Estimates of Co-variance Components and Genetic Parameters of Growth Traits in Boran Cattle Breed at Dida Tuyera Ranch, Southern Ethiopia

A thesis Submitted to the School of Graduate Studies Collage of Natural and Computational Sciences

Department of Microbial Cellular and Molecular Biology

Addis Ababa University

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In Partial Fulfillment of the Requirements for the Degree of Master of Science (MSc.) in Biology (Applied Genetics)

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Jan, 2019

Addis Ababa, Ethiopia

DEDICATION

This thesis is dedicated to my Uncle, Aba H/Giorgis Matente and my beloved husband Birhan Kassu for their unlimited encouragement, support and tolerance in the success of my life during my absence.

DECLARATION

This is to declare that the thesis prepared by Genet Zewdie, entitled: Estimates of Co-variance Components and Genetic Parameters of Growth Traits in Boran Cattle Breed and submitted in partial fulfillment of the requirements for the degree of Masters of Science in Biology (Applied Genetics) to the School of Graduate Studies of Addis Ababa University is my own independent work and has not previously been submitted by me or anybody else at another university. The materials obtained from other sources have been duly acknowledged in the thesis.

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ACKNOWLEDGMENTS

I express my gratitude and appreciation to Dr. Hailu Dadi, my co-advisor, for his continuous guidance, invaluable suggestions, kindness and encouragement starting from title selection, final proposal formulation and proposal implementation throughout this study. He repeatedly visited and evaluated my field studies. I learnt, from his devoted personality and energetic nature, not only professionalism but also professional ethics and seriousness for his constructive.

My sincere gratitude also goes to my major Advisors, Dr. Tesfaye Sisay for his open interactions and his humpless. Further, I need to express my heartfelt gratitude to my co-advisor Dr. Dereje Beyene, for his valuable advice, support, and assistance anytime when I need him, fruitful discussions continuous encouragement and for his parental care. I learnt from his the best because I learnt from you.

I also wish to place on record my deep sense of gratitude and due respect to my lovely husband Birhan Kassu for his patience, understanding, psychological and moral support and my uncle Aba H/Giorgis for his financial support in the attainment of my degree. I strongly believe that without your encouragement. I haven’t reached to this level. I thank you from the bottom of my heart.

In addition, I would like to extend my special thank for Dr. Selam Meseret and Tegegn Fantahun and all who directly and indirectly contributed to the successful accomplishment of the research work.

Finally, I would like to express my gratitude to Addis Ababa University, particularly the Department of Microbial, Cellular and Molecular Biology for accepting me to join the Master’s Program, for furnishing safe environment to get better knowledge in the field of Applied Genetics and their financial support.

ACRONYMS AND ABBREVIATIONS

AI-REML	Average Information Restricted Maximum Likelihood
BW	Birth Weight
CSA	Central Statistical Authority
DAGRIS	Domestic Animal Genetic Resource Information System
EIAR	Ethiopian Institute of Agricultural Research
GLM	General Leaner Model
h^2	Heritability
HF	Holstein Frisian
Log L	Log Likelihood
MFBCMR	Metekel Fogera Cattle Breed Conservation and Multiplication Ranch
ADG	Average Daily Gain
WW	Weaning Weight
σ^2a	Direct Additive Genetic Variance
σ^2m	Maternal Additive Genetic Variance
σ^2p	Phenotypic Variance

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ABSTRACT

Estimates of Co- Variance Components and Genetic Parameters of Growth Traits in Boran Cattle Breed at Dida Tuyera Ranch, Southern Ethiopia

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Addis Ababa University, Jan, 2019

Boran, a popular cattle breed, is predominantly utilized and widely distributed across various countries of Africa. Ethiopia is the origin of this promising breed in terms of milk and beef. In Ethiopia, genetic improvement of the indigenous cattle for dairy production is focusing on cross breeding. It has been practiced for the last five decades, but the success was very low. Therefore, there is a need to develop effective and sustainable genetic improvement schemes for indigenous cattle breeds in Ethiopia. A study was undertaken in Yabello district of Borana Zone with the objectives to estimate the covariance components and genetic parameters of Boran cattle growth traits for Birth Weight (BW),Weaning Weight(WW)and Average Daily Gain (ADG) of Boran calves. The total number of animals considered in this study was one thousand one hundred sixty two (1162), of which number of bulls was six hundred thirty four (634) and number of heifers was five hundred twenty eight (528). The fixed effects or non-genetic factors included in the animal model for the analysis of growth traits were sex, birth year and season. Least square means were estimated using General Linear Model of Statistical Analyses System, SAS. Pedigree was analyzed using Relax 2 program. Variance and covariance components were estimated using AI-REML implemented in the software DMU V.6 package (Madsen and Jensen, 2013). Genetic parameters were using R Studio program. The data records for BW = 1120, WW = 1144 and ADG = 1144 collected between 1991 and 2000. The estimation of the BW, WW and ADG of Boran calves was optimized by evaluating two models that either included or excluded the maternal genetic effects. The best model was chosen according to the log-likelihood ratio tests. Genetic parameters were estimated using R Studio. Sex of the calf significantly influenced BW and ADG ($P< 0.01$) but not significant for weaning weight. Birth year and calving season significantly ($P< 0.001$) influenced BW, WW and ADG. The direct heritability estimates to BW, WW and ADG were 0.17, 0.38 and 0.46, respectively. The corresponding maternal heritability estimates were 0.10, 0.17 and 0.15, respectively. The phenotypic correlation between BW and WW was 0.28 while this value was higher than 0.21 between BW and ADG and 0.65 between WW and ADG. The direct and maternal genetic correlation for BW, WW, and ADG were -0.47, -0.45 and -0.47, respectively. The low heritability estimates due to low genetic control because of presence of high environmental influence.

Key words: Boran cattle, growth traits, heritability, correlation

1. INTRODUCTION

1.1 Background and justification

Ethiopia is believed to have the largest livestock population in Africa. An estimate indicates that the country is a home for 59.5 million cattle, 30.7 million sheep, 30.2 million goats and 56.53 million poultry(CSA, 2016/17). Agricultural sector of Ethiopia accounts for about 42% of the GDP, employs about 85% of the labour force, and contributes around 90% of the total export earnings of the country. The sector is dominated by over 15 million smallholders producing about 95% of the national agricultural production. Hence, the overall economy of the country and the food security of the majority of the population depend on smallholder agriculture (CSA, 2015/16).

Cattle are the most important species followed by goats, camels, and sheep in the pastoral livestock production system, and are source of food in the form of milk, meat and source of other products such as fiber and hides (FAO, 2009). Major livestock species were imported to enhance .livestock productivity of Ethiopia throughcrossbreeding. Cattle herds are much larger in the pastoral areas and average about 75 head in Boran, Ethiopia. In the mixed farming areas, herds are much smaller being 5.7 head in East Harerghe, 8.6 in Illubabor and 11.8 in the central highlands (MoARD, 2007). In mixed farming system, cattle provide draught power and manure for cropland fertilization beside to milk production (Agajie*et al*., 2002), whereas the purpose of keeping cattle in pastoral production system is for breeding and selling, in agro- pastoral production system for meat and draught power (MoARD, 2007).

Poor health services, feed shortage and low genetic potential of animals are the main constraints that restrain livestock productivity of Ethiopia (Ibrahim and Olaloku, 2000). However, adaptation to harsh climatic conditions, ability to better utilize the limited and poor quality feed resources and tolerance to a range of diseases make indigenous livestock breeds of Ethiopia to be valuable source of genetic material (DAGRIS, 2009).

Efforts to improve genetic quality of cattle through selection require information on genetic parameters of cattle breed population. Without estimation of genetic parameters, breeding program setting which could be used as a tool for breed improvement program seems hardly possible. Genetic parameter estimates are needed for implementation of breeding programs and assessment of progress of ongoing programs (Bourdon, 1999; Wasike 2006; Arendok*et al*., 2010).

The genetic parameters are helpful in determining the method of selection, to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic gain (Javed*et al*., 2001).Knowledge of the magnitude of the (co) variance components in tropical cattle is scanty. Therefore, the complete covariance structure needs to be estimated. Even in case of inadequate pedigree information and data, some attempt at estimating genetic (co) variance components and genetic parameters is better than no attempt (Wasike*et al*., 2009).Growth rate remains the primary selection criterion for most beef cattle breeders aroundthe world, thus the correct prediction of the genetic value of beef cattle is required foroptimizing genetic gain (Archer, 1998).

The Ethiopian Boran breed originally descended from the first introduction of zebu into Africa from West Asia. The breed is well adapted to semi-arid tropical conditions and has a high degree of heat tolerance. The breed is resistant to many of the diseases prevailing in the tropics and has the ability to survive long periods of feed and water shortage (Ojango*et al*.,2006).

In Ethiopia, to meet the ever-increasing demand for meat, milk and milk products and thus contribute to economic growth, genetic improvement of the indigenous cattle has been proposed as one of the alternatives. However, there are no organized estimates of genetic parameters, animals breeding value information and sound selection schemes for cattle genetic improvement in Ethiopia (FAO, 2005).

1.2 Statement of the problem

Growth rate remains the primary selection criterion for both beef and dairy herds. Early growth of cattle has strong implications on both reproductive and production performances.Unique properties of Boran cattle have genetic basis and have been acquired by natural and human selection over generations. However, the breed has been used as the preferred dam breed in most of the dairy cattle crossbreeding studies over the last several decades. The Dida Tuyera station under the Oromia PastoralArea Development Commissionin the Borana rangelands is the only place where Ethiopian Boran pure breeding program is undertaken. The challenges for breed development in Ethiopia are shortage of infrastructures and facilities, weak support from the government and lack of well defined breeding objectives and goals.

