

**DESIGNING SUSTAINABLE BREEDING PROGRAM FOR BEGAIT
GOAT IN WESTERN TIGRAY, NORTHERN ETHIOPIA**



PhD DISSERTATION

HAGOS ABRAHAM HADGU

APRIL 2018

HARAMAYA UNIVERSITY, HARAMAYA

**DESIGNING SUSTAINABLE BREEDING PROGRAM FOR BEGAIT
GOAT IN WESTERN TIGRAY, NORTHERN ETHIOPIA**

**A PhD Dissertation submitted to the School of Animal and Range Sciences,
Postgraduate Program Directorate
HARAMAYA UNIVERSITY**

**In Partial Fulfillment of the Requirements for the Award of the Degree of
DOCTOR OF PHILOSOPHY IN ANIMAL BREEDING AND GENETICS**

Hagos Abraham

April 2018

Haramaya University, Haramaya

DEDICATION

I fully dedicate my efforts in this work to my daughter Kal (Kalkidan) and my family, who were always immersed in vision about my success.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this dissertation is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analyses and completion of this dissertation. Any scholarly matter that is included in the dissertation has been given recognition through citation. Every serious effort has been made to avoid any plagiarism in the preparation of this dissertation.

This dissertation has been submitted in partial fulfillment of the requirements for PhD degree in Animal Genetics and Breeding at Haramaya University. The dissertation is deposited in the Haramaya University Library and is made available to borrowers under the rules of the library. I solemnly declare that this dissertation has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotations from this dissertation may be made without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from or reproduction of this dissertation in whole or in part may be granted by the Head of the School or Department or the Director of the Postgraduate Program when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, but permission must be obtained from the author of the dissertation.

Name: Hagos Abraham

Signature: _____

School/Department: School of Animal and Range Sciences

Date of submission: April 2018

BIOGRAPHICAL SKETCH

The author, Mr. Hagos Abraham Hadgu, was born on the 28th of June, 1984 in Saesie Tsaeda Emba district, Eastern Administrative Zone of Tigray. He attended elementary education in Sewne Elementary School from 1992 to 1997 and junior education at Wolwallo Junior School from 1998 to 1999. He attended both high school and preparatory educations at Edaga Hamus Comprehensive Secondary School during the period between 2000 and 2005.

Then after he joined Alemaya University (now Haramaya University) in 2006 and awarded a B.Sc. degree in Animal Sciences in July 2008. Soon after graduation, he joined the Ministry of Agriculture and Rural Development and worked as Animal Production and Forage Development junior expert for about two months in South Wollo Administrative Zone of Amhara. Thereafter, he joined the School of Graduate Studies of Haramaya University in March 2009 to pursue M.Sc. study majoring Animal Production through financial support obtained from Ministry of Education. Upon completion of M.Sc. study, the author was employed by Ministry of Education and placed at Bule Hora University, as a lecturer until he joined the School of Graduate Studies of the Haramaya University in October 2012 for a PhD degree specialization in Animal Breeding and Genetics.

ACKNOWLEDGEMENTS

All praises and thanks from the core of the author's heart to Almighty God, without which nothing could have been possible for me.

I would like to express my deepest and sincere appreciation to my major advisor Dr. Solomon Gizaw for the invaluable contributions starting from inception to the completion of the study. Your constructive comments were always detailed and helpful. It was an honor and pleasure to work under your supervision.

I am truly thankful to my co-advisor Dr. Mengistu Urge for keen advice and helping. I will be always appreciative for your sagacious guidance and encouragement shown throughout the pursuit of this study.

I am very grateful to Bule Hora University for providing me study leave and guarantee my salary during the study period. I sincerely appreciate the opportunity that I have been given. I would like also to express my deepest appreciation to Shire Mytsebri Agricultural Research Center for allowing me to use different facilities during field work and write-up. I would like to extend my sincere appreciation to the School of Animal and Range sciences, School Graduate Committee of Animal and Range Sciences and Postgraduate Program Directorate of Haramaya University for provision of an assortment of services in all the process of the study time.

I am appreciative to many other people, which is impossible to list out all. Within the space provided here, it is difficult to acknowledge amply every individual who directly or indirectly supported me during the course of this study. I would grossly thank you all.

Lastly, though by no means at all the least, I would like to thank my wife Hirut Abraham for your love, support and sacrifices and our lovely daughter, Kal for your love. And most of all, I would like to be grateful my parents, brothers and sisters for the longstanding support and encouragement. Thanks for all your encouragement!

ACRONYMS AND ABBREVIATIONS

3MW	Three month weight
6MW	Six month weight
9MW	Nine month weight
12MW	Twelve month weight
AFK	Age at first kidding
ADG	Average daily weight gain
ADG-I	Pre-weaning daily weight gain
ADG-II	Post-weaning daily weight gain
BC	Before Christ
BecA	Bioscience of eastern and central Africa
BOKU	The University of Natural Resources and Life Sciences, Vienna
BLUP	Best Linear Unbiased Prediction
BW	Birth weight
CBBPs	Community Based Breeding Programs
CSA	Central Statistical Agency
DGE	Discounted genetic expression
DMY	Daily milk yield
DNA	Deoxyribonucleic acid
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GLM	General Linear Model
h^2	Heritability
HSD	Honest Significant Difference
ICARDA	International Center for Agricultural Research in the Dry Areas
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
KI	Kidding interval

ACRONYMS AND ABBREVIATIONS (*Cont...*)

LL	Lactation length
LS	Litter size
LMY	Lactation milk yield
LSM	Least squares means
NRC	National Research Council
P	Probability
PPR	Pest des petits ruminants
SAS	Statistical Analysis System
SE	Standard error
SPSS	Statistical Package for Social Sciences
SR	Pre-weaning survival rate
σ_a	Additive genetic standard deviation
σ_p^2	Phenotypic variance
σ_p	Phenotypic standard deviation

TABLE OF CONTENTS

STATEMENT OF THE AUTHOR	v
ACKNOWLEDGEMENTS	vii
ACRONYMS AND ABBREVIATIONS	viii
GENERAL ABSTRACT	xii
1. GENERAL INTRODUCTION	1
2. GENERAL BACKGROUND	4
2.1. Origin and Domestication of Goats	4
2.2. Goat Genetic Resources of Ethiopia	4
2.3. Goat Production Systems in Ethiopia	5
2.4. Performance of Goats in Ethiopia	6
2.4.1. Growth performance	6
2.4.2. Reproductive performance	7
2.4.3. Milk production performance	8
2.5. Genetic and Phenotypic Parameters	9
2.6. Genetic Improvement Programs	10
2.6.1. Nucleus breeding programs	11
2.6.2. Community based breeding programs	12
2.7. Identification of Breeding Objectives	13
2.8. Optimizing Alternative Breeding Schemes	14
3. GENERAL MATERIALS AND METHODS	16
3.1. Description of the Study Area	16
3.2. Survey Study	17
3.3. Monitoring Study	18
3.4. Identification of Breeding Objective	18
3.5. Description of Alternative Breeding Schemes	19
3.6. Data Analysis	20
4. GENERAL RESULTS	22
4.1. Household Information	22

4.2. Goat Production and Breeding Systems	22
4.3. Performance Parameters	23
4.3.1. Growth and reproductive performances	23
4.4.2. Milk production	25
4.5. Breeding Objective Identification	25
4.5.1. Using own-flock ranking experiment	25
4.5.2. Using bio-economic model	25
4.6. Design of Alternative Breeding Schemes	26
5. GENERAL DISCUSSION	27
6. GENERAL CONCLUSIONS AND RECOMMENDATIONS	33
7. REFERENCES	36
8. APPENDICES	48
8.1. APPENDIX A: PAPERES	48
8.2. APPENDEX B: QUESTIONNAIRES AND FORMS USED	141
8.3. APPENDEX C: SAMPLE PICTURES	151

DESIGNING SUSTAINABLE BREEDING PROGRAM FOR BEGAIT GOAT IN WESTERN TIGRAY, NORTHERN ETHIOPIA

GENERAL ABSTRACT

*Indigenous breeds adapt and survive in often challenging environments and diverse agro-ecological areas representing an important genetic resource for livelihood of their owners and the national economy at large. Therefore, there is a need to improve the productivity of indigenous animals through developing sustainable breeding programs so as to enhance their competitive advantage in the face of crossbreeding threats. The current study was performed in Kafta Humera district of Tigray National Regional State of Ethiopia with the general objective of developing sustainable breeding program for improving performance of Begait goat to assure the livelihoods of the breed owners and to survival of Begait goat as a breed. Specific objectives of the current study were to: (i) describe production systems and breeding practices for Begait goat breed (ii) evaluate some reproductive and productive performance parameters of the breed under village (on-farm) and research (on-station) management (iii) identify breeding objective of the breed owners using own-flock ranking experiment and developing bio-economic models and (iv) design and evaluate alternative breeding schemes for genetic improvement of the breed. This dissertation contained five papers/manuscripts. The results of **Paper I** were based on survey of 150 (100 small-scale and 50 large-scale) sample household heads, in-depth focus group discussions and personal observations. The results revealed that agricultural production system in the area was mixed crop-livestock production system. Two types of goat farming systems were identified specifically small-scale and large-scale farming systems. Goat flock sizes were 23.21 ± 13.42 and 68.43 ± 15.38 under small-scale and large-scale farming systems, respectively. The results indicated that farmers under the two farming systems keep goats to generate cash income, milk and meat for home consumption with different index value. Natural pasture, browse species, crop residues and crop aftermath were the accessible feed resources. Rivers, ponds and borehole were available water sources for domestic use and for watering animals in the study area. Mating under the two farming systems was uncontrolled because of communal grazing and watering points. Small-scale and large-scale farmers use body size, twinning ability and milk yield for does whereas body size, growth rate and libido for bucks as selection criteria both with different index values. Water shortage, feed and grazing land shortage, insufficient veterinary service and lack of market demand were the most significant goat production constraints in the area. **Papers II and III** were based on monitoring data collected under two management systems (on-farm and on-station) during the period between October 2014 and December 2016. The results showed that the overall least squares means and standard error (\pm SE) of body weight at birth (BW), three month (3MW), six month (6MW), nine month (9MW) and twelve month (12MW) were found as 2.69 ± 0.03 , 10.71 ± 0.44 , 15.60 ± 0.53 , 18.30 ± 0.43 and 22.36 ± 0.52 kg,*

respectively. The overall mean pre-weaning daily weight gain (ADG-I) was 89.10 ± 1.54 g/day, whereas post-weaning daily weight gain (ADG-II) was 54.24 ± 1.75 g/day. The overall mean values of age at puberty, age at first kidding (AFK) and kidding interval (KI) were 214.58 ± 1.20 , 429.24 ± 6.46 and 238.75 ± 2.04 days, respectively. Litter size (LS) in the current study ranged from 1 to 3 with the mean of 1.52 ± 0.02 kids per doe per kidding (**Paper II**). The overall mean daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL) included: 0.61 ± 0.01 kg, 64.3 ± 1.23 kg and 104 ± 1.22 days, respectively (**Paper III**). Non-genetic factors estimated (management system, kid sex, parity number, birth type and birth season) highly significantly ($p < 0.001$) influenced almost all body weights, reproductive and milk production parameters (**Papers II and III**). Under semi intensive management mean body weight of Begait kids at birth, 3, 6, 9, and 12 month were 2.81 ± 0.04 , 11.12 ± 0.43 , 16.45 ± 0.49 , 19.58 ± 0.37 and 24.13 ± 0.48 kg, respectively whereas the corresponding figures under extensive management were 2.59 ± 0.03 , 10.32 ± 0.46 , 14.76 ± 0.57 , 17.06 ± 0.49 and 20.62 ± 0.54 kg. Age at puberty, AFK and KI of semi intensively managed Begait does were 209.93 ± 1.65 , 415.09 ± 9.01 and 233.77 ± 3.12 days, respectively. The corresponding values of these traits in extensive management were 219.00 ± 1.63 , 444.33 ± 9.09 and 242.79 ± 2.66 days. The DMY, LMY and LL were 0.75 ± 0.01 kg, 85.6 ± 1.04 kg and 111 ± 1.21 days under semi intensive management, respectively whereas under extensive management these were 0.55 ± 0.01 kg, 56 ± 1.43 kg and 101 ± 1.57 days. Breeding objective traits were defined using own-flock ranking experiment and based on calculated economic values obtained developing bio-economic models (**Paper IV**). Traits highly preferred by farmers were body size, LS and DMY, whereas traits with the greatest economic values included: LS, 6MW and pre-weaning kid survival rate (SR) in their order of magnitude. Under **Paper V**, three alternative breeding schemes: two central nucleus-based (government ranch and commercial breeding schemes) and one village-based (cooperative village breeding scheme) were evaluated for annual genetic and economic gains and operational feasibility. The breeding schemes differed in number of tiers, flock size and selection method. The results indicated that central nucleus-based schemes were slightly better in genetic and economic gains when compared to village-based scheme. Government ranch breeding scheme seems more operationally feasible for improvement of the breed than the other schemes as government is investing in conservation and improvement of the breed. By the end of Growth and Transformation Plan III, government planned to export meat from Begait goat, sheep and cattle breeds, and developed a roadmap for its implementation, which can be considered as good opportunity. If it is not successful, the alternative schemes can be implemented with careful consideration of their limitations.

Keywords: Production system, breeding system, performance evaluation, breeding objective, breeding schemes

ARTICLES AND MANUSCRIPTS IN THE DISSERTATION

This dissertation is based on the following five papers/manuscripts, which will be referred in the text by their Roman numerals:

- I. Begait goat production systems and breeding practices in western Tigray, northern Ethiopia. (*Open Journal of Animal Sciences*, 7: 198-212: <https://doi.org/10.4236/ojas.2017.72016>)
- II. Growth and reproductive performances of Begait goat under semi intensive and extensive management in western Tigray, northern Ethiopia (*Accepted for publication by Tropical Animal Health and Production, Springer*)
- III. Milk production performance of Begait goat under semi intensive and extensive management in western Tigray, northern Ethiopia. (*Livestock Research for Rural Development, Volume 29, Article #240*: <http://www.lrrd.org/lrrd29/12/hags29240.html>)
- IV. Identification of breeding objectives for Begait goat in western Tigray, northern Ethiopia (*Accepted for publication by Tropical Animal Health and Production, Springer*)
- V. Simulated alternative breeding schemes for optimizing Begait goat improvement programs in western Tigray, northern Ethiopia (*Submitted*)

1. GENERAL INTRODUCTION

Goats are among the earliest animals to be domesticated and rank among important livestock species. Due to their ability to adapt to different environments, goats exhibit large diversity as a result of natural selection under diverse conditions (Morand-Fehr *et al.*, 2004). The number of goats is rising worldwide and they are becoming increasingly important around the world (Argüello, 2011). According to FAO statistics, in 2011, there were above 924 million heads of goats around the world. There are about 570 breeds and types of goats in the world, of which 89 are found in the continent of Africa (Galal, 2005).

Goat production is one of the integral parts of livestock farming activities in Ethiopia. The majority of goat population is found in large flocks in lowlands, but they are distributed in all agro-ecological zones of the country (Tesfaye, 2004). During the last 10 years, the goat population in Ethiopia increased more rapidly (134%) when compared to the sheep (65%) and cattle (38%) populations (FAOSTAT, 2016), however, increased numbers do not necessarily indicate a positive development of productivity (Aziz, 2010). At present, Ethiopia has about 30 million heads of goat (CSA, 2016) and is the sixth largest goat producer country in the world (FAOSTAT, 2014). Exotic and crossbred goats accounted for insignificant proportion (0.01%) of the total goat population in the country (CSA, 2016). The introduced major exotic goat breeds are Anglo-Nubian, Boer, Saanen and Toggenburg goats (Solomon *et al.*, 2014).

In Ethiopia, goats are kept for fulfilling multiple functions ranging from providing food (meat and milk) and non-food (skin and manure) products to socio-cultural purposes (Workneh *et al.*, 2003). Demand and prices for small ruminants' meat show an increasing trend because of urbanization and grow income in the cities and increased demand from the Gulf countries. According to Getachew and Mohamadou (2014), slaughter for goats was estimated at 8.70 million in 2011 and is expected to reach 13.00 million by 2023. Goat skins are valuable raw materials of leather products in which local highland goats produce thick, flexible and high quality skins with high price premium in the international leather products market (Solomon *et al.*, 2014). These authors also mentioned that skin of crossbred goats is relatively poor in its quality and suggested consideration of the trait during developing breeding programs.

However, the benefits derived from goats are the small portion of the potential in view of the vast genetic resources available in the country. For instance, in 2013 goats contributed only 11.0% and 1.4% of the national meat and milk production, respectively (FAOSTAT, 2016). Furthermore, the average income from goat export earnings obtained between 2005 and 2012 was about 3.3% of the total live animal export revenue (Getachew and Mohamadou, 2014). According to the same source, carcass yield of local goats remained at about 8 kg per head between 1999 and 2008, which was below the East African (11 kg) and the world (12 kg) average carcass yield throughout these years. Their productivity is constrained due to different factors related to biological, environmental and socio-economic factors. Among those factors, non-existence of sustainable breeding programs is an important impediment. Therefore, it is imperative to design and implement sustainable breeding programs to improve the livelihoods of goat owners and to meet the growing demand of goat meat for local consumption and international market.

There have been few attempts of genetic improvement programs of goats through upgrading the exotic genetic blood levels in Ethiopia. The visible examples are the FARM-Africa dairy goat development project in eastern and southern part of the country and also the Boer goat breeding strategy of Ethiopian Sheep and Goat Productivity Improvement Program. However, results indicated that crossbred goats did not perform better than indigenous goats if both groups were managed under similar management levels (Workneh *et al.*, 2003). In most cases, many small ruminants (sheep and goats) cross breeding programs in tropical countries were not successful due to the incompatibility of the genotype with the farmers breeding objectives, management methods and the prevailing environment of the tropical low input production systems (Workneh *et al.*, 2003; Wollny, 2003; Kosgey *et al.*, 2006).

Therefore, selective pure breeding of the adapted indigenous breeds is the best possible option of genetic improvement in the tropical countries like: Ethiopia. Local breeds in harsh tropical environmental conditions have special adaptive features such as tolerance of a wide range of disease, water scarcity tolerance and ability to better utilize the limited and poor quality feed. This makes them survive and be productive in the prevailing environment (Baker and Gray, 2004; Kosgey and Okeyo, 2007). To efficiently utilize these special features of local breeds,

there is a need of designing and implementing viable breeding programs that fit to the existing low input production systems. In Ethiopia, there is a more recently introduced and continuing community based breeding programs (CBBPs) aiming at the genetic improvement of small ruminants. These programs are organized by different nongovernmental organizations mainly BecA-ILRI Hub and ICARDA-ILRI-BOKU. A good example is one-tier CBBPs designed for four indigenous goats (Abergelle, Woyto-Guji, Central Highland and Western Lowland goats) and four indigenous sheep (Menz, Horro, Bonga and Afar) breeds.

