INHERITANCE OF ECONOMIC TRAITS OF DAIRY BUFFALOES IN PAKISTAN

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ABSTRACT

Inheritance of economic traits was studied in Nili-Ravi dairy buffaloes through analysis of data comprising 5037 records of daughters of 79 sires. Data were collected from three large-sized state dairy farms. Heritability, genetic and phenotypic correlations of some indicator traits on important production and reproduction traits were worked out. Based upon analysis of records for first lactation traits, higher values were recorded for heritability of first lactation milk yield, standard 305 days milk yield, lactation length, birth weight and first lactation peak daily yield (h^2 = 0.62, 0.61, 0.54, 0.39, 0.35, respectively). Comparatively lower heritability was recorded for reproductive traits including age at first calving, age at puberty and first calving interval (h^2 = 0.28, 0.21, 0.15, respectively). Analysis of records for all lactation traits provided higher values for heritability of lactation length, lactation yield, standard 305 days milk yield, yield per day of calving interval (h^2 = 0.43, 0.38, 0.34, 0.31, respectively) while peak daily yield, daily yield and calving interval had comparatively lower heritability (h^2 = 0.26, 0.24 and 0.18, respectively). The findings suggested that heritability estimates of first lactation economic traits provided a better tool for selective breeding, expected to lead to rapid aggregate genetic gains in dairy buffaloes. In addition, the milk yielding traits and birth weight were highly heritable and the reproductive traits were low.

Key Words: Dairy buffalo, Inheritance, Economic traits, Reproduction, lactation

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INTORDUCTION

The domestic buffalo is an important animal in the agricultural economy of many tropical and subtropical countries like Pakistan. Buffalo is contributing 12.1% to the world, 38.0% in Asia, 66.6% in Pakistan, 55.0% in India, 16.4% in China, 50.8% in Egypt and 65.2% in Nepal's total milk production (FAO, STAT, 2007). In addition to the milk buffalo is also used as an important source of beef production in Pakistan in the form of culled adult females, males and unwanted male calves. Buffalo is contributing around 1.3, 2.8, 24.4, 26.9, 0.6, 21.2, and 51.8% of the total meat production in the afore-mentioned countries. Its service to the people of most of these countries with regards to the supply of milk, meat and draught power is far greater than any other domestic animal.

Pakistani buffalo mainly comprises Nili-Ravi breed and is popular having a reputation for high milk yield. Nili-Ravi buffaloes yield milk to the tone of 1671±31.4 kg (Syed *et al*, 1996) and 2506.25±122.1 kg per lactation (Syed *et al.*, 1998). About 3700 kg of milk is produced in an average 300 days lactation period by nearly 14 percent of the registered buffaloes under progeny testing program is Pakistan (Asghar *et al*., 1992). In a study across overall parities, the highest milk yield of 2,836.50±15.68 liters per lactation was recorded in the high milk yielding group verses 1,657.04±18.34 liters/lactation in the lowest yielding group (Khan *et al*., 2008).

The productive/reproductive traits in dairy animals are influenced by several genetic and environmental factors. Any breed development programme would be based on the exploitations of the genetic variation. It is a well known fact that milk production increases with age at an ever till maximum production is attained and decreases later on. Khan *et al*. (2008) investigated the post-conception decline in milk yield and reported that dairy buffaloes in parity 3 had the least reduction in milk yield followed by parity 2, 4, 1, 5, and 6, indicating parity 3 as the best phase for milk production in dairy buffaloes. The reduction in milk was smallest in summer followed by winter, spring and autumn. Bashir *et al*., (2007) reported that economic returns from dairy buffaloes depend on lifetime performance. Herd life and productive life were also used to describe lifetime performance. They concluded that genetically productive life had positive correlation with lifetime milk yield (low) and herd life (high). The selection for productive life was found to increase herd life and lifetime milk yield also improved. The wide variation in milk production reported so far can be skillfully exploited if the extents of genetic and environmental causes of the variation are precisely known.

MATERIALS AND METHODS

Source of Data

Pedigree, breeding and performance records of Nili-Ravi buffaloes maintained at three state dairy farms Okara, Peshawar, and Kohat were utilized in the present study. The records comprised 5037 lactations of buffalo cows, related to 79 sires born during 1985 through 2004.

