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Somatic characteristics and reproduction of common vole, *Microtus arvalis* (Mammalia: Rodentia) populations in Slovakia

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Abstract: Reproduction potential and biometry of somatic characteristics of the common vole *Microtus arvalis* were evaluated and discussed. The results were processed on the basis of an extensive material (2,171 individuals) from the whole territory of Slovakia (315 sites situated at altitudes from 100 to 1500 m above sea level). Among the somatic characteristics studied, the highest variability was found in body length and the smallest in hind foot length. Highly significant differences were also found between the foot length of adult males and females. Populations of *M. arvalis* at low altitudes were less numerous than at higher altitudes. Altitudinal differences in average embryo numbers in female uteri as well as differences in follicle length in males during the reproductive season were also observed.

Key words: *Microtus arvalis*; common vole; somatometry; reproduction; altitude; Slovakia

Introduction

Voles (*Microtus* spp.) are the youngest group of rodents. They were recorded first from lower Pliocene and from lower Pleistocene they started to be very heterogeneous. From a total of 66 species of the *Microtus* genus six species occur in Slovakia: *M. agrestis* (L., 1761), *M. subterraneus* (de Selys-Longchamps, 1836), *M. tatricus* Kratochvíl, 1952), *M. oeconomus* (Pallas, 1776), *M. nivalis* Martins, 1842) and *M. arvalis* (Pallas, 1779). The distribution range of the common vole, *M. arvalis*, extends from the Atlantic coast of France to central Russia (Mitchell-Jones et al. 1999). The range is almost continuous with the exception of isolated populations in Iberia (Cruz et al. 2002). Twenty six subspecies are assumed to occur in Europe (Niethammer & Krapp 1982), however, the status of most of them is questionable.

Common vole is a species with wide ecological valence that is capable to increase its population density many times within a short period (Koshkina 1966). In Slovakia, it is common from lowlands to mountains (up to 1900 m a.s.l.). *Microtus arvalis* is a typical inhabitant of cultural steppe that was expanded by agriculture. Even though it is a steppe species. Results of Pelikán (1955), Kratochvíl (1959) and Ligač (1975) confirm that *M. arvalis* densely inhabit sparse wood vegetation (forest shelter-belts, newly forested areas etc.). The common vole can be found in the forest zone only in such sites where the ecological character of the forest was somehow disturbed (Kratochvíl & Pelikán 1955). The species occurs in the subalpine zone as well (Kratochvíl & Pelikán 1955; Flousek 1990; Uhlíková 2004).

The present paper presents new information about common vole population bionomics and habitus (reproduction potential, biometry of somatic characteristics). The aim of our study was to identify the relationship between the vole body mass and season and altitude, and changes in reproduction potential of females due to altitude as well as follicle length of males during the reproductive season.

Material and methods

We evaluated 2,171 individuals of *Microtus arvalis* collected from 1975 to 2007. The material was gathered and recorded in protocols at the workstations of the Slovak Academy of Sciences (Research Unit Staré Hory, Institute of Experimental Biology and Ecology), State Conservation Agency (Administration of Landscape Protected Area Ponitrie) and Constantine the Philosopher University in Nitra (Department of Ecology and Environmental Sciences).

Common voles (Table 1) were caught at 315 sites situated in 149 quadrates of the network of the Databank of Fauna of Slovakia and from 64 orographic units of Slovakia, ranging from 100 to 1500 m a.s.l. (Fig. 1). Common voles were caught into bascule traps by the line method (50 catching points at 10 m distance). The traps were checked in 24-hour intervals.

The following biometric data were observed: body weight (H) in grams, body length (LC), tail length (LCd), hind foot length (LTp), ala auris – ear length (LA) (lengths in mm).

The caught individuals were sexed (males – M, females – F) and assigned in three age categories (juveniles, subadults and adults). We identified if adult individuals were sexually active. We also determined the diameter of embryos and their number in both corners of uteri of gravid females.

Table 1. Common vole material evaluated in the present study.

Number of individuals Period of catchments	Sex	Age group				Total
		Adults	Sub adults	Juveniles	Undefined	
2171 ind. (26.2.1975–1.2.2007)	Males	441	427	14	74	956
	Females	506	386	23	69	984
	Undefined	4	10	5	212	231

