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Summary

The effects of slaughter age on expected progeny difference (EPD) of beef sire were examined for nine meat production traits. The nine traits were average daily body weight gain (DG) in the fattening period, carcass weight (CW), carcass weight per slaughter age (CWA), dressing percentage (DP), carcass grade (CG), marbling score (MS), marketing price of carcass (MP), carcass price per Kg of carcass weight (UP), and fattening profit (FP). Records collected 1983-1987 were for 1,052 Japanese Black steers, the offspring of five sires, produced and fattened in Miyagi Prefecture. The data were classified into short-term fattening (STF : slaughter age $<$ 1,000 days) and long-term fattening groups (LTF : slaughter age $\geqq$ 1,000 days).

Means and sire variance of DG and CWA were recognized to be smaller for LTF than STF, but LTF had larger means and sire variances for CG, MS, MP and UP. The skewness of the distribution of DG was negative (left-tailed) for LTF and positive (right-tailed) for STF. Significant sire effects were recognized for STF in eight traits (not for DP), and for LTF in six traits (not DG, CWA or DP). FP in LTF (580 to 664 yen/day) was lower than that in STF (653 to 739 yen/day), except for the offspring of one sire, suggesting that fattening efficiency decreased during long-term fattening. For the both LTF and STF, differences in sire ranking based on EPD were observed for CW, CWA, DP, CG, MS and UP. These results suggest that long-term fattening might be uneconomic for some sires.

Accurate sire evaluation is necessary for improvement of beef cattle. The BLUP (best linear unbiased prediction) method, that uses records of the relatives and numerator relationship matrix is more accurate than sire evaluation by the

selection index methods (1). But it is difficult to link the information on the genetic relationship of animals with fattening and carcass records when sire evaluation uses only field data. In the "Beef Sire Evaluation Project" managed by the Wagyu Registry Association, two sires in a nucleus herd are assigned every year and ear tags are put on their offspring. The purpose of the project is to survey the carcass and fattening performance of their offspring, providing consistent data from birth to slaughter.

Nagamine *et al.* (2) have reported higher correlations on large-scale fattening farms of Japanese Black than on small-scale fattening farms (i) between average daily body weight gain (DG) and marketing price of the carcass (MP); and (ii) between DG and fattening profit (FP). They considered that the explanation for these higher correlations lay in the difference in fattening periods on large and small scale farms. They also found a difference in sire ranking in expected progeny difference (EPD) regarding MP for the old and young slaughter age groups (3). The purpose of the present study is to investigate the effects of fattening period on meat production traits, and to estimate the EPD for different sires with respect to the fattening period.

Materials and Methods

Records of 1,261 Japanese Black steers (collected in the five years 1983-1987) were analyzed. These streers were born in Miyagi Prefecture as the offspring of six sires. Since 83.8% of the records were obtained in Miyagi Prefecture, the records of steers fattened in other areas were excluded from analyses. Records of one sire that had only five steers were also excluded. The number of records in the data file was finally 1052, for five sires.

The traits analyzed as dependent variables were average daily body weight gain (DG) during the fattening period, carcass weight (CW), carcass weight per slaughter age (CWA), dressing percentage (DP), carcass grade (CG), marbling score (MS), marketing price of carcass (MP), carcass price per Kg of carcass weight (UP) and fattening profit (FP). CWA was calculated by the method of Uchida and Yamagishi (4). FP was calculated using the following equation (Nagamine *et al.* (2)):

(marketing price of carcass—feeder cattele cost)/(fattening period in days).

As a result of preliminary analyses, the mean slaughter age was 999 days and the linear regressions of slaughter age on the all traits were significant. Then data were classified into short-term fattening (STF : slaughter age $<$ 1,000 days) and long-term fattening groups (LTF : slaughter age $\geqq$ 1,000 days). The number of progeny per year for each group are shown in Table 1. The mathematical model for analysis of variance was as follows :

