Reproductive Characteristics and Occurrence of Accessory Corpora Lutea in Sika Deer *Cervus nippon centralis* in Hyogo Prefecture, Japan

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**Abstract.** The age at puberty, pregnancy rate and the occurrence of accessory corpora lutea (ACL) were investigated in female sika deer killed between late February and mid-March in Hyogo Prefecture. No fawns had ovulated but puberty occurred in most of yearlings. The pregnancy rate of yearlings and of older females was calculated to be over 90%. These show that the population has high reproductive performance. ACL were found in 80.7% of 57 animals that had ovulated, and females with ACL carried heavier fetuses than those without ACL.

**Key words:** Sika deer; Reproduction; Ovary; Corpus luteum.

Though there have been many studies on the reproductive biology of various species of cervid, reports on sika deer *Cervus nippon* are comparatively few. A knowledge of reproduction is indispensable in the understanding of the population dynamics of a wild species. This study was conducted to obtain basic information concerning the reproductive biology of sika deer in Hyogo Prefecture. The age at puberty, pregnancy rate, and some other reproductive characteristics, such as the occurrence of accessory corpora lutea, of the population are described in this paper.

The existence of accessory corpora lutea in red deer *Cervus elaphus* has recently attracted attention from the viewpoint of reproductive physiology and endocrinology (e.g., Kelly & Challies, 1978; Kelly *et al.*, 1982, 1985; Adam *et al.*, 1985), however, only a few reports have been published on this structure in sika deer (Yamauchi *et al.*, 1984; Mullan *et al.*, 1988). Therefore, in initiating a physiological study of the sika deer, the occurrence rate and the diameters of accessory corpora lutea were examined with particular interest.

**Study Area**

The study area encompasses 823.94 km² and is located in the central part...
of Hyogo Prefecture (Fig. 1). Elevations vary from 50 to 1,510 m and average approximately 300 m. Forest covers 84.7% of this study area. Plantations of Japanese cedar Cryptomeria japonica and Japanese cypress Chamaecyparis obtusa are widely distributed and constitute 60.1% of the forest. Most of the national forests are a mixture of red pine Pinus densiflora and white oak Quercus serrata. Understories are dominated by dwarf bamboo, Sasa nipponica and S. senanensis, Eurya Eurya japonica and Japanese aucuba Aucuba japonica, which are favored food of the deer.

In this area, buck-only hunting has been conducted from December to January. Pest control for both sexes is permitted in other seasons. Annual harvests have been increasing and recently reached to 900 – 1,000 animals.

Materials and Methods

Ovaries, uteri and fetuses were collected from 62 female sika deer killed on 26 February, and 4, 5, 11, 12 and 18 March 1989. The age of 45 of these animals was determined by tooth replacement and by the cementum annuli of first incisors following the methods of Ohtaishi (1980) and Koike and Ohtaishi.
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(1985). The age of the other 17 animals, which were all pregnant, could not be
determined due to the absence of their lower jaws. Fetal weights were
measured with a platform scale.

Ovaries were fixed in 10% formalin and sectioned in ca. 2 mm thick
samples with a razor. When at least one corpus luteum was identified macroscopically, the female was judged to have had ovulated. The diameter of
corpora lutea was measured in 30 pairs of ovaries which were not deformed
during the fixing process. The diameter was represented by the formula
\[ \sqrt{\text{long diameter} \times \text{short diameter}} \]
of the largest in the series of sections. If more than one corpus luteum was
observed in a pair of ovaries, the number and size were recorded. The relatively larger corpora lutea were classified as primary corpora lutea (PCL), and the smaller ones as accessory corpora lutea (ACL), following Douglas (1966) and Kelly and Challies (1978).

Since there were no significant differences in the maternal age and the fetal
weight among the dates of kill (Mann-Whitney U-test, \( p > 0.05 \)), these data
were all combined in the statistical analysis. Significant differences were
tested by the Mann-Whitney U-test.

**Results**

An analysis of age-specific reproductive performances (Table 1) showed
that: all three fawns were neither pregnant nor had ovulated; six of the seven
yearlings were pregnant and one had not ovulated; among those aged two
years or older, only one individual, of 11 years, had not ovulated. The oldest
animal was 13 years old, and was pregnant. All of 57 animals that had

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Table 1. Age-specific number of samples, ovulated, and pregnancies
of sika deer in Hyogo Prefecture (specimens of nine and 12 years old
were not obtained).
ovulated were pregnant, and twinning was not observed. Ovulation and pregnancy rates were both calculated at 95.2% for 42 yearlings and older animals.

