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ANNUAL CYCLE OF ACTIVITY, REPRODUCTION, AND BODY MASS OF ANATOLIAN GROUND SQUIRRELS (*SPERMOPHILUS XANTHOPRYMNUS*) IN TURKEY

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Over a 3-year period (1999–2001), we monitored the annual timing of reproduction and hibernation and accompanying changes in body mass of free-living Anatolian ground squirrels (*Spermophilus xanthoprymnus*) in steppe habitat about 50 km south of Ankara, Turkey. Adult males emerged from hibernation during March, before breeding females. Yearling males emerged with adult males in 2000 but not in 2001. Yearlings of both sexes and adult females were at their lowest body mass of the active season at emergence. Adult males were 139–205% heavier than other age and sex classes when they emerged. Their body mass was near the lowest of the active season at the end of mating season. All adult males had descended testes at emergence, and most yearling males were reproductively active after their 1st hibernation. Females mated shortly after their emergence from hibernation and weaned only 1 litter each year. Females 1st reproduced as yearlings. Parturition occurred in April, and juveniles appeared aboveground from mid- to late May. Thereafter, all age and sex classes were simultaneously active until immergence. In each year, juveniles immerged into hibernation after nonjuveniles. Thus, the annual cycle of Anatolian ground squirrels resembles generally those of most species of hibernating ground squirrels in Europe and North America.

Key words: Anatolian ground squirrels, Ankara, annual cycle, body mass, reproduction, Rodentia, Sciuridae, *Spermophilus xanthoprymnus*

The annual cycle of hibernating ground squirrels (*Spermophilus*) consists of an inactive (hibernation) season and an active season characterized by emergence from hibernation in spring, mating, gestation, lactation, emergence and growth of juveniles, prehibernatory fattening, and immergence into hibernation (Michener 1983a, 1984a). Adult males usually emerge from hibernation before females, and mating occurs shortly after emergence of adult females (Barnes 1996). Juveniles appear aboveground about 8 weeks after females emerge from hibernation (Michener 1985). Thereafter, all age and sex classes are simultaneously active and engage in prehibernatory growth and fattening until immergence. The most general sequence of late summer and autumn immergence into hibernation is adult males 1st, followed by adult females, yearlings, then juveniles (Michener 1983a, 1984a).

Anatolian ground squirrels (*Spermophilus xanthoprymnus*) are distributed from the southern Caucasus through Anatolia to Palestine (Corbet 1978; Nowak 1991). In central Anatolia, they inhabit the steppe where their active season lasts from March through September (Karabağ 1953). Very little information exists on the annual cycle of Anatolian ground squirrels. Karabağ (1953) reported that males emerged from hibernation before females, but median dates of emergence were not given. He also noted that females mated soon after emergence and produced only 1 litter per year. The objectives of our research were to quantify the timing of events and accompanying changes in body mass during the annual cycle of Anatolian ground squirrels and to compare these patterns with those for other hibernating species of *Spermophilus*.

MATERIALS AND METHODS

From 1999 to 2001, we studied a population of Anatolian ground squirrels living in steppe habitat about 50 km south of Ankara, Turkey (39°28′N, 32°50′E; 1,180–1,205 m altitude).

Mean annual rainfall in this area is 416 mm, with one-third falling from March through May. December is the wettest month ($\bar{X}$ rainfall = 51 mm) and July the driest ($\bar{X}$ rainfall = 13 mm). January is the coolest month ($\bar{X}$ temperature = −1.5°C) and August the warmest ($\bar{X}$ temperature = 21.4°C). Climatological data were from the Ikizce Weather Station (39°36′N, 32°40′E; 925 m altitude), located 20 km from the study area.

A 3-ha core area of steppe was intensively trapped and an adjacent 4-ha area less intensively trapped using Tomahawk live traps (Model 104, 61 × 15 × 15 cm; Tomahawk Live Trap Co., Tomahawk, Wisconsin) baited with peanut butter. In these areas, ground squirrels

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were livetrapped weekly (median of 2 days/week) in 1999 (9 May–17 September), 2000 (13 March–15 August), and 2001 (2 March–24 April). These dates corresponded to the time juveniles 1st emerged from the natal burrows (1999) or to the time when ground squirrels began emerging from hibernation (2000 and 2001). Except for 2001, when the study encompassed only the beginning of the active season, livetrapping ended when ground squirrels immerged into hibernation. At 1st capture, ground squirrels were tagged with a numbered metal tag in each ear (National Band and Tag Co., Newport, Kentucky). In addition, fur was painted with a commercial hair dye (Voila, Kopaş Cosmetic, Çerkezkoy, Turkey) in individually recognizable patterns.

