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Reproductive performance of artificially and naturally bred Boran heifers and cows under ranch conditions in Tanzania

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Key words
Age at first calving, Boran, calving interval, mating types

1 SUMMARY

This study investigated the influence of non-genetic factors on reproductive performance of Boran cows and heifers reared under ranch conditions in Tanzania. Data on reproduction performance were collected from Kikulula Heifer Breeding Unit (KHBU) in northwestern Tanzania. Reproductive traits studied were age at first calving (AFC), calving interval (CI), days open (DO) and number of services per conception (NSC). General Linear Models (GLM) procedure of Statistical Analysis System (SAS) was used for data analyses. The overall means for AFC, CI and DO were **42.2±0.23 months, 463.6±1.93 days and 183.4±1.93 days, respectively. AFC was significantly (P<0.001) influenced by year-season and type of mating whereby heifers and cows bred in the late dry season performed better than those bred in the heavy rain season. Heifers bred by natural service were about 4 months younger at first calving than artificially bred ones. With regard to CI and DO, year-season of mating, type of mating and parity were also important sources of variation. Cows that calved in the heavy rain season had longest CI and DO than those calving in other seasons. The two traits significantly decreased from first to fourth parity and then increased. Artificially bred cows had poorer performance compared to those naturally bred. The overall mean for NSC for both heifers and cows was 1.57±0.01. Parity, year-season of mating and type of mating significantly (P<0.001) affected NSC. Heifers had the highest NSC (1.73) and were decreasing with age till fourth parity. Further, cows and heifers mated in the dry season had significantly more NSC than female cattle mated in the wet season; while artificially bred animals had significantly higher (1.71±0.03) NSC than naturally bred ones (1.53±0.03). From the findings, it is concluded that in order to improve reproductive performance, environmental factors should be accorded more serious consideration.**

2 INTRODUCTION

Reproduction in livestock is crucial for production of the necessary replacement stock, for reducing unproductive periods, for initiation of lactation, for increasing lifetime milk production and income (Das *et al.*, 1986). When the reproductive efficiency of a farm is poor losses that can occur include fewer calves being born due to longer calving intervals, increased veterinary costs due to more problematic cows, increased number of matings to achieve conception as a result of poor heat detection,

and increased number of replacement heifers needed for non-voluntary reproductive culls.

In tropical countries, *Bos indicus* cattle are the predominant species kept by the majority of small holder farmers. These cattle are well adapted to tropical environments. They possess a high degree of heat tolerance; they are fairly resistant to ticks and tick-borne diseases and to many other diseases, and have low nutritional requirements (Cunnigham & Syrstad, 1987). However, these cattle are characterised by high age at first calving, long calving intervals and low potential in terms of growth traits (Rege *et al.*, 2001).

In an attempt to combat this situation, imported *Bos taurus* germplasm from temperate countries has been widely used in crossbreeding with *Bos indicus* cattle in many parts of the tropics in order to improve cattle productivity (Syrstad, 1985). In producing crossbred stock, either exotic bulls or semen from exotic sires has been used on indigenous cows. It is of interest to know which of the two methods of mating is efficient under tropical conditions. The objective of this study was to investigate the factors affecting reproductive performance of Boran cows and heifers bred naturally with Boran bulls and those artificially inseminated with Friesian semen under ranch conditions.

3 MATERIALS AND METHODS

Data used in this study were collected from Kikulula Heifer Breeding Unit (KHBU) in Kagera region, North-western Tanzania. This region lies just below the equator between latitudes 1º 00´ and 2º 45´ south and is west of Lake Victoria.

