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THE INFLUENCE OF THE ALTITUDE ON SOMATIC CHARACTERISTICS SIZE OF COMMON VOLE (*Microtus arvalis*) IN SLOVAKIA

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Abstract

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In the article we assess how the altitude influences the somatic characteristics values of *Microtus arvalis* (Pallas, 1779). The statistical set consists of 947 adult individuals from various parts of Slovakia (315 localities from 100 to 1500 m a.s.l.). The influence of conditions changes on biometry of somatic characteristics (body weight, body length, as well as tail, hind foot and ala auris length) was observed in 6 hypsographic levels: planar, hillock, sub-mountainous, mountainous, oreal, subalpine.

Key words: common vole, *Microtus arvalis*, hypsographic levels, somatometry

Introduction

The distribution range of the common vole, *Microtus arvalis* (P a l l a s , 1779), extends from the Atlantic coast of France to central Russia (Mitchel-Jones et al., 1999). The range is almost continuous with the exception of isolated populations in Iberia (Zima, 1999; Cruz et al., 2002). Twenty six subspecies are assumed to occur in Europe (Niethammer, Krapp, 1982). The status of most of them is questionable.

Microtus arvalis is typical inhabitant of cultural steppe that was expanded by agriculture. Even though it is steppe species, the results of Pelikán (1955) and Kratochvíl (1959) confirm that *M. arvalis* densely inhabits sparse wood vegetation (forest shelter-belts, newly forested areas etc.). Kratochvíl, Pelikán (1955) point out that common vole can be found in forest zone only in such localities where the ecological character of the forest was somehow disturbed. The species occur in sub alpine zone as well (Kratochvíl, Pelikán, 1955; Flousek, 1990; Uhlíková, 2004).

The aim of the article is to assess the influence of altitude on the changes of somatic characteristics biometry of the common vole (*M. arvalis*) that is the most abundant small mammal in Slovakia. The values of body measurements are changing according to various factors (latitude – Bergmann's rule; altitude), due to the season influence throughout the year (Dehnel phenomenon, mostly in shrew family) as well as during life (graded) cycles of small terrestrial mammals. In cyclic vole populations the body size of voles tends to vary with population density, voles being smaller in the decline and low density phases than in the peak phase of the cycle (Sundell, Norrdahl, 2002). Voles tend to be relatively large in the peak phase and small in the decline and low phases – Chitty effect (Chitty, 1952). Bergmann's rule states in its original version that warm-blooded vertebrate species from cooler climates tend to be larger than congeners from warmer climates and is a valid ecological generalization for birds and mammals (Meiri, Dayan, 2003). I was found out that over 72% of the birds and 65% of the mammal species follow Bergmann's rule. Ochocińska, Taylor (2003) concluded that shrews followed the converse to Bergmann's rule. The Dehnel phenomenon (1949) means the skulls of shrews shrinks significantly over the winter and expands again in the spring. It affects not only the brain, but also other major organs such as the liver and kidneys. This factor explains why such small animals can survive harsh winters with associated reduction in food availability.

Material and methods

Evaluated material of *Microtus arvalis* consists of 947 adult individuals (441 males, 506 females) caught between 1975 and 2007 (Research Unit Staré Hory, Administration of Landscape Protected Area Ponitrie, Department of Ecology and Environmental Sciences). Individuals were caught on 315 localities, 149 quadrates of Fauna databank in Slovakia network (DFS) and from 64 orographic units of Slovakia that range from 100 to 1500 meters above sea level (Fig. 1). Processed material was obtained during small terrestrial mammals random catchments in last 30 years. Despite the lack of *M. arvalis* individuals from some parts of Slovakia, we can regard evaluated material as representative because we obtained statistically demonstrative sample from every hypsographic level.

Common vole was caught into the bascule traps by line method (50 catching points in 10 meters distance). The traps were controlled in 24-hour intervals.

We observed following biometric data (body weight in grams, body length – LC, tail length – LCd, hind foot length – LTp, ala auris length – LA, all length in millimeters).

The influence of conditions change on the biometry of somatic characteristics and reproduction potential was evaluated in 6 hypsographic zones L – lowland (up to 200 m a.s.l.), H – hillock (200–400 m a.s.l.), SM – sub-mountainous (400–600 m a.s.l.), M – mountainous (600–800 m a.s.l.), O – oreal (800–1200 m a.s.l.), SA – subalpine (above 1200 m a.s.l.).

Biometric data were processed by descriptive statistics (mean value of monitored characteristics, modus, range of characteristics value – minimal and maximal value and size of statistical set – N). We determined the differences of mean values of monitored characteristics according to sex and age category. We used analysis of ANOVA variance to test the hypotheses and to confirm the statistical demonstrativeness of obtained results and differences.

