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Genetic Parameters of Direct and Maternal Effects for Birth Weight of Friesian Calves under Egyptian Farm conditions

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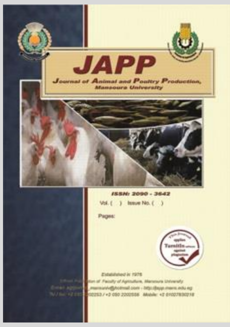

ABSTRACT

A total of 4889 birth weight (BW) records on calves of 1609 Friesian cows in Sakha experimental farm were collected between 1975 and 2020 year. The analytical model included the fixed effects of the parity, calving year and season, age at first calving, gestation period length and calf sex. Variance components, heritabilities, direct maternal correlations and breeding values (BV) were estimated using VCE6 program. Genetic trends of calves BW were evaluated by regressing BV on years of calving using GLM process of SAS software. Results showed highly ($P \leq 0.001$) significant effects of all studied fixed effects on BW. Direct (h^2_a), sire (h^2_s), maternal (h^2_m) and total (h^2_t) heritabilities and direct maternal correlations (r_{am}) estimates were 0.01, 0.10, 0.05, 0.09 and 0.01, respectively. Estimated BVs of calves, sires and dams ranged from -6.71 to 6.84, -6.04 to 4.38 and -7.29 to 8.86 kg, respectively. Range of BVs for dams was higher than for sires and calves, but the accuracy of calves BVs were higher than others. The genetic trend was not different from zero showing no indication of change in the genetic merit of BW in this farm during the period of study.Dam selection proved to be important for inducing high genetic progress in BW during the subsequent generation. Moreover, BV estimates of calves BW achieved higher accuracy ranging from 0.69 – 0.81% comparing to those for sires and dams by indirect selection. However, improvement in calves BW may also be achieved by practicing better management programs in this herd.

***Keywords*: Calves, birth weight, direct and maternal effects, heritability, genetic trends.

INTRODUCTION

There is no doubt that the calf birth weight (BW) is a critical aspect for livestock breeding issues that meaningfully influences the future milk and beef production of a herd (Bakır et al. 2004a), BW along with the subsequent growth performance are traits that commonly should be considered when setting the selection standards .BW is influenced by a collection of heritable, parental and management factors. Some influences may be coupled with the action of genes of both calf and the dam or with managerial factors that shape the calves and/or the dams (Sahin et al. 2017). However, it is one of the major determinant measures of calving ease rating. Also, Chud et al. (2014) emphasized the role of the dam heritable capacity in determining the calf function ability for a character like BW.

Several studies (Kamal et al., 2014; Lopez et al. 2020; Atashi et al., 2021) investigated various genetic and phenotypic traits effective for calves BW which mostly depended not only on animal genetics, but also on environmental conditions which they are exposed to. Therefore, maternal and direct genetic factors effective for BW have to be under concern for achieving optimal genetic improvement in livestock breeding programs. Beside, avoiding bulls with superior breeding value for BW as they may cause delivery obstacles or dystocia due to overweight births and likewise, inferior sires with minimal breeding values because their offspring will likely be below optimal weight, conceding their lives modest fitness.

The present paper aimed to evaluate the direct genetic aspects, maternal impacts and various environmental factors that influence on calves birth weight in an experimental dairy farm.

MATERIALS AND METHODS

Dataset

Records on birth weight (BW) calves of Sakha Experimental Farm were taken from the Animal Production Research Institute databank, Agricultural Research center; Agriculture Ministry and Land Reclamation. A total of 4889 BW records on calves of 1609 cows giving birth between 1975 to 2020 year were analyzed. The calves BW averaged 31.2±5.2 (Table 1).

Table 1. Descriptive statistics of birth weight data.

Number of base animals	501
Number of non-base animals	4890
Total number of animals	5391
Number of sires	258
Numbers of dams	1609
Total number of calves	4889
Number of male calves	2486
Number of female calves	2403
Mean birth weight of calves (±SD,kg)	31.2±5.2
Maximum birth weight of calves (kg)	57.0
Minimum birth weight of calves (kg)	12.0

Statistical analyses

The effectiveness of systematic environmental factors on BW trait were evaluated by a fitting the fixed effects of parity (PR), season (SC) and year (YC) of calving, age at first calving (AFC), gestation period length(GPL) and calf sex using the linear model:

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$$Y_{ijklmno} = \mu + A_i + B_j + C_k + D_l + F_m + P_n + e_{ijklmno}$$

Where,

$Y_{ijklmno}$: the phenotypic record of a provided trait on animal.

