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Maternal Effects of Japanese Shorthorn Cows on the Growth of Embryo-transferred Japanese Black Calves in a Cow-calf Grazing System

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ABSTRACT: The growth performance of embryo-transferred Japanese Black calves that were born from, and suckled by, Japanese Shorthorn cows in a cow-calf grazing system (BS-group, n = 5) was compared to that of Japanese Black calves from Japanese Black cows in a cowshed (BB-group, n = 5). The daily weight gain from birth to 1 month was higher in the BS-group than in the BB-group ($p<0.01$), and the same trend ($p<0.05$) was observed at 2 and 3 months of age. This resulted in body weight that was significantly higher for the BS-group between 1 and 3 months of age than what was observed for the BB-group ($p<0.05$). Heart girth was significantly greater in the BS-group than in the BB-group throughout the experimental period ($p<0.01$), and chest depth and withers height in the BS-group were significantly greater from 2 to 4 months of age ($p<0.05$) and at 4 months of age only ($p<0.05$). No difference in body length ($p>0.05$) was observed between the groups. These results suggest that the maternal effect of Japanese Shorthorn cows was positive for embryo-transferred Japanese Black calf growth during the early suckling stage. As Japanese Black calves are traded at a high price on the Japanese market, we conclude that this proposed production system is likely to improve the profitability of herd management in upland Japan. (**Key Words:** Japanese Shorthorn, Japanese Black Cattle, Embryo Transfer, Cow-calf Grazing)

INTRODUCTION

The Japanese Shorthorn (JS) is one of the Wagyu beef breeds, which was improved by crossbreeding imported Shorthorn bulls with the indigenous Nanbu cattle that were kept in upland areas in the northern region of Japan. The goal of this cross breeding was to enlarge the physique of the offspring and to endow them with milking and fattening abilities. JS were continuously improved thereafter to make them fit for summer pasture and were certified as indigenous Japanese beef cattle in 1957 (Takayasu, 1983). JS are resistant to cold weather, suited to grazing in upland areas, and good at rearing their calves. However, the liberalization of beef imports into Japan in 1991 profoundly altered the beef production system and the marbling score of beef has become the most economically important trait for discriminating indigenous beef from imported beef (Japan Meat Grading Association, 1988). The production of Japanese Black (JB) cattle in lowland areas is suited to this trend because the cattle produce highly marbled meat. In contrast, JS accumulate less intramuscular fat (Muramoto et al., 2004). The selling price of castrated JS and JB calves in the past half-decade (at the autumn market in Iwate Prefecture from 2008 to 2012) was 1,438 and 619 yen/kg, respectively. This disparity in price has caused immeasurable damage to the economy of upland areas.

The transfer of JB embryos to JS cows is an attractive option for stimulating the economy in upland areas. Sakaguchi et al. (2002) indicated that JS cows were suitable recipients for transferred JB embryos because the body size and milk yield of JS cows are greater than those of JB cows. Konashi et al. (2003) reported that this technology has an economic benefit when it is combined with calf rearing in a cow-calf grazing system. This technology involves a single embryo transfer using the ovulation synchronizing method (Pursley et al., 1995). Even when the transplantation is not successful, JS calves are obtained by natural mating with JS bulls during the next estrus. This system is generally advantageous to managers when the success of embryo transfers is ≥30%. In order to ensure the profitability of this technique, embryo-transferred JB calves must have increased growth performance relative to natural JB calves during the grazing period. As detailed data are not available

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for the growth performance of such embryo-transferred calves, the purpose of the present study was to evaluate the early-suckling stage growth performance of embryo-transferred JB calves that were borne and suckled by JS cows in a cow-calf grazing system.

MATERIALS AND METHODS

Procedure for embryo transfer

All animal treatments were approved by the Animal Care and Use Committee of *Tohoku* Agricultural Research Center. A total of 26 JS cows, which included 12 heifers, 7 primiparous cows, and 7 multiparous cows, were used as recipients for embryo transfer. Estrus synchronization was conducted as follows: the cows were injected intramuscularly with 3 ml (250 μg/ml) $PGF_{2\alpha}$ analogue (cloprostenol, Estrumate™; Shering-Plough Animal Health, Tokyo, Japan), and/or an intravaginal controlled internal drug releasing device (CIDR) containing 1.9 g of progesterone (Eazibreed™; Livestock Improvement Association of Japan, Inc., Tokyo, Japan) was inserted for 11 to 14 d. A cryopreserved-thawed JB embryo was transferred to the recipient 6.0 to 7.5 d after the onset of estrus.

