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Animal Model Heritability Estimates for Various Production and Reproduction Traits of Nili-Ravi Buffaloes

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ABSTRACT

Pedigree and performance records (N=3197) of 1322 Nili-Ravi buffaloes maintained at Livestock Experiment Station, Bahadarnagar, Okara, Pakistan during the period 1954 to 1998 were utilized for the estimation of heritability of various production and reproduction traits. The heritability values were estimated by using restricted maximum likelihood procedure fitting an individual animal model. The derivative-free restricted maximum likelihood set of computer programmes was used in this analysis. The heritability estimates were computed to be 0.01±0.02 for 305 day lactation milk yield (first record), 0.10±0.01 for 305-day lactation milk yield (all records), 0.001±0.01 for total lactation milk yield (first record), 0.07±0.06 for total lactation milk yield (all records), 0.06±0.05 for lactation length (first record), 0.11±0.06 for lactation length (all records) 0.07±0.14 for dry period (all records), 0.003±0.01 for age at first calving, 0.06±0.03 for service period (all records), 0.06±0.03 for gestation period (all records) and 0.04±0.05 for calving interval (all records). The low estimates for heritability for all the production and reproduction traits suggested that most of the observed variation in these traits was due to environmental conditions or non-additive genetic effects. They also indicated low correlation between genotype and phenotype of individual buffaloes and hence much more attention should be paid to the performance of collateral relatives and the progeny in selection programmes. The prospects of improvement of these traits from selection appeared to be poor. The improvement in these traits may be sought by the provision of better environmental conditions i.e. better feeding, better management etc.

Key Words: Animal model; Heritability; Nili Ravi buffalo; Pakistan

INTRODUCTION

Pakistan is primarily an agricultural country and the livestock plays an important role in the agrarian economy of the country. The livestock sector contributed 9% to the Gross Domestic Products and about 37% to the agriculture sector during the year 1998-99 (Anonymous, 1999). Among the other livestock in the country, buffaloes represent an important national genetic resource. There are two main breeds of buffaloes in Pakistan i.e. Nili Ravi and Kundi. The former is the best dairy buffalo in the world. They are the main dairy animals in Pakistan and supply about 75% of the milk produced in the country. These animals produce good quantity of milk, however, late age at first calving and long calving intervals of these animals result in reduced reproductive efficiency, calf crop and milk yield on lifetime basis. This indicates a need for the improvement of genetic merit of these buffaloes. The estimates of genetic parameters i.e. heritability and repeatability of different production and reproduction traits and genetic correlations among them are needed for the formulation of effective breeding plans and for estimation of breeding values. Salah-ud-Din (1989), Akhtar *et al.* (1990) and Khan *et al.* (1996) estimated heritability values for various performance traits of Nili-Ravi buffaloes but the methodology then used is outdated now. Best linear unbiased prediction procedure (BLUP) using animal model is now considered the method of choice for the estimation of breeding values of animals. It is considered more appropriate to use the estimates of genetic parameters from the same model as is used for the genetic evaluation of animals. Thus, the present study was planned to compute heritability estimates of different production and reproduction traits of Nili-Ravi buffaloes using the latest available analytical procedure.

MATERIALS AND METHODS

Pedigree and performance records (N=3197) of 1322 Nili-Ravi buffaloes maintained at Livestock Experiment Station, Bahadarnagar, Okara, Pakistan during the period 1954 to 1998 were utilized for the estimation of heritability of 305-day lactation milk yield (first record), 305-day lactation milk yield (all records), total lactation milk yield (first record), total lactation milk yield (all records), lactation length (first record), lactation length (all records), dry period (all records), service period (all records), gestation period (all records) and calving interval (all records). Only normal and complete records of the buffaloes were included in the analysis. Incomplete lactations showing any abnormality were not used. Lactation records of less than 150 days were also not considered in the analyses. Keeping in view the climatological data, the year of birth / calving / service was divided into following seasons. Winter, December to January; Spring, February to

