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The reproductive and milk performance merit of Butana cattle in Sudan

Dedicated to Prof. Dr. Peter Horst on the occasion of his 75th birthday

Abstract

Data from the Butana herd of Atbara Livestock Research Station were analyzed for the period 1949 – 1999. The least squares means for age at first calving, calving interval, milk yield per lactation, daily milk yield, lactation length and dry period were 45.05 ± 3.56 months, 382.38 ± 8.30 days, 1662.57 ± 108.96 kg, 6.10 ± 0.40 kg, 268.17 ± 5.56 days and 119.10 ± 8.30 days, respectively.
The analysis of variance revealed that the sire and parity number influenced the studied traits, while year-season of calving influenced the milk yield per lactation, daily milk yield and lactation length. Linear and quadratic regressions on lactation length significantly influenced milk yield per lactation and daily milk yield.
Heritability estimates for age at first calving, calving interval, milk yield per lactation, daily milk yield, lactation length and dry period were 0.19 ± 0.07, 0.09 ± 0.03, 0.26 ± 0.06, 0.27 ± 0.07, 0.04 ± 0.02, and 0.09 ± 0.03, respectively.
This study highlighted the importance of conserving the indigenous dairy cattle breeds for future generations. The presence of significant variation and the corresponding heritability estimates give promise of reasonable genetic improvement under selective breeding with respect to milk yield characters.

Key Words: Butana cattle, reproduction performance, milk yield

Zusammenfassung

Titel der Arbeit: **Reproduktions- und Milchleistungen von Butana Rindern im Sudan**
Leistungsdaten von Butana-Zuchtherden auf der Atbara Livestock Station aus den Jahren 1949-1999 wurden zur Berechnung der Laktationsleistung, tägliche Milchmenge, Laktationslänge, Trockenstehzeit, Erstkalbealter und Kalbeintervall herangezogen (1662,57 ± 108,96 kg, 6,10 ± 0,40 kg, 268,17 ± 5,56 Tage, 119,10 ± 8,30 Tage, 45,05 ± 3,56 Monate und 382,38 ± 8,30 Tage).
Jahr und Saison der Kalbung und Laktationsnummer beeinflussten alle Leistungsmerkmale außer Trockenperiode und Zwischenkalbezeit. Die Regression ersten und zweiten Grades der Laktationslänge auf die Laktationsleistung war signifikant und auf die tägliche Milchleistung hochsignifikant.
Heritabilitäts-Schätzwerte für Erstkalbealter, Zwischenkalbezeit, Laktationsleistung, tägliche Milchleistung, Laktationslänge und Trockenstehzeit waren 0,19 ± 0,07, 0,09 ± 0,03, 0,26 ± 0,06, 0,27 ± 0,07, 0,04 ± 0,02 und 0,09 ± 0,03.
Die Studie hebt die Bedeutung einer nutzungsorientierten Erhaltung der Butana Milchrinder hervor. Die vorhandene Leistungsvariabilität und geschätzte Heritabilität lassen eine erfolgreiche züchterische Verbesserung durch Reinzucht erwarten.

Schlüsselwörter: Butana Rinder, Fruchtbarkeit, Milchleistung

Introduction

Livestock play important roles for production of food and represent great socio-economic and cultural values in various societies around the world. Indigenous cattle form the backbone of relevant and sustainable livestock production in most Eastern

African countries because when compared with their exotic counterparts, they are better adapted to survive and reproduce under the region's harsh environments (OKOMO-ADHIAMBO, 2002).

In Sudan, the rural communities own 80% of the livestock and the nomadic tribes own 90% of the rural holdings with livestock playing a central role in their livelihoods. Attempts to infuse exotic improved blood into Sudanese dairy cattle population led in some cases to the extinction or near-extinction of the best local types of cattle (Butana and Kenana) in some areas of the country. Through experience, many herdsmen have come to understand that the best results are obtained by crossing the best local cattle (usually Butana and Kenana) with the exotic breeds (usually Friesian).

This has led to widespread concern over the fate of Butana and Kenana types and to efforts for conservation of these strains for both present and future use. This concern is motivated by the fact that the genotypes of the improved indigenous breeds may be required to upgrade or replace low producing cattle in harsh nomadic environments where exotic cattle cannot survive. Another cause for concern is the fact that the directions of future demand cannot be predicted with any certainty. Research, to improve the knowledge on indigenous animal genetic resources, is instrumental for increased awareness on the role of livestock and their genetic diversity and for the implementation of sustainable breeding programmes.

This study was conducted to estimate genetic parameters for some important productive traits including milk yield per lactation, daily milk yield, lactation length, dry period, calving interval and age at first calving of Butana cattle of Sudan. The effects of some environmental factors are also investigated. This is important for the success of any attempt to explore the possibilities of improvement and conservation of this local breed, which is now threatened by extensive and unplanned crossing with foreign breeds.

