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DEMOGRAPHIC AND INDIVIDUAL GROWTH STUDIES FOR *DIPODOMYS ORDII, PEROMYSCUS MANICULATUS* AND *REITHRODONTOMYS MEGALOTIS*

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ABSTRACT

This study provides intensive laboratory examinations of growth and birth rates of *Dipodomys ordii*, *Peromyscus maniculatus* and *Reithrodontomys megalotis* and less intensive field studies of birth and death rates of *D. ordii* and *P. maniculatus*. Growth rates for control groups of *D. ordii*, *P. maniculatus* and *R. megalotis*, using the standard small mammal body measurements, and eye lens weights for *P. maniculatus* and *R. megalotis*,were determined and the distributions of the antilogs of lnW and the means with respective standard errors plotted on a logarithmic scale. Most of the distributions have significant (.95) R^2 values, but dried eye lens weights seem to have the strongest correlations with age. Manipulation of three independent variables (photoperiod, temperature and food) for *P. maniculatus* caused k to shift enough to suggest that independent variables can affect growth, and require additional study. Two 8.35 mm mesh hardware cloth enclosures were constructed during 1971-72 to facilitate birth and death rate field studies for *D. ordii* and *P. maniculatus*. The *D. ordii* enclosure is 6.07 ha; whereas, the *P. maniculatus* enclosure is 2.02 ha. Natality and mortality data were recorded from the enclosures but inclement weather and questionable trapping results have hampered this part of the study. The life table data require more time to complete. In the interim, birth rates were determined for the three species on the basis of litter sizes born in the laboratory. A demographic model for the small rodent population in the desert ecosystem was developed, basically in mathematical form, that expresses the component relationships with the use of difference equations. Flow diagrams were prepared to demonstrate the strategy. Although the model was developed for the species involved it can easily be modified for all mammal species.

INTRODUCTION

The ecosystem is currently considered the basic functional unit of ecology with which one must deal, since it includes both the living and non-living components of the environment, both in continuous interaction. Only when the ecosystem is understood can the contribution of its component parts be clearly managed for the benefit of man. The basic structural components are: (1) non-living components; (2) producers, consumers and decomposers; and (3) some abstracts (energy, cybernetics, etc.) which represent various interactions of the first two. One may be tempted to conclude that the whole is simply the sum of all its components. Although the application of this additive principle to biology has repeatedly been questioned successfully, its inappropriateness is probably best shown in studies of functional ecology. Since these components are not strictly additive and we must extend our understandings to include functional relationships of organisms and their components, established techniques are not always useful and new ones must be developed. Many of these techniques are, at present, not well established, but must continually be developed if systems management is to become a reality.

The most important primary consumers in the desert ecosystems of North America have not yet been completely determined in all cases, but they must include the small mammals, among which are included several species of *Dipodomys* and *Peromyscus* and *Reithrodontomys megalotis*. Clearly, *Dipodomys* spp., *Peromyscus* spp. and *Reithrodontomys megalotis* occupy vital positions in the energetics of North American deserts and their interacting relationships with the totipotential ecosystem is unquestionable. The complexities of these interacting relationships requires systems analysis, a comprehensive analysis of the relationships between structure and function. According to Miller (1965), a natural system consists of a non-random accumulation of matter-energy in space and the organization provides the previously mentioned interactions among the components. Living systems are always open, requiring a continuous supply of matter-energy: and those are the systems of concern in systems analysis and the Desert Biome studies.

Although there are several species of *Dipodomys* and *Peromyscus* among the different desert types; *Dipodomys merriami*, *D. microps*, *D. ordii*, and *Peromyscus maniculatus* occupy perhaps the largest total space (Hall and Kelson, 1959), and may have a greater impact on the energetics of North American deserts than other small mammal species. For this reason it would be good if all four species were studied; however, funding levels did not permit this. A systems analysis must include, among its components, the production of *Dipodomys* spp., *P. maniculatus*, and *R. megalotis* whose population numbers are logically separated into different sizes (which relates directly with age structure) and numbers of individuals. Both of these are inseparably tied to the matter-energy which, of course, interacts within its organization.

This study provides intensive laboratory examinations of birth, death and growth rates of *D. ordii*, *P. maniculatus*, and *R. megalotis*. When these parameters are determined along with the interactions of some of their primary independent variables, the biomass production of the three species can be determined, modelled and predicted.

OBJECTIVES

Objectives of this study were:

1. To determine individual growth rates for *D. ordii* and *P. maniculatus*, and how these rates respond to independent variables. *Reithrodontomys megalotis* was added to the study later as the advisability seemed evident and data became available.
2. To determine the birth rates and litter sizes for *D. ordii*, *P. maniculatus* and *R. megalotis* in the laboratory. Field studies were also conducted for *D. ordii* and *P. maniculatus*.
3. To determine death rates for *D. ordii* and *P. manic-*

ulatus, and how they respond to independent variables in natural conditions.

4. To develop a model that will use the data of the first three objectives to describe the demography of the three species and also provide predictive capabilities.

METHODS

Growth Rates

Dipodomys ordii

Specimens used in this portion of the work came from several sources. The initial colony, 45 females and 15 males, were live-trapped at the Desert Range Experiment Station (Pine Valley), 81 km west of Milford, Utah, in Millard County. Ten additional pregnant, lab-reared females were purchased from Ecodynamics Inc. of Salt Lake City, Utah. These animals had been previously bred and housed at Dugway Proving Grounds in Tooele County, Utah. An additional 350 females and 50 males were trapped at various times throughout the study near Pahvant Butte, Millard County, Utah, and Ecodynamics collected an additional 400 females from Dugway Proving Grounds. About 100 females were used as replacements in the laboratory studies, and the remainder were observed for field pregnancy. The laboratory colony was maintained at 85 females and 15-20 males. Later an additional 25 females and 8 males were obtained from Ecodynamics after they discontinued operation.

The main breeding colony, which provided the normal growth data, was housed in the small mammal research laboratory at Brigham Young University, whereas the experimental animals were kept in controlled environment chambers. One half of the animals were caged in individual Metaframe aquaria (51.5 cm long, 26.5 cm wide and 31.0 cm deep) with perforated aluminum reptile covers. The other half were caged in galvanized metal boxes (45.5 cm long, 38.0 cm wide and 25 cm deep) with covers of 8.35 mm wire mesh. Sand (about 6.08 cm deep) was used as the substrate in each cage and nest cans with cotton were provided. Water and a standard food mixture of sunflower seeds, rolled oats and pigeon mix (Ecodynamics) were supplied continuously. Purina mouse breeder chow was also provided. Nine rats were also fed fresh green feed for a period of five months to possibly aid reproductive success. The temperature was held constant at 22 C and the photoperiod artificially maintained at 12 hr light and 12 hr dark with graduated intensities to simulate dawn and dusk.

The sexes were kept separate except when mating was attempted and the females were checked daily for estrus. External changes in the morphology of the vulva as described by Pfeiffer (1960) were used as indicators of estrus. When the full-flowered vulvar condition was achieved, it was presumed to indicate estrus and a male was introduced into the female's cage. Usually vigorous fighting ensued, but if the male survived the first few minutes he was left with the female for 3-4 days, then returned to his cage. The females were checked for vaginal plugs as an indication of successful coitus.

When a litter was born it was not disturbed until the following day, at which time the young were toe clipped and measured. Body weight, total length, tail length, ear length, and hind foot length measurements were taken daily from days 1-29 and then weekly up to 10 weeks. Body weight was determined to the nearest 0.05 g on an Ohaus triple beam balance; total and tail lengths were measured to the nearest 0.5 mm with a clear plastic metric rule, and ear and hind foot lengths were measured to the nearest 0.01 mm with a Mitutoyo dial caliper. After eyes of the young had opened and the individuals became more active, they were anesthetized with Penthrane (Abbott Laboratories, North Chicago, Illinois) to facilitate handling and obtaining accurate measurements. Daily observations were recorded for each litter to determine behavioral changes during development.

A separate mixed group of eight females and four males was housed in a large metal arena 2.5 m square and 1.5 m tall with 10 cm of sand on the floor. This arena was divided into three interconnected compartments. The compartments on each side contained water dishes, nesting cans, and nesting material, while the center compartment was used primarily for feeding. Reproduction was limited to a single litter (which was abandoned) under these conditions. Skull or lens data were not obtained for *D. ordii* due to the insufficient numbers of laboratory reared animals, since ten animals must be sacrificed each day to obtain the necessary data.

Peromyscus maniculatus

All of the animals used in this portion of the study were the progeny of 50 pairs of *Peromyscus maniculatus sonoriensis* collected approximately 19.32 km SE of Benmore Guard Station (Benmore Experimental Range), Tooele County, Utah, on July 16, 1971.

The colony was housed in the same laboratory and physical conditions as the *Dipodomys*, with the exception that wood shavings were used for the substrate, Purina mouse breeder chow was provided as the food, and only Metaframe aquaria were used for caging.

When the animals were brought into the laboratory, they were sexed and paired, one pair to a cage. Each cage was checked daily for food and water and inspected for the presence of a litter. When a litter was found, each member was marked by toe clipping. The same daily and weekly measurements and observations were made for *Peromyscus* as for *Dipodomys*, except that measurements were taken daily from 1-22 days and then weekly to 10 weeks. Over 100 animals were included in each daily age interval to reduce the variance and refine the confidence in relating age with the growth parameters.

Linear, quadratic, cubic, combined linear-quadratic, and linear-quadratic-cubic distributions were used to characterize the growth of *Peromyscus* (Smith and Jorgensen, 1972), but the instantaneous relative growth rate (IGR) of Brody (1945) is used in this report to express growth as a function of the rate between times of measurements and percentage of maximum size. This rate is expressed as $(dW/dt)/W$, where W is the parameter measured at the instant the rate of change dW/dt is measured. Since it is not entirely possible to develop the "instantaneous" rate of growth, it was necessary to integrate the infinite number of growth rates to derive $W = Ae^{kt}$. This is conveniently rewritten as:

$$\ln W = \ln A + kt$$

where: lnW is the natural logarithm of the variable (W) at time t-1, lnA is the natural logarithm of the variable (W) at $t = 0$, and k represents the instantaneous relative growth rate (when multiplied by 100, k = percentage growth rate). For comparative purposes, the instantaneous relative growth rate (k) is determined with:

$$k_n = \frac{\ln W_n - \ln W_{n-1}}{t_n - t_{n-1}}$$

thus, k is definitive and can be used to compare differences in rates of growth.

Additional studies on skull measurements and eye lens weights were also made to correlate age with the previously mentioned growth measurements. Ten individuals were sacrificed each day from 1-22 days for these data. On the day that an animal was to be sacrificed, it was removed from the nest and killed with an overdose of Penthrane. The standard daily measurements were taken, after which the entire animal was placed into a 10% formalin solution to fix the lenses. After a minimum of four days the animal was removed from the formalin solution; the head removed, skinned and the lenses extracted by making a slit in the cornea with a hooked insect pin and applying pressure to the side of the eyeball with curved forceps. The lenses were stored in a vial of 10% formalin, placed on spotting plates, and dried at 100 C for one week. After drying, they were removed from the oven and weighed individually to the nearest 0.0001 g on a Mettler laboratory balance.

After the lenses had been extracted, the skulls were placed in individually labeled paper cups, frozen and later stained and measured. The staining followed basically the methods described by Humason (1967), except that the amount of Alizarine stock solution used was increased 10 times. The skulls were thawed, placed into a compartmentalized tray, and covered with a 2% KOH solution. After two days this solution was replaced for two days with a solution containing 3 l of the 2% KOH and 30 ml of Alizarine stock solution. The skulls were then rinsed with water and again covered with 2% KOH for two days, after which they were rinsed with water and allowed to dry for measuring. Total length, zygomatic breadth, foramen magnum height, mastoidal breadth, nasal length, and cranium width were taken with dial calipers to the nearest 0.01 mm on each skull.

Controlled laboratory experiments were conducted to test the effects of different environmental parameters on the growth of *P. maniculatus*. Five pairs of previously unbred mice were placed in each of two environmental chambers where temperature was held constant at 22 C and photoperiod was set at 9 hr of artificial light and 15 hr of darkness in one chamber and 15 hr of light and 9 hr of dark in the other. Caging was the same in both chambers. In another experiment, five pairs of previously unbred mice were placed into each of two environmental chambers where the photoperiod was held constant at 12 hr light and 12 hr dark. All other variables were held constant except temperature, which was 15 C in the cold chamber and 30 C in the hot chamber. In another experiment, 20 pairs of previously unbred mice were placed into four sets of five cages each and held under standard laboratory conditions. All animals were fed *ad libitum* until a litter was born; then the males were removed and the females rearing litters were placed under four different feeding regimes. One group was fed 3.5 g/day, the second group 4 g/day, the third 5 g/day and the fourth 8 g/day. Data were obtained only for the 3.5 g/day and the 8 g/day experiments due to cannibalism of litters in the 4 and 5 g/day groups. When litters were born they were marked, weighed, measured, and observed using the standard procedure described earlier.

Reithrodontomys megalotis

All of the animals used in this portion of the study were the progeny of 20 pairs of *Reithrodontomys megalotis megalotis* captured live approximately 19 km SE of Benmore Guard Station, Tooele County, Utah, from September 1-8, 1971.

The colony was housed in the same laboratory as the *Dipodomys* and *Peromyscus* but the type of caging differed. The animals were caged in galvanized metal cages 25.5 cm long, 18 cm wide and 16.5 cm tall with covers of 8.35 mm wire mesh. The same type of substrate, nesting material, feed, and watering was used as was used for *Peromyscus*.

When the animals were brought into the laboratory they were treated the same as *Peromyscus*. The same standard growth data were calculated for *R. megalotis* but no experimental data were taken.

Birth Rates and Death Rates

Two hardware cloth enclosures were built during 1971-72 to facilitate studies of birth and death rates of both *D. ordii* and *P. maniculatus* in the field. The *Dipodomys* enclosure (6.07 ha) is located 11.27 km NE of the headquarters at the Desert Range Experiment Station in Pine Valley, Millard County, Utah. The installation site was selected after 10 days of trapping revealed a relatively high localized population of *D. ordii*.

The *Dipodomys* enclosure was constructed of 8.35 mm mesh hardware cloth, 120 cm wide, buried about 20 cm deep, so it projected about 90 cm above ground. The hardware cloth was secured on the inside of steel posts placed

3 m apart. Two Young live traps were placed at each stake in a 12 x 12 grid, 20 m apart, within the enclosure. The grid was first trapped for ten consecutive days in August, 1971. The animals caught were sexed, aged, marked by toe clipping, and released after the grid location where they were caught was recorded. Trapping was repeated in May, 1972, August, 1972, May, 1973, and August, 1973.

Simultaneously with the trapping inside the enclosure, animals were collected with Museum Special snap traps from similar habitats outside of the enclosure. These specimens were returned to the laboratory for studies on age structure, birth rates (by counting placental scars) and growth correlation with the laboratory-reared animals. Skull measurements and dried lens weights were taken for this correlation, but kill trapping and combined freezing deteriorated the specimens so that the measurements were unable to be correlated with the laboratory data. Future measurements should be taken on fresh killed animals or if preservation is necessary the animals to be preserved must be live caught and preserved immediately upon death as was done in the laboratory.

The *P. maniculatus* enclosure was constructed in April, 1972, and is located 0.4 km N of Benmore Guard Station (Benmore Experimental Range), Tooele County, Utah. Its construction and trap design were similar to the *D. ordii* enclosure, except: (1) the fence is topped with a galvanized metal flashing which projects away from the fence on the inside to prevent animals from climbing out, (2) it encompasses only 2.02 ha which seems sufficient for the smaller home range requirements of *P. maniculatus*, (3) Sherman traps were used instead of Young traps, and (4) the traps included on the 12 x 12 grid were spaced 12 m apart.

Although the area was selected as typical habitat for *P. maniculatus* and because of the presence of *P. maniculatus* in the fall, 1971, in the initial May, 1972, sampling period only *Perognathus parvus* were caught. Consequently, 15 pairs of *P. maniculatus* were introduced into the enclosure at that time, and the area trapped again in September, 1972. The May, 1973 trapping again revealed no *P. maniculatus*, so an additional six wild-caught pair and ten laboratory pair were introduced into the enclosure in June, 1973. Unfavorable trapping weather caused the September, 1973, trapping period to be abandoned so that trap death would not destroy the population.

Concurrent with the trapping periods inside the grid, about 100 female *P. maniculatus* were collected each time in comparable habitat outside of the grid. These were examined for placental scars, while skull measurements and lens data were taken to compare with the laboratory data. The natality and mortality collection studies were closely coordinated with the growth studies since both often used the same specimens and of necessity rely on a reasonable assessment of the age structures. The same preservation problems as encountered with *Dipodomys* curtailed this part of the study.

Mortality rates were to be determined from life tables which were to be generated from the enclosure data, and were to include mortality rate (q_x) life expectancy (e_x) and probability of death (Q_x); however the problems encountered in the enclosure studies precluded the possibility of generating any meaningful life table data. The *P. maniculatus* population would not sustain itself and *D. ordii* captured and marked inside the enclosure were subsequently caught outside the enclosure.

Model

A demographic model for the small rodent population in the desert ecosystem was developed, basically in mathematical form, that expresses the component relationships with the use of difference equations. Flow diagrams were also prepared to demonstrate the strategy. The model is intended to be representative for *D. ordii*, *P. maniculatus* and *R. megalotis* although it can easily be modified for all small mammal species. There has been no attempt to prepare or implement a computer model, thus, the dynamics are not elaborated -- only presented.

RESULTS

Growth Rates

Since one of the primary objectives of this work is rates of growth and how they respond to independent variables, it was necessary to compute methods for comparing these rates; thus, instantaneous relative growth rates (k) as defined by Brody (1945) were used. The figures and tables contained in Appendices 1-3 (Tables 1-31, Figures 1-64) present the (k) values and statistical analyses for different growth periods at various time intervals. When the variables are plotted on a log scale it illustrates the comparative nature of (k) for the growth periods as from days 1-70.

Dipodomys ordii

(Appendix 1; Tables 1-6, Figures 1-11). Rates of growth along with the instantaneous relative growth rates k were determined and statistically analyzed for *D. ordii* and are presented for body weight, total length, tail length, ear length, and hind foot length. Figures 1-5 and Tables 1-2 depict growth and its analyses for animals reared under standard laboratory conditions and analyzed for "time interval one" which consists of age divided into growth periods of 1-3, 4-12, 13-22, 23-29, and 30-70 days. Figures 6-10 and Tables 3-4 depict growth for the same animals analyzed for the "demographic model interval" which has age divided into growth periods of 1-21 (suckling), 22-28 (juvenile I), 29-63 (juvenile II), and 64-70 (sub-adult) days. Growth intervals 1 and 2 (which consist of age divided into growth periods of 1-3, 4-15, 16-29, and 30-70 days) were used in an attempt tc assess the most accurate depiction of the growth of *D. ordii*. The demographic model interval which is basically concerned with body weight was used in an effort to correlate observable growth periods such as weaning with biomass in order to get predictive capabilities relating age and biomass.

The R^2 values indicate how much variation is accounted for in the analyses, and when converted to r values they can be used to determine statistical significance ($a=.05$). A significant r suggests a significant correlation between the appropriate lnW (log of the variable) and the age of the growing animals when time is partitioned into growth periods in one of the three growth intervals.

All five parameters provided significant correlations of growth with age, since r was significant during all growth periods in intervals one and two (Tables 1 and 3) and during all growth periods of the demographic model interval with the exception of total length, tail length and ear length, during the 64-70 day growth period (Table 5). Since no individual parameter or interval consistently provided data with the highest significance throughout all growth periods and since the significance levels of all parameters are similar for any given growth period, it is possible to use any of the parameters as an indicator of growth.

There was a question of how closely the antilogs of lnW followed the actual data means, since this understanding is important in an interpretation of k. The means and standard errors of the body parameters are compared to the k value curves in Figures 1-11 and also in tabular form in Tables 2, 4 and 6. The two curves are almost identical for all of the body parameters but the confidence intervals of the means for total length and tail length are wider during all growth periods of the time intervals.

Since the correlations of growth parameters with age are always significant, one might consider using these parameters to predict age. This procedure is important to an evaluation of the population age structure. Although the process seems evident at first, since it would simply involve reading the predicted age from a graph, the results are not meaningful because of the lack of variation among days. It is possible that some non-parametric procedure could be utilized to provide predictive capabilities (Dapson and Irland, 1972).

Peromyscus maniculatus

(Appendix 2; Tables 7-24, Figures 12-59). Rates of growth along with instantaneous relative growth rates k were determined and statistically analyzed for *P. maniculatus* and are presented for body weight, total length, tail length, ear length, and hind foot length. Figures 12-16 and Tables 7-8 depict growth and its analyses for animals reared under standard laboratory conditions and analyzed for "time interval one" which consists of age divided into growth periods of 1-3, 4-12, 13-22, 23-29, and 30-70 days. Analyses of the dried eye lens weight data are provided in Figure 17 and Tables 9-10. Although most of the R^2 values for the skull measurements were not significant at the .95 level (Table 9) the skull and nasal lengths were and also provided a good accounting (high R^2 values) of the variation (Figures 18-19).

Since "interval one" was previously determined to provide the best fit for *P. maniculatus* (Smith and Jorgensen, 1972), "interval two" is not reported; however, the "demography model interval" is included. Figure 20 and Tables 11-12 (Appendix 2) depict growth and its analyses for this interval.

All five body parameters provided significant correlations of growth with age, since r was significant during all growth periods of both "interval one" and the "demography model interval" (Tables 7, 11). The eye lens weights, however, provide the best correlation of growth with age (Table 9), but the data are provided only through day 22.

Although the curves for the antilogs of lnW closely approximate those of the means for the five body parameters plus that of dried eye lens weights (Figures 12-17), this is not the case for total skull length and nasal length (Figures 18-19). The skull measurement k values are negative for the growth period 1-3 days of age; likely due to elongation of the skull and nasal areas as the young pass through the birth canal with a subsequent shortening (producing a negative growth rate) as the skull assumes its normal shape. All of the means have narrow confidence intervals, but as in *D. ordii*, total length and tail length exhibit the greatest variation.

Growth data for animals retained in a photoperiod of 15 hr light and 9 hr dark are reported in Figures 21-25 and Tables 13-14 for the five body parameters. Similar data for animals retained at 9 hr light and 15 hr dark are presented in Figures 26-30 and Tables 15-16. Comparisons of the two photoperiods are made in Figures 31-35. Like the R^2 values for the standard laboratory procedures, these were also significant at the .95 level. Of more interest are the k values since they can be used to compare the rates of growth under the experimental conditions. In all cases the antilogs of lnW approximate the means and the confidence intervals about the means are similar to those of animals reared under standard laboratory conditions even though the sample size was smaller in the experimental conditions.

Growth data for animals retained at a temperature of 15 C are reported in Figures 36-40 and Tables 17-18 for the five body parameters. Similar data for animals kept at 30 C are presented in Figures 41-45 and Tables 19-20. Comparisons of the two experimental temperatures, 15 C and 30 C, with the standard laboratory temperature 22 C are made in Figures 46-49. There is no comparative figure for total length since there was no significant difference. Unlike the R^2 values for the standard laboratory conditions, not all parameters were significant during all growth periods of the interval. At 15 C all are significant except total length which is not significant at all growth periods. The other four parameters are not significant during growth period 1-3 days but are significant thereafter.

Growth data for animals retained at standard laboratory conditions but where the mother was fed 3.5 g of food per day are reported in Tables 21-22. The means and standard errors are only calculated through day 14 due to a sample size reduction thereafter, but the r value is presented in Figures 50-54 and Tables 22-23. Comparisons of feeding levels 3.5 g, 8.0 g and *ad libitum* food per day are made in Figures 55-59. Unlike the R^2 values for the standard laboratory feeding level (*ad libitum*) not all parameters were significant during all growth periods of the interval during the experimental feeding levels. In the 3.5 g experiment all parameters except body weight were significant during the first two growth periods but body weight was significant only during the 4-12 day growth period. None of the parameters were significant beyond 12 days; however, this may be due to small sample size. In the 8.0 g experiment ear length and hind foot length were significant through 22 days but the other three parameters were significant only through 12 days. In all cases comparative growth rates beyond 3 days for *ad libitum* food exceeded growth rates for 8.0 g feeding which exceeded growth for 3.5 g feeding. The antilogs of lnW for all parameters closely approximate the means with narrow confidence limits about the means except for total length and tail length.

Reithrodontomys megalotis

(Appendix 3; Tables 25-31, Figures 60-64). Rates of growth along with the instantaneous relative growth rates k were determined and statistically analyzed for *R. megalotis* and are presented for body weight, total length, ear length, and hind foot length. Figures 60-62 and Tables 25-26 depict growth and its analyses for animals reared under standard laboratory conditions and analyzed for "time interval one". Only the body parameters that were significant with both a sample size of 100 and a sub-sample size of 10 are illustrated but all body parameters are tabled both on the basis of 100 and 10. Analyses of dried eye lens weights are provided in Figure 63, and along with the skull parameters are tabled in Tables 27-28, depict growth for the same animals analyzed for the "demographic model interval".

Only two body parameters (tail length, and ear length) provided significant correlations of growth with age during all growth periods in "interval one". Body weight was significant from 4 to 22 days and was included for comparative purposes. Total length and hind foot length had a significant r from 1-22 days, but showed no significant correlation of growth with age from days 23-70. Dried eye lens weight was the only skull parameter with a significant r from 1-22 days, other skull parameters showed a significant r for the 4-12 day period only. All parameters analyzed for the "demography model interval" were significant only from days 1-41.

In all cases there was a close correlation of the means with the antilogs of lnW and the confidence limits about the means were narrow and provided good correlations.

Birth and Death Rates

Birth rates have been determined for *D. ordii*, *P. maniculatus* and *R. megalotis* reared under standard laboratory conditions and are presented in Tables 32-34. The mean litter size of *D. ordii* (Table 32) was similar whether laboratory reared and bred or field reared and laboratory bred, but the male-female ratio of field-reared stock had a proportionately greater number of females to males than the laboratory stock; however, both showed a significantly greater number of females than males. The mean litter size of *P. maniculatus* (Table 33) appears to increase initially and then decrease as the number of successive litters increases with no significant overall difference in the male-female ratio. Similar results were detected in litter size of successive *R. megalotis* litters (Table 34), but *R. megalotis* seem to have more males born per litter than females. Field data on litter size were abandoned and not reported due to inability to age the field-caught animals for consideration in the modelling effort.

Enclosure data reported in Tables 35-36 are relatively brief due to the rather short time span over which the data have been collected. In addition the *D. ordii* data are suspect since an animal marked inside the enclosure was subsequently captured outside during the verification trapping. From 1971-1973 the plant production in the *D. ordii* enclosure was minimal due to a drought, and consequently field mortality of *D. ordii* was high. In the fall of 1972, however, considerable moisture fell causing the winter and spring annuals to produce. A subsequent increase in natality is evidenced in May and August, 1973, with an expected field mortality from May to August. No meaningful data are presented for *P. maniculatus*. The enclosure has failed to maintain a population of *P. maniculatus* even though it was originally established that a substantial population was there prior to installation.

Table 32. Mean number of young *Dipodomys ordii* born in the laboratory

	Lab Reared and Bred	Field Reared and Lab Bred	Total
Total Litters	11	9	20
Mean Number Males/Litter	1.27	1.00	1.15
Mean Number Females/Litter	1.81	2.44	2.10
Mean Litter Size	3.36	3.33	3.35

Table 33. Mean number of young *Peromyscus maniculatus* born in the laboratory per successive litter

	Litter Number												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
*Litters Sexed	34	25	11	8	4	2	2	2	2	1	1	1	93
Mean Number Males	2.29	2.96	2.36	1.88	3.00	3.00	2.50	3.00	2.00	3.00	2.00	3.00	2.25
Mean Number Females	1.94	2.80	2.91	2.63	2.75	2.50	2.00	1.50	2.50	2.00	2.00	1.00	2.39
Total Litters	41	32	18	10	5	2	2	2	2	1	1	1	117.
Mean Litter Size	4.22	5.00	4.78	4.20	5.60	5.50	4.50	4.50	4.50	5.00	4.00	4.00	4.62

*All litters born were not sexed.

Demographic Model

The history of mathematical modelling of animal and plant populations started in the 1920's with the works of Lotka (1923) and Volterra (1928). These types of models, which are still being developed, are based on an *a priori* understanding of the system. Consequently, there is no guarantee that these models bear any relation to the real world (Watt, 1962).

Table 34. Mean number of young *Reithrodontomys megalotis megalotis* born in the laboratory per successive litter

Successive Litter Number	Number of Litters	Average			Percent	
		Litter Size	Males	Females	Males	Females
1	69	3.29	1.90	1.39	52.7	42.3
2	37	3.86	2.24	1.62	58.0	42.0
3	30	4.23	1.90	2.33	44.9	55.1
4	17	4.71	2.76	1.94	58.8	41.2
5	12	4.25	2.17	2.08	50.9	49.1
6	10	4.10	1.80	2.30	43.9	56.1
7	9	4.00	2.00	2.00	50.0	50.0
8	8	3.88	2.00	1.88	51.6	48.4
9	5	3.60	1.60	2.00	44.4	55.6
10	1	5.00	2.00	3.00	40.0	60.0
1-10	198	3.83	2.05	1.78	53.49	46.51

Table 35. Enclosure data for *Dipodomys ordii*

	Population									
	Introduced		Recaptures		Field Mortality		Natality		Total Present	
Date	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
August 1971	28	21	28	21	0	0	0	0	28	21 = 49
May 1972	6	3	7*	4	21	17	0	0	11	5 = 16
August 1972	0	4	4**	4	7	1	0	1	3	9 = 12
May 1973	0	0	1***	2	2	2	27	8	28	10 = 10
August 1973	0	0	9	5	19	5	8	12	17	8 = 25

*Four animals (two of each sex) died in traps May 1972.
**One male died in trap August 1972.
***One male died in trap May 1973.

Table 36. Enclosure data for *Peromyscus maniculatus*

	Population									
	Introduced		Recaptures		Field Mortality		Natality		Total Present	
Date	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
May 1972	15	15	15	15	0	0	0	0	15	15 = 30
Sept. 1972	0	0	4*	1	11	14	4	7	7	8 = 15
May 1973	0	0	0	0	7	8	0	0	0	0 = 0
June 1973	8	8	0	0	0	0	0	0	8	8 = 16
Sept. 1973	Trapping postponed due to inclement weather.									

*One male died in trap.

Lately, several far more complex models have been developed for different plant and animal populations. All try to incorporate knowledge gained from field-experiments in connection with the species or groups of species. Several of these models are published in Patten (1971), whereas most of them are still being developed. This is especially true for the different IBP Biome modelling efforts. For a review of the "state-of-the-art", see the reports prepared by the different biomes in the USA (Patten, 1973; Holling, 1972).

Small mammal models have been developed by Bunnell (1972) and are being developed by Collier, Osborn and Stenseth (1973). The model reported here is still another being prepared for desert small mammals. The objectives are to develop a demographic model for the small rodent population in the desert ecosystem. The model is intended to be representative for *Peromyscus maniculatus*, *Dipodomys ordii*, and *Reithrodontomys megalotis*, which are important in the North American deserts. The model reported here is basically in mathematical form, expressing the component relationships with use of difference equations, although flow diagrams are also prepared to demonstrate the strategy. There has been no attempt to prepare or implement a computer model, since this will be done by the modelling groups in the US/IBP Desert Biome; thus, the dynamics are not elaborated -- only presented.

Generally the time interval between t and $t+1$, in difference equations, may be of any length. The generalized form of the difference equations is:

State variable at next time interval $(t + 1)$ =
State variable at present time interval (t) +
The absolute change in the state variable between
t and $t+1$

expressed mathematically as:

$$N_i(t+1) = N_i(t) + C_i(t) \qquad (1)$$

where: $N_i(t+1)$ = number of animals in category i at time $t + 1$;

$N_i(t)$ = number of animals in category i at time t; and

$C_i(t)$ = change in the number of animals in category i when going from time t to $t+1$; the amount can be negative, zero, or positive depending upon whether the i^{th} category is decreasing, unchanging or increasing. N_i and C_i are given in number of animals per hectare.

The t^{th} interval is defined in this paper as the interval from $t - 1$ to t (i.e. the first time interval is from $t = 0$ to $t = 1$).

When specific functional equations are given with values for all the parameters, a specific time interval is designated. Remembering that this submodel may be incorporated into a total ecosystem model for the desert, such time intervals should be long enough to include the discrete nature of certain population processes, and short enough to approximate the continuous nature of phenomena such as decomposition (Bunnell, 1973). The time interval for this model has been designated at seven days.

Definition of the Categories
(i.e. the State Variables)

Fetuses (N_1)—"Animals" from fertilization of an egg to parturition. A non-implanted embryo is assumed to be equivalent to an implanted one.

Sucklings (N_2)—Animals from birth to weaning. These are assumed to obtain all their energy from their mother. For the species the model represents, this assumption is not entirely acceptable, since sucklings may forage before weaning; the error, however, is assumed to be negligible.

Juveniles I ($N_{3,1}$)—Animals from weaning to one week later.

Juveniles II ($N_{3,2}$)—Animals from Juveniles I and lasting until they are assumed to be physiologically capable of reproducing.

Subadult Male (N_4)—Males in the period when they are increasing their reproductive activity.

Subadult Female (N_5)—Females in the period when they are increasing their reproductive activity. This category is further subdivided as: Pregnant ($N_{5,1}$), females that are pregnant but not lactating; Lactating ($N_{5,2}$), females that are lactating but not pregnant; Pregnant and Lactating ($N_{5,3}$), females that are both lactating and pregnant; Non-reproducing ($N_{5,4}$), females that are not reproducing; thus:

$$N_5 = \sum_{j=1}^{4} N_{5,j}.$$

Adult Male (N_6)—Males in maximum reproductive activity to death.

Adult Females (N_7)—Females in maximum reproductive activity to death. This category is further subdivided as: Pregnant ($N_{7,1}$), females that are pregnant, but not lactating; Lactating ($N_{7,2}$), females that are lactating, but not pregnant; Pregnant and Lactating ($N_{7,3}$), females that are not reproducing.

Thus:

$$N_7 = \sum_{j=1}^{4} N_{7,j}.$$

Description of the Model -- Demographic Part

The demographic model is presented as a flow diagram in Figure 65. Here is shown how the animals move from one category to the next as time advances. As seen from the figure, females and males are not separated before the subadult age-class. This is because, to our knowledge, the processes for aging and dying are the same, independent of the sex, for the young animals up to the subadults. Furthermore, the energy requirement of these animals can probably be predicted without knowing the sex.

Females moving from one sub-category to another in the subadult and adult age classes are shown in Figure 66. Notice, however, that when a female gives birth, there is no arrow showing flow to the box called FETUS in Figure 65. These flows (i.e. carbon flows) can be implemented best in the physiological part of the model, which is not given in this report.

