THESIS

SMALL MAMMAL ACTIVITY PATTERNS

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY JAMES FREDERICK LIPSCOMB ENTITLED SMALL MAMMAL ACTIVITY PATTERNS BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

SMALL MAMMAL ACTIVITY PATTERNS

Multiple regression techniques were used to derive a 14-term representation of the effects of temperature, time of day, number of days since baiting, wind velocity, and time of year on small mammal activity. This representation described 42 percent of the variability in activity observed for 837 hours during the summer of 1965. Trends in activity were found to agree with trends observed in 1964. Other factors hypothesized to affect small mammal activity include activities of predators, parental care and breeding behavior, precipitation, and residual effects of previous environmental conditions. Extreme weather conditions probably affect activity enough to bias small mammal trapping experiments.

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INTRODUCTION

Wild populations of small mammals are constantly exposed to sets of environmental conditions over which they have no control. Their responses to changing environmental situations are behavioral, and therefore patterns of small mammal activity are conditioned at least in part by the environment.

Ogilvie and Stinson (1966) found that several species of *Peromyscus* preferred floor temperatures between 25.8 C and 32.4 C. The laboratory mouse (*Mus musculus*) was found to prefer a temperature of 31.8 C.

Kavanau (1967) showed that when *Peromyscus* were allowed to control ambient illumination they selected bright starlight or dim moonlight levels during active periods and total darkness or very dim light for inactive periods.

These demonstrated preferences of laboratory animals are probably similar to those of wild animals. Unfortunately they give little indication how deviations from optima influence small mammal feeding activity and hence experimental trapping success.

The project described here was undertaken to study the impact of some factors which seemed likely to affect small mammal activity under natural conditions.

The study area was located on a grassy west-facing slope at an elevation of 9200 feet 34 miles west of Fort Collins, Colorado. Two species of small mammals were common on the area, masked shrews (*Sorex cinereus*) and western jumping mice (*Zapus princeps*).

MATERIALS AND METHODS

An Esterline-Angus, 20-pen event recorder was installed central to 20 bait stations arranged at 50-foot intervals in a truncated triangle pattern. This configuration was used to simplify wiring. The 50-foot interval between stations was chosen to conform with the standardized census procedures of Calhoun and Casby (1958).

Each bait station consisted of a 3-cc bait cup on a treadle which activated a mercury micro-switch when tipped. The cups were filled with peanut butter every third day during the study period.

The mercury switches produced a blue spark on activation which was masked from the bait cup area. No practical method could be devised to eliminate the slight electrical noise associated with this spark.

Every station was enclosed by a fence of 0.5-inch square wire mesh and covered with a slate shingle. One-and-one-half-inch-square entry points were placed on each of three sides. These entry points were located in the center of a "hallway" approximately 2 inches in diameter which was open at both ends. The bait station was located near the center of the fourth side. These devices protected the bait cup and treadle from precipitation and excluded birds and larger mammals from the station.

Weather data were obtained from a permanent weather station located approximately 300 yards from the study area. These data included air temperature, relative humidity, wind velocity, barometric pressure, and solar radiation. Time of day was corrected at noon and midnight so that sunrise and sunset always occurred at 0600 and 1800 hours respectively. Thus "time of day" as used in this discussion should be recognized as time relative to sunrise between midnight and noon, and as time relative to sunset between noon and midnight. Minutes of small mammal activity and average values for all weather data were calculated for 1-hour periods based on this time scheme. Additionally, maximum and minimum air temperature were recorded for each hour. Activity for fractional parts of hours (resulting from time corrections) was adjusted by proportion.

Investigations using infrared motion picture photography showed no characteristic feeding habits that could be used to distinguish species from recorder charts alone. Since the apparatus could not differentiate species, results and conclusions of this study are expressed in terms of total small mammal activity.

Data were collected during July and August of 1964 and 1965. A similar study was conducted by the author in 1970 to gain familiarity with the procedures used.

At the end of each summer's study period museum special traps were placed at each bait station. The trapline was operated for 3 days to determine which species were present on the study area.

RESULTS AND DISCUSSION

Graphs relating small mammal activity to each of the extrinsic factors considered in this discussion are shown in Figures 1 through 6. Most of these factors are interrelated to some degree. For example what appears to be a good correlation between activity and solar radiation is complicated by the fact that solar radiation is also highly correlated with time of day. Similar relationships exist between other factors. The kind of display represented by these figures consists, to whatever extent the factors are not independent, of several alternative ways of describing the same pattern.

