THE ROLE OF SNOW IN THE WINTER SURVIVAL OF THE MEADOW VOLE, MICROTUS PENNSYLVANICUS

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INTRODUCTION

Survival of many organisms in northern latitudes is dictated absolutely by the presence of snow each winter. Birds such as ptarmigan and grouse dive into the snow to escape the cold to hide from predators (Pruitt 1970), insects overwinter beneath the snow either as adults, or as pupae, or as larvae (Danks 1981), and many microtene rodents (e.g. lemmings, red-back voles, and meadow voles) remain active beneath the snow during the entire winter and may even reproduce there (Pruitt 1970). In all cases the animal is not only protected from cold but also is much less likely to suffer predation. Although the insulating effect of snow has been well documented (Formosov 1946 in Pruitt 1970) the actual microclimate beneath the snow with respect to organisms has only received limited study.

The objective of the present study was to document the microclimate within and adjacent to nests of the meadow vole, *Microtus pennsylvanicus*, in relation to snow depth, snow density, and air temperature above the snow.

METHODS

A 3 x 2.5 m enclosure, made from corrugated aluminum siding 1.25 m high, was used in this study. It was placed in an area of tall grass of known meadow vole activity. The siding extended to a depth of 15 cm in the soil to prevent the escape of the animals. An adjacent area was used as a control site.

Because it was difficult to find a vole nest, even in an enclosed area, the voles were further restricted in their movement by being forced to nest in 18 x 30 x 12 cm cages with a wire top. An 18 x 30 x 5 cm layer of turf was removed from within the enclosure and placed in each cage. The cage was then placed in the area from which the turf had been removed. The vole was thus provided with natural nesting material under natural micro-climatic conditions. A 5 cm diameter hole was drilled at one end of the cage and fitted with a rubber stopper. After the establishment of a permanent snowpack it was possible to remove the stopper without interfering to any extent with the snow cover thus permitting the vole to forage at will within the enclosure.

Thermisters were used to measure the temperature profile from 1 m above the soil surface to a depth of 5 cm within the soil, in both the enclosure and the control. Nest temperatures were measured in the enclosure. The thermisters exposed to the air were shielded. The signal from the thermisters was recorded hourly on a battery-driven multi-point chart recorder (Grant Instruments Model 2020B). The recorder was enclosed in a styrofoam chest placed below ground to reduce temperature fluctuations. The chest was kept above 0°C by means of gelfilled plastic bags (Freeze/Hot Pak) that were immersed in boiling water prior to being placed in the chest. The bags were changed every 12 h.

Plywood chimneys (Pruitt 1959) with removable, insulated lids, and with one end open at ground level, were used to live-trap animals beneath the snow to enable the investigator to weigh the animals and, to establish their reproductive status.

An array of 1 m long snow stakes was used to measure snow depth in both the enclosure and in the control area.

RESULTS AND DISCUSSION

The winter of 1982-83 was relatively mild with much higher precipitation than normal

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in December and much lower than normal precipitation in January and February. In December most of the precipitation fell as rain with the result that the shallow snowpack established in mid-month had been totally lost by December 25. Owing to lower than normal snowfalls in the subsequent two months, snow depth never exceeded 34 cm. In comparison, the amount of snow on the ground (Sudbury Airport) for a more normal winter (1981-82) ranged between 30 and 60 cm from December through February. As subsequent data will show, the snow in 1982-83 was inadequate to support meadow voles within the subnivean environment of the study site.

Fig. 1 shows maximum nest temperature plotted with corresponding surface temperatures and air temperature at 1 m, at the same time of day. Nest temperatures were almost always higher than air temperatures during the entire measurement period but surface temperatures outside the nest were close to 0^{o}C and fluctuated little. Both nest and air temperatures fluctuated considerably and in December the rise and fall of nest temperature was more or less in phase with air temperature. This relationship suggests a correlation between nest and air temperature during the period with little or no snow. No such correlation existed for January and February because the insulating effect of approximately 30 cm of snow was such that temperatures beneath the snow, including nest temperatures, became more independent of temperature conditions above the snow. The greatest difference between nest temperature and surface temperature occurred during this period and was approximately 8 C degrees. On 5 February 1983, nest surface and air temperatures were 8.5, 0, and -18.5^{o}C, respectively. This shows both the insulating effect of the snow and the ability of the vole to modify its microenvironment.