At each capture, age, sex (based on anal-genital distance—Kunz et al. 1996), body mass (±5 g; Pesola spring scale, Rebmattli, Baar, Switzerland), and reproductive condition were recorded. Males were defined as reproductive in spring if they had testes descended into a pigmented scrotum. Conception dates were determined for 7 pregnancies (2000: $n = 4$; 2001: $n = 3$) by observance of a copulatory plug in the vagina or by detection of sperm via vaginal lavage. During March 2000 and 2001, vaginal lavages were obtained by pipetting a small (about 50 µl) quantity of saline solution into the vagina and removing it again with a pipette. Samples were placed on a slide, air-dried, fixed with 70% alcohol, then inspected with a light microscope for the presence of sperm. The day on which vaginal evidence of insemination was obtained was considered the day of conception (Michener 1985). Gestation and lactation were determined on the basis of development of teats. Teats were enlarged and darkly pigmented during late pregnancy and were lighter and swollen during lactation. Parturition dates were determined for 5 females (2000: $n = 4$; 2001: $n = 1$) by detecting distension of the vulva and bloodstains on the surrounding fur. Parturition dates of other females were estimated by observance of a loss of body mass of 25–50 g between consecutive captures combined with the 1st signs of lactation (large, light-pigmented teats with surrounding fur flattened).

In 2000, the core area was frequently visited and livetrapped daily during the period of juvenile emergence. Litter emergence date was defined as 1st emergence of juveniles from natal burrows. Litter size at emergence was determined by counting juveniles at the natal burrows on their 1st day aboveground. Body mass of juveniles captured within 3 days of 1st emergence was considered to be their body mass at emergence from the natal burrows. Information on litter size at birth was also obtained for 2 females that were captured when pregnant and 2 females impregnated while in the laboratory. Body mass of ground squirrels at birth was obtained by individually weighing them (±0.1 g) on a digital balance within 24 h of birth.

Ground squirrels were identified as juvenile if trapped during the active season of their birth year and as yearling after their 1st hibernation. Those squirrels that hibernated ≥2 seasons were classified as adult. In certain conditions, we also use the term nonjuvenile (including yearlings and adults) when ages of ground squirrels that were not 1st trapped as juvenile, especially in the 1st year of study (1999), were unknown. At initial capture, juveniles were distinguished from nonjuveniles by size and mass (Boag and Murie 1981; French 1982).

During March, when ground squirrels were presumed to emerge from hibernation, the longest period during which we did not trap was 2 days in both 2000 and 2001. The study area was also frequently observed with binoculars (6–12 × 25) to detect the 1st appearance of a ground squirrel that was not marked with a hair dye. Thus, a ground squirrel was assumed to have emerged from hibernation in the interval between its 1st sighting and the preceding inspection on which it was not located. For ground squirrels captured in March, body mass at 1st capture was considered to be the body mass at emergence.

Length of mating season was determined from emergence time of females in both 2000 and 2001, as we found that all females ($n = 7$) with vaginal evidence of insemination had mated within a week after emergence (see ''Results''). In 2000, length of mating season was corroborated with data on parturition time of females and emergence time of their litters from the natal burrows.

During August 1999, 6 juvenile male and 7 juvenile female Anatolian ground squirrels were transported from the noncore trapping area to the laboratory where they were maintained under natural temperature and light regimes. They were housed individually in 30 × 30 × 40-cm cages. Food and water were provided ad libitum. Each ground squirrel was examined daily for torpor. Sawdust was placed on torpid ground squirrels to indicate by its subsequent presence or absence whether an arousal had occurred between observations (Barnes 1984). Within the 1st week of continuous activity in early spring (2000), reproductively mature males were paired with females inside the female's cage to determine latency between last arousal and conception. Vaginal lavages were performed each afternoon and inspected for the presence of sperm. The day on which sperm was detected in the lavage was considered the day of conception (Michener 1985).

We followed guidelines for the capture, handling, and care of mammals as approved by American Society of Mammalogists in our procedures (Animal Care and Use Committee 1998).