Graphs for both 1964 and 1965 are shown where data are available. Data points for 1964 were omitted to avoid confusion. The consistently lower activity levels for 1964 probably reflect lower small mammal populations in that year. Orr (1959) reported temperature, humidity, barometric and temporal response patterns for Peromyscus leucopus noveboracensis confined in large outdoor enclosures. His results were virtually identical in every case with the corresponding graphs in Figures 1 through 6. He did not, however, explore the intercorrelations between these factors.

The high inherent variability in these data required that many observations be available for correlation analysis if significant results were to be obtained. Previous studies of small mammal activity using photographic techniques (Pearson, 1960; Osterberg, 1962) failed to detect significant effects of weather on activity, largely due to low numbers of observed passes at one or two sensing stations. A large quantity of data (837 hours with complete information, 16,740 sensing station hours) was available for 1965 but not for 1964. Nevertheless the agreement in trends for the two years provides confidence for generalizing from an analysis of the 1965 results.

Variability which could be assigned to the study method (Fig. 1) was accounted for by assuming a linear increase in activity over the

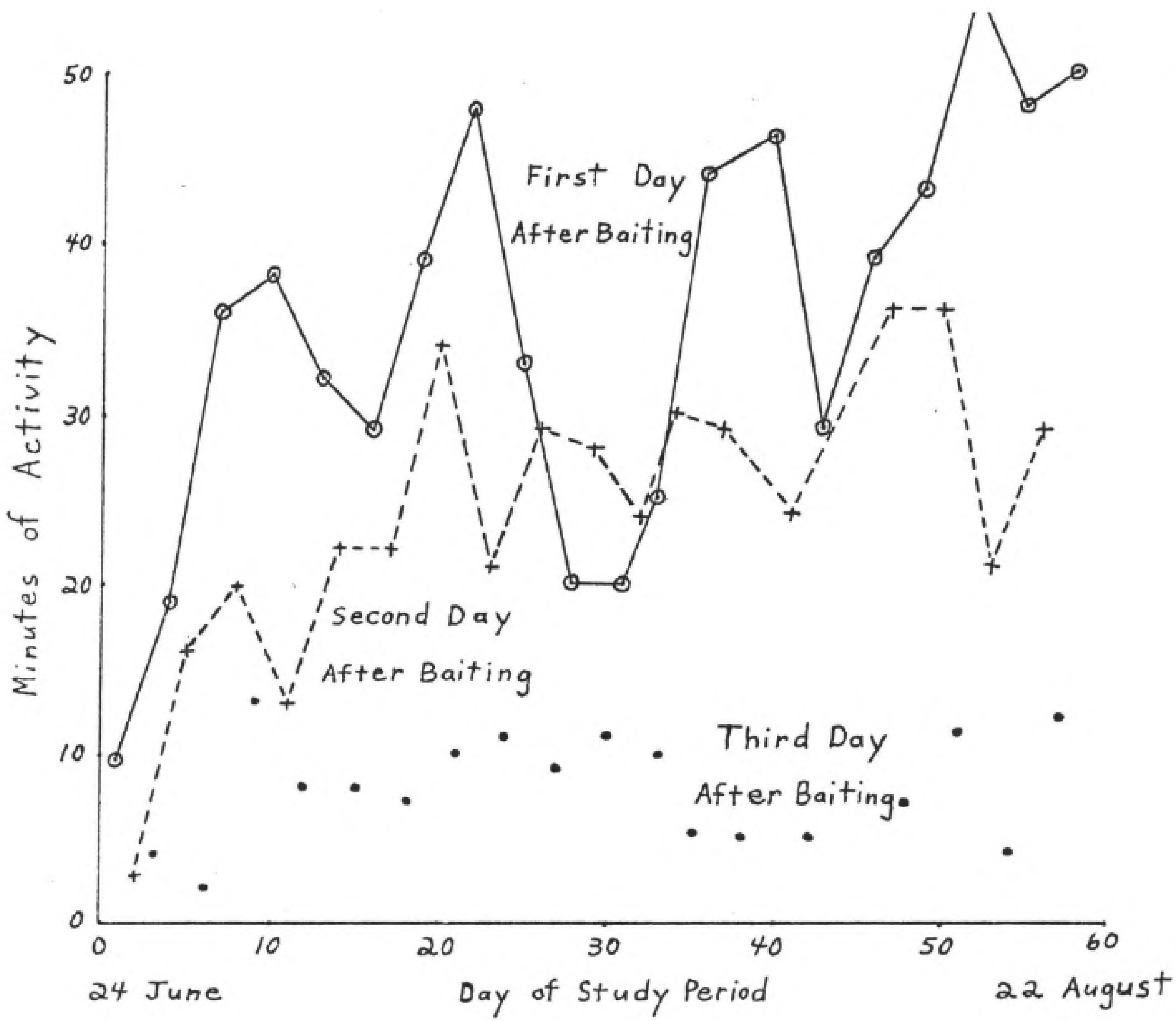

Figure 1. Average activity increase over study period for 1965.

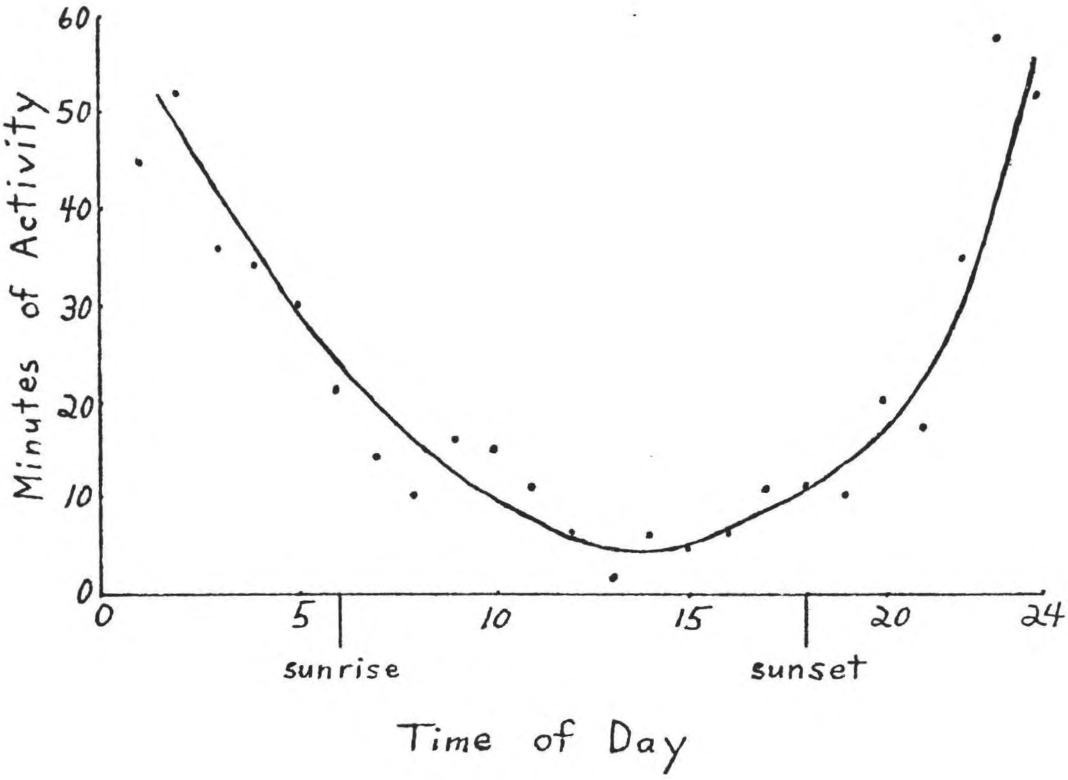

Figure 2. Activity as a function of time of day.

