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AGE AND SEASONAL ASPECTS OF SEXUAL DIFFERENCES IN SOCIAL VOLE, *MICROTUS SOCIALIS* (RODENTIA, ARVICOLINAE), IN THE SOUTH OF UKRAINE

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Age and Seasonal Aspects of Sexual Differences in Social Vole, *Microtus socialis,* (Rodentia, Arvicolinae), in the South of Ukraine. Sinyavskaya I. A. — Expression of sexual differences in social vole populations of virgin steppe reserve "Askania Nova" analyzed in the article. It is established that the severity of the sexual differences of value morphological features depending on the age of the animals and to a lesser degree on the season.

Key words: *Microtus socialis*, age variability, sexual differences, seasonal variation.

Возрастной и сезонный аспекты половых различий у общественной полёвки, *Microtus socialis* (Rodentia, Arvicolinae), на юге Украины. Синявская И. А. — В статье проанализировано проявление половых различий в популяции общественной полёвки целинной степи заповедника «Аскания-Нова». Установлено, что степень выраженности половых различий величины морфологических признаков изменчива в зависимости от возраста зверьков и в меньшей степени от сезона.

Ключевые слова: *Microtus socialis*, возрастная изменчивость, половые различия, сезонная изменчивость.

Introduction

Sexual differences obviously associated with differences in the size and proportions of the body and in the growth rate of animals of both sexes (Kaneko, 1978; Grulich, 1987; Heske, Ostfeld, 1990; Boonstra et. al., 1993; Stamps, 1993; Meyer et al, 1996; Schulte-Hostedde, Millar, 2000; Lammers et al., 2001; Isaac, 2005;). In most murine rodent species sexual differences, if detected, can be expressed in a bigger males size (Ralls, 1977 Panteleev et al, 1990; Markowski, Ostbye, 1992) or, conversely, females (Bank vole, 1981; Lammers et al., 2001). In some studies the differences were not registered at all (Hammond et al., 1999).

In murine rodents sexual differences of the majority morphological characters are slightly expressed (Panteleev et al, 1990; Meyer et al, 1996; Hammond et al., 1999) and often ignores in the practice of their comparative morphological studies. Meanwhile, the literature accumulated a lot of evidences of the specificity of sexual differences in different species (Kaneko, 1978; Grulich, 1987; Heske, Ostfeld, 1990; Boonstra et. al., 1993; Stamps, 1993; Meyer et al, 1996; Schulte-Hostedde, Millar, 2000; Lammers et al., 2001; Vasiliev et al, 2004) in different populations of the same species (Bergstrom, 1984; Grulich, 1987, Meyer et al, 1996; Vasil'ev et al, 2004), and depending on the season and population dynamics (Ivanter et al, 1985; Davis-Born, Wollf, 2000; Faleev, Yepifantseva, 2000; Vasil'ev et al, 2003). In this article, we discussed the seasonal and age aspects of sexual differences in social voles in southern Ukraine.

Material and methods

The study is based on the data on *Microtus socialis* morphology, collected in different seasons of 1973 in the expedition of the Department of Population Ecology of Schmalhausen Institute of Zoology NAS of Ukraine on the territory of the virgin steppe reserve "Askania-Nova". Totally, 644 specimens of *M. socialis* of different age were studied. The relative age of voles was estimated according to the degree of skull sculpturing (Emelyanov, Zolotukhina, 1975) and the data on vole's body length and mass. As a result of the performed analysis, the animals were divided into three age groups: juveniles, subadults and adults.

15 standard morphometric characters (body length — L, tail length — Ca, foot length — Pl, ear length — Au, body weight — W, spleen — Lie, adrenal glands — Adr, kidneys — Ren, intestines — Int,

liver — Hep, heart — Cor, lungs — Pul and thymus — Th) were analyzed. The weight of the kidneys and adrenal glands was considered separately from the left and from the right sides as the individual indices. For studying the structure differences of morphological traits canonical discriminant analysis was carried out. Above mentioned morphological features were used as the independent variables, sex and age were used as the dependent variable. Seasonal differences between samples of the same age and gender were assessed using Tukey HSD test. All calculations were performed using the statistical package Statistica for Windows, version 6.0 (StatSoft, 2001).