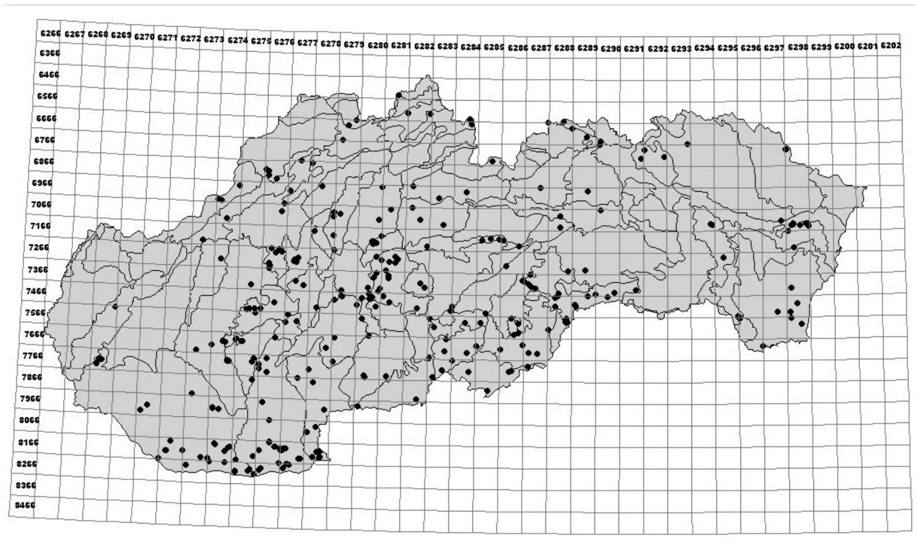

Fig. 1. Sites of *Microtus arvalis* catchments in Slovakia between 1975 and 2007. Sites are illustrated in quadrates of Databank of Fauna of Slovakia with delimitation of geomorphologic units.

The ratio of adult and subadult individuals was evaluated using χ^2 test. Reproduction was assessed considering the length of mating season during the year (based on data on gravid females) and potential size of the litter (based on numbers of embryos in both corners of uteri). Female fertility was assessed by the Emlen-Davis (1984) formula (in Pelikán 1966). Emlen-Davis formula ($F = \% \times \frac{T}{V}$) is the method that serves to estimate the reproduction potential of wild mammal population (F – gravidity frequency, % – percentage of visibly gravid females from overall number of adult females, T – number of observation days, V – number of gravidity days).

The influence of habitat change on the biometry of somatic characteristics and reproduction potential was evaluated in six hypsographic zones: L – lowland (up to 200 m a.s.l.; 696 ind.), K – hilly (200–400 m a.s.l.; 763 ind.), SM – submountainous (400–600 m a.s.l.; 353 ind.), M – mountainous (600–800 m a.s.l.; 208 ind.), O – supramontane (800–1200 m a.s.l.; 82 ind.), SA – subalpine (above 1200 m a.s.l.; 69 ind.).

Biometric data were processed by descriptive statistics (mean values of monitored characteristics, modus, range – minimal and maximal values, size of data set – N). Differences between mean values of monitored characteristics were evaluated according to sex and age category. One-way ANOVA was used to test hypotheses and significance of the observed differences.

Results and discussion

Biometry of Microtus arvalis somatic characteristics
Variability of somatic characteristics of *M. arvalis* was larger in adults than in subadults and among adults it was larger in males. The highest variability among the monitored characteristics was observed in body length and the lowest one in hind foot length (Table 2).

Previously, Mošanský (1957) observed the following average values of somatic characteristics of common vole from eastern Slovakia: weight (males 36.61 g, females 29.45 g), body length (males 112.1 mm, females 108.4 mm), tail length (males 38.3 mm, females 37.23 mm), hind foot length (males 16.85 mm, females 16.55 mm), ala auris length (males 11.7 mm, females 10.8 mm). The early spring population of *M. arvalis* in South Moravia reached the following weights: adult males from 18.33 to 32.17 g, adult females from 21.94 to 28.18 g (Zejda et al. 2004). The average body lengths were from 92.92 to 111.05 mm in adult males and from 98.64 to 110.77 mm in adult females; hind foot length was 15 mm, ala auris 10–15 mm, tail length was 28–45 mm and body length was up to 130 mm (Zejda et al. 2004). The differences in somatic features between common vole populations investigated in this study and those of the quoted authors were considerable, moreover, an increase in values in the west – east direction (in accordance with Bergmann's rule) was observed. These values originated from populations from eastern Slovakia and Moravia that had been investigated in earlier studies, however, our dataset (Table 2) represents materials from different parts of Slovakia. The influence of geographical position and hypsographic level

Table 2. Somatic characteristics of common vole.

