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Partitioning of space and time by the western jumping mouse, Zapus princeps Utahensis Hall

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PARTITIONING OF SPACE AND TIME BY THE WESTERN JUMPING MOUSE *ZAPUS PRINCEPS UTAHENSIS* HALL

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INTRODUCTION AND LITERATURE REVIEW

Intraspecific competition is important in determining habitat utilization by members of a single species. Effective use of habitat may involve partitioning the available resources: space, time and food among individuals of different age, sex, and/or reproductive state. Numerous publications deal with interspecific competition (McCloskey and Fieldwick 1975, Cody 1973, Rosenzweig 1973, Stewart and Levin 1973, Gaby 1972, Brown 1971, Koshkina 1971, Sheppe 1967, Caldwell and Gentry 1965, Cameron 1964, Clough 1964, Gause 1932), but little has been written on intraspecific competition among populations of organisms in nature.

The western jumping mouse, *Zapus princeps utahensis* Hall, is a small rodent that exhibits intraspecific competition. *Zapus* is known to inhabit narrow zones of lush, high elevation vegetation (Brown 1970). Due to its restricted habitat and limited occurrence, little information is available on its habits. *Zapus*, a hibernating animal, is active above ground approximately three months of each year (Brown 1967). The animals are often found at densities as high as six per .40 ha (Negus and Findley 1959). Myers (1969) reported the average home range for males as .30 ha and .24 ha for females. If this is true, there may be an overlap in the use of space and food by *Zapus*.

Home range is an indication of space utilization. Burt (1943) defined home range as the area in which an animal travels in search of food. In describing the importance of home range, Dice and

Clark (1953) determined that it affects population densities, reproduction, social organization, competition among individuals, food utilization, species relationships and other aspects of community dynamics.

Various methods are available for determining home range (Jennrich and Turner 1969, Mazurkiewiez 1969, Jorgensen 1968, Calhoun and Casby 1958, Dice and Clark 1953, Hayne 1949). Each of these methods assumes a circular or elliptical home range shape but there is little basis for such an assumption. Jorgensen and Tanner (1963) determined that there is unequal use of the area within the home range due to the availability of food, cover and function. Burge and Jorgensen (1973) produced a method of placing confidence statements on the chance that recaptures will be within specified distances of the center of activity.

One use of home range estimates involves determining probable interactions in space and time. This deals with the probability that two adjacent animals will be found at the same time in the region of their overlapping home ranges (Jorgensen 1968). Appropriate consideration of the differential temporal use of home range has been neglected. The probability of interaction between adjacent animals will vary as temporal patterns vary (Jorgensen and Hayward 1965). Availability and quality of food will also affect the activity of organisms (Rosenzweig 1973). In areas of optimal food availability and quality, dominant animals may force subdominant animals into suboptimal habitat.

The purpose of this study was to determine if intraspecific competition results in partitioning of space and time by *Z. princeps*.

STUDY AREA

The data were collected within the alpine cattle pasture at the Great Basin Experimental Station, Sanpete County, Utah, between July 2 and August 30, 1975. The area of the Great Basin Experimental Station in Ephraim Canyon is grazed by sheep in the summer months. To avoid confounding the rodent data with the effects of sheep grazing on rodent behavior, a sheep exclusion area was selected that showed, through preliminary trapping, *Zapus* in suitable quantities.

The alpine cattle pasture is in the sub-alpine zone of the Wasatch Plateau described by Ellison (1954). This area lies primarily above 3,048 m, but extends as low as 2,895 m in certain places.

The mean air temperature of the sub-alpine zone for the months of July and August is 12.6 C, and temperatures of 23.9 C are seldom attained. The mean length of the frost-free period is 84 days (Ellison 1954) with a mean annual precipitation of 8.76 cm for July and August.

The vegetation was predominately herbs, but two species of shrubs were often present--Gooseberry Currant (*Ribes montigenum*) and Red Elderberry (*Sambucus racemosa*).