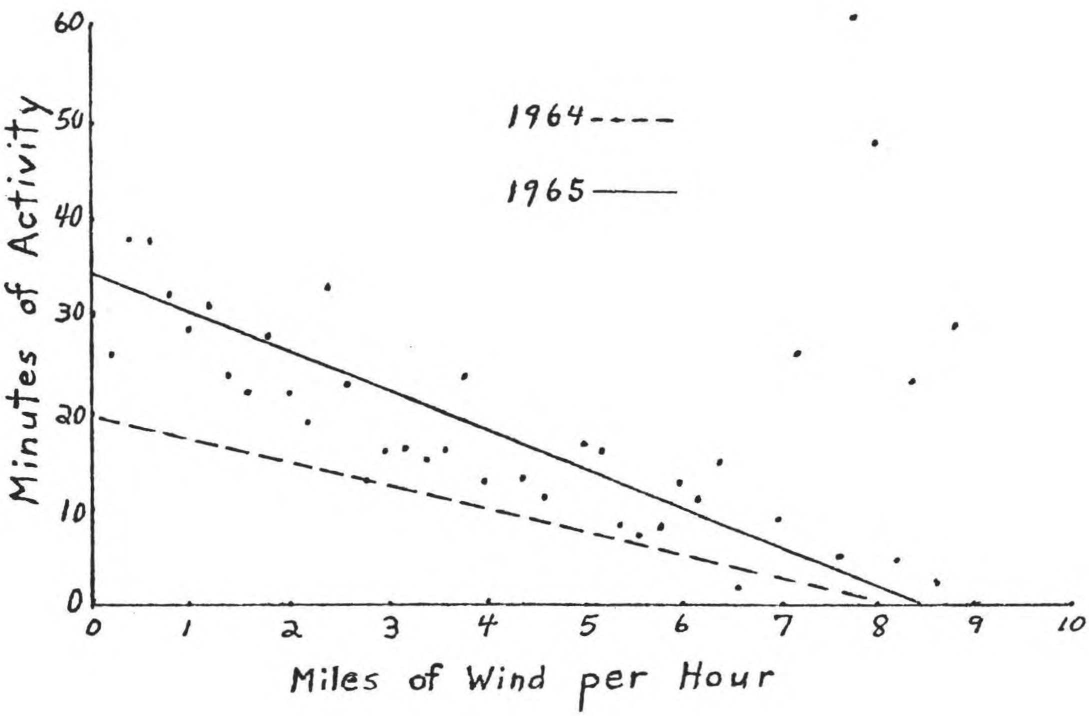

Figure 3. Activity as a function of wind velocity.

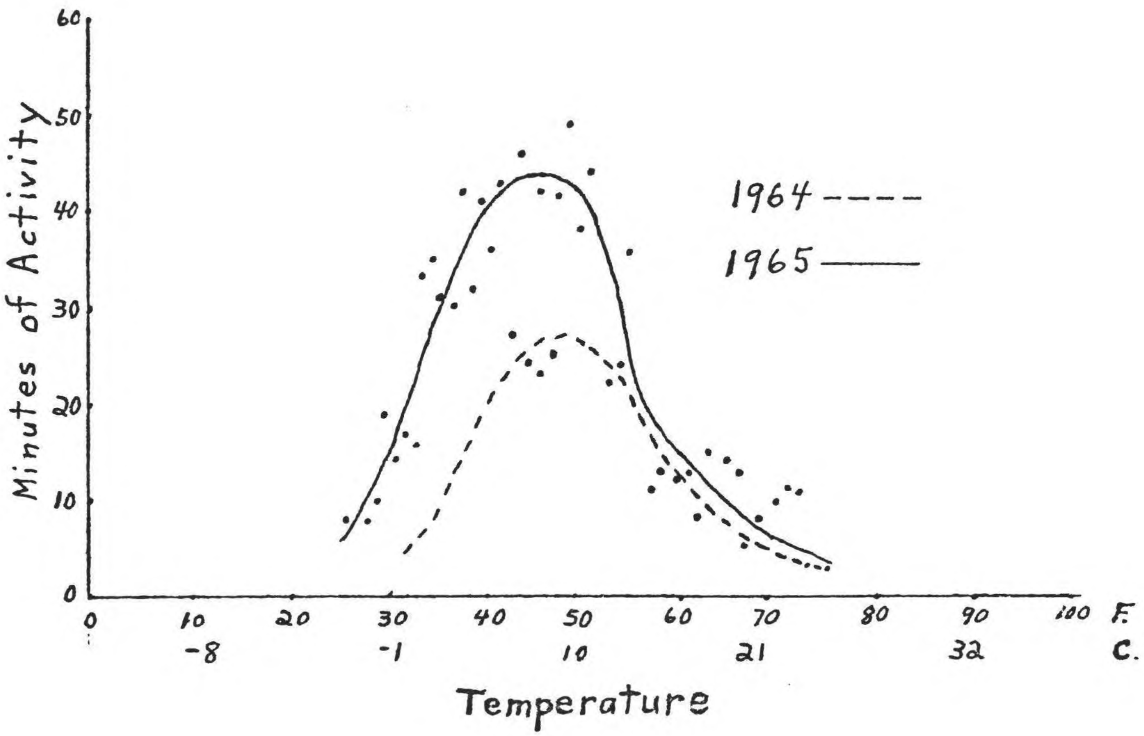

Figure 4. Activity as a function of average temperature.

