Original Research Article

Pre and Post-Weaning Growth and Survivability of Three Genotypes of Cattle at TALIRI Tanga, Tanzania

.

ABSTRACT

This study examined the growth performance of the three genotypes of cattle raised at TALIRI Tanga: Pure Boran (BB), Boran + Friesian (BF), and Boran + Jersey (BF) crosses. The 20 years of data (from 2001 to 2020) were used to examine the effects of calves' genotype, sex, amount of rainfall, season of birth, and type of rearing on growth parameters (birth weight, weaning weight, yearling weight, pre-weaning growth, and post-weaning growth, in kg and kg/day respectively). The General Linear Model was used to calculate growth parameters and correlations while, the Chi-square test performed to assess pre- and post-weaning survivability. BF calves were substantially heavier at birth than BB and BJ calves (P<0.05). Male calves were 4.1% heavier than female calves, at birth and the calves born during the dry season were 4.0% heavier than those born during the wet season. BB calves were significantly survived % better than BF and BJ in all growth stages female calves survived better by 3.57% than male calves and the bucket-reared calves had survived significantly higher than direct-suckled calves by 6.9% in pre-weaning stage.The phenotypic correlation between birth weight and weaning weight was moderately positive (0.3), as was between weaning weight and yearling weight. However, the correlation between weaning weight and pre-weaning growth, and between yearling weight and post-weaning were both strongly positive (0.9), while the correlation between birth weight and post-weaning growth was negative (r= -0.1). Thus, crossing exotic breeds with Boran cattle enhances crosses growth performance relative to Boran while also improving cross survivability in hot/humid environments compared to pure exotic cattle.
Keywords. *Calf survivability, correlation, crossbreeds, pre and post-weaning growth.*

1. INTRODUCTION

The demand for dairy and dairy products has increased due to increased population growth and improved per capita income in developing countries like Tanzania [1]. According to [2], annual milk production is estimated to be 3.4 billion liters while the demand is more than 8 billion liters. Over two-thirds (68%) of the milk produced in Tanzania is from smallholder farmers using traditionally managed herds mainly comprised of indigenous cattle breeds with comparable low productivity in terms of milk production (less than 3liters per day ([3]; [4] and [5]). The traditional herds have a low growth rate making them attain the age of production later than exotic breeds due to genetic and management challenges [6], [7] and [8]. Crossbreeding of indigenous breeds with exotic high-producing breeds has been used as one of the strategies to address the challenge of low productivity. For example, the government of Tanzania has been practicing cross-breeding of Boran cattle with exotic high-producing cattle breeds mainly Friesian, Ayrshire, and Jersey to improve the reproduction and production merits with high adaptability in hot/humid environments as addresses addressed in Animal genetics strategy and vision for Tanzania [9]; [10] and [11]. These cross-breeding schemes were conducted strategically in government livestock multiplication and research farms to produce dairy crossbred cattle suitable for particular regions.
Growth performance in dairy cattle breeds is of paramount importance because, among the breeding goals in a dairy enterprise is to have dairy animals which able to reach reproductive maturity (age at first calving) early at 26 to 30 months which is optimal in economic performance of dairy herd reproduction and production longevity [12]. Tanzania Livestock

Research Institute (TALIRI), Tanga Center established post-independence in 1961 has been charged with the responsibility of producing improved breeds of dairy cattle for smallholder farmers around the Tanga region and nearby areas and coastal regions. The zone is characterized by a hot and humid climate.
Despite the long-term strategies to improve local cattle in Tanga since independence, cross-breeding of Boran cattle with exotic dairy breeds, the information on the growth and survivability of the crossbreds has not been well documented. Because of the lack of this information, it has always been difficult to objectively assess the success achieved by the government through such efforts to improve milk production and consequently there has been poor planning for future follow up projects. As a result, the current study sought to evaluate and describe the performance of crossbred dairy calves produced at TALIRI - Tanga in terms of growth performance attributes (birth weight, weaning weight, and yearling weight) and their adaptability in hot/humid environments based on their pre and post-weaning survivability.

2. MATERIAL AND METHODS

2.1 Study area

The study was carried out at the Tanzania Livestock Research Institute (TALIRI- Tanga). The center was established after independence with the responsibility of producing dairy cattle suitable for hot and humid climates that were to be supplied to smallholder farmers. The center is in Tanga city, located between 40 21' – 60 24' S, 360 11' -382 26' E with average ambient temperature ranging from 15 ^{0}C and 35 ^{0}C and characterized by hot - humid climate receiving an average annual rainfall between 500mm to 1500mm/year[13]. The zone has two distinct rain seasons; a high rain season starting from March to May and a low rain season that spreads from November to December [14].

2.2 Animal management

Cattle under this study are those kept in the TALIRI – Tanga which are raised under a semi-intensive system and allowed to graze from 7:30 am to 13:00. They are supplemented with 1.5kg of concentrates during milking and thereafter continue to graze from 16:00 to 18:00 hrs. Breeding is done throughout the year using artificial insemination in which Boran cows/heifers are inseminated using Boran, Friesian and Jersey semen to obtain three F1 genotypes (Pure Boran – BB), (Boran x Friesian - BF) and (Boran x Jersey - BJ). Some calves were allowed to directly suckle while others were bucket fed with not less than 4 liters per day in two phases morning and evening. Weaning took place at about 3 months and the calves joined with the adult herd and grazed from 7:00 am to 6:00 pm. Weaned calves received midday concentrate supplementation at around 1kg per calf. Disease control measures were taken for all animals at the center including vaccinations against FMD, ECF, and other diseases. Sick animals were treated and dipping and deworming were done routinely to control tick and worm infestations.

