WINTER GROWTH DEPRESSION OF COMMON VOLE (*MICROTUS ARVALIS*)

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Abstract. In 573 individuals of common voles (*Microtus arvalis*) trapped in northeastern Lithuania from October to April in 2004–2009, growth depression for the juveniles of this species was observed in January–February, while for subadults in January–March. Growth depression was strongest in subadult voles. In harsh winters, subadults were smaller than in mild winters, whereas juveniles were larger. Growth depression was more pronounced and of longer duration in skull characters than in body mass. Cranial growth in *M. arvalis* was more inhibited than in *Myodes glareolus*. In winter and early spring, the juveniles of *M. arvalis* had the average body mass of 14.5 ± 0.07 g and the average body length of 81.6 ± 0.24 mm, whereas subadults 18.1 ± 0.27 g and 89.2 ± 0.70 mm, respectively. Body mass in juveniles from October to April grew by 1.0 g, whereas in subadults decreased by 2.0 g. Our main finding is that despite global climate warming tendencies growth depression in small mammals still occurs during the cold period.
Key words: *Microtus arvalis*, winter period, body mass decrease, cranial growth depression

INTRODUCTION

Seasonal variations in the growth rates of insectivores and small rodents were the subject of numerous studies from the seventh to the ninth decade of the past century (Pucek & Markov 1964; Kubik 1965; Pucek 1970; Brown 1973; Iverson & Turner 1974; Peterborg 1978; Pistole & Cranford 1983). It was shown that bank vole (*Clethrionomys* (= *Myodes*) *glareolus*) and meadow vole (*Microtus pennsylvanicus*) born in late autumn had a two-phase growth pattern. They grew rapidly until winter and then resumed rapid growth the following spring (Kubik 1965; Iverson & Turner 1974). Adult as compared to subadult individuals of *M. pennsylvanicus* were more vulnerable to unfavourable conditions in winter as they lost weight (Iverson & Turner 1974), whereas subadults continued to growth in winter, but at a significantly slower rate than in summer (Pistole & Cranford 1983).

In relation to apparently warmer winters in the Baltic over recent years (Stroch *et al.* 2008), we investigated if the peculiarities of small mammal growth described some decades ago, when winter conditions were more severe, have changed.

In this study, we tried to find out if common voles (*Microtus arvalis*) in the cold period really become smaller by losing body mass and if any changes occur in craniometrical features (if so what features are affected).

We also looked for the most depressed age group and aimed to determine if growth depression depends on winter harshness.

MATERIAL AND METHODS

The material was collected near Lake Ilgelis, Zarasai district, northeastern Lithuania (see map in Balčiauskas & Gudaitė 2006). A standard method of snap-trap lines was used with 25 to 50 traps for 1–3 nights (Balčiauskas 2004). The trapping of small mammals from October to April in 2004–2009 depended on weather conditions and on the start or end of the vegetative period. Winter weather was assessed using data from the nearest meteorological stations in Zarasai and Utena (LHS 2009). In the first two years of investigation started in 2004, negative average monthly temperatures were recorded in December, January, February and March. The negative temperatures in the last three winters were short-lived and lasted only one month in 2006/2007 and 2007/2008 or two months in 2008/2009 (Fig. 1). Thus, we defined the first two winters as colder and the last three as milder ones.

A total of 573 common vole (*Microtus arvalis*) individuals were trapped (Table 1). After weighing and measuring, the voles were dissected and divided into three age categories: juveniles, subadults and adults,
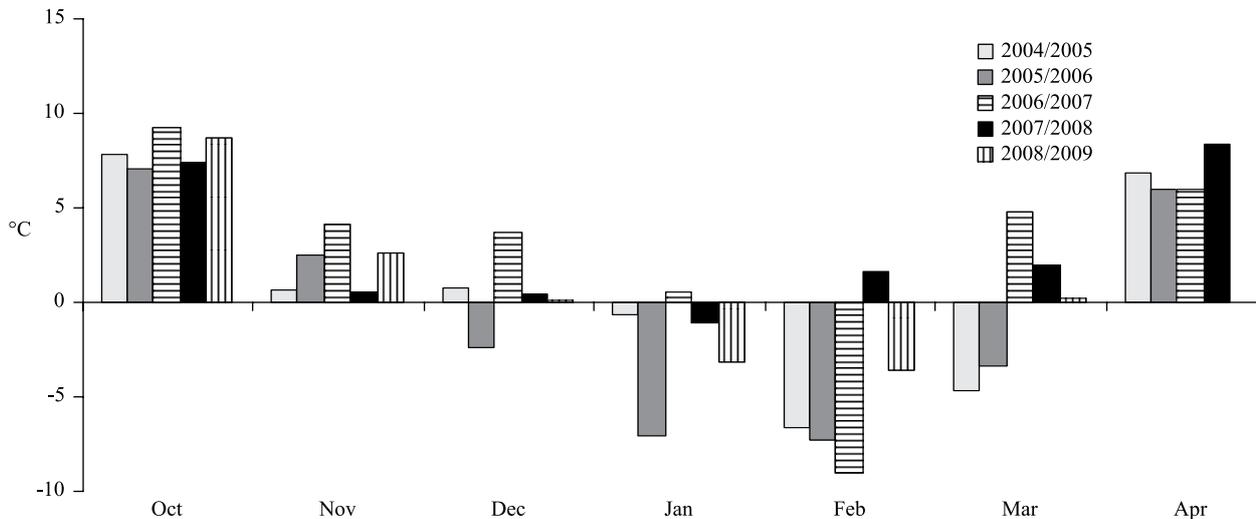
Figure 1. Average monthly temperatures for the study period (2004–2009).