Feeding system

Embryo-transferred male JB calves (n = 5) that were born to recipient JS cows between May and July and that were raised in grazing conditions (BS-group) were used for the study. The calves in this group and their mothers (JS cows) were allowed to graze without supplemental feed on 4.8 ha of pastureland predominantly covered by Kentucky bluegrass (*Poa pratensis*). The pastureland was separated into three sections, and animals were rotated between sections, according to grass quantity. JB male calves (n = 5), born between May and July and suckled by JB cows in a cowshed (BB-group) were used as a control group. The JB cows were fed hay silage *ad libitum* with 1 kg concentrated feed (TDN 68%, CP 15%) twice each day. The BB-group was fed hay silage *ad libitum* after birth, and provided with a quantity of concentrate feed (age 1 to 2 months: TDN 72%, CP 16%; after 2 months: TDN 68%, CP 18%) each day that was equal to 1.5% of body weight. Water and mineral salt were supplied *ad libitum*. Body weight was measured weekly, and withers height, body length, heart girth, and chest depth were measured every month for both groups.

Statistical analysis

From birth to 4 months of age, the mean daily weight gain (DG), body weight, withers height, body length, heart girth, and chest depth were calculated for every month of age. Group means were compared using Student's *t*-tests. Statistical significance was set at $p<0.05$.

RESULTS

Production efficiency

Nine of the 26 JS cows became pregnant following JB embryo transfer, but one calf was stillborn after 250 d of pregnancy. Five male and three female calves were produced a birth rate of 31%. The five male calves were used in the present study.

Daily weight gain (DG) and body weight changes

Figure 1 shows the DG of both groups for each month along with the standard DG level calculated from the curve proposed by the Japanese Wagyu Registry Association. In the first month, the BS-group DG (1.12±0.04 kg/d) was much larger than that of the BB-group (0.80±0.10 kg/d) and this difference was statistically significant ($p<0.01$). This trend continued throughout the experimental period, but was only statistically significant for the first month and between the second and third months ($p<0.05$). The DGs of all BS-group calves, except for one at 3 to 4 months of age, were superior to the standard. Figure 2 shows the body weight of the calves for each month. The weights of BS-group calves at 1, 2, and 3 months after birth were 65.8±2.9 kg, 96.6±10.0 kg, and 129.0±12.6 kg, respectively. BS-group body weights were significantly higher ($p<0.05$) than those of the BB-group at 1, 2, and 3 months of age (58.8±3.8 kg, 86.2±1.7 kg, and 110.9±5.8 kg, respectively).

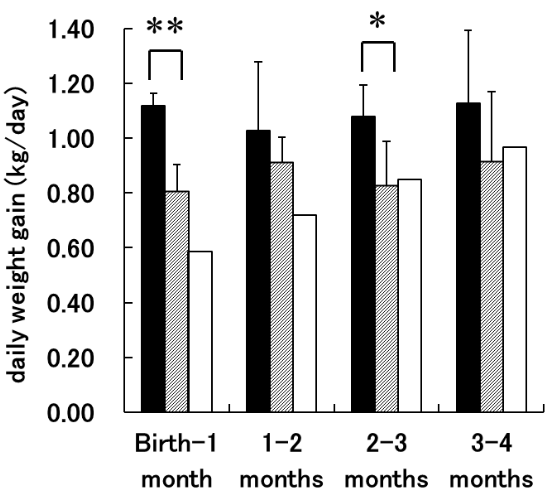

Figure 1. The monthly daily weight gain of Japanese Black (JB) calves born to Japanese Shorthorn (JS) cows (BS-group) and JB calves born to JB cows (BB-group). ■ BS-group: JB calves with JS cow on grazing land; ▨ BB-group: JB calves with JB cow in a cowshed; □ Standard from the Japanese Wagyu Registry Association. The data are shown as the mean±SD, and * ($p<0.05$) and ** ($p<0.01$) indicate the significant effects between the groups.

