—8,74)	17,19	9,06±0,60 (6,57—10,56)	17,52
kidney	12,06	11,25±0,45 (10,38—13,22)	9,84	11,30±0,53 (7,89—12,25)	12,46	8,78±1,08 (7,44—10,67)	17,48	8,76±0,43 (7,85—10,30)	13,04
liver	81,37	83,64±7,27 (73,18—98,17)	19,43	72,87—4,02 (60,08—90,50)	14,59	84,14±0,14 (74,21—94,07)	16,69	71,15±3,91 (62,55—74,15)	12,29
Relative length, % intestine	574	535,1±20,3 (447,8—569,4)	8,49	424,9±27,5 (411,2—519,6)	17,15	520,6±22,1 (492,4—576,4)	7,34	475,4±21,1 (402,9—543,3)	10,26
cecum	—	11,36±0,66 (9,18—12,88)	13,06	12,32±0,79 (8,0—14,73)	16,90	12,65±1,24 (10,16—15,38)	17,05	11,75±1,37 (6,88—14,89)	28,62

TABLE 4. Internal Indicators of Altai Birch Mice (region of Charyshskoe village, adult individuals)

Characters	May		June				July				August	
	males, n=7		males, n=95		females, n=39		males, n=52		females, n=51		males, n=3	
	$M \pm m$	C_V	$M \pm m$	C_V	$M \pm m$	C_V	$M \pm m$	C_V	$M \pm m$	C_V	$M \pm m$	C_V
Body weight, g	10,61 ± 0,32 (9,5—12,0)	8,11	11,12 ± 0,11 (9,0—14,0)	9,70	10,50 ± 0,19 (8,6—14,0)	11,35	11,04 ± 0,13 (8,9—13,0)	8,64	12,65 ± 0,24 (9,3—17,0)	13,84	12,10 ± 0,38 (11,15—12,8)	5,42
Index, ‰: heart	9,60 ± 0,52 (7,9—11,7)	14,23	9,99 ± 0,11 (8,2—12,2)	10,46	10,72 ± 0,24 (8,4—14,8)	12,66	9,84 ± 0,16 (7,6—14,0)	11,62	9,20 ± 0,19 (5,4—12,7)	14,06	9,00 ± 1,24 (7,3—11,4)	23,75
kidney	9,96 ± 0,26 (8,9—10,9)	7,04	10,68 ± 0,11 (8,08—13,4)	10,07	11,31 ± 0,23 (9,1—14,0)	12,12	10,58 ± 0,16 (8,4—13,9)	10,77	10,60 ± 0,19 (7,1—13,2)	12,26	9,80 ± 0,83 (8,2—11,0)	14,71
liver	70,58 ± 5,76 (49,5—84,2)	19,98	63,04 ± 1,38 (41,4—99,0)	20,24	66,69 ± 1,82 (52,6—85,1)	14,42	65,51 ± 2,15 (40,0—90,0)	23,2	69,85 ± 1,77 (42,7—97,5)	17,75	63,46 ± 3,31 (58,3—69,6)	9,00

possible differences due to age of the investigated animals, comparison was conducted only with respect to adult, overwintered individuals.

Analysis of the data shows that all birch mice have a very large heart and kidneys and a relatively large liver. For comparison we will cite the morphophysiological indicators of other small mammals, close to birch mice in body weight. The common shrew (*Sorex araneus*) from the flatland regions of the Transurals has a relative weight of the heart of $9.7 \pm 0.10\%$, of the kidney $10.4 \pm 0.5\%$, and liver $61.1 \pm 0.3\%$; the harvest mouse (*Micromys minutus* Pall) from these same regions has, respectively, 8.4, 9.0, and 64.8%. All birch mice according to the heart index either do not differ from or even exceed the shrews; they are very mobile animals with an intense metabolism.

It is known (Shvarts et al., 1968) that heart size is directly dependent on the degree of activity of the animal. Forest birch mice are considerably more mobile than redbacked voles and are similar in activity to such species as mice of the genus *Apodemus* (Merkova, 1955; Kulik et al., 1968). The heart index in birch mice is much greater than in redbacked voles ($5.5 \pm 0.13\%$ in the Southern Urals) and greater than in wood mice ($6.4 \pm 0.03\%$, also in the Southern Urals). The high heart index of the greater jerboa in connection with its mobility was described by S. S. Shvarts (1958). The high kidney index indicates the comparatively high level of metabolism in birch mice during the active period of life; intensification of metabolism is always accompanied by an increase in kidney weight (Shvarts, 1960).

The activity of birch mice is considerably influenced by temperature and precipitation. For the forest birch mouse there has been noted a sharp decline in activity or even its complete cessation during a drop in temperature below 10°C. S. S. Shvarts (1963) showed that sharp changes in weather conditions connected with interruptions in the feeding of animals result in an increase in the glycogen content of the liver, and, consequently, in an increase in the relative weight of the liver.