Statistical analyses.—Prior to parametric tests, Kolmogorov–Smirnov and Levene tests were used to evaluate data for normality and homoescedasticity, respectively. Effects of age (yearling and adult), sex, and year (2000 and 2001) on body mass of ground squirrels at emergence from hibernation were examined by means of univariate analysis of variance (ANOVA) using a 3-way factorial design. Age, sex, and year were included as fixed-effect factors (Model I ANOVA). Hochberg's GT2-method (Sokal and Rohlf 1995), which is based on unequal sample sizes, was used to detect differences among groups. Because sample sizes were small, we used Wilcoxon's signed-rank test (test statistic: T-value—Sokal and Rohlf 1995) to determine if adult males lost body mass during the mating season. Differences in body masses of male and female juveniles at emergence from natal burrows were examined using Welch's approximate t-test (test statistic: T-value—Sokal and Rohlf 1995), as the assumption of homoescedasticity was not valid in that case. We performed a simple linear regression, with calendar week and mean body mass as the independent and dependent variables, respectively, for juvenile males and females. From these, we calculated growth rates from time of emergence to mid-August for 2000. Differences in growth rates of male and female juveniles were analyzed by comparing slopes of regression lines (F-test—Sokal and Rohlf 1995). We did not know exact emergence dates of all ground squirrels, so Kolmogorov-Smirnov 2-sample tests (Sokal and Rohlf 1995) were selected to compare emergence dates of sexes. Thus, we tested the differences between relative cumulative frequency distributions of males and females that had emerged from hibernation. Differences in emergence dates between 2000 and 2001 were examined in the same way. Unless otherwise indicated, we used 2-tailed hypotheses. Statistical significance was assumed at $P \leq 0.05$. Data are presented as mean ±1 *SD* and overall range. We used the interquartile range (difference between the 75th percentile and the 25th percentile) only with Wilcoxon's signed-rank test, which is a nonparametric test.

RESULTS

Emergence from hibernation.—When the study area was visited during late February and early March 2000, no ground

TABLE 1.—Body mass (g) of age and sex classes of Anatolian ground squirrels (*Spermophilus xanthoprymnus*) weighed at emergence from hibernation in steppe habitat near Ankara, Turkey, in 2000 and 2001. Means that are not statistically different share a common letter.

	Adult		Yearling	
Year	Males	Females	Males	Females
2000				
$\bar{X} \pm SD$	312 ± 25^{a}	$174 \pm 24^{b,c}$	181 ± 10^{b}	$159 \pm 21^{b,c}$
n	5	9	4	4
2001				
$\bar{X} \pm SD$	272 ± 12^{a}	$172 \pm 22^{b,c}$	195 ± 41^{b}	133 ± 16^{c}
n	4	9	4	6

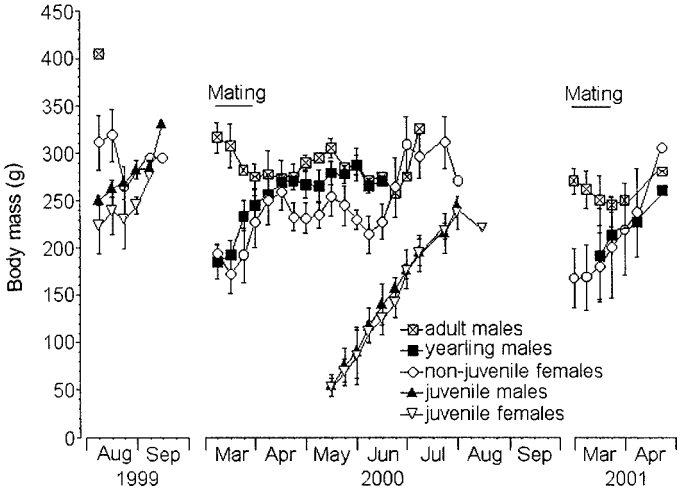

FIG. 1.—Body mass (g; mean ± *SD*) of Anatolian ground squirrels (*Spermophilus xanthoprymnus*) during their active season in steppe habitat near Ankara, Turkey. Body mass data are pooled per 1-week interval. Sample sizes (1999–2000–2001 pooled) for adult males = 1–5 (median = 2), yearling males = 1–4 (median = 3), nonjuvenile females = 1–17 (median = 6), juvenile males = 1–17 (median = 4), and juvenile females = 1–13 (median = 5).

squirrels were active. On 13 and 14 March, when part of the area was snow covered, 5 male ground squirrels (2 yearlings and 3 adults) were observed. Female ground squirrels were 1st seen aboveground on 15 March. By 31 March, when the area was free of snow, all ground squirrels resident on the core area were active. The interpolated median date of emergence for males (15 March) was significantly earlier than that for females (23 March; $n = 10$ males, 18 females; $D = 0.633$, 1-tailed test, $P < 0.005$).

