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Use of National Weather Station Records in Field Studies of Forest Species of Small Mammals

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ABSTRACT

I tested the hypothesis that temperatures from a National Weather Service (NWS) station were comparable to those 20 cm above the surface, the stratum utilized by most forest species of small mammals, of lowland swamp and upland hardwood forest habitats 35 km from the NWS station. Temperatures at the NWS station, whether every two hours during the day, mean daily, mean daily maximum and minimum, or monthly maximum and minimum, were similar to those in both the swamp and upland sites. Such differences that did occur typically varied only 3-5° C, and most often 1-2° C, between the NWS station and the field sites. Daily maximum and minimum temperatures at the NWS station were positively correlated with those in both the swamp and upland sites at all seasons. Use of temperature records from the NWS station located in a rural exposure, even though distant from a field site, would be suitable in describing relative temperatures encountered by animals active on the forest floor or up onto lower trunks of trees.

INTRODUCTION

Analyses of data from field studies of small mammals frequently test effects of weather conditions on demographic variables such as survival, activity, dispersal, and reproduction (Madison, 1985; Kriegsfeld et al., 2000; Jackson et al., 2001). Time constraints and limited resources often prohibit monitoring of temperatures within the study site itself, even though such technology is readily available (e.g., I-buttons, Dallas Semiconductor). Analyses of data from some studies may suggest importance of factors that were not a part of the original protocol, or long-term studies may require retrospective analysis of temperature conditions. In these cases researchers must obtain temperature data from elsewhere, typically from existing National Weather (NWS) stations, which are often located far from the study site (Jackson et al., 2001; Brady and Slade, 2004; Selås, 2006). In addition to variation in general temperature regimes between the study site and the NWS station, potential bias results from the standard positioning of recording instruments 1 m above the surface at NWS stations. Thus, reliability of such data in describing conditions at the actual study site is questionable. Elsewhere (Getz, 2005) I show that temperature records from a NWS station located 6.6 km from a study site did not accurately describe conditions encountered by the prairie vole (*Microtus ochrogaster*), meadow vole (*M. pennsylvanicus*), and short-tailed shrew (*Blarina brevicauda*). These small mammals occupied enclosed runways at the soil surface under a dense layer of vegetative and detritus cover.

During the course of a study of the red-backed vole, *Clethrionomys gapperi*, (Miller and Getz, 1972) temperature data were recorded at the level of activity in the habitat occupied by each species. These two species were active on the open forest floor and up on small fallen logs and tree stumps (both species) as well as up on trunks of trees (*P. leucopus*). Temperatures encountered by such species, when active, would not be subject to moderation by dense vegetative and detritus cover as were the voles and short-tailed shrew in the above study (Getz 2005). I here test the hypothesis that temperatures recorded at a distant NWS station are representative of those 20 cm above the surface of lowland swamp and upland forest sites 35 km from the NWS station.

METHODS AND MATERIALS

Study site

The field study site was located in a cedar swamp and an adjacent upland deciduous forest, 5 km NW of Storrs, Connecticut. The NWS station was located in a "rural exposure" site (Brumbach, 1965) at Bradley International Airport, 35 km NW of the field sites.

The two study sites were described in detail by Miller and Getz (1972). Vegetation of the swamp was composed of a 50-75% crown coverage of hemlock (*Tsuga canadensis*), southern white cedar (*Chamaecyparis thyroids*), yellow birch (*Betula lutea*), and red maple (*Acer rubrum*). An open (44% coverage) shrub stratum included pepper bush (*Clethra alnifolia*), mountain laurel (*Kalmia latifolia*), mountain holly (*Nemopanthus mucronatus*), ilex (*Ilex* sp.), and high bush bluebberry (*Vaccinium* sp.). In places there was a dense (100%) forb stratum of skunk cabbage (*Symplocarpus foetidus*) and cinnamon fern (*Osmunda cinnamomea*), but the overall average forb coverage was 31%. The surface was covered by a 5-10 cm layer of twigs and leaves.

The upland vegetation consisted of a second-growth stand of red and white oaks (*Quercus rubra* and *Q. alba*), with scattered red maple and hemlock. The trees were 15-18 m tall and had an average crown coverage of 75%. There was a sparse (5-15% coverage) shrub stratum of oaks, red maple, chestnut (*Castanea dentata*), maple-leaf viburnum (*Viburnum acerifolium*), and low bush blueberries (*Vaccinium* sp.). Forbs were very sparse (8% coverage). A well-developed 15-20 cm leaf layer covered the forest floor.

Temperature records

Eight temperature stations, each, (five Bristol and three Taylor recording thermographs) were placed in the swamp and upland forest (Miller and Getz, 1972). The stations were located within a 50-m radius at each site. So as to describe vegetative cover conditions specifically at the temperature stations, vegetative coverage within a 15 m radius around each station was visually estimated and means for the stations at each site calculated for the tree crown >15 m, shrubs, >1 m, and forbs, <1 m (Swamp: trees, 69.4% [deciduous, 30.6%; evergreen, 38.8%]; shrubs, 32.5%; forbs, 56.9%**.** Uplands: trees, 76.3% [deciduous, 69.4%; evergreen, 6.9%]; shrubs, 20.6%; forbs, 26.9%).