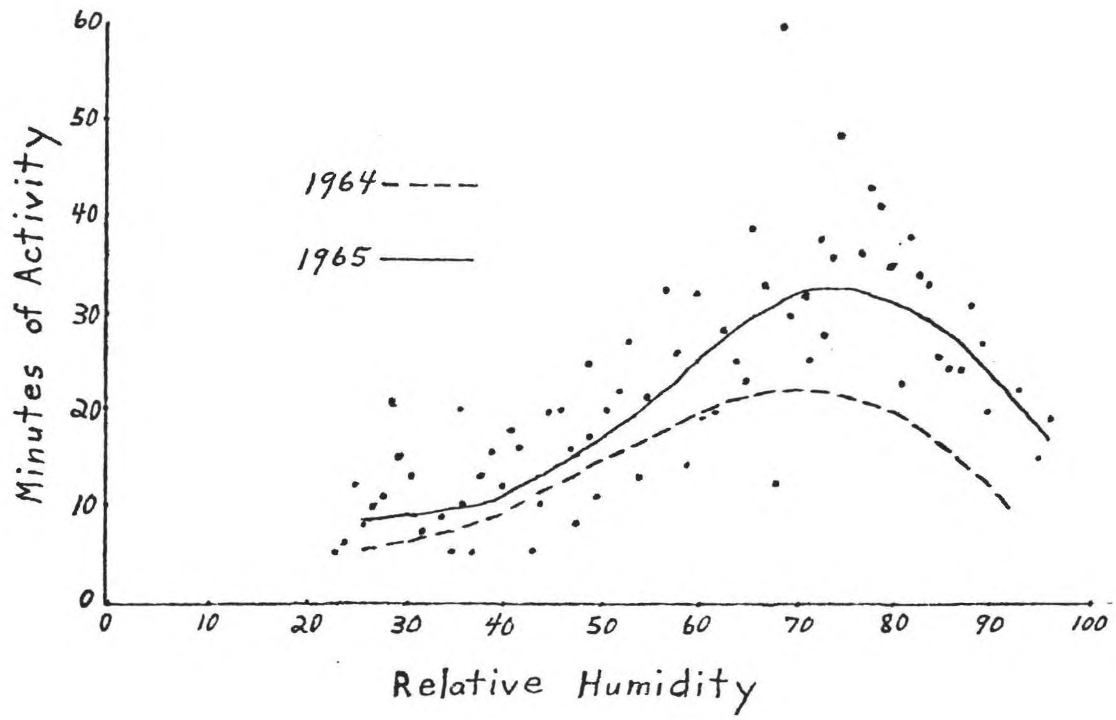

Figure 5. Activity as a function of relative humidity.