Results and their discussion

According to the results of the discriminant analysis first two canonical roots describe more than 90 % of the total variance of 15 morphologial features in seasonal samples of 1973 (phase of peak abundance of social voles).

The first canonical root describes the variability of the overall size (L, W) and weight of adrenal glands, kidneys, intestines, liver and heart (winter — $\chi^2 = 223.83$ $p < 0.001$; spring — $\chi^2 = 281.50$ $p < 0.001$, summer — $\chi^2 = 195.74$ $p < 0.001$; autumn — $\chi^2 = 201.04$ $p < 0.001$) in all four seasonal samples. The second canonical root illustrates differences in body proportions (winter — $\chi^2 = 54.85$ $p < 0.05$; spring — $\chi^2 = 90.69$ $p < 0.001$; summer — $\chi^2 = 70.23$ $p < 0.01$; autumn — $\chi^2 = 36.55$ $p > 0.05$). The length of the foot, the weight of the adrenal glands, and thymus give the maximal loadings on this component (table 1). Character of seasonal samples distribution in the space of values of the 1st and 2nd canonical roots demonstrated the increase of sexual differences with the age (fig. 1 ad; table. 3–6.). Magnitude of sexual differences on individual characters changes depending on the season.

Table 1. Load of morphological features on the first and second canonical roots
Таблица 1. Нагрузки мофологических признаков на первую и вторую канонические оси

Feature	Winter		Spring		Summer		Autumn	
	Root 1	Root 2	Root 1	Root 2	Root 1	Root 2	Root 1	Root 2
L	-0.726	-0.111	-0.506	-0.121	-0.647	0.462	-0.755	-0.037
Ca	-0.359	0.034	-0.292	-0.268	-0.390	0.495	-0.427	0.042
Pl	-0.189	-0.264	-0.130	0.108	-0.265	0.048	-0.207	-0.261
Au	-0.379	-0.097	-0.236	-0.033	-0.344	0.333	-0.383	-0.010
W	-0.693	-0.320	-0.599	0.004	-0.687	0.424	-0.695	-0.136
Lie	-0.164	0.038	-0.120	0.026	-0.147	0.178	-0.131	-0.220
s. Adr	-0.522	0.241	-0.535	-0.495	-0.367	0.573	-0.667	0.244
d. Adr	-0.470	0.228	-0.475	-0.393	-0.370	0.571	-0.635	0.219
s. Ren	-0.503	-0.146	-0.535	0.040	-0.480	0.325	-0.648	0.053
d. Ren	-0.494	-0.131	-0.523	0.028	-0.568	0.326	-0.628	0.071
Int	-0.488	0.042	-0.328	-0.256	-0.385	0.528	-0.466	0.092
Hep	-0.517	0.165	-0.524	-0.299	-0.491	0.634	-0.573	0.231
Th	0.349	0.189	0.275	0.044	0.278	-0.159	0.421	-0.088
Cor	-0.609	-0.031	-0.511	-0.130	-0.644	0.482	-0.688	-0.041
Pul	-0.532	-0.092	-0.459	-0.132	-0.504	0.385	-0.507	-0.032
% of total variance	78.83	18.06	84.19	12.12	78.72	15.51	75.68	21.34

Table 2. Distinction between social vole males and female (SqMD) of different age in 4 seasonal samples in 1973

Таблица 2. Различия между самцами и самками (SqMD) общественной полёвки разного возраста 4 сезонных выборок 1973 г.