The study was conducted in the Dida Tuyera ranch which was established in 1987 E.Cbecame functional in 1990 on 5550 hectare of land in Borana Zone, Oromia region, South Eastern Part of Ethiopia with the objective of conserving and improving Ethiopian Boran cattle through selection and controlled breeding.Borenais home and breeding tracts for Boran cattle breed though the breed is challenged by frequent drought, feed shortage, genetic dilution and poor genetic improvement. To overcome these problems there was an attempt on genetic improvement through selection at Dida Tuyera ranch and data were recorded for ten years. It is important to know and to estimate the covariance component and genetic parameter for Boran cattle breed. Moreover,this study was proposed to provide primary information which can be used as an important input for developing breeding strategy. Therefore, this study was aimed to fill the gaps which werebottleneck for improvement of Boran Breed.

1.3 Objectivesof the study

1.3.1 General objective

The general objective of this research was to estimate the genetic parameters of growth traits of Boran cattle breed.

The specific objectives of this study were:

- ❖ To know the phenotypic growth performances of Boran breed under their natural rangeland environment
- ❖ To know the influence of environment on growth trait of Boran breed
- ❖ To estimate Co-variance components and heritability and correlation (genetic and phenotypic) of growth traits

1.4 Hypothesis

The hypotheses of this study were:

I. The phenotypic growth performance of Boran cattle in there breed tract would not be influenced by the environment
II. Estimation of Co-variance components and genetic parameterswould not have a roll for future genetic improvement ofBoran cattle breed

2. LITERATURE REVIEW

2.1 Origin and Description of Boran cattle breed

Boran, a popular cattle breed, is predominantly utilized and widely distributed across various countries of Africa (DAGRIS, 2006). The Ethiopian Boran belongs to the group of Zebu cattle (*Bosindicus*), with their characteristic hump and pendulous dewlap. Available archaeological records indicate that zebu cattle are the most recent types of cattle to be introduced into Africa. Recent molecular genetics as well as archaeological evidences (Marshall, 2000; Hanotte*et al*., 2002) also showed that the introduction of Zebu cattle into Africa centred in East Africa rather than through the land connection between Egypt and the Near East. Zebu cattle are known to be better than the humpless cattle in regulating body temperature; hence have lower body water requirements. Their hardened hooves and lighter bones enable them to endure long migrations in search of water and feeds. These adaptive attributes have facilitated their importation and spread by Indian and Arabian merchants across the Red Sea to the drier agro-ecological regions of the Horn of Africa (Loftus and Cunningham, 2000).

The Large East African Zebu cattle breeds, like the present-day Boran of Ethiopia, Kenya and Somalia, and the Butana and Kenana of the Sudan have very similar morphological characteristics to that of the zebu breeds of Asia. They are maintained by mainly pastoral communities in the Horn of Africa. The Ethiopian Boran breed originally descended from the first introduction of zebu into Africa from West Asia. The breed established its presence first in the semi-arid and arid pastoral Borana plateau of southern Ethiopia. The Borana pastoralist community maintains the breed in the Borana vast range lands of Ethiopia. Pastoral movements and migrations led to spread of the Ethiopian Boran to the eastern rangelands in Ethiopia as well as into northern Kenya and southwestern Somalia. The Orma or Ethiopian Boran, the Somali Boran and the Kenya Boran have evolved from these migrations. The Boran is now considered to have distinct groups of unimproved and improved Boran cattle (DAGRIS, 2006).

The unimproved Boran is used in subsistence and semi commercial systems of production in Ethiopia, Kenya and Somali where it is commonly called Boran, Boran and Awai, respectively (Ojango*et al*., 2006).

The Ethiopian Boran described in this report is the unimproved type. The Boran cattle at present are found in the Ogaden, Sidama and Bale areas of Ethiopia and the adjoining regions of Somalia and Kenya. Boran cattle are reasonably large and have a good general body conformation. Their colour is mainly white, light gray, fawn or light brown with gray, black or dark brown shading on head, neck, shoulders and hindquarters. The horns are thick at the base, very short, erect and pointing forward. The hump is well developed in the male, is of pyramidal shape and overhanging to the rear or to one side. The dewlap is well developed. In the male, the preputial sheath is pendulous while in the female, the udder is well developed. Average wither height is 118 to 124 cm in males and 116 to 120 cm in females. Body weight ranges from 318 to 680 kg in males and 225 to 454 kg in females (Joshi *et al*., 1957; Alberro and Haile-Mariam, 1982).

2.2 Performance evaluation for growth trait for different genetic groups

Pre-weaning growth performances of cattle includes birth weight, weaning weight and average daily weight gain. Pre-weaning growth traits are the basics for the selection of a breed that has a response for genetic gain from their dam and sire lines. Growth rate remains the primary selection criterion for both beef and dairy herds (Habtamu*et al*., 2012). All birth, weaning weight and average daily gain have an influence on growth performances (Mekonnen, 1987; Gidey, 2001; Aynalem, 2006; Almaz, 2012). Growth performance can be influenced by year and season of birth and sex of the calf (Banjaw& Haile-Mariam, 1994; Aynalem, 2006; Amsalu, 2004; Getinet*et al*., 2009; Melaku*et al.*, 2011a; Almaz, 2012; Habtamu*et al*., 2012).

Most of the studies focused on birth weight, weaning weight, average daily gain up to weaning and yearling weight of calves. The weaning age was also variable among different herds that have contributed to a wider range of variation on weaning weights. The minimum overall performance (least squares) recorded for birth weight, weaning weight, yearling weight and average daily gain from birth to weaning were 17.7 kg, 40.0 kg, 111.2 kg and 330.6 gram/day, respectively (Alemseged and Chakravarty,2003; Jiregna*et al*., 2004; Aynalem, 2006), whereasthe maximum for corresponding traits were reported to be 32.4 kg, 176.7kg, 195.5 kg and 638 gram/day, (Ashebir, 1992; Banjaw and Haile-Mariam, 1994; Amsalu, 2004).

2.2.1Birth weight

Birth weight is the weight that is registered soon after birth within 24 hours. Birth weight is an indicator of the performance efficiency of the cow that has been important in predicting weaning weight and rate of gain in growth (Habtamu*et al.,* 2012; Almaz, 2012). Average milk production and mature live weight of animals with a higher birth weight is higher than those animals with a lower birth weight; and the better weight at birth of calves is a best indicator of the future performance of the calves in the breeding program. The Tables below (Table 2.1 and 2.2) indicate estimation of birth and weaning weight of indigenous cattle breeds of Ethiopia. As a production trait, birth weight is affected by fixed effects like sex of calf, parity, genotype, and season of birth and year of calving (Assemu and Dilip, 2014).

Table 2.1 pre-weaning growth performances of Boran calves

Birth weight	**Weaning weight**	**Average daily gain**	**Source**
23.3	54	438.4	Aynalem, (2006)
23.7	60.5	390	Amsalu, (2004)
25.2	157.5	535.5	Banjaw& Haile-Mariam,(1994)
22.9	95.2	401.4	Demeke*et al., (*2003)
23.3	79.0	-	Aynalem*et al.*, (2010)
25.2	157.2	-	Mekonnen, (1987)
26.6	79.4	-	Yohannes*et al.*, (2001)
23.7	94.2	-	Amsalu, (2003)

Table 2.2 Summary of pre-weaning weight for Ethiopian cattle breeds

Breed	**BW**	**WW**	**ADG/gram/day**	**Source**
Ogaden	21.5	91.7		Getinet*et al.*, (2009)
Barka	22.6	92.0		Aynalem,(2006)
Mahibere-Slassie composite cattle breed	24.5	102		Zewdu*et al.*, (2004)
Horo	17.5	39.8	407.9	Demissu*et al.*, (2013); Habtamu*et al.*, (2012)
	19.9	88.0		Aynalem, (2006)
Fogera	21.01	88.64		Almaz, (2012)
	21.5	122.8 114.2		MFBCMR, (2013) Addisu, (1999)
	22.45			
	21.9	100.9		Giday, (2001)
	23.1	-		Asheber, (1992)

2.2.2Weaning weight

Weaning weight is the weight of the calf at a weaning age, which is varying from breed to breed and the objective of the production system and the farms. Weaning weight is affected by genetic and environmental factors such as management, disease, season, year and other environmental difference (Giday, 2001; Melaku*et al.*, 2011; Habtamu*et al*., 2012; Assemu; Dilip, 2014). Weaning weight is the basic for selection of replacement herds in conservation and breeds improvement strategies in different countries

2.2.3 Average daily gain

Average daily gain is simply the rate of weight gain per day over a specified period of time. Pre-weaning daily weight gain was calculated as the difference between birth and weaning weights divided by the length of the period between them. These traits are expected to be influenced by direct and maternal genetic effects. Therefore, it is of great interest to evaluate their potential for improving beef production. Understanding of the genetic and environmental factors affecting these variables and their genetic relationships is required to implement optional breeding and selection programmes. Average daily gain is required to investigate future improvement possibilities (F. San Primitivo*et a*l., 2006)

The non-genetic factor like sex of calf, season and year had significant effect on growth traits. Knowledge on these factors and their influence on cattle performance are important in formulation of management and selection decisions (Goyache*et al*., 2003). In various studies, a number of factors have been included in analyses as main factors or their two- and/or three-way interactions either as fixed discrete or continuous effects to account for environmental sources of variation in animals' performance (Wasike, 2006). These factors and other stress causing factors affect the growth performance of individual (Almaz, 2012) which in turn affect the productivity of a given farm.

