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FEMALE REPRODUCTION IN THREE SPECIES OF *SOREX* IN HOKKAIDO, JAPAN

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I investigated the number of embryos, corpora lutea, and placental scars in *Sorex unguiculatus* from Hokkaido, Japan, and reported supplemental data on reproduction in *S. caecutiens* and *S. gracillimus*. Counts of corpora lutea and placental scars were not efficient indicators for reproductive history because some of them disappeared immediately after ovulation or parturition in *S. unguiculatus*.

Key words: *Sorex*, shrew reproduction, fecundity, Japan

Information on fecundity and reproductive status is essential to many ecological studies, including population and life-history studies. For some species of mammals, reproductive history of females can be estimated by investigating placental scars or luteal glands (Kirkpatrick, 1980). However, such histological investigations have been conducted for only a few species of *Sorex* (e.g., Baird et al., 1983; Brambell, 1935). Information is particularly scarce on the reproduction of shrews in Hokkaido, Japan, although Abe (1968) reported the mean litter size in two species and Ohdachi and Maekawa (1990) investigated female reproductive condition in different age groups for three species.

Herein, I report the numbers of embryos, corpora lutea, and placental scars in mature females for a common species of shrew, *Sorex unguiculatus*, in Hokkaido, and assess whether counts of corpora lutea and placental scars are effective indicators of reproductive history. In addition, I provide supplemental data on the numbers of embryos and corpora lutea for two other species in Hokkaido, *S. caecutiens* and *S. gracillimus*.

MATERIALS AND METHODS

Shrews were collected throughout Hokkaido from May 1988 to July 1990 in the season when snow cover was absent (usually April–November). In Horonobe, northern Hokkaido, sampling was conducted once a month from 1988 to 1990, but other areas were sampled only once or twice during the study period. Polyethylene pitfall traps (16-cm diameter at the opening; 20-cm depth) with no bait were used in all study areas, and smaller chloro-vinyl pitfalls (8-cm diameter; 13.5-cm depth) also were used in Horonobe from April to November 1989. Sampling sessions were for 2–5 nights (usually 3), and animals were removed from traps daily.

Four hundred seventeen *S. unguiculatus*, 62 *S. caecutiens*, and 117 *S. gracillimus* were obtained. I examined all females with visible embryos in the uterus and some of the sexually mature females (indicating elongation of uterus or development of mammary glands under the skin) with no visible embryos. These included 31 female *S. unguiculatus* with visible embryos and 12 with no visible embryos, three *S. caecutiens* with visible embryos and one with no visible embryos, and two *S. gracillimus* with visible embryos.

Shrews were dissected immediately after collection, and length of uterine horns, condition of mammary glands, and presence of embryos were

recorded. For *S. unguiculatus*, length of embryos (from ventral to dorsal margins including placenta and maternal uterus) was measured, and two stages of pregnancy were recognized on the basis of the average embryo length (excluding abnormal embryos): stage I, <8 mm; stage II, ≥ 8 mm. After reproductive condition was recorded, female reproductive tracts were preserved in 10% formalin. Complete serial sections (10 μm) were made for both ovaries of each individual and stained by the Masson trichrome technique, Goldner's method (Goldner, 1938). Slides were examined using a microscope (at 100 $\times$ and 200 $\times$ magnification), images on the microscopic videoscope were photographed at 25 $\times$ magnification, and number of corpora lutea and other histological condition were recorded. Entire reproductive tracts from females lacking visible embryos were cleared in benzene after removal of ovaries to examine for presence of placental scars or small implanted blastocysts.

RESULTS AND DISCUSSION

In *S. unguiculatus*, the average numbers of embryos were 5.6 in stage I ($n = 20$, $SD = 1.0$, range = 4–8) and 5.5 in stage II ($n = 11$, $SD = 0.5$, range = 5–6). No significant difference in litter size was detected between the stages (t -test, Aspin-Welch's method, $t = 0.37$, $n = 29.0$, $P > 0.8$). However, one of six embryos from one individual in stage II was extremely smaller than the rest of the siblings, suggesting it was being reabsorbed. Therefore, the number of embryos in the advanced stages in pregnancy may be reduced by resorption or death of some embryos during pregnancy.

Counts of placental scars were not useful for estimating female reproductive history in *S. unguiculatus* as they were not in *S. arcticus* (Baird et al., 1983), because placental scars disappeared immediately after parturition. Four of the 12 uteri lacking visible embryos were swollen in portions and showed lesions in the lumen that are typical of placental scars (Kirkpatrick, 1980). However, the remaining eight females demonstrated no special histological changes in the uterine horns, suggesting that these females had no placental scars or implanted blastocysts.

Counts of corpora lutea were not useful for estimating female reproductive history in *S. unguiculatus* because the number of corpora lutea tended to decrease from ovulation towards parturition. Average numbers of corpora lutea were 5.0 in mature females lacking visible embryos ($n = 12$, $SD = 1.5$, range = 2–8), 4.5 in stage I ($n = 10$, $SD = 1.2$, range = 3–7), and 4.1 in stage II ($n = 9$, $SD = 1.9$, range = 0–7). The average numbers did not differ significantly among the stages ($F = 0.87$, $P > 0.25$). However, one individual in stage II, which conceived well-developed fetuses, had no corpora lutea. Therefore, the decreasing number of corpora lutea towards more advanced reproductive stages probably is attributable to resorption of corpora lutea. A similar phenomenon was observed in *S. araneus* (Brambell, 1935) and *S. arcticus* (Baird et al., 1983).

Additionally, in *S. unguiculatus*, mature females lacking visible embryos contained no implanted blastocysts but had corpora lutea while they were lactating (Ohdachi and Maekawa, 1990). This finding suggests that in *S. unguiculatus* ovulation is a consequence of postpartum estrus with delayed implantation of blastocysts. This has been reported in *S. araneus* (Brambell, 1935) and *S. arcticus* (Baird et al., 1983).

Brambell (1935) estimated embryonic survivorship as the ratio of the number of embryos to the number of corpora lutea in *S. araneus*. However, this estimation is not appropriate for *S. unguiculatus* because the ratio exceeded one in some individuals. The number of corpora lutea was smaller than the number of embryos in 10 of 19 individuals examined or was equal to the number of embryos in seven of the 19 specimens.

Only three pregnant *S. caecutiens* were obtained, with 5, 7, and 9 embryos for each female ($\bar{X} = 7.0$). Abe (1968) reported the average litter size of this species was 7.1 for eight pregnant females from Hokkaido. Results of the present study are close to that of Abe (1968) despite a small sample. In

Eurasia, the average litter size of *S. caecutiens* ranges from 5.9 to 8.9 through its transcontinental range (Hanski, 1989), and variation in litter size seems to be related to habitat quality and the number of prior pregnancies (Dokuchaev, 1989).

I could examine ovaries for only two pregnant *S. caecutiens* and one mature female lacking visible embryos; these contained 5, 0, and 3 corpora lutea, respectively. One of the pregnant females, which had no corpora lutea, was in late pregnancy. This finding suggests that corpora lutea gradually degenerate as parturition approaches in this species as they do in *S. unguiculatus*.

Only two pregnant *S. gracillimus* were obtained; both had six embryos, and one uterus contained one reabsorbing embryo. The numbers of corpora lutea were three and four for each female.

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