April; Hot dry, May to June; Hot humid, July to September, Autumn, October to November. Various fixed effects observed to be significant sources of variation of different performance traits were fitted in the following model for the estimation of heritability. This included year of calving for 305-day lactation milk (first record) and total lactation milk yield (first record). The lactation length was fitted as a covariate (linear). For 305-day lactation milk yield and total lactation milk yield considering all records, the effect of lactation number was included in addition to the effect of year of calving and lactation length (convariate). The effects included for other performance traits were: year and season of calving for first lactation length; year and season of calving and lactation number for lactation length (all records); year of calving for dry period; year and season of service and lactation number for service period; season of service for gestation period; and year and season of calving and lactation number for calving interval. The heritability values were estimated by using restricted maximum likelihood (REML) procedure as proposed by Patterson and Thompson (1971) fitted an individual animal model. The derivative-free restricted maximum likelihood (DFREML) set of computer programmes (Meyer, 1997) was used for the analysis. All of the available pedigree information was included in the analysis in an attempt to minimize the bias due to selection and non-random mating. The convergence criterion (variance of function value –2 log likelihood) for various genetic parameters was 1 x 10^{-8}. The heritability estimates were computed by assuming the following mixed model:

$Y_{ijk} = \mu + A_i + F_j + e_{ijk}$ where, Y_{ijk} is the measurement of a particular trait; μ is the population mean; A_i is the random additive genetic effect of ith animal with mean zero and variance $\sigma^2_{A;}$ F_j is the fixed effects observed to be significant from the initial analyses and e_{ijk} is the random error with mean zero and variance σ^2_E Phenotypic variance (σ^2_P) was assumed to be the sum of additive genetic variance (σ^2_A) and the residual variance (σ^2_E). The heritability was calculated as σ^2_A/σ^2_p.

RESULTS AND DISCUSSION

The heritability estimates for various performance traits as obtained from the animal model analysis have been presented in Table I. They have been discussed in the following under separate headings:

Milk yield. The heritability estimates for first lactation 305–days milk yield was 0.01±0.02 (Table I). This estimate was calculated from animal model analysis of 1182 lactation records. The estimate of heritability as obtained in the present study was in agreement with the heritability estimate (0.04) reported by Rathi *et al.* (1971) in Indian buffaloes as cited by Basu (1985). Low estimate of heritability for first lactation 305-day milk yield had also been reported by Tailor *et al.* (1995) in Surti buffaloes of India. The data of 501 buffaloes were analysed by paternal half-sib correlation technique and the value of heritability was reported to be 0.08. The estimate of heritability for first lactation 305-day milk yield in the present study was not in agreement with the estimates of heritability reported by many other workers (Kornel & Patro, 1988; Dass & Sharma, 1993; Puri *et al.*, 1994). The estimates of heritability for first lactation 305-day milk yield as reported by these workers ranged from 0.30 to 0.43 in different Indian breeds of buffaloes.

The heritability estimates for 305-day milk yield considering all records of the available lactations was 0.10±0.01(Table I). This estimate was calculated from animal model analysis of 3141 lactation records of 1308 buffaloes. The estimate of heritability as obtained in the present study was in agreement with the heritability estimate (0.05) reported by Mourad *et al.* (1993) in Egyptian buffaloes for this trait. However, this estimate is lower than those of Velea *et al.* (1991), Pilla and Moioli (1992) and Tiwana *et al.* (1994) in Romanian (0.35), Italian (0.27) and Indian Murrah (0.44) buffaloes, respectively.

