ESTIMATION OF DIRECT GENETIC AND MATERNAL EFFECTS FOR WEANING TRAITS IN EGYPTIAN BUFFALO

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SUMMARY

Genetic parameters were estimated using REML in a multiple-trait animal model including direct genetic and maternal effects for birth and weaning weights and pre-weaning daily weight gain in 5519 Egyptian buffalo calves. Fixed effects considered were year-season of birth, sex of the calf and parity number of the dam for all traits plus weaning season and the linear covariate of age at weaning for the latter two traits, while direct additive and maternal additive effects were random for all traits. All fixed effects contributed significantly ($P < 0.001$) to variation in all traits. Average birth and weaning weights and pre-weaning daily weight gain were 34.12, 86.95 and 0.55 kg, respectively. Direct heritability estimates were 0.07, 0.27 and 0.27 for the three traits, respectively. The corresponding maternal heritabilities were 0.18, 0.08 and 0.01, respectively. Direct genetic correlations between these traits varied from low and negative (-0.11) between birth weight and daily gain to extremely high and positive (0.95) between weaning weight and pre-weaning daily gain. Direct heritabilities for weaning weight and pre-weaning daily gain and the genetic correlation between them may indicate the possibility to improve both traits through genetic selection for buffaloes in Egypt.

Keywords: buffalo, genetic parameters, weaning traits

INTRODUCTION

In Egypt, buffalo is considered to be the main dairy animal (Soliman, 2007) and buffalo milk is usually consumed fresh according to the demand of the Egyptian domestic market. Moreover, buffalo males between 2-24 months of age are considered important as a source of red meat. Buffalo contribute about 56% of the national milk production, in addition to about 42.6% of the total red meat produced in Egypt. Therefore, genetic improvement of buffalo products (milk and meat) is essential. Genetic improvement depends on the identification of animals capable of transmitting the desirable characteristics to their offspring. Thus, investigating improvement possibilities for different traits of sires, mature females and young calves is the fist step in the chain to construct suitable selection indices.

Studying weight and growth performance between birth and weaning is the target of this study. Moreover to the successive relationship between growth rate of males and beef yield, the literature demonstrated a positive relationship between pre-pubertal growth rate of young heifers and some reproductive traits like time to conception and age at first calving (Little and Kay, 1979), mammary gland development (Peticlerc *et al.*, 1984) and milk yield (Koenen and Groen, 1996).

Therefore, estimating genetic parameters for some growth traits early in life would be of great importance.

The objectives of this work were to separate direct and maternal genetic effects on birth and weaning traits and investigate the possibility to improve them through genetic selection for buffaloes in Egypt.

MATERIALS AND METHODS

Data:

Data originated from buffalo experimental herd of Mehallet Mousa, Kafr El-Sheik Governorate, belonging to the Animal Production Research Institute (APRI), Ministry of Agriculture and Land Reclamation were collected from 1988 to 2008. A total of 5519 records progeny of 215 sires and 1635 dams including dates and weights of birth and weaning of buffalo calves were collected. Parity number ranged from 1 to 8. Calves remained with their dams for 72 h to suckle colostrum, after then they received milk using buckets twice a day till weaning. Milk consumed by each calf starts from 4.5 kg/d during the 1st week of age, increased gradually to 5 kg during the 5th one and then decrease gradually to 1 kg received in the morning only during the last week of suckling. Sulking period varied from 2-4 months with an average of 95 d (ρ1.78). According to the feeding scheduale practiced for pre-weaning calves in the experimental herd of Mehallet Mousa, every calf received the amount of 0.5 kg of concentrates starting from the 4th week of age that gradually increased to the maximum of 1.75 kg in the last week before weaning. Moreover, every calf received 1 kg of berseem hay (*Trifolum alixandrinum*) starting from the 4th week of age untill weaning. Calving distribution is graphicaly presented (Fig.1) and it is more concentrated in winter months.