Begait goat on which this study focused is one of the breeds or types identified in the country. Begait goat is grouped under the Nubian family and mostly found in Kafta Humera district of western zone of Tigray and in some parts of northwestern zone of the region. Begait goat is hardy and possesses the ability to survive, adapt and reproduce under the harsh environmental conditions of these areas. The breed is large size (withers height of 77.5 ± 8.7 and 69.4 ± 5.3 cm; mature body weight of 46.4 ± 9.6 and 35.5 ± 6.3 kg for male and female, respectively). The most common color is white. It is distinguished by hairy thighs, long drooping ears and roman type facial profile. It is multipurpose breed. Nevertheless, there have been no systematically planned and organized studies undertaken to fully understand the production systems under which the breed is kept, performance potential of the breed and breeding objective of its keepers. General objective of the study was, hence, designing feasible breeding program for improving performance potential of the breed so as to ensure livelihoods of the breed keepers. To achieve this general objective, therefore, the following specific objectives were pursued:

- 1) To characterize production systems and breeding practices for Begait goat in western Tigray region of Ethiopia
- 2) To monitor some reproductive and productive performances of Begait goat under village (on-farm) and research (on-station) management to understand the potential of the breed
- 3) To define breeding objectives of the breed owners using own-flock ranking experiment and developing bio-economic models
- 4) To design and evaluate alternative breeding schemes and design optimal breeding scheme for Begait goat genetic improvement based on genetic and economic gains and operational feasibility

2. GENERAL BACKGROUND

2.1. Origin and Domestication of Goats

The origins of domestic goats (*Capra hircus*) remain uncertain and controversial (Luikart *et al.*, 2001), however, it is now widely recognized that the goat's wild ancestor is the Bezoar goat (*Capra aegagrus*) (Amills *et al.*, 2017). This origin was confirmed by archaeological and genetic studies (Pidancier *et al.*, 2006; Naderi *et al.*, 2007). The main characteristic of the Bezoar goat is the long saber or scimitar shaped horns. Goat is member of the family *Bovidae* and is closely related to the sheep as both are in the goat-antelope subfamily *Caprinae*. It is believed that goats are the earliest domestic animal and probably the first ruminant livestock, after the dog were domesticated and have been used for their milk, meat, hair and skins across much of the world. Archaeological data suggested two distinct places of domestication: the Euphrates river valley at Nevali Çori, Turkey (11,000 years ago) and the Zagros Mountains of Iran at Ganj Dareh (10,000 years ago) (Hirst, 2017). The author further indicated that the most important archaeological sites with evidence for the initial process of goat domestication were Cayönü, Turkey (8500-8000 B.C.), Tell Abu Hureyra, Syria (8000-7400 B.C.), Jericho, Israel (7500 B.C.) and Ain Ghazal, Jordan (7600-7500 B.C.).

2.2. Goat Genetic Resources of Ethiopia

It is believed that the first goats reached Egypt around 5000 B.C. and then spread south and west throughout Africa. African goats could be grouped into three main families: the Dwarf goats of West and Central Africa, the Savannah goats of sub-Saharan Africa and the Nubian type goats of North Africa (Tesfaye, 2004). The parents of the Nubian goats came from Asia (Kassahun and Solomon, 2008). It is believed that the first wave of goats entered Ethiopia from the north between 2000 and 3000 B.C. The ancestors of Ethiopian goats are closely associated with goat types, which migrated from the Middle East and North Africa (Tesfaye, 2004).

Indigenous goats of Ethiopia are found in all agro-ecological zones of the country and production systems. It is believed that these goats have evolved through a process of natural selection that resulted in goats selected for adaptation and survival rather than production *per se* (Kassahun and Solomon, 2008). The latest goat population in the country was estimated to about 30 million heads (CSA, 2016). Based on physical description, this huge goat population has been classified in to twelve goat types (Kassahun and Solomon, 2008). These are Afar, Abergelle, Arsi-Bale, Begait or Barka, Central Highland, Hararghe Highland, Kaffa, Long-eared Somali, Small-eared Somali, Woyto-Guji, Western Highland and Lowland. Molecular characterization using fifteen microsatellite markers (Tesfaye, 2004) indicated the presence of 8 distinct breeds. More recently, however, molecular characterization using mitochondrial DNA D-loop (Getinet, 2016) identified 7 genetically distinct types.

2.3. Goat Production Systems in Ethiopia

In order to put interactions between livestock and the environment in a system, livestock production systems must be defined, described and put in a geographic context (FAO, 1995). Livestock production systems are identified on the basis of contribution of the livestock sector to the total household revenue (income, food), type and level of crop agriculture practiced, types of livestock species kept, mobility and duration of movement (Solomon *et al.*, 2010a). Accordingly, goat and sheep production system in Ethiopia is broadly classified into three major namely mixed crop-livestock, agro-pastoral and pastoral and two minor including urban and peri-urban (landless) and ranching production systems (Solomon *et al.*, 2008). These production systems are subsistence oriented and virtually depend on traditional management system with no or very limited external inputs (Solomon *et al.*, 2010a). In general, goat production in Ethiopia is described under low input production system and is operated by smallholder farmers. This production system accommodates almost all of the goat population of the country (IBC, 2004). The same source indicated that the main features of the low input goat production systems are its full dependence on natural resources and the limited demand for inputs.

In the study area goats and other livestock were largely kept in extensive system and fully dependent on rain-fed pasture. The major challenges for goat production in the area included: severe water shortage, feed shortage, high disease prevalence, marketing problem and theft. Opportunities, however, exist for improving goat production in the area. If the communal grazing land is properly managed, it could be a good source of good quality feed to boost goat production in the area. At the world market, the demand for mutton and goat meat have been increasing due to an increase in income and increased population, hence, there is a growing demand for goats and their products in both the domestic and export markets. Designing and implementing goat improvement programs with full involvement of the farmers is also good opportunity in genetic potential improvement of goats in the area.

2.4. Performance of Goats in Ethiopia

Evaluations of the performance of economically significant traits of livestock species are very useful inputs for designing sustainable breeding programs. The most important performance traits of livestock are broadly classified into two main categories: reproductive and productive traits. All forms of output including meat, milk, hair and skins depend on these traits (ILCA, 1990). The performance traits are influenced by genetic and non-genetic factors.

2.4.1. Growth performance

Growth of an animal can be defined as an increase in live weight and body size while growth rate is the rate of increase in weight and body size during specific intervals of time. Growth traits are important factors influencing profitability in any meat producing enterprise. Growth performance may be separated in pre-weaning (birth weight, weaning weight and pre-weaning growth rate) and post-weaning (six month weight, yearling weight and mature weight). Rapid growth during the early period can minimize the cost of rearing and therefore provide more profit to the farmers. Body weights and growth rates in pre-weaning are often considered as an early indicator of the late growth and economic benefit and can affect body weight at puberty and at first kidding (Hanford *et al.*, 2006).

The growth performance of goats is influenced by genetic and non genetic factors. The early stage of growth performance of kids is largely affected by breed and the milk yield of does. Nutrition, parity, birth type, kid sex, birth season and year also influence growth performance of goats (Berhane and Eik, 2006; Mohammed *et al.*, 2013; Belay and Mengistie, 2013). Most of indigenous Ethiopian goats' adult body weight range from 25 to 40 kg (Peacock, 1996). It was indicated that growth rate of these goats declined from 104 g/day at 3 month to 87 g/day, 65 g/day and 44 g/day at 6 , 12 and 24 month, respectively (Mukassa-Mugerwa *et al.*, 1989). The mean body weights at birth, 3, 6 and 12 month of some indigenous Ethiopian goat breeds are presented in Table 1.

Table 1. Birth, three, six and twelve month weights (kg) of indigenous Ethiopian goat breeds

Breed	Management	BW	3MW	6MW	12MW	Source
Abergelle	On-farm	1.91	6.84	9.13	14.25	Belay and Mengistie, 2013
Arsi-Bale	On-station	-	6.95	9.00	14.31	Hailu <i>et al.</i> , 2008
Arsi-Bale	On-station	1.91	6.65	9.00	14.31	Mohammed <i>et al.</i> , 2013
Keffa	On-farm	2.78	9.00	-	-	Belete, 2009
Central highland	On-farm	2.01	9.02	13.82	20.61	Belay, 2008
Somali goats	On-station	3.19	11.67	-	-	Zelege, 2007
Bati	On-farm	2.70	10.44	15.57	-	Hulunim, 2014
Borana	On-farm	2.42	10.48	13.47	-	Hulunim, 2014
Short eared Somali	On-farm	2.19	8.76	13.10	-	Hulunim, 2014

BW: Birth weight, 3MW: three month weight, 6MW: six month weight, 12MW: twelve month weight

2.4.2. Reproductive performance

Reproductive performance is an important criterion when evaluating the structure of strength and weakness of the breeds in particular production system (Browing *et al.*, 2006). It has high impact on overall flock productivity. The reproductive process is regulated by genetic and non-genetic factors and the net effect of all these factors determine the level and efficiency of reproduction. Reproduction efficiency in female goats is determined by different processes. These processes are length of the breeding season, cyclic activity, ovulation rate, fertilization rate, post-partum anoestrous period and the growth and viability of the offspring. Reproductive efficiency as such can be measured and expressed as age at first kidding,

kidding interval, litter sizes at birth and weaning rate (Greyling, 2000). Accordingly, adequate knowledge on the reproductive performances of the indigenous breeds is crucial for planning practicable breeding program. Mean age at first kidding, kidding interval and litter size at birth of some of indigenous Ethiopian goats from different sources are shown in Table 2.

Table 2. Age at first kidding, kidding interval and litter size of indigenous Ethiopian goat breeds

Breed	Management	AFK (month)	KI (month)	LS	Source
‡(G/maksegnit)	On-farm	13.86±3.31	6.35±2.62	1.85±0.36	Alayu <i>et al.</i> , 2014
‡(Alaba)	On-farm	11.95±0.13	9.05±0.08	1.47±0.04	Deribe, 2009
Abergelle	On-farm	15.00±0.98	10.00±0.56	1.04±0.02	Belay and Mengistie, 2014
Arsi-Bale	On-station	28.5±2.22	10.5±1.12	1.6±0.06	Hailu <i>et al.</i> , 2008
Central Highland	On-farm	13.60±1.35	10.26±0.47	1.16±0.06	Mengistie <i>et al.</i> , 2013
Kaffa	On-farm	12.90±0.4	7.3±0.3	1.7±0.10	Belete, 2009
Afar	On-farm	17.10±2.3	8.0±0.97	-	Feki, 2013
Haraghe highland	On-farm	16.60±4.4	8.1±2.07	-	Dereje, 2011
Bati	On-farm	14.98±0.24	7.95±0.19	-	Hulunim, 2014
Borena	On-farm	15.86±0.22	8.42±0.17	-	Hulunim, 2014
Small eared som	On-farm	20.15±0.12	8.81±0.18	-	Hulunim, 2014

‡: unspecified goat breed; AFK: age at first kidding; KI: kidding interval; LS: litter size; G/maksegnit: Gumara-Maksegnit

2.4.3. Milk production performance

Goats in Ethiopia are multifunctional not specialized for any particular purpose. In places where there is no cultural taboo, they are milked and the milk is consumed fresh or processed into various products either alone or mixed with cow's milk (FARM-Africa, 1996). In central rift valley, eastern, southeastern, northeastern and northwestern lowlands (the study area) of Ethiopia, goat's milk is consumed. Goat milk differs from that of cow milk in the content of minerals, vitamins and high quality proteins (Brito *et al.*, 2011) and thus can have particular benefit in diets of the elderly, sick, babies, individuals with cow milk allergies, patients with ulcers and even preferred for raising orphan foals or puppies (Dhara *et al.*, 2012). However, very limited information is available regarding milk performance characters of Ethiopian goats. A comparison made between Abergelle and Bagait goats showed that Bagait goats are capable of producing 0.55 kg daily milk without supplementation, however, 0.70 kg with supplementation (Berhane and Eik, 2006). The corresponding figures recorded for Abergelle goats were 0.37 kg and 0.54 kg. Average milk yield per day and per lactation under on-station

management for Afar goats were 0.28 kg and 24 kg, respectively (Dereje *et al.*, 2015). In a comparison study between pure Afar breed (Adal) and Quarterbred with Saanen, quarterbred Saanen gave more lactation milk yield (31 kg) than the pure Afar goat (24 kg), and 84 days lactation length were reported for both genotypes (Banerjee *et al.*, 2000).

Goat lactation performance is influenced by different non-genetic factors such as: plane of nutrition, parity number, doe body weight, birth type, dry period, lactation length and season of kidding.

2.5. Genetic and Phenotypic Parameters

Knowledge of genetic parameters is the basis of sound livestock improvement programs. Estimates of heritabilities and genetic correlations are indispensable population parameters required in animal breeding research and during design and application of practical breeding plans (Imbayarwo-Chikosi, 2010). Heritability of a trait refers to the proportion of variation among individuals in a population that is due to variation in the additive genetic effects. A reliable estimate of heritability will help to decide which breeding program should be used. If the trait heritability is high ($h^2 > 0.30$), mass selection with little pedigree records may be enough for rapid selection response. However, if the heritability of a trait is low ($h^2 < 0.1$), response from selection on individual records will be slow. It needs accurate pedigree records, family selection or even progeny testing (Legates and Warwick, 1990).

Correlation is the measure of association between two characteristics or traits. Both genetic and phenotypic correlations are of particular interest to animal breeders. They are an integral part of breeding program design and analysis. The phenotypic correlation is an estimate of the association between two visible characteristics in the current flock. The genetic correlation is the correlation between breeding values. It is an estimate of the way in which selection of parents for one trait will cause a change in a second trait in the progeny. Observations of traits on related animals are used to estimate genetic correlations. Genetic correlations are an indication of the proportion of genes that affect both traits in the direction of the sign of positive or negative (Simm, 1998). Ideally such estimates should come from experiments with

the particular population used in the breeding program and should include all important traits (Koots *et al.*, 1994).

2.6. Genetic Improvement Programs

The objective of animal breeding is to genetically improve livestock populations so that they produce more efficiently under the expected future production circumstances. Genetic improvement aims for an active use of the genetic variation available, both within breeds and between breeds of livestock. Strategies for genetic improvement could follow three main pathways: i) selection within breeds (or strains), ii) selection between breeds (or strains) and iii) crossbreeding (Kosgey *et al.*, 2006; Markos *et al.*, 2006). To be successful in genetic improvement of livestock, proper breeding programs need to be planned, implemented and maintained. A breeding program is defined as the organized structure that is set up in order to realize the desired genetic improvement of the population (Dekkers *et al.*, 2004). Moreover, these authors indicated that successful genetic improvement requires breeding programs to have (at least) the following components: (i) a system to record data on selection candidates (ii) methods and tools to estimate the genetic merit (breeding value) of selection candidates (iii) a system to select the animals that become parents of the next generation and mate them to produce the next generation and (iv) a structure to disseminate the genetic improvement of the breeding program into the production population.

In the tropics, breed substitution of exotics for the local breeds and crossbreeding with breeds from temperate regions have widely used though have invariably been unsuccessful in long-term (Kosgey *et al.*, 2006). Largely, many small ruminants cross breeding programs in tropics were not successful due to the incompatibility of the genotypes with the breeding objectives, management approaches of the prevailing low input production systems of the area, absence of involvement of livestock owners and stakeholders in decision making and ownership of the initiatives on low regard to the potential of indigenous breeds (Workneh *et al.*, 2003; Kosgey *et al.*, 2006; Markos *et al.*, 2006), nevertheless, there are some examples in special tropical environments for instance the highlands and peri-urban areas which have shown successful introductions of exotic breeds and their crosses with local livestock (Philipsson *et al.*, 2006).

During designing and implementing breeding programs, participation of farmers, management aspects (access to feed, water and health care), policy support and institutional commitment, understanding markets and marketing systems are pre-conditions.

2.6.1. Nucleus breeding programs

This scheme is based on the principle that in each herd there is a small number of genetically very superior animals which if brought together will form a nucleus whose average genetic merit is far greater than that in any of the contributing herds (Nicoll, 1976 cited in FAO, 1982). The important element in this scheme is, therefore, willingness of a group of farmers to pool their high performing animals. Once the nucleus herd is assembled, an efficient system of recording and selection is implemented. The selected animals (typically male animals) will be distributed to participating farmers to disseminate the genetic superiority obtained at the nucleus to the base population. The nucleus can be categorized as open or closed. The open nucleus breeding scheme allows the flow of animals from the nucleus to the base population and vice versa, while the closed scheme allows only the flow of animals from the nucleus to the base population (Markos *et al.*, 2006; Aynalem *et al.*, 2011).

The main advantage in the nucleus scheme is that the genetic superiority of sire replacements coming into the base herds from the nucleus is far greater than what is achievable in each of the base herds. It is particularly attractive in situations where within-herd selection programs are ineffective because of small population size or inadequate technical skill (FAO, 1982). Nucleus breeding scheme had been implemented in a number of areas of Africa, some examples of which are Ankole cattle in Uganda, Sahiwal cattle in Kenya, Djallonké sheep in Côte d'Ivoire and Boer goat in South Africa have been found successful in improving the genetic worth of livestock. On the other hand, many nucleus breeding programs in tropics failed due to the lack of sustainable support and inadequate participation of farmers at the beginning of the program (Wollny, 2003; Kosgey *et al.*, 2006). In order to run such a program in a sustainable way it needs high infrastructure and technical input (Kosgey *et al.*, 2006).

2.6.2. Community based breeding programs

It is important to understand why developing countries generally have not been successful in sustaining structured genetic improvement activities. This is because of lack of technical and operational capacity, introduction of animal genetic resources from the developed countries without fully assessing their long-term implications, exclusion of livestock keepers from the breeding program, lack of detailed documentation on the operational plans and initiating genetic improvements with the short term projects (FAO, 2010). Another possible problem with breeding programs in developing countries is the frequently long and complicated bureaucracy involved in the supply of improved animals from the nucleus to participating farmers. The procedure is often subject to abuse by those in authority or those with powerful connections (Kosgey *et al.*, 2006). Limitation in human resource capacity, brain-drain, and professional commitment are also a serious bottleneck in developing countries impairing the relaying or continuous implementation of a breeding program.

Community based breeding programs (CBBPs) is a new approach of genetic improvement program proposed for the low input traditional smallholder farming system (Sölkner *et al.*, 1998; Kahi *et al.*, 2005; Aynalem *et al.*, 2011). Community is defined as the group of people having social, cultural and economic relationship based on common interest, goal, problems or practices shared interest and living in a well defined area (Aynalem *et al.*, 2009). Hence, CBBPs is defined as programs carried out by communities of smallholder farmers (villagers), often at subsistence level (Sölkner *et al.*, 1998). Different from the conventional top-down approach, CBBPs takes in account the indigenous knowledge of the communities on breeding practices and breeding objectives (Solomon *et al.*, 2013). Effecting a CBBPs is a process that requires a bottom-up approach (Mueller *et al.*, 2015), which necessitates that researchers and other development workers must fully understand the farmer's circumstances before the program is set up. CBBPs for a variety of livestock species has been established in different tropical countries. For instance in Ethiopia, CBBPs is designed for small ruminants (Solomon *et al.*, 2009; Gemed, 2010; Tadelle, 2010; Aynalem *et al.*, 2011; Solomon *et al.*, 2014).