The heritability estimates for total lactation milk yield (first record) was 0.001±0.01 (Table I). This estimate was calculated from animal model analysis of 1182 lactation records. The estimate of heritability as obtained in the

Table I. Heritability estimates for various production and reproduction traits of nili-ravi buffaloes

Traits	No. of Sires with progeny records	No. of records	No. of animals with records	No. of animals in pedigree	Heritability estimate ± Standard Error
Production Traits					
305-day lactation milk yield (first record)	48	1182	1182	1675	0.01±0.02
305-day lactation milk yield (all records)	51	3141	1308	1678	0.10±0.01
Total lactation milk yield (first record)	48	1182	1182	1675	0.001±0.01
Total lactation milk yield (all record)	51	3141	1308	1678	0.07±0.06
Lactation length (first record)	50	1183	1183	1677	0.06±0.05
Lactation length (all record)	52	3197	1322	1678	0.11±0.06
Dry period (all records)	46	1991	901	1676	0.07±0.14
Reproduction Traits					
Age at first calving	50	1183	1183	1677	0.003±0.01
Service period (all records)	51	2470	1122	1678	0.06±0.03
Gestation period (all records)	51	2923	1246	1677	0.06±0.03
Calving interval (all records)	48	1797	829	1676	0.04±0.05

present study was in agreement with the heritability estimates reported by Kornel and Patro (1988) in Surti (0.03) and Salah-ud-Din (1989) in Nili-Ravi (0.06) buffaloes, respectively. Low estimate of heritability for total lactation milk yield (first record) had also been reported by Umrikar and Deshpande (1985) in Murrah buffaloes of India. The data of 678 buffaloes were analyzed by paternal half-sib correlation technique and the value of heritability was reported to be 0.09. Several other workers (Raheja, 1993; Avadesian, 1996; Ayyat *et al.*, 1997) reported higher estimates of heritability for total lactation milk yield (first record) than the present study. The estimates of heritability as reported by these workers ranged from 0.20 to 0.28 in various breeds of buffaloes. The heritability estimate for total lactation milk yield considering all records of the available lactation was 0.07±0.06 (Table I). This estimate was calculated from animal model analysis of 3141 lactations records of 1308 buffaloes. The estimate of heritability as obtained in the present study was lower than the estimates of heritability reported by several other workers (Pilla & Moioli, 1992; Juma *et al.*, 1994; Tiwana *et al.*, 1994; Tonhati *et al.*, 1997) in various breeds of buffaloes. The estimates of heritability as reported by these workers ranged from 0.25 to 0.45.

Lactation length. The heritability estimate for first lactation length was 0.06±0.05 (Table I). This was based on the animal model analysis of 1183 lactation records. The estimate of heritability for lactation length as obtained in the present study was in agreement with the findings of other workers (Sharma & Basu, 1985; Salah-ud-Din, 1989; Raheja, 1993) who reported the heritability estimates ranging from 0.02 to 0.08 in various breeds of buffaloes. However, the estimate of heritability for lactation length in the present study was not in line with some other workers (Kanaujia *et al.*, 1990; Mohamed *et al.,* 1991; Ayyat *et al.*, 1997) who reported higher estimates of heritability (0.11 to 0.25) for lactation length in different breeds of buffaloes.

The heritability estimate for lactation length considering all records was 0.11±0.06 which was based on 3197 lactations of 1322 buffaloes (Table I). The finding of the present study regarding the estimate of heritability for lactation length (all records) was substantiated from the findings of Gogoi *et al.* (1984) and Tailor *et al.* (1992) who reported heritability estimates of 0.09 (Murrah) and 0.16 (Surti) for this trait, respectively. The heritability estimates for lactation length (all records) reported by Juma *et al.* (1994) and Tonhati *et al.* (1997) were zero (Iraqi buffaloes) and 0.01 (Murrah), respectively, which were lower than that observed in the present study. However, the heritability estimates as reported by Metry *et al.* (1994) and Tiwana *et al.* (1994) for lactation length (all records) were relatively very high than the present estimate. The values of heritability as found by these workers were 0.28 (Egyptian) and 0.36 (Murrah), respectively.