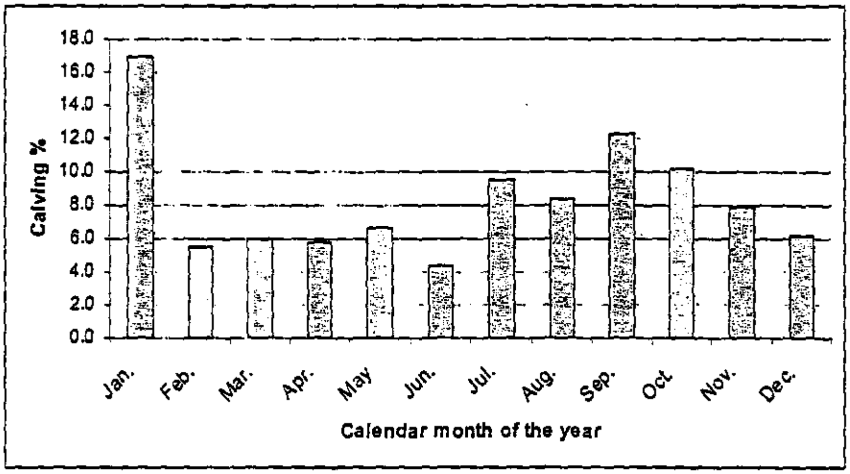

Figure1. Calving distribution throughout calendar month of the year

After restrictions, the percentage of 91.8% of calf records was kept in the file. Basic edits involved checks of dates, ages and weights. Records with missing weights or birth dates or sex codes were excluded. The present study included three variables, (birth and weaning weights and pre-weaning daily gain) that were measured in

Kilograms. Pre-weaning daily gain was calculated as the difference between birth and weaning weights divided by the period length between them in days.

Statistical analysis:

Estimates of genetic parameters were obtained by Restricted Maximum Likelihood, using the software VCE 4.0 (Groeneveld and García Cortés, 1998), fitting an animal model and incorporating all available pedigree information. The following animal model was assumed to analyze birth weight trait:

$$Y_{ijklmn} = \mu + YS_i + S_j + P_k + A_l + M_m + e_{ijklmn}$$

where:

μ = the overall mean,

Y_{ijklmn} = observation on the studied trait,

YS_i = fixed effect of year-season of calving (42 levels, presenting 21 years and two seasons per year),

S_j = fixed effect of calf sex (2 levels),

P_k = fixed effect of parity number of the dam (8 levels),

A_l = animal's direct additive genetic random effect,

M_m = maternal additive genetic random effect of the dam and

e_{ijklmn} = random residual effect associated with observation Y.

Two additional fixed effects, the linear covariate of calf-age at weaning and the fixed effect of weaning season, were added to the above mentioned model to analyze weaning weight and pre-weaning daily gain. Each year was divided into two seasons: hot (April through September) and mild for the rest of months. Phenotypic parameters were estimated by GLM procedures of SAS (SAS, 1999).

RESULTS AND DISCUSSION

Phenotypic parameters:

Table 1 presents estimates of phenotypic means (ρSD), minimums (Min.), maximums (Max.) and phenotypic coefficient of variation (CV%) for birth weight (BW) and weaning traits (WW and pre-weaning daily gain (PWG)) for buffalo calves. The phenotypic mean of birth weight (34.12) is in good agreement with those (33.5 to 35.1 kg) reported by Mostageer *et al.* (1981) and Fooda (2005) for Egyptian buffaloes. Moreover, the phenotypic mean of birth weight in this study is within the range of estimates (26 and 41 kg) reviewed by Taneja (1998) for some Asian buffalo breeds, with higher average for coefficient of variation (14.39%). Birth weight and pre-weaning daily gain, as expected, had higher values for coefficient of variation when compared with that for weaning weight.

In a review paper concerning buffalo breeding literature, Taneja (1998) stated that several non-genetic factors were included in models analyzing birth and weaning traits (sex of the calf, season, year of birth and parity of the dam) and all of them contributed significantly to variation on birth and weaning traits. Therefore, it is necessary to include those effects when analyzing such traits (Schammass *et al.* 1996 and Angulo and Jaramillo, 2005). Results obtained from the present study were in good agreement with other Egyptian results found in the literature (Sadek, 1980; Tantawy, 1984 and Fooda, 2005).

Table 1. Phenotypic means (±SD), minimums (Min.), maximums (Max.) and phenotypic coefficient of variation (CV) for birth weight (BW) and weaning traits (WW) and pre-weaning daily gain (PWG) of buffalo calves

Trait	Mean (SD)	Range		CV%
		Min.	Max.	
BW, Kg	34.12 (4.91)	20	55	14.39
WW, Kg	86.95 (8.10)	50	135	9.32
PWG, g	553.55 (86.87)	189	1051	15.69

Least squares means (LSM) and standard errors (±SE) for birth weight and weaning traits of buffalo calves by calf sex, parity of the dam and weaning season are shown in Table 2. As can be observed in the table, males had significantly higher means than females for all traits. Birth and weaning weights increased with parity number. Dams had offspring with significantly heavier birth and weaning weights in the 6th and 8th parity in comparison to other levels. Calves had significantly higher pre-weaning daily gain in the first parity. In addition, calves weaned from Apr. through Sep. tended to have heavier body weights than those weaned between Oct. through Mar.