The program has been found successful. For instance, body weights of Menz sheep at birth, 3 and 6 months of age increased by 0.42, 2.29 and 2.46 kg, respectively, in the third generation over the base generations though genetic progresses in reproductive traits of the breed were low (Tadelle *et al.*, 2012). In addition, in Bonga, selection of a ram from members accrues extra benefit. The ram will either be sold to other areas and fetch as much as birr 5000 or will be castrated and sold ensuring 50% marginal benefit of the ram. As such, members are keen to get their rams selected. However, poor commitment from management committees as well as selling selected breeding rams by members was indicated as a challenge in Menz and Horro (Zelalem *et al.*, 2015).

2.7. Identification of Breeding Objectives

One of the necessary steps in designing a breeding program is the identification of farmers' breeding objectives. Gameda *et al.* (2010) noted that definition of breeding objective should be the follow up activity after defining production system in designing genetic improvement programs. The breeding objective identifies traits that farmers want to be improved. Breeding objectives must be set at the national, regional or local levels by local stakeholders (and not by outsiders) to truly reflect the real needs of the area; farmers must support the direction of change (Ahuya *et al.*, 2005; Kosgey *et al.*, 2006; FAO, 2010). The ultimate goals of a breed at the macro-level should be expressed by agricultural development policy, market, production system of the country, region or locality (FAO, 2010). At the micro level the definition of breeding objectives means that the relative importance of improvement of different traits of the breed for a given production system must be determined (Groen, 2000). There are many participatory approaches used to describe breeding objectives of communities including participatory rural appraisal, choice experiment and ranking of live animals (own-flock and group animals ranking experiments) (Gameda *et al.*, 2010).

The recent developments in identification of breeding objectives where economic values from profit equations or bio-economic model are combined with preference-based method may increase farmer's acceptance of the breeding objectives and open the way for new approaches to the targeting of specific indices to assist genetic selection for niche market and production

situations within an industry (Nielsen *et al.*, 2014). A bio-economic modeling in livestock production systems presents the opportunity for incorporating some elements of human decision making and simulates the impact of such decisions using mathematical relationships produced from both biological and economic parameters (Rewe and Kahi, 2012).

Conventionally, breeding objectives aim at economic optimization which is achieved by the use of economic values for breeding objective traits. The economic value expresses the value of a unit change in the trait while keeping other traits under the aggregate genotype constant (Hazel, 1943; Beckman and van Arendonk, 1993). Economic values for breeding objective traits can be derived using profit functions or bio-economic modeling (Amer, 2006). In these approaches, economic values are derived as partial derivatives for a unit change of each trait in the breeding objective holding other traits constant (Solomon *et al.*, 2010b). This procedure requires: (a) definition of the production and marketing systems (b) identification of sources of revenue and expenses (c) identification of breeding objective traits (determining biological traits that affect revenue and costs) and finally, (d) deriving economic value of each trait. Economic values show the relative importance of traits in a given production system and they are important in selection index theory where the aggregate genotype is defined as a linear function of traits to be improved and each trait is multiplied by its economic weight.

2.8. Optimizing Alternative Breeding Schemes

Breeding planning combines all measures for developing and optimizing breeding programs, and it is always future-orientated (Herold *et al.*, 2012). Optimizing the different scenarios of the breeding program is useful procedure in evaluating the quality of breeding schemes through predicting selection response for the breeding objective traits and the economic return of the given scenario. Several computer programs have been developed to optimize breeding schemes. The models used to evaluate breeding schemes are either stochastic or deterministic models. The stochastic approach uses overlapping generations and allows for great flexibility in the design of breeding programs, but the large volumes of data allow only simulating one trait at a time. Deterministic method uses deterministic equations and population parameters to predict gain and inbreeding. ZPLAN and SelAction are the most commonly used computer

programs that use deterministic method. ZPLAN was first developed by Karras (1984), and was further developed by Nitter and Graser (1994). Using the gene-flow method and selection index procedures, the program enables to simulate different breeding plans in any livestock species. It can be applied for programs with several sub-populations, for populations used in a crossbreeding scheme and it considers several tiers in the scheme such as nucleus, multiplier and production levels (Willam *et al.*, 2008). ZPLAN calculates economic gains of the breeding program. It also calculates discounted return, costs and the profit of the breeding objective. The discounted return shows the monetary gain in terms of genetically improved animals in the population over the investment period. The discounted profit is calculated as the difference between the discounted return and the discounted costs. To be able to estimate the realistic discounted profit, ZPLAN requires the fixed and/or variable costs of the breeding program. The program and the documentation are being continuously expanded and updated (Willam *et al.*, 2008). A further development of this software for commercial utilization is released on the market under the name ZPLAN+, which is web based and use friendly.

SelAction uses a deterministic approach to evaluate the selection response in livestock breeding by considering the rate of inbreeding within the monitored population. However, it does not provide the option for an economic assessment of the monitored breeding programs (Herold *et al.*, 2012).

3. GENERAL MATERIALS AND METHODS

This dissertation is based on survey work to characterize production and breeding systems of Begait goat (**Paper I**), monitoring study to evaluate some performance traits of the breed under on-farm and on-station managements (**Papers II and III**), identification of breeding objective of the breed keepers using own-flock ranking experiment and developing bio-economic models (**Paper IV**) and designing and evaluating alternative breeding schemes for optimizing genetic improvement program for the breed (**Paper V**). The summary of materials and methods of the study are given in this section, but the detailed descriptions of materials and methods are presented under the respective papers appended.

3.1. Description of the Study Area

The study was conducted in Kafta Humera district of western zone of Tigray National Regional State (Figure 1). The study area was selected purposively based on its potential for Begait goat population and its distribution. The study district covers about 717650 hectare out of which 54.20% is arable. Humera town (now Setit Humera town), special district, is the capital of Kafta Humera district and western zone of the region. The town was founded at the end of 1880s during Menelik II regime. In addition to the official language Tigrigna, other languages *viz.* Amharic, Arabic and English (in rare cases) are spoken. At present, skin of the town extends on over 2000 hectare and it is a resident of above 31,000 settlers.

The study area is situated 1372 km northwest of Addis Ababa. Geographically, it is located in between latitudes 13°14'-14°27'N and longitudes 36°27'-37°32'E. The study area comprises *kolla* (lowland) and *weinadega* (midland) agro-climatic zones with an altitude ranging from 560-1849 meters above sea level. Kafta Humera district is subdivided in to 21 *kebeles* (the smallest administrative unit in Ethiopia) having own *kebele* towns.

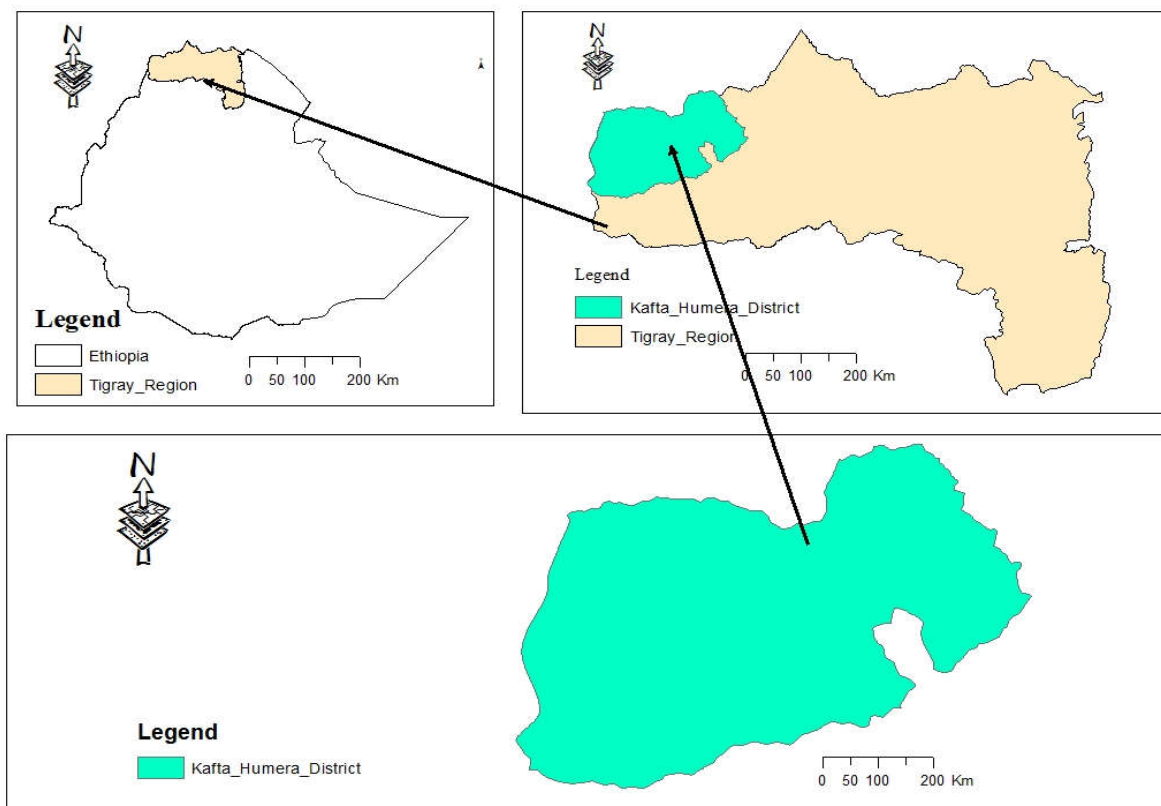


Figure 1. Map of the study area

3.2. Survey Study

Survey method was used for Paper I. Prior to site selection, livestock experts in the district were contacted for brief discussions and secondary data were reviewed to better understand the prevailing production system and the area dominated by Begait goat. Hence, the special district (Setit Humera town) and four rural *kebeles* were chosen purposively as study sites. A total of 150 Begait goat owning farmers (100 small-scale (owning up to 40 goat flock) and 50 large-scale (owning up to 215 goat flock)) were chosen randomly. Interviews were conducted at the farmers' residences using structured questionnaires. The questionnaires were pre-tested prior to commencement of interview and all necessary rearrangements were made to make sure that farmers easily understand it. The questionnaires covered information on general household characteristics, livestock possession, flock structure, purposes of keeping goat, breeding practices, marketing system and production constraints. Data were collected by the

researcher with the support of *kebele* development agents. To complement and cross-check the data gathered from individual interviews, focus group discussions were held with key informants. General information about the study district was obtained from published and unpublished secondary data sources.

3.3. Monitoring Study

Flock monitoring study (**Papers II and III**) was conducted on village flocks (on-farm study) and on flocks at Humera Begait animal species conservation, breeding and improvement center (on-station study). Reproductive and productive performance traits were evaluated. Data were collected in the period between October 2014 and December 2016. Traits recorded on does included: data on kidding date, litter size, daily milk yield, lactation length and parity number. Additionally, age at puberty and age at first kidding were recorded for those animals with known birth date. Traits for kids included: sex, weight at birth and at subsequent stages (3, 6, 9 and 12 months). Body weight of kids was taken using a suspended spring balance having 50 kg capacity with 0.2 kg precision. Pre- and post-weaning growth rates were determined based on these weight records (for detailed descriptions see **Paper II** appended).

During the on-station milk data collection, kids had free access to their mothers for the first week after kidding. Starting from the second week until dams refused their kids to suck milk, complete hand milking of both teats was made twice a day in the morning and in the evening using enumerator recruited on the ranch. On-farm, milking was done once a day in the morning starting from 7th day of kidding till the end of lactation. Daily milk yield was then estimated for each doe, multiplying the morning milk yield by 2. Data were collected by farmers with a close supervision of the researcher (detailed procedures are given in **Paper III**).

3.4. Identification of Breeding Objective

The present study identified breeding objective traits using own-flock ranking experiment and developing bio-economic models, which are adopted from Tadelle (2010) and Solomon *et al.*

(2010b), respectively. Under the own-flock ranking experiment, fifty five Begait goat owning farmers (thirty five small-scale and twenty large-scale) were visited early in the morning at their homesteads before animals were released for grazing. The family members asked to rank their best breeding does, with reasons, in terms of superiority for achieving their objectives in goat production. Reasons for the ranking were recorded. The same procedures were followed for the second and third best does, and the most inferior doe within each monitored flock. Life history, body weight and some linear body measurements were taken on the identified does. Bio-economic models relating different breeding objective traits with the components of production and marketing in subsistence Begait goat production system were constructed. The models were constructed using Excel spread sheet program. Details of the methodologies are given under **Paper IV**.

3.5. Description of Alternative Breeding Schemes

In the current study, we evaluated three alternative breeding schemes for annual genetic and economic gains and operational feasibility. These breeding schemes included: a) government ranch breeding scheme b) commercial breeding scheme and c) cooperative village breeding scheme. Scheme a and b were central nucleus-based breeding schemes that are designed to serve the entire Begait goats, while scheme c was one-tier breeding scheme based in villages and designed to serve Begait goats that are kept by small-scale farmers. Nucleus size of all the breeding schemes simulated was designed to be 5% of the base populations (**Paper V**).

The population parameters were number of breeding does, mating ratios, age at first kidding, number of kids per doe per kidding, productive lifetime and survival rates. Estimated genetic as well as phenotypic parameters (heritabilities and correlations) were derived from published reports of indigenous and exotic small ruminants. However, phenotypic standard deviations of the traits were calculated from monitoring study of the breed (**Papers II and III**).

Relating to costs, additional selection costs to the normal management system were calculated as cost parameters. These costs relate to data recording (enumerator, animal identification, stationary and weighing balance) costs. These were calculated for all schemes. In addition,

data analysis (animal breeding expert and electronic data processing) costs were calculated for government ranch and commercial breeding schemes since candidates are ranked according to their estimated breeding values. However, complex data processing expertise and related costs were not included for cooperative village breeding scheme since candidates are selected using mass selection and farmers' assessment. Costs were computed per doe per year using local currency (Birr) (**Paper V**).

3.6. Data Analysis

Data collected through questionnaire were entered and analyses were made by using SPSS (version 16.0, 2007). Statistical analyses including frequency, percentages, mean and standard deviation were used to describe questionnaire data. Statistical significance was tested using F test. Indices were calculated for all ranked variables (reasons of keeping goat, selection criteria and production constraints) using the formula: Index = sum of (3x for rank 1 + 2x for rank 2 + 1x for rank 3) given for a particular reason divided by the sum of (3x for rank 1 + 2x for rank 2 + 1x for rank 3) for overall reasons (Kosgey, 2004) (**Paper I**).

General Linear Model (GLM) procedure as implemented in SAS (2008) was employed to analyze the data generated from monitoring study (**Papers II and III**). The Tukey's HSD test of the same software was used to establish significantly different means for all significantly different fixed effects. Fixed effects evaluated for growth traits were management system (semi intensive, extensive), kid sex (male, female), parity order (1, 2, 3, 4), birth type (single, twin, triplet) and birth season (wet, dry), whereas for reproductive parameters management system, birth type, parity number and birth season were used as fixed effects. For litter size, the model included only management system, parity number and birth season (**Paper II**). For milk production parameters: management system, parity number and birth season were included in the model (**Paper III**). Data obtained from the own-flock ranking experiment was analyzed using the frequency procedure implemented in SAS (2008) statistical software (**Paper IV**). Proportions of traits preferred by owners were analyzed using the frequency procedure. The body measurements and other traits from the life history were analyzed using the GLM procedure. Marginal economic value of the traits was calculated developing bio-

economic models (**Paper IV**). Marginal economic value for a given trait was estimated as the change in profit resulting from an increase in one additive genetic standard deviation of the trait of interest while keeping all other traits constant. Economic values were calculated using Excel Tool (Solomon, 2017). Three alternative schemes were designed and evaluated using the computer program ZPLAN (Willam, *et al.*, 2008) (**Paper V**). Using the gene flow method and selection index procedures, ZPLAN enables to simulate different breeding schemes by deterministic approach. ZPLAN calculates genetic gain for aggregate genotype, the annual response for each trait, discounted return and discounted profit for a given investment period.

4. GENERAL RESULTS

The current study characterized and described Begait goat production and breeding systems, evaluated performance parameters under on-farm and on-station managements and identified breeding objectives of the breed owners by using preference method and by developing bio-economic models that were used as baseline data while designing and evaluating alternative breeding schemes for optimizing its breeding program in western Tigray, northern Ethiopia. Summary of main results obtained are presented below, whereas the detail can be referred in respective papers/manuscripts appended.

4.1. Household Information

The small-scale and large-scale farm household heads interviewed were similar in most of the characteristics assessed. Overall, 99% and 98% of the respondents were males and married, respectively. About two-third (69.67%) of them were literate. Overall mean (\pm SD) of age of household heads and family size was 50 ± 10.44 years and 5.85 ± 0.89 persons, respectively. Average land holding of sampled small-scale and large-scale farmers during data collection period (2014) was approximately 4.10 and 86.90 hectare, respectively. These figures indicate only privately owned arable land. For grazing, communal grazing areas were used (**Paper I**).

4.2. Goat Production and Breeding Systems

Agricultural production system in the study area was mixed crop-livestock production system. The study showed that there were two types of farming systems in the area: small-scale and large-scale based farming systems. Small-scale farmers own relatively small arable land that ranged between 1.50 and 19 hectare, while large-scale farmers cultivate from 20-600 hectare. The two most common food and cash crops grown in the study area are sorghum and sesame. Cropping was totally dependent on rainfall. Small-scale and large-scale farmers kept a mix of livestock species that constitute goats, sheep, cattle, donkeys and chicken. The results showed that there was a growing trend of livestock ownership from small-scale to large-scale farming systems. Small-scale and large-scale farmers kept from 9-40 and 41-215 goats, respectively.

Livestock production plays a major role for the household's economy. Among the livestock species, the role of goat as source of cash income was the primary reason of keeping goats, while milk and meat for home consumption were ranked as second and third most important traits under the two farming systems with different index values (**Paper I**).

Farmers practiced mixed-species stocking (herding goats with sheep). Goats and sheep were herded together on communal grazing areas by hired keepers or the young boys in the family. The respondent farmers indicated that natural pasture, browse species, crop residue and crop aftermath were main feed resources for goat. In wet season, farmers reported that they used mineral salt supplementation. The main sources of water supply included: rivers, ponds and borehole. Interviewed farmers take goats to water source every day. In dry season, however, animals travelled long distance to reach water source. Goats were housed together with sheep. The results revealed that there is no definite goat breeding season in the study area. Most of the farmers kept their own bucks, those without it used the neighbors' at no cost or buy from market. Water shortage, feed and grazing land shortage, poor veterinary services and lack of market demand were the most important goat production constraints identified in the study area (**Paper I**).

4.3. Performance Parameters

Overall, performance parameters of livestock are classified in to reproductive and productive traits. Under the current study, therefore, economically pertinent reproductive and productive performance traits of Begait goats were monitored under on-farm and on-station management conditions (**Papers II and III**).

4.3.1. Growth and reproductive performances

The overall least squares means (\pm SE) of body weights at birth (BW), three month (3MW), six month (6MW), nine month (9MW) and twelve month (12MW) of Begait goats were 2.69 ± 0.03 , 10.71 ± 0.44 , 15.60 ± 0.53 , 18.30 ± 0.43 and 22.36 ± 0.52 kg, respectively. The overall estimated pre-weaning daily weight gain (ADG-I) was 89.10 ± 1.54 g/day, while post-weaning

daily weight gain (ADG-II) was 54.24 ± 1.75 g/day. Under the present study, different non-genetic factors were shown to significantly affect growth of Begait kids differently. All body weights and weight gains were significantly ($p < 0.001$) affected by management system. The least squares means (\pm SE) for body weights at birth and at subsequent stages (3, 6, 9, and 12 month) of Begait goats under semi intensive management were 2.81 ± 0.04 , 11.12 ± 0.43 , 16.45 ± 0.49 , 19.58 ± 0.37 and 24.13 ± 0.48 kg, respectively while the least squares means (\pm SE) for ADG-I and ADG-II were 92.57 ± 1.57 g/day and 59.18 ± 2.01 g/day, respectively. The corresponding values for body weights in extensive management were 2.59 ± 0.03 , 10.32 ± 0.46 , 14.76 ± 0.57 , 17.06 ± 0.49 and 20.62 ± 0.54 kg, while ADG-I and ADG-II were 85.72 ± 1.88 g/day and 49.39 ± 2.81 g/day.

