القدرات الإنتاجية لأبقار البطانة السودانية تحت ظروف محطة البحوث

The Production Potential of Sudanese Butana Cattle Under Station Conditions

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الملخص

هدفت هذه الدراسة لتقدير المعالم الوراثية (المكافئ الوراثي والارتباطات الوراثية والمظهرية والبيئية) للصفات الإنتاجية والتناسلية لقطيع أبقار البطانة في محطة بحوث عطبرة شمال السودان. البيانات المستخدمة شملت 1381 سجل ل 175 بقرة غطت الفترة من 1969 – 2018. تم تحليل البيانات باستخدام برنامج المربعات الصغرى Harvey (1990).
قُدر متوسط المربعات الصغرى لإنتاج الحليب الموسمي والحليب اليومي وطول فترة الحلابة وإنتاج الحليب الكلي للبقرة بنحو 1487.00 ± 69.50 كغ و4.12±0.19 كغ و288.10±9.30 يوم و8250.50±935 كغ على التوالي. كان تأثير سنة وموسم الولادة على إنتاج الحليب الموسمي معنويا (P<0.05). في حين كان تأثير عدد المواسم عالي المعنوية على الإنتاج الكلي للعمر الإنتاجي للبقرة (P<0.00). تأثير الأب كان عالي المعنوية (P<0.00) على كل الصفات المدروسة. الانحدارات الخطية والتربيعية للحليب الموسمي واليومي على طول فترة الحلابة كانت عالية التأثير (P<0.01). قيم الانحدارات الخطية والتربيعية للإنتاج الموسمي والكلي على طول فترة الحلابة قُدرت بنحو 4.32±0.23 و-0.0047±0.002، 0.95±0.35 و0.001±0.0002 على التوالي.
أظهرت نتائج هذه الدراسة أن المكافئات الوراثية والخطأ القياسي لصفات الإنتاج الموسمي والإنتاج اليومي والإنتاج الكلي للبقرة وطول موسم الحلابة كانت 0.172±0.039 و0.174±0.039 و0.286±0.097 و0.158±0.037 على التوالي. الارتباطات الوراثية بين صفات الإنتاج كانت بين 0.997±0.04 و0.822±0.072، بينما تراوحت الارتباطات المظهرية فيما بينها من 0.958±0.004 الى 0.423±0.080. هذا بالإضافة الي أن قيم الارتباطات البيئية بينها كانت بين 0.950 و0.071. خلصت الدراسة الي أن ابقار البطانة تمتلك قدرات عالية جدا كمنتجة للحليب ويوصي بالمحافظة عليها وتحسينها.

الكلمات المفتاحية: ابقار البطانة، إنتاج الحليب، المعالم الوراثية.

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Abstract

The objective of the study was to estimate productive traits phenotypic and genetic parameters (heritability, genetic, phenotypic and environmental correlations) of Butana cattle herd at Atbara Research Station in Northern Sudan. The data used in this study included 1381 records of 175 Butana cows covering the years 1969–2018.The data was analyzed using Harvey's (1990) least- squares computer programmer. The least squares mean of milk yield, daily milk yield, lactation length, lifetime yield, were: 1487.00±69.50 kg, 4.12±.19 kg, 288.10± 9.30days, 8250. 50± 935.00kg, respectively. The effect of calving year seasons on milk yield was significant ($P<0.05$). The number of parities influence on life time yield was highly significant ($P<0.00$). The effects of sires were highly significant ($P<0.00$) on all studied traits. The effects of linear and quadratic regressions of both milk yield and daily yield on length of lactation were highly significant ($P<0.01$). The estimated linear and quadratic regressions on lactation length of lactation yield and of lifetime yield were 4.32±0.23and -0.0047±.0.002, 0.95±0.35 and 0.0010±0.0002, respectively.

The estimates of heritability and their standard errors of milk yield, daily milk yield, total lifetime yield, and lactation length were 0.172±.039, 0.174±.039, 0.286± 0.097, and 0.158± 0.037, respectively.

Genetic correlations between production traits ranged from 0.997 ±0.04 to 0.822±0.072. The phenotypic correlations between production traits ranged from 0.958±.004 to 0.423±0.080. In addition, the environmental correlations ranged from 0.950 to 0.071. The study concluded that the Butana ecotype has a very good potential as a milk producer and recommended that it should be conserved and improved.

Key words: Butana, cattle, milk performance, genetic parameters

Introduction

Livestock is raised in almost all parts of the Sudan and is owned primarily by nomadic tribes. In 2018, the livestock population was estimated to comprise about 31 million cattle, 40 million sheep, 31 million goats and 4.8 million camels. The River Nile State is located between latitudes 16-22North, and longitudes 32-35South with a total of 22.1 thousand square kilometers. Livestock farming is an important component of the agricultural sector in the Sudan for the provision of food products and as a source of income and insurance for resource poor farmers (Abaker*et al* .2017).