Selection of Breeding Stock and Breeding Policy

Since the establishment of these farms, the females stock was mainly selected on the basis of conformation and some performance indicators. Attention had not been paid to selection for breeding, based upon specific principles. The males with desired conformation and also, from the high yielding buffaloes were retained at the farm for future breeding. Rarely some of the bulls were also procured from other farms to provide greater genetic heterogeneity.

Data Extraction

History sheets of individual buffalo cow, milk recording registers, breeding registers maintained at the farms were scrutinized and the requisite information were fed to computer for data maintenance and analysis. The following data were collected from the records: Identification number of each animal, date of birth, weight at birth, date of service, date of calving, lactation milk yield and sire.

Estimation of Genetic Parameters and Statistical Analysis

The data on various productive and reproductive traits were analyzed to estimate the magnitude of various environmental and genetic sources of variation in these traits.
Following genetic parameters namely heritability, genetic and phenotypic correlations were estimated by using equations (Becker, 1975).

Heritability Estimation

1. For heritability estimation the mathematical model adopted was as follows:

$$\mathbf{h^2 = 4var_s / var_s + var_w} \quad (1)$$

Where:
h^2 = heritability,
var_s = the between sire variance
var_w = the within sire variance

2. The following formulae were used for calculating between and within sires variances:

$$Var_s = MS_s – MS_w/k \quad (2)$$
$$Var_w = MS_w \quad (3)$$

Where:
MS_s = the between sires mean square
MS_w = the within sire mean square
K = coefficient of variance being estimated

Genetic and Phenotypic Correlations

Correlation is the extent to which the variables vary with each other. Genetic correlation would be due to plieotropy and linkage. Phenotypic correlation is considered to be due to interaction between genetics and environment. The physiological and managemental variation result in altered expression of heritable traits.
Genetic correlation between two traits was calculated by the following formula:

$$r_g = cov\ _s/\sqrt{}var_{s(x)} * var_{s(y)} \quad (4)$$

Where,
r_g = the genetic correlation,
cov_s = the covariance between sires,

$var_{s(x)}$ = the between sire variance of trait x,
$var_{s(y)}$ = the between sire variance of trait y

Phenotypic correlation between two traits was calculated using the following formula:

$$r_p = cov_w + cov_s / \sqrt{(var_{w(x)} + var_{s(x)}) * (var_{w(y)} + var_{s(y)})} \qquad (5)$$

Where,

r_p = the phenotypic correlation,
cov_w = the covariance within sires,
cov_s = the covariance between sires,
$var_{w(x)}$ = variance of trait x within sires,
$var_{s(x)}$ = variance of trait x between sires,
$var_{w(y)}$ = variance of trait y within sires,
$var_{s(y)}$ = variance of trait y between sires,

The variances between and within sires for different traits were calculated as mentioned for calculating heritability. Covariances between sires and within sires were calculated using the following formulae:

$$cov_w = MCP_w \qquad (6)$$

$$cov_s = MCP_s - MCP_w/k \qquad (7)$$

Where,

MCP_w = mean cross products within sires,
MCP_s = mean cross products between sires.

All these analysis were performed using SAS package (Statistical Analysis System; 1997).

RESULTS AND DISCUSSION

Heritability Estimates of Economic Traits

The heritability estimates were worked out at two levels, i.e. for first lactation records and for all lactation records. Heritability estimate of first lactation milk yield was 0.62 in dairy buffaloes (Table I). For first lactation standard 305-day milk yield, first lactation peak daily milk yield, lactation length, birth weight, puberty age, age at first calving and calving interval were 0.61, 0.35, 0.54, 0.39, 0.21, 0.28 and 0.15, respectively. Heritability estimate of overall average lactation milk yield, standard 305-day milk yield, peak daily milk yield, lactation length, yield per day of calving interval and calving interval were 0.38, 0.34, 0.26, 0.43, 0.31 and 0.18, respectively.