Material and Methods

The data used in this study were extracted from Atbara Livestock Research Station records. They included 1894 records of 562 Butana cows covering the years 1949 – 1999. The data were classified into five periods according to the year of calving and according to the year of birth of the cow. Each period extended for ten years. Table 1 shows the distribution of animals over the years according to the year of birth of the cow.

Table 1
The distribution of animals over the years according to the year of birth of the cow (Die Verteilung der Tiere nach dem Geburtsjahr der Kuh)

Years	Number of cow
1949 – 1958	27
1959 – 1968	160
1969 – 1978	241
1979 – 1988	104
1989 – 1999	30
Total	562

The station is situated in the River Nile State in Northern Sudan. It is located at $17^{/} 42^{o}$ N latitude and $33^{/} 58^{o}$ E longitude at an altitude of approximately 345 meters above sea level and an average annual precipitation of 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.
Mixed model least-squares and maximum likelihood analysis 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 age at first calving:
$$Y_{jk} = \mu + C_j + S_k + e_{jk} \quad (1)$$
Where
Y_{ijk} = the $_{ijk}$th observation of the trait in question
μ = the overall mean
C_j = effect of j^{th} year-season of cow's birth (j = 1-15)
S_k = effect of k^{th} sire of cow (k = 1-21)
e_{ijk} = residual error

Model (2)
Analysis of dry period and calving interval
$$Y_{ijkl} = \mu + R_i + C_j + S_k + b_1A + e_{ijkl} \quad (2)$$
Where
C_j = effect of j^{th} year-season of calving (j = 1-15)
R_I = effect of i^{th} parity number (i = 1-5)
A = lactation length
b_1 = linear regression coefficient
Y_{ijkl}, μ, $S_{k,}$ and e_{ijkl} as in model (1) above

Model (3)
Analysis of milk yield per lactation and daily milk yield
$$Y_{ijkl} = \mu + R_i + C_j + S_k + b_1A + b_2A^2 + e_{ijkl} \quad (3)$$
Where
b_2 = quadratic regression coefficient
Y_{ijkl}, μ, $C_{j,}$ $R_{I,}$ A, $b_{1,}$ $S_{k,}$ and e_{ijkl} as in model (1 and 2) above

Model (4)
Analysis of lactation length:
$$Y_{ijkl} = \mu + R_i + C_j + S_k + b_1D + b_2D^2 + e_{ijkl} \quad (4)$$
Where
D = daily milk yield
Y_{ijkl}, μ, $R_{i,}$ $C_{j,}$ $S_{k,}$ $b_{1,}$ b_2 and e_{ijkl} as in model (1, 2and 3) above

The heritabilities were estimated by paternal half-sib variance analysis as described by BECKER (1975). Data were analyzed using HARVEY's computer programme (1990). Differences between means were tested using Duncan's Multiple Range Test (DMRT).

Results

The results (Table 2, 3, and 4) indicated that the sire of cow and parity number had significant ($p<0.05$) influences on all studied traits, while year-season of calving influenced ($p<0.05$) milk yield per lactation, daily milk yield and lactation length. Linear and quadratic regressions on lactation length had significant ($p<0.05$) effects on milk yield per lactation and daily milk yield. The results also showed that the linear and quadratic regressions on daily milk yield had a significant influence on lactation length. In addition, the results revealed that the linear regression on lactation length had a significant ($p<0.001$) effect on dry period.

Table 2
Least squares means and standard errors of age at first calving (model 1) (LSQ-Mittelwert der Erstkalbealter bei Butana-Rindern)

Items		n (522)	Age at first calving L.S.M ± S.E. (months)
Overall mean			45.05 ± 3.56
Sire			***
Year-season of calving			**
Winter	1949 – 1958	14	39.73 ± 5.52
Dry summer		10	34.96 ± 6.64
Wet summer		11	46.82 ± 6.60
Winter	1959 – 1968	59	43.07 ± 5.16
Dry summer		51	40.36 ± 5.22
Wet summer		34	41.27 ± 4.56
Winter	1969 – 1978	74	47.27 ± 4.18
Dry summer		91	44.83 ± 4.57
Wet summer		42	43.27 ± 4.63
Winter	1979 – 1988	31	50.36 ± 5.21
Dry summer		33	50.94 ± 5.36
Wet summer		33	49.04 ± 5.25
Winter	1989 – 1999	13	46.11 ± 6.15
Dry summer		12	47.71 ± 6.65
Wet summer		14	50.87 ± 6.52
Coefficient of variation			17.23%

L.S.M = least squares means S.E.= standard error n = total number of observations
Means without a common superscript differ significantly ($p<0.05$)
(Winter = November – February, Dry summer = March – June & Wet summer = July – October)
** = $p<0.001$ *** = $p<0.0001$

The estimated least squares means for age at first calving (Table 2) is 45.09 ± 3.56 months, with a coefficient of variation of 17.23%. The results also showed an increasing age at first calving over years and this has become more marked from the late seventies on.

