POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	53	1	123–127	2005

Short research contribution

Ping SUN[1], Xinquan ZHAO[1], Julia A. KLEIN[2], Wanhong WEI[3]

[1] Northwest Plateau Institute of Biology, Chinese Academy of Sciences
59 Xiguan Street, Xining 810001, Qinghai Province, China,
e-mail: pingsunny@msn.com; xqzhao@mail.nwipb.ac.cn
[2] Department of Environmental Science, Policy & Management, Division of Ecosystem Science,
University of California, 151 Hilgard Hall, Berkeley, CA 94720 USA, e-mail: jklein@nrel.colostate.edu
[3] College of Biosciences and Biotechnology, Yangzhou University
Yangzhou 225009, Jiangsu Province, China,
e-mail: whwei@yzv.com

LOCAL WARMING ABOUT 1.3°C IN ALPINE MEADOW HAS NO EFFECT ON ROOT VOLE (*MICROTUS OECONOMUS* L.) POPULATION DURING WINTER

ABSTRACT: The influence of air and soil warming on root vole (*Microtus oeconomus* L.) population was studied in winter period in top open chambers (OTC) (0.8–1.8 m^2) warmed by conical fiberglass material and situated in alpine meadow (3250 m) at Qinghai-Tibet Plateau, China. The OTCs were distributed on an area of 30 × 30 m of experimental warming site; another site of the same area was a control one. The root vole population was investigated on two pairs of sites in "low-grazing" and "high-grazing" (by sheep) parts of the meadow; mark-recapture method was used. The winter-season averaged air and soil temperature inside of the chambers were 1.3°C higher than the temperature outside the chambers. The warming in the chambers had no statistically significant effect on root vole numbers, on average body mass of individual, and on average body mass of males and females. In conclusion, as small as 1.3°C warming of soil and air introduced locally and on small (several m^2) scale, in the alpine meadow habitat in winter period, has possibly no effect on root vole numbers and biomass.

KEY WORDS: root vole (*Microtus oeconomus* L.), climate warming, experimental warming, population numbers, body mass, Qinghai-Tibet Plateau

The impact of climate warming on populations and communities of animals has recently received considerable attention. Current models predict an increase of global temperatures in the range 1.5–4.5°C by the end of the century, although considerable regional variation can be expected (Dunbar 1998). The initial effects of global warming on biotic communities are most likely to be manifested at high latitudes and altitudes where the growing season is short and mean summer temperatures are low (Bolin *et al.* 1986, Woodward 1987). The research into the response of population ecology to global change has been carried out by different scientists (Coulson *et al.* 1996, Cannon 1998, Milner *et al.* 1999); however, most of them were focused on model research.

The root vole (*Microtus oeconomus* L.) is the dominant species distributed in alpine meadows on the Qinghai-Tibet Plateau. Much research has been conducted on this species at high altitude (Jiang *et al.* 1991, Bian *et al.* 1994, Liu *et al.* 1994, Liu *et al.* 1999, Sun *et al.* 2002). However, research on vole populations in winter habitats as well as the possible effect of global warming in these conditions is still lacking. The aim of this study was to check whether the experimental warming in the winter period, introduced locally and on small scale in alpine sites, has an effect on root vole population.

This study was conducted at HAMERS (Haibei Alpine Meadow Ecosystem Research Station) located in the north-east Qinghai-Tibet Plateau (37°29'–37°45'N, 101°12'–101°23'E). The average altitude of the mountain areas is 4 000 m a. s. l. and the average altitude of the valley areas is 2 900–3 500 m a. s. l. The climate at HAMERS is dominated by the southeast monsoon and high pressure from Siberia. It has a continental monsoon type climate with severe and long winters and short and cool summers. The average air temperature is −1.7°C with maximum 27.6°C and minimum −37.1°C. During the winter months, the average air temperature can drop to −15 or even −20°C in highland areas (Zhao and Zhou 1999).