2.3 Data collection and analysis

Data was collected from 1,319 animals of three genotypes which are (BB) - 452 records, BF - 542 records, and BJ - 325 records covering a period of twenty years i.e. from the year 2001 to 2020. The number of records was 1,319 for birth weight, 1,170 for weaning weight at the age of 90 days and 918 for yearling weight. Other records were the calf's genotype according to its parents, sex, season of birth, and date of death. Secondary data for rainfall were obtained from the Tanzania Meteorological Agency (TMA) center at Tanga Airport located about 200 meters from TALIRI – Tanga.
The Growth parameters assessed under this study were pre-weaning growth rate and post-weaning growth rate expressed as shown in the formulas below: -

i. **Pre-weaning growth rate (PrWGr) =** $\frac{(Wnt-Brt)}{WnA}$

Where: - PrWGr = Pre-weaning Growth Rate (g/day), Wnt =Weaning Weight (kg), Brt = Birth Weight (kg), and WnA = Weaning Age (90 days).

ii. **Post-weaning growth rate (PoWGr) =** $\frac{(Yrt-Wnt)}{YrA-\mathrm{WnA}}$

Where: - PoWGr = Pre-weaning Growth rate (g/dy), Wnt = Weaning Weight (kg), Yrt = Yearling Weight (kg), WnA = Weaning Age (90 days), YrA = Yearling Age (365 days)

The pre-weaning survivabilityof the calves was estimated as the percentage of calves that survived from birth to weaning at 90 days, while the post-weaning survivability of calves (PosWSurv) was expressed as the percentage of calves that survived between 90 days and one year old.

The calf's season of birth was categorized into two seasons, which are the wet season (December and June) and the dry season (July and November). The effect of rainfall was categorized into three categories, i.e. Medium annual rainfall years involving the year with medium annual rainfall between 1109.77mm and 1209.77mm, above annual rainfall years included the years with medium annual rainfall above 1209.77mm, and the Low-level annual rainfall years included the years with an medium annual rainfall below 1109.77mm.
The data for growth traits and correlation of traits were analyzed using the General Linear Model (GLM) Statistical Analysis System (SAS, 2011, version 9.3).

Model.

$Y_{ijk} = \mu + G_i + S_j + Y_k + Se_l + GS_{ij} + GSe_{il} + R_m + E_{ijklm}$

Where**:-**

Y_{ijklm} = Observation i^{th} genotype, the j^{th} season of birth, k^{th} year of birth, l^{th} sex, and m^{th} Rainfall level,

μ = Overall mean,

Gi = Effect i^{th} genotype,

S_j = Effect of j^{th} season of birth**,**

Y_k = Effect of the k^{th} year of birth,

Se_l = Effect of l^{th} sex of calf

GS_{ij} = Effect due to interaction between genotype and season of birth;

GSe_{il} = Effect due to interaction between genotype and sex of the calf

R_m = Effect of m^{th} Rainfall level and

E_{ijkm} = Random error term.

Pre and post-weaning survivability of calves were assessed using the Chi-square test.
The General Linear Models (GLM) procedure of SAS software (SAS 2004) was used to analyze all traits measured with the MANOVA option for calculating partial correlation coefficients among the growth parameters under the present study.

3. RESULTS

3.1 Effect of the genetic and non-genetic factors on calf growth performance.

The results of the preweaning and postweaning growth performance of the calves in this study are presented in Table 1. It is shown that genotype and season of birth had a significant effect on birth weight at (P<0.05). Boran x Friesian (BF) calves were the heaviest at birth followed by Pure Boran (BB) and then Boran X Jersey (BJ) calves. There were no statistical differences between genotypes and season of birth in other growth parameters in this study. However, direct suckling calves exhibited significantly higher weaning weight than bucket milk-fed calves. Sex influenced birth weight where male calves are heavier than female calves, but sex did not affect other growth parameters. At the same level of significance, there was an influence of rearing type on weaning weight and pre-weaning growth, with direct suckling calves being heavier than bucket-fed calves in both weaning weight and pre-weaning growth.
The amount of annual rainfall in the year of birth did not influence birth weight (P<0.05) but significantly influenced the rest of the growth parameters (Table 1). Calves weaned during the years with medium rainfall were 11% heavier at weaning compared to those weaned in the years with above and below annual rainfall. In respect of yearling weights, calves born in the year with high annual rainfall had significantly higher yearling weights, 5% more than those born in the year with medium low annual rainfall. Pre-weaning growth was high for calves born in the year with medium annual rainfall, while the opposite was observed for post-weaning growth rate.

Table 1. Least squares mean (±SE) for effects of season of birth, genotype, sex, type of rearing, and level of rainfall in a year of birth on growth performance traits of calves

Source of variation		BW (kg)	WWt (kg)	YW (kg)	PrWGr (kg/day)	PoWGr (kg/day)
Genotype	BB	22.88±0.44^{b}	64.19±1.08	124.45±3.42	0.46±0.01	0.25±0.01
	BF	24.58±0.38^{a}	63.70±0.94	121.49±3.13	0.44±0.01	0.23±0.01
	BJ	20.89±0.35^{b}	62.73±0.86	123.98±2.81	0.47±0.01	0.25±0.01
Season	Dry	23.23±0.27^{a}	63.31± 0.71	121.86 ±2.33	0.45 ±0.01	0.24±0.01
	Wet	22.33±0.23^{b}	63.77±0.57	124.75±1.97	0.46±0.01	0.25±0.01
Sex	Female	22.13±0.24^{a}	63.47±0.61	123.51±1.10	0.46±0.01	0.24±0.01
	Male	23.13±0.24^{b}	63.62±0.62	123.1±2.04	0.45±0.01	0.24±0.01
Rearing type	Bucket	NA	60.25±0.43^{a}	122.98±1.46	0.42±0.01^{a}	0.25±0.01
	Suckling	NA	66.83±0.96^{b}	123.63±3.14	0.49±0.01^{b}	0.23±0.01
Rainfall Level	High	23.31±0.21	59.72±0.55^{a}	122.49±1.64^{a}	0.40 ±0.01^{a}	0.25±0.01^{a}
	Medium	23.14±0.32	66.05±0.85^{b}	116.12±2.29^{b}	0.47±0.01^{b}	0.20±0.01^{b}
	Low	23.18±0.22	59.35±0.61^{a}	121.50±1.72^{ab}	0.40±0.01^{a}	0.25±0.01^{a}

Note: BW = birth weight; WW = weaning weight, **YW** = yearling weight, **PrWGr** = pre-weaning growth rate, **PoWGr** = post-weaning growth rate, BB = Boran pure, BF = Boran + Friesian crosses and BJ = Boran + Jersey, FE = Female calves, ME = Male calves, BSK = Bucket fed calves and DRS = Suckling calves. Mean with different superscripts in the same column within the factor are significantly different (P<0.05).

