EFFECT OF MILK YIELD ON GROWTH OF MULTIPLE CALVES IN JAPANESE BLACK CATTLE (WAGYU)

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Summary

An experiment was conducted to examine the feasibility of producing multiple calves using embryo transfer in Japanese Black cattle. Milk yield of cows and forage intake of calves were measured for 11 cows with single calves, 14 cows with twins and one cow with triplets. The means of 26 weeks cumulative milk yield were 854, 1028 and 1271 kg for cows having singles, twins and triplets, respectively. Male birth weights for single calves, twins and triplet were 34.9, 26.6 and 19.9 kg, and female ones were 31.7, 24.1 and 22.1 kg, respectively. Weight and daily gain of calves were affected by weeks (W), sex (S), the number of calves (N), parity, birth season, W × N, S × N and regression on milk yield. Growth rate was higher for single calves than for twins until about 9 weeks of age, then weights increased at a similar rate. Male calf weaning weights for singles, twins and triplets were 207.0, 177.1 and 162.2 kg, and those for females were 185.4, 151.6 and 180.4 kg, respectively. Average regression coefficients of calf growth on milk yield were significant, and single calf was affected more than twin calves by increment of milk yield. As the number of calves per cow increased, hay intake of calves decreased and concentrate intake tended to increase between 6 and 13 weeks of age.

(**Key Words:** Beef Cattle, Embryo Transfer, Multiple Calves, Milk Yield, Calf Growth, Feed Intake)

Introduction

Induction of multiple pregnancy could be one of the effective ways to improve efficiency of beef production (Wyatt et al., 1977). Generally, twinning rate of beef breeds is lower than that of dairy breeds in natural mating and AI (Rutledge, 1975; Gregory et al., 1990). Some papers were focused on embryo and fetal survival rate in case of bilateral embryo transfer (Anderson et al., 1978; Smith et al., 1982; Reid et al., 1986; Davis et al., 1989). However, there has been little study regarding multiple calves growth especially in Japanese Black cattle (Wagyu) even in natural twins. We reported the early embryonic loss after bilateral embryo transfer in Japanese Black cows (Izaike et al., 1988 and 1991). Calves produced in that study were then reared to examine their growth until weaning. The objective of this study was to evaluate the ability of Japanese Black cows to nurse multiple calves.

Materials and Methods

Embryos transferred were collected by multiple ovulation and *in vitro* fertilization in Japanese Black heifers and cows. Fourteen sets of twins and one set of triplets were produced. Detailed descriptions of embryo transfer procedures used in this experiment were reported by Izaike et al. (1988) and by Goto et al. (1988). Ten cows produced single calves by embryo transfer or AI. These were chosen as a standard. The mean of parity was the same as the twin group. One twin calf died within 6 hours after birth by accident. The remaining twin was treated as a single calf.

Heifers and cows were fed 20 kg of silage, 2 kg of hay and 2 kg of concentrate per day. Calves were fed hay *ad libitum* and a pelleted creep ration up to a maximum of 2.5 kg per

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Received November 5, 1991
Accepted August 11, 1992

day. Triplet calves were fed milk replacer as a powder (2.0 kg per day per 3 calves) from 4 to 10 weeks of age.

Daily milk yield was measured by a calf-suckling technique in weeks 1 to 9, 11, 13, 17, 21 and 26 postpartum. Cows and calves were separated at 09:00 and allowed to nurse at 16:00. Then they were separated again. The next morning at 09:00 the calves were weighed, allowed to nurse, and reweighed. Cow and calves were separated again and at 16:00 the calves were weighed, allowed to nurse, and reweighed. The sum of the two differences in calf weight was taken as daily milk yield of the cow. Hay and concentrate offered and refused were weighed for calf's daily forage intake while the calf was separated at 3, 4, 6, 8, 11, 13, 17, 21 and 26 weeks of age. Calf weight was calculated as the mean of weights before and after suckling at 09:00. Male calves were not castrated during the experiment.