TABLE 1. *Number of Progeny per Year for Each Sire*

Sire	Birth year of progeny					
	1980	1981	1982	1983	1984	Total
Short-term fattening[a]						
A	0	136	18	0	0	154
B	1	155	83	31	13	283
C	0	0	0	19	3	22
D	1	14	0	0	0	15
E	1	28	8	20	30	87
Long-term fattening[b]						
A	22	119	9	0	0	150
B	13	118	54	21	5	211
C	0	0	1	11	3	15
D	9	10	0	0	0	19
E	6	32	8	22	28	96

[a]: STF, Slaughter age less than 1,000 days.
[b]: LTF, Slaughter age 1,000 days or more.

$$Y_{ijk} = \mu + s_i + B_j + a(x_{ijk} - \bar{x}) + e_{ijk} \quad \cdots\cdots(1)$$

where

Y_{ijk} : observation of the k^{th} steer born in the j^{th} year as an offspring of the i^{th} sire
μ : overall mean,
s_i : effect of the i^{th} sire,
B_j : effect of the j^{th} birth year of steers,
a : linear regression coefficient of Y_{ijk} on starting age of fattening,
x_{ijk} : starting age of fattening of the k^{th} steer born in the j^{th} year as an offspring of the i^{th} sire,
$\bar{x}$: mean starting age of fattening,
e_{ijk} : error.

The sire effect and error were treated as random effects, and the effect of birth year was treated as fixed. Analysis of covariance was carried out using SAS (5).

Sire EPD was evaluated by the BLUP method described by Henderson (6). A numerator relationship matrix was prepared for the assigned five sires and fifteen sires that appeared within five generations of ancestral pedigree and had large genetic contribution to the steers. The mathematical model for evaluation of EPD was that given in equation (1), and the computer program for calculation of EPD was that of Ujiie and Yamaki (7).

Results and Discussion

The means, standard deviations and skewness of the distribution regarding meat production traits of fattening steers are given in Table 2. The mean DG was higher in the STF than in the LTF group. The skewness of distribution of DG was negative (left-tailed) for LTF and positive (right-tailed) for STF, suggesting that stagnation of growth in the LTF group changed the mean and skewness of distribution of DG. Murata (8) also reported a negative skewness in CW. These results suggest that long-term fattening targeted on the improvement of meat quality in Japanese Black moves the distribution of CW and DG towards the left-tailed pattern.

Considerable differences in the skewness of distribution between fattening groups were recognized for CG, MS, MP and UP.

Analysis of covariance results comparing LTF and STF groups are shown in Table 3. The effect of a steer's birth year was significant for DP and MS in the STF group, and also for eight traits (i.e.; except for MS) in the MTF group: i.e., the traits concerned with meat quantity and price were more significantly affected by a steer's birth year in the LTF group.

The effect of sire was significant for eight traits (not DP) in the STF group, and also significant for six traits (not DG, CWA or DP) in the LTF group. The

TABLE 2. *Means, Standard Deviations and Skewness of Meat Production Traits*

Trait	Short-term fattening[a]		Long-term fattening[b]	
	Mean±S.D.	Skewness	Mean±S.D.	Skewness
DG[c] (Kg/Day)	0.57±0.10	0.06	0.49±0.08	−0.19
Carcass weight (Kg)	385.2±40.6	−0.28	390.0±41.4	−0.14
CWA[d] (Kg/Day)	0.42±0.05	−0.01	0.36±0.05	−0.17
Dressing percent. (%)	61.2±1.6	0.06	61.3±1.7	0.11
Carcass grade[e]	3.7±0.9	−0.73	3.4±1.1	−0.45
Marbling score[f]	5.6±2.7	0.66	6.6±2.9	0.38
Marketing price (1,000 yen)	742±163	0.57	803±202	0.85
Unit price[g] (yen/Kg)	1928±388	1.13	2052±437	0.82
Fattening profit (yen/day)	710±240	0.44	803±202	0.45

a, b: as in Table 1.
c: Daily gain during fattening period
d: Carcass weight per slaughter age
e: Grades Tokusen, Gokujo, Jo, Chu, Nami and Togai were scored as 1, 2, 3, 4, 5 and 6, respectively.
f: Marbling scores were converted to numerical values as follows, 1→1.00, 1+→1.33, 2−→1.67, 2→2.00, 2+→2.33 and so on.
g: Carcass price per Kg of carcass weight

