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Estimation of Genetic and Crossbreeding Parameters for Birth Weight in Baladi Cattle and their Crosses with Abondance and Tarentaise Breeds in Egypt

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ABSTRACT

Genetic and crossbreeding parameters for birth weight (BWT) were estimated in pure Baladi (BB), Abondance (AB) with BB crossbred and Tarentaise (TR) with BB crossbred calves. Data were collected from breeders in two governorates and from Sids Experimental Farm belonging to Animal Production Research Institute. Data included 9334 records of calves born for 174 sires and 5182 dams. Data consisted of seven genotypes; BB, ½ AB/TR ½ BB, ¾ AB/TR ¼ BB and ⅞ AB/TR ⅛ BB. Group differences were highly significant, (P<0.0001). Least squares means of BWT were 22.3, 32.4, 32.4 and 32.6 kg for BB, ½ AB, ¾ AB and ⅞ AB, respectively and were 32.0, 32.0 and 31.9 kg for ½ TR, ¾TR and ⅞ TR, respectively. Individual and maternal additive and maternal heterosis effects were studied, variance components and heritability estimates were estimated. The individual additive effects of AB and TR for BWT were significant being -9.98 kg and -9.43 kg, respectively. Maternal additive effects were significant and positive being 4.86 kg and 4.81 kg for AB and TR, respectively. Maternal heterosis estimates were non-significant with small magnitude and was negative for AB crossbreds (-0.06 kg) and was positive for TR crossbreds (0.12 kg). Heritability estimates for BWT were 0.16, 0.51 and 0.55 for BB, AB crossbreds and TR crossbreds, respectively. In general, Crossbred calves of AB or TR were higher in BWT than pure BB calves. Individual additive effects show an advantage for AB and TR crossbreds, while maternal additive effects expressed the superiority of the BB dams over the crossbred dams. Results reveal that genetic improvement of BWT in BB could be achieved by crossing with AB or TR breeds for higher BWT.

Keywords: Baladi cattle, Abondance, Tarentaise, crossbreeding, birth weight and genetic parameters.

INTRODUCTION

The introduction of European dual-purpose breeds could improve calf birth weight and productivity of local cattle. Favourable effects of crossing cattle are heterosis effects and the additive differences between breeds. Several studies have indicated the advantages of crosses between local cattle (Baladi) and European breeds in several aspects. (Mostageer *et al*., 1987; Arafa, 1996; Afifi *et al*., 1996; Nasr *et al*., 1997 and Ibrahim *et al.,* 2005). The advantage of crossbred animals over the pure bred animals is the exhibit of heterosis or hybrid vigor. So, crossbred animals are expected to have greater performance than the pure local cattle. Generally, the level of heterosis is higher under poor environmental conditions than under good environmental conditions, (Skrypzeck *et al*., 2000). Leal and MacNeil (2018) reported that crossbred animals grow more rapidly and well adapted mostly when the parental breeds are genetically distant. This better performance occurs due to combining additive breed effects and heterosis.

The weight of the newly born calf is of great importance to the producer. Selvan *et al*. (2018) reported that because birth weight of calves is easily measured and correlated with other performance traits, it should be considered in the genetic improvement programs.

Differences in breed additive and heterosis effects help to explain the differences in the animal performance, Leal and MacNeil (2018). Information about the genetic parameters and differences between breeds are essential to evaluate the suitability of breeds for crossbreeding, (Brandt *et al*., 2010). The estimation of the crossbreeding parameters is affected by type, numbers and by the estimability problems of genetic groups included in the crossbreeding experiment, (Lema *et al*., 2011).

Estimates of variance components and genetic parameters for birth weight of crossbred data have been reported in many studies, (Mourão *et al*., 2007; Haile *et al*., 2011; Chen *et al*., 2012; Vega-Murillo *et al*., 2012 and Selvan *et al*., 2018).

Previous research work on the experimental herd of the Animal Production Research Institute (APRI) crossbred animals of AB and TR breeds with pure BB covered the differences between the genetic groups in some productive traits, blood and milk parameters and final weights with carcass traits, (Ibrahim *et al*., 2005; Abdelharith, 2009 and Tawfik, 2010). The authors concluded better average daily gain, feed conversion rate, dressing-out percentages, higher birth weight and higher milk yield of crossbred animals than BB.

The objective of this study was to estimate genetic and crossbreeding parameters for birth weight in Egyptian Baladi crossbreds with French breeds Abondance and Tarentaise.