μ: the overall mean.

A_i: the fixed effect of i[th] parity (i=1, 2…6).

B_j: the fixed effect of j[th] calving season (j =1(Jan. - Mar.); 2(April - June); 3 (July - Sept.) and 4(Oct. - Dec.) .

C_k: the fixed effect of k[th] calving year (k = 1(from 1975-1990); 2 (from1991-2000); 3(from 2001-2009) and 4(from 2010-2020).

D_l: the fixed effect of l[th] age at first calving (l ≤29; from 29–31; from 31–35 and > 35 months).

F_m: the fixed effect of m[th] gestation period length (m≤ 272; from 273–277; from 278–282 and > 282 days).

P_n: the fixed effect of n[th] sex (n=1(male) and 2(female).

$e_{ijklmno}$: random residual assumed to be independent, naturally distributed with mean zero and variance σ^2_e. The significant fixed factors were applied to create contemporary groups (CG) for the trait, which were involved in genetic aspects calculations.

Components of variance, heritabilities and breeding values were evaluated by VCE6 program (Groeneveld *et al., 2010*). The model was designed in a matrix symbols as follow:

$$y = Xb + Za + Sm + Ws + e, \text{ and}$$

$$var\begin{bmatrix} a \\ m \\ s \\ e \end{bmatrix} = \begin{bmatrix} A\sigma^2 a & 0 & 0 & 0 \\ 0 & A\sigma^2 m & 0 & 0 \\ 0 & 0 & A\sigma^2 s & 0 \\ 0 & 0 & 0 & I_i\sigma^2 e \end{bmatrix}$$

Where *y*: a vector of observations, *b*: a vector of fixed effects with an incidence matrix *X*, *a*: a vector of random animal effects with an incidence matrix *Z*, *m:* a vector of random dam effects with an incidence matrix *S*, *s*: a vector of random sire effects with an incidence matrix *W*, and *e*: a vector of random residual effects. *A* the numerator relationship matrix between animals, *I* an identity matrix, σ^2_a is the direct additive genetic variance, σ^2_m is the maternal additive genetic variance, σ^2_s is the sire additive genetic variance, and σ^2_e is the residual variance. The total heritability was estimated according to Willham (1980) using the following formula:

$$h^2_t = (\sigma^2_a + 0.5 * \sigma^2_m + 0.5 * \sigma^2_s) / \sigma^2_p, \text{ where}$$

h^2_t = total heritability, σ^2_a = direct additive genetic variance,

σ^2_m = maternal additive genetic variance

σ^2_s = sire additive genetic variance

σ^2_p = phenotypic variance

Prediction of breeding values:

Predicted breeding values (PBVs), predicted error variance (PEV) (i.e. standard errors, SE) and prediction accuracies ($r_{A\hat{A}}$) for the animals were estimated from REML using the statistical packet PEST (Groeneveld et al., 2001) for the same design to estimate the variance components and the heritability values.

Solution for an animal equation was calculated from the pedigree file, single animal at a time for animals with or without records (sires and dams). A diagonal element (d_t) and an adjusted right-hand side (y^*_t) were collected from each pedigree file record for the t[th] animal. For animal with or without records, the formula used to estimate the PBV was (Kennedy, 1989):

$$PBV = [y_t/d_t]$$

The predicted error variance (PEV) for the predicted (PBV_p) were evaluated for each individual as: $PEV_p = d_j\sigma^2_e$ (Korsgaard et al., 2002). The accuracy of PBV for each animal was calculated according to Henderson (1975) as:

$$r_{A\hat{A}} = \sqrt{1+F_j - d_j\alpha_a}$$

Where $r_{A\hat{A}}$ = the accuracy of prediction of a given animal breeding value; F_j=inbreeding coefficient of animals (supposed fit to be zero); d_j=the j[th] diagonal element of inverted of the fitting block coefficient matrix; and $\alpha_a = \sigma^2_e/\sigma^2_a$.

Genetic trend of BW was evaluated through regressing BV on years of calving by GLM technique of SAS software (SAS, 2014).

