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GENETIC AND PHENOTYPIC EVALUATION FOR REPRODUCTIVE PERFORMANCE OF EGYPTIAN BUFFALOES

M. H. KHALIL[1], K. A. MOURAD[2], M. M. MOHAMED[2] AND J. B. OWEN[3]

[1]*Department of Animal Production, Faculty of Agriculture at Moshtohor, Zagazig University, Banha Branch, Moshtohor, Egypt*

[2]*Animal Production Research Institute, Ministry of Agriculture, Dokki, Cairo, Egypt*

[3]*Centre for Arid Zone Studies, University of Wales, Bangor LL57 2UW*

ABSTRACT

An analysis of cow reproductive traits was carried out on 2057 lactation records of Egyptian buffaloes. A total of 651 daughters (paternal half-sisters) of 82 sires were available for the analysis. Reproductive traits analysed were age at first, second and third calving (AC), number of services per conception (NSC), gestation length (GL) and calving interval (CI). Year of calving affected most reproductive traits ($P < 0{\cdot}001$) while no important differences were detected among months of calving. Means of NSC, GL and CI decreased linearly ($P < 0{\cdot}01$) as parity advanced. Age of cow at calving exerted a pronounced effect ($P < 0{\cdot}001$) on NSC and CI. There was no systematic change in the estimates of heritability and sire components of variance for reproductive measures over the first three lactations. Heritability estimates for NSC and GL in the different parities were generally low, ranging between 0·04 and 0·18, while moderate estimates for AC and CI were obtained. Phenotypic correlations between reproductive traits were positive and relatively moderate or low. For most traits, positive and relatively high or moderate estimates of genetic correlations were observed. Mating bull was found to be an important source of variation for reproductive performance of Egyptian buffaloes. The highly significant effect of mating bull on reproductive traits could be considered as evidence for the importance of evaluating bull semen quality before the mating of cows.

KEYWORDS: buffaloes, genetic gain, phenotypic selection, reproductive performance.

INTRODUCTION

IN many developing countries and in Egypt, in particular, agricultural production is mainly in the hands of numerous small farmers. In such situations the buffalo serves as an economically important source of milk and meat. The major factors limiting full utilization of this species in agricultural production are, besides nutrition, lack of improved breeding stock and low reproductive efficiency. However, the major causes of low reproductive efficiency in the buffalo are the relatively late onset of puberty and long post-partum service period and calving interval (Jalatge and Buvanendran, 1971; Lundström, Abeygunawardena, de Silva and Perera, 1982). The problem of silent heats in buffaloes is much more prevalent than in cattle and is considered one of the causes that lengthens the calving interval and delays the age at calving.

Information on the genetic aspects of reproductive performance of the Egyptian buffaloes is scarce. Therefore, the main objective of this study was to conduct a genetic evaluation for reproductive performance of Egyptian buffaloes. Special attention was paid to the estimation of the effect of mating bull on such reproductive performance.

MATERIAL AND METHODS

Records of reproductive performance of a herd of Egyptian buffaloes raised at Mehallet Mousa Experimental Farm, Animal Production Research Institute, Ministry of Agriculture, Egypt were used in this study. Data on 2057 lactation records on 651 cows sired by 82 bulls were collected over a period of 11 years from 1962 to 1972. Animals were kept on fields of Egyptian clover (*Trifolium alexandrinum*) to graze *ad libitum* through the period from December to May. During these months, cows that were heavy milk producers and those in the last 2 months of pregnancy were supplemented with extra dry concentrates proportional to their weight and production. During the other months of the year (beginning of June until the end of November), animals were housed in open sheds for their protection from direct solar radiation and given a dry concentrate according to their live weight and production. Hay of Egyptian clover or green sweet sorghum was offered only to heavy milk producers.

Bulls were assigned to mate the females naturally and at random. Artificial insemination was only practised when there was a probability of genital disease infection. Heifers were served for the first time when they reached 24 months, while buffalo cows were usually served 2 months *post partum*. Pregnancy was detected by rectal palpation 60 days after the last service. Buffaloes that failed to conceive were rebred in the next heat period. Calves were left to suck their dams for 3 days after calving and were bucket fed afterwards until weaning at 3·5 months.

