#1004

The Effect of Altitude Upon Various Physical and Reproductive Factors in a Population of *Peromyscus maniculatus*.

Undergraduate Research Report
Idaho Wilderness Research Center
Taylor Ranch Field Station
June - August 1975
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According to Davis (1939) a single subspecies of deer mouse, Peromyscus maniculatus serratus (Davis) exists in central Idaho which is found nowhere else in North America. This study was designed to investigate what affect altitude had upon various physical and reproductive factors in a population of this subspecies.

The Idaho Primitive Area was chosen as the site for the study because of the proximity of populations of deer mice at high and low elevations and because of the facilities offered by the Taylor Ranch Field Station, University of Idaho Wilderness Research Center. The field station served as a base for the field work, and the help received from the station personnel enabled my project to operate smoothly.

MATERIALS, METHODS AND STUDY AREA

This study was conducted on a series of five geographical benches located north of the Taylor Ranch Field Station. The study area's boundarys consisted of Big Creek to the south, Cliff Creek to the west, and a curving ridge line forming the northern and eastern limits.

Twenty trapping stations were utilized; each station consisted of 50 museum special traps (Wiener and Smith 1972) spaced 3 meters apart in a line transect (Larrison and Johnson 1973). Each station was maintained three days and checked twice daily to rebait and remove the catch.

Each trap was baited with a mixture of peanut butter, rolled oats, suet, and cooking oil (Stickel 1948; Holdenreid 1954; Taber and Cowan 1971).

Specimens were obtained during the months of June, July, and August 1975, and during December 1975, to January 1976. The winter samples were collected between elevations 1036 m. and 1328 m., trapping was not done at higher elevations due to snow depth.

Statistics were calculated using a statistical package (EZSTAT) designed for use with the CALL/VS computer system. Elevation was designated as the independent variable (X) and each physical measurement, body weight, and litter size was in turn used as the dependent variable (Y). The program for linear regression (LREG) was used to calculate the regression coefficient, standard error of the regression coefficient, T value, and correlation coefficient for each set of X and Y variables.

RESULTS

The summer project included data from 3000 trap nights. A total of 130 specimens were obtained for a trapping success of 4.3 percent. The winter sampling resulted in 1320 trap nights and obtained 39 samples, for a success of 2.9 percent.

Plants were classified as dominant or subdominant depending on the density of each species present in the study area (Table 1). The elevation was recorded for each specimen (Table 2) in addition to the museum measurements, weight, sex, reproductive condition of females, pelage coloration, date, and weather conditions (Table 3).

Table 1. Vegetation of study area. Species nomenclature according to Hitchcock and Cronquist (1974).

Dominants:	Balsamorphiza sagittata (Balsamroot) Agropyron spicatum (Bluebunch Wheatgrass)
Subdominants:	Bromus tectorum (Cheatgrass) Artemisia tridentata (Sagebrush) Brodiaea douglasii (Wild Hyacinth) Gilia aggregata (Scarlet Gilia) Erigeron speciosus (Showy Daisy) Cirsium spp. (Thistle)

Effect of Altitude

No relationship was found in either summer or winter populations between altitude and body weight or physical dimensions. Females in the summer population exhibited no significant correlation between elevation and the number of embryos present.