The instruments were covered by aluminum painted tent-shaped 50 cm wide plywood shelters on 20 cm high legs that allowed for free circulation of air over the sensitive elements of the instruments. The temperature-sensitive elements of the instruments were positioned 20 cm above the surface. This allowed for recording temperatures typical of those encountered by the small mammals during their periods of activity. Ink pens traced the temperatures on paper charts. The charts were changed weekly and the ink pens filled. Temperature sensors were calibrated every few months with glass mercury thermometers. The temperature stations were maintained from June 1963-June 1967.

Data analysis

Temperature data were compiled from the recorder charts at 2-hour intervals, beginning at midnight (00 hours). Mean temperatures for the swamp and upland were analyzed for 10-day periods during winter (8-17 January 1966), spring (2-11 May 1964), summer (23 July-1 August 1966), and autumn (23 October-1 November 1964). These dates represented periods of greatest continuous low winter temperatures and high summer temperatures and of typically moderate spring and autumn temperatures recorded during the study. Daily maximum and minimum temperatures for the swamp and upland were compiled for all years for the months of January-February (winter), April-May (spring), July-August (summer), and October-November (autumn). These comparisons were restricted to the two months most representative of each season. Monthly mean maximum and minimum temperature were calculated for all months, June 1963-June 1967. Equivalent compilations and means were obtained for the same dates from records of the NWS station. Significance of differences between the two habitats and the NWS station were determined by use of one-way ANOVA, followed by Tukey's honestly significant difference (HSD) post-hoc multiple comparison tests (Zar, 1999). Correlation analyses of temperatures at the NWS station and the field sites utilized Pearson's r (Zar 1999).

RESULTS

Daily temperatures were generally higher at the NWS station than in either the swamp or upland sites; the differences of the total 24-hr and day-time temperatures were significant only during summer (Fig. 1, Table 1). Differences were greatest (3-4° C) for about four hours (0800-1200) during the morning (Fig. 1); only those during the summer were significant (F = 5.322; df = 2,6; P = 0.05). When only night-time temperatures were considered, temperatures at the NWS station were significantly higher than those in the upland during winter and the swamp during summer and autumn (Table 1).

Although night-time differences for all seasons and day-time differences during summer were significant, actual daily maximum and minimum temperatures in both the swamp and upland sites differed little (usually <2° C) from those at the NWS station (Table 2). Greatest differences occurred during the day in summer (Table 1). For all four seasons there was a significant correlation (P <0.01; Pearson's r test) of both daily maximum (Swamp: winter, r = 0.77; spring, r = 0.70; summer, r = 0.90; autumn, r = 0.75. Upland: winter, r = 0.89; spring, r = 0.97; summer, r = 0.52; autumn, r = 0.98) and minimum temperatures (Swamp: winter, r = 0.76; spring, r = 0.87; summer, r = 0.82; autumn, r = 0.88. Upland: winter, r = 0.82; spring, r = 0.48; summer, r = 0.88; autumn, r = 0.95) at the NWS station and both field sites. When all months were compared, monthly maximum and minimum temperatures at the NWS station did not differ significantly from those in either the swamp or upland sites (Maximum temperatures: $F = 0.18$; df = 2,134; P = 0.84. Minimum temperatures: $F = 1.00$; df = 2,136; P = 0.37).

DISCUSSION AND CONCLUSIONS

Even though the National Weather Service (NWS) station was located 35 km from the study sites, temperatures there were very close to those in both the swamp and upland sites. Thus, the results of this study support the hypothesis that temperatures at a NWS station were representative of those 20 cm above the surface of sites 35 km from the NWS station. The few differences that were recorded were brief and usually of a magnitude of only 1-2° C; only the maximum temperatures in the swamp habitat during summer deviated from those at the (NWS) station by up to 6° C and then for only about four hours during the morning. Higher temperatures at the NWS station during the summer most likely result from the exposure of the NWS station to full sunlight, whereas the study sites were shaded by vegetation.

The Bradley Airport NWS station was located in a rural exposure, with minimal urban climate effects (Brumbach, 1965). The predominately hilly terrain for northern Connecticut, in which this study was conducted, presents the potential for differences in local climate. Comparison of records from 1931-1960 for nine NWS stations located at distances of 10-160 km from each other showed that such differences were relatively minor (greatest differences: mean monthly maximum temperatures, 1.9° C; mean monthly minimum temperatures, 2.7° C; mean monthly temperatures, 2.2° C; Brumbach, 1965).