MATERIALS AND METHODS

Data

Data utilized in this study were collected from 2250 breeders at two governorates and from Sids Experimental Farm belonging to Animal Production Research Institute. Breeders' data of the French Egyptian Program were provided by the General Organisation of Veterinary Service (GOVS). The program started in the year 1996 to improve the milk and meat production of Egyptian Baladi cattle by crossing Baladi cows with two French breeds Abondance (AB) and Tarentaise (TR). These two breeds were selected favouring their colour which resembles Baladi cattle colour beside their great production of milk and meat. Pure Baladi cows (BB) were inseminated by the imported semen of the two French breeds to make F1 (½ AB/TR ½ BB) generation, then F2 (¾ AB/TR ¼ BB), F3 (⅞ AB/TR ⅛ BB) and F4 (15/16 AB/TR 1/16 BB). From the third and fourth generations, crossbred bulls have been made to inseminate pure Baladi cows. Data of these crossbred bulls were not included in the analyses and kept only records of pure Baladi crossed by pure French semen. The crossbred trial was applied in two governorates; Fayoum and Bany-Sweif in Mid Egypt. All data collected from this program was only corssbred. No pure Baladi or French calves were available.

At later time, a similar trial was conducted in Sids Experimental Farm, Bany-sweif governorate, APRI, with small numbers of cows which were not enough to make genetic evaluation for the herd. So, crossbred data of GOVS program was utilized, in addition, the pure Baladi data of APRI to form contemporary groups.

In winter, animals at small holders were fed mainly Egyptian clover (berseem) and in summer some concentrates with corn forages (Darawa) with a period of suckling might expand for six months. Animals were kept in different housing systems according to the breeder's facilities ranging from loose open yards to closed housing with ceiling fans or open shaded.

Total collected data of birth weight were 9334 records born for 174 sires and 5182 dams. Description of data categories in different genetic groups is presented in Table (1).

Table 1. Description of data in the different genetic groups.

Genetic group*	Number of calves	Sires	Dams
Baladi pure (BB)	329	20	123
½ AB ½ BB	3844	35	2094
¾ AB ¼ BB	817	32	425
⅞ AB ⅛ BB	134	17	70
½ TR ½ BB	3468	28	2088
¾ TR ¼ BB	653	24	335
⅞ TR ⅛ BB	89	18	47
Total	9334	174	5182

***Sire breed listed first**

Crossbreeding genetic parameters

Crossbreeding genetic parameters were calculated according to Dickerson (1992) through the estimation of the coefficients of the expected contribution of the genetic effects. The Dickerson model equations included all additive and non-additive effects. The parameters of direct individual additive effect (gI), maternal genetic effect (gM), individual heterosis (hI), maternal heterosis (hM), recombination loss effects in the individual (rI) and in the dam (rM) are presented in Table (2).

Table 2. Coefficients of breed effects for the different genetic groups.

Genetic group	g^I	g^M	h^I	h^M	r^I	r^M
Baladi pure (BB)	1.0	1.0	0	0	0	0
½ AB/TR ½ BB	0	1.0	1	0	0	0
¾ AB/TR ¼ BB	-0.5	0	0.5	1	0.25	0
⅞ AB/TR ⅛ BB	-0.75	-0.5	0.25	0.5	0.19	0.25

g^I: individual additive effects, g^M : maternal additive effect, h^I : individual heterosis, h^M : maternal heterosis, r^I: individual recombination loss and r^M : maternal recombination loss. Estimates of g^I and g^M were calculated by subtract the BB coefficients - French breeds coefficients.

Statistical Analyses

Data were grouped in 53 contemporary groups (CG) to include the crossbred data and their contemporary pure bred data of the same years but under different management, (Sids Farm). The groups were clustered by herd, season and year of calf birthdate. Data included two seasons; winter and summer for 14 years data from 1996 to 2009. As data were mainly from the breeders, age of cows or parity number were not available.