RESULTS AND DISCUSSION

As shown in Table 1.the average mean of BW was 31±5.2 kg in sequence with the findings of (Atil et al., 2005;Ali et al., 2019 ; Magwaba et al., 2019),but lower than a range of 34 -40 kg reported by several authors (Kaygısız et al., 2012;Yaylak et al., 2015; Abdel Fattah et al., 2019;Almasri et al., 2020 ; Atashi et al., 2021), and higher than 28.6 kg (Safaa and Gharib, 2017 and Hussein et al.,2022) in Friesian cows.

Factors affecting calve birth weight

Table 2 presents least squares means± standards errors of environmental factors affecting calves BW.

Effect of parity (PR):

Parity highly influenced BW (P<0.001). Steady similar increases in BW (P<0.001) were attained after the first parities due to dams maturity. Similar results were obtained by different investigators (Kaygisiz et al., 2011; 2012; Sahin et al.,2012*;* Dhakal et al.,2013; Kamal et al.,2014; Safaa and Gharib, 2017; Selvan et al,.2018 ; Almasri et al.,2020*;* Hussein et al.,2022). Also, BW increased with advancement of PR number (Raja et al., 2010*;* Sahin et al.,2012) as calf BW is a function of dams stage of maturity . Therefore poor BW calves are usually progeny of premature dams .However, Almasri et a*l*.(2020) reported that late PR old dams may produce low BW calves due to aging. While, Vallejo et al. (1990*)* ;Kaygısız (1996) and Srivastava et al.(2020) indicated that PR had no meaningful effect on BW of calves.

Effect of season of calving (SC):

SC affected calves BW (P<0.001). Winter and spring calvings showed higher (p<0.001) BW than summer and autumn. These results were similar to those of Kaygisiz et al. (2011, 2012*)*, Sahin et al. (2012), Kamal et al. (2014*)*, Sanad and Gharib (2017), Zulkadir et al.(2018) , Selvan et al.(2018*)*, Hussein et al.(2022) .While, Almasri et al.(2020*)* noticed that the lightest BW were found in Autumn probably depending on the availability of the dietry and climate conditions for the good production. While, Manoj et al. (2014*)* and Magwaba et al.(2019) reported non-significant influence of SC on BW due to time changes of birth and population capacity.

Effect of year of calving (YC):

YC influenced calves BW (P<0.001). The period from 1991-2000 exhibited the highest BW relative to other years of data collection. The current YC effects agreed with the results of many authors (Kaygisiz et al.,2011, 2012; Yaylak et al., 2015; Safaa and Gharib, 2017; Zulkadir et al.,2018 ;Magwaba et al.,2019*;* Hussein et al.,2022), but are in contrast to those of (Sahin et al.,2012*;*Almasri et al.,2020; Nurgiartiningsih et al.,2020) ,who obtained non-significant effects of YC on BW of calves.

Effect of Age at first calving (AFC):

The AFC effect on BW was highly significant (P<0. 001, Table 2) and complied with the results of Stefano et al, (2000), Kamal et al. (2014*)*, Magwaba et al. (2019*)*, and Atashi et al. (2021). BW of calves increased with the advancement of AFC of dams (Zulkadir et al., 2018; Atashi et al., 2021), while, Sahin et al. (2012) reported decreasing in BW by increasing AFC.

Effect of gestation period length (GPL)

GPL had significant (P<0.001) influence on BW. This was in agreement with the results of Kamal et al. (2014), Selvan et al. (2018*)* and Rezende et al. (2020). Also, Wattiaux, (1996) emphasized that for each day extension in GPL will cause 0.5 kg increase in BW .Moreover, Lopez et al. (2020) recorded positive genetic association of 0.53 and moderate phenotypic correlation of 0.21 between BW and GPL.

Table 2. Least square means (LSM) and standard errors (SE) for factors affecting calves birth weight.