Male kids were heavier at birth and at subsequent stages (3, 6, 9 and 12 month), and ADG-I and ADG-II as compared to the female kids. The effect of birth type on the body weights and weight gains of kids at different ages was highly significant. Single kids were heavier than twins and twins than triplets. Parity number had highly significant ($p < 0.001$) effect on BW, 3MW and ADG-I, but its effect on 6MW, 9MW, 12MW and ADG-II was not significant ($p > 0.05$). Regarding birth season, kids born during wet season had larger body weights (BW, 3MW and 6MW) and weight gains (ADG-I and ADG-II) as compared to those kids born in dry season. However, there was insignificant difference in body weights at 9MW and 12MW in relation to birth season. The overall means of age at puberty, age at first kidding (AFK) and kidding interval (KI) were 214.58 ± 1.20 , 429.24 ± 6.46 and 238.75 ± 2.04 days, respectively. Litter size at birth (LS) in the current study ranged from 1-3 with the mean of 1.52 ± 0.02 kids. Management system and birth type had highly significant ($p < 0.001$) effect on age at puberty, AFK and KI. Age at puberty, AFK and KI were 209.93 ± 1.65 , 415.09 ± 9.01 and 233.77 ± 3.12 days under semi intensive management whereas 219.00 ± 1.63 , 444.33 ± 9.09 and 242.79 ± 2.66 days under extensive management, respectively. However, results of the study showed the effect of management system was not significant on LS (1.53 ± 0.03 Vs 1.51 ± 0.03). Effect of parity number and birth season was highly significant ($p < 0.001$) on LS. Larger LS was obtained during wet season from large parities (**Paper II**).

4.4.2. Milk production

Milk production performances including daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL) were evaluated under different management systems. The overall least squares means (\pm SE) of DMY, LMY and LL were 0.61 ± 0.01 kg, 64.3 ± 1.23 kg and 104 ± 1.22 days, respectively. The effect of management system and other non-genetic factors included in the model (parity number and birth season) was highly significant ($p < 0.001$) on all milk production traits. Under semi intensive management the DMY, LMY and LL were 0.75 ± 0.01 kg, 85.6 ± 1.04 kg and 111 ± 1.21 days, respectively while the corresponding figures under extensive management were 0.55 ± 0.01 kg, 56 ± 1.43 kg and 101 ± 1.21 days (**Paper III**).

4.5. Breeding Objective Identification

4.5.1. Using own-flock ranking experiment

Various traits were listed by the farmers as preferred traits of breeding does indicating the multi-functional role of goat in the area. Overall, body size (21.25%) was considered the most crucial trait, followed closely by twinning ability (multiple-birth) (20.00%), daily milk yield (18.13%) and pre-weaning kid survival (11.25%). Other important traits considered by the farmers included: good mothering ability (9.38%), drought resistant (5.00%), kidding interval (4.38%), kid weight at birth and kid sex with equal index value (3.75%), udder size (1.88%), beauty and good temperament with equal index value (0.63). The breeding does grouped as best had higher mean values for all measured traits (body weight, body length, chest girth, daily milk yield and age) when compared to the animals classified as poor doe (**Paper IV**).

4.5.2. Using bio-economic model

Marginal economic values for 7 traits (six month weight, average daily weight gain, mature body weight of doe, litter size, pre-weaning kid survival rate, kidding interval and daily milk yield) were calculated by developing bio-economic models. Economic values of all the traits exclusive of mature body weight of doe were positive meaning a unit increase in genetic merit

of these traits had a greater weight on revenues than costs. Among the considered traits, litter size had the highest economic value followed by six month weight, pre-weaning kid survival rate and daily milk yield (**Paper IV**). This showed that results of the two methods were in close agreement. Use of these methods concurrently, therefore, helps in identifying precise breeding objective traits and calculating economic values that are used by ZPLAN computer program for further analysis.

4.6. Design of Alternative Breeding Schemes

Three alternative breeding schemes, two central nucleus-based (scheme a and b) and one village-based (scheme c): a) government ranch breeding scheme b) commercial breeding scheme and c) cooperative village breeding scheme were evaluated based on annual genetic gain, discounted profitability and operational feasibility (**Paper V**). The results revealed that annual genetic gain of central nucleus-based schemes were higher when compared to that of village-based scheme. The highest predicted annual genetic gain was obtained from six month weight under all the evaluated schemes, which was in the range of 0.7590 and 0.6747 kg. All the evaluated schemes resulted in a positive marginal profitability. The highest profitability was, however, predicted from the central nucleus-based schemes because of a higher genetic gain due to the fact that selection was based on BLUP estimated breeding values compared to selection on phenotypes under the village-based scheme. In general, all the evaluated schemes resulted in considerable improvements and profitability of the breeding program.

From operational feasibility point of view, the government ranch breeding scheme seems to be more operationally feasible since government is investing more on the breed since the last six years. The ranch was established aiming on conservation, breeding and improvement of all Begait animal species including goat, sheep and cattle. It is now operational and a roadmap for all these animals has been already developed. Therefore, this can be considered as good opportunity. When the ranch is unsuccessful, commercial central nucleus-based and village-based breeding schemes are implementable considering their limitations.

5. GENERAL DISCUSSION

Results of **Paper I** indicated that agricultural production system in the area was mixed crop-livestock production system. The production system was performed by small-scale and large-scale farmers. The two farming systems differed in cropland holding and livestock ownership, which was in line with the findings of Yohannes (2018) in northwestern lowlands of Amhara region. Goat production was part of the existing farming systems. Both small-scale and large-scale farmers kept moderately larger flock sizes, which can be considered as good opportunity for designing and implementing village-based and central nucleus-based breeding programs in the area, respectively. The reason for keeping goat was similar under the existing farming systems. The main reason was to generate cash income, which was in agreement to the results reported by other researchers (Adane and Girma, 2008; Kosgey *et al.*, 2008; Assen and Aklilu, 2012), who reported that cash income as the most important reason in goat farming. Also goat's meat and milk were used as source of food by both small-scale and large-scale farmers. This could be due to the fact that goats are not subjected to religious taboos and also indicate their role in the area.

The obtained results, thus, clearly indicated that goat farming is seen as an option to generate income through sale of live animals, but also contributes to household consumption through meat and milk production. The conclusion is made that the main breeding objective for both farming systems is to increase meat and milk production. On the other hand, the high literacy rate obtained was strength in enhancing goat production since literate communities are more likely adopt new technologies, which may enhance commercialization of enterprises. High literacy rate in the area was similar with reports from other areas (Endeshaw, 2007; Belete, 2009).

Based on the survey results and personal observations, the main feed resource for goat in the study area were natural pasture and browsing species during dry and wet seasons. This was as rangelands provide the major source of feed during wet and dry seasons, and extensive system of grazing was the only grazing practice in the area all over the year. Goats were herded and housed together with sheep. During night, they were housed with shelter constructed by using

locally reachable and cheap materials. This result was in disagreement with results of other studies elsewhere in Ethiopia (Belete, 2009; Dereje, 2011; Feki, 2013), who reported presence of separate housing of small ruminants. Mating was random with uncontrolled manner. Goats usually grazed in mixed sex groups and does could be bred at any time of the year, therefore, kids were born all the year round though the most common months of the year with frequent births were between October and November. Free and uncontrolled mating practices and occurrence of births throughout the year in the present study is in agreement with Mengistie *et al.* (2013). In the current study, farmers' selection of breeding stock gave more weight for body conformation. Unfortunately, they cannot tell much about the future productivity of an animal simply by looking at it. Ideally, selection should be the combination of visual appraisal and evaluation of performance records (**Paper I**).

As revealed in this study utilization of breeding buck/s born within the flock, uncontrolled mating, lack of awareness about inbreeding and small flock size may lead to accumulation of inbreeding and decreased genetic diversity (Jaitner *et al.*, 2001; Kosgey, 2004). However, communal grazing practiced by the Begait goat owners in both production systems allows breeding females to mix with males from other flock. This can reduce the risk of inbreeding by increasing the effective population size (Jaitner *et al.*, 2001).

The effective population size (N_e) and the rate of inbreeding coefficient (ΔF) were calculated for Begait goat flock considering the existing flock size. Under random mating and when goat flocks of a household were not mixed, N_e and ΔF were found as 6.86 and 0.07 under small-scale farming system, respectively. The corresponding figures under large-scale farming were 8.68 and 0.06, respectively. In both cases, the level of inbreeding was close to the maximum acceptable level of 0.063 (Armstrong, 2006).

Good understanding of production constraints in the area is pertinent for genetic improvement of Begait goats. It is apparent that the problems facing goat production in the area are many, however, water shortage, feed and grazing land shortage, poor veterinary services and lack of organized marketing system were the most important like in many other developing countries. These findings are supported by Egbe Nweji *et al.* (1999) and Omoike (2006), who reported

that the major problems of small ruminant rearing are inadequate supply of water and pasture especially during dry season and problems arising from inadequate veterinary services and infrastructure. Kosgey (2004) also noted that small ruminant production is constrained by low management level, disease and parasites, inadequate feed and poor marketing (**Paper I**).

The growth and reproductive performances of Begait goat were relatively better as compared to other indigenous goats (Deribe, 2008; Hailu *et al.*, 2008; Belay and Mengistie, 2013; Mohammed *et al.*, 2013; Hulunim, 2014); however, they were affected by the non-genetic factors studied (management system, kid sex, parity number, birth type and birth season) (**Paper II**). High body weight traits (BW, 3MW, 6MW, 9MW and 12MW) in semi intensive management may be attributed to better nutrition and other management practices. These agreed with findings of earlier researchers (Zealelem and Anal, 2014), who reported that improper feeding extremely affects the growth rate and body energy reserve of animals. The difference in body weights because of sex at all growth stages in the present study is similar with that reported by Momoh *et al.* (2013). This difference may result due to differences in sexual chromosomes, possibly in the position of genes related to growth, physiological characteristics and difference in endocrinal system, which lead to differences in animal growth (Momoh *et al.*, 2013) (**Paper II**).

Single born kids were heavier than twins and twins than triplet kids, which were consistent from birth to 12 month. For traits, such as body weight or growth rate, it has been frequently reported that usually singles are heavier than multiple born at different stages of growth and have higher growth rate in different growth phases (Baneh and Hafezian, 2009; Kesbi and Tari, 2015). This is due to the fact that singles had the advantage over the twins and triplets because of absence of intra natal competition for the nutrients resulting in higher birth weight. Robinson *et al.* (1977) indicated that heaviest weights of single births at later weights in comparison with twin and triple births could be related to their weights at birth. Hailu *et al.* (2008) also indicated that the birth weight influenced the growth rate (weight gain) in the subsequent periods. Thus, birth weight of kids is regarded as one of the most important causal factors for improving growth performance of kids (**Paper II**).

Parity number had a significant effect on only BW, 3MW and ADG-I, but its effect on 6MW, 9MW, 12MW and ADG-II was insignificant. This is supported by research with sheep. Ebagi *et al.* (1996) indicated non-significant effect of parity of ewe on lambs' body weight at 6 and 9 month of age and noted that the effect of parity of ewe on lambs' growth performance up to weaning was more than in post-weaning performance. This can be due to the fact that, young dams continue growing during pregnancy and lactation hence competing with their foetus and kids respectively for the available nutrients (Sonola, 2015). Mothering ability also increases with age or parity and is related to body size and milk production, which is reflected on kids live body weights (Belay and Mengistie, 2013) (**Paper II**).

Birth season exerted significant effect on body weights at BW, 3MW and 6MW and weight gains, where higher body weights and weight gains were observed in wet season. This might be attributable to the availability of quality feed during wet season. This result is in agreement with Birtee *et al.* (2015), who reported that the higher growth rate and eventual body weight for wet season born kids might have resulted from accessibility of more succulent and nutritious feeds during wet season. In general, the significant effect of season of kidding on body weights reflects the differences in the availability of quality and quantity of feeds. However, birth season had no significant effect on 9MW and 12MW (**Paper II**).

Animals kept under semi intensive management, singles and wet season born female kids reached puberty and gave birth at younger ages. KI for does in semi intensive management and for those single kidded in wet season was short. This showed that the importance of feed on reproductive performance of does. However, parity number showed no effect on these traits, but it significantly influenced LS. LS of Begait goat gradually increased with parity. This may be due to improved efficiency of reproduction as the doe matures (Levasseur and Thibault, 1980). Birth season significantly affected LS, does that kidded in wet season recorded larger LS compared to dry season kidders. This result was in agreement with Hailu *et al.* (2008). Larger LS in wet season could be because of the availability of green grasses and browses, which resulted in higher body condition score and body weight during mating. This claim was confirmed by Amoah *et al.* (1996), who reported that improved mating weights of the dams significantly improved LS (**Paper II**).

The estimates for DMY, LMY and LL in the current study were comparatively higher when compared to different researchers' findings (Lemma *et al.*, 2003; Mohammed *et al.*, 2012) for other indigenous goats. This may be because of different factors such as breed performance and management, udder size and milking methods as well as milking frequency differences (Capote *et al.*, 1999; Salama *et al.*, 2003; Högberg, 2011; Mohammed *et al.*, 2012) (**Paper III**).

As expected management system affected the milk yields and lactation length. Lactating does in semi intensive management showed higher DMY, LMY and longer LL. This may resulted from better feeding and other management practices on-station. These results are in line with similar studies made by Berhane and Eik (2006). Parity number significantly affected DMY and LMY. Milk yields advanced with parity number. The increasing trend in milk yields with increasing parity order may be result of better udder development and growth in size of the animal. The shortest LL was recorded in parity one, in consistent with Carnicella *et al.* (2008). DMY, LMY and LL were significantly affected by birth season. This result may relate with the availability of feed during wet season and feed scarcity in dry season. Several authors attributed seasonal variations in milk yield to climatic conditions and/or availability of pasture (El-Abid and Abu Nikhaila 2010; Ishag *et al.*, 2012) (**Paper III**).

The study identified sound breeding objective traits for the breed that include a complete and concise definition of biological traits that are thought to be economically noteworthy under future production conditions in the area. Dekkers and Gibson (1998) reported that a clear and well-accepted breeding objective is an important feature for optimizing selection strategies. Breeding objectives are usually derived using bio-economic models. Preference based approaches also offer another means of assessing the appropriate values of desirable traits in breeding programs. Nielsen *et al.* (2014) suggested that the combination of bio-economic models and preference-based method increase farmer's acceptance of the breeding objective and open way for new approaches of targeting of specific indices to assist genetic selection for niche market and production situations within an industry. This indicates that concurrent use of own-flock ranking experiment and bio-economic models specifically, and the use of combination of methods overall avoids overlooking of any important question for selection.

Hence, defining appropriate breeding objectives to account for the perspectives of different key stakeholders requires a multidisciplinary approach. The present study also evaluated three alternative breeding schemes in terms of 1) annual genetic gain 2) profit and 3) operational feasibility to optimize breeding program for the breed (**Paper V**). The results obtained show that the genetic and economic gains increased with a rise in population size and using BLUP. Maximum amount of genetic and economic gains achieved in the central nucleus-based schemes because large flock size was considered and selection was based on estimated breeding values using BLUP. Similar to the results of the present study, it has been reported that accompanied with an increase in the population size and using BLUP estimated breeding values, genetic and economic gains also correspondingly increased (Gandini *et al.*, 2014; Borzi *et al.*, 2017).

The most optimal scheme involves two-tier central nucleus-based government ranch, resulting in reasonable genetic and economic gains and operational feasibility. Since the last six years, government is investing in conservation, breeding and improvement of Begait animal species. Presently, government also planned to export meat of these animals by the end of Growth and Transformation Plane III. As part of the plan, government developed roadmap aiming on performance improvement of these animals. These can be considered as good opportunities to start a big central nucleus-based breeding plan within a short period of time. Regardless of sensible results in annual genetic and economic gains, the commercial central nucleus-based and village-based breeding schemes seem to be operationally difficult. Essentially, these schemes are based on many genetically interlinked nucleus flocks, which depend on farmers' (large-scale and small-scale) participation and their commitment. Thus, this makes them more challenging to launch in a short period of time.

6. GENERAL CONCLUSIONS AND RECOMMENDATIONS

This study provides good insights into the existing production systems, reproductive and productive performances of the breed under on-farm and on-station management systems, defined breeding objectives of the breed owners and evaluated alternative designs of breeding programs for improving the genetic merits of Begait goats. The results revealed that economic stay of the population in the area is agriculture with mixed farming system that was performed by small-scale and large-scale farmers. Goat production in the area was an integral part of the mixed crop-livestock production system where it was reared for its multiple roles. The study showed that the mean household goat size is slightly larger. This might be due to the role of goat for the livelihood of farmers. The large goat flock sizes are fitting for designing village-based breeding programs as large flocks enable to increase selection intensity. It was also observed that there are large-scale farmers who owned more than 200 goats, which is a good chance to establish central nucleus-based breeding programs. Goat production in the study area is, however, constrained by different factors mainly water shortage, feed and grazing area shortage, poor veterinary services and lack of organized marketing system.

Monitoring studies revealed that productivity of Begait goat in terms of growth, reproductive and milk production was relatively better when compared to most of other local goat breeds. Almost all non-genetic factors studied (management, kid sex, birth type, parity number and birth season) significantly influenced these parameters. Breeding objective traits were 6MW, LS, DMY and SR that were identified using own-flock ranking experiment and developing bio-economic models. There was strong alignment between the two methods of identifying breeding objectives used.

The high economic significance of goat with large flock size in the study area suggests that designing sustainable and appropriate genetic improvement programs could have good possibility of success. Moreover, reasonably better reproductive and productive performances of Begait goat in the harsh environmental stresses would create an opportunity to improve the productivity of the breed by addressing the major production constraints. The poor breeding

practices such as uncontrolled breeding, mixed flock herding and negative selection of young males should also be addressed.

Sustainable breeding program that considers multifunctional roles of Begait goat in the area was designed. Three alternative breeding schemes: two central nucleus-based and one village-based schemes were simulated and all schemes resulted in better annual genetic and economic gains. Of the simulated breeding schemes, government ranch was recommended for genetic improvement of the breed under the defined production system as it is more operationally feasible when compared to the other schemes. On the other hand, the other two schemes can be used when government ranch is not successful.

FUTURE RESEARCH PRIORITIES

- ❖ The amount of milk suckled by kids and nutritional value analysis of milk were not measured due to budget limitations. Therefore, these activities need to be investigated.
- ❖ Future studies shall focus on non-genetic factors not measured by this study such as effect of year, month, doe weight, daily milking frequency etc.
- ❖ The current study revealed that Begait goats are known for their multiple-birth and the trait is among the identified breeding objective traits. Hence, molecular genetic studies should be future studies aiming on gene (s) identification that influence multiple-birth.
- ❖ In the present work, productive and reproductive performances of the breed were evaluated. Future works should focus on estimating (co)variance components and genetic parameters using several alternative animal models and estimate genetic and phenotypic relationships among these traits.
- ❖ Future research works should focus on setting up and evaluating the recommended breeding scheme.