Group	Somatic characteristics	*N*	Mean ± SD	Range
Adult individuals	Weight (g)	830	26.32 ± 6.49	17–50
	Body length (mm)	651	102.14 ± 8.46	80–127
	Tail length (mm)	650	33.48 ± 4.51	23–48
	Hind foot length (mm)	682	15.94 ± 0.94	14–18
	Ear length (mm)	172	11.09 ± 1.11	9–13
Adult males	Weight (g)	397	26.62 ± 6.82	17–50
	Body length (mm)	313	102.41 ± 8.58	80–127
	Tail length (mm)	304	33.77 ± 4.74	23–48
	Hind foot length (mm)	332	16.15 ± 0.95	14–18
	Ear length (mm)	85	10.98 ± 1.07	9–13
Adult females	Weight (g)	433	26.06 ± 6.17	17–49.5
	Body length (mm)	338	101.89 ± 8.35	80–125
	Tail length (mm)	346	33.22 ± 4.28	23–47
	Hind foot length (mm)	350	15.75 ± 0.89	14–18
	Ear length (mm)	87	11.19 ± 1.13	9–13
Subadult individuals	Weight (g)	712	16.82 ± 2.19	12–21
	Body length (mm)	397	90.00 ± 5.23	75–102
	Tail length (mm)	400	29.50 ± 3.28	23–39.1
	Hind foot length (mm)	412	15.49 ± 0.84	14–17.5
	Ear length (mm)	73	10.49 ± 0.86	9–13
Subadult males	Weight (g)	371	17.01 ± 2.18	12–21
	Body length (mm)	202	90.96 ± 5.20	78–102
	Tail length (mm)	205	30.13 ± 3.33	23–39
	Hind foot length (mm)	210	15.66 ± 0.80	14–17.5
	Ear length (mm)	32	10.64 ± 0.98	9–13
Subadult females	Weight (g)	335	16.60 ± 2.20	12–21
	Body length (mm)	193	88.98 ± 5.08	75–100
	Tail length (mm)	193	28.85 ± 3.11	23–39.1
	Hind foot length (mm)	199	15.33 ± 0.84	14–17.5
	Ear length (mm)	41	10.37 ± 0.74	9–12.2

Explanations: N – number of individuals, SD – standard deviation.

on somatic characteristics of *M. arvalis* is discussed in another paper (Baláž 2010).

Somatic characteristics of the common vole, especially body length, tail length and weight are not stable and vary considerably. They depend on geographical location, population, but also on the stage of reproduction cycle. We also proved the dependency of body length on sexual activity. Comparing adults and subadults, significant differences were found in all measured body parts and weight ($P < 0.01$; Table 3).

Comparison of measurements of various body parts of adult males and females by ANOVA revealed statistically significant differences only in hind foot length ($P < 0.01$), whereas differences in body weight ($P = 0.213$), body length ($P = 0.442$), tail length ($P = 0.1193$), ala auris (ear) length ($P = 0.1903$) were not significant.

Comparison of the weight of gravid and non-gravid adult females of the common vole revealed an average increase in weight of 18.35% during gravidity (Fig. 2).

Weight of *M. arvalis* adults (both sexes) increased with altitude (from plains to submountainous areas) during all seasons, except for winter (from December to February) when a decrease of weight with altitude gradient was observed. From the seasonal point of view the highest weight was observed in summer and the lowest in winter months, however, in plains the lowest weight for both sexes was recorded during winter.

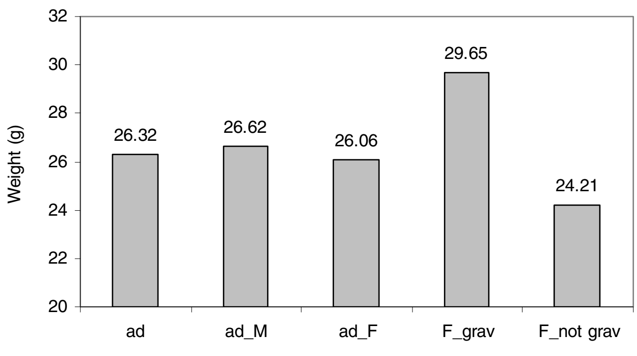

Fig. 2. Average weights of different groups of adult common voles. ad – adult individuals in total, ad_M – adult males, ad_F – adult females, F_grav – gravid females, F_not grav – other adult females non-gravid.

The weight increase with altitude is in accordance with Bergmann's rule. The highest weight during summer is connected to availability of diverse food, whereas low weight in winter and spring months can be explained by limited food offer. From the demographic aspect, the highest density of *M. arvalis* populations is

Table 3. Differences in somatic characteristics between sexes and age categories of common vole.

		F (ANOVA)	Means	
Weight (g)	ad – sad	$2.9.10^{-217**}$	26.32 (ad)	16.82 (sad)
	ad M – F	0.213	26.62 (M)	26.06 (F)
Body length (mm)	ad – sad	10^{-113**}	102.14 (ad)	90.00 (sad)
	ad M – F	0.442	102.41 (M)	101.89 (F)
Tail length (mm)	ad – sad	$7.27.\ 10^{-48**}$	33.48 (ad)	29.50 (sad)
	ad M – F	0.1193	33.77 (M)	33.22 (F)
Hind foot length (mm)	ad – sad	$3.76.\ 10^{-15**}$	15.94 (ad)	15.49 (sad)
	ad M – F	$1.87.\ 10^{-8**}$	16.15 (M)	15.75 (F)
Ear length (mm)	ad – sad	$4.92.\ 10^{-5**}$	11.09 (ad)	10.49 (sad)
	ad M – F	0.1903	10.98 (M)	11.19 (F)

Explanations: ad – adult individuals, sad – subadult individuals, M – males, F – females, ** $P < 0.01$.

Table 4. Changes of common vole weight (g) in different hypsographic zones during the year.