In an alpine meadow, dominated by *Kobresia humilis* and various grasses and forbs two sites differring by grazing intensity of sheep were fenced. These sites are referred to as the "high-grazing" meadow (HGM) and "low-grazing" meadow (LGM). Each site (30 × 30 m) had both control and warmed plots. Air warming was simulated by using the top open chambers (OTC) made of conical fiberglass according to the standard set by the International Tundra Experiment Program (ITEX) (Klein 2003). The size of OTC ranged between 0.8–1.8 m^2. The fiberglass material has a high solar transmittance (86%) in the visible wavelength and low transmittance (<5%) in IR radiation (Marion 1996). Voles could freely move inside and outside of the OTC.

Each site had 8 control and 8 OTC plots. Each plot contained one trap (for a total of 16 traps per site). All traps were 8–10 m apart. The traps were opened and baited with carrots at 10:00 and closed at 16:30 (Beijing Standard Time) daily. All traps were checked every 20 minutes in order to avoid death of root voles due to cold weather. All animals captured were marked with an ear-perforation code and cutting nails, weighed (to nearest 0.1 g) and immediately released at the capture station. This experiment was performed at regular intervals (during the middle ten days of a month) in February, March, April, November and December of 2001 and in January of 2002.

Trap counts are generally proportional to estimated numbers within a species and can be therefore indices of densities (Slide and Blair 2000). The counts of *M. oeconomus* individuals captured in different experimental plots were used as indices of N (number) of individuals, namely N_{EW} and N_C (N in experimentally warmed and control plots, respectively), N_{EWH} and N_{CH} (N_{EWH} in "high-grazing" meadow and N_{CH} its control, respectively), and N_{EWL} and N_{CL} (N_{EWL} in "low-grazing" meadow and N_{CL} its control, respectively). Other species of rodents captured in the traps were also recorded. The numbers of root voles captured inside and outside of the OTC were used to estimate the effect of warming inside the chambers. The average body mass in the population including BM_{EW} (body mass in experimental warming plot), and BM_C (body mass in control plot), and the mass of males and females in every plot, i.e., BM_{MEW} and BM_{MC} (male body

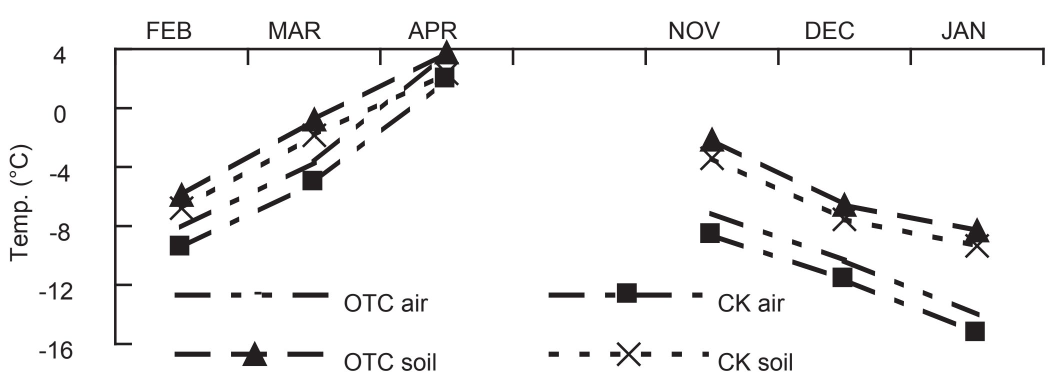

Fig. 1. The temperature of air and soil inside and outside of open top chambers (OTC) in winter 2001 and 2002. OTC air: air temperature in OTC; CK air: air temperature in control; OTC soil: soil temperature in OTC; CK soil: soil temperature in control.

mass in experimental warming and control plots), BM_{FEW} and BM_{FC} (female body mass in experimental warming and control plots) were analysed.

HOBO dataloggers were used to measure the air and soil temperatures inside and outside of the OTC. Separate probes were placed in the permanent shade at 5 and 15 cm aboveground, and at 5 and 10 cm depth belowground at the center of each plot. The temperatures were measured at the middle of ten days periods in each month. The temperature was recorded at 2-minute intervals and averaged over 10-day periods.

The one-sample *K-S* test was used to verify the type of distribution of the data. All data were then analyzed by an independent-sample t-test. The temperature differences were analyzed by one-way ANOVA. Wilcoxon t-test was used to test the differences between numbers of root voles captured inside and outside of OTC.