based on their reproductive status and the presence of *gl. thymus* (Balčiauskas 2005). Immature individuals were characterised by a closed vagina, thread-like uterus or hardly visible abdominal testes. Subadult animals had developed, but inactive reproductive organs – small nipples and a closed vagina in females and abdominal testes in males. Adult animals (overwintered, scrotal testes, pregnancy, open or plugged vagina) were present in too low numbers for analysis of growth.

Skulls were cleaned with *Dermestes* larvae. To evaluate cranial growth, we used 17 skull characters (Balčiauskienė 2006, 2007) measured under a binocular with a micrometric eyepiece with an accuracy of up to 0.1 mm.

The following skull characters (eight mandibular and nine maxillary) were measured: X_1 – total length of mandibula at *processus articularis*, excluding incisors; X_2 – length of mandibula, excluding incisors; X_3 – height of mandibula at, and including, the first molar; X_4 – maximum height of mandibula, excluding coronoid process; X_5 – coronoid height of mandibula; X_6 – length of mandibular diastema; X_7 – length of mandibular tooth row; X_8 – length of molar M_1; X_9 – length of *nasalia*; X_{10} – breadth of braincase measured in the widest part; X_{11} – zygomatic skull width; X_{12} – length of cranial (upper) diastema; X_{13} – zygomatic arc length; X_{14} – length

of *foramen incisivum*; X_{15} – length of maxillary tooth row; X_{16} – length of molar M^1; X_{17} – incisor width across both upper incisors (Balčiauskienė 2006, 2007).

RESULTS

A total of over one and a half thousand small mammals were trapped in October–April of 2004–2009, with *M. arvalis* constituting about 35% of the total number of the animals caught. This portion was smallest in harsh winters, accounting for 23.8%, and largest in mild winters, reaching 37.5% (Table 1).

At the beginning of the cold season, the share of *M. arvalis* in a small mammal community was smallest, reaching 20 to 30%. Towards spring, the number of these animals increased, constituting over 60% of all small mammals trapped (Table 2). This may be because the overwintering or survival rate for this species in the study area was better than for other small mammals.

The investigated population of *M. arvalis* was male-biased (Table 1), females on average comprised 45.8%. In the third year of the study, females surpassed males, accounting for over 55%, but this was not statistically significant. The female share was smallest during the first (32%, NS) and last winter (38%, $\chi^2 = 4.29$, $p < 0.05$).

Table 1. Share, age and sex composition of *M. arvalis* in 2004–2009 (October–April).

Year	Total trapped, N	*M. arvalis*, n / %	Juveniles	Subadults	Adults	Males	Females
2004/2005	118	28 / 23.7	1	2	25	19	9
2005/2006	218	52 / 23.9	6	19	27	29	23
2006/2007	385	165 / 42.9	144	18	3	74	91
2007/2008	447	143 / 32.0	96	15	32	74	68
2008/2009	483	185 / 38.3	137	27	13	109	68
Total	1,651	573 / 34.7	381	81	100	304	257

Table 2. Monthly shares of *M. arvalis* in 2004–2009 (October–April).

Month	Total caught, N	*M. arvalis*, n	*M. arvalis*, %
October	201	58	28.9
November	356	48	13.5
December	409	117	28.6
January	226	97	42.9
February	171	56	32.7
March	92	53	57.6
April	193	144	74.6

Significant differences were found in the age structure of *M. arvalis*. In harsh winters, adult voles dominated in the population, constituting about 50 to 90% of all trapped voles. By contrast, in mild winters juveniles prevailed, comprising about 70 to 90% of the animals trapped (Table 1). These differences in the population structure in harsh and mild winters were highly significant ($\chi^2 = 12.6$ and over, $p < 0.001$).

The monthly dynamics of the population age structure show the prevalence of juvenile individuals at the beginning of the cold period. The subadult share started to increase in February. Maturation continued until March – from this month onwards the share of adult voles increased (Fig. 2).

In juvenile *M. arvalis*, a slow increase in the average body mass from November to January was followed by a decrease in February. In October, the average body mass was 14.1 g and by April it increased by only 1 g. Thus, the growth was very slow. A decrease in the average body length was observed one month earlier, in January. In March, juvenile voles resumed growth (Table 3).