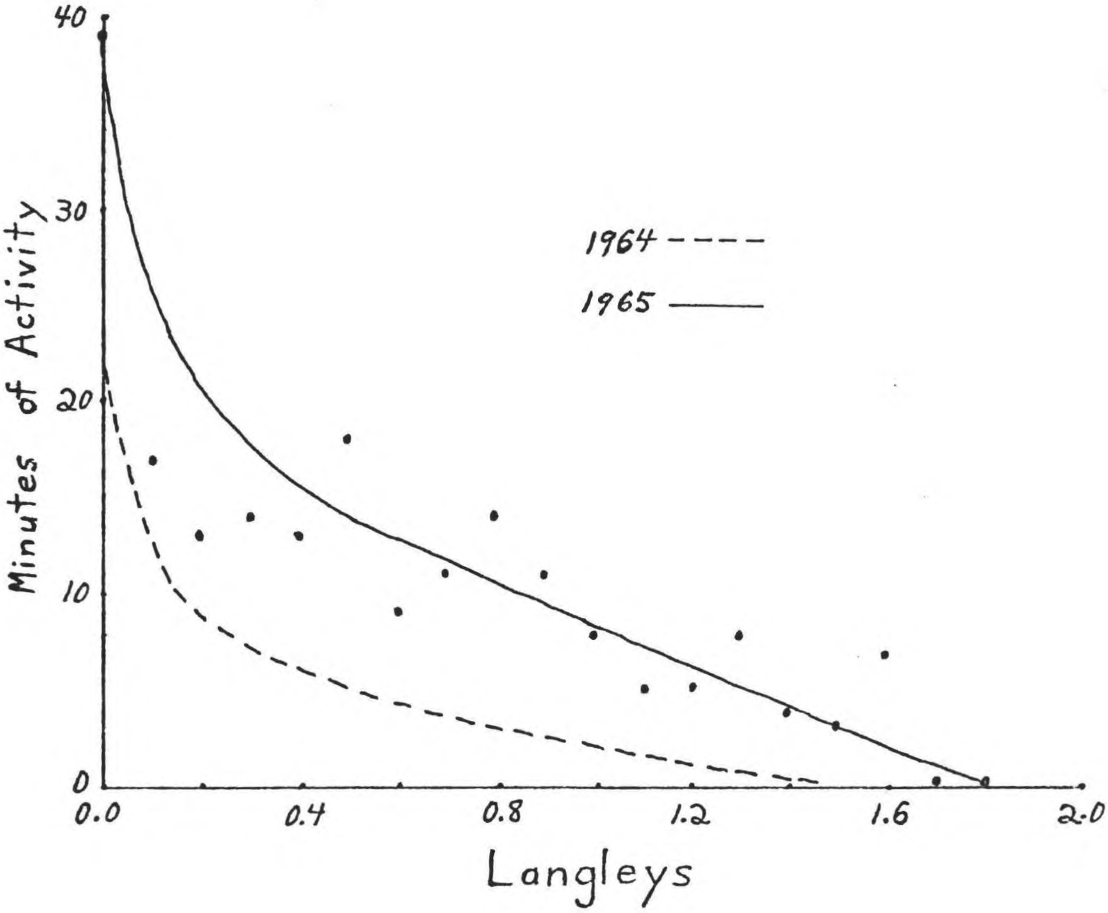

Figure 6. Activity as a function of solar radiation.

summer and by blocking out the variation between the first and second days following baiting of the stations. The increase in activity during the study period may be the result of increased small mammal populations, acclimitization to the bait stations or a combination of these factors. The significantly lower activity on the second day after baiting may be due to glazing of the peanut butter which diminished its scent and may have decreased its palatibility as well. Activity on the third day was so low as to indicate total utilization of bait at many of the stations. This indication is corroborated by field observations of total utilization at as many as 15 (75%) of the stations after the third day. It was assumed that activity patterns on the third day after baiting were not comparable to those of the first two days, and these data were not considered in the analysis.

Activity during hours where average wind speed was higher than 7.0 miles per hour was inconsistantly high and variable. Presumably gusts of wind were strong enough to move treadles at some of the bait stations. Data for these hours were discarded.

Data were punched on cards for computer analysis and coefficients of determination (R^2) were computed for all possible regressions containing the 15 variables judged most likely to be important (Table 1). The R^2 value for the regression containing all variables was .4239. Figure 7 shows the highest R^2 for regressions containing 0,1,2,...,15 variables and suggests a rapid convergence on the true inherent variance of these data (approximately 57% of the total variation). This variance includes portions due to factors influencing activity but not considered in our analysis, as well as the portion due to lack of precision in measuring small mammal activity.

It is possible to calculate a six term regression accounting for 40% of the variation. The only data required for this regression are time of day, time of year, and time since baiting. This regression probably represents the optimum ratio of predictive ability to data collecting effort.

The large number of data points made it possible to demonstrate statistical significance for several other factors which had relatively slight influence on small mammal activity. A fourteen term regression,

Table 1. List of environmental factors and abbreviations.

Factor	Abbreviation
Time of day	TD
Time of day squared	TD^2
Average temperature	TP
Average temperature squared	TP^2
Days since start of study period	DY
Days since last baiting of stations	BT
Average wind velocity	WD
DY, BT interaction	DY*BT
DY, TD interaction	DY*TD
DY, TD^2 interaction	$DY*TD^2$
DY, WD interaction	DY*WD
DY, BT, TD interaction	DY*BT*TD
DY, BT, TD^2 interaction	$DY*BT*TD^2$
DY, BT, WD interaction	DY*BT*WD
TP, WD interaction	TP*WD