MATERIALS AND METHODS

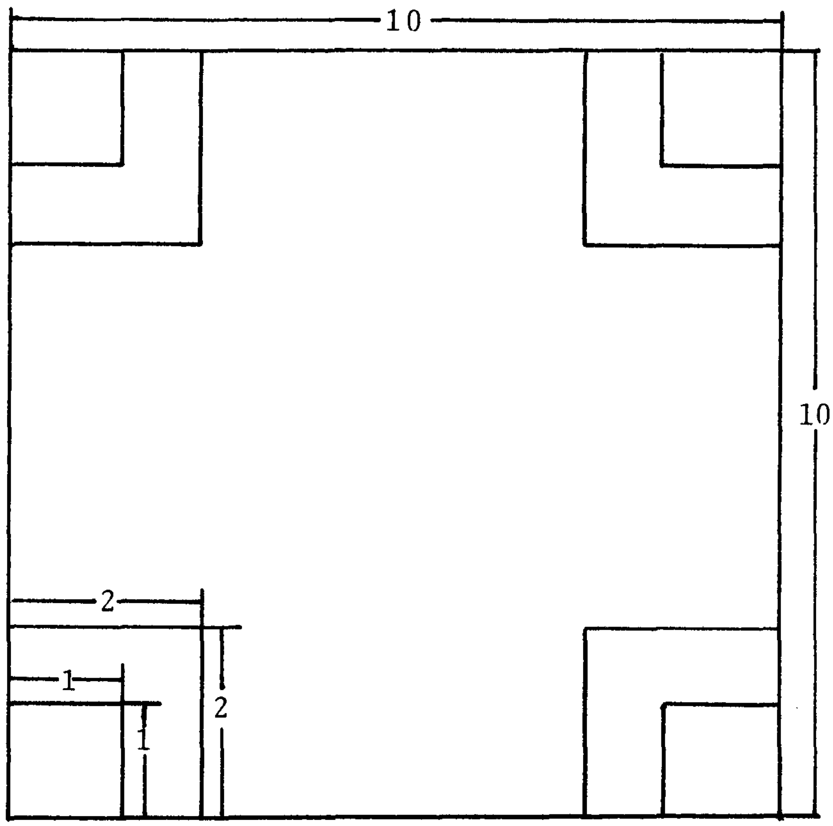
Certain problems are apparent with the use of conventional live-trapping techniques in assessing small mammal activity. Most methods share the problem of restricting the animal's movements for the remainder of the trapping interval once it has been captured. A second problem is that an accurate estimation of temporal use of home range is difficult to obtain. A 2.02 ha electric activity grid described by Garcia et al. (1974) was selected as the trapping method for the study. This method allows for quick release of captured animals and provides accurate estimates of temporal use of home range.

Data were collected during three nine-day trapping periods (July 15-July 23, August 4-August 12, August 22-August 30). Eight days separated the trapping periods to allow for animal recovery and grid maintenance. The sequential toe clip method (Hamilton 1937) was used for marking the animals. Information recorded for each animal upon capture was location of capture, species, age class and reproductive status.

To monitor phenological changes, vegetational analyses were conducted in early July and late August. The vegetational analyses were conducted at ten randomly-chosen trap sites. Presence of plant species, estimates of total cover, cover contributed by each species, and number of individuals per species per quadrat were recorded. Data for trees were extracted from quadrats of 100 m^2, cornered at randomly selected trapping stations. Information for shrubs was collected from 4 m^2 plots located at each corner of the 100 m^2 plots. Herbaceous data were collected from a 1 m^2 plot at each corner of the 100 m^2 plot (Fig. 1).

Burge and Jorgensen's (1973) method of home range determination was applied for each animal captured three or more times in the second trapping period. Periods 1 and 3 contained hibernators not available for active competition and were omitted from the spatial and temporal analyses. Few males were captured 3 or more times in the second trapping period. This dictated the use of data obtained for males from all three trapping periods. Chi-square analysis was used in determining differential temporal utilization of habitat between males and females, males with descended testes and non-descended testes, lactating females and all males, lactating females and non-estrous females, and non-estrous females and all males. This analysis was used for all animals regardless of the number of recaptures. Estrous females were noticeably lacking in the data; this was due to the difficulty in ascertaining the estrous state in Z. princeps.