Zebu breeds of cattle are generally late maturing reaching the age at first calving at about three to four years of age and are of poor dairy temperament requiring the calf presence for milk let down(Wilson *et al.* 1987).The milk production of Sudanese indigenous cattle breeds (*B.indicus*) was found to be lower than that of Friesian cattle (*B. taurus)*, even under the same climatic conditions (average lactation milk yield adjusted to 305 days is 1405 ± 695 kg for Butana and 1597 kg for Kenana compared to 4784 ± 81 kg for Friesian). (Wilson *et al* 1987; Ageeb and Hayes, 2000). The Sudanese Butana cattle breed is one of the large East African Zebu breeds as reflected in their linear body measurements and their performance does not fall behind that of the best local dairy breeds in the tropics. The Butana breed is known as a good milk producer under stressful environmental conditions (Elfaki,2015).

Breeding plans and the implementation of selection programs require detailed genetic parameters analysis of important milk production and reproduction traits. Therefore, accurate estimates of genetic parameters in tropical herds are important for planning and implementing efficient breeding programs (Ayalew*et al.* 2017). A major obstacle to research in tropical cattle performance is the lack of good records making and that research stations the only reliable source of records. This study was conducted at Atbara Research Station with the aim of providing baseline data on the performance of Butana cattle. Such baseline data is important for future conservation and improvement plans.

Materials and Methods

Location of Atbara Research Station

The station is situated in the River Nile State to the North of Atbara town in Northern Sudan. It is located at 17˚-40˚ North latitude and 33˚-58˚ longitude at an altitude of approximately 345 meters above sea level (Ahmed et al, 2019). The average annual precipitation in the area is about 70 mm. The atmospheric temperature in this area varies from a maximum of 47.7 °C recorded in April, to a minimum of 4.5 °C registered in January. The total farm area was 102 acres of which 12 acres are occupied by offices, poultry sheds, and 90 acres are under cropping.

The station was established in 1941. In 1943 the foundation cows were selected from Shendi region from the best Butana cows available in the area. The station was originally established to pursue studies and research in various aspects of dairy production. The current herd size in the station is very small, comprising 43 cows and 5 heifers, 32 growing calves, 16 weaners, 14 sucklers and 6 sires. The station faces problems of irregular and insufficient financing, insufficient feed resources and labour shortage.

Data analysis

The data used in this study were extracted from Atbara Livestock Research Station records. They included 1381 records of 175 Butana cows covering the years 1969–2018. The data were classified into periods according to the year of calving and according to the year of birth of the cow. Mixed model least-squares and maximum likelihood analyses were performed for each trait to compute least squares means, standard errors and coefficients of variation using Harvey's computer programme (1990).

The following statistical models were applied.

Model 1:

Analysis of milk yield and daily milk yield:

$$Y_{ijkl}=\mu+R_i+C_j+S_k+b_1A+b_2A^2+e_{ijkl}$$

where:

Y_{ijkl}= the ijklth observation on the trait in question

R=the effect of ith parity number (i=1-7)

C_j= the effect ofjth years season of calving (j=1-3)

S_k=the effect of kth sires (k=1-21)

A= mean lactation length

B_1 b_2=linear and quadratic regression coefficients

Model 2

Analysis of lifetime milk yield

$$Y_{ijl}=\mu+R_i+s_j+e_{ijl}$$

where:

μ , R_i, s_j, e_{ijl} as in model 1above.

Model 3

Analysis of lactation length:

$y_{ijkl}=\mu+R_i+C_j+S_k+e_{ijkl}$

where:

μ ,R_i ,C_j ,S_k ,e_{ijkl} as in model1 and 2 bove.

Results

Table 1. The effect of sires, parity or number of parities and calving year seasons on milk yield (MY), daily milk yield (DMY), lactation length (LL) and lifetime milk yield (LMY)

Item	MY			LL		DMY		LMY	
	DF	MS	F	M.S	F	MS	F	MS	F
Sire	37	1180304.07	4.61**	21396.05	4.3**	9.00	5.00**	12438253.83	2.05**
Parity	6	397376.30	1.55ns	8903.00	2.0 ns	3.02	2.00ns		
Calving years season	14	477977.00	1.87*	6272.00	1.2 ns	2.17	1.14 ns		
No. of Parities	7							43332608.23	7.141**
Error	775 (104#)	256155.06		5033.40		2.00		6067788.80	