The overall calving interval (Table 3) was estimated as 382.38 ± 8.30 days, with a coefficient of variation of 17.87%. The effect of parity number showed a shortening of the interval with advancing parity number. The results also indicated that cows in the first parity had a significantly ($p<0.05$) longer calving interval (404.65 ± 8.99 days) than those in the other parities.

Table 3
Least squares means and standard errors of calving interval and dry period (model 2) (LSQ-Mittelwerte der Zwischenkalbezeit und Trockenstehzeiten bei Butana Rindern)

Items		n = (996)	Calving intervall	Dry period
			L.S.M ± S.E (days)	
Overall mean			382.38 ± 8.30	119.10 ± 8.30
Sire			**	**
Parities			**	**
First parity		269	404.65 ± 8.99[a]	141.37 ± 8.99[a]
Second parity		280	375.66 ± 8.91[b]	112.38 ± 8.91[b]
Third parity		249	374.86 ± 9.08[b]	111.58 ± 9.08[b]
Fourth parity		198	374.36 ± 9.48[b]	111..08 ± 9.48[b]
Year-season of calving			n.s	n.s
Winter	1949 – 1958	12	370.47 ± 23.45	107.18 ± 23.45
Dry summer		11	366.50 ± 24.38	103.18 ± 24.38
Wet summer		11	355.74 ± 22.77	92.46 ± 22.77
Winter	1959 – 1968	79	364.13 ± 12.81	100.85 ± 12.81
Dry summer		136	364.77 ± 11.69	101.49 ± 11.69
Wet summer		37	357.27 ± 14.58	93.99 ± 14.58
Winter	1969 – 1978	121	381.09 ± 10.82	117.81 ± 10.82
Dry summer		149	387.08 ± 10.44	123.80 ± 10.43
Wet summer		84	390.98 ± 11.32	127.69 ± 11.32
Winter	1979 – 1988	113	388.68 ± 12.02	125.40 ± 12.02
Dry summer		94	398.04 ± 12.21	134.76 ± 12.21
Wet summer		65	392.92 ± 13.08	129.64 ± 13.09
Winter	1989 – 1999	43	394.64 ± 17.14	131.36 ± 17.14
Dry summer		18	410.72 ± 21.31	147.44 ± 21.31
Wet summer		23	412.71 ± 20.95	149.43 ± 20.95
Linear regression on lactation length			0.33566 ± 0.02659***	-0.6643 ± 0.0266***
Coefficient of variation			17.87%	68.90%

L.S.M = least squares means S.E.= standard error n = total number of observations
Means without a common superscript differ significantly ($p<0.05$)
(Winter = November – February, Dry summer = March – June & Wet summer = July – October)
** = $p<0.001$ *** = $p<0.0001$ n.s = not significant

The overall mean of dry period was 119.10 ± 8.30 days (Table 3) with a coefficient of variation of 68.90%. Advanced parity numbers resulted in a shortening of the dry period, and cows in the first parity had a significantly ($p< 0.05$) longer dry period (141.37 ± 8.99 days) than those in later parities.

The overall mean for milk yield per lactation (Table 4) was 1662.57 ± 108.96 kg, with a coefficient of variation of 37.22%. The results also revealed that the yield increased with advancing parity number and that the maximum milk yield per lactation was reached after the fifth parity (1805.97 ± 112.61). The milk yield after the fifth parity was significantly ($p<0.05$) higher than the yield after the first, second and third parities, while it was similar ($p>0.05$) to the yield in the fourth lactation. The milk yield after the first parity was significantly ($p<0.05$) lower than after all other parities.

The linear regression coefficient on lactation length was 6.38 ± 0.151 while the quadratic regression was found to be negative and small (-0.0045 ± 0.001).