The probability of interaction was used as an index of intraspecific competition. Temporal activity curves were drawn for each animal captured three or more times at different trap sites. In the second trapping period the area under each curve was determined, and the overlap of curves between adjacent animals used to



Trap Site

Tree Analyses - 100 m^2 box

Shrub Analyses - 4 m^2 boxes

Herb Analyses - 1 m^2 boxes

Figure 1. Illustration of the method used for analysis of vegetation.

describe the maximum likelihood of overlap in time. The equation used was:

$$\frac{\text{Overlap}}{\text{Total Area A}} \quad X \quad \frac{\text{Overlap}}{\text{Total Area B}}$$

To calculate the minimum likelihood of overlap in time, activity points were plotted for each animal captured three or more times in the second trapping period (excepting males). The probability of an animal being captured at any hour was determined. The probability of two adjacent animals being active in the same hour is the product of their individual probabilities of activity for that hour. The total temporal overlap of the two animals during the entire night was obtained by summing the probability of overlap values for the individual hours of the period of concern.

Simple correlation analyses were conducted on the values obtained for the probability of interaction in space and the two values for the probable interaction in time.

Vegetation data and topographical changes were correlated with home range data to make it meaningful in terms of habitat requirements.

RESULTS AND DISCUSSION

One hundred eighty-six _Zapus_ captures occurred throughout the summer. Figure 2 gives percentages of total animals caught in each reproductive class during each of the three trapping periods.

Males with descended testes were the rodents most often trapped in the first trapping period. This is in accordance with Brown (1967) and Clark (1972) who found that males with descended testes appeared in abundance approximately two weeks before females appeared in substantial numbers.

In the second trapping period fewer males with descended testes were captured.

In the third trapping period, a significantly smaller number ($P < .05$) with descended testes was found, while a corresponding increase in the number of males with non-descended testes was noted. This occurrence is likely due to the ascension of testes in active males and to the appearance of sub-adult males in the population.

These data imply that the males assume an inactive role in reproduction approximately one-half of the way through their period of above-ground activity, and from that time they are concerned primarily with obtaining fat reserves for the approaching period of hibernation.

