WINTER ECOLOGY OF SMALL MAMMALS IN THE URAL MOUNTAINS

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ABSTRACT

Observations were made of winter ecology of small rodents inhabiting the upper belts of the Ural Mountains. Animal transitions, fur insulation properties, changes in the relative weight of some inner organs and population age structure dynamics were examined.

INTRODUCTION

A very interesting region for a zoologist is the Ural Mountain chain, an area that stretches for over 2,000 km in a meridianal direction through several zones, from tundra in the North to steppes in the South. Floral belts are distinguished in the Urals as follows: a) Montane-steppe; b) montane-forest-steppe; c) montane-forest; d) subaltitudinal; e) altitudinal. A stable snow cover in the upper belts begins on approximately September 16. Its maximal thickness is reached between February and March. According to observations, snow cover thickness in the northern part of the middle Urals increases 17 to 18 cm with every 100 m increase in elevation. In the altitudinal belt of the Denezhkin Kamen Mountain, snow covered the ground for about 239 to 268 days in some years.

There are three groups of small mammals in the Urals: 1) Those characteristic of a certain altitudinal and landscape zone (in the Urals, these are mainly steppe and tundra species); 2) Dwellers of all landscape zones and corresponding altitudinal belts (for example, *Clethrionomys rutilus, Sorex* spp.); 3) Animals that are characteristic of upper belts only (for example, *Ochotona alpina hyperborea, C. rufocanus*).

In the upper belts, small mammals are active year-round. Our observations have shown that in the alpine belt (as distinguished from the plain) voles were almost never found on the snow cover, but actively moved below it among stones.

METHODS

We investigated small mammal winter ecology by mass marking with Rodamine-C and Rodamine-6G. The dyes were added to 1 cm³ pieces of bread or fried dough. Such bait was eaten no less readily than the undyed bait. No deaths were recorded during the experimental period. Animals succeeded in reproduction and many of them survived more than one year. Rodamine-C could be found in urine, intestines, and on snouts, chests and forefeet of the voles for seven days after the bait was eaten. Rodamine-6G was noticed only in the course of two days; integuments were less dyed. Experience has shown that dyed bait is better if spread in deep areas of subnivean paths. Phosphorus-32, Calcium-45 and Strontium-89 osteotropic isotopes were also widely used in marking. Addition of Sodium-22, Zinc-65, Ferrum-59, Cobalt-60, and Phosphorus-32 to the bait was also practiced.

The methods helped to reveal territorial distribution of animals in the mountains. Fig. 1 shows the line transects for registration of migration of rodents in the Ural Mountains. From the top of the Kukshik Mountain, a stone field extended far into the forest belt. We placed dyed bait on subnivean paths throughout the stone field. Traps were placed at a distance of 5 to 100 m and sheltered in ditches within the snow. Captures of 22 northern red-backed voles (*C. rutilus*) and grey-sided voles (*C. rufocanus*) from 2 to 9 February 1978 evidenced a marked concentration of animals in the stone field in winter. In spring, summer and autumn, voles moved up to 1.5 km away from the stone field.

Thawed patches were recorded in the top region of the Bakhty chain in late April 1979. The greater part of the slope was covered with deep snow, névé and ice crumbs. We tried to learn the role of the first thawed patches in the life of overwintered animals involved in reproduction. Dyed bait was spread on a 0.5 ha thawed patch. Four parallel trap lines were arranged below it (100 m distance between lines, 25 traps per line at a distance of 8 to 12 m). Traps were placed among stones under the snow. The shortest distance from the thawed patch to the nearest line was 50 m. The most remote line was near the fooded zone edge down to the stone field. A stream crossed the central part of the lines.

RESULTS

Twelve hours after the dye was spread, eight overwintered voles were caught (five *C. rufocanus,* three *Clethrionomys glareolus*). Only two females showed no dye at dissection, one being at a late stage of pregnancy, the other lactating. The dye was carried by animals no farther than 300 m. Fifteen voles were