Table 4
Least squares means and standard errors of milk yield per lactation, daily milk yield and lactation length (models 3 and 4) (LSQ-Mittelwerte der Milchleistung und Laktationslänge bei Butana Rindern)

Items		n = (1574)	Milk yield per lactation	Daily milk yield	Lactation length
			L.S.M ± S.E (kg)		L.S.M ± S.E (days)
Overall mean			1662.57 ± 108.96	6.10 ± 0.41	268.17 ± 5.56
Sire			***	***	**
Parities			***	***	***
First parity		382	1410.85 ± 111.11[c]	5.11 ± 0.41[c]	290.66 ± 6.69[a]
Second parity		381	1600.86 ± 110.72[b]	5.88 ± 0.41[b]	261.80 ± 6.47[bc]
Third parity		326	1694.73 ± 110.90[b]	6.24 ± 0.41[a]	263.33 ± 6.63[bc]
Fourth parity		266	1800.43 ± 111.78[a]	6.59 ± 0.41[a]	259.72 ± 7.11[bc]
Fifth parity		219	1805.97 ± 112.61[a]	6.60 ± 0.42[a]	256.32 ± 7.48[ab]
Year-season of calving			***	***	*
Winter	1949 – 1958	18	1562.41 ± 163.83	5.95 ± 0.60	239.48 ± 21.38
Dry summer		15	1691.66 ± 173.66	6.54 ± 0.64	204.56 ± 23.45
Wet summer		17	1742.60 ± 166.19	6.49 ± 0.62	230.32 ± 21.92
Winter	1959 – 1968	114	1623.12 ± 120.96	5.98 ± 0.45	245.69 ± 10.44
Dry summer		179	1623.28 ± 118.05	5.98 ± 0.44	248.71 ± 09.52
Wet summer		68	1823.70 ± 126.07	6.59 ± 0.47	242.57 ± 12.07
Winter	1969 – 1978	204	1533.37 ± 114.25	5.62 ± 0.42	267.21 ± 08.07
Dry summer		238	1501.33 ± 113.85	5.43 ± 0.42	263.55 ± 07.95
Wet summer		137	1512.85 ± 116.39	5.52 ± 0.43	265.16 ± 08.97
Winter	1979 – 1988	175	1708.29 ± 117.94	6.03 ± 0.44	268.95 ± 09.54
Dry summer		151	1678.75 ± 117.72	6.02 ± 0.44	286.85 ± 09.57
Wet summer		101	1727.40 ± 120.23	6.23 ± 0.45	281.42 ± 10.69
Winter	1989 – 1999	72	1686.19 ± 131.68	6.20 ± 0.49	320.58 ± 14.55
Dry summer		47	1796.81 ± 137.78	6.53 ± 0.51	319.05 ± 16.21
Wet summer		38	1726.71 ± 140.08	6.19 ± 0.52	308.45 ± 17.03
Linear regression on lactation length			6.38 ± 0.151***	0.00435 ± 0.00055***	
Linear regression on daily milk yield					5.53 ± 1.2***
Quadratic regression on lactation length			-0.0045 ± 0.00109*	-0.0000178 ± 0.0000041**	
Quadratic regression on daily milk yield					-1.21 ± 0.3
Coefficient of variation			37.22%	28.8%	27.93%

L.S.M = least squares means S.E.= standard error n = total number of observations
Means without a common superscript differ significantly (p<0.05)
(Winter = November – February, Dry summer = March – June & Wet summer = July – October)
* = p<0.05 ** = p<0.001 *** = p<0.0001

The overall mean for daily milk yield (Table 4) was 6.10 ± 0.40 kg with a coefficient of variation of 28.87%. The maximum daily milk yield was reached in the fifth lactation. The daily milk yield after the fifth parity was significantly ($p<0.05$) higher than the daily milk yield in the first and second lactations, while it was not significantly different ($p>0.05$) from the daily milk yield after the third and fourth parities. The daily milk yield of the first lactation was significantly ($p<0.05$) lower than that of other parities. The linear regression of daily milk yield on lactation length was 0.00435, while the quadratic regression was found to be negative and small 0.000178.

The least squares means shown in Table 4 indicate that the overall mean for lactation length was 268.17 ± 5.56 days with a coefficient of variation of 27.93%. The first lactation period (290.66 ± 6.69) was significantly ($p<0.05$) longer than the lactation period in the second, third and fourth lactations, while it was not significantly different ($p>0.05$) from the lactation period following the fifth parity. The least squares analysis also revealed an increasing lactation period over years and this has become more marked from the late seventies onwards. The linear regression of lactation length on daily milk yield was positive (5.53 ± 1.20), while the quadratic regression was found to be negative (-1.20 ± 0.33).

Table 5 shows the heritability estimates for the studied traits. The results showed that the heritability estimates of reproductive traits (age at first calving and calving interval) were rather low (0.20 ± 0.07 and 0.096 ± 0.03, respectively). Milk yield per lactation, daily milk yield were found to have a moderate value of heritability (0.26 ± 0.06 and 0.27 ± 0.07, respectively), while for lactation length and dry period, they were found to be low (0.04 ± 0.02 and 0.096 ± 0.03, respectively).