TABLE 3. *Analysis of Covariance for Meat Production Traits (Mean Squares)*

Source	d.f.	DG	Carcass weight	CWA	Dress. percent.	Carcass grade	Marbling score	Market. price	Unit price	Fattening profit
Short-term fattening										
Birth year	4	0.06	5518	0.009	51**	5.3	62.0*	0.11	0.73	0.4
Sire	4	0.31**	22123**	0.068**	17	87.9**	894.0**	1.82**	16.9**	0.8**
Fattening age[a]	1	0.01	28609**	0.059**	0	0.1	0.0	0.06	0.06	0.0
Residual		4.72	861230	1.163	1241	380.4	3031.0	12.6	63.7	30.6
Long-term fattening										
Birth year	4	0.12**	6840*	0.033**	34*	8.0*	44.0	0.5**	2.4**	1.4**
Sire	4	0.02	20403*	0.023	22	131.6**	1051.0**	3.7**	24.8**	3.1**
Fattening age	1	0.02	30240**	0.037**	10	3.7*	43.0**	0.4**	0.7*	0.1
Residual		2.95	780181	0.891	1323	385.4	2364.0	15.4	65.1	23.3

*: $p<0.05$, **: $p<0.01$

a: The age at which fattening begins

insignificant effect of sire on DG and CWA in the LTF group might be a manifestation of the stagnation of growth during the longer fattening period.

Uchida and Yamagishi (4) have reported that the effect of sire was not significant on the DP of Japanese Black fattened in Miyagi Prefecture, a result confirmed in both fattening groups of the present study.

The least square means of meat production traits for the five assigned sires are shown in Table 4. Those for DG and CWA for all five sires were smaller in the LTF than in the STF group, while the opposite was true for CW. CG for all sires except A were similar for both LTF and STF groups. MS was increased under long-term fattening for all five sires.

MP and UP were better in the LTF than that in the STF group, which agrees well with the result of Nagamine *et al.* (3). There was a lower FP under LTF except for sire A. This might be explained by a decrease in fattening efficiency during long-term fattening. Actual FP was calculated by deducting feeder cattle cost, cost of feed, cost of labor and fees, etc., from MP, and the FP used in this study is not equal to actual FP, but may closely correlate with actual one. The lower FP relating to four out of five sires in the LTF group means that long-term fattening was unwise for these four sires, and suggests that decisions on the appropriate slaughter age for progeny should be related to the sire.

EPD evaluated by the BLUP method and sire ranking based on EPD are shown in Table 5. For DG, there was no difference in sire ranking between LTF and STF groups. In the ranking, sire B was top, and sire A was bottom. The

TABLE 4. *Least Square Means of Meat Production Traits for the Progeny of Each Sire*

Sire	DG Kg/Day	Carcass weight Kg	CWA Kg/Day	Dress. Percent. %	Carcass grade	Marbling score	Market. price 1,000 yen	Unit price yen/Kg	Fattening profit yen/Day
Short-term fattening									
A	0.53	370.7	0.39	61.1	3.1	7.4	821	2221	773
B	0.58	385.0	0.42	60.8	4.0	4.5	692	1809	683
C	0.58	372.4	0.43	60.5	4.2	4.6	684	1831	727
D	0.54	366.8	0.39	60.2	4.0	4.8	665	1815	653
E	0.55	379.3	0.40	60.6	3.4	6.5	779	2053	739
Long-term fattening									
A	0.49	392.0	0.36	61.2	2.5	8.9	969	2465	821
B	0.50	398.2	0.37	61.3	3.8	5.4	766	1924	633
C	0.50	405.4	0.37	61.5	4.0	5.1	756	1861	664
D	0.49	377.8	0.35	60.3	3.8	5.4	707	1877	580
E	0.48	382.6	0.36	60.9	3.3	7.1	801	2072	653

TABLE 5. *Expected Prediction Difference and Rank (in Parentheses) of the Progeny of Each Sire*