Season	Juvenis	Subadultus	Adultus
Winter	**0.42**	**12.74**	**19.82**
Spring	**5.04**	**15.91**	**24.19**
Summer	**1.74**	**20.75**	**48.98**
Autumn	**0.71**	**11.17**	**24.21**

Table 3. The average value of morphological features in males and females of the winter sampling social vole

Таблица 3. Средняя величина морфологических признаков у самцов и самок зимней выборки общественной полёвки

Feature	Females			Males		
	juvenis (n = 20)	subadultus (n = 23)	adultus (n = 29)	juvenis (n = 31)	subadultus (n = 9)	adultus (n = 28)
	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE
L	74.55 ± 1.34	93.98 ± 0.72	100.93 ± 0.54	73.50 ± 1.25	92.78 ± 1.26	99.73 ± 0.67
Ca	17.68 ± 0.27	21.20 ± 0.38	22.33 ± 0.32	17.40 ± 0.27	21.28 ± 0.75	21.41 ± 0.31
Pl	14.48 ± 0.11	15.02 ± 0.09	14.91 ± 0.09	14.47 ± 0.09	15.39 ± 0.14	15.43 ± 0.08
Au	6.85 ± 0.14	7.91 ± 0.09	8.24 ± 0.07	6.84 ± 0.09	7.94 ± 0.13	8.27 ± 0.09
W	12.88 ± 0.61	24.13 ± 0.53	27.63 ± 0.49	12.66 ± 0.61	24.70 ± 1.00	29.95 ± 0.63
Lie	39.60 ± 3.52	82.91 ± 6.65	75.34 ± 4.47	46.74 ± 3.70	74.72 ± 8.89	70.95 ± 5.95
s. Adr	3.38 ± 0.29	7.37 ± 0.28	8.47 ± 0.29	2.98 ± 0.14	5.33 ± 0.34	6.70 ± 0.17
d. Adr	2.88 ± 0.22	6.28 ± 0.24	7.07 ± 0.26	2.63 ± 0.16	4.67 ± 0.31	5.59 ± 0.17
s. Ren	122.10 ± 5.75	190.87 ± 4.11	231.03 ± 6.13	121.16 ± 4.96	214.61 ± 13.56	228.75 ± 4.55
d. Ren	123.65 ± 5.56	193.65 ± 3.97	233.02 ± 6.33	123.40 ± 5.18	218.17 ± 14.78	229.16 ± 4.19
Int	3.34 ± 0.14	6.26 ± 0.16	6.85 ± 0.25	3.31 ± 0.14	5.62 ± 0.25	6.32 ± 0.15
Hep	768.25 ± 40.38	1650.00 ± 54.84	1997.24 ± 57.94	744.19 ± 36.01	1455.56 ± 52.47	1610.00 ± 44.66
Th	27.48 ± 2.09	16.54 ± 1.66	8.03 ± 0.80	31.47 ± 2.04	20.00 ± 5.64	3.82 ± 0.52
Cor	91.48 ± 4.64	153.37 ± 4.01	184.48 ± 3.21	87.77 ± 4.19	154.39 ± 5.12	172.18 ± 3.01
Pul	101.35 ± 3.47	154.17 ± 2.47	167.31 ± 3.34	98.18 ± 3.42	155.06 ±5.04	165.84 ± 3.29

Note. M — mean value, SE − standard error.

Table 4. The average value of morphological features in males and females of the spring sampling of social vole

Таблица 4. Средняя величина морфологических признаков у самцов и самок весенней выборки общественной полёвки