The calf growth and forage intake were analyzed by least-squares procedures (Harvey, 1988). The models included age of calf at a giving week, sex of calf, the number of calves, parity and birth season as the main effects. Birth weight and milk yield were used as the covariates. The models also included two-factor interactions. Those which were found to be unimportant ($p > 0.15$) were deleted from the final models. Parity was classified into 5 classes (1st, 2nd, 3-4th, 5-7th and 8-9th parities) according to the previous study (Shimada et al., 1988). Records from triplets were not used in the statistical analysis.

Results and Discussion

The arithmetic means of parity, gestation length, birth weight and 26 weeks weight of calves are presented in table 1. Parity was designed to be similar between single and twin groups; mean parity of single group was 4.1 ± 1.8 after adding the record of the calf born a twin but raised as single. The potential milk yield between single and twin group caused by parity should be similar. However, the difference in daily milk yield between two groups was approximately 1 kg (figure 1). Genetic potential in milk yield could be significant between these two groups since the difference based on previous records adjusted to 3-4th parity was 0.7 kg per day. However, more intense suckling of twins might have stimulated the milk production of the cows. The means of 26 weeks cumulative milk yield were 854, 1028

TABLE 1. SUMMARY OF ANIMAL DATA FROM EXPERIMENT

Item	No.	Mean ± S.D.	Range
Single			
Parity	10	3.9 ± 1.8	1 – 8
Gestation length (days)	10	288.2 ± 3.6	284 – 294
Birth weight (male, kg)	4	34.9 ± 6.0	30.5 – 43.5
Birth weight (female, kg)	6	31.7 ± 3.1	27.8 – 35.7
26 weeks weight (male, kg)	5[1)]	207.0 ± 31.3	171.9 – 258.0
26 weeks weight (female, kg)	6	185.4 ± 14.4	169.0 – 209.3
Twin			
Parity	14	4.1 ± 2.0	1 – 9
Gestation length (days)	14	283.5 ± 3.5	276 – 290
Birth weight (male, kg)	14	26.6 ± 4.2	18.0 – 37.0
Birth weight (female, kg)	14	24.1 ± 2.6	19.5 – 29.0
26 weeks weight (male, kg)	11[2)]	177.1 ± 17.1	153.1 – 208.2
26 weeks weight (female, kg)	9[3)]	151.6 ± 13.0	138.9 – 181.9

[1)] Because of a twin calf's unexpected death, data from another calf were used as the single calf's records except parity, gestation length and birth weight.

[2)] Two calves were removed at 8 weeks of age and one calf was used as single.

[3)] Four calves were removed at 8 weeks of age and one calf died.

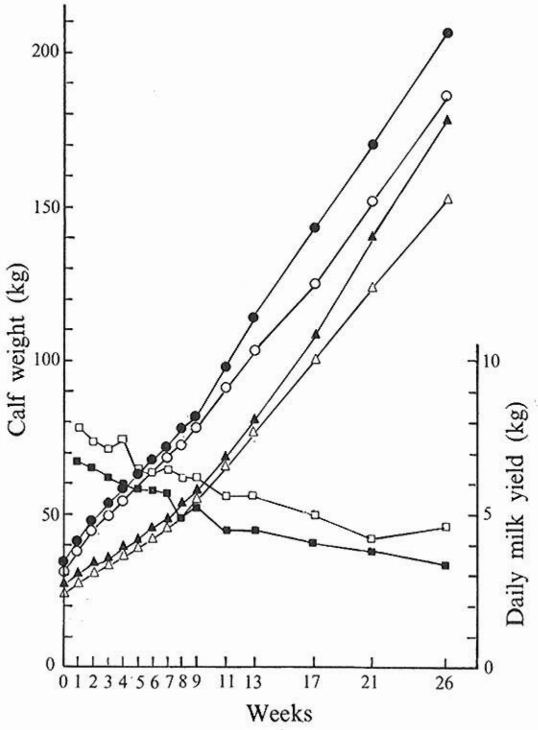

Figure 1. Milk yield and calf growth for singles and twins.
Singles: ■, milk yield; ●, male calves; ○, female calves
Twins: □, milk yield; ▲, male calves; △, female calves.

and 1271 kg for cows with single, twin and triplet calves, respectively. The mean of the single group was close to the estimate of 843.9 kg for 3-4th parity reported in previous study (Shimada et al., 1989). Wyatt et al. (1977) reported 39% more milk yield from Hereford × Holstein cows with twins than from ones with single calf. The smaller difference in this experiment might be caused by lower ability for milk yield in Japanese Black cows. Reid et al. (1986) reported that cows with twin calves had a slightly higher milk yield to weaning than those with single calf in crossbred cattle. Also Smith et al. (1982) reported higher milk yield in cows producing twins in beef cattle.

