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ESTROUS AND GESTATION PERIODS IN RICHARDSON’S GROUND SQUIRRELS

Howell (1938) stated that the gestation period of Spermophilus richardsonii "as determined ... from specimens held in captivity, is about 28 to 32 days." I previously showed (Michener, 1977) that, on the bases of the maximum number of days females were held captive prior to parturition, and of the minimum period between emergence from hibernation and commencement of lactation, that the gestation period was probably between 23 and 26 days. Because copulations are observed rarely in the field or in captivity, a more precise determination of the gestation period requires an indirect method of establishing when copulation occurred. The aims of this study were to determine the time between emergence from hibernation and the onset of female receptivity to males, to estimate the time of copulation, and to determine the lengths of the estrous and gestation periods.

Richardson’s ground squirrels located 8 km E Picture Butte, Alberta (49°52’N, 112°40’W, elev. 870 m) were trapped in spring of 1979. Males commenced emergence from hibernation on 8 March and females began emerging on 14 March; most females (19 of 33) appeared from 18 to 23 March. From 14 to 23 March females were trapped daily (with the exception of 17 March) and a vaginal smear was taken from each female at each capture. Smears were prepared from material obtained by flushing the vagina three times with two drops of 0.9% saline dispensed from an eyedropper inserted about 5 mm. The fluid was expressed onto a slide, air-dried, and stained with Shorr’s stain (Shorr, 1941). The dropper was rinsed three times in water and once in saline before reuse. The 10 females that were found to have sperm in the smear were subsequently held in captivity; nine survived to parturition. Squirrels were maintained in plastic cages containing sawdust, paper towels, and cotton batting, and were provided with water and rodent chow ad lib. plus daily supplements of sunflower seeds and fresh fruit or vegetables. Seven females were housed in a building subject to natural temperature and light regimes and three were housed at 20°C on a 12L:12D regime. During the anticipated time of parturition females were examined an average of eight times each day and, when pups were detected, parturition was estimated to have commenced at the mid-point of the interval between that examination and the previous one. The maximum possible error in detection of the time of parturition was 4 h.

Vaginal smears were scanned by two independent observers under 400× magnification for the presence of sperm and the number of sperm in the entire smear was counted. When sperm were detected the preceding and subsequent smears were scanned again to confirm the exact period over which sperm were detectable. The proportion of the area of the smear occupied by cornified epithelial cells was estimated from three fields of view under 100× magnification and scored to the nearest 10% interval on a scale from 0% (no cornified cells) to 100% (entirely cornified cells).

An opaque, yellowish-white copulatory plug of gel-like consistency was found slightly extruded from the vaginal orifice of a female on 21 March at 0915 h. The plug, approximately 2 cm long, was removed and a smear immediately taken. This female had the longest sperm-to-parturition interval. No sperm were present in the smear taken from this female 23 h earlier; had she bred immediately following her release on 20 March, the maximum possible copulation-to-parturition time was 23.5 days. Of five females captured both the day before and the day after the appearance of sperm only one was found with a copulatory plug, indicating that if plugs formed they persisted less than 24 h. The average (±SD) sperm count per smear on the first day that sperm were detected was 344 ± 198 (range: 40–675; n = 10), whereas the average count 1 day later was 15 ± 30 (range: 0–78; n = 7). This rapid decline in abundance of sperm in the vagina and the 21.5-h range between the longest and shortest sperm-to-parturition times (Table 1) suggested that sperm typically persisted in the vagina no more than 24 h. The maximum possible gestation period, calculated for six females from which a smear had been obtained the day prior to the first detection of sperm, averaged 22 days 23 ± 10 h (range: 22 days 15.5 h to 23 days 13 h). The gestation period of Richardson’s ground squirrels is, therefore, typically at least 22 days (Table 1) and at most 23 days; 22.5 days probably represents the best estimate. Data collected from an additional 13 pregnancies in 1980 confirmed this estimate (Table 1). Neither maternal age nor length of time in captivity prior to parturition appeared to affect the length of the gestation period (Table 1).
TABLE 1.—Time elapsed from first appearance of sperm in vaginal smear to parturition in Richardson's ground squirrels. Females are listed in order of decreasing length of sperm-to-parturition interval.

