Application of Progesterone Measurement for Age and Body Weight at Puberty, and Postpartum Anestrus in Korean Native Cattle

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ABSTRACT. Studies were conducted in Korean native cattle to determine the age and body weight at puberty, and to determine the postpartum anestrus intervals based on plasma progesterone profiles, rectal palpation, ultrasonography and estrus observation. Korean native cattle reached puberty at 344 days of age and at 188 kg body weight as determined by plasma progesterone profiles, but estrous behavior was not detected until 3 months later, at a body weight of 215 kg. Prolonged postpartum anestrus occurred in 40% of smallholders cows, where animals were tethered and fed hay and rice straw, whereas its incidence was only 6.8% in a well managed herd that was grazed and housed. Plasma progesterone profiles were used to monitor ovarian activity postpartum in standard fed cows (n=44) and restricted fed cows (n=20). In standard fed cows 81.8% showed luteal activity by 50 days postpartum, compared to 55% in restricted fed cows. Approximately 40% of cows in both groups had shown observable estrous behavior by this time. This study indicates that one or more ovulations had occurred before pubertal heifers and postpartum cows showed overt estrous behavior. It was concluded that improved management and feeding practices should result in improved reproductive performance.

KEY WORDS: Korean native cattle (*Bos taurus coreanae*), postpartum anestrus, progesterone, puberty, ultrasonography.

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The population of Korean native cattle (*Bos taurus coreanae*) has increased from 1.6 million in 1990 to 2.3 million in 1998, but there has been a decrease in the number of farms raising beef from a peak of 0.6 million in 1990 to 0.4 million in 1998. Korean native cattle have traditionally been an important livestock resource in Korea not only for meat production but also for draught power. However, there is an increasing use of mechanical tillers and the traditional farming system is changing rapidly, with fewer smallholders and more large farmers. Korean native cattle are mainly used for beef production at this time, but low production efficiency means that the intercalving interval is more than 365 days.

While analysis of breeding records suggests that the age at puberty in Korean native cattle is about 24 months [13], investigators report that puberty is attained between 14 to 36 months [4, 7, 10]. Poor estrus detection is probably the most important reason for delayed breeding [9, 17], resulting in an extended calving interval [5, 7–9].

There are great variations among individual cows in the age at which heat signs first occur, depending on the level of nutritional intake. Chung *et al.* [3, 4] reported that the first estrus in heifers fed with a nutritious diet occurred at 14.6 months, when body weight was 265 kg whereas those fed a restricted ration showed first estrus at 23 months at a body weight of 250 kg.

As a result of the many endocrine studies conducted, a much more accurate picture of the hormonal changes which occur when cows return to full ovarian cyclicity after calving has been built up [2, 14, 18]. The first ovulation usually occurs later after parturition in beef cattle than in dairy cows. It is equally well established that the frequency and intensity of suckling can affect the duration of the postpar-

tum period of anestrus. It has been shown that chronic undernutrition and suckling interact to suppress gonadotrophin secretion to very low levels in cows for prolonged periods after calving [19, 25, 27]. This suppression is most likely the result of central inhibition of hypothalamic GnRH release, which, in severely undernourished cows, may be to levels below those necessary for the normal maintenance of pituitary LH and FSH synthesis and storage [26, 27].

A better understanding of the physiological mechanisms controlling reproduction in Korean native cows is required before improvements in reproductive efficiency can be achieved. The purpose of this study was to determine the age at puberty, and the relationships between plasma progesterone profiles and postpartum anestrus in this breed.

MATERIALS AND METHODS

Experiment I: Study on age and body weight at puberty

Animals: Thirteen heifers from a well managed herd were used. Animals were fed corn silage and hay in a balanced ration (NRC standard). Analyses of feeds supplied to the animals at different stages of growth are presented in Table 1.

Table 1. Analysis of feeds supplied to the heifers at different stages of growth

	Body weight (kg)				
	< 100	100–150	151–200	201–250	251–300
DM	2.70	4.11	5.56	6.16	7.11
TCP	0.16	0.48	0.62	0.68	0.76
TDN	0.72	2.81	3.70	4.11	4.64

Blood sampling regime: Blood samples were collected from the jugular vein into heparinized containers twice a week from 8 to 24 months of age. The blood was centrifuged at 3,000 g and the plasma decanted and stored at -20°C until assay. Plasma progesterone concentrations were quantified by radioimmunoassay using antibody coated tubes and ^{125}I progesterone as the radioligand (FAO/IAEA progesterone RIA kits). The sensitivity of the assay was 0.1 ng/ml and intra- and interassay coefficients of variation were 9.7% and 13.6%, respectively. Plasma progesterone levels above 1.0 ng/ml were considered as being indicative of luteal activity.

Rectal palpation, estrus observation and body weight: The ovaries and uterus were examined by rectal palpation weekly from 8 to 24 months of age. All heifers were observed for estrous behavior by experienced herdsmen twice a day (08:00 and 18:00 hr) and weighed weekly from 8 to 24 months of age.