Table I. ***Heritability estimates of various productive and reproductive traits in dairy buffaloes***

Trait	First Lactation	All Lactations
Lactation yield	0.62	0.38
Standard 305-day milk yield	0.61	0.34
Peak daily milk yield	0.35	0.26
Lactation length	0.54	0.43
Yield per day of calving interval	-	0.31
Birth weight	0.39	-
Age at puberty	0.21	-
Age at first calving	0.28	-
Calving interval	0.15	0.18

Phenotypic Correlations of Economic Traits

Relationship among phenotypic traits is given in Table II. The first lactation milk yield was correlated positively with total lactation milk yield, milk per day of calving interval, peak milk yield, standard 305-day milk yield, lactation length and birth weight, and negatively with age at puberty and first calving. Overall lactation milk yield followed the same pattern of correlation-ship. Yield per day of calving interval was correlated positively with peak milk yield, standard 305-day milk yield and negatively with calving interval. Peak milk yield influenced the standard lactation yield and lactation length. Standard milk yield was positively correlated with lactation length and birth weight while negatively with age at puberty and age at first calving.

The birth weight was found as a good indicator of productivity affecting first lactation milk yield, overall lactation yield, standard 305-day milk yield and lactation length. Age at puberty and age first calving were very strongly correlated. Among the lactation traits it favorably influenced first lactation yield, overall lactation yield and standard 305-day milk yield. Age at first calving influenced the lactation traits in a similar way. Increasing calving interval decreased yield per day of calving interval very strongly.

Table II. ***Phenotypic correlation between traits of economic importance in dairy buffaloes***[1]

Trait	LMY	YPDCI	PMY	SMY	LL	AAP	AFC	CI	BW
FLMY	0.84**	0.56**	0.41**	0.84**	0.39**	-0.72**	-0.70**	-0.00	0.71**
LMY		0.45**	0.67**	1.00**	0.39**	-0.72**	-0.72**	-0.02	0.89**
YPDCI			0.21*	0.47**	0.01	0.13	0.13	-0.71**	-0.13
PMY				0.65**	0.21*	0.02	0.01	-0.16	0.15
SMY					0.37**	-0.70**	-0.68**	-0.01	-0.82**
LL						-0.02	-0.02	0.15	0.23*
AAP							1.00**	-0.14	-0.07
AFC								0.13	-0.02
CI									0.10

1 FLMY: First lactation milk yield; LMY: lactation milk yield; YPDCI: Yield per day of calving interval; PDMY: peak daily milk yield; SLY; standard 305-day yield; LL: lactation length; AAP: Age at Puberty; AFC: Age at first calving; CI: calving interval; BW: calf birth weight; * P<0.05; ** P<0.01

Genotypic Correlations of Economic Traits

As shown in Table III, genotypic correlation of first lactation milk yield was positive and significant with overall lactation yield, yield per day of calving interval, standard 305-day milk yield, lactation length and birth weight. It was negatively associated with peak milk yield, age at puberty and age at first calving. Overall lactation milk yield followed the same pattern except that it showed no relationship with the peak milk yield. Yield per day of calving interval related positively with standard milk yield and negative with peak yield. In turn it was supported by early puberty, younger age at first calving, shorter calving interval and smaller birth weight.

Peak milk yield was associated with prolonged lactation, older age at puberty and first calving, prolonged calving interval and heavier birth weight. It correlated negatively with the standard 305-day milk yield. Standard 305-day milk yield was strongly affected by lactation length and birth weight.

Table III shows that a young age at puberty will result in higher first lactation milk yield, overall lactation milk yield, yield per day of calving interval, peak milk yield and lactation length. A younger age at first calving will show the same pattern except no influence on lactation length. Shorter calving interval will increase yield per day of calving interval but it will decrease peak milk yield. A higher birth weight shortened age at puberty and first calving and prolonged calving interval. It affected all lactation parameter favorably; however, the yield per day of calving interval was affected adversely.