Gestation length in cows with single calf was 288.2 days and it was similar to the estimate of 287.4 days reported by Oishi et al. (1985) in this breed. Gestation length in cows with twins was 283.5 days with range of 276-290 days. Average birth weight of twin calves was 76% of single calf within sex, and was similar to the birth weight of calves from heifer in a previous study (Shimada et al., 1988). The result of this study, shorter gestation length and smaller birth weight in twin calves, was in agreement with the results of the other studies (Anderson et al., 1978 and 1982; Davis et al., 1989). Gestation length of cows producing triplets was 284 days and the birth weights of calves were 19.1 (♂), 20.7 (♂) and 22.1 (♀).

Calf growth is shown in figure 1. The difference of weight between sigles and twins increased until about 9 weeks of age. Then the difference tended to remain constant. The interactions in calf growth between experiment week and the number of calves were significant (table 2). Figure 2 shows the changes in calf daily gain (DG) between two consecutive weight records. Changes in the single group was quite similar to the growth pattern of calves for 3-4th parity cows in previous report (Shimada et al., 1988). Differences in daily gain between the two groups were decreasing from 3 to 8 weeks. The significant interaction between sex and the number of calves reflected the fact that the difference between sex within group was increasing after 9 weeks of age (figure 1, table 2). Both of the average partial regression and individual regressions for the number of calves classes for calf growth on milk yield were significant (table 2). The average regression coefficients were 2.35, 0.05 and 0.06 in calf weight, DG between experiment weeks and

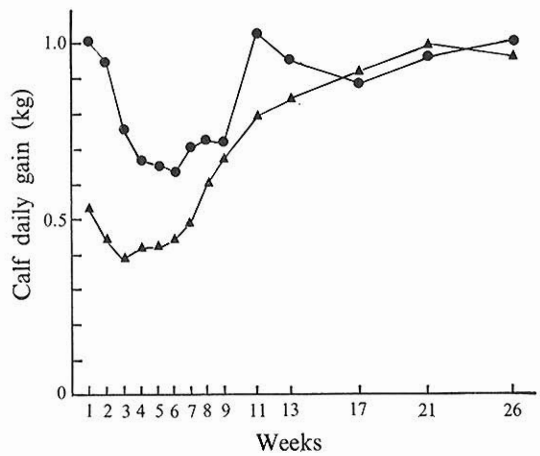

Figure 2. Calf daily gain between experiment weeks.
●, Singles; ▲, Twins.

TABLE 2. ANALYSIS OF VARIANCE FOR WEIGHT AND DAILY GAIN (DG) OF CALVES

Source	d.f.	Mean squares (kg^2)		
		Weight	DG between exp. weeks	DG from birth to exp. week
Week (W)	13	34407***	0.8609***	0.2771***
Sex (S)	1	2324***	0.7953***	0.4803***
No. of calves (N)	1	6420***	3.5107***	6.3863***
Parity of cow	4	1035***	0.1033*	0.1979***
Birth season	3	758***	0.0756+	0.2490***
W × N	13	324***	0.0957***	0.0292**
S × N	1	691**	0.1015+	0.1768***
Regressions				
Milk yield (kg/day)	1	2307***	1.3000***	1.6059***
× N	1	1239***	0.2000*	0.2288***
Birth weight (kg)	1	7273***	–	–
Error (d.f.)		64 (422)	0.0337 (423)	0.0109 (423)

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

DG from birth to experiment week, and individual ones were 3.96, 0.08 and 0.08 in single calf and 0.74, 0.03 and 0.04 in twin calves, respectively. Growth of single calf was affected more than twin calves by milk yield of cow. This result was in contrast to the result reported by Smith et al. (1982).