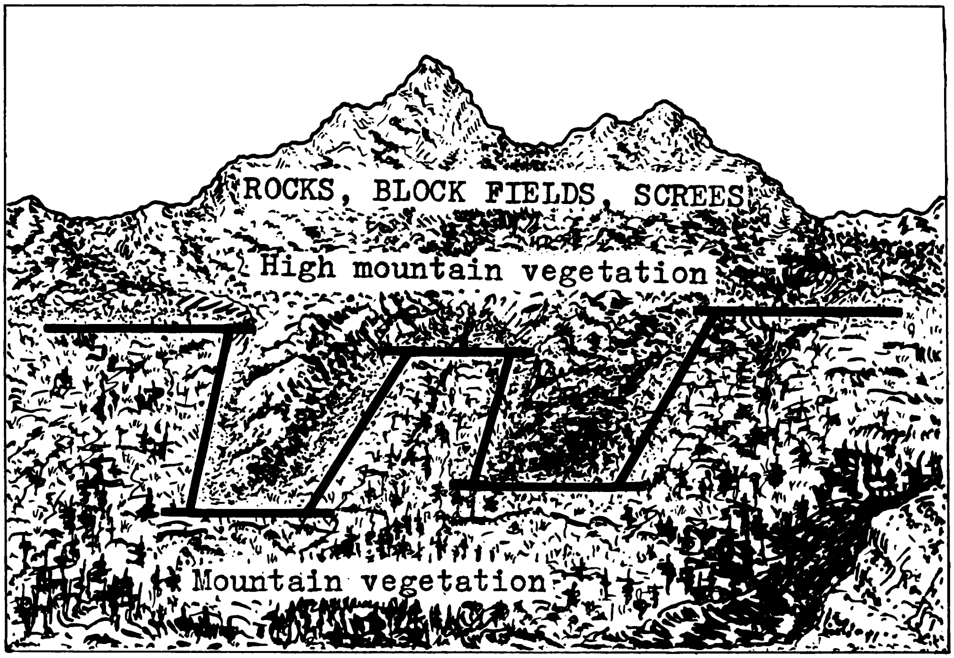

Fig. 1.—Scheme of line transects for registration of migration of rodents.

caught over a four day period—only four females lacked the dye (nursing or pregnant). All overwintered males caught in the lines had consumed the dyed food. Catches evidenced distribution on a territory of over 6 ha and nearly simultaneous visits to the 0.5 ha thawed patch.

DISCUSSION

Of special interest in studying small mammal winter ecology are their adaptive patterns. The thermoregulatory role of the snow cover in the life of small mammals in winter is well known. Measurements made in the Polar Urals have shown that in December, when a 100 m mantel of snow covered the mountains and surrounding air temperature fell to −45° to −48°C at night, subnivean air temperature was stable at −7° to −8°C. Daily fluctuations in air temperature below the snow cover were at most 3–4°C, while those above it were 10°C fluctuations. Although some authors believe that small mammal body sizes make their physical thermoregulation insignificant, some data indicate the opposite. Thus, it was shown on *Peromyscus maniculatus* that better insulation of their winter fur in comparison with summer pelage was the main adaptation of animals to prevent cooling in winter (Hart and Heroux, 1953). These authors also noted that as fur insulation increased, a lower metabolism was seen in mice. The best heat conserving properties of skins were recorded by Polish zoologists for the bank vole in higher altitudes (Kostelecka-Myrcha et al., 1970). The importance of physical as well as chemical thermoregulatory adaptations of small mammals to unfavorable surroundings was outlined by many authors.

We investigated insulation properties of skins of small rodents inhabiting higher altitudes with the help of an isolated temperature recorder. Fig. 2 reviews heat insulation of summer and winter fur for six species of rodents in terms of their heat transfer coefficient. Basically, similar insulation properties were recorded for all species (*C. glareolus, Microtus oeconomus, Microtus arvalis, Apodemus agrarius, Apodemus sylvaticus*) during summer. It is known that fur insulation qualities undergo significant seasonal changes. Thus, in summer *P. maniculatus* is 21.4% less insulated than in winter (Hart, 1956). Our data for mice and voles show an 11 to 12% difference. Besides good fur insulation, many highland rodent species have peculiar chemical thermoregulation (for example, constant body temper-