Table 5
Heritability estimates of studied traits of Butana cattle (Heritabilitäts-Schätzwerte für Merkmale der Butana-Rinder)

Trait	h^2 ± S.E.
Age at first calving	0.19 ± 0.07
Calving interval	0.096 ± 0.03
Milk yield per lactation	0.26 ± 0.06
Daily milk yield	0.27 ± 0.07
Lactation length	0.04 ± 0.02
Dry period	0.096 ± 0.03

h^2: heritability estimate, S.E.: standard error

Discussion

Reproductive traits:

Age at first calving:

The presence of significant differences between sires regarding age at first calving indicates that selection amongst Butana cattle will bring reasonable benefits. This is probably a necessary step in the process of conserving this breed for future generations.

An early age at first calving reduces the unproductive life of the cow and shortens the generation interval, thus enabling earlier performance indication. Age at first calving of indigenous cattle breeds in the tropics tends to be comparable late compared with cattle breeds in temperate countries. The overall mean age at first calving obtained in this study (45.05 months) was in agreement with the average reported by REGE (1998) who stated that the least squares mean of age at first calving in tropical cattle was 42.60 ± 0.55 months in a review study based on results from 80 reports in the literature on crossbreeding in the tropics. The mean age at first calving of the Butana found in this study is similar to those reported by EL-HABEEB (1991), SOHAEL (1984), BALA and NAGARCENKAR (1981), DAHLIN (1998) and WOLLNY et al. (1998) for Kenana, White Fulani, Hariana and Sahiwal, respectively, in the Sudan and other tropical countries (Table 6).

Crossbred cattle in the Sudan tend to show a district earlier age at first calving (OSMAN and RUSSELL, 1974 and ISHAG, 2000) (Table 6).

Reasons for differences in age of first calving are to a large degree linked to levels of feeding and husbandry, but also to selection for high performance.

Table 6
Age at first calving for indigenous dairy cattle breeds and crosses in the tropics (Erstkalbealter von Milchrinderrassen und Kreuzungen in den Tropen)

Genetic group	Country	Age at first calving (months) (M ± S.E.)	Source
Butana	Sudan	45.05 ± 3.56	Present study
Kenana	Sudan	47.01 ± 12.91	EL-HABEEB (1991)
White Fulani	Nigeria	45.40 (64 records)	SOHAEL (1984)
Hariana	India	51.60 ± 0.70	BALA & NAGARCENKAR (1981)
Sahiwal	Pakistan	44.10 (2000 records)	DAHLIN (1998)
Malawi zebu	Malawi	49.80 ± 9.00	WOLLNY et al. (1998)
50% Butana x 50% Bos taurus	Sudan	34.20 (375 records)	OSMAN & RUSSELL (1974)
25% Butana x % Bos taurus	Sudan	34.40 (495 records)	OSMAN & RUSSELL (1974)
50% Kenana x 50% Friesian	Sudan	40.50 ± 15.30	ISHAG (2000)
50% Sahiwal x 50% Friesian	India	31.30 ± 0.50	RAO & TANEJA (1980)

Calving interval:

The results showed a decreasing interval with advancing parity number, and that cows in the first parity had a significantly ($p<0.05$) longer calving interval than those in the later parities. This trend could be attributed to lactation stress and continuous body growth in young growing animals and the ability of older cows to gain body weight and condition quickly after calving (YOUSIF et al., 1998).

The overall calving interval obtained in this study was very close to the optimum calving interval (12 – 13 months), and the results are comparable with those reported by EL-HABEEB (1991) for Sudanese Kenana cattle, but it were lower than those obtained by MORDE and AKINOKUN (1986), BALA and NAGARCENKAR (1981), BHATNAGAR et al. (1981) and KUMAR (1982) for White Fulani, Hariana, Sahiwal and Tharparkar cattle, respectively (Table 7).

The estimate obtained in this study also compares favourably with the value obtained for 50% crossbred cattle (Kenana x Friesian) in the Sudan by ISHAG (2000), and was lower than those obtained by OSMAN and RUSSELL (1974) and BHATNAGAR et al. (1981) for Butana x Bos taurus and Sahiwal x Brown Swiss crossbred cows, respectively.

The heritability estimates of age at first calving and calving interval in this study were rather low, indicating that most of the variation in these traits was due to environmental causes, and therefore improvement of these two reproductive traits lies mainly in better feeding and management.

