Genetic relationships among year classes for marbling traits in Japanese Black cattle

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Introduction and Objective

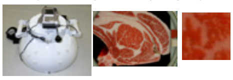
Marbling scores (MS) in Japan is an economically important factor, and the improvement with emphasis on MS is advanced. However, MS is visually classified into 12 levels by a grader, and the evaluation is subjective. Thus, the scale of the classification might change by year. In addition, MS standard may become severe by year. Hence, MS at present might not be able to be treated as the same as a few years ago.

The objective of this study was to estimate genetic parameters for marbling traits using a random regression model on year class.

Materials and Methods

Data

- The Data were **7,359** Japanese Black cattle at carcass market in Hokkaido, Japan during Apr/00-Mar/07
- The number of Pedigree records were **27,015**.
- Digital images of the 6-7th cross section were taken by two photography equipments.



A: 2 mega pixel (1cm is 60pixel)
Using Apr/00-Nov/04

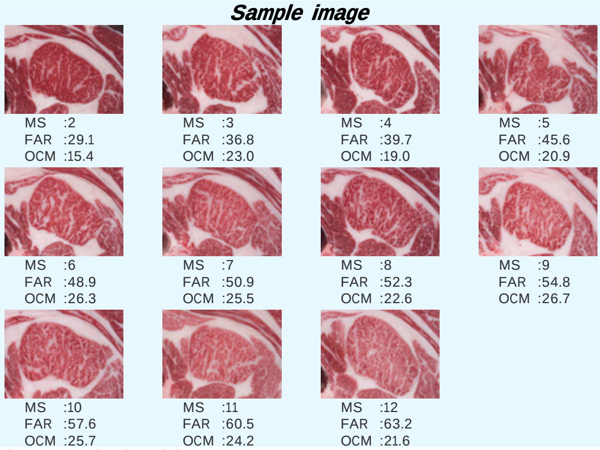
B: 12 mega pixel (1cm = 100 pixel)
Using Dec/04-Mar/07

Traits analyzed

- Marbling score (MS, 1 to 12) by grader, fat area ratio (FAR) and overall coarseness of marbling (OCM) * by image analysis.

*OCM of A = 0.6 × OCM of B

Sample image



Statistical model

- **Fixed effects**
  Date at carcass market (146 levels), sex of animal (2 levels) and slaughter age (11 levels).
- **Random effects**
  Fattening farm (203 levels) and additive genetic effects with random regression on year class (Apr/00-Mar/01, Apr/01-Mar/02, Apr/02-Mar/03, Apr/03-Mar/04, Apr/04-Mar/05, Apr/05-Mar/06 and Apr/06-Mar/07) using **second-order Legendre polynomials**, and **heterogeneous residual variances based on year class.**

Using Gibbs3f90 program
(200,000 rounds and 50,000 burn-in)

Results and Conclusions

Distribution of data

Number of records and mean (±SD) by year class

Year class	n	MS	FAR	OCM
Apr/00-Mar/01	1514	4.9±2.2	35.8±7.7	19.3±5.1
Apr/01-Mar/02	1253	5.2±2.3	38.8±7.7	19.7±5.2
Apr/02-Mar/03	1195	5.9±2.5	41.4±7.6	20.1±4.8
Apr/03-Mar/04	732	5.5±2.5	40.1±7.4	20.0±5.1
Apr/04-Mar/05	489	5.4±2.3	41.8±7.7	20.8±4.6
Apr/05-Mar/06	846	5.4±2.2	43.7±8.2	21.3±3.7
Apr/06-Mar/07	1330	5.4±2.0	44.4±8.0	21.6±3.7

Genetic (above diagonal) and fattening farm (below diagonal) correlations among year class

MS

Year class	1.	2.	3.	4.	5.	6.	7.
1. Apr/00-Mar/01		0.97	0.92	0.88	0.88	0.91	0.96
2. Apr/01-Mar/02	0.90		0.99	0.97	0.97	0.98	0.98
3. Apr/02-Mar/03	0.73	0.95		1.00	0.99	0.99	0.96
4. Apr/03-Mar/04	0.58	0.87	0.98		1.00	0.99	0.95
5. Apr/04-Mar/05	0.46	0.77	0.91	0.98		0.99	0.95
6. Apr/05-Mar/06	0.30	0.59	0.75	0.85	0.94		0.98
7. Apr/06-Mar/07	0.06	0.20	0.32	0.44	0.61	0.84	