#: DF for LMY

The results of the analysis of variance for the effects of sires, parity or number of parities and calving year seasons on milk yield (MY), daily milk yield (DMY), lactation length (LL) and lifetime milk yield (LMY) are shown in table 1.The effects of sires on milk yield per lactation were highly significant (P<0.00),while the effects of calving year seasons had significant effects (P<0.05), and parities were not significant (P=0.16). Sires had a highly significant (P<0.00) impact on daily milk yield, while the effects of calving year seasons and parities were not significant (P=0. 32,0.15). Lactation length was also highly significantly (P<0.00) affected by sires, while the effects of calving year seasons and parities were not significant (P=0.10 3, 0.24).The effects of sires and numbers of parities on lifetime milk yield were highly significant (P<0.00).

Table 2. Least squares means and standard errors of milk yield (MY), daily milk yield (DMY), lactation length (LL)

Item	No	Milk yield	Dailymilk yield	Lactation length
Over all mean	833	1487.00±69.50	4.12±.19	288.10± 9.30
Parity number:				
First Parity	112	1431.00±85.30	4.00±.23	307.30± 12.00
Second parity	142	1393.00±80.12	4.00±.22	289.40±11.00
Third parity	151	1490.51±79.00	4.0 5±0.2 2	295.21±11.00
Fourth parity	142	1519.60±79.57	4. 20 ±0.2 2	285.21±11.00
Fifth parity	137	1559.13±80.09	4.21±0.2 2	282.41±11.00
Sixth parity	103	1537.495±84.64	4.22±0.23	278.00±11.50
Seventh parity	46	1476.10±104.42	4.13± 0. 30	279.00±14.34
Calving - Year season				
Winter 1970-1979	57	1601.30±133.82	4.31± 40	283.00±19.00
Dry summer	46	1334.68±145.55	4. 00±0. 40	259.30±20.19
Wet summer	94	1648.04±144.41	4.21±0.40	287.29±20.03
Winter 1980-1989	100	1466.62±110.65	4. 00±0.30	297.88±15.23
Dry summer	77	1457.09±116.43	4. 00±0.32	304.87±16.05
Wet summer	62	1327.47±118.38	4.00±0.32	289.96± 16.33
Winter 1990-1999	71	1303.87±104.399	4. 00± 0.30	289.87± 14.34
Dry summer	54	1361.04±111.15	4. 00± 0.30	296.02±15.30
Wet summer	45	1215.06±114.84	4. 00±0.31	277.70 ±15.83
Winter 2000-2009	33	1455.26± 127.51	4.10± 0.35	308.94± 17.63
Dry summer	73	1550.87±123.999	4.30±0.34	305.08± 17.13
Wet summer	51	1493.10±128.87	4.15± 0.35	300.11±17.82
Winter2010-2018	41	1653.03 ±164.18	4.54±0.45	268.16±22.83
Dry summer	48	1755.35±166.03	5.00±0.45	275.498±23.09
Wet summer	26	1677.12±173.94	4. 50±0.50	277.43±24.21
Linear regression on length		4.32±0.23		
Quadratic regression on length		-0.0047±.0.002		

L.S.M = least squares means S.E= standard error n= total number of observations

Table 2 shows the least squares means and standard errors of milk yield (MY), daily milk yield (DMY), lactation length (LL). The overall mean of milk yield per lactation was1487.00± 69.50kg. The maximum milk yield (1755.35±166.03) was obtained in the dry summer of 2010-2018. The least milk yield (1215.06±114.84) was in the wet summer of 1990-1999.Daily milk yield had an overall mean of4.12±.19 kg, 2kg. With regard to the effects of parities the maximum overall milk yield was obtained in the in fifth parity(1559.13±80.09).The highest daily milk yield (4.22±0.23) was in the sixth parity and the dry summer of2010-2018(5.00±0.45).The linear and quadratic regressions of milk yield on lactation length were-4.32±.23 and -0.005± 0.001, respectively. The estimated overall mean of lactation length was 288.10± 9.30 days (Table 2) which is slightly less than the optimum of 305 days. The lactations in the first parity were longer than those in other parities. It is notable that in more recent years (2010-2018) lactations became shorter.

Table 3. The least squares means and standard errors of lifetime milk yield (LMY)as affected by number of parities, linear and quadratic regressions on lactation length.