7. REFERENCES

- Adane Hirpa and Girma Abebe. 2008. Economic Significance of Sheep and Goats. Economic significance of sheep and goats. In Yami Alemu, and Merkel, R.C. (eds.). Sheep and goat production handbook for Ethiopia. Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP), 1–4.
- Ahuya, C.O., Okeyo, A.M., Mwangi, N. and Peacock, C. 2005. Developmental challenges and opportunities in the goat industry: The Kenyan experience. *Small Ruminant Research*, 60: 197-206.
- Alayu Kidane, Surafel Melaku and Aynalem Haile. 2014. Characterization of goat population and breeding practices of goat owners in Gumara-Maksegnit watershed, north Gondor, Ethiopia. *Agricultural Journal*, 9(1): 5-14.
- Alexandre, G., Aumont, G., Mainuad, J.C., Fleury, J. and Naves, M. 1999. Productive performances of Guadeloupean Creole goats during the suckling period, *Small Ruminant Research*, 34: 155-160.
- Amer, P.R. 2006. Approaches to formulating breeding objectives. *Pages 31–38 in Proceedings of the 8th World Congress on Genetics Applied to Livestock Production*, Belo Horizonte, Brasil, Aug. 13–18, 2006.
- Amills, M., Capote, J. and Tosser-Klopp, G. 2017. Goat domestication and breeding: a jigsaw of historical, biological and molecular data with missing pieces. *Animal Genetics*, doi:10.1111/age.12598.
- Amoah, E.A., Gelaye, S., Guthrie, P. and Rexroad Jr., C.E. 1996. Breeding season and aspect of reproductive of female goat. *Journal Animal Science*, 74: 723-728.
- Argüello, A. 2011. Trends in goat research, a review. *Journal of Applied Animal Research*, 39(4): 429-434.
- Armstrong, J.B. 2006. Inbreeding: Why we will not do it? Accessed on December 25, 201 from <http://www.parispoodles.com/Inbreeding.html>.
- Assen Ebrahim and Aklilu Hailemical. 2012. Sheep and goat production and utilization in different agro ecological zones in Tigray, Ethiopia. *Livestock Research for Rural Development*, 24(1).

- Aynalem Haile, Markos Tibbo, Gemedu Duguma, Tadelles Mirkena, Okeyo, M., Iniguez, L., Wurzinger, M. and Sölkner, J. 2009. Community-based sheep breeding: a new approach to genetic improvement. pp.291-300 In: *Tamrat Degefa and Fekede Feyissa (eds). Proceedings of the 16th Annual conference of the Ethiopian Society of Animal Production (ESAP)*, October 8-10, 2008. Part II Technical Session. ESAP, Addis Ababa, Ethiopia.
- Aynalem Haile, Wurzinger, M., Mueller, J., Tadelles Mirkena, Gemedu Duguma, Mwai, M., Sölkner, J. and Rischkowsky, R. 2011. Guidelines for setting up community-based sheep breeding programs in Ethiopia. ICARDA - tools and guidelines No.1. Aleppo, Syria, ICARDA.
- Aziz, M.A. 2010. Present status of the world goat populations and their productivity. *Lohmann information*, 45(2): 42-52.
- Baneh, H. and Hafezian, H. 2009. Effects of environmental factors on growth traits in Ghezel sheep. *African Journal of Biotechnology*, 8: 2903-2907.
- Banerjee, A.K., Animut, G. and Ermias, E. 2000. Selection and breeding strategies for increased productivity of goats in Ethiopia. In: Merkel, R.C., Abebe, G. and Goetsch, A.L. (Eds.), *The opportunities and challenges of enhancing goat production in east Africa*, pp. 70-79. Debu University, Awassa, Ethiopia, 10-12 November, 2000
- Beckman, H. and van Arendonk, J.A.M. 1993. Derivation of economic values for veal, beef and milk production traits using profit equations. *Livestock Production Science*, 34: 35-56.
- Belay Deribe. 2008. Growth, Reproductive Performance and Carcass Characteristics of Abergelle and Central Highland Goat types under Traditional and Slightly Improved Management in Sekota woreda. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia.
- Belay Deribe and Mengstie Taye. 2013. Evaluation of growth performance of Abergelle goats under traditional management systems in Sekota district, Ethiopia. *Pakistan Journal of Biological Sciences*, 16(14): 692-696.
- Belay Deribe and Mengstie Taye. 2014. Reproductive performance of Abergelle goats raised under traditional management systems in Sekota district, Ethiopia. *Iranian Journal of Applied Animal Science*, 4(1): 59-63.

- Belete Shenkute. 2009. Production and marketing systems of small ruminants in Goma district of Jimma zone, western Ethiopia. M.Sc. thesis, Hawassa University, Awassa, Ethiopia.
- Berhane Gebreyohannes and Eik, L.O. 2006. Effect of vetch (*Vicia sativa*) hay supplementation on performance of Begait and Abergelle goats in northern Ethiopia I. Milk yield and composition. *Small Ruminant Research*, 64: 225–232.
- Birtee, P.T., Danquah, B.A. and Salifu, A.S. 2015. Growth performance of West African Dwarf goats reared in the transitional zone of Ghana. *Asian Journal of Animal Sciences*, 9(6): 370-378.
- Brito, L.F., Silva, F.G., Melo, A.L.P., Caetano, G.C., Torres, R.A., Rodrigues, M.T. and Menezes, G.R.O. 2011. Genetic and environmental factors that influence production and quality of milk of Alpine and Saanen goats. *Genetics and Molecular Research*, 10(4): 3794-3802.
- Capote, J., Lopez, J.L., Caja, G., Peris, S., Arguello, A. and Darmanin, N. 1999. The effects of milking once or 2x daily throughout lactation on milk production of Canarian dairy goats. In: *Milking and milk production of dairy sheep and goats*. Barillet, F. and Zervas, N.P. (Eds.). Wageningen, Netherlands. pp. 267-273.
- Carnicella, D., Dario, M., Ayres, M.C.C., Laudadio, V. and Dario, C. 2008. The effect of diet, parity, year and number of kids on milk yield and milk composition in Maltese goat. *Small Ruminant Research*, 77:71–74.
- Dekkers, J.C.M. and Gibson, J. 1998. Applying breeding objectives to dairy cattle improvement. *Journal of Dairy Sciences*, 81 (2): 19-35.
- Dekkers, J.C.M., Gibson, J.P., Bijma, P. and van Arendonk, J.A.M. 2004. Design and optimization of animal breeding programs. Iowa State university lecture notes.
- Dereje Tadesse, Mengistu Urge, Getachew Animut and Yoseph Mengesha. 2015. A review of productive and reproductive characteristics of indigenous goats in Ethiopia. *Livestock Research for Rural Development*, 27(34).
- Dereje Tsegaye. 2011. Community-based characterization of Hararghe HighLand goats in Darolabu district western Hararghe Ethiopia. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia.

- Deribe Gemiyu. 2009. On-farm performance evaluation of indigenous sheep and goats in Alaba, southern Ethiopia. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia.
- Dhara, K.C., Ray, N., Taraphder, S. and Guha, S. 2012. Milk production performance of Black Bengal goats in West Bengal. *International Journal of Livestock Production* 3(2): 17-20.
- Ebangi, A.L., Nwakalor, L.N., Mba, D.A. and Abba, D. 1996. Factors affecting the birth weight and neonatal mortality of Massa and Fulbe sheep breed in a hot and dry environment of Cameroon. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux*, 49:349-353.
- Egbe-Nwiyi T.N.C., Igbjekwe, F.N. and Nwosu C. O. 1999. Gastro-Intestinal Parasitism and Associated Haematological Changes in Small Ruminants in the Semi arid region of north-eastern Nigeria. *Bulletin of Animal Health and Production in Africa*, 47(2): 61-70.
- El-Abid, K.E. and Abu Nikhaila, A.M.A. 2010. A study on some non-genetic factors and their impact on milk yield and lactation length of Sudanese Nubian Goats. *Australian Journal of Basic and applied Sciences*, 4(5): 735-739.
- Endeshaw Assefa. 2007. Assessment on production system and marketing of goats at Dale district (Sidama Zone). M.Sc. thesis, Hawassa University, Hawassa, Ethiopia
- Falconer, D.S. and Mackay, T.F.C. 1996. Introduction to quantitative genetics. Fourth edition. Pearson Education Limited, Essex, UK.
- FAO (Food and Agricultural Organization of the United Nations). 1982. Breeding plans for ruminant livestock in the tropics. FAO *Animal Production and Health* paper 34. Rom, Italia
- FAO (Food and Agricultural Organization). 1995. World Livestock Production systems: Current status, issues and trends. Animal production and health paper.
- FAO (Food and Agriculture Organization of the United Nations). 2010. *Breeding strategies for sustainable management of animal genetic resources*. FAO Animal Production and Health Guidelines 3. FAO Rome, Italy.
- FAOSTAT. 2014. <http://faostat.fao.org/default.aspx>. Accessed on February 25, 2017.
- Feki Misbah. 2013. Community-based characterization of Afar goats breeds in Aysaita district of Afar region. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia

- Galal, S. 2005. Biodiversity in goats. *Small Ruminant Research*, 60: 75-81.
- Farm-Africa, 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (International Livestock Research Institute), Nairobi, Kenya
- Gandini, G., Del Corvoa, M., Biscarinic, F. and Stella, A. 2014. Genetic improvement of small ruminant local breeds with nucleus and inbreeding control: a simulation study. *Small Ruminant Research*, 120: 196-20.
- Gemeda Duguma. 2010. Participatory definition of breeding objectives and implementation of community based sheep breeding programs in Ethiopia. Doctorial dissertation, Austrian University of Natural Resource and Applied Sciences (BOKU), Vienna, Austria.
- Gemeda Duguma, Tadelles Mirkena, Aynalem Haile, Iñiguez, L., Okeyo, A.M., Markos Tibbo, Rischkowsky, B., Sölkner, J. and Wurzinger, M. 2010. Participatory approaches to investigate breeding objectives of livestock keepers. *Livestock Research for Rural Development*, 22(4).
- Getachew Legese and Mohamadou Fadiga. 2014. Small ruminant value chain development in Ethiopia: Situation analysis and trends. ICARDA/ILRI Project Report. Nairobi, Kenya: International Center for Agricultural Research in the Dry Areas/International Livestock Research Institute
- Getinet Mekuriaw. 2016. Molecular characterization of Ethiopian indigenous goat populations: genetic diversity and structure, demographic dynamics and assessment of the kisspeptin gene polymorphism. Doctorial dissertation, Addis Ababa University, Addis Ababa, Ethiopia.
- Goddard, M.E. 1998. Consensus and debate in the definition of breeding objectives. *Journal of Dairy Science*, 81(2): 6-18.
- Greyling, J.P.C. 2000. Reproduction traits in the Boer goat doe. *Small Ruminant Research*, 36: 171-177.
- Groen, A.F. 2000. Definition of breeding goal. In: Galal, S., Boyazoglu, J. and Hammond, K. (eds). *Developing Breeding Strategies for Lower Input Animal Production Environments*. The International Committee for Animal Recording (ICAR), No. 3, 25-104.

- Hagos Abraham, Solomon Gizaw and Mengistu Urge. 2017. Begait goat production systems and breeding practices in Western Tigray, North Ethiopia. *Open Journal of Animal Sciences* 7(2): 198-212.
- Hailu Dadi, Gameda Duguma, Shelima, B., Takele Fayera, Million Tadesse, Tatek Woldu and Tesfaye Alemu. 2008. Non-genetic factors influencing post-weaning growth and reproductive performances of Arsi-Bale goats. *Livestock Research for Rural Development*, 20(3).
- Hanford, K.J., van Vleck, L.D. and Snowder, G.D. 2006. Estimates of genetic parameters and genetic trend for reproduction, weight, and wool characteristics of Polypay sheep. *Livestock Science*, 102: 72-82.
- Hazel, L.N. 1943. The genetic basis for construction of selection indices. *Genetics*, 28: 476-490.
- Hirst, K.K. 2017. The domestication history of goats (*Capra hircus*). Accessed on February 08, 2017.
- Högberg, M. 2011. Milk yield and composition in Swedish landrace goats (*Capra hircus*) kept together with their kids in two different systems. M.Sc. thesis, Swedish University of Agricultural Sciences (SLU). pp 29.
- Hulunim Gatew. 2014. On-farm phenotypic characterization and performance evaluation of Bati, Borena and Short-Eared Somali Goat Populations of Ethiopia. M.Sc. thesis, Haramaya University, Haramaya, Ethiopia
- IBC (Institute of Biodiversity Conservation). 2004. The State of Ethiopia's farm animal genetic resources: country report. A contribution to the first report on the state of the world's animal genetic resources. IBC, May 2004. Addis Ababa, Ethiopia.
- Imbayarwo-Chikosi, V.E. 2010. Dairy Cattle Genetics and Breeding Module, Faculties of Agriculture and Veterinary, University of Zimbabwe, Harare, Zimbabwe.
- ILCA (International Livestock Centre for Africa). 1990. Livestock system research manual. Working Paper No. 1. Vol. 1, Addis Ababa, Ethiopia. 287p.
- Ishag, I.A., Abdalla, S.A. and Ahmed, M-K.A. 2012. Factors affecting milk production traits of Saanen goat raised under Sudan-semi arid conditions. *Journal of Animal and Feed Research*, 1(5): 435-438.

- Karras, K. 1984. ZPLAN- software program for optimising breeding planning in livestock. Institute of Animal Husbandry and Animal Breeding, Univ Hohenheim, Stuttgart, Germany [in German].
- Kassahun Awgichew and Solomon Abegaz. 2008. Breeds of sheep and goats. In Yami, A., Merkel, R.C. (eds), Sheep and goat production handbook for Ethiopia. Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP), pp5-26.
- Kesbi, F.G. and Tari, A.R. 2015. Relative growth rate in sheep: heritability and relationship with absolute growth rate and body weight. *Songklanakarin Journal of Science and Technology*, 37(1): 21-27.
- Koots, K. R., Gibson, J. P. and Walton, J. W. 1994. Analyses of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. *Animal Breeding Abstract*, 62: 825-853.
- Kosgey, I.S. 2004. Breeding objectives and breeding strategies for small ruminants in the tropics. Doctorial dissertation, Animal Breeding and genetics Group, Wageningen University.
- Kosgey, I.S., Baker, R.L., Udo, H.M.J. and van Arendonk, J.A.M. 2006. Successes and failures of small ruminant breeding programs in the tropics: a review. *Small Ruminant Research*, 61: 13-28.
- Legates, J.E. and Warwick, E.J. 1990. Breeding and improvement of farm animals. 8th edition. McGraw-Hill Publishing Company. 140pp.
- Lemma Fita, Lemma Aberra, Nega Tolla and Tesfaye Alemu. 2003. Effect of different legume supplementation on milk production performance of Borana Goats. In: Yilma Jobre and Getachew Gebru (eds.), Proceedings of the 10th Annual conference of the Ethiopian Society of Animal Production, 22-24 August 2002. Addis Ababa, Ethiopia. pp 363-365.
- Levasseur, M. and Thibault, C. 1980. Reproductive life cycles. In: E.S.E. Hafez (Editor), reproduction in farm animals, Lea and Febiger, 4th edn., Philadelphia, PA, pp 130-149.
- Luikart, G., Gielly, L., Excoffier, L., Vigne, J-D., Bouvet, J. and Taberlet, P. 2001. Multiple maternal origins and weak phylogeographic structure in domestic goats. *PNAS*, 98(10): 5927-5932.

- Markos Tibbo, Philipsson, J. and Workneh Ayalew. 2006. Sustainable sheep breeding programs in the Tropics: a Framework for Ethiopia. The Deutscher Tropentag: Prosperity and Poverty in a Globalized World-Challenges in Agricultural Research, University of Bonn, Bonn, Germany, October 11-13.
- Mengistie Taye, Belay Deribe and Mussie H. Melekot, 2013. Reproductive performance of Central Highland goats under traditional management in Sekota district, Ethiopia. *Asian Journal of Biological Sciences*, 6: 271-276.
- Mohammed Bedhane, Aynalem Haile, Hailu Dadi and Tesfaye Alemu. 2012. Estimates of genetic and phenotypic parameters for milk traits in Arsi-Bale goat in Ethiopia. *Livestock Research for Rural Development*, 24(6).
- Mohammed Bedhane, Aynalem Haile, Hailu Dadi. and Tesfaye Alemu 2013. Estimates of genetic and phenotypic parameters for growth traits in Arsi-Bale goat in Ethiopia. *Journal of Animal Science Advance*, 3(9): 439-448.
- Momoh, O.M., Rotimi, E.A. and Dim, N.I. 2013. Breed effect and non-genetic factors affecting growth performance of sheep in a semi-arid region of Nigeria. *Journal of Applied Biosciences*, 67: 5302-5307.
- Morand-Fehr, P., Boutonnet, J.P., Devendra, C., Dubeuf, J.P., Haenlein, G.F.W., Holst, P., Mowlen, L. and Capote, J. 2004. Strategy for goat farming in the 21st century. *Small Ruminant Research*, 51: 175-183.
- Mukasa-Mugerwa, E. 1989. A review of a productive performance of female *Bos indicus* (zebu) cattle. ILCA Monograph 6. ILCA, Addis Ababa, Ethiopia.
- Mueller, J.P., Rischkowsky, B., Haile, A., Philipsson, J., Mwai, O., Besbes, B. and Valle Zárate, A. 2015. Community based livestock breeding programmes: Essentials and examples. *Journal of Animal Breeding and Genetics*, 132(2): 155-168.
- Naderi, S., Hamid-Reza, R., François, P., Michael, G.B., Blum, R.N, Hamid-Reza, N., Ozge, B., Marjan, M., Oscar, E., Gaggiotti, Paolo A.M., Aykut, K., Jean-Denis, V. and Pierre, T. 2008. The goat domestication process inferred from large-scale mitochondrial DNA analysis of wild and domestic individuals. *PNAS*, 105(46):17659-17664.
- Nicoll, G.B. 1976. The place of permanent large-scale breeding schemes in livestock improvement. *New Zealand Journal of Agricultural Science*, 10: 49-57.