Experiment II: Study on postpartum anestrus

Animals:

Standard fed cows (Group 1): Forty-four suckled cows from a well managed herd were used in this study. They were fed corn silage and hay in a balanced ration (NRC standard). Animals were 3 to 9 years of age (Mean=5.4) and in their first to seventh parity (Mean=3.5). The analyses of feeds supplied to the animals at pre and postpartum periods are given in Table 2.

Restricted fed cows (Group 2): Twenty suckled cows from small holders were used in this study. They were fed hay and rice straw but not a balanced ration. Animals were 3 to 11 years of age (Mean=5.5) and in their first to sixth parity (Mean=2.9).

Blood sampling regime: Blood samples were collected via the jugular vein into heparinized containers, at 3 day intervals from 15 to 80 days postpartum. The blood was centrifuged at 3,000 g and the plasma decanted and stored at -20°C until analysed for plasma progesterone using the RIA kit as mentioned above. Plasma progesterone levels above 1.0 ng/ml were considered to be indicative of luteal activity.

Rectal palpation, ultrasonography and estrus observation: The ovaries and uterus were examined by rectal palpation and ultrasonography (EUREKA SA-600, Medison Co, Korea) at 6 day intervals from 15 to 80 days postpartum. Follicles and cystic ovaries were classified as "small", "large", or "cystic" according to their estimated diameters of < 15 mm, 15 to 25 mm or > 25 mm, respectively. All cows were observed for estrous behavior by experienced herdsmen twice a day (08:00 and 18:00 hr).

RESULTS

Experiment I: Based on plasma progesterone profiles, mean ($\pm$ SEM) age and body weight at puberty of Korean native cattle were 344 ± 15 days and 188.5 ± 15.6 kg, respectively, compared with 433 ± 21 days and 215 ± 18.2 kg as determined by estrus observation.

Representative plasma progesterone profiles illustrating commencement of ovarian activity in Korean native heifers

Table 2. Analysis of feeds supplied to the pre and postpartum cows

	Prepartum ^{a)} (range)	Postpartum (range)
DM	8.54 (7.09–11.06)	10.93 (9.8–11.67)
TCP	1.03 (0.66–1.46)	1.38 (0.93–1.65)
TDN	4.82 (3.73–7.02)	6.36 (5.81–6.89)

a) For 3 months prepartum.

Fig 1. Plasma progesterone profiles in two Korean native heifers during the peri-pubertal period.

Table 3. Percentages of Korean native cattle on two nutritional regimes showing ovarian activity at various times postpartum, as determined by progesterone profiles, rectal palpation and ultrasonography or by estrus observation

	% showing ovarian activity			
	Progesterone profiles		Estrus observation	
	Group 1 ^{a)}	Group 2 ^{b)}	Group 1 ^{a)}	Group 2 ^{b)}
20	11.4	0	0	0
21–30	34.1	20.0	18.2	15.0
31–40	29.5	20.0	15.9	15.0
41–50	6.8	15.0	9.1	10.0
51–60	11.4	5.0	13.6	10.0
61–70	0	0	9.1	15.0
71–80	0	0	9.1	0
81	6.8	40.0	25.0	35.0
Total	100.0	100.0	100.0	100.0
(No. of cows)	(44)	(20)	(44)	(20)

a) Group 1: Standard fed cows. b) Group 2: Restricted fed cows.

are presented in Fig. 1.

Experiment II: Based on plasma progesterone profiles, 81.8% of standard fed cows showed luteal activity by 50 days postpartum, compared to 55% of restricted fed cows. Approximately 40% of cows of both groups had shown observable estrous behavior by this time (Table 3).

Representative plasma progesterone profiles of postpartum cows are presented in Fig. 2, and ovarian status as examined by ultrasonography is presented in Table 4. Four categories of profile were observed. Profile 1 is representative of cows with a normal postpartum anestrus interval (45 days), while Profile 2 and 3 represent those found in cows with more prolonged periods of postpartum anestrus (55 days and 80 days, respectively). These cows were diagnosed as having inactive ovaries or follicular cysts. Cystic wall thickness was 1.2 mm by ultrasonography and plasma progesterone concentrations were below 0.8 ng/ml. The cows represented by Profile 4 had persistent corpus luteum with pyometra from first ovulation which failed to regress, or luteinized follicle. Cystic wall thickness was 4.8 mm by ultrasonography and plasma progesterone concentration was 5.2 ng/ml.

Prolonged postpartum anestrus occurred in 40% of smallholders cows, where animals were tethered and fed hay and rice straw, whereas its incidence was only 6.8% in the well managed herd that was grazed and housed.

DISCUSSION

Korean native cattle in this study reached puberty at 344 days of age and at 188 kg body weight as based on plasma progesterone profiles, whereas estrous behaviors were detected at 433 days of age and at 215 kg body weight. Based on plasma progesterone profiles and ultrasonography, 81.8% of standard fed cows had resumed ovarian activity by 50 days postpartum, compared to 55% of restricted fed cows, but approximately 40% of cows of both groups had shown observable estrus signs. These results indicate that one or more ovulations had occurred before estrous behavior was observed at the onset of puberty and postpartum.