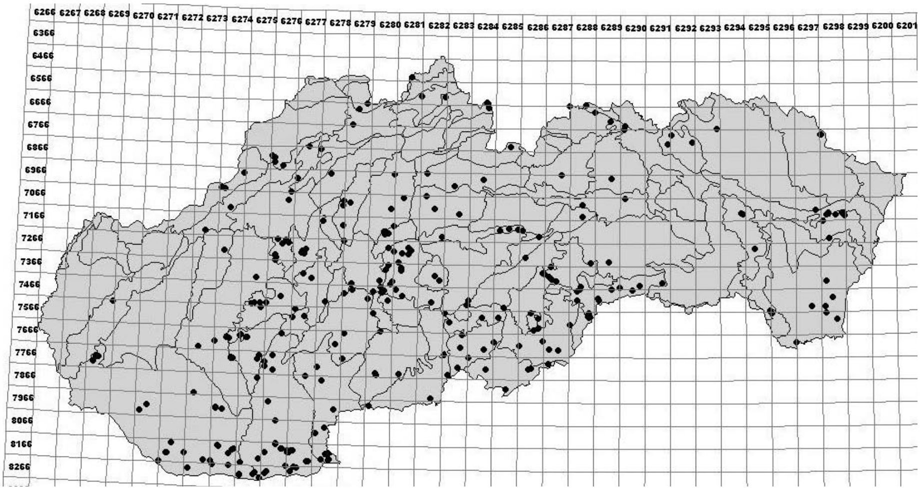

Fig. 1. Localities of *Microtus arvalis* catchments in Slovakia between 1975 and 2007 (localities illustrated in quadrates of Fauna databank of Slovakia with delimitation of geomorphologic units).

Results and discussion

Somatic characteristics of Microtus arvalis populations in Slovakia

The somatic characteristics, body length, tail length and weight especially, are not stable characteristics, but are considerably variable. They depend on geographic location, population, but also from cycle phase, in which the population occur (Adamczewska-Andrejewska, Nabaglo, 1977; Mošanský, 1957). The dependency of body length on sexual activity of individuals was also proved. We assessed the size of somatic characteristics and the weight of adult common voles using statistics (descriptive statistics) (Table 1).

The highest variability was confirmed in weight and the lowest variability was determined in hind foot length. The foot length is most stable somatic characteristics and thus it is important in the light of species determination. The hind foot length is important taxonomic characteristics of *M. arvalis* species that is considerably stable during the life (it is statistically proved that this attribute does not change since sub adult age). Using Anova test to test the somatic characteristics we did not prove any statistically significant differences between males and females. Males have larger all monitored somatic characteristics with ala auris length exemption, that is statistically indemonstrably larger in females.

T a b l e 1. Somatic characteristics of *Microtus arvalis* (adult individuals summary and males and females specially).

Group	Somatic characteristics	N	sh ± SO	Range
Adult individuals M+F	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
	foot length (mm)	682	15.94 ± 0.94	14 – 19
	ala auris length (mm)	172	11.09 ± 1.11	9 – 13
From that:				
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
	foot length (mm)	332	16.15 ± 0.95	14 – 19
	ala auris 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
	foot length (mm)	350	15.75 ± 0.89	14 – 19
	ala auris length (mm)	87	11.19 ± 1.13	9 – 13

Notes: N – number of individuals, SH – mean value, SO – standard deviation, M – males, F – females.

The changes of Microtus arvalis somatic characteristics with altitude increase

The body measurements and weight of wild animals vary according to various environmental factors. The clinal change of body measurements and weight in dependency of continental location and altitude for several small terrestrial mammals is documented. The highest influence on somatic characteristics changes have climatic factors, mainly temperature, that change in horizontal and vertical direction. High altitudes are usually colder than low altitudes, so individuals living at high altitudes generally have increased energy demands and energy intake (Hammond et al., 2001).

We monitored and statistically evaluated the changes of somatic characteristics with the altitude increase in 6 hypsographic levels in Slovakia (from 100 m a.s.l. to 1500 m a.s.l.). We found out the changes that are statistically proved for all monitored characteristics. We proved indirect proportion between somatic characteristics values and altitude as with altitude increase the decrease of average values of monitored somatic characteristics and weight occur (Figs 2–6).

In the case of weight (Fig. 2) and body length (Fig. 3) the average values in hypsographic levels are variable, but the change (decrease of weight and body length) with altitude is not clinal. Despite the fact that trend curve indicates the values decrease in the higher hypsographic levels direction. Using ANOVA test we found out statistically proved difference (P = 0.0067) of body length mean values between lowland and sub alpine level individuals.