- Nielsen, H.M., Amer, P.R. and Byrne, T.J. 2014. Approaches to formulating practical breeding objectives for animal production systems. *Acta Agriculturae Scandinavica, Section A-Animal Science*, 64(1): 2-12.
- Nitter, G. and Graser, H.U. 1994. ZPLAN– a PC program to optimize livestock selection programs. Proc 5th WCGALP, Guelph, Canada, 22, 77-78.
- Ogola, T.D.O. and Kosgey, I.S. 2012. Breeding and development of dairy goats: eastern Africa experience. *Livestock Research for Rural Development*, 24(1).
- Omoike A., 2006. Prevalence of diseases among sheep and goats in Edo State Nigeria. *Journal of Agriculture and Social Research*, 6(2):23-31.
- Peacock, C. 1996. Improving goat production in the tropics. A Manual for development workers. Published jointly by FARM-Africa and Oxfam (UK and Ireland), Oxfam, UK. pp87.
- Philipsson, J., Rege, J.E.O. and Okeyo, A.M. 2006. Sustainable breeding for tropical farming systems. In: Ojango, J.M., Malmfors, B., Okeyo, A.M. (Eds.). Animal Genetic Training Resources, version 2.2006. International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden.
- Pidancier, N., Jordan, S., Luikart, G. and Taberlet, P. 2006. Evolutionary history of the genus *Capra* (Mammalia, Artiodactyla): discordance between mitochondrial DNA and Y-chromosome phylogenies. *Molecular Phylogenetics and Evolution*, 40:739–749.
- Rewe, T.O. and Kahi, A.K. 2012. Design and application of bio-economic modelling in livestock genetic improvement in Kenya: A Review. *Egerton Journal of Science and Technology*, 12: 113-119.
- Robinson, J.J., McDonald, I., Fraser, C. and Croffs, R.M.J. 1977. Studies on reproduction in prolific ewes. I. Growth of the products of conception. *Journal of Agricultural Science Cambridge*, 88: 539-552
- Salama, A.A.K., Such, X., Caja, G., Rovai, M., Casals, R., Albanell, E., Marin, M.P. and Mart, A. 2003. Effects of once versus twice daily milking throughout lactation on milk yield and milk composition in dairy goats. *Journal of Dairy Science*, 86: 1673-1680.
- Simm, G. 1998. Genetic improvement of cattle and sheep. Farming Press Miller Freeman UK LTD.433pp.

- Sölkner, J., Nakimbugwe, H. and Valle-Zárate, A. 1998. Analyses of determinants for success and failure of village breeding programmes. In: Proceedings of sixth world congress on Genetics Applied to Livestock Production, Vol. 25 Armidale, NSW, 11-16 January 1998, Australia, 273-280.
- Solomon Abegaz, Girma Abebe and Kassahun Awgichew. 2008. Sheep and Goat Production Systems in Ethiopia: Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP), pp27-32.
- Solomon Abegaz, Mwai, O., Grum Gebreyesus, Aynalem Haile, Rischkowsky, B.A., Solomon Gizaw and Tadelle Dessie. 2014. Review of goat research and development projects in Ethiopia. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute.
- Solomon Abegaz, Sölkner, J., Solomon Gizaw, Tadelle Dessie, Aynalem Haile, Tadelle Mirkena, Tesfaye Getachew and Wurzinger, M. 2014. Optimizing alternative schemes of community-based breeding programs for two Ethiopian goat breeds. *Acta Agraria Kaposváriensis*, Vol. 18(1): 47-55.
- Solomon Gizaw, Komen, H. and Van Arendonk, J.A.M. 2009. Optimal village breeding schemes under smallholder sheep farming systems. *Livestock Sciences*, 124: 82-88.
- Solomon Gizaw, Aynalem Haile and Tadelle Dessi. 2010b. Breeding objectives and breeding plans for Washera sheep under subsistence and market-oriented production systems. *Ethiopian Journal of Animal Production*, 10(1): 1-18.
- Solomon Gizaw; Azage Tegegne; Berhanu Gebremedhin, and Hoekstra, D. 2010a. Sheep and goat production and marketing systems in Ethiopia: characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 23. 58p. Nairobi (Kenya).
- Solomon Gizaw, Tesfaye Getachew, Zewde Edea, Tadelle Mirkena, Gameda Duguma, Markos Tibbo, Rischkowsky, B., Mwai, O., Tadelle Dessie, Wurzinger, M., Sölkner, J. and Aynalem Haile. 2013. Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia: A basis for designing community-based breeding programs. ICARDA working paper, Aleppo, Syria. 47pp

- Solomon Gizaw. 2017. A tool for estimating economic values of traits for designing small ruminant breeding programs under smallholder. *Economic_values_of_traits-Tool_10* systems. <https://www.researchgate.net/publication/318463573> Accessed 2017
- Sonola, V.S. 2015. Evaluation of performance of Norwegian dairy goats in Mgeta Morogoro Valley Silvery Sonola Morogoro, Tanzania. M.Sc. thesis, Sokoine University of Agriculture, Morogoro, Tanzania. Pp104.
- Tadelle Mirkena. 2010. Identifying breeding objectives of smallholders/pastoralists and optimizing community-based breeding programs for adapted sheep breeds in Ethiopia. Doctorial dissertation, Austrian University of Natural Resource and Applied Sciences (BOKU), Vienna, Austria.
- Tesfaye Alemu. 2004. Genetic characterization of indigenous goat population of Ethiopia using microsatellite DNA markers. Doctorial dissertation, Deemed University, Karnal (Haryana), India.258pp.
- Willam, A., Nitter, G., Bartenschlager, H., Karras, K., Niebel, E. and Graser, H.-U. 2008. ZPLAN manual for a PC-program to optimize livestock selection schemes. Manual Version 2008 for Source Code “z10.for”. Universität Hohenheim, Stuttgart, Germany.
- Wollny, C.B.A. 2003. The need to conserve farm animal genetic resources in Africa: should policy makers be concerned? *Ecological Economics*, 45: 341–351.
- Workneh Ayalew, Rischkowsky, B., King, J.M. and Bruns, E. 2003. Crossbreds did not create more net benefits than indigenous goats in Ethiopian smallholdings. *Agricultural Systems*, 76: 1137-1156.
- Yohannes Dagneu. 2018. Comparative performance evaluation of Gumz, Rutana and Gumz-Rutana sheep and designing conservation-based breeding program in north western lowlands of Amhara, Ethiopia. Doctorial dissertation, Haramaya University, Haramaya, Ethiopia
- Zelalem Gutu, Aynalem Haile, Rischkowsky, B., Mulema, A.A., Kinati, W. and Girma T. Kassie. 2015. Evaluation of community-based sheep breeding programs in Ethiopia. Addis Ababa, ICARDA.

- Zealelem Geberstadik and Anal, A.K. 2014. Indigenous sheep breeds of North Ethiopia: characterization of their phenotype and major production system. *Tropical Animal Health and Production*, 46: 341-347
- Zelege, Z.M. 2007. Environmental influences on pre-weaning growth performances and mortality rates of extensively managed Somali goats In Eastern Ethiopia. *Livestock Research for Rural Development*, 19(12).

8. APPENDICES

8.1. APPENDIX A: PAPERES

PAPER I**Begait goat production systems and breeding practices in western Tigray,
Northern Ethiopia**

Hagos Abraham^{1*}, Solomon Gizaw³, Mengistu Urge²

¹Bule Hora University, Department of Animal Science, P.O. Box 144, Bule Hora, Ethiopia

²Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia

³International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author: hagsabr@gmail.com

Published by Open Journal of Animal Sciences 7(2): 198-212 (2017) and reprinted with kind permission of Open Journal of Animal Sciences.

The original article is available online at <https://doi.org/10.4236/ojas.2017.72016>

Abstract

A study was undertaken to characterize production system, breeding practices and production constraints of Begait goat in Kafta humera district, northwestern lowlands of Ethiopia. Personal observations, focus group discussions and a detailed structured questionnaire were used to collect data from 150 respondents (100 small-scale and 50 large-scale farmers). Mixed crop-livestock production system was found to be the dominant farming system in the study district. The farmers kept a variety of livestock species including goats, sheep, cattle, chickens and donkeys. Small ruminants are the most numerous and are of great importance in the area. Goats are herded with sheep in the open fields by the young boys in the family/hired grazers. They have a number of roles though mainly kept as a source of cash income. Breeding was generally uncontrolled. Size, growth rate and libido were the most frequently reported traits in selecting bucks, whereas does were selected based on size, twinning ability and milk yield. Effective population size and rate of inbreeding were calculated by considering random mating and flocks were not mixed. The major constraints hampering goat production in the area were water scarcity, feed and grazing land shortages and insufficient veterinary services among the others. Therefore, addressing these constraints is important to design a successful genetic improvement scheme in the area for goat.

Keywords: *Farming system, husbandry practice, marketing, production constraints*

Introduction

Goats (*Capra hircus*) are of the most beneficial animals. Ethiopia is one of the top ten goat producing countries in the world. As per the livestock census carried out in 2016, Ethiopia owns approximately 30 million goats; of which 71.57% are females and the rest 28.43% are males. Majority of the national goat population is found in the lowlands. Nearly all (99.99%) of the goats are indigenous types [1] [2], which have become adapted to a wide agro-ecological zones of the country [3] due to natural selection. The environmental adaptation of indigenous breeds facilitates livestock production in a range of agro-ecological conditions and constraints [4].

Goats are deeply embedded in almost every African culture and are true friends to the rural poor [5]. For instance, goats in Ethiopia are important to the subsistence, economic and social livelihoods of their owners [6] [7] [8]. On top of this, Ethiopia generates hard currency through exporting live goats, goat meat and goat skins. At optimum off-take rates, the country has a potential to deliver 1.13 and 2.00 million goats to national and international markets per annum, respectively [7].

Despite the large goat population is found in the country and its contributions to household income and to the country's national economy, productivity per unit of animal is low. Genetic improvement is one way to increase productivity of the goat genetic resources in the country. According to [9], development of animal genetic improvement plans will only be successful when accompanied by good understanding of the production system and when simultaneously addressing constrains. However, there is little or no adequate information on majorities of indigenous goat breeds/types in Ethiopia to design appropriate breeding plans, suggesting a low level of priority for this area of research. Specifically, the study aims at:

- ❖ Characterizing production system and breeding practices of Begait goat
- ❖ Identifying the major constraints facing Begait goat production in its home tract

Materials and methods

Description of the study area

This research work was done in Kafta and Setit humera districts of western zone of Tigray National Regional State, northwest lowlands of Ethiopia. Setit humera town, a special district, is the administrative center of Kafta humera district and western zone of the region. In this study, the district has been integrated as part of Kafta humera district. The study area covers a total area of 71.80 km² of which 54.20% is cropland.

The study area is situated 1372 km away from the administrative center of Addis Ababa city to northwest direction. It is bordered by Sudan to the west, Tahtay Adyabo district to the east, Eritrea to the north and Wolkayit and Tsegedei districts to the south. Geographically, it is located in between the latitudes 13°14'-14°27'N and longitudes 36°27'-37°32'E. The study area comprises *kolla* (lowland) and *weina dega* (midland) agro-climatic zones with an altitude ranging from 560-1849 m above sea level. The annual precipitation in the lowlands and midlands is 448.8 and 1102.5 mm, respectively [10] occurring between Jun and September. The mean minimum and maximum temperatures in the lowlands are 25°C and 27.5°C, respectively while the corresponding values in the midlands are 20°C and 25°C. The hottest months are between April and June with temperatures rising up to 42°C.

Farming system

The agricultural production system in the study area is mixed farming. There are two types of farming systems in the district viz. small-scale and large-scale based farming systems. As a result, farm activities predominantly crop production and livestock rearing are performed by small-scale and large-scale farmers. According to [11], above half (58%) of the total cropland is cultivated by large-scale farmers while small-scale farmers cultivate the rest 42%. Crop production is a rain fed production system without irrigation practice. Sesame and sorghum are the major staple food and cash crops grown in the area. Other crops like cotton, millet, maize and *teff* are well grown.

Livestock production is similar in both farming systems, and it is a traditional type which is characterized by minimal inputs as is in other areas of Ethiopia. [12] Demonstrated that low input production system is found in all livestock production systems prevailing in the country except in Peri-urban and urban system. The most dominant farm animal species of the area are cattle and small ruminants. Animal feeding is free grazing.

Sampling and data collection

Prior to site selection, livestock experts in the district were contacted for brief discussions. In addition, secondary data were reviewed to better understand the current production systems and the area dominated by Begait goat. Based on this information, four rural *kebeles* and the special district were selected as study sites. A total of 150 Begait goat owning farmers (100 small-scale and 50 large-scale farmers) were selected at random.

Interviews were conducted at the farmers' residences using structured questionnaire with the assistance of development agents. The questionnaires covered information on key household characteristics, livestock possession, flock structure, purposes of keeping goat, mating system, marketing system and production constraints. To complement the survey work, focus group discussions were held with a total of 8-10 key informants per selected study site. In addition, general information about the district was obtained from secondary data sources.

Data analysis

The survey data were analyzed using SPSS software (SPSS for windows, release 16.0, 2007). F test was applied when required to test statistical significances. Indices were calculated for all ranking data using the formula: $\text{Index} = \frac{\sum[3 \text{ for rank } 1+2 \text{ for rank } 2+1 \text{ for rank } 3]}{\sum[3 \text{ for rank } 1+2 \text{ for rank } 2+1 \text{ for rank } 3]}$ given for an individual reason divided by $\sum[3 \text{ for rank } 1+2 \text{ for rank } 2+1 \text{ for rank } 3]$ for all reasons [13]. By considering the number of breeding males (N_m) and breeding females (N_f), the effective population size (N_e) and rate of inbreeding (ΔF) were also estimated using the equations of $N_e = 4(N_m \times N_f)/(N_m + N_f)$ and $\Delta F = 1/2N_e$, respectively [14].

Results and discussion

Household information

Table 1 presents some key characteristics of the respondents across the two farming systems. The overall average age of the sampled household head was 50 ± 10.44 years, implying that the respondents were adults with a good experience in goat farming. The overall mean family size was 5.85 ± 0.89 , which is comparable with the national estimate of 4.80 persons per household [15].

Table 1. Background characteristics of the respondents by farming system

Descriptor variables	Small-scale farming	Large-scale farming	Overall
	(n = 100)	(n = 50)	(N = 150)
	Mean \pm SD	Mean \pm SD	Mean \pm SD
Age (years)	48.24 \pm 9.88	53.10 \pm 10.85	50.00 \pm 10.44
Family size	5.91 \pm 0.94	5.75 \pm 0.80	5.85 \pm 0.89
Sex	Percent	Percent	Percent
Male	98.00	100.00	98.67
Female	2.00	-	1.33
Educational level			
Illiterate	27.00	38.00	30.67
Literate	73.00	63.00	69.33
Marital status			
Married	97.00	100.00	98.00
Unmarried	1.00	-	0.67
Widowed	2.00	-	1.33

N: Number of interviewed households; SD: Standard deviation

Of the total sampled household heads, 98.67% were males. The rest (1.33%) households were female headed. Indeed, it is unlikely to find a female headed household unless she is widowed or divorced. Literacy rate among the household heads was 69.33%. Similar results were reported by [16] in Dale district and [17] in Goma district. The better educational background obtained in this study would be a good opportunity for further animal genetic improvement programs in the study area, since literate communities are more likely adopt and practice new technologies. The study also revealed that most (98%) of the respondents were married. The percentage of unmarried and widowed was 0.67% and 1.33%, respectively. The present

findings indicate that goat farming can be performed by every social class of the community regardless of their background characteristics, viewing the significant importance of goat for its owners.

Livestock holding and flock structure

Table 2 demonstrates flock structure and livestock possession across the two farming systems. The results showed that the sampled small-scale farmers owned 23.21 goats, 21.68 sheep, 9.62 cattle, 9.45 chickens and 0.97 donkeys. The corresponding values for interviewed large-scale farmers were 68.43, 65.41, 11.29, 11.16 and 1.24, respectively. None of the respondents owned mules and horses. This finding supports the fact that mules and horses could not adapt the hot environmental conditions of the area.

The mean flock size of goats in the present study was close to the work of [18] and [19], who reported that 44.0 and 48.5 heads per household in Siti zone of Somali region and Abergelle district of Amhara region, respectively. In contrast, the mean flock size recorded in this study is higher than the previous average flock size of 21.20 Begait goats in the area [20]. This difference might be due to random sampling error or due to changes in goat farming system over time in the area.

Table 2. Mean livestock holdings and flock structure across the two farming systems

Livestock species	Small-scale farming (mean ± SD)	Large-scale farming (mean ± SD)	Overall (mean ± SD)
Goat	23.21 ^b ±10.42	68.43 ^a ±15.94	43.67±17.49
Kids	5.56 ^b ±2.22	19.39 ^a ±4.33	12.34±4.96
Buckling	1.75 ^b ±1.28	5.78 ^a ±1.07	3.29±1.22
Doeling	2.75 ^b ±2.29	8.42 ^a ±1.88	5.36±2.17
Bucks	2.04 ^b ±0.92	2.33 ^a ± 0.81	1.94±0.89
Does	10.74 ^b ±8.41	31.39 ^a ±6.99	20.19±7.98
Castrates	0.37 ^b ±0.47	1.12 ^a ±0.43	0.70±0.46
Sheep	21.68 ^b ±17.86	65.41 ^a ±15.07	42.90±17.09
Cattle	9.62 ^b ±4.68	11.29 ^a ±3.98	10.19±4.51
Chicken	9.45 ^b ±3.69	11.16 ^a ±0.70	10.24±3.57
Donkey	0.97 ^b ±0.28	1.24 ^a ±0.34	1.10±0.20

Means with different letter within the same row are significantly different ($p < 0.05$); SD: standard deviation

The number of males and females in the sample population and their ages were often used as an indicator of a traditional management system in Africa [21]. The present finding revealed that the proportion of does represents the largest class followed by suckling kids, while castrates represent the lowest proportion (Table 2). This is in good agreement with previous findings in Ethiopia [22] [23] [24] [17] and elsewhere in Africa [25] [26] [27]. The higher proportion of does than other age groups suggests that adult females stay in a flock for breeding purposes and/or milk production. However, the less number of buckling when compared to doeling is because of marketing and slaughtering of buckling. There was a high level of elimination of the majority of born male kids.

Table 3. Percentage of households owning livestock species across the two farming systems

Livestock species	Small-scale farming		Large-scale farming		Overall	
	n = 100	%	n = 50	%	N = 150	%
Goat	100	100.00	50	100.00	150	100.00
Sheep	80	80.00	38	76.00	118	78.67
Cattle	66	66.00	33	66.00	99	66.00
Chicken	69	69.00	30	60.00	99	66.00
Donkey	67	67.00	29	58.00	96	64.00

Small ruminants were the predominant livestock species in the area (Table 3) and this shows that their wide acceptability and ease of adaptation in the area. Sheep and goat numbers are growing fastest in the mixed farming systems [28] as subsistence farmers prefer small stock because the risk of losing large ruminants is high [29]. In rural areas of Ethiopia, because of their subsistence and economic reasons, goats and sheep have been described as *bank reserve* which can be drawn upon when cash money is required. This confirms a study by [30], who reported that keeping livestock, especially small ruminants plays role as safety net that enables households to get quick income to settle urgent financial needs.

Purposes of keeping goat

Knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding goals [6] [31]. Table 4 summarizes reasons of keeping goats and the ranking of these purposes by owners. The most frequently reported reason for keeping goat was cash income generation followed by milk and meat production for home use. This implies that sale of goats to generate cash constitute the primary purpose among the other benefits of keeping goats in the area. This was also observed in similar studies [32] [33] [34] [35], who reported that cash income as the most important reason in goat farming. However, the purpose of keeping goats in rural areas of South Africa is mainly for traditional purposes and meat consumption [36].