3.2 Effect of genotype by sex interaction on growth performance traits

On the effect of genotype by sex interaction on pre weaning growth of calves was significant (Table 2). Male BJ grew faster during pre-weaning stage than their contemporary. Other interactions i.e genotypes by sex and genotype by season were tested and found to be insignificant.

Table 2. Effect of Genotype by sex interaction on growth performance traits

Variable	Male			Female			p-value
	BB	BF	BJ	BB	BF	BJ	
BW	22.58±0.37^{a}	24.96±0.28^{b}	22.39±0.43^{c}	21.90±0.35^{ac}	24.41±0.34^{b}	21.01±0.43^{c}	0.3571
WWt	62.98±1.01^{ab}	65.37±0.93^{b}	62.97±1.16^{ab}	61.33±0.96^{a}	65.01±0.94^{b}	64.97±1.16^{b}	0.1518
YW	22.97±2.80^{c}	119.49±2.95^{a}	118.88±3.31^{ac}	123.45±2.67^{c}	123.17±2.87^{ac}	122.64±3.36^{ac}	0.7544
PrWGr	0.44±0.01^{a}	0.45±0.01^{a}	0.45±0.01^{a}	0.44±0.01^{a}	0.45±0.01^{a}	0.49±0.01^{b}	0.0379
PoWGr	0.25±0.01^{a}	0.22±0.01^{a}	0.23±0.01^{a}	0.25±0.01^{a}	0.23±0.01^{a}	0.23±0.01^{a}	0.8869

Note: **BW**= birth weight; **WWt** = weaning weight, **YW**= yearling weight, **PrWGr**= pre-weaning growth rate, **PoWGr**= post-weaning growth rate, BB = Boran pure, BF = Boran + Friesian crosses and BJ = Boran + Jersey. Means with different superscripts in the same row within the specific factor are significantly different (P<0.05).

3.3 Calves Survivability

Table 4 shows that genotypes, sex, type of rearing, and amount of rainfall influenced pre-weaning survivability (p<0.05). The BB calves expressed significantly high pre and post-weaning survivability followed by BJ crosses and lastly BF crosses. More female calves survived compared to male calves while bucket-reared calves had significantly higher pre-weaning survivability than those reared by direct suckling. Calves born in the years with high annual rainfall expressed significantly higher pre-weaning survivability followed by those calved born in the years with medium rainfall. Genotype and amount of rainfall had a significant effect on post-weaning survivability while other variables like season of birth, type of rearing, and sex did not affect post-weaning survivability. Calves born in the years with medium rainfall had higher post-weaning survivability followed by those calved on the years with lower rainfall and finally those born in high rainfall years.

Table 3. Effects of the season, genotype, sex, type of Rearing, and Rainfall on the Pre and Post Weaning calves' survivability.

Variables		Pre-weaning survivability		Post-weaning survivability	
		Percentage %	p-value	Percentage %	p-value
Genotype	BB	92.26	0001	90.17	<.0001
	BF	83.76		65.12	
	BJ	92.00		82.61	
Season	Dry	86.64	0.0606	78.23	0.8815
	Wet	90.00		78.60	
Sex	Female	90.53	0.0409	79.59	0.3501
	Male	86.96		77.34	
Rearing type	Bucket feeding	89.64	0.0069	79.04	0.2076
	Suckling	82.78		74.50	
Rainfall	High	94.25	<.0001	72.19	<.0001
	Medium	90.16		88.64	

Low	82.05	80.94

BB = Boran pure, BF = Boran + Friesian crosses, and BJ = Boran + Jersey. Mean with different superscripts in the same column within the factor are significantly different (P<0.05).

3.4 Correlation between growth traits

Table 4 summarizes the study's findings on correlations, which demonstrates that there was a strong and favorable correlation (r=0.9) between weaning weight and pre-weaning growth, Weaning weight and birth weight had a moderately positive correlation (r=0.32). The Birth weight and yearling weight had a moderately significant low correlation (r=0.134) while weaning weight and yearling weight had a moderately significant correlation (r=0,278). Yearling weight and post-weaning growth rate similarly had a significant moderate correlation (r=0.231). However, there was only a weak negative connection (r= -0,074 and r= -0,074) between birth weight and pre-weaning growth rate as well as between weaning weight and post-weaning growth rate respectively.

Table 4. Correlation between growth traits

DF = 893	BW	WW	YW	PrWGr	PoWGr
BW	1	0.3261***	0.1348***	-0.1134***	0.0213ns
WW		1	0.2783***	0.9023***	-0.0747*
YW			1	0.231***	0.937***
PrWGr	-			1	-0.0881*
PoWGr					1

BW= birth weight; **WW**= weaning weight, **YW** = yearling weight, **PrWGr** = pre-weaning growth rate, **PoWGr**= post-weaning growth rate. Significant level. (*P < 0.05.) (**P < 0.01) and (***P < 0.001).