Mean maximum daily air temperatures from January to March were 2.2–4.5°C below average in 2000 but were 2.7–6.6°C above average in 2001. Anatolian ground squirrels emerged from hibernation earlier in 2001 than in 2000 (interpolated median dates of emergence = 21 March for 28 ground squirrels in 2000 and 14 March for 23 ground squirrels in 2001, all age and sex classes pooled, $D = 0.435$, $P < 0.025$). When 1st visited in 2001 on 2 March, the study area was completely free of snow, and 1 adult male was already active. The 1st yearling male was not observed until 22 March, suggesting that yearling males emerged later from hibernation than adult males in 2001. The 1st female ground squirrel was observed aboveground on 5 March. Ground squirrels continued to emerge from hibernation until late March. The interpolated median date of emergence for adult males (7 March) was significantly earlier than that for breeding females (14 March; $n = 4$ males, 15 females; $D = 0.683$, 1-tailed test, $P < 0.05$).

Body mass.—Analyses of body mass at emergence revealed significant interactions among year, age, and sex ($F = 7.123$, $d.f. = 1, 37$, $P = 0.011$) and also between age and sex ($F = 28.784$, $d.f. = 1, 37$, $P < 0.001$), indicating that the effect of sex on body mass at emergence of a ground squirrel depended on age. Body mass did not differ significantly between years within any age and sex category (all $P \geq 0.288$; Table 1). At emergence, males were significantly heavier than females in the same age class (except yearlings in 2000), and adult males were significantly heavier than yearling males. Yearling and adult females did not differ significantly in body mass at emergence in either year (Table 1).

Yearlings of both sexes and adult females were at their lowest body mass of the active season at emergence in spring. Females gained body mass during gestation until parturition. Body mass was almost constant during lactation but increased prior to immergence into hibernation (after mid-June). Adult males lost body mass during the mating season (2000–2001 pooled, $n = 6$, body mass in the beginning of mating season, median = 280 g, interquartile range = 270–312 g; minimum body mass during the mating season, 262 g, 242–275 g, $T = 0$, 1-tailed test, $P = 0.016$), whereas yearling males gained body mass after emergence. Thus, after the 1st months of activity in spring, body mass was indistinguishable between yearling and adult males. Males increased body mass prior to immergence into hibernation (after June; Fig. 1).

Newly emerged juvenile ground squirrels weighed 24.7% of the body mass of their mothers that were captured in the same collection period (mothers, 247.5 ± 23.15 g, range 210–275 g, $n = 8$; juveniles, 61.1 ± 15.60 g, 40–100 g, $n = 33$). Body masses of juvenile males were not significantly different from those of juvenile females at the time of emergence from natal burrows (males, 66.0 ± 20.10 g, range 40–100 g, $n = 21$; females, 58.3 ± 11.97 g, 40–90 g, $n = 21$, $t = 1.49$, $P > 0.10$). Thus, juvenile ground squirrels weighed 62.1 ± 16.79 g ($n = 42$) at about 4 weeks of age. Litter mass (= litter size at emergence [4.7] × body mass of recently emerged juveniles [62.1]) was 292 g at 1st emergence from the natal burrows.

Juveniles increased body mass throughout the active season (Fig. 1). Growth rates of juvenile males were not significantly different from those of juvenile females (males, 18.71 g/week; females, 18.96 g/week, $F = 0.077$, $d.f. = 1, 16$, $P = 0.785$).

