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First Lactation Genetic Parameters of Buffaloes Under Multiple Trait Animal Model

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المقاييس الوراثية لفترة الإدرار الأولي في الجاموس بإستخدام النموذج الحيواني للصفات المتعددة

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خلاصة: هناك الكثير من خطط البرمجة المتوفرة لحساب مكونات التباين والتباين المرافق ضمن النماذج ذات الصفات المتعددة. تعتبر العلاقة نصف الأخوية من جهة الأب الأكثر استخداما لتقدير المقاييس الوراثية للصفات ذات الأهمية الاقتصادية في الجاموس. والنماذج المستخدمة هي ذات الصفة الواحدة بإهمال التباين المرافق مع الصفات الأخرى. كذلك تهمل علاقة المصفوفات. أجريت هذه الدراسة لتقدير المقاييس الوراثية لصفات أول فترة إدرار في الجاموس النيلي الرافي بإستخدام الأنموذج الحيواني ذو لصفات المتعددة. إنتاج الحليب في أول فترة إدرار تم توريثه بنسبة ١٧٪ عند اعتبار صفات مثل العمر والفترة بين الولادات. تم توريث العمر عند أول ولادة بنسبة ١٨٪ مع وجود علاقة وراثية منخفضة جدا مع الصفات الأخرى. كانت صفات طول فترة الإدرار وفترة الجفاف والفترة بين الولادات ذات معاملات توريث منخفضة. اختلفت التقديرات بتضمين أو حذف الصفات حسب التباين المرافق بين هذه الصفات. لا يعني وجود علاقة وراثية قوية بين إنتاج الحليب وطول فترة الإدرار (٠,٧٤) تلقائيا الانتخاب لصفة إنتاج الحليب فقط.

ABSTRACT : There are many computational algorithms available for estimating (co) variance components under multiple trait models. Paternal half-sib correlation is the most commonly used method for estimating genetic parameters of economic traits of buffaloes. The models used are single trait, ignoring covariances with other traits. The relationship matrices are also ignored. This study was undertaken to estimate genetic parameters of first lactation traits of Nili Ravi buffaloes under a multiple trait animal model. First lactation milk yield was 17% heritable when traits such as age of calving interval were considered. Age at first calving was 18% heritable with very low genetic correlations with other traits. Lactation length, dry period and calving interval were lowly heritable traits. Estimates differed by inclusion or exclusion of traits due to the covariances present among all these traits. A high genetic correlation between milk yield and lactation length (0.74) does not warrant the selection of milk yield as the only trait.

Until recently, simple best linear unbiased prediction (BLUP) evaluation of animals was very popular. Due to the unavailability of computational algorithms and a very high computation cost, it was not feasible to incorporate huge relationship matrices to avoid selection bias over time. Most of the genetic parameters available for various species of livestock were from single trait models, especially for species such as buffalo where large data sets with recording of traits other than milk production are not available.

The availability of statistical algorithms has changed. Computer programs available for multiple trait analysis include DFREML (Meyer, 1988), PEST (Groenveld *et al.* 1990), MTDFREML (Boldman *et al.* 1993), DMU (Jensen and Madsen, 1993), and MTC (Misztal, 1994). With such software, solutions to mixed model equations and estimation of variance components are by restricted maximum likelihood (REML) (Patterson and Thompson, 1971). All of them support animal models with fixed and random cross-classified effects as well as covariables. These programs are basically written for main frame computers or at least for work-stations and are not user-friendly for the Personal Computer (PC) environment. The DFREML and even PEST have been modified for this purpose and are available for use on PC's. The same is true for MRTDFREML and MTC that can be run under Disk Operating System (DOS) or Operating System 2 (OS/2) environments.

Genetic parameters for dairy cattle elsewhere are available for animal models in single trait and multiple trait situations. Traits such as type and other auxiliary traits have even been studied. Misztal *et al.* (1992), for example, reported genetic correlations among yield and type traits under a multiple trait animal model for Holsteins. Using REML procedures, Raheja (1992, 1993) reported genetic parameters for milk yield, lactation length, service period, calving interval, and dry and open periods for Murrah buffaloes. Multiple trait genetic parameters for economic traits of Nili-Ravi buffaloes are not available.