4. DISCUSSION

4.1 Effects of genotypes on growth performance

The observed differences in birth weights between pure Boran and Boran x Friesian cattle in the present study concur with other studies by [15]; [16]; [17] and [4] whereby Boran x Friesian calves were superior in birth weight. This could be due to the effects of heterosis and breed effect, so this study reaffirms the fact that the growth performance of *B.indicus* (Boran) cattle bred with *B.taurus* cattle, primarily Friesian, is better when compared to pure breed Boran. Meanwhile, the similarity in birth weight between pure Boran and Boran x Jersey crosses might be due to the relatively small body size of Jersey cattle compared to Friesian cattle [18]. The small birth weight of the pure Boran and Jersey cross calves implies that they have less heat stress making them highly adaptable in hot and humid environments and hence perform economically better in low-input dairy cattle management systems where there is a feed shortage compared to Friesian crosses [19]. However, the Friesian crossbred calves did not maintain weaning and post-weaning the birth weight advantage they had over the Jersey crossbred and pure Boran calves. This observation is contrary to previous findings showing that Jersey cattle typically have lower growth rates compared to Friesian cattle [20] and that Jersey-Boran crossbred calves may exhibit slower growth compared to Friesian-Boran crosses.

However, genotype-by-sex interaction showed an effect on pre weaning growth which implies that, except for pre weaning growth, the other pre and post-weaning growth parameters investigated in the current study for the three genotypes are the same independent of an animal's sex. Male BJ grown faster than their contemporalycontemporary for the genotype by sex interaction although, this study found no significant differences for both genotype and sex effect on pre weaning growth. This was caused by a combination of factors, including the higher feed efficiency of the Jersey breed, the Boran breed's good adaptability in hot, humid environments, and growth hormone differences caused by sex that benefit male calves. The results of the present investigation concur with the findings published in [21] on crossing of indigenous Holo cattle with both Jersey and Friesian Bako Ethiopia, furthermore, according to other research, male Jersey-local cattle hybrids grow far faster than their counterparts [22]; [23] and [24] revealed this was due to their resilient to environment pressure.

4.2 Effects of non-genetic factors on growth performance

The observed low birth weight of the calves born in the wet season compared to those born in the dry season is because the pregnancy of the calves born in the wet season was conceived and raised during the dry season where feed and water shortage is a common phenomenon which might cause maternal nutritional restrictions ultimately leads to lighter birth weight. Similar findings were reported in [25]; [26]; [27] and [28]. In a study [29], the effect of maternal undernutrition on muscle fiber formation (myogenesis) especially during embryonic and fetal stages which consequently affects the birth weight and growth performances of a particular offspring was elaborated. Such effect of season was also reported by [30] found that the number of muscle fibers for large animals, is fixed prenatally especially in the first trimester whilst maternal nutrition in the first trimester is essential for the subsequent birth weight and growth performance of the progeny. The finding reveals the importance of seasonal breeding whereby the farmers are advised to breed their cattle in the wet season when there is enough feed for the mother and for pregnancy development. In addition, wet calving results in less pneumonia and calf scouring which could result in a high risk of deaths of calves during the wet season [31].

The observed higher birth weight in male calves compared to female calves in the present study is similar to other studies reported by [32]; [33] and [34], this might be because, fetus of the male calves found to have relatively high level of estrogen hormones compared to female fetus, effect of estrogen hormone as among the growth hormone increases growth rate of the male fetus than female fetus [24]. On the other hand, male fetuses are reported to have relatively long gestation compared to female fetuses which makes male calves have high birth weights compared to female calves [35]. Notwithstanding, the insignificant effect of sex on other growth performance traits in the present study might be due to the management under which those animals were kept [36]. Some other factors that contributed to the faster growth of male calves compared to female calves are genetics, hormones, and environmental conditions. It has also been proven that one of the primary reasons for the faster growth of male calves is the presence of androgens, which are male sex hormones because male calves start producing higher levels of testosterone at a certain stage of development, leading to increased muscle and bone growth compared to female calves as Testosterone is a prominent androgen that stimulates the growth of muscle and bone tissues [37]. With more testosterone hormone, male calves tend to have a higher muscle-to-fat ratio than female calves, leading to rapid muscle growth and accelerated bone growth which contributes to their larger body size [38].

This study revealed that calves fed direct suckling have higher weaning weight and pre-weaning growth than those given bucket milk, this is the same as reported in other investigations by [39] and [40], this could be related to bucket milk feeding, in which the calf is often given significantly less milk than in direct suckling due to variables such as attendant errors and others. By doing so, the present study concluded that direct suckling of the calves promotes pre-weaning weight gain in dairy calves as also concluded in the study by [41], because direct suckling results in relatively high milk intake which improves average daily gain, increase energy intake and consequently high DM intake leads to higher live weight gain [42]. However, direct suckling of calves may have the negative effect of delayed development of the rumen due to limited uptake of solid feeds [43]. This study also revealed that management of calves does not affect post-weaning growth performance which is similar to the study reported by [44] and [45]. It was also found in the study by [41], that calves who consume fewer marketed feeds during pre-weaning had delayed post-weaning growth due to reduced adaption to solid feeds, as discussed above.

4.3 Effect of genotype on calves' survivability

Crossing Boran cattle with exotic breeds increases the survivability of the cross-bred cattle in hot/humid environments compared to pure exotic breeds, as found in the current study, and is consistent with the findings of other studies reported by [46]; [47]; [48], and [49]. This might be due to physiological and morphological modifications that crossbred animals experience in comparison to their exotic parents, which help them adapt to hot, humid environments that are typically characterized by high temperatures and humidity. Such changes include changes in body size, hair coat, hide texture, and hematological characteristics, which allow them to have unique features that allow them to regulate their body temperature more effectively, resulting in less heat stress than pure Bos taurus [50].