Feature	Females			Males		
	juvenis (n = 39)	subadultus (n = 16)	adultus (n = 15)	juvenis (n = 93)	subadultus (n = 9)	adultus (n = 9)
	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE
L	76.69 ±1.17	97.34 ± 0.90	102.60 ± 0.49	74.58 ± 0.63	94.61 ± 1.08	103.44 ± 1.12
Ca	18.68 ± 0.34	22.94 ± 0.51	24.23 ± 0.46	18.19 ± 0.17	21.17 ± 0.52	21.78 ± 0.55
Pl	14.71 ± 0.10	15.00 ± 0.11	15.43 ± 0.11	14.77 ± 0.07	15.39 ± 0.11	15.78 ± 0.15
Au	7.14 ± 0.10	8.06 ± 0.12	8.50 ± 0.10	7.10 ± 0.06	8.11 ± 0.11	8.50 ± 0.19
W	14.10 ± 0.53	25.28 ± 0.69	28.86 ± 0.67	12.89 ± 0.30	25.56 ± 0.78	32.04 ± 0.83
Lie	46.28 ± 3.21	67.66 ± 4.17	96.60 ± 6.83	51.35 ± 3.89	97.72 ± 16.17	87.89 ± 6.41
s. Adr	3.88 ± 0.17	8.06 ± 0.43	9.13 ± 0.44	2.90 ± 0.07	6.22 ± 0.29	6.83 ± 0.26
d. Adr	3.32 ± 0.15	6.73 ± 0.29	7.63 ± 0.46	2.53 ± 0.07	5.50 ± 0.42	5.94 ± 0.41
s. Ren	128.47 ± 4.05	213.97 ± 6.87	242.43 ± 6.85	118.74 ± 2.58	223.22 ± 9.25	272.72 ± 10.80
d. Ren	131.72 ± 4.25	214.28 ± 7.33	248.97 ± 5.22	121.81 ± 2.66	225.39 ± 8.52	273.22 ± 12.15
Int	3.72 ± 0.12	6.36 ± 0.25	5.63 ± 0.24	3.31 ± 0.07	5.16 ± 0.30	5.46 ± 0.40
Hep	855.13 ± 36.80	1683.13 ± 56.01	2046.67 ± 80.02	771.34 ± 20.63	1467.78 ± 66.99	1734.44 ± 79.29
Th	29.27 ± 1.78	8.88 ± 1.15	4.83 ± 1.01	30.54 ± 1.24	6.83 ± 1.04	3.89 ± 0.81
Cor	93.77 ± 3.28	158.44 ± 4.52	169.80 ± 4.65	82.55 ± 1.84	148.39 ± 5.64	175.78 ± 4.32
Pul	105.69 ±2.91	158.38 ± 3.21	189.67 ± 7.00	100.07 ± 1.76	160.72 ± 7.10	177.50 ± 7.64

Note. M — mean value, SE − standard error.

Table 5. The average value of morphological features in males and females of the summer sampling of social vole

Таблица 5. Средняя величина морфологических признаков у самцов и самок летней выборки общественной полёвки

Feature	Females			Males		
	juvenis (n = 57)	subadultus (n = 32)	adultus (n = 9)	juvenis (n = 14)	subadultus (n = 16)	adultus (n = 15)
	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE
L	73.23 ± 1.16	96.56 ± 0.62	101.78 ± 1.17	80.21 ± 1.61	97.13 ± 0.69	99.87 ± 0.58
Ca	18.21 ± 0.26	22.92 ± 0.31	24.44 ± 0.74	18.96 ± 0.40	21.81 ± 0.32	22.47 ± 0.48
Pl	14.35 ± 0.08	15.20 ± 0.11	15.17 ± 0.08	15.00 ± 0.22	15.50 ± 0.13	15.40 ± 0.11
Au	6.82 ± 0.10	8.20 ± 0.06	8.44 ± 0.13	7.46 ± 0.10	8.25 ± 0.14	7.93 ± 0.14
W	12.17 ± 0.52	23.78 ± 0.47	26.49 ± 0.91	15.26 ± 0.64	24.44 ± 0.47	26.62 ± 0.44
Lie	65.18 ± 4.86	97.95 ± 5.43	104.06 ± 11.59	73.43 ± 8.32	91.38 ± 6.83	93.20 ± 5.45
s. Adr	3.28 ± 0.23	7.02 ± 0.21	7.56 ± 0.39	3.21 ± 0.17	5.59 ± 0.20	6.17 ± 0.35
d. Adr	2.73 ± 0.18	5.89 ± 0.19	6.50 ± 0.41	2.71 ± 0.16	4.75 ± 0.25	5.20 ± 0.28
s. Ren	125.93 ± 4.43	214.55 ± 4.86	234.67 ± 9.55	139.07 ± 5.21	231.53 ± 6.08	226.53 ± 9.29
d. Ren	128.55 ± 4.56	217.03 ± 4.85	236.06 ± 9.86	143.14 ± 4.93	232.88 ± 6.37	234.83 ± 5.87
Int	2.97 ± 0.11	5.02 ± 0.14	5.86 ± 0.34	3.60 ± 0.19	4.33 ± 0.15	4.88 ± 0.11
Hep	864.39 ± 45.41	1855.94 ± 54.60	2023.33 ± 94.12	989.29 ± 48.21	1641.25 ± 53.22	1668.67 ± 42.02
Th	26.39 ± 1.61	11.52 ± 1.81	10.78 ± 2.31	26.86 ± 2.17	9.06 ± 1.40	9.07 ± 1.50
Cor	75.77 ± 2.65	136.56 ± 2.65	146.94 ± 4.20	88.43 ± 3.97	133.56 ± 2.61	146.37 ± 2.64
Pul	98.93 ± 2.59	150.25 ± 3.18	170.28 ± 6.22	106.57 ± 3.43	148.03 ± 5.22	164.37 ± 5.33