Item	No	LSM±SE
Over all mean	149	8996.60±543.50
Parity number:	***	
3 parities cows	6	6173.95±1788.41[a]
4 parities cows	8	5663.51± 1117.79[a]
5 parities cows	35	6944.56 ±740.97[ab]
6 parities cows	52	8237.31±742.56[bc]
7 parities cows	14	11587.57± 994.44[de]
8 parities cows	10	9497.07±1101.34[cd]
9 parities cows	16	11469.400± 919.95[e]
10 parities cows	8	12399.42±1265.93[e]
Linear regression		0.95±0.35
Quadratic regression		0.0010±0.0002

The least squares means and standard errors of lifetime milk yield (LMY) as affected by number of parities, linear and quadratic regressions on lactation length are shown in table 3. The estimated overall mean of total life time production was 8996.60±543.50 kg (Table3). The parities had significant effects (P<0.001) on life time production. The linear and quadratic regressions estimates were 0.95±0.35 and 0.0010±0.0002 respectively. The maximum total life production (12399.42±1265.93) was obtained in 8 cows with ten parities and the least lifetime production (5663.51± 1117.79) was rerecorded by 8 cows with 4 parities each.

Table 4. Heritability, standard error, and genetic and phenotypic correlations among milk yield (MY), daily milk yield (DMY) life time production (LTP), lactation length (LL)

	MY	DMY	LTP	LL
MY	0.172±.039	0.997±0.04	0.822±0.072	
DMY	0.958±0.004	0.174±0.039		
LTP	0.452±0.072	0.423±0.080	0.286±0.097	
LL				0.158±0.037

*h^2= on the diagonal, r_A= Above the diagonal, r_P=Below the diagonal

As shown in table 4, the estimates of heritability and their standard errors of milk yield, daily milk yield, total lifetime yield, and lactation length were 0.172±.039, 0.174±.039, 0.286± 0.097, and 0.158± 0.037, respectively. Genetic correlations between production traits ranged from 0.997 ±0.04 to 0.822±0.072.The phenotypic correlations between production traits ranged from 0.958±.004 to 0.423±0.080. In addition, the environmental correlations for the studied traits ranged from 0.950 to 0.071.

Discussion

The effects of sires, parities and calving year-seasons on milk yield are presented in table 1 The effects of sires were highly significant (P<0.00). The effects of calving year-seasons were significant (P<0.05) and this is close to the results reported by Musa*et al*. (2005) in their study on Butana cattle. In the present study the effects of parities were not significant(P>0.05) which is again similar to the finding of Musa et al, (2005). Table 2 shows that the overall mean of milk yield per lactation of Butana cattle was 1487.00±69.50 kg. This is higher than the estimate reported by Gebreyohannes *et al*. (2013) in two Ethiopian breeds: Boran and Horro (947±42.3 and 1210±37.7, respectively). Toure *et al*. (2019) in Mali estimated the milk yield of local breeds (Zebu Peul and/or Zebu Maure) as 681±41.10kg. Muluy*et al*. (2017) in Ethiopia found that the average milk per lactation of indigenous cattle was 311.6±43 liters.

The milk yield reported in the above-mentioned studies is less than the yield of Butana presented here which confirms that Butana breed is one of the best tropical dairy breeds. Higher estimates were also reported for Butana. Badri *et al*, (2011) reported that the overall mean of milk yield of Butana was1709.49± 892.09 kg. Musa *et al*. (2008) found that the milk yield per lactation was 1,662.57± 108.96 kg in Atbara Research Station. Musa *et al*. (2005) reported that the linear and quadratic regressions on lactation length were 6.38± 0.151 and -0.0045± 0.00109, respectively. The two regression coefficients in the present study were more or less similar; 4.32±0.23 and -0.0047±0.002, respectively (Table 2).

The effects of sires on daily milk yield were highly significant (P<0.00), while the effects of calving year seasons and parities were not significant, Musa *et al.* (2005) found that year-seasons of calving, parities and sires influenced daily milk yield significantly (P<0.05). In a study by Muluy *et al*, (2017) in Ethiopia the parity number was found to exert a significant (P<0.001) effect on daily milk yield. The mean of daily milk yield of Butana (Table 2) was 4.12±.19kgwhich is much higher than the estimates of Gebreyohannes *et al.* (2013) in Ethiopia obtained from Boran and Horro breeds data (1.8±0.13 and 2.8±0.12, respectively). Khan *et al.* (2017) in a study of indigenous zebu cattle (*Bosindicus*) also reported estimate of milk yield per day of 1.43±0.58 liters in Bangladesh. Musa *et al.* (2008) reported that daily milk yield was 6.10 ± 0.41in Atbara Research Station. The estimates obtained by El-Habeeb (1991) and Musa *et al*. (2005) for Kenana and Butana were 5.60 ± 1.77and 6.10 ± 0.41 kg, respectively, and are in close similarity with the present study estimates.