In contrast to Boran cattle, exotic breeds lack natural resistance to tropical diseases like Anaplasmosis, Theileriosis, Cowdriosis, and other parasites and diseases transmitted by ticks. This is because Boran cattle have naturally evolved this resistance through natural selection, adaptation, and disease exposure, which over time stimulate the immune system. In the current study, as in the findings of [51], acquired immunity in Boran cattle increases their survivability when compared to crosses.

4.4 Effect of non-genetic factors on calves' survivability

The season of birth of the calf did not affect both pre and post-weaning survivability in the present study similar to reports by [52] and [53]. For the season to affect the survivability of calves, the fluctuations in ambient temperature, humidity, and rainfall, which influence resource availability, climatic conditions, and overall stress levels in young calves should occur over a period of time, but in the present study, the season of birth encountered only the time when a calf born and while the management after birth were more or less the same. Some researchers address several conditions that contribute to heat stress in calves being high ambient temperature, high humidity, lack of shed, inadequate ventilation, and overstocking which trigger the adrenal steroid and restrict the postnatal ability to absorb immunoglobulin eventually compromising the calf's survivability [53] and [54], but the temperature and other environmental factors for the calves were appropriately taken into account in the current study to prevent heat stress.

In this study, the female calves revealed higher survivability than male calves in both pre and post-weaning stages. These findings are in line with those by [47]; [55] and [56]. According to [56] an extra X in the female chromosome protects the animal against harmful mutation compared to males.In addition, the vitality of X chromosomes for the normal development of an animal increases the possibility of female animals resisting adverse environments compared to male calves which are heterozygous. Hence, male calves can be more prone to certain health issues, such as respiratory problems and digestive disorders, which may make them more susceptible to diseases and early death. In some cases, female calves receive more attention and better feeding practices because they are seen as an investment in the dairy herd's future milk production [57] hence a higher survival rate.

In this study, the types of rearing of calves had significant effects on pre and post-weaning survivability which is in candid with findings reported by [52] and [58], where direct suckling or *ad libitum* milk-fed calves had lower survivability compared to bucket milk-fed calves. This might be caused by partial suckling, uniformity of amount of milk given to calf daily in direct suckling due to poor milking techniques by the attendant, and poor nutritional status of a dam. Poor rumen development in direct suckling calves compared to bucket-reared calves, on the other hand, makes them less acclimated to solid feeds and hence limits their survivorship, according to a study reported by [43]. In that study, bucket-rearing calves had improved survivorship because they were introduced to solid nutrition early, promoting rumen development, as opposed to direct suckling calves that were satisfied by milk.

4.5 Correlation between growth traits

The positive phenotypical correlation between birth weight and weaning and yearling weights in the present study is similar to the findings reported by [59] in Ethiopia (r= 0.2). Similarly, [60] in South Africa, contended that selection for cattle with high birth weight results in weaning and yearling weights, since most of the genes that influence birth weight also determine the weaning weight and yearling weight [15] and [61]. A negative phenotypic correlation between birth weight and post-weaning growth means that the birth weight does not determine post-weaning growth performance because of the time differences between them hence the environmental effect is more substantial than the genetic effect [62] and [63]. The same phenomenon was found between weaning weight and post-weaning growth as elaborated above. However, these findings on the negative correlation between birth weight and post-weaning growth concurred with those reported by [4] in Boran and their crosses with Friesian and Jersey cattle in Ethiopia. This could be due to nutritional factors, where inadequate nutrition during pregnancy can lead to lower birth weight, and this early nutritional deficiency may have long-term effects on growth potential even after weaning, resulting in a negative correlation between birth weight and post-weaning growth [64] and [65]. Furthermore, poor situations during fetal development might result in metabolic programming, which changes the body's metabolism and growth patterns. Low birth weight caused by poor prenatal conditions can have a significant impact on post-weaning growth.

5 CONCLUSION

Based on the study's findings, it can be concluded that breeding Boran cattle with exotic breeds, particularly the Friesian breed, increases the animals' birth weights, which in turn affects how well they grow, this guarantees that they will reach sexual maturity at the appropriate time and produce milk for a longer period, which is the key breeding goal in the dairy sector. The results of this study also showed that calves' birth weight is influenced by sex and the time of year they are born, and this will have an impact on the production of these animals in their later life stages.

On the other hand, crossing Boran cattle with exotic breeds, specifically Friesian and Jersey breeds, improved the survivability of the crosses in hot humid environments compared to their pure exotic counterparts due to adaptive genes acquired from Boran cattle, which is prevalent in such environments. However, an animal's birth weight informs breeders and farmers about the animal's genetic superiority in predicting future growth performance and is advised to be used as a key factor in selecting animals for the next generation.

ETHICAL APPROVAL

This work has received the Tanzania Livestock Research Institute's Livestock Research Ethical Clearance, offered with reference number TLRI/RCC.21/004 and dated November 1st, 2021.

REFERENCES

[1] Kidoido M,Korir L. Do low-income households in Tanzania derive income and nutrition benefits from dairy innovation and dairy production. Food Security. 2015;7(3): 681 – 692. Available: https://doi.org/10.1007/s12571-015-0419-z

[2] URT United Republic of Tanzania, The Ministry of Livestock and Fisheries Hon. MashimbaNdaki (MP) Speech on the Expected Expenditure Financial year 2021/22 of the Ministry of Livestock and Fisheries. Ministry of Livestock and Fisheries. 2021; 31pp.

[3] NBS National Bureau of Statistics (2021/2022) Livestock Sector - National Report. NBS, Dar es Salaam, Tanzania. 2022. Available:http://www.nb .go.tz/nbs/takwimu/Agr2021-22/Livestock_Sector_National_Report.zip.

[4] Demeke S, Neser F W C, Schoeman S J. Estimates of genetic parameters for Boran, Friesian, and crosses of Friesian and Jersey with the Boran cattle in the tropical highlands of Ethiopia, reproduction traits. Journal of Animal Breeding and Genetics. 2004;121(1), 57–65. Available: https://doi:10.1046/j.0931-2668.2003.00438.