Dry period. The estimate of heritability for dry period computed on the basis of 1991 lactation records from 901 buffaloes was 0.07±0.14 (Table I). The estimate for heritability for dry period in the present study was in agreement with the results of some other workers (Marques *et al.*, 1994; Tiwana *et al.*, 1994; Dutt & Taneja, 1995) who reported the heritability estimates for dry period in different breeds of buffaloes ranging from 0.07 to 0.10. However, Juma *et al.* (1994) reported a relatively higher heritability value for dry period in Iraqi buffaloes. The data of 282 buffaloes consisting of 842 lactation records collected during the period 1967 to 1988 at the Misan Animal Breeding Station, Iraq were analysed. The heritability estimate was calculated to be 0.18. In Nili Ravi buffaloes of Pakistan Salah-ud-Din (1989) reported a negative estimate of heritability (-0.07±0.04) for dry period from the paternal half sib analysis of 2587 lactation records.

Age at first calving. The heritability estimate for age at first calving was 0.003±0.01 (Table I). This was computed using animal model from 1183 records. Very low estimate of heritability for age at first calving had also been reported in the literature. The value reported by Juma *et al.* (1994) was 0.01 in Iraqi buffaloes. The present estimate of heritability was, however, lower than those of Salah-ud-Din (1989), Chakravarty and Rathi (1989), Dahama *et al.* (1991), Dutt and Taneja (1995), Khan *et al.* (1996) and Tonhati *et al.* (1997) who reported the heritability estimates of age at first calving ranging from 0.20 to 0.45 in various breeds of buffaloes. Very low estimate of heritability for age at first calving as obtained in the present study suggested that the trait was mostly under the influence of environment. Additive genetic effects are not very important in the control of the trait and improvement in the trait *i.e*. reduction in age at first calving may be sought through better feeding and management.

Service period. The estimate of heritability for service period in the present study was computed to be 0.06±0.03 (Table I). This estimate was worked out from 2470 records of 1122 buffaloes. It was in agreement with the findings of Tiwana *et al.* (1994). The breeding records of 270 Murrah buffaloes collected over a period of 18 years were analyzed. The heritability of service period was reported to be 0.07. Metry *et al.* (1994) also reported a very low heritability value (zero) for service period in Egyptian buffaloes.

Gestation period. The estimate of heritability for gestation period was 0.06±0.03 (Table I). This estimate was calculated from 2923 records of 1246 buffaloes. Similar estimate of heritability for this trait had also been reported by Johari and Bhat (1979) as cited by Basu (1985) in Indian buffaloes. The value of heritability as reported by these workers was 0.032.

Calving interval. The estimate of heritability for calving interval based on 1797 calvings of 829 buffaloes was 0.04±0.05 (Table I). It was in line with the findings of Metry *et al.* (1994). The data of 316 buffaloes sired by 77 bulls, comprising of 1538 records was analyzed using paternal half-sib correlation technique. The heritability of calving interval was reported to be 0.02. It was also in agreement with the results obtained from many other studies (Salerno, 1960; Alim, 1978; Vikkram & Desai, 1979). The estimates of heritability for calving interval as obtained by these workers ranged from 0.04 to 0.06 in different breeds of buffaloes. Slightly higher estimates of heritability (0.10 to 0.13) for calving interval as compared to the present study had also been reported by some other workers (Vankov, 1991; Juma *et al.*, 1994; Tonhati *et al.*, 1997) in various breeds of buffaloes. However, the estimate of heritability for calving interval as reported by Tiwana *et al.* (1994) was found to be the highest (0.30) ever reported in the literature.

In the present study, the estimates of heritability for various production traits were all unusually low and ranged from 0.001 to 0.11. Similar trend (0.003 to 0.06) was observed for the reproduction traits. However, all these estimates are within the range of the estimates published world wide. The low estimates of heritability suggested that additive gene action is not important for these traits and thus genetic progress through selection within the herd will be slow. The low values of heritability further suggested that variation in performance traits were completely due to environmental influences. Therefore, for example, reduction in length of dry period could be achieved with better feeding and better management practices. Hormonal therapy may be worth while for the treatment of reproductive disorders to reduce length of dry period.