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Table 7
Calving interval for indigenous dairy cattle breeds and crosses in the tropics (Zwischenkalbezeit von Milchrinderrassen und Kreuzungen in den Tropen)

Genetic group	Country	Calving interval (days) (M ± S.E.)	Source
Butana	Sudan	382.38 ± 8.30	Present study
Kenana	Sudan	446.10 ± 126.00	EL-HABEEB (1991)
White Fulani	Nigeria	420.98 ± 4.11	MORDE &AKINOKUN (1986)
Hariana	India	570.00 ± 12.00	BALA & NAGARCENKAR (1981)
Sahiwal	India	426.00 ± 4.00	BHATNAGAR et al. (1981)
Tharparkar	India	430 (750 cows)	KUMAR (1982)
50% Butana x 50% Bos taurus	Sudan	436 (189 records)	OSMAN & RUSSELL (1974)
25% Butana x 75% Bos taurus	Sudan	448 (226 records)	OSMAN & RUSSELL (1974)
50% Kenana x 50% Friesian	Sudan	421.60 ± 78.40	ISHAG (2000)
50% Sahiwal x 50% Brown Swiss	India	407 ± 2.00	BHATNAGAR et al. (1981)

Productive traits:

Lactation length

Analysis of variance showed that the parity number had a significant ($p<0.001$) effect on lactation length. There was a decline from the first lactation up to the fourth lactation and then an increase in the remaining lactations. This finding may give some clues to the explanation of the increase in milk yield during subsequent lactations. This indicates that the increase in average daily milk yield was the cause of such variation and not the length of lactation.

Year-season of calving introduced significant ($p<0.05$) variation in lactation length. OSMAN (1972) in his study on Sudanese cattle at Ghazala Gawazat showed that year of calving had a significant effect on lactation, but season of calving had no effect. The variation in this 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 8 shows lactation length mean for Butana in the present study, other indigenous breeds and crossbred cows in the tropics. The mean lactation length obtained is shorter than the optimal lactation length (305 days) generally accepted as a standard. This could be due to managerial and disease problems and it may be a true expression of the genetic potential of the herd. This is close to the findings of ALIM (1960) for Kenana, but it is higher than that reported by DEMEKE et al. (2004) for Boran cattle in Ethiopia. However, this result is lower than those reported by BHATNAGAR et al. (1981) and BALA and NAGARCENKAR (1981) for Sahiwal and Hariana cattle in India respectively.

Compared with crossbred cows in the Sudan the estimate obtained here (268,17 days) does not appear to be unduly small. ISHAG (2000) found that the average lactation length of 1008 records of 50% crossbred Sudanese Kenana x Friesian cows was 291.3 ± 67.2 kg. The estimate obtained in the current study is shorter than that reported by REGE (1998) for Bos taurus x Bos indicus F_1 crossbred cows. The Author stated that lactation length of F_2 cows was 8% (26 days) less than that of F_1 animals. Lactation length was found to have a very low heritability estimate. This estimate does not differ significantly from that reported by EL-AMIN (1969) for Northern Sudanese cattle whose estimate was 0.011 ± 0.007.

Table 8
Lactation length means for indigenous dairy cattle breeds and crosses in the tropics (Laktationslänge von Milchrinderrassen und Kreuzungen in den Tropen)

Genetic group	Country	Lactation length (days) (M ± S.E.)	Source
Butana	Sudan	268.17 ± 5.56	Present study
Kenana	Sudan	224.00 ± 82.00	ALIM (1960)
Boran	Ethiopia	193.00 ± 6.00	DEMEKE et al. (2004)
Hariana	India	311.00 ± 18.00	BALA & NAGARCENKAR (1981)
Sahiwal	India	326.00 ± 4.00	BHATNAGAR et al. (1981)
50% Kenana x 50% Friesian	Sudan	291.30 ± 67.20	ISHAG (2000)
Bos indicus x Bos taurus F_1	Tropics	309.00 ± 3.60	REGE (1998)
Bos indicus x Bos taurus F_2	Tropics	283.00 ± 10.10	REGE (1998)

Dry period:
The variability of dry period among parities may be attributed to improper management (milking and drying off practices) and physiological factors related to fertility. The results also showed a decreasing trend towards the optimum length.
The overall mean dry period was found to be 119.10 ± 8.30 days, which is longer than the optimum dry period (60 days). This result is comparable with that obtained by KHALLAFALLA (1977) and BAHATNAGAR et al. (1983) for Kenana and Sahiwal cattle respectively (Table 9). This result is similar to that calculated by ISHAG (2000) for crossbred cows (Friesian x Kenana) in the Sudan (Table 9).
The low heritability estimate for dry period obtained in the present study is consistent with those estimated by EL-AMIN (1969), KHALLAFALLA (1977) and AHMED and SIVARAJASINGAM (1998) for indigenous dairy cattle in the Sudan and in Pakistan.