3.1 Management of animals: New born calves were left to suckle until weaning at about 4 months of age. Weaned and adult cattle grazed on natural pastures, comprising mainly of *Cynodon spp*, *Panicum spp*, *Eragrostis spp*, and *Andropogon spp* for about 8 hours per day and were returned to the sleeping paddocks in the afternoon. The length of grazing period depended on season, and it was always longer during the dry season than during the wet season. Animals were occasionally supplemented with rocks made from natural salt (NaCl). Boran heifers and cows were kept into two groups; one comprised of those intended for natural mating by Boran bulls and the other group comprised of those intended to be inseminated with Friesian semen to produce F_1 crosses. Heifers joined the mating groups when they were about 15-18 months of age. Detection of heat on cows and heifers to be bred by artificial insemination using Friesian semen was initially done using vasectomised bulls or steers and later by close observation of the heifers and cows early in the morning and late evening by trained staff and herdsmen. Heifers and cows intended to be mated by Boran bulls were also monitored daily by trained staff and herdsmen to detect heat. Dates of mating were recorded daily and pregnancy diagnoses were done routinely in order to determine number of services that led to conception. All animals underwent routine disease control measures, especially against tick- borne diseases and worm infestations.

3.2 Data classification: Seasons of birth or calving were categorized into four classes as heavy rain season (March-May) =1; light rain season (September-December) = 2; early dry season (January-February) = 3; and late dry season (June-August) = 4. Parturition numbers were coded 0 (heifers) to 6. Types of mating were coded as NS and AI for natural mating and artificial insemination, respectively. Data available for age at first calving (AFC) were from 1990-1996, records for calving interval (CI) and days open (DO) were available from 1993-1998 and for number of services per conception data were available from 1993-1999 and 1994-1999 for artificial insemination and natural mating, respectively.

3.3 Data analyses: Data were analyzed using GLM procedures of SAS (2000). Model I was used to analyze age at first calving (AFC) in which year-season of birth and type of mating were included as fixed effects. Model II was employed in the analyses of calving intervals (CI) and days open (DO) whereby fixed effects of parity, year-season of calving, and type of mating were fitted. In analysing the number of services per conception, fixed effects of year-season of mating, , type of mating and parity were fitted in the model (Model III).

The following models were used:

Model I: $Y_{ijk} = \mu + \alpha_i + \delta_j + (\alpha\delta)_{ij} + e_{ijk}$

Where;

Yijk = Age at first calving

μ = Overall mean

αi = Effect due to year-season of birth (1990…1996; 1…4)

δj = Effect due to type of mating (natural versus artificial)

(αδ)ij = Two -way interactions effects as indicated by notations

eijk = Random residual effect N(0, σe2)

Model II: $Y_{ijkl} = \mu + \alpha_i + \delta_j + \chi_k + (\alpha\chi)_{ij} + (\delta\chi)_{jk} + e_{ijkl}$

Where;

Y_{ijkl} = Calving interval or days open

μ = Overall mean

α_i = Effect of year-season of calving (1992…1998; 1…4;)

δ_k = Effect of parity (1…6)

χ_l = Effect due to type of mating (natural versus artificial)

$(\alpha\chi)_{il}$; $(\delta\chi)_{jk}$ = Two- way interaction effects as per notations

e_{ijkl} = Random residual effect N(0, σ_e^2)

Model III: $Y_{ijkl} = \mu + \alpha_i + \delta_j + \chi_k + e_{ijkl}$

Where;

Y_{ijkl} = Number of services per conception

μ = Overall mean

α_i = Effect of year-season of mating (1993…1999; 1…4;)

δ_j = Effect of parity (0…6)

χ_k = Effect due to type of mating (natural versus artificial)

e_{ijkl} = Random residual effect N(0, σ_e^2).

4 RESULTS

4.1 Age at first calving (AFC): The overall mean AFC was 42.2 ± 0.23 months with a coefficient of variation (CV) of 17.5 % (Table 1). There were highly significant (P < 0.001) influences of year-season of birth, and type of mating on AFC (Table 2). The interaction between type of mating and year-season of birth was also significant (P < 0.05). There was no clear trend in AFC due to year-season effect. However, there was tendency for heifers born in late dry (June to August) season to calve earlier than those born during the heavy rain season months (March to May). Heifers bred by artificial insemination were older at calving than naturally bred heifers by 3.9 months.