Season	Lowland (L)		Hilly (K)		Sub-mountainous (SM)	
	Male	Female	Male	Female	Male	Female
Spring	22.62	22.57	27.33	26.03	27.66	27.01
Summer	27.13	26.14	33.2	30.03	33.98	31.81
Autumn	25.36	24.4	25.96	25.16	28.44	27.39
Winter	23.5	22.31	22.65	21.87	21.1	18.5

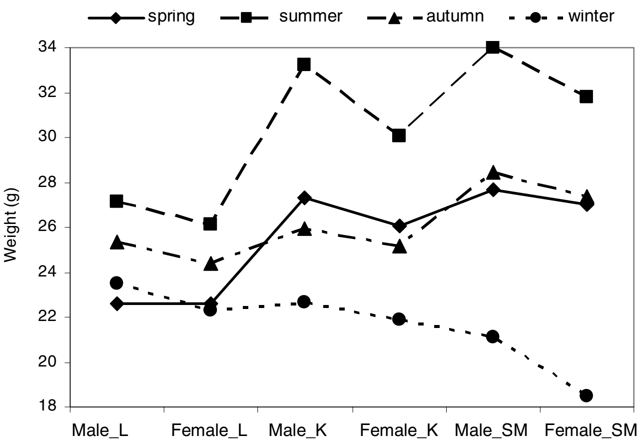

Fig. 3. Body mass changes of common vole in different hypsographic zones of Slovakia during the year. Hypsographic zones: L – lowland, K – hilly, SM – sub mountainous.

in autumn (September to November). High population density is connected with higher frequency of mutual meetings of individuals and increased stress that has a direct influence on weight reduction, which is in contrast to summer months (Fig. 3, Table 4).

Our results confirmed that hypsographic zones and seasons have an important influence on body mass and other somatic features and their changes in the common vole. Environmental conditions change with altitude increase and these significantly influence the body weight. In addition, changes in food supply and environmental conditions throughout the year (seasonal changes) and invasive hematophagous parasites have negative influence on growth, energy usage and immune response of rodents. These changes have a great impact on body parameters and body mass of *M. arvalis* (Birney et al. 1976; Butet 1996; Devevey et al. 2008). Populations of *M. arvalis* at low altitudes are smaller than in higher altitudes. Yoccoz & Mesnager (1998) and others claim that Microtinae body weight varies temporally and geographically: it is low before the beginning of winter and is highest in northern cyclic populations, particularly at peak densities as well as in island populations. Yoccoz & Mesnager (1998) suggested that the overall larger body weight of *Myodes glareolus* (Schreber, 1780) resulted in higher survival rate while the reproduction success was lower and somatic portion (accumulation) was higher. Lower predation impact is one of the possible causes for larger body size of the alpine bank vole.

Reproduction potential of Microtus arvalis

Sex ratio in common voles and the changes in this ratio throughout the year are related to reproduction activity. Sex ratio is an important structural and dynamic characteristic of a population. The ratio is sensitively influenced by inter-population processes and thus belongs to the most important indicators in population analysis. The ratio of males and females in trapped rodent individuals not always corresponds with the real state in a population. The errors lay in the trapping method, time, number of trapped individuals and ratio of juveniles and adults in the population (Gliwicz 1983). By using our trapping method, the sex ratio

Table 5. Sex ratios of common vole during the year (catchments in years 1975–2007).

Month	sad – 823 ind.			ad – 951 ind.		
	M	F	χ^2	M	F	χ^2
January	28	21	1	5	5	0
February	1	11	8.3	11	7	0.89
March	12	8	0.8	83	53	6.62
April	5	8	0.69	47	57	0.96
May	12	10	0.18	31	28	0.15
June	3	5	0.5	22	32	1.85
July	18	12	1.2	35	60	6.58
August	13	16	0.31	27	44	4.07
September	134	91	8.22	63	115	15.19
October	102	106	0.08	46	57	1.17
November	79	70	0.54	48	34	2.04
December	20	28	1.33	23	14	2.19
Total	427	386	2.07	441	506	4.46

For abbreviations see Table 3.

Table 6. Reproduction activity and potential of common vole from 1977 to 2006.

Month	NCF	NPF	%	Number of embryos in uterus								ANE
				2	3	4	5	6	7	8	9	
January	5	1	20	–	1	–	–	–	–	–	–	3
February	7	0	0	–	–	–	–	–	–	–	–	–
March	53	6	11.3	–	–	4	1	1	–	–	–	4.5
April	57	30	–	–	2	6	9	9	1	3	–	5.3
May	28	16	57.1	–	–	2	2	5	4	2	1	6.3
June	31	17	54.8	–	2	3	3	4	4	3	1	5.9
July	59	25	42.4	1	–	2	7	6	6	4	–	5.96
August	44	15	34.1	–	3	3	3	2	4	–	–	5.07
September	118	14	11.9	1	1	4	5	2	–	–	–	4.46
October	57	6	10.5	–	–	3	3	–	–	–	–	4.5
Total	459	130	28.3	2	9	27	33	29	19	13	2	5.47

Explanations: NCF – number of caught females, NPF – number of pregnant females, % – percentage ratio of pregnant females from total of caught females in certain month, ANE – average number of embryos.

was in favour of males in the age category of juveniles (sad – 823 ind.) and in favour of females among adults (ad – 951 ind.). In subadults, prevalence of females was recorded in February, August and October and of males in the other months; but generally the sex ratio was balanced. In adults, the prevalence of females was recorded in March, April and June to September. The reason for female prevalence among trapped individualts in this period could be increased food searching; the sex ratio was generally misbalanced (Table 5).