Combining all sites, the winter-season average air and soil temperature inside the chambers at 4 different levels (5 and 15 cm aboveground, and 5 and 10 cm belowground) was 1.3°C warmer than outside of the chambers (Fig. 1)

The data suggested that the experimental warming had no effect on root vole numbers in the alpine meadow during winter. The difference between N_{EW} and N_C, averaged over both sites of different grazing intensity, was insignificant ($t = 1.649$, $df = 22$, $P > 0.1$; Fig. 2). Within the "high-grazing" site, root vole numbers were significantly higher in the warmed plots as compared to the non-warmed plots ($t = 2.278$, $df = 10$, $P < 0.05$, Fig. 2). Within the "low-grazing" site, there was no difference between N_{EWL} and N_{CL} ($t = 0.87$, $df = 10$, $P > 0.1$, Fig. 3). There was no effect of grazing history on the difference between both experimental warming plots ($t = 1.066$, $df = 10$, $P > 0.1$, N_{EWH} *vs* N_{EWL}), with

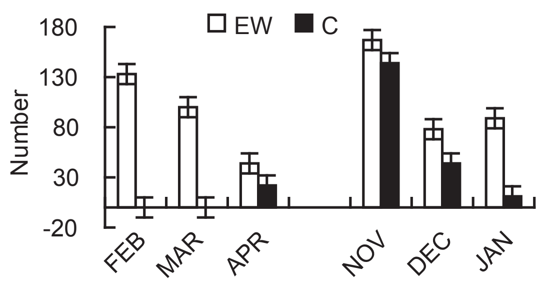

Fig. 2. Root vole numbers in experimental warming and control plots in "high-gazing" meadow in winter 2001 and 2002. EW – experimental warming, C – control.

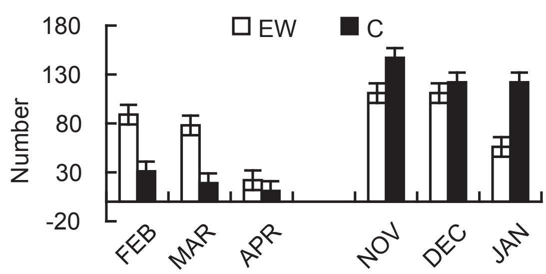

Fig. 3. Root vole numbers in experimental warming and control plots in "low-grzing" meadow in winter 2001 and 2002. W – experimental warming, C – control.

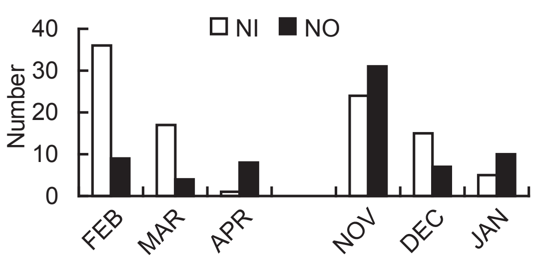

Fig. 4. Numbers of root voles captured inside and outside of experimental warming chambers in "high-grazing" meadow in winter 2001 and 2002. NI – number captured inside of chambers, NO – number captured outside of chambers.

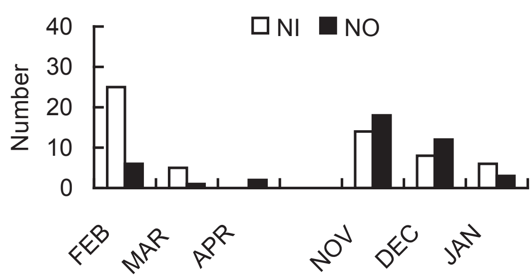

Fig. 5. Numbers of root voles captured inside and outside of experimental warming chambers in "low grazing" meadow in winter 2001 and 2002. NI – number captured inside of chambers, NO – number captured outside of chambers.

Table 1. Root vole body mass (g) in different plots in high and low grazing sites during winter 2001 and 2002.