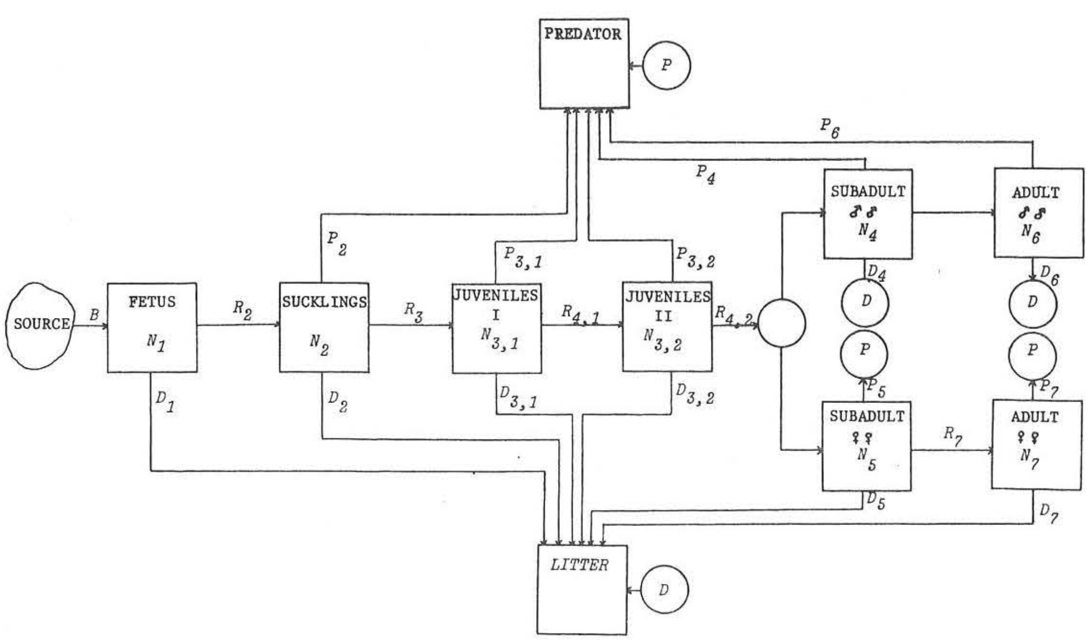

Figure 65. Flow diagram for aging in the demographic model.

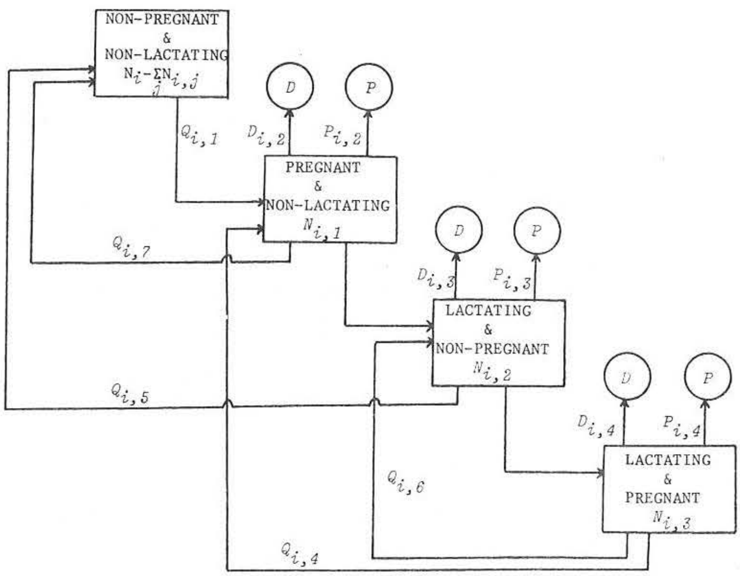

Figure 66. Flow diagram for subadult and adult females that are capable of reproducing.

Aging as a process is a common feature for all categories considered in the model, thus, the mathematical form describing this process is similar in all categories. Therefore, the function for the recruitment rate from category $i - 1$ to i is developed at the beginning of this section. Since all other processes are described by quite different mathematical functions, these are developed in the appropriate sections.

An optimal (or maximal) rate is identified and developed first in each section for all processes, but then followed by the different functions that adjust it when the environment is suboptimal.

The definitions and units, if any, for all of the mathematical symbols used are in Appendices 4, 5 and 6. Appendix 4 gives the definitions for the state variables while definitions for the intermediate algebraic variables are included in Appendix 5. Appendix 6 includes definitions for the parameters used and a preliminary list of proposed numeric values for these parameters. Since there is a general lack of field or laboratory data, several of these parameters are based solely on general biological knowledge. Therefore, one of the objectives of the simulation is to assess whether or not the system is sensitive to these parameters. If the system is sensitive to one or more of the parameters, field or laboratory studies should be proposed to estimate the missing parameters.

Aging—The instantaneous recruitment rate (Timin et al., 1973), $\partial R_i/\partial t$, into the i^{th} category from the $i - 1^{th}$ category is given as:

$$\partial R_i/\partial t = .5\ [N_{i-1}(t)/\tau_{i-1} + N_i(t)/\tau_i] \qquad (2)$$

where: τ_{i-1} and τ_i is the length, in days, of the $i - 1^{th}$ and the i^{th} category respectively. $N_{i-1}(t)$ and $N_i(t)$ is the number of animals in the $i - 1^{th}$ and i^{th} category in the previous time interval.

Assuming that the numbers of animals in the different categories are constant in a given time interval, $t - 1^{th}$, transfer from the $i - 1^{th}$ category to the i^{th} category is defined with:

$$R_i(t+1) = \int_0^7 (\partial R_i/\partial t)\cdot dt = 3.5[N_{i-1}(t)/\tau_{i-1} + N_i(t)/\tau_i] \qquad (3)$$

Number of Fetuses (N_1)

$$N_1(t+1) = N_1(t) = B - R_2 - D_1 \qquad (4)$$

where: B = number of eggs that have been fertilized in the $t + 1^{th}$ interval;

R_2 = number of animals born in the $t + 1^{th}$ interval; and

D_1 = number of fetuses aborted or resorbed in the $t + 1^{th}$ interval.

Calculation of B—the rate of female pregnancy (b_1) as a function of age (Fig. 67), given that all other factors are optimum is:

$$b_1 = \begin{cases} 0 & \text{for suckling and juvenal females} \\ b_{1,1} & \text{for subadult females} \\ 1 & \text{for adult females} \end{cases} \qquad (5)$$

The average prenancy rate for the subadult females is $b_{1,1}$. Equation 5 then means that if everything is optimum during the time interval in question, $b_1 \cdot N_{1,4}$ of females will be pregnant.

When "the other factors" are suboptimum, this rate is decreased by multiplicative correction terms. The factors are identified in the model as: (I) density of subadult and adult males, (II) quantity and (III) quality of the food consumed by the females, and (IV)the time of the year.

Density of Mature Males (I)—The suboptimal mature male density (Fig. 68) which modified b_1 is given as:

$$b_2 = \begin{cases} \alpha_1 \cdot \{1 - exp[-\gamma_1 \cdot (N_4 + N_6)]\} & \text{for } N_4 + N_6 \le N_{opt} \\ \dfrac{1}{N_{opt} - N_{m,max}} \cdot [-N_{m,max} + (N_4 + N_6)] & \text{for } N_4 + N_6 > N_{opt} \end{cases} \qquad (6)$$

where: N_{opt} = that density of mature males for which there is no limitation in females becoming pregnant,

$N_{m,max}$ = that density of mature males for which the rate of females becoming pregnant is zero,

α_1 = the asymptote of the function (b_2), and

γ_1 = control parameter for the rate at which the asymptote is approached

Thus, α_1 and γ_1 are found by solving the following system of equations:

$$\begin{aligned} \alpha_1 \cdot [1 - exp(-\gamma_1 \cdot N_{opt})] &= 1.0 \\ \alpha_1 \cdot [1 - exp(-\gamma_1 \cdot 0.1N_{opt})] &= 0.5 \end{aligned} \qquad (7)$$

A measure of the quantity of the food actually consumed (II) relative to what the animal needs is indicated with the index I_f, defined with:

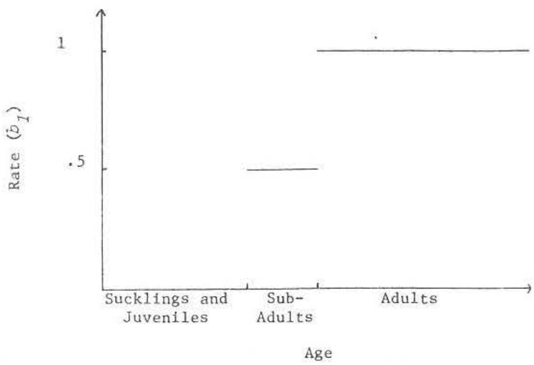

Figure 67. The optimal rate of being pregnant (b_1) for a female, as a function of age.

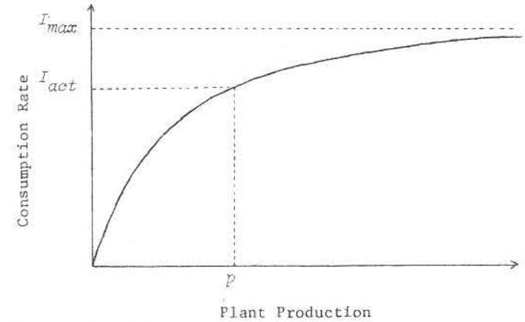

Figure 69. The functional response curve, and how to find the index, I_f from it. Then for a plant production equal to P, we have a numerical value of I_f equal to I_{act}/I_{max}.

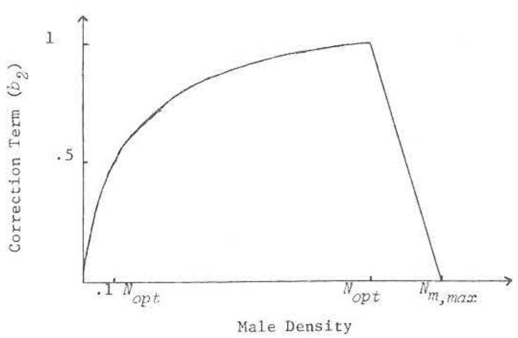

Figure 68. Correction terms (b_2) of the rate at which females become pregnant, as a function of mature male density.

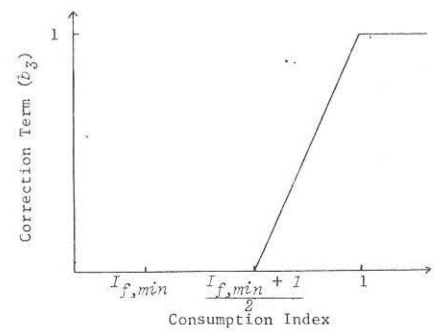

Figure 70. Correction term (b_3) for the pregnancy rate as a function of the food quantity consumed.

$$I_f = I_{act}/I_{max} \qquad (8)$$

where: I_{max} is the maximum amount an animal can ingest during a time interval (Holling, 1959 and 1966).

This value is assumed to be equal to the animal's food requirement. The actual amount of food ingested (I_{act}) in a time interval is a function of the plant food production as illustrated in Figure 69. Then I_{max} is equal to the assymptote of the functional response curve (Fig. 69), whereas I_{act} is equal to the numerical value of the function given by the plant production. It seems reasonable to assume that a minimum value of I_f can be obtained, below which the animal will not survive, i.e.:

$$I_{f,min} \leq I_f \leq 1 \qquad (9)$$

This value would be found most easily in a laboratory study although an early approximation might be obtained from data already existing.

When the animal cannot get enough food to satisfy its maximum requirement (I_{max}), the subsequent pregnancy rate is corrected with b_3 (Fig. 70), given as:

$$b_3 = \begin{cases} 0 & \text{for } I_f \leq \frac{I_{f,min} + 1}{2} \\ \frac{2}{1 - I_{f,min}} \cdot \left(I_f - \frac{I_{f,min} + 1}{2}\right) & \text{for } \frac{I_{f,min} + 1}{2} < I_f \leq 1 \\ 1 & \text{for } I_f > 1 \end{cases} \qquad (10)$$

The phosphorus content in that part of the vegetation that serves as food for the small mammal species in question was used as a measure of food quality (III) using the procedures proposed by Schultz (1964, 1969) and Bunnel (1972). Now there is a factor (b_4) (Fig. 71) for the quality of the food consumed given by:

$$b_4 = \begin{cases} 0 & \text{for } Nu \leq \frac{Nu_{min} + Nu_{max}}{2} \\ \frac{2}{Nu_{max} - Nu_{min}} \cdot (Nu - Nu_{min}) & \text{for } \frac{Nu_{min} + Nu_{max}}{2} < Nu \leq Nu_{max} \\ 1 & \text{for } Nu > Nu_{max} \end{cases} \qquad (11)$$

Some of the species considered in this model have cessation of breeding for some periods in the year (IV) (T_{stop} to T_{start}). It is assumed that this cessation is not caused by any of the factors previously discussed. Thus, it is an observed phenomenon that cannot be explained, but a correction term (b_5) (Fig. 72) is computed and given by:

$$b_5 = \begin{cases} 1 & \text{for } T \leq T_{stop} \\ 0 & \text{for } T_{stop} < T < T_{start} \\ 1 & \text{for } T \geq T_{start} \end{cases} \qquad (12)$$

Combining all these functions as done by Lassiter and Hayne (1971), the number of fertilized eggs per time interval may be defined with:

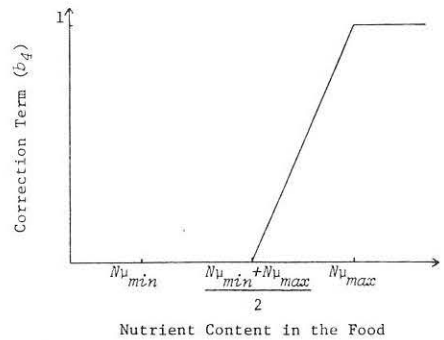

Figure 71. Correction term (b_4) for pregnancy rate as a function of the nutrient content in the consumed food.

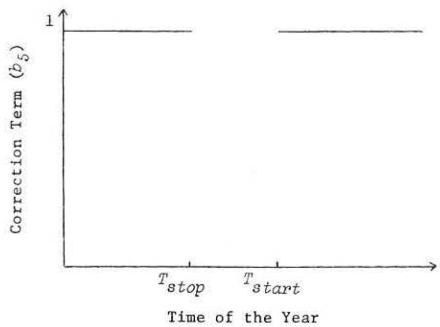

Figure 72. Correction term (b_5) for the breeding stop at certain times of the year.

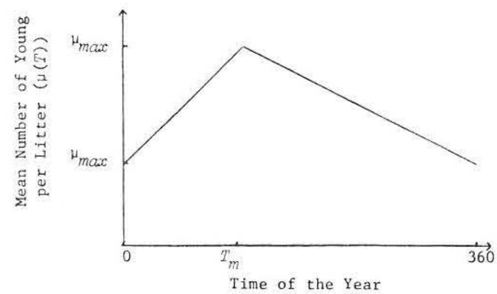

Figure 73. The mean number of young per litter $\mu(T)$ as a function of the time of the year.

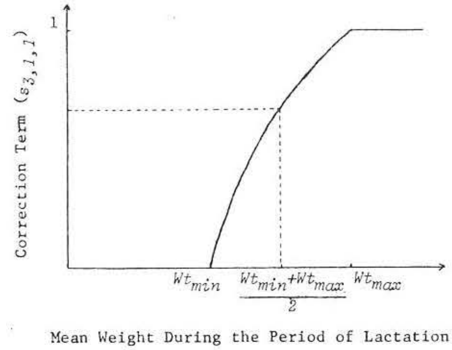

Figure 74. Correction term ($s_{3,1,1}$) of juvenile I as a function of their weight as sucklings.

$$B = [N_{5,4} \cdot b_{1,1} + N_{7,4} \cdot 1] \cdot b_2 \cdot b_3 \cdot b_4 \cdot b_5 \cdot \mu(T) \tag{13}$$

where: $\mu(T)$ is the mean number of fetuses, as a function of the time in the year.

One might argue that there is also genetic variation in the population, but by considering the mean and assuming that the number of fetuses follow a normal distribution (or any kind of symmetrical distribution) this is taken into consideration in an implicit way be using the mean. The function $\mu(T)$ (Fig. 73) is given by:

$$\mu(T) = \begin{cases} \frac{\mu_{max} - \mu_{min}}{T_m} \cdot T & \text{for } T \leq T_m \\ \frac{\mu_{max} - \mu_{min}}{T_m - 360} \cdot (T - 360) & \text{for } T > T_m \end{cases} \tag{14}$$

Thus, B (Equation 13) provides the total number of eggs being fertilized in a time interval of seven days.

Calculation of R_2—By using the general equation given in (3), R_2 is determined with:

$$R_2 = 3.5[N_1(t)/\tau_1 + N_2(t)/\tau_2] \tag{15}$$

Calculation of D_1—The survival rate rather than the death rate was used to simplify the description of the entire model. Due to the age of the female, there is an optimal fraction of the fertilized eggs that will survive. This optimal fraction $s_{1,1}$ is given by:

$$s_{1,1} = \begin{cases} 0.75 & \text{for subadult females} \\ 1 & \text{for adult females} \end{cases} \tag{16}$$

Then due to the quantity and quality of food consumed by females, this optimal survival rate is reduced by similar terms as those given in equations 10 and 11. The decreased survival, as a function of decreased food consumption, is $s_{1,2}$ given by:

$$s_{1,2} = \begin{cases} 0 & \text{for } I_f \leq \frac{I_{f,min} + 1}{2} \\ \frac{2}{1 - I_{f,min}} \cdot \left(I_f - \frac{I_{f,min} + 1}{2}\right) & \text{for } \frac{I_{f,min} + 1}{2} < I_f \leq 1 \end{cases} \tag{17}$$ [1]

[1] Note that $s_{1,2}$ is the same function as b_3 in equation 10.

The function used for simulating decreased survival due to lack of nutrients, is:

$$s_{1,3} = \begin{cases} 0 & \text{for } Nu \leq \frac{I_{f,min} + 1}{2} \\ \frac{2}{Nu_{max} - Nu_{min}} \cdot (Nu - Nu_{min}) & \text{for } \frac{Nu_{min} + Nu_{max}}{2} < Nu \leq Nu_{max} \\ 1 & \text{for } Nu > Nu_{max} \end{cases} \quad (18)^2$$

[2] Note that $s_{1,3}$ is the same function as b_4 in equation 11.

Then the total mortality of the fetuses in the interval may be found according to Lassiter and Hayne (1971) with:

$$D_1 = N_1(t) \cdot (1 - s_{1,1} \cdot s_{1,2} \cdot s_{1,3}) - [(D_{5,2} + D_{5,4} + D_{7,2} + D_{7,4}) \cdot \mu(T)] \quad (19)$$

The reason for $[(D_{5,2} + D_{5,4} + D_{7,2} + D_{7,4}) \cdot \mu(T)]$ is that if the mother dies, then all the fetuses will die. The complete definition of these terms will be provided while discussing N_5 and N_7 for subadult and adult females, respectively.

Number of Suckling (N_2)—

$$N_2(t+1) = N_2(t) + R_2 - R_3 - D_2 - P_2 \quad (20)$$

where: R_2 = number of animals born in the $t + 1^{th}$ interval, defined in equation 15,

R_3 = number of sucklings weaned in the $t + 1^{th}$ interval, found by substituting the correct terms in equation 3,

D_2 = number of sucklings that died from non-predatory death in the $t + 1^{th}$ interval, and

P_2 = number of sucklings that were killed by predators in the $t + 1^{th}$ interval.

Calculation of D_2—It is assumed that 10 to 15% of the sucklings will be injured by the mother or die due to some genetic diseases; thus, the maximum survival rate of sucklings, represented by $s_{2,1}$ will be .090 to .085. The quality and quantity of the mothers food will reduce this survival fraction by:

$$s_{2,2} = s_{1,2} \quad (21)$$

which is defined in equation 17, and

$$s_{2,3} = s_{1,3} \quad (22)$$

which is defined in equation 18. Furthermore, if the mother dies, then all the sucklings will die as well, where the death rate of the mother is $D_{5,3}$ and $D_{5,4}$ and $D_{7,3}$ and $D_{7,4}$ for subadults and adults, respectively; thus:

$$D_2 = N_2(t) \cdot (1 - s_{2,1} \cdot s_{2,2} \cdot s_{2,3}) - (D_{5,3} + D_{5,4} + D_{7,3} + D_{7,4}) \cdot \mu(T) \quad (23)$$

Calculation of P_2—The predation rate on sucklings is assumed to be constant and equal to 1%, thus:

$$P_2 = .01 \cdot N_2(t) \quad (24)$$

Number of Juveniles I ($N_{3,1}$)—

$$N_{3,1}(t+1) = N_{3,1}(t) + R_3 - R_{4,1} - D_{3,1} - P_{3,1} \quad (25)$$

where: R_3 = number of sucklings that were weaned in the $t + 1^{th}$ interval, found by substituting the correct terms in equation 3,

$R_{4,1}$ = number of juvenile I that advanced into the next category in the $t + 1^{th}$ interval, found by substituting the correct terms in equation 3,

$D_{3,1}$ = number of animals in the category that died from non-predatory death in the $t + 1^{th}$ interval, and

$P_{3,1}$ = number of animals in the category that were killed by predators in the $t + 1^{th}$ interval.

Calculation of $D_{3,1}$—The survival rate in the juvenile I category is assumed to be a function of the animal weights in the suckling stage. This weight reflects the health status of these animals. The mean of the weight at $t - 1$ and $t - 2$ is arbitratily used to represent this weight. The animals weight at $t - 2$ is multiplied (weighted) with .33, while the animals weight at $t - 1$ is multiplied (weighted) with .67, thus:

$$\overline{Wt} = .33\ \overline{Wt}(t-2) + .67\ \overline{Wt}(t-1) \quad (26)$$

The survival rate as a function of the animals weight during the period of lactation (Fig. 74) is:

$$s_{3,1,1} = \begin{cases} 0 & \text{for } \overline{Wt} < \overline{Wt}_{min} \\ \alpha_2 \cdot [1 - exp(-\gamma_2 \cdot \overline{Wt}) & \text{for } \overline{Wt}_{min} < \overline{Wt} < \overline{Wt}_{max} \\ 1 & \text{for } \overline{Wt} > \overline{Wt}_{max} \end{cases} \quad (27)$$

where: $\overline{Wt}_{min}$ = that value of $\overline{Wt}$ given in equation 26, which is the minimum value that the juveniles are still able to survive at,

α_2 = maximum value of $s_{3,1,1}$ when $\overline{Wt} \to \infty$, and

γ_2 = parameter controlling the rate at which $s_{3,1,1}$ approaches α_2.

The numerical values of these parameters are found by solving the following system of equations:

$$\alpha_2[1 - exp(-\gamma_2 \cdot \overline{Wt}_{max})] = 1$$
$$\alpha_2[1 - exp(-\gamma_2 \cdot \frac{\overline{Wt}_{max} + \overline{Wt}_{min}}{2} = .67 \quad (28)$$

where: $\overline{Wt}_{max}$ is that value of $\overline{Wt}$ given in equation 26 when the maximum values for $Wt(t-2)$ and $Wt(t-1)$ are used.

The density of the species, i.e. all weaned animals, is assumed to determine the fraction of juveniles that will be able to establish their own home ranges (Fig. 75). During high density juveniles will have difficulties in establishing their own home ranges, since they may have to go longer distances, which means that these animals will be more vulnerable to adverse environmental factors such as predation, in addition to that type of predation ($P_{3,1}$) described later, and inclement weather. The following represents (Fig. 75) this mortality factor:

$$s_{3,1,2} = \begin{cases} 1 - \left[\sum_{i \le 3} N_i(t) \Big/ N_{t,max}\right]^2 & \text{for } \sum_{i \le 3} N_i \le N_{t,max} \\ 0 & \text{for } \sum_{i \le 3} N_i > N_{t,max} \end{cases} \qquad (29)$$

where: $N_{t,max}$ = maximum value of $\sum_{i \le 3} N_i(t)$, for which the animals still can establish a home range.

The quality (equation 30) and quantity (equation 31) of the food consumed by the juveniles will affect the survival rate according to:

$$s_{3,1,3} = \begin{cases} 0 & \text{for } I_f \le \frac{I_{f,min} + 1}{2} \\ \frac{2}{1 - I_{f,min}} \cdot \left(I_f - \frac{I_{f,min} + 1}{2}\right) & \text{for } \frac{I_{f,min} + 1}{2} < I_f \le 1 \\ 1 & \text{for } I_f > 1 \end{cases} \qquad (30)$$

Note that I_f and $I_{f,min}$ refer to the animal itself, not as in equation 17 where it refers to the mother.

$$s_{3,1,4} = \begin{cases} 0 & \text{for } Nu \le \frac{Nu_{min} + Nu_{max}}{2} \\ \frac{2}{Nu_{max} - Nu_{min}} \cdot Nu - Nu_{min} & \text{for } \frac{Nu_{min} + Nu_{max}}{2} < Nu \le Nu_{max} \\ 1 & \text{for } Nu > Nu_{max} \end{cases} \qquad (31)$$

Also, the variable Nu and the parameters Nu_{min} and Nu_{max} refer to the animal itself and not to the mother as in equation 18.

Soil moisture will affect the survival rate in the following manner:

$$s_{3,1,5} = \begin{cases} 0 & \text{for } Wa \le Wa_{min} \\ \alpha_3 \left[1 - exp(-\gamma_3 \cdot Wa)\right] & \text{for } Wa_{min} < Wa \le Wa_{max} \\ 1 & \text{for } Wa > Wa_{max} \end{cases} \qquad (32)$$

where: Wa = soil moisture (% water of wet weight soil),

Wa_{min} = minimum soil moisture in which the animal can survive,

Wa_{max} = maximum soil moisture, above which survival of the animal does not improve; although extremely high soil is considered detrimental, it is rare, local and does not persist long,

α_3 = maximum value of $s_{3,1,5}$ when $Wa \to \infty$, and

γ_3 = parameter controlling the rate at which $s_{3,1,5}$ approaches α_3.

The numerical values for these parameters are found by solving the following system of equations:

$$\alpha_3 \left[1 - exp(-\gamma \cdot Wa_{max})\right] = 1$$

$$\alpha_3 \left[1 - exp\left(-\gamma \cdot \frac{Wa_{max} + Wa_{min}}{2}\right)\right] = .67 \qquad (33)$$

This function is of the same form as equation 27. By combining all these factors, the total number of animals in the category that died during the $t + 1^{th}$ interval is:

$$D_{3,1} = N_{3,1}(t) \cdot (1 - s_{3,1,1} \cdot s_{3,1,2} \cdot s_{3,1,3} \cdot s_{3,1,4} \cdot s_{3,1,5}) \qquad (34)$$

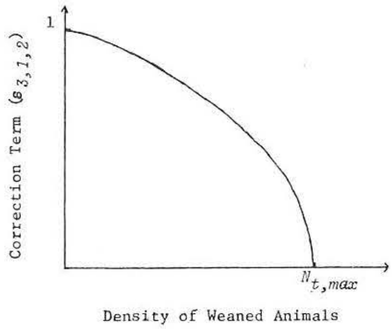

Figure 75. Correction term ($s_{3,1,2}$) for the survival rate, as a function of the weaned animal density.

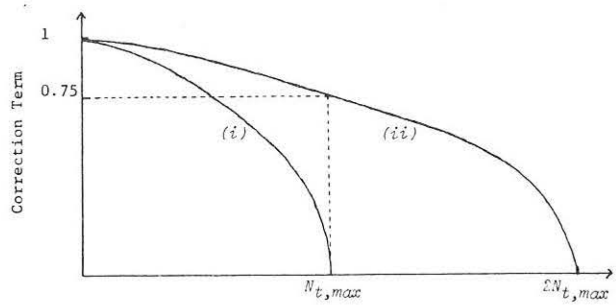

Figure 76. Figure showing the differently pronounced effect of the animal density on the survival of the two juvenile categories, I and II; $s_{3,1,2}$ is given by (*i*) and $s_{3,2,2}$, is given by (*ii*).

Calculation of $P_{3,1}$—The correction factor $s_{3,1,2}$ given in equation 29 accommodates the high mortality in the juvenile categories while they are establishing their own home ranges. The predation rate on sucklings independent of the small mammal density is assumed to be equal to 7% for both juvenile categories I and II. Therefore the first weeks fraction of the total juvenile categories I and II may be multiplied by .07; thus:

$$P_{3,1} = .07 \cdot N_{3,1}(t) \cdot [\tau_{3,1} \big/ (\tau_{3,1} + \tau_{3,2})] \qquad (35)$$

Number of Juveniles II ($N_{3,2}$)—

$$N_{3,2}(t+1) = N_{3,2}(t) + R_{4,1} - R_{4,2} - D_{3,2} - P_{3,2} \qquad (36)$$

where: $R_{4,1}$ = number of animals that leave the juvenile I category during the $t + 1^{th}$ interval, found by substituting the correct terms in equation 3,

$R_{4,2}$ = number of juvenal males and females that mature during the $t + 1^{th}$ interval, found by substituting the correct terms in equation 3,

$D_{3,2}$ = number of animals in the category that died from non-predatory death in the $t + 1^{th}$ interval, and

$P_{3,2}$ = number of animals in the category that were killed by predators in the $t + 1^{th}$ interval.

Calculation of $D_{3,2}$—After animals survive the juvenile I category and if all environmental factors are optimal, it is assumed that they will have a probability of survival $s_{3,2,1} = 1$. If some of the environmental factors that have been identified as important are suboptimal, then this rate of survival will be reduced. There is an assumption that the higher the density of weaned animals, the higher the death rate due to the lack of good home range sites. Although the assumption is the same as for juvenile I animals, the effect is not as pronounced, thus it is defined:

$$s_{3,2,2} = \begin{cases} 1 - \left[\sum_{i \leq 3} N_i(t) / 2 \cdot N_{t,max} \right]^2 & \text{for } \sum_{i \leq 3} \leq 2 \cdot N_{t,max} \\ 0 & \text{for } \sum_{i \leq 3} N_i > 2 \cdot N_{t,max} \end{cases} \quad (37)$$

where: $N_{t,max}$ is the same as that used in equation 29, but the factor 2 is an arbitrary choice. The use of 2 gives $s_{3,2,2} = 0.75$ for $\sum_{i \leq 3} N_i(t) = N_{t,max}$, whereas $s_{3,1,2} = 0$ for the same density.

This essentially provides a reasonable estimate of surviving in the natural environment after the animals have passed from juvenile I category to juvenile II category (Fig. 76).

The correction terms of food quantity and quality for the survival rate are the same as equations 30 and 31, respectively, i.e.:

$$s_{3,2,3} = s_{3,1,3} \quad \text{for quantity} \quad (38)$$

$$s_{3,2,4} = s_{3,1,4} \quad \text{for quality} \quad (39)$$

Similarly, the correction term for the effects on the survival rate of soil moisture is the same as equation 32, i.e.:

$$s_{3,2,5} = s_{3,1,5} \quad (40)$$

The combining of all these functions provides the total number of animals ($D_{3,2}$) in juvenile II category that died during the $t + 1^{th}$ interval:

$$D_{3,2} = N_{3,2}(t) \cdot (1 - s_{3,2,1} \cdot s_{3,2,3} \cdot s_{3,2,4} \cdot s_{3,2,5}) \quad (41)$$

Calculation of $P_{3,2}$—Using the same reasoning described for equation 35, the total number of animals from the juvenile II category that are killed by predators is:

$$P_{3,2} = .07 \cdot N_{3,2}(t) \cdot [\tau_{3,2} \ (\tau_{3,1} + \tau_{3,2})] \quad (42)$$

Number of Subadult Males (N_4)—

$$N_3(t+1) = N_3(t) + (1-q) \cdot R_{4,2} - R_6 - D_4 - P_4 \quad (43)$$

where: $R_{4,2}$ = number of juveniles that mature during the $t + 1^{th}$ interval,

R_6 = number of animals that advance into the adult male category in the $t + 1^{th}$ interval,

D_4 = number of animals that died from non-predatory death during the $t + 1^{th}$ interval,

P_4 = number of animals that are killed by predators in the $t + 1^{th}$ interval, and

q = fraction of the animals that mature during the $t + 1^{th}$ interval that are females.

The functional relationships are explained above, therefore only the equations for how the terms used in equation 43 are determined here. These are:

$$D_4 = N_4(t) \cdot (1 - s_{4,3} \cdot s_{4,4} \cdot s_{4,5}) \quad (44)$$

where:

$$s_{4,3} = s_{3,1,3} \quad (45)$$

$$s_{4,4} = s_{3,1,4} \quad (46)$$

$$s_{4,5} = s_{3,1,5} \quad (47)$$

$$P_4 = .05 \cdot N_4(t) \quad (48)$$

Number of Subadult Females (N_5)—

$$N_5(t+1) = N_5(t) + q \cdot R_{4,2} - R_7 - D_5 - P_5 \quad (49)$$

The symbols used here should be clear since they are similar to those defined in equation 43 for subadult males:

$$D_5 = N_5(t) \cdot (1 - s_{5,3} \cdot s_{5,4} \cdot s_{5,5}) \quad (50)$$

where:

$$s_{5,3} = s_{3,1,3} \quad (51)$$

$$s_{5,4} = s_{3,1,4} \quad (52)$$

$$s_{5,5} = s_{3,1,5} \quad (53)$$

$$P_5 = .05 \cdot N_5(t) \quad (54)$$

Number of Adult Males (N_6) and Adult Females (N_7)—

$$N_6(t+1) = N_6(t) + R_6 - D_6 - P_6 \text{, and} \quad (55)$$

$$N_7(t+1) = N_7(t) + R_7 - D_7 - P_7 \quad (56)$$

The symbols used here should be clear since they are similar to those defined in equation 43 for subadult males:

$$D_i = N_i(t) \cdot (1 - s_{i,3} - s_{i,4} - s_{i,5}) \quad (57)$$

where:

$$s_{i,3} = s_{3,1,3} \quad (58)$$

$$s_{i,4} = s_{3,1,4} \quad (59)$$

$$s_{i,5} = s_{3,1,5} \quad (60)$$

$$P_i = .025 \cdot N_i(t) \quad (61)$$

Transfer within the Subadult and Adult Female Categories—Because the mathematical expressions for the processes shown in Figure 2 are similar for both subadult and adult females, they will be treated together. The index indicating the specific category will be given so that $i = 5$ is for the subadult female category, and $i = 7$ is for the adult female category.

Pregnant but Non-lcatating Females ($N_{i,1}$)—

$$N_{i,1}(t+1) = \sum_{m=1}^{n_p} N_{i,1,m}(t+1) \quad (62)$$

where: n_p is the number of time intervals $(t, t+1)$ in the gestation period.

Terms in the summation are defined as:

$$N_{i,1,m}(t+1) = \begin{cases} Q_{i,1} + Q_{i,4} & \text{for } m = 1 \\ N_{i,1,m-1}(t) - Q_{i,7} - D_{i,2,m-1} - P_{i,2,m-1} & \text{for } m > 1 \end{cases} \tag{63}$$

where: $Q_{i,1}$ = number of non-reproducing females that become pregnant during the $t + 1^{th}$ interval,

$Q_{i,4}$ = number of females that are both pregnant and lactating, and have their entire litter either weaned or killed during the $t + 1^{th}$ interval,

$Q_{i,7}$ = number of pregnant females that abort their entire litter during the $t + 1^{th}$ interval,

$D_{i,2,m-1}$ = number of the $m - 1^{th}$ sub-category that died from non-predatory death during the $t + 1^{th}$ interval, and

$P_{i,2,m-1}$ = number of the $m - 1^{th}$ sub-category that are killed by predators during the $t + 1^{th}$ interval.

These terms are then calculated with:

$$Q_{i,1} = B/\mu(T) \tag{64}$$

where: B and $\mu(T)$ are defined in equations 13 and 14, respectively.

$$Q_{i,4} = R_3 / \mu(T) + N_2(t)\cdot[1 - s_{2,1} \cdot s_{2,2} \cdot s_{2,3}] / \mu(T) \tag{65}$$

where: R_3 can be found by referring to equation 3.