For subadults, the November data should be disregarded because of small sample size (one individual). Growth depression in the voles of this age group was longer and continued in February and March. Growth resumption was observed in April, though from October to April subadult voles on average lost 11% of body mass (Table 3).

Data on the skull growth of juvenile *M. arvalis* are presented in Table 4. It shows that cranial growth in the cold period is subjected to various patterns. For example, the growth of some characters stopped, no changes were found in the average length of the mandibula over the period of three months, December, January and February, the average breadth of the braincase in the widest part decreased over the period of two months, January and February, while the coronoid height of the mandibula increased from November to January, then in February its average length was smaller (Fig. 3).

The stunting of skull growth in subadult *M. arvalis* was more pronounced than in juveniles (Table 5). With

Table 3. Monthly averages of body mass (Q, g) and length (L, mm) in *M. arvalis* in 2004–2009.

Month	Juv			Sub			Ad		
	N	Q	L	N	Q	L	N	Q	L
Oct	55	14.1 ± 0.17	77.2 ± 0.49	3	20.1 ± 1.05	89.7 ± 1.51	–	–	–
Nov	34	14.5 ± 0.22	80.8 ± 0.62	1	16.5	83.1	13	22.2 ± 0.99	95.4 ± 3.09
Dec	94	14.3 ± 0.14	82.5 ± 0.48	12	17.7 ± 0.93	91.4 ± 2.16	–	–	–
Jan	86	14.7 ± 0.12	81.6 ± 0.46	8	19.3 ± 1.05	95.0 ± 3.55	–	–	–
Feb	44	14.4 ± 0.29	82.9 ± 0.81	10	18.3 ± 0.79	89.8 ± 1.83	2	20.8 ± 1.25	93.5 ± 0.95
Mar	25	14.9 ± 0.27	83.7 ± 0.81	12	17.4 ± 0.63	86.6 ± 1.12	16	21.4 ± 0.69	94.3 ± 1.71
Apr	40	15.1 ± 0.20	83.4 ± 0.66	35	17.9 ± 0.34	87.9 ± 0.87	69	22.9 ± 0.47	95.3 ± 0.73
Average	378	14.5 ± 0.07	81.6 ± 0.24	81	18.1 ± 0.27	89.2 ± 0.70	100	22.5 ± 0.37	95.1 ± 0.65
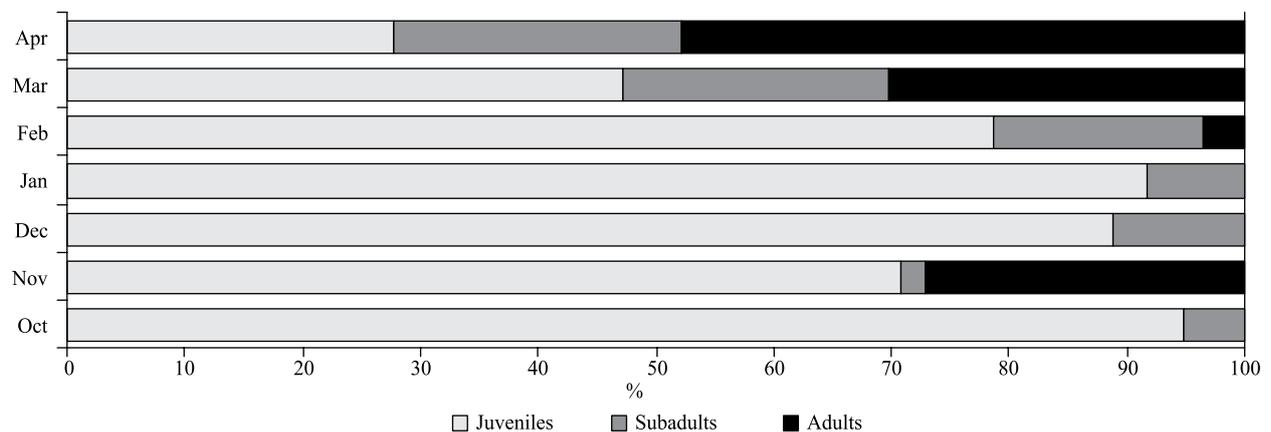
Figure 2. Dynamics of the age structure of the *M. arvalis* population in 2004–2009 (October–April).