Sire	DG Kg/Day	Carcass weight Kg	CWA Kg/Day	Dress. percent. %	Carcass grade	Marbling score	Market. price 1,000 yen	Unit price yen/Kg	Fattening profit yen/Day
Short-term fattening									
A	−28.3	−3.6	−11.2	3.0	−0.7	2.1	97	302	43
	(5)	(4)	(5)	(1)	(1)	(1)	(1)	(1)	(1)
B	19.4	8.0	9.6	1.4	0.2	−0.8	−28	−102	−28
	(1)	(1)	(1)	(2)	(4)	(5)	(4)	(5)	(5)
C	5.2	−2.2	8.8	−0.4	0.2	−0.5	−18	−50	3
	(2)	(3)	(2)	(4)	(5)	(4)	(3)	(3)	(3)
D	−6.4	−4.5	−10.5	−1.8	0.1	−0.4	−32	−66	−13
	(3)	(5)	(4)	(5)	(3)	(3)	(5)	(4)	(4)
E	−9.6	2.4	−5.5	0.1	−0.5	1.3	65	159	28
	(4)	(2)	(3)	(3)	(2)	(2)	(2)	(2)	(2)
Long-term fattening									
A	−7.1	−1.2	−5.9	0.6	−1.0	2.8	158	443	89
	(5)	(3)	(4)	(3)	(1)	(1)	(1)	(1)	(1)
B	4.7	5.5	5.4	2.2	0.1	−0.6	−17	−58	−28
	(1)	(2)	(2)	(1)	(3)	(4)	(4)	(3)	(5)
C	3.9	6.3	5.8	1.6	0.2	−0.6	−1	−68	3
	(2)	(1)	(1)	(2)	(4)	(5)	(3)	(4)	(3)
D	−2.2	−8.0	−6.2	−3.2	0.2	−0.5	−53	−98	−25
	(3)	(5)	(5)	(5)	(5)	(3)	(5)	(5)	(4)
E	−5.8	−5.2	−4.6	−1.2	−0.3	1.1	30	106	21
	(4)	(4)	(3)	(4)	(2)	(2)	(2)	(2)	(2)

range of EPD became smaller in the LTF group. The difference of least square means of DG between the LTF and STF groups (Table 4) was 0.04 kg/day for sire A and 0.05 to 0.08 kg/day for the other sires. This means that the steers produced by sire A do not shown clear stagnation of growth during long-term fattening in comparison with those of other sires. Nagamine *et al.* (2) have reported no difference in sire ranking on EPD of DG between LTF and STF groups, as confirmed in the present study. They have also found that the range of EPD of DG was larger for LTF sires than STF. This disagrees with results from the present study but this probably reflects different characteristics of the sires assigned in the two different studies. Since fattening efficiency is considerably affected by DG, it is necessary to examine more closely the interaction between the length of fattening period and sire for DG.

The range of EPD for MP and FP in the LTF group were 211,000 yen and 177 yen/day, respectively. These were much large than for STF : 129,000 yean and 71 yen/day. These results show that the differences in EPD among sires for MP

and FP tended to increase in the longer fattening period.

The traits that have different sire ranking for EPD between the LTF and STF groups were CW, CWA, DP, CG, MS and UP. The rank of sire B for EPD in UP rose from fifth position in the STF group to third position in the LTF group. The least square mean of UP for sire B in the LTF group increased to 1,924 yean/kg from 1,809 yen/kg in the STF group. It is conceivable that sire B is the most suitable for long-term fattening among the four sires excepting sire A. However, since FP decreased during long-term fattening, these may in practice be no improvement of income.

The range of EPD for MS for LTF sires was larger (3.4) than that for STF (2.9), but the rate of range to the average for MS in the LTF group was not as large as that for UP and FP.

It has been reported that the MS of Japanese Black reaches its plateau by around 24 months of age, and after that is difficult to improve (9). However, improvement of MS after 24 months of age was recognized in all five sires assigned in the present research. Further, there was also a difference among sires in the improvement of MS in LTF.

In general, it can be concluded that the means and sire variances for DG and CWA decreased, whereas those for CG, MS, UP and MP increased during long-term fattening. Although UP and MP increased in LTF, the FP decreased, suggesting that long-term fattening is uneconomic. The appropriate slaughter age for steers should be decided from a consideration of the characteristics of the sire. It will be necessary to further examine the interaction between sire characteristics and slaughter age in order to optimize determination of slaughter age.

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