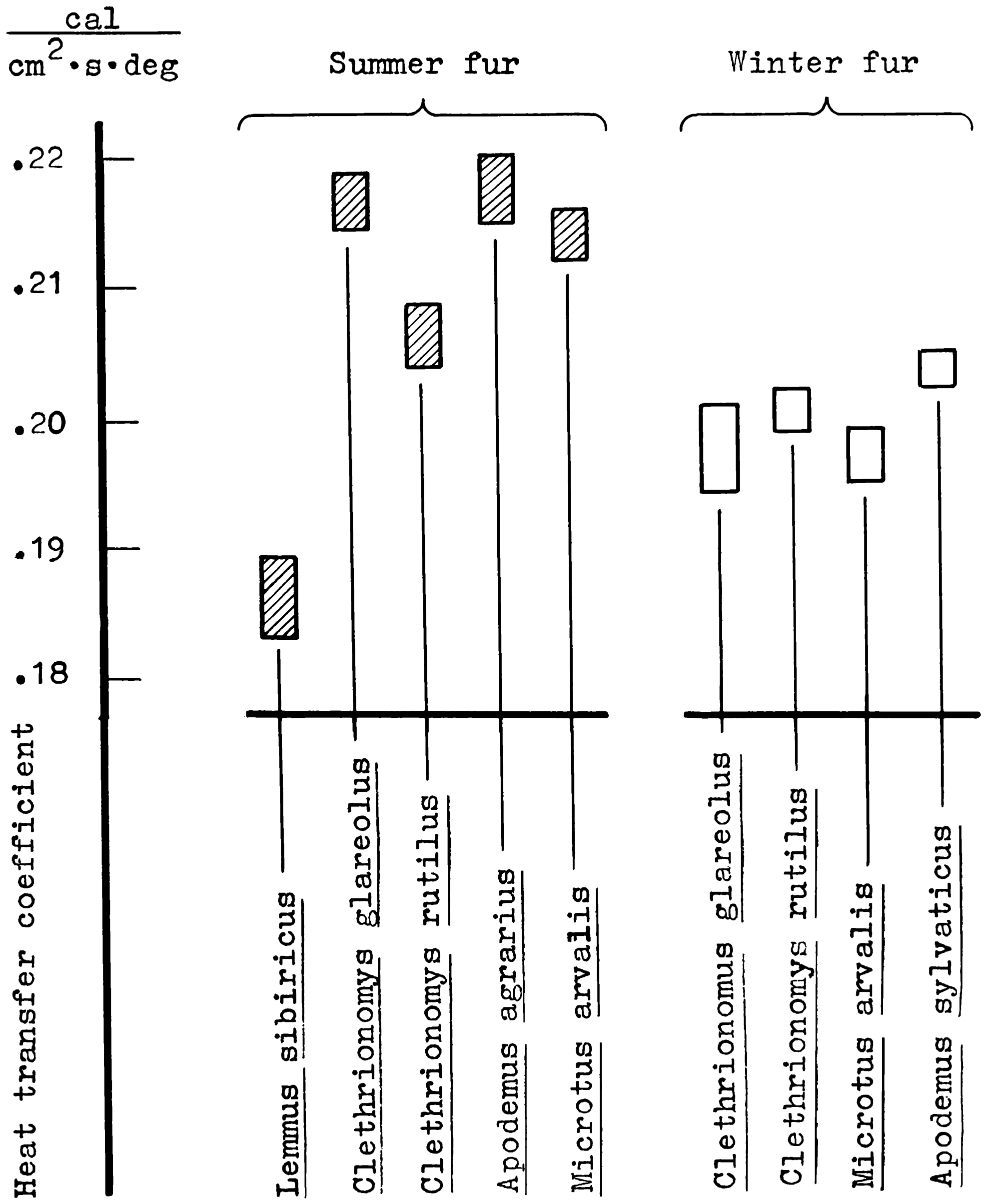

Fig. 2.—Heat insulation of skins of some rodent species.

ature), evidently connected with an improved physical thermoregulation. Experiments on *C. glareolus* from the upper belts of the Urals have shown that the critical level of their gas exchange is almost 45% lower in summer than in winter.

Studies of morphological structure of summer and winter skins have revealed regularities common for rodents inhabiting the Ural Mountains: increase of hair thickness towards winter and changes in the hair structure and in hair root ratio. Thus, in summer, some 300 hair per 4 mm^2 can be counted on the back of a bank vole; in winter the number is 422 (sides = 280 and 366, respectively; belly = 220 and 280). In winter, guard hairs are more than two times thinner, but 1.5 to 1.8 times longer (from 8.4 mm to 11.5 mm on the back).

Method of morphophysiological indicators developed by Schwarz (1980) is widely used in the