Table 2.3. Non genetic factors influencing growth performance of dairy cattle in Ethiopia

	Traits				
Factors	BW	WW	Source	ADG	Source
Sex	**	NS	Melaku *et al., (*2011)	***	Belay *et al*., (2016);Hailu*et al*., (2004)
	***	**	Almaz, 2012	***	Mengistu *et al*., (2017)
Season	**		Getinet *et a*l.,(2009)	****	Belay *et al*., (2016);Hailu*et al*., (2004)
	**	**	Melaku *et al*.,(2011)	***	Mengistu s., (2017)
	***	***	Habtamu *et al*.,(2010)		
	***	***	Almaz.,(2012)		
Year	Ns		Getinet *et al*.,(2009)	***	Belay *et al*., (2016);Hailu*et al*., (2004)
	**	*	Melaku *et al*., (2011)		
	*	***	Habtamu *et al*.,(2010)		
	**	***	Almaz.,(2012)		
Parity	**		Getinet *et al*.,(2009)		
	Ns	*	Melaku *et al*., (2011)		
	***	**	Habtamu *et al*.,(2010		
	***		Mengistu *et al*., (2017)		

*N.B. ***P<0.001; **P<0.01; *P<0.05; NS=Not Significant, BW=birth weight; WW=weaning weight*

Table 2.4.Summary of some literatures on genetic parameter estimates for growth traits in beef cattle in global aspect

Breed	**Country**	**h^2_a**	**h^2_m**	**r am**	**h^2T**	**Source**
Birth weight						
Hereford	Australia	0.41	0.08	0.04	0.46	Meyer, (1992)
Bt& Bi	Canada	0.31	0.14	-0.27	-	Koots*et al*., (1994)
Nellore	Brazil	0.22	0.12	-0.72	0.10	Eler et al., (1995)
Boran	Ethiopia	0.24	0.09	-0.55	0.17	H-Mariam & K. Mersha, (1995)
Gobra	Senegal	0.07	0.04	-0.17	0.08	Diop& Van Vleck, (1998)
Brahman	S. A.	0.45	0.08	-0.35	-	Mostert*et al*., (1998)
Brahman	Venezuela	0.33	0.08	-0.37	0.28	Plasse*et al*., (2002a)
Brahman	Venezuela	0.33	0.06	-0.02	0.30	Plasse*et al*., (2002b)
Weaning weight						
Hereford	Australia	0.14	0.13	-0.58	0.09	Meyer, (1992)
Bt& Bi	Canada	0.24	0.13	-0.30	-	Koots*et al*., (1994)
Nellore	Brazil	0.13	0.13	0.32	0.14	Eler*et al*., (1995)
Boran	Ethiopia	0.21	0.06	-0.57	0.21	H-Mariam & K. Mersha,(1995
Gobra	Senegal	0.20	0.21	-0.61	0.12	Diop& Van Vleck,(1998)
Brahman	S. A.	0.25	0.08	-0.33	-	Mostert et al., (1998)
Brahman	Venezuela	0.07	0.14	-0.13	0.12	Plasse et al., (2002)
Average daily gain						
Charolais	Spain	0.22	0.18	0.06	-	Rodriguez *et al*., (2006)
Asturiana de los Valles	Australia	0.49	0.37	-0.87	-	Goyache*et al*., (1997)
Romosinuano	Colombia	0.32	0.20	-	0.42	Sarmiento1 and Garcia, (2007)
Simmental	Hungary	0.31	-	-	-	Kebede and Komlosi, (2015)
Horo	Ethiopia	0.29	0.21	-	-	Habtamu*et al*., (2011)
Boran	Ethiopia	0.06	-	-	0.21	Haile -Mariam &Kassa, (1995)
Fogera	Ethiopia	0.062	0.02	-	-	Mekuriaw*et al*., (2016)

2.3 Co-variance components and genetic parameters for growth traits

Growth rate remains the primary selection criterion for most beef cattle breeders around the world, thus the correct prediction of the genetic value of beef cattle is required for optimizing genetic gain (Archer, 1998). (Tosh *et al*., 1999) emphasized that values for genetic parameters are needed to implement breeding programmes and to asses breeding strategies. Growth traits in beef cattle are important in selection programmes. Consequently, the relative importance of direct and maternal genetic effects for growth should be considered when beef producers formulate breeding program (Ferreira *et al*., 1999).

Knowledge of components of variance and genetic parameters are required in designing breeding programmes for genetic improvement (Elere*t al*., 1995; Peters *et al*., 1998).

A successful selection programme for improvement of performance traits in beef cattle depend on selection for a specific trait and understanding how selection for one trait may influence other production traits. The genetic relationship among growth traits has been studied by estimating genetic correlations between growth traits (Archer *et al*., 1998). Methods to estimate covariance components and genetic parameters in beef cattle due to maternal effects have been presented by (Meyer, 1992).

The potential for genetic improvement of a trait largely depends upon genetic variation existing in the population of interest. The genetic composition of a population can be studied by considering the relative importance of heredity and environmental factors affecting the performance of individual in that population (Gebeyehu*et al.,* 2014). Knowledge of genetic parameters is the basis of sound livestock improvement programmes (Choudhary*et al.,* 2003; Wasike*et al.,* 2006; Edward *et al.,* 2013; Gebeyehu*et al.,* 2014). The estimates of genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic gains (Edward *et al.,* 2013; Gebeyehu*et al.,* 2014).

Advances in statistical animal breeding and broadening its range of application and traits of interest provide great opportunities for animal agriculture. Estimating genetic parameters for various livestock traits has been a main topic of animal breeding during the past half century (Sang, 2003). Estimation of genetic parameters then involves partitioning of observational components, i.e. phenotypic covariances between relatives, into causal components such as variances due to additive genetic effects, dominance, epistasis and permanent and temporary environmental effects. This utilizes the known degree of relationship between animals and the resulting expectations of covariances between them (Gebeyehu*et al.,* 2014). Much more information on heritability, repeatability and genetic correlation estimates for growth and reproductive traits of indigenous Ethiopian cattle breeds are not available

2.3.1Heritability (h^2)

Heritability is the proportion of phenotypic variance that is due to heredity. It is a measure of the degree to which a trait is genetically determined. Obviously, heritability is important among the several factors determining how much genetic improvement can be made in any trait (Aynalem, 2006).

For different breeds heritability estimates show a high level of variability depending on the traits. This variation is as a result of the differences in the population structure of the herds that provided the data, the model fitted for the analysis, the breed and the environment where the data was obtained. As a result, it is important that estimates from one population are treated with caution when used in other populations (Wasike, 2006). Within a given data, heritability can be computed both from the genetic as well as the additive variance; i.e., $h^2= \sigma^2G / \sigma^2P$ (in broad sense) and $h^2 = \sigma^2A / \sigma^2P$ (narrow sense) (Khalid *et al.*, 2001; Cilek and Sahin, 2009).

With this formula heritability can be increased by providing uniform environment, use of multiple measurements, adjustment of records, and accurate measurement of data. The low heritability is caused not only by a low genetic variance but also by a higher phenotypic variance due to small herd size and by random or unidentified environmental factors (Khalid *et al.,* 2001).

Comparison of heritability estimates for productive and reproductive traits depict lower estimates for female reproductive than productive traits. This was because female reproductive traits were highly influenced by the environment and the reproductive performance of the cattle could thus be more improved through manipulation of production environment than within breed genetic selection (Wasike, 2006). Different estimates of heritability may be found for the same trait in different populations or in one population at different times.Estimation of heritability of pre-weaning growth traits of Ethiopian cattle range from 0.03 (Almaz, 2012) to 0.68 (Habtamu*et al.*,2011). Which mainly be attributed to lack of well-structured pedigree data and lack of well-organized farm performance traits records. Heritability of pre-weaning growth traits for Boran cattle breed and other indigenous breeds are summarized in Table below (Table 2.5).

Table 2.5. Heritability of pre-weaning growth for some Ethiopian indigenous cattle

Trait	**Breed**	**h^2**	**Source**
Birth weight			
	Fogera	0.38	Asheber, (1991)
		0.03	Almaz, (2012)
	Ethiopian Boran	0.25	Aynalem*et al*., (2010)
		0.13	Arnason and Kassa,(1987)
		0.32	Banjaw and Haile-Mariam, (1994)
	Horo	0.68	Habtamu*et al*., (2011)
Weaning weight	Fogera	0.06	Almaz, (2012)
		0.22	Asheber, (1991)
	Ethiopian Boran	0.43	Aynalem*et al*., (2010)
		0.22.	Arnason and Kassa , (1987)
		0.24	Banjaw and Haile-Mariam, (1994)
Yearling weight	Brahman(S.A)	0.25	Mostert*et al*., (1998)
	Australia	0.16	Meyer, (1992)
	Nellore	0.16	Eler*et al*., (1995)
	Ethiopian Boran	0.34	H-Mariam &KMersha, (1995)
Final weight	Gobra	0.14	Diop& Van Vleck, (1998)
	Hereford	0.22	Meyer, (1992)
	Brahman (Venezuela)	0.16	Plasse*et al*., (2002)

2.3.2 Correlation

Is a measure of the strength (consistency, reliability) of the relationship between performance in one trait and performance in another trait. A correlation between two traits is a simple function of the covariance of the traits and their standard deviations (σxσy). For traits of birth weight and weaning weight (Bourdon, 2000).

Correlations are measures of the strength of association between two variables. High correlation values imply strong association between variables and vice versa (Bourdon, 2000). Correlations can also be positive or negative implying positive and negative association, respectively. Phenotypic, genetic and environmental correlations are measures of the strength of the relationship between animal performance among traits, breeding values and environmental effects between traits, respectively (Belay, 2014).

s

2.3.2.1 Phenotypic correlation

Some of the most common and useful correlation in animal breeding is correlation between trait.

Phenotypic correlations ($r_{x,y}$) is a measure of the strength (consistency, reliability)of the relationship between (phenotypic value) in one trait and performance in another trait . Phenotypic correlations are helpful because they give us a sense of the observable relationship between traits (Bourdon, 2000).

$$r_{x,y} = \frac{cov\ (x,y)}{\sqrt{\sigma_x^2 * \sigma_y^2}}$$

Where each x, y pair represent an individual's phenotypic value for two traits.