Table 2. Least squares means (LSM) and standard errors (±SE) for birth weight and weaning traits of buffalo calves by calf sex, parity of the dam and weaning season

Effect	Number of records	BW, Kg LSM	BW, Kg SE	WW, Kg LSM	WW, Kg SE	PWG, g LSM	PWG, g SE
Calf sex:							
Male	2785	35.67^{a}	0.11	88.38^{a}	0.18	551.84^{a}	1.88
Female	2734	34.32^{b}	0.11	86.60^{b}	0.18	547.53^{b}	1.91
Parity:							
1	1080	29.08^{f}	0.16	84.88^{e}	0.26	584.46^{a}	2.83
2	935	32.10^{e}	0.17	86.08^{d}	0.28	565.32^{b}	3.01
3	760	34.41^{d}	0.19	87.11^{c}	0.31	551.61^{c}	3.33
4	649	35.88^{c}	0.20	87.41^{bc}	0.33	539.53^{cd}	3.54
5	561	36.67^{b}	0.21	88.24^{ab}	0.35	540.14^{d}	3.77
6	508	37.14^{b}	0.22	89.05^{a}	0.37	543.21^{d}	3.98
7	442	36.98^{b}	0.24	88.26^{abc}	0.40	537.14^{d}	4.27
8	584	37.67^{a}	0.21	88.85^{a}	0.35	536.05^{d}	3.74
WS:							
Apr.-Sep.	2359	---	---	88.31^{a}	0.19	554.98^{a}	2.01
Oct.-Mar.	3160	---	---	86.66^{b}	0.17	544.39^{b}	1.84

BW=birth weight; WW=weaning weight; PWG =pre-weaning daily gain; WS= weaning season.

^{abc}Means within a column with different superscripts differ significantly ($P<0.05$).

Genetic parameters:

Direct and maternal heritabilities and correlations between direct and maternal genetic effects

There are few estimates separating and correlating direct and maternal effects on birth and weaning traits in buffaloes. Table 3 presents estimates from the employed multivariate analysis for birth and weaning weights and pre-weaning daily gain of Egyptian buffalo calves. As can be seen in the table, direct heritability estimates were low to moderate, averaging 0.20. Direct heritability was 0.07 for birth weight. This result is somewhat lower than that (0.12) reported for Egyptian buffaloes by Fooda (1996). Many authors (Sreedharan and Nagarcenkar, 1978; Basu and Rao, 1979 and Vijai *et al.*, 1993) suggested that the low direct heritability estimates, frequently reported for birth weight in the literature, is probably due to the large influence of the maternal effect.

Direct heritability was 0.27 for both weaning traits. Direct heritability for WW is within the range of estimates (0.23 to 0.33) reported by Baht (1979) and Carrero (2000) for Indian and Brazilian buffaloes and lower than that (0.10) estimated by Anglo *et al.* (2006) for buffaloes in Colombia. Moreover, direct heritability estimate for WW in this study is within the range (0.27 to 0.30) reported for different breeds of cow calves (Meyer *et al.*, 1993 &1994).

In contrast to direct heritability, estimate of maternal heritability in this study was higher for birth weight (0.18) than those estimated for weaning traits (0.01 to 0.08). This result indicates the importance of the maternal effect on birth weight. Moreover, Tomar *et al.* (1995), analyzing data for beef cows, clearly indicated that the genetic group of the dam had significant effect on birth weight of their calves. Meyer *et al.* (1994) reported moderately low heritability estimates for weaning traits ranging from 0.11 to 0.12 for Wokalup cow-calves.

Table 3 presents correlations between direct and maternal genetic effects for birth and weaning traits. Estimates were moderate and negative (-0.23) for birth weight and clearly low for weaning traits (0.07 to -0.07). Similar results for weaning weight were reported by Anglo *et al.* (2006).

Table 3. Genetic parameter estimates for birth weight and weaning traits of buffalo calves

Trait	Direct h^2	Maternal h^2	$r_{(A,M)}$
BW	0.07	0.18	-0.23
WW	0.27	0.08	0.07
PWG	0.27	0.01	-0.07

h^2= heritability; $r_{(A,M)}$=correlation between direct and maternal additive effects.
BW=birth weight; WW=weaning weight; PWG =pre-weaning daily gain.

Large and negative estimates between direct and maternal correlations were frequently reported in the literature for several breeds of beef cattle. Koch (1972) suggested that large and negative estimates of $r_{(A,M)}$ didn't reflect a marked adverse genetic relationship between growth and maternal performance but were possibly due to some environmental factors or differential management practices of animals causing a negative dam-offspring covariance. As indicated by Baker (1980), possible reasons for such environmental covariance included the so-called "fatty udder syndrome" (i.e., an effect of the plan of nutrition during growth on cow's maternal ability). Moreover, Cundiff (1972) and Koch (1972) added that the moderately to strongly negative estimates of $r_{(A,M)}$ obtained in various studies were likely to be potentially biased downwards due to the negative environmental covariance between maternal effects in adjacent generations.