Mating and reproduction.—In 2000, the mating season started in mid-March and extended through the 1st week of April. In 2001, the 1st female to emerge from hibernation mated on 8 March. The mating season continued over the next 3 weeks. All adult males ($n = 9$) in the study area during the mating season of both 2000 and 2001 had descended testes and

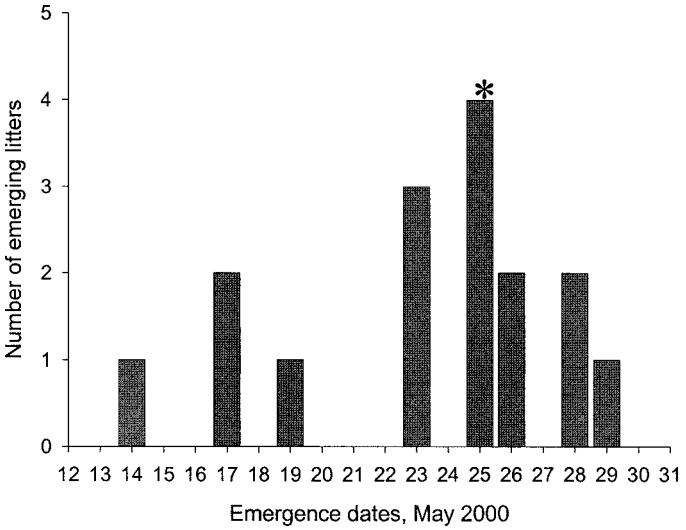

FIG. 2.—Distribution of emergence dates of litters of Anatolian ground squirrels (*Spermophilus xanthoprymnus*) from the core study area in steppe habitat near Ankara, Turkey, in 2000. The median date of emergence of litters is indicated by an asterisk (*).

scrotal pigmentation at emergence from hibernation. Six of 8 yearling males likewise emerged with scrotal pigmentation, but only 2 of the 6 had descended testes at their 1st capture. Testes of the other 4 males and also of 1 of 2 males that did not emerge with scrotal pigmentation descended into a pigmented scrotum within 10 days, but their scrota were smaller than those of adults (observed visually in the field; 2000–2001 pooled, $n = 7$ yearling males and 9 adult males). Body mass of 1 yearling male that showed no signs of reproductive activity was significantly lower than those of reproductive yearling males (135 g versus reproductive males, 195.7 ± 20.1 g, range = 170–220 g, $n = 7$, $t = 2.83$, $P < 0.05$). The testes of yearling and adult males regressed during April. Despite frequent observations during the mating season in both years, aboveground copulations were not observed; we assume that copulations normally occur underground. Some reproductive males captured during the mating season had sustained injuries. On 27 March 2000, we saw 2 adult males approach one another, then grapple with each other for about 0.5 min without interruption. When these males were captured 2 days later, they exhibited injuries, probably as a result of observed fighting.

Females mated shortly after emerging from hibernation. The maximum latency between emergence and conception, determined for females with vaginal evidence of insemination, was 4.6 ± 0.98 days (range 3–6 days, 2000–2001 pooled, $n = 7$). The latency between last arousal from torpor and conception, determined for laboratory-impregnated females, was 7.7 ± 1.53 days (range 6–9 days, $n = 3$). In 2000, except for 1 adult female that died before evidence of breeding could be obtained, all females (4 yearlings, 11 adults, and 5 of unknown age) resident on the core area during the mating season became pregnant. All gave birth, but 3 females (1 yearling and 2 adults) disappeared from the core area before the expected time of natal emergence, and their young were not observed aboveground. Females 1st reproduced as yearlings. For females giving birth in the field, the average gestation period (interval from detection of sperm or copulatory plug to time of parturition) was 25.4 ± 0.55 days (range 25–26 days, 2000–2001 pooled, $n = 5$).

Four females gave birth in captivity. Two of these were impregnated in the field. Gestation periods of other 2 females that were impregnated in captivity were 26 and 28 days. Litter size at birth was 5.8 ± 2.36 (range 4–9, $n = 4$ litters). Body mass of ground squirrels was 5.7 ± 0.53 g (range 5.0–6.7 g, $n = 23$) at birth and 47.4 ± 2.96 g (range 43.7–50.8 g, $n = 4$) after 30 days in captivity. Litter mass at birth was 32.7 ± 11.76 g (range 21.7–47.9 g, $n = 4$ litters).