Though the birth weight of triplets made little difference, 5 weeks weights of a female calf and the average weight of male calves were about 40 kg and 30 kg, respectively. Weight differences among triplets were increasing. Even the milking ability of cows with triplets was highest for Japanese Black cows; about 10 kg per day in 1 and 2 weeks, 7 kg per day at 8 weeks and 4 kg per day at 26 weeks. However triplets started to lick the milk powder from 4 weeks of age and consumed it completely from 5 to 10 weeks of age, so that the differences in live weight did not increase after 5 weeks. It suggests that an appropriate level of milk replacer for multiple calves could reduce the variance in calf weight. Weaning weights of triplets were 157.4 kg and 166.9 kg in male calves and 180.4 kg in typical free-martin female calf.

The least-squares analysis of variance for feed

TABLE 3. ANALYSIS OF VARIANCE FOR FEED INTAKE OF CALVES

Source	d.f.	Mean squares (kg^2)	
		Hay	Concentrate
Week (W)	8	7.0609***	16.2989***
No. of calves (N)	1	0.5172*	–
Parity	4	0.4039***	0.2404**
Birth season	3	0.3679**	–
W × N	8	0.1690*	–
Regressions			
Milk yield (kg/day)	1	–	0.0343
× W	8	–	0.1323*
Birth weight (kg)	1	–	0.0021
× W	8	–	0.1276+
Error		0.0772	0.0653
(d.f.)		(254)	(248)

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

intake is shown in table 3. The effects of week, the number of calves, parity, birth season and week × the number of calves interaction were significant for hay intake, while week, parity and intraclass regression on milk yield within weeks had significant influences on concentrate intake. Figure 3 shows the daily intake changes of calves.

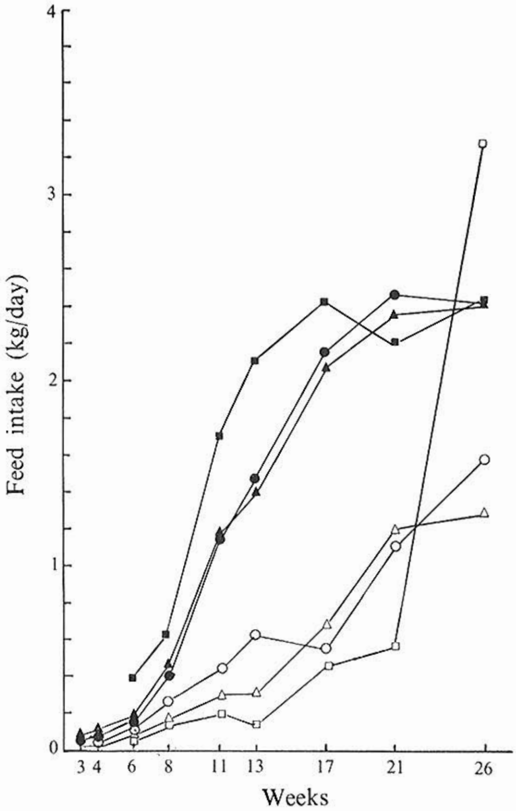

Figure 3. Daily feed intake of single and multiple calves.
Hay: ○, Singles: △, Twins: □, Triplets
Concentrate: ●, Singles: ▲, Twins: ■, Triplets.

The hay intake of triplet calves was lower than those of single and twin calves, and the differences among the groups were increasing as the time progressed until 13 weeks of age. However, concentrate intake of triplet calves was higher than those of the other two groups between 6 and 17 weeks of age. Partial regression coefficient of concentrate intake on milk yield within experiment weeks were negative until 8 weeks. This suggested that the shortage of milk from the cow could be compensated by increasing intake of the concentrate. Somerville et al. (1983) reported similar result. The relationship between the milk and concentrate intake of the calves to 150 days of age was negative ($r = -0.26$) in crossbred beef cattle, and they also found a negative relationship between milk and hay intake. But the relationship was positive in this study. Boggs et al. (1980) reported that milk intake had a negative effect on grass intake by 2 to 6 months grazing calves in Polled Herefords.

Partial regression coefficients of concentrate intake on birth weight within experiment weeks tended to be negative up to 8 weeks of age.