Factor						LSM±SE	P-value
Parity	**1**	**2**	**3**	**4**	**5**	**≥6**	
	$29.52±0.12^{c}$	$31.42±0.14^{b}$	$32.16±0.17^{a}$	$32.45±0.20^{a}$	$32.6±0.26^{a}$	$32.34±0.2^{a}$	<.0001
SC	1 (Jan. - Mar.)	2 (April - June)	3 (July - Sept)	4 (Oct. - Dec.)			
	$32.22±0.13^{a}$	$32.24±0.15^{a}$	$31.24±0.15^{b}$	$31.3±0.14^{b}$			<.0001
YC	1975-1990	1991-2000	2001-2009	2010-2020			
	$31.51±0.14^{c}$	$32.24±0.13^{a}$	$31.58±0.14^{b}$	$31.67±0.17^{b}$			0.0003
AFC	≤ 29	> 29-31	> 31-35	> 35			
	$31.45±0.15^{b}$	$31.42±0.13^{b}$	$32.11±0.14^{a}$	$32.01±0.16^{a}$			0.0002
GPL	≤ 272	273-277	278-282	> 282			
	$30.23±0.14^{c}$	$31.72±0.13^{b}$	$32.64±0.14^{a}$	$32.41±0.16^{b}$			<.0001
Sex	Male	Female					
	$32.33±0.10^{a}$	$31.16±0.10^{b}$					<.0001

SC=season of calving; YC=year of calving; AFC=age at first calving in months; GPL=gestation period length in days.

Effect of gender:

Sex of calves affected BW (P<0.001). Male and female calves averages were 32.33±0.10 and 31.16±0.10 kg, respectively (Table 2), with about 1.17 kg increase in BW favoring (P<0.001) males compered to females. These results confirmed those of Kaygisiz et al. (2011, 2012), Sahin et al.(2012*)*, Dhakal et al.*(*2013*)*, Kamal et al.(2014),Yaylak et al.(2015) ,Soydan (2018), Zulkadir et al.(2018), Selvan et al.(2018), Magwaba et al.(2019), Nurgiartiningsih et al.*(*2020*)*, Almasri et al.(2020) , Atashi et al.(2021) and Hussein et al.,(2022) . Also, similar to our results (Yaylak et al., 2015; Soydan, 2018*;* Hoka et al., 2019*;* Nurgiartiningsih et al.,2020; Atashi et al.,2021; Hussein et al.,2022*)* obtained higher BW for males compared to females.

Soydan (2018) indicated that such high male calves BW resulted probably from the male gender anabolic hormones effects (Uzmay et al. 2010) during the prenatal growth stages of calves which usually possess longer GPL than females. Controversially , Bakır et al. *(*2004b*)*, Kaygısız and Tümer *(*2007*)*, Rezende et al.*(*2020*)* and Srivastava et al.*(*2020*)* revealed non-significant effects of gender on BW (P>0.05).

Heritability estimates :(h^2)

Table 3 displays the estimates of variance components and genetic parameters of the studied trait. Direct (h^2_a); sire (h^2_s); maternal (h^2_m) and total (h^2_t) heritabilities and direct maternal correlation (r_{am}) were 0.01, 0.10, 0.05, 0.09 and 0.01, respectively. The present values revealed that sire heritability was higher than maternal and direct heritability, while, maternal heritability was higher than direct heritability.

Table 3. Variance components, heritability and direct maternal correlation estimates of calves birth weight

Items	BW	SE
σ^2_a	0.27	0.51
σ^2_s	2.37	0.42
σ^2_m	1.18	0.32
σ^2_e	20.46	0.53
σ^2_p	24.28	1.01
h^2_a	0.01	0.02
h^2_s	0.10	0.02
h^2_m	0.05	0.01
h^2_t	0.09	0.02
r_{am}	0.01	0.03

σ^2_a = direct genetic variance; σ^2_s= sire genetic variance; σ^2_m =dam genetic variance; σ^2_e = residual variance; σ^2_p = phenotypic variance; h^2_a = direct heritability; h^2_s = sire heritability; h^2_m = dam heritability; Total heritability=h^2_t; r_{am}=direct maternal genetic correlation; BW= birth weight; SE=standard error

The current results on sire heritability (h^2_s= 0.10 ±0.02) were lower than 0.24 and 0.62 obtained by Akbulut et al. *(*2001*)* and Aksakal et al. *(*2012*)*. Moreover, Bahashwan et al. (2015) revealed high positive (p<0.01) association between sire birth weight category and calves growth features with high positive Pearson correlation coefficient of (0.84) with calves BW.