Reproductive traits examined included age at first (AC1), second (AC2) and third calving (AC3), number of services per conception (NSC), gestation length (GL) and calving interval (CI). These traits were analysed using Harvey's (1977) mixed models where sires and cows-within-sires, as random components, contributed to variance components associated with differences among sires of paternal half-sibs and among cows having repeated measurements, respectively. Data on AC1, AC2 and AC3 were analysed fitting the effects of year and month of calving and sire. NSC, GL and CI for each parity were analysed fitting these effects along with age of cow as a covariable while overall NSC, GL and CI were analysed fitting the effects of year, month, parity, sire, cow within sire and age of cow as a covariable. The absence of records in some subclasses did not permit the inclusion of all possible interactions. Henderson's method 3 was utilized to estimate the genetic and phenotypic variance and covariance components for the different traits. The estimates of genetic and phenotypic variances and covariances were used to compute heritabilities and genetic and phenotypic correlations. By equating mean squares of random effects to their expectations, estimates of variance components, i.e. sire (σ^2_s), cow within sire ($\sigma^2_{c:s}$) and remainder (σ^2_e) were obtained. Paternal half-sib heritabilities (h^2) for reproductive traits in each lactation were calculated as four times the ratio of σ^2_s to the sum of σ^2_s and σ^2_e. Heritabilities across all lactations were estimated for NSC, GL and CI by the paternal half-sib method as: $h^2 = 4\sigma^2_s/(\sigma^2_s + \sigma^2_{c:s} + \sigma^2_e)$. Genetic and phenotypic correlation coefficients between any two traits were computed by using the formulae outlined by Harvey (1977). The approximate standard errors for h^2 were computed according to Swiger, Harvey, Everson and Gregory (1964).

Data on NSC, GL and CI were also analysed using the same model as for sire, but replacing sire with mate of cow (mating bull). Accordingly, estimates of variance components of random effects for mating bull (in each lactation separately) and for mating bull and cow within mating bull (across all lactations) were obtained.

RESULTS AND DISCUSSION

Means, standard errors and coefficients of variation (CV) for calving age, NSC, GL and CI are given in Table 1. Means reported here fall within the range of estimates obtained on Egyptian buffaloes (e.g. Alim, 1978; Oloufa and Stino, 1979), Murrah buffaloes in Sri Lanka (Jalatge and Buvanendran, 1971; Lundström *et al.*, 1982) and under village conditions in India (Raut, Singh and Choudhary, 1974). However, long calving interval and large number of services per conception as well as delayed age at calving (Table 1) may be caused by several factors, e.g. the operator's decision, delayed onset of ovarian activity, silent heat or missed oestrus due to weak symptoms and

TABLE 1

Least-squares means, standard errors and coefficients of variation of reproductive traits of Egyptian buffaloes

Traits		Mean	s.e.	CV†
Age at calving (months)				
Lactation	1	60·4	1·6	53·1
	2	78·2	3·8	45·0
	3	92·2	1·8	10·1
No. of services per conception				
Lactation	1	2·06	0·120	44·5
	2	1·90	0·083	48·2
	3	1·67	0·065	54·5
	4	1·45	0·072	62·5
	5	1·31	0·099	69·1
	6	1·15	0·149	78·7
	all	1·59	0·033	56·9
Gestation length (days)				
Lactation	1	319	2·7	2·8
	2	320	1·8	5·7
	3	315	1·4	5·8
	4	315	1·6	6·5
	5	308	2·2	6·7
	6	308	3·3	6·7
	all	314	0·6	6·5
Calving interval (days)				
Lactation	1	676	21·9	26·2
	2	597	15·9	34·1
	3	508	13·1	23·2
	4	477	14·2	33·0
	5	423	18·4	37·2
	6	364	26·7	43·2
	all	498	19·7	31·6

† Coefficient of variation calculated as the remainder standard deviation divided by the overall least-squares mean of the trait (Harvey, 1977).

the time elapsing before receiving a fertile service (Lundström *et al.*, 1982). It is well documented that poor oestrous detection is one of the most important factors involved in fertility problems of buffaloes. In Murrah buffaloes in Sri Lanka, ovarian activity is often delayed 100 to 300 days after parturition (Lundström *et al.*, 1982). Reports from India (Kanaujia, Balaine and Rathi, 1975; Paragaonkar and Kaikini, 1977) suggest that the average service periods for River and Nagpuri buffaloes are approximately 113 and 68 days, respectively. In Egypt, results of Oloufa and Stino (1979) and Mourad, Youssif and Khattab (1985) indicated that the mean interval from calving to conception was 141 and 175 days, respectively.