<table>
<thead>
<tr>
<th>Female</th>
<th>Sperm first detected</th>
<th>Parturition</th>
<th>Sperm-to-parturition interval</th>
<th>Captivity-to-parturition interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>March</td>
<td>Hour</td>
<td>April</td>
<td>Hour</td>
</tr>
<tr>
<td>1979</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>21</td>
<td>0915</td>
<td>12</td>
<td>2215</td>
</tr>
<tr>
<td>93*</td>
<td>22</td>
<td>1045</td>
<td>13</td>
<td>1935</td>
</tr>
<tr>
<td>22*</td>
<td>23</td>
<td>1230</td>
<td>14</td>
<td>1715</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>1045</td>
<td>6</td>
<td>1515</td>
</tr>
<tr>
<td>92*</td>
<td>20</td>
<td>1000</td>
<td>11</td>
<td>1030</td>
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<td>0930</td>
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<tr>
<td>35</td>
<td>21</td>
<td>1000</td>
<td>12</td>
<td>0315</td>
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<td>0930</td>
<td>12</td>
<td>0215</td>
</tr>
<tr>
<td>37</td>
<td>23</td>
<td>1100</td>
<td>14</td>
<td>0230</td>
</tr>
</tbody>
</table>

Mean ± SD (n = 9) 22 days 0.5 h ± 8.0 h

1980**

Mean ± SD (n = 13) 21 days 22.0 h ± 10.0 h

* Captured as adults in 1978; therefore, at least 2 years old.
** Additional data collected in 1980 using the same study area and methods as in 1979 and with estimates of the time of parturition accurate to within 2.75 h. Maximum possible gestation period 22 days 22 h ± 9 h (range: 22 days 9 h to 23 days 14 h; n = 10 females sampled the day prior to the first detection of sperm).

On the first day of emergence from hibernation females exhibited few or no cornified cells in their smears (Fig. 1) and the vaginal orifice was completely or partly closed. Scattered cornified epithelial cells appeared in the smear on the second day and the vulva was raised with the vaginal lips separated. By the third day above ground the smear was composed of clumped cornified cells and the vulva was swollen and open. For 8 of 10 females, sperm appeared among the clumped cornified cells on the fourth day postemergence when the vaginal lips were swollen and rugose, and the vaginal opening was at its maximum for the season. The other two females bred on their fifth day above ground. Females, therefore, typically copulated about 48 h after cornified cells commenced shedding in abundance from the vaginal epithelium. Following copulation, there was a rapid decline in the extent of cornification so that 2 to 3 days postcopulation only a few scattered cornified cells appeared in the smear. Leukocytes typically appeared in the smear the day after sperm were present. The rapid appearance and disappearance of sperm in the smears suggested that behavioral estrus was a short period of less than 24 h.

Four unmated females were held captive under natural temperature and light regimes, and vaginal smears were examined daily. I considered a female to be in estrus from the time cornified cells increased rapidly in abundance until leukocytes appeared. For unmated females, estrus lasted an average (±SD) of 3.0 ± 2.3 days (range: <1–9 days, n = 12) with an interval of 5.1 ± 1.5 days (range: 3–7 days, n = 10) between each estrus. Two females still exhibited estrous cycles when killed 3 to 4 weeks after their emergence from hibernation, but the other two females ceased cycling and entered an anestrous condition about 5 weeks after their emergence from hibernation.

Because of the paucity of information given by Howell (1938), the source of discrepancy between his second-hand report of a 28 to 32-day gestation for Richardson’s ground squirrels and the actual period of 22.5 days cannot be determined. Denniston (1957) reported a 17-day gestation for the sibling species S. elegans (formerly S. richardsonii elegans; Robinson and Hoffmann, 1975) based on the observation of a successful copulation involving a newly captured female that exhibited a "cornified vaginal smear." Viable hybrids between S. elegans and S. richardsonii (Nadler et al., 1971; Koeppl et al., 1978) suggest similar developmental patterns for the two species; a 6-day difference in their gestation periods seems unlikely.

