RESULTS AND DISCUSSION

4 RESULTS AND DISCUSSION

4.1 Means and variation of uncorrected records

Means, standard deviations and coefficients of variation for initial milk yield (M90), 305-day milk yield (M305), total milk yield (TMY), lactation length (LP), dry period (DP), calving interval (CI), M305 per day of calving interval (MCI1), TMY per day of calving interval (MCI2) in the first, second, third and fourth lactation and across all lactations are given in Tables 13, 14 and 15 in Friesian, Shorthorn and Jersey trials, respectively. Means and variations of age at first (AC1) and second (AC2) calving are also presented in these tables.

In Friesian trial, means of M305 for Friesians and their up-grades with Domiati of 1617 and 1792 kg in the first and second lactations were lower than those of 1788 and 2018 kg reported by Arafa (1987) and those of 1745 and 2265 kg reported by Mostageer et al. (1987) with Friesians and their up-grades with Domiati for the same parities. Also, estimates of age at first calving (38 months) was higher than that of 34 months obtained by Arafa (1987) and of 36 months recorded by Mostageer et al. (1987) for the same two breeds and their up-grades.

In Shorthorn trial, means of M305 and TMY of Shorthorns and their up-grades with Domiati were 1552 and 1677 kg in the first lactation and 1786 and 1871 kg in the second lactation. For the same two breeds and their up-grads, estimates of the present study appear to be higher than the corresponding estimates of 1362 and 1582 kg in the first lactation and 1756 and 1844 kg in the second lactation recorded by Aboustate (1975), but lower than those recorded by Arafa (1987) for the same parities. AC1 (36.03 months) obtained in this trial was higher than that of 35.1 months recorded by Aboustate, (1975) and of 35.8 months recorded by Arafa (1987).

In Jersey trial, means of M305 and TMY for Jerseys and their up-grades with Domiati were 1501 and 1620 kg in the first lactation and 1742 and 1826 kg in the second lactation. In comparison with the same two breeds and their up-grades, estimates obtained here were lower than the corresponding estimates of 1606 and 1762 kg in the first lactation and 1834 and 1969 kg in the second lactation recorded by Aboustate (1975). Age at first calving obtained in Jersey trial (34.8 months) was higher than that of 32.5 months recorded by Aboustate (1975).

Table (13). Actual means and their standard deviations and percentages of variation (V%) for different traits in the first four lactations and in all lactations in **Friesian trial.**

Trait	Parity	No	Mean	SD	V%
M90 (kg)	1st	294	781	168	19
	2nd	242	908	203	17
	3rd	192	992	208	17
	4th	139	1058	232	19
	All	1323	955	245	18
M305 (kg)	1st	686	1617	555	25
	2nd	569	1792	617	25
	3rd	428	1904	681	26
	4th	289	2019	722	24
	All	2754	1870	699	23
TMY (kg)	1st	686	1757	701	30
	2nd	569	1948	784	30
	3rd	428	2118	1210	31
	4th	289	2196	897	28
	All	2754	2032	923	29
LP (day)	1st	686	298	97	28
	2nd	569	295	98	28
	3rd	428	296	102	30
	4th	289	299	101	27
	All	2754	295	98	25
MCI1 (kg/day)	1st	565	3.86	1.48	32
	2nd	457	4.51	1.54	26
	3rd	316	4.81	1.75	27
	4th	240	5.11	1.88	25
	All	2195	4.63	1.81	27
MCI2 (kg/day)	1st	565	4.14	1.57	31
	2nd	457	4.82	1.64	25
	3rd	316	5.13	1.82	25
	4th	240	5.43	1.92	23
	All	2195	4.93	1.87	25
DP (day)	1st	618	169	121	65
	2nd	477	124	87	66
	3rd	331	130	100	76
	4th	246	125	90	72
	All	2321	141	104	65
CI (day)	1st	617	448	111	24
	2nd	470	423	92	20
	3rd	325	431	102	22
	4th	245	421	98	22
	All	2298	432	102	20
AC (month)	1st	745	37.99	11.64	24
	2nd	617	52.89	12.03	19

Table (14). Actual means and their standard deviations and percentages of variation (V%) for different traits in the first four lactations and in all lactations in **Shorthorn trial.**

Trait	Parity	No.	Mean	SD	V%
M90 (kg)	1st	125	624	207	22
	2nd	108	842	240	24
	3rd	85	891	315	25
	4th	66	930	295	27
	All	582	840	296	22
M305 (kg)	1st	483	1552	612	31
	2nd	398	1786	619	31
	3rd	314	1884	668	30
	4th	251	1915	779	34
	All	1953	1824	668	24
TMY (kg)	1st	483	1677	743	36
	2nd	398	1871	708	35
	3rd	314	1959	764	35
	4th	251	2005	866	37
	All	1953	1920	768	28
LP (day)	1st	483	291	98	30
	2nd	398	276	78	27
	3rd	314	266	81	31
	4th	251	256	100	34
	All	1953	276	85	24
MCI1 (kg/day)	1st	436	3.56	1.70	39
	2nd	336	4.46	1.91	36
	3rd	251	5.01	1.88	29
	4th	195	5.35	1.77	30
	All	1625	4.52	2.01	30
MCI2 (kg/day)	1st	436	3.78	1.80	39
	2nd	336	4.61	1.94	36
	3rd	251	5.17	1.88	29
	4th	195	5.51	1.79	29
	All	1625	4.69	2.04	29
DP (day)	1st	435	179	141	76
	2nd	335	149	121	83
	3rd	251	144	102	65
	4th	195	138	103	76
	All	1641	153	122	68
CI (day)	1st	436	458	113	23
	2nd	336	417	98	23
	3rd	251	417	101	23
	4th	195	408	98	24
	All	1625	427	105	20
AC (month)	1st	509	36.03	6.88	18
	2nd	440	50.94	8.07	15

Table (15). Actual means and their standard deviations and percentages of variation (V%) for different traits in the first four lactations and in all lactations in **Jersey trial.**

Trait	Parity	No	Mean	SD	V%
M305 (kg)	1st	285	1501	542	31
	2nd	201	1742	605	26
	3rd	154	1954	671	29
	4th	102	1997	688	28
	All	986	1810	663	25
TMY (kg)	1st	285	1620	689	37
	2nd	201	1826	713	28
	3rd	154	2092	806	34
	4th	102	2106	796	33
	All	986	1927	785	29
LP (day)	1st	285	282	105	33
	2nd	201	269	96	26
	3rd	154	283	103	34
	4th	102	279	105	37
	All	986	282	102	29
MCI1 (kg/day)	1st	210	3.87	1.43	34
	2nd	157	4.81	1.33	23
	3rd	106	5.34	1.56	25
	4th	73	5.44	1.62	26
	All	729	4.82	1.61	25
MCI2 (kg/day)	1st	210	4.12	1.53	34
	2nd	157	4.96	1.35	21
	3rd	106	5.66	1.53	25
	4th	73	5.59	1.64	25
	All	729	5.05	1.63	22
DP (day)	1st	220	134	120	86
	2nd	171	110	96	76
	3rd	115	100	88	80
	4th	78	113	97	82
	All	774	115	100	74
CI (day)	1st	212	432	96	21
	2nd	159	408	84	19
	3rd	107	419	95	24
	4th	74	414	88	13
	All	735	420	93	20
AC (month)	1st	285	34.80	11.05	21
	2nd	201	48.72	11.59	20

For the three up-grading trials, means and phenotypic standard deviations for milk production traits (M90, M305, TMY, MCI1 and MCI2) generally increased with the advancement of parity (Tables 13, 14 and 15). On the other hand, CI and DP generally decreased as parity advanced. These observations agree well with those of Ragab et al. (1973), Adeneye and Adebanjo, (1978), Al-Rawi and Alani (1981), Biswas et al. (1982), Arafa (1987), Abdel-Glil (1991) and Zahed (1994).

Results in Tables 13, 14, and 15 reveal that Friesian trial (Friesian and Domiati and their up-grades) ranked first for milk yield traits, then followed by Shorthorn trial (Shorthorn and Domiati and their up-grades) and Jersey trial (Jersey and Domiati and their up-grades) in each of the first four lactations. El-Itriby and Asker (1958) and Arafa (1987) concluded that the Friesians and their up-grades with Domiati were superior in their performance relative to the Shorthorn and Domiati and their up-grades. Findings of El-Itriby et al. (1963) with Jerseys and their up-grades with Domiati and Fahmy et al. (1976) with Shorthorns and their up-grades with Domiati showed that Shorthorns and their up-grades were superior in performance compared with Jerseys and their up-grades. On the other hand, results of Aboustate (1975) showed that performance of Jerseys and their up-grades with Domiati were better than that for shorthorns and their up-grades with Domiati.

Percentages of phenotypic variation (V%) for all traits except DP in the first four lactations and across all lactations are within the range of 17 and 32 % in Friesian trial (Table 13), 15 and 39 % in Shorthorn trial (Table 14), 13 and 37 % in Jersey trial (Table 15). Estimates of V% reviewed from literature ranged from 27 to 34 % by Abdel Glil (1991), from 9 to 22 % by Salem (1991), from 17 to 41 % by Thorpe et al. (1994), from 11 to 17 % by Zahed (1994) and from 11 to 29 % by Gad (1995). However, estimates of variation obtained in the present study are higher than those variations obtained in literature. The high variations in most traits lead to state that phenotypic selection for milk traits within these up-grades is effective method to improve their performances.

Percentages of variation for DP are very high and ranged from 65 to 76 %, 58 to 83% and 74 to 86% in Friesian, Shorthorn and Jersey trials, respectively (Tables 13, 14 and 15). High V% for DP was also observed by El-Itriby et al. (1963) with Jerseys and their up-grades with Domiati, Abdel-Glil (1991) in the first three lactations for Friesian cattle, Salem (1991) with imported and locally born Friesian and Gad (1995) with Friesian, Holstein Friesian and Brown Swiss.

4.2 Non-genetic Aspects

Full details of models used are presentd in Tables 11 and 12 (in material and methods). ANOVA of models included effects of year-season combination in different traits are presented in Tables 16 through 25. Other ANOVA Tables included effects of year and season separately are presented in Appendices 1 through 10.

Year-Season

In the three trials, year-season of calving combination, generally, affected (P<.05 or P<.01 or P<.001) most traits studied in separate lactations and across all lactations (Tables 20 through 25). On the other hand, year-season of calving effect on DP and CI were generally non-significant. Madalena et al. (1990a) showed that year-season affected most traits studied (TMY, LP, CI in the first lactation and TMY, MCI2 in the second lactation). Also, Zahed (1994) recorded significant year-season effect (P<.001) on all milk yield traits in the first three lactations.

Age effect

For all lactations of the three up-grading trials, coefficients of linear regressions of most traits on age at calving reveal, in general, that there was a positive and significant (P<0.01 or P<0.001) linear association between age at calving and each of these traits (Tables 26, 27 and 28). On the contrary, DP and CI in general indicated a negative association with age at calving. Highly significant regression coefficients for M305 or TMY on age at calving was found by Ragab and Sourour (1963), Mohamed (1979), Arafa (1987), Martinez et al. (1988), Soliman et al. (1989), Abdel-Glil (1991), Salem (1991), Zahed (1994) and Gad (1995).

4.3 Breed group comparisons

For breed-group comparisons in the three up-grading trials, models 8, 10 and 12 were used (i.e. models included the effect of year-season combination). ANOVA for these models of the three up-grading trials are presented in Tables 20 through 25. Results of the analysis using models including the effects of year and season separately are given in Appendices 1 through 10.

In Friesian trial (Friesian, Domiati and their up-grades), breed-group effects were always significant (P<0.05 or P<0.01 or P<0.001) and formed an important source of variation in each separate lactation and across all lactations (Table 20 and 21). In Shorthorn trial (Shorthorn, Domiati and their up-grades) as well as in Jersey trial (Jersey, Domiati and their up-

Table (16). F-ratios of least-squares analysis of variance of milk production traits in the first four separate lactations and in all lactations in **Friesian trial**.

Source of variation	M90 D.F.	M90 F	M305 D.F.	M305 F	TMY D.F.	TMY F	LP D.F.	LP F	MCI1 D.F.	MCI1 F	MCI2 D.F.	MCI2 F	DP D.F.	DP F
First parity'														
Year-Season	45	2.1***	79	2.9***	79	2.4***	79	1.9***	77	1.6**	77	1.5**	77	1.3*
Age as covariate:														
Linear	1	20.9***	1	48.2***	1	40.9***	1	6.1**	1	20.1***	1	26.3***	1	.3
Quadratic	1	.1	1	10.8***	1	10.5***	1	1.2	1	3.5	1	4.6*	1	.5
Genetic covariate terms:														
G^I	1	.9	1	2.6	1	1.3	1	.2	1	.5	1	.4	1	.001
G^M	1	1.1	1	3.4	1	1.8	1	.3	1	.7	1	.7	1	.01
H^I	1	1.3	1	3.5	1	1.9	1	.4	1	.7	1	.7	1	.01
H^M	1	1.2	1	2.96	1	1.2	1	.1	1	.8	1	.7	1	.000
R^I	1	1.1	1	2.9	1	1.2	1	.1	1	.7	1	.6	1	.002
R^M	1	1.2	1	1.1	1	1.2	1	.01	1	.8	1	1.2	1	1.5
Remainder df	240		598		598		598		479		479		532	
Remainder M.S.		21087		165413		284532		7124		1.5		1.6		11920
Second parity'														
Year-Season	51	2.7***	84	2.04***	84	1.8***	84	1.8***	80	2.1***	80	1.8***	82	1.1
Age as covariate:														
Linear	1	18.3***	1	22.8***	1	20.2***	1	7.2**	1	7.97**	1	11.6***	1	.4
Quadratic	1	.1	1	1.1	1	1.4	1	.1	1	.000	1	.1	1	3.6*
Genetic covariate terms:														
G^I	1	.1	1	1.3	1	1.1	1	1.0	1	2.1	1	3.1	1	1.4
G^M	1	.01	1	0.96	1	.8	1	.7	1	1.8	1	2.5	1	1.2
H^I	1	.003	1	.8	1	.7	1	.7	1	1.6	1	2.4	1	1.2
H^M	1	.01	1	.7	1	.8	1	.7	1	1.4	1	2.5	1	1.1
R^I	1	.02	1	.7	1	.7	1	.6	1	1.5	1	2.5	1	1.1
R^M	1	.4	1	4.8*	1	.4	1	.1	1	2.9	1	.4	1	.8
Remainder df	182		476		476		476		368		368		386	
Remainder M.S.		23790		194157		331151		6598		1.4		1.4		6807
Third parity'														
Year-Season	57	2.03***	86	1.6***	86	9.5***	86	1.4**	79	2.2***	79	1.9***	79	.8
Age as covariate:														
Linear	1	7.9**	1	15.9***	1	20.2***	1	14.99***	1	.1	1	2.8	1	3.9*
Quadratic	1	3.3	1	5.5**	1	7.9**	1	7.2**	1	.3	1	2.3	1	.1
Genetic covariate terms:														
G^I	1	.3	1	.1	1	.1	1	.3	1	.8	1	0.97	1	.8
G^M	1	.3	1	.01	1	.01	1	.5	1	.7	1	.8	1	.8
H^I	1	.3	1	.000	1	.01	1	.5	1	.6	1	.7	1	.7
H^M	1	.1	1	.03	1	.1	1	.1	1	.4	1	.7	1	.8
R^I	1	.1	1	.03	1	.1	1	.1	1	.4	1	.7	1	.9
R^M	1	.1	1	.8	1	2.04	1	1.1	1	.1	1	.3	1	.8
Remainder df	126		333		333		333		228		228		243	
Remainder M.S.		29547		253184		423266		7664		1.6		1.6		9621

Table (16). Cont.

Source of variation	M90		M305		TMY		LP		MCI1		MCI2		DP	
	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F
Fourth parity'														
Year-Season	56	1.6*	81	1.6**	81	1.3	81	1.5**	77	2.1***	77	1.7**	77	.6
Age as covariate:														
Linear	1	3.03	1	20.2***	1	15.1***	1	5.5*	1	12.03***	1	17.9***	1	.6
Quadratic	1	.1	1	6.4**	1	4.2*	1	.2	1	3.3	1	3.3	1	1.7
Genetic covariate terms:														
G^{I}	1	.2	1	2.5	1	1.5	1	.2	1	1.7	1	2.1	1	.1
G^{M}	1	.2	1	2.2	1	1.2	1	.1	1	1.5	1	1.8	1	.1
H^{I}	1	.2	1	1.9	1	1.1	1	.1	1	1.4	1	1.8	1	.1
H^{M}	1	.04	1	2.01	1	1.2	1	.2	1	1.4	1	1.7	1	.1
R^{I}	1	.1	1	1.9	1	1.02	1	.1	1	1.5	1	1.8	1	.1
R^{M}	1	.04	1	1.01	1	1.2	1	1.9	1	.1	1	.4	1	.2
Remainder df	74		199		199		199		154		154		160	
Remainder M.S.		38699		231278		398351		6881		1.6		1.5		8158
All parities''														
Year-Season	85	5.5***	91	4.6***	91	3.2***	91	3.3***	91	4.4***	91	3.4***	91	1.9***
Parity	7	2.9**	7	2.1*	7	3.2**	7	6.1***	7	1.0	7	.9	7	6.5***
Age as covariate:														
Linear	1	48.5***	1	127.1***	1	110.3***	1	53.2***	1	32.1***	1	65.8***	1	2.7
Quadratic	1	31.0***	1	58.7***	1	34.3***	1	4.5*	1	48.2***	1	58.2***	1	.1
Genetic covariate terms:														
G^{I}	1	.6	1	2.0	1	1.4	1	.4	1	.6	1	.8	1	.02
G^{M}	1	.3	1	1.0	1	.7	1	.1	1	.3	1	.3	1	.1
H^{I}	1	.1	1	.6	1	.4	1	.1	1	.1	1	.1	1	.1
H^{M}	1	.5	1	1.8	1	1.6	1	.7	1	.3	1	.6	1	.03
R^{I}	1	.4	1	1.6	1	1.5	1	.6	1	.3	1	.5	1	.02
R^{M}	1	3.3	1	3.0	1	11.7***	1	8.2**	1	.3	1	3.9*	1	.6
Remainder df	1222		2647		2647		2647		2088		2088		2214	
Remainder M.S.		33764		246492		511672		7318		1.8		1.8		9425

' Data of separate lactations were analysed using Model 2.

'' Data of all lactations were analysed using Model 6.

*= P<.05, **=P<.01, ***=P<.001

Table (17). F-ratios of least-squares analysis of variance of reproductive traits in the first four parities and in all parities in **Friesian trial.**

Source of variation	CI D.F.	CI F	AC++ D.F.	AC++ F
First parity+				
Year-Season	77	1.4*	84	7.4***
Age as covariate:				
Linear	1	.2		
Quadratic	1	.000		
Genetic covariate terms:				
G^I	1	.01	1	1.8
G^M	1	.02	1	1.7
H^I	1	.03	1	1.4
H^M	1	.002	1	1.5
R^I	1	.02	1	1.4
R^M	1	.7	1	0.1
Remainder df	531		654	
Remainder M.S.		11118		51.04
Second parity+				
Year-Season	81	1.1	84	4.9***
Age as covariate:				
Linear	1	4.9*		
Quadratic	1	.9		
Genetic covariate term:				
G^I	1	.1	1	1.2
G^M	1	.1	1	1.2
H^I	1	.1	1	1.002
H^M	1	.1	1	0.79
R^I	1	.1	1	0.95
R^M	1	.3	1	0.001
Remainder df	380		526	
Remainder M.S.		7558		69.5
Third parity+				
Year-Season	79	1.2		
Age as covariate:				
Linear	1	17.7***		
Quadratic	1	4.6*		
Genetic covariate term:				
G^I	1	.5		
G^M	1	.6		
H^I	1	.5		
H^M	1	.3		
R^I	1	.4		
R^M	1	.1		
Remainder df	237			
Remainder M.S.		8893		

Table (17). Cont.

Source of variation	CI D.F.	CI F
Fourth parity+		
Year-Season	77	1.3
Age as covariate:		
Linear	1	2.3
Quadratic	1	1.05
Genetic covariate term:		
G^I	1	.1
G^M	1	.1
H^I	1	.1
H^M	1	.2
R^I	1	.1
R^M	1	.3
Remainder df	159	
Remainder M.S.		8482
All parities+++		
Year-Season	91	1.9***
Parity	7	6.3***
Age as covariate:		
Linear	1	20.8***
Quadratic	1	3.0
Genetic covariate term		
G^I	1	.9
G^M	1	.6
H^I	1	.6
H^M	1	1.2
R^I	1	1.1
R^M	1	.1
Remainder df	2191	
Remainder M.S.		9566

+ Data of separate lactations were analysed using Model 2.

++ Age at first and second calving were analysed using Model 4.

+++ Data of all lactations were analysed using Model 6.

* = P<.05, ** =P<.01, *** =P<.001

Table (18). F-ratios of least-squares analysis of variance of milk production traits in the first four lactations and in all lactations in **Shorthorn trial.**

Source of variance	M305 D.F.	M305 F	TMY D.F.	TMY F	LP D.F.	LP F	MCI1 D.F.	MCI1 F	MCI2 D.F.	MCI2 F	DP D.F.	DP F
First parity'												
Year-Season	74	1.9***	74	2.04***	74	2.02***	73	1.5**	73	1.4*	73	1.1
Age as covariate												
Linear	1	21.7***	1	16.2***	1	.1	1	12.2***	1	11.6***	1	.2
Quadratic	1	2.6	1	1.7	1	.2	1	2.6	1	1.9	1	.2
Genetic covariate terms												
G^I	1	4.8*	1	4.003*	1	1.8	1	.8	1	1.1	1	.03
G^M	1	4.2*	1	3.5	1	1.6	1	.6	1	.8	1	.02
H^I	1	3.5	1	2.98	1	1.5	1	.4	1	.6	1	.01
H^M	1	5.2*	1	3.99*	1	.7	1	1.7	1	1.9	1	.2
R^I	1	4.99*	1	4.04*	1	1.1	1	1.3	1	1.6	1	.1
R^M	1	.1	1	.06	1	1.8	1	2.4	1	2.6	1	.97
Remainder df	400		400		400		354		354		353	
Remainder M.S.		237099		367308		7560		1.9		2.2		18340
Second parity'												
Year-Season	74	1.4*	74	1.2	74	1.2	69	1.5**	69	1.4*	69	.7
Age as covariate												
Linear	1	15.7***	1	9.1**	1	.01	1	12.5***	1	9.8***	1	.7
Quadratic	1	.1	1	.2	1	1.8	1	.01	1	.2	1	.3
Genetic covariate terms												
G^I	1	.03	1	.2	1	2.02	1	2.01	1	1.5	1	.3
G^M	1	.1	1	.1	1	1.9	1	2.2	1	1.6	1	.3
H^I	1	.1	1	.1	1	2.1	1	2.4	1	1.8	1	.3
H^M	1	.01	1	.6	1	2.7	1	1.1	1	.6	1	.1
R^I	1	.005	1	.6	1	2.8	1	1.1	1	.6	1	.2
R^M	1	2.03	1	2.5	1	.3	1	1.9	1	2.5	1	.4
Remainder df	315		315		315		258		258		257	
Remainder M.S.		302107		416604		5629		2.7		2.8		15344
Third parity'												
Year-Season	70	1.8***	70	1.4*	70	.9	67	1.9***	67	1.9***	67	1.6**
Age as covariate												
Linear	1	5.2*	1	2.8	1	1.04	1	5.9**	1	5.6**	1	.6
Quadratic	1	4.9*	1	.6	1	1.1	1	9.9***	1	5.8**	1	1.4
Genetic covariate terms												
G^I	1	1.5	1	.5	1	.002	1	4.1*	1	3.3	1	1.8
G^M	1	1.6	1	.5	1	.001	1	4.3*	1	3.5	1	1.8
H^I	1	1.7	1	.6	1	.001	1	4.4*	1	3.6	1	1.8
H^M	1	.5	1	.2	1	.01	1	2.1	1	2.1	1	1.4
R^I	1	.6	1	.2	1	.02	1	2.2	1	2.04	1	1.4
R^M	1	2.1	1	1.1	1	.1	1	.9	1	.5	1	.3
Remainder df	235		235		235		175		175		175	
Remainder M.S.		321741		489078		6697		2.2		2.3		8744

Table (18). Cont.

Source of variance	M305 D.F.	M305 F	TMY D.F.	TMY F	LP D.F.	LP F	MCI1 D.F.	MCI1 F	MCI2 D.F.	MCI2 F	DP D.F.	DP F
Fourth parity'												
Year-Season	69	1.8***	69	1.7**	69	1.97***	59	1.2	59	1.1	59	.9
Age as covariate												
Linear	1	4.5*	1	7.4**	1	6.6**	1	.1	1	1.3	1	.3
Quadratic	1	4.7*	1	2.1	1	.2	1	5.3*	1	6.9**	1	1.7
Genetic covariate terms												
G^{I}	1	.003	1	.3	1	1.1	1	3.7*	1	2.9	1	1.5
G^{M}	1	.01	1	.2	1	.99	1	3.8*	1	3.1	1	1.6
H^{I}	1	.02	1	.2	1	1.04	1	3.96*	1	3.2	1	1.5
H^{M}	1	.1	1	.8	1	1.7	1	2.99	1	2.1	1	1.6
R^{I}	1	.1	1	.7	1	1.4	1	2.9	1	2.1	1	1.7
R^{M}	1	1.2	1	1.8	1	1.9	1	.5	1	.7	1	.002
Remainder df	173		173		173		127		127		127	
Remainder M.S.		420251		540816		7506		2.5		2.6		11346
All parities''												
Year-Season	91	3.2***	91	2.9***	91	2.4***	95	2.8***	95	2.7***	91	1.6***
Parity	7	1.6	7	2.1*	7	3.3***	7	1.7	7	1.8	7	.7
Age as covariate												
Linear	1	32.7***	1	35.1***	1	7.96**	1	15.7***	1	20.1***	1	.7
Quadratic	1	40.3***	1	28.5***	1	1.6	1	17.3***	1	15.3***	1	8.5**
Genetic covariate terms:												
G^{I}	1	.8	1	.01	1	1.4	1	7.1**	1	6.4**	1	2.2
G^{M}	1	1.2	1	.1	1	1.3	1	7.8**	1	7.3**	1	2.3
H^{I}	1	1.8	1	.2	1	1.3	1	9.5**	1	8.6**	1	2.4
H^{M}	1	.01	1	.7	1	2.3	1	4.9*	1	4.2*	1	1.9
R^{I}	1	.01	1	.8	1	2.5	1	4.8*	1	4.2*	1	1.9
R^{M}	1	2.7	1	3.7*	1	.2	1	.01	1	.1	1	.1
Remainder df	1846		1846		1846		1514		1514		1537	
Remainder M.S.		319718		451480		6462		2.8		2.9		13893

' Data of separate lactations were analysed using Model 2.

'' Data of all lactations were analysed using Model 6.

*= $P<.05$, **=$P<.01$, ***=$P<.001$

Table (19). F-ratios of least-squares analysis of variance of reproductive traits in the first four parities and in all parities in **Shorthorn** trial.

Source of variance	CI D.F.	CI F	AC++ D.F.	AC++ F
First parity'				
Year-Season	73	1.5**	68	2.4***
Age as covariate:				
Linear	1	.05		
Quadratic	1	.1		
Genetic covariate terms:				
G^I	1	.4	1	0.08
G^M	1	.3	1	0.09
H^I	1	.4	1	0.14
H^M	1	.02	1	0.30
R^I	1	.1	1	0.29
R^M	1	2.2	1	0.36
Remainder df	354		434	
Remainder M.S.		11247		38.98
Second parity'				
Year-Season	69	1.1	68	2.2***
Age as covariate				
Linear	1	2.05		
Quadratic	1	1.9		
Genetic covariate terms:				
G^I	1	.8	1	0.05
G^M	1	.7	1	0.05
H^I	1	.8	1	0.06
H^M	1	.8	1	0.01
R^I	1	.9	1	0.001
R^M	1	.3	1	0.95
Remainder df	258		365	
Remainder M.S.		9251		54.3
Third parity'				
Year-Season	67	1.1		
Age as covariate				
Linear	1	.3		
Quadratic	1	6.5**		
Genetic covariate terms:				
G^I	1	.97		
G^M	1	.9		
H^I	1	.9		
H^M	1	.2		
R^I	1	.3		
R^M	1	.6		
Remainder df	175			
Remainder M.S.		9522		

Table (19). Cont.

Source of variance	CI D.F.	CI F
Fourth parity+		
Year-Season	59	.9
Age as covariate		
Linear	1	2.8
Quadratic	1	.01
Genetic covariate terms:		
G^{I}	1	2.7
G^{M}	1	2.6
H^{I}	1	2.6
H^{M}	1	2.9
R^{I}	1	2.8
R^{M}	1	.2
Remainder df	127	
Remainder M.S.		9612
All parities+++		
Year-Season	91	1.6***
Parity	7	3.8***
Age as covariate		
Linear	1	2.7
Quadratic	1	7.03**
Genetic covariate terms:		
G^{I}	1	2.5
G^{M}	1	2.3
H^{I}	1	2.6
H^{M}	1	2.02
R^{I}	1	1.9
R^{M}	1	.1
Remainder df	1518	
Remainder M.S.		10126

\+ Data of separate lactations were analysed using Model 2.

++ Age at first and second calving were analysed using Model 4.

+++ Data of all lactations were analysed using Model 6.

*=P<.05 , **=P<.01 , ***=P<.001

Table (20). F-ratios of least-squares analysis of variance of milk production traits in the first four lactations and in all lactations in **Friesian trial**.

Source of Variation	M90		M305		TMY		LP		MCI1		MCI2		DP	
	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F	D.F.	F
First parity'														
Breed group	7	1.7	7	39.3***	7	37.1***	7	17.4***	7	19.0***	7	27.7***	7	5.7***
Year-season	45	2.1***	79	2.9***	79	2.4***	79	1.9***	77	1.5**	77	1.5**	77	1.3*
Age as covariate:														
Linear	1	19.4***	1	48.2***	1	40.6***	1	6.2**	1	19.9***	1	26.0***	1	.3
Quadratic	1	.04	1	10.9***	1	10.4***	1	1.2	1	3.4	1	4.5*	1	.5
Remainder df	239		597		597		597		478		478		531	
Remainder M.S.		21169		165677		285000		7130		1.5		1.6		11939
Second parity'														
Breed Group	7	3.2**	7	33.5***	7	31.7***	7	19.8***	7	16.5***	7	24.3***	7	5.3***
Year-Season	51	2.7***	84	2.1***	84	1.8***	84	1.8***	80	2.1***	80	1.8***	82	1.1
Age as covariate:														
Linear	1	18.4***	1	23.5***	1	20.4***	1	7.3**	1	8.9**	1	12.5***	1	.5
Quadratic	1	.1	1	1.2	1	1.5	1	.1	1	.01	1	.1	1	3.4
Remainder df	181		475		475		475		367		367		385	
Remainder M.S.		23873		193245		331370		6607		1.4		1.4		6799
Third parity'														
Breed Group	7	.8	7	18.7***	7	20.1***	7	11.1***	7	8.8***	7	14.5***	7	1.4
Year-Season	57	2.0***	86	1.5**	86	9.6***	86	1.4**	79	2.1***	79	1.8***	79	.8
Age as covariate:														
Linear	1	6.5**	1	17.0***	1	21.8***	1	15.9***	1	.1	1	3.0	1	3.9*
Quadratic	1	3.1	1	5.5**	1	7.9**	1	7.2**	1	.2	1	2.0	1	.1
Remainder df	125		332		332		332		227		227		242	
Remainder M.S.		29691		252612		420828		7652		1.6		1.6		9659
Fourth parity'														
Breed Group	7	.5	7	14.6***	7	14.8***	7	9.0***	7	6.3***	7	11.0***	7	1.8
Year-Season	56	1.5*	81	1.5**	81	1.3	81	1.6**	77	2.1***	77	1.6**	77	.5
Age as covariate:														
Linear	1	3.1	1	22.8***	1	18.0***	1	7.1**	1	11.7***	1	18.5***	1	.6
Quadratic	1	.1	1	7.7**	1	5.7**	1	.6	1	3.2	1	3.6*	1	1.6
Remainder df	73		198		198		198		153		153		159	
Remainder M.S.		39170		226801		386420		6698		1.6		1.5		8207
All parities''														
Breed Group (BG)	7	4.4***	7	92.3***	7	70.9***	7	51.6***	7	56.4***	7	80.2***	7	10.4***
Cow within BG	419	1.7***	717	2.4***	717	2.7***	717	2.2***	582	1.5***	582	1.8***	598	1.5***
Year-Season	73	3.5***	75	3.6***	75	2.5***	75	2.6***	75	3.9***	75	3.5***	75	1.8***
Parity	7	2.5**	7	1.5	7	.6	7	3.0**	7	9.0***	7	7.8***	7	10.6***
Age as covariate:														
Linear	1	12.6***	1	6.7**	1	.2	1	20.1***	1	70.3***	1	62.0***	1	33.1***
Quadratic	1	24.6***	1	53.1***	1	19.4***	1	.2	1	78.8***	1	82.9***	1	8.2**
Remainder df	814		1945		1945		1945		1521		1521		1631	
Remainder M.S.		27842		179891				5557		1.6		1.5		8367

' Data of separate lactations were analysed using Model 8.
'' Data of all lactations were analysed using Model 12.
*= P<.05, **=P<.01, ***=P<.001

Table (21). F-ratios of least-squares analysis of variance of reproductive traits in the first four parities and in all parities in **Friesian** trial.

Source of Variation	CI D.F.	CI F	AC⁺⁺ D.F.	AC⁺⁺ F
First parity⁺				
Breed group	7	3.0**	7	3.6***
Year-season	77	1.4**	84	7.3***
Age as covariate:				
Linear	1	.1		
Quadratic	1	.01		
Remainder df	530		653	
Remainder M.S.		11105		51.1
Second parity⁺				
Breed Group	7	5.8***	7	1.9
Year-Season	81	1.1	84	4.9***
Age as covariate:				
Linear	1	4.4*		
Quadratic	1	.8		
Remainder df	379		525	
Remainder M.S.		7464		69.7
Third parity⁺				
Breed Group	7	3.3**		
Year-Season	79	1.2		
Age as covariate:				
Linear	1	18.3***		
Quadratic	1	3.9*		
Remainder df	236			
Remainder M.S.		8867		
Fourth parity⁺				
Breed Group	7	2.8**		
Year-Season	77	1.3		
Age as covariate:				
Linear	1	3.0		
Quadratic	1	1.5		
Remainder df	158			
Remainder M.S.		8381		
All parities⁺⁺⁺				
Breed Group (BG)	7	12.3***		
Cow within BG	597	1.9***		
Year-Season	75	2.2***		
Parity	7	17.7***		
Age as covariate:				
Linear	1	102.8***		
Quadratic	1	33.9***		
Remainder df	1609			
Remainder M.S.		7729		

⁺ Data of separate lactations were analysed using Model 8.
⁺⁺ Age at first and second calving was analysed using Model 10.
⁺⁺⁺ Data of all lactations were analysed using Model 12.
* = P<.05, ** = P<.01, *** = P<.001

Table (22). F-ratios of least-squares analysis of variance of different milk production traits in the first four lactations and in all lactations in **Shorthorn trial**.

Source of Variation	M90 D.F.	M90 F	M305 D.F.	M305 F	TMY D.F.	TMY F	LP D.F.	LP F	MCI1 D.F.	MCI1 F	MCI2 D.F.	MCI2 F	DP D.F.	DP F
First parity'														
Breed group	6	3.6**	7	10.9***	7	9.3***	7	5.02***	7	7.2***	7	7.3***	7	.9
Year-season	39	1.8**	74	1.9***	74	2.1***	74	2.01***	73	1.5**	73	1.4*	73	1.1
Age as covariate:														
Linear	1	3.2	1	20.5***	1	15.1***	1	.1	1	12.1***	1	11.4***	1	.1
Quadratic	1	1.2	1	2.7	1	1.8	1	.1	1	2.6	1	1.9	1	.2
Remainder df	77		399		399		399		353		353		352	
Remainder M.S.		19121		236722		366248		7541		1.9		2.2		18361
Second parity'														
Breed Group	6	3.8**	7	3.9***	7	3.2**	7	2.1*	7	4.2***	7	4.3***	7	.4
Year-Season	32	1.2	74	1.4*	74	1.2	74	1.2	69	1.6**	69	1.5**	69	.7
Age as covariate:														
Linear	1	3.9*	1	14.7***	1	8.7**	1	.001	1	12.3***	1	9.6**	1	.6
Quadratic	1	.2	1	.1	1	.2	1	1.8	1	.02	1	.3	1	.4
Remainder df	67		314		314		314		257		257		256	
Remainder M.S.		42023		301357		417543		5616		2.6		2.8		15347
Third parity'														
Breed Group	6	3.8**	7	2.2*	7	1.5	7	.6	7	2.5**	7	2.5**	7	.7
Year-Season	27	1.9*	70	1.9***	70	1.5**	70	.9	67	2.05**	*67	2.1***	67	1.6**
Age as covariate:														
Linear	1	.9	1	4.5*	1	2.3	1	.8	1	5.2*	1	4.8*	1	.5
Quadratic	1	.3	1	4.3*	1	.4	1	1.3	1	9.8**	1	5.7**	1	1.4
Remainder df	49		234		234		234		174		174		174	
Remainder M.S.		49738		316309		482682		6670		2.2		2.2		8750
Fourth parity'														
Breed Group	6	2.8*	7	1.6	7	1.8	7	1.8	7	1.5	7	1.6	7	1.1
Year-Season	23	.9	69	1.8***	69	1.7**	69	1.96***	59	1.2	59	1.1	59	.98
Age as covariate:														
Linear	1	.2	1	4.5*	1	7.4**	1	6.5**	1	.1	1	1.2	1	.2
Quadratic	1	.2	1	4.7*	1	2.1	1	.2	1	5.3*	1	6.8**	1	1.7
Remainder df	34		172		172		172		126		126		126	
Remainder M.S.		63730		420936		542261		7549		2.5		2.6		11100
All parities''														
Breed Group (BG)	7	10.2***	7	13.2***	7	11.6***	7	4.2***	7	11.7***	7	11.7***	7	1.7
Cow within BG	173	2.1***	479	3.6***	479	3.4***	479	2.8***	430	2.8***	430	2.9***	433	2.0***
Year-Season	62	2.4***	79	3.4***	79	2.9***	79	2.2***	79	3.3***	79	3.0***	83	1.2
Parity	7	1.1	7	2.4*	7	1.8	7	5.4***	7	14.2***	7	11.3***	4	15.2***
Age as covariate:														
Linear	1	.8	1	14.5***	1	.3	1	25.02***	1	105.0***	1	82.7***	1	67.3***
Quadratic	1	6.1**	1	32.4***	1	9.01**	1	7.1**	1	52.6***	1	42.7***	1	70.9***
Remainder df	330		1378		1378		1378		1099		1099		1111	1
Remainder M.S.		34002		193783		286614		4462		1.9		1.9		10845

' Data of separate lactations were analysed using Model 8.
'' Data of all lactations were analysed using Model 12.
*= P<.05 **=P<.01 ***=P<.001

Table (23). F-ratios of least-squares analysis of variance of reproductive traits in the first four parities and in all parities in **Shorthorn** trial.

Source of Variation	CI D.F.	CI F	AC++ D.F.	AC++ F
First parity+				
Breed group	7	2.7**	7	1.3
Year-season	73	1.5**	68	2.4***
Age as covariate:				
Linear	1	.03		
Quadratic	1	.1		
Remainder df	353		433	
Remainder M.S.		11272		38.8
Second parity+				
Breed Group	7	1.4	7	1.0
Year-Season	69	1.1	68	2.1***
Age as covariate:				
Linear	1	1.99		
Quadratic	1	1.9		
Remainder df	257		364	
Remainder M.S.		9267		54.2
Third parity+				
Breed Group	7	1.04		
Year-Season	67	1.1		
Age as covariate:				
Linear	1	.3		
Quadratic	1	6.4**		
Remainder df	174			
Remainder M.S.		9571		
Fourth parity+				
Breed Group	7	1.2		
Year-Season	59	.97		
Age as covariate:				
Linear	1	3.1		
Quadratic	1	.01		
Remainder df	126			
Remainder M.S.		9399		
All parities+++				
Breed Group (BG)	7	2.3*		
Cow within BG	430	2.0***		
Year-Season	79	1.6***		
Parity	7	26.5***		
Age as covariate:				
Linear	1	187.2***		
Quadratic	1	85.3***		
Remainder df	1099			
Remainder M.S.		7926		

\+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10.
+++ Data of all lactations were analysed using Model 12.
* = P<.05 ** =P<.01 *** =P<.001

Table (24). F-ratios of least-squares analysis of variance of milk production traits in the first four lactations and in all lactations in **Jersey trial**.

Source of variation	M305 D.F.	M305 F	TMY D.F.	TMY F	LP D.F.	LP F	MCI1 D.F.	MCI1 F	MCI2 D.F.	MCI2 F	DP D.F.	DP F
First parity'												
Breed group	5	7.3***	5	5.9***	5	2.4*	5	3.2**	5	3.3**	5	1.7
Year-season	72	2.1***	72	1.9***	72	1.7***	64	1.2	64	1.2	67	1.04
Age as covariate:												
Linear	1	6.9**	1	5.5**	1	.02	1	7.95**	1	8.5**	1	.002
Quadratic	1	3.02	1	1.8	1	.02	1	7.2**	1	8.03**	1	.1
Remainder df	205		205		205		138		138		145	
Remainder M.S.		216806		364384		8875		1.76		1.97		13248
Second parity'												
Breed group	5	5.5***	5	5.4***	5	1.4	5	.96	5	1.9	5	1.2
Year-Season	74	2.8***	74	3.4***	74	3.4***	66	1.6*	66	1.9**	67	1.5*
Age as covariate:												
Linear	1	3.7*	1	4.7*	1	.1	1	7.1**	1	9.7**	1	.4
Quadratic	1	.03	1	.03	1	2.8	1	4.5*	1	4.002*	1	.5
Remainder df	119		119		119		83		83		96	
Remainder M.S.		210200		260023		4719		1.22		1.12		7069
Third parity'												
Breed group	5	1.3	5	1.2	5	1.7	5	1.03	5	.98	5	.5
Year-Season	66	1.8**	66	1.4	66	1.3	58	1.6	58	1.2	60	1.3
Age as covariate:												
Linear	1	1.9	1	3.3	1	4.2*	1	.09	1	.1	1	.3
Quadratic	1	2.6	1	2.8	1	4.3*	1	.2	1	.000	1	.3
Remainder df	80		80		80		40		40		47	
Remainder M.S.		310304		518508		9013		1.78		1.98		6477
Fourth parity'												
Breed group	5	.7	5	1.2	5	1.3	4	.1	4	.6	4	.6
Year-Season	52	1.7*	52	1.6	52	1.2	45	1.5	45	1.6	47	1.1
Age as covariate:												
Linear	1	.02	1	1.03	1	.02	1	.2	1	1.8	1	.5
Quadratic	1	1.3	1	3.2	1	1.8	1	.1	1	1.4	1	.03
Remainder df	42		42		42		21		21		24	
Remainder M.S.		317852		469543		10539		2.03		1.9		8609
All Parities''												
Breed group(BG)	5	7.4***	5	6.2***	5	2.05	5	3.4**	5	3.7**	5	1.0
Cow within BG	277	2.9***	277	2.7***	277	2.1***	206	2.2***	206	2.8***	215	2.0***
Year-Season	76	3.8***	76	3.1***	76	2.003***	76	2.2***	76	2.4***	76	1.6**
Prity	7	1.5	7	.9	7	.8	7	3.8***	7	3.9***	7	3.5***
Age as covariate:												
Linear	1	12.5***	1	6.3**	1	.1	1	19.8***	1	20.5***	1	10.2***
Quadratic	1	8.2**	1	5.001*	1	.5	1	20.4***	1	22.4***	1	11.2***
Remainder df	618		618		618		432		432		468	
Remainder M.S.		189568		293655		6578		1.4		1.3		7092

' Data of separate lactations were analysed using Model 8.

'' Data of all lactations were analysed using Model 12.

*= P<.05 **=P<.01 ***=P<.001

Table (25). F-ratios of least-squares analysis of variance of reproductive traits in the first four parities and for all parities in **Jersey** trial.

Source of variation	CI D.F.	CI F	AC[++] D.F.	AC[++] F
First parity[+]				
Breed group	5	1.7	5	1.1
Year-season	64	1.3	73	3.9***
Age as covariate:				
Linear	1	.02		
Quadratic	1	.08		
Remainder df	140		206	
Remainder M.S.		8493		54.02
Second parity[+]				
Breed group	5	1.3	5	1.5
Year-Season	66	1.4	65	1.4*
Age as covariate:				
Linear	1	1.6		
Quadratic	1	1.3		
Remainder df	85		130	
Remainder M.S.		6167		98.1
Third parity[+]				
Breed group	5	.3		
Year-Season	59	.9		
Age as covariate:				
Linear	1	1.4		
Quadratic	1	1.3		
Remainder df	40			
Remainder M.S.		9702		
Fourth parity[+]				
Breed group	4	3.6*		
Year-Season	46	3.6***		
Age as covariate:				
Linear	1	5.4*		
Quadratic	1	11.6**		
Remainder df	21			
Remainder M.S.		2742		
All Parities[+++]				
Breed group(BG)	5	1.3		
Cow within BG	207	1.3**		
Year-Season	76	1.3*		
Prity	7	2.9**		
Age as covariate:				
Linear	1	8.1**		
Quadratic	1	7.0**		
Remainder df	437			
Remainder M.S.		7260		

[+] Data of separate lactations were analysed using Model 8.
[++] Age at first and second calving was analysed using Model 10.
[+++] Data of all lactations were analysed using Model 12.
* = P<.05 ** =P<.01 *** =P<.001

Table (26). Estimates of partial regression coefficients (b's) of different traits of all parities on age at calving in Friesian trial.

Parity	M90		M305		TMY		LP		MCI1		MCI2		DP		CI	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Linear regression (b±SE)																
First'	9.57***	2.17	19.23***	2.77	23.15***	3.63	1.44**	.57	.04***	.009	.05***	.01	.40	.72	-.23	.69
Second'	7.51***	1.75	11.50***	2.37	14.03***	3.11	1.18**	.44	.02**	.007	.03***	.007	-.35	.49	1.09*	.52
Third'	5.05**	1.99	11.70***	2.84	17.14***	3.67	1.97***	.49	.003	.008	.01	.008	1.25*	.64	2.64***	.62
Fourth'	4.69	2.67	15.22***	3.19	17.67***	4.16	1.46**	.55	.03***	.010	.04***	.009	-.51	.67	1.19	.68
All''	5.22***	1.47	5.53**	2.14	-1.39	3.00	-1.69***	.38	.06***	.007	.06***	.007	-2.92***	.51	-4.96***	.49
Quadratic regression (b±SE)																
First'	-.04	.22	-.34***	.10	-.44***	.14	-.02	.02	-.0007	.0004	-.0008*	.0004	.02	.03	-.002	.03
Second'	.04	.16	-.11	.10	-.16	.14	-.01	.02	-.00003	.0003	-.0001	.0003	-.04	.02	-.020	.02
Third'	-.06	.04	-.20**	.09	-.31**	.11	-.04**	.01	-.0001	.0002	-.0003	.0002	-.006	.02	-.035*	.02
Fourth'	-.07	.22	-.38**	.14	-.42**	.18	-.01	.02	-.0008	.0004	-.0008*	.0004	-.039	.03	-.038	.03
All''	-.07***	.01	-.12***	.02	-.09***	.02	-.001	.003	-.0005***	.00006	-.0005***	.00005	.011**	.004	.021***	.004

' Data of separate lactations were analysed using Model 8.
'' Data of all lactations were analysed using Model 12.
*= P<.05, **=P<.01, ***=P<.001

Table (27). Estimates of partial regression coefficients (b's) of different traits of all parities on age at calving in Shorthorn trial.

Parity	M90		M305		TMY		LP		MCI1		MCI2		DP		CI	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Linear regression (b±SE)																
First'	5.52	3.11	20.10***	4.44	21.44***	5.53	.19	.79	.046***	.01	.048***	.01	-.43	1.31	-.18	1.02
Second'	7.61	3.84*	16.24***	4.23	14.71**	4.98	.02	.58	.050***	.01	.045**	.01	-.86	1.08	-1.18	.84
Third'	-4.71	4.93	10.51*	4.96	9.39	6.13	.65	.72	.035*	.02	.034*	.02	-.70	.97	.59	1.02
Fourth'	2.56	6.16	13.79*	6.47	19.99**	7.34	2.21**	.87	.006	.02	.022	.02	-.64	1.30	2.11	1.20
All''	2.93	3.34	12.90***	3.39	2.38	4.12	-2.57***	.51	.128***	.01	.11***	.01	-6.1***	.75	-11.1***	.80
Quadratic regression (b±SE)																
First'	.41	.38	-.58	.35	-.59	.44	.02	.06	-.002	.001	-.002	.001	-.04	.10	.03	.08
Second'	-.14	.32	-.09	.31	.18	.36	.06	.04	.0002	.001	.0006	.001	-.05	.08	.08	.06
Third'	-.19	.34	-.62*	.30	-.24	.37	.05	.04	-.003**	.001	-.002**	.001	.07	.06	.16**	.06
Fourth'	-.22	.50	-.84*	.39	-.64	.44	-.02	.05	-.003*	.001	-.003**	.001	.10	.08	-.01	.07
All''	-.07**	.03	-.15***	.03	-.10**	.03	.01**	.004	-.001***	.0001	-.001***	.0001	.06***	.01	.06***	.01

' Data of separate lactations were analysed using Model 8.

'' Data of all lactations were analysed using Model 12.

*= P<.05, **=P<.01, ***=P<.001

Table (28). Estimates of partial regression coefficients of different traits of all parities on age at calving in **Jersey** trial.

Parity	M305 b ± SE	TMY b ± SE	LP b ± SE	MCI1 b ± SE	MCI2 b ± SE	DP b ± SE	CI b ± SE
Linear rgression (b+SE)							
1st	16.08± 6.13**	18.71± 7.94**	0.16±1.24	0.0582±0.0206**	0.0635±0.0218**	-0.09±1.77	0.21±1.44
2nd	10.86± 5.62*	13.58± 6.25*	0.26±0.84	0.0430±0.0162**	0.0483±0.0155**	-0.77±1.18	-1.47±1.15
3rd	9.15± 6.73	15.81± 8.69	2.34±1.15*	-0.0094±0.0310	0.0124±0.0327	0.88±1.75	2.75±2.29
4th	1.74±11.48	14.17±13.96	0.28±2.09	0.0182±0.0381	0.0495±0.0373	1.61±2.28	3.29±1.41*
All	14.81± 4.18***	13.05± 5.21**	-0.26±0.78	0.0624±0.0130***	0.0610±0.0135***	-3.11±0.97***	-2.90±1.02**
Quadratic regression (b+SE)							
1st	-0.24± 0.14	-0.25± 0.18	0.0039±0.0284	-0.0012±0.0005**	-0.0014±0.0005**	-0.010±0.040	-0.01±0.03
2nd	-0.03± 0.16	0.03± 0.18	0.0410±0.0246	-0.0010±0.0005*	-0.0009±0.0005*	-0.025±0.035	0.04±0.03
3rd	-0.36± 0.23	-0.49± 0.29	-0.0800±0.0387*	0.0004±0.0008	-0.000001±0.0009	-0.026±0.050	-0.07±0.06
4th	-0.73± 0.66	-1.43± 0.80	-0.1617±0.1195	-0.0006±0.0022	-0.00260±0.0022	-0.026±0.141	-0.28±0.08**
All	-0.094±0.033**	-0.091±0.041*	0.0042±0.0060	-0.0005±0.0001***	-0.00050±0.0001***	0.026±0.008***	0.02±0.01**

* Data of separate lactations were analysed using Model 8.

** Data of all lactations were analysed using Model 12.

* = P<.05 ** = P<.01 *** = P<.001

grades), breed-group effects were mostly significant in the first and second lactations and across all lactations (Tables 22, 23, 24 and 25). In general, non-significant effects were observed in the third and fourth parities. The significant effects of breed group were reported by Aboustate (1975) for M305 and TMY (with Shorthorns and their crosses with Domiati); by Donald et al. (1977) for M305 and LP with Ayrshire, Jersey and Friesian and their crosses; by Rincon et al. (1982) for TMY of Holstein, Ayrshire, Brown Swiss and their crosses; by Alba and Kennedy (1985) for TMY of Criollo, Jersey and their crosses; by El-Amin et al. (1986) for CI of Butan, Holstein, Shorthorn and their crosses; by Arafa (1987) for M90, M305, TMY, LP, DP and CI of Shorthorn, Friesian and their crosses with Domiati. Madalena et al. (1990a), McAllister et al. (1994) and Thorpe et al. (1994) also reported significant effect of breed group on some milk traits.

In separate lactations and across all lactations of Friesian trial, M90, M305, TMY, LP, MCI1 and MCI2 generally increased with the increase of the proportion of Friesian blood from 1/2 to 15/16 (Table 29). In Egypt, the increase of milk traits with the increase of Friesian blood was also observed by El-Itriby and Asker (1958), Arafa (1987) and Mostageer et al. (1987). Means for length of CI increased with the increase of Friesian blood, while inconsistent trend was found with DP (Tables 29 and 30). Age at first (AC1) and second (AC2) calving increased with the increase of proportion of Friesian blood from 1/2 to 7/8 (Table 30).

Least-squares means of each breed group for milk yield traits in Friesian trial (M90, M305, TMY, LP, MCI1 and MCI2) increased with the advance of parity (Table 29). For 1/2F1/2D, 3/4F1/4D, 7/8F1/8D and 15/16F1/16D, LP also increased with the advancement of parity. Dealing with groups of inter-se mating [$(3/4F\ 1/4D)^2$ and $(7/8F1/8D)^2$], the highest LP is found in the third parity, and the lowest one was found in the second parity. For each up-graded group (i.e. 1/2F1/2D, 3/4F1/4D, 7/8F1/8D and 15/16F1/16D), CI and DP decreased, in general, with the increase of parity, while inconsistent trend was obtained with groups of inter-se mating of $(3/4F1/4D)^2$ and $(7/8F1/8D)^2$.

In separate lactations and across all lactations of Shorthorn trial, least-squares means for M90, M305, TMY, LP, MCI1 and MCI2 generally decreased with the increase of proportion of Shorthorn (S) blood from 1/2S to 7/8S (Table 31), and increased thereafter (i.e. for 15/16S). Least-squares means for CI increased with the increase of the proportion of Shorthorn blood from 1/2S to 7/8S (Table 34), while indefinite trend was observed for DP (Tables 31 and 32). Such decreasing trend of milk

Table (29). Least-square means and their standard errors of milk production traits for different breed groups in **Friesian trial**.

Breed Group	M90 (kg) No.	M90 (kg) Mean±SE	M305 (kg) No.	M305 (kg) Mean±SE	TMY (kg) Mean±SE	LP (day) Mean±SE	MCI1 (kg/day) No.	MCI1 (kg/day) Mean±SE	MCI2 (kg/day) Mean±SE	DP (day) No.	DP (day) Mean±SE
First parity'											
Domiati(D)	9	623± 57	130	959± 86	934±104	206±15	118	2.41±0.22	2.36±0.22	167	231±18
Friesian(F)	102	795± 28	217	1937± 78	2197± 91	343±12	174	4.48±0.19	4.98±0.18	175	130±15
1/2F-1/2D	10	780± 56	86	1534± 87	1594±105	287±15	66	3.81±0.23	3.93±0.23	68	176±19
3/4F-1/4D	54	805± 30	102	1766± 84	1900±100	298±14	85	4.48±0.21	4.77±0.21	86	138±18
7/8F-1/8D	57	773± 30	87	1794± 85	1972±102	318±14	71	4.32±0.22	4.67±0.22	71	152±19
15/16F-1/16	31	775± 37	32	1884±108	2070±134	343±20	24	4.33±0.34	4.72±0.34	24	154±29
(3/4F-1/4D)²	21	753± 45	22	1769±125	2056±158	352±24	19	3.96±0.38	4.47±0.38	19	128±33
(7/8F-1/8D)²	10	832± 56	10	2118±157	2363±201	363±31	8	4.64±0.50	5.14±0.51	8	128±44
Significance		ns		***	***	***		***	***		***
Second parity'											
Domiati(D)	7	599± 71	156	1124± 90	1134±109	208±16	129	3.12±0.27	3.13±0.25	138	181±14
Friesian(F)	79	911± 35	160	2132± 80	2499± 95	361±13	128	4.96±0.24	5.68±0.23	130	108±11
1/2F-1/2D	15	877± 55	61	1830± 95	1881±116	284±16	51	4.77±0.28	4.94±0.27	53	132±15
3/4F-1/4D	46	903± 38	75	1966± 90	2108±109	304±15	59	5.02±0.27	5.32±0.26	63	110±14
7/8F-1/8D	48	926± 37	67	2189± 91	2326±110	327±16	53	5.35±0.28	5.62±0.27	54	97±15
15/16F-1/16D	21	948± 52	23	2394±138	2553±175	358±25	16	6.26±0.46	6.55±0.45	17	66±29
(3/4F-1/4D)²	18	928± 54	19	1950±142	2154±180	296±25	14	5.00±0.44	5.48±0.43	14	106±28
(7/8F-1/8D)²	8	917± 68	8	1886±185	2129±238	302±34	7	4.32±0.55	4.74±0.54	8	147±36
Significance		**		***	***	***		***	***		***
Third parity'											
Domiati(D)	4	900± 98	112	1253± 98	1277±278	214±17	87	3.54±0.35	3.51±0.33	96	162±20
Friesian(F)	63	1020± 42	122	2264± 83	2674±270	353±14	84	5.36±0.32	6.10±0.30	87	126±17
1/2F-1/2D	16	923± 64	49	2010±108	2155±284	297±18	42	5.21±0.37	5.38±0.35	44	114±23
3/4F-1/4D	39	1011± 46	60	2131±103	2347±281	311±18	43	5.43±0.37	5.81±0.35	44	93±22
7/8F-1/8D	36	1035± 47	51	2101±106	2315±283	313±18	35	5.48±0.38	5.79±0.36	35	129±23
15/16F-1/16D	14	980± 72	14	2448±190	2939±348	376±33	9	5.59±0.68	6.50±0.67	9	115±50
(3/4F-1/4D)²	13	942± 69	13	2151±184	2579±343	380±32	10	4.58±0.59	5.40±0.58	10	112±42
(7/8F-1/8D)²	7	933± 84	7	2241±234	2659±391	397±41	6	4.48±0.77	5.23±0.76	6	168±57
Significance		ns		***	***	***		***	***		ns
Fourth parity'											
Domiati(D)	6	997±117	73	1338±124	1308±155	204±22	61	3.85±0.40	3.75±0.36	64	174±23
Friesian(F)	42	1075± 59	81	2454± 99	2790±122	359±18	62	5.85±0.34	6.53±0.30	63	97±19
1/2F-1/2D	17	1029± 74	39	2284±125	2468±157	318±22	36	5.30±0.40	5.54±0.36	37	157±23
3/4F-1/4D	28	1098± 60	40	2256±119	2439±149	315±21	34	5.94±0.39	6.24±0.35	34	112±23
7/8F-1/8D	24	1094± 69	33	2196±128	2379±161	301±23	27	5.82±0.42	6.11±0.39	28	116±25
15/16F-1/16D	6	1127±116	7	2886±232	3467±300	440±40	7	5.76±0.65	6.90±0.62	7	96±44
(3/4F-1/4D)²	10	959± 90	10	2073±202	2207±260	319±35	8	5.74±0.64	6.01±0.60	8	121±42
(7/8F-1/8D)²	6	990±118	6	2069±271	2421±351	360±47	5	4.63±0.91	5.28±0.87	5	88±63
Significance		ns		***	***	***		***	***		ns
All parities''											
Domiati(D)	39	820± 39	653	1294± 54	1341± 81	221± 9	540	3.20±0.14	3.19±0.14	623	213± 9
Friesian(F)	403	1037± 20	753	2339± 44	2736± 65	358± 7	580	5.24±0.11	5.88±0.12	596	149± 7
1/2F-1/2D	156	1024± 30	394	2174± 59	2373± 89	308± 9	328	5.17±0.14	5.46±0.16	340	168± 9
3/4F-1/4D	269	1029± 24	403	2215± 54	2514± 80	325± 8	318	5.16±0.13	5.59±0.15	326	157± 9
7/8F-1/8D	239	1006± 24	328	2212± 56	2460± 83	325± 9	255	5.14±0.14	5.52±0.15	259	159± 9
15/16F-1/16D	89	1021± 32	93	2407± 84	2743±125	360±13	69	5.31±0.23	5.91±0.24	70	148±15
(3/4F-1/4D)²	86	1028± 35	88	2320± 94	2671±140	356±15	70	5.08±0.24	5.66±0.26	71	155±16
(7/8F-1/8D)²	42	1023± 45	42	2288±125	2632±186	354±20	35	5.15±0.31	5.75±0.34	36	142±21
Significance		***		***	***	***		***	***		***

' Data of separate lactations were analysed using Model 8.

'' Data of all lactations were analysed using Model 12.

ns= non-significant (P>0.05),

* = P<.05, ** =P<.01, *** =P<.001

( )² = inter-se mating.

Table (30). Least square means and their standard errors of reproductive traits for different breed groups in **Friesian trial.**

Breed Group	CI (day) No.	CI (day) Mean±SE	AC++ (month) No.	AC++ (month) Mean±SE
First parity+				
Domiati(D)	167	407±18	181	41.0±1.62
Friesian(F)	174	471±16	220	37.5±1.41
1/2F-1/2D	68	454±19	89	34.7±1.58
3/4F-1/4D	86	438±18	103	37.0±1.51
7/8F-1/8D	71	466±19	88	37.6±1.54
15/16F-1/16	24	504±29	32	36.4±1.91
$(3/4F-1/4D)^2$	19	469±32	22	38.6±2.18
$(7/8F-1/8D)^2$	8	479±43	10	41.1±2.83
Significance		**		***
Second parity+				
Domiati(D)	135	384±14	165	54.3±1.83
Friesian(F)	129	475±12	175	53.4±1.56
1/2F-1/2D	53	414±16	69	49.3±1.82
3/4F-1/4D	62	422±15	85	51.7±1.70
7/8F-1/8D	53	441±15	71	52.6±1.77
15/16F-1/16D	16	379±31	24	52.4±2.37
$(3/4F-1/4D)^2$	14	428±29	19	54.1±2.65
$(7/8F-1/8D)^2$	8	442±37	9	57.0±3.48
Significance		***		**ns**
Third parity+				
Domiati(D)	92	395±21		
Friesian(F)	87	481±18		
1/2F-1/2D	43	408±23		
3/4F-1/4D	43	421±23		
7/8F-1/8D	35	442±24		
15/16F-1/16D	9	530±48		
$(3/4F-1/4D)^2$	10	486±41		
$(7/8F-1/8D)^2$	6	531±55		
Significance		**		
Fourth parity+				
Domiati(D)	64	367±25		
Friesian(F)	63	466±21		
1/2F-1/2D	37	454±25		
3/4F-1/4D	34	418±25		
7/8F-1/8D	27	418±28		
15/16F-1/16D	7	527±45		
$(3/4F-1/4D)^2$	8	429±44		
$(7/8F-1/8D)^2$	5	461±64		
Significance		**		
All parities+++				
Domiati(D)	612	427±10		
Friesian(F)	592	506± 8		
1/2F-1/2D	338	468±11		
3/4F-1/4D	323	479±10		
7/8F-1/8D	257	489±11		
15/16F-1/16D	69	518±17		
$(3/4F-1/4D)^2$	71	512±19		
$(7/8F-1/8D)^2$	36	493±24		
Significance		***		

+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10
+++ Data of all lactations were analysed using Model 12.
ns= non-significant (P>0.05), * = P<.05, ** =P<.01, *** =P<.001

Table (31). Least-square means and their standard errors of milk production traits for different breed groups in **Shorthorn** trial.

	M90 (kg)		M305 (kg)		TMY (kg)	LP (day)		MCI1 (kg/day)	MCI2 (kg/day)	DP (day)	
Breed Group	No.	Mean±SE	No.	Mean±SE	Mean±SE	Mean±SE	No.	Mean±SE	Mean±SE	No.	Mean±SE
First parity'											
Domiati (D)	39	440± 60	93	1060± 92	1094±118	237±17	96	2.57±0.26	2.63±0.27	96	214±24
Shorthorn (Sh)	33	669± 47	92	1685± 78	1847±101	293±14	68	4.06±0.25	4.36±0.26	68	160±22
1/2Sh-1/2D			103	1799± 94	1867±120	279±17	103	4.38±0.27	4.54±0.28	103	166±25
3/4Sh-1/4D	3	686±123	115	1658± 89	1850±114	327±16	103	3.56±0.26	3.89±0.28	103	188±24
7/8Sh-1/8D	4	665±110	28	1608±122	1779±154	332±22	21	3.23±0.39	3.49±0.41	21	213±37
15/16Sh-1/16D	5	722± 84	9	1899±192	2174±240	363±34	8	3.78±0.66	4.07±0.70	8	132±64
(3/4Sh-1/4D)[2]	20	744± 57	20	1867±159	2039±200	310±29	17	4.31±0.50	4.56±0.53	17	153±48
(7/8Sh-1/8D)[2]	21	663± 52	23	1479±146	1607±184	272±26	19	3.78±0.45	3.96±0.48	19	164±43
Significance		**		***	***	***		***	***		ns
Second parity'											
Domiati (D)	32	635± 66	80	1453± 98	1486±112	256±13	79	3.50±0.34	3.57±0.34	79	166±23
Shorthorn (Sh)	33	940± 65	67	1863±100	2008±114	299±13	56	4.49±0.35	4.76±0.36	56	141±24
1/2Sh-1/2D			98	1911±106	1930±122	253±14	94	4.84±0.37	4.83±0.37	94	151±25
3/4Sh-1/4D	3	926±153	91	1839±105	1934±121	282±14	66	4.59±0.39	4.73±0.40	66	162±27
7/8Sh-1/8D	1	640±251	18	1584±163	1655±189	284±22	10	3.38±0.65	3.43±0.67	10	192±48
15/16Sh-1/16D	5	931±122	8	2104±256	2013±300	241±35	4	6.39±1.02	6.52±1.05	4	83±77
(3/4Sh-1/4D)[2]	16	920± 80	16	2016±195	2222±228	331±26	13	5.22±0.74	5.85±0.75	13	134±54
(7/8Sh-1/8D)[2]	18	976± 75	20	2008±179	2005±209	266±24	13	6.04±0.67	6.31±0.69	13	103±50
Significance		**		***	**	*		***	***		ns
Third parity'											
Domiati (D)	30	748±112	71	1740±132	1761±149	254±15	59	4.73±0.40	4.73±0.41	59	136±23
Shorthorn (Sh)	28	906±111	50	1925±135	2033±152	271±16	38	5.22±0.42	5.43±0.43	38	150±24
1/2Sh-1/2D			93	2014±145	2018±166	261±18	80	5.26±0.43	5.26±0.44	80	154±25
3/4Sh-1/4D	1	1097±285	63	1915±151	2030±174	264±19	43	5.13±0.48	5.49±0.48	43	145±28
7/8Sh-1/8D	2	486±224	8	1410±262	1538±316	264±36	6	3.82±0.84	4.29±0.85	6	134±52
15/16-1/16D	3	1478±185	4	2529±353	2747±431	345±50	3	6.69±0.97	7.33±1.99	3	80±60
(3/4Sh-1/4D)[2]	11	1061±129	13	2246±252	2129±304	246±35	11	6.44±0.79	6.34±0.81	11	89±49
(7/8Sh-1/8D)[2]	10	1073±120	12	2411±240	2351±289	267±33	11	7.16±0.68	7.13±0.69	11	64±42
Significance		**		*	ns	ns		**	**		ns
Fourth parity'											
Domiati (D)	20	796±114	58	1701±166	1722±185	238±23	44	4.77±0.46	4.83±0.47	44	136±30
Shorthorn (Sh)	23	959± 86	38	2234±174	2396±193	318±24	27	5.49±0.47	5.95±0.47	27	117±30
1/2Sh-1/2D			80	2016±187	2101±209	258±25	64	5.59±0.46	5.74±0.47	64	149±30
3/4Sh-1/4D	1	1025±321	43	1987±206	2035±230	241±28	33	5.89±0.55	6.01±0.56	33	125±36
7/8Sh-1/8D	2	569±256	6	1642±352	1602±398	216±47	4	4.61±1.09	4.78±1.11	4	170±72
15/16Sh-1/16D	2	1530±206	3	2341±438	2396±495	276±59	2	6.37±1.36	6.55±1.38	2	-56±90
(3/4Sh-1/4D)[2]	10	1035±125	12	2391±336	2544±379	265±45	11	6.20±0.88	6.65±0.89	11	143±58
(7/8Sh-1/8D)[2]	8	1080±130	11	2299±294	2250±331	246±40	10	7.57±0.90	7.82±0.91	10	48±59
Significance		*		ns	ns	ns		ns	ns		ns
All parities''											
Domiati(D)	162	633± 53	444	1458± 97	1611±112	278±12	408	2.16±0.30	2.40±0.31	408	149±13
Shorthorn(Sh)	157	843± 43	300	1871± 82	2127± 95	319±10	228	2.99±0.26	3.43±0.27	228	125±11
1/2Sh-1/2(D)	22	1018± 99	525	1949± 85	2095± 98	284±11	460	3.57±0.26	3.81±0.27	460	132±12
3/4Sh-1/4D	41	982± 83	381	1917± 88	2117±101	305±11	306	3.34±0.28	3.67±0.28	306	126±12
7/8Sh-1/8D	32	827± 71	85	1768±134	1953±154	308±17	65	3.04±0.44	3.34±0.45	65	127±23
15/16Sh-1/16D	21	956± 76	32	1915±191	2129±220	313±24	23	3.61±0.62	4.04±0.64	23	80±36
(3/4Sh-1/4D)[2]	71	976± 53	85	2247±139	2513±160	333±18	68	3.88±0.44	4.24±0.44	68	112±23
(7/8Sh-1/8D)[2]	76	958± 53	101	2102±133	2302±153	312±17	83	4.12±0.42	4.50±0.44	83	92±23
Significance		***		***	***	***		***	***		ns

' Data of separate lactations were analysed using Model 8.
'' Data of all lactations were analysed using Model 11.
ns= non-significant (P>0.05), * = P<.05 **=P<.01 ***=P<.001

Table (32). Least-square means and their standard errors of reproductive traits for different breed groups in Shorthorn trial.

Breed Group	CI (day) No.	CI (day) Mean±SE	AC++ (month) No.	AC++ (month) Mean±SE
First parity+				
Domiati (D)	97	427±20	105	37.1±1.1
Shorthorn (Sh)	68	472±19	93	36.2±0.9
1/2Sh-1/2D	103	424±20	106	34.6±1.2
3/4Sh-1/4D	103	494±20	122	35.2±1.1
7/8Sh-1/8D	21	526±30	29	36.0±1.5
15/16Sh-1/16D	8	474±51	10	40.7±2.3
$(3/4Sh-1/4D)^2$	17	461±38	20	39.2±1.8
$(7/8Sh-1/8D)^2$	19	449±35	24	37.1±1.6
Significance		**		ns
Second parity+				
Domiati (D)	79	393±18	99	50.6±1.4
Shorthorn (Sh)	56	433±19	69	50.7±1.2
1/2Sh-1/2D	94	389±20	104	49.4±1.4
3/4Sh-1/4D	67	429±21	103	52.2±1.3
7/8Sh-1/8D	10	459±37	20	52.8±2.1
15/16Sh-1/16D	4	396±60	8	55.8±3.0
$(3/4Sh-1/4D)^2$	13	481±42	17	51.3±2.3
$(7/8Sh-1/8D)^2$	13	412±39	20	50.9±2.1
Significance		ns		ns
Third parity+				
Domiati (D)	59	382±21		
Shorthorn (Sh)	38	424±23		
1/2Sh-1/2D	80	411±24		
3/4Sh-1/4D	43	429±27		
7/8Sh-1/8D	6	472±53		
15/16-1/16D	3	427±62		
$(3/4Sh-1/4D)^2$	11	352±50		
$(7/8Sh-1/8D)^2$	11	356±42		
Significance		ns		
Fourth parity+				
Domiati (D)	44	386±27		
Shorthorn (Sh)	27	452±28		
1/2Sh-1/2D	64	420±27		
3/4Sh-1/4D	33	407±33		
7/8Sh-1/8D	4	449±66		
15/16Sh-1/16D	2	265±83		
$(3/4Sh-1/4D)^2$	11	420±53		
$(7/8Sh-1/8D)^2$	10	339±54		
Significance		ns		
All parities+++				
Domiati(D)	405	533±16		
Shorthorn(Sh)	224	572±14		
1/2Sh-1/2(D)	456	531±14		
3/4Sh-1/4D	304	546±14		
7/8Sh-1/8D	63	568±23		
15/16Sh-1/16D	23	538±33		
$(3/4Sh-1/4D)^2$	68	547±23		
$(7/8Sh-1/8D)^2$	82	532±22		
Significance		*		

\+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10
+++ Data of all lactations were analysed using Model 12.

yield with the increase of the proportion of Shorthorn blood was also detected by most of the Egyptian studies (e.g. El-Itriby and Asker, 1958; Aboustate, 1975; Fahmy et al., 1976; Arafa, 1987).

Least-squares means for each genetic group of each lactation in Shorthorn trial showed that M90, M305, TMY, MCI1 and MCI2 generally increased with the increase of order of lactation (Table 31).While inconsistent or decreasing trend was observed for LP, CI and DP (Tables 31&32). The increasing trend of M305 and TMY with the advance of parity for Shorthorns and their crosses with Domiati was also recorded by Aboustate (1975), Fahmy et al. (1976) and Arafa (1987).

In Jersey trial, least-squares means of most traits in separate lactations showed that no clear trend was detected with the increase of the proportion of Jersey blood (J) in the different genetic groups (Tables 33&34). Across all lactations, means of M305, TMY, MCI1 and MCI2 decreased with the increase of the proportion of Jersey blood from 1/2J to 15/16J (Table 33). Means of different genetic groups for LP were approximately the same for all genetic groups, while means for DP showing a decreasing trend as the proportion of Jersey blood increases. For CI, no clear trend was observed (Table 34). El-Itriby et al. (1963) and Aboustate (1975) noted that means of M305 and/or TMY increased with the increase of the proportion of Jersey blood in up-graded groups.

Peak of M305 and TMY was reached in the fourth parity for up-graded groups of 3/4 J and 7/8 J , while the maximum yield for 1/2 J and 15/16J was attained in the third parity (Table 33). Means of MCI1 and MCI2 increased also with the increase of parity, reaching their maximum in the third parity for 1/2 J group and in the fourth parity for up-graded groups of 3/4 J, 7/8 J and 15/16 J. For LP, DP and CI, no clear trend was observed for each genetic group with advancing of parity.

The inter-se mating of 3/4F1/4D, 7/8F1/8D, 3/4S1/4D and 7/8S1/8D produced cows with better performance than the other grades (Tables 29-32). Sometimes, these grades of inter-se mating had superior (or approached) performance relative to the exotic paternal purebreds (Friesian and Shorthorn). In Egypt, the same observation was reported by Fahmy et al. (1976) with Shorthorns and their crosses with Domiati and by Arafa (1987) with Shorthorn, Friesian and their crosses with Domiati.

Table (33). Least-square means and their standard errors of milk production traits for different breed groups in **Jersey** trial.

Breed group	No	M305 (kg) Mean ± SE	TMY (kg) Mean ± SE	LP (day) Mean ± SE	No	MCI1 (kg/day) Mean ± SE	MCI2 (kg/day) Mean ± SE	No	DP (day) Mean ± SE
First parity'									
Domiati(D)	32	798 ± 135	793 ± 172	209 ± 27	17	2.32 ± 0.53	2.43 ± 0.56	18	134 ± 43
Jersey(J)	43	1618 ± 108	1746 ± 136	291 ± 21	36	4.24 ± 0.31	4.61 ± 0.33	37	106 ± 25
1/2J-1/2D	36	1363 ± 127	1434 ± 162	245 ± 25	31	3.42 ± 0.37	3.56 ± 0.39	31	179 ± 31
3/4J-1/4D	50	1811 ± 125	1981 ± 159	332 ± 24	39	5.10 ± 0.41	5.26 ± 0.43	41	87 ± 35
7/8J-1/8D	81	1631 ± 101	1748 ± 127	283 ± 19	57	4.23 ± 0.30	4.55 ± 0.32	61	125 ± 24
15/16J-1/16D	43	1616 ± 132	1801 ± 168	298 ± 26	30	3.75 ± 0.43	4.13 ± 0.46	32	186 ± 35
Significance		***	***	*		**	**		ns
Second parity'									
Domiati(D)	16	1419 ± 183	1495 ± 209	241 ± 28	10	4.07 ± 0.56	3.94 ± 0.54	11	173 ± 40
Jersey(J)	29	1810 ± 147	1849 ± 170	282 ± 23	24	4.85 ± 0.37	4.90 ± 0.36	25	98 ± 26
1/2J-1/2D	29	2400 ± 175	2564 ± 201	304 ± 27	26	5.40 ± 0.50	5.81 ± 0.49	26	100 ± 36
3/4J-1/4D	41	1691 ± 151	1768 ± 174	266 ± 24	31	4.71 ± 0.40	4.81 ± 0.39	35	134 ± 28
7/8J-1/8D	55	1532 ± 128	1595 ± 150	240 ± 20	42	4.87 ± 0.32	4.96 ± 0.32	49	124 ± 22
15/16J-1/16D	31	1647 ± 170	1743 ± 195	257 ± 26	24	5.34 ± 0.45	5.52 ± 0.44	25	70 ± 33
Significance		***	***	ns		ns	ns		ns
Third parity'									
Domiati(D)	9	1529 ± 329	1453 ± 422	258 ± 55	3	3.13 ± 1.65	2.93 ± 1.73	3	196 ± 98
Jersey(J)	24	2024 ± 185	2231 ± 232	335 ± 30	20	4.77 ± 0.67	5.35 ± 0.68	20	114 ± 37
1/2J-1/2D	21	2443 ± 254	2570 ± 322	321 ± 42	15	6.50 ± 0.91	6.74 ± 0.95	16	80 ± 47
3/4J-1/4D	34	1839 ± 188	1975 ± 236	247 ± 31	26	5.60 ± 0.61	5.97 ± 0.62	28	71 ± 34
7/8J-1/8D	41	1933 ± 164	2072 ± 204	269 ± 27	30	5.33 ± 0.56	5.65 ± 0.56	34	116 ± 31
15/16J-1/15D	25	2112 ± 214	2368 ± 270	346 ± 35	12	4.48 ± 0.83	4.86 ± 0.86	14	127 ± 45
Significant		ns	ns	ns		ns	ns		ns
Fourth parity'									
Domiati(D)	3	1618 ± 743	1947 ± 901	337 ± 134					
Jersey(J)	17	2118 ± 260	2612 ± 310	356 ± 44	11	5.99 ± 0.92	6.99 ± 0.90	12	115 ± 57
1/2J-1/2D	14	2190 ± 296	1867 ± 477	191 ± 70	9	5.02 ± 1.21	4.84 ± 1.18	10	133 ± 76
3/4J-1/4D	29	2110 ± 246	2418 ± 292	338 ± 41	22	5.65 ± 0.66	6.16 ± 0.65	24	72 ± 42
7/8J-1/8D	27	2266 ± 279	2545 ± 333	320 ± 48	20	5.34 ± 0.67	5.79 ± 0.66	20	158 ± 41
15/16J-1/16D	12	1722 ± 357	1740 ± 429	225 ± 63	11	5.48 ± 0.84	5.28 ± 0.83	12	121 ± 52
Significance		ns	ns	ns		ns	ns		ns
All parities'									
Domiati(D)	60	1214 ± 142	1273 ± 173	225 ± 23	30	2.87 ± 0.44	2.85 ± 0.47	32	181 ± 29
Jersey(J)	152	1798 ± 120	2003 ± 144	295 ± 18	123	4.38 ± 0.32	4.70 ± 0.36	127	141 ± 21
1/2J-1/2D	125	2077 ± 134	2231 ± 161	281 ± 20	100	4.70 ± 0.35	4.93 ± 0.38	102	178 ± 22
3/4J-1/4D	247	1794 ± 119	1971 ± 143	283 ± 18	187	4.38 ± 0.31	4.61 ± 0.35	201	161 ± 20
7/8J-1/8D	252	1762 ± 103	1937 ± 125	275 ± 16	184	4.37 ± 0.29	4.64 ± 0.32	200	157 ± 18
15/16J-1/16D	150	1756 ± 128	1902 ± 154	275 ± 19	105	4.55 ± 0.36	4.73 ± 0.39	112	142 ± 22
Significance		***	***	ns		**	**		ns

' Data of separate lactations were analysed using Model 8.

'' Data of all lactations were analysed using Model 12. ns= non-significant (P>0.05,

*= P<.05 **=P<.01 ***=P<.001

Table (34). Least-square means and their standard errors of reproductive traits for different breed groups in Jersey trial.

Breed group		CI (day) No	CI (day) Mean ± SE	AC++ (month) No	AC++ (month) Mean ± SE
First parity+					
Domiati(D)		17	448 ± 37	32	30.5 ± 2.8
Jersey(J)		37	419 ± 21	43	37.0 ± 1.8
1/2J-1/2D		31	481 ± 25	36	33.0 ± 2.9
3/4J-1/4D		39	401 ± 28	50	35.7 ± 1.8
7/8J-1/8D		57	415 ± 21	81	35.0 ± 1.5
15/16J-1/16D		31	468 ± 29	43	36.0 ± 2.0
Significance			ns		ns
Second parity+					
Domiati(D)		10	417 ± 39	16	39.2 ± 4.8
Jersey(J)		25	367 ± 25	29	52.3 ± 2.7
1/2J-1/2D		26	443 ± 33	29	45.2 ± 4.3
3/4J-1/4D		31	407 ± 28	41	51.9 ± 2.5
7/8J-1/8D		43	411 ± 22	55	49.1 ± 2.2
15/16J-1/16D		24	368 ± 31	31	48.7 ± 2.9
Significance			ns		ns
Third parity+					
Domiati(D)		3	403 ±121		
Jersey(J)		20	450 ± 47		
1/2J-1/2D		15	456 ± 65		
3/4J-1/4D		26	393 ± 42		
7/8J-1/8D		31	419 ± 38		
15/16J-1/15D		12	454 ± 59		
Significant			ns		
Fourth parity+					
Domiati(D)		12	511 ± 36		
Jersey(J)		9	429 ± 46		
1/2J-1/2D		22	423 ± 28		
3/4J-1/4D		20	475 ± 28		
7/8J-1/8D		11	378 ± 34		
15/16J-1/16D					
Significance			*		
All parities+					
Domiati(D)		30	446 ± 26		
Jersey(J)	1	126	445 ± 16		
1/2J-1/2D	1	100	477 ± 18		
3/4J-1/4D	2	187	458 ± 15		
7/8J-1/8D	2	186	464 ± 15		
15/16J-1/16D	1	106	444 ± 17		
Significance			ns		

+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10.
+++ Data of all lactations were analysed using Model 12.
ns= non-significant (P>0.05, *= P<.05 **=P<.01 ***=P<.001

4.4. Genetic components

Estimates of genetic components for different traits in the three up-grading trials were obtained from models 8, 10 and 12.

4.4.1 Individual (direct) Additive Effect (G^I)

4.4.1.1 G^I in Friesian trial

For all milk production traits in Friesian trial (M90, M305, TMY, LP, MCI1 and MCI2), estimates of individual additive effect ($G^I = g^I_D - g^I_F$) in each separate lactation were generally large and in favour of Friesian cows (Table 35). DP recorded positive estimates of G^I in favour of Friesian cows. This indicates that the Friesian cows are superior ($P<0.01$ or $P<0.001$) over Domiati cows in their direct additive effects for all milk production traits. Such superiority in G^I of Friesian cattle, raised in Egypt, is also observed in most studies reviewed. In this respect, Vencovsky et al. (1970) found that the deviation of Holstein from Guzera breed in direct additive effect was 353 kg of milk. Robison et al. (1981) showed that additive superiorities (direct effect) of Holstein over Ayrshire and Brown Swiss, respectively were 759 and 857 kg for first lactation milk yield. For milk yield, Cunningham and Syrstad (1987) reported that Friesian had direct additive superiorities (G^I) of 488, 456 and 1600 kg over Brown Swiss, Jersey and Sahiwal cattle, respectively. Martinez et al. (1988) concluded that for contribution of each one percent of Holstein gene, an increase of 10.02, 12.02, 12.51 and 12.15 kg in milk yield were expressed for first, second, third and first to fifth lactation yield, respectively. Madalena et al. (1990a) reported that the additive breed difference (direct additive) between Holstein and Guzera cattle was large and positive for M305 (3140 kg), LP (216 day) and MCI1 (7.79 kg/day). They added that estimates for these traits were larger under high management system than under low management. Ahlborn-Breier and Hohenboken (1991) reported large additive breed difference (direct effect) for milk yield between Holstein Friesian and Jersey (908 kg) in favour of Holstein Friesian. With Bos taurus (Friesian) and Bos indicus (Sahiwal), Thorpe et al. (1993) estimated 746 kg of milk as the difference in additive breed effect between the two breeds.

Estimates of G^I for lengths of CI in different parities were large ($P<0.01$ or $P<0.001$) and in favour of Domiati cows (Table 35). G^I for AC1 was positive and in favour of Friesian cows, while G^I estimate of AC2 was negative and in favour of Domiati cows; with insignificant effect for both traits. This indicates that, relative to Domiati, Friesian cows showed longer (unfavourable) CI and calved at the first time at younger

Table (35). Estimates of individual (G^I) and maternal (G^M) additive genetic effects for different traits in first four lactations and in all lactations in **Friesian trial.**

Trait[a]	G^I Estimate	G^I SE	G^M Estimate	G^M SE
First lactation[+]				
M90	-244.5**	89.9	-209.8	110.8
M305	-1523.8***	113.0	-1646.8***	159.6
TMY	-1939.9***	148.2	-2178.8***	209.3
LP	-213.5***	23.4	-242.9***	33.1
MCI1	-3.12***	.37	-3.05***	.53
MCI2	-3.94***	.38	-4.08***	.54
DP	144.5***	32.3	156.6***	46.3
CI	-111.3***	31.1	-122.9**	44.6
AC[++]	3.04	2.08	-1.03	2.81
Second lactation[+]				
M90	-481.8***	105.9	-445.5***	119.2
M305	-1591.9***	136.6	-1556.1***	193.3
TMY	-1992.5***	178.9	-2088.5***	253.1
LP	-209.6***	25.2	-218.7***	35.7
MCI1	-3.22***	.41	-2.91***	.59
MCI2	-3.97***	.42	-3.85***	.59
DP	123.8***	28.2	121.4**	40.4
CI	-81.6**	29.7	-92.7*	42.5
AC[++]	-0.81	2.64	-5.58	3.62
Third lactation[+]				
M90	-163.2	153.6	-168.2	171.4
M305	-1549.3***	191.7	-1530.6***	277.7
TMY	-2172.4***	247.5	-2335.0***	358.5
LP	-233.4***	33.3	-274.9***	48.3
MCI1	-2.46***	.62	-1.76*	.93
MCI2	-3.71***	.62	-3.41***	.92
DP	39.6	47.1	8.0	70.2
CI	-175.4***	45.5	-246.0***	67.8
Fourth lactation[+]				
M90	-125.0	207.3	-94.1	244.5
M305	-1601.7***	245.5	-1391.2***	347.8
TMY	-2226.5***	320.4	-2071.0***	454.0
LP	-249.7***	42.1	-256.1***	59.7
MCI1	-2.62***	.73	-2.22*	1.04
MCI2	-3.93***	.71	-3.74***	1.02
DP	128.5**	51.8	157.0*	74.6
CI	-149.0**	52.4	-144.6*	75.5
All lactations[+++]				
M90	-290.9***	45.5	-244.9***	48.8
M305	-1517.3***	53.7	-1423.0***	75.3
TMY	-1993.7***	75.2	-1967.6***	105.4
LP	-202.2***	9.4	-216.5***	13.1
MCI1	-2.88***	0.1	-2.43***	0.2
MCI2	-3.81***	0.1	-3.50***	0.2
DP	97.7***	12.7	99.5***	17.9
CI	-122.0***	12.3	-139.6***	17.3

a Data of milk yield recorded in kg; LP, CI and DP in days; MCI1 and MCI2 in kg/day; AC in months.
+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10.
+++ Data of all lactations were analysed using Model 12.
* = P<.05, ** =P<.01, *** =P<.001.

age by 3.04 months while calved at the second time at older age by 0.8 months than Domiati cows. Thus, the advantages of Friesian cows for lactation traits were offset partially by longer CI than Domiati cows. The same trend was observed by Thorpe et al., (1993) with Bos taurus and Sahiwal cattle. In literature, Martinez et al. (1988) revealed that replacement of pure Zebu genes by Holstein genes was associated with a reduction in AC1 by 6 months along with a reduction in CI by 37 days. Touchberry (1992) showed that Holsteins exceeded Gurnseys ($P<0.05$) by 9.4 days for CI. The same author reported earlier age at first calving (8.6 days) for Gurnseys than for Holsteins, but with non-significant effect.

Estimates of G^I for most milk production traits (M90, M305, TMY, LP, MCI1 and MCI2) increased generally with the advancement of parity in favour of Friesians (Table 35). The increasing trend of G^I with advancing of parity from the first to the third parity was reported for milk yield by Martinez et al. (1988). Touchberry (1992) stated that Holsteins exceeded Gurnseys by 2336, 2691 and 2514 kg of 305-day milk in first, second and combined first and second lactations, respectively, i.e. the additive genetic differences between Guernsey and Holstein increased from the first parity to the second one. Individual additivity of cows (G^I) for DP decreased with the increase of parity up to the third parity, and increased in the fourth one (Table 35).

Across all lactations, negative estimates of G^I for all milk traits (M90, M305, TMY, LP, MCI1 and MCI2) were significant ($P<0.001$) and in favour of Friesian cows (Table 35). Positive significant ($P<0.001$) estimate of G^I was obtained for DP in favour of Friesian cows, but negative significant ($P<0.001$) estimate was recorded for CI in favour of Domiati cows.

4.4.1.2 G^I in Shorthorn trial

Similar to Friesian trial, estimates of G^I for most milk traits in Shorthorn trial were in favour of Shorthorn breed (Table 36), i.e. Shorthorn additive effects had significant variation in lactational performance of crossbred cows. Such superiority of G^I estimates in Shorthorn over Domiati ($P<0.05$ or $P<0.01$ or $P<0.001$) for most traits indicates that Shorthorn could be used as an effective breed in dairy industry in Egypt in genetic improvement by crossing with Domiati cattle.

Table (36). Estimates of individual (G^I) and maternal (G^M) genetic effects for different traits in the first four lactations and in all lactations in Shorthorn trial.

Trait[+]	G^I Estimate	G^I SE	G^M Estimate	G^M SE
First Parity[+]				
M90	-364.6***	94.9	-301.6	158.3
M305	-858.1***	164.3	-649.9**	230.9
TMY	-1126.8***	204.4	-957.9***	286.7
LP	-127.4***	29.3	-121.6**	41.1
MCI1	-1.46**	.51	-.98	.73
MCI2	-1.80***	.55	-1.32	.77
DP	71.3	50.8	74.9	71.6
CI	-95.6**	39.8	-107.1*	56.1
AC[++]	-1.81	1.99	-4.90	2.68
Second parity[+]				
M90	-378.2**	117.3	-382.6*	191.3
M305	-639.2***	197.6	-612.2*	282.02
TMY	-672.5**	232.6	-684.8*	331.96
LP	-39.7	26.98	-63.3	38.5
MCI1	-2.34***	.71	-2.57**	1.02
MCI2	-2.61***	.73	-3.11**	1.05
DP	60.4	54.6	85.7	78.1
CI	-63.9	42.4	-91.2	60.7
AC[++]	-3.97	2.56	-5.26	3.47
Third Parity[+]				
M90	-406.8**	154.9	-398.7	332.5
M305	-515.9*	255.1	-668.06	370.8
TMY	-669.5*	315.1	-797.3	458.1
LP	-55.9	37.04	-62.05	53.9
MCI1	-1.74**	.72	-2.56**	1.06
MCI2	-2.20**	.73	-2.98**	1.07
DP	52.7	46.04	99.9	67.2
CI	-54.4	48.2	-19.7	70.3
Fourth Parity[+]				
M90	-417.7*	186.2	-469.5	373.5
M305	-720.4*	332.2	-899.6	485.2
TMY	-759.0*	377.1	-934.4	550.7
LP	-53.3	44.5	-68.7	65.0
MCI1	-1.86	1.04	-2.27	1.46
MCI2	-2.24*	1.05	-2.80	1.48
DP	121.7	69.2	172.9	97.2
CI	21.4	63.7	54.2	89.5
All parities[+++]				
M90	-329.3***	44.04	-179.4*	80.1
M305	-649.4***	63.1	-629.0***	85.4
TMY	-778.7***	76.7	-819.2***	103.9
LP	-65.2***	9.6	-87.1***	12.9
MCI1	-1.70***	.2	-1.50***	.3
MCI2	-1.98***	.2	-1.98***	.3
DP	69.7***	16.9	85.6***	22.9
CI	-38.8**	14.5	-49.4**	19.7

a Data of milk yield recorded in Kg; LP, DP and CI in days; MCI1 and MCI2 in Kg/day; AC in months.

\+ Data of separate lactations were analysed using Model 8.

++ Age at first and second calving was analysed using Model 10.

+++ Data of all lactations were analysed using Model 12.

* = P<.05, ** =P<.01, *** =P<.001

Negative insignificant estimates of G^I were recorded for CI in the first three parities in favour of Domiati cows. AC1 and AC2 recorded insignificant negative estimates of G^I in favour of Domiati cows. Similar to Friesian cows, however, Shorthorn cows recorded superior individual additivity over Domiati cows for milk traits was offset with longer CI and older ages at first and second calving.

With the advancement of parity, G^I estimates for M90 increased from the first parity to the fourth one, while estimates of M305 and TMY decreased generally from the first to the third, and increased in the fourth one (Table 36). Inconsistent trend of G^I was recorded for MCI1, MCI2, LP and DP. G^I estimates for CI decreased from the first to the fourth parity, while estimates for age at calving increased from the first parity to the second one (in favour of Domiati cows).

Across all lactations, estimates of G^I for milk traits were negative and significant ($P<0.01$ or $P<0.001$) in favour of Shorthorn breed (Table 36). G^I for DP was positive and in favour of Shorthorn cows, while it was negative for CI in favour of Domiati cows.

4.4.1.3 G^I in Jersey trial

In separate lactations, the negative estimates of G^I for milk production traits (M305, TMY, LP, MCI1 and MCI2) were in favour of Jersey cows, although they were insignificant in most cases (Table 37). Positive G^I for DP in the first three parities, indicate that Domiati cows had longer DP than Jersey cows.

Opposite to Friesian and Shorthorn breeds, estimates of G^I for CI were generally positive and non-significant, indicating that Jersey cows recorded shorter CI than Domiati cows. Negative and significant estimates of G^I for AC1 and AC2 show that Domiati cows had younger age at first and second calving than Jersey cows.

With the advancement of parity, estimates of G^I for milk production traits recorded inconsistent trend (Table 37). Small number of records per breed group may be responsible for such indefinite trend in Jersey trial. This is clear, since standard errors of G^I estimates in Jersey trial are higher than those obtaind in Friesian and Shorthorn trials (Tables 35, 36 and 37).

Across all lactations, estimates of G^I for milk production traits were negative and significant ($P<0.001$) in favour of Jersey breed (Table 37). Estimates of G^I for DP ($P<0.05$) and CI were positive and revealing that Domiati cows had longer DP and CI than Jersey cows.

Table (37). Estimates of individual (G^I) and maternal (G^M) genetic effects for different traits in the first four lactations and in all lactations in **Jersey trial.**

Trait	G^I Estimate	G^I SE	G^M Estimate	G^M SE
First lactation+				
M305	-1234.3***	234.2	-1117.3***	266.7
TMY	-1465.8***	303.7	-1347.7***	345.8
LP	-133.4**	47.3	-132.5**	53.9
MCI1	-2.75**	.92	-2.45**	.95
MCI2	-3.14**	.97	-2.97**	1.01
DP	16.5	73.6	38.4	76.6
CI	40.0	63.3	61.3	65.2
AC	-8.76*	4.31	-9.40*	4.68
Second lactation+				
M305	-106.6	310.4	446.6	356.1
TMY	-57.9	345.2	564.5	396.1
LP	-15.9	46.5	16.2	53.3
MCI1	-1.11	.91	-.60	1.01
MCI2	-1.31	.87	-.52	.97
DP	102.1	65.2	90.0	72.3
CI	71.5	64.6	112.5	70.6
AC	-17.01*	7.59	-16.97*	7.90
Third lactation+				
M305	-504.8	539.2	-106.7	565.3
TMY	-905.5	697.0	-491.8	730.7
LP	-76.0	91.9	-76.1	96.3
MCI1	-1.80	2.56	.07	2.40
MCI2	-2.73	2.70	-.83	2.53
DP	97.7	151.5	38.1	136.6
CI	-43.0	189.4	-33.5	177.5
Fourth lactation+				
M305	-501.6	1184.3	-234.1	1089.4
TMY	-653.8	1439.5	-829.0	1324.1
LP	1.5	215.6	-83.0	198.3
MCI1	1.05	1.74	1.12	1.97
MCI2	2.56	1.70	2.76	1.92
DP	-38.4	110.2	-66.9	124.6
CI	115.0	64.2	94.1	72.4
All lactations+++				
M305	-655.2***	122.3	-271.5*	126.1
TMY	824.1***	152.3	-422.1**	156.9
LP	-80.5***	22.8	-65.7**	23.5
MCI1	-2.02***	.43	-1.36**	.43
MCI2	-2.41***	.42	-1.69***	.41
DP	56.7*	30.0	71.8**	29.5
CI	4.4	31.9	27.5	31.2

\+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using model 10
+++ Data of all lactations were analysed using Model 12.
* = P<.05 ** =P<.01 *** =P<.001

4.4.1.4 G^I across all grading trials

For milk traits across all up-grading trials, foreign breeds (Friesian, Shorthorn and Jersey) always surpassed Domiati breed ($P<0.05$ or $P<0.01$ or $P<0.001$) in their individual (direct) additive effects (Tables 35&36&37). Significant effects of direct additivity were observed for milk production traits by different investigators working on different breeds of dairy cattle (Robison et al., 1981; Martinez et al., 1988; Madalena et al., 1990a; Ahlborn-Breier and Hohenboken, 1991; Touchberry, 1992; Thorpe et al., 1993; Zarnecki et al., 1993; McAllister et al., 1994). Also, estimates of G^I in favour of Friesian breed were higher than those G^I in favour of Jersey and Shorthorn breeds. In this respect, dairy cattle producers could expect different performances from Friesian x Domiati or Shorthorn x Domiati or Jersey x Domiati because differences in individual additivity (direct effect) of cows were generally important. For DP, Friesians showed the lowest G^I,followed by Shorthorn and Jersey (Tables 35&36&37). Also, Friesian breed showed higher G^I for CI compared with Shorthorn and Jersey breeds. Among the three foreign breeds, Friesian recorded the lowest G^I for AC1 and AC2 than Jersey and Shorthorn. In the literature, significant estimates of G^I were recorded for AC1 (Martinez et al., 1988; Thorpe et al., 1993) and for CI (Martinez et al., 1988; Touchberry, 1992; Thorpe et al., 1993). On the other hand, insignificant G^I was reported for CI by Madalena et al. (1990a) and for AC1 by Touchberry (1992).

4.4.2 Maternal Additive Effect (G^M)

4.4.2.1 G^M in Friesian trial

For milk production traits (M90, M305, TMY, LP, MCI1 and MCI2) in Friesian trial, estimates of maternal additive effect ($G^M = g^M_D - g^M_F$) in each separate lactation were large and in favour of Friesian dams (Table 35). Since G^M for milk traits are negative and significant ($P<0.05$ or $P<0.01$ or $P<0.001$), a daughter of Friesian dam had higher milk (M90, M305, TMY, LP, MCI1 and MCI2) than a daughter of Domiati dam. Estimates of breed-group differences in G^M cited from the literature evidenced the superiority of Friesian dams relative to other breeds of dairy cattle. In this respect, Donald et al. (1977) revealed that reciprocal heifers of first cross of larger breed (Friesian) generally yielded more milk than those of smaller breed (Ayrshire or Jersey). The Jersey x British Friesian animals were better in G^M of 305-day milk yield by 172±205 kg, 490±217 kg and 724±396 kg than animals of British Friesian x Jersey in the first, second and combined first and second lactations, respectively, i.e. additive maternity was in favour of British- Friesian dams. They added that Ayrshire x Friesian and Friesian x Ayrshire recorded also large differences in G^M in favour of Friesian dams. Robison et al. (1981) reported that Holstein maternity exceeded those maternities for Ayrshire and Brown Swiss by 607 kg (P<0.01) and 476 kg (P<0.01) for 305-day milk yield and 494 kg (P<0.01) and 375 kg (P<0.05) for fat-corrected milk yield.

Also, G^M estimates for DP were positive and mostly significant (P<0.05 or P<0.01 or P<0.001) and in favour of Friesian dams (Table 35), i.e. a daughter of Friesian dam showed shorter DP than a daughter of Domiati dam. With reproductive traits, the negative estimates of G^M for CI were significant (P<0.05 or P<0.01 or P< 0.001) and in favour of Domiati dams (Table 35). Negative estimates of G^M for AC1 and AC2 were also in favour of Domiati dams, i.e. additive maternity of Friesian dams showed longer CI and older AC1 and AC2 than additive maternity of Domiati dams. Results of Thorpe et al. (1993) worked on Bos Taurus (Ayrshire and Friesian), Sahiwal and their crosses showed that daughters of Sahiwal dam recorded 602 kg in TMY higher than daughters of Bos Taurus dam (P<0.001), i.e. additive maternity was in favour of Sahiwal cattle. Also, daughters of Sahiwal dams recorded insignificant longer CI by 18 days than daughter of Bos Taurus. On the other hand, the same authors concluded that maternal additive effect for AC1 was 68 days in favour of Bos taurus dams.

Estimates of G^M for M90 increased from the first parity to the second one and decreased thereafter (Table 35). For M305, a decreasing trend from the first to the fourth parity was observed. A decreasing trend of G^M was detected from the first parity to the third for MCI1, MCI2 and DP (in favour of Friesian dams). The additive maternity for AC1 and AC2 (in favour of Domiati breed) increased from the first parity to the second one (Table 35). On the other hand, additive maternity (G^M) for TMY, LP and CI showed inconsistent trend.

Across all lactations and in favour of Friesian dams, negative and significant (P<0.001) estimates of G^M were detected for M90, M305, TMY, LP, MCI1 and MCI2 (Table 35). Positive estimate of G^M (P<0.001) for DP was observed (in favour of Friesian dams), while negative one (P<0.001) was obtaind for CI in favour of Domiati dams.

4.4.2.2 G^M in Shorthorn trial

Similar to Friesian trial and in favour of Shorthorn dams, negative and mostly significant (P<0.05 or P<0.01 or P<0.001) estimates of G^M for milk production traits in the first four lactations were recorded (Table 36). Thus, a daughter of Shorthorn dam recorded higher M90, M305, TMY, LP, MCI1 and MCI2 than a daughter of Domiati dam. Estimates of G^M for DP were positive and in favour of Shorthorn dams, i.e. shorter DP is recorded by a daughter of Shorthorn dam than that recorded by a daughter of Domiati dam.

With reproductive traits, insignificant negative G^M estimates for CI (in favour of Domiati dams) were recorded in the first three parities. Also, negative insignificant estimates of G^M were obtained for AC1 and AC2 (in favour of Domiati dams). So, a daughter of Domiati dam recorded shorter CI along with younger AC1 and AC2 than a daughter of Shorthorn dam.

Additive maternity in favour of Shorthorn for M90 increased from the first parity to the fourth, while it decreased from the first to the second for M305 and TMY and from the first parity to the third for LP, and increased thereafter (Table 36). G^M for MCI1 and MCI2 increased from the first parity to the second one, then remained at a constant level up to the fourth parity. The additive maternity for DP increased from the first parity to the fourth, while a decreasing trend was observed for CI. Estimates of G^M increased for age at calving from the first parity to the second one (AC2).

Negative G^M estimates for milk production traits across all lactations (Table 36) were significant ($P<0.05$ or $P<0.01$ or $P<0.001$) and in favour of Shorthorn dams. Positive G^M estimate ($P<0.001$) was recorded for DP (in favour of Shorthorn dams), while it was negative ($P<0.01$) for CI (in favour of Domiati dams).

4.4.2.3 G^M in Jersey trial

In this trial, most estimates of additive maternity (G^M) for milk production traits (M305, TMY, LP, MCI1 and MCI2) were negative and in favour of Jersey dams (Table 37). Ahlborn-Breier and Hohenboken (1991) with Holstein and Jersey recorded a negative G^M (-102 kg) for 305-day milk yield in favour of Jersey breed, i.e. daughters of Jersey dams showed an increase in milk yield, whereas daughters of Holstein-Friesian dams showed a reduction in milk yield. The same authors concluded that additive maternity for milk yield represented 11% of the individual additive effects. Insignificant estimates of G^M for DP were generally positive and in favour of Jersey dams. Positive G^M estimates for CI (in favour of Jersey dams) were observed in the first and second parities, while negative G^M (in favour of Domiati dams) were recorded in the third and fourth parities. In favour of Domiati dams, negative and significant ($P<0.05$) G^M were recorded for AC1 and AC2.

The first parity showed the highest G^M for most milk production traits (M305, TMY, MCI1, MCI2 and LP), while the third parity recorded the lowest estimates (Table 37). In favour of Domiati dams, positive estimates of G^M were detected in the second parity for M305, TMY and LP. Dealing with DP, G^M estimates increased from the first parity to the second one, and decreased thereafter. Estimates of G^M for CI increased from the first parity to the second. Additive maternity (G^M) for age at calving increased from the first parity (AC1) to the second (AC2).

Negative and significant estimates of G^M (Table 37) for milk traits across all lactations (M305, TMY, LP, MCI1 and MCI2) indicate that daughters of Jersey dams had higher milk traits than daughters of Domiati dams. Also, positive and significant G^M ($P<0.01$) for DP and insignificant G^M estimate for CI indicate that daughters of Jersey dams recorded higher milk production traits and shorter DP and CI than daughters of Domiati dams.

4.4.2.4 G^M across all grading trials

For most traits across all up-grading trials (Tables 35 36 and 37), estimates of G^M were generally in favour of the foreign dams (Friesian, Shorthorn and Jersey). For milk production traits in most cases, Friesian dams ranked first for additive maternity, followed by Shorthorn dams, then Jersey dams. Also, Friesian dams ranked first for additive maternity (G^M) of DP, but Jersey dams recorded the lowest G^M for CI. Friesian dams ranked first for AC1 and AC2, followed by Shorthorn and Jersey dams, i.e. Friesian dams are the youngest breed for AC1 and AC2. In this respect, additive maternity reported by Robison et al. (1981) for fat-corrected milk yield of Holstein exceeded those maternities for Ayrshire and Brown Swiss. With Holstein and Jersey breeds, Ahlborn-Breier and Hohenboken (1991) concluded that maternal additivity (G^M) for milk yield of Jersey dams exceeded those of Holstein dams.

4.4.3 Individual (Direct) Heterosis (H^I)

Estimates of heterosis components for different traits in the three grading trials are presented in Tables 38, 39 and 40.

4.4.3.1 H^I in Friesian trial

In this trial (Table 38), the direct heterotic superiority (H^I) of crossbred cows in M90 over the average of their parental purebreds were 43.7 kg (6.1%) in the first parity and 65.1 kg (8.6%) in the second one. Dealing with M305, estimates of H^I were generally positive where

Table (38). Estimates of individual (H^I) and maternal (H^M) heterotic effects for different traits in the first four lactations and in all lactations in **Friesian trial.**

Trait[a]	H^I Actual estimate	H^I SE	H^I %	H^M Actual Estimate	H^M SE	H^M %	H^I/G^I %	H^M/G^M %
First lactation[+]								
M90	43.7	40.4	6.1	52.7	30.9	7.4	17.9	25.1
M305	-17.0	45.0	-1.1	247.5***	47.7	17.1	-1.1	15.0
TMY	-69.2	59.0	-4.4	307.8***	62.6	19.6	-3.6	14.1
LP	-4.2	9.3	-1.5	25.2**	9.9	9.2	-2.0	10.4
MCI1	.16	.15	4.7	.73***	.16	21.1	5.1	23.9
MCI2	.07	.16	1.8	.85***	.16	23.3	1.8	20.8
DP	-3.9	13.4	-2.1	-38.4**	13.9	-21.3	-2.7	-24.5
CI	-4.5	12.9	-1.0	-1.3	13.4	-0.3	-4.0	-1.1
AC[++]	-3.16***	0.84	-8.2	-0.49**	0.81	-1.3	-103.9	-47.6
Second lactation[+]								
M90	65.1	41.6	8.6	105.8**	33.1	14.0	13.5	23.7
M305	31.3	56.3	1.9	270.7***	60.2	16.6	2.0	17.4
TMY	-67.8	73.7	-3.7	273.6***	78.8	15.0	-3.4	13.1
LP	-13.2	10.4	-4.6	18.3	11.1	6.4	-6.3	8.4
MCI1	.25	.17	6.1	.72***	.19	17.7	7.8	24.1
MCI2	.13	.17	2.8	.74***	.19	16.7	3.3	19.2
DP	-1.0	11.8	-0.7	-31.1**	12.7	21.5	-0.8	-25.6
CI	-5.0	12.4	-1.1	4.0	13.4	0.9	-6.1	4.3
AC[++]	-3.52**	1.11	-6.5	-0.37	1.04	-0.7	-434.6	-6.6
Third lactation[+]								
M90	-22.4	55.2	-2.3	57.7	45.9	6.0	-13.7	34.3
M305	84.0	80.7	4.7	242.0**	82.5	13.7	5.4	15.8
TMY	-18.2	104.1	-0.9	273.1**	106.6	13.8	-0.8	11.7
LP	-7.6	14.0	-2.7	25.7	14.3	9.1	-3.5	9.3
MCI1	.45	.26	10.1	.59**	.25	13.1	18.3	33.5
MCI2	.22	.26	4.6	.68**	.25	14.1	5.9	19.9
DP	-28.5	19.6	-19.9	-33.7	18.6	-23.5	-72.0	-421.3
CI	-45.8**	18.8	-10.5	-3.7	17.9	-0.8	-26.1	-1.5
Fourth lactation[+]								
M90	-14.4	66.6	-1.3	38.4	56.8	3.7	-11.5	-40.8
M305	136.9	101.5	7.2	142.9	92.5	7.5	8.5	10.3
TMY	65.8	132.5	3.2	116.5	120.7	5.6	3.0	5.6
LP	-2.1	17.4	-0.7	7.7	15.8	2.7	-0.8	3.0
MCI1	.38	.29	7.7	.91***	.27	18.8	14.5	41.0
MCI2	.16	.29	3.1	.86***	.26	16.7	4.1	23.0
DP	21.7	20.9	16.0	-24.1	19.1	-17.8	16.9	-15.4
CI	3.2	21.1	0.7	-17.9	19.3	-4.3	2.1	-12.4
All lactations[+++]								
M90	62.6***	15.1	6.7	60.7***	13.3	6.5	21.5	24.8
M305	185.6***	21.6	10.2	264.1***	22.0	14.5	12.2	18.6
TMY	159.7***	30.2	7.8	338.9***	30.8	16.6	8.0	17.2
LP	3.4	3.7	1.2	29.4***	3.8	10.2	1.7	13.6
MCI1	0.562***	0.1	13.3	0.561***	0.1	13.3	19.4	23.0
MCI2	0.499***	0.1	11.0	0.668***	0.1	14.8	13.1	19.1
DP	-4.9	5.1	-2.7	-17.0***	5.2	-9.4	-5.0	-17.1
CI	-6.5	4.9	-1.4	15.9**	5.0	3.4	-5.3	11.4

a Data of milk yield recorded in kg; LP, CI and DP in days; MCI1 and MCI2 in kg/day; Ac in months.

\+ Data of separate lactations were analysed using Model 8.

++ Age at first and second calving was analysed using Model 10.

+++ Data of all lactations were analysed using Model 12.

* = P<.05, **=P<.01, ***=P<.001.

Table (39). Estimates of individual (H^I) and maternal (H^M) heterotic effects for different traits in the first four lactations and in all lactations in **Shorthorn trial.**

Trait⁺	H^I Actual estimate	H^I SE	H^I %	H^M Actual estimate	H^M SE	H^M %	H^I/G^I %	H^M/G^M %
First Parity⁺								
M90	65.7	94.0	11.8	68.6	93.2	12.4	18.0	22.7
M305	264.2***	76.6	19.2	160.4*	71.8	11.7	30.8	24.7
TMY	227.99**	95.3	15.5	249.1**	89.3	16.9	20.2	26.0
LP	2.5	13.6	1.0	52.9***	12.8	20.1	2.0	43.5
MCI1	.72**	.23	22.0	-.05	.22	-1.6	49.3	-5.1
MCI2	.72**	.35	20.7	.08	.23	2.3	40.0	6.1
DP	-6.3	23.6	-3.4	10.5	21.8	5.6	-8.8	14.0
CI	-17.1	18.1	-3.8	53.4**	17.1	11.9	-17.9	49.9
AC⁺⁺	-2.24*	1.00	-6.0	-0.29	.88	-0.8	-123.8	-5.9
Second parity⁺								
M90	42.5	115.3	5.4	-94.6	177.3	-12.0	11.2	-24.7
M305	126.5	98.7	7.6	48.7	94.4	2.9	19.8	8.0
TMY	129.3	116.2	7.4	110.3	111.2	6.3	19.2	16.1
LP	-5.2	13.5	-1.9	25.1*	12.9	9.1	-13.1	39.6
MCI1	.20	.33	5.0	-.02	.33	-.5	8.5	-0.8
MCI2	.11	.34	2.8	.07	.34	1.8	4.2	2.3
DP	13.7	25.6	9.0	17.5	25.6	11.4	22.7	20.4
CI	-8.2	19.9	-2.0	40.9*	19.9	9.9	-12.8	44.8
AC⁺⁺	-1.60	1.26	-3.2	1.67	1.17	3.4	-40.3	31.7
Third Parity⁺								
M90	43.9	207.3	5.3	-175.2	168.1	-21.2	10.8	-43.9
M305	17.5	125.0	1.0	-81.2	116.8	-4.4	3.4	-12.2
TMY	-47.2	154.4	-2.5	-51.3	144.2	-2.7	-7.1	-6.4
LP	-16.9	18.2	-6.5	-6.9	16.95	-2.6	-30.2	-1.1
MCI1	-.15	.35	3.2	-.18	.38	-3.7	-8.6	-7.0
MCI2	-.25	.35	-5.0	.05	.38	1.0	-11.4	1.7
DP	23.5	22.4	16.5	-4.96	24.2	-3.5	44.6	-5.0
CI	2.9	23.4	.7	20.3	25.3	5.1	5.3	103.0
Fourth Parity⁺								
M90	-21.3	244.7	-2.4	-116.1	212.6	-13.2	-5.1	-24.7
M305	-10.6	170.8	-.5	-27.3	167.8	-1.4	-1.5	-3.0
TMY	7.8	193.9	.4	-57.3	190.5	-2.8	1.0	-6.1
LP	-14.8	22.9	-5.4	-30.9	22.5	-11.1	-27.8	-45.0
MCI1	.12	.47	2.5	.25	.49	4.9	6.5	11.0
MCI2	.05	.47	1.1	.21	.50	4.1	2.2	7.5
DP	53.7	31.3	42.6	19.6	33.04	15.5	44.1	11.3
CI	31.5	28.8	7.5	12.04	30.4	2.9	147.2	22.2
All parities⁺⁺⁺								
M90	192.2***	46.8	26.0	114.2***	30.6	15.5	58.4	63.6
M305	194.5***	29.1	11.7	170.0***	28.4	10.2	29.9	27.0
TMY	157.5***	35.4	8.4	192.9***	34.5	10.3	20.2	23.5
LP	-10.5**	4.4	-3.5	15.9***	4.3	5.3	-16.1	18.3
MCI1	.57***	.1	22.1	.39***	.1	15.2	33.5	26.0
MCI2	.48***	.1	19.9	.40***	.1	16.4	24.2	21.2
DP	7.8	7.7	5.7	-6.4	7.6	-4.7	11.2	-7.5
CI	-13.04*	6.6	-2.4	6.5	6.5	1.2	-33.6	13.2

a Data of milk yield recorded in Kg; LP, DP and CI in days; MCI1 and MCI2 in kg/day; AC in months.

⁺ Data of separate lactations were analysed using Model 8.

⁺⁺ Age at first and second calving was analysed using Model 10.

⁺⁺⁺ Data of all lactations were analysed using Model 12.

* = P<.05, **=P<.01, ***=P<.001

Table (40). Estimates of individual (H^I) and maternal (H^M) effects for different traits in the first four lactations and in all lactations in Jersey trial.

Trait	H^I Actual estimate	H^I SE	H^I %	H^M Actual estimate	H^M SE	H^M %	H^I/G^I %	H^M/G^M %
First lactation+								
M305	116.9	85.8	9.6	452.8***	119.8	37.5	9.5	40.5
TMY	118.1	111.2	9.3	533.2***	155.3	42.0	8.1	39.6
LP	.9	17.3	.3	64.1**	24.2	25.7	0.7	48.4
MCI1	.29	.29	8.8	1.42***	.43	43.5	10.5	58.0
MCI2	.17	.31	4.9	1.40**	.46	39.9	5.4	47.1
DP	21.8	25.2	18.4	-42.2	36.6	-35.5	132.1	-109.9
CI	21.2	20.2	4.9	-42.1	30.1	-9.7	53.0	-68.7
AC	-0.64	2.41	-1.8	1.77	1.71	5.3	7.3	18.8
Second lactation+								
M305	553.3***	120.4	34.2	-193.8	161.0	-12.0	519.0	-43.4
TMY	622.4***	133.9	37.2	-211.2	179.0	-12.6	1074.9	-37.4
LP	32.1	18.0	12.3	-13.6	24.1	-5.2	201.9	-84.0
MCI1	.50	.39	11.3	-.04	.44	-1.0	45.0	-6.7
MCI2	.78*	.37	17.8	-.06	.42	-1.3	59.5	-11.5
DP	-12.1	28.0	-8.9	9.5	31.1	7.1	-11.9	10.6
CI	41.0	26.3	10.4	1.0	31.4	0.2	57.3	0.9
AC	.04	3.93	0.1	5.05	2.78	11.1	0.23	29.8
Third lactation+								
M305	398.1	211.8	22.4	-131.5	212.7	-7.4	78.8	-123.2
TMY	413.6	273.8	22.4	-92.1	275.0	-5.0	45.6	-18.7
LP	-.1	36.1	-.04	-49.9	36.2	-16.8	-0.1	-65.6
MCI1	1.87*	.90	47.4	.68	.78	17.4	103.9	971.4
MCI2	1.90*	.96	45.9	.82	.82	19.9	69.6	98.8
DP	-59.6	50.1	-38.4	-44.8	45.7	-28.9	-61.0	-117.6
CI	9.5	67.2	2.2	-35.1	57.8	-8.2	22.1	-104.8
Fourth lactation+								
M305	267.4	385.6	14.3	166.3	339.9	8.9	53.3	71.0
TMY	-175.1	468.7	-7.6	296.2	413.2	13.0	-26.7	35.7
LP	-84.6	70.2	-24.4	39.0	61.9	11.2	-5640	47.0
MCI1	.06	.63		-.16	.83		5.7	-14.3
MCI2	.20	.61		-.28	.81		7.8	-10.1
DP	-28.5	40.9		38.9	53.7		-74.2	58.1
CI	-20.8	23.1		-1.1	30.6		-78.1	-1.2
All lactations+++								
M305	383.8***	43.9	25.5	80.4	44.3	5.3	58.6	29.6
TMY	402.0***	54.6	24.5	114.3*	55.2	7.0	48.8	27.1
LP	14.8	8.2	6.7	13.0	8.3	5.0	18.4	19.8
MCI1	.66***	.14	18.6	.34*	.1	9.3	32.7	25.0
MCI2	.72***	.13	19.2	.40**	.1	10.4	30.0	23.7
DP	15.0	10.2	9.3	-5.1	10.0	-3.2	26.5	-7.1
CI	23.1*	10.5	5.2	3.7	10.6	.8	525.0	13.5

+ Data of separate lactations were analysed using Model 8.
++ Age at first and second calving was analysed using Model 10.
+++ Data of all lactations were analysed using Model 12.
* = P<.05 **=P<.01 ***=P<.001

crossbred cows recorded 31.3 kg (1.9%), 84 kg (4.7%) and 136.9 kg (7.2%) higher than their parental purebred mean in the second, third and fourth parities, respectively. Positive direct heterotic superiority (H^I) for TMY was recorded only in the fourth parity (Table 38). The trend observed for M305 was also observed for MCI1 and MCI2 where crossbred cows recorded positive estimates of H^I in the first four separate lactations. MCI1 or MCI2 showed more heterosis than M305 and TMY alone. Similar result was found by Donald et al. (1977). In this respect, positive H^I for milk production traits were detected by some investigators working on Friesian and their crosses with native cattle (Fahmy et al., 1976; Singh, 1982; Arafa, 1987; Martinez et al., 1988; Madalena et al., 1990a; Thorpe et al., 1993). Other investigators working on Friesian and their crosses with different European breeds reported positive heterosis for milk production traits (e.g. McDowell and McDaniel, 1968; Brandt et al., 1974; Donald et al., 1977; Robison et al., 1981; Rincon et al., 1982; Pedersen and Christensen, 1989; Van der Werf and de Boer, 1989b; Ahlborn-Breier and Hohenboken, 1991; Touchberry, 1992; Boichard et al., 1993; Zarnecki et al., 1993). For LP and DP, negative H^I in the first four lactations (Table 38) were favourable and indicating that crossbred cows showed shorter length of DP than the average of their parents. In most studies all over the world, negative estimates of H^I for LP and/or DP were also found with Friesians and their crosses (McDowell and McDaniel, 1968; Donald et al., 1977; Rincon et al., 1982; Touchberry, 1992; Thorpe et al, 1993). With reproductive traits, crossbred cows showed younger AC1 and AC2 along with shorter CI than the average of their purebreds (Table 38). Such reduction in AC1 and/or CI was also observed by most of the studies including Friesians and their crosses with different breeds (Donald et al, 1977; Rincon et al., 1982; Teodoro et al., 1984; Martinez et al., 1988; Madalena et al., 1990a&b; Thorpe et al., 1993). This means that crossing Domiati cows with Friesian bulls was associated with an increase in milk and a reduction in lengths of LP, DP, CI, AC1 and AC2. These observations give a hint for the importance of crossing Friesian bulls with Domiati cows.

The absolute values (or percentages) of H^I for M90 (Table 38) increased from 43.7 kg (or 6.1%) in the first parity to 65.1 kg (or 8.6%) in the second parity. Also, absolute estimates (and percentages) of H^I for M305, TMY, MCI1 and MCI2 generally increased with the advancement of parity, while inconsistent trend was recorded for lengths of LP and DP. H^I as absolute values (or percentages) for CI decreased from the first parity to the third, while H^I for age at calving increased ($P<0.001$) from the first parity to the second one.

In data of all lactations, heterotic effects were significant ($P<0.001$) for milk production traits of M90, M305, TMY, MCI1 and MCI2 (Table 38). Percentages of H^I for milk production traits ranged from 6.7 to 13.3%, indicating that favourable milking performance could be attained from crossing of Friesian bulls with native cows in Egypt. Also, all lactations of crossbred cows showed longer LP and shorter DP and CI than their purebred mean. However, significant heterotic effects were also detected by different investigators working on Friesians and their crosses (Robison et al., 1981; Van der Werf and deBoer, 1989b; Ahlborn-Breier and Hohenboken, 1991; Touchberry, 1992; Zarnecki et al., 1993; McAllister et al., 1994).

4.4.3.2 H^I in Shorthorn trial

Estimates of H^I for milk production traits in the first four separate lactations of Shorthorn trial were generally positive and indicating the superiority of crossbred cows over their parental purebred average (Table 39). For M90, H^I accounted for 65.7 kg (11.8%), 42.5 kg (5.4%) and 43.9 kg (5.3%) in the first three parities in a descending order. H^I for M305, TMY, MCI1 and MCI2 were generally positive; indicating that crossing Egyptian cows with Shorthorn bulls was associated with an increase in performance of milk production traits than the average of the parental purebred mean. This notation could be evidenced through that there is a wide variation in positive percentages of H^I for milk production traits (Table 39) since they ranged from 0.4 to 22.0% in the first four lactations in this trial. The superiority of Shorthorn crosses for milk production traits in Egypt was also reported by Fahmy et al. (1976) and Arafa (1987). Heterotic effects (H^I) in the first four lactations were generally negative for LP and positive for DP; indicating that crossbred cows recorded shorter LP but with longer DP than the average of their parental mean. Heterotic superiority for reproductive intervals (Table 39) showed that crossing Egyptian cows with Shorthorn bulls leads to a short CI and a reduced AC1 and AC2. With Shorthorn x Native cattle in Egypt, Fahmy et al. (1976) came to the same conclusion.

Heterotic superiority (H^I) of crossbred cows including Shorthorn blood for M90 and M305 decreased, in general, from the first parity up the fourth one (Table 39). Absolute estimates (or percentages) of H^I for TMY, LP, MCI1 and MCI2 also decreased from the first parity to the third one. For DP, a reverse trend of H^I was observed, i.e. H^I increased with the increase of parity. Refers to reproductive intervals, estimates (or percentages) of H^I for CI increased from the first parity to the fourth one and from the first parity to the second for age at calving.

In data of all lactations, H^I were positive and significant (P<0.001) for most milk production traits of M90, M305, TMY, MCI1 and MCI2 (Table 39). These positive estimates of H^I ranged from 8.4 to 26.0%. Negative estimate of H^I for LP and CI indicate that crossbred cows including Shorthorn blood recorded significant (P<0.05 or P<0.01) shorter LP and CI than average of purebreds. On the other hand, H^I for DP was positive, i.e. crossbred cows had longer DP than the average of purebreds.

4.4.3.3 <u>H^I in Jersey trial</u>

The favourable positive estimates of H^I for milk traits (M305, TMY, MCI1 and MCI2) in the first four separate lactations reveal that crossbred cows including Jersey blood were superior than their purebred parents (Table 40). Estimates of H^I show that there is a similar variation in direct superiority of crossbred cows from one milk trait to another, i.e. H^I for M305 and TMY averaged 17.7% relative to 17.6% for MCI1 and MCI2. For LP, H^I in the first and second parities were positive, while estimates of the third and fourth parities were negative (Table 40). However, positive H^I for milk traits were also reported by Donald et al. (1977) with Friesian x Jersey and Ayrshire x Jersey crosses; Alba and Kennedy (1985) with Jersey x Criollo crosses and Ahlborn-Breier and Hohenboken (1991) with Holstein Friesian x Jersey crosses. Generally, negative estimates of H^I for DP showed that crossbred cows including Jersey blood had shorter DP than the mean of their purebred parents. With reproductive traits, positive estimates of H^I were recorded for CI and AC2, but negative for AC1, i.e. crossbred cows including Jersey blood had longer CI and older AC2 and younger AC1. Opposite to the present results, Donald et al. (1977) with Friesian x Jersey and Ayrshire x Jersey reported negative estimates of H^I for CI.

Heterotic superiority (H^I) of crossbred cows for milk traits (M305, TMY, MCI1 and MCI2) in Jersey trial, generally increased from the first parity to the third (Table 40). Estimates and percentages of H^I for LP increased also from the first to the second parity and decreased thereafter. On the contrary, H^I for DP decreased from the first to the third parity. H^I for CI and age at calving increased from the first parity to the second.

The favourable significant H^I (P<0.001) for all milk production traits across all lactations (Table 40) showed that Jersey-up-graded cows were superior than their parental purebreds. These crossbred cows recorded also longer DP and CI than the average of their purebreds.

4.4.3.4 H^I across all grading trials

For milk production traits across all lactations in all grading trials, heterotic superiority (H^I) of crossbred cows over their purebreds were significantly ($P<0.01$) evidenced (Tables 38, 39 and 40). For most milk production traits, Jersey trial showed higher estimates and percentages of H^I than Friesian and Shorthorn trials. Therefore, Jersey trial ranked first for H^I of milk traits, followed by Shorthorn trial, while Friesian trial ranked the third one.The small number of records used in Jersey trial may be the cause of such rank ing. This notation is also clear since standard errors of H^I estimates in Jersey trial are higher than those obtained in Friesian and Shorthorn trials (Tables 38&39&40). Crossbred cows showed shorter ($P<0.01$) LP in Shorthorn trial than the average of their parental means, while they had insignificant long LP in Friesian and Jersey trials. Crossbred cows of Jersey trial showed the largest insignificant positive H^I for DP, followed by Shorthorn trial, while Friesian trial recorded insignificant negative estimates.

With reproductive intervals, crossbred cows in Friesian trial reported younger age at first and second calving than that in Shorthorn and Jersey trials. Shorthorn and their up-grades showed lower H^I for CI than for Friesians and their up-grades, while Jerseys and their up-grades recorded positive and unfavourable H^I for CI.

4.4.4 Maternal heterosis effect (H^M)

Estimates of maternal heterosis (H^M) for milk production traits and reproductive intervals in the three up-grading trials are presented in Tables 38, 39 and 40.

4.4.4.1 H^M in Friesian trial

In the first four lactations, estimates of H^M ranged from 38.4 to 105.8 Kg for M90, 142.9 to 270.7 kg for M305, 116.5 to 307.8 kg for TMY, 0.59 to 0.91 kg/day for MCI1 and 0.68 to 0.86 kg/day for MCI2 and from 7.7 to 25.7 day for LP (Table 38). The corresponding percentages of H^M ranged from 3.7 to 14% for M90, 7.5 to 17.1% for M305, 5.6 to 19.6% for TMY, 13.1 to 21.1% for MCI1, 14.1 to 23.3% for MCI2 and 2.7 to 9.2% for LP. H^M for all milk yield traits (M90, M305, TMY) averaged 202.7, 216.7, 190.9 and 99.3 kg in the 1st, 2nd, 3rd and 4th parity, respectively, while H^I for these traits averaged -14.2, 9.5, 14.5 and 62.8 kg in the same order (Table 38). This maternal heterotic superiority (MHS) relative to H^I in each separate parity (i.e. percentage of MHS= $((H^M - H^I)/H^I)*100$ was evidenced from one parity to another since percentages of MHS were mostly positive and decreased with advance of parity (Table 41). These positive and significant ($P<0.01$ or $P<0.001$) estimates of H^M for milk yield traits (M90, M305, TMY, MCI1 and MCI2) in the first four lactations indicate the superiority of crossbred dams in heterotic maternity over their purebred dams. This notation was evidenced since percentages of maternal heterosis (H^M) relative to maternal additive (G^M) were high (Table 38) and ranged from 23.4 to 40.8% for M90, 10.3 to 17.4% for M305, 5.6 to 14.1% for TMY, 23.9 to 41.0% for MCI1 and 19.2 to 23.0% for MCI2; i.e. H^M is of considerable importance to improve milk traits of up-graded Friesian-Domiati cows. However, H^M might indicate that crossbred dams provide better maternal conditions to their progeny than that of purebred dams. Thrope et al. (1993) showed that estimates of H^M for TMY and annual milk yield were moderate, but with insignificant effects. Ahlborn-Breier and Hohenboken (1991) found insignificant negative estimate of H^M for milk yield.

Positive estimates of H^M are recorded for LP in the first four lactations, but a significant ($P<0.01$) effect was observed only in the first lactation (Table 38). This result was evidenced since percentages of H^M relative to G^M were moderate or high in the first four lactations and ranged from 3.0 to 10.4%. Thorpe et al. (1993) concluded that estimate of H^M for LP was very small with insignificant effect. The favorable negative H^M observed for DP in all separate lactations (significant, $P<0.01$ only in the first and second lactations) indicate that crossbred dams recorded shorter length of DP than purebred dams.

Negative estimates of H^M for CI in the first four lactations (Table 38) reveal that crossbred dams reduced length of CI compared to their purebred dams. Also, negative H^M for AC1 and AC2 show that crossbred dams recorded younger ages at first (AC1) and (AC2) calving than their purebred dams. Percentages of H^M/G^M for AC1 and AC2 indicate also that maternal heterosis or crossbred dams relative to their dam additive genes were favourable and high (-25.2% for AC1 and -46.4% for AC2); i.e. H^M is of considerable importance to improve AC1 and AC2 of up-graded Friesian-Domiati cows. These favorable estimates of H^M for CI and AC2 were also observed by Thrope et al. (1993).

Estimates of H^M for M90 and M305 increased from the first parity to the second and decreased thereafter, while H^M for TMY generally decreased with increase of parity. Inconsistent trend of H^M was observed for MCI1, MCI2, LP and DP (Table 38). Heterotic maternity of crossbred dams in Friesian trial for CI increased from the first parity to the second

Table (41). Maternal heterotic superiority (MHS) relative to H^I for milk yield traits in the three grading trials.

	Breed groups		
	Friesians	Shorthorn	Jersey
Trait	MHS%	MHS%	MHS%
First parity			
M90	20.6	4.4	
M305	1556.0	-39.3	287.3
TMY	545.0	9.3	351.5
MCI1	356.0	-106.9	389.7
MCI2	1114.0	-88.9	723.5
Average	**718**	**-44**	**438**
Second parity			
M90	62.5	-322.6	
M305	765.0	-61.5	-135.0
TMY	503.5	-14.7	-133.9
MCI1	188.0	-105.0	-108.0
MCI2	469.0	-36.4	-107.7
Average	**398**	**-108**	**-121**
Third parity			
M90	357.6	-499.1	
M305	188.0	-564.0	-133.0
TMY	1400.0	-8.7	-122.3
MCI1	31.1	-20.0	-63.6
MCI2	209.0	120.0	-56.8
Average	**437**	**-194**	**-94**
Fourth parity			
M90	366.7	-445.1	
M305	4.4	-157.5	-37.8
TMY	77.1	-834.6	269.2
MCI1	139.4	108.3	-366.7
MCI2	325.0	320.0	-240.0
Average	**183**	**-202**	**-94**
All parities			
M90	-3.0	-40.6	-79.1
M305	42.3	-12.6	-71.6
TMY	112.2	22.5	-48.5
MCI1	-0.18	-31.6	-44.4
MCI2	33.9	-16.7	
Average	**37**	**-16**	**-61**

one and decreased thereafter. Also, H^M for age at calving increased from the first parity (AC1) to the second one (AC2).

H^M for milk yield across all lactations ranged from 6.5 to 16.6%, while H^I for these traits ranged from 6.7 to 13.3% (Table 38). Estimates of H^M for all milk yield traits (M90, M305, TMY, LP, MCI1, MCI2) were positive and significant (P<0.01), while it was negative for DP (P<0.001). This maternal heterotic superiority relative to H^I (i.e. percentage of MHS=((H^M - H^I)/H^I)*100 was evidenced since percentages of MHS for milk yield traits were mostely positive and averaged 37%. These results in Friesian trial lead to state that crossbred cows resulted from crossbred dams including Friesian blood gave more heterosis than those crossbred cows resulted from purebred dams. Unfortunately, unfavorable positive (P<0.01) estimate of H^M for CI was observed. For dairy producers, superiority of crossbred dams for milk production traits over their purebred ones may have some implications to develop specific maternal crosses.

4.4.4.2 H^M in Shorthorn trials

For all milk yield traits, estimates of H^M in the first parity were positive (averaged 8.3%), while they were negative in the second, third and fourth parities (averaged -0.3%, -6.2% and -1.7%, respectively). The effects were generally insignificant (Table 39). H^M for all milk yield traits (M90, M305 and TMY) averaged 159.4, 21.5, 102.6 and 66.9 kg in the 1st, 2nd, 3rd and 4th parity, respectively, while H^I for these traits averaged 185.9, 99.4, 4.7 and -8.0 kg in the same order (Table 39). Averages of H^M estimates were mostely lower than those of H^I in the first four lactations (Table 39). This was evidenced since percentage of MHS= ((H^M - H^I)/H^I)*100 were negative and increased with advancement of parity (Table 41). The insignificant effect of H^M for milk traits in Shorthorn trial indicate that crossbred dams including Shorthorn blood and their purebred dams have the same heterotic maternity, i.e. dairy producers should expect similar maternity from purebred and crossbred dams. This trend is clear since percentages of H^M/G^M in the first two parities contradicted with those of the 3rd and 4th parities (Table 39). For LP, H^M in the first two parities were positive and they had significant effects (P<0.05 or P<0.01), while insignificant negative estimates were obtained in the third and fourth parities. Positive H^M for DP were not favorable, and consequently, crossbred dams (Shorthorn x Domiati) recorded longer length of DP than their purebred dams.

Unfavorable positive estimates of H^M were recorded for CI in the first four parities (Table 39). Contradicting estimates of H^M were observed for AC1 and AC2 where H^M for AC1 was negative, while H^M for AC2 was positive with fortunately insignificant effect for both.

Superior heterotic maternity of crossbred dams for M90 and M305 decreased from the first parity to the second and third parities and increased in the fourth one (Table 39). TMY showed generally a decreasing trend. For MCI1, H^M decreased from the first parity to the second one and increased thereafter, while H^M for MCI2 remained constant in the first three parities and increased in the fourth one (Table 39). Inconsistent trend of H^M was observed for DP. With H^M for CI, a decreasing trend was recorded, while H^M for age at calving increased from the first parity to the second one.

Estimates of H^M for milk traits across all lactations in Shorthorn trial were positive and significant ($P<0.001$), while H^M for DP was negative and insignificant (Table 39). Opposite to Friesian trial, H^M for milk yield triats across all lactation were lower than those estimates of H^I since H^M ranged from 10.2 to 16.4%, while H^I ranged from 8.4 to 29.1%. Maternal heterotic superiority relative to H^I (i.e. percentages of MHS= $((H^M - H^I) / H^I) * 100$ for milk triats confirmed these results since MHS for most traits were mostly negative and averaged -16% (Table 41). These unexpected results lead to state that crossbred cows resulted from crossbred dams including shorthorn blood have less heterosis for milk yield traits than those crossbred cows resulted from purebred dams. As in Friesian trial, unfavorable positive estimate of H^M for CI was observed.

4.4.4.3 H^M in Jersey trial

Estimates of H^M for M305, TMY, MCI1 and MCI2 in the first parity were positive and significant ($P<0.01$ or $P<0.001$), while they were generally negative and nonsignificant in the three subsequent parities (Table 40). The H^M% for M305 and TMY averaged 39.8% in the first parity, -12.3% in the second, -6.2% in the third and 11% in the fourth. In the first four lactations, estimates of H^M ranged from -193.8 to 452.8 kg for M305, -211.2 to 533.2 kg for TMY, -.04 to 1.42 kg for MCI1, -.06 to 1.40 kg for MCI2 (Table 40). The corresponding percentages of H^M ranged from -12 to 37.5 % for M305, -12.6 to 42% for TMY, -1.0 to 43.5% for MCI1 and -1.3 to 39.9% for MCI2 (Table 40). H^M for M305 and TMY averaged 73.5 and 131.5 kg for the first four parities while the corresponding averages for H^I for the same traits were 333.9 and 122.6 kg, respectively. Negative percentages of MHS were generally observed

(Table 41) which reveal that crossbred cows resulted from crossbred dams including Jersey blood have less heterosis for milk yield traits than those crossbred cows resulted from purebred dams. This was expected since percentages of H^M/G^M in the first four lactations were high and contradicted from one lactation to another (Table 40). Estimates of H^M for LP were positive only in the first (25.7%) and fourth (11.2%) parities. Negative estimates of H^M for DP in the first (-35.5%) and third (-28.9%) parities were favourable, while unfavorable positive H^M was recorded in the second parity (7.1%).

Opposite to Friesian and Shorthorn trials, CI in Jersey trial showed in general, favorable negative H^M in the first four lactations (Table 40), while unfavourable estimates of H^M for AC1 and AC2 were observed. Fortunately, negative H^M for CI and positive H^M for AC1 and AC2 lead to state that crossbred cows (Jersey x Domiati) resulted from crossbred dams had different heterotic maternity for reproductive intervals than those cows resulted from purebred dams.

Superior heterotic maternity of crossbred cows for M305 and TMY decreased from the first parity to the second and increased thereafter, while inconsistent trend was obtained for MCI1 and MCI2 (Table 40). For LP, H^M decreased from the first parity to the third one. Inconsistent trend of H^M was observed for CI, while H^M for age at calving increased from the first to the second one.

For most milk yield traits studied, estimates of H^M across all lactations were positive and mostly significant (Table 40). H^M for milk production traits ranged from 5.3 to 10.4%, while estimates of H^I ranged from 18.6 to 25.5%. As for Shorthorn trial and opposite to Friesian trial, H^M for milk traits were lower than those estimates of H^I since maternal heterotic superiority relative to H^I (i.e. $(H^M - H^I)/H^I)*100$ in this trial were mostly negative and averaged -61% (Table 41). Therefore, crossbred cows resulted from crossbred dams including Jersey blood had lower heterosis for milk traits than those crossbred cows resulted from purebred dams. In favour of milk traits, insignificant negative estimate of H^M for DP was recorded. As in Friesian and Shorthorn trials, unfavorable positive estimates of H^M was recorded for CI. Opposite to this result, Thorpe et al. (1993) found that H^M in crossbred dams could reduce CI by 18 days.

4.4.4.4 H^M across all grading trials

Estimates of H^M for milk traits (M90, M305, TMY, LP, MCI1 and MCI2) in up-grades of Friesian trial were generally higher than in up-grades of Shorthorn and Jersey trials (Tables 38, 39 and 40). Also, Friesians and their up-grades recorded higher H^M for LP along with favorable lower H^M for DP.

Positive unfavorable estimates of H^M were recorded in the three up-grading trials for CI, where significant heterotic maternity ($P<0.01$) was observed in Friesian trial only (Table 38, 39 and 40). Friesians and their up-grades recorded the lowest H^M for AC1 and AC2 than the other up-grades in the two trials.

Results of heterotic maternity in crossbred cows of the three trials show that Friesian maternity for milk production and reproductive intervals (except for CI) ranked first, followed by maternities of Shorthorn and Jersey in a descending order, i.e. crossbred cows resulted from crossbred dams including Friesian blood had superior heterotic maternity compared to those cows resulted from crossbred dams including blood of Shorthorn or Jersey.

4.4.5 Individual (direct) recombination effect (R^I)

Estimates of R^I for milk production traits and reproductive intervals in the three up-grading trials are presented in Tables 42, 43 and 44 .

4.4.5.1 R^I in Friesian trial

In the first four separate lactations, estimates of R^I ranged from -21.9 to 79.3 kg for M90, 9.4 to 204.6 kg for M305, -25.3 to 293.4 kg for TMY, 0.08 to 0.49 kg/day for MCI1, 0.28 to 0.58 kg/day for MCI2 and 5.4 to 42.5 day for LP (Table 42). The corresponding percentages of R^I ranged from -2.1 to 10.4%, 0.5 to 14.1%, -1.2 to 18.7%, 1.8 to 12.2%, 5.8 to 15.8% and 1.9 to 15.0%. Estimates of R^I for all milk traits (M90, M305, TMY, LP, MCI1 and MCI2) in the first three lactations were positive and generally significant in most cases (Table 42). For all milk yield traits in the first three lactations, estimates of R^I were positive and averaged 176.4, 126.9 and 151.9 kg in 1st, 2nd and 3rd parity, respectively, while they were negative in the fourth lactation and averaged -37.8 kg. A positive and significant R^I for these milk yield traits indicate that crossbred cows including Friesian blood mothered heifers with higher milking ability than did purebred Friesian cows when both groups were mated to the same purebred Friesian bulls. Contrary to the present results, negative and

Table (42). Estimates of individual (R^I) and maternal (R^M) recombination loss effects for different traits in the first four lactations and in all lactations in **Friesian trial.**

Trait[a]	R^I Estimate	R^I SE	R^M Estimate	R^M SE	R^I/G^I %	R^M/G^M %
First lactation[+]						
M90	31.2	27.1	14.4	22.8	12.8	6.9
M305	204.6***	54.1	201.5***	46.2	13.4	12.2
TMY	293.4***	71.0	293.4***	60.6	15.1	13.5
LP	34.7**	11.2	40.7***	9.5	16.3	16.8
MCI1	.42*	.18	.30*	.16	13.5	9.8
MCI2	.58**	.18	.47**	.16	14.7	11.5
DP	-33.5*	15.9	-21.4	13.5	-23.2	-13.7
CI	5.4	15.3	21.5	13.1	4.9	17.5
AC[++]	.46	0.93	0.49	0.79	15.1	47.6
Second lactation[+]						
M90	79.3**	30.5	78.9**	25.7	16.5	17.7
M305	136.3*	66.9	238.7***	56.9	8.6	15.3
TMY	165.2	87.6	263.3***	74.5	8.3	12.6
LP	5.4	12.3	19.1	10.5	2.6	8.7
MCI1	.34	.21	.54**	.18	10.6	18.6
MCI2	.42*	.21	.60***	.18	10.6	15.6
DP	-16.3	14.6	-23.0	12.2	-13.2	-19.0
CI	6.6	15.3	5.1	12.8	8.1	5.5
AC[++]	0.81	1.22	1.05	1.04	100.0	18.8
Third lactation[+]						
M90	13.8	40.5	14.8	34.9	8.5	8.8
M305	177.3*	93.2	185.7**	78.0	11.4	12.1
TMY	264.7*	120.3	294.4**	100.7	12.2	12.6
LP	42.5**	16.2	44.7***	13.5	18.2	16.3
MCI1	.08	.29	.11	.25	3.3	6.3
MCI2	.28	.29	.33	.25	7.5	9.7
DP	-16.5	22.6	.2	19.2	-41.7	2.5
CI	18.5	22.0	36.9*	18.7	10.5	15.0
Fourth lactation[+]						
M90	-21.9	51.5	-13.2	47.9	-17.5	-14.0
M305	9.4	101.0	81.6	89.7	0.6	5.9
TMY	-25.3	131.8	112.4	117.0	-1.1	5.4
LP	6.5	17.3	19.6	15.4	2.6	7.7
MCI1	.49	.30	.33	.27	18.7	14.9
MCI2	.44	.29	.41	.26	11.2	11.0
DP	-16.9	21.5	-15.7	19.1	-13.2	-10.0
CI	-10.8	21.9	6.7	19.4	-7.3	4.6
All lactations[+++]						
M90	45.5***	11.6	30.2**	10.4	15.6	12.3
M305	216.0***	23.6	205.4***	21.0	14.2	14.4
TMY	291.7***	33.0	258.5***	29.5	14.6	13.1
LP	30.8***	4.1	30.0***	3.7	15.2	13.9
MCI1	0.37***	0.1	0.33***	0.1	12.8	13.6
MCI2	0.50***	0.1	0.45***	0.1	13.1	12.9
DP	-14.0**	5.6	-12.5**	5.1	-14.3	-12.6
CI	18.8***	5.4	23.2***	4.9	15.4	16.6

a Data of milk yield recorded in kg; LP, CI and DP in days; MCI1 and MCI2 in kg/day; Ac in months.

\+ Data of separate lactations were analysed using Model 8.

++ Age at first and second calving was analysed using Model 10.

+++ Data of all lactations were analysed using Model 12.

* = P<.05, **=P<.01, ***=P<.001 .

Table (43). Estimates of individual (R^I) and maternal (R^M) recombination loss effects for different traits in the first four lactations and in all lactations in **Shorthorn trial.**

Trait⁺	R^I Estimate	R^I SE	R^M Estimate	R^M SE	R^I/G^I %	R^M/G^M %
First Parity⁺						
M90	37.4	46.2	58.7	39.2	10.3	19.5
M305	147.5	78.6	134.4	72.01	17.2	20.7
TMY	197.04*	97.8	181.1*	89.6	17.5	18.9
LP	25.3	14.03	27.1*	12.9	19.9	22.3
MCI1	.21	.24	.09	.23	14.4	9.2
MCI2	.28	.26	.12	.24	15.6	9.1
DP	-4.3	24.3	-3.7	22.6	-6.0	-4.9
CI	22.2	19.1	25.5	17.7	23.2	23.8
AC⁺⁺	0.71	0.86	1.54	.83	39.2	31.4
Second parity⁺						
M90	-.1	81.4	117.8	71.6	-0.02	30.8
M305	114.6	96.97	57.1	92.9	17.9	9.3
TMY	190.8	114.1	83.1	109.4	28.4	12.1
LP	31.4**	13.2	19.7	12.7	79.1	31.1
MCI1	.34	.37	.19	.34	14.5	7.4
MCI2	.57	.38	.34	.45	21.8	10.9
DP	-.5	28.2	-3.1	26.4	-0.8	-3.6
CI	40.1	21.9	35.8	20.5	62.8	39.3
AC⁺⁺	0.59	1.15	1.16	1.14	14.9	22.1
Third Parity⁺						
M90	-51.3	86.4	317.8***	92.4	-12.6	79.7
M305	106.4	125.96	27.2	126.8	20.6	4.1
TMY	40.4	155.6	-5.9	156.7	6.0	-0.7
LP	-13.5	18.3	.7	18.4	-24.2	1.1
MCI1	.48	.40	.27	.40	27.6	10.5
MCI2	.47	.40	.30	.40	21.4	10.1
DP	-22.7	25.5	-31.2	25.4	-43.1	-31.2
CI	-18.3	26.6	-2.3	26.6	-33.6	-11.7
Fourth Parity⁺						
M90	-27.3	110.1	314.5**	105.8	-6.5	66.9
M305	141.8	171.1	61.9	171.6	19.7	6.9
TMY	148.2	194.2	38.2	194.8	19.5	4.1
LP	-14.04	22.9	-14.8	23.0	-26.3	-21.5
MCI1	.55	.50	.17	.51	29.6	7.5
MCI2	.61	.50	.24	.52	27.2	8.6
DP	15.2	33.3	-1.4	34.1	12.5	-0.8
CI	7.6	30.6	-3.1	31.4	35.5	-5.7
All parities⁺⁺⁺						
M90	95.8***	19.7	31.2	19.4	29.1	17.4
M305	246.3***	27.0	156.4***	27.6	37.9	24.9
TMY	281.8***	32.8	181.9***	33.6	36.2	22.2
LP	18.9***	4.1	17.1***	4.2	29.0	19.6
MCI1	.52***	.1	.38***	.1	30.6	25.3
MCI2	.54***	.1	.40***	.1	27.3	21.2
DP	-9.8	7.3	-14.4*	7.5	-14.0	-16.8
CI	1.6	6.2	6.4	6.4	4.1	13.0

a Data of milk yield recorded in Kg; LP, DP and CI in days; MCI1 and MCI2 in kg/day; AC in months.
⁺ Data of separate lactations were analysed using Model 8.
⁺⁺ Age at first and second calving was analysed using Model 10.
⁺⁺⁺ Data of all lactations were analysed using Model 12.
* = P<.05, **=P<.01, ***=P<.001

Table (44). Estimates of individual (R^I) and maternal (R^M) effects for different traits in the first four lactations and in all lactations in Jersey trial.

Trait	R^I Estimate	R^I SE	R^M Estimate	R^M SE	R^I/G^I %	R^M/G^M %
First lactation+						
M305	227.1***	60.0	115.0*	57.7	18.4	10.3
TMY	267.7***	77.8	136.5	74.9	18.3	10.1
LP	32.1**	12.1	8.6	11.6	24.1	6.5
MCI1	.71***	.21	.16	.20	25.8	6.5
MCI2	.70**	.23	.24	.21	22.3	8.1
DP	-20.8	18.3	6.9	16.4	-126.1	18.0
CI	-20.9	15.0	-4.3	13.6	-165.9	-7.0
AC	0.89	0.86	0.60	0.86	10.2	6.4
Second lactation+						
M305	-97.4	80.7	-134.8	72.5	-91.4	-30.2
TMY	-106.0	89.8	-143.4	80.6	-183.1	-25.4
LP	-6.8	12.1	-14.5	10.8	-42.8	-89.5
MCI1	-.01	.22	.11	.20	-0.9	18.3
MCI2	-.02	.21	.11	.19	-1.5	21.2
DP	4.56	15.6	-7.9	14.7	4.5	-8.8
CI	.3	15.7	-4.0	14.5	0.4	-3.6
AC	2.53	1.39	0.93	1.41	14.9	5.5
Third lactation+						
M305	-65.0	106.6	9.4	105.4	-12.9	8.8
TMY	-44.8	137.9	44.3	136.2	-4.9	9.0
LP	-24.7	18.1	-1.0	17.9	-32.5	-1.3
MCI1	.34	.39	.05	.39	18.9	71.4
MCI2	.41	.41	.10	.41	15.0	12.0
DP	-22.3	22.9	1.6	23.0	-22.8	4.2
CI	-17.4	29.0	1.1	29.2	-40.5	3.3
Fourth lactation+						
M305	81.7	170.8	60.6	188.9	-16.3	25.9
TMY	145.8	207.6	66.2	229.6	22.3	8.0
LP	19.1	31.1	-4.8	34.4	1273	-5.8
MCI1	-.08	.41	-.01	.40	-7.6	-0.9
MCI2	-.14	.40	-.26	.39	-5.5	-9.4
DP	19.4	26.8	.8	25.1	50.5	-48.4
CI	-.59	15.3	-32.4*	14.7	-0.5	0.9
All lactations+++						
M305	40.3	22.2	19.9	23.2	6.2	7.3
TMY	57.2*	27.7	29.2	28.8	6.9	6.9
LP	6.5	4.1	2.3	4.3	8.1	3.5
MCI1	.17**	.06	.17*	.07	8.4	12.5
MCI2	.20**	.06	.20**	.07	8.3	11.8
DP	-2.6	5.0	-5.8	5.2	-4.6	-8.1
CI	1.8	5.3	1.1	5.5	40.9	4.0

+ Data of separate lactations were analysed using model 8

++ Age at first and second calving was analysed using model 10

+++ Data of all lactations were analysed using Model 12.

* = P<.05 **=P<.01 ***=P<.001

significant recombination effects for 305-day yields of milk, fat and protein were reported by Pedersen and Christensen (1989) for all breed combinations [Finnish Ayrshire (F) x Red Danish (R), F x Holstein-Freisian (H), H x R, H x Danish Friesian (D)] particularly for Holstein Friesian crosses. Van der Werf and de Boer (1989b) with Dutch-Friesian x Holstein-Friesian found that recombination effects for 305-day milk traits in the first lactation were -101.2 kg for M305, -75.9 kg for fat-protein corrected milk, -1.325 kg for fat yield and -3.457 kg for protein yield.

Information in the literature concerning estimates of R^I of crossbreeding experiments in dairy cattle are scarce. Most of these available results are contradicted. However, reviewed values for R^I are often not significant (McAllister, 1986) or significant but with small magnitude (Ericson, 1987). Van der Werf and de Boer (1989a) concluded that estimates of recombination effect were negative and smaller than estimates of heterosis.

Estimates of R^I for DP in the first four lactations were negative, while positive estimates were recorded for CI, AC1 and AC2 (Table 42), although all these traits had insignificant recombination effect. The insignificant effect of R^I indicates that there should be little difference in heterosis as measured and expected in a particular cross.

Heterosis was assumed to represent dominance effects and half of additive by additive effects, whereas the recombination effects represent half of the additive by additive effects (Van der Werf and de Boer, 1989 a&b). Here, estimates of R^I for most milk traits (e.g. M305, TMY, MCI1 and MCI2) were generally larger than estimates of heterosis (Tables 38 and 42), which implies that the dominance effects on these traits were negative in most parities. Similar concept was observed for LP and CI. For DP, estimates of R^I were smaller than H^I, which implies that the dominance effect on DP was positive in most parities.

In Friesian trial, loss of direct recombination for M90, MCI1 and MCI2 increased from the first parity to the second or the third parity and decreased thereafter, while no definite trend was observed for M305, TMY and LP (Table 42). For DP, R^I increased from the first parity to the second one and remained approximately constant in the third and fourth lactations. R^I for CI increased from the first parity to the third one and decreased in the fourth. Also, R^I for age at calving increased from the first calving to the second.

Across all lactations (Table 42), direct recombination effect for all milk traits and CI were positive and significant (P<0.001). As for each separate lactation, positive and significant estimates of R^I indicate that crossbred cows including Friesian blood mothered heifers with higher milking ability than did purebred cows when both groups were mated to the same purebred bulls. Contrary to the present results, negative estimates of R^I for milk traits (TMY, fat yield and protein yield) were reported by Pedersen and Christensen (1989) and Biochard et al. (1993) for data of all lactations. In this respect, Christensen and Pedersen (1988) and Pedersen and Christensen (1989) with Holstein Friesian x Danish Friesian, Finnish Ayrshire x Holstein Friesian and Holstein Friesian x Red Danish showed that there is a considerable variation in estimates of R^I for milk production traits, where estimates ranged from -0.4 to -12%. Biochard et al. (1993) with data of three lactations of Holstein Friesian x French Black or White reported a wide variation in estimates of R^I for yield traits (milk, fat and protein) which reached 40 to 86% of the direct heterosis.

4.4.5.2 R^I in Shorthorn trial

In the first four lactations, estimates of R^I for milk traits (M90, M305, TMY, LP, MCI1 and MCI2) were generally positive and non-significant (Table 43). In these lactations, R^I ranged from -51.3 to 37.4 kg for M90, 106.4 to 147.5 kg for M305, 40.4 to 197.0 kg for TMY, 0.21 to 0.55 kg/day for MCI1, 0.28 to 0.61 kg/day for MCI2 and -14.0 to 31.4 day for LP. The insignificant effect for R^I indicate that epistatic recombination losses for these traits in up-graded Friesian-Domiati cows were negligible, and therefore there is a potential advantage to use crossbred cows including Shorthorn blood to develop parental strains having more available heterosis to be used in crossbreeding stratification systems in Egypt. As in Friesian trial, estimates of R^I for DP were negative and nonsignificant. Estimates of R^I recorded for CI, AC1 and AC2 were positive and insignificant. Again, the insignificant effect of R^I estimates showed that epistatic effects appear to have little influence on these traits.

In the Shorthorn trial, estimates of R^I for M90, M305 and TMY decreased from the first to the third parity and increased in the fourth (Table 43). Estimates for the three traits averaged 127.3 kg in the first parity, 101.8 kg in the second parity, 31.8 kg in the third parity and 87.6 kg in the fourth ones. An opposite trend for MCI1 and MCI2 was observed. R^I for LP increased from the first to the second parity and decreased thereafter. No definite trend for DP and CI was observed. For age at calving, R^I estimate decreased from the first parity (AC1) to the second (AC2).

Estimates of R^I for most milk yield traits (M90, M405, TMY, MCI1 and MCI2) were larger than estimates of direct heterosis (Tables 39 and 43), which implies that the dominance effect in these traits was negative in most cases. Similar trend was observed for LP and CI. Estimates of R^I for DP were smaller than H^I, which show that the dominance effect on DP was positive in most parities.

As in Friesian trial, estimates of R^I for all milk traits across all lactations were positive and significant (Table 43). Opposite to the present results, negative estimates of R^I for milk traits across lactations were reported by Pedersen and Christensen (1989) for Finnish Ayrshire x Red Danish in Denemark. The significant positive effect of R^I for milk traits in Shorthorn trial, as noted in Friesian trial, show that crossbred dams mothered cows with higher milking ability than did purebred Shorthorn dams when both groups were mated to the same purebred Shorthorn bulls. R^I for DP was negative, while it was positive for CI, but with insignificant effect.

4.4.5.3 R^I in Jersey trial

Estimates of R^I were positive for most milk traits (Table 44). The estimates averaged 247.4 kg, -101.7 kg, -54.9 kg and 113.8 kg in the first four parities in descending order. In these lactations, R^I ranged from -97.4 to 227.1 kg for M305, -106.0 to 267.7 kg for TMY, -24.7 to 32.1 day for LP, -0.01 to 0.71 kg/day for MCI1 and -0.02 to 0.70 kg/day for MCI2. In general, R^I for DP and CI were favourable since they were negative and non-significant (Table 44). For AC1 and AC2, R^I were also favourable since they were positive and nonsignificant (Table 44). Fourtunatly, these favourable estimates of R^I in Jersey trial indicate that there is a potential advantage in using more available heterosis to develop parental strains including Jersey blood to be used in crossbreeding systems.

Estimates of R^I for M305, TMY and LP decreases from the first parity to the third (similar to M305, TMY in Shorthorn trial), while no definite trend is observed with R^I for MCI1, MCI2, DP and CI (Table 44). As in Friesian trial, R^I for age at calving increased from the first parity to the second one.

Data of all lactations show that estimates of R^I were positive for all traits except DP (Table 44), with non-significant effect for most traits ($P<0.05$ or $P<0.01$ for TMY, MCI1 and MCI2). These estimates of R^I for most traits were favourable to state that corssbred dams including Jersey blood could be effective to improve milk traits and reproductive intervals in up-grading trial with native cattle.

4.4.5.4 R^I across all grading trials

Data of the three trials show that R^I estimates for most milk traits in Shorthorn trial were higher than those for the other two trials (Tables 42 43&44). Jersey trial recorded the lowest R^I for milk traits. The three trials recorded negative R^I for DP since the highest estimates were recorded for Friesian trial, while Jersey trial recorded the lowest estimates. Friesian trial showed the highest positive R^I ($P<0.001$) for CI, while Shorthorn trial recorded the lowest estimates. R^I for AC1 and AC2 were positive and insignificant in the three up-grading trials. AC1 of Friesians and their up-grades with Domiati had the lowest estimate of R^I, while AC2 of Shorthorns and their up-grades with Domiati had the lowest estimate.

4.4.6 Maternal recombination effect (R^M)

Estimates of maternal recombination effect (R^M) for milk traits and reproductive intervals in the three up-grading trials are presented in Tables 42, 43 and 44.

4.4.6.1 R^M in Friesian trial

In the first four separate lactations, estimates of R^M ranged from -13.2 to 78.9 kg for M90, 81.6 to 238.7 kg for M305, 112.4 to 294.4 kg for TMY, 0.11 to 0.54 kg/day for MCI1, 0.33 to 0.60 kg/day for MCI2 and 19.1 to 44.7 day for LP (Table 42). The positive and generally significant estimates of R^M (Table 42) for milk traits were favorable since R^M in the first four lactations were moderate or relatively large and they averaged 169.7, 193.6, 164.9 and 60.2 kg in the 1st, 2nd, 3rd and 4th parity, respectively. Such positive and significant R^M for milk traits indicate that crossbred dams including Friesian blood mothered cows with higher milking ability than did purebred Friesian dams when both groups were mated to the same purebred Friesian bulls. The negative and insignificant estimates of R^M for DP were favorable for the dairy producers, while the positive R^M for CI and AC1 were unfavourable (Table 42). Literature concerning estimates of R^M in crossbreeding experiments in dairy cattle is not available to be presented here for comparison of R^M with those obtained in the present study.

Estimates of R^M for milk yield traits (M90, M305, TMY, MCI1 and MCI2) and DP were generally smaller than estimates of H^M (Tables 38 and 42), which show that the dominance effect in these traits was positive.

On the other hand, R^M for LP and CI were generally larger than H^M which implies that the dominance effect in LP and CI was negative.

With the advancement of parity, estimates of R^M for M90 and M305 increased from the first parity to the second and decreased thereafter, while no definite trend was observed for TMY, LP, MCI1, MCI2, DP and CI (Table 42). R^M for age at calving increased from +0.49 month for AC1 to 1.05 month for AC2.

Data of all lactations gave the same trend observed for the separate lactations since estimates of R^M for all milk traits and CI were positive while R^M for DP was negative (Table 42). The recombination effect on all traits was significant (P<0.01 or P<0.001). R^M for milk traits and DP were smaller than estimates of H^M, while R^M for LP and CI were larger than H^M.

4.4.6.2 R^M in Shorthorn trial.

R^M in the first four lactations were positive (Table 43) and ranged from 58.7 to 317.8 kg for M90, 27.2 to 134.4 kg for M305, -5.9 to 181.1 kg for TMY, 0.09 to 0.27 kg/day for MCI1 and 0.12 to 0.34 kg/day for MCI2 and -14.8 to 27.1 day for LP. For yield traits of M90, M305 and TMY, estimates of R^M averaged 124.7, 86, 113 and 138.2 kg in the 1st, 2nd, 3rd and 4th parities, respectively. Such insignificant recombination effect on milk yield traits was favorable in dairy industry and indicate that epistatic recombination losses for these traits in Shorthorn crosses were negligible and therefore there is a potential advantage to use crossbred dams including Shorthorn blood to develop parental strains to be used in crossbreeding stratification systems in Egypt.

As for R^I, estimates of R^M for DP were negative and insignificant (Table 43), while reversble, unfavourable positive signs were observed for CI, AC1 and AC2 in most cases. For M90, MCI1 and MCI2, there was a general increase in R^M with the advancement of parity, while a decreasing trend was observed for M305, TMY and LP. Inconsistent trend in R^M was recorded for DP and CI. R^M for age at calving decreased from the first parity to the second one.

As in Friesian trial, data of all lactations supported results of the separate lactations since R^M for all milk traits (M90, M305, TMY, LP, MCI1, MCI2) were positive and highly significant (P<0.01 or P<0.001) along with favorable negative estimate of R^M for DP. On the other hand, unfavourable positive estimate of R^M was recorded for CI as shown in results of separate lactations.

4.4.6.3 R^M in Jersey trial

In the first four lactations, estimates of R^M ranged from -134.8 to 115.0 kg for M305, -143.4 to 136.5 kg for TMY, -0.01 to 0.16 kg/day for MCI1, -0.26 to 0.24 kg/day for MCI2 and -14.5 to 8.6 day for LP (Table 44).

Estimates of R^M for milk yield traits (M305, TMY, MCI1, MCI2) were generally positive and insignificant (Table 44). The estimates for M305 and TMY averaged 125.7, 139.1, 26.8 and 63.4 kg in the first, second, third and fourth parity, respectively. Positive R^M estimates for these traits indicate that crossbred dams including Jersey blood mothered cows with higher milking ability than did purebred Jersey dams when both groups were mated to the same purebred Jersey bulls.

Opposite to Friesian and Shorthorn trials, DP recorded positive R^M with insignificant effect. Positive insignificant estimates of R^M were recorded for AC1 and AC2. The insignificant R^M indicates that epistatic effects appear to have little influence on these traits.

Maternal recombination effects (R^M) for M305 and TMY decreased from the first parity to the second and increased thereafter (Table 44). R^M for MCI1 and MCI2 decreased generally with advancement of parity, while indefinite trend was observed for LP and DP. Estimates of R^M increased from the first parity to the third for CI and from the first parity to the second for age at calving.

Maternal recombinations for milk traits of all lactations were similar to those of separate lactations where most estimates were positive and insignificant (Table 44). Estimates of R^M for CI and DP were of opposite sign to those of separate lactations with insignificant effect. Such insignificant R^M for all traits across all lactations confirmed the fact that epistatic recombination losses in these traits were negligible.

4.4.6.4 R^M across all grading trials

The three trials recorded positive estimates of R^M for milk traits and CI (Tables 42, 43 and 44). R^M estimates for most milk traits in Friesian trial were higher than those of the other two trials. The lowest R^M for DP and CI were recorded by Shorthorn and Jersey trials, respectively. For AC1 and AC2, Friesian trial recorded the lowest R^M.

4.5 Evaluation of each up-graded group relative to purebreds

4.5.1 Additive effect

Estimates of direct (G^I) and maternal (G^M) additive effects for milk traits in each up-graded group of the three trials are presented in **Tables 45, 46 and 47**. For all milk traits in the three trials, estimates of G^I and G^M for each breed-group were in favour of the foreign breed, i.e. Friesian, Shorthorn and Jersey (**Tables 45, 46 and 47**). Also, estimates of G^I and G^M increased with the increase of foreign blood from 1/2 to 15/16, i.e. breed group with blood proportion of 15/16 Friesian or Shorthorn or Jersey recorded the highest estimates of G^I and G^M relative to the proportion of 1/2 or 3/4 or 7/8. These observations were evidenced since percentages of additive effect relative to least-square mean of the trait (i.e. G^I/LSM or G^M/LSM) were high and increased with the increase of foreign blood from 1/2 to 15/16. The estimates of G^I/LSM in Friesian, Shorthorn and Jersey trials, respectively averaged 54.2, 26.5 and 41.0% for 1/2E1/2D, 55.7, 28.7 and 43.3% for 3/4E1/4D, 60.3, 25.4 and 47.2% for 7/8E1/8D and 65.4, 30.6 and 51.4% for 15/16E1/16D, while the respective estimates of G^M/LSM averaged 46.1, 20.2 and 25.2% for 1/2E1/2D, 50.1, 24.1 and 38.0% for 3/4E1/4D, 57.9, 24.7 and 44.4% for 7/8E1/8D and 63.2, 29.5 and 50.1% for 15/16E1/16D. In the three trials, a breed group with blood proportion of 15/16 had the highest estimates of G^I/LSM and G^M/LSM relative to the other breed-groups.

In Friesian and Shorthorn trials, inter-se mating groups of $(3/4E1/4D)^2$ and $(7/8E1/8D)^2$ showed higher estimates of G^I and G^M than those of their corresponding breed groups of 3/4E1/4D and 7/8E1/8D (Tables 45 and46). This trend was confirmed since estimates of G^I/LSM and G^M/LSM for inter-se mating groups [$(3/4E1/4D)^2$ and $(7/8E1/8D)^2$] were higher than for up-graded groups of 3/4E1/4D and 7/8E1/8D. The G^I/LSM estimates in Friesian and Shorthorn trials, respectively averaged 59.4 and 30.0% for group of $(3/4E1/4D)^2$ and 62.4 and 30.8% for group of $(7/8E1/8D)^2$. Also, these inter-se matings in Shorthorn trial only had higher estimates of G^I and G^M than for all other breed groups in this trial.

4.5.2 Heterotic effect

In Friesian (F) trial, percentages of H^I for milk production traits (M305, TMY and LP) averaged 8.6% for 1/2F, 5.9% for 3/4F, 2.6% for 7/8F and 2.4% for 15/16F, while percentages of H^M averaged 11.9% for 3/4F, 5.3% for 7/8F and 4.7% for 15/16F (**Table 48**). In Shorthorn (S) trial, H^I averaged 6.7% for 1/2S, 4.9% for 3/4S, 0.8% for 7/8S and 1.1% for 15/16S, while H^M averaged 9.7% for 3/4S, 1.5% for 7/8S and 2.1% for

Table (45). Estimates of additive effects on milk production traits for each separate up-graded group in **Friesian** trial.

Trait	G^I Estimate	G^I SE	G^I/LSM⁺ (%)	G^M Estimate	G^M SE	G^M/LSM* (%)
1/2Friesian-1/2Domiati:						
M305 (kg)	-1044.1***	29.0	51.1	-813.0***	33.1	39.8
TMY (kg)	-1403.6***	37.4	64.3	-1192.9***	42.7	54.6
LP (day)	-137.7***	5.1	47.2	-127.0***	5.9	43.8
3/4Friesian-1/4Domiati:						
M305 (kg)	-1138.2***	30.6	52.9	-1006.2***	28.2	46.8
TMY (kg)	-1546.4***	46.4	65.3	-1384.1***	42.7	58.4
LP (day)	-151.6***	5.8	48.9	-139.9***	5.3	45.0
7/8Friesian-1/8Domiati:						
M305 (kg)	-1194.6***	32.9	58.5	-1134.0***	30.7	55.6
TMY (kg)	-1558.7***	42.4	71.5	-1495.3***	39.5	68.9
LP (day)	-151.9***	6.2	50.8	-146.9***	5.8	49.2
15/16Friesian-1/16Domiati:						
305 (kg)	-1300.5***	45.0	61.9	-1255.4***	41.8	59.8
TMY (kg)	-1756.5***	58.0	77.6	-1698.0***	53.8	75.0
LP (day)	-176.8***	8.5	56.8	-170.7***	7.9	54.8
(3/4Friesian-1/4Domiati)²:						
M305 (kg)	-1143.0***	36.6	55.5	-1143.0***	36.6	55.5
TMY (kg)	-1567.9***	47.1	70.5	-1567.9***	47.1	70.5
LP (day)	-161.1***	7.0	52.3	-161.1***	7.0	52.3
7/8Friesian-1/8Domiati)²:						
M305 (kg)	-1194.3***	48.6	58.1	-1194.3***	48.6	58.1
TMY (kg)	-1645.5***	62.5	73.9	-1645.5***	62.5	73.9
LP (day)	-171.1***	9.2	55.2	-171.1***	9.2	55.2

⁺= G^I/LSM or G^M/LSM = G^I or G^M relative to least-square mean of the trait.

*= P<.05, **=P<.01, ***=P<.001

Table (46). Estimates of additive effects on milk production traits for each separate up-graded group in **Shorthorn** trial.

Trait	G^I Estimate	G^I SE	G^I/LSM+ (%)	G^M Estimate	G^M SE	G^M/LSM* (%)
1/2Shorthorn-1/2Domiati:						
M305 (kg)	-428.8***	38.9	28.6	-238.4***	45.01	15.9
TMY (kg)	-540.3***	46.9	33.5	-388.7***	54.4	24.1
LP (day)	-45.1***	5.8	17.5	-53.1***	6.7	20.7
3/4Shorthorn-1/4Domiati:						
M305 (kg)	-508.2***	43.4	32.1	-414.8***	39.9	26.2
TMY (kg)	-628.3***	54.3	35.5	-527.6***	50.04	29.8
LP (day)	-52.04***	6.8	18.5	-45.9***	6.3	16.3
7/8Shorthorn-1/8Domiati:						
M305 (kg)	-456.9***	51.8	27.9	-442.5***	46.2	27.0
TMY (kg)	-550.1***	63.8	30.4	-540.1***	56.9	29.8
LP (day)	-52.5***	8.2	17.9	-50.3***	7.4	17.2
15/16Shorthorn-1/16Domiati:						
M305 (kg)	-609.6***	61.1	35.4	-585.04***	55.9	33.9
TMY (kg)	-722.5***	74.7	37.9	-697.3***	68.3	36.5
LP (day)	-54.2***	9.4	18.4	-53.1***	8.6	18.1
(3/4Shorthorn-1/4Domiati)^2:						
M305 (kg)	-629.7***	47.02	34.0	-629.7***	47.02	34.0
TMY (kg)	-762.2***	57.7	37.2	-762.2***	57.7	37.2
LP (day)	-55.9***	7.1	18.8	-55.9***	7.1	18.8
7/8Shorthorn-1/8Domiati)^2:						
M305 (kg)	-671.8***	50.3	36.6	-671.8***	50.3	36.6
TMY (kg)	-778.6***	60.2	38.6	-778.6***	60.2	38.6
LP (day)	-50.4***	7.3	17.1	-50.4***	7.3	17.1

+= G^I/LSM or G^M/LSM= G^I or G^M relative to least-square mean of the trait.

*= P<.05, **=P<.01, ***=P<.001

Table (47). Estimates of additive effects on milk production traits for each separate up-graded group Jersey trial.

Trait	G^I Estimate	G^I SE	G^I/LSM^+ (%)	G^M Estimate	G^M SE	G^M/LSM^* (%)
1/2Jersey-1/2Domiati:						
M305 (kg)	-678.9***	90.2	41.2	-302.9***	86.5	18.4
TMY (kg)	-817.4***	107.9	51.3	-448.7***	103.4	28.2
LP (day)	-75.3***	15.6	30.6	-71.4***	14.9	29.0
3/4Jersey-1/4Domiati:						
M305 (kg)	-794.9***	116.02	44.5	-684.6***	101.8	38.3
TMY (kg)	-969.4***	144.6	52.2	-844.4***	126.9	45.4
LP (day)	-94.6***	20.4	33.2	-86.4***	17.9	30.3
7/8Jersey-1/8Domiati:						
M305 (kg)	-769.8***	103.9	48.9	-718.5***	97.1	45.7
TMY (kg)	-955.1***	131.2	57.4	-896.8***	122.6	53.9
LP (day)	-92.0***	20.9	35.2	-87.6***	19.5	33.6
15/16Jersey-1/16Domiati:						
M305 (kg)	-858.3***	124.9	53.9	-829.8***	119.5	52.2
TMY (kg)	-992.4***	160.5	61.0	-966.0***	153.6	59.4
LP (day)	-99.8***	25.5	39.3	-98.0***	24.4	38.6

+= G^I/LSM or G^M/LSM= G^I or G^M relative to least-square mean of the trait.

*= P<.05, **=P<.01, ***=P<.001

Table (48). Estimates of heterotic effects on milk production traits for each separate up-graded group relative to purebreds in **Friesian trial**.

Trait	H^I Actual estimate	SE	%	H^I/G^I (%)	H^M Actual estimate	SE	%	H^M/G^M (%)	Total heterosis Actual estimate	%	$(H^I+H^M)/(G^I+G^M)$ (%)
1/2Friesian-1/2Domiati:											
M305	231.0***	17.2	12.0	22.1					231.0	12.0	12.4
TMY	210.7***	22.2	10.1	15.0					210.7	10.1	8.1
LP	10.6***	3.1	3.7	7.7					10.6	3.7	4.0
3/4Friesian-1/4Domiati:											
M305	131.9***	8.5	6.5	11.6	263.8***	16.9	13.1	26.2	395.7	19.6	18.5
TMY	162.4***	12.8	7.4	10.5	324.8***	25.6	14.7	23.5	487.2	22.1	16.6
LP	11.7***	1.6	3.9	7.7	23.3***	3.2	7.8	16.7	35.0	11.7	12.0
7/8Friesian-1/8Domiati:											
M305	60.6***	4.4	3.2	5.1	121.3***	8.9	6.3	10.7	181.9	9.5	7.8
TMY	63.4***	5.7	3.1	4.1	126.8***	11.4	6.2	8.5	190.2	9.3	6.2
LP	5.0***	.8	1.7	3.3	10.0***	1.7	3.5	6.8	15.0	5.2	5.0
15/16Friesian-1/16Domiati:											
M305	45.2***	4.2	2.3	3.5	86.9***	8.0	4.5	6.9	132.1	6.8	5.2
TMY	58.5***	5.3	2.9	3.3	112.5***	10.3	5.5	6.6	171.0	8.4	5.0
LP	6.0***	.8	2.1	3.4	11.6***	1.5	4.0	6.8	17.6	6.1	5.1
$(3/4Friesian-1/4Domiati)^2$											
M305	109.9***	12.7	5.7	9.6	144.6***	16.8	7.6	12.7	254.5	13.3	11.1
TMY	152.4***	16.4	7.5	9.7	200.5***	21.6	9.9	12.8	352.9	17.4	11.3
LP	17.9***	2.4	6.3	11.1	23.6***	3.2	8.3	14.6	41.5	14.6	12.9
$(7/8Friesian-1/8Domiati)^2$:											
M305	57.5***	9.9	3.0	4.8	65.4***	11.3	3.4	5.5	122.9	6.4	5.1
TMY	81.6***	12.7	4.0	5.0	92.7***	14.5	4.5	5.6	174.3	8.5	5.3
LP	9.9***	1.9	3.4	5.8	11.2***	2.1	3.9	6.5	21.1	7.3	6.2

*= P<.05, **=P<.01, ***=P<.001

15/16S (**Table 49**). In Jersey (J) trial, H^I averaged 17.9% for 1/2J, 5.6% for 3/4J, 3.0% for 7/8J and 1.4% for 15/16J, while H^M averaged 11.2% for 3/4J, 6.0% for 7/8J and 2.8% for 15/16J (**Table 50**). For both estimates of H^I and H^M (i.e. total heterosis), the estimates in Friesian, Shorthorn and Jersey trials respectively averaged 8.6, 6.7 and 17.9% for 1/2E1/2D, 8.9, 7.3 and 8.4% for 3/4E1/4D, 4.0, 1.2 and 4.5% for 7/8E1/8D and 3.6, 1.6 and 2.1% for 15/16E1/16D. The above mentioned figures indicate that absolute estimates or percentages of heterosis (H^I or H^M or both together) decreased with the increase of the proportion of foreign blood from 1/2 to 15/16 in Friesian trial, 1/2 to 7/8 in Shorthorn trial and 1/2 to 15/16 in Jersey trial. Accordingly, a breed group of 3/4F1/4D in Friesian trial, $(3/4S1/4D)^2$ in Shorthorn trial and 1/2J1/2D in Jersey trial recorded the highest total heterotic superiority, while 15/16F1/16D in Friesian trial, 7/8S1/8D in Shorthorn trial and 15/16J1/16D recorded the lowest total heterotic superiority. Also, inter-se -mating groups of $(3/4E1/4D)^2$ and $(7/8E1/8D)^2$ recorded higher heterortic superiority than groups of 3/4E1/4D and 7/8E1/8D, respectively **(Tables 48 and 49).** In the meantime, inter-se -mating group of $(3/4E1/4D)^2$ showed higher heterosis than group of $(7/8E1/8D)^2$.

For milk traits, in Friesian (F) trial, percentages of H^I relative to G^I averaged 14.9% for 1/2F, 9.9% for 3/4F, 4.2% for 7/8F and 3.4% for 15/16F, while the corresponding estimates of H^M relative to G^M averaged 22.1, 8.7 and 6.8%, respectively (**Table 48**). In Shorthorn (S) trial, H^I relative to G^I averaged 30.1% for 1/2S, 15.4% for 3/4S, 3.1% for 7/8S and 3.2% for 15/16S, while the corresponding estimates of H^M relative to G^M averaged 36.7, 6.4 and 6.4%, respectively (**Table 49**). In Jersey (J) trial, H^I/G^I averaged 35.2% for 1/2J, 11.8% for 3/4J, 5.9% for 7/8J and 2.6% for 15/16J, while the corresponding estimates of H^M/G^M averaged 26.9, 12.4 and 5.1%, respectively (**Table 50**). For estimates of total heterosis (i.e. H^I+H^M) relative to total additive (i.e. G^I+G^M), the estimates in Friesian, Shorthorn and Jersey trials respectively averaged 14.9, 30.1 and 35.2% for 1/2E1/2D, 15.7, 25.1 and 18.9% for 3/4E1/4D, 6.3, 4.7 and 9.0% for 7/8E1/8D and 5.1, 4.7 and 3.8% for 15/16E1/16D (**Tables 48, 49 and 50**). These notations were evidenced since percentages of heterosis relative to additive effect (i.e. H^I/G^I or H^M/G^M or H^I+H^M/G^I+G^M) were mostly positive and high for group of 15/16E1/16D (**Tables 48, 49 and 50**). The above results indicate also that percentages of H^I/G^I or H^M/G^M or H^I+H^M/G^I+G^M decreased with the increase of the proportion of foreign blood from 1/2 to 15/16 in Friesian and Jersey trials and from 1/2 to 7/8 in Shorthorn trial, i.e. H^I and H^M or both together are of considerable importance to improve milk traits of up-graded cows of 15/16F1/16D, Table (49). Estimates of heterotic effects on milk production traits for each separate up-graded group purebreds in **Shorthorn trial**.

Trait	H^I			H^I/G^I	H^M			H^M/G^M	Total heterosis		
	Actual estimate	SE	%	%	Actual estimate	SE	%	%	Actual estimate	%	$(H^I+H^M)/(G^I+G^M)$ %
1/2Shorthorn-1/2Domiati:											
M305	190.4***	20.5	13.5	44.4					190.4	13.5	44.4
TMY	151.6***	24.7	9.8	28.1					151.6	9.8	28.1
LP	-8.02**	3.1	-3.1	17.8					-8.0	-3.1	17.8
3/4Shorthorn-1/4Domiati:											
M305	93.4***	12.7	6.3	18.4	186.9***	25.3	12.5	45.1	280.3	18.8	30.4
TMY	100.7***	15.8	6.03	16.03	201.3***	31.7	12.1	38.1	302.0	18.1	26.1
LP	6.2**	1.9	2.3	11.9	12.3**	3.9	4.5	26.8	18.5	6.8	18.9
7/8Shorthorn-1/8Domiati:											
M305	14.3	9.5	.9	3.1	28.7	18.9	1.8	6.5	43.0	2.7	4.8
TMY	10.1	11.7	.6	1.8	20.1	23.3	1.1	3.7	30.2	1.7	2.8
LP	2.3	1.5	.8	4.4	4.5	3.02	1.6	8.9	6.8	2.4	6.6
15/16Shorthorn-1/16Domiati:											
M305	24.6***	7.1	1.5	4.04	47.2***	13.7	2.9	8.1	71.8	4.4	6.0
TMY	25.3**	8.7	1.4	3.5	48.6**	16.7	2.7	7.0	73.9	4.1	5.2
LP	1.1	1.1	.4	2.03	2.1	2.1	.7	4.0	3.2	1.1	3.0
(3/4Shorthorn-1/4Domiati)²											
M305	145.1***	15.9	8.7	23.04	190.9***	20.9	11.5	30.3	336.0	20.2	26.7
TMY	163.2***	19.5	8.9	21.4	214.7***	25.7	11.7	28.2	377.9	20.6	24.8
LP	7.4**	2.4	2.6	13.2	9.7**	3.2	3.4	17.4	17.1	6.0	15.3
(7/8Shorthorn-1/8Domiati)²:											
M305	69.6***	8.3	4.1	10.4	79.1***	9.5	4.7	11.8	148.7	8.8	11.1
TMY	71.4***	9.9	3.8	9.2	81.2***	11.3	4.4	10.4	152.6	8.2	9.8
LP	1.9	1.2	.6	3.8	2.1	1.4	.7	4.2	4.0	1.3	4.0

*= P<.05, **=P<.01, ***=P<.001.

Table (50). Estimates of heterotic effects on milk production traits for each separate up-graded group relative to purebreds in **Jersey trial**.

Trait	H^I Actual estimate	SE	%	H^I/G^I (%)	H^M Actual estimate	SE	%	H^M/G^M (%)	Total heterosis Actual estimate	%	$(H^I+H^M)/(G^I+G^M)$ (%)
1/2Jersey-1/2Domiati:											
M305	375.9***	43.4	25.8	55.4					375.9	25.8	55.4
TMY	368.7***	51.9	26.2	45.1					368.7	26.2	45.1
LP	3.9	7.5	1.6	5.2					3.9	1.6	5.2
3/4Jersey-1/4Domiati:											
M305	110.3***	24.1	6.6	13.9	220.5***	48.2	13.2	32.2	330.8	19.8	22.4
TMY	125.02***	30.0	7.2	12.9	250.0***	60.0	14.4	29.6	375.0	21.6	20.7
LP	8.2*	4.2	3.0	8.7	16.4*	8.5	5.9	19.0	24.6	8.9	13.6
7/8Jersey-1/8Domiati:											
M305	51.3***	9.8	3.5	6.7	102.7***	19.7	7.0	14.3	154.0	10.5	10.3
TMY	58.3***	12.4	3.8	6.1	116.7***	24.8	7.5	13.0	175.0	11.3	9.4
LP	4.4*	2.0	1.7	4.8	8.8*	4.0	3.5	10.0	13.2	3.2	7.3
15/16Jersey-1/16Domiati:											
M305	28.5***	6.9	1.9	3.3	54.8***	13.3	3.7	6.6	83.3	5.6	4.9
TMY	26.4**	8.9	1.7	2.7	50.8**	17.1	3.3	5.3	77.2	5.0	3.9
LP	1.8	1.4	0.7	1.8	3.4	2.7	1.4	3.5	5.2	2.1	2.6

*=P<.05, **=P<.01, ***=P<.001

7/8S1/8D and 15/16J1/16D. Relative to the additive effect, a breed group of 3/4E1/4D in Friesian and Shorthorn trials and 1/2E1/2D showed the highest heterotic superiority, while groups of 15/16F1/16D, 7/8S1/8D and 15/16J1/16D recorded the lowest heterotic superiority **(Tables 48, 49 and 50)**. Also, inter-se -mating groups of $(3/4E1/4D)^2$ and $(7/8E1/8D)^2$ recorded mostly higher heterotic superiority relative to additive effect (i.e. H^I/G^I or H^M/G^M or H^I+H^M relative to G^I+G^M) than groups of 3/4E1/4D and 7/8E1/8D, respectively. In practice, inter-se -mating group of $(3/4E1/4D)^2$ showed higher percentages of heterosis relative to additive effect than group of $(7/8E1/8D)^2$.

4.5.3 Recombination effect

Estimates of recombination effects of milk traits for each inter-se -mating group relative to purebreds in Friesian and Shorthorn trials are presented in **Table 51**. Estimates of R^I for inter-se -mating groups of $(3/4E1/4D)^2$ and $(7/8E1/8D)^2$ in these two trials were higher than those estimates of H^I **(Tables 48, 49 and 51)**. These significant ($P<0.001$) and favorable estimates imply that dominance effects were negative. R^I and R^M for milk traits in these two crossbreeding trials indicate also that recombination effect decreased with the increase of foreign blood from 3/4F and 3/4S to 7/8F and 7/8S. Therefore, inter-se -mating group of $(7/8E1/8D)^2$ showed lower recombination effect than group of $(3/4E1/4D)^2$. However, these positively favorable and significant ($P<0.001$ or $P<0.01$) recombination effect for milk traits in Friesian and Shorthorn trials indicate that crossbred cows of 3/4E1/4D or 7/8E1/8D mothered heifers with higher milking ability when mated with bulls of the same breed group (or of the same blood proportion) than when mated with purebred bulls.

Superiority of 3/4E1/4D over 7/8E1/8D for recombination effect were evidenced from percentages of R^I or R^M relative to additive effect **(Table 51)**. These percentages of recombination effect relative to additive effect (i.e. R^I/G^I or R^M/G^M or R^I+R^M relative to G^I+G^M) were positive and higher in groups of 3/4E1/4D than in groups of 7/8E1/8D **(Table 51)**. In dairy industry, such favorable recombination effect in groups of 3/4E1/4D and 7/8E1/8D for milk traits indicate that epistatic recombination losses in these inter-se mating groups were negligible and therefore there is a potential advantage to use crossbred cows or dams including foreign blood (Friesian or Shorthorn) to develop parental strains to be used in crossbreeding stratification systems in Egypt.

Table (51). Estimates of recombination effects on milk production traits for each separate inter-se mating group relative to purebred in **Friesian** and **Shorthorn** trials.

Trait	R^I Estimate	R^I SE	R^I/G^I (%)	R^M Estimate	R^M SE	R^M/G^M %
(i) Friesian trial:						
(3/4Friesian-1/4Domiati)^2:						
M305 (kg)	182.1***	12.1	15.9	144.6***	16.8	12.7
TMY (kg)	252.7***	27.2	16.1	200.5***	21.6	12.8
LP (day)	29.7***	4.0	18.4	23.6***	3.2	14.6
(7/8Friesian-1/8Domiati)^2:						
M305 (kg)	73.2***	12.6	6.1	65.4***	11.3	5.5
TMY (kg)	103.8***	16.2	6.2	92.7***	14.5	5.6
LP (day)	12.6***	2.3	7.4	11.2***	2.1	6.5
(ii) Shorthorn trial:						
(3/4Shorthorn-1/4Domiati)^2:						
M305 (kg)	240.6***	26.3	38.2	190.9***	20.9	30.3
TMY (kg)	270.5***	32.3	35.5	214.7***	25.7	28.2
LP (day)	12.2**	3.9	21.8	9.7**	3.2	17.4
(7/8Shorthorn-1/8Domiati)^2:						
M305 (kg)	88.6**	10.6	13.2	79.1***	9.5	11.8
TMY (kg)	90.9***	12.7	11.7	81.2***	11.3	10.4
LP (day)	2.4	1.5	4.8	2.1	1.4	4.2

*= P<.05, **=P<.01, ***=P<.001

4.6 Comparison between breed-group models and regression models

Coefficients for breed additive, heterosis and recombination effects were expressed as decimal fractions in fitting the model. Partial regression coefficients derived from these fractions were expressed as percentages of gene contribution (Martinez et al, 1988). These coefficients were obtained by dividing the original partial regression coefficients by 100. **Tables 52, 53, 54 and 55** present comparison between breed-group analyses (i.e. models with orthogonal contrasts) and regression analyses (i.e. models with genetic covariate terms) of the first four separate lactations and across all lactations in the two up-grading trials.

Sum of squares due to fitting the genetic-group model account for all genetic effects whereas the multiple regression model used in this study accounted for only additive, heterotic and recombination effects. Differences in sum of squares due to fitting these two analyses permit testing the magnitude of non-linear genetic effects (such as additive x dominance and linkage) as well as to detect the accuracy of these analyses in the estimation of genetic components (i.e. G^I, G^M, H^I, H^M, R^I and R^M) in these up-grading trials carried out in Egypt. However, regression analysis permit estimation of genetic parameters (that allow prediction of the performance of up-grades that have not actually been tested) and estimation of the importance of nonlinear genetic effects such additive x dominance and linkage effects (Martinez et al, 1988). The comparisons between analyses shown in **Tables 52, 53, 54 and 55** suggest that the additional genetic effects (e.g. nonlinear effects of additive x dominance and linkage) did not significantly reduce the error variance. Robison et al. (1981) proposed a regression model for estimation of genetic effects from crossbreeding experiment including Holstein, Ayrshire and Brown Swiss cattle. They found that this procedure has three advantages over conventional analyses of crossbreeding data: (1) It is less complex statistical procedure, (2) It provides a clear understanding of the genetic components and (3) It allows prediction of breed crosses that were not included in the data set.

For most traits in the first four separate lactations and in all lactations, insignificant differences between the two analyses indicate that additive x dominance and linkage (i.e. non-linear effects) were not important in the two up-grading trials **(Tables 52, 53, 54 and 55)**. Consequently, the amount of heterosis estimated for these different traits were basically due to dominance. Robison et al. (1981) and Martinez et al. (1988) came to the same conclusion. Also, the present results reveal that prediction of different up-grades between Domiati and each of Firesian or

Table 52. Comparison of reduction in sum of squares due to fitting breed group and genetic covariate terms in models including year and season separately in **Friesian** trial.

Trait	Parity	Models compared	df_R	df_e	MS_e	F_d
M90	1st	1 vs 7	1	1	2366	1.0
	2nd	1 vs 7	1	1	542	1.0
	3rd	1 vs 7	1	1	13829	1.0
	4th	1 vs 7	1	1	163	1.0
	All	5 vs 11	419	420	70305	0.06
M305	1st	1 vs 7	1	1	142984	1.0
	2nd	1 vs 7	1	1	164872	1.0
	3rd	1 vs 7	1	1	482062	1.0
	4th	1 vs 7	1	1	973858	1.0
	All	5 vs 11	720	721	4753516	0.01
TMY	1st	1 vs 7	1	1	116071	1.0
	2nd	1 vs 7	1	1	83710	1.0
	3rd	1 vs 7	1	1	689849	1.0
	4th	1 vs 7	1	1	2523755	1.0
	All	5 vs 11	720	721	1014300	0.48
LP	1st	1 vs 7	1	1	9339	1.0
	2nd	1 vs 7	1	1	989	1.0
	3rd	1 vs 7	1	1	5692	1.0
	4th	1 vs 7	1	1	38345	1.0
	All	5 vs 11	720	721	12152	0.85
MCI1	1st	1 vs 7	1	1	0.2	1.0
	2nd	1 vs 7	1	1	3.0	1.0
	3rd	1 vs 7	1	1	0.77	1.0
	4th	1 vs 7	1	1	0.002	1.0
	All	5 vs 11	585	586	2.63	0.12
MCI2	1st	1 vs 7	1	1	0.4	1.0
	2nd	1 vs 7	1	1	3.0	1.0
	3rd	1 vs 7	1	1	0.09	1.0
	4th	1 vs 7	1	1	1.3	1.0
	All	5 vs 11	585	586	2.81	0.10
DP	1st	1 vs 7	1	1	8294	1.0
	2nd	1 vs 7	1	1	9718	1.0
	3rd	1 vs 7	1	1	13805	1.0
	4th	1 vs 7	1	1	1057	1.0
	All	5 vs 11	601	602	12287	0.84
CI	1st	1 vs 7	1	1	12845	1.0
	2nd	1 vs 7	1	1	11326	1.0
	3rd	1 vs 7	1	1	52815	1.0
	4th	1 vs 7	1	1	20888	1.0
	All	5 vs 11	600	601	14479	1.16*
AC	1st	3 vs 9	1	1	55	0.98
	2nd	3 vs 9	1	1	47	0.96

DF_R = Difference in df due to fitting breed group and covariate terms in models of analysis.
DF_e = Difference in remainder df due to fitting breed group and covariate terms models.
MS_e = [Difference in remainder SS due to fitting breed group and covariate terms] / DF_e.
MS_R = [Difference in reduction SS due to fitting breed group and covariate terms] / DF_R.
F_d = MS_R / MS_e, *= p<.05, **= p<.01, ***= p<.001

Table 53. Comparison of reduction in sum of squares due to fitting breed group and genetic covariate terms in models including year and season separately in **Shorthorn** trial

Trait	Parity	Models compared	df_R	df_e	MS_e	F_d
M305	1st	1 vs 7	1	1	428372	1.0
	2nd	1 vs 7	1	1	667683	1.0
	3rd	1 vs 7	1	1	1071836	1.0
	4th	1 vs 7	1	1	56901	1.0
	All	5 vs 11	482	483	709885	0.16
TMY	1st	1 vs 7	1	1	934594	1.0
	2nd	1 vs 7	1	1	411084	1.0
	3rd	1 vs 7	1	1	1582867	1.0
	4th	1 vs 7	1	1	13081	1.0
	All	5 vs 11	482	483	961851	0.68
LP	1st	1 vs 7	1	1	22076	1.0
	2nd	1 vs 7	1	1	614	1.0
	3rd	1 vs 7	1	1	20789	1.0
	4th	1 vs 7	1	1	753	1.0
	All	5 vs 11	482	483	12883	0.92
MCI1	1st	1 vs 7	1	1	0.2	1.0
	2nd	1 vs 7	1	1	9.5	1.0
	3rd	1 vs 7	1	1	8.0	1.0
	4th	1 vs 7	1	1	0.05	1.0
	All	5 vs 11	432	433	5.25	0.60
MCI2	1st	1 vs 7	1	1	0.6	1.0
	2nd	1 vs 7	1	1	8.8	1.0
	3rd	1 vs 7	1	1	9.0	1.0
	4th	1 vs 7	1	1	0.04	1.0
	All	5 vs 11	432	433	5.59	0.59
DP	1st	1 vs 7	1	1	14182	1.0
	2nd	1 vs 7	1	1	11347	1.0
	3rd	1 vs 7	1	1	17928	1.0
	4th	1 vs 7	1	1	14394	1.0
	All	5 vs 11	435	454	28960	0.78
CI	1st	1 vs 7	1	1	2836	1.0
	2nd	1 vs 7	1	1	5343	1.0
	3rd	1 vs 7	1	1	4820	1.0
	4th	1 vs 7	1	1	21658	1.0
	All	5 vs 11	433	434	16723	1.30*
AC	1st	3 vs 9	1	1	189	100.6
	2nd	3 vs 9	1	1	214	1.0

DF_R = Difference in df due to fitting breed group and covariate terms in models of analysis.

DF_e = Difference in remainder df due to fitting breed group and covariate terms models.

MS_e = [Difference in remainder SS due to fitting breed group and covariate terms] / DF_e.

MS_R = [Difference in reduction SS due to fitting breed group and covariate terms] / DF_R.

F_d = MS_R / MS_e, *= p<.05, **= p<.01, ***= p<.001

Table 54. Comparison of reduction in sum of squares due to fitting breed group and genetic covariate terms in models including effects of year-season combination in **Friesian** trial

Trait	Parity	Models compared	df_R	df_e	MS_e	F_d
M90	1st	2 vs 8	1	1	1487	52.3
	2nd	2 vs 8	1	1	8687	60.3
	3rd	2 vs 8	1	1	11446	8.1
	4th	2 vs 8	1	1	4301	19.7
	All	6 vs 12	408	408	45581	0.6
M305	1st	2 vs 8	1	1	7567	5664.7**
	2nd	2 vs 8	1	1	627673	70.6
	3rd	2 vs 8	1	1	443242	71.5
	4th	2 vs 8	1	1	1117608	17.2
	All	6 vs 12	702	702	431021	1.66*
TMY	1st	2 vs 8	1	1	4697	15085.5**
	2nd	2 vs 8	1	1	227392	318.1*
	3rd	2 vs 8	1	1	1232776	47.6
	4th	2 vs 8	1	1	2760610	13.4
	All	6 vs 12	702	702	951349	1.47*
LP	1st	2 vs 8	1	1	3520	241.1*
	2nd	2 vs 8	1	1	2283	382.9*
	3rd	2 vs 8	1	1	11720	50.4
	4th	2 vs 8	1	1	43220	10.2
	All	6 vs 12	702	702	12197	1.33*
MCI1	1st	2 vs 8	1	1	0.08	2428.9*
	2nd	2 vs 8	1	1	8.0	17.5
	3rd	2 vs 8	1	1	0.09	982.4*
	4th	2 vs 8	1	1	0.02	2531.4*
	All	6 vs 12	567	567	2.44	1.70*
MCI2	1st	2 vs 8	1	1	0.15	2058.3*
	2nd	2 vs 8	1	1	6.0	36.7
	3rd	2 vs 8	1	1	1.01	150.2
	4th	2 vs 8	1	1	1.2	78.7
	All	6 vs 12	567	567	2.67	1.97*
DP	1st	2 vs 8	1	1	2108	894.6*
	2nd	2 vs 8	1	1	9955	19.4
	3rd	2 vs 8	1	1	446	105.4
	4th	2 vs 8	1	1	345	274.5*
	All	6 vs 12	583	583	12386	1.13*
CI	1st	2 vs 8	1	1	17907	13.4
	2nd	2 vs 8	1	1	43223	6.9
	3rd	2 vs 8	1	1	15065	12.6
	4th	2 vs 8	1	1	24488	7.6
	All	6 vs 12	582	582	14647	1.27*
AC	1st	4 vs 10	1	1	28.0	24.1
	2nd	4 vs 10	1	1	6.0	50.8

DF_R = Difference in df due to fitting breed group and covariate terms in models of analysis.
DF_e = Difference in remainder df due to fitting breed group and covariate terms models.
MS_e = [Difference in remainder SS due to fitting breed group and covariate terms] / DF_e.
MS_R = [Difference in reduction SS due to fitting breed group and covariate terms] / DF_R.
F_d = MS_R / MS_e, *= p<.05, **= p<.01, ***= p<.001

Table 55. Comparison of reduction in sum of squares due to fitting breed group and genetic covariate terms in models including year-season combination in **Shorthorn** trial.

Trait	Parity	Models compared	df_R	df_e	MS_e	F_d
M305	1st	2 vs 8	1	1	387512	32.7
	2nd	2 vs 8	1	1	537469	14.2
	3rd	2 vs 8	1	1	1592794	2.1
	4th	2 vs 8	1	1	302382	14.4
	All	6 vs 12	468	468	690528	1.07*
TMY	1st	2 vs 8	1	1	790217	21.7
	2nd	2 vs 8	1	1	122031	62.3
	3rd	2 vs 8	1	1	1985747	2.6
	4th	2 vs 8	1	1	292322	16.9
	All	6 vs 12	468	468	936917	1.02*
LP	1st	2 vs 8	1	1	15457	12.5
	2nd	2 vs 8	1	1	9641	2.5
	3rd	2 vs 8	1	1	12947	2.8
	4th	2 vs 8	1	1	143	30.1
	All	6 vs 12	468	468	12353	0.99
MCI1	1st	2 vs 8	1	1	0.06	1255.3*
	2nd	2 vs 8	1	1	13.0	4.4
	3rd	2 vs 8	1	1	12.0	0.8
	4th	2 vs 8	1	1	2.0	7.5
	All	6 vs 12	415	415	5.19	1.24*
MCI2	1st	2 vs 8	1	1	0.08	1081.0*
	2nd	2 vs 8	1	1	12.0	5.8
	3rd	2 vs 8	1	1	12.0	1.3
	4th	2 vs 8	1	1	2.0	1.5
	All	6 vs 12	415	415	5.51	1.17*
DP	1st	2 vs 8	1	1	11144	9.4
	2nd	2 vs 8	1	1	14758	2.1
	3rd	2 vs 8	1	1	7660	3.5
	4th	2 vs 8	1	1	42269	0.9
	All	6 vs 12	426	426	21844	1.13*
CI	1st	2 vs 8	1	1	2475	67.9
	2nd	2 vs 8	1	1	5196	9.2
	3rd	2 vs 8	1	1	943	32.1
	4th	2 vs 8	1	1	36397	0.4
	All	6 vs 12	419	419	15895	1.47*
AC	1st	4 vs 10	1	1	135	1.13
	2nd	4 vs 10	1	1	87	0.17

DF_R = Difference in df due to fitting breed group and covariate terms in models of analysis.

DF_e = Difference in remainder df due to fitting breed group and covariate terms models.

MS_e = [Difference in remainder SS due to fitting breed group and covariate terms] / DF_e.

MS_R = [Difference in reduction SS due to fitting breed group and covariate terms] / DF_R.

F_d = MS_R / MS_e, *= p<.05, **= p<.01, ***= p<.001

Shorthorn should made by using these simple analyses of breed-group model or regression-analyses model, i.e. both analysis gave the same accuracy in estimating genetic components. However, this may not be true in other situations (such as in commercial herds) and should always be tested.

In practice, the two statistical genetic analyses presented here should serve as a guide in the design and analysis of up-grading experiments so that the maximum useful information can be gained concerning a definite set of random mating breeds and their crosses. Genetic estimates obtained in this manner are particularly useful in the making of predictions, selection of breeding materials and evaluation of breeding systems.