Estimates of CV given in Table 1 showed that variations in age at calving, NSC and CI were relatively high compared with that of GL. Poor mangement of buffalo herds in Egypt leads to such high variation in reproductive performance. The coefficients of variation for age at calving in the first two lactations (0·531 and 0·450) are much higher than the corresponding estimate in the third lactation (0·101), i.e. variation in age at calving decreased as parity advanced.

Year of calving

The effect of year was significant for AC2, AC3, NSC and CI traits ($P < 0{\cdot}001$). Estimates of individual year effects are too numerous to be reported here. Most of the reviewed studies indicated significant influence of year of calving on reproductive traits in Egyptian and/or Indian buffaloes (e.g. Basu, Bhoserekar, Goswami and Sarma, 1978; Farrag, El-Shinnawy, Abdel-Aziz and El-Irian, 1982; Kotby, Bedeir, El-Sobhy and Eid, 1987). However, there was no trend for year effect on reproductive traits studied. It is clear that the year effects represented primarily management or environmental rather than genetic changes, since the effect of sire was accounted for in the models of analysis.

Month of calving

Means of month of calving did not show any specific trend for most reproductive traits studied. The effects of month of calving on age at calving and GL were not significant, while significant effects for CI and NSC were observed. Cows calving during autumn and winter had shorter calving intervals and fewer services per conception. However, most of the Egyptian studies (e.g. El-Fouly, Afifi and Kirella, 1977; Farrag *et al.*, 1982; Mourad, Khattab and Ibrahim, 1989) reported a significant effect for month or season of calving on reproductive traits of Egyptian buffaloes. It appears from this and other Egyptian studies that a considerable proportion of the animals remain anoestrus for a prolonged period in the summer, until the advent of the next winter season (i.e. favourable months for conception), thereby contributing to a lengthening of the mean CI. The findings of El-Fouly *et al.* (1977) indicated that an important reason is a delayed onset of post-partum ovarian activity, rather than a delay in conception once ovarian activity has commenced. Monthly variations in fertility could be attributed to changes in either males or females. Photoperiodicity, temperature, level of nutrition and exercise appear to be the main factors responsible for the monthly variation in reproductive performance of Egyptian buffaloes.

Lactation sequence

Least-squares means given in Table 1 lead to the conclusion that NSC, GL and CI decreased linearly as parity advanced ($P < 0{\cdot}001$). Other Egyptian studies have shown a curvilinear trend for parity effects on reproductive performance of buffaloes (e.g. Salem, 1983; Kotby *et al.*, 1987). Results of the Egyptian (Salem, 1983; Kotby *et al.*, 1987) and Indian (Gurnani, Nagarcenkar and Gupta, 1976; Swain and Bhatnagar, 1983) studies reported that the first two calving intervals were the longest. These results could be attributed to a longer open period required by buffaloes which have still not reached mature size. Age at calving in the first two lactations was, therefore, rather high (Table 1). Stocking rates which were too high, low level of nutrition, inactive ovaries in young cows, silent heat (quiet ovulation), late access to bulls, or inbreeding are all considered to be possible explanations for this result (El-Nouty, 1971; El-Wishy, Ghallab and El-Baghdady, 1984).