This study indicated that S. richardsonii, like S. tridecemlineatus (Foster, 1934; Simmons, 1944, 1946), typically breeds during the first postemergence estrus after being above ground.
for 4 days. When isolated from males, females of both species exhibit estrous cycles for several weeks. Under natural conditions virtually all females are successfully bred shortly after emergence and, because of the synchrony in emergence of females, all parturitions occur within a period of less than 2 weeks (Michener, 1979). Gestation in S. richardsonii is 22.5 days; a female, therefore, usually gives birth on her 27th day after emergence from hibernation. Reproduction immediately following emergence and a short gestation period ensure that juvenile Richardson’s ground squirrels have a long growing season in which to accumulate sufficient fat reserves in preparation for the 6-month hibernation period.

I am indebted to L. Haney of Haney Farms 1979 Ltd. for permitting me unrestricted access to his land. I thank L. Brown for assistance in scoring vaginal smears and T. Dolman for assistance in recording parturition times. This study was supported by an NSERC General Research Grant from the University of Lethbridge. Data obtained in 1980 were added after this manuscript was accepted for publication.

**Literature Cited**


NOTES ON THE BREEDING BIOLOGY OF THICK-TAILED AND SILVERY GALAGOS IN CAPTIVITY

The taxonomy of galagos represents one of the more vexing areas in the classification of the order Primates. Some recent studies have begun to clarify relationships within this group, particularly those of grand or thick-tailed galagos, Galago crassicaudatus. Dixson and Van Horn (J. Zool., 183:517–526, 1977) suggested that morphological and physiological differences between two subspecies, G. c. argentatus and G. c. crassicaudatus, might be sufficient to warrant their assignment to separate species. Olson (unpubl. Ph.D. thesis, Univ. of London, London, UK, 804 pp., 1979) produced extensive morphometric information to support such a distinction, and treated the former group and related subspecies as the taxon Otolemur crassicaudatus, while allocating the latter group and its allies to the taxon O. garnetti. We offer additional information on the reproductive patterns of these taxa under laboratory conditions. Our findings, like those of the above authors, indicate that species-level separation is appropriate; unlike Olson (1979), however, we see no justification for placing these galagos in a distinct genus.

The information presented herein was taken from records of the Duke University Center for the Study of Primate Biology and History. To avoid nomenclatural confusion, we will refer to G. c. argentatus (or O. crassicaudatus of Olson, 1979) as the "silvery galago" and to G. c. crassicaudatus (O. garnetti of Olson, 1979) as the "thick-tailed galago." Our data include observations on 111 silvery galagos, 133 thick-tailed galagos, and four hybrids. These records include breeding data from 1959 through June of 1979.

Hybridization.—The Duke Primate Center has attempted to produce hybrids in this species complex since 1974. Of seven breeding-season pairings in that period, two have resulted in births. A male thick-tailed galago (DUPC #422) and a female silvery galago (DUPC #729) produced a set of twins in 1974 and another twin litter in 1977. The only survivor from these litters is a female (DUPC #750) born in 1974; the others died from traumatic injuries sustained shortly after birth. The surviving hybrid most closely resembles the silvery galago in external appearance; its body size (approximately 1,400 g) is within the range of variation of the other silvery galagos at Duke (see below). Efforts to backcross the hybrid to male silvery galagos have failed.

Gestation length.—Dixson and Van Horn (1977) reported gestation lengths ranging from 126 to 138 days in thick-tailed galagos (X = 132.2). Eaton et al. (Anim. Behav., 21:309–315, 1973) reported similar findings (range, 130–136; X = 132.8). In four cases based on observed copulations in our colony offspring were born 121, 123, 130, and 133 days later. Another birth occurred 119 days after a previous birth to the same female. Thus the range of variation in gestation length is at least 119 to 138 days. We have no data on gestation length in silvery galagos.

Litter size and birth interval.—The two groups differ markedly in the patterning of births. Silvery galagos tend to give birth only once per year, often to multiple offspring; thick-tailed galagos frequently give birth to single offspring twice a year. Of 60 births in nine different matrilineages of silvery galagos, half (30) were to multiple offspring (24 sets of twins, 6 sets of triplets). Only three of 86 births in 12 distinct matrilineages of thick-tailed galagos were to twins; the remainder were to single offspring. This propensity for multiple offspring in silvery galagos was also noted by Pasztor and Van Horn (J. Human Evol., 5:333–337, 1976), who reported multiple-offspring frequencies of 39.0% in silvery galagos and 9.3% in thick-tailed galagos.