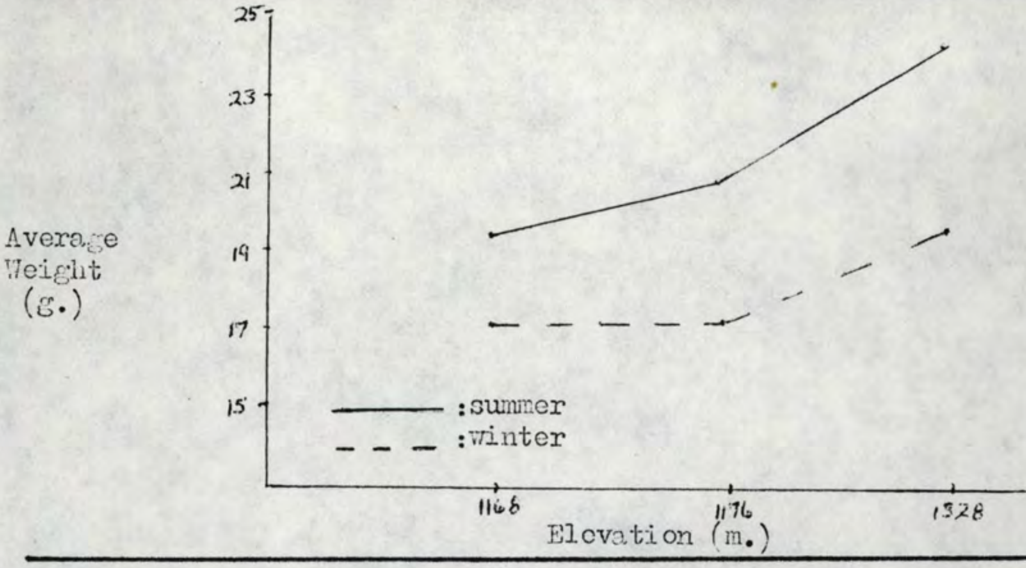
Body Lengths and Body Weights

A significant correlation coefficient (r=0.867) was found in the summer population between the total body length and the total body weight. A 33 percent weight loss was noted between the summer population and winter population collected at the same elevations (Fig. 1).

Table 2. Trapping stations, elevations, and total number of specimens obtained at each station.

Station	Elevation	#Specimens	Station	Elevation	#Specimens
1	1036m.	9	11	1487m.	5
2	1168	19	12	1524	6
3	1176	16	13	1645	10
4	1243	9	14	1767	11
5	1298	5	15	1853	2
6	1328	28	16	1865	9
7	1365	5	17	1914	3
8	1389	2	18	1950	4
9	1426	4	19	2023	8
10	1450	3	20	2069	11

Fig. 1. Change in body weight between winter and summer populations.



Mature vs. Immature Specimens

No concentrations of males were found at any particular elevation, nor did the density of the mice increase with elevation (Fig. 2). Separation of mature and immature specimens was determined by pelage coloration (Larrison 1967; Cowan and Guiguet 1975). Of the 114 females collected, 30 (26%) were classed as immature; 10 (62%) of the 16 male specimens were immature.