Sex ratio in common voles generally varies between trapping periods and years. For example in 2000, Briner et al. (2007) found that the ratio of males and females oscillated between 1:1 and 1:2 except for September and October, when males were slightly more numerous (the trend in sex ratio was similar to that described by Adamczewska-Andrejewska & Nabaglo 1977). In 2001, males were less abundant throughout the year and in late summer females were 7–8 times more numerous than males. Voles have long been known to have seasonally affected sex ratios, with males usually being more numerous in winter and spring (Stein 1953; Adamczewska-Andrejewska 1981; Nabaglo 1981).

Based on our survey, reproduction of the common vole began on 28 February because 10 mm long embryos were found on 8 March and the reproduction activity ended on 13 November as 4 mm long embryos were found on 27 October. Thus, the reproduction season of *M. arvalis* lasted 258 days. The number of embryos ranged from 2 to 9. Generally, a higher average number of embryos (2.81) was found in the right upper uterus corner than in the left corner (2.68). Gravidity lasted 19 to 22 days (average 20 days). The gravidity frequency (according to Emlen-Davis formula) was 3.65. Considering the average number of litter (5.47), the number of young from one female was 19.97.

Individuals of *M. arvalis* mature very early and some can reproduce even in the first year of life. According to Kratochvíl (1959), reproduction of *M. arvalis* lasts from mid February to mid October. It was discovered that in mild winters the sexual activity extends to the winter months. Females mature in the age of 4 to 6 weeks. Young voles become independent in three weeks and young born in spring can reproduce in the same year, however, they live only 8 months. On the other hand, young born in summer and autumn begin to reproduce next year and live up to 18 months.

We can point out that the average number of embryos in common vole uteri was 5.47. This resulted from our observation in April when there were 9 females with 9 embryos and 9 females with 6 embryos in their uterus. But the highest average number of embryos was found in May (Table 6).

We also determined the potential size of the litter (on the basis of developing embryos in both corners of the uterus) and the length of mating period throughout the year (on the basis of gravidity data). Considering these extensive data we estimated the length of reproduction period as 9 months. We rarely recorded gravid females in January (one gravid female). The average number of embryos was lower at the beginning and the end of the growing season than in the middle (the highest average number of embryos were from May to July): the average number of embryos was 6.3, 5.9 and 6 in May, June and July, respectively. At the beginning of the reproduction season (in March as the January case was exceptional) we recorded only 4.5 embryos. The number of embryos in individual females ranged from 2 to 9, the most frequent number of embryos was 5 (recorded in 33 females). In May and June we recorded females with 9 embryos. By analyzing the number of embryos in uterus corners of *M. arvalis* females we found a higher number of embryos in right corner (2.81) than in left corner (2.68).

Pelikán (1982) stated 3.8 as the average number of embryos in common vole uteri at the beginning of the reproduction season. Zejda et al. (2004) recorded the beginning of births from mid February, thus mating of voles began in the last decade of January. Early onset of vole's reproduction season together with the increasing density from the beginning of the year are the preconditions to further population growth that very often leads to overpopulation (Reichstein 1964). Jánová et al. (2008) figured out that the average size of *M. arvalis* litter on clover fields in southern Moravia (Czech Republic) was 6.5 and the maximal average number of embryos during the reproduction season was 6.85 in June. Breeding females were observed from April to October in south Moravia. On the other hand, Pelikán (1982) recorded the largest average number of embryos in July (5.6).

We observed that the reproduction of common vole started already in January (no reproduction was recorded in February). The peak of reproduction activity was during three summer months. We found the highest values in April (52.6%), May (57.1%) and June (54.8%) by analyzing the representation of gravid females. Kratochvíl (1959) stated that if the population density of common vole was high in the middle of the summer, it declined gradually. The highest number of gravid females (30) was recorded in April and the most intense reproduction of these small terrestrial mammals was from April to July. We can assume that the individuals from spring litter were also involved in the reproduction process. Participation of more generations in the reproduction process is considered one of the main causes of rapid increase in population density that is a characteristic feature in reproduction dynamics of many species of the Muridae family (subfamily Arvicolinae).