Table 9
Dry period mean for indigenous dairy cattle breeds and crosses in the tropics (Trockenstehzeiten von Milchrinderrassen und Kreuzungen in den Tropen)

Genetic group	Country	Dry period (days) (mean ± S.E.)	Source
Butana	Sudan	119.10 ± 8.30	Present study
Kenana	Sudan	174.00 ± 5.10	KHALLAFALLA (1977)
Sahiwal	India	139.70 (first lactation of 580 cows)	BHATNAGAR et al. (1983)
50% Kenana x 50% Friesian	Sudan	96.31 ± 70.16	ISHAG (2000)

In general, lactation length and dry period are influenced by milk yield and time of reconception and altogether reflect a high dependence on management and feeding levels. Therefore, any effort to improve these traits by selection within the herd will be ineffective and the most useful way is a direct selection for higher milk yield and by improving the management practices.

Milk yield:
The parity number in the present study was found to exert a significant ($p<0.001$) effect on milk yield per lactation and daily milk yield. These findings are in agreement

with those reported by SAEED et al. (1987) and EL-HABEEB (1991) in their studies on Kenana and Butana cattle respectively. Moreover, the results revealed that milk yield exhibited an increasing trend with advancing parity number up to the fifth lactation. These findings are in agreement with those stated by YOUSIF et al. (1998) and ISHAG (2000) in their studies on crossbred cows in the Sudan. This is probably due to the increase in body size and development of the udder during recurring pregnancies (FADLEL-MOULA, 1994).

The analysis of variance indicated significant ($p<0.001$) phenotypic variation in milk yield per lactation and daily milk yield due to the effect of year-season of calving. This variation in milk yield between periods and seasons may be due to changes in management, feed quality and quantity. Other reasons may include change in the genetic constitution of the herd.

Analysis of variance showed that the sire of cow had a significant ($p<0.001$) effect on milk yield per lactation and daily milk yield. Comparable results were reported by EL-HABEEB (1991) for Butana cattle. Also it was similar to the results reported by RAO and DOMMERHOLT (1981) for Tharparkar and Sahiwal cattle in India.

The high value of the coefficient of variation for milk yield per lactation and daily milk yield in this study could be due to the variation in lactation length besides other genetic and environmental factors. The mean lactation milk yield and daily milk yield obtained in the present study were comparable with that reported by EL-HABEEB (1991) and BHATNAGAR et al. (1981) for Kenana and Sahiwal cattle in Sudan and Pakistan, respectively (Table 10). However, it was higher than those reported by DUC and TANEJA (1984) and DEMEKE et al. (2004) on Hariana and Boran cattle data in India and Ethiopia respectively.

In comparison with crossbred cows performance, the mean milk yield per lactation estimated in this study was lower than that reported by OSMAN and RUSSELL (1974) who studied data on local cattle (Butana) x Bos taurus (Holstein-Friesian, Ayrshire and Guernsey) crossbred cows at Ghurashi Farm in Northern Sudan (Table 10). The authors also noticed that all components of stress (death rate, infertility etc) increased with increasing proportions of exotic inheritance. Also this result was lower than that obtained by ISHAG (2000) (Table 10) for Kenana x Friesian crossbred cows in the Sudan, while the estimated mean milk yield per lactation was higher than that reported by WOLLNY et al. (1998) who reported that the average milk yield of Malawi zebu x Friesian crosses in small holder farms ($n = 38$) to be 1163 ± 999 kg per cow per year. The higher standard deviation (999) might be due to small data size and other systematic effects.

In a review study based on results from 80 reports in the literature on crossbreeding in the tropics. REGE (1998) reported mean lactation milk yield as 2195 ± 30.1 kg and 1725 ± 105.1 for F_1 and F_2 Bos indicus x Bos taurus crossbreds, respectively. The decline in performance following *inter se* mating of F_1s has been attributed to a reduction in heterozygosity. SYRSTAD (1989) concluded that performance of F_2 was worse than that of F_1 in all traits studied e. g. milk yield (by 452 kg representing 24%).

In their study of economic evaluation of crossbreeding for dairy production in Kenya KAHI et al. (1999) concluded that the Sahiwal exhibited lower breed effects for health costs, reproduction costs and feed costs compared to that of the B. taurus. That may be due to the fact that Sahiwal (B. indicus) is more adapted to the tropical stress of poor nutrition, disease challenge and heat stress than the B. taurus cattle.

The annual milk yield (Milk yield per lactation x 365 x CI^{-1}) in this study is 1588 kg while crossbreds in Sudan produced between 1751 kg (OSMAN and RUSSELL, 1974) and 2095 kg (ISHAG, 2000). This comparison does not consider the higher yield in total solid of indigenous cows and differences in husbandry cost.
Assuming that crossbred cows in the Sudan have the same low economic efficiency as the crossbred cows of Kenya and that the results for crossbred cows are taken as a true indication of the performance potential of crossbred cattle in the Sudan then it seems that the increase in production realized through crossbreeding may not be sufficient to cover the extra costs incurred through increased feed and management requirements.