The present study deals with estimation of genetic parameters of some first lactation traits of Nili-Ravi buffaloes under a multiple trait animal model.

Materials and Methods

Data on performance traits that were recorded

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before the second calving were used from four institutional herds and four data recording centers. The traits analyzed included age at first calving, first lactation, milk yield, lactation length, dry period and first calving interval. The records were required to have milk yield information of at least 305 days, or less with lactation length of at least 60 days. A total of 1352 lactation records over a 25 year period were available for the analyses. April through September was considered as summer and October through March as winter.

Milk yield (kg) was included in all six models (M1 to M6) compared but inclusion of other traits differed. In the first model, lactation length (days) was included. The second and third models had three traits; the second had age at calving while the third had calving interval. The fourth and fifth models had milk yield, age at first calving and calving interval but not lactation length or dry period. The sixth model had all five traits. The number of lactations was 1352 for the first two models and 809 for M3 to M6. The only fixed effect in all the models was herd-year-season subclass. The levels of this effect varied for the first two and the last four models because in the latter case only five of the eight herds were represented. Although all known relationships were included in the matrix, the number of animals added (other than animals with records) were not more than 15% of the actual records indicating the limitation of the pedigree information available.

The statistical model for the first analysis (M1) was:

$$Y = (I_t \otimes X)\, b + (I_t \otimes Z)\, a + e$$

where Y is a matrix of dependent variables having vectors of age at first calving, milk yield, lactation length, dry period and calving interval; b is a vector of fixed effects (herd-year-season combinations); a and e are vectors for random animal and environment effects; t is number of traits, i.e. 5; $\otimes$ is Kronecker product, X and Z are incidence matrices for b and a vectors. The other models were similar to this one but the size of the various matrices varied according to the number of the traits and the records available for them. Genotype by environment interaction was ignored. The distributional and other assumptions were similar to Da and Grossman (1991). The computer software used was MTC (Misztal, 1994).

Results and Discussion

Means and standard deviations of the five traits analyzed are given in Table 1. Milk yield averaged 1959 kg which was more than what is usually reported for Nili-Ravi buffaloes (Cady *et al.* 1983; Reddy and Taneja, 1983a). The major reason for this higher average was that the animals used in this study included prospective bull mothers which are usually better animals than the population in general. The dry period was the most variable trait followed by the milk yield and calving interval. The means and the standard deviations for these traits were within the range of statistics reported for buffaloes in most studies. For example, age at first calving was similar to the study by Ashfaq and Mason (1954), where the average age was 47 months. Salah-ud-Din (1989) also reported a similar average (48 months). Other studies on Pakistani buffalo show similar means but the means of other breeds of buffalo are quite different. In Egyptian buffaloes, Alim (1978) reported age at first calving to be 40 months for a sample of 240 buffaloes. As for the high coefficient of variation for the dry period, a similar variation (62%) was reported by Raheja (1992) for Murrah Buffaloes. First lactation milk yield was 28% variable and lactation length 21% variable.

Estimate of heritabilities of the traits from different models are given in Table 2. When milk yield was was considered along with lactation length (Model 2) or with lactation length and age of calving (Model 3), the estimate was only 11% for heritability. But when the other two traits, i.e. dry period and calving interval

TABLE 1

Means, standard deviations (SD) and coefficients of variation (CV) of first lactation traits

Trait	Mean	SD	CV(%)
Age at first calving, month	49.2	7.4	15.1
First lactating milk yield, kg	1958.7	641.9	32.8
Lactation length, day	277.1	45.1	16.3
Dry period, day	274.9	169.5	61.7
Calving interval, day	588.9	192.0	32.6

TABLE 2

Heritability estimates under different models (M1 to M6)

Trait	M1	M2	M3	M4	M5	M6
Age at first calving, month	-	0.11	-	0.18	0.18	0.18
First lactation milk yield, kg	0.11	0.11	0.17	0.17	0.17	0.17
Lactation length, day	0.10	0.10	0.13	-	0.13	0.13
Dry period, day	-	-	-	0.08	-	0.09
Calving interval, day	-	-	0.09	0.11	0.11	0.12

were considered (Model 3, Model 4 and Model 5), the additive genetic fraction of variance increased to 17%. This parameter did not change when all the five traits were considered simultaneously (Model 6). Age at first calving had similar heritability of less than 15%. The lowest value was for dry period, meaning that most of the variation in this trait was due to the environment. Genes had very little role to play. Calving interval which is composed of lactation length and dry period had a heritability estimate in between these two traits (Model 6).