The corpora lutea examined were generally round, and pale tan in the color (Fig. 2-A). In the luteal tissue, the septa were often developed giving the structure a lobular form. The central cavity, filled with fluid or asper tissue, was rarely found. Obvious differences between the structure of PCL and ACL were not detected macroscopically. Large follicles were often coexistent with the corpora lutea.

Fig. 2-A. Macroscopical view of a pair of ovaries from a pregnant sika deer.
Fig. 2-B. A case in which a primary corpus luteum and an accessory corpus luteum coexist in one ovary. R, right ovary; L, left ovary; PCL, primary corpus luteum; ACL, accessory corpus luteum; F, follicle.
ACL were found in 46 (80.7%) of 57 animals that had ovulated. There was only one ACL detected per pair of ovaries. Fourteen (30.4%) of 46 ACL were in the ovary containing PCL (Fig. 2-B). No significant difference in age was found between those females with ACL and those without ($p > 0.05$). Mean fetal weight of females with ACL was significantly heavier than those without ($p < 0.01$), 1,112.4 g and 648.8 g, respectively; Fig. 3).

No significant relationship was found between the diameters of corpora lutea and the weight of fetuses ($p > 0.05$). The mean diameter of corpora lutea in females without ACL was 9.62 mm, whereas in those with ACL, the mean of PCL's was 8.84 mm and the mean of ACL's was 5.55 mm. However, no significant difference was found in the diameter of corpora lutea between females with ACL and those without ($p > 0.05$). The ratios of ACL diameter to PCL diameter were very variable (Fig. 4); the mean ACL diameter was 62.8% of the mean PCL diameter.

**Discussion**

Since no corpora lutea were found in fawns, and six out of seven yearlings were pregnant, the puberty of a large number of females must occur at the age of yearlings in this population. The pregnancy rate of yearlings and older exceeded 90%. These results coincide with those of sika deer which were introduced in southern England and New Zealand (Chapman, 1974; Davidson, 1976). Pregnant fawns of this species have been reported by Chapman and
Fig. 4. Frequency distribution of the percentage of accessory corpora lutea (ACL) diameter to primary corpora lutea (PCL) diameter.

Horwood (1968), Chapman (1974) and Mullan et al. (1988). The reason why no pregnant fawns were found in this study may be due to the small sample size of this age class. However, pregnancy in fawns appears to be very uncommon in sika deer, as pointed out by Chapman and Horwood (1968).

Like other cervids, a low pregnancy rate and delayed sexual maturation have been reported in high density populations of sika deer (Ohtaishi, 1975; Yamauchi et al., 1984; Kaji et al., 1988). Compared to those reports, sika deer in Hyogo Prefecture continue to show high levels of reproductivity. This suggests that the local population has not yet attained to the limit of carrying capacity because of the intensive logging which leads to abundant forage productivity, and because of population reduction by hunting.

Because ACL were found in almost all age classes and there was no significant difference in age between females with ACL and those without, it is suggested that ACL occur independently of age. The ACL occurrence rate in the present study is one of the highest compared to the various species reviewed by Sadleir (1987). However, it is suggested that the frequency of ACL depends on the time of sampling (Mullan et al., 1988).

The diameter of corpora lutea in female red deer without ACL is larger than in those with ACL (Kelly & Challies, 1978). Also, the corpora lutea, including ACL, increase in size during pregnancy in elk Cervus canadensis and
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red deer (Morrison, 1960; Kelly & Challies, 1978). These phenomena were not clear in the present study, this may due to the short and limited sampling period. The tendency that ACL are about half the diameter of PCL, resembles the case of red deer described by Kelly and Challies (1978).

The fact, that heavier fetuses occurred in females with ACL than in those without, seemingly supports the theory that ACL are formed in the period of early pregnancy, as described by Guinness et al. (1971). However, Yamauchi et al. (1984) concluded that the origin of ACL is the retrograde corpora lutea of estrus formed at infertile ovulation since there are degenerate luteal cells in ACL. Also in the present study, like the report by Kelly and Challies (1978) on red deer, some ACL were found in females with small fetuses (see Fig. 3). These results make the determination of the origin and the formation time of ACL difficult. To elucidate these facts, it will be necessary to study ovaries from various seasons not only macroscopically but also microscopically.

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References

Kelly, R. W. & C. N. Challies. 1978. Incidence of ovulation before the onset of the rut and during