Age at calving

Cow age in months, treated as a covariate, had a significant effect on NSC and CI

TABLE 2

Variance component estimates (σ^2) and proportions of variation (V) due to sire effects† for some reproductive traits in the first three and all lactations of Egyptian buffaloes

Traits		Sire of cow d.f.	σ^2_s	V	Remainder d.f.	σ^2_e	V
Age at calving							
Lactation	1	79	25	0·023	543	1030	0·977
	2	67	243	0·164***	382	1241	0·836
	3	45	13	0·130***	216	86	0·870
No. of services per conception							
Lactation	1	79	0·04	0·045*	543	0·84	0·955
	2	81	0·03	0·034*	544	0·84	0·966
	3	68	0·01	0·012	382	0·83	0·988
	all	73	0·01	0·012*	1283	0·82	0·976
Gestation length (days)							
Lactation	1	61	0·77	0·010	308	80·0	0·990
	2	67	10·5	0·030	382	334·5	0·970
	3	68	9·8	0·028	382	334·5	0·972
	all	73	‡	0·000	1283	423·1	1·000
Calving interval (days)							
Lactation	1	79	1802	0·054*	543	31421	0·946
	2	67	3123	0·070*	382	41411	0·930
	3	45	2057	0·129**	216	13876	0·871
	all	73	1337	0·049***	1283	24757	0·913

† d.f., $\sigma^2C:S$ and V for cow-within-sire, respectively were 437, 0·01 and 0·012 ($P < 0{\cdot}001$) for NSC, 437, 0·0 and 0·0 for GL and 437, 1035 and 0·038 ($P < 0{\cdot}001$) for CI; effect of sire tested against cow within sire and all other effects tested against the remainder mean square.

[illegible] set to zero.

($P < 0{\cdot}001$). The corresponding linear regression coefficients suggested an increase in NSC and CI as the cows become older (b = 0·016 (s.e. 0·003) and 2·92 (s.e. 0·54) for NSC and CI, respectively).

Sire components of variance and heritability estimates

Sire components of variance for age at calving, GL and CI generally increased with lactation number (Table 2), so that heritabilities increased with the advance of parity (Table 3). On the other hand, sire components of variance for NSC showed the opposite trend. This means that with advance of lactation number, the rôle of genetic factors controlling the performance of this trait decreased.

A true variation between sires for reproductive traits in Egyptian buffaloes was observed (Table 2), and the moderate heritability estimates for CI and age at calving (Table 3) indicate that selection for such traits may be effective. These heritability estimates for CI and age at calving are in agreement with those of the other studies (e.g. Amble, Gopalan, Malhotra and Mehrotra, 1970; Rathi, Balaine and Acharya, 1971; Johari and Bhat, 1979). It should be pointed out, however, that in certain studies low heritabilities have also been reported (El-Itriby and Asker, 1956; Kanaujia *et al.*, 1975; Bawa and Dhillon, 1980).

Genetic and phenotypic correlations

Estimates of genetic (r_G) and phenotypic (r_P) correlations among reproductive traits are given in Table 3.

In general, estimates of r_P between age at calving and NSC and GL were low, indicating a low phenotypic association among these traits. Similar findings were reported by Kanaujia *et al.* (1975). On the other hand, moderate estimates of r_P between NSC and CI were obtained. Consequently, any improvement in service period of the Egyptian buffaloes would be phenotypically associated with an improvement in calving interval. This result is in agreement with that

TABLE 3

Estimates of heritability with s.e. (on diagonal) and genetic (below diagonal) and phenotypic (above diagonal) correlations for reproductive traits of Egyptian buffaloes

Traits		Age at calving	NSC	GL	CI
Age at calving					
Lactation	1	0·09 ± 0·101	0·08	0·04	0·15
	2	0·65 ± 0·181	0·17	0·05	0·08
	3	0·52 ± 0·275	0·17	0·16	0·57
No. of services per conception (NSC)					
Lactation	1	0·13	0·18 ± 0·111	−0·12	0·39
	2	0·71	0·16 ± 0·108	0·01	0·35
	3	†	0·04 ± 0·123	0·01	0·49
	all	0·28	0·05 ± 0·042	−0·02	0·35
Gestation length (days) (GL)					
Lactation	1	†	0·12	0·04 ± 0·141	0·09
	2	0·49	0·20	0·12 ± 0·131	0·09
	3	†	0·22	0·11 ± 0·131	0·18
	all	0·14	†	†	0 08
Calving interval (days) (CI)					
Lactation	1	0·87	0·03	†	0·22 ± 0·114
	2	0·35	0·65	0·34	0·28 ± 0·148
	3	0·92	†	†	0·52 ± 0·229
	all	0·68	0·22	†	0·20 ± 0·066

† Negative estimates of variance component set to zero.

obtained by Johari and Bhat (1979) on the Indian buffaloes.