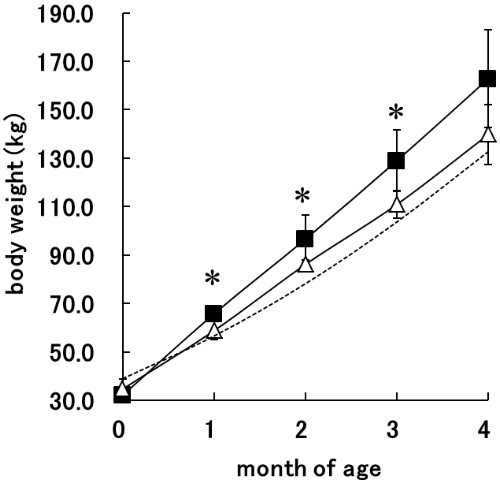

Figure 2. The body weight of Japanese Black (JB) calves born to Japanese Shorthorn (JS) cows (BS-group) and JB calves born to JB cows (BB-group) during the first 4 months of life. ─■─ BS-group: JB calves with JS cow on grazing land; ─△─ BB-group: JB calves with JB cow in a cowshed; ---- Standard from the Japanese Wagyu Registry Association. The data are shown as the mean±SD, and * ($p<0.05$) indicates the significant effects between the groups.

Changes of physical size

Heart girth, chest depth, withers height, and body length are shown in Figure 3. No difference in heart girth was observed between groups at birth, but the heart girth of the BS-group at 1 month of age was significantly greater ($p<0.01$) than that of the BB-group (92.1±2.4 cm vs. 86.5±1.1 cm). The difference between groups increased with time and remained significant ($p<0.01$) throughout the experimental period. Significant differences ($p<0.05$) in chest depth were observed after 2 months of age. Chest depth was 2.0, 2.9, and 3.6 cm greater in the BS-group than in the BB-group at 2, 3, and 4 months of age, respectively. The withers height was significantly greater ($p<0.05$) in the BS-group than in the BB-group after 4 months of age, and there was no difference in body length ($p>0.05$) between the groups during the experimental period.

DISCUSSION

The key factor for calf growth is the milk yield of the beef cow (Cutter and Nielsen, 1987; Shimada et al., 1988). High growth performance was expected for embryo-