Models

Three models were applied for:

1- Estimation of the least squares means of the different genetic groups (GG) for birth weight (BWT) for the crossbred data where each of the two French breeds was analysed separately with the pure bred data, using PROC MIXED of the Statistical Analysis System (SAS, 2002). The model used was:

$$y_{ijklm} = \mu + GG_i + CG_j + SX_k + (GG*SX)_{ik} + s_l + e_{ijklm}$$

where: **y_{ijklm} is the observation of birth weight, μ is the general mean, $(GG)_i$ is the fixed effects of GG (4 GG for each of the French breeds with the pure Baladi), $(CG)_j$ is the CG, (53 CG), $(SX)_k$ is sex of calf (2; male and female), $(GG*SX)_{ik}$ is the interaction between GG and SX, s_l is the random effect of the sire and e_{ijklm} is the random error term$(0, \sigma^2_e)$.**

2- Using the same procedure (MIXED), crossbreeding genetic parameters were estimated and suitable estimable contrasts were fitted. From the full model of Dickerson (1992), only three parameters were estimable; g^I, g^M and h^M. The model used was :

$$y_{ijklmno} = \mu + CG_i + SX_j + g^I{}_k + g^M{}_l + h^M{}_m + s_n + e_{ijklmno}$$

where: **$g^I{}_k$ is the individual additive effect, $g^M{}_l$ is the maternal additive effect and $h^M{}_m$ is the maternal heterosis effect.**

The other effects, y, CG, SX, s and e were described in the previous model.

3- Animal model analyses were performed to estimate variance components and genetic parameters for BWT in each breed data separately. Single-trait derivative-free restricted maximum likelihood (DF- REML) with animal model analysis (Boldman *et al.*, 2000) was used to apply the models. The analyses were solved iteratively and were terminated when the change in the variance of the function values (-2 log likelihood) was below 10^{-9}. The model used was:

$$y = X\beta + Za + e$$

Where: **y is the vector of BWT observation, β is the vector of GG, CG and SX effects which previously described, X is the incidence matrix related observations to β, a is the vector of animal, Z is the incidence matrix related observations to a and e is the random error.**

RESULTS AND DISCUSSION

Genetic group performance

Least squares means of calf BWT in the different genetic groups of BB and AB and TR crossbreds are presented in Table (3). The effects of GG, CG, SX and interaction between GG and SX were highly significant on BWT. In general, BB calves had lower BWT than crossbred calves of AB or TR breeds. Baladi calves least squares mean was 22.3 kg while ½AB½BB, ¾AB¼BB and ⅞AB⅛BB were heavier, (32.4, 32.4 and 32.6 kg), respectively. Male calves were heavier than female calves, especially in the first generation F1 calves (½AB/½BB), it was the heaviest (33.1 kg). Abdelharith (2009) reported lower weights for BWT for F1 (½AB ½BB), (27.1) kg and it was higher than BB calf BWT with significant effects. On other crossing trial, BB cows with Friesian and Shorthorn European breeds, Arafa *et al.* (2000) reported heavier crossbred calves than the BB calves. The authors reported 26.6, 26.4 and 20.8 kg for BB calf BWT in crossbreeding trials with Friesian, Shorthorn and Jersey, respectively.

The least squares means of calf BWT in the different genetic groups of TR and BB crossbreds are also shown in Table (3). Almost same trend of results was found as the AB crossbred genetic groups except for that the interaction between GG and SX was not significant and the genetic group ⅞ TR ⅛ BB was not the heaviest calves. Upgrading BB with TR in APRI trial revealed that male F1 calves were heavier than male F1 AB crossbred calves, 30.0 *vs* 27.0 kg, respectively, Abdelharith (2009). In general, male calves had higher BWT than female calves and highest weights were in ½ TR ½ BB and ¾ TR ¼ BB genetic groups, 32.6 kg.

Table 3. Least squares means (LsMeans) ± standard errors (S.E.) of birth weight (BWT) for Baladi (BB), Abondance (AB) and Tarentaise (TR) genetic groups.

Genetic group	LsMeans ± S.E. AB	LsMeans ±S.E. TR
μ	31.2 ± 1.25	30.8 ± 1.29
Genetic group (GG)	(***)	(***)
Baladi pure (BB)	22.3 ± 0.48	22.5 ± 0.46
½ French ½ BB	32.4 ± 0.24	32.0 ± 0.23
¾ French ¼ BB	32.4 ± 0.25	32.0 ± 0.25
⅞ French ⅛ BB	32.6 ± 0.33	31.9 ± 0.37
Calf Sex	(***)	(***)
Male	30.4 ± 0.25	30.2 ± 0.25
Female	29.4 ± 0.24	28.9 ± 0.24
GG*Sex	(***)	
Baladi pure (BB) Male	23.1 ± 0.55	23.3 ± 0.54
Baladi pure (BB) Female	21.6 ± 0.57	21.7 ± 0.55
½ French ½ BB Male	33.1 ± 0.25	32.6 ± 0.24
½ French ½ BB Female	31.7 ± 0.24	31.3 ± 0.23
¾ French ¼ BB Male	32.7 ± 0.28	32.6 ± 0.28
¾ French ¼ BB Female	32.1 ± 0.26	31.3 ± 0.26
⅞ French ⅛ BB Male	32.8 ± 0.39	32.4 ± 0.48
⅞ French ⅛ BB Female	32.4 ± 0.41	31.3 ± 0.47