The positive and moderate estimates of r_G between NSC and CI indicated that a greater number of conceptions per service was genetically associated with a longer CI. Similar results were reported by Johari and Bhat (1979). This result might be expected because CI is a function of service period (i.e. number of services per conception) and gestation length, which does not seem to be affected much by the service period (Kanaujia *et al.*, 1975). Estimates of r_G among age at calving and CI and NSC were also moderate or high, in agreement with Kanaujia *et al.* 1975). This leads to the conclusion that any reduction in age at calving is likely to be accompanied by a simultaneous reduction in calving interval as well, although shortening CI is not a goal in itself. The ultimate goal in selection for better fertility should be to shorten CI in parallel with an improvement in NSC.

Mating bull variance component

Estimates of variance components of mating bull in the first four, and in all lactations, are presented in Table 4. The significant effect of mating bull, herein, on reproduction traits could be considered as evidence for the importance of evaluating bull semen quality before the mating of cows. Evaluation criteria might include motility, sperm concentration, abnormal sperms, percentage of sperm cells alive etc.

Components of variance due to mating bull for reproductive performance increased, in general, with the advance of lactation number from the first to the fourth lactation (Table 4). This could be attributed to the fact that

TABLE 4

Variance component estimates (σ^2) and proportions of variation (V) due to mating bull effects† for some reproductive traits in the first four and all lactations of Egyptian buffaloes

Traits		Mating bull			Remainder		
		d.f.	σ^2B	V	d.f.	σ^2e	V
No. of services per conception							
Lactation	1	51	0·048	0·071*	319	0·624	0·929
	2	70	0·037	0·041*	557	0·857	0·959
	3	58	0·101	0·102***	397	0·893	0·898
	4	47	0·100	0·119**	228	0·742	0·881
	all	44	0·094	0·090**	1305	0·920	0·882
Gestation length (days)							
Lactation	1	51	4·3	0·050	319	80·2	0·950
	2	70	‡	0·000	557	509·5	1·000
	3	58	31·8	0·096***	397	298·5	0·904
	4	47	53·4	0·412***	228	76·3	0·588
	all	44	1·3	0·003	1305	470·1	0·997
Calving interval (days)							
Lactation	1	68	664	0·020	556	31828	0·980
	2	57	13886	0·316***	397	30042	0·684
	3	48	481	0·034	227	13667	0·966
	4	73	3174	0·192**	129	14595	0·808
	all	41	3189	0·187***	1276	11365	0·666

† d.f., $\sigma^2C:B$ and V for cow within mating bull ($C:B$), respectively were 229, 0·029 and 0·028 ($P < 0{\cdot}001$) for NSC, 229, 0·0 and 0·0 for GL and 202, 2500 and 0·147 ($P < 0{\cdot}001$) for CI; mating bull effect was tested against cow within mating bull and all other effects tested against the remainder mean square.

‡ Negative estimate of variance component set to zero.

genital systems of cows, and their hormonal levels, are more favourable and give better reproductive efficiency and a higher conception rate in older cows than in heifers.

Conclusions

There was poor reproductive efficiency in the animals investigated here which was probably due to managerial factors, mainly nutrition (green fodder availability dependent on climatological factors) together with the fact that no effective selection programme for reproductive performance was carried out. This poor performance is one limiting factor for the effective use of this species in Egypt.

Effects of year and month of calving and parity should be considered in the bull evaluation programmes for female fertility of Egyptian buffaloes.

The low estimates of heritability obtained here suggest that there is little scope for improving the reproductive performance of Egyptian buffalo through direct selection. The positive correlation between age at calving and calving interval is desirable to combine them into an index with a view to improve reproductive efficiency of Egyptian buffaloes. However, the measures most likely to achieve an improved reproductive efficiency in Egyptian buffaloes are an improvement of nutrition and selection for short calving interval and early age at calving.

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