Table 4. Growth dynamics of skull characters (mm) in juvenile *M. arvalis* in 2004–2009 (October–April).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr
X_1	11.4 ± 0.06	11.5 ± 0.08	11.6 ± 0.05	11.7 ± 0.05	11.7 ± 0.06	11.8 ± 0.07	11.7 ± 0.07
X_2	10.9 ± 0.07	11.2 ± 0.08	11.2 ± 0.05	11.3 ± 0.05	11.3 ± 0.06	11.4 ± 0.09	11.2 ± 0.05
X_3	4.5 ± 0.03	4.6 ± 0.03	4.7 ± 0.02	4.7 ± 0.02	4.7 ± 0.03	4.8 ± 0.03	4.8 ± 0.03
X_4	5.8 ± 0.04	5.9 ± 0.04	6.0 ± 0.03	6.0 ± 0.03	6.1 ± 0.04	6.1 ± 0.04	6.0 ± 0.05
X_5	6.3 ± 0.04	6.4 ± 0.04	6.4 ± 0.03	6.5±0.03	6.4 ± 0.03	6.4 ± 0.04	6.4 ± 0.05
X_6	3.1 ± 0.02	3.1 ± 0.02	3.1 ± 0.02	3.1 ± 0.02	3.1 ± 0.02	3.1 ± 0.03	3.1 ± 0.02
X_7	4.7 ± 0.03	4.8 ± 0.03	4.8 ± 0.02	4.8 ± 0.02	4.8 ± 0.02	4.9 ± 0.04	4.8 ± 0.03
X_8	2.5 ± 0.01	2.5 ± 0.01	2.5 ± 0.01	2.5 ± 0.01	2.5 ± 0.01	2.5 ± 0.02	2.5 ± 0.01
X^9	5.4 ± 0.04	5.3 ± 0.05	5.5 ± 0.03	5.6 ± 0.03	5.5 ± 0.03	5.3 ± 0.05	5.4 ± 0.04
X^{10}	9.6 ± 0.05	9.6 ± 0.08	9.6 ± 0.05	9.6 ± 0.03	9.6 ± 0.05	9.7 ± 0.06	9.5 ± 0.04
X^{11}	11.5 ± 0.06	11.9 ± 0.07	11.9 ± 0.05	12.1 ± 0.04	12.1 ± 0.06	12.0 ± 0.06	12.1 ± 0.05
X^{12}	6.1 ± 0.04	6.2 ± 0.03	6.3 ± 0.03	6.4 ± 0.03	6.4 ± 0.04	6.4 ± 0.04	6.4 ± 0.05
X^{13}	6.9 ± 0.06	7.2 ± 0.06	7.2 ± 0.03	7.3 ± 0.04	7.2 ± 0.06	7.2 ± 0.07	7.4 ± 0.07
X^{14}	3.7 ± 0.06	3.7 ± 0.03	3.8 ± 0.02	3.8 ± 0.02	3.8 ± 0.03	3.7 ± 0.04	3.9 ± 0.03
X^{15}	5.4 ± 0.02	5.5 ± 0.03	5.5 ± 0.02	5.5 ± 0.02	5.5 ± 0.03	5.5 ± 0.04	5.5 ± 0.03
X^{16}	1.8 ± 0.01	1.8 ± 0.01	1.9 ± 0.01	1.9 ± 0.01	1.9 ± 0.01	1.9 ± 0.02	1.8 ± 0.01
X^{17}	2.3 ± 0.01	2.3 ± 0.01	2.3 ± 0.02	2.4 ± 0.01	2.4 ± 0.01	2.4 ± 0.02	2.3 ± 0.04
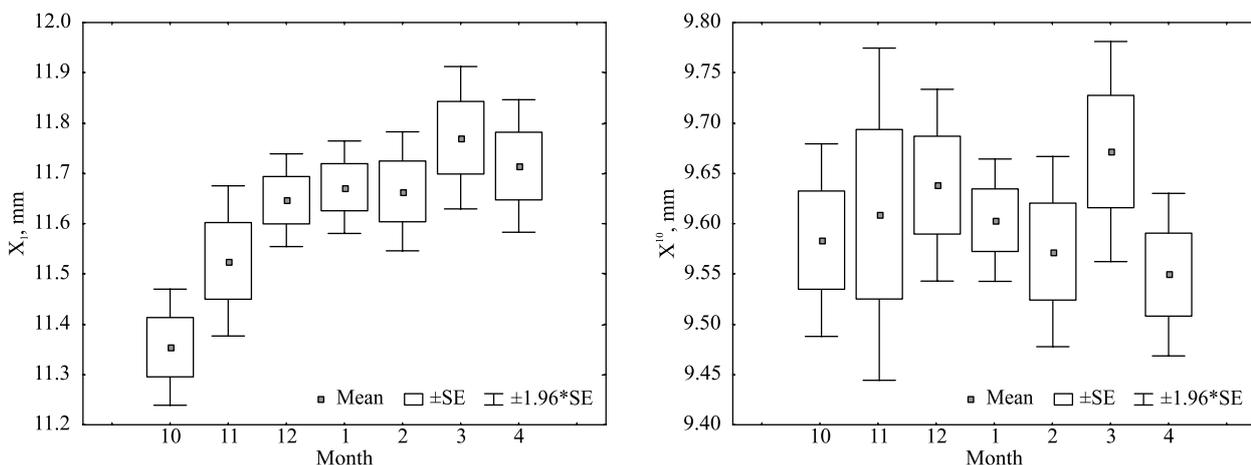
Figure 3. Growth dynamics of X_1 – total length of mandibula at *processus articularis*, excluding incisors, and X^{10} – breadth of braincase measured in the widest part in juvenile *M. arvalis* in 2004–2009 (October–April).

regard to mandibular length, it started one month later, in January, continued in February and March and was statistically significant (January–March, $t = 5.0$, $p < 0.001$). Growth decrease in the length of the mandibular tooth row was stunted in January, February, March and April, which is a longer period than for other characters (Fig. 4). Growth depression of X^{15} – the length of the maxillary tooth row – was also long.