Genetic and phenotypic correlations:

Table 4 presents estimates of genetic correlations (above the diagonal) and phenotypic correlations (below the diagonal) between the studied traits. Phenotypic correlation between the studied traits ranged from -0.38 to 0.75. This range is comparable with that (-0.26 to 0.81) reported by Fooda (2005) for Egyptian buffaloes. Pre-weaning daily gain had high and positive (0.75) phenotypic correlation with weaning weight, while phenotypic correlation between birth weight and pre-weaning daily gain was moderate and negative (-0.38). This last estimate is slightly higher and comparable with that (-0.26) reported by Fooda (2005) for Egyptian buffaloes.

As can be noticed in Table 4, direct genetic correlation between birth weight and weaning weight was moderate and positive (0.22), while it was low and negative (-0.11) between birth weight and pre-weaning daily gain. The moderate and positive direct genetic correlation between birth and weaning weight (0.22) is favorable because direct selection for the trait with higher direct heritability (weaning weight) is expected to have a positive correlated response in birth weight.

Direct genetic correlations between birth weight and pre-weaning daily gain was clearly low and negative. (-0.11) indicating that selection to improve pre-weaning daily gain is not expected to have an effective correlated response in birth weight. This would be useful to avoid problems related to calving difficulties. Weaning weight had high and positive (0.95) genetic correlation with pre-weaning daily gain. This may indicate that genetic selection to improve weaning weight is expected to have a strong correlated response in growth rate.

Table 4. Direct genetic correlations (above the diagonal) and phenotypic correlations (below the diagonal) between birth weight and weaning traits of buffalo calves

Trait	BW	WW	PWG
BW	-----	0.22	-0.11
WW	0.32		0.95
PWG	-0.38	0.75	

BW=birth weight; WW=weaning weight; PWG =pre-weaning daily gain

Estimate for matrnal heritability found for birth weight and direct heritability estimates for weaning traits in this study were high enough to permit genetic progress. Correlations between direct and maternal effects for weaning traits were not significanty different from zero, indicating that selection to improve growth traits can be carreid out by simultaneous selection for direct genetic and maternal performance (Meyer *et al* ., 1994).

CONCLUSION

Direct heritabilities for weaning weight and pre-weaning daily gain and the genetic correlation between them may indicate the possibility to improve both traits through genetic selection among buffaloes in Egypt. In contrast to direct heritability, estimate of maternal heritability was higher for birth weight (0.18) than those estimated for weaning traits (0.01 to 0.08) indicating the importance of the maternal effect on birth weight.

Direct genetic correlations between birth weight and pre-weaning daily gain was clearly low and negative (-0.11) indicating that selection to improve pre-weaning daily gain is expected to have little effective correlated response in birth weight. This would be useful to avoid problems related to calving difficulties. Weaning weight had high and positive (0.95) genetic correlation with pre-weaning daily gain, indicating that genetic selection to improve one of them is expected to have an effective correlated response in the other.

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تقدير التأثيرات الوراثية المباشرة والأمية لصفات الفطام في الجاموس المصري

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قدرت المعايير الوراثية لعدد ٥٥١٩ سجلاً لأوزان الميلاد والفطام ومعدل الزيادة اليوميه فى مرحلة ما قبل الفطام بإستخدام نموذج الحيوان وبرنامج (RMEL) . إشتمل النموذج الإحصائي على التأثيرات الثابتة لكل من سنة وموسم الولادة وجنس العجل المولود وترتيب موسم الوضع للأم والتأثير العشوائى لكل من التأثير الوراثى التجمعى والأمي لكل الصفات. كما تضمن النموذج التأثيرات الثابته على صفتى الفطام لكل من موسم الفطام ومعامل الانحدار الخطى للعمرعند الفطام.

أظهرت النتائج تأثيراً معنوياً لكل التأثيرات الثابتة على جميع الصفات تحت الدراسة. بلغ متوسط وزنى الميلاد و الفطام ٣٤,١٢ و ٨٦,٩٥ كجم، على الترتيب بينما بلغ متوسط معدل الزيادة الوزنية اليومية 0.55 كجم. كانت تقديرات العمق الوراثى المباشر للصفات الثلاثة السابقه ٠,٠٧ و ٠,٢٧ و ٠,٢٧، على الترتيب. وكانت التقديرات المقابلة للعمق الوراثى الأمي ٠,١٨ و ٠,٠٨ و ٠,٠١، على الترتيب. بلغت تقديرات معاملات الارتباط الوراثية 0.11- بين وزن الميلاد والزيادة الوزنية و ٠,٩٥ بين وزن الفطام والزيادة الوزنية. تشير تقديرات العمق الوراثى المباشر لصفتي وزن الفطام والزيادة الوزنية اليومية والارتباط الوراثى بينهما إلى إمكانية تحسين كلتا الصفتين من خلال الإنتخاب الوراثى.