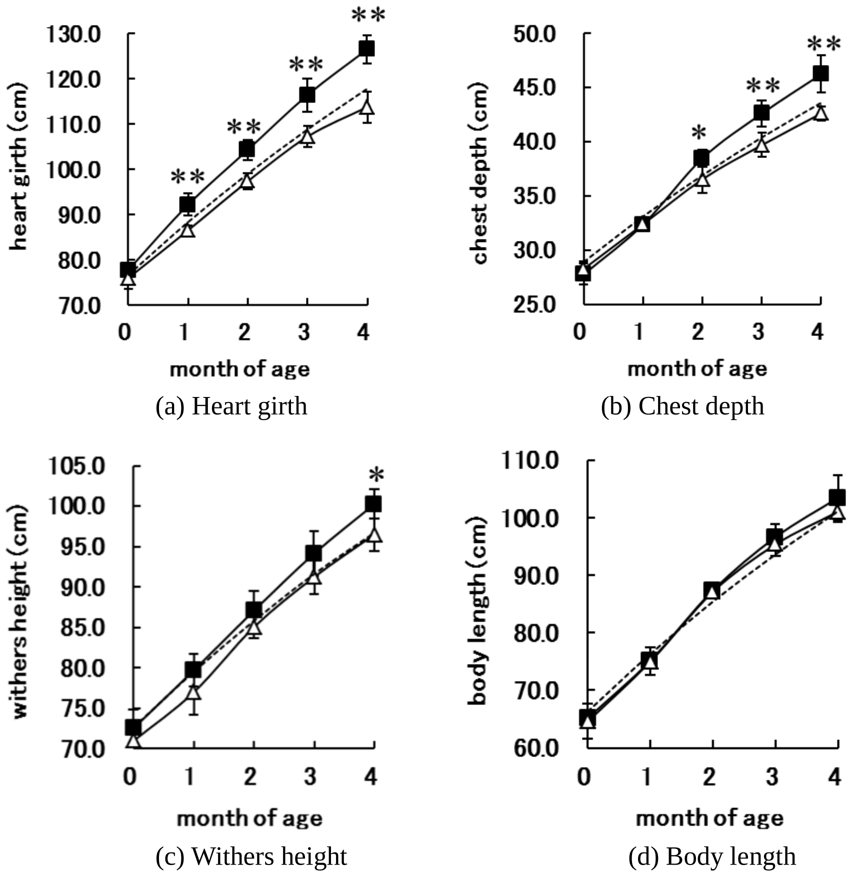

Figure 3. Physical size changes in Japanese Black (JB) calves born to Japanese Shorthorn (JS) cows (BS-group) and JB calves born to JB cows (BB-group). ─■─ BS-group: JB calves with JS cow on grazing land; ─△─ BB-group: JB calves with JB cow in a cowshed; ---- Standard from the Japanese Wagyu Registry Association. The data are shown as the mean±SD, and * ($p<0.05$) and ** ($p<0.01$) indicate significant differences between groups.

transferred JB calves born to JS recipients because JS cows have high milk yield (Shingu et al., 2002). Konashi et al. (2003) conducted two separate embryo-transfer experiments and reported conception rates of 40.9% and 36.8% in JS cows. The birth rate of 31% in the present study was lower than these reported rates. However, this birth rate exceeded 30%, which would result in a profit of more than 2,201 yen per recipient from the model management balance in the year of 1999 and 2001 (Konashi et al., 2003).

It is generally accepted that calves grow more slowly on pasture ground than in cowsheds, and this has been demonstrated for JB calves (Fukuhara et al., 1973). In the present study, however, we showed that JB calves in the BS-group, which were born and suckled in pastureland, were superior to JB calves raised in a cowshed (BB-group) in daily weight gain, body weight, heart girth, chest depth, and withers height. These advantages are due to the maternal effects of JS cows, which overcame the adverse influence of grazing.

One of the most important maternal effects is milk production ability (Shimada et al., 1988). Over 180 d, the milk yield of JS cows and JB cows is 1,500 to 2,000 kg (Shuji et al., 1997; Shingu et al., 2002) and 500 to 1,000 kg (Shimada et al., 1988; Shingu et al., 2002), respectively. JS cows have a milk yield that is approximately 2 times that of JB cows. The amount of suckling was not measured in the present study, but there is a high correlation ($r = 0.88$, $p< 0.01$) between the amount suckled and DG up to 8 weeks of age (Kyuma et al., 1979). The DG of the BS-group was greater than the standards set by the Japanese Wagyu Registry Association and statistically higher than that of the BB-group during the first month and between the second and third months of age. The more rapid weight gain of the BS-group, as compared to the BB-group, is attributed to higher milk production by JS cows than by JB cows.

Growth in the early suckling stage is not only affected by the amount of milk intake but also by fat intake (Christian et al., 1965). Shingu et al. (2002) reported that there are no differences in colostrum fat percentage between JS and JB cows during the first 6 d after parturition, but the milk yield was 4 times greater in JS cows. Two weeks after parturition, the fat percentage of milk from JB cows was 1.5 times that of JS cows, but the milk yield was twice as high in JS cows as it was in JB cows. This suggests that the fat intake of the BS-group was higher than that of the BB-group during the first month. This higher fat intake also explains the greater DG for the BS-group than for the BB-group during the first month and resulted in greater body weight changes in the BS-group than in the BB-group during the experimental period.

The higher body weight, in comparison to standard data, resulted in larger heart girth in the BS-group throughout the experimental period. The BS-group also had greater chest depth than the standard after 2 months of age, and greater withers height after 4 months of age. However, the BS-group did not differ from the standard in body length. The physical size changes at different times in the BS-group can be explained by the theory described by Guenther et al. (1965), in which withers height and body length are strongly related to skeletal growth and skeletal growth is more closely related to month of age than to nutritional conditions. In contrast, none of the physical data for the BB-group was above the standard levels. From these results, we conclude that the growth performance of the BS-group surpassed the standard level in terms of physical size.

We were concerned that dietary diarrhea might occur in the BS-group as a result of excessive ingestion of the milk provided by JS cows. However, no such physical symptoms were observed.

Castrated JB calves are shipped to the stock market before fattening, and the growth target for the market is 240 to 250 kg at 8 months of age. The age at time of shipment has recently become lower in order to reduce production costs. To accommodate this trend, calves with excellent growth, like the BS-group in the present study, are necessary. In addition, the production of JB calves by embryo transfer is likely to lead to improvements in profitability and stability of herd management in the uplands of the northern part of Japan.

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