The effects of nutrition on the onset of puberty in beef

Fig 2. Representative plasma progesterone profiles illustrating different types of postpartum ovarian activity seen in Korean native cattle.

heifers have been reviewed by Schillo *et al.* [22] and Grings *et al.* [6]. It was clear in those works that age at puberty is related inversely to plane of nutrition. Bergfeld *et al.* [1] examined the influence of dietary energy intake on the development of dominant ovarian follicles in prepubertal heifers. They found that heifers in two groups developed ovulatory follicles of similar size at the pubertal ovulation, but the pubertal ovulation was on average 63 days later in heifers fed a lower-energy diet compared with those fed greater amounts of dietary energy.

Table 4. Types of ovarian activity postpartum investigated by plasma progesterone profiles and ultrasonography in Korean native cows

Classification	Pattern of plasma P_4 ^{a)} profiles	No. of cows (%)		Ovarian state (Ultrasonography)	No. of cows (%)	
		Group 1 ^{b)}	Group 2 ^{c)}		Group 1 ^{b)}	Group 2 ^{c)}
Profile I	Normal	35 (79.5)	11(55.0)	Normal	35 (79.5)	11(55.0)
Profile II	Cycle delayed	4 (9.0)	1(5.0)	Inactive ovaries	4 (9.0)	1(5.0)
Profile III	Cycle ceased with low P_4 ^{a)}	3 (6.8)	8(40.0)	Inactive ovaries	2 (4.5)	7(35.0)
Profile IV	Cycle ceased with high P_4 ^{a)}	2 (4.5)	0(0)	Follicular cysts	1 (2.3)	1(5.0)
				Persistent corpus luteum	1 (2.3)	0(0)
				Luteal cyst	1(2.3)	0(0)
Total		44 (100)	20(100)		44 (100)	20(100)

a) P_4 : Progesterone. b) Group 1: Standard fed cows. c) Group 2: Restricted fed cows.

In *Bos taurus* cows, puberty is attained at about 7–12 months of age and 250–300 kg body weight. As first service is usually delayed until about 15 months of age, first calving occurs at 24–36 months [5]. In *Bos indicus* cows, puberty generally occurs later and at a higher percentage of adult body weight [20]. Oyedipe *et al.* [16] reduced the age of puberty by improved protein feeding.

In Korean native cows, Han *et al.* [7] reported that age at first estrus varied from 12 to 36 months. Chung *et al.* [4] reported that in heifers kept under similar conditions to those in this study, first estrus was at 14.6 months when body weight was 265 kg, while age at the first calving was 28.9 months at 436 kg body weight. However, when heifers were fed a restricted diet, first estrus occurred at 23.0 months and a body weight of 250 kg, while age at first calving was 38.9 months. In this study, mean age at puberty of Korean native heifers (11.3 months) as determined by plasma progesterone profiles was less than that reported by Chung *et al.* [4], and occurred at a lower body weight (188 kg). However, when observed estrous behavior was the criterion used, age at puberty (14 months) was similar to that observed by Chung *et al.* [4] although the body weight at which first estrus was observed (215 kg) was less. This study indicates that one or more ovulations had occurred before the first visible signs of estrus were observed. This finding may reflect inadequacies in the intensity and timing of estrus detection, or that these ovulations were associated with weak or short-lived estrous signs.

Calving interval is perhaps the major parameter used to assess bovine reproductive efficiency, and individual cows in both dairy and beef herds undergo calving intervals in excess of the average economic optimum of 365 days [9, 11, 12]. The postpartum acyclic period is of variable length and is affected by various factors, particularly nutritional status, season, suckling and milk yield [15, 21, 23, 24, 26]. Milked dairy cows have been reported to resume ovarian cycles, as determined by milk progesterone measurement, after 24.0 ± 0.6 (SEM) days postpartum [2], whilst the figure for suckling beef cows was 56.9 ± 2.5 days [17].

In this study, more standard fed cows (81.8%) showed elevation of plasma progesterone indicating an ovulation by 50 days postpartum than did restricted fed cows (55%). However, there were no differences in the proportions of cows observed in estrus signs at this time. Since observations for estrus signs were carried out by experienced herds-men, our results suggest that a high proportion of ovulations occurring during the early postpartum period were associated with little or no estrous behavior, or with short duration of estrus [10, 16]. The results of this study indicate that postpartum ovarian activity was reestablished later in Korean native cows than in dairy cows, and that the first ovulation postpartum occurred earlier in standard fed cows than in restricted fed cows. Further, these results indicate that plasma progesterone profiles assessed by RIA and ultrasonography can be utilized for monitoring postpartum ovarian activity and may be helpful for the early detection of ovarian dysfunction.

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