***: (P<0.0001)**

Crossbreeding parameters

Individual additive effects (g^I)

Estimates of individual additive genetic effects (g^I) for BWT in AB and TR crossbred calves were expressed as a deviation from the BB breed. The estimates were negative and significant, indicating an advantage for the French breeds AB and TR on BB, (-9.98 and – 9.43 kg), respectively, Table (4). The AB crossbreds show higher g^I estimate than TR. Arafa *et al*. (2000) in trials of upgrading BB with Friesian and Shorthorn dairy breeds reported negative and significant estimates of g^I for BWT of calves, (-6.42 and -5.95), respectively and also in favour of the European breeds. Davis *et al*. (1998) in crossing Tarentaise with beef Herford reported negative and significant g^I estimate (-2.3) in favour of Herford. Depending on breed performance of milk or meat that involved in the crossing trials, estimates of g^I and significance are differed. As an example, Skrypzeck *et al*. (2000) in three breed crossbreds (Afrikaner, Simmentalr and Herford), the additive crossbreeding parameters were positive in Simmentaler and negative for Afrikaner and Herford. Leal and MacNeil (2018) had the same conclusion on different breeds.

Maternal additive effects (g^M)

Estimates of maternal additive effects (g^M) for BWT in AB and TR crossbreds are presented in Table (4). The estimates were positive and highly significant and show an advantage for the BB cows over the crossbred cows. The estimates of g^M in both AB and TR crossbred calves were in a close range, 4.86 and 4.81 kg, respectively. In agreement with these results, Arafa *et al*. (2000) reported positive estimate of g^M in favour of the BB dams over the Jersy dams but reported negative estimates in favour of Friesian and Shorthorn dams. Davis *et al*. (1998) reported negative non-significant estimate (-0.14) for g^M in a crossbred data between Tarentaise and Herford.

Maternal heterosis (h^M)

Estimates of h^M for BWT in crossbred calves are presented in Table (4). Both estimates are non-significant and of small magnitude, (-0.06 and 0.12), respectively. The estimate of h^M of AB crossbred calves was negative and in favour of the BB dams that could give calves with birth weight slightly heavier than the crossbred AB dams. On the contrary, the estimate of h^M of crossbred TR calves was positive and had an advantage for the TR crossbred dams that give calves with higher birth weight than the pure BB dams. Arafa *et al*. (2000) in upgrading BB with three European dairy breeds, Friesian, Shorthorn and Jersy, the estimates of h^M were positive and in favour of the crossbred dams. Positive and significant estimate of h^M was reported by Davis *et al*. (1998) in favour of crossbred dams of Tarentaise and Herford breeds. Crossbred dams in crossing native breeds with imported breeds' trials have been reported to produce higher calf birth weight than the native. Positive estimates of h^M and in favour of the crossbred dams were reported by Haile *et al*. (2011), Lema *et al*. (2011) and Leal and MacNeil (2018).

Table 4. Estimates of individual (g^I) and maternal (g^M) additive effects and maternal heterosis (h^M) for BWT in Abondance and Tarentaise crossbred calves.

Breed Cross	g^I (kg)	g^M (kg)	h^M (kg)
Abondance	-9.98 ± 0.52 (P<0.0001)	4.86 ± 0.36 (P<0.0001)	-0.06 ± 0.28 (P<0.834)
Tarentaise	-9.43 ± 0.51 (P<0.0001)	4.81 ± 0.41 (P<0.0001)	0.12 ± 0.35 (P<0.730)

Variance components and heritability estimates

A univariate model was fitted for each breed separately. Variance components of BWT and heritability estimates are presented in Table (5). The heritability estimates of BWT were 0.51 and 0.55 for AB crossbreds and TR crossbreds, respectively, whereas the heritability estimate for BB was 0.16. The discrepancies of heritability estimates could be refer to relatively smaller number of data for BB. Also, smaller genetic variation in BB calves accompanied with higher environmental variance could affect the heritability estimate of BB. Previous crossing trials on BB and their crosses with European breeds did not cover the genetic evaluation for multi breed data. In general, estimates of variance components and heritability are within the range of different breeds for BWT trait in the literature. Chen *et al*. (2012) reported heritability estimate of 0.38 for Chinese Nanyang crossbred data with Italian Piedmontese and Selvan *et al*. (2018) reported 0.67 in Zebu crossbred with Holstein Friesian. Haile *et al*. (2011) reported heritability estimate of 0.33 for crossbred Ethiopian Boran with Holstein Friesian.