FAR

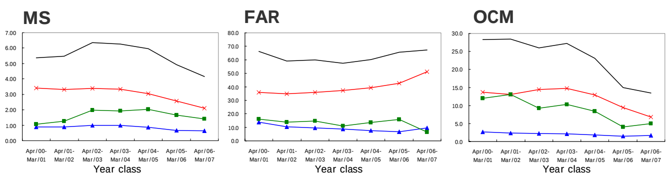
Year class	1.	2.	3.	4.	5.	6.	7.
1. Apr/00-Mar/01		0.98	0.95	0.94	0.95	0.95	0.93
2. Apr/01-Mar/02	0.93		0.99	0.99	0.98	0.97	0.91
3. Apr/02-Mar/03	0.77	0.95		1.00	0.99	0.96	0.89
4. Apr/03-Mar/04	0.64	0.87	0.98		1.00	0.97	0.90
5. Apr/04-Mar/05	0.56	0.79	0.91	0.97		0.99	0.93
6. Apr/05-Mar/06	0.49	0.63	0.72	0.80	0.92		0.98
7. Apr/06-Mar/07	0.37	0.34	0.34	0.42	0.60	0.87	

OCM

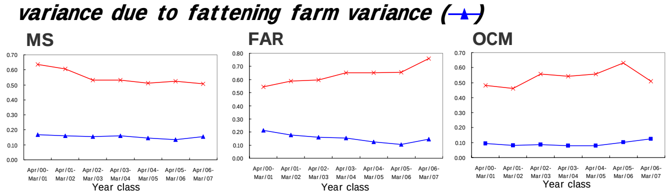
Year class	1.	2.	3.	4.	5.	6.	7.
1. Apr/00-Mar/01		0.92	0.80	0.73	0.73	0.81	0.94
2. Apr/01-Mar/02	0.94		0.97	0.94	0.94	0.97	0.93
3. Apr/02-Mar/03	0.82	0.97		0.99	0.99	0.99	0.85
4. Apr/03-Mar/04	0.74	0.92	0.99		1.00	0.98	0.81
5. Apr/04-Mar/05	0.71	0.89	0.96	0.99		0.98	0.82
6. Apr/05-Mar/06	0.71	0.83	0.87	0.90	0.95		0.91
7. Apr/06-Mar/07	0.64	0.62	0.59	0.61	0.71	0.89	

Variance components

additive genetic variance, fattening farm variance, residual variance, phenotypic variance



Heritability estimates and proportions of phenotypic variance due to fattening farm variance



Conclusions

- Mean of FAR has increased though mean of MS hasn't increased.
  →MS standard became severe.
- Variance components for MS and OCM change over time.
- Heritability estimates for MS tends to decrease though those for FAR increase.
- Genetic correlations for MS and FAR were 0.9 or higher among most of the year classes.

For 7 years, MS could be treated as the same traits.
*However, when analyzing MS for longer period of time (e.g. over 10 years), further investigation may be needed.

A P P E N D I X

Carcass data

The carcass data were collected from Japanese Black steers shipped between April, 2000 and March, 2007 to a meat processing plant in Hokkaido, Japan. This data set was edited so that a minimum of 3 animals were included in each of the following subclasses: date at carcass market, slaughter age in months, fattening farm and sire. The final number of animals was 7,359. There were 146 subclasses for dates at carcass market, 11 subclasses for slaughter age (25, 26, ...35 mo), and 203 for fattening farm.

Marbling traits

The marbling traits considered were fat area ratio (FAR), overall coarseness of marbling particles (OCM) calculated by image analysis, and beef marbling score (MS) which was evaluated by an expert grader. Detailed methods of calculation are shown bellow.

Digital images of the carcass cross section were taken between the 6th and 7th ribs by two types of photographing equipment (**A** and **B**). **A** was set a 2 mega pixels digital camera (1cm = 60 pixels) used between April, 2000 and November, 2004. **B** was set a 12 mega pixels digital camera (1cm = 100 pixels) used between December, 2004 and March, 2007. A flowchart of image analysis traits is illustrated in Figure 1, and details of these traits are as follows.

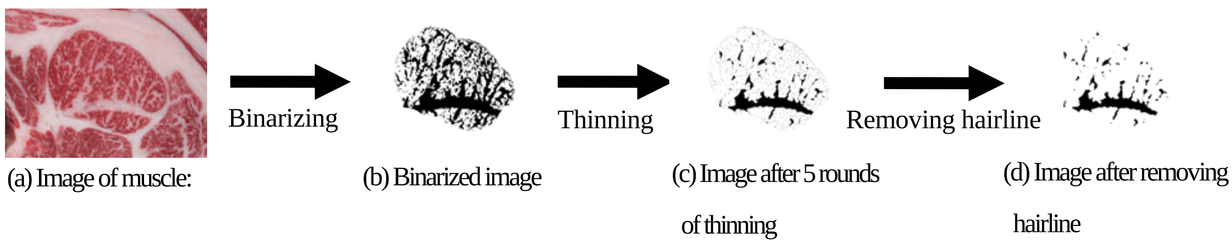


Figure 1. Detailed flow of image analysis to calculate coarseness of marbling particles.

FAR: ribeye with a border line (Figure 1-a) were binarized as lean and fat using the image analysis program. FAR was calculated by dividing all pixels of the fat image (Figure 1-b) by ribeye area.

OCM: The binarized image (Figure 1-b) was thinned with 5 rounds (Figure 1-c), and the hairlines were removed (Figure 1-d) using the image analysis program. OCM was calculated by dividing all pixels of fat from thinning image without the hairline (Figure 1-d) by all pixels of fat image (Figure 1-b). A high OCM value indicates a muscle involving many rough marbling particles. OCM in **B** equipment was timed 0.6 to equal the value in **A** equipments.

Sample image

MS :2

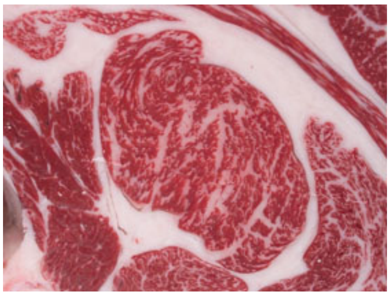
FAR :29.1

OCM :15.4

MS :3

FAR :36.8

OCM :23.0



MS :4

FAR :39.7

OCM :19.0

MS :5

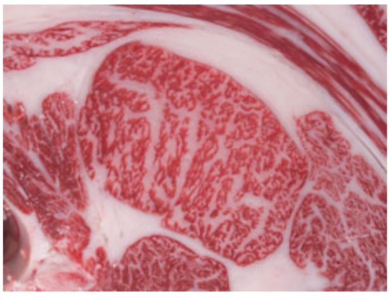
FAR :45.6

OCM :20..9

MS :6

FAR :48.9

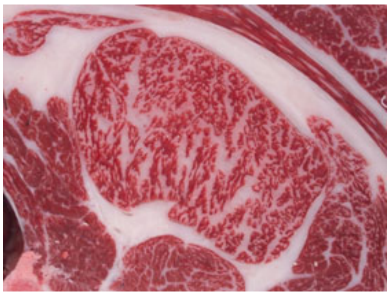
OCM :26.3



MS :7

FAR :50.9

OCM :25.5



MS :8

FAR :52.3

OCM :22.6

MS :9

FAR :54.8

OCM :26.7

MS :10

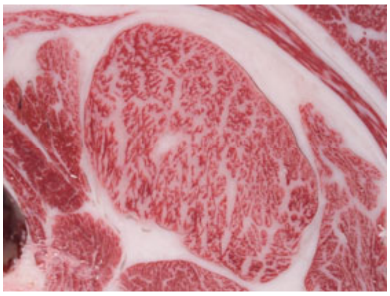
FAR :57.6

OCM :25.7

MS :11

FAR :60.5

OCM :24.2



MS :12

FAR :63.2

OCM :21.6

Table 1. Numbers of sires, MGS, and common sires (above diagonal) and MGS (bellow diagonal) in each pair of year class

	Year class	Number of sires	Number of MGS	1.	2.	3.	4.	5.	6.	7.
1.	Apr/00-Mar/01	53	234		33	24	15	12	12	12
2.	Apr/01-Mar/02	54	197	145		28	20	14	15	12
3.	Apr/02-Mar/03	30	190	142	141		19	14	16	15
4.	Apr/03-Mar/04	31	147	112	110	110		18	19	15
5.	Apr/04-Mar/05	38	115	87	91	97	87		26	18
6.	Apr/05-Mar/06	47	154	101	103	107	92	84		29
7.	Apr/06-Mar/07	57	165	100	103	106	91	92	101	

Table 1. Eigenvalues of additive genetic and fattening farm covariance matrices for each trait

Traits	Eigenvalues of additive genetic covariance matrices						Eigenvalues of fattening farm covariance matrices					
	First	(%)[a]	second	(%)	Third	(%)	First	(%)	second	(%)	Third	(%)
MS	3.007	(97.9)	0.055	(1.8)	0.009	(0.3)	0.713	(83.3)	0.118	(13.7)	0.025	(2.9)
FAR	37.738	(97.6)	0.713	(1.8)	0.233	(0.6)	7.390	(81.8)	1.148	(12.7)	0.493	(5.5)
OCM	11.868	(95.3)	0.517	(4.1)	0.070	(0.6)	1.822	(90.1)	0.118	(5.9)	0.081	(4.0)

[a] Percentage of the total eigenvalue.

Table 2. Estimates of additive genetic (co)variance from quadratic random regression model

	Additive genetic variance			Fattening farm variance		
	Intercept	Linear	Quadratic	Intercept	Linear	Quadratic
MS						
Intercept	2.994			0.690		
Linear	-0.155	0.033		-0.049	0.122	
Quadratic	-0.125	-0.015	0.045	-0.112	0.006	0.044
FAR						
Intercept	37.661			7.254		
Linear	1.638	0.581		-0.829	1.26	
Quadratic	0.399	0.242	0.471	-0.397	0.097	0.520
OCM						
Intercept	11.721			1.799		
Linear	-0.751	0.198		-0.167	0.135	
Quadratic	-1.064	-0.103	0.535	-0.104	0.009	0.087