Note. M — mean value, SE – standard error.

Table 6. The average value of morphological features in males and females of the autumn sampling of social vole

Таблица 6. Средняя величина морфологических признаков у самцов и самок осенней выборки общественной полёвки

Feature	Females			Males		
	juvenis (n = 46)	subadultus (n = 44)	adultus (n = 11)	juvenis (n = 48)	subadultus (n = 16)	adultus (n = 15)
	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE	M ± SE
L	76.09 ± 0.95	96.52 ± 0.73	104.00 ± 0.74	75.97 ± 1.16	93.13 ± 1.10	101.43 ± 1.28
Ca	18.63 ± 0.33	22.30 ± 0.32	24.45 ± 0.49	18.56 ± 0.27	20.88 ± 0.52	23.23 ± 0.37
Pl	14.76 ± 0.11	15.13 ± 0.07	15.00 ± 0.15	14.61 ± 0.09	15.63 ± 0.09	15.70 ± 0.12
Au	7.12 ± 0.09	8.16 ± 0.09	8.45 ± 0.08	7.11 ± 0.10	8.00 ± 0.11	8.33 ± 0.14
W	13.13 ± 0.43	22.12 ± 0.42	25.36 ± 0.90	13.06 ± 0.52	21.50 ± 0.62	25.71 ± 0.74
Lie	64.98 ± 4.80	80.95 ± 3.83	76.41 ± 6.65	65.21 ± 7.21	95.81 ± 11.30	126.73 ± 13.22
s. Adr	3.38 ± 0.14	7.43 ± 0.25	8.09 ± 0.33	3.16 ± 0.16	5.75 ± 0.19	6.63 ± 0.32
d. Adr	2.77 ± 0.13	6.20 ± 0.19	6.86 ± 0.47	2.69 ± 0.15	4.84 ± 0.18	5.60 ± 0.26
s. Ren	124.15 ± 3.57	216.13 ± 5.68	238.82 ± 8.54	123.29 ± 3.98	191.34 ± 8.15	224.17 ± 8.16
d. Ren	126.54 ± 3.42	216.40 ± 5.72	241.68 ± 7.54	126.93 ± 4.04	189.75 ± 7.39	223.00 ± 9.52
Int	3.39 ± 0.09	5.43 ± 0.19	6.10 ± 0.48	3.23 ± 0.11	4.64 ± 0.19	5.50 ± 0.26
Hep	766.20 ± 24.71	1375.23 ± 38.15	1568.18 ± 81.22	745.42 ± 34.02	1075.63 ± 41.04	1283.33 ± 44.55
Th	30.64 ± 1.91	7.25 ± 0.91	3.59 ± 0.59	27.23 ± 1.89	13.63 ± 2.15	9.50 ± 1.11
Cor	87.53 ± 2.57	140.42 ± 2.59	160.59 ± 4.35	85.52 ± 2.95	131.75 ± 4.11	154.40 ± 4.12
Pul	108.22 ± 2.67	157.61 ± 3.23	182.73 ± 8.81	108.28 ± 2.80	146.84 ± 4.77	174.97 ± 11.18

Note. M — mean value, SE – standard error.