In 2000, most parturition occurred between 17 and 25 April (mean body mass of females decreased in this interval; Fig. 1), and juveniles emerged from natal burrows when about 4 weeks old. Juveniles from 2 litters 1st emerged from the natal burrows 29 and 31 days after birth. Litters appeared aboveground 59.6 ± 1.74 days (range 57–63 days, $n = 14$) after the 1st day that the mother was captured in spring. Dates of the mother's 1st capture and emergence of her litter from the natal burrows were positively correlated ($n = 14$, $r = 0.924$, $P < 0.01$), indicating that early-emerging females weaned litters at an earlier date than did late-emerging females. In 2001, the 1st female that emerged from hibernation gave birth on 2 April, but we do not know how long parturitions actually continued that year.

In 1999, the 1st juvenile was observed aboveground on 9 May, and emergence of litters continued until late May. The median date of emergence of litters was 25 May in 2000 (range 14–29 May, $n = 16$ litters; Fig. 2). Litter size at 1st emergence from the natal burrows that year was 4.7 ± 1.39 (range 3–9, $n = 15$ litters). The most common litter sizes at emergence were 4 (46%) and 5 (33%). All females (3 yearlings, 8 adults, and 5 of unknown age) that gave birth in the core area and were still alive at the expected time of natal emergence weaned litters. Females produced only 1 litter each year.

Immergence into hibernation.—In both 1999 and 2000, juvenile Anatolian ground squirrels appeared to immerge into hibernation after nonjuveniles. Except for 1 female that remained active until mid-September 1999, 13 of 14 nonjuveniles that survived to the following spring disappeared from the core area before 13 August. Juveniles remained active until mid-September, the last being trapped on 17 September. Immergence occurred earlier in 2000. Except for 1 ground squirrel that was trapped on 3 August 2000, 8 of 9 adults that emerged from hibernation during March 2001 had disappeared from the study area before August. On 15 August, when the study area was last visited, at least 5 ground squirrels, most likely juveniles, were still active.

DISCUSSION

For some hibernating ground squirrels, timing of emergence in spring is correlated with climatic variables such as maximum air temperature, soil temperature, snow cover, and snow depth (Michener 1984a). The earlier dates of emergence in 2001 by *Spermophilus xanthoprymnus* in our study were associated with warmer-than-normal spring temperatures, as occurs in

S. elegans (Fagerstone 1988), *S. richardsonii* (Michener 1977), and *S. townsendii* (Rickart 1982). This pattern is different, however, from that of *S. parryii* reported by Buck and Barnes (1999), which emerges at the same time of year, even though air temperature and snow cover differ substantially.

Adult male Anatolian ground squirrels emerged from hibernation earlier than breeding females, and mating occurred shortly after female emergence. This is typical of many species of *Spermophilus* (Michener 1984a; Millesi et al. 1999a, 1999b). This pattern apparently serves to increase reproductive opportunities for males (Barnes 1984; French 1982; Michener 1983b). The immediacy of breeding after emergence (Table 2) also presumably allows juveniles time to grow and deposit body fat prior to hibernation and allows lactating females time to restore body reserves after weaning litters (Barnes 1996; French 1982; Murie and Boag 1984).

Adult male Anatolian ground squirrels had spermatogenic testes either when they emerged from hibernation or shortly thereafter because they could inseminate females shortly after female emergence, which occurred a maximum of 6 days later. In some other species of hibernating ground squirrels, testicular development occurs only at euthermic body temperature (Barnes et al. 1986, 1987), so testes remain undeveloped during the heterothermic portion of hibernation (Barnes 1996). The development of male reproductive competence requires at least 11.5 days in *S. richardsonii* and *S. parryii* and 31 days in *S. lateralis* after resumption of post-torpor euthermy (Barnes 1996). Thus, adult male Anatolian ground squirrels appear to have ended torpor before females and undergone testicular development during a period between terminal arousal from torpor and emergence from hibernacula, as occurs in *S. parryii* (Barnes and Ritter 1993), *S. richardsonii* (Michener 1992), and *S. columbianus* (Young 1990). Kart (2000) found that male *S. xanthoprymnus* ended torpor 20 days before females in the laboratory.