The assumption is that a female will first kill her sucklings, thus move to the pregnant category, then she may abort her fetuses.

It is assumed that when a female aborts or kills her litter, she will do it in an all-or-none way. This is supported by observing that the species in question will, in most cases, kill one suckling at a time, but she will kill the entire litter within a few days. Since the model considers time intervals of one week, the process will be observed as an all-or-none process; consequently:

$$Q_{i,7} = N_1(t)\cdot [1 - s_{1,1} \cdot s_{1,2} \cdot s_{1,3}] / \mu(T) \tag{66}$$

where: $s_{1,1}$ is given in equation 16, $s_{1,2}$ in 17 and $s_{1,3}$ in 18.

$$D_{i,2,m-1} = N_{i,1,m-1}(t)\cdot[1 - s_{i,3} \cdot s_{i,4} \cdot s_{i,5}] \tag{67}$$

$$P_{i,2,m-1} = \begin{cases} .05\cdot N_{5,1,m-1}(t) & \text{for } i = 5 \\ .025\cdot N_{7,1,m-1}(t) & \text{for } i = 7 \end{cases} \tag{68}$$

The total number of pregnant but non-lactating females that dies in the time interval is therefore given as:

$$D_{i,2} = \sum_m (D_{i,2,m} + P_{i,2,m}) \tag{69}$$

Lactating but Non-pregnant Females ($N_{i,2}$)—

$$N_{i,2}(t+1) = \sum_{m=1}^{n_l} N_{i,2,m}(t+1) \tag{70}$$

where: n_l is the number of time intervals $(t,t+1)$ in the lactation period.

Terms in the summation are defined as:

$$N_{i,2,m}(t+1) = \begin{cases} N_{i,1,n_p}(t) - Q_{i,7} - D_{i,2} - P_{i,2} & \text{for } m = 1 \\ N_{i,1,m-1}(t) + Q_{i,6} - Q_{i,5} - D_{i,3,m-1} - P_{i,3,m-1} & \text{for } m > 1 \end{cases} \tag{71}$$

where: $Q_{i,6}$ = number of both pregnant and lactating females that abort their fetuses but do not kill their sucklings during the $t + 1^{th}$ interval.

$Q_{i,5}$ = number of lactating females that kill or wean their sucklings during the $t + 1^{th}$ interval,

$D_{i,3,m-1}$ = number of the $m - 1^{th}$ sub-category that died from non-predatory death during the $t + 1^{th}$ interval, and

$P_{i,3,m-1}$ = number of the $m - 1^{th}$ sub-category that are killed by predators during the $t + 1^{th}$ interval.

These terms are then calculated using the same reasoning as in equation 66:

$$Q_{i,6} = Q_{i,7} \tag{72}$$

where: $Q_{i,7}$ are given in equation 66.

$$Q_{i,5} = \left(N_2(t)\cdot[1 - s_{2,1} \cdot s_{2,2} \cdot s_{2,3}] + R_3\right) / \mu(T) \tag{73}$$

$$D_{i,3,m-1} = N_{i,2,m-1}(t)\cdot[1 - s_{i,3} \cdot s_{i,4} \cdot s_{i,5}] \tag{74}$$

$$P_{i,3,m-1} = \begin{cases} .05\cdot N_{5,2,m-1}(t) & \text{for } i = 5 \\ .025\cdot N_{7,2,m-1}(t) & \text{for } i = 7 \end{cases} \tag{75}$$

The total number of lactating but non-pregnant females that died in the time interval is therefore given as:

$$D_{i,3} = \sum_m (D_{i,3,m} + P_{i,3,m}) \tag{76}$$

Pregnant and Lactating Females ($N_{i,3}$)

$$N_{i,3}(t+1) = \sum_{k=1}^{n_l} \sum_{m=2}^{n_p} N_{i,3,k,m}(t+1) \tag{77}$$

Terms in the summation are defined as:

$$N_{i,3,k,m}(t+1) = \begin{cases} [N_{i,2,m-1}(t) + Q_{i,6} - Q_{i,4} - D_{i,3,m-1} - P_{i,3,m-1}] \cdot B/\mu(T) & \text{for } k = 1 \\ N_{i,3,k-1,m-1}(t) - Q_{i,6} - Q_{i,4} - D_{i,4,k-1,m-1} - P_{i,4,k-1,m-1} & \text{for } k > 1 \end{cases} \tag{78}$$

where:

$$P_{i,4,k,m} = \begin{cases} .05\cdot N_{5,3,k,m}(t) & \text{for } i = 5 \\ .025\cdot N_{7,3,k,m}(t) & \text{for } i = 7 \end{cases} \tag{79}$$

$$D_{i,4,k,m} = N_{i,3,k,m}(t) \cdot [1 - s_{i,3} \cdot s_{i,4} \cdot s_{i,5}] \tag{80}$$

The total number of females that are both pregnant and lactating, that died in the time interval is therefore given as:

$$D_{i,4} = \sum_k \sum_m (D_{i,4,k,m} + P_{i,4,k,m}) \tag{81}$$

Non-reproducing females ($N_{i,4}$)—The number of non-reproducing females ($N_{i,4}$) is found by subtracting the number of reproducing females from the total number of females known to be in the subadult or adult female categories, thus:

$$N_{i,4}(t+1) = N_i(t+1) - \sum_{j=1}^{3} N_{i,j}(t+1) \qquad (82)$$

DISCUSSION

Most of the growth data that have been analyzed for *D. ordii*, *P. maniculatus*, and *R. megalotis* concern the results of animals grown under standard laboratory conditions. Although most of the R^2 values were determined to be significant (when converted to r) at the .95 level, one must consider two items in their interpretations: (1) the size of n, which when too large reduces the usefulness of r and (2) what percentage of the variation must be accounted for before the correlation is considered to be biologically sound so that k can be accepted as a reliable estimate of the instantaneous relative growth rate. When the growth curves in Appendices 1-3 are examined, the correlations seem rather precise within the prescribed growth periods for the time intervals; thus, one is inclined to be rather liberal in setting lower limits on R^2. It was determined that $R^2 \geqslant .25$ should provide enough accountability to accept a significant correlation and k as realistically representing growth rates. This does not mean the k values for those analyses with $R^2 < .25$ are in error, it simply means the confidence is not as strong.

Total body weight is perhaps the most interesting of all parameters measured, because of its implications for biomass as it related to secondary production. The antilogs of lnW, means and k values for body weight of the three species (Appendices 1-3) should accurately represent the instantaneous relative growth rates for the growth periods and time intervals involved up to 70 days of age, since there is such a close relationship between the antilogs of lnW and the means and since there are narrow confidence limits about the means. It is possible that beyond 70 days the close correlation of antilogs of lnW and the means for body weight would become less reliable, but since *D. ordii*, *P. maniculatus* and *R. megalotis* have reached reproductive age by this time one can be safe in estimating biomass up to adulthood in these species. Beyond that a close correlation likely is not necessary since k shows very little increase as evidenced by the flatness of the body weight curves (Figures 1, 12, 60, Appendix 2). Admittedly, the growth rates provided for these three species were obtained under standard laboratory conditions, but they can be considered representative for the time intervals prescribed, which generally includes the time when the animals are actually growing. Following this time period, variations in weight might be more a matter of responses to environmental stresses and changes rather than actual growth phenomena.

Independent environmental variables that may affect growth, when altered for *P. maniculatus*, seem to be reflected by shifts in k (Figures 21-59, Appendix 2). Generally, it might be concluded that longer photoperiods will accelerate growth (Figures 21-25, 31-35, Appendix 2), but animals retained in less light will soon catch up after foraging begins (Figs. 26-35, Appendix 2). The precise reason for this is not clear, although it might be as simple as the amount of time the female stays in the nest each day; thus, availing herself to the suckling young.If this reasoning is correct, growth would probably be slower in the field where foraging time is increased. Increased foraging time could be related to a quantity and/or quality of food as well as to photoperiod and/or temperature. When a lactating female receives varying quantities of food at suboptimal levels the growth of the young is curtailed in accordance with the feeding level (Figures 55-59, Appendix 2). This growth curtailment, best exemplified by body weight (Figure 55, Appendix 2) is likely due to the compound effect of foraging time and nutritional condition of the mother. Whatever, it appears that the genetic limitations of the young are met shortly after their foraging begins if sufficient food is available (Figures 12-16, Appendix 2) and they reach trappable age. If adequate food is not available, however, growth rates may never reach their genetic potential and young reared under these conditions may be permanently impaired (Figures 55-59, Appendix 2). Although manipulation of environmental variables affected all parameters, the growth differences were usually greatest for body weight.

One possible weakness of these analyses is an inability to assess k under field conditions. Originally, it was assumed that shifts in k under field conditions would not differ significantly from those established in the laboratory, but analyses of data obtained while experimenting with independent variables (photoperiod, temperature, and food) would suggest that the assumption may not be valid. It is possible, not likely, that variations in k may compensate for each other sufficiently to result in animals all being about the same size shortly after they become trappable. If so, estimates of biomass could be made by correlating body weight with age.

There have been several attempts to correlate weight with age as reviewed by Brody (1945), or other parameters with age as in Dapson and Irland (1972), but since many of them were interested in predicting age, the results were not particularly satisfying. This study was concerned more with the characterization of growth as far as weight was concerned. Attempts to age organisms should be done with parameters other than body weight such as dried eye lens weights, which consistently had the highest r value (Appendices 2-3), or with tyrosine content of lenses (Dapson and Irland, 1972). After an animal has reached three days of age there is a close correlation of dried eye lens weights and age up to 23 days of age, and curves beyond that age generated by Ecodynamics (1970) show good regression analyses correlation well into adulthood.

Data collected from the field enclosures are rather incomplete since time and weather have not yet allowed sufficient sampling replications for adequate analyses and the kill-trapped animals were unable to be aged due to specimen preparation technique. A drought in the summer of 1972, which virtually stopped seed production, followed by the most severe winter in 60 years was likely the cause of death in the enclosures. When a seed-eating and caching mammal has no winter feed it cannot be expected to survive. The enclosures will be monitored on the same biannual schedule in the future, with the data being provided to the Biome when it is available.

Demographic models must, of necessity, include the influence of all environmental factors, if they are to be entirely realistic. Since a model of this extent would likely require more data, the model presented here is designed to key on some essential factors without total committment to all independent variables. In this regard, the density-dependent factors regarding predation are not included even though they undoubtedly operate. Predation is simply accounted for as discrete rates, regardless of causes for rate changes.

Figures 65 and 66 provide the maximum detail considered necessary, but may be simplified if some components are "black-boxed" further. The most reasonable condensations seem to be in "black-boxing" N_1 of Figure 65 with all components in Figure 66. This simply provides for sucklings directly from reproducing females. Another reduction might reasonably be the consolidation of subadults with adults to form reproducing males and females, although this seems to include greater risk since (D) may vary appreciably between subadult males and adult males. If these adjustments were made, Figures 65 and 66 would be modified accordingly (Figure 77). Obviously, some rather crude assumptions are made, the most questionable being that all reproducing adults and subadults die and/or are preyed upon at the same rate. The mathematical definitions of the states and rate changes are not prepared since Figure 77 is only intended to demonstrate how the model can be simplified and require less data input.

States included in Figures 65 and 66 may require an exposure of their respective reasons for being included. Generally, all available eggs are assumed to be fertilized (B), the limitations being primarily a matter of how many are available at the time of copulation. No limitations are placed on the males or viability of sperm. After implantation, there is a recognized mortality among the fetuses. Some are resorbed and assumed to be part of those that die, even though they are recycled directly back to the female. Fetuses that are aborted are often recycled directly also, but occasionally they are left dead and enter the decomposer level.

One might also question partitioning the juvenile stages. This was basically a matter of trying to accommodate early vulnerability to predation and exposure when young first leave the nest to begin foraging. Also, there is invariably a change in growth rates (Appendices 1-3) at about this same time. Subadults and adult males and females were partitioned because of the varying social positions apparently occupied by the four classes.

It seems that all of the states can vary as far as input into predation and litter and the model partitioning is based on the best logic available. Although it is possible to reduce the number of states and difference relationships, and is often necessary, further reduction will certainly reduce its realism; thus, decreasing the confidence one might have in the results. Probably the best method for reducing it would be to first implement this model to determine where change has little impact on the results. Develop it as a simulator.

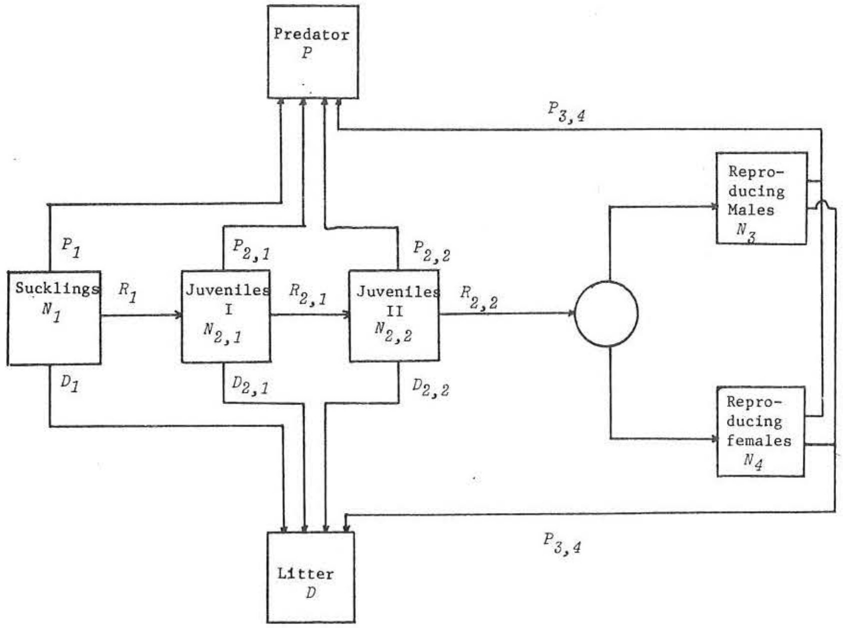

Figure 77. Modified flow diagram for aging in the demographic model.

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APPENDIX 1

Growth Data Analyses for *Dipodomys ordii*

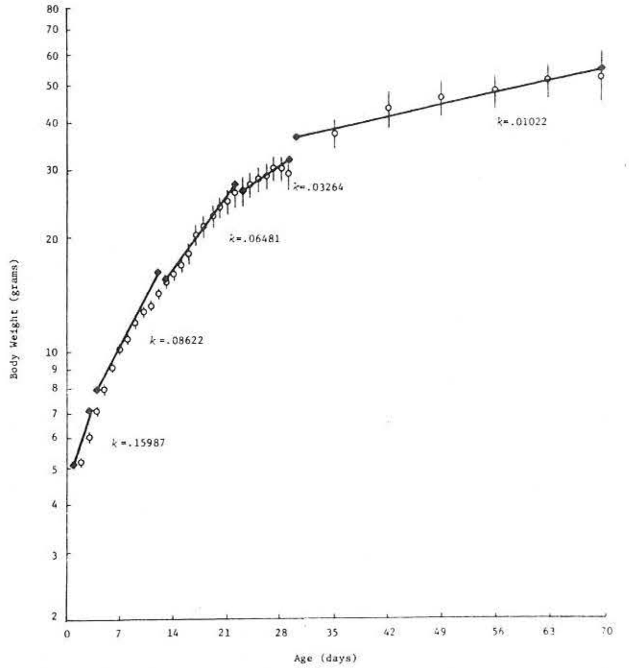

Figure 1. Means, standard errors (p=.95) and growth rates for body weight of *Dipodomys ordii* reared under standard laboratory conditions: interval 1.

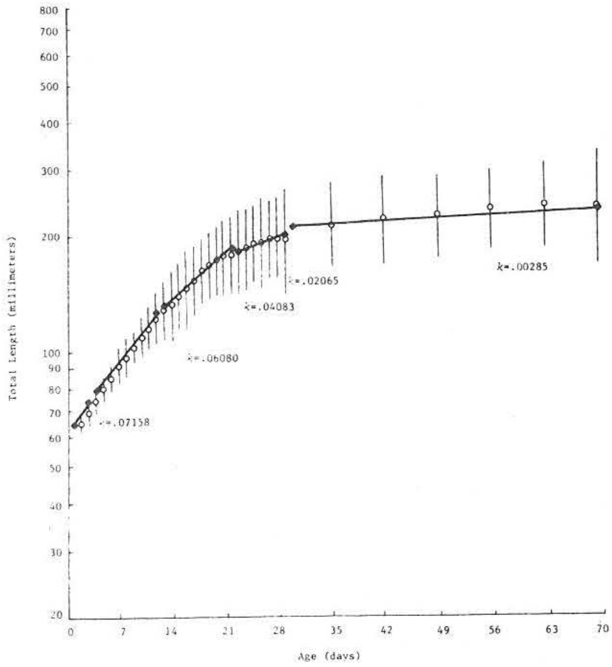

Figure 2. Means, standard errors (p=.95) and growth rates for total length of *Dipodomys ordii* reared under standard laboratory conditions: interval 1.

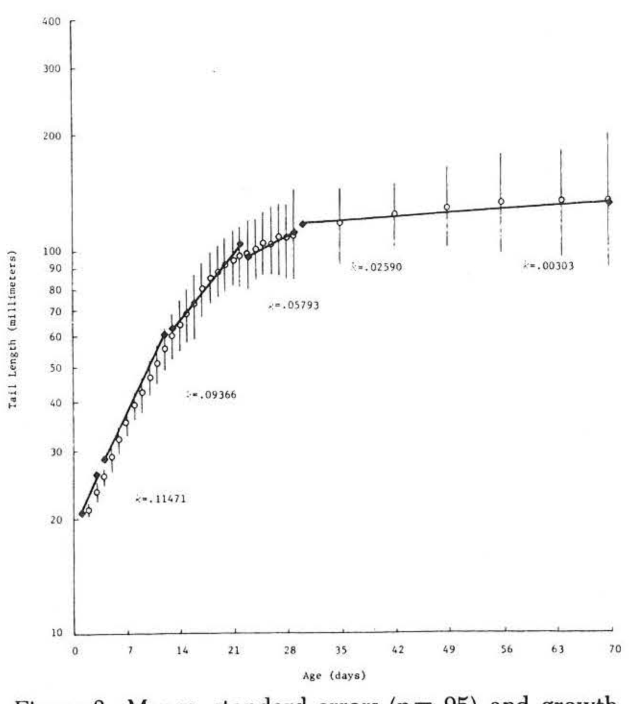

Figure 3. Means, standard errors (p=.95) and growth rates for tail length of *Dipodomys ordii* reared under standard laboratory conditions: interval 1.

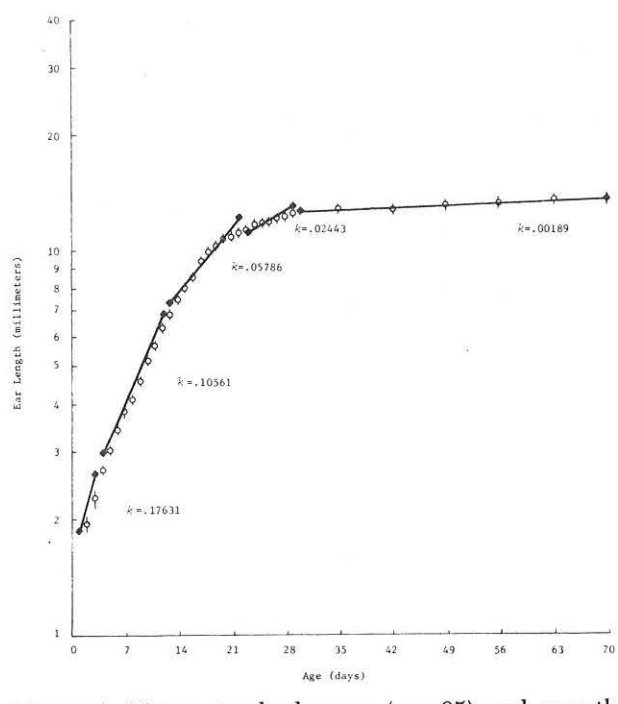

Figure 4. Means standard errors (p=.95) and growth rates for ear length of *Dipodomys ordii* reared under standard laboratory conditions: interval 1.

Appendix 1 (continued)

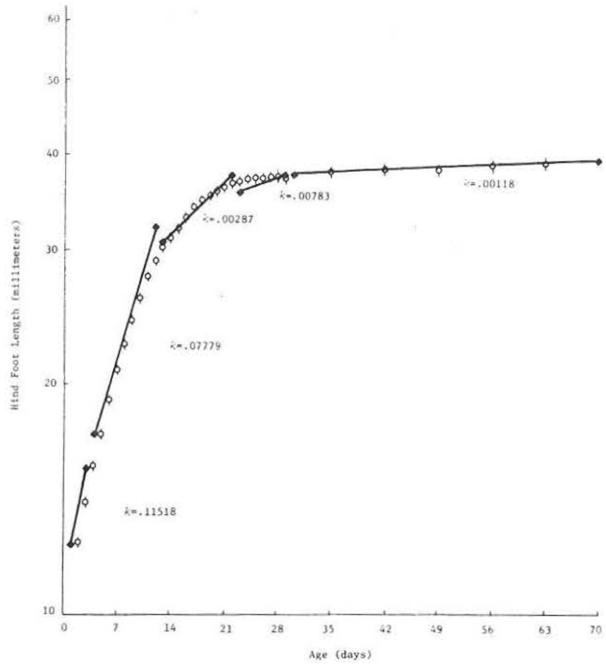

Figure 5. Means, standard errors (p=.95) and growth rates for hind foot length of *Dipodomys ordii* reared under standard laboratory conditions: interval 1.

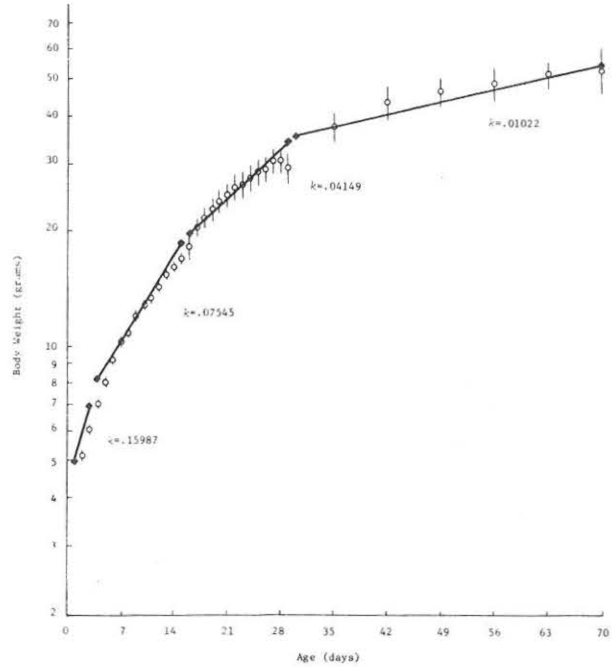

Figure 6. Means, standard errors (p=.95) and growth rates for body weight of *Dipodomys ordii* reared under standard laboratory conditions: interval 2.

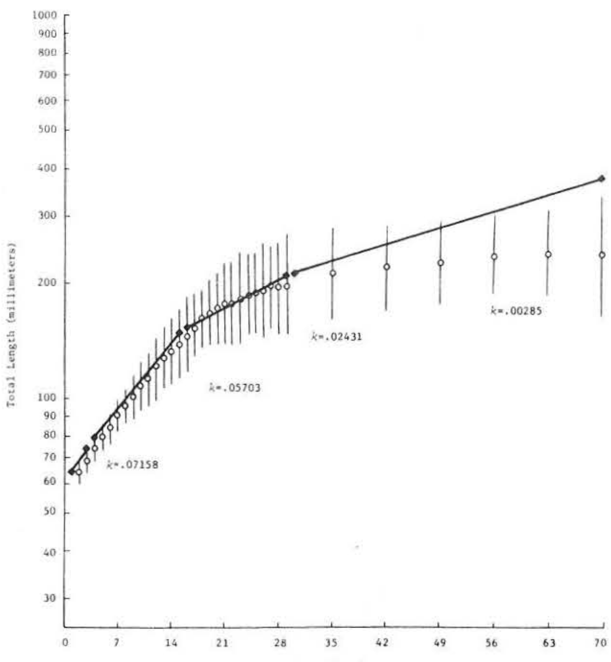

Figure 7. Means, standard errors (p=.95) and growth rates for total length of *Dipodomys ordii* reared standard laboratory conditions: interval 2.

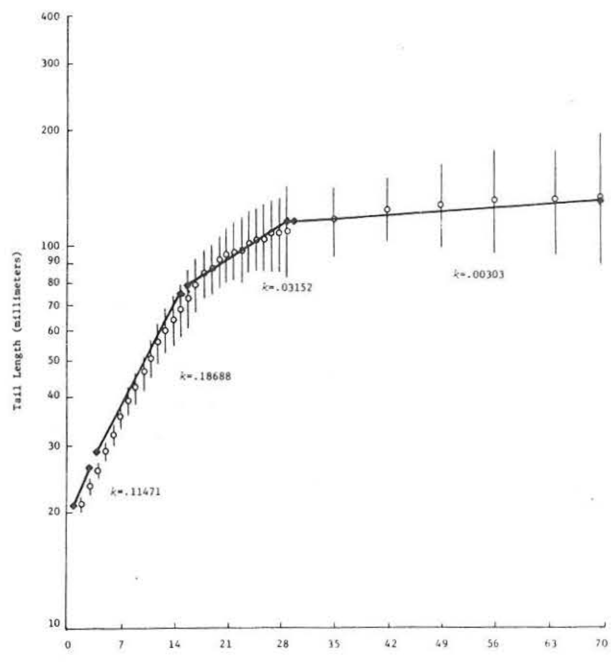

Figure 8. Means, standard errors (p=.95) and growth rates for tail length of *Dipodomys ordii* reared under standard laboratory conditions; interval 2.

Appendix 1 (continued)

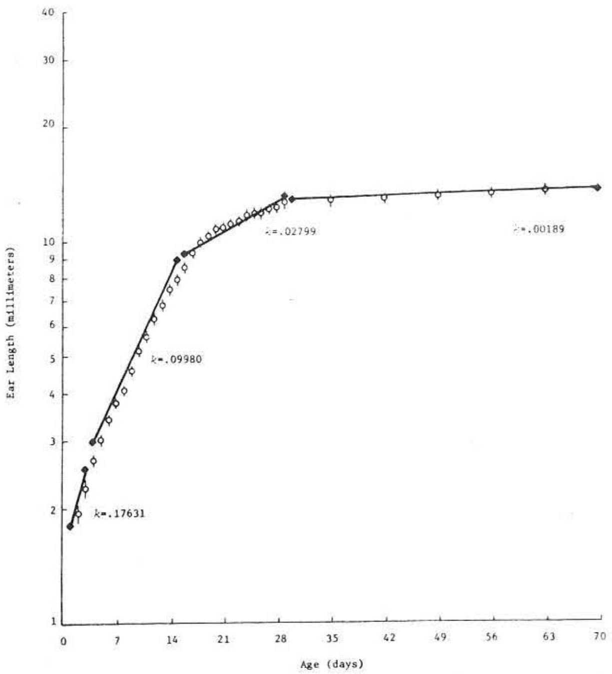

Figure 9. Means, standard errors (p=.95) and growth rates for ear length of *Dipodomys ordii* reared under standard laboratory conditions: interval 2.

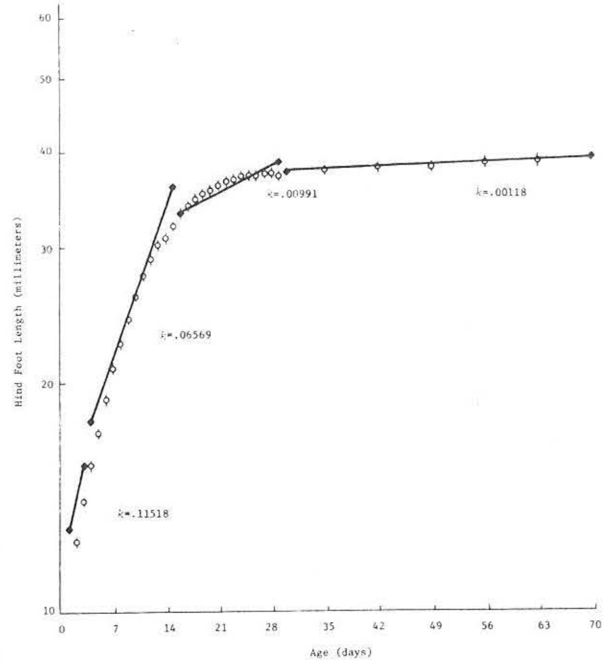

Figure 10. Means, standard errors (p=.95) and growth rates for hind foot length of *Dipodomys ordii* reared under standard laboratory conditions: interval 2.

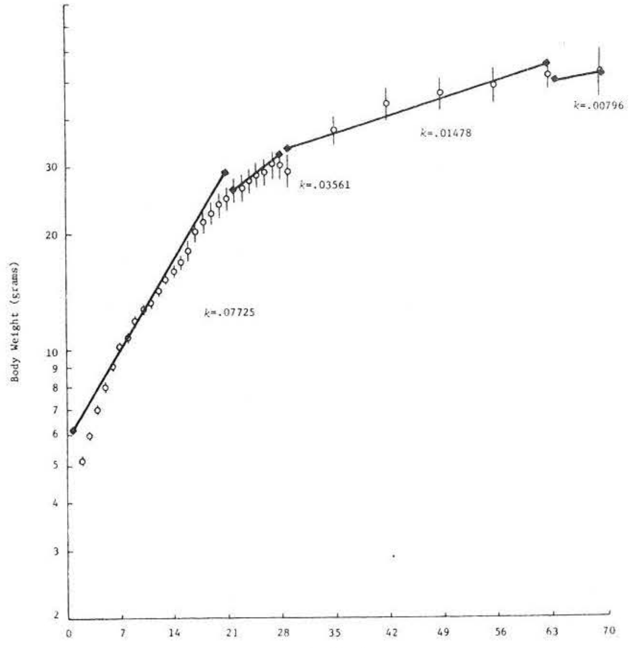

Figure 11. Means, standard errors (p=.95) and growth rates for body weight of *Dipodomys ordii* reared under standard laboratory conditions: model intervals.