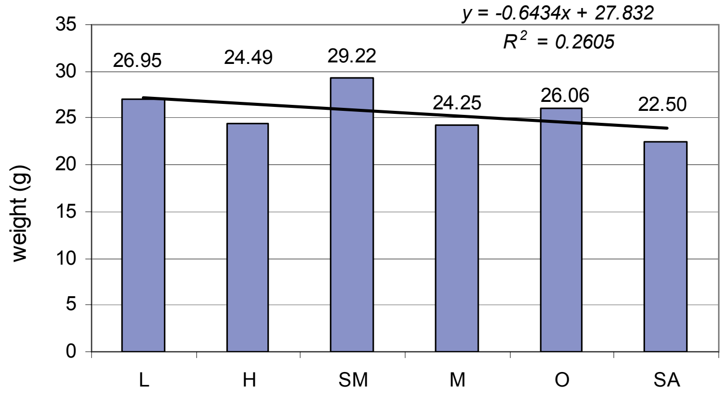

Fig. 2. The average weights of adult voles in various hypsographic levels in Slovakia (L – lowland, H – hillock, SM – sub-mountainous, M – mountainous, O – oreal, SA – subalpine).

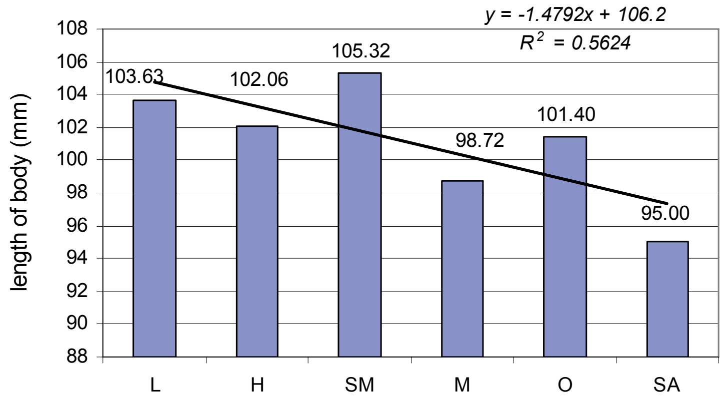

Fig. 3. The average body lengths of adult voles in various hypsographic levels in Slovakia (abbreviations see in Fig. 2).

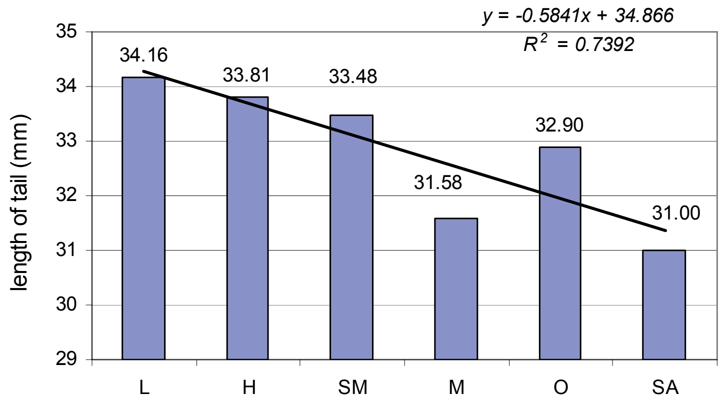

Fig. 4. The average tail lengths of adult voles in various hypsographic levels in Slovakia (abbreviations see in Fig. 2).

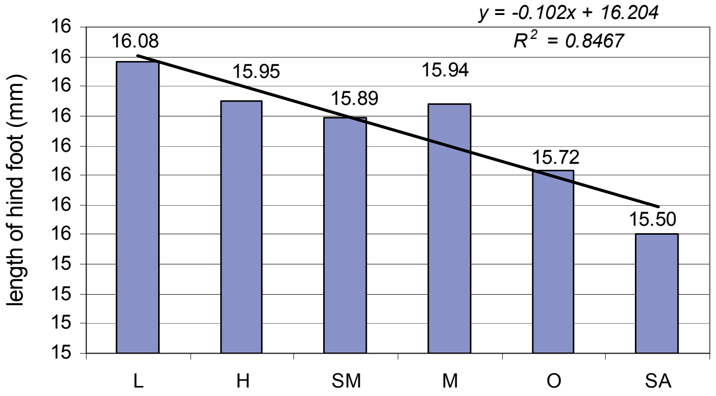

Fig. 5. The average hind foot lengths of adult voles in various hypsographic levels in Slovakia (abbreviations see in Fig. 2).