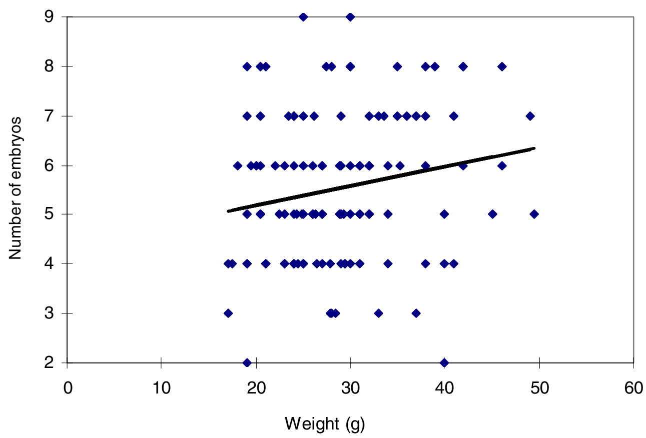

Fig. 4. Positive correlation between weight and number of embryos of common vole females.

By using regression analysis, we found a relationship between weight (body length, respectively) and number of embryos. We confirmed a positive correlation (body length: $R^2 = 0.0416$; weight: $R^2 = 0.0362$) in both cases, i.e., the larger the body length and weight of vole females was the higher number of embryos they had in their uterus (Fig. 4). In contrast, Smith & McGinnis (1968) determined a negative correlation between the body size (weight) and litter size of *Peromyscus* sp. and declared that it was probably due to bigger species living longer and taking longer to mature. It is very important to respect the phases of population cycle in voles, especially the "Chitty effect" which has a great influence on the body mass (increases) and litter size (decreases). "Chitty effect" means that the average body mass of adult voles in high density phases is 20–30% bigger than in low-density phases of the population cycle. Oli (1999) described three hypothesis (or three explanations) of this effect. In our study, voles were trapped during the common years of their population cycles, thus the Chitty effect could not be confirmed by evaluation of individuals from peak population densities. In our study, neither negative correlation nor positive correlation were evident between the body size and litter size of *M. arvalis.*

The number of embryos in uterus of gravid females changed according to altitude (Fig. 5). It is generally known that species and their populations are subject to certain changes along the vertical gradient, i.e., with increasing altitude the types of habitats are changing, which allows survival of species with diverse ecological niches. The average number of embryos was 4.89 in lowlands and gradually increased to 5.93 in the submountainous zone. A decrease was noticed in the mountainous level (5.35) and a significant decrease in the subalpine zone (4.00). *Microtus arvalis* is a species with wide ecological valence, but it could be found mostly at in lower altitudes and in the subalpine level it forms only isolated populations. Kratochvíl & Pelikán

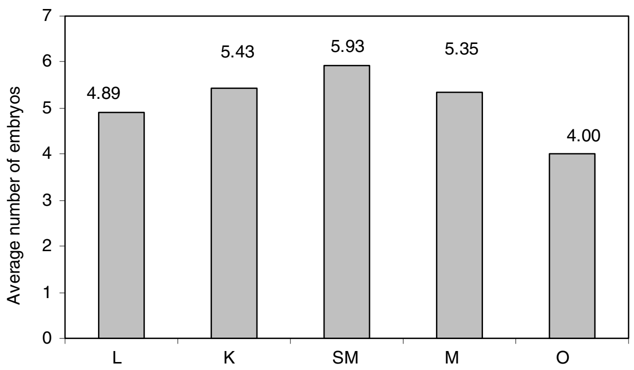

Fig. 5. Average number of embryos of common vole in various hypsographic zones of Slovakia. Hypsographic zones: L – lowland, K – hilly, SM – sub mountainous, M – mountainous, O – supramontane.

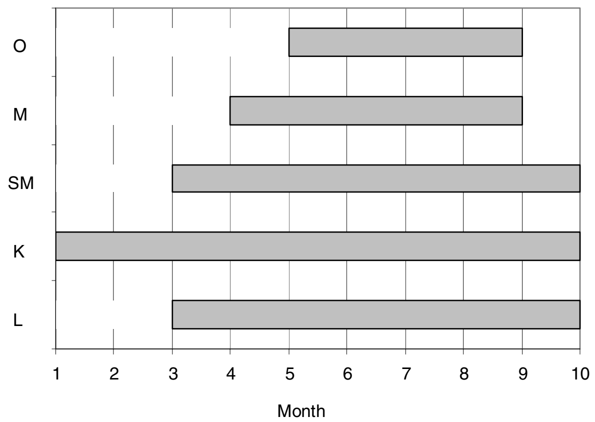

Fig. 6. Duration of common vole reproduction season in various hypsographic zones of Slovakia. For hypsographic zones see Fig. 5.

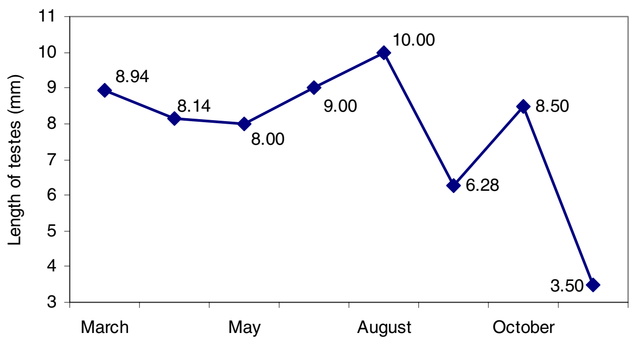

Fig. 7. Dynamics of follicle (testes) length of common vole males during reproduction season (during the year).