Appendix 1 (continued)

Table 1. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Dipodomys ordii* reared under standard conditions: interval 1

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	1.47177	0.15987	1-3	0.25465	0.50462*
	1.74349	0.08622	4-12	0.59965	0.77437*
	1.92078	0.06481	13-22	0.46044	0.67855*
	2.54620	0.03264	23-29	0.21210	0.46054*
	3.29270	0.01022	30-70	0.60571	0.77827*
Total Length	4.09464	0.07158	1-3	0.29843	0.54628*
	4.13370	0.06080	4-12	0.74742	0.86453*
	4.36437	0.04083	13-22	0.53373	0.73056*
	4.74284	0.02065	23-29	0.25874	0.50866*
	5.27545	0.00285	30-70	0.28872	0.53732*
Tail Length	2.92560	0.11471	1-3	0.21841	0.46734*
	2.98840	0.09366	4-12	0.72368	0.85069*
	3.39927	0.05793	13-22	0.46939	0.68512*
	3.99989	0.02590	23-29	0.19206	0.43824*
	4.68195	0.00303	30-70	0.12449	0.35283*
Ear Length	0.45680	0.17631	1-3	0.23211	0.48177*
	0.67850	0.10561	4-12	0.75856	0.87095*
	1.26036	0.05786	13-22	0.63869	0.79918*
	2.87125	0.02443	23-29	0.39716	0.63020*
	2.48377	0.00189	30-70	0.20396	0.45161*
Hind Foot Length	2.40433	0.11518	1-3	0.33954	0.58270*
	2.54254	0.07779	4-12	0.78880	0.88814*
	3.14313	0.02287	13-22	0.45231	0.67253*
	3.42327	0.00783	23-29	0.23258	0.48226*
	3.59137	0.00118	30-70	0.16730	0.40902*

*significant at α=.05

Table 2. Data analyses. Means and standard errors (p=.95) for growth of *Dipodomys ordii* reared under standard laboratory conditions: interval 1

Parameter	Age in Days	Sample Size (N)	Mean $\overline{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1				
	2	56	5.1500	0.1682	
	3	57	6.0666	0.2457	7.03
	4	61	7.0770	0.3015	8.08
	5	57	8.0131	0.3429	
	6	62	9.1540	0.4084	
	7	62	10.2346	0.4628	
	8	56	10.8339	0.4595	
	9	62	12.0661	0.5507	
	10	62	12.8354	0.6160	
	11	59	13.3804	0.6113	
	12	62	14.3620	0.7054	16.12
	13	60	15.2258	0.7978	15.64
	14	60	16.0208	0.8262	
	15	60	16.9891	0.9213	
	16	58	18.1534	1.0490	
	17	53	20.2178	1.0572	
	18	52	21.6201	1.0529	
	19	52	22.7211	1.1551	
	20	48	24.0426	1.1245	
	21	42	24.9678	1.2778	
	22	48	26.0895	1.1287	27.94
	23	50	26.5329	1.3522	26.58
	24	41	27.7060	1.2515	
	25	46	28.7434	1.2595	
	26	42	29.1023	1.5062	
	27	43	30.4964	1.3308	
	28	38	30.6341	1.3890	
	29	19	29.1526	1.6334	32.14
	35	38	37.5052	1.5754	
	42	33	43.7596	1.5976	
	49	33	46.9423	1.7777	
	56	34	48.0146	1.9282	
	63	34	51.9470	1.5389	
	70	25	52.4299	2.5628	55.15
Total Length	1				
	2	56	64.5625	0.9330	
	3	57	69.3684	1.0597	74.44
	4	61	74.3115	1.1455	79.04
	5	57	79.5000	1.4427	
	6	62	84.9435	1.6953	
	7	62	91.2097	1.9486	

Table 2 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\overline{X}$	Standard Error (SE)	Antilog of lnW
	8	56	96.2679	2.4078	
	9	62	102.8226	2.4997	
	10	62	108.6935	2.8283	
	11	59	114.5424	3.1003	
	12	62	121.7016	3.2976	127.74
	13	60	128.1333	3.7032	131.63
	14	60	133.5000	4.007	
	15	60	139.1917	4.2200	
	16	58	145.4655	4.5796	
	17	53	154.7358	4.1553	
	18	52	162.2115	3.9890	
	19	52	167.1923	4.1653	
	20	48	173.0541	4.0075	
	21	42	176.9524	4.7612	
	22	48	180.1042	4.1725	188.67
	23	50	181.5200	5.4214	181.27
	24	41	186.8537	4.9669	
	25	46	191.1848	4.8028	
	26	42	192.7738	5.5506	
	27	43	197.2325	4.9699	
	28	38	197.8816	5.1878	
	29	19	197.1579	6.6640	204.38
	35	38	212.2763	5.2249	
	42	33	223.3182	4.7654	
	49	33	227.6212	4.8573	
	56	34	232.0441	4.7776	
	63	34	234.9412	5.0328	
	70	25	236.8400	6.7990	237.46
Tail Length	1				
	2	56	21.0179	0.5766	
	3	57	23.6140	0.7475	26.31
	4	61	25.8197	0.7625	28.79
	5	57	29.0789	0.9119	
	6	62	32.1048	0.9968	
	7	62	35.7339	1.1426	
	8	56	36.3036	1.5005	
	9	62	42.8145	1.6356	
	10	62	46.7581	1.9168	
	11	59	50.9407	2.2366	
	12	62	55.8952	2.4571	60.34
	13	60	59.9917	2.7131	62.80
	14	60	63.9667	2.9376	
	15	60	68.0083	3.1047	
	16	58	72.4569	3.5354	
	17	53	79.2547	3.2713	
	18	52	84.7211	3.0484	
	19	52	87.9038	3.2883	
	20	48	91.9583	3.1514	
	21	42	94.5833	3.6880	
	22	48	96.8333	3.4175	104.58
	23	50	97.4400	4.0638	96.54
	24	41	100.9878	3.9715	
	25	46	104.0000	3.8046	
	26	42	104.6786	4.2054	
	27	43	107.9186	4.1533	
	28	38	108.6447	4.4389	
	29	19	108.6316	5.5094	112.17
	35	38	117.7500	4.3064	
	42	33	124.8636	4.1876	
	49	33	127.2424	4.9671	
	56	34	131.2647	6.2342	
	63	34	132.4412	6.2934	
	70	25	133.9200	8.3100	132.95
Ear Length	1				
	2	56	1.9080	0.846	
	3	57	2.2756	0.9760	2.66
	4	61	2.6903	0.1012	3.00
	5	57	3.0307	0.1263	
	6	62	3.4098	0.1493	
	7	62	3.8298	0.1644	
	8	56	4.1841	0.1648	
	9	62	4.6706	0.1768	
	10	62	5.2142	0.1788	
	11	59	5.6679	0.2012	
	12	62	6.2766	0.2276	6.96
	13	60	6.8704	0.2702	7.39
	14	60	7.5091	0.2902	
	15	60	7.9708	0.3066	
	16	58	8.5589	0.3071	
	17	53	9.3454	0.2487	
	18	52	9.8938	0.2230	
	19	52	10.3238	0.2577	
	20	48	10.7410	0.2145	
	21	42	10.9064	0.2376	
	22	48	11.2764	0.1925	12.30
	23	50	11.3195	0.3224	11.25
	24	41	11.6861	0.3564	
	25	46	11.8649	0.2163	

Appendix 1 (continued)

Table 2 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	26	42	11.8440	0.3256	
	27	43	12.2667	0.2208	
	28	38	12.3676	0.2538	
	29	19	11.9916	0.3057	13.07
	35	38	12.8021	0.2247	
	42	33	12.9902	0.2358	
	49	33	13.2612	0.2404	
	56	34	13.4105	0.2617	
	62	34	13.5385	0.2927	
	70	25	13.6444	0.3781	13.74
Hind Foot Length	1				
	2	56	12.4585	0.2593	
	3	57	13.9899	0.3230	15.64
	4	61	15.5947	0.3860	17.29
	5	57	17.2369	0.4457	
	6	62	19.0288	0.5003	
	7	62	20.8773	0.5289	
	8	56	22.5412	0.6383	
	9	62	24.3454	0.6215	
	10	62	25.9919	0.6557	
	11	59	27.5569	0.7198	
	12	62	29.0654	0.6828	32.14
	13	60	30.0532	0.7274	30.88
	14	60	31.1656	0.6892	
	15	60	32.0184	0.6716	
	16	58	33.0058	0.6810	
	17	53	34.1152	0.5955	
	18	52	34.9978	0.5492	
	19	52	35.4180	0.422	
	20	48	35.9403	0.3395	
	21	42	36.1235	0.3665	
	22	48	36.5803	0.3333	37.71
	23	50	36.5971	0.4666	35.87
	24	41	37.1377	0.3995	
	25	46	37.1277	0.3577	
	26	42	37.3106	0.4782	
	27	43	37.5345	0.3637	
	28	38	37.6870	0.4027	
	29	19	37.2031	0.6046	37.71
	35	38	37.9357	0.3826	
	42	33	38.1863	0.4390	
	49	33	38.4466	0.4448	
	56	34	38.6617	0.4402	
	63	34	38.7896	0.4500	
	70	25	39.0019	0.5946	39.25

Table 3. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Dipodomys ordii* reared under standard laboratory conditions: interval 2

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	1.47177	0.15987	1-3	0.25465	0.50462*
	1.80782	0.07545	4-15	0.64611	0.80380*
	2.33647	0.04149	16-29	0.44996	0.67079*
	3.29270	0.01022	30-70	0.60571	0.77827*
Total Length	4.09464	0.07158	1-3	0.29843	0.54628*
	4.15655	0.05703	4-15	0.79170	0.88977*
	4.65890	0.02431	16-29	0.49748	0.70532*
	5.27545	0.00285	30-70	0.28872	0.53732*
Tail Length	2.92560	0.11471	1-3	0.21841	0.46734*
	3.02929	0.08688	4-15	0.76737	0.87597*
	3.87084	0.03152	16-29	0.40309	0.63489*
	4.68195	0.00303	30-70	0.12449	0.35283*
Ear Length	0.45680	0.17631	1-3	0.23211	0.48177*
	0.71373	0.09980	4-15	0.82902	0.91050*
	1.79442	0.02799	16-29	0.58465	0.76461*
	2.48377	0.00189	30-70	0.20396	0.45161*
Hind Foot Length	2.40433	0.11518	1-3	0.33954	0.58270*
	2.61515	0.06569	4-15	0.81333	0.90184*
	3.37601	0.00991	16-29	0.39367	0.62743*
	3.59137	0.00118	30-70	0.16730	0.40902*

*significant at α=.05

Table 4. Data analyses. Means and standard errors (p=.95) for growth of *Dipodomys ordii* reared under standard laboratory conditions: interval 2

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1				
	2	56	5.1500	0.1682	
	3	57	6.0666	0.2457	7.03
	4	61	7.0770	0.3015	8.25
	5	57	8.0131	0.3429	
	6	62	9.1540	0.4084	
	7	62	10.2346	0.4628	
	8	56	10.8339	0.4595	
	9	62	12.0661	0.5507	
	10	62	12.8354	0.6160	
	11	59	13.3804	0.6113	
	12	62	14.3620	0.7054	
	13	60	15.2258	0.7978	
	14	60	16.0208	0.8262	
	15	60	16.9891	0.9213	18.73
					19.89
	16	58	18.1534	1.0490	
	17	53	20.2178	1.0572	
	18	52	21.6201	1.0529	
	19	52	22.7211	1.1551	
	20	48	24.0426	1.1245	
	21	42	24.9678	1.2778	
	22	48	26.0895	1.1287	
	23	50	26.5329	1.3522	
	24	41	27.7060	1.2515	
	25	46	28.7434	1.2595	
	26	42	29.1023	1.5062	
	27	43	30.4964	1.3308	
	28	38	30.6341	1.3890	
	29	19	29.1526	1.6334	34.12
	35	38	37.5052	1.5754	
	42	33	43.7596	1.5976	
	49	33	46.9423	1.7777	
	56	34	48.0146	1.9282	
	63	34	51.9470	1.5389	
	70	25	52.4299	2.5628	55.15
Total Length	1				
	2	56	64.5625	0.9330	
	3	57	69.3684	1.0597	74.44
	4	61	74.3115	1.1455	79.83
	5	57	79.5000	1.4427	
	6	62	84.9435	1.6953	
	7	62	91.2097	1.9486	
	8	56	96.2679	2.4078	
	9	62	102.8226	2.4997	
	10	62	108.6935	2.8283	
	11	59	114.5424	3.1003	
	12	62	121.7016	3.2976	
	13	60	128.1333	3.7032	
	14	60	133.5000	4.007	
	15	60	139.1917	4.2200	149.90
	16	58	145.4655	4.5796	154.47
	17	53	154.7358	4.1553	
	18	52	162.2115	3.9890	
	19	52	167.1923	4.1653	
	20	48	173.0541	4.0075	
	21	42	176.9524	4.7612	
	22	48	180.1042	4.1725	
	23	50	181.5200	5.4214	
	24	41	186.8537	4.9669	
	25	46	191.1848	4.8028	
	26	42	192.7738	5.5506	
	27	43	197.2325	4.9699	
	28	38	197.8816	5.1878	210.61
	29	19	197.1579	6.6640	
	35	38	212.2763	5.2249	
	42	33	223.3182	4.7654	
	49	33	227.6212	4.8573	
	56	34	232.0441	4.7776	
	63	34	234.9412	5.0328	
	70	25	236.8400	6.7990	237.46
Tail Length	1				
	2	56	21.0179	0.5766	
	3	57	23.6140	0.7475	23.31
	4	61	25.8197	0.7625	29.08
	5	57	29.0789	0.9119	
	6	62	32.1048	0.9968	
	7	62	35.7339	1.1426	
	8	56	36.3036	1.5005	
	9	62	42.8145	1.6356	
	10	62	46.7581	1.9168	
	11	59	50.9407	2.2366	
	12	62	55.8952	2.4571	
	13	60	59.9917	2.7131	
	14	60	63.9667	2.9376	
	15	60	68.0083	3.1047	75.18

Appendix 1 (continued)

Table 4 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	16	58	72.4569	3.5354	79.04
	17	53	79.2547	3.2713	
	18	52	84.7211	3.0484	
	19	52	87.9038	3.2883	
	20	48	91.9583	3.1514	
	21	42	94.5833	3.6880	
	22	48	96.8333	3.4175	
	23	50	97.4400	4.0638	
	24	41	100.9878	3.9715	
	25	46	104.0000	3.8046	
	26	42	104.6786	4.2054	
	27	43	107.9186	4.1533	
	28	38	108.6447	4.4389	
	29	19	108.6316	5.5094	117.92
	35	38	117.7500	4.3064	
	42	33	124.8636	4.1876	
	49	33	127.2424	4.9671	
	56	34	131.2647	6.2342	
	63	34	132.4412	6.2934	
	70	25	133.9200	8.3100	132.95
Ear Length	1				
	2	56	1.9080	0.846	
	3	57	2.2756	0.9760	2.66
	4	61	2.6903	0.1012	3.03
	5	57	3.0307	0.1263	
	6	62	3.4098	0.1493	
	7	62	3.8298	0.1644	
	8	56	4.1841	0.1648	
	9	62	4.6706	0.1768	
	10	62	5.2142	0.1788	
	11	59	5.6679	0.2012	
	12	62	6.2766	0.2276	
	13	60	6.8704	0.2702	
	14	60	7.5091	0.2902	
	15	60	7.9708	0.3066	9.03
	16	58	8.5589	0.3071	9.30
	17	53	9.3454	0.2487	
	18	52	9.8938	0.2230	
	19	57	10.3238	0.2577	
	20	48	10.7410	0.2145	
	21	42	10.9064	0.2376	
	22	48	11.2764	0.1925	
	23	50	11.3195	0.3224	
	24	41	11.6861	0.3564	
	25	46	11.8649	0.2163	
	26	42	11.8440	0.3256	
	27	43	12.2667	0.2208	
	28	38	12.3676	0.2538	
	29	19	11.9916	0.3057	13.20
	35	38	12.8021	0.2247	
	42	33	12.9902	0.2358	
	49	33	13.2612	0.2404	
	56	34	13.4105	0.2617	
	63	34	13.5385	0.2927	
	70	25	13.6444	0.3781	13.73
Hind Foot Length	1				
	2	56	12.4585	0.2593	
	3	57	13.9899	0.3230	16.64
	4	61	15.5947	0.3860	17.81
	5	57	17.2369	0.4457	
	6	62	19.0288	0.5003	
	7	62	20.8773	0.5289	
	8	56	22.5412	0.6383	
	9	62	24.3454	0.6215	
	10	62	25.9919	0.6557	
	11	59	27.5569	0.7198	
	12	62	29.0654	0.6828	
	13	60	30.0532	0.7274	
	14	60	31.1656	0.6892	
	15	60	32.0184	0.6716	36.23
	16	58	33.0058	0.6810	33.45
	17	53	34.1152	0.5955	
	18	52	34.9978	0.5492	
	19	52	35.4180	0.422	
	20	48	35.9403	0.3395	
	21	42	36.1235	0.3665	
	22	48	36.5803	0.3333	
	23	50	36.5971	0.4666	
	24	41	37.1377	0.3995	
	25	46	37.1277	0.3577	
	26	42	37.3106	0.4782	
	27	43	37.5345	0.3637	
	28	38	37.6870	0.4027	
	29	19	37.2031	0.6046	38.86
	35	38	37.9357	0.3826	
	42	33	38.1863	0.4390	
	49	33	38.4466	0.4448	
	56	34	38.6617	0.4402	
	63	34	38.7896	0.4500	
	70	25	39.0019	0.5946	39.24

Table 5. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Dipodomys ordii* reared under standard laboratory conditions: model intervals

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	1.75239	0.07725	1-21	0.82394	0.90771*
	2.48434	0.03561	22-28	0.23709	0.48691*
	3.08276	0.01478	29-63	0.65483	0.80921*
	3.40514	0.00796	64-70	0.14477	0.38048*
Total Length	4.16814	0.05383	1-21	0.89860	0.94794*
	4.72811	0.02146	22-28	0.27076	0.52034*
	5.20556	0.00435	29-63	0.36751	0.60622*
	5.36766	0.00138	64-70	0.01398	0.11823
Tail Length	3.05487	0.08071	1-21	0.88008	0.93812*
	3.99497	0.02635	22-28	0.19289	0.43919*
	4.59668	0.00488	29-63	0.19396	0.44040*
	4.85215	0.00044	64-70	0.00042	0.02049
Ear Length	0.72929	0.09263	1-21	0.90898	0.95392*
	1.86481	0.02513	22-28	0.42248	0.64998*
	2.43829	0.00285	29-63	0.26038	0.51027*
	2.56189	0.00072	64-70	0.00629	0.07930
Hind Foot Length	2.64816	0.05570	1-21	0.85808	0.92632*
	3.41655	0.00826	22-28	0.25864	0.50856*
	3.59649	0.00104	29-63	0.12620	0.35524*
	3.34265	0.00460	64-70	0.18084	0.42525*

*significant at α=.05

Table 6. Data analyses. Means and standard errors (p=.95) for growth in body weight of *Dipodomys ordii* reared under standard laboratory conditions: model intervals

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
Body Weight	1				6.22
	2	56	5.1500	0.1682	
	3	57	6.0666	0.2457	
	4	61	7.0770	0.3015	
	5	57	8.0131	0.3429	
	6	62	9.1540	0.4084	
	7	62	10.2346	0.4628	
	8	56	10.8339	0.4595	
	9	62	12.0661	0.5507	
	10	62	12.8354	0.6160	
	11	59	13.3804	0.6113	
	12	62	14.3620	0.7054	
	13	60	15.2258	0.7978	
	14	60	16.0208	0.8262	
	15	60	16.9891	0.9213	
	16	58	18.1534	1.0490	
	17	53	20.2178	1.0572	
	18	52	21.6201	1.0529	
	19	52	22.7211	1.1551	
	20	48	24.0426	1.1245	
	21	42	24.9678	1.2778	29.19
	22	48	26.0895	1.1287	26.23
	23	50	26.5329	1.3522	
	24	41	27.7060	1.2515	
	25	46	28.7434	1.2595	
	26	42	29.1023	1.5062	
	27	43	30.4964	1.3308	
	28	38	30.6341	1.3890	32.49
	29	19	29.1526	1.6334	33.49
	35	38	37.5052	1.5754	
	42	33	43.7596	1.5976	
	49	33	46.9423	1.7777	
	56	34	48.0146	1.9282	
	63	34	51.9470	1.5389	55.31
	70	25	52.4299	2.5628	52.56

APPENDIX 2

Growth Data Analyses for *Peromyscus maniculatus*

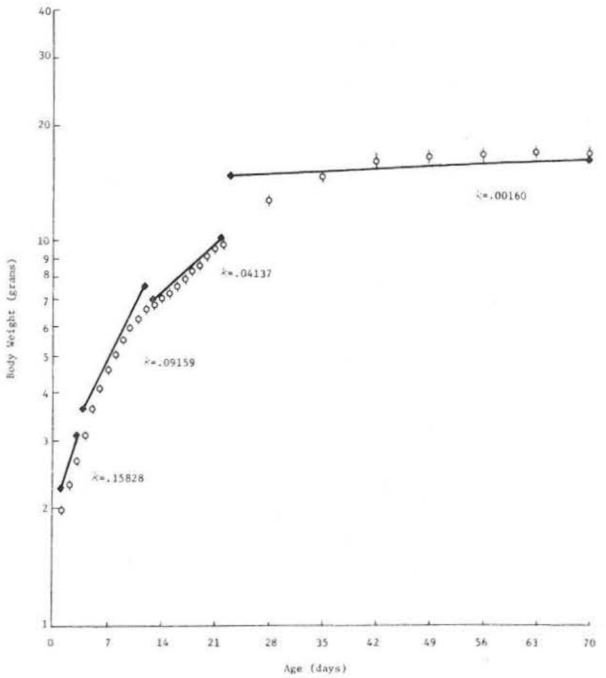

Figure 12. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions.

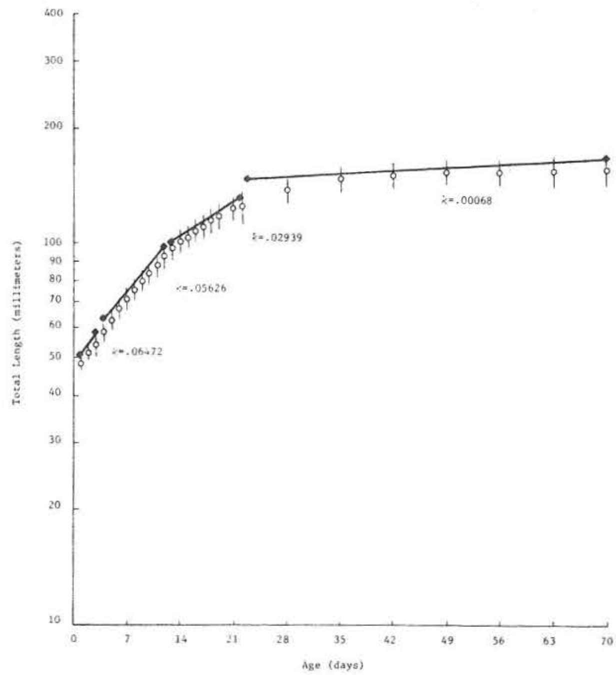

Figure 13. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions.

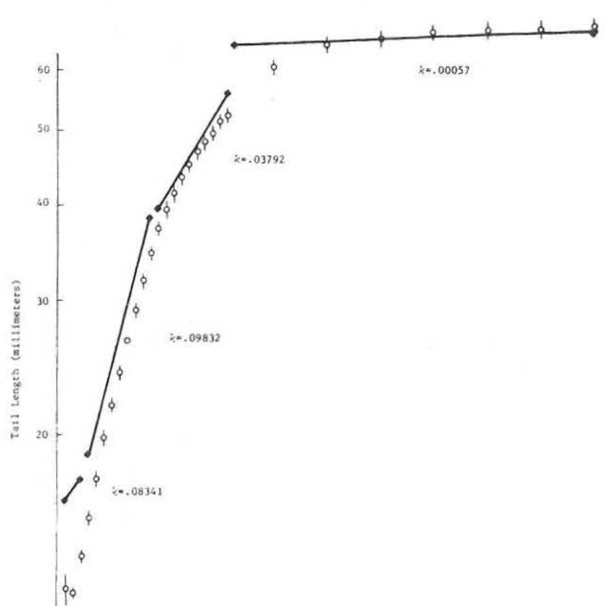

Figure 14. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions.

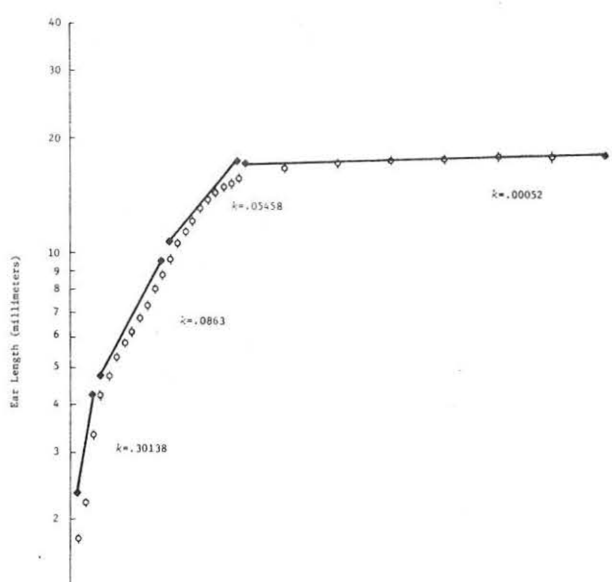

Figure 15. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions.

Appendix 2 (continued)

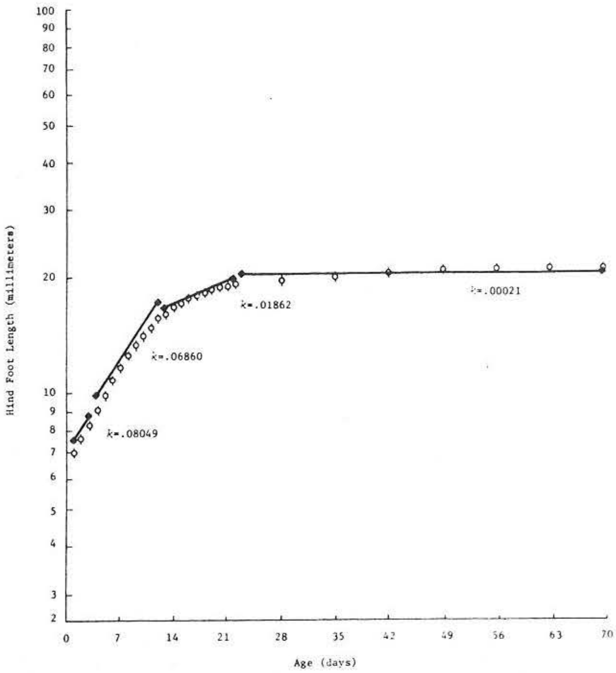

Figure 16. Means, standard errors (p=.95) and growth rates for hind foot length of *Peromyscus maniculatus* reared under standard laboratory conditions.

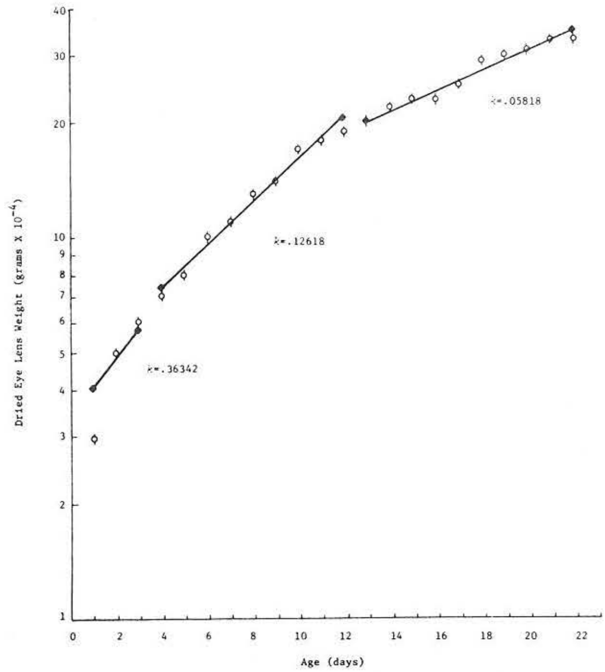

Figure 17. Means, standard errors (p=.95) and growth rates for dried eye lens weight of *Peromyscus maniculatus* reared under standard laboratory conditions.

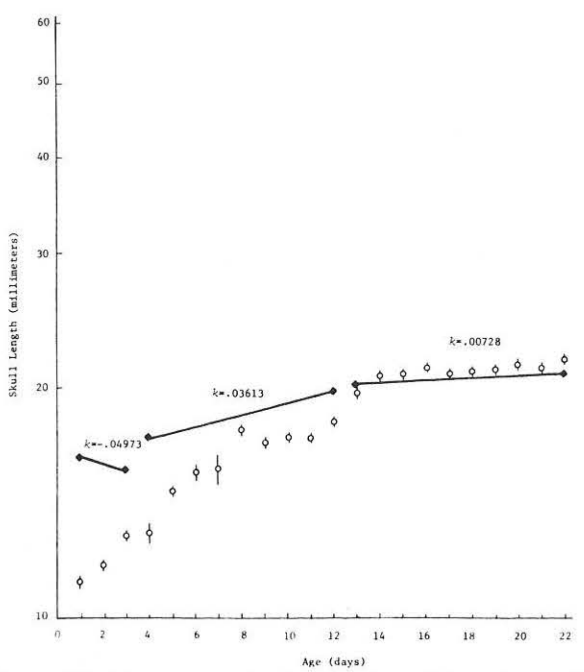

Figure 18. Means, standard errors (p=.95) and growth rates for skull length of *Peromyscus maniculatus* reared under standard laboratory conditions.

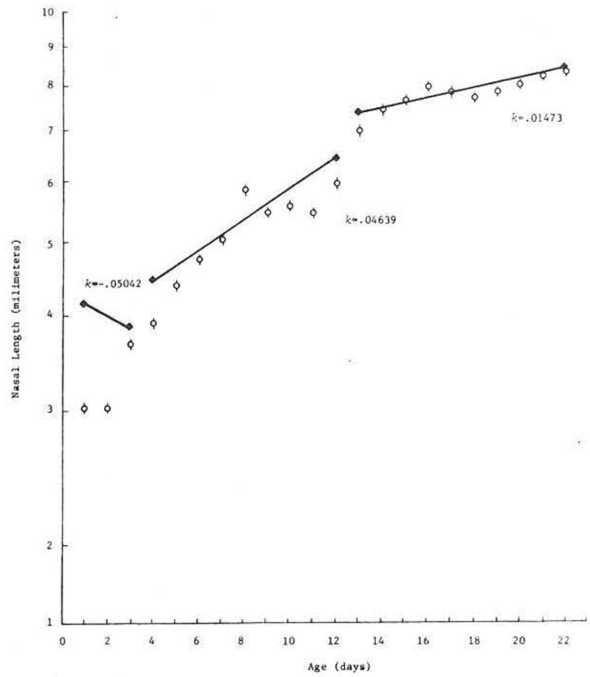

Figure 19. Means, standard errors (p=.95) and growth rates for nasal length of *Peromyscus maniculatus* reared under standard laboratory conditions.

Appendix 2 (continued)

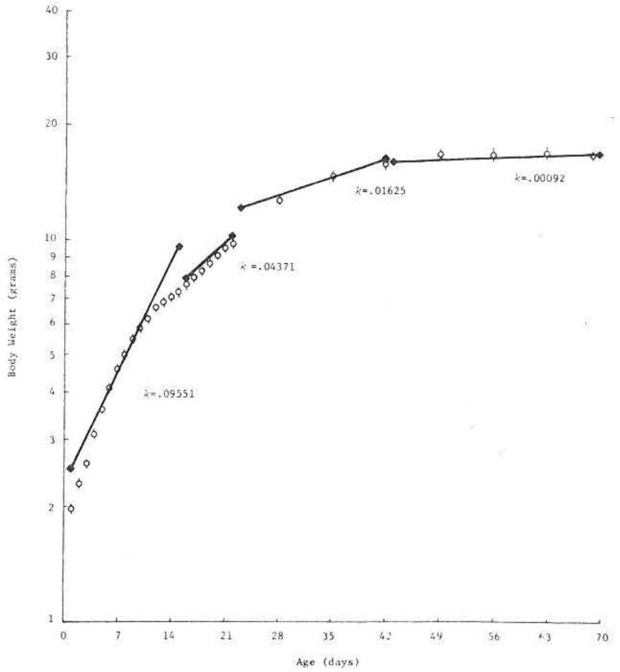

Figure 20. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions: model intervals.

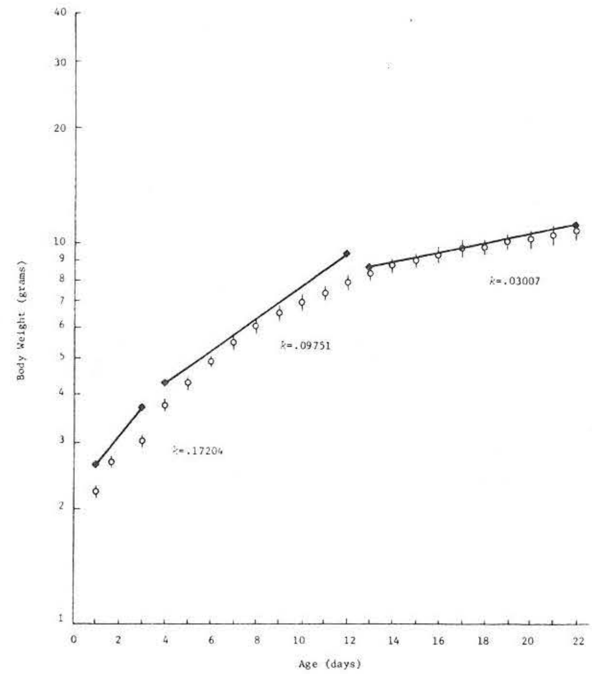

Figure 21. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark.

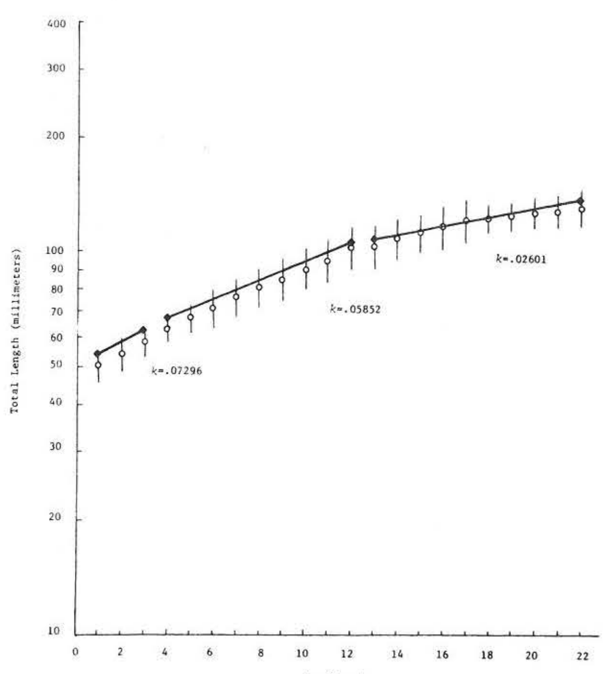

Figure 22. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark.

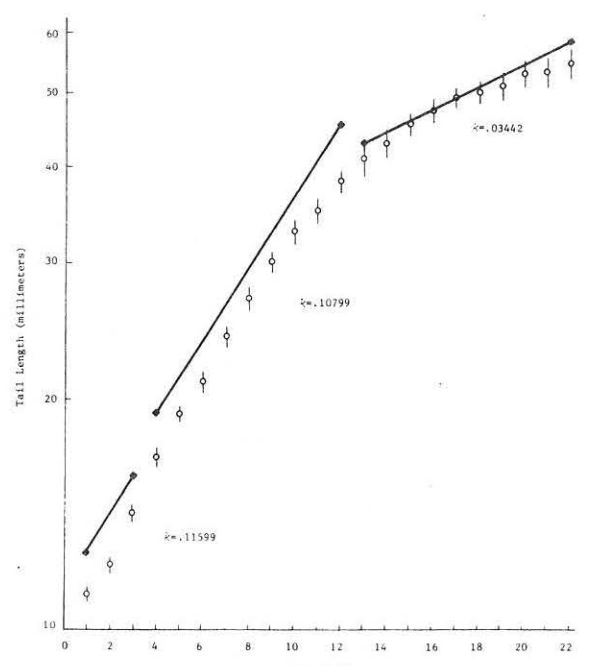

Figure 23. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark.

Appendix 2 (continued)

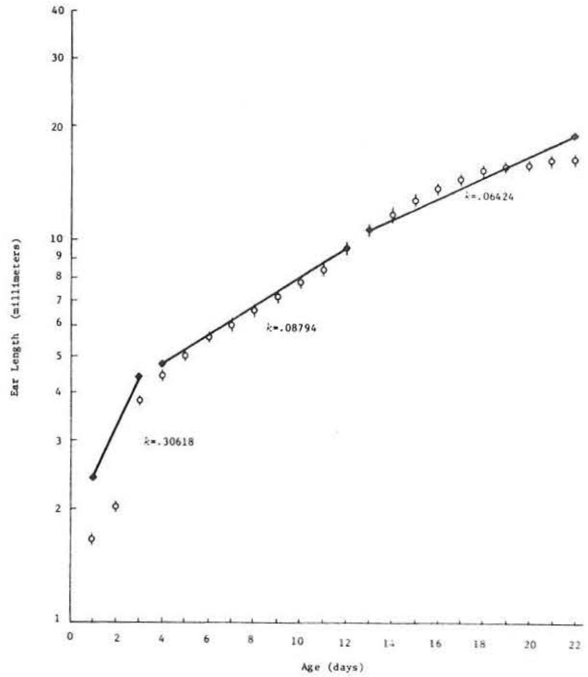

Figure 24. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark.

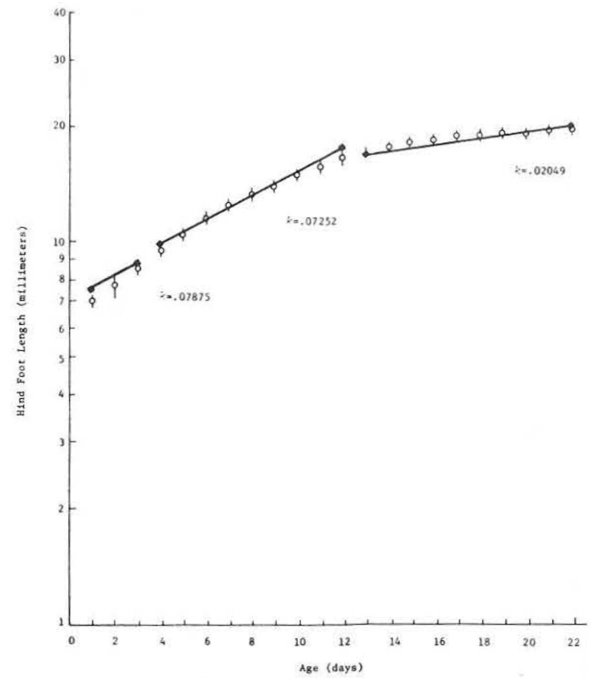

Figure 25. Means, standard errors (p=.95) and growth rates for hind foot length of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark.

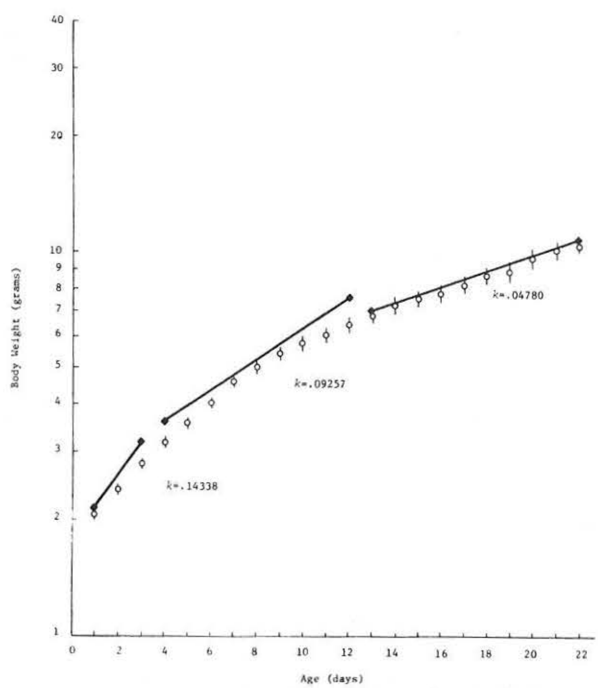

Figure 26. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark.