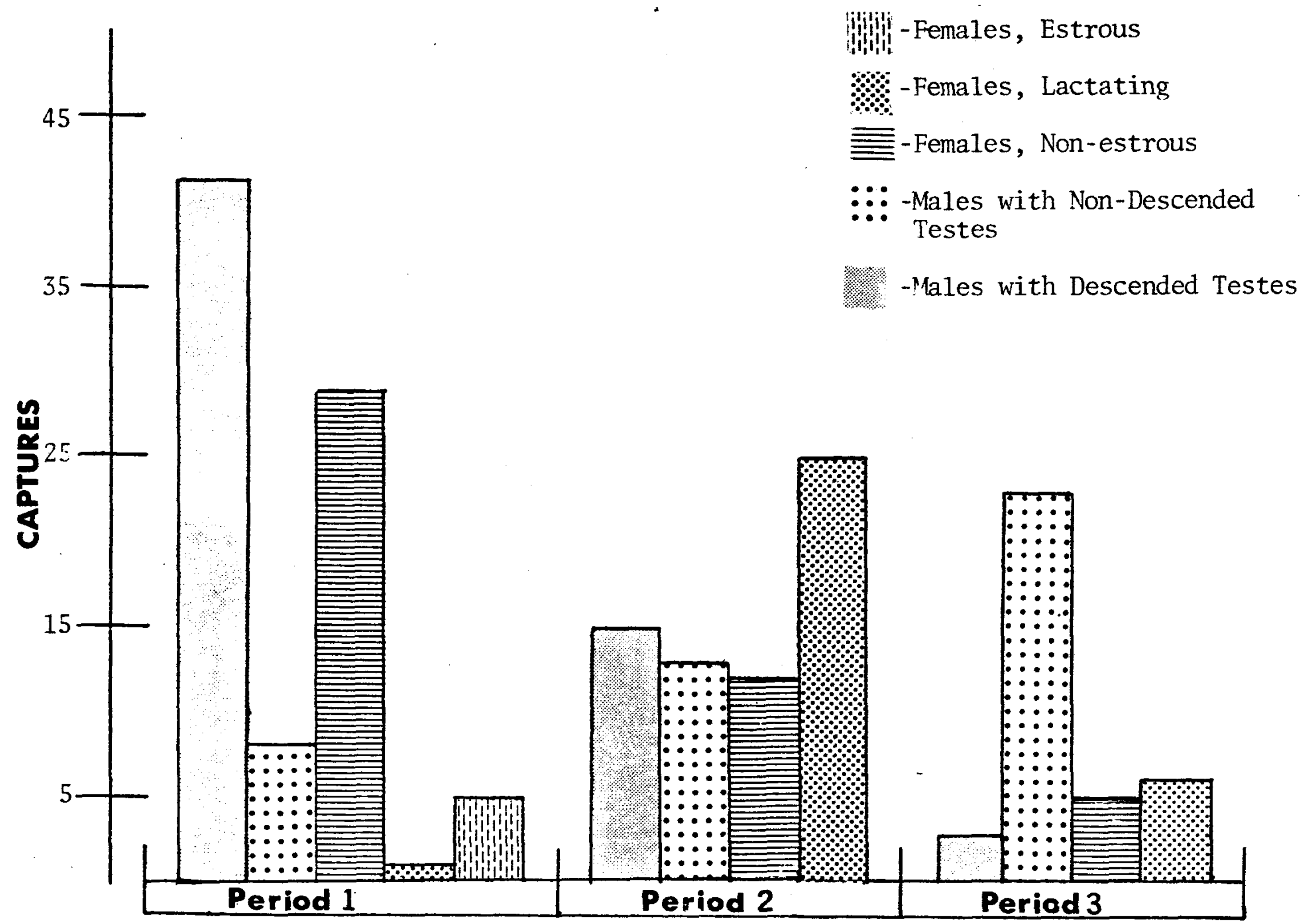


Figure 2. Percentages of total animals caught in each reproductive class during each of the three trapping periods.

Estrous females were noticeably lacking in the data--only five were found throughout the summer. These data do not imply that estrous females were present in low numbers. Due to the difficulty in determining an estrous state in small rodents, many estrous females were likely classified as non-estrous. The five estrous females detected in the first trapping period indicated that there were estrous females present at the same time as reproductively active males.

Non-estrous females were likely emerging from hibernation and not physiologically ready to reproduce. Fewer non-estrous females were found in the second trapping period. This reduction was probably due to females changing from a non-estrous state (which in reality may have been an estrous state) to a lactating state.

Significantly fewer non-estrous females were trapped in the third period. Since significantly fewer total animals were trapped in this period (the last two trapping nights yielded no Zapus), the hibernation period was likely beginning, and therefore was the cause of reduction in numbers across all reproductive classes excepting males with non-descended testes.

Only one lactating female was captured in trapping period 1, but in trapping period 2 significantly more lactating females were caught than in periods 1 and 3. The appearance of most lactating females approximately 16 days after their first detection is in accordance with Brown (1967) who stated that the gestation period for _Zapus_ is 18 days.

Vegetation Analysis and General Topography

Table 1 lists dominant shrub and herb species with their corresponding frequencies. The predominant trees on the grid were Alpine Fir (_Abies lasiocarpa_) and Engelmann Spruce (_Picea engelmannii_). Major topographical changes and dominant vegetation types are mapped in Figure 3. The grid is superimposed on the map. The dotted line connects those traps in which _Zapus_ were caught four or more times.

The area enclosed by the dotted line is dominated by Red Elderberry (_Sambucus racemosa_) and Wild Currant (_Ribes montigenum_). A stream that persisted throughout the summer bordered the area of the grid where _Zapus_ were caught most frequently. This is in accordance with Clark (1972) who determined that the area of _Zapus_ dominance is an area with water nearby and it is also an area of lush vegetation.