4.2 Calving intervals (CI) and days open (DO): The overall means for CI and DO were 463.6 ± 1.93 and 183.4 ± 1.93 days with coefficients of variation of 14.9 and 35.4 %, respectively (Table 3). All effects (except parity and type of mating for DO) fitted in the model in analyses of CI and DO were highly significant (P < 0.001). However there were also significant influences of parity (P<0.01) and type of mating (P<0.05) on DO (Table 4). There was a decrease in both traits with increase in parturition number up to 4th parity and then increased considerably in subsequent parities. There was no specific trend in CI and DO with years. However, the shortest CI was observed in the light rain season while the longest CI was observed in the heavy rain seasons. Naturally bred cows tended to calve again about 50 days earlier than artificially bred cows. Open days for naturally bred cows were lower by 22.5 % compared to artificially bred cows.

Table 1: Least squares means (standard error) for age at first calving (in months).

Source of Variation	Factor	N	LSM(se)
CV=17.5%			
Overall		1458	42.2 (0.23)
			***
Year-Season of birth	I990 - Heavy rain	28	51.5 (1.99)
	1990 - Light rain	71	47.1 (0.89)
	1990 - Early dry	52	46.1 (1.09)
	1990 - Late dry	71	45.2 (1.17)
	I991 - Heavy rain	25	48.0 (2.01)
	1991 - Light rain	233	36.2 (0.65)
	1991 - Early dry	15	45.0 (2.38)
	1991 - Late dry	40	42.2 (1.35)
	I992 - Heavy rain	70	48.4 (3.78)
	1992 - Light rain	122	46.4 (4.25)
	1992 - Early dry	32	48.8 (1.58)
	1992 - Late dry	20	45.5 (2.00)
	I993 - Heavy rain	20	48.4 (2.01)
	1993 - Light rain	174	39.3 (0.68)
	1993 - Early dry	11	55.8 (4.51)
	1993 - Late dry	40	44.6 (1.37)
	1994 – Heavy rain	51	48.5 (1.42)
	1994 – Light rain	59	43.9 (1.28)
	1994 – Early dry	48	48.5 (1.53)
	I994 - Late dry	14	40.5 (4.11)
	1995 – Heavy rain	12	49.2 (4.51)
	1995 - Light rain	10	46.4 (4.25)
	1995 - Early dry	23	48.7 (1.54)
	1995 – Late dry	47	44.4 (1.19)
	1996 – Heavy rain	16	50.7 (2.78)
	1996 – Light rain	129	38.8 (0.80)
	I996 – Early dry	10	46.5 (2.54)
	1996 – Late dry	15	33.9 (3.91)
			***
Type of mating	Natural	992	43.7 (0.53)
	AI	466	47.6 (0.74)

*** = P<.001

Table 2: Analysis of variance for age at first caving (AFC).

Source	DF	Mean square	F value	Pr > F
Year -Season of birth (YS)	27	707.9	13.04	<.0001
Type of mating (ToM)	1	991.3	18.26	<.0001
YS * ToM	27	81.9	1.51	0.0460
Residual	1402	54.3		

Table 3: Least squares means (standard error) for calving interval (days) and days open.