[5] West J W. Effects of heat stress on production in dairy cattle. Journal of Dairy Science. 2003; 86(6): 2131 – 2144. Available:https://doi.org/10.3168/jds.S0022-0302(03)73803-X

[6] Wassena FJ, Mangesho W E, Chawala A, Laswai GH, Bwire JM, Kimambo A E, Lukuyu B, Sikumba G, Maass BL. Effects of season and location on cattle milk produced and producer milk prices in selected villages of Tanga and Morogoro Regions, Tanzania. Livestock Research for Rural Development. 2015;27(10). Available: http://www.lrrd.org/lrrd27/10/wass27191.html

[7] Mwambene P L, Chawala A, Illatsia E, Das S M, Tungu B, Loina R. Selecting indigenous cattle populations for improving dairy production in the Southern Highlands and Eastern Tanzania. Livestock. Resource. Rural Development. 2014; 26(3).Available:http://www.lrrd.org/lrrd26/3/mwam26046.html

[8] Heinrichs A J, Heinrichs B S. A prospective study of calf factors affecting first-lactation and lifetime milk production and age of cows when removed from the herd1. Journal of Dairy Science. 2011; 94(1), 336–341. Available: https://doi:10.3168/jds.2010-3170

[9] Mruttu H, Ndomba C, Nandonde S, Brook K N. Animal genetics strategy and vision for Tanzania. Tanzania Livestock Master Plan Background Paper. 2016: Available: https://creativecommons. org/licenses/by/4.0.

[10] Galukande E, Mulindwa H, Wurzinger M, Roschinsky R, Mwai A O, Sölkner J. Cross-breeding cattle for milk production in the tropics: achievements, challenges and opportunities. Animal Genetic Resources. 2013; 52, 111-125. Available: https://doi.org/10.1017/S2078633612000471.

[11] Kurwijila L R. Evolution of dairy policies for smallholder production and marketing in Tanzania. Smallholder dairy production and marketing—Opportunities and constraints. 2002: 298.
[12] Wathes D C, Pollott GE, Johnson K F, Richardson H and Cooke JS. Heifer fertility and carry over consequences for life time production in dairy and beef cattle, Animal. 2014: 8(s1),91-104. Available: https://doi.org/10.1017/S1751731114000755.
[13] Gamoyo M, Reason C, Obura D. Rainfall variability over the East African coast. Theoretical and Applied Climatology. 2014: 120(1-2), 311–322. Available: https://doi:10.1007/s00704-014-1171-6.
[14] Swai E, Schoonman L. Microbial quality and associated health risks of raw milk marketed in the Tanga region of Tanzania. Asian Pacific Journal of Tropical Biomedicine. 2011;1(3): 217–222.Available:https://doi.org/10.1016/S2221-1691(11)60030-0.
[15] Haile A, Joshi B K, Ayalew W, Tegegne A, Singh A. Genetic evaluation of Ethiopian Boran cattle and their crosses with Holstein Friesian for growth performance in central Ethiopia. Journal of Animal Breeding and Genetics. 2010;128(2), 133–140. Available: http://doi:10.1111/j.1439-0388.2010.0088.
[16] Fernando P R P, Sinniah J, Thatchaneshkanth S. Productive and reproductive performance of Jersey cattle in the Hill Country of Sri Lanka. Global Veterinarian. 2016;17(4), 392-400. Available: http://doi:10.5829/idosi.gv.2016.392.400
[17] Habtamu A, Solomon A, Yoseph M. Influence of non-genetic factors on growth traits of Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle. International Journal of Livestock Production. 2012; 3(7), 72-77. Available:http://doi:10.5897/IJLP11.015
[18] Hickson R E, Zhang I L, McNaughton L R. Brief communication: Birth weight of calves born to dairy cows in New Zealand. In Proceedings of the New Zealand Society of Animal Production. 2015; 75-257-259.
[19] Heins B J, Hansen L B, Seykora A J, Hazel A R, Johnson D G, Linn J G. Short communication: Jersey × Holstein crossbreds compared with pure Holsteins for production, mastitis, and body measurements during the first 3 lactations. Journal of Dairy Science. 2011; 94(1), 501–506. Available: http://doi:10.3168/jds.2010-3232.
[20] Miglior F, Fleming A, Malchiodi F, Brito L. F, Martin P, Baes C F. A 100-Year Review: Identification and genetic selection of economically important traits in dairy cattle. Journal of dairy science. 2017;100(12), 10251-10271. Available: https://doi.org/10.3168/jds.2017-12968.
[21] Abera H, Abegaz S, Mekasha Y. Influence of non-genetic factors on growth traits of Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle. International Journal of Livestock Production. 2012;3(7), 72-77. Available: https://doi.10.5897/IJLP11.015.
[22] Mohamed A. Estimates of genetic parameters of birth weight, age at first calving and milk production traits in Holstein Friesian dairy herds kept in three state farms. An MSc Thesis presented to School of Graduate studies of Alemaya University. 2004; p. 89.
[23] Hundie D, Beyene F, Duguma G. Early Growth and Reproductive Performances of Horro Cattle and thier F1 Jersey Crosses in and around Horro-Guduru Livestock Production and Research Center, Ethiopia. Science, Technology and Arts Research Journal. 2013; 2(3), 134-141. Available: https://doi. 10.4314/star.v2i3.98752.
[24] Manzi M, Junga JO, Ebong C, Mosi R. Factors affecting pre and post-weaning growth of six cattle breed groups at Songa Research station in Rwanda. Livestock Research for Rural Development. 2012; 24: 4. Availablehttp://62.24.102.115:8080/xmlui/handle/123456789/1207
[25] Topal M, Aksakal V, Bayram B Yaganoglu A M. An analysis of the factors affecting birth weight and actual milk yield in Swedish red cattle using regression tree analysis. Journal of Animal and Plant Sciences-Japs. 2010; 20(2) 63-69 Available:info:eu-repo/semantics/closedAccess.
[26] Kamal M M, Van Eetvelde M, Depreester E, Hostens M, Vandaele L, Opsomer G. Age at calving in heifers and level of milk production during gestation in cows are associated with the birth size of Holstein calves. Journal of Dairy Science. 2014; 97(9), 5448-5458.Available: https://doi.org/10.3168/jds.2014-7898.
[27] Segura-Correa J C, Magaña-Monforte J G, Aké-López J R, Segura-Correa V M, Hinojosa-Cuellar J A, Osorio-Arce M M. Breed and environmental effects on birth weight, weaning weight and calving interval of zebu cattle in Southeastern Mexico. Tropical and Subtropical Agroecosystems. 2017;20(2), 297-305. Available: http://www.redalyc.org/articulo.oa?id=93952506011