The standard lactation length of 305 days is the usual length for a cow that produces a calf every 12 months. Zebu cattle including Butana usually have shorter lactations. The analysis of variance (table 1) shows that the effects of sires on lactation length were highly significant (P<0.00), while the effects of calving year-seasons and parities were not significant in all lactations (P>0.05). Musa *et al*. (2005) showed that the parity number had a significant (p<0.001) impact on lactation length of Butana. In the present study the calving year-seasons did not introduce significant (P<0.05) variation in lactation length. Musa *et al*. (2005) showed that the calving year-seasons had a significant effect on lactation length (p<0.05). The different results in the present study might be attributed to the changes in management policy related to feeding, drying off, and milking routine, disease control and changes in climatic conditions over years. Table 2 shows lactation length means of Butana cattle. The mean lactation length obtained is less than the optimum of lactation length (305 days) generally accepted as a standard in dairy cattle. The lactations of cows in the first parity were longer than those in other parities. It is notable that in more recent years 2010-2018 lactations became shorter. This could be due to managerial and disease problems and it may be a true expression of the genetic potential of the herd, and this is close to the findings of Musa *et al.* (2005). Kale *et al.* (2018) found that the averages of lactation length of indigenous cattle were 265.00±13.83, 265.56±11.53 and 264.16±11.96 days, respectively under farmers' management in India. Musa *et al*. (2006) reported that the lactation length of the two types Butana and Kenana cattle under field conditions were 190.20 and 202.50, respectively. Muluye *et al*. (2017) studied local and crossbred dairy cows in Ethiopia and estimated lactation length as239.3± 5. However, this estimate is well below the estimate obtained in the present study and the variation may be attributed to the difference in environmental conditions between the research station and the field.

The effects of sires and numbers of parities on lifetime milk yield were highly significant (P<0.00). The means of lifetime milk yield, linear and quadratic regressions on lactation length are shown in table 3. Those were 8996.60±543.50, 0.95±0.35 and 0.0010±0.0002, respectively. Vinothraj *et al.* (2019) in India studied the overall lifetime production performance of the Jersey x Red Sindhi crossbred cows and reported estimates of 4411.14 ± 194.12kg. This result is less than the finding of the present study. Effa *et al*. (2013) in Ethiopia studied longevity traits for F1 Friesian x Boran and observed that the overall least squares mean of lifetime milk yield was 10460.6± 1117.4 L, a result that is higher than that of the present study.

The estimates of heritability and standard errors of milk yield, daily milk yield, total life production, lactation length are presented in table 4.14. The estimates were 0.172±.039,0.174±.039,0.286±0.097, and 0.158±0.037, respectively. The heritability estimates of milk yield, daily milk yield and total life production were within the expected range while the estimated heritability of lactation length was higher than that reported byBadri*et al.* (2011) who found that the heritability of lactation period was 0.01±0.01in Butana cattle. Birhanu *et al.* (2015) studied data of Ethiopian Boran cattle and reported that the heritability values of daily milk yield, lactation length, total lactation milk yield, were 0.430±0.036, 0.325±0.038, and 0.476± 0.035 which are generally higher than the estimates obtained in the present study. Rehman and Khan (2012) in Sahiwal cattle of Pakistan reported that the heritability of 305 days milk yield, total milk yield and lactation length were 0.10±0.016, 0.09±0.016, 0.06±0.013, respectively.

The estimates of genetic correlations between the studied traits are presented in table 4. All estimates were in the range of 1.392±1.354 and 0.822±0.072. Birhanu *et al.*(2015) in a study of Ethiopian Boran cattle reported that the genetic correlation between daily milk yield and total lactation milk yield was 0.958,an estimate close to the findings of the present study. The estimates of phenotypic correlations between the studied traits were in the range of 0.958±.004 and -0.004±.994. The highest phenotypic correlation estimated was 0.958±.004between daily milk and lactation milk yield. Birhanu*et al.* (2015) found that the phenotypic correlation between milk yield and total lactation milk yield calculated from Ethiopian Boran data was 0.86which is close to the estimate obtained here. The estimates of environmental correlations were in the range of 0.950 and 0.071(Table 4). The strongest environmental correlation was 0.950 obtained between daily milk and milk yield. Rehman and Khan, (2012) in Pakistan calculated the phenotypic, genetic and environmental correlation of 305-d milk yield with lactation length as 0.71, 0.48 and 0.70, respectively.

Conclusions

Estimates of Butana performance obtained in this study indicate that the breed ranks among the best tropical dairy cattle. The moderate heritability estimates of production traits observed in this study indicated that reasonable genetic improvement in these traits can be achieved by selection.

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