TABLE 1

DOMINANT HERB AND SHRUB GENERA

Analysis 1	% Frequency
Shrubs	
Sambucus	15
Ribes	20
Herbs	
Artemisia	68
Achillea	23
Geranium	45
Lathyrus	73
Trisetum	58
Erythronium	18
Analysis 2	
Shrubs	
Sambucus	17
Ribes	25
Herbs	
Artemisia	67
Achillea	63
Geranium	45
Lathyrus	63
Trisetum	63
Erythronium	17

Other herbaceous species present at lower frequencies:

Penstemon	Delphinium
Thalictrum	Stellaria
Castilleja	Aguilegia

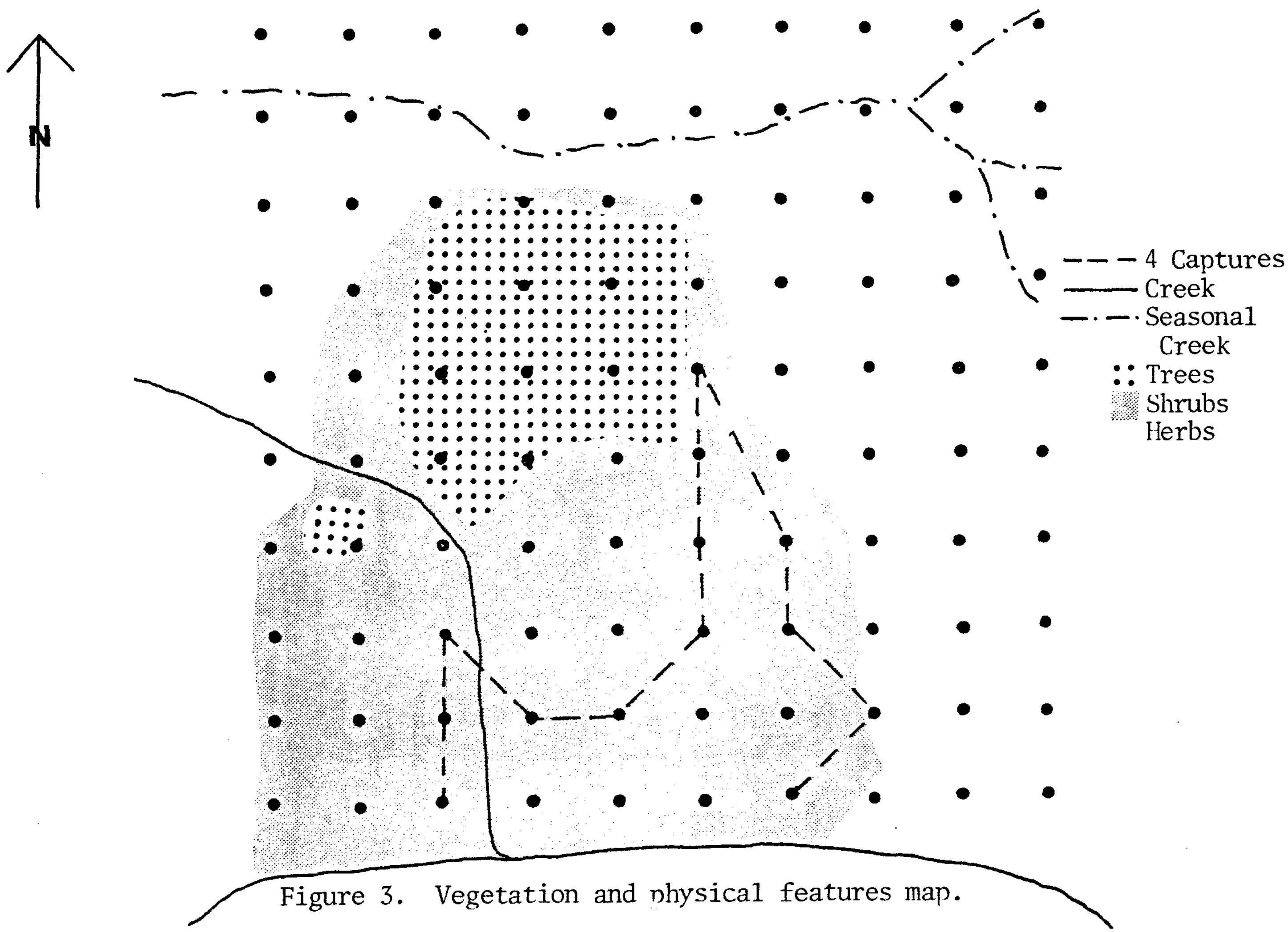


Figure 3. Vegetation and physical features map.