Source of Variation	Levels	N	LSM(se)	
			Calving interval (CV=14.9%)	Days open (CV=35.4 %)
Overall		1860	463.6 (1.93)	183.4 (1.93)
			***	**
Parity	1	490	488.3 (4.42)	207.8 (4.14)
	2	722	477.3 (4.17)	197.3 (3.90)
	3	304	467.6 (6.04)	187.9 (5.65)
	4	183	458.6 (14.03)	178.2 (13.13)
	5	78	496.7 (27.89)	216.8 (26.10)
	6	83	483.4 (22.15)	203.9 (20.74)
Year-Season of calving			***	***
	I992 -Heavy rain	35	502.3(13.66)	222.6 (12.79)
	I992-Light rain	82	474.7 (11.76)	194.7 (11.01)
	I992-Early dry	24	479.7 (16.03)	199.5 (15.01)
	I992-Late dry	23	460.2 (15.99)	179.8 (14.96)
	I993-Heavy rain	41	481.4 (15.38)	201.4 (14.40)
	I993-Light rain	119	458.4 (9.54)	178.4 (8.93)
	I993-Early dry	22	490.3 (15.75)	212.1 (14.74)
	I993-Late dry	197	463.8 (8.55)	182.9 (8.00)
	1994-Heavy rain	36	504.2 (13.62)	224.2 (12.75)
	1994-Light rain	216	457.1 (8.51)	178.1 (7.96)
	1994-Early dry	34	483.8 (16.33)	203.6 (15.28)
	1994-Late dry	20	460.2 (17.74)	179.4 (16.60)
	I995-Heavy rain	198	492.3 (9.41)	211.5 (8.81)
	I995-Light rain	36	454.2 (13.55)	174.6 (12.68)
	I995-Early dry	47	502.4 (13.56)	222.3 (12.70)
	I995-Late dry	19	469.6 (18.79)	189.4 (17.62)
	1996-Heavy rain	30	504.1 (14.43)	222.5 (13.51)
	1996-Light rain	205	461.3 (9.15)	181.3 (8.56)
	1996-Early dry	32	486.2 (26.31)	206.2 (24.63)
	1996-Late dry	156	476.5 (9.00)	196.9 (8.42)
	I997-Heavy rain	50	500.1 (12.10)	220.4 (11.33)
	I997-Light rain	120	473.4 (9.49)	191.6 (8.89)
	I997-Early dry	17	486.1 (19.73)	206.9 (18.47)
	I997-Late dry	21	469.1 (20.48)	189.1 (19.17)
	1998-Heavy rain	31	494.8 (35.93)	215.6 (33.63)
	1998-Light rain	11	471.5 (41.05)	191.6 (38.43)
	1998-Early dry	27	486.8 (16.30)	206.8 (15.26)
	1998-Late dry	11	458.2 (24.47)	178.2 (22.90)
			***	*
Type of mating	Natural	1073	453.7 (3.05)	173.5 (2.85)
	AI	787	503.6 (12.71)	223.8 (11.89)

*** = P<.001; ** = P<0.01; * = P< 0.05

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4.3 Number of services per conception (NSC): The mean number of services per conception was 1.57 ± 0.01 with a coefficient of variation of 48.5 % (Table 5). The effects of parity, year-season of mating and type of mating were highly significant (P < 0.001) sources of variation in number of services per conception for both heifers and cows in Kikulula ranch (Table 6). Numbers of services per conception were highest among heifers (1.73) and were decreasing with parity up to 5th parturition and then increased in subsequent parities. There was a tendency for number of services per conception to be lower in the heavy rain season compared to the other seasons.. Naturally bred heifers and cows required fewer (1.53) services in order to conceive compared to those artificially inseminated (1.71).

Table 4: Analysis of variance for calving interval and days open.

Source	DF	Calving Interval			Days Open		
		Mean square	F value	Pr > F	Mean square	F value	Pr > F
Parity	5	22346.6	4.66	0.0003	17029.9	4.05	0.0012
Year -Season of calving (YS)	27	17090.6	3.56	<.0001	16012.0	3.81	<.0001
Type of mating (TOM)	1	77807.8	16.22	<.0001	27634.1	6.57	0.0104
YS * TOM	27	13461.7	2.81	<.0001	9891.2	2.35	0.0001
Parity * TOM	5	30968.1	6.46	<.0001	26771.4	6.37	<.0001
Residual	1794	4797.3			4203.4		

5 DISCUSSION

5.1 Age at first calving (AFC): The mean AFC of 42.2 months observed in the present study is within the range expected for *Bos indicus* cattle in the tropics with reported values ranging from 35.1 to 53 months (Alberro, 1983; Sharma, 1983; Weitze, 1984, Mukassa-Mugerwa *et al*., 1989). This mean is also lower than the 45 to 53 months) reported in other studies (Wagenaar *et al*., 1986; Saeed *et al*., 1987; Mukasa-Mugerwa *et al*., 1989; Haile-Mariam *et al*., 1993) for different *Bos indicus* cattle.