A clear dependence between the specifics of nutrition and the length of the intestine has been established in many animal species (Velichko, 1939; Naumov, 1939; Bol'shakov, 1972). All birch mouse species are characterized by a comparatively short intestine and cecum: By this indicator they sharply differ from herbivorous voles and are close to seminivorous mice. For comparison we will point out that, for example, in the Southern Urals the relative length of the intestine in redbacked voles comprises $648 \pm 12\%$, that of the cecum, $32 \pm 0.4\%$; in forest birch mice, respectively, 483 ± 9 and $18 \pm 2\%$. Significant differences between the studied birch mouse species and populations of a single species from various regions could not be established with our material, which indicates the similar character of the nutrition of the animals. In the stomachs of birch mice we constantly found insects, foliage, and seeds.

There are also no distinct species differences with respect to the other internal indicators. Of interest are the close values of the coefficients of variation of internal characters in the various species. For example, in adult forest birch mouse males the C_V of the heart index in Orenburg Oblast comprises 17.5–17.7%; in Sverdlovsk, 14.0%; in Tomsk, 13.4%; in Karelia, 13.1%. The liver index is, respectively, 12.5–13.0, 13.0, 14.75, and 9%. In birch mice, as in other hibernating rodents, one might expect a decline in the indexes of the

TABLE 5. Internal Indicators of Tien Shan and Caucasus Birch Mice (adult individuals)

Characters	Tien Shan birch mouse (Terskei Ala-Tau, n=2)	Caucasus birch mouse (Teberda Reserve, n=1)
Body weight, g	9,3	10,0
Body length, mm	71	69
Heart index, ‰	71,2	13,0
Kidney index ‰	11,3	11,0
Liver index, ‰	66,4	70,6
Relative length of intestine, ‰	483	460
Relative length of cecum, ‰	15	14

heart and kidney and an increase in the index of the liver in connection with the preparation of the animals for hibernation at the end of summer. In fact, in the forest birch mouse in Orenburg Oblast such phenomena are expressed in both males and females (heart and kidney indexes); however in steppe and Altai birch mice we demonstrated no regular changes in internal indicators according to months.

We will compare the internal characteristics of birch mice young born in the current year and of adult, overwintered animals. Thus, in young animals from Southern Karelia (body weight 5.4 ± 0.67 g, $n = 13$) the index of the heart is equal to 10.9 ± 8.86 ‰; the kidney, 9.45 ± 0.27 ‰; the liver, 54.4 ± 4.9 ‰; the relative length of the intestine, 496 ± 38.6 %; the cecum, 10.9 ± 0.7 %. In young wood birch mice from Orenburg Oblast in July (males, body weight 7.05 ± 0.08 g, $n = 20$), respectively: 10.84 ± 0.3 , 11.9 ± 0.4 , and 70.4 ± 2.3 ‰; 479.6 ± 17.7 and 11.8 ± 0.54 %; in steppe birch mice in July of the same region (males, body weight 6.52 ± 0.16 g, $n = 26$): 10.48 ± 0.23 , 11.37 ± 0.31 , and 57.34 ± 1.57 ‰; 456.9 ± 10.03 and 11.16 ± 0.37 % (compare with the data of Tables 1-3). In birch mice there is no appreciable fall in the heart index with age, i.e., the development of the indicator proceeds in them according to the type in shrews, animals with an intense metabolism (Shvarts et al., 1968, p. 116). The relative liver weight in young birch mice is similar to or less than that in adults. This is also a peculiar exception from the general rule: A larger liver in adult mammals was noted earlier only in bats and shrews (Shvarts et al., 1968), linked by the authors to the high activity of these animals, which does not decline with age.

Although there are no distinct geographical differences between the different populations of forest and steppe birch mice, it is necessary to note the fact that a comparison of the limits of variation in the indicators of the heart and kidney index in adult forest birch mice from the southern (Orenburg Oblast) and northern (Karelia) boundaries of the distribution range demonstrates the higher extreme values of characters in the north. This may indicate that the tendency of increase in the relative heart and kidney weights, noted in many species in moving to the north and into the mountains (Shvarts, 1963; Bol'shakov, 1969), is in some degree manifested also in the forest birch mouse.

Earlier (Bol'shakov, 1972) there was noted an increase in these indexes in forest birch mice in the mountains of the Urals as compared with flatland (heart 9.9 and 8.3 ‰; kidney 13.1 and 9.6 ‰). Such a tendency was not found in steppe birch mice: In Chelyabinsk Oblast and in the south of Sverdlovsk Oblast (northern boundary of the species distribution) the animals are characterized by a variation in characters similar to that in the central regions of the distribution (Orenburg Oblast): heart 6.9 - 13.0 ‰ (on the average 9.0); kidney, 7.1 - 11.5 ‰ (on the average 8.8); liver, 42.6 - 75.0 ‰ (on the average 50.2). Possibly, in the given instance more material is required for more well-grounded conclusions.

In characterizing the internal characteristics of the birch mouse fauna of the USSR as a whole, one can note their considerable "leveling": similarity in different species, absence or weak expression of geographical differences, as well as changes in indicators during the active period. Similar characteristics were noted by certain authors for other hibernating rodents, for example E. S. Nekrasov (1975) for the greater suslik. Possibly, this is a more widespread property of hibernating animals.

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