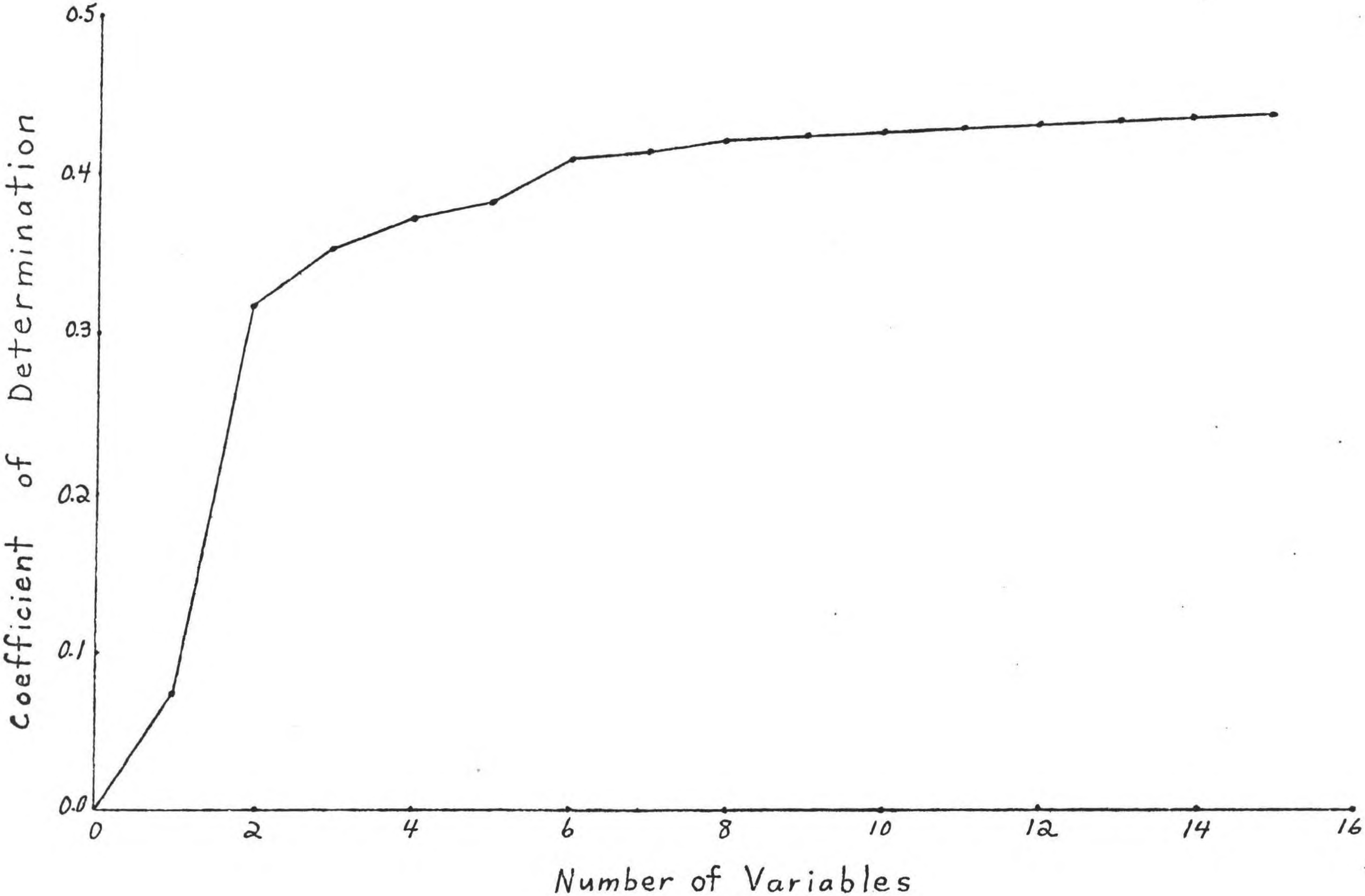

Figure 7. Coefficient of determination as a function of variables in regression.

all of whose coefficients are significant at least at the 0.10 level, is given by ACTIVITY = 72.6 - 13.0 TD + 0.483 TD^2 + 0.773 TP - 0.0106 TP^2 + 0.779 DY - 5.11 BT - 1.51 DY*BT - 0.120 DY*TD + 0.005 DY*TD^2 + 0.278 TD*DY*BT - 0.0096 TD^2*DY*BT - 0.0087 WD*DY + 0.0057 WD*DY*BT. (Symbols are as listed in Table 1.) This regression accounts for 42% of the total variation in the data (correlation coefficient = 0.65). Complete statistical analysis of this predictor is included as an appendix.