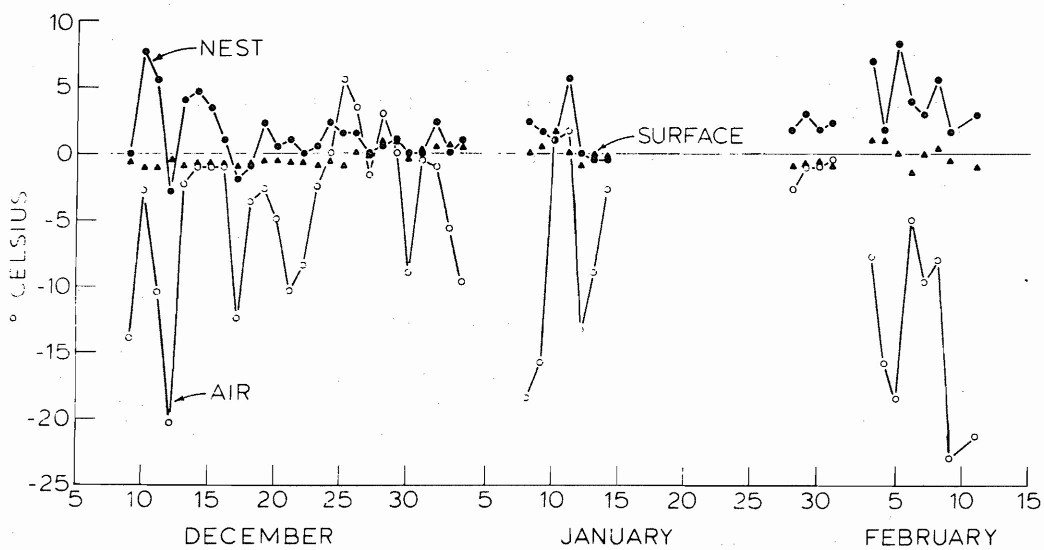

Figure 1

A regression of nest temperature against air temperature (Fig. 2) for data collected in December suggests not one corelation but two. Within a span of air temperature from approximately -4^{o}C to 1^{o}C it appears that a meadow vole is able to maintain a nest temperature that is above freezing and warmer than the air. Below -4^{o}C a different relationship is seen in which nest temperatures are in general below freezing and decrease much more slowly than air temperatures.

The intersection of the two curves suggests that there may be a critical air temperature (-2.2 C), when snow is shallow or absent, below which a meadow vole is not able to modify its microclimate or to be highly active. The data infer that at colder temperatures animals were inactive and may well have been in a state of torpor. This is interpreted as an adaptive strategy to conserve energy and to maintain an adequate core temperature. This occurs when temperatures surrounding the animal are such that maintaining a high level of activity to forage would result in more energy being expended as heat than was taken in as food.

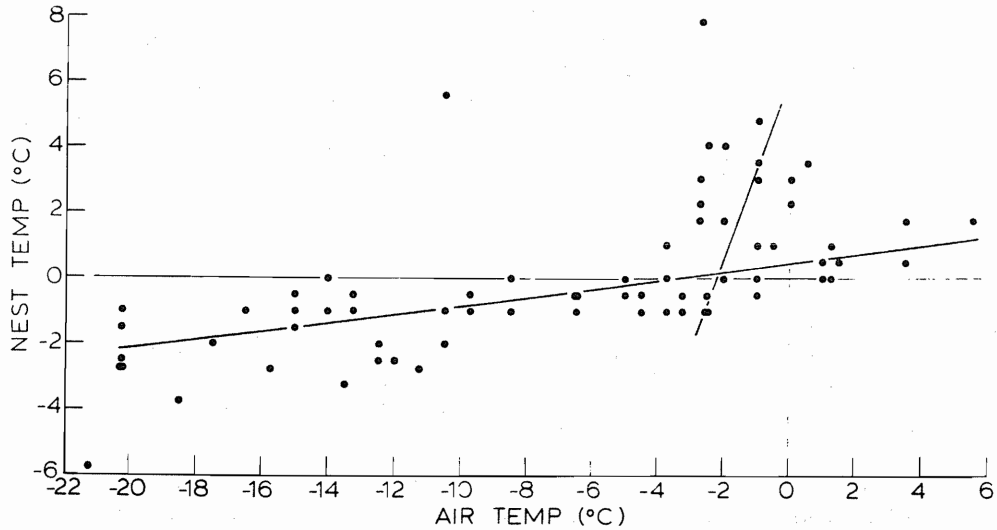

Figure 2

Figure 3 shows a plot of the Thermal Index of snow (Marchand 1982) against time and indicates a fairly rapid increase in the thermal index, and hence the insulative capacity of the snow, as snow cover deepened during January and early February. The highest value corresponded to the maximum depth of snow received for the winter (February 6). Vole mortality (M) plotted for the same period shows that all deaths occurred with Thermal Index values below 100 cm.cm^{3}g^{-1}. No mortality occurred during the period when the thermal index values were highest even though the Hiemal Threshold (200 g.g cm.cm^{3}g^{-1}, according to Marchand 1982) was never reached. The reason may be attributed to a relatively mild winter.

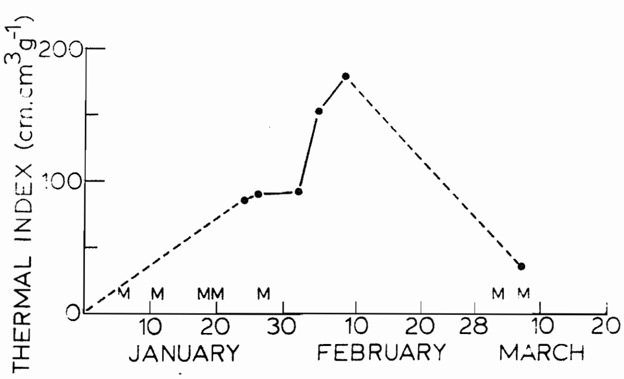

Figure 3

CONCLUSIONS

The most critical periods for the winter survival of meadow voles are, the onset of cold temperatures before an adequate snow cover has been established, and the spring thaw when flooding of nests may occur. The winter of 1982-83 had repeated periods of thaw, cold temperatures, wet snow, rain and freezing rain. Moreover, the Hiemal Threshold was never attained. In addition to being exposed to cold temperatures, the meadow voles also were exposed to rain. Wet fur loses its ability to insulate and makes the animal even more vulnerable to cold. Under the circumstances experienced during a winter like that of 1982-83 small mammals such as the meadow vole frequently face critical environmental conditions. Only voles whose nests, perhaps more by chance than design, are located in areas where snow tends to accumulate more deeply or under some natural protection (e.g. fallen trees), have a good chance of surviving a winter such as that described.

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