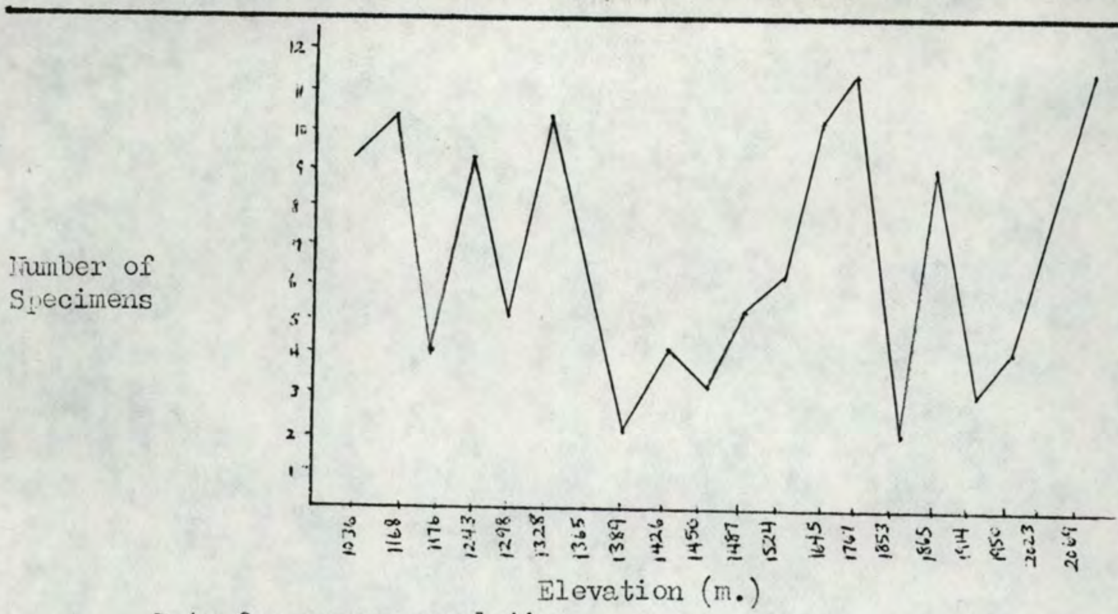
Sex Ratio

The sex ratio of the summer population was found to be significantly biased ($P<0.005$) in favor of females; 88% females:12% males; this was also found in the winter population; 77% females:23% males ($P<0.005$). Of the 114 females taken in the summer sample, 11 (9.7%) were not pregnant but showed evidence of placental scars; there where an average 6.3 scars per female. No relationship was found between the size of females and the number of scars present.

Litter Size and Breeding Season

An average in utero litter size of 2.5 was found for all pregnant females. Litter size of those females classed as mature was greater

Fig. 2. Correlation of small mammal density with elevation.



Data for summer population.

than the litter size of those breeding females classed as immature. The mature females averaged 2.6 embryos as compared to the immature female's 2.0. Impregnated females were taken in June, indicating that sexual activity was in progress in the month of May. Embryos were present in the winter population, indicating that this population of Peromyscus maniculatus was still sexually active during those months.

DISCUSSION

Bergman's rule is often quoted when discussing the physical aspects of high elevations and cooler climates. This rule states that within a given species, animals tend to be larger and more rotund in cool climates

Table 3. Monthly average temperatures and precipitation.

Month	Minimum	Maximum	Precip.	Snow
June*	40.9°F.	71.9°F.	0.06in.	--
July	50.3	89.3	0.04	--
August	41.9	78.4	0.03	--
September	39.9	76.7	0.01	--
October	32.2	55.9	0.09	--
November	20.0	38.2	0.04	0.46in.
December	22.0	33.6	0.07	0.32
January*	13.6	27.4	0.08	1.11

*Data was collected in part for: June (9th.-30th.) and January (1st.-12th.)

(Smith 1974). This general tendency has been noted for elevational changes within species. Davis (1938) and Jones (1970) noted that body size, weight, and body appendages within a species increase with increasing elevation. No relationship between body dimensions or weight and elevation was found in this study. The elevational difference of 1033 meters apparently was too small an increment to indicate any elevational affects, or the sample size was too small to detect any significant differences.

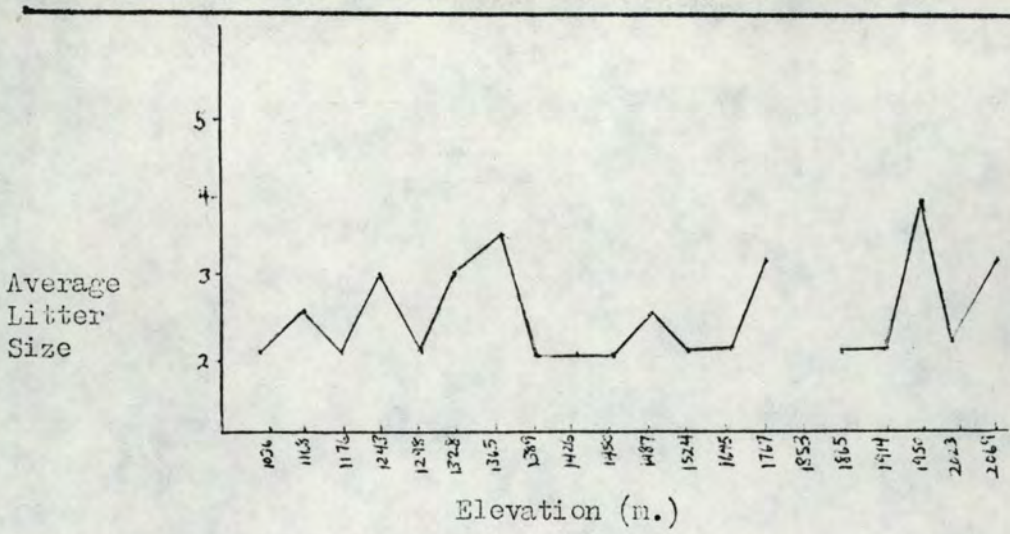
As the altitude increases the density of small mammals has been shown to increase (Odum 1949; Gentry et. al. 1968; Kritzman 1974); this was not found in the present study (Fig. 2).