Table 5. Estimates of genetic variance (σ^2_a), environmental variance (σ^2_e), phenotypic variance (σ^2_p) and heritability estimates (h^2) ± standard error and C.V (%)

Item	Baladi pure	Abondance crossbreds	Tarentaise crossbreds
N	329	4795	4210
σ^2_a	2.03	3.87	5.06
σ^2_e	10.49	3.74	4.15
σ^2_p	12.52	7.61	9.21
h^2	0.16 ± 0.11	0.51 ± 0.05	0.55 ± 0.07
C^2	0.84 ± 0.11	0.49 ± 0.05	0.45 ± 0.07
C.V.%	18.97	11.69	12.08

C^2:environmental proportion and
C.V (%): coefficient of variation

CONCLUSION

Birth weight has been improved by crossing BB with French breeds AB and TR due to individual additive effects of both AB and TR and the maternal heterosis of TR. Maternal heterosis of AB did not have any effect on BWT and did not increase the birth weight. Maternal additive effects expressed the superiority of the Egyptian Baladi cows over the crossbred cows which may lead to an increase of the calf birth weight. Results reveal that genetic improvement of calf BWT in BB could be achieved by crossing with AB or TR breeds for higher BWT.

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تقدير المعايير الوراثية و معايير الخلط لصفة وزن الميلاد في الماشية البلدية و خلطانها مع سلالات الأبندانس والتارنتيز في مصر

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تم تقدير المعايير الوراثية و معايير الخلط لصفة وزن الميلاد في عجول و عجلات الماشية البلدية و خلطانها مع سلالات الأبندانس والتارنتيز. تم تجميع البيانات المستخدمة من بيانات الولادات عند المربين في محافظتين و كذلك من محطة سدس التابعة لمعهد بحوث الانتاج الحيواني. وكانت البيانات عبارة عن 9334 سجل مواليد 174 طلوقة و 5182 بقرة. تكونت البيانات من سبع مجموعات وراثية هي على التوالي بلدي نقي ، ½ أبندانس/تارنتيز ½ بلدي ، ¾ أبندانس/تارنتيز ¼ بلدي و ⅞ أبندانس/تارنتيز ⅛ بلدي.كانت الفروق بين المجموعات الوراثية عالية المعنوية وكانت تقديرات متوسط وزن الميلاد هي 22.3 ، 32.4، 32.4 ، 32.6 كجم للبلدي النقي و ½ أبندانس ، ¾ أبندانس و ⅞ أبندانس على التتابع و كانت 32.0، 32.0 و 31.9 كجم للمجموعات ½ تارنتيز ، ¾ تارنتيز و ⅞ تارنتيز على التتابع.تم دراسة التأثير الفردي و الأموي التجمعي و الهجين الأموي وكذلك تم تقدير مكونات التباين و المكافئ الوراثي. كان التأثير الفردي التجمعي لوزن الميلاد في خلطان الأبندانس و التارنتيز معنوي و قيمته -9.98 و -9.43 كجم على التوالي. أما التأثير الأموي التجمعي فكان معنويا و موجب القيمة 4.86 و 4.81 كجم لخليط الأبندانس و التارنتيز على التوالي. أما تأثير الهجين الأموي فكان غير معنويا و ذو قيمة صغيرة وكان سالب القيمة -0.06 كجم في خليط الأبندانس و موجب القيمة 0.12 كجم لخليط التارنتيز.كانت قيم المكافئ الوراثي 0.16 ، 0.51 و 0.55 للبلدي و خليط الأبندانس و خليط التارنتيز على التوالي. و كانت أوزان المواليد الخليطة أعلى من المواليد البلدي النقية.أظهرت نتائج معايير الخلط أن التأثير الفردي أعلى ميزة للخليط عن البلدي في حين أن التأثير الأموي أظهر تفوق الأمهات البلدية عن الخليطة. و كذلك أظهرت النتائج أنه يمكن تحقيق التحسين الوراثي لصفة وزن الميلاد في الماشية البلدية عن طريق خلطها مع سلالات الأبندانس و التارنتيز.