2.3.2.2 Genetic correlation

A measure of the strength (consistency, reliability) of the relationship between breeding values for one trait and breeding value for another trait. The reason why genetic correlations are so important is that if two traits are genetically correlated, selection for one will cause genetic change in the other. Furthermore, performance in one trait can be used to help predict breeding value in genetically correlated trait. The genetic correlation expresses the extent to which two characters are influenced by the same genes and it is important when selecting for net merit involving several traits. Linkage can also affect different traits and cause genetic correlation. Estimates of genetic correlation between any pair of traits suggest that selection for one trait can lead to an indirect genetic response in the other trait (Bourdon, 2000).

3. MATERIALS AND METHODS

3.1 Description of the study area

The study was carried out in Borana zone, Yabello district specifically; Dida Tuyera Boran cattle improvement ranch. Is situated at about 550 km South of Addis Ababa and 20 km North of Yabello town Yabello district is characterized by a semi-arid climate. Annual mean daily temperature varies from 19 to 24ºC. The average annual rainfall was600 mm. The rainfall distribution is bimodal, but erratic and unreliable. About 59% of annual precipitation occurs from March to May and 27% from September to November (Coppock, 1994). The only currently available ranch involved in the improvement of Ethiopian Boran cattle is the Dida Tuyera ranch of Yabello district and. It is part of the Borana plateau which covers 95,000 km², or 8.5% of the total area of Ethiopia and 14.6% of the lowland areas (Coppock, 1994).

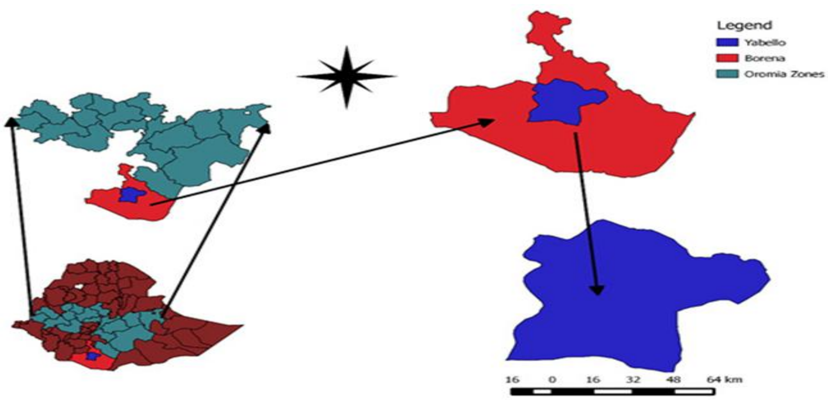

Figure 3.1.Map of the Yabellodistrict in EthiopiaSource (Abdisa*et al*., 2017)

3.2 Herd management and breeding program

Dida Tuyera improvement ranch has so far engaged in conservation of Boran cattle population. The ranch operates an open nucleus breeding scheme at present time. The open breeding schemes undertake a selection and improvement activities on pure Boran cattle. The Boran breeding scheme used natural mating using superior Boran bulls. At Dida Tuyera ranch, the major controlled breeding season lasted for three to four months, between August and December depending on the availability of the pastures. The Boran breeding unit operated as a single sire mating system. Cows and heifers in the breeding herd were divided into breeding units composed of a maximum of 50 cows, and each breeding unit was kept in separate paddocks. Health management scheme has prevention and control practices, the control measures were taken for internal and external parasites, prevention focuses on vaccination against Blackleg, Brucellosis, Deworming, LCD(Light chain deposition) and Anthrax once in every 6 to 8 month and once per year for CBPP(Contagious Bovine Pleuropneumonia).

3.3 Data collection and preparation

The data for this study were obtained from farm records of Dida Tuyera Ranch that has been collected by cattle registration card and performance record format, which covers from 1991 to 2000. All the available data which were filtered, and crosschecked for its consistency and informativeness. The growth traits analyzed included birth weight, weaning weight and pre-weaning average daily gain. The evaluation included the records of 1162 Boran cattle (634 bulls and 528 heifers) for growth traits. The pedigree sample size was 1487. Pedigree information traits were also included for heritabilities and correlations calculation. The data were collected from individual animal card recorded in to excel sheet and records with irregularity in pedigree information and dates were discarded. Individuals that appear as both sire and dam and duplicate records and individuals that were parents of themselves were deleted.

Table 3.1. Description of data used for Boran cattle growth traits analysis.

Number of animals	BW	WW	ADG
Number of animals before editing	1730	1730	1730
Number of animals after editing	1162	1162	1162
Number of male animals	634	634	634
Number of Female animals	528	528	528
Number of Sires after editing	48	48	48
Number of Dam after editing	623	623	623

In this study, four seasons were classified based on weather and climatic conditions of the area as suggested by (Homann, 2004); (1) March to May, main rainy season, (2) July to August, small dry season (3) September to November, small rainy season and (4) December to February, severe dry season. Animals with extremely low and high records for all traits (outliers) were excluded from the analysis. The pedigree file containing all animals with all known relationships was constructed using Relax2 (Strandén and Vuori, 2006). After clearing the data for consistency of pedigree information the pedigree file contains a total of 1487 animals, 48 sires and 623 dams.

3.4 Statistical analysis

3.4.1 Analysis of fixed effects

General linear model procedures of the Statistical Analysis System were used to determine the effects of non-genetic factors birth year, season and sex on the selected economic traits. The presence of any significant differences was checked by using Tukey'sKramer multiple comparison tests. Fixed effects which were significant ($p<0.05$) were fitted in to the model to estimate the genetic parameters. The effects included in the model for the analysis of growth traits were sex 2 classes(female and male), birth year 10 classes(1991-2000)and season4 classes(main rainy season, small dry season, small rainy and severe dry seasons)for BW, WW and ADG respectively. In case of weaning weight weaning age was fitted as fixed effect. In order to determine the fixed effects to be included in the model, a preliminary analysis was performed using the General Linear Models Procedure (PROC GLM) Statistical Analysis System. Fixed effects thought to be important enough to be included in the genetic analysis. Fixed effects like dam age and parity were not recorded and not included in the analysis. The following model was fitted for BW, WW and ADG.

Model fittedfor the analysis of fixed effects:

$$Y_{ijkn} = \mu + Y_i + Z_j + S_k + e_{ijkn}$$

Where:

Y_{ijkln} = *records of the n^{th} animal*

μ = overall mean

Y_i= the fixed effects of i^{th} birth year (i= 1991-2000)

Z_j= the effect of the j^{th} season of birth (j= 1, 2, 3,4)

S_k= the effect of k^{th} sex (k= 1, 2)

e_{ijkn}= residualeffects

3.4.2 Co-variance andcorrelationanalyses for phenotype

Co-variance

Covariance is the average product of deviations from the means of two variables (how two traits or values vary together in a population) (Bourdon, 2000). Mathematically, the covariance of variable X and Y is then, from population data:

$$\sigma_x^2 = \frac{\sum(x_i - \mu)^2}{N}$$

$$cov\ (x, y) = \frac{\sum(x_i - \mu_x)(y_i - \mu_{y)}}{N}$$

Where each x_i, $y_i$pair represent an individual's phenotypic values for two traits and the denominator (n) is the number of x_i, y_i pairs

Correlation:

Phenotypic correlations ($r_{x,y}$) is a measure of the strength (consistency, reliability)of the relationship between (phenotypic value) in one trait and performance in another trait . Phenotypic correlations are helpful because they give us a sense of the observable relationship between traits (Bourdon, 2000).

$$r_{x,y} = \frac{cov\ (x, y)}{\sqrt{\sigma_x^2 * \sigma_y^2}}$$

Where each x, y pair represent an individual's phenotypic value for two traits. Using the above equation, phenotypic correlations were estimate between BW and WW, BW and ADG and WW and ADG.

3.4.3 Co- variance components and genetic parameters analyses

Covariance components and the genetic parameters(phenotypic and genetic were estimated using a uni-variate and bi-variate animal model using two different models which fitted direct additive and dam's additive genetic as a random effect and the fixed effects. The Likelihood ratio tests were conducted to determine the most suitable model that better explain the data.

Variance and covariance components were estimated using AI-REML (Gilmour *et al.*, 1995) implemented in the software DMUV.6 package (Madsen and Jensen, 2013). Genetic parameters, heritability and genetic correlation were post processed from variance co-variance output using R Studio program (R Studio, 2016).

The model equations used for the analysis were;

Model1: $Y = Xb + Z_1a + e$

Model2: $y = Xb + Z_1a + Z_2m + e$

Where,

y = vector of the animal's record for each considered trait (BW, WW, ADG),

b = vector of fixed effects

X = incidence matrix of fixed effects

a = vector of direct additive genetic effect

m = vector of maternal additive genetic effect

Z_1 = incidence matrix for direct additive genetic effect

Z_2 = incidence matrix for maternal additive genetic effect

e = vector of random error

4. RESULT AND DISCUSSION

4.1 Effects of non- genetic factors on growth traits

The present study indicated that all fixed effects (sex, birth season and birth year of the calf) had a significant effect (P<0.001) on all traits studied. Means, standard deviation (SD) and coefficient of variation (CV %) for different traits are presented in the Table (4.1).

Table 4.1.Estimated phenotypic means, standard deviations (SD), minimum (Min.) and maximum (Max.) for birth, weaning and average daily gain traits at Dida Tuyera Boran improvement ranch

Traits	**N**	**Mean**	**SD**	**CV (%)**	**Range**	
					Min (kg)	Max (kg)
BW(kg)	1120	20.50	3.71	10.60	15.00	
WW(kg)	1144	118.81	27.00	15.10	75.00	143
ADG(g)	1144	0.44	0.13	18.50	0.34	0.80

N.B. N, number of observation; BW, birth weight; WW, weaning weight; ADG, average daily gain.

