CHANGES IN DIRECT AND MATERNAL HERITABILITIES FOR PREWEANING GROWTH TRAITS IN JAPANESE BLACK CATTLE (WAGYU)

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SUMMARY

Direct and maternal heritabilities and direct-maternal genetic correlations for preweaning calf growth traits were estimated in Japanese Black cattle, so-called Wagyu. Data from 1707 Wagyu calves born from 1937 to 1991 were collected and edited. (Co)variance components were estimated using REML with an animal model. The traits analyzed were cumulative daily gains from birth to 30, 60, 90, 120, 150 and 180 days and daily gains between given days for body weight, hip height, body length, chest girth, chest depth and thurl width. Heritability estimates were quite variable across traits and also the patterns in change were different. Generally, estimates of both direct and maternal heritabilities for hip height, body length and chest depth were smaller than ones for the other three traits. Maximum maternal heritabilities for body weight, body length and thurl width were larger than direct ones. In contrast, for hip height and chest girth direct heritabilities were larger than maternal ones.

INTRODUCTION

Heritabilities reported for calf growth traits were mainly the direct ones especially in Wagyu, and usually birth weight and weaning weight around six months were considered. Recently, authors suggested that the calf daily gain in weight from birth to around two months of age could be suitable for evaluation of maternal ability (1988, 1992). In this paper, some body measurements were studied as well as body weight. DFREML by Meyer (1989) allows the model to include three random effects, so that direct and maternal heritabilities can be estimated simultaneously. Maternal effects have been recognized as important for preweaning growth rate in beef cattle, though, the real magnitude of genetic effects on the body measurements is not clear. The purposes of this study were to estimate direct and maternal heritabilities and to clarify the changes in those parameters for some preweaning growth traits.

MATERIALS AND METHODS

Base animals as the experimental herd were introduced from Hyogo, Tottori, Shimane, Okayama and Hiroshima prefectures, when the experiment station was established in 1937. A total of 1707 calves were produced until 1991 and 1041-1105 calves with records (Table 1) were used after edits in this study; eliminating the records of calves from twinning, ET, early weaning and records out of $\pm 3\sigma$. The weight and thirteen parts of calf body were measured at birth and then monthly. Calves were weaned at six months of age. No selection was practiced on both males and females. The traits analyzed in this study were body weight, hip height, body length, chest girth, chest depth and thurl width. Linear interpolation was used to calculate the adjusted values on 30, 60, 90, 120, 150 and 180 days, then cumulative daily gains from birth to given days and daily gains between given days were calculated for each trait. Estimates of (co)variance components were obtained by REML using a derivative free algorithm under the animal model. All calculations were carried out separately by trait and day using DFREML written by Meyer (1989). The model included both direct and maternal additive genetic effects and a respective non-zero covariance as random factors. Fixed effects fitted were birth year, season, calf sex and parity. In introduced animals out of the other herds, pedigree information tracing back to the grand parents of sires and to the parents of dams was utilized to connect the relationships between animals.

RESULTS

The means for growth traits are shown in Table 1. Calf daily gain in weight for the first month was higher than the following two months, then the peak occurred at the fifth month, while in the other traits the highest daily gain was found in the first month.

Table 2 shows the direct, maternal heritabilities and genetic correlation between direct and maternal effects. Heritability estimates were quite variable across traits and also the patterns in changing were different. Generally, estimates of both direct and maternal heritabilities for hip height, body length and chest depth were smaller than ones for the other three traits. Maximum maternal heritabilities for body weight, body length and thurl width were larger than direct ones. In contrast, for hip height and chest girth direct heritabilities were larger than maternal. Direct heritability for hip height tended to increase with time, while maximum maternal heritabilities for daily gain between given days for the other traits were found in the first two months. Except for hip height, direct-maternal correlations for cumulative daily gain were negative.

DISCUSSION

The base animals of this experimental herd were introduced from Hyogo prefecture and 4 prefectures in Chugoku district, from where genetic resources have been provided to the whole country (Nomura and Sasaki, 1986).