The relatively low predictive ability of the above expression, as measured by R^2 or by the coefficient of variation (0.932), may be due in large part to the effects of lag influences. Small mammal activity at any time is influenced not only by the environmental conditions at that time but also by previous conditions. For example a long period of severe weather could be followed by great activity even if prevailing conditions were still far from optimal. It is also possible that an activity period started under favorable conditions will be continued under unfavorable conditions, if there is a rapid change, though no new period would normally have been initiated under the unfavorable conditions.

CONCLUSIONS

It is probable that small mammal activity is influenced by many factors not considered in our predictive equation. Some of these factors are precipitation, predator activity, reproductive behavior and parental care of young, as well as the lag influence discussed above. From our results it appears doubtful that a simple predictive equation for small mammal activity can be developed. Nevertheless some general conclusions seem justified by the data, at least as hypotheses for future investigation.

The daily pattern of high night time and low daylight activity emerges as the most definite result of the study. The activity curve is approximately a parabola rather than the expected sinusoid but this result may be due to the discontinuity introduced at midnight by time correction. The report of Osterberg (1962) that *Blarina brevicauda* activity reached peaks near sunrise and sunset does not necessarily conflict with these results, but if that reported pattern is characteristic of *Sorex cinereus*, the midnight activity peak of *Zapus princeps* must be extremely abrupt. Our results agree very closely with the pattern reported by Orr (1959) for *Peromyscus*.

Another pattern of interest is the apparent preference for temperatures near 9 C (48 F), considerably lower than those preferred by *Peromyscus* and *Mus* as reported by Ogilvie and Stinson (1966), but again exactly as reported by Orr (1959).

The relationship between wind velocity and activity is not as clear-cut as it appears in Fig. 1. The pattern of decreasing activity with increasing wind velocity is apparently real, but it is significant only in its interaction with day of the year. (Its effect was slight in the beginning but increased through the study period.)

Solar radiation and relative humidity were too closely associated with time of day and temperature respectively to show any real effect on small mammal activity. The latter factors in each case showed higher correlations with activity and were therefore assumed to be the primary factors involved. No relationship between small mammal activity and barometric pressure was demonstrated.

It should be observed that although several authors (Orr, 1959; Pearson, 1960) stated that high humidity is conducive to high activity, their results as well as ours showed a definite decrease in activity for relative humidity greater than 80%. This may indicate a preference for humidities in the 70%-80% range or a preference for the temperatures which most frequently occur when the humidity is at that level (at Pingree Park these temperatures are between 5 C (40 F) and 10 C (50 F) during the summer).

The results of this study have several implications for small mammal trapline investigations. The need to consider time of day in trapline studies has been generally recognized. The importance of this factor is reiterated here. Time of year is also quite important and if two studies are to be compared, seasonal agreement should be considered. The third, and probably least often recognized consideration, is that environmental conditions, especially extreme conditions, do affect small mammal activity and hence trapline success. Although we were unable to predict activity with much confidence under normal conditions, definite effects of extreme conditions are undeniable. Abnormally high or low temperatures or high wind velocities do reduce small mammal activity significantly.

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APPENDIX

CHARACTERISTICS OF REGRESSION PREDICTOR FOR SMALL MAMMAL ACTIVITY

Results of t-tests of significance for all coefficients in my predictive equation are given in Table 2. Table 3 is an analysis of variance for this regression. Other statistics of interest include the coefficient of multiple correlation 0.6501; the coefficient of determination, 0.4227; the standard error of the estimate, 27.82; and the coefficient of variation, 0.932.

Table 2. Significance tests of regression coefficients.

Variable	Coefficient	t-Test	Significance level
Constant	72.65601	2.71	0.01
TD	-13.00031	10.53	0.01
TD^2	0.48295	10.24	0.01
TP	0.77341	1.74	0.10
TP^2	-0.01059	2.07	0.05
DY	0.77898	3.43	0.01
DY*TD	-0.12005	2.75	0.01
DY*WD	-0.00868	3.00	0.01
$DY*TD^2$	0.00514	3.04	0.01
BT	-5.11342	1.65	0.10
DY*BT	-1.50791	6.31	0.01
DY*BT*TD	0.27779	6.26	0.01
$DY*BT*TD^2$	-0.00960	5.73	0.01
DY*BT*WD	0.00566	1.69	0.10

Table 3. Analysis of variance for regression predictor.

Source	SS	DF	MS	F
Regression	466304	13	35870	46.35
Deviations	636962	823	774	
Total	1103266	836		