Habitat Partitioning

Table 2 lists the coefficients of determination for maximum and minimum likelihood interactions between adjacent animals. Coefficients obtained for all 3 categories (male vs. male, female vs. female, and male vs. female) were positive, but not significant ($P < .05$). If habitat partitioning were taking place, the coefficients would be negative and significant. The coefficients were small, suggesting that density independent factors, such as climate and predation, were playing a more important role in this population than were density dependent factors. The environmental pressures cause the population to emphasize reproduction, obtaining of fat reserves, and avoidance of predators. Owls were heard in the vicinity of the grid on several occasions.

Time and Space

The activity curve for all *Zapus* was bimodal with peaks at approximately 11:00 p.m. and 4:00 a.m. (Fig. 4). Curves drawn for each reproductive class yielded essentially the same curve. The greatest change in activity occurred as complete darkness approached (9:30 p.m.) and as the night approached complete light (5:00 a.m.), demonstrating that *Zapus* showed a definite preference for the time period 10:00 p.m. to 4:00 a.m. The curve tends toward crepuscular-type activity, but chi-square analysis demonstrated that it is not significant. The chi-square analysis was also used to determine that there was no preference for any three-hour block of time by any of the reproductive types.

TABLE 2

COEFFICIENTS OF DETERMINATION FOR MAXIMUM AND MINIMUM LIKELIHOOD OF SPATIAL AND TEMPORAL INTERACTIONS BETWEEN ADJACENT ANIMALS

Interactions	Coefficients of Determination	
	Maximum Likelihood	Minimum Likelihood
Male vs. Male	.0716*	.0044*
Female vs. Female	.0153*	.0104*
Female vs. Male	.0022*	.0001*