Table 1. Number of records and means for growth traits in Japanese Black cattle (Wagyu)

Trait		30	60	90	120	150	180
Body Weight (kg)							
Cumulative[1]	Records	1104	1077	1065	1073	1088	1082
	Means	0.7169	0.6535	0.6547	0.6706	0.6866	0.6927
Between[2]	Records	1104	1099	1100	1103	1041	
	Means	0.6056	0.6615	0.7096	0.7395	0.6917	
Hip Height (cm)							
Cumulative	Records	1098	1099	1099	1099	1103	1093
	Means	0.2554	0.2310	0.2114	0.1966	0.1841	0.1727
Between	Records	1098	1103	1105	1104	1101	
	Means	0.2085	0.1737	0.1536	0.1348	0.1145	
Body Length (cm)							
Cumulative	Records	1098	1097	1098	1097	1097	1094
	Means	0.4047	0.3425	0.3110	0.2893	0.2709	0.2539
Between	Records	1101	1105	1098	1101	1096	
	Means	0.2843	0.2485	0.2215	0.1975	0.1689	
Chest Girth (cm)							
Cumulative	Records	1094	1093	1096	1094	1096	1091
	Means	0.4725	0.3928	0.3533	0.3294	0.3102	0.2928
Between	Records	1091	1094	1092	1100	1090	
	Means	0.3165	0.2748	0.2550	0.2351	0.2063	
Chest Depth (cm)							
Cumulative	Records	1098	1097	1097	1093	1095	1095
	Means	0.1661	0.1472	0.1345	0.1260	0.1185	0.1115
Between	Records	1094	1097	1099	1094	1093	
	Means	0.1281	0.1097	0.1002	0.0877	0.0766	
Thurl Width (cm)							
Cumulative	Records	1092	1098	1098	1097	1097	1093
	Means	0.1346	0.1089	0.0956	0.0876	0.0819	0.0766
Between	Records	1100	1099	1102	1100	1095	
	Means	0.0852	0.0689	0.0632	0.0588	0.0504	

1) Cumulative daily gain from birth to a given day.
2) Daily gain between given days.

Table 2. Estimates of direct and maternal heritabilities and direct-maternal gemetic correlations for growth traits in Japanese Black (Wagyu) cattle

Trait	Heritability	30	60	90	120	150	180
Body Weight							
Cumulative[1]	h_A^2	0.08	0.06	0.23	0.24	0.24	0.28
	h_M^2	0.34	0.35	0.39	0.41	0.40	0.42
	r_{AM}	-0.94	-0.44	-0.66	-0.73	-0.73	-0.79
Between[2]	h_A^2	0.18	0.22	0.03	0.06	0.05	
	h_M^2	0.32	0.00	0.09	0.13	0.05	
	r_{AM}	-0.78	1.00	-0.66	-0.99	-0.40	
Hip Height							
Cumulative	h_A^2	0.11	0.08	0.06	0.06	0.23	0.22
	h_M^2	0.00	0.05	0.08	0.05	0.10	0.08
	r_{AM}	0.99	1.00	0.63	0.90	-0.26	-0.18
Between	h_A^2	0.07	0.05	0.02	0.08	0.08	
	h_M^2	0.08	0.05	0.00	0.15	0.15	
	r_{AM}	-0.98	-0.23	1.00	-0.82	-0.82	
Body Length							
Cumulative	h_A^2	0.01	0.03	0.12	0.09	0.09	0.13
	h_M^2	0.13	0.24	0.19	0.22	0.19	0.19
	r_{AM}	-1.00	-1.00	-0.35	-0.56	-0.37	-0.39
Between	h_A^2	0.08	0.09	0.15	0.03	0.10	
	h_M^2	0.12	0.00	0.07	0.00	0.06	
	r_{AM}	-0.99	-0.99	-0.93	-0.68	-1.00	
Chest Girth							
Cumulative	h_A^2	0.36	0.24	0.27	0.12	0.10	0.15
	h_M^2	0.16	0.22	0.22	0.16	0.21	0.23
	r_{AM}	-0.71	-0.67	-0.78	-0.55	-0.93	-0.89
Between	h_A^2	0.19	0.04	0.03	0.12	0.04	
	h_M^2	0.20	0.00	0.01	0.04	0.00	
	r_{AM}	-1.00	0.99	0.99	-1.00	-0.49	
Chest Depth							
Cumulative	h_A^2	0.02	0.10	0.13	0.17	0.14	0.08
	h_M^2	0.07	0.15	0.20	0.16	0.17	0.18
	r_{AM}	-0.57	-0.61	-0.74	-0.36	-0.50	-0.76
Between	h_A^2	0.06	0.00	0.15	0.12	0.01	
	h_M^2	0.14	0.00	0.03	0.08	0.02	
	r_{AM}	-0.99	0.99	-0.99	-1.00	-1.00	
Thurl Width							
Cumulative	h_A^2	0.05	0.13	0.12	0.20	0.20	0.21
	h_M^2	0.17	0.24	0.37	0.28	0.24	0.21
	r_{AM}	-0.02	-0.25	-0.63	-0.49	-0.43	-0.37
Between	h_A^2	0.06	0.07	0.08	0.03	0.09	
	h_M^2	0.16	0.04	0.15	0.00	0.11	
	r_{AM}	-0.58	-0.34	-0.82	-1.00	-1.00	