Comparison of the growth of *M. arvalis* in harsh and mild winter periods revealed that juvenile voles were larger in harsh than in mild winters. Their body mass (15.6 ± 0.68 g and 14.5 ± 0.07 g, respectively, $p < 0.05$) and length (87.7 ± 2.36 mm and 81.5 ± 0.24 mm, respectively, $p < 0.01$) differed significantly, a few cranial characters differed at a near significant level, whereas most other cranial characters showed no significant differences (Table 6). Possibly, small sample size may have contributed to the results obtained – only seven

juveniles were trapped during harsh winters.

Subadult voles in harsh winters exhibited a stronger growth depression. In mild winters, the average body mass of subadult *M. arvalis* was 18.5 ± 0.33 g and body length 89.8 ± 0.88 mm, whereas in harsh winters, 16.9 ± 0.29 g and 87.4 ± 0.95 mm, respectively. The average body mass was significantly smaller ($p < 0.01$), as well as two cranial characters, while most other cranial characters tended to be smaller without statistical significance (Table 7).

Discussion

It was shown on various small mammal species that there are differences in their growth in warm and cold periods. Analysis of the data on the variability of craniometric features allowed to conclude that seasonal changes in

Table 5. Growth dynamics of skull characters (mm) in subadult *M. arvalis* in 2004–2009 (October–April).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr
X_1	12.0 ± 0.32	12.1	12.2 ± 0.20	12.4 ± 0.19	12.1 ± 0.13	11.5 ± 0.07	11.9 ± 0.08
X_2	11.8 ± 0.28	11.8	11.7 ± 0.15	11.8 ± 0.09	11.5 ± 0.13	11.2 ± 0.10	11.4 ± 0.08
X_3	4.7 ± 0.23	4.7	4.9 ± 0.14	5.1 ± 0.11	5.0 ± 0.06	4.8 ± 0.04	4.9 ± 0.03
X_4	6.3 ± 0.09	6.3	6.4 ± 0.15	6.4 ± 0.11	6.1 ± 0.13	6.0 ± 0.04	6.1 ± 0.04
X_5	6.5 ± 0.18	6.4	6.8 ± 0.14	6.9 ± 0.06	6.5 ± 0.12	6.5 ± 0.07	6.6 ± 0.04
X_6	3.1 ± 0.14	3.2	3.1 ± 0.04	3.3 ± 0.08	3.2 ± 0.04	3.2 ± 0.04	3.2 ± 0.02
X_7	4.8	5.0	5.0 ± 0.05	5.0 ± 0.06	4.9 ± 0.05	4.9 ± 0.05	4.8 ± 0.03
X_8	2.5	2.5	2.6 ± 0.03	2.6 ± 0.04	2.5 ± 0.02	2.5 ± 0.02	2.5 ± 0.02
X^9	5.9 ± 0.05	5.7	5.6 ± 0.12	6.0 ± 0.14	5.8 ± 0.05	5.7 ± 0.10	5.7 ± 0.04
X^{10}	9.8		9.6 ± 0.17	9.5 ± 0.23	9.6 ± 0.10	9.7 ± 0.08	9.6 ± 0.05
X^{11}	12.5 ± 0.46		12.2 ± 0.09	12.4 ± 0.27	12.4 ± 0.09	12.1 ± 0.10	12.4 ± 0.08
X^{12}	6.9 ± 0.14		6.5 ± 0.11	6.8 ± 0.13	6.5 ± 0.08	6.5 ± 0.08	6.5 ± 0.04
X^{13}	7.1 ± 0.28		7.6 ± 0.10	7.4 ± 0.07	7.4 ± 0.09	7.4 ± 0.07	7.5 ± 0.07
X^{14}	4.0 ± 0.11	3.9	4.1 ± 0.07	4.1 ± 0.06	4.0 ± 0.06	3.8 ± 0.07	3.9 ± 0.03
X^{15}	5.4 ± 0.09	5.6	5.6 ± 0.03	5.7 ± 0.06	5.6 ± 0.04	5.5 ± 0.06	5.5 ± 0.04
X^{16}	1.8	1.7	1.9 ± 0.03	1.9 ± 0.04	1.9 ± 0.04	1.9 ± 0.03	1.9 ± 0.01
X^{17}	2.5 ± 0.09	2.3	2.4 ± 0.03	2.5 ± 0.04	2.4 ± 0.02	2.4 ± 0.02	2.4 ± 0.02
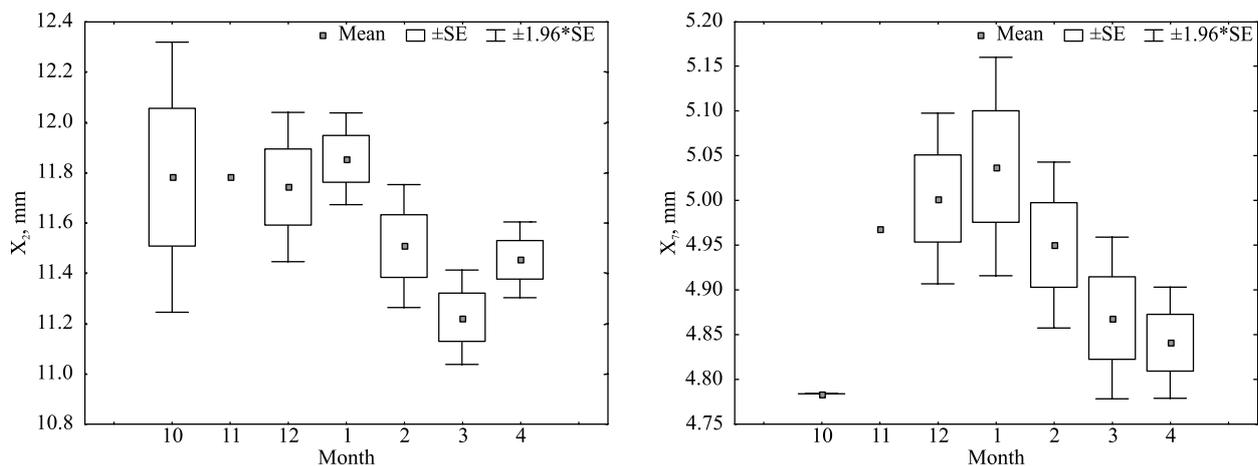
Figure 4. Growth dynamics of X_2 – length of mandibula, excluding incisors, and X_7 – length of mandibular tooth row in subadult *M. arvalis* in 2004–2009 (October–April).