The direct heritability (h^2_a) estimate of BW (0.01) was nearly in line with 0.04 found by Kaygisiz et al.(2012) and within the limit of 0.02 to 0.48 stated by Karabulut et al. (2012*)*,but lower than the range of 0.12 to 0.26 obtained by Johanson et al. (2011) , Sahin et al.(2012*)* and Soydan(2018*)*, and that of 0.07 to 0.11reported by Sahin et al.(2017).

In general, as presented in Table 3, h^2_a estimate of BW was lower than the maternal heritability (h^2_m) estimate and in disagreement with the results of Sahin et al. (2017), who revealed reverse results.

The present h^2_m estimate of BW was 0.05±0.01 within the limits of 0.04 to 0.09 calculated by Jamrozik et al.(2005), Tilki et al. (2008*)* and Sahin et al.(2017) ,but lower than of 0.08 to 0.19 reported by Johanson et al.(2011*)*, Sahin et al.(2012*)*, Sanad and Gharib, (2017), Soydan (2018), Zulkadir et al.(2018) and Selvan et al.(2018),but higher than 0.002 ;0.02 reported by Kaygisiz et al. (2012*)* and Chin-Colli et al.(2016),respectively .Furthermore, Kamal et al. (2014) revealed that 26.2% of the variation in BW of calves born were made by the dam.

The total heritability estimate (h^2_t) of BW was around 0.09±0.02 within the range of 0.09 to 0.26 stated by Sahin et al. (2017), but greater than 0.06 found by Almasri et al.(2020), but lower than 0.12 to 0.32 reported by Kaygisiz et al.(2012), Sanad and Gharib (2017), Selvan et al.(2018) , Zulkadir et al.(2018) and Udeh et al.(2020).

Genetic correlations between direct and maternal effects:

As presented in Table 3, direct maternal genetic correlation (r_{am}) was weak positive approaching zero ,lower than the limits from -0.39 to -0.76 as found by Sahin et al. (2012*)*, Vostry et al (2014), Sahin et al (2017) and Yin and König, (2018) and than from -1.0 and 0.96 reported by Zulkadir et al. (2018*)* and Soydan (2018).

Breeding value (BV):

Expected BV of BW estimated from calves; sires and dams are given in Table (4). The estimates ranged from -6.71 to 6.84, -6.04 to 4.38 and -7.29 to 8.86 kg for calves, sires and dams, respectively. The BV estimates for sire were lower than -4.40 to 6.85 as estimated by Magwaba et al. (2019).

Table 4. Range of calves, sires and dams predicted breeding values (BV) with their accuracy for birth weight

	Calves-BV	Sire-BV	Dam-BV
Minimum	-6.71	-6.04	-7.29
Maximum	6.84	4.38	8.86
Range(kg)	13.55	10.42	16.15
Accuracy %	0.69 – 0.81	0.45 – 0.63	0.51 – 0.72

The ranges of BV for dams were higher than those for sires and calves in accordance with the results of Zulkadir et al. (2018). Table 4 and Fig 1.showed the magnitude of dam BV, as it provided the highest limit of BV for BW. Hence, selection of dams for BW in the following generation is supposed to cause the highest heritable progress in the studied herd. However, Sanad and Gharib (2017) revealed that the range of calves BV was higher than that for dams and sires.

The accuracy of BV for calves BW were higher than those of sires and dams, being from 0.69 to 0.81% , 0.45 to 0.63 and 0.51 to 0.72 % ,respectively. This trend agreed with the results of Sanad and Gharib (2017), who obtained BV range from 79-80, 74-78, and 68-77% for calves, sires, and dams, respectively and the trend results of Hussein et al.,(2022) .This suggested that, the possibility of genetic improvement should be effective through calves which had the highest accuracy compared to sires and dams. High accuracy levels of BVs should help animal breeders to practice genetic improvement in their herds. However, Zulkadir et al. (2018) showed that the accuracy of sire BV was higher than those of dams and calves probably due the greater number of offspring per sire available.

Genetic trend for calves across generations:

Figure 2 presents an evaluation for means of calves BV values for BW according to years of study. In general, irregular fluctuations were observed for genetic trend in BW by years and the values were negative in some years and positive in others, revealing no particular genetics plans have been practiced for improving BW in the studied herd. Thus, there was no heritable progress in calves BW. Fluctuations appearing in BW by years may be caused by random drift or by changes in environmental conditions as suggested by Kaygısız et al. (2012).