Sex of the calves had a significant effect (P<0.01) on BW and ADG but not on WW (Table 4.2). This sex difference in growth performance might be because of Physiological difference between male and female. Year and season had a highly significant effect (p<0.001) on all traits considered. This might be due to the difference of rain fall and forage availability. Because, the calves born during main rain season gets more feed than during small rainy season, dry season and small dry season. The dams which give birth during main rainy season get the advantage of green forage available than during small rainy and dry season and they become in better body condition and produce more milk for calves. The weights of Boran cattle presented in this study are lower than those found in the literature

Table 4.2. Least squares means and standard error (LSM ± SE) of BW, WW and ADG (gm**)**

Factors	N	Birth weight		Weaning weight		Average daily gain	
		LSM	SE	LSM	SE	LSM	SE
Sex		**		NS		**	
Female	528	18.48	22.38	117.62	26.12	0.45	0.15
Male	634	22.19	12.42	119.52	27.68	0.43	0.11
Season		***		***		***	
Main rainy	890	20.84	17.13	117.07	28.02	0.43	0.13
Short dry	149	17.87	22.13	126.63	19.57	0.53	0.12
Short rainy	88	21.71	13.47	116.12	22.89	0.42	0.1
Long dry	35	20.17	21.10	131.6	28.07	0.48	0.14
Year		***		***		***	
1991	90	20.31	2.89	72.05	11.28	0.28	0.06
1992	36	18.33	3.93	99.83	9.70	0.40	0.06
1993	128	22.62	3.92	125.41	17.44	0.52	0.09
1994	182	23.88	3.45	132.64	22.79	0.53	0.16
1995	217	24.81	2.52	135.67	14.94	0.49	0.09
1996	135	24.48	3.21	137.75	19.35	0.48	0.08
1997	194	24.26	39.24	109.25	19.82	0.38	0.1
1998	129	19.33	13.40	95.34	18.10	0.33	0.08
1999	42	22.57	8.22	125.71	27.63	0.54	0.13
2000	9	23.33	3.5	121.55	7.69	0.45	0.05
				***		***	
WAM							
5	48	-	-	119.43	28.5	0.63	0.22
6	117	-	-	113.85	30.1	0.52	0.18
7	291	-	-	111.34	29.5	0.44	0.13
8	52	-	-	121.89	24.1	0.43	0.1
9	177	-	-	123.98	24.6	0.4	0.09

*N.B. WAM: Weaning age by month; ***: P<0.001; ** P< 0.01; NS: Not Significant*

Scholars show that non-genetic factors have exerted an effect on growth traits (Banjaw and Haile-Mariam, 1994; Demeke*et al*., 2003; Amsalu, 2004 and Aynalem, 2006). Banjaw and Haile-Mariam, 1994reported that birth year and sex had significant effect on birth weight, weaning weight and pre-weaning average daily gain on Boran cattle.

The least squares mean analysis indicated that there was a significant difference ($P<0.001$) between sex at birth; male calves were heavier by 3.71kg than female calves which might be due to the physiological difference between male and females calves. 21.5kg (Getinet*et al.,* 2009; 23.3kg (Aynalem*et al.,* 2010); 17.5kg (Demissu*et al*., 2013) for Ogaden Ethiopian Boran and Horro breeds respectively.

4.1.1 Birth weight

The overall mean birth weight of the Boran cattle breed calves was 20.5±3.71 kg (Table 4.1.). The result was lower than the value of 23.3±0.36 kg (Aynalem*et al*., 2010), 23.7kg (Amsalu, 2003); from previous works on the same breed and 22.0kg, Addisu*et al*., 2010 for the Fogera cattle. The result is higher than birth weight of the Horro breed which was reported as 17.2±2.25 kg (Demissu*et al*., 2013). The trend in the values of BW at the improvement sites had shown a variable with advancements of year (Figure 4.1). This might be attributed to poor recording system implemented at the improvement centers, lack of attention for growth performance traits, occurrence of inbreeding and deterioration of the production environments (feed quality and seasonality; and disease prevalence). These factors can have negative effect on the dam of the calf.

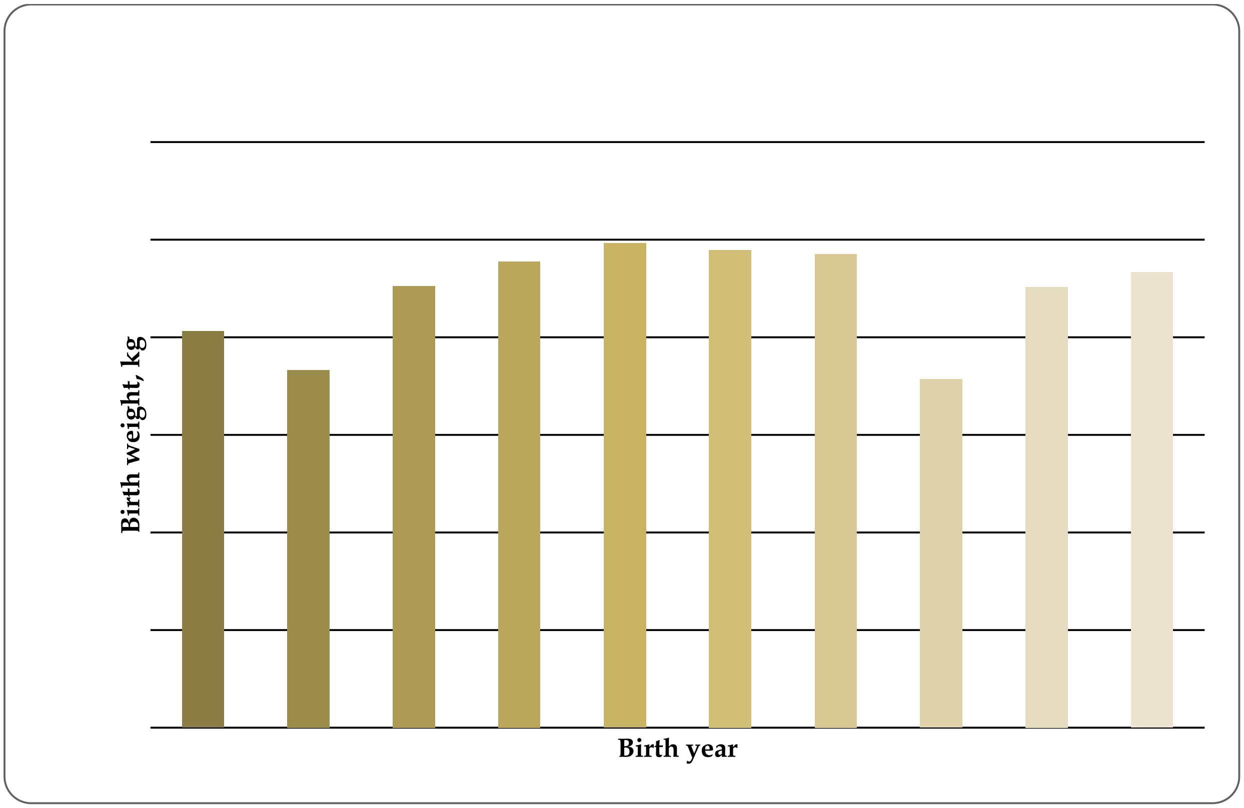

Figure 4.1. Trends of average birth weight of Boran calves over the years

4.1.2 Weaning weight

The overall mean of weaning weight of Boran calves was 118.1±27kg (Table 4.1). The weaning age of the Boran calves at DidaTiyura ranch was 180 days on the average. The result is higher than the report of (Zewdu*et al*., 2004) 102±6.89kg for Mahibere-Slassie composite cattle breed;Almaz, 2012 and 79.0±1.51kg (Aynalem*et al*., 2010) for Ethiopian Boran breed calves at Abernossa cattle breeding and improvement ranch. The result is significantly lower than 157.17±1.2kg reported by (Mekonnen, 1987) for the same breed and 122.8kg reported for Fogera cattle breed (MFBCMR, 2013).Generally, the higher value of this study because of the availability of pasture for growing and better management of the calves.

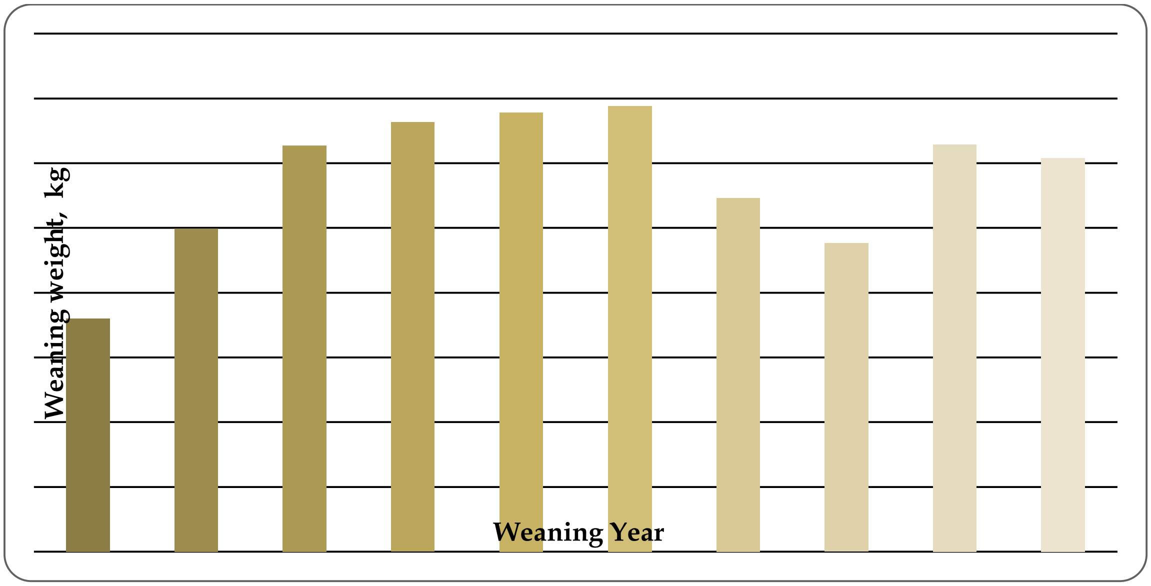

Figure 4.2. Trends of weaning weight of Boran calves over years.