Samples from the summer and winter populations exhibited a 33 percent difference in body weight (Fig. 1), denoting a change in body weight over the seasons, contrary to what Lynch (1973) found.

Litter size at birth is a function of the ovulation rate and the prenatal mortality rates (Krebs 1964). An approximation to litter size is obtained by counting embryos in females (Flake 1974). The mouse embryo at 9½ days or beyond is easily recognized, having the C-shape characteristic of all vertebrate embryos (Rugh 1964; Theiler 1972). Using this stage as the criteria for determining litter size an average litter of 2.5 was found.

Small mammals have been found to exhibit variations in litter size due to latitude and altitude (Moore and Price 1948; Lord 1960; Krebs 1964; Blus 1966; Vaughan 1972; Lackey 1974). Dunmire (1960) and Swain (1970) found a positive correlation between elevation and litter size. Contrary to this I found no correlation (Fig. 3). Litter size of young females tended to be smaller than those of older females (McCulloch and Inglis 1961). In agreement with Jameson (1953) and Brown (1964), no correlation was found between litter size and body length of breeding females.

Fig. 3. Comparison of elevation and average litter size.



Data is taken from summer population. No sample for 1853m.

The 6.3 placental scar average per nonpregnant female would possibly indicate a larger size litter exists, but Conaway (1955) indicates the average litter size is often less than the number of scars observed; while Davis and Emlen (1948) found the number of scars to vary with the size of the female. Thus no conclusions could be drawn relating placental scar number to litter size.

The sex ratio of most mammal populations is approximately one to one. This concept was originally put forth by R.A. Fischer in 1929 (Fischer 1958) when he stated that because each sex contributes equally to the genetic composition of future generations, selection will act to equalize the expenditure of energy in producing offspring of each sex. Leigh (1970) demonstrated that differential adult mortality between the sexes does not alter the expected sex ratio at birth. Thus it would appear that regardless of adult mortality before birth the sex ratio of offspring would be one to one.