Table 10
Milk yield per lactation and daily milk yield means for indigenous dairy cattle breeds and crosses in the tropics (Milchleistung von Milchrinderrassen und Kreuzungen in den Tropen)

Genetic group	Country	Milk yield per lactation (kg) (M ± S.E.)	Daily milk yield (kg) (M ± S.E.)	Source
Butana	Sudan	1662.57 ± 108.96	6.10 ± 0.41	Present study
Kenana	Sudan	1423.58 ± 551.70	5.60 ± 1.77	EL-HABEEB (1991)
Boran	Ethiopia	529.00 ± 65	2.80 ± 0.10	DEMEKE et al. (2004)
Hariana	India	1151.00 ± 45.00		DUC & TANEJA (1984)
Sahiwal (305 days)	India	1998 ± 23.00		BHATNAGAR et al. (1981)
50% Butana x 50% Bos taurus	Sudan	2150 (272 records)		OSMAN & RUSSELL (1974)
50% Kenana x 50% Friesian	Sudan	2417.20 ± 921.00	7.34 ± 2.44	ISHAG (2000)
Malawi zebu x Friesian	Malawi	1163.00 ± 999.00		WOLLNY et al. (1998)
Bos indicus x Bos taurus F_1	Tropics	2195.00 ± 30.10		REGE (1998)
Bos indicus x Bos taurus F_2	Tropics	1725.00 ± 105.10		REGE (1998)

Heritability estimates for milk yield per lactation and daily milk yield obtained in this study were consistent with those estimates obtained by EL-AMIN (1969) and EL-HABEEB (1991) for Northern Sudan cattle. They are also comparable with those reported by AHMED and SIVARAJASINGAM (1998) for Sahiwal cattle in Pakistan.
In a comparative study, OJANGO and POLLOTT (2002) studied the relationship between Holstein bull breeding values for milk yield derived in both the UK and Kenya using data being selected from herds (Holstein Friesian dams) containing daughters of bulls used in both countries. They reported difference in genetic variance for milk yield between the two countries, with the heritability for first lactation 305-days milk yield being 0.45 ± 0.02 in UK and 0.26 ± 0.06 in Kenya. They also stated that the relative rate of response in Kenyan milk yield based on UK breeding values was estimated to be 44% of the rate expected in the UK.
The moderate value of heritabilities found for milk yield per lactation and daily milk yield indicates that there is good scope for moderate selection, even though selection is a slow process. However, in addition, there is a substantial amount of variation that is due to environment, therefore improvement of management practices must be considered when breeding policies are to be formulated.

Conclusions

It can be concluded that in some major production traits the Sudanese Butana cattle compare favourably with some of the best breeds in tropical countries and their

performance does not fall far behind that of 50% crossbred cattle in the Sudan, particularly if it is afforded the same level of management that crossbred cattle usually get. The F_1 cows often perform relatively well but it seems difficult to establish a sustainable system of crossbreeding for further improvement. Crossbreeding Kenana and Butana with B. taurus is probably a useful strategy in riverain areas and around major towns where sufficient feed and reasonable levels of management can be provided. However, in nomadic areas probably the best strategy is to use improved Butana and Kenana bulls for crossbreeding with breeds of poor productivity in harsh conditions where B. taurus crossbreds cannot survive. This will be a useful contribution to the improvement of nutrition for people living in harsh environments.
The improvement of dairy traits in Northern Sudanese cattle is foremost a matter of improved feeding and management. These include the traits of low heritability, such as lactation length and dry period. On the other hand, milk yield per lactation and daily milk yield exhibited heritabilities of a moderate level, so that there is reasonable scope for improvement by selection, even though selection is a slow process. Also it can be concluded that this local breed constitutes an irreplaceable stock of adapted germplasm, and it must be conserved for the fact that their loss may mean the loss of valuable unique genes which cannot be easily replaced if at some future time changes in production conditions require their use.
Consideration must be given to the establishment of Butana herds for the purpose of conservation on a commercial basis. This study lends support to the view that such herds can be self-supporting provided they are well managed and the stocks are carefully selected. The estimates of productivity presented above indicate that well managed herds of Butana will not be a financial burden on the state and will help preserve the breed.
In Sudan, an economic evaluation of crossbreeding strategy using appropriate economic evaluation criteria such as used by KAHI et al. (1998) for Kenya is needed to determine whether the genetic differences between native breeds and European cattle breeds will yield greater economic benefits.

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