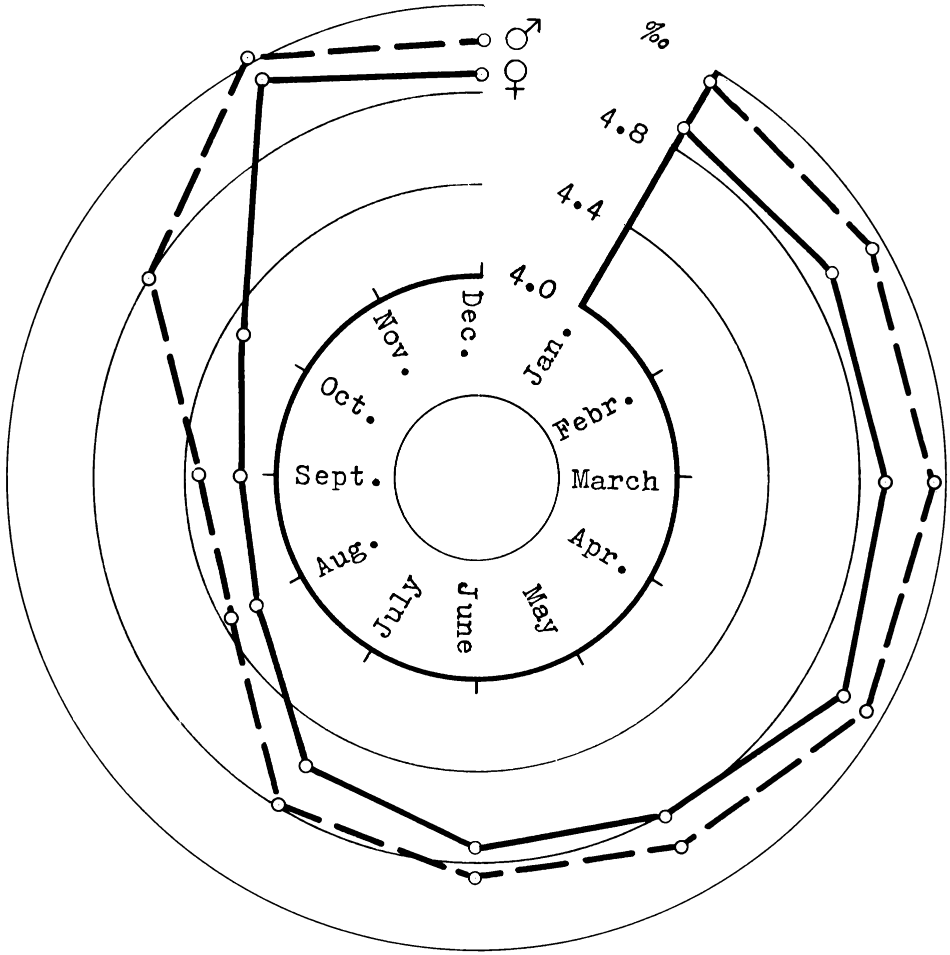

Fig. 3.—Seasonal changes of the relative weight of heart in *Clethrionomys rufocanus.*

Soviet Union for research on animal adaptive patterns. Briefly, the method is viewed as follows: relative weight of inner organs, blood composition and other indices are indicators of animal physiological adaptation. Our material on seasonal changes in relative heart weights indicates that variability of the bank and northern red-backed voles taken from the plain and upper belts roughly coincide. One can see reduction in relative heart weight from winter towards summer (minimum in summer months, rise in autumn and stabilization in the winter period). However, this regularity is displayed differently in subaltitudinal and altitudinal zones on one hand and in the plain forest zone on the other. Firstly, all changes are shifted in time, especially in autumn. In plain rodents heart indices slowly rise from July to November (from 5.1 ± 0.13 to 5.6 ± 0.10% in male and from 5.4 ± 0.12 to 5.8 ± 0.11% in female bank voles; from 6.5 ± 0.12 to 7.0 ± 0.22% in male and from 6.7 ± 0.14 to 7.5 ± 0.18% in female northern red-backed voles) and stabilize at the higher level reached.

In voles of the upper belts the index is stable during July, August and perhaps early September. In October a sharp increase is noticed (from 5.9 ± 0.11 to 7.1 ± 0.15% in male and from 6.7 ± 0.20 to 7.5 ± 0.17% in female bank voles; from 7.9 ± 0.24 to 8.6 ± 0.13% in male and from 7.3 ± 0.18 to 8.3 ± 0.17% in female northern red-backed voles). The high level is retained during the entire winter. As this is accompanied by a sharp increase in hemoglobin content and in relative kidney weight, one can speak of a strongly pronounced physiological reorganization connected with winter approach in the mountains. Seasonal changes of the relative weight of heart and kidney of *C. rufocanus* are shown