The significant influence of season of birth on AFC in this study concurs with results by Miranda *et al.* (1982) and that may probably be attributed to the quality and quantity of forage available to heifers when they were born, which in turn affected their growth performance. Also, heifers born during the light rain and late dry seasons entered breeding phase during the heavy rain and early dry seasons which are better months in terms of quality and quantity of pastures, hence they had better chances of showing estrus and conceiving on first service. However, Haile *et al.* (2009) reported that the effect of month of birth did not influence AFC among Boran cattle and their crosses with Friesian in Ethiopia.

The significant effect of year of birth could be attributed to variability in management and climate especially rainfall between different years. Similar observations were made by Sharma (1983) and Haile *et al.* (2009). The late calving of artificially bred heifers compared to those mated by bulls was probably as a result of low conception rates. Many factors could contribute to the situation such as poor heat detection by herdsmen and the efficiency of conducting the artificial insemination. Heifers that run with breeding bulls have more chances of conceiving earlier since it is easier for the bulls to detect and mount heifers in oestrus.

5.2 Calving interval and days open: The mean calving interval of 463.6 days is similar to the 465 days reported by Haile-Mariam *et al.* (1993) for Boran cattle in Ethiopia. However this mean is much lower than that reported by Wagenaar *et al.* (1986) of 597.8 days for Fulani cattle of Niger and Mukasa-Mugerwa *et al.* (1989) of 762.5 days for Highland zebu in Ethiopia. On the other hand, Haile *et al.* (2009) reported low mean calving interval of 439.0 days for Boran cattle in Central Ethiopia.

In agreement with the present results, other researchers (Choudhuri *et al*., 1984; Haile *et al*., 2009) have also reported significant effects of year of calving on calving interval. In the current study the effect of year could be attributed to variability in management, climate especially rainfall, feeding levels and disease incidences between different years.

Table 5: Least squares means (standard error) of number of services per conception.

Source of Variation (CV=48.5%)	Levels	n	LSM(se)
Overall		6463	1.57 (0.01)
			***
Parity	0	2570	1.73 (0.03)
	1	1492	1.67 (0.03)
	2	1249	1.63 (0.03)
	3	552	1.57 (0.04)
	4	307	1.42 (0.05)
	5	133	1.64 (0.07)
	6	160	1.68 (0.06)
Year-season of mating			***
	I993-Heavy rain	16	1.44 (0.19)
	I993-Light rain	257	1.51 (0.05)
	I993-Early dry	17	2.46 (0.19)
	I993-Late dry	35	2.35 (0.13)
	1994-Heavy rain	434	1.53 (0.04)
	1994-Light rain	378	1.55 (0.04)
	1994-Early dry	474	1.62 (0.04)
	1994-Late dry	447	1.76 (0.04)
	I995-Heavy rain	316	1.32 (0.05)
	I995-Light rain	121	1.51 (0.07)
	I995-Early dry	595	1.66 (0.03)
	I995-Late dry	273	1.78 (0.05)
	1996-Heavy rain	568	1.41 (0.04)
	1996-Light rain	790	1.40 (0.03)
	1996-Early dry	259	1.84 (0.05)
	1996-Late dry	425	1.96 (0.04)
	I997-Heavy rain	169	1.41 (0.06)
	I997-Light rain	9	1.41 (0.25)
	I997-Early dry	289	1.58 (0.05)
	I997-Late dry	53	1.59 (0.10)
	1998-Heavy rain	122	1.52 (0.07)
	1998-Light rain	162	1.06 (0.06)
	1998-Early dry	55	1.65 (0.10)
	1998-Late dry	118	1.87 (0.07)
	I999-Heavy rain	12	1.58 (0.22)
	I999-Light rain	11	1.51 (0.23)
	I999-Early dry	51	1.47 (0.11)
	I999-Late dry	7	1.56 (0.29)
			***
Type of mating	Natural	3364	1.53 (0.03)
	AI	3099	1.71 (0.03)