brain size accompanied by changes in the capacity of the cranium capsule might be considered as a general pattern for a large group of palearctic and nonarctic species of small mammals. The regression is less pronounced in voles than in shrews. Winter depression in shrews was investigated first (Pucek & Markov 1964; Pucek 1970). In overwintered shrews, brain weight never reaches the value inherent in young animals before winter regression (Airoldi & Hoffmann 1984).

In narrow-headed vole (*Microtus gregalis*), the average age of initial reproductive activity depends on the date of birth and there is a seasonal variation in body mass, which differs in successive generations. In root vole (*Microtus oeconomus*), there is a significant difference in the weight of the crystalline lens in specimens of the same age born in spring or at the end of summer (Pokrovski 1971). In *M. pennsylvanicus*, animals born in the middle to late summer stopped growing in the fall and resumed growth in spring; they maintained weight throughout the Minnesota winter (Brown 1973). In contrast, individuals of the same species under more severe winter conditions typical of Manitoba lost considerable weight during mid-winter before beginning to gain again in February (Iverson & Turner 1974).

Growth stunting mainly occurs in the cold period, but there may be various factors involved in this phenomenon. Frank and Zimmermann (1957) considered that for *M. arvalis* the variability in growth is so important in all age classes that age determination based on morphological characters is impossible. Martinet and Spitz (1971) pointed out the influence of the photoperiod and the quality of food on the growth of *M. arvalis*, while other authors recorded a reduced growth rate in *M. pennsylvanicus* under a short photoperiod (Pistole & Cranford 1983; Dark & Zucker 1983; Donham *et al.* 1989).

Daketse and Martinet (1977) noted for *M. arvalis* a decrease in body growth and fertility with increasing tem-

Table 6. Cranial measurements in juvenile *M. arvalis* in 2004–2009, depending on winter harshness.