The trend of weaning weight of Boran calves is shown on Figure 4.2. Up to the years of 1996, the growth graph shows incremental pattern which might be due to special attentions given for the ranch and better feed availability. The down and up pattern between years of 1997 to 2000 might be associated with the presence of inbreeding, shortage of forage availability and frequent drought.

4.1.3 Average daily gain

The overall mean average daily gain of Boran cattle breed calves was 0.44 ± 0.13 kg (Table 4.1). The result was lower than a 0.53g reported by (Mekonnen, 1994) for the same breed and higher than the value of 0.40 ±20.6 kg reported by (Mengistu*et al*., 2007) for Horo breed and in general, a 1.11kg (Rodriguez *et al*., 2006); a 0.96 kg (Goyache*et al*.,1997), a 0.75±0.14kg (Hailu*et al*., 2004) were reported for different breeds thought the world. Average daily gain for female calves were higher than males due to special management was given to females to improve the growth rate of replacement heifersto enable them reach puberty and start production life earlier. This results in improvement of their life weights production and reproduction(Mengistu*et al*., 2017).

The trend in the values of ADG at the improvement sites had shown a variable with advancements of year. Due to fluctuation of management, deterioration of the quality and quantity of feeds and disease prevalence (Almaz,2012; Yosef, 2006)

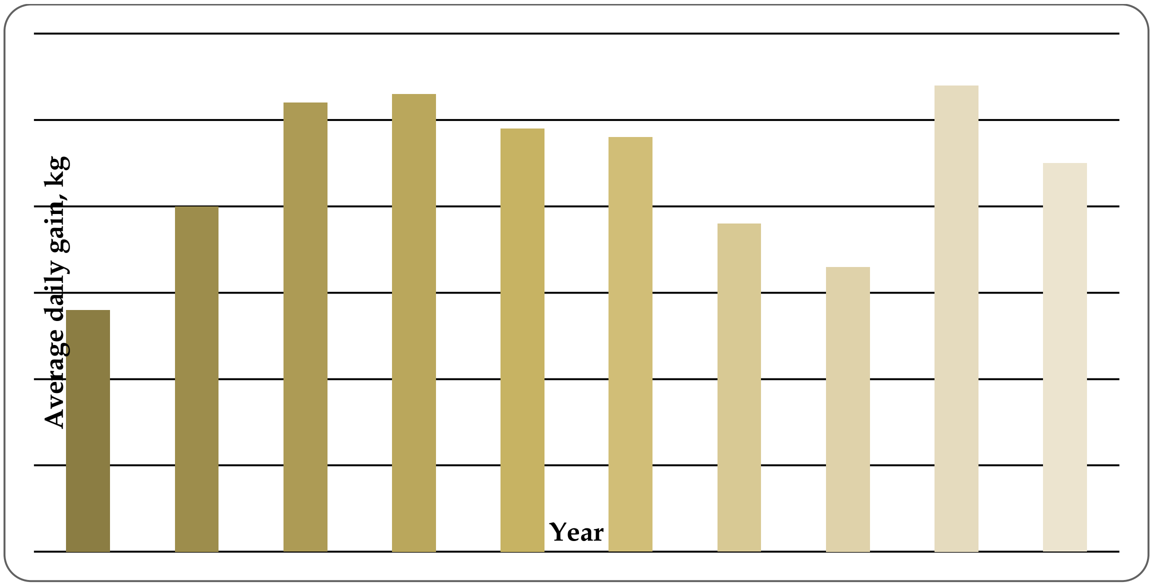

Figure 4.3. Trends of average daily gain of Boran calves over the year

4.2 Co-variance components and genetic parameters ofgrowth traits

4.2.1 Univariate analysis

The results of single-trait analysis using two animal models to estimate additive genetic variance (σ^2_a), maternal additive genetic variance (σ^2_m), additive and maternal additive genetic covariance (σ_{am}), residual variance (σ^2_e), phenotypic variance (σ^2_p), direct heritability (h^2_a), maternal heritability (h^2_m), correlation between direct and maternal additive genetic effects (r_{am}) and total heritability (h^2_T)for different traits are presented in (Table 4.3 and Table 4.4).

4.2.1.1Birth weight

The computed heritability values for growth traits depended on the fitted models. The estimated direct heritability ((h^2_d)) for birth weight for Boran cattle breed at Dida Tuyera Improvement Ranch ranged from 0.15 to 0.17 (Table 4.3) which is lower than the heritability of 0.24 (Mekonnen, 1994), 0.24 (Haile-Mariam and Kassa, 1995), 0.25±0.05 (Aynalem*et al*.,2010) and 0.32 (Banjaw and Haile-Mariam1994) obtained for AbernossaBoran improvement ranch.For Horro cattle and their cross breeds direct heritability of 0.68±0.09 was reported by (Habtamu*et al*., 2011) and higher than 0.12 reported for Fogera cattle(Aynalem*et al*., 2016). In Kenya, direct heritability was 0.34 for birth weight in Kenyan Boran cattle (Wasike, 2006). The estimated direct heritabilities were 0.28 and 0.25 ± 0.003 for South African Brahman and Tuli breeds, respectively (Pico, 2004; Assan, 2012). The current estimate was also lower than 0.22 reported for Nellore (*Bosindicus*) cattle in Brazil (Eler*et al*., 1995), 0.41 value estimated or Australian breed(Meyer, 1992) and 0.33 (Plasse*et al*., 2002a) foundfor Brahman breed in Venezuela. Low heritability indicates that gene expressionhighly influenced by environment.

Maternal heritability (h^2_m) for birth weight was 0.10. When the maternal effects were included in model 2, the estimates of maternal heritabilities were declined for all the traits.The presentestimate is higher than $h^2_m$of 0.09 obtained by (Haile-Mariam &Kassa, 1995) for Boran breed in Ethiopia. Similarly, other authors also estimated lower h^2_mranged from 0.04 to 0.12in different cattle breeds (Eler*et al*., 1995; Diop&Vanvieck,1998; Mostert*et al*., 1998; Assemu, 2015).

The genetic correlation (r_{am}) between direct and maternal genetic effects for BW was negative -0.47(Table 4.3), the current estimate was higher than the estimate of -0.35 (Banjaw and Haile-Mariam, 1994) and slightly lower than the estimates of -0.55 (Haile-Mariam &Kassa, 1995) for the samebreed. In other studies, genetic correlations between direct and maternal genetic effects for BW were -0.42 and -0.17 for Fogera cattle(Asemu,2016) and Gobra cattle (Diop& Van Vleck, 1998), respectively. Genetic correlations estimated for Brahman cattle were-0.37 and -0.35 (Plasse*et al*., 2002a, Mostert*et al*., 1998). In contrast, positive correlations for direct and maternal genetic effects for BWwere reported for Nellore cattle (Eler*et al*., 1995, r_{am}=0.72; Plasse*et al*., 2002b, r_{am}=e 0.22).This indicates unfavorable interference between them (Meyer, 1992).

The total heritability for BW was 0.17 which is similar to the estimates of 0.17 (Haile -Mariam &Kassa, 1995) for Boran breed and less than the estimates of 0.28 and 0.30 obtained by (Plasse*et al*., 2002a; 2002b) in Brahman cattle. But, higher than the estimates of 0.10 for Nellore (Eler*et al*., 1995)and 0.08 value obtained for Gobra(Diop& Van Vleck, 1998).

4.2.1.2 Weaning weight

As indicated in (Table 4.4) directheritabilities for weaning weight were0.38which is higher direct heritability estimate than 0.22 (Arnason and Kassa, 1987), 0.24 (Banjaw and Haile-Mariam, 1994) and 0.21 (KassaMersha and Haile-Mariam, 1995) for Boran calves, but lower than 0.43±0.04 reported by (Aynalem*et al*., 2010) for the same breed. For Ethiopian Fogera cattle breed, direct heritability of 0.24 was reported by (Belay *et al*., 2016). The relatively high direct heritability estimate for WW in this study denotes the fact that direct genetic effects constitute a significant portion of the phenotypic variance for WW of Boran calves; suggesting that better genetic progress would be expected through direct genetic selection. Such high direct heritability is possibly due to the exclusion of maternal effects in model 1.

The estimate of direct heritability (model 1) of WW was higher in comparison to heritabilities reported by other authors in different countries (Plasse*et al*., 2002a;2002b; Diop& Van Vleck, 1998; Elere*t al*., 1995).

The maternal heritability of WW was 0.19 in model 2(Table 4.4). The estimate of maternal heritability we found in this study was higher than maternal heritability of 0.06 estimated inBoran cattle(Haile-Mariam &Kassa, 1995) and 0.016inFogera cattle in Ethiopia(Assemu ,2016), but lower than the maternal heritability estimate of 0.25 inBrahman cattle(Mostert*et al*., 1998). As mentioned before, maternal heritabilities estimated in Weaning weight (0.19 to 0.38) were higherthan birth weight (0.15 to 0.17) indicating the importance of the maternal effect on weaning weight. Moreover, direct heritability estimate was close to the corresponding maternal heritability for both birth weight (Table 4.4). These results may indicate the high interference between direct and maternal effects on the genetic progress of this trait.Therefore, both direct and maternal effects should be considered for birth weight (Rodriguez*et al*.,2006).