Similarly improvement in production is likely to be achieved by improved feeding and management practices, alleviation of heat stress and better control of diseases, including vaccination programs. Steps must be taken to reduce the age at first calving, which at the moment is around 50 months. This could be achieved by better management and by better feeding of calves before and after weaning. Such steps would warrant a reduction in production costs. In addition, some emphasis must be placed on genetic improvement; this would require the implementation of a wide spread milk recording and testing system. Once elite buffaloes had been identified, it would be possible to establish a nucleus of animals for use in breed improvement.

The low estimates of heritability for various production and reproduction traits as obtained in the present study also suggested that either sources of environmental variation have not been identified or accounted for or certain factors are confounded with cow effects causing the additive genetic component to be under estimated. For milk yield, a possible source of variation that could not be taken into account was the variation due to different milkman. All buffaloes are hand milked because a milking machine has not probably been devised for them due to the peculiar anatomical structure of their teats. About 10- 14 buffaloes are usually allotted to each milkman but the identity of each milkman for each lactation was unavailable for this study. Another possible reason for the low estimates of heritability could be the reduced variability among the animals due to selection. However, in the present herd, selection of animals was based primarily on pedigree or phenotypic characteristics such as body colour rather than on true merit and therefore would not be expected to reduce variability among the animals to a marked extent.

In order to improve dairy economy, emphasis on culling of buffaloes not showing estrous within four to six months after calving, or not conceiving despite repeat breeding is worth consideration. Culling could improve the reproductive performance to some extent, however, the genetic effect in the population would be negligible. In traits which are having low heritability such as calving interval, it is essential to use bulls tested with a reasonably high accuracy for the trait in question. Hence, improved feeding and management, along with some culling of buffaloes is the most important way to achieve quick reduction in calving interval as well as age at first calving.

The results of the present study suggested that it seems certain that selection of buffaloes for production and reproduction traits can not be very effective. An implication of these results is that any marked improvement obtained in the reproductive efficiency of the dairy animal population must be brought about by improvement of nutritional and or other environmental factors that exert an influence on the process of reproduction. Better feeding and management is an essential prerequisite for lowering the age at first calving in buffaloes. Basu *et al.* (1984) reported that the growth rate in buffalo calves was maximum between 3 to 12 months, which declined sharply after one year of age. The young females, when one year old, were generally kept together with older animals and as a result they failed to get their due share of nutrition. The problem appeared to be management. This contention in further substantiated by the findings that the mean age at first heat in buffalo heifers in India was reduced from 34 to 28 months, which was partly attributed to the improved management (Basu, 1985).

Similarly, a great reduction in calving interval can be brought about by improving the environmental conditions. Ashfaq and Mason (1954) reported that calving interval was reduced from 20 months to less than 13 months in 4 years period as a result of improvement in the management of Nili Ravi buffaloes during 1947-51. Since, calving interval is the linear combination of gestation period and service period, and the former being only about 3% variable (Basu, 1985), most of the variation in service period can be attributed to non-genetic factors related to feeding, management, climate and intensity of breeding operations., The initiation of breeding 45 to 50 days post-calving, coupled with an intensive program of heat detection and efficient insemination is essentially to be practiced.

As already mentioned, the heritability estimates for almost all the production and reproduction traits under study were low. The heritability estimates usually vary between breeds, herds, level of productivity, method of estimation and even periods of time for a particular trait. Inbreeding might reduce the genetic variance (Falconer & Mackay, 1997), where as different management and environmental factors in different breeds, herds and years might increase the phenotypic variation. The low estimate of heritability could also be a function of lower production, misidentification and for animal model incomplete pedigrees might also have contributed to the lower heritabilities. The low heritability is caused not only by a low genetic variance but rather a higher phenotypic variance due to small size of herd, random or unidentified environmental factors. Considering, that the climate, disease and other environmental factors exert great effects on performance in subtropical and tropical regions, it was not surprising that heritability may be low.

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