In winter and autumn significant differences between juvenile males and females were not observed ($p > 0,05$) at any characters. Among the juvenile voles the highest value of sexual differences was noted in spring samples (table 2, 4). In spring, females in comparison with males are characterised by higher weight of body and adrenal glands ($p = 0.0003 — 0.0001$). In summer, males are larger in body weight, length of feet and ears ($p = 0.001–0.03$).

A greater level of sexual differences was found in the group of subadult individuals (table 3–6). Weight of adrenal glands in seasonal samples of female was larger than in males ($p = 0.02—0.0008$). In spring samples the weight of intestine ($p = 0.02$) was significantly greater in females. In autumn samples females were characterized by greater length of feet ($p = 0.006$), and the weight of the liver ($p = 0.0009$). These can be explained by their faster growth and development compared with males (Peskov et all, 2011), and also by the increased level of metabolic processes connected with offsprings bearing and nursing.

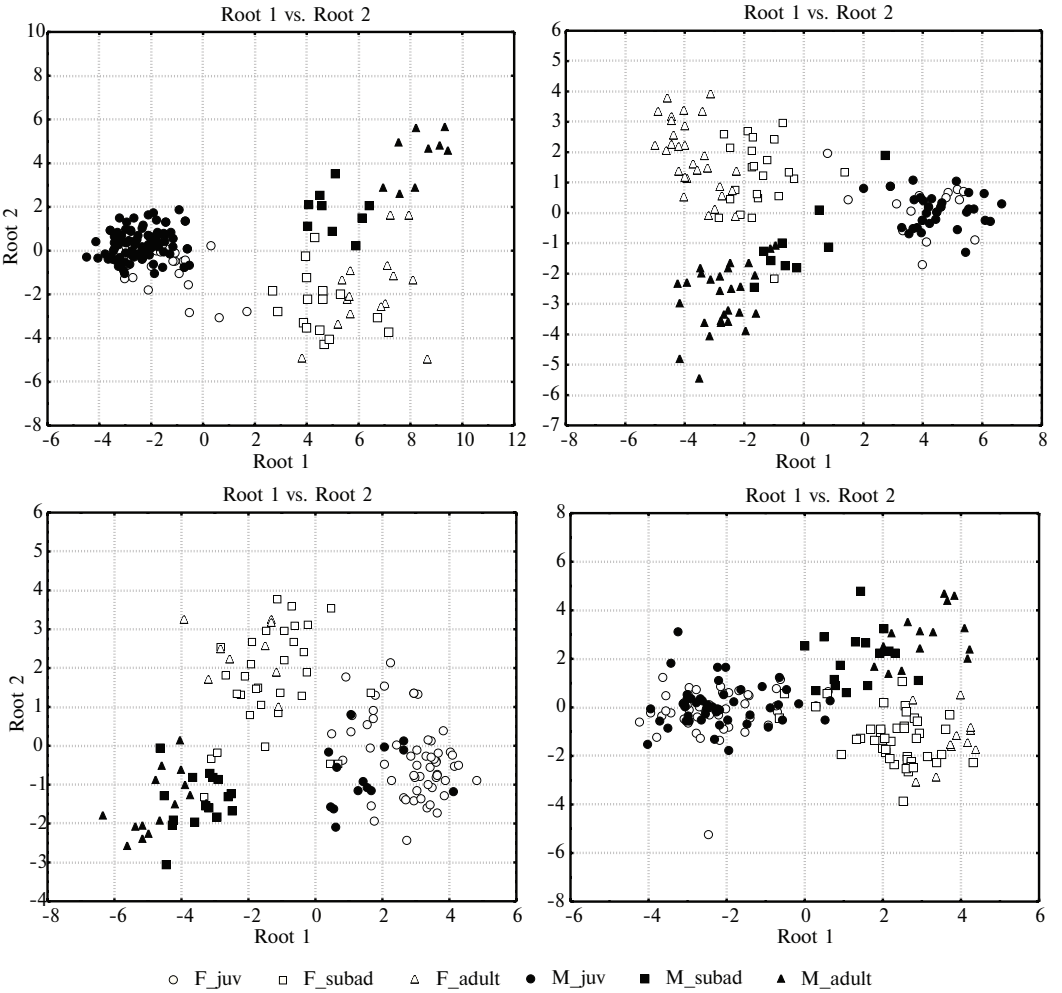

Fig. 1. Sexual differences in seasonal samples of social vole (*a* — winter, *b* — spring, *c* — summer, *d* — autumn).

Рис. 1. Половые различия в сезонных выборках общественной полёвки (*a* — зима, *b* — весна, *c* — лето, *d* — осень).

Adult males and females did not differ in body length, but the average body weight was significantly greater in males of winter samples ($p = 0.03$). Sexual differences in this sample is proven for feet length ($p = 0.0002$), which typically bigger in males. These facts are known for many species of voles (Bashenina, 1977; Meyer et al, 1996). However, weight of the adrenal glands ($p = 0.0003–0.00003$), liver ($p = 0.00003$) and thymus ($p = 0.003$) significantly greater in females. In spring and summer samples of *M. socialis* variability of measurable traits is negligible and detected only for tail length ($p = 0.01$), and weight of liver ($p = 0.02$). Adult males collected in autumn were characterized by significantly bigger feet length ($p = 0.001$), weight of spleen ($p = 0.0007$) and thymus ($p = 0.008$). In the adult voles this combination of traits might be connected with physiological juvenility (Schwartz et al, 1968).