The body weight with the altitude increase does not change significantly, even thou it decreases. But the decrease is not statistically proved. As the body length decreases significantly (statistically proved) with altitude increase we can state that in higher hypsographic levels the individuals of common vole are smaller, but stouter (with thicker layer of subdermal fat as the protection against low temperatures). They have higher weight in proportion to body that is important as better thermal insulation and protection from more extreme conditions in oreal and subalpine level (mainly from lower temperature). The temperature decreases with altitude as well as latitude. Both factors have fundamental influence on anatomic–morphologic and physiologic processes and adaptations connected to them. In the frame of determined changes we can apply Bergmann's rule even though in limited degree. With the altitude increase and thus temperature decrease we recorded body length decrease, but stable weight.

Te decrease of other somatic characteristics (length of tail, hind foot and ala auris) is gradual with the altitude increase (Figs 4–6). The differences in tail length and hind foot length values between exemplars from lowland and sub alpine level are statistically highly proved (P values are as follows: tail length $8.77.10^{-7}$, hind foot length 0.00113). The differences in ala auris length between the lowest and highest hypsographic zones are not proved (P = 0.3564).

When we assessed end body parts (tail, hind foot and ala auris lengths) we confirmed the validity of Allen's rule as their values drop with altitude increase.

We determined the drop of all somatic characteristics and weight of *M. arvalis* from lowland to sub alpine level by realized statistical analyses. We recorded negative correlation between monitored characteristics values of common vole and altitude. We can state direct dependence between average somatic characteristics values and temperature (with average temperature drop the body measurements and weight decrease). The changes of somatic characteristics in various hypsographic zones were assessed by Baláž, Ambros (2005, 2006) for *Sorex araneus* and *S. minutus* species. They declare that body measurements of shrews increase with altitude.

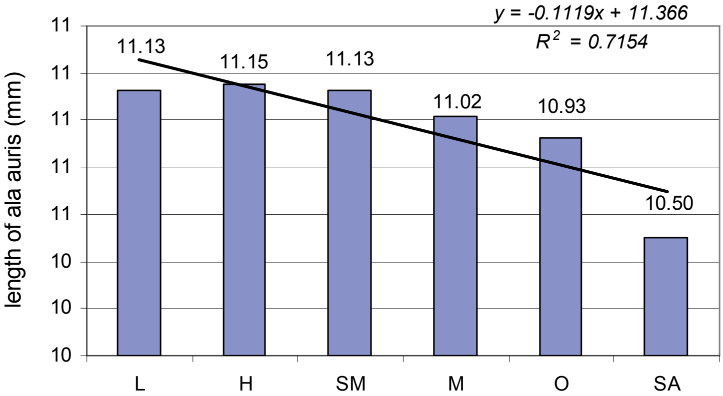

Fig. 6. The average ala auris lengths of adult voles in various hypsographic levels in Slovakia (abbreviations see in Fig. 2).

On the basis of our discoveries we can apply classic ecological rules (Bergmann's and Allen's rules), even though these are valid with some limitations as they are applicable to larger latitudes (in latitude direction, not in altitude direction) and for species within related genus. Allen's Rule is the biological rule described by Joel Asaph Allen in 1877 and documents a century-old biological observation that strong positive correlations exist among latitude, ambient temperature, and limb length in mammals. Although genetic selection for thermoregulatory adaptation is frequently presumed to be the primary basis of this phenomenon, important but frequently overlooked research has shown that appendage outgrowth is also markedly influenced by environmental temperature (Serrat et al., 2008).

Conclusion

In our article we assessed the influence of altitude on somatic characteristic values of *Microtus arvalis* (Pallas, 1779). The material of common vole consists of 947 adults from various parts of Slovakia (315 localities, from 100 to 1500 m a.s.l.). The influence of conditions changes on biometry of somatic characteristics (weight, body length, and tail, hind foot, ala auris lengths) was observed in 6 hypsographic levels: planar, hillock, sub- mountainous, mountainous, oreal, subalpine).

We figured out the decrease of all monitored characteristics with altitude increase. The demonstrativeness of results was tested by ANOVA test and only in the case of weight and ala auris length we found out non-significant difference. The temperature has the highest influence on somatic characteristics that decrease with altitude increase as well as values of monitored somatic characteristics. We confirmed indirect dependency between somatic characteristics values and altitude, but direct dependency between these characteristics and temperature. In higher hypsographic levels the *M. arvalis* individuals´ bodies are shorter, but the weight is not changed significantly (in comparison with lower levels). That means they are smaller, but stouter (and that is adaptation on conditions with lower temperatures).

Translated by author

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