Table 4. Reasons for keeping goats as ranked by respondents in the area

Purpose	Small-scale (n = 100)			Index	Large-scale (n = 50)			Index
	Rank				Rank			
	Rank1	Rank2	Rank3		Rank1	Rank2	Rank3	
Cash income	79	11	8	0.445	40	6	5	0.457
Meat home consumption	8	7	78	0.193	3	3	39	0.180
Milk	13	82	5	0.347	7	41	2	0.350
Skin	0	0	2	0.003	0	0	1	0.003
Saving value	0	0	7	0.012	0	0	3	0.010

Index = $\sum [3 \text{ for rank } 1 + 2 \text{ for rank } 2 + 1 \text{ for rank } 3]$ for particular purpose divided by $\sum [3 \text{ for rank } 1 + 2 \text{ for rank } 2 + 1 \text{ for rank } 3]$ for all purposes. The highest index value indicates the highest importance of the trait

Land holding and goat production

Mixed crop-livestock production system takes place as an important source of livelihood in the area. Large ruminant animals such as goats are kept and a vast area of land is cultivated. Goat holding of small-scale farmers was in the range of 9-40, while large-scale farmers owned between 41 and 215 goats. Overall cropland holding of small-scale and large-scale farmers was observed to be 4.10 (range: 1.50-19) and 86.90 (range: 20-600) hectares, respectively. This indicates that there is huge crop residue production in the study area, a considerable source of goat feed. Normally, crop residues are grazed or stockpiled for animal feeding. In some cases, the stored residues are sold during the critical period of feed scarcity. Sorghum crop residues are by far the most abundant feed resource in the area.

Goat husbandry practices

Feeds and feeding management

The different feed resources reported in the area were natural pasture, browse species, crop residue and crop aftermath. Private grazing land was not common in the area. It was reported that communal grazing was the most abundant feed source for goat in the area though grazing drastically reduces in the dry season. Indigenous browse species are available feed resources for goats mainly in the dry season and the drought periods (March-June). It was indicated that *Acacia mellifera*, *Acacia seyal*, *Anogeissus leiocarpus*, *Bananite aegyptica*, *Dichrostachys cinerea*, *Sclerocarya birrea*, *Combretum hertmannianum*, *Rhus nataliensis*, *Zizyphus spina-cristi* were the predominant plant species widely utilized as goat feed source.

Crop residue and crop aftermath grazing were the other vital feed resources of goat during crop harvesting and after harvesting has occurred. Animals feed on the residue in two ways. The harvested crop residue is stacked near to homestead and fed to selected group of animals in the dry season. Otherwise, standing residue is left for grazing. However, the expansion of cropland, increase in livestock population and area enclosure are negatively affecting feed resource in the area.

Water sources and watering management

Water resource is pertinent and vital for the subsistent life of livestock and livestock owners. In the study area, river, pond and borehole form the major source of water for domestic use and livestock watering. Indeed, water points are limited and large number of animals watered at the same water points leading to high chances of spreading diseases and land degradation. There were only two government constructed water points. Besides, private water points were very few.

Distance to water points varied with season and was invariably longer during the dry season. This posed challenges to breeders and sometimes limited access to water. A large proportion

(45.33%) of the respondents travel 6-10 km to water their animals in the dry season. While in the wet season 67.33% of the total respondents watered their animals at a distance of less than 1 km. Shorter watering frequencies were used to water animals in the area. The proportions of the respondents that watered their goats once a day and twice in a day were 82% and 18%, respectively. Watering with more than a day frequency is not reported.

Housing system

Based on personal observations and interviewed households' information, goats were housed with sheep in nights. None of the respondents had provision for accommodating different age groups. Only sick ones and newly born kids/lambs were retained alone in sheds. Sheds were constructed of locally available materials. Sheds were not permanent as animals migrate from place to place in search of feed and water. However, farmers in urban areas used permanent houses separated from or attached to their homesteads.

Herding practice

The common herding management in the area was free grazing. All the interviewed farmers replied that they herded goats with sheep. One or two herdsman and at least one herding dog used to accompany flocks for grazing. There is also the possibility of mixing with other goats and sheep flocks in the nearby vicinity of villages. Flocks of small size of less than 30 were pooled together to a maximum size of 60 to 120 heads for grazing. And then the flocks owned by different farmers were taken together by hired grazers.

Common goat diseases and health management

Diseases are a major constraint to the improvement of livestock industry in the tropics as they decrease production and increase the morbidity and mortality [37]. The most commonly prevailing diseases which hamper goat production in the study area are presented in Table 5. Respondents indicated that diseases affect all age groups of goats and mortalities from disease

are high. More than half (53%) of the sampled respondents were able to separate between the different diseases. Diseases were named according to their symptoms.

Table 5. Local names and scientific equivalents of the common goat diseases in the area

Scientific name	Local name (<i>Tigrigna</i>)
PPR (pest des petits ruminants)	Gulhay
Foot rot	Mojelle
Orf/Contagious Ecthyma/Sore mouth	Af-gumed
Pasteurellosis	Mi'eta
Small pox	Enfrir
Anthrax	Megerem

Vaccination services were provided by Bureau of Agriculture and Rural Development of the district at seven clinics. In addition, farmers use modern drugs either from government clinics or open markets and treat their animals themselves. Some farmers also claimed that veterinary officers were called to treat their sick animals. The most extensively used drug in the area was oxytetracycline and locally known as *leshlesh*. Likewise, branding was applied when animals get sick and for identification purpose.

Origin, distribution and current status of Begait goat

Indeed, there is no documented information on the exact origin of Begait goat. According to [20], it is believed that the breed was derived from Nubian type goats. In the area the breed is also known as *Barka*. From individual interviews, 37% of sampled farmers agreed that the breed's name "*Barka*" is an indicator of the breed's origin that is *Barka* area from Eritrea while most (63%) of the respondents believed that the breed's origin could be Eritrea and Sudan. From the focus group discussions, it became obvious that Begait goat is primarily kept by Beni Amir ethnic group who lives in Eritrea and Sudan bordering Ethiopia. This observation is supported by [38], who documented that Beni Amir ethnic group occupies the borders between much of Eritrea's Barka valley and eastern Sudan.

Despite the exact date of immigration remains unclear, Begait goat is extensively distributed across northwestern lowlands of Ethiopia. It is estimated that 110,500 Begait goats are found

in northwestern and western zones of Tigray region. Based upon the results of focus group discussions and individual interviews, population size of the breed is at increasing trend. The possible reason reported for this trend was the involvement of more farmers in Begait goat production as the breed is more prolific and resistant to drought conditions with better milk yield and meat quality. At present, Bureau of Agriculture and Rural Development of Tigray region has established a ranch, at Mai Woyni *kebele*, western zone of the region, for all Begait animal species aiming at conservation, breeding and improvement.

Breeding practice and selection criteria

In the study area, mating was random. There was no report of controlled mating. Bucks run with does throughout the year and castration was an uncommon practice in the area. This resulted in indiscriminate and uncontrolled breeding. The productive life span of buck was reported on average 5 years. Most (83%) of the respondents had own buck. Farmers who had no breeding males, purchase buck from local markets or got buck service from their neighbors. This finding is in line with previous findings [39] [40] [14].

The most common way of selecting goats as parents for the coming generations is to use the offspring of a chosen parent (buck and/or doe). Linear index is the best strategy for selecting replacements in the livestock industries [41]. Selection criteria for buck and doe with corresponding index values are presented in Table 6.

The respondents prioritized body size, growth rate and libido as selection criteria for buck whereas the most important selection criterion for does were body size, twining ability and milk yield under both farming systems with different index value. Others like mothering ability, kid survival, kidding interval and age at puberty were also reported as criteria but with lower rankings.

Table 6. Selection criteria for buck and doe in the study area as ranked by owners

Class and selection criteria	Small-scale (n = 100)			Index	Large-scale (n = 50)			Index
	Rank				Rank			
	Rank1	Rank2	Rank3		Rank1	Rank2	Rank3	
Buck								
Body size	55	12	9	0.330	27	6	5	0.327
Drought resistance	12	12	19	0.132	6	6	9	0.130
Growth rate	11	47	12	0.232	6	23	6	0.233
Libido	8	21	45	0.185	4	10	22	0.180
Coat color	10	5	11	0.085	5	3	6	0.090
Horn	4	3	4	0.037	2	2	2	0.040
Doe								
Body size	57	9	9	0.330	28	5	4	0.327
Age at puberty	5	3	2	0.038	3	2	1	0.047
Kidding interval	5	3	4	0.042	3	2	2	0.050
Twining ability	6	51	15	0.225	2	25	8	0.213
Milk yield	9	11	50	0.165	5	6	25	0.173
Kid survival	7	10	5	0.077	3	5	3	0.073
Mothering ability	11	13	15	0.123	6	5	7	0.117

Index = $\frac{\sum [3 \text{ for rank 1} + 2 \text{ for rank 2} + 1 \text{ for rank 3}] \text{ for particular trait}}{\sum [3 \text{ for rank 1} + 2 \text{ for rank 2} + 1 \text{ for rank 3}] \text{ for all traits}}$.

Effective population size and level of inbreeding

The effective population size (N_e) and level of inbreeding (ΔF) were calculated for Begait goat using the averaged breeding males and females under closed breeding practice. Majority of the bucks were originated from their respective flocks which lead to inbreeding. Communal herding in contrast increases genetic diversity by rising N_e [6], which is a common practice in the study area. The obtained results for N_e and ΔF under small-scale farming system were 6.86 and 0.07, respectively and the corresponding values under large-scale farming system were 8.68 and 0.06. In both cases the rate of inbreeding was corresponding to the maximum acceptable value of 0.063 [42].

Reproductive performance

According to respondents, the age at puberty in Begait goat was 7.41 ± 1.85 months for males and 8 ± 1.78 months for females. The present finding is within the range of age at sexual

maturity reported for most of the tropical goat breeds under extensive system of management [43] [20].

The reported mean age at first kidding (AFK) for Begait goat was 14.18 ± 1.24 months. This is in agreement with that reported by [44] for Metema goats that have mean AFK of 13.6 ± 2.44 months. This result is also in agreement with reported age at first kidding for Arsi-Bale goats which is 14.88 ± 0.3 months [16] and shorter than for Somali short-eared goats which is 19.9 ± 7.93 months AFK under traditional management conditions.

Begait goat breed, according to the respondents had an average kidding interval of 8.4 ± 1.37 months. This result was shorter than the reported kidding interval for Abergelle and Central Highland goats which were 11.31 ± 2.21 and 10.3 ± 1.42 months, respectively [45]. Higher longevity under adverse conditions is one of the adaptation traits of tropical livestock. The mean reproductive lifespan of does in the flock was reported 11.44 ± 1.17 years and the average number of kids per doe per lifespan was 15.32 ± 1.76 .

Acquisition and disposal

The famous methods used to acquire goats by small-scale and large-scale farmers were new born, buying and inheritance with different index values (Table 7). This is in good agreement with the findings of [46] and [33] in Uganda. Whereas disposal was through selling, slaughtering in holidays and death in that order (Table 7).

Goat marketing in the study area was traditional type. All (100%) of the respondents reported that weighing balance is unknown for selling and/or buying animals; rather visual assessment was used to estimate body condition of animals. Hence, selling price was fixed by negotiation between sellers and buyers. This result agreed with many research reports [47] [48] [16] from Ethiopia. The study results also indicated that higher numbers of goats are sold and better price is fetched in holidays although farmers sell goats at any time of the year depending on their need for money. Goat owners sold their goats primarily for purchasing food items, health

expenses, farm input expenses (fertilizer and cropland rent), labor expenses (herdsman and laborers), school expenses for children and to pay back credit.

Table 7. Ways of acquiring and disposing goat in the study area as ranked by owners

Way of acquiring and disposing goat	Small-scale (n = 100)			Index	Large-scale (n = 50)			
	Rank				Rank			
	Rank1	Rank2	Rank3		Rank1	Rank2	Rank3	
Acquiring (Entered through)								
Born	55	29	13	0.393	27	14	6	0.383
Bought	33	46	13	0.340	17	23	7	0.347
Gift	7	7	14	0.082	3	4	7	0.080
Inheritance	5	18	60	0.185	3	9	30	0.190
Disposing (Exited through)								
Sale	61	19	16	0.395	30	9	8	0.387
Death	19	16	52	0.235	10	8	26	0.240
Slaughter	11	55	22	0.275	6	28	11	0.283
Theft	5	7	7	0.060	2	4	4	0.060
Predator	4	3	3	0.035	2	1	1	0.030

Index = $\frac{\sum [3 \text{ for rank 1} + 2 \text{ for rank 2} + 1 \text{ for rank 3}] \text{ for particular method}}{\sum [3 \text{ for rank 1} + 2 \text{ for rank 2} + 1 \text{ for rank 3}] \text{ for all methods}}$.

Production constraints

Interviews with the sampled farmers revealed key problems constraining goat production in the area (Table 8). Water shortage, feed and grazing land shortages and inadequate veterinary services were ranked first, second and third, respectively. In line with the present findings previous studies [49] [50] indicated that the major problems of small ruminant farming include inadequate supply of water and pasture mainly in the dry season and problems arising from inadequate veterinary services and infrastructure.

Table 8. Ranked goat production constraints in the study area

Constraints	Small-scale (n = 100)			Index	Large-scale (n = 50)			Index
	Rank				Rank			
	Rank1	Rank2	Rank3		Rank1	Rank2	Rank3	
Feed and grazing area shortages	19	35	13	0.233	9	17	6	0.223
Water shortage	32	16	24	0.253	17	8	11	0.260
Inadequate veterinary services	21	21	15	0.200	10	11	8	0.200
Labor shortage	6	4	13	0.065	3	2	7	0.067
Market problem	13	15	16	0.142	7	8	8	0.150
Theft	6	5	11	0.065	3	2	6	0.063
Predators	3	4	8	0.042	1	2	4	0.037

Index = $\sum [3 \text{ for rank } 1 + 2 \text{ for rank } 2 + 1 \text{ for rank } 3]$ for particular constraint divided by $\sum [3 \text{ for rank } 1 + 2 \text{ for rank } 2 + 1 \text{ for rank } 3]$ for all constraints.

Conclusion

This study provides insight in to agricultural production system, breeding practices and major production constraints encountered in goat farming in the study area, which are preconditions in developing breeding programs. The present study also revealed that there are two types of farming systems in the area namely small-scale and large-scale farming. Goat production is an integral component of the existing farming systems by providing multifunctional roles to its owners. The high economic significance of goat coupled with its large flock size in the study area would suggest the scope of genetic improvement schemes in the area. However, water scarcity, feed and grazing area shortages, poor veterinary services and market linked problems should be addressed.

Acknowledgement

The authors would like to acknowledge farmers for their willingness to share their indigenous knowledge concerning the breed while nursing for the first author during his field stay.

References

- [1] Nether lands-African Business Council (2010) Livestock in Ethiopia and opportunity analyses for Dutch investment. Fact sheet: NABC.

- [2] Central Statistical Agency of Federal Democratic Republic of Ethiopia (2016) Agricultural Sample Survey: Report on livestock and livestock characteristics (private peasant holdings). *Statistical Bulletin Number 583*.
- [3] Workneh, A. (1992) Preliminary survey of indigenous goat types and goat husbandry practices in southern Ethiopia. M.Sc. Thesis, Alemaya University, Alemaya.
- [4] Köhler-Rollefson, I. (2000) Management of Animal Genetic Diversity at Community Level. Eschborn, Germany: GTZ. <http://hdl.handle.net/10568/3679>
- [5] Peacock, C. (2005) Goats: Unlocking their potential for Africa's farmers. *Paper presented at the 7th Conference of Ministers Responsible for Animal Resources*, Kigali, 31st October - 4th November 2005.
- [6] Jaitner, J., Sowe, J., Secka-Njie, E. and Dempfle, L. (2001) Ownership pattern and management practices of small ruminants in The Gambia-implications for a breeding program. *Small Ruminant Research*, **40**, 101-108.
- [7] Adane, H. and Girma, A. (2008) Economic significance of sheep and goats. In Yami Alemu, and Merkel, R.C. (eds.). *Sheep and goat production handbook for Ethiopia. Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP)*, 1–4.
- [8] Assen, E. and Aklilu H. (2012) Sheep and goat production and utilization in different agro ecological zones in Tigray, Ethiopia. *Livestock Research for Rural Development*, **24** <http://www.lrrd.org/lrrd24/1/asse24016.htm>
- [9] Baker, R.L. and Gray, G.D. (2003) Appropriate breeds and breeding schemes for sheep and goats in the tropics: the importance of characterizing and utilizing disease resistance and adaptation to local stresses. In: R. Sani, G.D. Gray and R.L. Baker, (eds.), <https://cgspace.cgiar.org/handle/10568/2933>
- [10] Ethiopian Agricultural Research Organization (2002) An assessment of the Agricultural Production Base, Technological Packages and Innovation and Intervention Strategies for Commercial farmers in Kafta Humera Wereda of Tigray Regional State.
- [11] Kafta Humera District Livelihood Report (2007) Disaster Prevention and Preparedness Agency, Ethiopia (accessed at 14 October 2009).
- [12] Institute of Biodiversity Conservation (2004) The state of Ethiopia's farm animal genetic resources: country report. A Contribution to the first report on the state of the world's animal genetic resources. IBC. May 2004. Addis Ababa.
- [13] Kosgey, I.S. (2004) Breeding objectives and breeding strategies for small ruminant in the tropics. Ph.D. Thesis, Wageningen University, Wageningen.

- [14] Falconer, D.S. (1989) Introduction to quantitative genetics. 3rd Edition, Longman Scientific and Technical, New York, USA
- [15] Central Statistical Agency of the Federal Democratic Republic of Ethiopia (2010) Summary and Statistical Report of the 2007 Population and Housing Census Result, Addis Ababa
- [16] Endeshaw, A. (2007) Assessment of Production and Marketing System of Goats in Dale District Sidama zone. M.Sc. Thesis, University of Hawssa, Awassa.
- [17] Shenkute, B., Getahun, L., Azage, T., Hassen, A. (2010) Small ruminant production in coffee-based mixed crop-livestock system of western Ethiopian Highlands: Status and prospectus for improvement. *Livestock Research for Rural Development*, **22** <http://www.lrrd.org/lrrd22/10/shen22186.htm>
- [18] Hulunm, G. (2014) On-farm phenotypic characterization and performance evaluation of Bati, Borena and short eared Somali goat populations of Ethiopia. M.Sc. Thesis, Haramaya University, Haramaya.
- [19] Solomon, A. (2014) Design of community based breeding programs for two indigenous goat breeds of Ethiopia. Ph.D. Thesis, BOKU-University of natural resources and life sciences, Vienna.
- [20] Farm-Africa (1996) Goat types of Ethiopia and Eritrea. Physical description and management systems. *Published jointly by FARM-Africa and International Livestock Research Institute.*
- [21] Wilson, R.T. (1986) Livestock production in central Mali: long term studies on cattle and small ruminants in the Agro-pastoral system. ILCA Research report number 14, 116.
- [22] Tsedeke, K. (2007) Production and Marketing of Sheep and Goats in Alaba, SNNPR. M.Sc. Thesis, Hawassa University, Awassa.
- [23] Dhaba, U., Belay, D., Solomon, D. and Taye, T. (2012) Sheep and Goat Production Systems in Ilu Abba Bora Zone of Oromia Regional State, Ethiopia: Feeding and Management Strategies. *Global Veterinaria*, **9**, 421-429.
- [24] Ahmed, S., Kefelegne, K. and Kefena ,E. (2015) Breeding Objective, Selection Criteria and Breeding Practice of Indigenous Goats in Western Ethiopia: Implications for Sustainable Genetic Improvemnt. *Greener Journal of Agricultural Sciences*, **5**, 167-176.
- [25] Niekerk, W.A. and Pimentel, P.L. (2004) Goat production in the smallholder section in the Boane district in Southern Mozambique. *South African Journal of Animal Science*, **34**, 123-125.