[28] Mulindwa H E, Kifaro G C, Ssewannyana E. Comparative pre-weaning growth of Zebu cattle and their crosses with Sahiwal and Boran. Uganda Journal of Agricultural Sciences. 2012;13 (1): 35-44.
[29] Wilson S J, Ross J J, Harris A J A. critical period for formation of secondary myotubes defined by prenatal undernourishment in rats. Development. 1988;102, 815-21.Available:https://doi.org/10.1242/dev.102.4.815.
[30] Li M, Zhou X, Chen Y, Nie Y, Huang H, Chen H, Mo D. Not all the number of skeletal muscle fibers is determined prenatally. BMC Developmental Biology. 2015 ;15(1). Available: http//doi:10.1186/s12861-015-0091-8.
[31] Hordofa D, Abunna F, Megersa B, Abebe R. Incidence of morbidity and mortality in calves from birth to six months of age and associated risk factors on dairy farms in Hawassa city, southern Ethiopia. 2021; 7(12). Available: https://doi.org/10.1016/j.heliyon.2021.e08546.
[32] Micke G C, Sullivan T M, Magalhaes R S, Rolls P J, Norman S T, Perry V E A. Heifer nutrition during early-and mid-pregnancy alters fetal growth trajectory and birth weight. Animal Reproduction Science. 2010;117(1-2). Available: https://doi.org/10.1016/j.anireprosci.2009.03.010.
[33] Dhakal K, Maltecca C, Cassady J P, Baloche G, Williams CM, Washburn S P. Calf birth weight, gestation length, calving ease, and neonatal calf mortality in Holstein, Jersey, and crossbred cows in a pasture system. Journal of Dairy Science. 2013; 96(1), pp.690-698. Available: https://doi.org/10.3168/jds.2012-5817.
[34] Selvan A S, Tantia M S, Kumaresan A, Kumar A, Kumar D R, Karuthadurai T, Upadhyay A. Phenotypic and genetic parameters estimation for birth weight in Zebu and crossbred calves born under organized farm conditions in India. International Journal of Livestock Research. 2018; 8(06), 48-58. Available: http//doi.10.5455/ijlr.20170706104426.
[35] Uzmay C, Kaya I, Ayyılmaz T. Analysis of risk factors for dystocia in a Turkish Holstein herd. Journal of Animal and Veterinary Advances. 2010;9 (20): 2571-2577. Available: https://doi 10.3923/javaa.2010.2571.2577.
[36] Diao Q Y, Zhang R, Yan T U. Current research progresses on calf rearing and nutrition in China. Journal of integrative agriculture. 2017; 16(12), 2805-2814. Available: https://doi.org/10.1016/S2095-3119(17)61767-2
[37] Handelsman D J, Hirschberg A L, Bermon S. Circulating testosterone as the hormonal basis of sex differences in athletic performance. Endocrine reviews. 2018; 39(5), 803-829. Available: https://doi.org/10.1210/er.2018-00020.
[38] Kim T N, Choi K M. Sarcopenia: definition, epidemiology, and pathophysiology. Journal of bone metabolism. 2013; 20(1), 1-10. Available: https://doi.org/10.11005/jbm.2013.20.1.1.
[39] Jasper J, Weary D M. Effects of Ad Libitum Milk Intake on Dairy Calves. Journal of Dairy Science. 2002; 85(11), 3054–3058. Available: http//doi:10.3168/jds.s0022-0302(02)7.
[40] Moallem U, Werner D, Lehrer H, Zachut M, Livshitz L, Yakoby S, Shamay A. Long-term effects of ad libitum whole milk prior to weaning and prepubertal protein supplementation on skeletal growth rate and first-lactation milk production. Journal of Dairy Science. 2010; 93(6), 2639-2650. Available: https://doi.org/10.3168/jds.2009-3007.
[41] Broucek J, Uhrincat M, Kisac P, Hanus A. Effect of Different Rearing during the Milk-Feeding Period on Growth of Dairy Calves. Agriculture. 2020; 10(8), 346. Available: http//doi:10.3390/agriculture10080346.
[42] Margerison J K, Preston TR, Berry N, Phillips C J C. Cross-sucking and other oral behaviors in calves, and their relation to cow suckling and food provision. Applied. Animal. Behaviors. Sci. 2003; 80, 277–286. Available: https://doi.org/10.1016/S0168-1591(02)00231-9.
[43] Staněk S, Zink V, Doležal O, Štolc L. Survey of pre-weaning dairy calf-rearing practices in Czech dairy herds. Journal of Dairy Science. 2014; 97(6), 3973-3981. Available: https://doi.org/10.3168/jds.2013-7325.
[44] Cheema A T, Bhatti S A, Akbar G, Wynn P C, Muhammad G, Warriach H M, McGill D. Effect of weaning age and milk feeding level on pre-and post-weaning growth performance of Sahiwal calves. Animal Production Science. 2016;58(2), 314-321. Available: https://doi.org/10.1071/AN15719.
[45] Todd C G, Leslie K E, Millman S T, Bielmann V, Anderson N G, Sargeant J M, DeVries T J. Clinical trial on the effects of a free-access acidified milk replacer feeding program on the health and growth of dairy replacement heifers and veal calves.