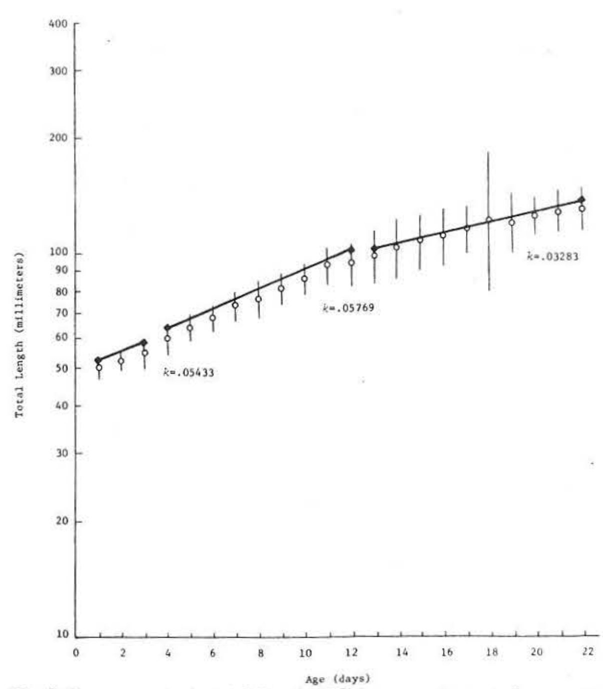

Figure 27. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark.

Appendix 2 (continued)

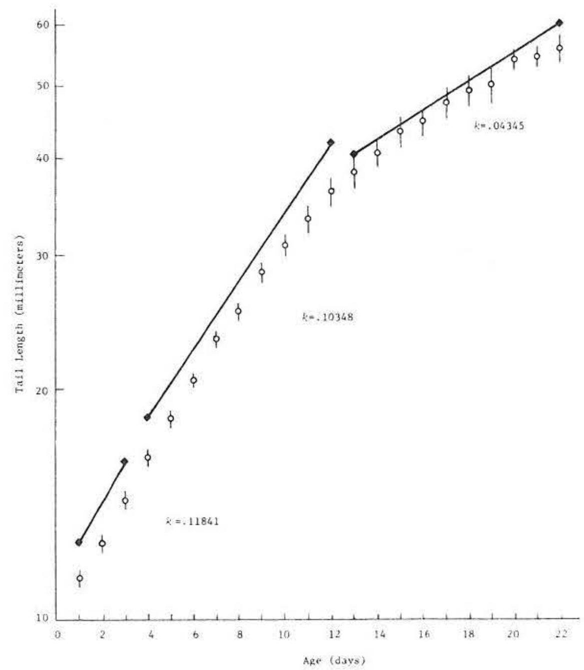

Figure 28. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark.

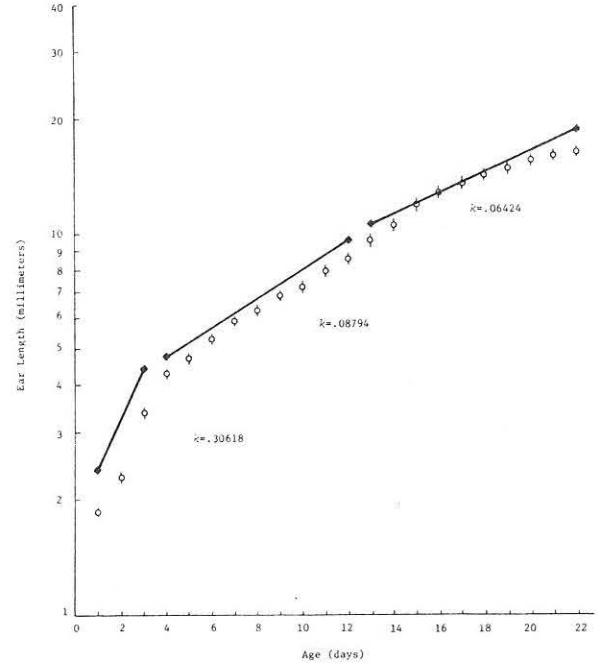

Figure 29. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark.

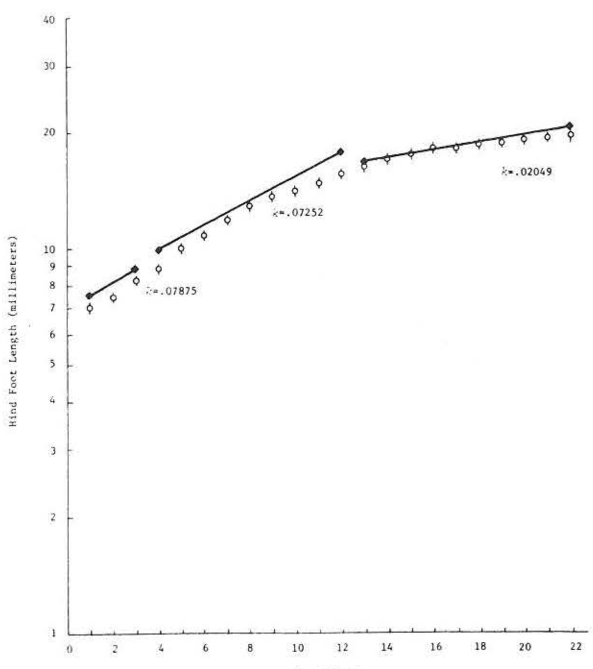

Figure 30. Means, standard errors (p=.95) and growth rates for hind foot length of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark.

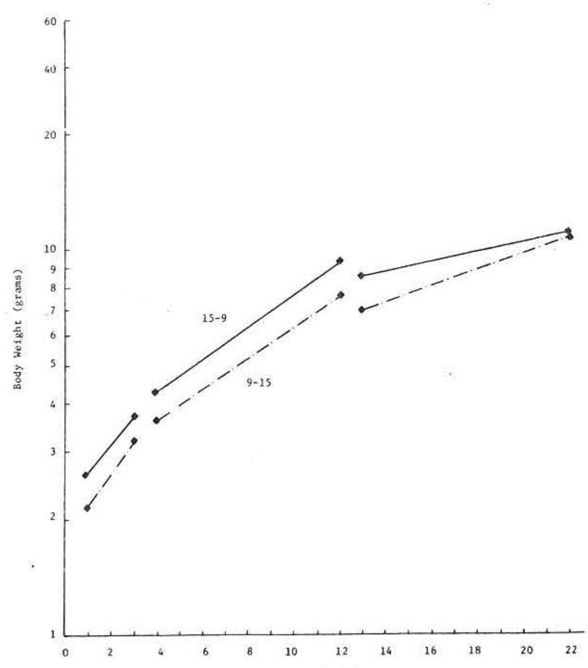

Figure 31. Comparison of growth rates for body weight of *Peromyscus maniculatus* reared under photoperiods of 15 hr light, 9 hr dark and 9 hr light, 15 hr dark.

Appendix 2 (continued)

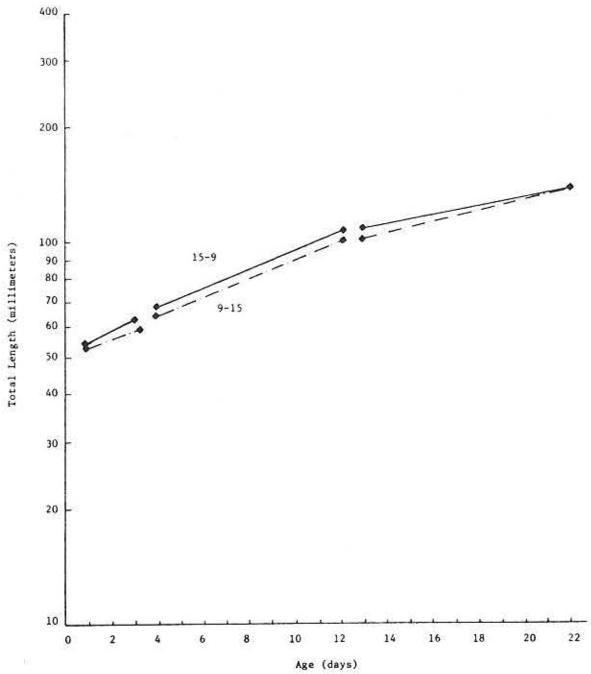

Figure 32. Comparisons of growth rates for total length of *Peromyscus maniculatus* reared under photoperiods of 15 hr light, 9 hr dark and 9 hr light, 15 hr dark.

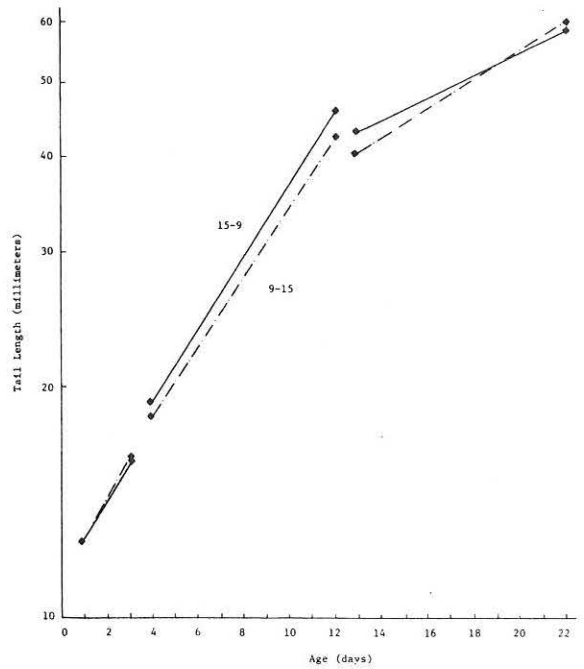

Figure 33. Comparison of growth rates for tail length of *Peromyscus maniculatus* reared under photoperiods of 15 hr light, 9 hr dark and 9 hr light, 15 hr dark.

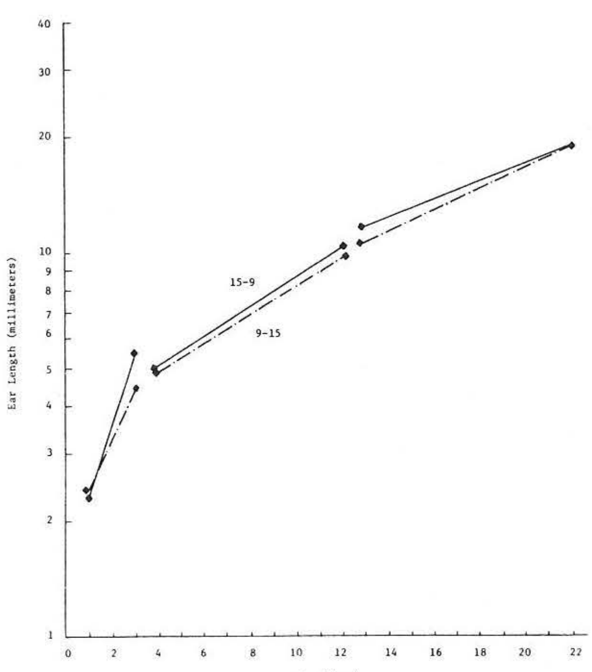

Figure 34. Comparison of growth rates for ear length of *Peromyscus maniculatus* reared under photoperiods of 15 hr light, 9 hr dark and 9 hr light, 15 hr dark.

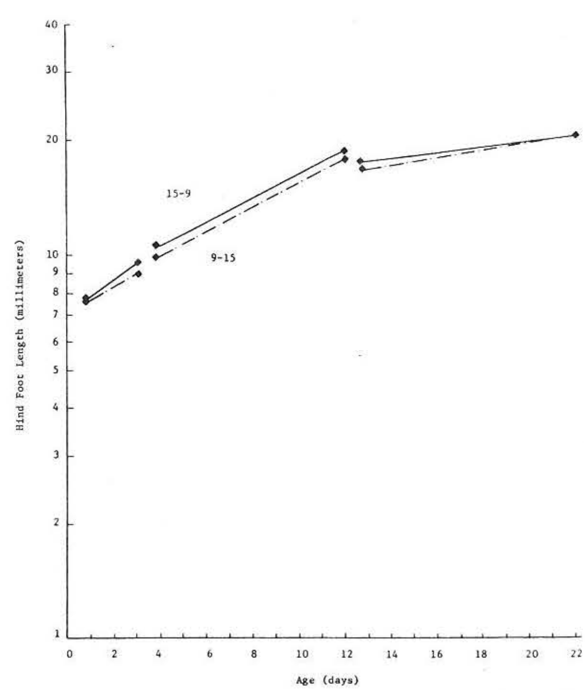

Figure 35. Comparison of growth rates for hind foot length of *Peromyscus maniculatus* reared under photoperiods of 15 hr light, 9 hr dark and 9 hr light, 15 hr dark.

Appendix 2 (continued)

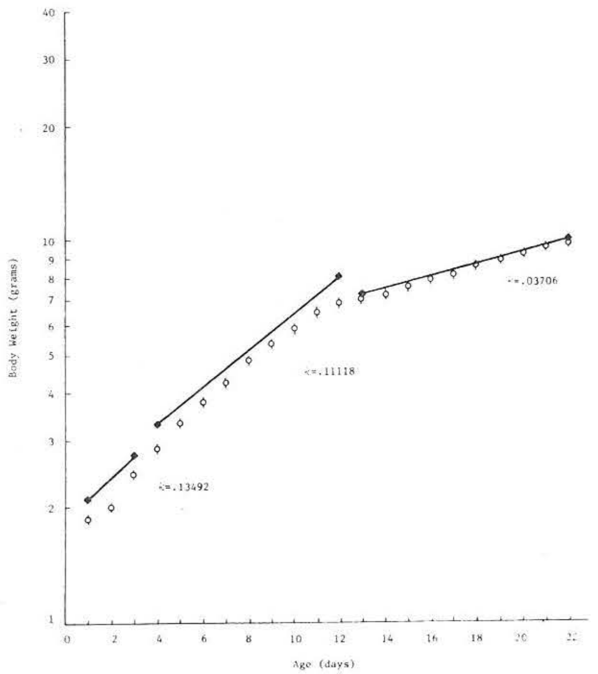

Figure 36. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions, 15 C.

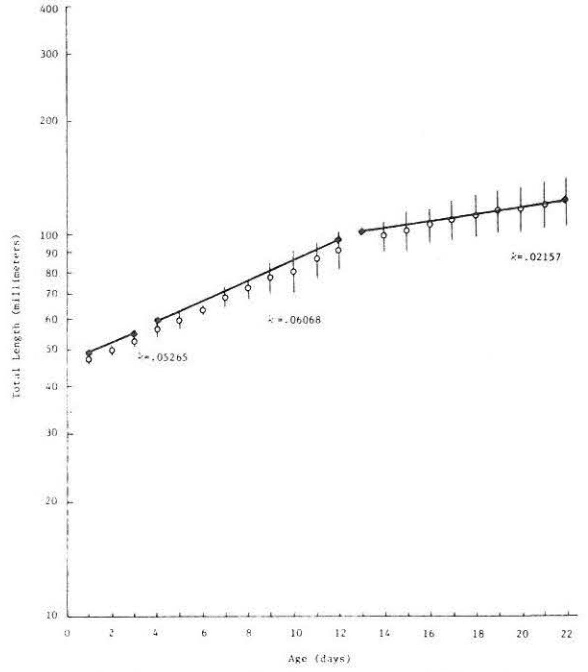

Figure 37. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions, 15 C.

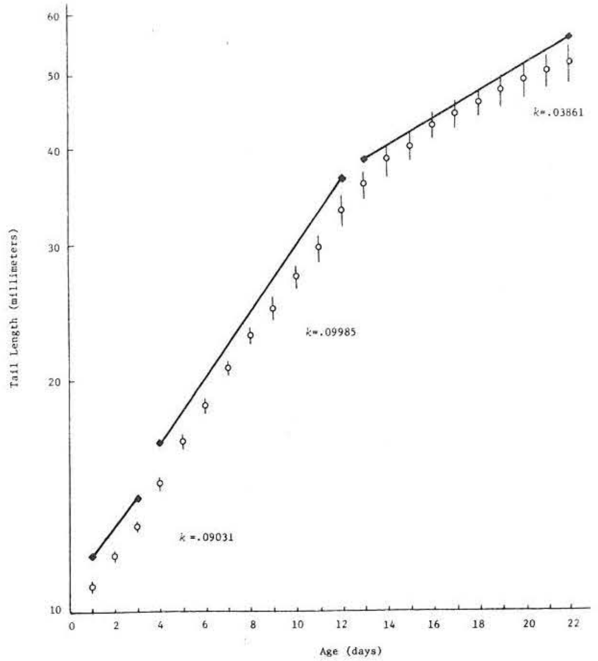

Figure 38. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions, 15 C.

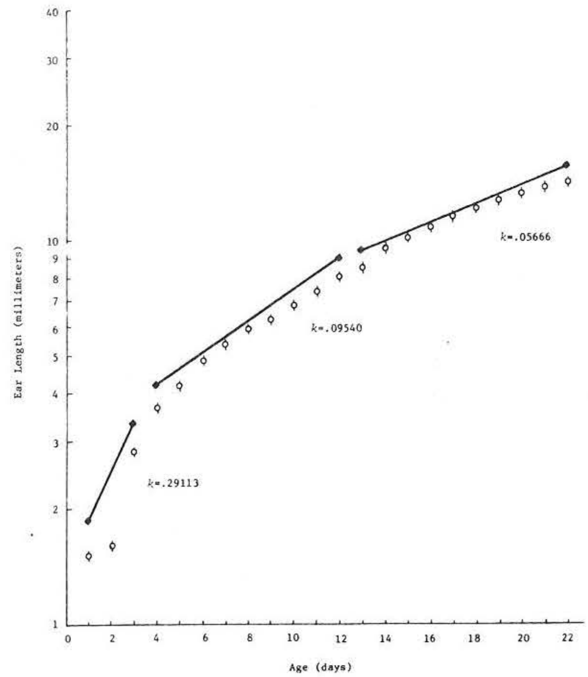

Figure 39. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions, 15 C.

Appendix 2 (continued)

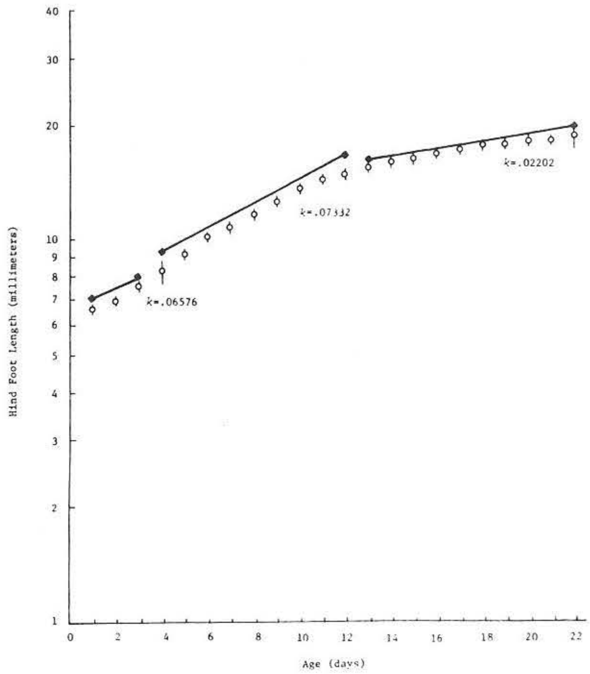

Figure 40. Means, standard errors (p=.95) and growth rates for hind foot length of *Peromyscus maniculatus* reared under standard laboratory conditions, 15 C.

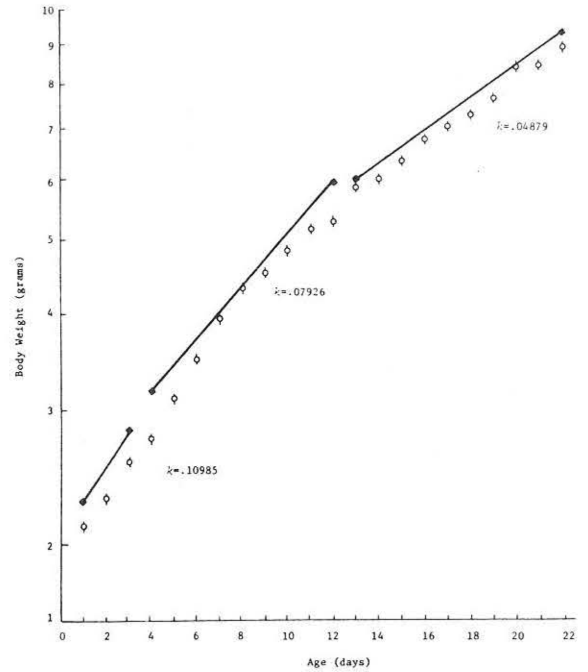

Figure 41. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions, 30 C.

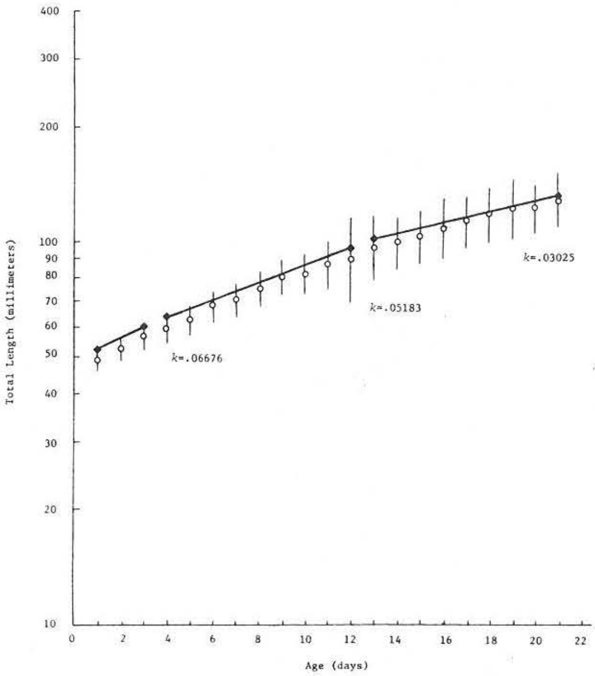

Figure 42. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions, 30 C

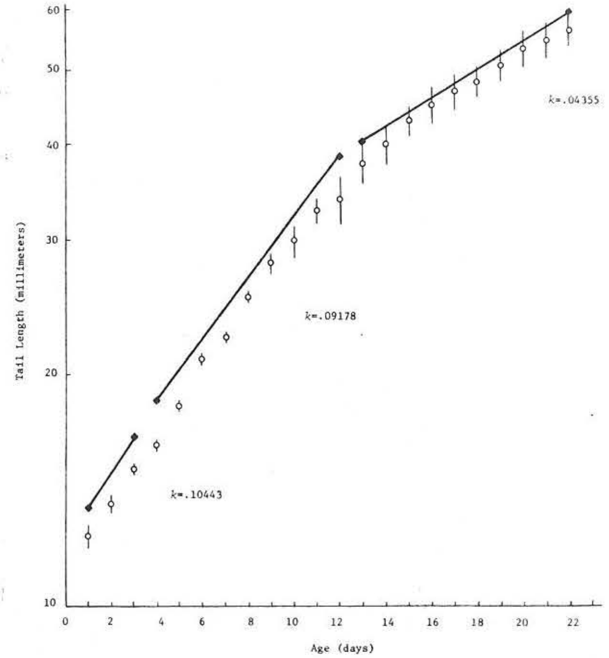

Figure 43. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions, 30 C.

Appendix 2 (continued)

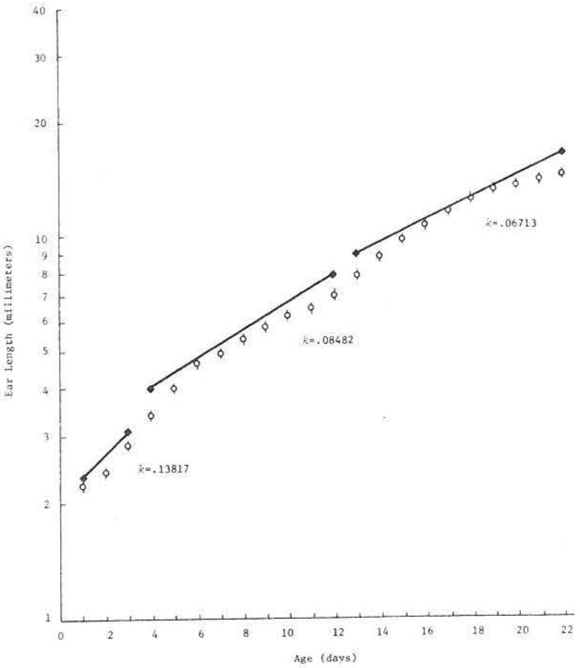

Figure 44. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions, 30 C.

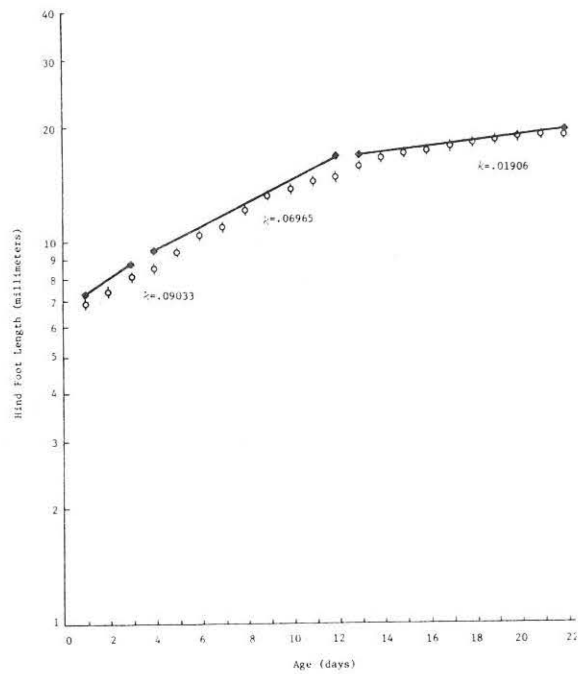

Figure 45. Means, standard errors (p=.95) and growth rates for hind foot of *Peromyscus maniculatus* reared under standard laboratory conditions, 30 C.

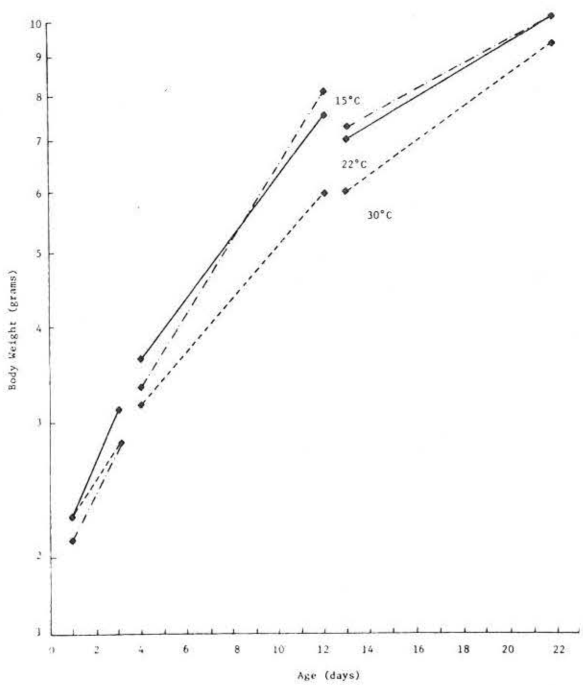

Figure 46. Comparison of growth rates for body weight of *Peromyscus maniculatus* reared at 15, 22 and 30 C.

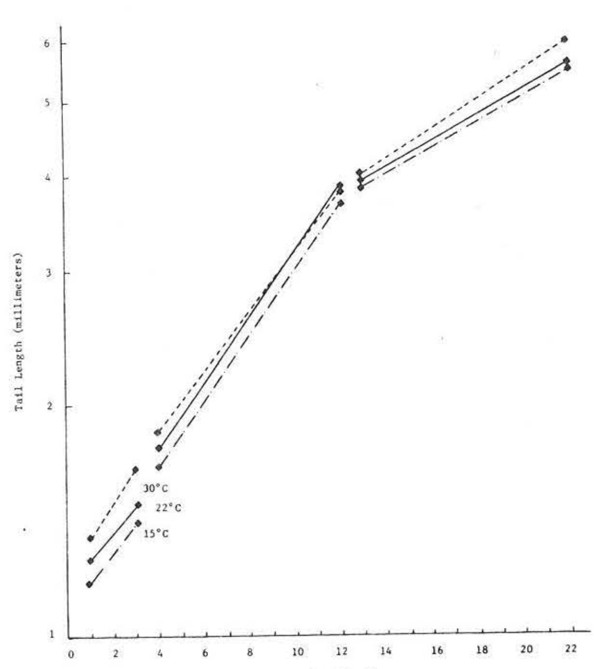

Figure 47. Comparison of growth rates for tail length of *Peromyscus maniculatus* reared at 15, 22 and 30 C.

Appendix 2 (continued)

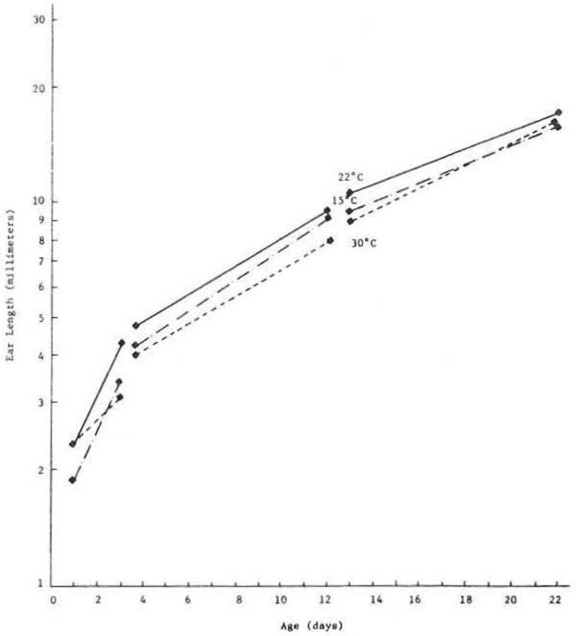

Figure 48. Comparison of growth rates for ear length of *Peromyscus maniculatus* reared at 15, 22 and 30 C.

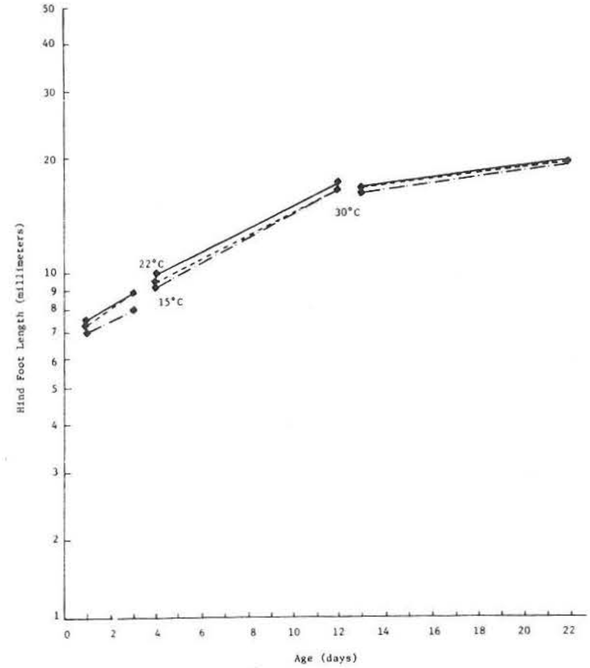

Figure 49. Comparison of growth rates for hind foot length of *Peromyscus maniculatus* reared at 15, 22 and 30 C.

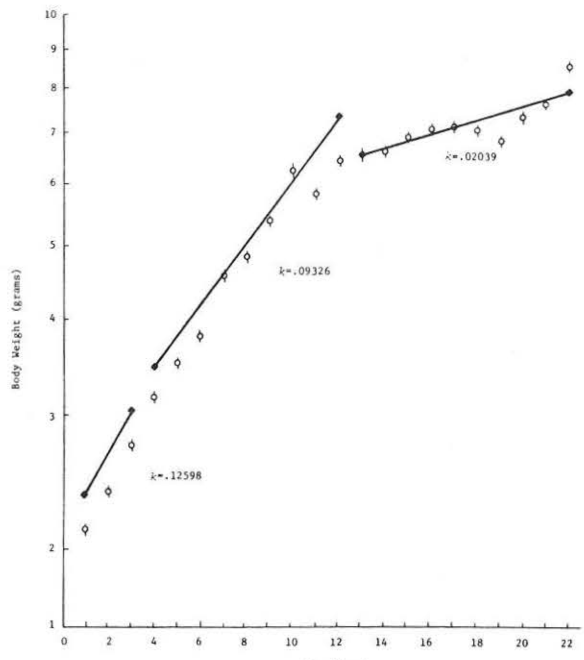

Figure 50. Means, standard errors (p=.95) and growth rates for body weight of *Peromyscus maniculatus* reared under standard laboratory conditions, fed 8 g/day.

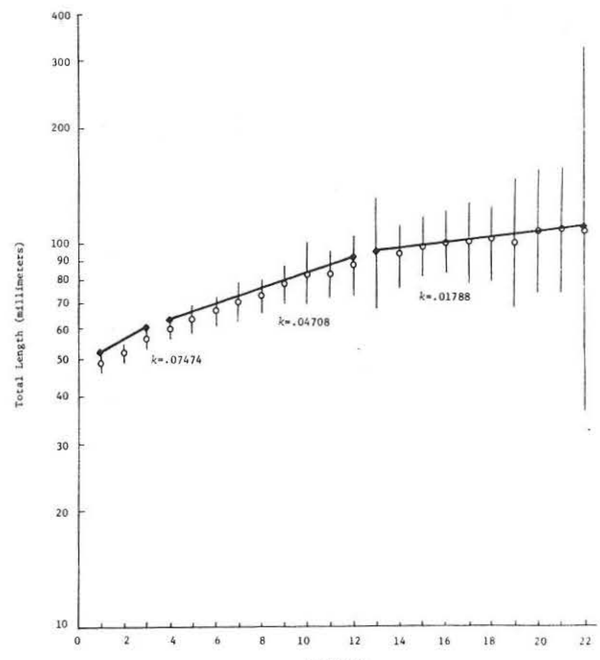

Figure 51. Means, standard errors (p=.95) and growth rates for total length of *Peromyscus maniculatus* reared under standard laboratory conditions, fed 8 g/day.