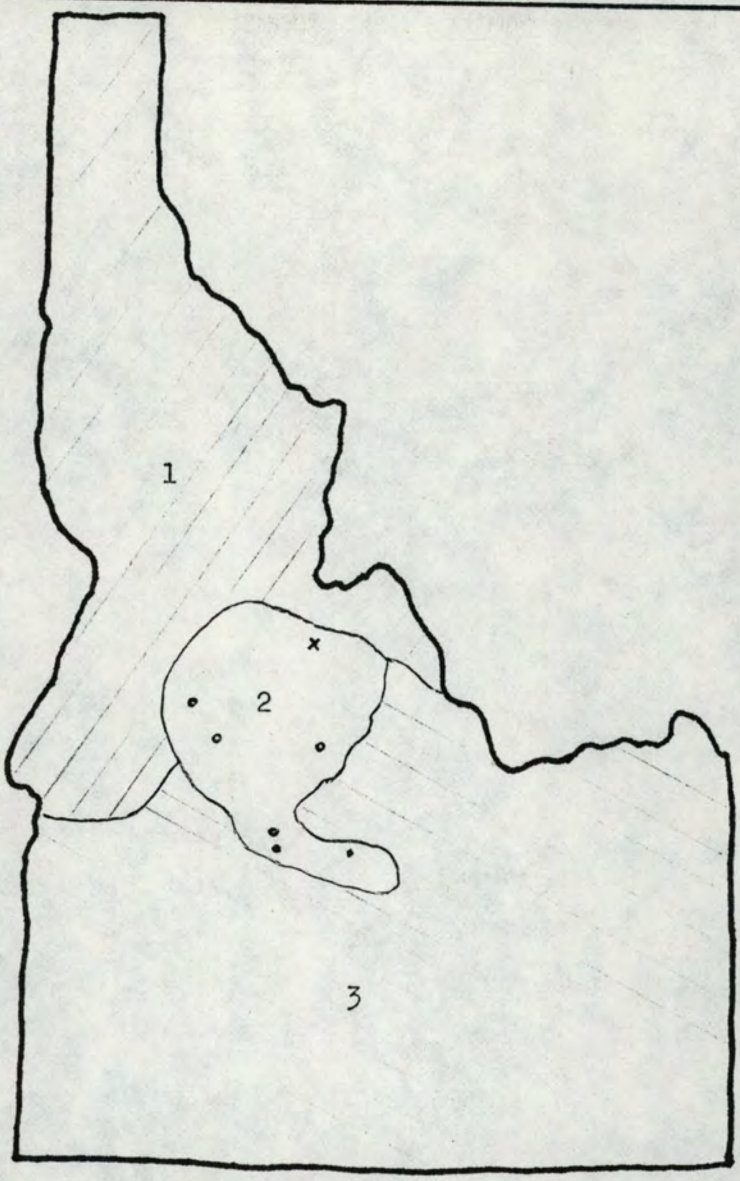
Close approximations to Fischer's equal sex ratio have been observed in the field (Blair 1940, 1942) but in general for small mammals a tendency for males to be more abundant has become evident (Manville 1956; Weir 1960; Terman and Sassaman 1967; Baker 1969; Canham 1970; Crawley 1970; Swain 1970; Long 1973; O'Farrell et. al. 1975). An excess of males was not found in this study, but rather an excess of females at a ratio of seven to one.

This type of altered ratio was found by Kalela (1971) when he noted that during the seasonal cyclic highs of the Grey-sided Vole (Clethrionomys rufucanus) the mature females greatly predominated late in the breeding season. Evans (1948) found that in the house mouse (Mus musculus) the percent of females in a population was greater after a decline from the cyclic peak. Sheppe (1963) in a study of Peromyscus maniculatus in the Pacific Northwest found a preponderance of females in his adult catch and suggested that in the Northwest, female P. maniculatus tend to live longer than males. This longer survival rate for females was also noted by Wright (1971) and Petrusewicz (1960).

Reproductive periods in P. maniculatus have been found to be either limited to specific months (Long 1973) or to be continuous over the year (M'Closkey 1970). Larrison (1970) described the general breeding season for P. maniculatus in Washington as being from February to November. Pregnant samples were taken in the summer population in early June. Females in the winter population were exhibiting early signs of pregnancy in January. Winter breeding in P. maniculatus was noted by Brown (1945) while O'Farrell (1973) recorded general activity and movement in deer mice at temperatures of -23°C. Thus it would appear that the breeding season of the P. maniculatus population at the Taylor Ranch Field Station extends further into the winter months than those noted by Larrison (1970).

William B. Davis in 1939 published a description of a new subspecies of Peromyscus maniculatus found in Idaho (Davis 1939). He named this subspecies the Sawtooth White-footed Mouse or Peromyscus maniculatus serratus. Davis described the subspecies as occupying territory geographically intermediate between the ranges of P.m. sonoriensis to the south and

Fig. 4. Map showing the distribution of the deermouse in Idaho (Davis 1939).