I conclude therefore that usage of temperature data from a distant weather station, in this case the Bradley Airport NWS station 35 km away, would be appropriate for describing temperatures encountered by small mammals when active on or above the surface floor of both lowland swamps or upland forests. Whereas actual temperatures in a forested site may deviate slightly from those recorded at the weather station, the latter do provide a good picture of temperature patterns at the remote sites. NWS station data should be obtained from stations located in rural exposures so as to reduce bias from urban climate effects (Brumbach, 1965). Professionalism of the person(s) maintaining the NWS service weather stations should also be taken into account in respect to reliability of temperature records. Although the comparisons in this study related to conditions encountered by small mammals, the same conclusions apply to any small animal living on the forest floor or active on fallen logs and the lower trunks of trees.

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Table l. Mean daily temperatures, (°C; compiled at 2-hr intervals) 20 cm above the surface in a swamp and adjacent upland forest, 5 km NW of Storrs, Connecticut and at a National Weather Service station (NWS) at Bradley International Airport, 35 km from the field sites. Data were analyzed for a 10-day period in respect to the entire 24-hr period, day-time (08-20 hrs), and night-time (22-06 hrs) during a very cold winter period (8-17 January 1966), a period of very high summer temperatures (23 July-1 August 1966) and periods of moderate temperatures during spring (2-11 May 1964) and autumn (23 October-1 November 1964). Field site values with an asterisk (*) differ from those at the NWS station at <0.05 (Tukey's HSD test).

Season	Time	Site			*F*; df	P
		NWS station	Swamp	Upland		
Winter	24 hrs	-6.1 ± 0.6	-7.1 ± 0.6	-7.5 ± 0.7	1.24; 2,33	0.30
	08-20	-5.8 ± 0.7	-6.0 ± 0.8	-6.0 ± 0.8	0.57; 2,18	0.58
	22-06	-7.7 ± 0.4	-8.5 ± 0.3	-9.5 ± 0.5*	5.78; 2,12	0.02
Spring	24 hrs	16.6 ± 1.2	13.8 ± 2.2	14.5 ± 2.5	0.46; 2,33	0.64
	08-20	21.0 ± 1.3	19.0 ± 2.0	20.6 ± 1.9	0.34; 2,18	0.72
	22-06	10.5 ± 1.1	6.4 ± 1.3	5.9 ± 1.3	4.14; 2,12	0.04
Summer	24 hrs	23.2 ± 1.3	18.2 ± 1.0*	19.6 ± 1.1*	5.13; 2,33	0.01
	08-20	26.4 ± 0.9	20.5 ± 1.0	22.1 ± 1.0	9.65; 2,18	<0.01
	22-06	18.8 ± 0.7	15.0 ± 0.8*	16.2 ± 0.9	5.60; 2,12	0.02
Autumn	24 hrs	9.7 ± 1.3	13.8 ± 2.2	14.5 ± 2.5	1.52; 2,33	0.23
	08-20	12.7 ± 1.5	9.7 ± 1.8	11.2 ± 12.0	0.68; 2,18	0.52
	22-06	5.6 ± 0.8	2.7 ± 0.4*	3.5 ± 0.4	7.05; 2,12	<0.01

Table 2. Mean daily maximum and minimum temperatures 20 cm above the surface of a swamp and adjacent upland forest, 5 km NW of Storrs, Connecticut and at a National Weather Service (NWS) station at Bradley International Airport, 35 km from the field sites (winter, January-February; spring, April-May; summer, July August; autumn, October-November). Field site values with an asterisk (*) differ from those at the NWS station at <.05 (Tukey's HSD test).

Season	Temperature	Site			*F*; df	P
		N. W. S.	Swamp	Upland		
Winter	Maximum	1.5 ± 0.3	1.5 ± 0.2	1.0 ± 0.3	1.13; 2,884	0.32
	Minimum	-8.1 ± 0.4	-6.7 ± 0.3*	-8.8 ± 0.3	11.84; 2,883	<0.01
Spring	Maximum	18.8 ± 0.4	18.1 ± 0.4	19.5 ± 0.4*	2.89; 2,912	0.06
	Minimum	5.0 ± 0.3	2.5 ± 0.3*	3.1 ± 0.2*	36.51; 2,910	<0.01
Summer	Maximum	29.1 ± 0.3	23.1 ± 0.2*	24.7 ± 0.3*	204.68; 2,741	<0.01
	Minimum	15.7 ± 0.2	13.0 ± 0.2*	14.0 ± 0.2*	31.04; 2,739	<0.01
Autumn	Maximum	16.2 ± 0.4	12.9 ± 0.4*	14.5 ± 0.4*	18.67; 2,668	<0.01
	Minimum	3.0 ± 0.3	0.5 ± 0.2*	1.0 ± 0.3*	18.26; 2,669	<0.01

Figure 1. Seasonal comparisons of average temperatures, compiled at 2-hr intervals for 10-day periods, in a cedar swamp and adjacent upland deciduous forest with those recorded at a National Weather Service station 35 kilometers away. For dates of records, see Table 1.