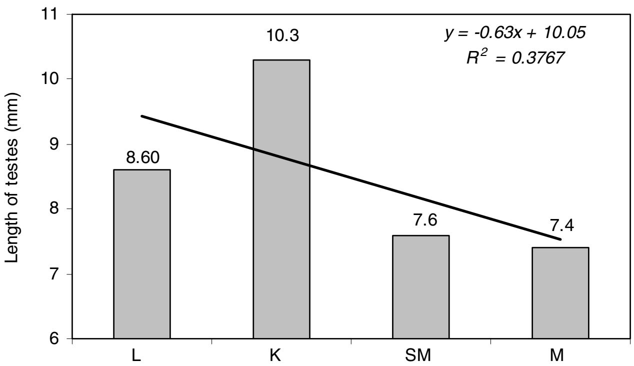

Fig. 8. Follicle length of common vole males from spring in various hypsographic levels in Slovakia. For hypsographic zones see Fig. 5.

(1955) explained the expansion of the common vole into higher altitudes in connection with human activities. The common vole migrates from non-forest biotopes in the submountainous level along autochthonous roads and clearings to the meadow enclaves in mountainous and subalpine levels. It appears that the litter size of *M. arvalis* positively correlated with altitude, but it is not as clear due to a decrease in the mountainous zone. Increased litter size in northern populations probably reflects shortening of the breeding season by the climate in northern latitudes compared to southern latitudes as shown by Smith & McGinnis (1968) for *Peromyscus.* In contrast, Weihe (1965) found that the number of young in rats was lower at 3,450 m than at 540 m a. s.l.

The reproduction period and litter size (number of embryos in uterus) in common vole changed according to the climatic conditions in various altitudes (Figs 5, 6). The longest reproductive period was recorded in the hilly level (9 months) and the shortest one in the supramontane level (only 4 months). The shortening of the reproductive period in common vole with altitude is connected with environmental conditions, mainly temperature decrease. Considering the length of reproduction activity through the year and the number of embryos in uteri of gravid females we can state that the reproduction potential of *M. arvalis* in Slovakia is the highest in submountainous, respectively hilly level. Shorter reproduction period and lower number of embryos in mountainous areas could be the mechanism to hamper species reproduction at higher altitudes. Extreme conditions act as limiting factors in common vole population growth.

The change of male sexual activity can be observed based on follicle length during the reproduction season (Fig. 7). The follicle length in adult males reached peaks in periods of the highest reproduction activity (March, August and October), but the highest average value was in August. The average follicle length in March was 8.94 mm and was connected with the onset of the reproduction season. In April and May follicle length decreased to 8 mm, which could be related to the involvement of males from early spring litter into the reproduction process. During the period of intense reproduction in July and August follicle length was highest (10 mm). After this period follicle length decreased to 6 mm in September and moderately increased to 8.5 mm in October (end of the reproduction season). Follicle length in November was the lowest (3.5 mm).

We tested the dependency of follicle length on altitude at the beginning of the reproduction season (March, April) and recorded a decrease of average follicle length with altitude (Fig. 8). The average follicle length was 8.6 mm, 10.3 mm and 7.4 mm in lowlands, hilly zone and mountainous zone, respectively. Thus follicle length of males decreased with altitude and correlated with the shortening of the reproductive period and decrease in litter size.

The common vole is one of the most common herbivores in Central European meadow habitats. Additionally, it is a rodent species of great ecological function because of its aboveground and belowground activity within the ecosystem. The common vole is a model species with representative population cycles. Therefore understanding the various attributes of this species is very important for ecological studies.

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References

Adamczewska-Andrejewska K.A. 1981. Population structures of *Microtus arvalis* (Pall.) against the background of a community of rodents in crop fields. Pol. Ecol. Stud. **7:** 193–211.

Adamczewska-Andrejewska K.A. & Nabaglo L. 1977. Demographic parameters and variations in numbers of the common vole. Acta Theriol. **22:** 431–457.

Baláž I. 2010. The influence of the altitude on somatic characteristics size of common vole (*Microtus arvalis*) in Slovakia. Ekológia (Bratislava) **29:** 174–181. DOI: 10.4149/ekol_2010_02_174_

Birney E.C., Grant W.E. & Baird D.D. 1976. Importance of vegetative cover to cycles of *Microtus* populations. Ecology **57:** 1043–1051.

Briner T., Favre N., Nentwig W. & Airoldi J.P. 2007. Population dynamics of *Microtus arvalis* in a weed strip. Mammal. Biol. **72:** 106–115. DOI: 10.1016/j.mambio.2006.07.006

Butet A. 1996. Does food quality drive cycle in *Microtus arvalis*? Study on a french atlantic marsh population, pp. 177–188. In: Ecology & Behaviour, Proceedings of the European Congress of Mammalogy, Museu Bocage, Lisboa.