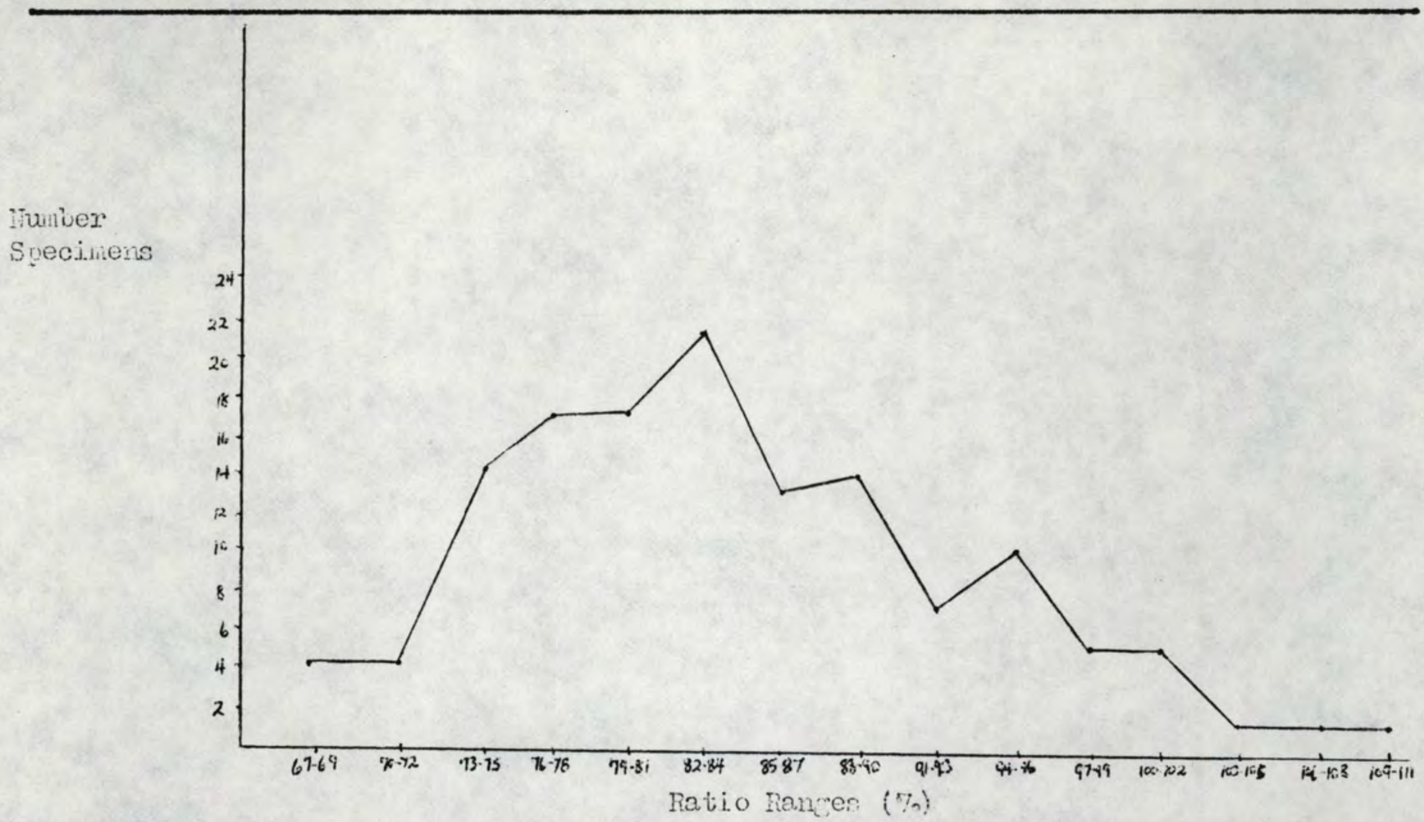


Dots indicate localities where specimens of serratus have been examined or recorded. Area 1 P.m. artemisiae, Area 2 P.m. serratus, and Area 3 P.m. sonoriensis. X indicates Taylor Ranch Field Station.