Journal of Dairy Science. 2017;100(1), 713–725. Available: http//.doi:10.3168/jds.2016-11401.
[46] Ferede Y, Mazengia H, Bimrew T, Bitew A, Nega M, Kebede A. Pre-Weaning Morbidity and Mortality of Crossbred Calves in Bahir Dar Zuria and Gozamen Districts of Amhara Region, Northwest Ethiopia. Open Access Library Journal. 2014; 1: e600. Available: http://dx.doi.org/10.4236/oalib.1100600.
[47] Davis R B, Norberg E, Fogh A. Estimation of genetic parameters for young stock survival in beef x dairy crossbred calves. Animal. 2019; 1–7. Available: http//.doi:10.1017/s1751731119002386.
[48] Danish Agriculture and Food Council F.m.b.A. 2016 Danish *Agriculture and Food Council* F.m.b.A., Skejby, Denmark. 2016.
[49] Mostari M, Khan M, Roy B, Hossain S, Huque K. Growth performance of yearling F1 progeny of different crossbred beef cattle. Bangladesh Journal of Animal Science. 2017; 46(2), 82–87. Available: http//doi:10.3329/bjas.v46i2.34433.
[50] Mateescu R G, Sarlo Davila K M, Hernandez A S, Andrade A N, Zayas G A, Rodriguez E E, Oltenacu P A. Impact of Brahman genetics on skin histology characteristics with implications for heat tolerance in cattle. Frontiers in Genetics. 2023; 14, 1107468. Available: https://doi.org/10.3389/fgene.2023.1107468.
[51] Long N M, Collier R J, Smith J F. Comparison of 2 methods of assessing calf birth weights in dairy calves. Journal of Dairy Science. 2012; 95(12): 7206-7209. Available: https://doi.org/10.3168/jds.2012-6051.
[52] Debnath S. Effect of breeding bulls on growth performance and survivability of Brahman crossbreds in rural areas of Bangladesh. Journal of Agriculture, Food and Environment. 2022; 2708-5694, 3(1), 21-25. Available: https://doi.org/10.47440/JAFE.2022.3104.
[53] Azizzadeh M, Shooroki H F, Kamalabadi A S, Stevenson M A. Factors affecting calf mortality in Iranian Holstein dairy herds. Preventive Veterinary Medicine. 2012; 104(3-4), 335–340. Available: http//doi:10.1016/j.prevetmed.2011.12.0.
[54] Manzoor A, Kalkal H, Ahuja R, Argade A, Nazir T. Effect of heat and cold stress and its management in dairy animals. Advanced Research in Veterinary Sciences. 2021; 22, 82.
[55] Van Pelt M, Eding H, Vessies P, de Jong G, Developing a genetic evaluation for calf survival during rearing in The Netherlands. Interbull Bulletin. 2012; (46).
[56] Ohno S. Sex chromosomes and sex-linked genes (Vol. 1). Springer Science and Business Media. 2013.
[57] Palczynski L J, Bleach E C, Brennan M L, Robinson P A. Appropriate dairy calf feeding from birth to weaning:“it’s an investment for the future”. Animals. 2020; 10(1), 116. Available: https://doi.org/10.3390/ani10010116.
[58] Hulbert L E, Moisá S J. Stress, immunity, and the management of calves 1. Journal of Dairy Science. 2016; 99(4), 3199–3216. Available: doi:10.3168/jds.2015-10198 10.3168/jds.2015-10198.
[59] Kuthu ZH, Javed K, Awan K, Ahmad N, Ahad A. A Study on Phenotypic and Genetic Correlations between Birth Weight and other Growth Traits in Teddy Goat. Journal Dairy Veterinary Animal Resources. 2017; 5(5): 00158. Available: http//doi: 10.15406/jdvar.2017.05.00158.
[60] Maiwashe A, Bradfield M, Theron H, Van Wyk J. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. Livestock Production Science. 2002; 75(3), 293–300. Available: http//doi:10.1016/s0301-6226(01)00324.
[61] Utsunomiya Y T, Do Carmo A S, Carvalheiro R, Neves H H, Matos M C, Zavarez L B, Garcia J F. Genome-wide association study for birth weight in Nellore cattle points to previously described orthologous genes affecting human and bovine height. BMC genetics. 2013; 14(1), 1-12. Available: https://doi.org/10.1186/1471-2156-14-52.
[62] Wakchaure R, Ganguly S, Praveen K. Genotype x environment interaction in animal breeding: a review. Biodiversity. Conservation. Change. Climate. 2016; 3, 60-73.
[63] Lopez B I, Santiago K G, Seo K, Jeong T, Park J E, Chai H H, Lim D. Genetic Parameters of Birth Weight and Weaning Weight and Their Relationship with Gestation Length and Age at First Calving in Hanwoo (Bostauruscoreanae). Animals. 2020; 10(6), 1083. Available: http//doi:10.3390/ani10061083.
[64] Coleman L, Back P, Blair H, López-Villalobos N, Hickson R. Sire effects on birth weight, gestation length, and pre-weaning growth of beef-cross-dairy calves: A case study in New Zealand. Dairy. 2021; 2(3), 385-395.Available: https://doi.org/10.3390/dairy2030030.

[65] Ilatsia E D, Migose S A, Muhuyi W B, Kahi A K. Sahiwal cattle in semi-arid Kenya: Genetic aspects of growth and survival traits and their relationship to milk production and fertility. Tropical Animal Health and Production. 2011; 43, 1575-1582. Available: https://doi.org/10.1007/s11250-011-9845-x.