	df	Harsh winter		Mild winter	
		Avg ± SE	Min–max	Avg ± SE	Min–max
X_1	300	11.7 ± 0.08	11.4–12.0	11.6 ± 0.02	10.2–12.9
X_2	249	11.5 ± 0.12	11.3–11.9	11.2 ± 0.03*	9.9–12.5
X_3	365	4.8 ± 0.06	4.6–5.0	4.7 ± 0.01*	4.0–5.2
X_4	259	6.1 ± 0.09	5.9–6.3	6.0 ± 0.02	5.2–6.7
X_5	267	6.5 ± 0.04	6.4–6.6	6.4 ± 0.01	5.7–7.1
X_6	363	3.0 ± 0.05	2.9–3.2	3.1 ± 0.01	2.8–4.1
X_7	368	4.9 ± 0.05	4.7–5.0	4.8 ± 0.01	4.2–5.3
X_8	368	2.5 ± 0.04	2.3–2.6	2.5 ± 0.00	2.2–2.8
X^9	337	5.7 ± 0.14	5.3–6.3	5.5 ± 0.01**	4.7–6.2
X^{10}	149	9.6 ± 0.23	9.4–9.8	9.6 ± 0.02	8.9–10.3
X^{11}	233	12.1 ± 0.06	12.0–12.2	11.9 ± 0.02	10.8–13.8
X^{12}	339	6.4 ± 0.10	6.1–6.8	6.3 ± 0.02	5.5–7.2
X^{13}	206	7.4 ± 0.09	7.3–7.5	7.2 ± 0.02	6.3–7.9
X^{14}	340	3.9 ± 0.07	3.7–4.1	3.8 ± 0.01	3.4–6.1
X^{15}	353	5.6 ± 0.10	5.2–5.9	5.5 ± 0.01*	5.0–6.0
X^{16}	367	1.9 ± 0.05	1.7–2.0	1.9 ± 0.00	0.9–2.2
X^{17}	367	2.4 ± 0.01	2.3–2.4	2.3 ± 0.01	0.6–2.7

*Note: significant differences are indicated by * – p < 0.10, ** – p < 0.05*

Table 7. Cranial measurements in subadult *M. arvalis* in 2004–2009, depending on winter harshness.

	df	Harsh winter		Mild winter	
		Avg ± SE	Min–max	Avg ± SE	Min–max
X_1	61	11.8 ± 0.07	11.4–12.4	12.0 ± 0.08	10.9–13.3
X_2	54	11.3 ± 0.10	10.7–12.0	11.6 ± 0.06**	10.8–12.4
X_3	76	4.8 ± 0.05	4.4–5.3	4.9 ± 0.04	4.4–5.7
X_4	55	6.1 ± 0.04	5.9–6.4	6.2 ± 0.04	5.4–7.2
X_5	57	6.5 ± 0.06	6.2–6.8	6.6 ± 0.05	6.1–7.8
X_6	76	3.1 ± 0.02	2.9–3.3	3.2 ± 0.02	2.9–3.5
X_7	76	4.9 ± 0.04	4.5–5.2	4.9 ± 0.02	4.4–5.2
X_8	76	2.5 ± 0.02	2.3–2.8	2.5 ± 0.01	2.4–2.8
X^9	76	5.7 ± 0.06	5.3–6.3	5.7 ± 0.04	5.1–6.6
X^{10}	34	9.6 ± 0.07	9.2–9.9	9.6 ± 0.04	9.0–9.9
X^{11}	53	12.1 ± 0.06	11.6–12.5	12.4 ± 0.06***	11.7–13.7
X^{12}	72	6.5 ± 0.04	6.0–6.8	6.6 ± 0.04	5.9–7.5
X^{13}	51	7.5 ± 0.06	7.1–7.8	7.4 ± 0.05	6.8–8.2
X^{14}	74	3.9 ± 0.04	3.6–4.5	3.9 ± 0.03	3.4–4.4
X^{15}	73	5.6 ± 0.03	5.3–6.0	5.6 ± 0.03	5.2–5.9
X^{16}	77	1.9 ± 0.02	1.7–2.1	1.9 ± 0.01	1.7–2.2
X^{17}	77	2.4 ± 0.02	2.2–2.6	2.4 ± 0.01	2.2–2.7

*Note: significant differences are indicated by * – p < 0.10, ** – p < 0.05, *** – p < 0.005*

perature. The largest and most fertile animals were those raised at low temperatures under long-day conditions and fed with alfalfa harvested in spring. Lidicker (1973) found that the period of reduced or suspended growth in California vole (*Microtus californicus*) was not winter in the Mediterranean climate of coastal California, but rather a dry season, usually June through October, under field conditions. Winter weight reduction in juveniles was found in taiga vole (*Microtus xanthognathus*) in central Alaska, which allowed to interpret the phenomenon as a means of reducing food requirements (Wolff & Lidicker 1980). Another explanation for body mass reduction in the cold period names the phenomenon as adaptive response cued by some factor such as day length (Iverson & Turner 1974). It was also found that in subadult short-tailed vole (*Microtus agrestis*) body mass was lost under conditions of predation risk. Voles from the field plots without mammalian and avian predators generally lost less or gained more weight in autumn and winter than voles from the corresponding control grids (Carlsen *et al.* 1999).

In mild winter, weather leads to the formation of ice on the ground, which is detrimental for survival, as it was shown for *M. oeconomus* (Aars & Ims 2002). These authors also point out that voles adjusted their body mass to a certain

mean during the winter so as to maximize winter survival. The survival rate in males was lower than in females, possibly due to their larger body mass, and this resulted in female-biased population sex ratios in spring (Aars & Ims 2002). Other authors explain sex ratio as a result of migration (Bryja *et al.* 2005). Our data show that in general the winter population of *M. arvalis* was dominated by males, although we did not find any dependence on winter harshness – the female share was smallest in harsh 2004/2005 and mild 2008/2009 winters.