In some *Spermophilus* species (*S. armatus*—Balph 1984; *S. beldingi*—Morton and Sherman 1978; *S. columbianus*—Murie and Harris 1978, 1982), yearling males typically are not sexually mature and emerge later than adult males and breeding females. In other species (*S. parryii*—McLean and Towns 1981; *S. richardsonii*—Michener 1983b), yearling males are sexually mature and emerge and breed at the same time as adults, although in 1 arctic population of *S. parryii*, about 50% of yearling males are nonreproductive. In that population, the spring emergence sequence is adult males, reproductive yearling males, adult females, yearling females, and, finally, nonreproductive yearling males (Buck and Barnes 1999). In *S. xanthoprymnus*, yearling males are usually sexually mature after their 1st hibernation but may or may not emerge with adult males, an observation also made by Fagerstone (1988) for Wyoming ground squirrels (*S. elegans*).

Millesi et al. (1998) and Buck and Barnes (1999) reported that in *S. citellus* and *S. parryii*, respectively, reproductive yearling males that emerge earlier than their nonreproductive counterparts have relatively high spring body mass. That body mass of 1 nonreproductive yearling male was significantly lower than body mass of other reproductive yearling males at emergence suggests that achieving reproductive condition was related to body mass. Unlike adult males, yearling males in both years did not lose body mass during the mating season. This pattern could be evidence that yearling males did not breed to any significant extent. Female Anatolian ground squirrels, however, 1st bred as yearlings, as do females of most species of *Spermophilus* (Michener 1983a).

TABLE 2.—Time intervals between emergence of females from hibernation and mating and between emergence of females from hibernation and emergence of their litters from natal burrows and duration of mating season of hibernating *Spermophilus* species.

Species	Time from emergence to mating (days)	Time from emergence to litter emergence (days)	Duration of mating season (weeks)
Spermophilus			
armatus[a]	2–4	52–54[k,l]	2–3
beldingi[b]	4–6	54[k]	2–3
brunneus[c]	1–2	51–54[m]	~2
citellus[d]	3	67–68[n]	3–4
columbianus[e]	4	58[k,l]	~2
elegans[f]	1–3	52–58[m]	1–2
parryii[g]	3–4	56–57[l]	1–2
richardsonii[h]	3–4	56–57	3–5
saturatus[i]	1–2	68[n]	~2
xanthoprymnus[j]	3–6	63	~3

[a] Balph (1984); Slade and Balph (1974).
[b] Morton and Sherman (1978); Sherman (1989); Sherman and Morton (1984).
[c] Sherman (1989); Yensen and Sherman (1997).
[d] Millesi et al. (1998, 1999a, 1999b).
[e] Murie and Harris (1978, 1982).
[f] Fagerstone (1982, 1988).
[g] Buck and Barnes (1999); Byrom and Krebs (1999); Carl (1971); Lacey et al. (1997).
[h] Michener (1983b, 1984b, 1985).
[i] Kenagy (1989); Kenagy and Barnes (1988); Kenagy et al. (1989).
[j] This study.
[k] Michener (1985).
[l] Calculated as (the interval from emergence to mating + gestation + the interval from birth to litter emergence).
[m] Calculated as (the interval from emergence to mating + the interval from mating to litter emergence).
[n] Calculated as (median or mean date of litter emergence − median or mean date of female emergence).

In hibernating mammals, females have to complete mating, gestation, lactation, and prehibernatory fattening during a short active season. Juveniles also have to grow and deposit body fat prior to hibernation. Hence, Anatolian ground squirrels produce only 1 litter per year, as do most hibernating *Spermophilus* (Kenagy and Barnes 1988; Michener 1998; Millesi et al. 1999a; Slade and Balph 1974; Yensen and Sherman 1997).

The length of the about 3-week mating season of Anatolian ground squirrels is within the range of most other species of *Spermophilus* (Table 2). Because sex ratio among ≥1-year-old Anatolian ground squirrels is female-biased (Gür 2001) and all females mate during the mating season, polygyny appears to be a statistical necessity. Polygyny is widespread among ground-dwelling squirrels (Dobson 1984).

Adult male *S. xanthoprymnus* were heavier than females at emergence and lost body mass during the mating season, as occurs in other ground squirrel species (Buck and Barnes 1999; Fagerstone 1988; Michener 1998; Millesi et al. 1999b; Morton

and Sherman 1978). Because yearlings of both sexes and adult females gained mass as adult males lost mass, as in *S. richardsonii* (Michener 1984b), loss of mass by adult males did not appear to be due to lack of forage early in the active season but instead appeared to be due to energetic demands of breeding as in other species (Buck and Barnes 1999; McLean and Towns 1981; Michener and Locklear 1990). That adult male Anatolian ground squirrels lost body mass and sustained injuries during the mating season suggest that male–male competition occurs as reported for other ground squirrels (Armitage 1981; Michener 1984a). The greater body mass of adult males on emergence from hibernation could be advantageous in male–male competition for access to females (Kenagy 1989).

