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HETEROTIC COMPONENTS FOR BIRTH WEIGHT IN THREE UP-GRADING TRIALS OF DAIRY CATTLE RAISED IN EGYPT

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SUMMARY

Data of three up-grading trials of local Domiati cattle with Friesian (Friesian trial), Dairy Shorthorn (Shorthorn trial), and Jersey (Jersey trial) were used to quantify the importance of direct additive effect (G^I), maternal additive effect (G^M), direct herterosis (H^I), maternal heterosis (H^M), direct recombination effect (R^I) and maternal recombination effect (R^M) for birth weight of calves.

In the three trials, cow breed group effect was significant (P<0.05 or 0.001) on birth weight of their calves.

Means of birth weight increased with the increase of Friesian (F) blood in the cow from ½ to 7/8F and of Shorthorn(S) blood from ½ to 3/4S but decreased with the increase of Jersey (J)blood from ½ to 15/16 J.

Estimates of individual additive effects (G^I) in Friesian and Shorthorn trials were significant (P<0.001), large and in favour of the European breed. Direct heterotic superiority (H^I) of crossbred cows were evidenced over their purebred parental breed groups. Estimates of H^M percentages were 4.1, 5.1 and 5.1% in Friesian, Shorthorn and Jersey trials, respectively. Positive and significant (P<0.05 or P<0.001) estimates of R^I were recorded. R^M was significant (P<0.001) only in Friesian trial.

***Keywords:** dairy cattle, Egypt, birth weigh, additive, heterotic and recombination effects*

INTRODUCTION

Dairy cattle industry in Egypt has two goals being milk and beef production. Beef from dairy cattle in this country is obtained mainly from calves that passed the veal stage. However, crossbreeding and up-grading of dairy cattle in Egypt was performed directly to improve milk production and indirectly to increase meat production. Birth weight is considered as an important component of meat production in dairy cattle in Egypt. Most studies of crossbreeding experiments showed that crossbreed dams give calves with heavier birth weight than straightbred ones (Gregory *et al.*, 1985; Elzo *et al.*, 1990; Cundiff *et al.*, 1992 and Thorpe *et al.*, 1993).

The objective of the present work was to quantify genetic group differences, additive effects (direct and maternal), heterotic effects (direct and maternal) and recombination effects (direct and maternal) for birth weight of calf in three trials of up-grading Domiati cows with Friesian, Dairy Shorthorn and Jersey bulls when raised under hot climatic conditions.

MATERIALS AND METHODS

Records of the study were collected from three dairy herds located at El-Gimmiza, El-Serow and Sids experimental stations. El-Gimmiza is in mid Delta, El-Serow station is in the north part of Nile Delta, while Sids station is in mid Egypt. These stations belong to the Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture. Three up-grading trials were carried out in these stations. In El-Gimmiza station, Domiati cows were up-graded with Friesian bulls (Friesian trial), those of El-Serow station were up-graded with dairy Shorthorn (Shorthorn trial) and those cows raised in Sids station were up-graded with Jersey (Jersey trial). Details of breeding plan and management in each crossbreeding trial of the study were described by Arafa *et al.* (1998). Records of cows of each of the three experimental up-grading trials were edited in separate files for statistical analyses. Information of each parity for each cow included pedigree, breed group, birth date, parity, age at first calving, calving date, age at calving, birth weight and sex of the calf.

Data and model of analysis

Birth weight of the calf in each up-grading trial was analyzed separately using mixed model program of Harvey (1990). Data used in the present study were collected over a period of 21, 20 and 23 years in Friesian, Shorthorn and Jersey trials, respectively. These trials started in 1954, 1956 and 1953 in the three trials in the same order. The linear mixed model used for analyzing data of birth weight was:

$$Y = XB + ZU + e$$

Where:

Y = An (N x 1) observational vector,

X= Incidence matrix for fixed effects (breed group, year-season, parity, sex and age as covariate),

B= vector of fixed effects including covariate of age of cow,

Z= Incidence matrix for random effect

U= Vector of random cow effect

,e= Vector of random error.

Sire or dam of the cow was not recorded in pedigree file of animals and consequently not included in the model of analysis.

Estimation of heterotic components

Crossbreeding genetic effects of direct additive (G^I), maternal additive (G^M), direct heterosis (H^I), maternal heterosis (H^M), direct recombination effect (R^I) and maternal recombination effect (R^M) were estimated according to Dickerson theory (Dickerson, 1992).

The coefficients for individual additive effect (G^I) and maternal additive effect (G^M) were calculated as the deviation of the proportion of Domiati genes (g^I_D) from the proportion of European genes (g^I_E),i.e.

$$G^I = g^I_D - g^I_E \text{ and } G^M = g^M_D - g^M_E$$

Where g^I_D, g^I_E, g^M_D, g^M_E represent the proportion of Domiati and European genes in the individual (I) and the dam (M). The coefficients for individual herterosis (H^I) and maternal heterosis (H^M) were calculated for the daughter and the dam, respectively. Coefficients for recombination effect (individual and maternal) were calculated according to Van der Werf and de Boer, (1989a) equation as: {Ps (1-Ps) + Pd (1-Pd)}, where Ps = fraction of sire genes and Pd = fraction of dame genes. All coefficients calculated are presented in table 1.

Table 1. Coefficient of expected contribution for genetic effects in groups of purebreds and crossbreeds

Breed Groups *	g^I_D	g^I_E	G^I_{D-E}	g^M_D	g^M_E	G^M_{D-E}	H^I	H^M	R^I	R^M
Domiati (D)	1.000	0.000	1.00	1.000	0.000	1.00	0.00	0.00	0.00	0.00
European (E)	0.000	1.000	-1.00	0.000	1.000	-1.00	0.00	0.00	0.00	0.00
½ E ½ D	0.500	0.500	0.00	1.000	0.000	1.00	1.00	0.00	0.00	0.00
¾ E ¼ D	0.250	0.750	-0.50	0.500	0.500	0.00	0.50	1.00	0.25	0.00
7/8 E 1/8 D	0.125	0.875	-0.75	0.250	0.750	-0.50	0.25	0.50	0.19	0.25
15/16 E1/16 D	0.063	0.938	-0.88	0.125	0.875	-0.75	0.13	0.25	0.11	0.19
(¾ E ¼ D)2**	0.250	0.750	-0.50	0.250	0.750	-0.50	0.38	0.50	0.38	0.25
(7/8E1/8 D)2**	0.125	0.875	-0.75	0.125	0.875	-0.75	0.22	0.25	0.22	0.19

*Sire breed listed first.

**Coefficients of inter-se mating were used for genetic components in Friesian and Shorthorn trials only (i.e. inter se mating in Jeresy trial was not practiced).

RESULTS AND DISCUSSION

Means and variations

Means of birth weight in the three up-grading trials (Table 2) reveal that birth weight of the Friesian trial ranked first then followed by Shorthorn and Jersey trials in a descending order.

Phenotypic variation for birth weight in Jersey trial was the highest (15%) followed by variation of trials of Shorthorn (13%) and Friesian (10%). The high variations for birth weight lead to state that phenotypic selection within these up-grades is effective method to improve their performance.

Table 2. Actual means and their standard deviations (SD) and percentages of variation (V%) for birth weight in Friesian, Shorthorn and Jersey trials

Trial	No	Mean	SD	V%
Friesian	1555	30.5	4.3	10
Shorthorn	621	27.7	5.2	13
Jersey	695	22.0	4.1	15

Genetic group comparisons

In the three trials, genetic group effect was always significant ($P<0.05$ or $P<0.001$) and formed an important source of variation in birth weight of the calf (Tables 3,4). Olson *et al.* (1985), Newman *et al.* (1988), Gergory *et al.* (1991), Isogai *et al.* (1994) and Matin and Bhuiyan (1996) reported significant effect of genetic group on birth weight of calves of different breeds of dairy and/or beef cattle.

Birth weight of the calf increased with the increase of the proportion of Friesian blood (F) in the cow from ½F to 7/8F and of Shorthorn blood from ½S to ¾S but decreased with the increase of Jersey blood (J) from ½ J to 15/16 J (Table 4). The increase of birth weight with the increase of blood of exotic breed was also reported by Duraes (1981) in USA; Sivarajasingam and Kumar (1983) in Austria and Matin and Bhuiyan (1996) in Bangladesh. On the other hand, a decrease in birth wight of calf with the increase of Jersey blood was observed by Sivarajasingam and Kumar (1983) from crossing of Jersey with Australian Illawarra Shorthorn.

Table 3. Tests of significance of factors affecting birth weight in the three up-grading trials

Up-grading trial	Source of variance						
	Gnetic Group (GG)	Cow within GG	Year-Season	Parity	Sex	Age at calving+	
						Linear	Quadratic
Friesian	***	***	***	***	***	*	ns
Shorthorn	***	***	***	ns	ns	ns	ns
Jersey	*	***	***	**	***	ns	ns

ns=non-significant, *=P<0.05, **=P<0.01, ***=P<0.001,+ =Age at calving as covariate.

Table 4. Least squares means and their standard errors of birth weight in the three up-grading trials

Genetic Group	Friesian trial		Shorthorn trial		Jersey trial	
	No	Mean ± SE	No	Mean ± SE	No	Mean ± SE
Domiati(D)	97	26.6 ± 0.4	188	26.4 ± 0.9	12	20.8 ± 1.3
European(E)	552	31.2 ± 0.3	149	30.6 ± 0.8	69	19.8 ± 1.0
½E ½D	187	30.4 ± 0.4	18	31.4 ± 1.9	29	23.6 ± 1.3
¾E ¼D	286	30.5 ± 0.3	34	31.4 ± 1.5	203	22.8 ± 0.7
7/8E 1/8D	241	31.0 ± 0.3	36	30.6 ±1.2	235	21.7 ± 0.6
15/16E 1/16D	82	30.9 ± 0.5	31	30.9 ± 1.2	147	21.6 ± 0.7
$(3/4E\ 1/4D)^2$	70	30.8 ± 0.6	76	29.9 ± 1.0		
$(7/8E\ 1/8D)^2$	40	30.6 ± 0.7	90	31.3 ± 0.9		
Test of significance		***		***		*

*=P<0.05, ***=P<0.001

Direct (G^I) and maternal (G^M) additive effects:

Estimates of individual additive effect ($G^I=g^I_D - g^I_E$) for birth weight of the calf in Friesian and Shorthorn trials were large and significant ($P<0.001$) and in favour of the European breeds (Table 5), i.e. Friesian and Shorthorn cows are superior over Domiati in their estimates of G^I for birth weight of their calves. The significant estimates of G^I for birth weight were also recorded by Dillard *et al.* (1980), Trail *et al.* (1982), Koch *et al.* (1985) and Olson *et al.* (1985) working on different breeds of beef cattle. However, G^I for birth weight in Friesian trial was superior to that in Shorthorn trial (Table 5). In Jersey trial, insignificant estimate of G^I for birth weight was in favour of Domiati cows (Table5). Since differences in G^I of the cow were generally important (Arafa, 1996), therefore, dairy cattle producers in Egypt could expect different performances of cows for birth weight of their calves from Friesian x Domiati or Shorthorn x Domiati.

Table 5. Estimates of individual (G^I) and maternal (G^M) additive genetic effects for birth weight in the three up-grading trials

Trial	G^I		G^M	
	Estimate (kg)	SE	Estimate (kg)	SE
Friesian	-6.42***	0.61	-5.90***	0.76
Shorthorn	-5.95***	0.80	-4.18**	1.57
Jersey	0.60^{ns}	1.50	2.99*	1.55

In Friesian and Shorthorn trials, estimates of maternal additive effect ($G^M = g^M_D - g^M_E$) for birth weight of the calf were in favour of dams of Friesian (P<0.001) and Shorthorn (P<0.01). In Jersey trial, G^M was in favour of Domiati dams (P<0.05). This means that Friesian and Shorthorn dams gave cows that produced calves with heavier birth weight than Domiati dams, while Domiati dams gave cows that produced calves with heavier birth weight than those of Jersey dams. In agreement with the present results, significant estimates of G^M were recorded by Dillard *et al.*(1980), Trail *et al.* (1982), Olson *et al.* (1985) and Thorpe *et al.* (1993). On the other hand, Koch *et al.* (1985) found that G^M for birth weight was not significant.

Direct (H^I) and maternal (H^M) heterosis

In the three up-grading trials, estimates of (H^I) for birth weight of progeny of crossbred cows (Table 6) were positive and significant (P<0.05 or P<0.001). This indicates that up-grading of Domiati cows with Friesians or Shorthorns or Jerseys will lead to an increase in birth weight of the resulted crossbred calves, i.e. heavier birth weight would be attained by up-grading Friesian, Shorthorn or Jersey bulls with Egyptian native Domiati cows. In agreement with the present results, Koch *et al.* (1985), Reimer *et al.* (1985), Hohenboken and Webet (1989), Gregory *et al.* (1991) and Thorpe *et al.* (1993) found that H^I for birth weight was positive and significant. On the contrary, Wessely *et al.* (1986) found that crossing Holstein Friesian breed with German Black Pied was responsible for a reduction in the calf birth weight, amounting by 10% of the parental mean. Also, Dillard *et al.* (1980), Trail *et al.* (1982), Gotti *et al.* (1985), Olson *et al.* (1985), Miquel (1988) and Arthur *et al.* (1989) found insignificant H^I for birth weight of the calf.

Jersey trial ranked first in heterotic superiority for birth weight (2.39 kg or 11.8%), followed by those of Shorthorn trial (1.83 kg or 6.4%) and Friesian trial (0.81 kg or 2.8%).

Table 6. Estimates of individual (H^I) and maternal (H^M) heterosis for birth weight in the three up-grading trials

Trial	H^I			H^M		
	Estimate(kg)	SE	%	Estimate(kg)	SE	%
Friesian	0.81***	0.22	2.8	1.18***	0.21	4.1
Shorthorn	1.83*	0.95	6.4	1.46*	0.63	5.1
Jersey	2.39***	0.66	11.8	1.04**	0.43	5.1

In the three up-grading trials, estimates of H^M for birth weight (Table 6) were positive and significant (P<0.05 or P<0.01 or P<0.001). These observations indicate that cows born to crossbred dams gave calves with heavier birth weight than cows born to straightbred dams. Thus, crossbred dams had considerable importance to improve birth weight of calves resulting from up-grading Domiati cows with European bulls of Friesian, Shorthorn or Jersey.

Estimates of H^M represented 4.1, 5.1 and 5.1% in Friesian, Shorthorn and Jersey trials, respectively. These estimates of H^M fall within the range of 2.9 to 6.3% reported by Gregory *et al.* (1985), Kress *et al.* (1990) and Cundiff *et al.* (1992). In this respect,Gregory *et al.* (1985) with Boran x Ankole and Boran x Zebu stated that crossbred dams gave calves heavier at birth (1.6 kg and 6.4%) than those from straightbred dams (P<0.05). Elzo *et al.* (1990) with Brahman (B) and B x Angus (A) reported that non-additive maternal effect for birth weight was important (P<0.01). They added that calves will be heavier when born to B x A crossbred dams than when their dams were either B or A. Results of Cundiff *et al.* (1992) with Hereford, Angus, Shorthorn and crossbred dams revealed that over all ages (2-12 years) maternal heterosis for weight of calves of crossbred dams was larger than that of straightbred ones by 1.0 kg at birth (P<0.01). Also. Thorpe *et al.* (1993) with Sahiwal cattle and their crosses with Bos taurus (Ayrshire and Friesian) found that calves born from F_1 dams were nearly 1.9 kg heavier than the mean weight of calves born by purebred Bos taurus and Sahiwal dams. On the opposite side, Dillard *et al.* (1980) and Olson *et al.* (1985) reported insignificant estimates of H^M for birth weight.

Direct (R^I) and maternal (R^M) recombination effect:

Heterosis was assumed to represent dominance effect plus half of the additive by additive effect, whereas the recombination effects represent half of the additive by additive effect (Van der Werf and de Boer, 1989 a&b). Estimates of R^I (Table 7) for calf birth weight in Friesian, Shorthorn and Jersey trials (0.58, 0.46 and 0.25 kg, respectively) are generally lower than estimates of H^I. This implies that dominance effect was positive and significant.

Estimates of R^I for birth weight in Friesian trial was the highest (0.58 kg) then followed by that in Shorthorn and Jersey trials in a descending order (Table 7).

Table 7. Estimates of individual (R^I) and maternal (R^M) recombination effects for birth weight in the three up grading trials

Trial	R^I		R^M	
	Estimate (kg)	SE	Estimate (kg)	SE
Friesian	0.58***	0.13	0.52***	0.11
Shorthorn	0.46*	0.22	0.27^{ns}	0.21
Jersey	0.25*	0.13	-0.02^{ns}	0.12

In Friesian trial, R^M for birth weight was positive (0.52 kg) and significant ($P<0.001$). A positive and significant R^M for birth weight indicate that crossbred cows including Friesian blood mothered heifers could produce calves with heavier birth weight than did purebred Friesian cows when both groups were mated to the same purebred Friesian bulls. R^M was positive and non-significant in Shorthorn trial, but negative (-0.02 kg) and non-significant in Jersey trial. However, the non-significant effect of R^M in Shorthorn and Jersey trials shows that epistatic effect appeared to have little influence on birth weight of calves produced by crossbred dams.

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