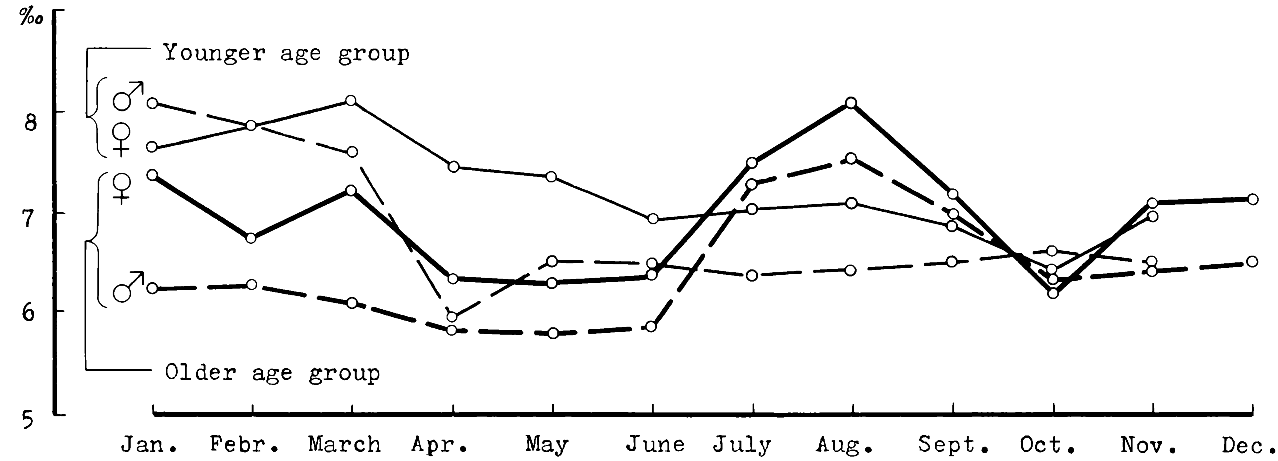

Fig. 4.—Seasonal changes of the relative weight of kidney in *Clethrionomys rufocanus*.

in Figs. 3 and 4, respectively. Relative heart weight changes in *C. rufocanus* are manifested peculiarly, although they are within the scheme (Fig. 3). In nature, these rodents exhibit a sharp decrease in relative heart weight in August and September (from 4.9 ± 0.26 to 4.2 ± 0.17% in males and from 5.0 ± 0.19 to 4.6 ± 0.11% in females), followed by a sharp increase in October to November (up to 5.6 ± 0.15% in males and 5.6 ± 0.19% in females). In December, the exponent somewhat decreases again and is stable in winter and early spring. Comparisons of *C. rufocanus* taken from the South and Polar Urals revealed parallel changes in their relative heart weights (voles from the Polar Urals have larger hearts), which suggests that similar reactions to seasonal changes of the environment. It is interesting to note that the most pronounced seasonal changes in the relative body weight of altitudinal *C. rufocanus* occur in the summer period, while in winter the exponents are stable. The same regularity is recorded for other internal indices which suggests considerable stable living conditions under the snow.

The last chapter concerns dynamics in the vole population age structure. Our investigations in the Ural Mountains have shown that regarding litter size, mountainous and plain populations of rodent and insectivorous species do not differ. In subarctic populations, this index is higher. For example, average litter size of the northern red-backed vole in the South Urals is 6.0 for plain, 6.1 for mountainous, and 9.8 for the Jamal tundra.

Early sex maturation is typical for mountainous populations. Their reproduction period is calendar (but not phenological), coincident with the reproductive period of the same species on the plain. In different regions of the Ural Mountains, reproduction of the field and northern red-backed voles begins at the same time—late April to early May. In the upper belts, this period is shifted. Pregnant females are caught in large numbers only during the second half of May to early June, when the mountains are still snow-covered. Overwintered mountainous northern red-backed voles start breeding at average weights of 22.8 g (range, 19.3 to 25.0 g for females) and 24.3 g (range, 22.8 to 27.0 g for males). As in the Transurals, they produce two litters per year for the most part. Only single specimens have shown three litters per year. Thus, only two of seventeen old females caught in the Zigalg Range early in August could be considered fruitful as that. In July, pregnant females of the first litter are found in traps. In August they can produce one more litter. Towards late August, reproduction of the northern red-backed vole in mountainous and plain regions ceases entirely. Analysis of the population age structure made on the material obtained from the upper belts of the Denezhkin Kamen and Kosvinsky Kamen Mountains has shown that in autumn young animals of the first year accounted for some 95% of the population. It was determined by Schwarz (1980) that specificity of subarctic population age structure lies in high mortality of offspring of the first litter. In mountainous populations of the northern red-backed vole, a great number of the young born in spring survive to autumn and play an important role in population reproduction. As an illustration let us consider a *C. glareolus* population. We determined age groups by calculating molar tooth development rate and thymus size aside from weight and body size estimations. The results demonstrated that age group abundances in mountainous populations were governed by the number of animals that survived the first generations which meet winter at maturity and readily reproduced in spring. Thus, in late winter a *C. glareolus* population in the Ural Mountains consists of specimens from the first spring generation (20–25%), voles of the second and third generations (70–75%) and a small number of old animals. Animals of the third generation do not reach maturation towards winter (males and females). From the second generation only single specimens mature towards autumn.

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