Appendix 2 (continued)

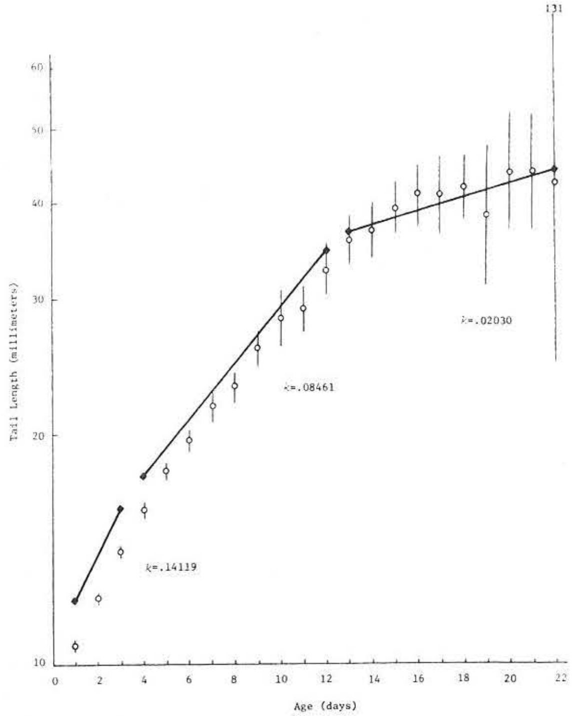

Figure 52. Means, standard errors (p=.95) and growth rates for tail length of *Peromyscus maniculatus* reared under standard laboratory conditions, fed 8 g/day.

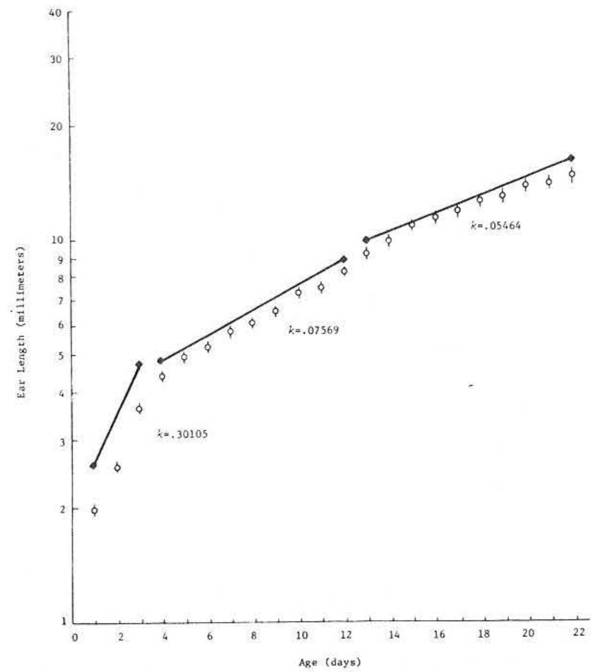

Figure 53. Means, standard errors (p=.95) and growth rates for ear length of *Peromyscus maniculatus* reared under standard laboratory conditions, fed 8 g/day.

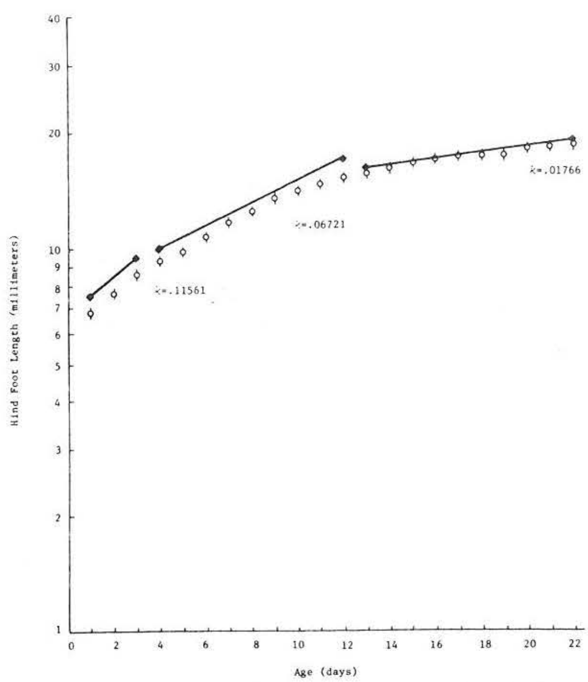

Figure 54. Means, standard errors (p=.95) and growth rates for hind foot length of *Peromyscus maniculatus* reared under standard laboratory conditions, fed 8 g/day.

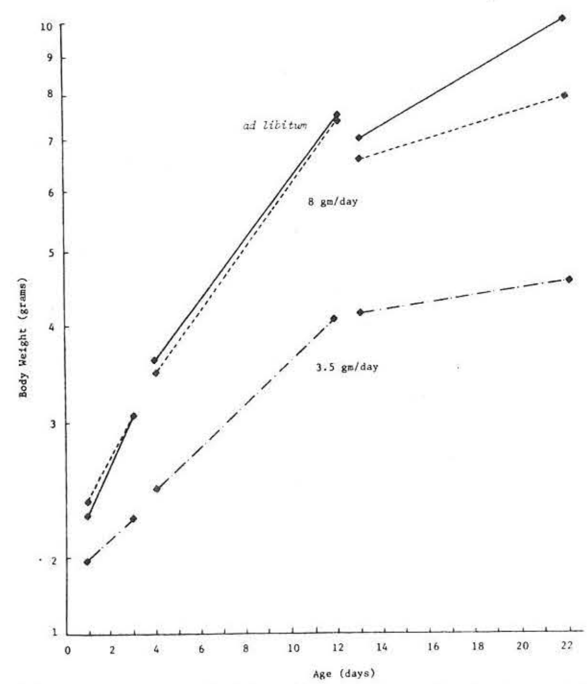

Figure 55. Comparison of growth rates for body weight of *Peromyscus maniculatus* fed *ad libitum*, 8 g/day and 3.5 g/day.

Appendix 2 (continued)

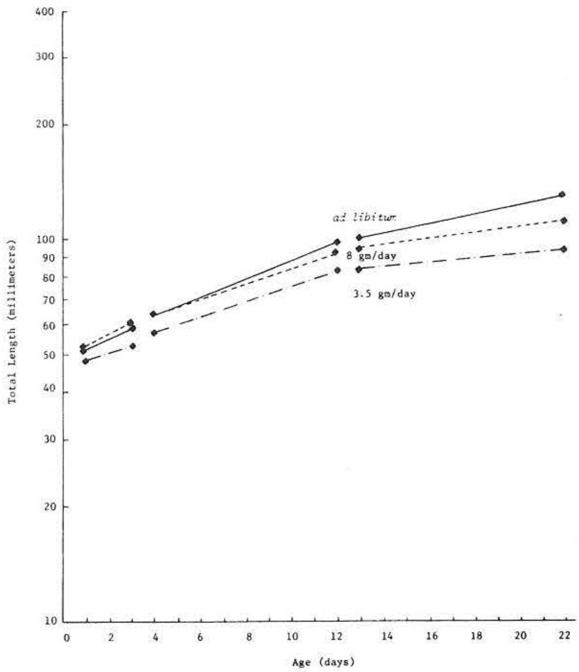

Figure 56. Comparison of growth rates for total length of *Peromyscus maniculatus* fed *ad libitum*, 8 g/day and 3.5 g/day.

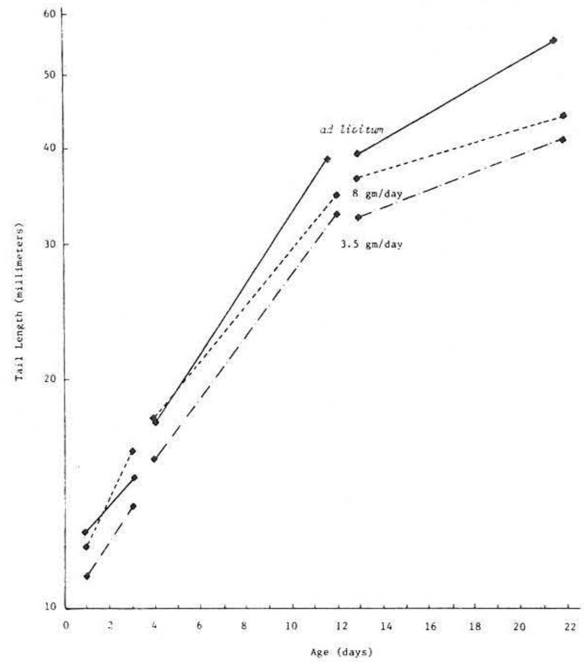

Figure 57. Comparison of growth rates for tail length of *Peromyscus maniculatus* fed *ad libitum*, 8 g/day and 3.5 g/day.

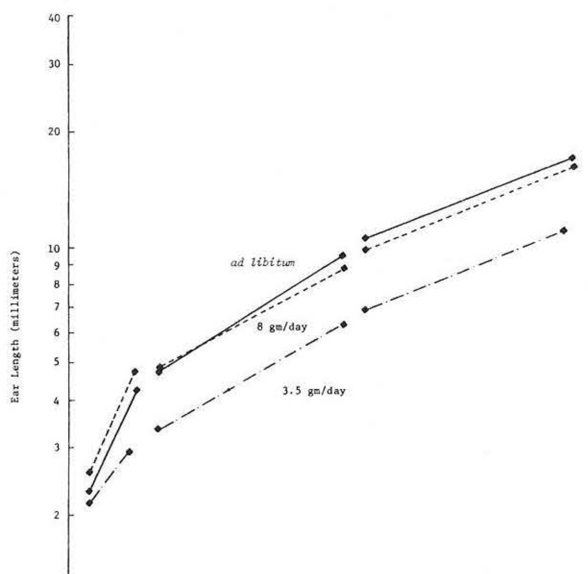

Figure 58. Comparison of growth rates for ear length of *Peromyscus maniculatus* fed *ad libitum*, 8 g/day and 3.5 g/day.

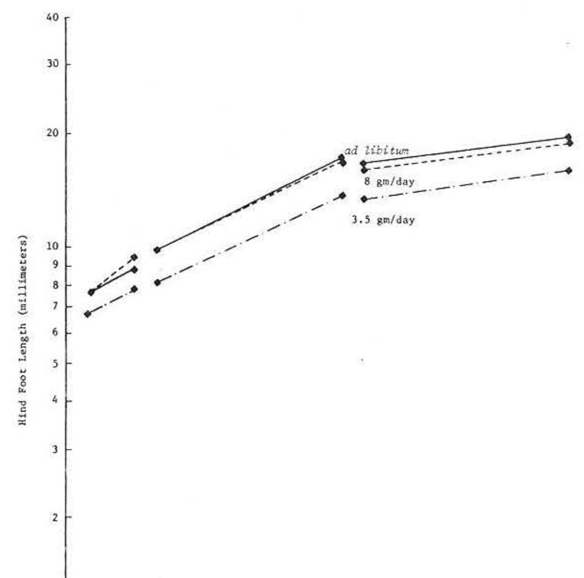

Figure 59. Comparison of growth rates for hind foot length of *Peromyscus maniculatus* fed *ad libitum*, 8 g/day and 3.5 g/day.

Appendix 2 (continued)

Table 7. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.66102	0.15828	1-3	0.37966	0.61616*
	0.92566	0.09159	4-12	0.63025	0.79388*
	1.41083	0.04137	13-22	0.42262	0.65009*
	2.66652	0.00160	23-70	0.11384	0.33740*
Total Length	3.87527	0.06472	1-3	0.35569	0.59639*
	3.91997	0.05626	4-12	0.78728	0.88726*
	4.23351	0.02939	13-22	0.46072	0.67876*
	4.98719	0.00068	23-70	0.23789	0.48773*
Tail Length	2.45307	0.08341	1-3	0.11878	0.34464*
	2.47548	0.09832	4-12	0.81635	0.90352*
	3.18183	0.03792	13-22	0.55723	0.74647*
	4.16125	0.00057	23-70	0.12132	0.34818*
Ear Length	0.53995	0.30138	1-3	0.47287	0.68765*
	1.21799	0.08630	4-12	0.75276	0.86761*
	1.65607	0.05458	13-22	0.69317	0.83256*
	2.84218	0.00052	23-70	0.19165	0.43777*
Hind Foot Length	1.94262	0.08049	1-3	0.34692	0.58899*
	2.02402	0.06860	4-12	0.78758	0.88745*
	2.58473	0.01862	13-22	0.54394	0.73752*
	3.00802	0.00021	23-70	0.07552	0.27480*

*significant at α=.05

Table 8. Data analyses. Means and standard errors (p=.95) for growth of *Peromyscus maniculatus* reared under standard laboratory conditions

Parameter	Age in Days	Sample Size (N)	Mean $\overline{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1	142	1.9778	0.0503	2.27
	2	149	2.3030	0.0639	
	3	148	2.6804	0.0777	3.11
	4	144	3.1173	0.0967	3.63
	5	138	3.6496	0.1158	
	6	133	4.1240	0.1205	
	7	122	4.6028	0.1432	
	8	122	4.0389	0.1559	
	9	120	5.5066	0.1561	
	10	118	5.9203	0.1708	
	11	118	6.2766	0.1768	
	12	117	6.6452	0.1843	7.54
	13	115	6.8613	0.1750	7.01
	14	116	7.1245	0.1829	
	15	116	7.3538	0.1882	
	16	113	7.6548	0.2037	
	17	116	7.9508	0.2172	
	18	112	8.3441	0.2323	
	19	115	8.6885	0.2284	
	20	110	9.1153	0.2342	
	21	113	9.5300	0.2267	
	22	104	9.8491	0.2350	10.18
	28	110	12.7872	0.3154	
	35	107	14.7967	0.3566	
	42	107	16.1107	0.4733	
	49	102	16.5813	0.5735	
	56	99	16.7689	0.5962	
	63	99	17.0408	0.6416	
	70	97	16.9978	0.6427	16.08
Total Length	1	142	48.1725	1.6513	51.37
	2	149	51.3133	0.6360	
	3	148	54.8277	0.7093	58.50
	4	144	58.6736	0.7148	63.12
	5	138	62.7898	0.8232	
	6	133	67.1165	0.8012	
	7	122	71.1762	0.8886	
	9	122	75.3689	0.9997	
	9	120	79.7750	1.0451	
	10	118	83.7669	1.1006	
	11	118	88.2246	1.1605	
	12	117	93.2991	1.2446	98.59
	13	115	97.2348	1.2470	100.99
	14	116	100.8664	1.3267	
	15	116	104.2241	1.3563	

Table 8 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\overline{X}$	Standard Error (SE)	Antilog of lnW
	16	113	108.0044	1.3205	
	17	116	111.0905	1.3895	
	18	112	115.1295	1.4028	
	19	115	117.9609	1.3619	
	20				
	21	113	123.1460	1.2382	
	22	104	125.1442	1.3056	131.63
	28	110	139.5000	1.2732	
	35	107	147.7850	1.1961	
	42	107	151.2056	1.3111	
	49	102	153.3068	1.4205	
	56	99	154.8586	1.4827	
	63	99	156.0303	1.519	
	70	97	156.6804	1.527	153.55
Tail Length	1	142	12.6232	1.6513	12.63
	2	149	12.4832	0.2337	
	3	148	13.9723	0.2446	14.92
	4	144	15.6250	0.2821	17.60
	5	138	17.5072	0.3369	
	6	133	19.8120	0.3735	
	7	122	21.8451	0.4598	
	8	122	24.1229	0.5475	
	9	120	26.6625	0.5172	
	10	118	29.1102	0.5701	
	11	118	31.7881	0.6536	
	12	117	34.5342	0.6822	38.67
	13	115	37.1087	0.7347	39.41
	14	116	39.4008	0.7680	
	15	116	41.4784	0.7230	
	16	113	43.3805	0.7298	
	17	116	45.0388	0.7625	
	18	112	46.9955	0.8067	
	19	115	48.3739	0.8050	
	20	110	49.6727	0.8269	
	21	113	51.3274	0.8805	
	22	104	52.2019	0.7986	55.48
	28	110	60.3227	0.7395	
	35	107	64.4906	0.7350	
	42	107	66.0701	0.7829	
	49	102	67.0784	0.8517	
	56	99	67.5606	0.8678	
	63	99	67.9596	0.8654	
	70	97	68.2938	0.9106	66.75
Ear Length	1	142	1.7943	0.0499	2.32
	2	149	2.2959	0.1270	
	3	148	3.3387	0.1560	4.24
	4	144	4.2357	0.1222	4.77
	5	138	4.7888	0.1048	
	6	133	5.3266	0.0919	
	7	122	5.8022	0.1047	
	8	122	6.2457	0.1179	
	9	120	6.7322	0.1253	
	10	118	7.3075	0.1476	
	11	118	8.0515	0.1778	
	12	117	8.8031	0.2091	9.52
	13	115	9.5939	0.2081	10.64
	14	116	10.5655	0.2293	
	15	116	11.4211	0.2470	
	16	113	12.2974	0.2431	
	17	116	13.0276	0.2448	
	18	112	13.8805	0.2148	
	19	115	14.4737	0.2017	
	20	110	14.9111	0.1940	
	21	113	15.2613	0.1787	
	22	104	15.6050	0.1854	17.39
	28	110	16.6859	0.1603	
	35	107	17.1857	0.1650	
	42	107	17.5307	0.1573	
	49	102	17.7119	0.1682	
	56	99	17.8555	0.1788	
	63	99	17.9347	0.1852	
	70	97	17.9829	0.1817	17.78
Hind Foot Length	1	142	7.0293	0.0962	7.59
	2	149	7.5625	0.1171	
	3	148	8.2352	0.1269	8.88
	4	144	9.0428	0.1491	9.95
	5	138	9.8536	0.1689	
	6	133	10.7640	0.1887	
	7	122	11.6977	0.1935	
	8	122	12.5351	0.2044	
	9	120	13.4116	0.1976	
	10	118	14.1479	0.2023	
	11	118	14.9343	0.1911	
	12	117	15.7101	0.1952	17.24
	13	115	16.2960	0.1931	16.88
	14	116	16.8666	0.1789	

Appendix 2 (continued)

Table 8 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	15	116	17.3013	0.1709	
	16	113	17.7238	0.1566	
	17	116	18.0828	0.1474	
	18	112	18.4252	0.1415	
	19	115	18.6638	0.1385	
	20	110	18.9185	0.1290	
	21	113	19.1223	0.1323	
	22	104	19.3284	0.1528	19.97
	28	110	19.9457	0.1289	
	35	107	20.2929	0.1205	
	42	107	20.4224	0.1133	
	49	102	20.5096	0.1186	
	56	99	20.6716	0.1942	
	63	99	20.6291	0.1266	
	70	97	20.6576	0.1267	20.53

Table 9. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of skulls of *Peromyscus maniculatus* reared under standard laboratory conditions

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Lens Weight	-8.18573	0.36342	1-3	0.44550	0.66745*
	-7.57469	0.12618	4-12	0.91954	0.94892*
	-6.89356	0.05818	13-22	0.92452	0.96151*
Skull Total Length	2.57337	-0.04973	1-3	0.04[illegible]44	0.20357
	2.53206	0.03613	4-12	0.56910	0.75439*
	2.92890	0.00728	13-22	0.29546	0.54356*
Zygomatic Breadth	1.87072	-0.06665	1-3	0.06776	0.26031
	1.90635	0.02457	4-12	0.30443	0.55175
	2.09949	0.01026	13-22	0.12450	0.35285
Foramen Magnum Height	0.87440	0.02547	1-3	0.01227	0.11077
	0.94833	0.03230	4-12	0.37512	0.61247*
	1.24585	0.00381	13-22	0.00505	0.07106
Mastoidal Breadth	1.78600	0.01240	1-3	0.00239	0.04889
	1.87614	0.02825	4-12	0.24868	0.50861
	2.20901	0.00121	13-22	0.00400	0.06325
Nasal Length	1.50519	-0.05042	1-3	0.01942	0.13938
	1.31158	0.04636	4-12	0.57022	0.75513*
	1.81674	0.01473	13-22	0.35931	0.59942*
Cranium Width	2.03463	-0.03940	1-3	0.04096	0.20239
	2.02471	0.02910	4-12	0.62524	0.79072*
	2.58174	-0.01490	13-22	0.01624	0.12744

*significant at α=.05

Table 10. Data analases. Means and standard errors (p=.95) for growth of skulls of *Peromyscus maniculatus* reared under standard laboratory conditions

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Lens Weight	1	6	0.0003	0.0001	0.00040
	2	8	0.0005	0.0000	
	3	7	0.0006	0.0000	0.00057
	4	6	0.0007	0.0001	0.00074
	5	9	0.0008	0.0000	
	6	7	0.0010	0.0000	
	7	8	0.0011	0.0001	
	8	10	0.0013	0.0001	
	9	8	0.0014	0.0001	
	10	10	0.0017	0.0002	
	11	6	0.0018	0.0001	
	12	5	0.0019	0.0000	0.00205
	13	7	0.0020	0.0001	0.00203
	14	10	0.0022	0.0001	
	15	9	0.0023	0.0000	

Table 10 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	16	9	0.0023	0.0001	
	17	7	0.0025	0.0001	
	18	10	0.0029	0.0001	
	19	8	0.0030	0.0000	
	20	9	0.0031	0.0001	
	21	6	0.0033	0.0000	
	22	10	0.0033	0.0001	0.00344
Skull Length	1	6	11.2883	0.8886	12.47
	2	8	11.7337	0.2966	
	3	7	12.8151	0.6000	11.29
	4	6	12.9083	1.0390	14.53
	5	9	14.6300	0.5668	
	6	7	15.5014	1.1443	
	7	8	15.6375	1.6874	
	8	10	17.5800	0.3409	
	9	8	17.0350	0.3943	
	10	10	17.3500	0.4772	
	11	6	17.2983	1.4467	
	12	5	18.1080	0.3029	19.39
	13	7	19.7543	0.4530	20.55
	14	10	20.7590	0.3569	
	15	9	20.8544	0.5572	
	16	9	21.3200	0.5227	
	17	7	20.9571	0.3735	
	18	10	21.0860	0.3810	
	19	8	21.1750	0.4345	
	20	9	21.5155	0.7783	
	21	6	21.3567	0.6997	
	22	10	21.8880	0.4499	21.96
Zygomatic Breadth	1	6	5.6283	0.4062	6.07
	2	8	5.7075	0.3815	
	3	7	6.1129	0.2637	5.31
	4	6	6.5250	0.7281	7.41
	5	9	7.4222	0.4681	
	6	7	7.8928	0.6084	
	7	8	7.9400	0.5098	
	8	10	8.8660	0.5709	
	9	8	8.6000	0.6123	
	10	10	8.2180	0.5115	
	11	6	8.2150	0.5601	
	12	5	8.1760	0.3056	9.02
	13	7	9.3657	0.4646	9.29
	14	10	8.9870	0.2651	
	15	9	9.9333	0.8298	
	16	9	9.1589	0.2983	
	17	7	9.3271	0.4457	
	18	10	10.1060	0.5985	
	19	8	9.7575	0.6042	
	20	9	9.4522	0.4976	
	21	6	10.3000	0.7557	
	22	10	10.1900	0.4108	10.17
Foramen Magnum Height	1	6	2.1667	0.3551	2.45
	2	8	2.3137	0.1734	
	3	7	2.6229	0.1541	2.58
	4	6	2.8400	0.3203	2.93
	5	9	2.9256	0.2753	
	6	7	2.9743	0.3627	
	7	8	3.0762	0.2559	
	8	10	3.3080	0.1971	
	9	8	3.4587	0.1200	
	10	10	3.3990	0.2327	
	11	6	3.8217	0.2985	
	12	5	3.5340	0.3079	3.79
	13	7	3.5471	0.2810	3.65
	14	10	3.9360	0.2307	
	15	9	3.8078	0.3246	
	16	9	3.6956	0.0865	
	17	7	3.6800	0.1941	
	18	10	4.1650	0.1652	
	19	8	3.6512	0.1126	
	20	9	3.7756	0.2359	
	21	6	3.5850	0.5127	
	22	10	3.6750	0.2549	3.77
Mastoidal Breadth	1	6	5.3933	0.4567	6.03
	2	8	5.5100	0.7180	
	3	7	6.5029	0.4668	6.11
	4	6	6.8833	0.6280	7.30
	5	9	7.2555	0.2395	
	6	7	7.7771	0.4681	
	7	8	7.6487	0.4382	
	8	10	8.4750	0.2699	
	9	8	8.7525	0.2195	
	10	10	7.9980	0.1804	

Appendix 2 (continued)

Table 10 (continued)

Parameter	Age in Days	Sample Size (N)	Mean X̄	Standard Error (SE)	Antilog of lnW
	11	6	8.7117	0.6311	
	12	5	8.9020	0.2533	9.11
	13	7	9.0871	0.2010	9.24
	14	10	9.4440	0.2282	
	15	9	9.4167	0.5209	
	16	9	9.3422	0.2526	
	17	7	9.3157	0.2093	
	18	10	9.5630	0.1527	
	19	8	9.2950	0.2228	
	20	9	9.3178	0.1309	
	21	6	8.8433	0.6273	
	22	10	9.4920	0.2359	9.34
Nasal Length	1	6	3.0450	0 1993	4.28
	2	8	3.0662	0.2432	
	3	7	3.6786	0.1770	3.87
	4	6	3.9100	0.4062	4.47
	5	9	4.3833	0.1834	
	6	7	4.7528	0.6217	
	7	8	5.2037	0.2698	
	8	10	5.8740	0.1944	
	9	8	5.4862	0.2364	
	10	10	5.5910	0.0320	
	11	6	5.4833	0.4563	
	12	5	5.9600	0.4620	6.48
	13	7	7.0686	0.5371	7.45
	14	10	7.4710	0.2472	
	15	9	7.6722	0.4142	
	16	9	7.9989	0.2072	
	17	7	7.8914	0.3309	
	18	10	7.7420	0.3219	
	19	8	7.8900	0.1606	
	20	9	8.0411	0.4024	
	21	6	8.2717	0.2481	
	22	10	8.4130	0.3633	8.50
Cranium Width	1	6	6.8217	0.3735	7.35
	2	8	7.0387	0.3540	
	3	7	7.5143	0.3348	6.79
	4	6	7.6883	0.6578	
	5	9	8.6044	0.2397	
	6	7	9.0128	0.5111	
	7	8	9.2625	0.2032	
	8	10	9.6190	0.2324	
	9	8	10.0300	0.4036	
	10	10	10.0140	0.2631	
	11	6	9.6267	0.6430	
	12	5	9.9660	0.1939	8.49
	13	7	10.3314	0.3528	10.89
	14	10	10.9710	0.1542	
	15	9	10.9011	0.3233	
	16	9	10.9589	0.1464	
	17	7	10.9671	0.2287	
	18	10	11.0150	0.1152	
	19	8	10.7887	0.2309	
	20	9	10.7533	0.2958	
	21	6	11.1067	0.5221	
	22	10	10.1230	2.2341	9.51

Table 11. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: model intervals

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.82183	0.09551	1-15	0.81434	0.90240*
	1.36713	0.04371	16-22	0.28569	0.53449*
	2.11231	0.01625	23-42	0.32544	0.57047*
	2.75128	0.00092	43-70	0.30905	0.55592*
Total Length	3.89968	0.05657	1-15	0.91070	0.95430*
	4.29901	0.02588	16-22	0.21665	0.46545*
	4.78663	0.00577	23-42	0.34030	0.58335*
	5.02705	0.00036	43-70	0.73694	0.85845*
Tail Length	2.47043	0.09522	1-15	0.90279	0.95015*
	3.30358	0.03137	16-22	0.32185	0.56731*
	3.92830	0.00653	23-42	0.26103	0.51091*
	4.20555	0.00022	43-70	0.17568	0.41914*
Ear Length	0.88454	0.12028	1-15	0.83816	0.91551*
	1.92170	0.04031	15-22	0.45754	0.67641*
	2.71912	0.00354	23-42	0.14627	0.38245*
	2.87139	0.00029	43-70	0.61716	0.78559*
Hind Foot Length	1.99640	0.06754	1-15	0.90271	0.95011*
	2.66462	0.01432	16-22	0.32043	0.56606*
	2.94824	0.00170	23-42	0.88669	0.94164*
	3.02104	0.00010	43-70	0.16531	0.40658*

Table 12. Data analyses. Means and standard errors (p=.95) for growth in body weight of *Peromyscus maniculatus* reared under standard laboratory conditions: model intervals.

Parameter	Age in Days	Sample Size (N)	Mean X̄	Standard Error (SE)	Antilog of lnW
Body Weight	1	142	1.9778	0.0503	2.50
	2	149	2.3030	0.0639	
	3	148	2.6804	0.0777	
	4	144	3.1173	0.0967	
	5	138	3.6496	0.1158	
	6	133	4.1240	0.1205	
	7	122	4.6028	0.1432	
	8	122	5.0389	0.1559	
	9	120	5.5066	0.1561	
	10	118	5.9203	0.1708	
	11	118	6.2766	0.1768	
	12	117	6.6452	0.1843	
	13	115	6.8613	0.1750	
	14	116	7.1245	0.1829	
	15	116	7.3538	0.1882	9.52
	16	113	7.6548	0.2037	7.89
	17	116	7.9508	0.2172	
	18	112	8.3441	0.2323	
	19	115	8.6885	0.2284	
	20	110	9.1153	0.2342	
	21	113	9.5300	0.2267	
	22	104	9.8491	0.2350	10.25
	28	110	12.7872	0.3154	
	35	107	14.7967	0.3566	
	42	107	16.1107	0.4733	16.34
	49	102	16.5813	0.5735	
	56	99	16.7689	0.5962	
	63	99	17.0408	0.6416	
	70	99	16.9978	0.6427	16.69

Table 13. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light and 9 hr dark

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	.79116	.17204	1-3	.51828	.71991*
	1.07092	.09751	4-12	.69919	.83617*
	1.76158	.03007	13-22	.37941	.61596*
Total Length	3.92484	.07296	1-3	.58088	.76215*
	3.97970	.05852	4-12	.88460	.94053*
	4.35586	.02601	13-22	.83171	.91198*
Tail Length	2.42176	.11599	1-3	.54679	.73945*
	2.52457	.10799	4-12	.91428	.95617*
	3.31886	.03442	13-22	.80311	.89616*
Ear Length	.43355	.41756	1-3	.81495	.90274*
	1.25414	.08943	4-12	.88073	.93847*
	1.76315	.05323	13-22	.82671	.90923*
Hind Foot	1.95739	.09537	1-3	.61440	.78383*
	2.07711	.07137	4-12	.85993	.92732*
	2.65722	.01663	13-22	.70858	.84177*

*significant at α=.05

Table 14. Data analyses. Means and standard errors (p=.95) for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light, 9 hr dark

Parameter	Age in Days	Sample Size (N)	Mean X̄	Standard Error (SE)	Antilog of lnW
Body Weight	1	16	2.0937	0.1200	2.17
	2	16	2.4225	0.1509	
	3	16	2.7969	0.193	3.20
	4	16	3.2375	0.2364	3.64
	5	16	3.6187	0.2647	
	6	16	4.0625	0.3207	
	7	16	4.5687	0.3618	
	8	16	5.0406	0.3829	
	9	16	5.5219	0.4071	
	10	16	5.8062	0.4655	
	11	16	6.0937	0.5298	
	12	16	6.4719	0.6276	7.64
	13	16	6.8812	0.6469	7.05
	14	16	7.2969	0.6939	
	15	16	7.5531	0.7404	

Appendix 2 (continued)

Table 14 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	16	16	7.8437	0.7779	
	17	16	8.2062	0.8588	
	18	16	8.7031	0.8605	
	19	16	8.9187	0.9339	
	20	15	9.7300	0.6973	
	21	15	10.0633	0.7477	
	22	15	10.4167	0.8197	10.84
Total Length	1	16	50.3438	1.2147	52.98
	2	16	52.8750	1.1665	
	3	16	56.1250	1.3775	59.08
	4	16	60.4063	1.2321	64.32
	5	16	64.1875	1.2905	
	6	16	68.0000	1.4458	
	7	16	73.3750	1.6961	
	8	16	76.8562	2.0108	
	9	16	82.1250	1.9516	
	10	16	85.7500	1.9673	
	11	16	89.8750	2.1359	
	12	16	94.6250	2.3680	102.10
	13	16	98.6875	2.9718	103.13
	14	16	103.4688	3.3057	
	15	16	109.1875	3.3571	
	16	16	112.2813	3.4960	
	17	16	115.5313	3.6236	
	18	16	122.9688	8.974	
	19	16	120.6250	3.9483	
	20	15	126.0000	2.2689	
	21	15	128.1333	2.4029	
	22	15	130.4000	2.4869	138.51
Tail Length	1	16	11.3125	0.3615	12.64
	2	16	12.5625	0.4434	
	3	16	14.3438	0.529	16.02
	4	16	16.3750	0.5446	18.05
	5	16	18.3438	0.5799	
	6	16	20.5938	0.4675	
	7	16	23.2813	0.8623	
	8	16	25.4375	0.8169	
	9	16	28.5313	0.9331	
	10	16	30.9063	1.0461	
	11	16	33.5625	1.2076	
	12	16	36.4063	1.266	42.22
	13	16	38.5313	1.5691	40.69
	14	16	40.8750	1.3181	
	15	16	43.5625	1.5123	
	16	16	45.0000	1.4393	
	17	16	47.5625	1.7678	
	18	16	49.0938	1.9509	
	19	16	50.1250	2.0528	
	20	15	54.1000	0.8678	
	21	15	54.6667	0.9878	
	22	15	55.9333	1.1564	60.16
Ear Length	1	16	1.8662	0.1654	2.40
	2	16	2.3187	0.3759	
	3	16	3.4481	0.3158	4.43
	4	16	4.3219	0.1614	4.79
	5	16	4.7337	0.2332	
	6	16	5.3075	0.1789	
	7	16	5.9019	0.1515	
	8	16	6.3231	0.2187	
	9	16	6.9056	0.1834	
	10	16	7.3256	0.219	
	11	16	8.0206	0.2848	
	12	16	8.6494	0.3804	9.68
	13	16	9.6644	0.4558	10.64
	14	16	10.6725	0.4526	
	15	16	12.0250	0.6035	
	16	16	12.8262	0.6094	
	17	16	13.7162	0.6355	
	18	16	14.3950	0.5925	
	19	16	14.9325	0.5293	
	20	15	15.7433	0.4518	
	21	15	16.1553	0.4053	
	22	15	16.5080	0.3923	18.97
Hind Foot Length	1	16	7.0675	0.2004	7.59
	2	16	7.5300	0.2632	
	3	16	8.2712	0.2152	8.89
	4	16	8.9350	0.2809	9.97
	5	16	10.0244	0.3203	
	6	16	10.8037	0.2807	
	7	16	11.8556	0.248	
	8	16	12.8650	0.2516	
	9	16	13.5725	0.2768	
	10	16	14.2094	0.3073	
	11	16	14.8744	0.2664	
	12	16	15.7081	0.2830	17.81
	13	16	16.3750	0.2634	16.95
	14	16	17.2000	0.2236	
	15	16	17.6169	0.2111	

Table 14 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	16	16	18.1106	0.2361	
	17	16	18.2437	0.2271	
	18	16	18.6156	0.3213	
	19	16	18.8031	0.2898	
	20	15	19.1113	0.2003	
	21	15	19.3200	0.2035	
	22	15	19.6087	0.4178	20.37

Table 15. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 9 hr light and 15 hr dark

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	.73397	.14338	1-3	.50162	.70825*
	.92246	.09257	4-12	.67777	.82326*
	1.33191	.04780	13-22	.37953	.61606*
Total Length	3.91619	.05433	1-3	.51005	.71417*
	3.93399	.05769	4-12	.89747	.94734*
	4.20928	.03283	13-22	.74258	.86329*
Tail Length	2.41956	.11841	1-3	.69674	.83470*
	2.50177	.10348	4-12	.93614	.96754*
	3.14159	.04345	13-22	.81389	.90215*
Ear Length	.57139	.30618	1-3	.55644	.74594*
	1.21550	.08794	4-12	.90370	.95063*
	1.53046	.06424	13-22	.83862	.91576*
Hind Foot	1.94881	.07875	1-3	.57418	.75774*
	2.01063	.07252	4-12	.91445	.95626*
	2.56372	.02049	13-22	.80236	.89574*

*significant at α=.05

Table 16. Data analyses. Means and standard errors (p = .95) for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 hr light, 9 hr dark

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1	15	2.2233	0.1921	2.62
	2	15	2.6600	0.2026	
	3	15	3.1267	0.2278	3.70
	4	15	3.7567	0.2943	4.31
	5	15	4.3233	0.3845	
	6	15	4.9000	0.4174	
	7	15	5.4800	0.4653	
	8	15	6.0667	0.4672	
	9	15	6.5833	0.5119	
	10	15	7.0200	0.5854	
	11	15	7.4333	0.6309	
	12	15	7.9033	0.6351	9.40
	13	15	8.3167	0.6142	8.60
	14	15	8.7300	0.6014	
	15	15	9.0633	0.6267	
	16	15	9.4333	0.6230	
	17	15	9.7267	0.6431	
	18	14	9.8000	0.5651	
	19	14	10.0964	0.5185	
	20	14	10.3464	0.6648	
	21	14	10.5786	0.8121	
	22	14	10.8107	0.9509	11.28
Total Length	1	15	50.6667	1.4403	54.43
	2	15	54.6333	1.5734	
	3	15	58.6333	1.72221	62.99
	4	15	63.3333	1.5913	67.56
	5	15	67.7333	1.7202	
	6	15	71.8333	2.1272	
	7	15	76.6000	2.2013	
	8	15	81.1000	2.1538	
	9	15	85.7000	2.4485	
	10	15	90.7667	2.4599	
	11	15	95.4000	2.7468	
	12	15	100.5333	2.5200	107.88
	13	15	104.8667	2.4388	
	14	15	109.7333	2.1930	
	15	15	114.0000	2.0336	

Appendix 2 (continued)

Table 16 (continued)

Parameter	Age in Days	Sample Size (N)	Mean X̄	Standard Error (SE)	Antilog of lnW
	16	15	117.6333	2.0081	
	17	15	121.5667	2.1633	
	18	14	123.4286	1.5988	
	19	14	125.2143	1.5900	
	20	14	127.5714	1.8700	
	21	14	129.1786	1.9527	
	22	14	130.9286	2.0013	138.10
Tail Length	1	15	11.4667	0.4945	54.43
	2	15	12.3333	0.6054	
	3	15	14.4667	0.6956	62.99
	4	15	16.8000	0.7581	67.56
	5	15	19.2667	0.8072	
	6	15	21.8000	1.037	
	7	15	24.2867	1.2145	
	8	15	27.2333	1.0661	
	9	15	30.1333	1.1825	
	10	15	33.0333	1.1259	
	11	15	35.6667	1.1220	
	12	15	38.5000	1.0690	107.88
	13	15	41.1333	1.1639	109.18
	14	15	43.3667	1.4014	
	15	15	45.9333	1.0581	
	16	15	47.9000	1.2614	
	17	15	49.6000	1.3080	
	18	14	50.6071	1.2209	
	19	14	51.7500	1.2748	
	20	14	53.2500	1.2394	
	21	14	53.8214	1.4989	
	22	14	55.0000	1.599	138.10
Ear Length	1	15	1.6640	0.0852	12.64
	2	15	2.0700	0.2613	
	3	15	3.8293	0.1529	15.94
	4	15	4.4173	0.1473	19.22
	5	15	5.1173	0.2532	
	6	15	5.6307	0.1671	
	7	15	6.0553	0.2994	
	8	15	6.5453	0.1966	
	9	15	7.2160	0.2485	
	10	15	7.8787	0.3557	
	11	15	8.4607	0.5020	
	12	15	9.6753	0.4460	45.60
	13	15	10.5660	0.5395	43.21
	14	15	11.7967	0.4687	
	15	15	12.8227	0.4682	
	16	15	13.7220	0.4123	
	17	15	14.5107	0.3289	
	18	14	15.3386	0.3651	
	19	14	15.6571	0.3470	
	20	14	15.8736	0.3867	
	21	14	16.3157	0.3211	
	22	14	16.4386	0.3145	58.91
Hind Foot Length	1	15	7.0987	0.2154	7.78
	2	15	7.7900	1.0188	
	3	15	8.5953	0.314	9.42
	4	15	9.6053	0.3510	10.54
	5	15	10.5540	0.3841	
	6	15	11.5893	0.4375	
	7	15	12.6387	0.4607	
	8	15	13.4807	0.5309	
	9	15	14.2713	0.5328	
	10	15	15.1207	0.5019	
	11	15	15.8380	0.4440	
	12	15	16.5860	0.4439	18.78
	13	15	17.1680	0.3246	17.69
	14	15	17.8966	0.2621	
	15	15	18.3146	0.3193	
	16	15	18.6140	0.3095	
	17	15	19.0366	0.3449	
	18	14	19.1678	0.2516	
	19	14	19.2521	0.2677	
	20	14	19.4428	0.2697	
	21	14	19.7085	0.2625	
	22	14	19.7907	0.2637	20.55

Table 17. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 C

Parameter	lnA	Instantaneous Relative Growth Rate (*k*)	Age in Days (*t*=*t*-1)	R^2	Correlation Coefficient (*r*)
Body Weight	0.61571	.13492	1-3	.51695	.71899*
	0.76059	.11118	4-12	.85099	.92249*
	1.50549	.03706	13-22	.29673	.54472*
Total Length	3.85961	.05265	1-3	.50238	.70878*
	3.85272	.06068	4-12	.91363	.95583*
	4.35053	.02157	13-22	.13416	.36627
Tail Length	2.37777	.09031	1-3	.59363	.77047*
	2.40866	.09985	4-12	.87765	.93682*
	3.15188	.03861	13-22	.63403	.79626*
Ear Length	0.33645	.29113	1-3	.52077	.72164*
	1.06515	.09540	4-12	.84674	.92018*
	1.51571	.05666	13-22	.84536	.91943*
Hind Foot Length	1.89180	.06576	1-3	.43577	.66012*
	1.93391	.07332	4-12	.92818	.96342*
	2.50884	.02202	13-22	.77388	.87970*

*significant at α=.05

Table 18. Data analyses. Means and standard errors (p=.95) for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 15 C

Parameter	Age in Days	Sample Size (N)	Mean X̄	Standard Error (SE)	Antilog of lnW
Body Weight	1	24	1.8750	0.0720	2.11
	2	24	2.0917	0.0911	
	3	24	2.4646	0.1291	2.77
	4	24	2.8583	0.1400	3.34
	5	24	3.3333	0.1340	
	6	24	3.7917	0.1871	
	7	24	4.2875	0.2054	
	8	24	4.8812	0.2122	
	9	24	5.4062	0.2584	
	10	24	5.9583	0.5740	
	11	24	6.5104	0.3006	
	12	24	6.9083	0.3083	8.11
	13	24	7.1062	0.3935	7.29
	14	24	7.3292	0.4534	
	15	24	7.6042	0.4705	
	16	22	7.9977	0.5378	
	17	22	8.1886	0.6466	
	18	22	8.6568	0.6437	
	19	22	9.0409	0.6860	
	20	22	9.2932	0.7326	
	21	22	9.6204	0.7898	
	22	22	9.8591	0.8157	10.17
Total Length	1	24	47.5417	0.0979	49.99
	2	24	49.9583	0.9059	
	3	24	52.8125	0.9269	55.53
	4	24	56.3125	0.9999	
	5	24	59.9583	1.0206	
	6	24	63.7917	0.0849	
	7	24	68.2500	1.2273	
	8	24	72.8750	1.2324	
	9	24	77.1042	1.4406	
	10	24	80.6042	2.3157	
	11	24	86.6042	1.9108	
	12	24	91.8125	2.0496	97.51
	13	24	Void*	Void*	102.51
	14	24	99.3125	1.8821	
	15	24	102.7500	2.0722	124.58
	16	22	105.9773	1.9913	
	17	22	109.2500	2.1927	
	18	22	112.1136	2.2424	
	19	22	115.3409	2.4164	
	20	22	117.3409	2.4776	
	21	22	120.1136	2.4613	
	22	22	122.2727	2.7951	124.58
Tail Length	1	24	10.7917	0.2559	11.79
	2	24	11.8333	0.3828	
	3	24	12.9375	0.3698	14.12
	4	24	14.7083	0.5735	16.57
	5	24	16.6458	0.6831	
	6	24	18.5000	0.7310	
	7	24	20.7500	0.7822	
	8	24	22.8958	0.8113	
	9	24	24.9792	0.9848	
	10	24	27.1458	1.1209	

Appendix 2 (continued)

Table 18 (continued)

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
	11	24	29.8958	1.0991	
	12	24	33.4375	1.4588	36.81
	13	24	36.0833	1.3629	38.59
	14	24	38.7708	1.4882	
	15	24	40.3542	1.4797	
	16	22	42.8409	1.5474	
	17	22	44.3409	1.6023	
	18	22	45.9318	1.6239	
	19	22	47.5000	1.6856	
	20	22	48.9318	1.6777	
	21	22	50.2500	1.6602	
	22	22	51.4545	1.6911	54.65
Ear Length	1	24	1.5192	0.0584	1.87
	2	24	1.6142	0.0833	
	3	24	2.8362	0.3450	3.35
	4	24	3.7062	0.2373	4.24
	5	24	4.2046	0.2351	
	6	24	4.8637	0.1930	
	7	24	5.3879	0.1639	
	8	24	5.9092	0.1671	
	9	24	6.2575	0.2013	
	10	24	6.7825	0.2153	
	11	24	7.4925	0.2272	9.10
	12	24	8.0796	0.2953	9.50
	13	24	8.5792	0.2834	
	14	24	9.5242	0.3618	
	15	24	10.2242	0.4328	
	16	22	10.9586	0.2514	
	17	22	11.5482	0.2506	
	18	22	12.2704	0.2930	
	19	22	12.8413	0.2217	
	20	22	13.3986	0.2630	
	21	22	13.9395	0.3453	
	22	22	14.4786	0.3686	15.83
Hind Foot Length	1	24	6.6862	0.1561	7.07
	2	24	7.0012	0.1893	
	3	24	7.6292	0.1998	8.07
	4	24	8.3679	0.9368	9.27
	5	24	9.2242	0.2231	
	6	24	10.2129	0.2173	
	7	24	10.8542	0.2328	
	8	24	11.6891	0.2558	
	9	24	12.6308	0.2614	
	10	24	13.6320	0.2758	
	11	24	14.4075	0.2121	
	12	24	14.9662	0.2345	16.65
	13	24	15.4629	0.2078	16.36
	14	24	15.9120	0.2326	
	15	24	16.2791	0.2304	
	16	22	16.9009	0.1990	
	17	22	17.2449	0.2397	
	18	22	17.5463	0.2275	
	19	22	17.8390	0.2217	
	20	22	18.0895	0.2129	
	21	22	18.2759	0.2427	
	22	22	18.5699	1.3678	19.94

* Data unavailable due to computer manipulation.

Table 19. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *Peromyscus maniculatus* reared under standard laboratory conditions: 30 C

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.71194	0.10985	1-3	0.15198	0.38984
	0.83722	0.07926	4-12	0.64164	0.80102*
	1.15950	0.04879	13-22	0.52699	0.72594*
Total Length	3.89476	0.06676	1-3	0.45213	0.67240*
	3.94764	0.05183	4-12	0.79678	0.89262*
	4.21378	0.03025	13-22	0.69834	0.83566*
Tail Length	2.49772	0.10443	1-3	0.21376	0.46234
	2.55324	0.09178	4-12	0.80130	0.89515*
	3.13247	0.04355	13-22	0.70705	0.84086*
Ear Length	0.71761	0.13817	1-3	0.11556	0.33994
	1.04860	0.08482	4-12	0.69777	0.83532*
	1.32198	0.06713	13-22	0.81759	0.90420*
Hind Foot Length	1.90920	0.09033	1-3	0.24695	0.49694
	1.97293	0.06965	4-12	0.82528	0.90844*
	2.55719	0.01906	13-22	0.78058	0.88350*

*significant at α=.05

Table 20. Data analyses. Means and standard errors (p=.95) for growth of *P. maniculatus* reared under standard laboratory conditions: 30 C

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
Body Weight	1	26	2.1269	0.2772	2.27
	2	25	2.3220	0.2276	
	3	25	2.5600	0.1156	2.83
	4	19	2.7684	0.1282	3.17
	5	19	3.1184	0.1469	
	6	19	3.5195	0.1980	
	7	15	3.9433	0.2532	
	8	15	4.3233	0.2731	
	9	19	4.5342	0.3394	
	10	19	4.8347	0.3611	
	11	18	5.1972	0.4245	
	12	20	5.2900	0.5344	5.97
	13	15	5.8867	0.5080	6.00
	14	19	6.0105	0.4188	
	15	19	6.3289	0.4330	
	16	15	6.7600	0.4923	
	17	18	7.0333	0.4599	
	18	18	7.2722	0.4797	
	19	18	7.6472	0.4879	
	20	14	8.4107	0.5372	
	21	18	8.4611	0.5384	
	22	18	8.9250	0.4929	9.31
Total Length	1	26	49.3077	1.5140	52.50
	2	25	52.5600	1.3361	
	3	25	56.2600	1.0557	60.03
	4	19	59.2895	1.2693	63.68
	5	19	63.3947	1.4454	
	6	19	68.2105	1.4201	
	7	15	70.9667	1.7126	
	8	15	75.5333	1.7934	
	9	19	80.1316	2.0116	
	10	19	83.2632	2.1694	
	11	18	87.8055	2.8737	
	12	20	89.6750	5.0111	96.44
	13	15	96.1667	3.8284	100.18
	14	19	99.7368	2.8648	
	15	19	103.3421	3.0642	
	16	15	108.1000	3.5119	
	17	18	111.0555	3.0863	
	18	18	113.5833	3.0984	
	19	18	117.2222	3.0008	
	20	14	122.0357	3.4368	
	21	18	123.1944	3.0404	
	22	18	125.8611	3.0483	131.49
Tail Length	1	26	12.4231	1.1286	13.49
	2	25	13.6600	0.9996	
	3	25	15.1000	0.7833	16.62
	4	19	16.2895	0.5218	
	5	19	18.2632	0.6871	
	6	19	20.9474	0.8673	
	7	15	22.4000	0.8552	
	8	15	25.3000	0.9550	
	9	19	28.0263	1.0535	
	10	19	30.0000	1.2556	
	11	18	32.8055	1.6882	
	12	20	33.8250	2.879	38.62
	13	15	37.8000	2.1903	40.36
	14	19	40.0789	1.6736	
	15	19	42.9474	1.7536	
	16	15	45.0000	2.1046	
	17	18	46.9167	1.5044	
	18	18	48.3611	1.7610	
	19	18	50.5833	1.8658	
	20	14	53.1429	2.2849	
	21	18	54.5833	1.7945	
	22	18	56.2500	1.9382	59.73
Ear Length	1	26	2.2273	0.3943	2.35
	2	25	2.4140	0.3583	
	3	25	2.8480	0.3546	3.10
	4	19	3.4374	0.3033	4.00
	5	19	4.0084	0.2157	
	6	19	4.6447	0.1950	
	7	15	4.9433	0.2259	
	8	15	5.3987	0.1553	
	9	19	5.7710	0.2151	
	10	19	6.2000	0.2520	

Appendix 2 (continued)

Table 20 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
	11	18	6.7467	0.3435	
	12	20	6.9950	0.6224	7.89
	13	15	7.8667	0.5397	8.97
	14	19	8.7658	0.4619	
	15	19	9.7684	0.4836	
	16	15	10.6433	0.6025	
	17	18	11.5055	0.3654	
	18	18	12.4694	0.3894	
	19	18	13.0722	0.3637	
	20	14	13.4679	0.3690	
	21	18	14.0055	0.3052	
	22	18	14.4278	0.3414	16.41
Hind Foot	1	26	6.8388	0.4837	7.38
	2	25	7.4436	0.4269	
	3	25	8.1228	0.3264	8.85
	4	19	8.5221	0.3040	9.50
	5	19	9.3989	0.3473	
	6	19	10.4263	0.3214	
	7	15	10.9987	0.2930	
	8	15	12.0620	0.2135	
	9	19	13.1500	0.2519	
	10	19	13.8368	0.2788	
	11	18	14.4100	0.2665	
	12	20	14.7400	0.8786	16.57
	13	15	15.7367	0.3017	16.64
	14	19	16.5131	0.2378	
	15	19	16.9815	0.1924	
	16	15	17.2533	0.2765	
	17	19	17.8138	0.2276	
	18	18	18.0305	0.2098	
	19	18	18.3472	0.2416	
	20	14	18.6464	0.2282	
	21	18	18.7627	0.2019	
	22	18	18.8694	0.211	19.60

Table 21. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *P. maniculatus* reared under standard laboratory conditions: fed 3.5 g/day

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.62989	0.06175	1-3	0.15802	0.39751
	0.65040	0.06277	4-12	0.72473	0.85131*
	1.28558	0.01067	13-22	0.20499	0.45275
Total Length	3.82758	0.04672	1-3	0.64866	0.80539*
	3.86229	0.04653	4-12	0.93111	0.96494*
	4.23224	0.01531	13-22	0.77010	0.87755
Tail Length	2.31408	0.10043	1-3	0.89016	0.94348*
	2.38633	0.09210	4-12	0.95268	0.97605*
	3.15714	0.02550	13-22	0.87799	0.93701
Ear Length	0.62111	0.15349	1-3	0.58306	0.76358*
	0.90057	0.07865	4-12	0.76212	0.87299*
	1.25282	0.05271	13-22	0.91570	0.95692
Hind Foot Length	1.83207	0.07780	1-3	0.70337	0.83867*
	1.85126	0.06384	4-12	0.95075	0.97506*
	2.36156	0.01913	13-22	0.83355	0.91298

*significant at α=.05

Table 22. Data analyses. Means and standard errors (p=.95) for growth of *P. maniculatus* reared under standard laboratory conditions: fed 3.5 g/day

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1	10	1.8500	0.0501	1.99
	2	10	2.0450	0.1253	
	3	7	2.1143	0.3574	2.25
	4	6	2.2500	0.5184	2.46
	5	7	2.6500	0.1816	
	6	6	2.6417	0.0975	
	7	6	2.8250	0.1339	
	8	5	3.0200	0.1332	
	9	5	3.0800	0.1716	
	10	4	3.4000	0.1142	
	11	4	3.5250	0.1760	
	12	3	3.8000	0.3218	4.05
	13	3	4.0000	0.4049	4.15
	14	3	4.1167	0.5899	
Total Length	1	10	45.7500	0.8546	48.13
	2	10	48.6000	0.7423	
	3	7	50.1429	1.6144	52.82
	4	6	53.3333	2.6530	57.28
	5	7	57.6429	2.1033	
	6	6	61.5000	1.3854	
	7	6	63.0833	1.5383	
	8	5	67.6000	2.0625	
	9	5	68.9000	1.6061	
	10	4	71.2500	0.6995	
	11	4	75.2500	1.7604	
	12	3	77.8333	1.4198	83.09
	13	3	81.0000	1.8579	84.01
	14	3	83.3333	2.8384	
Tail Length	1	10	10.1500	0.1710	11.17
	2	10	11.2000	0.2984	
	3	7	12.4286	0.4043	13.66
	4	6	13.5833	0.7398	15.70
	5	7	15.5714	0.5460	
	6	6	18.0833	0.6680	
	7	6	19.3333	0.8801	
	8	5	21.5000	1.5311	
	9	5	22.9000	1.6571	
	10	4	24.6250	1.0492	
	11	4	26.8750	1.1946	
	12	3	28.6667	1.0727	32.81
	13	3	31.0000	1.8579	32.72
	14	3	32.3333	3.9112	
Ear Length	1	10	1.8850	0.0709	2.16
	2	10	2.1250	0.0673	
	3	7	2.6143	0.4588	2.94
	4	6	3.0417	0.7389	3.37
	5	7	3.5386	0.2954	
	6	6	3.6833	0.1611	
	7	6	4.0583	0.1893	
	8	5	4.5000	0.3773	
	9	5	4.6700	0.3079	
	10	4	4.8875	0.4439	
	11	4	5.1875	0.6911	
	12	3	5.6167	0.5117	6.32
	13	3	6.3500	0.4261	6.94
	14	3	7.1500	1.0551	
Hind Foot Length	1	10	6.2320	0.1555	6.74
	2	10	6.7950	0.2488	
	3	7	7.2714	0.2122	7.88
	4	6	7.8583	0.2324	8.21
	5	7	8.0143	0.4544	
	6	6	8.7083	0.2572	
	7	6	9.2917	0.1946	
	8	5	10.3800	0.2193	
	9	5	10.7900	0.0867	
	10	4	11.3750	0.5553	
	11	4	12.0500	0.3703	
	12	3	12.4000	0.3354	13.69
	13	3	13.1333	0.5682	13.59
	14	3	13.5000	0.4922	

Appendix 2 (continued)

Table 23. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *P. maniculatus* reared under standard laboratory conditions: fed 8 g/day

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.74003	0.12598	1-3	0.28573	0.53453*
	0.87993	0.09326	4-12	0.59466	0.77114*
	1.62113	0.02039	13-22	0.11064	0.33262
Total Length	3.88215	0.07474	1-3	0.53088	0.72861*
	3.96428	0.04708	4-12	0.73206	0.85560*
	4.32663	0.01788	13-22	0.15616	0.39517
Tail Length	2.35408	0.14119	1-3	0.46301	0.68044*
	2.53725	0.08461	4-12	0.57734	0.75982*
	3.33956	0.02030	13-22	0.03343	0.18283
Ear Length	0.65855	0.30105	1-3	0.61816	0.78623*
	1.27730	0.07569	4-12	0.82484	0.90820*
	1.58844	0.05464	13-22	0.63316	0.81434*
Hind Foot Length	1.90543	0.11561	1-3	0.28335	0.53249*
	2.03278	0.06721	4-12	0.83055	0.91134*
	2.56576	0.01766	13-22	0.56265	0.75009*

*significant at α=.05

Table 24. Data analyses. Means and standard errors (p=.95) for growth of *P. maniculatus* reared under standard laboratory conditions: fed 8 g/day

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1	37	2.1243	0.0905	2.37
	2	43	2.3907	0.1360	
	3	36	2.7542	0.1729	3.05
	4	.36	3.1694	0.2239	3.49
	5	36	3.5264	0.2475	
	6	34	3.8147	0.2983	
	7	27	4.5704	0.4280	
	8	32	4.8406	0.3230	
	9	28	5.3929	0.3052	
	10	17	6.2823	0.5429	
	11	24	5.8417	0.4406	
	12	24	6.4250	0.5250	7.38
	13	28	6.5661	0.5700	6.59
	14	24	6.6229	0.4329	
	15	27	6.9111	0.4850	
	16	24	7.0917	0.4806	
	17	16	7.1250	0.4375	
	18	20	7.0725	0.4683	
	19	8	6.8500	0.2873	
	20	10	7.3800	0.3830	
	21	10	7.6250	0.4395	
	22	4	8.5250	0.4762	7.91
Total Length	1	37	48.7297	0.7835	52.24
	2	43	52.1279	1.0377	
	3	36	56.6111	1.0429	60.70
	4	36	60.4167	1.1583	63.56
	5	36	63.5139	1.3518	
	6	34	66.7059	1.5721	
	7	27	70.8999	2.1100	
	8	32	73.2188	1.8754	
	9	28	78.1786	2.3570	
	10	17	82.5882	3.9330	
	11	24	83.2500	2.8522	
	12	24	87.9375	3.5345	92.66
	13	28	94.4643	6.3896	95.48
	14	24	94.4167	3.5155	
	15	27	98.8148	3.6159	
	16	24	100.8750	3.8020	
	17	16	101.3750	5.0753	
	18	20	103.5000	4.0570	
	19	8	100.5625	7.7794	
	20	10	107.5500	7.5867	
	21	10	109.0500	7.7750	
	22	4	109.5000	23.2560	112.05

Table 24 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Tail Length	1	37	10.5811	0.3880	12.12
	2	43	12.2558	0.5355	
	3	36	14.0417	0.5278	16.07
	4	36	15.9861	0.6245	17.72
	5	36	17.9583	0.7825	
	6	34	19.6912	1.0449	
	7	27	21.8999	1.4962	
	8	32	23.1563	1.5249	
	9	28	25.9643	1.9217	
	10	17	28.4118	3.3501	
	11	24	29.2500	2.4774	
	12	24	32.5833	2.9534	34.88
	13	28	35.6786	2.8095	36.70
	14	24	36.8750	3.1566	
	15	27	39.4259	3.1422	
	16	24	41.1250	3.2822	
	17	16	41.0000	4.6416	
	18	20	42.0000	3.6747	
	19	8	38.5000	8.8917	
	20	10	43.8500	7.2635	
	21	10	43.9000	7.2131	
	22	4	42.5000	22.8884	44.07
Ear Length	1	37	1.9959	0.0966	2.60
	2	43	2.5686	0.1816	
	3	36	3.6797	0.2384	4.76
	4	36	4.4264	0.1439	4.85
	5	36	4.9347	0.1627	
	6	34	5.2868	0.1759	
	7	27	5.8074	0.1888	
	8	32	6.0766	0.1564	
	9	28	6.5304	0.2000	
	10	17	7.2618	0.3851	
	11	24	7.5771	0.3284	
	12	24	8.2646	0.3133	8.89
	13	28	9.1678	0.4477	9.95
	14	24	9.9875	0.5484	
	15	27	10.8518	0.4967	
	16	24	11.4375	0.4611	
	17	16	11.8844	0.6044	
	18	20	12.7675	0.4786	
	19	8	13.0000	0.7419	
	20	10	13.7600	0.7338	
	21	10	14.0150	0.7516	
	22	4	14.7625	0.8984	16.28
Hind Foot Length	1	37	6.8216	0.5480	7.54
	2	43	7.6616	0.4807	
	3	36	8.5583	0.5566	9.50
	4	36	9.3055	0.5576	9.98
	5	36	9.8194	0.2017	
	6	34	10.6897	0.2179	
	7	27	11.7000	0.3610	
	8	32	12.5062	0.3175	
	9	28	13.6357	0.3120	
	10	17	14.3147	0.4645	
	11	24	14.7041	0.2664	
	12	24	15.3166	0.2757	17.09
	13	28	15.9071	0.3281	16.36
	14	24	16.2979	0.2601	
	15	27	16.8870	0.2771	
	16	24	17.2374	0.3002	
	17	16	17.3625	0.3660	
	18	20	17.5025	0.2682	
	19	8	17.4937	0.2259	
	20	10	18.1150	0.2083	
	21	10	18.4250	0.3390	
	22	4	18.9750	0.6818	19.18

APPENDIX 3

Growth Data Analyses for *Reithrodontomys megalotis*

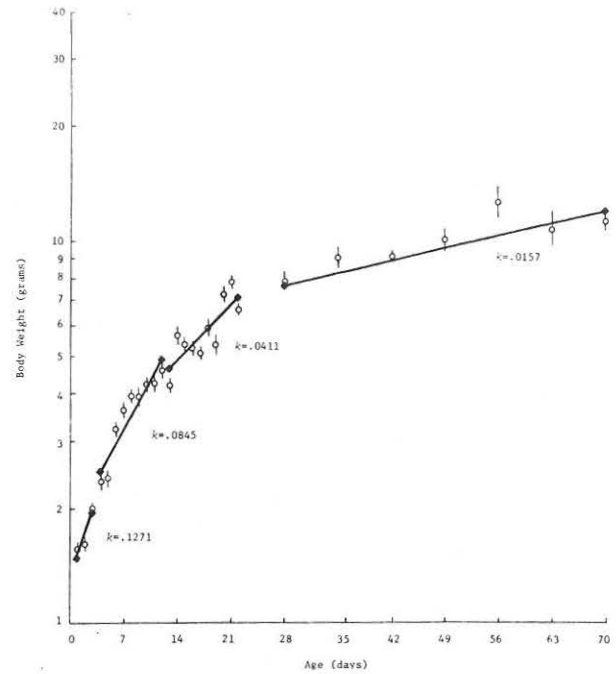

Figure 60. Means, standard errors (p=.95) and growth rates for body weight of *Reithrodontomys megalotis* reared under standard laboratory conditions.

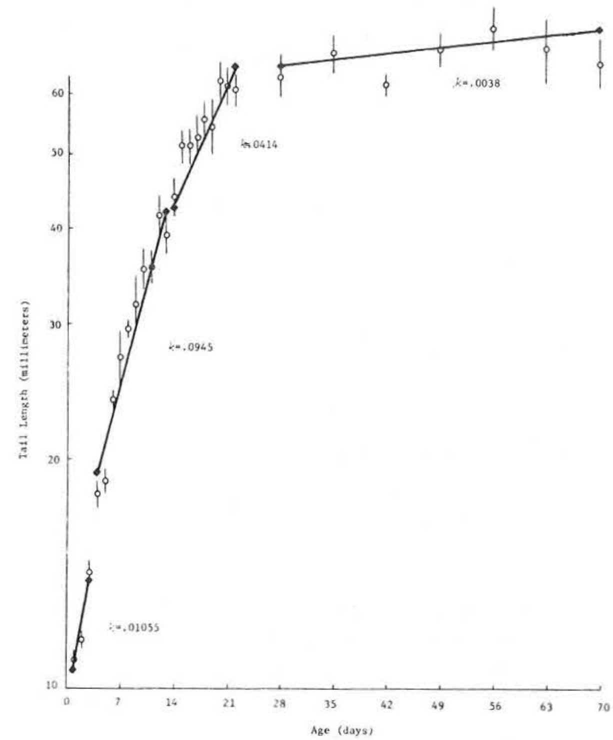

Figure 61. Means, standard errors (p=.95) and growth rates for tail length of *Reithrodontomys megalotis* reared under standard laboratory conditions.

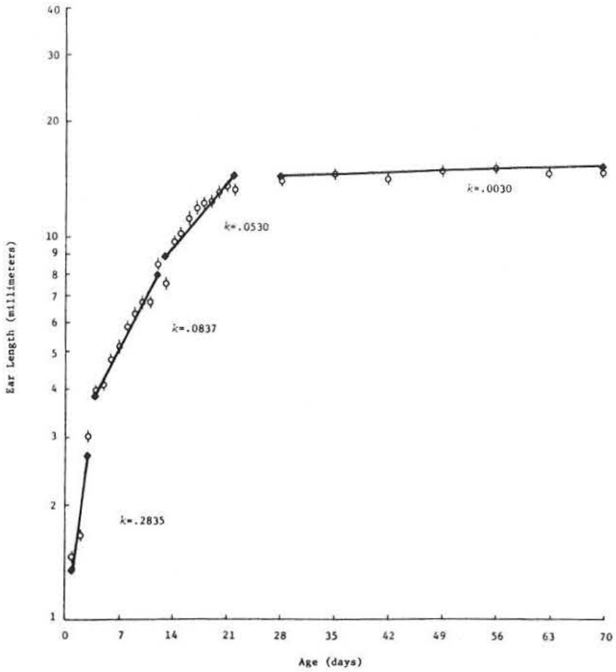

Figure 62. Means, standard errors (p=.95) and growth rates for ear length of *Reithrodontomys megalotis* reared under standard laboratory conditions.

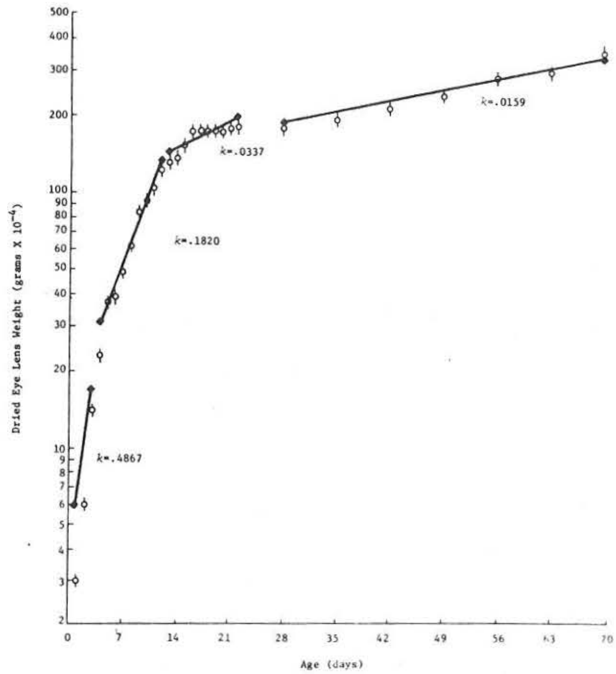

Figure 63. Means, standard errors (p=.95) and growth rates for dried eye lens weight of *Reithrodontomys megalotis* reared under standard laboratory conditions.

Appendix 3 (continued)

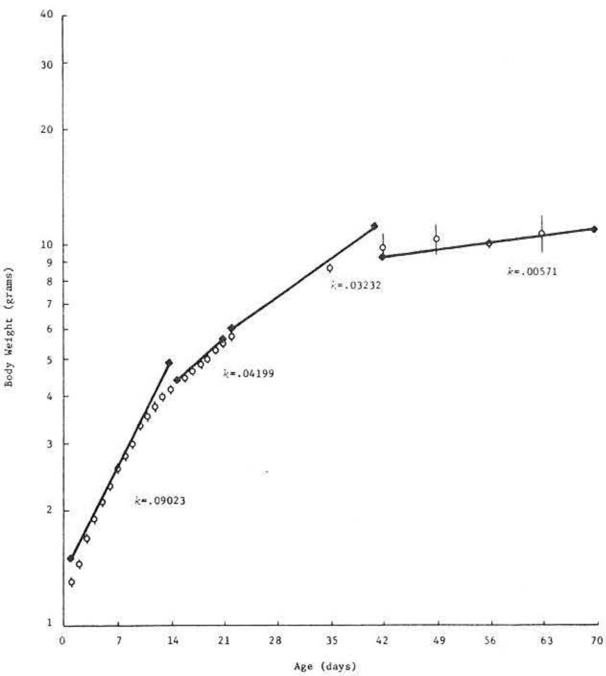

Figure 64. Means, standard errors (p=.95) and growth rates for body weight of *Reithrodontomys megalotis* reared under standard laboratory conditions, model intervals.