Fig.2. Mean calve breeding values of birth weight according to years

CONCLUSION

According to the current results, the environmental aspects of parity, calving year and season, age at first calving and gender should be taken into consideration when calves are evaluated for BW. In addition, improvement in calves BW could be achieved through better feeding, housing system and management practices of pregnant cows during dry off period.

The weak heritability estimates of BW in the current study may justify the poor selection results of BW in the dairy herd under study. Genetic improvement could be more efficient, under good feeding and management practices for dams during the late stage of gestation.

Dam BVs for calve BW possessed the highest range. Therefore, dam selection should cause better genetic improvement in this herd in the subsequent generation. Moreover, high accuracy of calve BV relative to sire's or dam's (0.69 – 0.81%) may achieve more improvement in BW by indirect selection and good management.

There is no evidence of apparent systematic improvement or modification in the inherited merit of BW during the period of this study, as there were no direct selection plans or any other genetic tendency was practiced for altering the genetic makeup of the herd. Thus, effective breeding strategies should be applied on calves BW associated with more advanced herd managements. However, it is recommended, that selection should be practiced for moderate BV of calves BW, management practices should be controlled well and the cows selection should be applied in a modest way since large BW are not recommended to avoid dystocia.

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المعالم الوراثية للتأثيرات المباشرة والأموية على وزن الولادة في عجول الفريزيان تحت ظروف المزرعة المصرية.

شيرين كمال السيد جنينة و محمد حمادة محمد عبد الحميد الصاوى و المعتز بالله محفوظ مصطفي شعراوى و اشرف علي مهني اسماعيل.
معهد بحوث الانتاج الحيواني - مركز البحوث الزراعية - وزارة الزراعة -الدقي - الجيزة

الملخص

تم تحليل عدد 4889 سجلًا للعجول المولودة لعدد 1609 بقرة فريزيان بين 1975 إلى 2020 في محطة بحوث سخا (مزرعة حكومية بكفر الشيخ) لتقدير المعالم الوراثية للتاثيرات المباشرة والاموية و لدراسة تأثيرات العوامل البيئية المختلفة.وهي ترتيب موسم الولادة وموسم وسنة الولادة ، والعمر عند أول ولادة ، وطول فترة الحمل ، وجنس العجل المولود على وزن العجول عند الولادة. تم تقدير مكونات التباين والمكافيء الوراثي والقيم التربوية باستخدام برنامج VCE6 (Groeneveld et al. 2010), وتم تقدير الاتجاهات الوراثية لهذة الصفة بتقدير انحدار القيم التربوية للاوزان على سنوات الولادة باستخدام GLM لبرنامج (SAS, 2014).- أظهرت الدراسة معنوية التأثيرات ($P\le 0.001$) البيئية المدروسة على وزن العجول عند الولادة. - بلغت قيم المكافيء الوراثي المباشر للعجول(h^2_a)وللطلوقة(h^2_s) وللام (h^2_D)والكلي (h^2_T)للاوزان 0.01 ؛ 0.10 ؛ 0.05 ؛0.09 علي الترتيب ولمعامل الارتباط المباشر الامى(r_{am}) 0.01. -تراوحت القيم التربوية لهذة الصفة من -6.71 إلى 6.84 كجم و من -6.04 إلى 4.38 كجم ومن -7.29 إلى 8.86 كجم للعجول و الطلايق والامهات على التوالي. - كانت تقديرات القيم التربوية للامهات أعلى من مثيلاتها للطلائق والعجول. بينما كانت نسبة دقة تقديرالقيم التربوية للعجول أعلى من مثيلتها للطلائق والامهات وكانت قيم الاتجاهات الوراثية كانحدار للقيم التربوية للاوزان علي سنوات الولادة تقارب الصفروكان ذلك متوقعًا لعدم وجود انتخاب مباشر أواتجاة وراثي لتحسينها. -في هذه الدراسة:يوصي بتطبيق استراتيجيات تربية وادارة فعالة للقطعان الحكومية مع اتباع برامج تحسين حقيقيةلأوزان العجول بعد الولادة وذلك لعلاقتها بتحسين الاداء الانتاجى والتناسلى وطول الحياة الانتاجية بماشية اللبن.