Table III. ***Genotypic correlation between traits of economic importance in dairy buffaloes***[1]

Trait	LMY	YPDCI	PMY	SMY	LL	AAP	AFC	CI	BW
FLMY	1.00**	0.93**	-0.22*	1.00**	0.60**	-0.77**	-0.75**	0.00	0.90**
LMY		0.89**	-0.19	1.00**	1.00**	-0.71**	-0.75**	0.00	0.93**
YPDCI			-0.56**	0.91**	0.015	-0.36**	-0.28*	-1.00**	-0.61**
PMY				-0.33**	0.24*	1.00**	1.00**	0.70**	0.63**
SMY					1.00**	0.12	0.10	-0.05	0.88**
LL						0.27*	0.20	0.02	0.89**
AAP							1.00**	0.24*	1.00**
AFC								0.33**	1.00**
CI									0.81**

[1] FLMY: First lactation milk yield; LMY: lactation milk yield; YPDCI: Yield per day of calving interval; PDMY: peak daily milk yield; SLY; standard 305-day yield; LL: lactation length; AAP: Age at Puberty; AFC: Age at first calving; CI: calving interval; BW: calf birth weight; * P<0.05; ** P<0.01

Heritability Estimates of Lactation Traits

The findings of the present study showed relatively higher heritability value for first lactation traits and relatively smaller values for overall lactation traits in Nili-Ravi dairy buffaloes. During the first lactation the genetic base for lactation traits is expressed more vigorously while during later lactations the feeding support, disease occurrence, breeding management and other management parameters may confound the genetic value, decreasing its expression. Relatively smaller values were reported for first lactation milk yield by Singh *et al*. (1987; 0.52).

First lactation milk yield is an important indicator of production performance of the dairy buffaloes in later lactations, because a larger considerable development of the secretory tissues in the udder takes place during first lactation. In addition, the gland cistern capacity is maximized if production in first lactation is high. It is therefore, expected that the higher the milk yield in first lactation the better will be the production in later lactations. The higher heritability estimate (0.62) of first lactation milk yield in buffaloes in the herds studied could be explained in terms of larger total genetic variance. Therefore, direct selection for improving first lactation milk yield is expected to bring rapid genetic progress.

Yield per day of calving interval had moderate heritability (0.31) and direct selection for this trait would be expected to yield reasonable genetic improvement. This trait is a function of both lactation milk yield and length of calving interval. Thus it may not be selected directly in a breeding program. Improvement in milk yield per day of calving interval be capitalized on genetic progress in lactation yield and curtailing length of calving interval. Calving interval be shortened through improved reproduction management of herd, in addition to increasing selection pressure in favor of short calving interval. Simultaneous improvement in both lactation yield and calving interval would result in considerable enhancement in yield per day of calving interval.

Heritability estimate of first lactation standard 305-day milk yield worked out in this study 0.61 confirm the earlier value of Seeland *et al*. (1984; 0.65±0.13) in buffaloes of half-sib groups. However, Freitas *et al*. (1995) reported much lower heritability estimate of (0.06) for first lactation standard 300-day milk yield in crossbred dairy cattle. Cumulative homozygosity in the herd as a result of inbreeding could have increased total genetic variance leading to high heritability estimate.

Heritability estimate of first lactation peak daily milk yield in this study (0.35) was a little higher than the estimate given by Dahama and Malik (1991; 0.22) in Indian buffaloes. This trait would be expected to give rapid response to direct selection. Optimal environment would however, be a prerequisite for exploiting full genetic potential of the animal.

Heritability estimate of first lactation length found in this study was 0.54 which was almost the same as reported earlier by Singh *et al*. (1987; 0.50) in Nili-Ravi buffaloes. Singal *et al*. (1994; 0.03) presented smaller h^2 in Sahiwal cattle in India. Buffaloes generally, have shorter lactations and longer calving interval. The high estimate of heritability in the present study suggested that selection in favor of lactation length in first lactation would bring rapid improvement in length of lactation.

Heritability estimate for average daily milk yield recorded in this study (0.24) was almost the same as reported by Yadav *et al*. (1992) in Sahiwal cattle (0.26) while Singh and Yadav (1987) reported much lower h^2 in Indian buffaloes (0.07±0.04). The present results showed that this trait may be considered in selection program for improving overall production performance.

Heritability Estimates of Growth and Reproduction Traits

The heritability of birth weight, age at puberty, age at first calving and calving interval were relatively low (0.39, 0.21, 0.28, 0.15), which may be due to greater influence of environment and management of health, feeding and breeding than genetics.