The genetic correlation between direct and maternal genetic effects (r_{am}) for WW was -0.45, negative value (Table 4.4). The estimate was comparable with a negative value of -0.57 reported by H/ Mariam and Mersha(1995) for Boran cattle. The current result was lower than the genetic correlation estimates ofDiop& Van Vleck (1998) and Meyer (1992), but higher than the estimates of Koots*et al*.(1994) inCanada breed and Eler*et al*. (1995) inNellore breed. In contrast, the genetic correlation between direct and maternal genetic effects was positive for WW (r_{am}=0.11) in Brahman breed (Plasse*et al*., 2002b). Total heritability (h^2_t):The total heritabilityestimate was 0.38 for WW in Boran cattle in this study (Table 4.4). This value for WW was higher than the estimate of 0.21 in Boran breed (H/mariam and Mersha,1995).Plasse*et al*. 2002), Eler*et al.,* 1995 andDiop&Van Vleck, 1998) reported total heritabilities of0.12, 0.14 and 0.12, respectively. The lower heritability estimates might be associated with animals management variation through time (Almaz, 2012; Belay, 2014), the quality of records, data management (Meyer, 2005) and data size (Yosef, 2006).

4.2.1.3 Average daily gain

The estimated direct heritability for average daily gain inthe presented study was0.46(Table 4.4). In other studies, direct heritability estimates of 0.07 and 0.29 were found in pure Boran breed and their crossbreds, respectively(Aynalem, 2006). The present estimate of direct heritability of ADG was comparable with the estimate of 0.5 reported in different breeds (Banjaw and H/Mariam, 1994; F. Goyache*et al*., 1997; Hailu*et al*., 2004), but higher than the direct heritability estimates reported by (Aynalem*et al*., 2016) andBelay *et al*., (2016) in Fogera cattleand (Rodriguez*et al*., 2006) in Charolais beef cattle. This indicted that these trait are not much influenced by environment. So there is scope for improvement of these traits by minimizing the environmental variation.

The maternal heritability of ADG was 0.14 (Table 4.4). The direct heritability was higher than the estimates of 0.05 and 0.06 reported inGobra (Diop& Van Vleck, 1998), but, lower than the estimate of 0.35 (Hailu*et al*.,2004).The results showed that the inclusion of maternal effects in genetic evaluation of early growth traits in Boran cattle is of crucial importance.The exclusion of maternal effects (model 1) leads to upward biased estimates for co-variance components. As a result, accurate estimation of co-variance components is a perquisite for designing Boran cattle genetic improvement program and genetic evaluation system.

The total heritability was0.0028for ADG. The total heritability of ADG waslower than the ADG (0.48) estimate reported by (Hailu*et al*., 2004).When the h^2 of a trait is high, correlation between the phenotype and genotype of individuals, on average, should also be high, and selection on the basis of own phenotype should be effective. It can be inferred that, the heritability value for growth traits is variable depending on the breed, the production system and the method of estimation.

Table 4.3. Estimates of co-variance components (kg) and log likelihood from univariate analysis of birth weight, weaning weight and Average daily gain

Models	σ^2_d	σ^2_m	σ_{am}	σ^2_e	σ^2_p	**Log likelihood Values(−2Log L)**
Birth weight						
Model 1	1.67	-	-	8	9.67	3714.6
Model 2	1.4	0.98	-0.17	8.1	10.48	3651.2
Weaning weight						
MWW1	129.4	-	-	206.5	336	7808
MWW2	53.1	45.8	201	225	324	7637.1
Average daily gain						
MADG1	0.004	-	-	0.005	0.009	4249.66
MADG2	0.002	0.001	-0.0002	0.005	0.009	4176.94

N.B. σ^2d: direct additive genetic variance, σ^2m: maternal additive genetic variance, σam: covariance between direct additive and maternal additive genetic effects, and σ^2e: error variance; −2log L: log likelihood and σ2p- phenotypic variance.

The genetic correlation between direct and maternal genetic effects (r_{am}) for ADG was -0.46 (Table 4.5) negative values. The estimate was lower than with the estimates of -0.49 reported by (Hailu *et al*., 2004) for beef cattle. Comparable negative estimates of r_{am} were also reported for ADG in Simmental, Angus and Hereford cattle (Trus and Wilton, 1988). The largest negative r_{am} suggests that selection for genetically superior animals for ADG resulted in those genetically inferior for the maternal genetic components of ADG. According to (Meyer, 1992), there might be have been a number of reasons for such genetic relationship, for instance, environmental factors related to management systems and husbandry practices (Hailu, 2004).

Table 4.4. Estimates of direct and maternal heritability and genetic correlation for Boran cattle breed under univariate animal model.

	Parameters					
Models	**h^2_d**	**SE**	**h^2_m**	**SE**	**r_{am}**	**h^2_T**
Birth weight						
Model 1	0.17	0.51	-		-	
Model2	0.15	0.43	0.10	0.2	0.47	0.15
Weaning weight						
Model 1	0.38	0.52	-		-	
Model 2	0.19	0.43	0.17	0.22	-0.45	0.69
Average daily gain						
Model1	0.46	0.56	-		-	
Model 2	0.30	0.46	0.15	0.2	-0.47	0.0028

N.B.h^2_T: total heritability ($h^2_T = (\sigma^2_d + 0.5\sigma^2_m + 1.5\sigma_{dm})/\sigma^2 p$; estimated according to Willham, 1972), S.E. Standard error. h^2_d: heritability, h^2_m: maternal heritability and. r_{am}: co-variance between direct and maternal genetic effects.

The direct heritability estimate was close to the corresponding maternal heritability for weaning weights (Table 4.4). These results may indicate the high interference between direct and maternal effects on the genetic progress of this trait. Therefore, both direct and maternal effects should be considered for weaning weights. Althoughmaternal heritability estimates of thebirth weight and average daily gain were lower than the direct heritability. Therefore, selection for direct effect would only consider.

4.2.2 Bivariate analysis

Estimates of (co)variance components are presented in Table 4.5 while estimates of h^2_d, h^2_m,h^2_T and the direct genetic correlations and maternal genetic correlations are presented in Table 4.6 for BW, WW and ADG from bivariate analysis.

The estimates of the correlations from the bivariate analyses between the three growth traits in the Borancattle breed (i.e. BW versus WW, BW versus ADG and WW versus ADGare given in (Tables 4.6).The effect of the bivariate animal models in comparison to the univariate on the magnitude of the estimates of genetic parameters between traits is quite evident. As can be seen inTables 4.5heritabilities are higher in comparison to that of the univariate analysis (Table4.4) Genetic correlations between the traits studied were favorable, indicating that selection for one trait will improve others in a desired direction, helping the breeding process as a whole.

Table 4.5. Estimates of (co) variance components, direct and maternal heritability and total heritability from bi-variate analyses of BW, WW and ADG fitting two animal models

Models	**Variance components**				**Genetic parameter**			
	σ^2a	σ^2m	σ^2e	σ^2p	h^2d	h^2m	r_{am}	h^2_T
Birth weight								
Model 1	1.65	-	8	9.65	0.17		-	0.17
Model2	1.93	0.046	7.71	9.67	0.2	0.005	-0.45	0.17
Weaning weight								
Model 1	127.17	-	208.73	336	0.41		-	0.37
Model2	82.33	38	213.25	333.6	0.32	0.15	-0.46	0.64
Average daily gain								
Model 1	0.0039	-	0.005	0.0089	0.43		-0.48	0.43
Model2	0.002	0.001	0.0057	0.0087	0.35	0.14		0.28

N.B.h^2T: total heritability (h^2T= (σ^2d+ 0.5σ^2m+ 1.5σ_{dm})/σ^2pWillham, 1972), h^2d: heritability, h^2m: maternal heritability, σ^2d: direct additive genetic variance, σ^2m: maternal additive genetic variance and σ^2e: error variance,σ^2p: total variance ,$r_{am:}$ genetic correlation between direct and maternal

Direct heritability of the growth traits*:* The direct heritability estimates from bivariate analysis varied from 0.17 to 0.43 for BW and WW and ADG (Table 4.5). The direct Heritabilities from bivariate analysis for the traits lie within the range of previous reports (Banjaw and Haile-Mariam1994; Hailu *et al*., 2004; Aynalem, 2006) for Boran cattle.

Maternal heritability of the growth traits*:* The estimated values for maternal heritability of BW, WW and ADG were 0.005, 0.15 and0.14, respectively. Which lie within the range of previous scholars ((Haile-Mariam&Kassa-Mersha, 1995 and Belay *et al*., 2016) for Boran and Fogera cattle respectively.

Direct genetic correlations (r_d):The correlation between the direct genetic components(r_d) of BW and WW (r_d = 0.96) was larger under model (2) than correlation between ADG and WW from Model 1(r_d = 0.62).Although the correlations between the traits were positive, difference in estimates between the models were observed for all traits. These estimates were higher than the values of0.373and 0.314 reported by Mekonnen and H. Kassa-Mersha (1995)and Belay *et al*., (2016) for BW and WW in Boran and Fogera cattle, respectively. Belay *et al*., (2016) estimated direct genetic correlation of 0.91 between ADG and WW in Fogera cattle.

Maternal genetic correlation (r_m): The correlation between the maternal components (r_m) of BW and WW (r_m = 0.97) was larger than under model 2 than (ADG and WW). The estimate obtained in study was higher than the reports of Mekonnen H/mariam andKassa-Mersha, (1995) and Almaz *et al*., (2016)0.082 and 0.6. Estimates from the bivariate analyses were similar to those from univariate analysis but the estimates for heritability were relatively higher.

The genetic correlations between the direct and maternal effects (r_{am}) were large and negative for ADG (-0.48). These values for BW were in contrast to the list of estimates from pervious published studies presented by Meyer (1992), which were mostly positive (0.04).Estimates of r_{am} for WW and ADG were highly negative (Table 4.5). Corresponding large negative genetic correlations were reported for WW in other beef cattle studies such as those by (Cantet *et al.*, 1993 and Schoeman *et al.* 2000). Comparable negative estimates of r_{am} were also reported for ADG in Simmental, Angus and Hereford cattle (Trus and Wilton,1988). In this study, the larger negative r_{am} possibly suggests that selection for genetically superior animals for WW resulted in those genetically inferior for the maternal genetic components of WW (Cantet *et al.*, 1993).

