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Genetic studies of production efficiency traits and their uses in sire evaluation

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ABSTRACT

The information with respect to first lactation production and reproduction traits for each buffalo maintained at Network Project on Buffaloes, Livestock Research Station, Vallabhnagar from 1976 to 2004 were used for the present study. The MY/FLL and MY/FCI was significantly affected by sire, MY/FCI by period of calving and MY/FCI, MY/ASC and MY/AFCON by season of calving. The heritability estimates for MY/FLL and MY/FCI were 0.343±0.145 and 0.199±0.125, respectively. Heritability estimates for MY/ASC and MY/AFCON were low. The genetic association of AFC with MY/FCI, MY/ASC and MY/AFCON was positive and high. The phenotypic correlation of AFC with MY/ASC and MY/AFCON was negative and significant.

The genetic association of FSP and FCI with MY/FLL and MY/ASC was positive and low to moderate while with MY/FCI and MY/AFCON were negative and low to moderate. The phenotypic association of FSP and FCI with MY/FCI, MY/ASC and MY/AFCON was negative and significant. The genetic and phenotypic correlation coefficients among production (FLMY, 305 MY and FPY) and production efficiency traits (MY/FLL, MY/FCI, MY/ASC and MY/AFCON) were positive and moderate to high.

Among production efficiency traits maximum sires (47.83%) showed above average breeding value estimated by MY/FCI. The range as percentage of average breeding value was the maximum for breeding value estimated by MY/ASC at 85.19%. Among the multi traits 46.37% sires showed breeding value more than average breeding value estimated by $IVSI_1$. The breeding value estimated by $IVSI_1$ also showed maximum (228.09%) range as percentage of average breeding value among all the traits under study. The rank correlation coefficients between single and multi traits were positive, high and significant. Considering the computational facilities required for construction of selection index, selection of sire can be made on the basis of MY/ASC with good reliability when selection index is not available.

Key words: Genetic studies, Production efficiency traits, Sire evaluation

Selection index incorporating production and reproduction traits would be the most efficient measure of net merit of buffaloes, but it needs computational facilities and is cumbersome (Kandasamy *et al.* 1991). The production efficiency traits combine production and reproduction traits in different combinations, due to which these efficiency traits appear to be useful criteria for comparing the economic merit of dairy animals and are easy to compute. Moreover, the heritability estimates of production efficiency traits were reported to be higher as compared to the estimates for first lactation 305 days or less milk yield (Gandhi and Gurnani 1991). Therefore, the present study was planned to estimate the genetic and phenotypic parameters of production efficiency traits and their uses in selecting sires in Surti buffaloes

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MATERIALS AND METHODS

The information with respect to first lactation production and reproduction traits of Surti buffalo maintained at Network Project on Buffaloes, Livestock Research Station, Vallabhnagar from 1976 to 2004 were used to generate the production efficiency traits. Abortions, pathological causes affecting lactation, calves born dead, abnormal, premature births and culling of animals during milking period were considered as abnormal records and hence excluded from the study. The efficiency traits generated were milk yield per day of lactation length (MY/FLL), milk yield per day of calving interval (MY/FCI), milk yield per day of age at second calving (MY/ASC) and milk yield per day of age at conception after first calving (MY/AFCON)

Mixed model least-squares analysis (Harvey 1990) was carried out to study the effect of sires, periods and seasons of calving. The total duration of 28 years were grouped into 6 periods. The 3 seasons were rainy season (July – October), winter (November – February) and summer (March – June).

The differences between sub means were tested for significance by Duncan's new multiple range test (DMRT)

Heritability and genetic correlations were computed by paternal half-sib correlation method, while standard error of heritability and genetic correlations were estimated as per Swiger *et al*. (1964) and Robertson (1959) respectively. The phenotypic correlations were calculated using conventional statistical procedure (Snedecor and Cochran 1968).

The breeding value of all the Surti sires used between 1973 to 2004 in 10 different sets of bulls under Network Project on Buffaloes, were estimated using single traits, viz. production efficiency as well as multi traits, viz. 2 index values $IVSI_1$ and $IVSI_2$. The selection indices as recommended by Kothari (2005) for this herd are as follows.

$IVSI_{1} =$ 1.32 (305 MY) – 3.76 (FSP) + 2.66 (FDP)

$IVSI_{2} =$ 0.62 (305 MY) + 0.44 (FDP)

RESULTS AND DISCUSSION

The average MY/FLL, MY/FCI and MY/ASC were (Table 1) in agreement with the reports of Patel (1994) and Tailor (1995) in Surti buffaloes. On the other hand, considerably higher values for these parameters were reported by Bhalaru and Dhillon (1981), Kandasamy *et al.* (1991) and Triveni *et al.* (2001) in Murrah buffaloes, which indicated breed differences. The effect of sire was significant on MY/FLL and MY/FCI, but nonsignificant on MY/ASC and MY/AFCON. Similar results were also reported by Pathodiya (1997) and Tailor (1995) in Surti buffaloes. The differences due to period of calving were highly significant on MY/FCI only among all the production efficiency traits under study. Reports of Kumar (1984) and Tailor (1995) are in consonance with the present results. Patel (1994), however, found nonsignificant effect of period of calving on MY/FCI.

Calving season had significant effect on MY/FLL, MY/AFC and MY/AFCON, a finding in confirmation with the reports of Kumar (1984), Kandasamy *et al.* (1991) and Tailor (1995). The DMRT results indicated that milk yield per day of first lactation length was significantly higher for buffaloes that calved during summer as compared to buffaloes that calved during other seasons (Table 1). The MY/ASC and MY/AFCON was significantly higher for buffaloes that calved during summer and winter as compared to buffaloes that calved during rainy season. However, the differences between summer and winter calvers were also significant. Tailor (1995) on the other hand, observed that buffalo that calved during winter had significantly higher MY/ASC than buffaloes that calved during summer and rainy seasons.

The heritability estimates for MY/FLL were moderate. Moderate estimates for MY/FLL were also reported by Basavaiah (1978) and Kandasamy *et al.* (1991) in Murrah buffaloes. However, Tailor (1995) reported higher estimates of heritability for this trait. Heritability estimates for MY/FCI was 0.199±0.125. Low estimates of heritability for MY/FCI were reported by Patel (1994) in Surti and Verma and Yadav (1989) in Nili-Ravi buffaloes. On the other hand, Tailor (1995) reported moderate estimates of heritability for this trait. The heritability estimates for MY/ASC was low at 0.075±0.106. Low estimates of heritability for MY/ASC was also reported by Umrikar and Deshpande (1985). However, Bhalaru and Dhillon (1987) and Kandasamy *et al.* (1991) reported moderate to high estimates of heritability for this trait. Heritability estimates for MY/AFCON was not significantly different from zero. The magnitude of heritabilities indicated that MY/FLL and MY/FCI had considerable genetic variability among production efficiency traits and hence, mass selection would be effective in bringing about genetic improvement in these traits along with appropriate pedigree selection and progeny testing programme.

The genetic association of AFC with MY/FLL were positive and low, while with MY/FCI, MY/ASC and MY/AFCON were positive and high (Table 2). Similar estimates

Table 1. Least-squares means of first lactation production efficiency traits

Effect	N	Mean±SE			
		MY/FLL (kg)	MY/FCI (kg)	MY/ASC (kg)	MY/AFCON (kg)
μ	461	3.95±0.07	2.16±0.05	0.49±0.01	0.58±0.01
Period of calving					
1	81	3.57^a±0.27	1.94^a±0.23	0.50^a±0.05	0.59^a±0.06
2	98	3.83^a±0.23	1.97^a±0.20	0.48^a±0.04	0.56^a±0.05
3	130	3.83^a±0.21	1.87^a±0.18	0.41^a±0.04	0.47^a±0.05
4	98	4.20^a±0.22	2.35^b±0.19	0.46^a+±0.04	0.52^a±0.54
5	44	3.84^a±0.41	2.00^a±0.36	0.58^a±0.08	0.69^a±0.10
6	10	4.40^a±0.43	2.85^c±0.37	0.54^a±0.08	0.63^a±0.10
Season of calving					
Summer	90	4.14^b±0.10	2.28^a±0.08	0.54^c±0.01	0.63^c±0.02
Rainy	264	3.78^a±0.08	2.12^a±0.06	0.45^a±0.01	0.52^a±0.01
Winter	107	3.92^a±0.09	2.09^a±0.07	0.49^b±0.01	0.57^b±0.02

Different superscript indicated differences among means at 5% level of significance.

Table 2. Genetic and phenotypic correlations of first lactation traits with production efficiency traits

Traits	Phenotypic correlation				Genetic correlation			
	MY/FLL	MY/FCI	MY/ASC	MY/AFCON	MY/FLL	MY/FCI	MY/ASC	MY/AFCON
AFC	0.001±0.046	0.029±0.046	–0.324±0.044**	–0.371±0.043**	0.212±0.324	0.561±0.378	0.567±0.800	0.600±1.024
FSP	–0.081±0.046	–0.322±0.044**	–0.128±0.046**	–0.101±0.046*	0.243±0.538	–0.414±0.765	0.076±0.915	–0.020±1.062
FCI	–0.062±0.046	–0.345±0.043**	–0.132±0.046**	–0.114±0.046*	0.429±0.834	–0.308±1.068	0.063±1.258	–0.091±1.442
FLMY	0.616±0.036**	0.741±0.031**	0.908±0.019**	0.878±0.022**	0.988±0.157	0.818±0.175	0.937±0.162	0.963±0.302
305 MY	0.675±0.034**	0.784±0.028**	0.902±0.020**	0.875±0.022**	0.987±0.151	0.869±0.142	0.992±0.180	0.952±0.360
FPY	0.483±0.040**	0.387±0.043**	0.356±0.043**	0.346±0.043**	0.743±0.202	0.500±0.325	0.990±0.576	0.904±0.846
FDP	–0.103±0.46*	–0.646±0.035**	–0.251±0.045**	–0.255±0.045**	–0.062±0.740	–0.621±1.58	0.661±1.81	0.704±2.13

* P<0.05, ** P<0.01.

Table 3. Breeding value estimated on the basis of single and multi traits

Traits	Avg. BV	No of sires above BV	No of sires below BV	% above avg BV	% below avg BV	Maximum BV	Minimum BV	Range of BV	% of avg BV
Production traits									
FLMY	1065.99	19	27	46.37	53.63	1626.00	727.87	898.13	84.25
305 MY	1037.18	15	31	32.67	67.33	1617.86	726.75	891.11	85.92
FPY	6.80	25	21	54.34	45.66	8.50	5.45	3.03	44.56
FDP	248.86	21	25	45.65	54.35	350.60	163.00	187.60	75.33
Production efficiency traits									
MY/FLL	3.89	19	27	46.37	53.63	5.23	2.88	2.35	44.93
MY/FCI	2.08	22	24	47.83	52.17	2.93	1.40	1.53	52.22
MY/ASC	0.47	21	25	45.65	54.35	0.72	0.32	0.40	85.19
MY/AFCON	0.55	19	27	46.37	53.63	0.83	0.37	0.46	55.42
Multi traits									
$IVSI_1$	1232.96	19	27	46.37	53.63	3590.38	779.23	2811.15	228.09
$IVSI_2$	752.56	17	29	35.95	63.05	1921.70	550.62	1371.08	182.14

were also reported by Tailor (1995) in Surti buffaloes.

The phenotypic correlation of AFC with MY/FLL and MY/FCI was positive and nonsignificant, a finding in agreement with the reports of Tailor (1995). As expected, the phenotypic association of AFC with MY/ASC and MY/AFCON was negative and significant (Table 2). The results indicated that MY/ASC and MY/AFCON decreases with increase in age at first calving. The genetic association of FSP and FCI with MY/FLL and MY/ASC was positive and low to moderate while with MY/FCI and MY/AFCON were negative and low to moderate (Table 2). Similar results were observed by Patel (1994) and Tailor (1995). The phenotypic association of FSP and FCI with MY/FLL were negative and nonsignificant while negative and significant with MY/FCI, MY/ASC and MY/AFCON, indicating milk yield per day during lactation length, calving interval, age at second calving and age at first conception after first calving decreased as first service period and calving interval increased.

As expected, the genetic correlation coefficients among production (FLMY, 305 MY and FPY) and production efficiency traits (MY/FLL, MY/FCI, MY/ASC and MY/AFCON) were positive and moderate to high (Table 2). Similar results were also observed by Patel (1994), Tailor (1995) and Pathodiya (1997). The positive and high genetic association among production and production efficiency traits indicated pleotrophic effects of gene.

The phenotypic correlation coefficients among production (FLMY, 305 MY and FPY) and production efficiency traits (MY/FLL, MY/FCI, MY/ASC and MY/AFCON) were also positive and significant (Table 2), a finding in agreement with the reports of Patel (1994), Tailor (1995) and Pathodiya (1997). The production efficiency increased due to increase in milk production.

Among production efficiency traits (Table 3) maximum sires (22 sires, 47.83%) showed above average breeding value estimated by MY/FCI. The range as percentage of average breeding value was maximum for breeding value estimated by MY/ASC at 85.19%. Among the multi traits 46.37% sires (19 Nos) showed breeding value more than average breeding value estimated by $IVSI_1$. The breeding value estimated by $IVSI_1$ also showed maximum range (228.09%) as percentage of average breeding value among all the traits under study.

Table 4. Rank and product moment correlation between single and multi traits

Traits	Correlation coefficients			
	Rank		Product moment	
	$IVSI_1$	$IVSI_2$	$IVSI_1$	$IVSI_2$
FLMY	0.814**	0.978**	0.680**	0.786**
305 MY	0.853**	0.978**	0.965**	0.995**
FPY	0.572**	0.615**	0.465**	0.513**
FDP	–0.367*	0.068	–0.196	0.014
MY/FLL	0.910**	0.895**	0.744**	0.704**
MY/FCI	0.913**	0.772**	0.671**	0.640**
MY/ASC	0.758**	0.918**	0.619**	0.709**
MY/AFCON	0.744**	0.896**	0.602**	0.688**

*,P < 0.05; **,P < 0.01.

The rank correlation coefficients between multi trait ($IVSI_1$ and $IVSI_2$) and single trait (production efficiency traits, viz. MY/FLL, MY/FCI, MY/AFC and MY/AFCON) were positive, high and significant (Table 4). The results indicated that ranking of sires based on breeding value estimated by single (efficiency traits) and multi traits (index value) are almost similar. Therefore, it is concluded that selection of sires can be made either on single (MY/FLL, MY/FCI, MY/AFC and MY/AFCON) or multi traits ($IVSI_1$ and $IVSI_2$).

The objective of the breeders is to select the sire as early as possible. Among the above traits, breeding value based on multi traits ($IVSI_1$ and $IVSI_2$) were discriminated among bulls to the maximum extent followed by breeding value estimated on the basis of MY/ASC. It was concluded that the breeding value on the basis of multi traits would select the sires more accurately. However, selection of sire can be made on the basis of MY/ASC with good reliability when selection index is not available.

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