* Non-significant $P < .05$

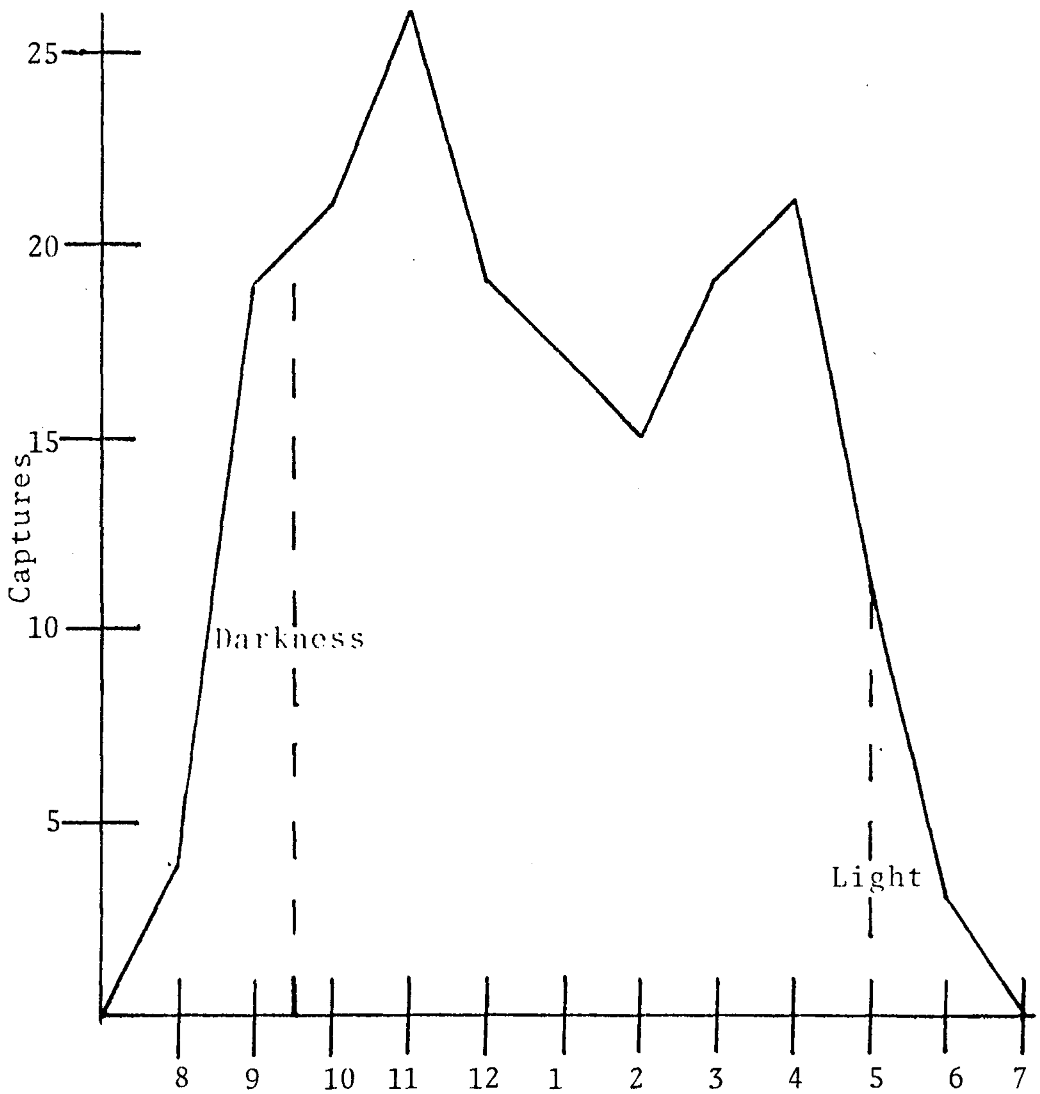


Figure 4. *Zapus* captures per hour over three trapping periods.

SUMMARY AND CONCLUSIONS

One hundred eighty-six Zapus were captured during the summer. Animals were classified according to reproductive status, and each corresponding class was scrutinized. Chi-square analyses indicated that no 3-hour block of time was preferentially used by any reproductive type, but Zapus showed a definite activity preference for the time period 10:00 p.m. to 4:00 a.m. (the period of total darkness). The activity curve for Zapus was crepuscular with peaks of activity occurring at 11:00 p.m. and 4:00 a.m.

Males with descended testes dominated the first trapping period (July 15 to July 23), lactating females dominated the second period (August 4 to August 12), and males with non-descended testes dominated the third period (August 22 to August 30). The gestation period for females was approximately 16 days.

Major vegetation types and topographical features of the grid were mapped. Chi-square analyses demonstrated that Zapus showed a preference for an area of the grid dominated by shrubs. The coefficients of determination obtained from the correlation of probable temporal and spatial interaction indicated that little partitioning of habitat, with respect to space and time, was taking place. Food was not included in this study, but its effects were possibly more significant than space and time. The low, non-significant coefficients of determination for all competitive relationships indicated random activity with respect to other individuals in the population. The restrictive pressures of the density independent factors were more important than the density dependent factors.

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VITA

PARTITIONING OF SPACE AND TIME BY

THE WESTERN JUMPING MOUSE

ZAPUS PRINCEPS

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Department of Zoology

M. S. Degree, April 1977

ABSTRACT

Zapus princeps was studied in Sanpete County, Utah. Data were gathered during three trapping periods in the subalpine zone. An electric activity grid was used to monitor differential use of space and time. Vegetation analyses were conducted to monitor phenological changes that occurred throughout the summer and also to determine the cover contributed by each major vegetation type. *Zapus* was more active in the area of the grid with shrubs as the major cover component. No reproductive type favored any 3-hour block of time through the night. The gestation period for *Zapus* was approximately 16 days.

Partitioning of habitat with respect to time and space was not a significant factor in abating intraspecific competition in *Zapus*. The density independent factors were possibly the most important restricting factors in this population.

COMMITTEE APPROVAL: