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Body size, organ size, and sex ratios in adult and yearling Belding ground squirrels

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BODY SIZE, ORGAN SIZE, AND SEX RATIOS IN ADULT AND YEARLING BELDING GROUND SQUIRRELS

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Abstract.— A five-year study of Belding ground squirrels was conducted at high altitude in the Sierra Nevada. Body weight and body length varied seasonally depending upon the fat depletion-deposition cycle, age, and sex. Adult males tended to be heavier and longer than adult females, particularly in the last half of the active season. A similar pattern was present in yearlings. Yearling squirrels were often distinguishable from adults on the basis of body size. Mean body weights were greater in adults throughout the season, and mean body lengths were greater in adults through the first half of the season. Adults also had larger internal organs than yearlings at the beginning of the season. In liver and heart this difference was sustained. Sex ratios in adults and in yearlings were 1:1 but there was considerable spatial and temporal asymmetry in distribution of the sexes. Males tended to live in areas peripheral to lush meadows occupied by females and young.

The Belding ground squirrel (*Spermophilus beldingi beldingi*) is a hibernator that lives in the central Sierra Nevada Mountains mainly from the eastern divide to the edge of the Great Basin at altitudes between 1,825 m and 3,650 m (Storer and Usinger, 1970). During a five-year, mark-release study of *S. b. beldingi* our records of retrapped animals enabled us to compile data on individuals of known age and sex for prolonged periods. In the course of this study it became clear that three functional groups, based upon age, existed within the population: juveniles, yearlings, and adults. Characteristics of juveniles have been previously reported (Morton, Maxwell, and Wade, 1974). Herein we report on seasonal changes in body size, organs, and on sex ratios in both yearling and adult *S. b. beldingi*.

Methods

The study was conducted from 1969 through 1973 in meadows and their bordering areas in Lee Vining Canyon, Mono County, California. Most of our information stems from work done at Big Bend (elevation ca 2,100 m) and especially at Tioga Pass (elevation ca 3,000 m). The active seasons are similar in duration for populations at both areas but may begin six weeks or more apart due to climatic differences associated with altitude (Morton, 1975). All data reported on body weights, body lengths, and sex ratios of squirrels of known age are from Tioga Pass animals. Data on organ weights were combined for the two populations at 10-day intervals throughout the active season in order to bolster sample size.

Squirrels were captured alive in Tomahawk wire-mesh traps baited with peanut butter. Those to be released were toe-clipped, and those retained for specimens were etherized. In some cases specimens were collected with a .22 caliber rifle. Body weights were measured to the nearest 0.1 g on a pan balance. Body lengths were taken with calipers to the nearest 0.1 cm. Wet weights of freshly excised and debrided organs were measured to the nearest 0.01 g on an analytical pan balance.

Certain small meadows or sections of large meadows were used only for mark-release studies. Separate data logs were maintained for each toe-clipped animal. In our terminology juveniles are the young of the year, yearlings were born in the preceding year, and adults are all animals older than yearlings.

Results

The first *S. b. beldingi* to emerge each season were adult males. Within a few days, however, some adult females and yearlings could be found. The pace of emergence varied somewhat from year to year, depending upon snow cover. Adults tended to enter hibernation earlier than yearlings. On the average each individual was active above ground for about three months (Morton, 1975).

Body weight.— There were large seasonal differences in body weight due primarily to fat depletion or deposition and to sex and age differences (Fig. 1).

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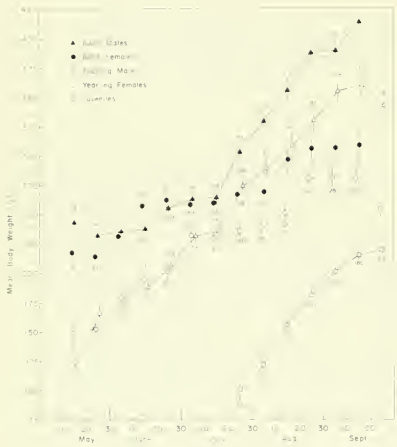

Fig. 1. Seasonal change in mean body weight of *Spermophilus beldingi beldingi* at Tioga Pass. Data were accumulated over five seasons, 1969-73. Numerals indicate sample size; vertical bars denote ± 2 S.E.

Upon emerging in mid-May adult females at Tioga Pass were lighter than adult males, but during pregnancy they became heavier than males. In late July and for the remainder of the active season mean weights of adult males were significantly greater than those of adult females ($P<0.05$). The sexes of yearlings were not different in weight until late July. Thereafter, as in adults, males were heavier. Seasonal trends in body weight were much the same for each sex, particularly in the second half of the season. During the first half of the season yearlings were still growing rapidly. As a group, yearlings never achieved adult weight. Adults were significantly heavier ($P<0.05$) than their yearling counterparts of the same sex at every class interval throughout the season. The large weight gain observed in all animals during the last half of the season was due to fat deposition (Morton, 1975).

Body length.— Growth in yearlings, as indicated by body length, occurred throughout the season (Fig. 2), but from

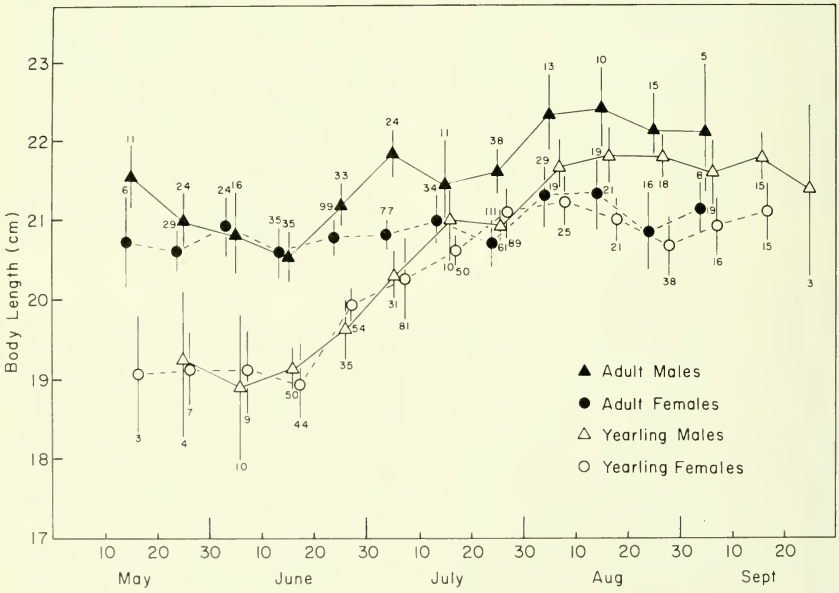

Fig. 2. Seasonal change in mean body length of *Spermophilus beldingi beldingi* at Tioga Pass. Data were accumulated over five seasons, 1969-73. Numerals indicate sample size; vertical bars denote ± 2 S.E.

mid-July on yearling females as a group were indistinguishable from adult females in body length. The same was true of males except that the smaller males handled in August and September invariably were yearlings.

Body length increased in adult males as the season progressed, suggesting that maximum size in *S. b. beldingi* males may not be reached until beyond their second year of life.

Organ weights.— Liver weights increased rapidly following emergence in all animals (Fig. 3), but the increase was more rapid in females than in males. Between the third and sixth weeks of activity livers of females were larger than those of males ($P<0.05$). Liver hypertrophy in females was coincident with lactation.

By the twelfth week of the season yearlings had livers of adult size. Livers for all ages and sexes were smaller at the end of hibernation than at the beginning. Apparently this organ atrophied during hibernation.

The heart, kidneys, and spleen, were larger in adults than in yearlings during the first part of the season (Fig. 4). This difference was particularly noticeable and prolonged in heart weight.

Sex Ratios.— During the five years of this study a total of 341 yearlings (170 males and 171 females) and 484 adults (238 males and 246 females) were handled. The sex ratio for either age group did not differ from 1:1 according to a chi-square test ($P>0.50$).

Discussion

Body size.— Although yearling ground squirrels often represent a substantial por-

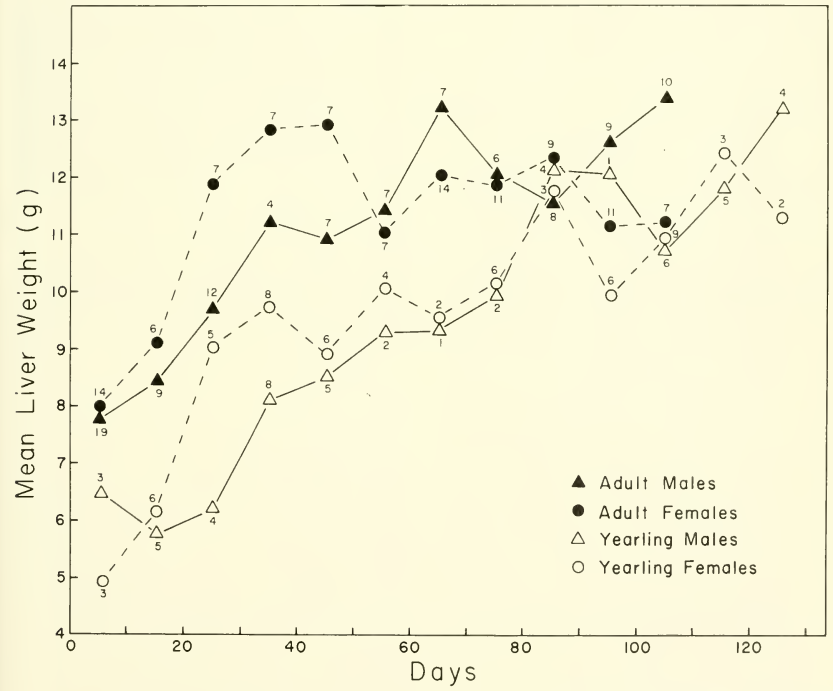

Fig. 3. Seasonal changes in mean liver weight of *Spermophilus beldingi beldingi* from Big Bend and Tioga Pass. Numerals indicate sample size. Day 0 of abscissa refers to time first squirrels emerged from hibernation.

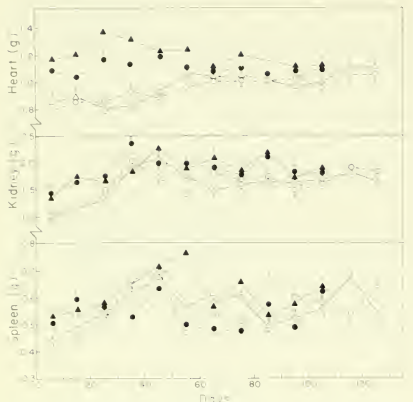

Fig. 4. Seasonal changes in mean weight of spleen, kidneys, and heart in *Spermophilus beldingi beldingi* from Big Bend and Tioga Pass. Numerals indicate sample size. Symbols as in Figure 3. Day 0 of abscissa refers to time first squirrels emerged from hibernation.

tion of the population and may interact in unique ways with other members (Michener and Michener, 1973), there is little published evidence that they differ externally from older animals. Even in such large-bodied species as *S. undulatus* juveniles reach adult size, or nearly so, by the time they are ready for hibernation (Mayer and Roche, 1954). *A priori* this might be predicted since captive juveniles of hibernatory *Spermophilus*, particularly those from high latitude or high altitude, tend to be precocious and to have exceptionally high growth rates (Clark, 1970; Morton and Tung, 1971). In the case of *S. b. beldingi*, at least, by the time they enter hibernation feral juveniles have foot and tail lengths indistinguishable from those of adults (Morton and Tung, 1971). Nonetheless, neither maximum body weight nor maximum body length is achieved in *S. b. beldingi* until well into the second or possibly even third year of life. Furthermore, we have found that yearling males are sexually immature and do not reproduce (Morton and Gallup, unpubl.). Yearling females do reproduce. Similar age differences in reproductive capacity have been found in *S. armatus* (Slade and Balph, 1974).

The differences in body size noted in age classes of *S. b. beldingi* probably are not unique among ground squirrels. Such differences are likely to be overlooked unless the investigator examines large numbers of animals of known age over a span of several consecutive seasons.

Sex ratios.— An unbalanced sex ratio in favor of females has been reported for many ground squirrel populations. This ratio may approach or exceed 3:1 (McCarley, 1966; Michener and Michener, 1971; Sheppard, 1972; Turner, 1972). In a few cases, however, the ratio found did not differ significantly from 1:1 (Clark, 1970; Murie, 1973; present study). In his study of *S. b. oregonus*, Turner (1972) found that the sex ratio was 1:1 in juveniles. He suggests that because juvenile males tend to wander and explore more than females they incur greater mortality, resulting in an unbalanced sex ratio in older animals. In *S. b. beldingi* the sex ratio in juveniles is also 1:1; males probably wander more than females in that they have larger home ranges than females and are more likely to expand their range late in the season (Morton, Maxwell, and Wade, 1974). Although this behavior would seem to make juvenile males more susceptible to predation, we have no evidence that it does. To the contrary, males and females occur in equal numbers in both yearlings and adults. The sexes are not distributed randomly throughout the habitat occupied, however. In our trapping at burrow systems located in lush meadow areas reserved for mark-release studies, adult females outnumbered males by 1.3:1 when all data were summed. The ratio tended to fluctuate seasonally, however, and was sometimes near 3:1, particularly at midseason. We often captured adult males at a particular burrow system only a few times per season, during the first days or weeks following emergence and again at the very end of the season. This suggests that some males were forced from the colony by conflicts associated with reproduction and were able to return only in time to enter their traditional hibernaculum. If this is correct, it follows that displaced males should be found in areas peripheral to main colonies. We found this to be the case. When males were desired for specimens, they could usually be found by collecting animals scattered in lodgepole pine stands fringing mea-

dows, and in rocky outcrops and talus slopes in steep areas above the meadows

A tendency for males to live in areas peripheral to the main colonies has been observed previously in *S. armatus* (Balph and Stokes, 1963) and in *S. richardsonii* (Quanstrom, 1971). Turner (1972) did not believe, however, that this occurred in *S. b. oregonus*. The spatial distribution of the sexes could vary enormously depending upon such factors as habitat physiography and upon intrinsic characteristics of the population itself.

Undoubtedly unbalanced sex ratios exist in many ground squirrel populations. Such ratios may be a function of interpopulational or interspecific differences in breeding systems and social organization (Murie, 1973). However, an investigator who confines his work to locations with maximum animal density or to those of easy accessibility could obtain an inaccurate measurement of sex ratio.

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