As pointed out by Meyer(1992), there might have been a number ofreasons for such genetic relationship, for instance, environmental factors related to management systems and husbandry practices may be contributing for high direct and maternal genetic correlations. It was further more indicated by (Schoeman andJordaan,2001) that such large negative r_{am} estimates were considerably reduced in across breed population by the inclusion of the breed proportions and non-additive effects in the model fitted. The large negative estimates obtained in this study as well as those reported estimates are thus most likely not reflecting a true antagonism, but are biased estimates of the true relationship between direct and maternal genetic effects. The bivariate estimates of genetic correlations between direct and maternal effects (Table 4.5**)** for BW (- 0.45), WW(-0.46) and for ADG (0.48) which is comparable estimates with that of the univariate analysis.

Table 4.6.Phenotypic (Above diagonal) and genetic correlation (Below diagonal) for growth traits

Parameters	BW	WW	ADG
BW	*	0.28	0.21
WW	0.62	*	0.65
ADG		0.96	*

Correlations between Growth Traits

Since livestock are usually bred for multiple rather than single traits to bring about production efficiency in their lifetime, there is always bound to be a relationship between traits. This relationship can be shown through the correlation of trait values positively or negatively on the individual of a population (Falconer, 1989).The phenotypic correlation between two characters can be influenced by inheritance, environmental or both. As indicated in Table 4.6, the phenotypic correlation between the birth weight with weaning weight and average daily gain were low. The reason could be the BW of calf depends on the intra uterine environment of the dam, health status of the dam and nutrition of the dam before birth. However, ADG and WW were having high phenotypic correlation. Similarly, high phenotypic correlations were reported by (Lobo *et al*. 2000), 0.96; (Cucco *et al*. 2009) 0.91: (Habtamu, 2010) 0.91 and (Almaz2012) 0.99.But it was opposite to the reports of (Wasike2006) and (Aynalem, 2006) who found a low phenotypic correlation for growth traits. On the other hand, strong and moderately high genetic correlation was observed between WW and ADG. 0.65(Table 4.6) correspondingly, a moderate phenotypic correlation of 0.64 (Plasse *et al*., 2002) and 0.62 (Pico, 2004) were reported for WW and ADG. This indicated that the traits are not much influenced by environment. So there is scope for improvement of these traits by minimizing the environmental variation (Bekele *et al*.,2016).

Selection based on WW is more effective than BW. The direct genetic correlation estimate for BW*WW (0.62) was lower than that of ADG*WW(0.96).This indicated that traits are not influenced by environment. Phenotypic correlation for all traits was lower than genetic correlation, which is consistent with the majority of reported results. This is because of the influence of environmental factors (fixed effect those are: sex, season and year) and environmental correlation. Therefore, selection based on genetic correlation is recommended.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Almost all the non-genetic factors considered in the study had an effect on the growth performances of the breed. Year of birth followed by season had a great effect and this could be basically from the fluctuation of management practices implemented by the ranch.

The heritability estimate and genetic correlation of birth and weaning weight of the current study for Boran cattle breed was low both compared to other reports of the same breed. Additionally, presence of inconsistence recording system of the ranch as well as poor overall management problem followed by the ranch contributes for the lower parameter estimate. Selection would be effective for WW weight and would produce important correlated responses for all measurements of growth. Results from the current study, as expected, show that both ADG and WW would respond favorably to selection and that changing one would lead to correlated response in the other. Selection would be more accurate for ADG than for WW because heritability is greater.

5.2 Recommendations

Based on the facts and figures obtained in this study, the following recommendations were amended.

- The recording system of the ranch that is a base for accurate estimation of genetic parameter and genetic gain for selection procedure, should be improved and follow national (scientific) recording systems for all growth performance traits.

- The lower result of heritability in this study is attributed by the highest environmental pressure present in the ranch that affects the genetic potential of the breed. Therefore, selection of the best animals, which was mainly done by the body size, should be improved and must be done with special care considering environmental effect. Therefore producers should decide on for a long-term strategy of achieving change in these traits firstly through improvement of the production environment and then by appropriate technology.

- The growth performance of the animals is influenced by both genetic and non-genetic factors. It has been pointed out that the Ethiopian Boran cattle also need better management and in terms of feeding, housing, disease.

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APPENDIX

Appendix:Table1: Analysis of variance (ANOVA) of BW

Source	DF	ANOVAs SS	Mean Square	F Value	Pr> F
Sex	1	3969.46514	3969.46514	13.81	0.0002
Season	3	1264.41869	421.47290	1.47	0.2220
Year	9	30621.09428	3402.34381	11.84	<.0001

*** = *highly significant (P<0.001), * *significant (P<0.01), *significant (P<0.05) and NS non-significant (P>0.05)*

Appendix:Table 2: Analysis of variance (ANOVA) of WW

Source	DF	ANOVA SS	Mean Square	F Value	Pr> F
Sex	1	1041.9649	6609.3247	20.48	<.0001
Season	3	19756.2684	1925.0014	5.97	0.0005
Year	9	448715.9163	45752.9489	141.79	<.0001

*** = *highly significant (P<0.001), * *significant (P<0.01), *significant (P<0.05) and NS non-significant (p>0.05)*

Appendix:Table 3: Analysis of variance (ANOVA) of ADG

Source	DF	ANOVA SS	Mean Square	F Value	Pr> F
Sex	1	0.02251103	0.02251103	2.63	0.1051
Season	3	0.24597468	0.08199156	9.58	<.0001
Year	9	7.34707136	95.39	95.39	<.0001

*** = *highly significant (P<0.001), * *significant (P<0.01), *significant (P<0.05) and NS non-significant (P>0.05)*

Appendix table 4: Record format sheets followed at the Dida Tuyera Breeding and Improvement Ranch

INDIVIDUAL COW LIFE TIME PRODUCTION RECORD Photograph for ID

One side

የእርባታውስም/Name of the ranch: Dida Tuyera breeding and improvement ranch

የላሟቁጥር/Cow's ID………………………… የተወለደችበትቀን/Birth Date …… ዝርያ/Breed ……የላሟአባትስም/ Sire's Name…………………. ቁጥር/ID.No……………………………ዝርያ/Breed ……………………..

የላሟእናትቁጥር/ Dame ID……………….የላሟእናትዝርያ/Dam Breed ……………………..የተገዛችበትቀን/Date Purchased…..

የተገዛችበትዋጋ/Cost/Birr…………..

አንደኛአመትአለባ /1st lactation			2ኛአመትአለባ /2nd lactation			3ኛአመትአለባ / 3rd lactation			4ኛአመትአለባ /4thlactation		
ከ/From ……………… ለ/To …………………			ከ/From ………………………… ለ/To ……………………………			ከ/From ……………………… ለ/To ……………………………			ከ/From …………………… ለ/To ………………………..		
የታለበችው/Milked			የታለበችው/Milked			የታለበችው/Milked			የታለበችው/Milked		
ወር/Month	ቀን/Days	ሊትር/Liter	ወር/Monተh	ቀን/Days	ሊትር/Liter	ወር/Month	ቀን/Days	ሊትር/Liter	ወር/Month	ቀን/Days	ሊትር/Lite

የተሸጠችበትቀን/Date Sold: ………………………… የገዥውስም/To whom: …………….ዋጋ/Price …………….

የሞተችበትቀን/Date Died: ………………… የሞተችበትምክንት/Cause of Death: …………………

5ኛአመትአለባ/5th lactation			6ኛአመትአለባ//6th lactation			7ኛአመትአለባ/ 7th lactation			8ኛአመትአለባ/8thlactation		
ከ/From ……………… ለ/To …………………			ከ/From ………………………… ለ/To ……………………………			ከ/From ……………………… ለ/To ……………………………			ከ/From …………………… ለ/To ………………………..		
የታለበችው/Milked			የታለበችው/Milked			የታለበችው/Milked			የታለበችው/Milked		
ወር/Month	ቀን/Days	ሊትር/Liter	ወር/Monተh	ቀን/Days	ሊትር/Liter	ወር/Month	ቀን/Days	ሊትር/Liter	ወር/Month	ቀን /Days	ሊትር /litre

የርቢመዝገብ/BREEDING RECORD

የእርባታውስም/Name of ranch፡ Dida Tuyera…….

. የላሟመለያቁጥር/Cow’s ID. ………………

የወሊድዙር/ Parity	የማህፀንእረፍት/Breeding Rest				የማስጠቅያመመዝገብያ/Breeding records						ቀን/Date			ጥጃ/Calf		ማስታወሻ/ Remarks
	የተወለደችበትቀን / Date Calved	ደርታያልተጠቃችበት ቀን/In heat but no bred														
		1	2	3	1ኛየተጠቃችበትቀን/ 1st service Date	የኮርማቁጥር/ Bull ID	2ኛየተጠቃችበት ቀን/ 2nd Service Date	የኮርማቁጥር/ Bull ID	3ኛየተጠቃችበት ቀን/3rd service date/	የኮርማቁጥር/ Bull ID	የነጠፈችበትቀን/Dry off	የምትወልድበትቀን/Due date	የወለደችበትቀን/Date calved	ፆታ /Sex	መለያቁጥር ID	

የጤናመዝገብ/ HEALTH RECORD

የእርባታውስም//Name of ranch ………………Dida Tuyera ………

የላሟመለያቁጥር//cow's ID.No. ………………………

ክትባቶች/ Vaccination							ምርምር/Diagnosis	ህክምና /Treatment	አስተያየት/ Observation
የሳምባ/CBPP	የአባሰንጋ/Anthrax	የአፍተእግር/Black Leg	FMD Footand mouth disease	ውርጃ/ Brucellosis	የቆዳበሽታ / LCD	የውስጥጥገኛ/ Deworming			
Date	Date	Date	Date	Date	Date	Date			