Heritability estimates for first lactation milk yield reported in the literature have a wide range. Estimates of less than 10% (Johari and Bhat, 1979; Reddy and Taneja 1984a) and as high as 65% (Singh, 1967) have been reported. Most studies however, report this parameter to be in the range of 15 to 20% (Bhalaru and Dhillon, 1978; Gurung and Johar, 1982). Estimates of variance in age at first calving due to additive genetic effects vary widely. Heritability estimates as low as 0.12 (Reddy and Taneja, 1984b) and as high as 0.32 (Gurung and Johar, 1982) have been reported for buffaloes. Heritability estimates for the other traits, calving interval, dry period and lactation length, also vary widely in the literature. Calving interval was reported to be entirely an environmentally controlled trait by Akhtar *et al.* (1992).

Phenotypic and genetic correlations for the model having all traits (Model 6) are presented in Table 3. Phenotypic correlations among the traits were low except for the correlation between lactation length and milk yield and between dry period and calving interval. Estimates of genetic correlations between age at calving and dry period and age at calving and calving interval were 0.619 and 0.534 respectively. These estimates imply that reducing the age at first calving will reduce the dry period and the calving interval. The genetic correlation between milk yield and lactation length was 0.742. Thus, increasing milk yield without restricting lactation length would not be a good option because it would increase lactation length. The other high genetic correlation was between calving interval and dry period, due perhaps to part and whole relationship between the two traits.

Raheja (1992) used the REML procedure under multiple trait model for calculation of sire components of variance and covariance for genetic parameters estimation in Murrah buffaloes. The relationship matrix was assumed to be an identity matrix. Heritability estimates for first lactation milk yield, lactation length and dry period were 0.28, 0.05 and 0.05 respectively. Days open was also in the model as a fourth trait. When gestation period was added as the fifth trait, heritability estimates were 0.23, 0.08, and 0.05 for the three traits (Raheja, 1993). Milk yield had

TABLE 3

Estimates of phenotypic (below diagonal) and genetic (above diagonal) correlations and heritabilities (diagonal) among first lactation traits

Trait	1	2	3	4	5
Age at first calving, month	0.179	0.045	0.009	0.001	-0.001
First lactation milk yield, kg	-0.114	0.167	0.742	0.066	0.321
Lactation length, day	-0.011	0.662	0.130	0.015	0.363
Dry period, day	0.619	-0.047	0.087	0.092	0.903
Calving interval, day	0.534	0.227	0.366	0.955	0.121

a genetic correlation of 0.51 with lactation length and -0.31 with dry period. Genetic correlation between lactation length and dry period was 0.17. High positive genetic correlation between milk yield and lactation length and low genetic correlation between lactation length and dry period and milk yield and dry period in the present study are similar to findings of Raheja (1993). The high correlation between first lactation length and first calving interval was expected because lactation length is part of calving interval and a major source of variation in it. Increasing lactation length would increase the calving interval and thus would decrease the response to selection (per unit of time) by increasing the generation interval.

First lactation milk yield is about 15-20% heritable in Nili-Ravi buffaloes with a high genetic correlation with lactation length. Thus selection based only on first lactation milk yield is likely to increase the lactation length and consequently, the calving interval. Thus, for better economic gains, a restricted selection index (restricting change in lactation length) might be considered. Also, the genetic parameters differ from population to population and should be calculated for the given population for application. The usual procedures applied ignore covariances with other traits of economic importance. To account for the relationship matrix is computationally expensive and available commercial software usually do not account for it. Its inclusion, however, improves the accuracy of the estimates. These aspects of genetic parameters estimation should be taken into account for estimation of genetic parameters for implementation in any selection program.

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