Although low population density, especially at the end of active season, did not allow us to evaluate body mass of age and sex classes at immergence into hibernation, sexual differences in seasonal patterns of changes in body mass in Anatolian ground squirrels were generally similar to those reported for other species of hibernating ground squirrels (Buck and Barnes 1999; Fagerstone 1988; Kenagy et al. 1989; Millesi et al. 1999b).

Relative to body mass at emergence of adult females (170 g), body mass of neonatal Anatolian ground squirrels (3.4%) and litter mass at birth (19.2%) both are within the ranges reported for neonates and litters of other hibernating *Spermophilus* species (Michener 1989). Relative juvenile mass (37% of emergence mass of adult females) and relative litter mass (172% of emergence mass of adult females) at 1st emergence from the natal burrows are also comparable to other species of ground squirrels (Michener 1989).

In *S. xanthoprymnus*, we did not observe the significant difference between growth rates of juvenile males and females that has been reported for other species of *Spermophilus* (Boag and Murie 1981). Gains in body mass of juveniles (sexes pooled) were 19 g/week, comparable to values reported for other species of ground squirrels (10–39 g/week—Boag and Murie 1981).

Because juveniles of hibernating species of ground squirrels have to both grow and deposit fat prior to immergence into hibernation, adaptations that maximize the weaning-to-immergence interval are expected. Members of the subgenus *Spermophilus* are characterized by a more compressed interval from mother emergence from hibernation to litter emergence than species in other subgenera (Michener 1985). The interval from median emergence date of breeding females to median emergence date of juveniles in *S.* (*Spermophilus*) *xanthoprymnus* was 63 days. Comparable intervals for obligate hibernating species of *Spermophilus* are 51–68 days (Table 2). Also, like other ground squirrels, juvenile *S. xanthoprymnus* immerged later than nonjuveniles, doubtless because they had to both grow and fatten before their 1st hibernation (Michener 1984a).

Özet (= Summary)

Üç yıllık bir süre boyunca (1999–2001), Türkiye, Ankara'nın yaklaşık 50 km güneyindeki step habitatta serbest yaşayan Anadolu yer sincaplarında (*Spermophilus xanthoprymnus*) üremenin ve hibernasyonun ve bu olaylara eşlik eden vücut ağırlığındaki değişimlerin yıllık zamanlamasını izledik. Ergin erkekler, mart ayında üreyen dişilerden önce hibernasyondan çıktı. Bir yaşındaki erkekler, 2000 yılında ergin erkeklerle aynı zamanda hibernasyondan çıktı, ancak 2001 yılında çıkmadı. Her iki eşeyin bir yaşındakileri ve ergin dişiler, hibernasyondan çıkışta aktif sezonun en düşük vücut ağırlığındaydı. Ergin erkekler, hibernasyondan çıktıkları zaman diğer yaş ve eşey sınıflarından % 139–205 daha ağırdı. Vücut ağırlıkları, eşleşme döneminin sonunda aktif sezonun en düşük değerine yakındı. Ergin erkeklerin hepsi, hibernasyondan çıkışta skrotal keselere inmiş testislere sahipti. Çoğu bir yaşındaki erkek, ilk hibernasyonlarından sonra eşeysel olarak aktifti. Dişiler, hibernasyondan çıkışlarından kısa bir süre sonra çiftleşti ve her yıl sadece bir batın verdi. Dişiler, ilk olarak bir yaşındayken üremeye başladı. Doğumlar, nisan ayında gerçekleşti. Gençler, mayıs ayının ikinci yarısında toprak üzerinde aktiveye başladı. Bundan sonra, tüm yaş ve eşey sınıfları, hibernasyona girişe kadar eş zamanlı olarak aktifti. Gençler, her yıl genç olmayanlardan sonra hibernasyona girdi. Bu yüzden, Anadolu yer sincabının yıllık yaşam döngüsü, genel olarak Avrupa ve Kuzey Amerika'da hibernasyona giren çoğu yer sincabı türününkine benzerdir.

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