		BM_{EW}	BM_{C}	BM_{MEW}	BM_{MC}	BM_{FEW}	BM_{FC}
	FEB	19.50±2.43	—	20.50±1.87	—	18.10±2.61	—
	MAR	21.40±3.02	—	23.32±2.11	—	19.00±2.12	—
HGM	NOV	17.73±3.35	18.54±4.13	17.95±2.28	18.76±4.46	17.49±4.48	18.28±4.13
	DEC	17.51±4.22	16.65±5.58	17.60±1.13	17.90±4.16	17.48±5.14	12.90±0.00
	JAR	17.98±3.95	23.40±0.00	17.50±2.81	—	18.26±4.80	23.40±0.00
	FEB	18.69±2.36	18.50±2.71	19.50±2.10	18.63±2.42	16.25±1.06	18.00±4.85
	MAR	20.79±4.72	20.25±3.74	23.30±2.39	21.10±3.47	14.50±0.71	16.00±0.00
LGM	NOV	18.55±3.10	19.87±4.73	19.93±3.40	21.16±5.06	16.48±0.17	17.83±3.58
	DEC	18.71±4.04	20.49±6.44	20.93±3.80	23.74±6.71	15.38±0.57	16.79±3.75
	JAR	18.08±2.71	24.28±7.88	20.85±1.77	29.83±7.98	16.23±0.61	19.43±3.42

HGM – "high-grazing" meadow plot, LGM – "low-grazing" meadow plot, BM_{EW} – root vole body mass in experimental warming plot, BM_{C} – root vole body mass in control plot, BM_{MEW} – male root vole body mass in experimental warming plot, BM_{MC} – male root vole body mass in control plot, BM_{FEW} – female root vole body mass in experimental warming plot, BM_{FC} – female root vole body mass in control plot.

a marginal effect of grazing history on the difference between control plots ($t = -1.145$, $df = 10$, $P > 0.1$, N_{CH} *vs* N_{CL}).

In order to understand the effect of experimental warming on root vole numbers during winter, the number of root voles captured inside and outside of OTC were counted simultaneously (Figs. 4 and 5). Wilcoxon T-test indicates that there were no differences between numbers of root voles captured inside and outside of OTC in HGM and LGM, separately ($z = -0.946$, $P > 0.1$, HGM; $z = -0.318$, $P > 0.1$, LGM).

Average individual body mass values are listed in Table 1. There was no difference between BM_{EW} and BM_{C} ($t = -1.797$, $df = 14$, $P > 0.05$). The body mass of males and females in experimental warming plots were, separately, similar to their controls ($t = -1.150$, $df = 13$, $P > 0.1$, BM_{MEW} *vs* BM_{MC}; $t = -1.156$, $df = 14$, $P > 0.1$, BM_{FEW} *vs* BM_{FC}).

The initial effects of global warming on biotic communities are most likely to be manifested at high altitudes. However, we found no significant effect of experimental warming on root vole numbers or body mass during the winter in alpine sites. One explanation for this may be that the scale of experimental warming was too small in comparison to the home range of the voles. The chambers have an area between 0.8–1.8 m^2. Within each site, the eight chambers account for 0.7–1.6% of the site. The vole's home range is 3922.0 ± 860.1 m^2 for an adult male and 1786.2 ± 278.8 m^2 for an adult female (Sun *et al.* 1982). Therefore, the home ranges were far larger than the sizes of experimental plots. However our results seem to support the hypothesis that number of root voles in the alpine sites will not increase probably with the elevating of air temperature. But the experimental warming studies that are undertaken in order to examine the effect of climate warming on small mammals must scale the experiment to be appropriate to the size of their natural home range. The scale of most current experimental warming manipulations may be too small to adequate study of the effect of climate warming on small mammal populations.

In conclusion, as small as 1.3°C warming of soil and air introduced locally and on small (several m^2) scale, in the alpine meadow habitat in winter period was proved to have no effect on root vole numbers and their biomass. However, the way of experimentation with OTC in open air is interesting as the research method and is promising in the studies of the warming effects.

ACNOWLEGMENTS: We thank HAMERS for logistic support, special thanks to Dr. Andrew I. Hsiao for critical reviewing of the manuscript. This project was supported by grants from the key project (KZCX1-09-01) of the Chinese Academy of Sciences to X. Zhao, and HAMERS Foundation to W. Wei.

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(Received after revising July 2004)