P.m. artemisiae to the west, north, and east (Fig. 4), but that serratus did not appear to be a race of intergrades or hybrids between the two. It was considerably larger and although certain characters of both sonoriensis and artemisiae were combined in serratus, the characters appeared to have reached a higher stage of development in serratus.

Davis constructed a ratio of tail length to head and body length with

Fig. 5. Subspecies identification using the ratio of tail to head and body length (Davis 1939).



which to separate the three subspecies. Peromyscus maniculatus artemisiae's ratio equaled 80 percent; sonoriensis equaled 73 percent; while serratus, with a longer tail, equaled 92 percent. Using Davis criteria for separating the subspecies Figure 5 was constructed for the total number of samples obtained in this study.

An average tail to head and body ratio of 84.2% was found for the specimens obtained in both sampling periods. This average, based on Davis' criteria, would indicate that artemisiae is the subspecies of P. maniculatus present. Calculating the 95% confidence intervals for the experimental data I concluded that if the mean of the obtained samples was to fit the ratio of 80% given by Davis, a mean value ranging from 78.3% to 81.7% would be acceptable. Since the experimental datas' average of 84.2% exceeded the upper confidence boundary, the null hypothesis that the population consists of entirely *artemisiae* must be rejected. Using the same calculation process but assuming the population consists of serratus, confidence limits of 90.4% and 93.7% are obtained. This hypothesis too must be rejected because the lower confidence boundary of 90.4% exceeds the data average of 84.2%.

As a result of these calculations and the data distribution in Figure 5, I postulate that one of two possible processes are being represented. The data may indicate that two separate subspecies are occurring in the same general area and maintaining their integrity. This possibility has been shown to occur in other subspecies of *Peromyscus maniculatus* (Blair 1953; King and Dice 1968). The other possibility is that interbreeding and integradation of characters has occurred between *artemisiae* and *serratus*. Which of these possibilities actually exists will have to be resolved by further study.

Hall and Kelson (1959) indicate that Davis description of *serratus* and their projected range comprise the only known population of this subspecies in North America. From the distribution in Figure 5 and the confidence interval calculations, it would appear that the exact range of *serratus* is uncertain and that the present status of *serratus* is unknown.

SUMMARY

1) No correlation was found between body dimensions, weight, or litter size and elevation.

2) A significant correlation was found between body length and body weight.

3) A 33 percent weight loss was noted between the summer population and winter population collected at the same elevations.

4) Females predominated by a ratio of seven to one.

5) Mature females had greater litter sizes than young females.

6) <u>Peromyscus maniculatus</u> bred during the winter months.

7) The average litter size was 2.5.

8) The range of <u>Peromyscus maniculatus serratus</u> is uncertain and would appear to warrant farther investigation.

ACKNOWLEDGMENTS

This project was made possible through an honorarium from the Wilderness Research Center of the University of Idaho, Moscow, Idaho. I am indebted to Drs. P.D. Dalke, J.T. Flinders, J.M. Peek, and S.R. Peterson, Department of Wildlife, for their review of the manuscript. To Dr. D.R. Johnson and Prof. E.J. Larrison, Department of Biological Sciences, for their assistence in literature research. Particular thanks to Mr. and Mrs. James Bennett, Steven Anderson, Al Steuter, and Arlo Lewis for their assistence during the summer months; and to John Gimbel for his help during the winter sampling period. A special word of thanks to Prof. Kenneth Sowles without whose aid and extra efforts the project would have been impossible.

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