Are the findings of other authors in consistence with our results? We found that in *M. glareolus* growth regression and renewal occurred earlier than in *M. arvalis*. Growth depression in *M. glareolus* lasted in December and January and renewal occurred in February (Balčiauskienė *et al.* 2009). Subadults of these voles keep their body mass relatively stable (body mass in April was almost the same as in October), increasing in length for about 8 mm. In *M. arvalis* of the same age group, body mass and length in April were smaller than in October.

Huminski and Krajewski (1977) for *M. arvalis* found a higher body growth rate in warm than in cold winter. We confirm this for subadult voles. As for the manifestation of growth depression, we would like to support the point of view of Aars and Ims (2002) that there is an optimum body mass for wintering and it is smaller than in the vegetative period. By minimizing body mass, subadult *M. arvalis* get advantages, especially in harsh winters. Thus, despite general climate warming tendencies growth depression in small mammals still occurs during the cold period.

In juvenile *M. arvalis*, the most pronounced growth depression was found in maxillary characters (X^{10}, X^{12}, X^{13}) and X_1. In juvenile *M. glareolus*, some skull elements were found to be stunted in growth (X^{10}) or continued to grow until a certain month and then stopped growing (X_7 and X^{14}), or they grew at the beginning of the non-vegetative period, then stopped growing and again resumed growth towards spring (X_3, X_5, and X_6). Most of these were mandibular characters.

In subadult *M. arvalis*, growth depression was found in all skull elements, with the exception of X_6. In subadult *M. glareolus*, some skull elements exhibited depression either throughout the non-vegetative period (X_7 and X^{14}) or towards spring (X_8, X^{12}, X^{16} and X^{17}). A long lasting growth depression was characteristic of X^{10}.

Comparison of the growth pattern of the two vole species in the cold period in northeastern Lithuania allows us to conclude that (i) growth depression and renewal in *M. arvalis* occurred later than in *M. glareolus*, (ii) the juveniles of *M. arvalis* were less affected than *M. glareolus* of the same age group, (iii) the subadults of *M. arvalis* lost body mass, whereas those of *M. glareolus* did not, (iv) growth depression of some cranial characters in

M. arvalis was of longer duration than in *M. glareolus*. Adult animals of both species were present in too low numbers for analysis of growth.

Consequently, winter and spring have a more negative effect on the growth of *M. arvalis* than on the growth of *M. glareolus*. Juveniles are more vulnerable in *M. glareolus,* whereas subadults in *M. arvalis*.

CONCLUSIONS

Growth depression in the juveniles of common vole (*M. arvalis*) in the cold period was observed in January and February, while in subadults in January to March. Growth depression was strongest in subadult voles. Body mass in juveniles from October to April increased by 1.0 g, whereas in subadults decreased by 2.0 g. Growth depression was more pronounced and of longer duration in cranial characters than in body mass.

The subadults of *M. arvalis* were smaller in harsh than in mild winters (16.9 ± 0.29 g and 18.5 ± 0.33 g, respectively, $p < 0.05$), whereas juveniles were larger in harsh than in mild winters (15.6 ± 0.68 g and 14.5 ± 0.07 g, respectively, $p < 0.05$).

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PAPRASTOJO PELĖNO (*MICROTUS ARVALIS*) AUGIMO SULĖTĖJIMAS ŽIEMĄ

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SANTRAUKA

Iš Zarasų rajone 2004–2009 metais spalio–balandžio mėnesiais sugautų 573 paprastųjų pelėnų nustatyta, kad jauniklių augimas sulėtėdavo sausio–vasario, o lytiškai nesubrendusių – sausio–kovo mėnesiais. Augimas labiau sulėtėdavo lytiškai nesubrendusių pelėnų grupėje. Šaltomis žiemomis šio amžiaus paprastieji pelėnai buvo mažesni nei šiltesnėmis žiemomis. Jaunikliai, priešingai, didesni užaugdavo, kai žiemos buvo šaltesnės. Augimo sulėtėjimas buvo akivaizdesnis pagal kaukolių matmenis negu pagal individų svorį. Palyginus su ruduoju pelėnu (*Myodes glareolus*), paprastojo pelėno kaukolės augimas žiemą sulėtėdavo labiau. Žiemą ir anksti pavasarį paprastojo pelėno jaunikliai vidutiniškai svėrė 14,5 ± 0,07 g, o jų kūno ilgis buvo 81,6 ± 0,24 mm. Lytiškai nesubrendusių individų atitinkami matmenys buvo 18,1 ± 0,27 g ir 89,2 ± 0,70 mm. Jaunikliai nuo spalio iki balandžio mėnesio priaugo 1 g, o lytiškai nesubrendusių svoris sumažėjo 2 gramais. Pagrindinė šio tyrimo išvada – nežiūrint globalaus klimato atšilimo smulkiųjų žinduolių augimas žiemą vis dar sulėtėja.