Table 25. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *R. megalotis* reared under standard laboratory conditions: n=100

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.2482	0.1271	1-3	0.2813	0.5303*
	0.4029	0.0845	4-12	0.4963	0.7044*
	0.8676	0.0411	13-22	0.2555	0.5055*
	1.8053	0.0157	23-70	0.2092	0.4573*
Total Length	3.7609	0.0647	1-3	0.3550	0.5958*
	3.7895	0.0537	4-12	0.6862	0.8283*
	4.0837	0.0303	13-22	0.5089	0.7133*
	4.7579	0.0044	23-70	0.2299	0.4794*
Tail Length	2.3960	0.1055	1-3	0.4327	0.6577*
	2.4496	0.0945	4-12	0.7285	0.8535*
	3.0958	0.0414	13-22	0.5220	0.7224*
	4.0245	0.0038	23-70	0.1931	0.4394*
Ear Length	0.3730	0.2835	1-3	0.4612	0.6791*
	1.0368	0.0837	4-12	0.7426	0.8617*
	1.4669	0.0530	13-22	0.6001	0.7746*
	2.5732	0.0030	23-70	0.1970	0.4438*
Hind Foot Length	1.8136	0.0887	1-3	0.4904	0.7002*
	1.9031	0.0638	4-12	0.7205	0.8488*
	2.4023	0.0194	13-22	0.4368	0.6609*
	2.8252	0.0009	23-70	0.0453	0.2128*

*significant at α=.05

Table 26. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *R. megalotis* reared under standard laboratory conditions: n=10

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.4087	.1300	1-3	.3195	.5563
	0.6668	.0848	4-12	.6079	.7796*
	0.9555	.0487	13-22	.4854	.6967*
	1.9007	.0084	23-70	.2799	.5290
Total Length	3.7444	.0862	1-3	.6732	.8204*
	3.8684	.0614	4-12	.8251	.9083*
	4.1701	.0329	13-22	.7061	.8402*
	4.8253	.0020	23-70	.2392	.4890
Tail Length	2.3621	.1329	1-3	.5156	.7180*
	2.5983	.1051	4-12	.8171	.9048*
	3.2106	.0467	13-22	.7109	.8431*
	4.1493	.0015	23-70	.6780	.8234*
Ear Length	0.3022	.3401	1-3	.5496	.7413*
	1.1064	.0888	4-12	.8458	.9196*
	1.5477	.0539	13-22	.7394	.8598*
	2.6303	.0010	23-70	.9162	.9571*
Hind Foot Length	1.8138	.0929	1-3	.5784	.7605*
	2.0453	.0577	4-12	.7914	.8896*
	2.4590	.0194	13-22	.6268	.7917*
	2.8773	.0004	23-70	.1776	.4214

*significant at α=.05

Table 27. Data analyses Means and standard errors (p=.95) for growth of *R. megalotis* reared under standard laboratory conditions

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
Body Weight	1	151	1.3030	0.0307	1.45
	2	140	1.4568	0.0397	
	3	134	1.6925	0.0539	1.87
	4	125	1.9166	0.0656	2.09
	5	125	2.1234	0.0730	
	6	125	2.3464	0.0825	
	7	125	2.5864	0.0925	
	8	122	2.8160	0.1130	
	9	118	3.0339	0.1147	
	10	107	3.3602	0.1444	
	11	111	3.5441	0.1428	
	12	104	3.7581	0.1495	4.12
	13	108	3.9671	0.1575	4.05
	14	106	4.1985	0.1682	
	15	105	4.3557	0.1758	
	16	105	4.4742	0.1762	
	17	104	4.6500	0.1832	
	18	104	4.8365	0.1906	
	19	103	5.0732	0.2009	
	20	103	5.3223	0.2018	
	21	102	5.5647	0.2159	
	22	102	5.7441	0.2050	5.87
	28	102	11.6867	8.5544	
	35	100	8.6969	0.2048	
	42	98	9.8078	1.5285	
	49	91	10.4633	1.6535	
	56	86	10.0023	0.3228	
	63	84	11.3810	2.0046	
	70	82	10.8686	0.3644	10.24
Total Length	1	151	43.0464	0.5008	45.60
	2	140	46.1214	0.5162	
	3	134	48.9590	0.5817	52.19
	4	125	52.2040	0.6995	54.81
	5	125	54.9240	0.7831	
	6	125	57.9920	0.9081	
	7	125	61.2920	1.0132	
	8	122	64.5779	1.1172	
	9	118	68.3263	1.1468	
	10	107	72.7150	1.3916	

Appendix 3 (continued)

Table 27 (continued)

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
Total Length	11	111	76.1081	1.4302	
	12	104	80.1154	1.5264	84.18
	13	108	84.0741	1.5290	87.97
	14	106	87.9811	1.5449	
	15	105	91.6762	1.5477	
	16	105	94.9238	1.6067	
	17	104	97.7163	1.5576	
	18	104	100.4375	1.6266	
	19	103	103.5825	1.6272	
	20	103	106.0291	1.6216	
	21	102	108.4265	1.6456	
	22	102	111.4755	2.1697	115.58
	28	102	122.6127	1.2588	
	35	100	127.8250	1.1017	
	42	98	131.4031	1.3759	
	49	91	133.4011	1.9821	
	56	86	133.8139	1.1243	
	63	84	136.3095	2.9351	
	70	82	135.6707	1.2316	158.38
Tail Length	1	151	11.0232	0.1810	12.19
	2	140	12.2750	0.1965	
	3	134	13.6157	0.2309	15.05
	4	125	15.2200	0.2814	16.89
	5	125	17.6840	1.5885	
	6	125	18.7800	0.4266	
	7	125	20.5720	0.4802	
	8	122	22.7213	0.5685	
	9	118	25.0424	0.6208	
	10	107	27.8364	0.7960	
	11	111	30.1532	0.8305	
	12	104	32.7404	0.8773	35.87
	13	108	35.3704	0.8836	37.86
	14	106	37.8396	0.8733	
	15	105	40.0286	0.9111	
	16	105	42.3381	0.9300	
	17	104	44.0048	0.9115	
	18	104	45.6779	0.9376	
	19	103	47.4563	0.9561	
	20	103	48.8155	0.9771	
	21	102	50.2647	0.9793	
	22	102	51.4862	0.9133	54.92
	28	102	58.2304	0.8019	
	35	100	60.9600	0.7528	
	42	98	62.2449	0.7074	
	49	91	62.9890	0.7515	
	56	86	63.4418	0.7826	
	63	84	64.0000	0.7821	
	70	82	64.2012	0.7822	72.96
Ear Length	1	151	1.4967	0.0377	1.92
	2	140	1.9171	0.1002	
	3	134	2.7455	0.1311	3.39
	4	125	3.5589	0.0766	3.94
	5	125	3.9943	0.0772	
	6	125	4.4016	0.0882	
	7	125	4.7386	0.0947	
	8	122	5.0985	0.0985	
	9	118	5.5048	0.1137	
	10	107	6.0610	0.1580	
	11	111	6.5345	0.1742	
	12	104	7.1701	0.2083	7.69
	13	108	7.8156	0.2171	8.62
	14	106	8.5845	0.2389	
	15	105	9.2731	0.2595	
	16	105	9.9854	0.2606	
	17	104	10.5938	0.2342	
	18	104	11.1550	0.2313	
	19	103	11.6317	0.2208	
	20	103	11.9987	0.2080	
	21	102	12.2671	0.2178	
	22	102	12.5317	0.1919	13.90
	28	102	13.5763	0.1423	
	35	100	13.9717	0.1337	
	42	98	14.2571	0.1353	
	49	91	14.3745	0.1400	
	56	86	14.4575	0.1374	
	63	84	14.5630	0.1387	
	70	82	14.6481	0.1514	16.17

Table 27 (continued)

Parameter	Age in Days	Sample Size (N)	Mean X	Standard Error (SE)	Antilog of lnW
Hind Foot Length	1	151	6.1571	0.0751	6.69
	2	140	6.7026	0.0862	
	3	134	7.3515	0.0893	7.99
	4	125	8.0070	0.1135	8.65
	5	125	8.6095	0.1636	
	6	125	9.3322	0.1464	
	7	125	10.0076	0.1559	
	8	122	10.6774	0.1782	
	9	118	11.3757	0.1787	
	10	107	12.1133	0.2193	
	11	111	12.6730	0.2242	
	12	104	13.2587	0.2020	14.41
	13	108	13.7754	0.2914	14.21
	14	106	14.1524	0.1807	
	15	105	14.6079	0.1788	
	16	105	14.9792	0.1856	
	17	104	15.2671	0.1879	
	18	104	15.5409	0.1877	
	19	103	15.8078	0.1754	
	20	103	16.0339	0.1714	
	21	102	16.2087	0.1747	
	22	102	16.4135	0.1642	16.92
	28	102	17.0510	0.1273	
	35	100	17.2401	0.1192	
	42	98	17.3083	0.1168	
	49	91	17.3536	0.1237	
	56	86	17.3926	0.1230	
	63	84	17.4435	0.1205	
	70	82	17.4705	0.1257	17.81

Table 28. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of skulls of *R. megalotis* reared under standard laboratory conditions

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days ($t=t-1$)	R^2	Correlation Coefficient (r)
Dried Eye Lens	-9.6263	0.4867	1-3	0.4323	0.6574*
	-8.6014	0.1820	4-12	0.9322	0.9655*
	-6.9336	0.0337	13-22	0.6200	0.7874*
	-6.7643	0.0159	23-70	0.9804	0.9901*
Skull Total Length	2.2411	0.0683	1-3	0.2656	0.5153
	2.3662	0.0371	4-12	0.6839	0.8269*
	2.6658	0.0113	13-22	0.1985	0.4455
	2.8731	0.0017	23-70	0.2810	0.5300
Zygomatic Breadth	1.6980	0.0496	1-3	0.1116	0.3340
	1.8599	0.0266	4-12	0.5816	0.7626*
	2.0332	0.0106	13-22	0.1004	0.3168
	2.2512	0.0006	23-70	0.0293	0.1711
Foramen Magnum Height	0.7337	0.0570	1-3	0.0517	0.2273
	0.8292	0.0297	4-12	0.4024	0.6343*
	1.0644	0.0090	13-22	0.0835	0.2889
	1.2950	0.0008	23-70	0.0136	0.1166
Mastoidal Breadth	1.5132	0.0362	1-3	0.0457	0.2138
	1.7198	0.0346	4-12	0.5563	0.7458*
	2.0563	0.0033	13-22	0.0454	0.2130
	2.1200	0.0002	23-70	0.0040	0.0632
Nasal Length	0.8588	0.0994	1-3	0.4501	0.6708*
	1.0450	0.0572	4-12	0.7338	0.8566*
	1.4497	0.0216	13-22	0.6049	0.8005*
	1.8263	0.0033	23-70	0.1613	0.4016
Cranium Width	1.7787	0.0461	1-3	0.2434	0.4933
	1.9281	0.0268	4-12	0.6096	0.7807*
	2.1876	0.0044	13-22	0.1397	0.3737
	2.2845	0.0001	23-70	0.0014	0.0374

*significant at α=.05

Appendix 3 (continued)

Table 29. Data analyses. Means and standard errors (p=.95) for growth of skulls of *R. megalotis* reared under standard laboratory conditions

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Lens Weight	1	10	0.0000	0.0000	0.00010
	2	10	0.0001	0.0000	
	3	10	0.0001	0.0001	0.00028
	4	10	0.0002	0.0001	0.00038
	5	10	0.0004	0.0000	
	6	10	0.0004	0.0000	
	7	10	0.0005	0.0000	
	8	10	0.0006	0.0000	
	9	10	0.0008	0.0001	
	10	10	0.0009	0.0001	
	11	10	0.0010	0.0001	
	12	10	0.0012	0.0001	0.00163
	13	10	0.0013	0.0001	0.00151
	14	10	0.0014	0.0000	
	15	10	0.0015	0.0001	
	16	10	0.0018	0.0000	
	17	10	0.0017	0.0001	
	18	10	0.0017	0.0001	
	19	10	0.0018	0.0000	
	20	10	0.0018	0.0000	
	21	10	0.0018	0.0000	
	22	10	0.0018	0.0001	0.00204
	28	10	0.0018	0.0001	
	35	10	0.0020	0.0000	
	42	10	0.0020	0.0000	
	49	10	0.0024	0.0001	
	56	10	Void*	Void*	
	63	10	Void*	Void*	
	70	10	Void*	Void*	
Skull Total Length	1	10	9.5650	0.6574	10.06
	2	10	9.8600	0.6334	
	3	10	10.9520	0.6799	11.18
	4	10	11.7250	0.7814	12.35
	5	10	12.1490	0.3571	
	6	10	12.7910	0.2390	
	7	10	13.9290	1.4013	
	8	10	14.5760	0.2612	
	9	10	14.6230	0.3538	
	10	10	15.0610	0.7228	
	11	10	15.0360	0.8252	
	12	10	15.7220	0.2916	16.62
	13	10	15.5880	0.7350	16.65
	14	10	17.1500	0.3583	
	15	10	16.6790	0.2853	
	16	10	18.4700	2.5292	
	17	10	16.9690	0.3366	
	18	10	17.7120	0.4257	
	19	10	17.5570	0.3724	
	20	10	17.9750	0.2891	
	21	10	18.2750	0.2170	18.43
	22	10	17.6255	0.2289	
	28	10	18.4010	0.4443	
	35	10	19.1890	0.3340	
	42	10	18.6740	0.5681	
	49	10	18.7220	0.1804	
	56	10	20.1720	0.2705	
	63	10	19.8600	0.5967	
	70	9	19.5311	0.5236	19.92
Zygomatic Breadth	1	10	5.6400	0.4694	5.73
	2	10	5.4880	0.4035	
	3	10	6.2190	0.4657	6.33
	4	10	6.8680	0.3869	7.14
	5	10	7.0540	0.3718	
	6	10	7.2480	0.1338	
	7	10	7.5690	0.3784	
	8	10	8.2180	0.1840	
	9	10	8.0980	0.2124	
	10	10	8.1860	0.2293	
	11	10	8.1220	0.3726	
	12	10	8.5070	0.2726	8.83
	13	10	8.4660	0.5107	8.76
	14	10	8.6960	1.1542	
	15	10	9.0450	0.1968	
	16	10	9.4430	0.3095	
	17	10	8.9330	0.2734	
	18	10	9.2580	0.3174	
	19	10	9.4310	0.2261	
	20	10	9.6470	0.2008	

Table 29 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Zygomatic Breadth	21	10	9.3090	0.2145	
	22	10	9.2178	0.3261	9.64
	28	10	9.7610	0.3328	
	35	10	9.7410	0.2063	
	42	10	9.6050	0.2818	
	49	10	9.3360	0.1303	
	56	10	10.3390	0.3856	
	63	10	10.1050	0.3586	
	70	9	9.6711	0.1978	9.90
Foramen Magnum Height	1	10	2.2560	0.3172	0.85
	2	10	1.9970	0.2866	
	3	10	2.4920	0.1939	2.46
	4	10	2.7230	0.1977	2.58
	5	10	2.4820	0.1759	
	6	10	2.6550	0.1711	
	7	10	2.6100	0.1626	
	8	10	2.9000	0.1221	
	9	10	3.1270	0.1947	
	10	10	2.9480	0.1625	
	11	10	3.0750	0.2272	
	12	10	3.2810	0.1751	
	13	10	2.9820	0.2289	3.27
	14	10	3.2580	0.1059	3.25
	15	10	3.5090	0.1349	
	16	10	3.4720	0.1503	
	17	10	3.2830	0.1753	
	18	10	3.6270	0.2477	
	19	10	3.4200	0.0582	
	20	10	3.2150	0.2212	
	21	10	3.4280	0.1424	
	22	10	3.5778	0.1714	
	28	10	3.5560	0.2599	3.53
	35	10	3.5600	0.2406	
	42	10	3.5740	0.1715	
	49	10	3.3310	0.2457	
	56	10	3.6760	0.2940	
	63	10	3.6210	0.1544	
	70	9	3.3244	0.2988	3.86
Mastoidal Breadth	1	10	4.7670	0.4408	4.54
	2	10	4.3440	0.2829	
	3	10	5.0730	0.3833	5.00
	4	10	5.9340	0.6280	6.41
	5	10	6.3170	0.4189	
	6	10	6.8050	0.1668	
	7	10	6.8410	0.3154	
	8	10	7.7810	0.1288	
	9	10	7.5360	0.1775	
	10	10	7.6650	0.3110	
	11	10	7.7480	0.3975	
	12	10	7.7970	0.2286	8.45
	13	10	7.8020	0.4403	8.15
	14	10	8.4310	0.1364	
	15	10	8.2300	0.1942	
	16	10	8.5860	0.1868	
	17	10	8.0000	0.1545	
	18	10	8.3310	0.2164	
	19	10	8.4100	0.1732	
	20	10	8.2790	0.1447	
	21	10	8.4640	0.1487	
	22	10	8.2411	0.1669	8.39
	28	10	8.4290	0.2079	
	35	10	8.4400	0.0864	
	42	10	8.3120	0.2813	
	49	10	8.0870	0.0597	
	56	10	8.7350	0.3327	
	63	10	8.5980	0.1707	
	70	9	8.2933	0.2827	8.44
Nasal Length	1	10	2.4050	0.1617	2.60
	2	10	2.5360	0.1101	
	3	10	2.9390	0.2339	3.18
	4	10	3.3770	0.3387	3.57
	5	10	3.4460	0.1053	
	6	10	3.8750	0.1568	
	7	10	3.9080	0.3758	
	8	10	4.5010	0.0719	
	9	10	4.5290	0.2153	
	10	10	5.0300	0.2869	
	11	10	4.8450	0.2265	
	12	10	5.1940	0.2732	5.64
	13	10	5.4010	0.1968	5.64
	14	10	5.7790	0.1348	
	15	10	5.7760	0.1431	

Appendix 3 (continued)

Table 29 (continued)

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Nasal Length	16	10	6.0550	0.1751	
	17	10	5.9120	0.2249	
	18	10	6.3230	0.2554	
	19	10	6.2070	0.2331	
	20	10	6.6350	0.2108	
	21	10	6.6560	0.1630	
	22	10	6.4567	0.1509	6.84
	28	10	6.8250	0.2389	
	35	10	7.3130	0.1420	
	42	10	6.5550	0.9156	
	49	10	7.4780	0.2338	
	56	10	7.8740	0.3543	
	63	10	7.7650	0.2844	
	70	9	7.6344	0.2324	7.82
Cranium Width	1	10	5.9720	0.3018	6.19
	2	10	6.1330	0.1936	
	3	10	6.5540	0.3870	6.80
	4	10	7.3580	0.4551	7.65
	5	10	7.4340	0.3044	
	6	10	7.9680	0.1461	
	7	10	8.0370	0.2995	
	8	10	8.8880	0.1330	
	9	10	8.5920	0.2874	
	10	10	8.8910	0.3085	
	11	10	8.6920	0.2869	
	12	10	9.0890	0.1603	13.07
	13	10	9.0940	0.3371	9.43
	14	10	9.7160	0.1790	
	15	10	9.5020	0.1439	
	16	10	9.7450	0.2027	
	17	10	9.4350	0.2004	
	18	10	9.7080	0.1183	
	19	10	9.7430	0.1467	
	20	10	9.6350	0.1517	
	21	10	9.7180	0.1664	
	22	10	9.8100	0.1331	9.81
	28	10	9.7530	0.2141	
	35	10	9.9440	0.1902	
	42	10	9.9280	0.4005	
	49	10	9.6780	0.1117	
	56	10	10.0990	0.2916	
	63	10	9.8760	0.3245	
	70	9	9.8433	0.2423	9.88

* Data unavailable due to computer manipulation.

Table 30. Data analyses. Instantaneous relative growth rates and correlation coefficients for growth of *R. megalotis* reared under standard laboratory conditions: model intervals

Parameter	lnA	Instantaneous Relative Growth Rate (k)	Age in Days (t=t-1)	R^2	Correlation Coefficient (r)
Body Weight	0.33029	0.09023	1-14	0.74916	0.86554*
	0.85098	0.04199	15-21	0.14733	0.38383*
	1.08858	0.03232	22-41	0.26808	0.51776*
	1.98889	0.00571	42-70	0.55358	0.74402*
Total Length	3.77750	0.05474	1-14	0.86087	0.92783*
	4.12594	0.02813	15-21	0.31243	0.55895*
	4.49742	0.01066	22-41	0.41304	0.64268*
	4.82693	0.00127	42-70	0.50785	0.71263*
Tail Length	2.42409	0.09616	1-14	0.88997	0.94338*
	3.16993	0.03761	15-21	0.31927	0.56503*
	3.68036	0.01300	22-41	0.43059	0.65619*
	4.08278	0.00117	42-70	0.40939	0.63983*
Ear Length	0.67954	0.12323	1-14	0.82769	0.90977*
	1.57607	0.04763	15-21	0.40071	0.63301*
	2.35961	0.00840	22-41	0.33423	0.57812*
	2.61659	0.00097	42-70	0.44107	0.66413*
Hind Foot Length	1.86536	0.06594	1-14	0.88057	0.93838*
	2.44274	0.01736	15-21	0.24662	0.49660*
	2.72306	0.00377	22-41	0.18046	0.42480*
	2.83609	0.00035	42-70	0.01134	0.10648

*significant at α=.05

Table 31. Data analyses. Means and standard errors (p=.95) for growth of skulls of *R. megalotis* reared under standard laboratory conditions: model intervals

Parameter	Age in Days	Sample Size (N)	Mean $\bar{X}$	Standard Error (SE)	Antilog of lnW
Body Weight	1	151	1.3030	0.0307	1.52
	2	140	1.4568	0.0397	
	3	134	1.6925	0.0539	
	4	125	1.9166	0.0656	
	5	125	2.1234	0.0730	
	6	125	2.3464	0.0825	
	7	125	2.5864	0.0925	
	8	122	2.8160	0.1130	
	9	118	3.0339	0.1147	
	10	107	3.3602	0.1444	
	11	111	3.5441	0.1428	
	12	104	3.7581	0.1495	
	13	108	3.9671	0.1575	
	14	106	4.1985	0.1682	4.91
	15	105	4.3557	0.1758	4.39
	16	105	4.4742	0.1762	
	17	104	4.6500	0.1832	
	18	104	4.8365	0.1906	
	19	103	5.0732	0.2009	
	20	103	5.3223	0.2018	
	21	102	5.5647	0.2159	5.65
	22	102	5.7441	0.2050	6.04
	28	102	11.6867	8.5544	
	35	100	8.6969	0.2048	
	42	98	9.8078	1.5285	9.28
	49	91	10.4633	1.6535	
	56	86	10.0023	0.3228	
	63	84	11.3810	2.0046	
	70	82	10.8686	0.3644	10.81

APPENDIX 4

Definition of State Variables in the Demographic Model

Mathematical symbol	Definition	Units
$N_1(t)$	Number of fetuses at time t.	number/ha
$N_2(t)$	Number of sucklings at time t.	number/ha
$N_{3,1}(t)$	Number of juveniles in their first week at time t.	number/ha
$N_{3,2}(t)$	Number of juveniles in their second category at time t.	number/ha
$N_4(t)$	Number of subadult males at time t.	number/ha
$N_5(t)$	Number of subadult females at time t.	number/ha
$N_{5,1}(t)$	Number of subadult females that are pregnant but not lactating at time t.	number/ha
$N_{5,2}(t)$	Number of subadult females that are lactating but not pregnant at time t.	number/ha
$N_{5,3}(t)$	Number of subadult females that are both pregnant and lactating at time t.	number/ha
$N_{5,4}(t)$	Number of non-reproducing subadult females at time t.	number/ha
$N_6(t)$	Number of adult males at time t.	number/ha
$N_7(t)$	Number of adult females at time t.	number/ha
$N_{7,1}(t)$	Number of adult females that are pregnant but not lactating at time t.	number/ha
$N_{7,2}(t)$	Number of adult females that are lactating but not pregnant at time t.	number/ha
$N_{7,3}(t)$	Number of adult females that are both pregnant and lactating at time t.	number/ha
$N_{7,4}(t)$	Number of non-reproducing adult females at time t.	number/ha
$N_{5,1,m}(t)$	Number of pregnant subadult females at time t in the m^{th} week of gestation.	number/ha
$N_{7,1,m}(t)$	Same as $N_{5,1,m}(t)$, but for adult females.	number/ha
$N_{5,2,m}(t)$	Number of lactating subadult females at time t in the m^{th} week of lactation.	number/ha
$N_{7,2,m}(t)$	Same as $N_{5,2,m}(t)$, but for adult females.	number/ha
$N_{5,3,k,m}(t)$	Number of subadult females that are both lactating and pregnant at time t in the k^{th} week of lactation and the m^{th} week of gestation.	number/ha
$N_{7,3,k,m}(t)$	Same as $N_{5,3,k,m}(t)$ but for adult females	number/ha

APPENDIX 5

Definition of Intermediate Algebraic Variables in the Demographic Model

Mathematical symbol	Definition	Units
B	Number of eggs fertilized during a time interval.	number/ha/week
R_2	Number of animals born in a time interval.	number/ha/week
R_3	Number of sucklings weaned in a time interval.	number/ha/week
$R_{4,1}$	Number of juvenile I animals that advance to the next age category.	number/ha/week
$R_{4,2}$	Number of animals that leave the juvenile II category in a time interval.	number/ha/week
R_6	Number of subadult males that advance into the next age category.	number/ha/week
R_7	Number of subadult females that advance into the next age category.	number/ha/week
D_1	Number of aborted fetuses in a time interval.	number/ha/week
D_2	Number of sucklings that died of non-predatory causes in a time interval.	number/ha/week
$D_{3,1}$	Number of juvenile I animals that died of non-predatory causes in a time interval.	number/ha/week
$D_{3,2}$	Number of juvenile II animals that died of non-predatory causes in a time interval.	number/ha/week
D_4	Number of subadult males that died of non-predatory causes in a time interval.	number/ha/week
D_5	Number of subadult females that died of non-predatory causes in a time interval.	number/ha/week
D_6	Number of adult males that died of non-predatory causes in a time interval	number/ha/week
D_7	Number of adult females that died of non-predatory causes in a time interval.	number/ha/week
$D_{5,2}$	Number of pregnant subadult females that died in a time interval.	number/ha/week
$D_{5,2,m}$	Number of pregnant subadult females in the m^{th} week of gestation that died of non-predatory causes in a time interval.	number/ha/week
$D_{5,3}$	Number of the lactating subadult females that died in a time interval.	number/ha/week
$D_{5,3,m}$	Number of lactating subadult females in the m^{th} week of lactation that died of non-predatory causes in a time interval.	number/ha/week
$D_{5,4}$	Number of subadult females that are both lactating and pregnant, that died in a time interval.	number/ha/week
$D_{5,4,m}$	Number of subadult females that are both lactating and pregnant in the k^{th} week of lactation and in the m^{th} week of gestation that died of non-predatory causes in a time interval.	number/ha/week
$D_{7,2}$, $D_{7,2,m}$, $D_{7,3}$, $D_{7,3,m}$	Same as $D_{5,2}$; $D_{5,2,m}$; $D_{5,3}$; $D_{5,3,m}$; but for adult females.	number/ha/week
$D_{7,4}$, $D_{7,4,k,m}$	Same as $D_{5,4}$ and $D_{5,4,k,m}$, but for adult females.	number/ha/week
P_2	Number of sucklings killed by predators in a time interval.	number/ha/week
$P_{3,1}$	Number of juvenile I animals killed by predators in a time interval.	number/ha/week
$P_{3,2}$	Number of juvenile II animals killed by predators in a time interval.	number/ha/week
P_4	Number of subadult males killed by predators in a time interval.	number/ha/week
P_5	Number of subadult females killed by predators in a time interval.	number/ha/week
P_6	Number of adult males killed by predators in a time interval.	number/ha/week
P_7	Number of adult females killed by predators in a time interval.	number/ha/week
$P_{5,2,m}$	Number of pregnant subadult females in the m^{th} week of gestation that are killed by predators in a time interval.	number/ha/week
$P_{5,3,m}$	Number of lactating subadult females in the m^{th} week of lactation that are killed by predators in a time interval.	number/ha/week
$P_{5,4,k,m}$	Number of subadult females that are both lactating and pregnant in the k^{th} week of lactation and the m^{th} week of gestation that are killed by predators in a time interval.	number/ha/week
$P_{7,2,m}$, $P_{7,3,m}$, $P_{7,4,k,m}$	Same as $P_{5,2,m}$; $P_{5,3,m}$, and $P_{5,4,k,m}$; but for adult females.	number/ha/week
$Q_{5,1}$	Number of non-reproducing subadult females that become pregnant in a time interval.	number/ha/week
$Q_{5,4}$	Number of subadult females that are both pregnant and lactating, and with sucklings either weaned or killed during a time interval.	number/ha/week
$Q_{5,5}$	Number of lactating subadult females with sucklings either weaned or killed during a time interval.	number/ha/week
$Q_{5,6}$	Number of subadult females that are both lactating and pregnant, that abort their fetuses in a time interval.	number/ha/week
$Q_{5,7}$	Number of pregnant subadult females that abort their fetuses in a time interval.	number/ha/week
$Q_{7,1}$ to $Q_{7,7}$	Same as $Q_{5,1}$ to $Q_{5,7}$, respectively; but for adult females.	number/ha/week
b_1	Per female pregnancy rate, as a function of the individual animals age.	$week^{-1}$
b_2	Correction factor of the pregnancy rate (b_1) as a function the density of mature males.	none
b_3	Correction factor of the pregnancy rate (b_1) as a function of the females consumption rate.	none

Appendix 5 (continued)

Mathematical symbol	Definition	Units
b_4	Correction factor of the pregnancy rate (b_1) as a function of the nutrient content in the food consumed.	none
b_5	Correction factor of the pregnancy rate (b_1) as a function of the time of year.	none
$s_{1,1}$	Optimum survival rate per individual fetus, as a function of the mothers age.	$week^{-1}$
$s_{1,2}$	Correction factor of the optimum survival rate ($s_{1,1}$) for the fetuses, as a function of mother's consumption rate.	none
$s_{1,3}$	Correction factor of the optimum survival rate ($s_{1,1}$) for the fetuses, as a function of the nutrient content in the mother's food.	none
$s_{2,1}$	Optimum survival rate per individual suckling. (actually a parameter)	$week^{-1}$
$s_{2,2}$	Correction factor of the optimum survival rate for the sucklings, as a function of the mother's consumption rate.	none
$s_{2,3}$	Correction factor of the optimum survival rate for the sucklings, as a function of the nutritional content in the mother's food.	none
$s_{3,1,1}$	Optimum per animal survival rate of the juvenile I category, as a function of their weight as sucklings.	$week^{-1}$
$s_{3,1,2}$	Correction factor for the survival rate of the juvenile I category, as a function of the number of weaned animals in the area.	none
$s_{3,1,3}$	Correction factor for the survival rate of the juvenile I category, as a function of the animal's consumption rate.	none
$s_{3,1,4}$	Correction factor for the survival rate of the juvenile I category, as a function of the nutrient content in their food.	none
$s_{3,1,5}$	Correction factor for the survival rate of the juvenile I category, as a function of soil moisture.	none
$s_{3,2,1}$	Optimum per animal survival rate of the juvenile II category. (actually a parameter)	$week^{-1}$
$s_{3,2,2}$ to $s_{3,2,5}$	Same as $s_{3,1,2}$ to $s_{3,1,5}$, respectively but for the juvenile II category.	none
$s_{4,3}$ to $s_{4,5}$	Same as $s_{3,1,3}$ to $s_{3,1,5}$, respectively but for the subadult male category.	none
$s_{5,3}$ to $s_{5,5}$	Same as $s_{3,1,3}$ to $s_{3,1,5}$, respectively but for the subadult female category.	none
$s_{6,3}$ to $s_{6,5}$	Same as $s_{3,1,3}$ to $s_{3,1,5}$, respectively but for the subadult male category.	none
$s_{7,3}$ to $s_{7,5}$	Same as $s_{3,1,3}$ to $s_{3,1,5}$, respectively but for the adult female category.	none

Mathematical symbol	Definition	Units
α_1	Assymptote of b_2.	none
γ_1	Parameter controlling the rate at which the assymptote α_1, is approached.	——[a]
α_2	Assymptote of $s_{3,1,1}$.	$week^{-1}$
γ_2	Parameter controlling the rate at which the assymptote, α_2, is approached.	——[a]
α_3	Assymptote of $s_{3,1,5}$.	none
γ_3	Parameter controlling the rate at which the assymptote α_3 is approached.	——[a]
I_f	Index measuring the actual consumption rate, relative to the maximum consumption rate of an animal.	none
I_{act}	Actual consumption rate of an animal.	cal/week
I_{max}	Assymptote of the functional response curve, i.e. the maximum consumption rate of an animal.	cal/week
Nu	Nutrient content of the animals food measured by the P-content.	% P of dry wt
T	Time of the year. (1-360)	days
$\mu(T)$	Mean number of young in the litter.	number
$\overline{Wt}$	Mean weight of the sucklings.	grams
$\overline{Wt}(t-1)$	The individual weight of the sucklings at the end of the last week before weaning.	grams
$\overline{Wt}(t-2)$	The individual weight of the sucklings at the end of the pentultimate week before weaning.	grams
Wa	Soil moisture.	% water
n_p	Number of time intervals in the gestation period.	weeks
n_l	Number of time intervals in the lactation period.	weeks

[a]The units, although available, are not useful to the model.

APPENDIX 6

Definition of Parameter Used with Values Proposed to be Used for the Different Species

Mathematical Symbol	Definition	Unit	Proposed Value to be Used [a]		
			Peromyscus maniculatus	*Dipodomys ordii*	*Reithrodontomys megalotis*
$b_{1,1}$	The average optimum value of b_1 for subadult females.	$week^{-1}$	.5	.5	.5
N_{opt}	Number of mature males at which the value of b_2 is 1.	number/ha	7	2	7
$N_{m,max}$	Number of mature males at which the value of b_2 is 0, and for densities above which b_2 will continue to be 0.	number/ha	300	12-13	300
$N_{t,max}$	The maximum number of weaned animals that can be in the area.	number/ha	700	30	700
$I_{f,min}$	The minimum value of I_f at which the animal can still be alive.		.625	.571	.600
Nu_{min}	The minimum phosphorus content in the food at which level the animal can still be alive.	%P of dry wt.	___ [b]	___ [b]	___ [b]
Nu_{max}	That phosphorus content at which an increase will not result in any increase of the survival rate.	%P of dry wt.	___ [b]	___ [b]	___ [b]
T_{stop}	Time of the year at which the breeding stops	days	none	240	none
T_{start}	Time of the year at which the breeding starts.	days	none	30	none
ν_{min}	Minimum mean number of young per litter.	number/litter	4	3	4
ν_{max}	Maximum mean number of young per litter.	number/litter	5	4	5
$s_{2,1}$	Maximum survival rate for sucklings.	$week^{-1}$	.085-.09	.085-.09	.085-.09
$s_{3,2,1}$	Maximal survival rate for the juvenile II category.	$week^{-1}$	1	1	1
$\overline{Wt}_{min}$	That value of $\overline{Wt}$ which is so that a decrease of $\overline{Wt}$ will result in immediate death of the juvenile I animals.	grams			
$\overline{Wt}_{max}$	That $\overline{Wt}$ which will result in $s_{3,1,1} = 1$.	grams			
Wa_{min}	The minimum soil moisture in which animals can survive.	% water	___ [c]	___ [c]	___ [c]
Wa_{max}	That soil moisture at which an increase will not result in further increase in the survival rate.	% water	___ [c]	___ [c]	___ [c]

Appendix 6 (continued)

Mathematical symbol	Definition	Unit	Proposed Value to be Used		
			Peromyscus maniculatus	*Dipodomys ordii*	*Reithrodontomys megalotis*
τ_1	Length of the gestation period.	days	21-22	25-28	21-22
τ_2	Length of the lactation period.	days	14-16	21-22	13-15
$\tau_{3,1}$	Length of the juvenile I category.	days	7	7	7
$\tau_{3,2}$	Length of the juvenile II category.	days	19-21	32-37	15-20
τ_4	Length of the subadult male category.	days	25-30	30-40	25-30
τ_5	Length of the subadult female category.	days	25-30	30-40	25-30
τ_6	Length of the adult male category.	days	400	700	400
τ_7	Length of the adult female category.	days	400	700	400

[a]These values are tentative and may change as available data are analysed more completely.

[b]SCHULTZ (1969) used 0.06% as the lower limit and .6% as the upper limit for *Lemmus trimucronatus* in Barrow, Alaska. These values have not yet been estimated for desert small mammals.

[c]These data are not yet available and may have to refer to the burrow humidity.