The reproductive efficiency in multiple ovulation and embryo transfer was not high (Izaike et al., 1988 and 1991), however, the results of the present study shows the capability of Japanese Black cows which had higher milk production to nurse twins. To improve reproductive rate and to choose high milk yield cow as recipients could be the important points for induction of twinning in Japanese Black cattle.

Acknowledgements

The authors wish to express their appreciation to Dr. R. L. Willham, Iowa State University for his helpful suggestions.

Literature Cited

Anderson, G. B., P. T. Cupps, M. Drost, M. B. Horton and R. W. Wright, Jr. 1978. Induction of twinning in beef heifers by bilateral embryo transfer. J. Anim. Sci. 46:449.

Anderson, G. B., R. H. BonDurant and P. T. Cupps. 1982. Induction of twins in different breeds of cattle. J. Anim. Sci. 54:485.

Boggs, D. L., E. F. Smith, R. R. Schalles, B. E. Brent, L. R. Corah and R. J. Pruitt. 1980. Effects of milk and forage intake on calf performance. J. Anim. Sci. 51:550.

Davis, M. E., W. R. Harvey, M. D. Bishop and W. W. Gearheart. 1989. Use of embryo transfer to induce twinning in beef cattle: Embryo survival rate, gestation length, birth weight and weaning weight of calves. J. Anim. Sci. 67:301.

Goto, K., Y. Kajihara, S. Kosaka, M. Koba, Y. Nakanishi and K. Ogawa. 1988. Pregnancies after co-culture of cumulus cells with bovine embryos derived from *in-vitro* fertilization of *in-vitro* matured follicular oocytes. J. Reprod. Fert. 83: 753.

Gregory, K. E., S. E. Echternkamp, G. E. Dickerson, L. V. Cundiff, R. M. Koch and L. D. Van Vleck. 1990. Twinning in cattle: I. Foundation animals and genetic and environmental effects on twinning rate. J. Anim. Sci. 68:1867.

Harvey, W. R. 1988. User's guide for LSMLMW. Mixed model least-squares and maximum likelihood computer program. Ohio State University, Columbus, Ohio.

Izaike, Y., O. Suzuki, K. Shimada, K. Fujita and M. Kosugiyama. 1988. Twin pregnancy diagnosis and early embryonic loss after bilateral egg transfer in beef cattle. Jpn. J. Anim. Reprod. 34:236.

Izaike, Y., O. Suzuki, K. Shimada, N. Takenouchi and M. Takahashi. 1991. Observation by ultrasonography of embryonic loss following the transfer of two or three embryos in beef cows. Theriogenology 36:939.

Oishi, T., K. Shimada and K. Nishikawa. 1985. Genetic studies on reproductive characters in Japanese Black cattle. 2. Differences of gestation length and growth rate of fetus observed among bulls. Bull. Chugoku Natl. Agric. Exp. Stn. B28:1.

Reid, J. P., J. W. Wilton and J. S. Walton. 1986. Comparative productivity of cows after receiving two embryos at transfer. Can. J. Anim. Sci. 66: 373.

Rutledge, J. J. 1975. Twinning in cattle. J. Anim. Sci. 40:803.

Shimada, K., Y. Izaike, O. Suzuki, T. Oishi and M. Kosugiyama. 1988. Milk yield and its repeatability in Japanese Black cows. Asian-Australasian J. Anim. Sci. 1:47.

Shimada, K., Y. Izaike, T. Oishi, M. Kosugiyama and O. Suzuki. 1989. Heritability and repeatability estimates for milk yield in Japanese Black cows. Proc. of the 6th Internatl. Congr. of SABRAO. II:917.

Smith, S. P., E. J. Pollak and G. B. Anderson. 1982. Maternal influences on growth of twin and single calves. J. Anim. Sci. 55:533.

Somerville, S. H., B. G. Lowman, R. A. Edwards and G. Jolly. 1983. A study of the relationship between plane of nutrition during lactation and certain production characteristics in autumn-calving suckler cows. Anim. Prod. 37:353.

Wyatt, R. D., M. B. Gould and R. Totusek. 1977. Effects of single vs simulated twin rearing on cow and calf performance. J. Anim. Sci. 45:1409.