*** = $P < 0.001$;

Table 6: Analysis of variance for number of services per conception.

Source	DF	Mean square	F value	Pr > F
Parity	6	4.30	9.66	<.0001
Year-Season of mating	27	7.78	13.48	<.0001
Type of mating	1	31.46	54.52	<.0001
Residual	6428	0.58		

Cows that calved during the light wet season and those calving in the late dry season tended to have shorter calving intervals than others because they entered the breeding phase during periods, which had plenty of forages; hence they were in better nutritional status for normal cycling and conception. Oyedipe *et al.* (1982), working with White Fulani heifers, reported calving intervals of 15.3 and 18 months for the dry and wet seasons, respectively, and suggested that the difference was due to the fact that cows calving in the dry season could take advantage of improved nutritional conditions during the subsequent rainy season to meet their total requirements for maintenance, growth and lactation. In addition, a larger proportion of dry-season calves died due to inadequate nutrition. Both factors led to earlier re-establishment of oestrus in cows that calved in the dry season.

Cows under natural mating tended to have shorter CI than their counterparts under artificial insemination. Haile-Mariam *et al.* (1993) also observed that Boran cows naturally mated to Boran bulls had shorter CI (by 87 days) than Boran cows artificially inseminated with Friesian semen. The same reasons discussed above (under AFC) on superiority of naturally bred heifers over artificially bred heifers could explain the similar phenomenon in cows.

The mean CI of approximately 464 days is 3 months above the ideal CI of one year clearly indicating that reproduction was not optimal. Assuming a gestation period of 280 days, it means the days open averaged about 184 days or approximately 6 months. A multitude of reasons could account for such a long calving to conception period including the ranch type of management, nutrition, bulls used and competence levels in conducting artificial insemination.

5.3 Number of services per conception (NSC): The number of services per conception (NSC) depends largely on the mating system being practiced. It is always lower under uncontrolled natural breeding and higher where hand-mating or artificial insemination is used. In this study heifers and cows allocated to bulls for natural mating needed fewer services to conceive than those under artificial insemination. The mean NSC observed in the current study is within the range of 1.5 to 1.66 for tropical cattle reported elsewhere (Sharma, 1983; Asimwe & Kifaro, 2007). On the other hand, Haile *et al.* (2009) reported a relatively higher (2.4) NSC than in the present study. The significant effect of parity on NSC observed in this study is in agreement with a number of studies (Negussie *et al.*, 1998; Demeke *et al.*, 2004; Haile *et al.*, 2009). From these studies it has been observed that older cows are more efficient with respect to reproduction than heifers or first calvers. In the current study, heifers and cows mated during the heavy rain and light rain seasons required fewer services than those mated during the two dry seasons. This might probably be ascribed to the better nutritional status of cows associated with large quantities of forages that animals have access to during the rainy seasons. Most female cattle would be in good body condition for breeding during these seasons (Choudhuri *et al.,* 1984).

From the results of this study, it is concluded that the performance levels of heifers and cows were not very different from those reported elsewhere in the tropics. All environmental factors studied had significant influences on reproductive performance of Boran cows. The data confirm that artificially bred heifers and cows have consistently poor performance compared to naturally bred animals. In order to improve the performance of artificially bred heifers and cows, it is necessary to improve on the aspects of proper heat detection, timing of insemination and competence levels in conducting artificial insemination.

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