Although the heritability estimate of birth weight for Nili-Ravi dairy buffaloes has been found to be relatively smaller but its impact on dairy production is far immense. But as per its genetic correlation with others, this trait in turn affects age at puberty and first calving, calving interval, lactation milk yield, lactation length and yield per day of calving interval. The greater birth weight would support further development of the calf through accelerated organs development, better physiological indicators and digestive efficiency, resulting in a reasonable productive life in the future. Chaurasia *et al*. (1982) reported higher heritability estimate (0.52) of birth weight in Murrah buffaloes in India than the present findings. The moderate estimate of heritability of birth weight and the higher impact of this trait on future productivity of the dairy animals makes this trait a stronger tool in the selection procedures for establishing a dairy herd.

Heritability estimate of age at puberty found in the present study (0.21) identified this trait as a candidate for direct selection. It is indicated by age and body weight and is the outcome of management of health and nutrition. Italian studies have reported that the delay in puberty and the consequent delay in conception is one of the problems that lead to low reproductive efficiency of the buffalo species, thus lengthening the non-productive life. Many factors influence age at puberty such as breed, season, climate, nutrition, and growth rate (Borghese *et al*, 1993, 1997). Campanile *et al*., (2001) concluded that nutritional management and growth from the time of weaning and during the pre-pubertal period has a considerable influence on age and body weight at first conception in buffalo heifers. The heritability estimate of 0.21 in the present study would be considered moderate suggesting that better management of the animals for obtaining earlier mature body weight would help improve this crucial trait in addition to direct selection for earlier maturity.

Heritability estimate of age at first calving found in this study (0.28) was lower than Khattab and Sultan (1990) who reported a higher (0.59) value for Holstein Friesian cattle. In contrary, Raheja (1992) reported lower heritability estimate of 0.24±0.16 in Murrah buffaloes. Singh and Yadav (1987) also reported lower heritability estimate of 0.23±0.06 in Nili-Ravi buffaloes in India. Age at first calving bears economic importance as a smaller age will reduce the cost of production and consequently the economic life of a female is prolonged.
The heritability estimate of first calving interval found during this study was smaller (0.15). Sachdeva and Gurnani (1989) reported similar value (0.16) of heritability for this breed. Singh *et al*. (1987; 0.14) reported relatively smaller heritability estimates. In contrary, Singh and Basu (1988) reported higher (0.26±0.13) heritability estimate in Indian buffaloes. Longer calving interval affects overall lifetime production and reproduction performance through reduced milk production and smaller number of calves. Length of calving interval depends on reproduction management of the herd. Timely heat detection and proper insemination would ensure conception. The lower heritability estimate (15%) of first calving interval suggested relatively smaller contribution of genetic factors to this trait. Thus, direct selection for this trait is expected to bring slower progress. Better care and reproduction management of the animal are key factors for improving calving interval.

Phenotypic and Genetic Correlations of Economic Traits

The present study has identified stronger relation-ship among various traits of economic importance. Birth weight has already been discussed having moderate heritability but an immense impact on productivity due to its correlation with the lactation, growth and reproductive parameters. Similarly age at puberty and first calving affected lactation traits.

In previous studies, correlation between first lactation yield and puberty age has been reported (Nagarcenker, 1979, r = 0.003) in Riverian buffaloes. Sane *et al*. (1972) reported higher phenotypic correlation (0.01) and low genetic correlation (0.14) between the two traits in Murrah buffaloes. Phenotypic and genetic correlation between first lactation yield and first calving interval has been found (Dong and Vleck, 1989) to be 0.27 in Holstein cows. Sachdeva and Gurnani (1989) reported a positive genetic correlation between the two traits in dairy animals. Correlations between first peak milk yield and first calving interval was reported as 0.10 (Roy and Katpatal, 1988) in Jersey cows.

CONCLUSION

Based upon the present findings it may be concluded that first lactation traits are highly heritable; birth weight is a predictor of future growth and productivity; and age at puberty and first calving are indicators of life time productivity of Nili-Ravi dairy buffaloes.

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