Cruz R., Santos S., Mira A., Monteiro A., Queiros F. & Mathias M.L. 2002. First record of the common vole *Microtus arvalis* (Pallas 1778) for Portugal. Mammalia **64:** 606–609.

Devevey G., Niculita-Hirzel H., Biollaz F., Yvon C., Chapuisat M. & Christe P. 2008. Developmental, metabolic and immunological costs of flea infestation in the common vole. Funct. Ecol. **22:** 1091–1098. DOI: 10.1111/j.1365–2435.2008.01493.x

Flousek J. 1990. Hraboš polní (*Microtus arvalis*) v subalpínském stupni Krkonoš. Opera Corcontica **27:** 149–156.

Gliwicz J. 1983. Age structure, pp. 111–117. In: Petrusewicz K. (ed.), Ecology of the Bank Vole, Acta Theriol. **28**.

Jánová E., Heroldová M. & Bryja J. 2008. Conspicuous demographic and individual changes in a population of the common vole in a set-aside alfalfa field. Ann. Zool. Fenn. **45:** 39–54.

Koshkina T.V. 1966. O periodicheskikh izmeneniyach chislennosti polevok (na primere Kolskogo poluostrova). Bjul. Mosk. Obshch. Izpyt. Prir. Biol. **71 (3):** 14–25.

Kratochvíl J. 1959. Hraboš polní *Microtus arvalis*. Nakladatelství Československé akademie věd, Praha, 357 pp.

Kratochvíl J. & Pelikán J. 1955. Zur Verbreitung der Feldmaus im Nationalpark der Hohen Tatra. Folia Zool. Entomol. **4:** 303–312.

Ligač S. 1975. Kvantitatívne zmeny v populáciách niektorých druhov drobných cicavcov Tríbča. Lynx (Praha), n. s. **16:** 31–36.

Mitchell-Jones A.J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P.J.H., Spitzenberger F., Stubbe M., Thissen J.B.M., Vohralík V. & Zima J. 1999. Atlas of European Mammals. The Academic Press, London, 495 pp.

Mošanský A. 1957. Príspevok k poznaniu rozšírenia a taxonometrie niektorých druhov drobných cicavcov na východnom Slovensku. Zborník Slovenského národného múzea, Prírodné vedy **3 (5):** 1–42.

Nabaglo L. 1981. Demographic processes in a confined population of the common vole. Acta Theriol. **26:** 163–183.

Niethammer J. & Krapp F. 1982. *Microtus arvalis* (Pallas 1779) – Feldmaus, pp. 282–318. In: Niethammer J. & Krapp F. (eds), Handbuch der Säugetiere Europas, Band 2/I Rodentia II, Akademische Verlagsgessellschaft, Wiesbaden.

Oli K.O. 1999. The chitty effect: A consequence of dynamic energy allocation in a fluctuating environment. Theor. Popul. Biol. **56:** 293–300. DOI: 10.1006/tpbi.1999.1427

Pelikán J. 1955. O stavu některých drobných ssavců ve Vysokých Tatrách na jaře 1955. Zool. Entomol. Listy **4 (4):** 295–302.

Pelikán J. 1966. Srovnání plodnosti čtyř druhů myšic rodu *Apodemus*. Zool. Listy **15 (2):** 125–130.

Pelikán J. 1982. *Microtus arvalis* on mown and unmown meadow. Československá akadémia věd, Praha, 36 pp.

Reichstein H. 1964. Untersuchungen zum Körperwachstum und zum Reproductionspotential der Feldmaus, *Microtus arvalis* (Pallas, 1779). Z. Wiss. Zool. **170:** 112–222.

Smith M.H. & McGinnis J.T. 1968. Relationships of latitude, altitude, and body size to litter size and mean annual production of offspring in *Peromyscus*. Res. Popul. Ecol. **10:** 115–126.

Stein G.H.W. 1953. ber das Zahlenverhältnis der Geschlechter bei der Feldmaus, *Microtus arvalis*. Zool. Jahrb. Syst. **82:** 137–156.

Uhlíková J. 2004. The common vole, *Microtus arvalis* (Mammalia: Rodentia) in subalpine and alpine habitats of the Krkonoše Mts (Czech Republic). Acta Soc. Zool. Bohem. **68:** 281–286.

Weihe W.H. 1965. Influence of altitude and cold on pregnancy and lactation of rats fed on two different diets. Int. J. Biometeor. **9 (1):** 43–52.

Zejda J., Zapletal M., Heroldová M. & Tkadlec E. 2004. Analýza časně jarního vzorku populace hraboša polního (*Microtus arvalis*). Lynx (Praha), n.s. **35:** 247–252.

Yoccoz N.G. & Mesnager S. 1998. Are alpine bank voles larger and more sexually dimorphic because adults survive better? Oikos **82:** 85–98.

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