Sexual differences in the body mass and length were described in the literature for such arvicoline species: *Microtus agrestis*, *M. gregalis*, *M. arvalis*, *M. socialis*, *M. oeconomus* (Bashenina, 1962, 1977; Meyer et al, 1996). Variability of organs is determined by differences in the animal growth rate and duration of different seasons, sex and age structure of population, weather and feeding conditions (Schwartz et al, 1968; Ivanter et al, 1985). For example, weight of liver and intestine in females significantly higher than in similar age groups males. This is related to the specificity of energy consumption, accumulation and elevation of nutrient reserves in females during pregnancy and lactation, (Schwartz et al, 1968; Ivanter et al, 1985).

The same is established in case of adrenal gland weight. The adrenals are known to be the indicator of stress (Schwartz et al, 1968; Ivanter et al, 1985). Thus, a higher level of instability to stress in females observes due to their faster growth in comparison with males during breeding season. (Schwartz et al, 1968).

Sexual differences in the length of the foot in social vole are apparently formed very early (Peskov et al, 2011), as already in juvenile males foot is longer than in females. Differences in the length of the tail between males and females occur in semimature specimens — the females tail is significantly longer than that of males. This is advantageous from an energy point of view as a long tail provides additional heat transfer surface thereby reducing the risk of overheating (Panteleev et al, 1990). Our results agree with the results obtained for *Microtus gregalis* (Dupal, Abramov, 2010) *Clethrionomys rutilus* (Novikov, Faleev, 1988) by morphological and craniological features.

We concluded that sexual differences in different age groups of social vole associated with unequal rate of growth in the various periods of ontogeny. The value sexual difference and the degree of maturity in voles increase with age and dependent on the season. In young immature voles sex differences almost unexpressed with the exception of individuals from the spring samples, where the females are significantly larger than males. The maximum gender differences were found in subadults *M. socialis*; the mean values of all signs in females that grow faster than males are significantly bigger. In autumn, when the reproduction is not so intense the opposite pattern is observed. Therefore the combination of male and female in one sample in comparative morphological studies of voles is only allowed for juveniles, while, subadult and adult animals should be analyzed separately.

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