1) Cumulative daily gain from birth to a given day.
2) Daily gain between given days.
h_A^2, direct heritability; h_M^2, maternal hiritability;
r_{AM}, direct-maternal genetic correlation.

The changing pattern of daily gain in weight between given days shown in Table 1 was quite similar to previous findings (Shimada et al., 1988). However, the means in weight daily gain after 3 months were smaller than ones in previous paper (Shimada et al., 1988). Authors showed that the maximum correlation coefficient between cumulative milk yield and calf daily gain in weight was found during first 8 weeks, though in this genetic study the maternal heritability in the cumulative calf daily gain increased gradually to 180 days. Because of good growth between 120 and 180 days caused by the good environment, data obtained after 1980 were excluded more than before so that the error variance tended to decrease. However, maternal heritabilities for daily gain in weight between given days were small between days 60 to 180.

Mukai et al. (1992) reported that the direct heritabilities for wither height, chest girth and thurl width of this breed were 0.297, 0.104 and 0.116, respectively. Heritabilities for chest girth and thurl width they reported were smaller than ones in this study. Mukai et al. (1992) discussed that the herd they used had a high relationship coefficient of 13% because of long term inbreeding. In this study sires used were introduced by rotation from the herds of this area, so that little increment of the inbreeding coefficient was found.

Maternal genetic effects for growth traits in Wagyu have not been reported so far. However, Waldron et al. (1993) reported that animal models which ignored maternal effects tended to overestimate direct heritability for calf weight in Angus and Hereford. Togashi and Yokouchi (1982) reported maternal heritabilities of preweaning growth for Hereford that maternal heritabilities for 3 months weight, wither height, body length, thurl width and heart girth were the maximum ranging from 0.4 to 0.7. Generally, those maternal heritabilities were larger than ones in this study. Trus and Wilton (1988) reported the larger direct heritabilities (0.27–0.43) than maternal ones (0.16–0.27) for preweaning gain in weight up to 200 days in 5 beef breeds. Authors (1988) measured the milk yield of Wagyu directly and reported that the variation in milk yield in this breed was extremely large, which might resulted the larger maternal heritability in weight in this study.

Meyer (1992), Meyer et al. (1993), Núñez–Dominguez et al. (1993) and Waldron et al. (1993) reported that maternal environmental effects for weaning weight were larger than maternal genetic effects in some herds. The magnitude of maternal environment effects in Wagyu should be considered in further study.

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