- [26] Dossa, L.H., Sangaré, M., Buerkert, A., Schlecht, E. (2015) Production objectives and breeding practices of urban goat and sheep keepers in West Africa: regional analysis and implications for the development of supportive breeding programs. *SpringerPlus*, **4**, 281.
- [27] Otieno, O.G., Junga, J.O., Badamana, M.S. and Amimo, J.O. (2015) Indigenous knowledge used in breeding and management of *Capra hircus* populations in Kajiado and Makueni Counties, Kenya. *Open Journal of Genetics*, **5**, 111-135. <http://dx.doi.org/10.4236/ojgen.2015.53009>
- [28] de Haan, C., Steinfeld, H. and Blackburn, H. (1997) Livestock and the environment: Finding a balance. <http://www.fao.org/docrep/x5303e/x5303e00.htm>
- [29] Sölkner, J., Nakimbugwe, H. and Valle Zarate, A. (1998) Analysis of determinants for success and failure of village breeding programmes. *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production*. Armidale, 273-280
- [30] Apori, S.O, D.Y. Osei, S.W.A., Rhule, C.D., Oppong-Anane, K. (2011) Livestock marketing in the coastal savannah zone of Ghana. *Proceedings of the 17th Biennial Conference of the Ghana Society of Animal Production*, 20-23 July 2011, 43- 45
- [31] Rewe, T.O, Indetie, D., Ojango, J.M.K. and Kahi, A.K. (2006) Breeding objectives for the Boran breed in Kenya: Model development and application to pasture-based production systems. *Animal Science Journal*, **77**, 63-177.
- [32] Kugonza, D.R , Bareeba, F.B. and Kirembe, G. (2001) Characterization of meat goat management systems in three districts of central Uganda. *MUARIK Bulletin*, **4**, 26–29.
- [33] Semakula, J., Mutetikka, D., Kugonza, R.D. and Mpairwe, D. (2010) Smallholder goat breeding systems in humid, sub humid and semi arid agro-ecological zones in Uganda. *Global Veterinaria*, **4**, 83-291.
- [34] Arse, G., Feyisa, H., Gurmessa U., Merga, M. and Girma, D. (2013) Assessment on challenges and opportunities of goat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia. *African Journal of Agricultural Research*, **8**, 26-31.
- [35] Byaruhanga, C., Oluka J. and Olinga, S. (2015) Socio-economic Aspects of Goat Production in a Rural Agro-pastoral System of Uganda. *Universal Journal of Agricultural Research*, **3**, 203-210.
- [36] Braker, M.J.E., Udo, H.M.J. and Webb, E.C. (2002) Impacts of intervention objectives in goat production within subsistence farming systems in South Africa. *South African Journal of Animal Science*, **32**, 185-191.

- [37] Mwacharo, J.M. and Drucker, A.G. (2005) Production objectives and management strategies of livestock-keepers in Southeast Kenya: implications for a breeding programme. *Tropical Animal Health and Production*, **37**, 635-652. <http://www.ncbi.nlm.nih.gov/pubmed/16619880>
- [38] Chisholm, H. 1911. *Beni-Amer*. *Encyclopædia Britannica* 3, 11th edition. Cambridge University Press.
- [39] Ndamukong, K.J.; Sewell, M.M. and Asanji, M.F. (1989) Management and productivity of small ruminants in northwest province of Cameroon. *Tropical Animal Health and Production*, **21**, 109-119
- [40] Ngere, L.O.; Adu, I.F. and Okubanjo, I.O. (1984) The indigenous goats of Nigeria. FAO Animal Genetic Resources Information, Rome, **3**, 1-9.
- [41] Dekkers, J.C. and Gibson, J.P. (1998) Applying breeding objectives to dairy cattle improvement. *Journal of Dairy Science*, **81**, 19–35.
- [42] Armstrong, J.B. (2006) Inbreeding: Why we will not do it? <http://www.parispoodles.com/Inbreeding.html>.
- [43] Wilson, R.T. (1991) Small ruminant production and the small ruminant genetic resource in tropical Africa. FAO Animal production and health, Rome, paper number 88.
- [44] Tesfaye, T. (2009) Characterization of goat production systems and on- farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metema woreda, Amhara region, Ethiopia. M.Sc. Thesis, Haramaya University, Haramaya.
- [45] Belay, D. (2008) Growth, reproductive performance and carcass characteristics of Abergelle and Central Highland goat types under traditional and slightly improved management in Sekota Woreda. M.Sc. Thesis, Haramaya University, Haramay
- [46] Ssewanyana, E., Onyait, O.A., Okwir, W., Ekoi, M., Okello, M., Masaba, J. and Ajibo, G.E. (2004) Characteristics of rural goat production and marketing in Kumi and Lira districts, Uganda. *Uganda Journal of Agricultural Science*, **9**, 289-293
- [47] Ayele, S., Assegid, W., Jabbar, M.A., Ahmed, M.M. and Belachew, H. (2003) Livestock marketing in Ethiopia: A review of structure, performance and development initiatives. *ILRI Socio-economics and Policy Research working paper* 52.
- [48] Gezahegn, A., Mohammad, A.J., Hailemariam, T., Elias, M. and Getahun, K. (2003) Seasonal and inter-market differences in prices of small ruminants in Ethiopia. *Journal of Food Products Marketing*, **12**, 59-77.

- [49] Egbe-Nwiyi, T.N.C., Igbjekwe, F.N. and Nwosu, C.O. (1999) Gastro-Intestinal Parasitism and Associated Haematological Changes in Small Ruminants in the Semi arid region of north-eastern Nigeria. *Bulletin of Animal Health and Production in Africa*, **47**, 61-70.
- [50] Omoike, A. (2006) Prevalence of diseases among sheep and goats in Edo State Nigeria. *Journal of Agriculture and Social Research*, **6**, 23-31.

PAPER II**Growth and reproductive performances of Begait goat under semi intensive and extensive management in western Tigray, northern Ethiopia**

Hagos Abraham^{1*}, Solomon Gizaw³, Mengistu Urge²

¹Bule Hora University, Department of Animal Science, P.O. Box 144, Bule Hora, Ethiopia

²Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia

³International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author: hagsabr@gmail.com, kalhagos1@gmail.com

Accepted for publication by Tropical Animal Health and Production (Springer)

Abstract

The study was conducted in Kafta Humera district of Tigray region with the objectives to investigate growth and reproductive parameters of Begait goat under different management systems and identify some non-genetic factors influencing these parameters. Data were collected from October 2014 to December 2016 and analyzed by using the GLM procedure of SAS version of 9.2. The results of least squares means (\pm SE) for weight at birth, 3, 6, 9 and 12 month were 2.81 ± 0.04 , 11.12 ± 0.43 , 16.45 ± 0.49 , 19.58 ± 0.37 and 24.13 ± 0.48 kg, respectively under semi intensive management whereas the corresponding figures for the extensive management were 2.59 ± 0.03 , 10.32 ± 0.46 , 14.76 ± 0.57 , 17.06 ± 0.49 and 20.62 ± 0.54 kg. Pre- and post-weaning daily weight gains under semi intensive management were 92.33 ± 1.51 and 59.18 ± 2.01 g/day, respectively while under extensive management these were 85.72 ± 1.88 and 49.39 ± 2.81 g/day, respectively. Under semi intensive management mean age at puberty, age at first kidding and kidding interval were 209.93 ± 1.65 , 415.09 ± 9.01 and 233.77 ± 3.12 days, respectively while these lengths were 219.00 ± 1.63 , 444.33 ± 9.09 and 242.79 ± 2.66 days under extensive management, respectively. Litter size ranged between 1 and 3 with the mean of 1.53 ± 0.03 and 1.51 ± 0.03 under semi intensive and extensive management, respectively. In conclusion, almost all non-genetic factors (management system, kid sex, birth type, parity number and birth season) highly significantly ($p<0.001$) influenced growth and reproductive performances of Begait goat.

Keywords: Growth rate; age at puberty; age at first kidding; litter size; kidding interval; non-genetic factors

Introduction

Goat husbandry is integral to livestock production in tropics and subtropics (Knights and Garcia 1997). This may have been due to their less initial investment, low input requirement, higher prolificacy, early sexual maturity and ease in marketing (Kumar et al. 2010). Their preferred diet is principally ignored by other animals and they contribute substantially to the solution of food problems in many arid and semi arid areas, where hunger and malnutrition are prevalent (Musa 2015). On the other hand, increasing human population, urbanization and growing incomes coupled with changing consumer preferences are creating more demand for these animals and their products (Kosgey and Okeyo 2007). Thus, improvement programs are necessary to increase and sustain the productivity of goats. However, to formulate sound goat improvement programs, research efforts must be made to study the reproduction and production performance of indigenous goat types. Because indigenous goats are tolerant to diseases and parasites, which have good flocking instinct, ability to walk long distances in search of feed and highly tolerant to adverse climatic conditions with high endurance to droughts and to low and fluctuating nutrient availability (Kosgey et al. 2008).

Ethiopia has rich biodiversity of goat genetic resources, where distributed over widespread agro-climatic conditions that are kept for the purpose of food source, cash income generation, socio-cultural wealth and source of other valuable non-food products like: skin and manure. The latest estimate of Ethiopia's goat population is about 30 million of heads (CSA 2016), excluding some pastoral areas of Afar and Somali Regional States, the indigenous goats being the most dominant population. They inhabitate all agro-climatic zones and production systems in these areas. Therefore, it is imperative to know reproductive and productive characteristics of the indigenous and adapted goats, which can provide primary information to understand their performance potential by using locally available resources. On the other hand, there is limited previous research report on the evaluation of both reproductive and productive parameters of most indigenous Ethiopian goats. This study was, therefore, undertaken to:

- ✓ Investigate the status of growth and reproductive parameters of Begait goat under different management systems
- ✓ Identify some non-genetic factors influencing growth and reproductive parameters.

Materials and methods

Description of the study area

The research work was conducted in Kafta Humera district of western zone of Tigray National Regional State, Ethiopia. The study district is situated 1372 km away from the administrative center of Addis Ababa city to northwest direction. Geographically, it is located in between the latitudes 13°14'-14°27'N and longitudes 36°27'-37°32'E. The study district comprises *kolla* (lowland) and *weinadega* (midland) agro-climatic zones with an altitude ranging from 560 to 1849 meters above sea level. The annual precipitation in the lowlands and midlands is 448.8 and 1102.5 mm, respectively (EARO 2002) occurring between June and September. The mean minimum and maximum temperatures in the lowlands are 25°C and 27.5°C, respectively while the corresponding values in the midlands are 20°C and 25°C. The hottest months are between April and June with temperatures rising up to 42°C. Detailed descriptions of the study area are indicated in previous works (Abraham et al. 2017).

Animal management and data collection procedures

Data for the current study were collected under two management systems specifically (i) semi intensive management system where Begait goats were maintained at Humera Begait animal species conservation, breeding and improvement ranch (14°06'N, 036°13'E and 889 meters above sea level) and (ii) extensive management system where Begait goats were maintained at farmers' houses in Adebay (14°12'N, 36°45'E and 660 meters above sea level) and Rawyan (14°17'N, 36°37'E and 600 meters above sea level) rural *kebeles* between October 2014 and December 2016. Animals at ranch were allowed to freely graze within the confines of the ranch in the daytime and housed at night. There were permanent water troughs and animals had free access to clean water. During dry season, animals were supplemented with sorghum grain, sorghum by-products (chaff and stover), harvested grass hay and agro-industrial by-products. Under rural *kebeles*, animals depend on native pasture grazing on communal areas without any supplementation. Farmers housed their animals at night. Ponds, borehole and River were sources of water for domestic use and watering animals. The reproductive and productive parameters under study were given below.

Growth parameters

Weight (kg) at birth and at subsequent stages (3, 6, 9 and 12 month) of individual kids was recorded. Body weight of kids was taken by using a suspended spring balance having 50 kg capacity with 0.2 kg precision. Pre-and post-weaning growth rates were determined by using the formula:

$$\text{Growth rate} = \frac{\text{Final body weight} - \text{initial body weight}}{\text{Number of days}} * 1000\text{g}$$

Reproductive parameters

Data on reproductive parameters: kidding date, sex of kid, birth type and parity number were recorded within 24 hours. Age at puberty and age at first kidding were documented for those animals with known birth date. Age at puberty was estimated in days when does exhibited the sign of first heat by observing wagging tail, swelling and watery discharge from the vulva, jumping tendency to others and bleating (Hafez 1987). Age at first kidding was calculated as the difference in days between birth and first kidding date of does. Kidding interval was calculated as the difference in days between two successive kiddings for all does with more than one kidding record. Litter size was defined as the number of total kids born per kidding per doe.

Data analysis

Data validation and all necessary editions were made before making statistical analyses. Data were analyzed by using the GLM procedure of SAS (2008) and means of significant effects were separated by using Tukey's HSD test. Growth parameters were analyzed by using management system, sex of kid, birth type, parity number and season of birth as main effects while for reproductive parameters management system, birth type, parity number and season of birth were fitted as fixed effects in the model. The following general linear models were used.

Model 1: For growth parameters

$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_m + \varepsilon_{ijklm}$. Where; Y_{ijklm} = response variable; μ = overall mean; a_i = fixed effects of the i^{th} management system (i = semi-intensive, extensive); b_j = fixed effects of the j^{th} sex (j = female, male); c_k = fixed effects of the K^{th} birth type (k = single, twin, triplet); d_l = fixed effects of the l^{th} parity (l = 1, 2, 3, 4); e_m = fixed effects of the m^{th} season of birth (m = wet, dry) and ε_{ijklm} = random error.

Model 2: For reproductive parameters

$Y_{ijkl} = \mu + a_i + b_j + c_k + d_l + \varepsilon_{ijkl}$. Where; Y_{ijkl} = response variable; μ = overall mean; a_i = fixed effects of the i^{th} management (i = semi-intensive, extensive); b_j = fixed effects of the j^{th} birth type (j = single, twin, triplet); c_k = fixed effects of the k^{th} parity (k = 1, 2, 3, 4); d_l = fixed effects of the l^{th} season of birth (l = wet, dry) and ε_{ijkl} = random error.

Results and discussion

Growth performance

The body weights of Begait goat in this study are slightly higher than the values reported for other Ethiopian indigenous goats (Dadi et al. 2008; Bedhane et al. 2013; Deribe and Taye 2013).

The least squares means (\pm SE) and test of significance of non-genetic factors affecting body weight at birth and at subsequent stages (3, 6, 9 and 12 month) of Begait goat is presented in Table 1, while Table 2 indicates the least squares means (\pm SE) and test of significance of the non-genetic factors affecting pre- and post-weaning average daily weight gains of Begait goat. Management effect was highly significant ($p < 0.001$), affecting kid's body weight from birth to 12 month of age and weight gains. As expected, semi intensively managed goats attained higher body weight at all stages than under extensive management system. Similarly, goats under semi intensive management showed superiority at pre-and post-weaning weight gains

(Table 2). A better diet for the goats under semi-intensive management may explain these differences in growth performance. The findings of Paramasivam et al. (2002), Kolachhapati (2006) and Herrera et al. (2011) supported findings of the present study. In general, variation in supply and composition of feeds and fodder affects weight of kids at different stages of growth.

The weights at birth and at other stages, and pre-and post-weaning weight gains revealed that male kids showed superiority in growth than females and the differences between the two sexes were significant at all stages and in pre- and post-weaning weight gains. Such results were reported by Gebrelul et al. (1994), Husain et al. (1996) and Akhter et al. (2000). The significant effect of the sex of kid on traits related to growth may be due to the aggressive behavior of males during feeding and suckling (Hafez, 1993) and due to secretion of different sexual hormones in males and females (Baneh and Hafezian 2009). That could be one of the important reasons in which females have smaller body and lighter weight compared to males (Rashidi et al. 2008).

Among the different birth types, single kids showed the highest weight persistent from birth to 12 month and pre-and post weight gains than twins and twins than triplets. The results concur with previous findings (Husain et al. 1996; Hary and Schwartz 2002; Kuthu et al. 2013). Evidently, single born kids had better opportunities in the uterus of their dams compared to twin and triplet born kids and hence they were heavy at birth. The higher weights of single born kids were probably because of the initial higher weight gain by these kids. However, the disadvantage of the twin and triplet born kids on the following weight growth may result from weaker birth than the singles (Marbouk et al. 2010). Birth weight of kids is considered as one of the most important contributory factors for survival and for improving growth performance of kids (Husain et al. 1996). Normally, kids body weights decreased as litter size increase (Alkass et al. 1996).

Parity number was only significant in body weight at birth and 3 month, and pre-weaning weight gain. Its effect on body weight at 3, 6, 9 and 12 month and post-weaning weight gain was not significant. Significantly higher body weights (birth and 3 month) and pre-weaning

weight gain were observed in the fourth parity, whereas the lowest were in the first parity. This agrees with the findings of Bemji et al. (2006), who indicated that body weight of does significantly increased with parity number which reflected on the birth weights of their kids. This should also have effect on their early growth rate. Older dams are larger in body and tend to be better milk producers (Stobart et al. 1986) and accompanied by increased kid weight at birth and up to weaning (Negi et al. 1987). The effect of parity of the dam on kids is, thus, imparted as maternal influence whose direct influence is limited to the nursing period (Deribe and Taye 2013). Despite of this, Husain et al. (1996) and Al-Shorepy et al. (2002) reported insignificant effect of parity of does at kidding for all growth traits.

Table 1. Least squares means (\pm SE) for the effect of management system, sex of kid, birth type, parity of dam, season of birth affecting body weight at different stages of Begait goat

Factors	N	Growth traits (kg)								
		BW	N	3MW	N	6MW	N	9MW	N	12MW
Overall	638	2.69 \pm 0.03	544	10.71 \pm 0.44	535	15.60 \pm 0.53	531	18.03 \pm 0.43	525	22.36 \pm 0.52
Management		***		***		***		***		***
Semi intensive	290	2.81 ^a \pm 0.04	269	11.12 ^a \pm 0.43	265	16.45 ^a \pm 0.49	263	19.58 ^a \pm 0.37	260	24.13 ^a \pm 0.48
Extensive	348	2.59 ^b \pm 0.03	275	10.32 ^b \pm 0.46	270	14.76 ^b \pm 0.57	268	17.06 ^b \pm 0.49	265	20.62 ^b \pm 0.54
Sex of kid		***		***		***		***		***
Male	329	2.85 ^a \pm 0.03	264	11.71 ^a \pm 0.36	259	16.77 ^a \pm 0.48	258	19.31 ^a \pm 0.57	255	23.32 ^a \pm 0.50
Female	309	2.52 ^b \pm 0.03	280	9.77 ^b \pm 0.48	276	14.50 ^b \pm 0.43	273	17.35 ^b \pm 0.47	270	21.45 ^b \pm 0.39
Birth type		***		***		***		***		***
Single	262	2.91 ^a \pm 0.03	244	11.47 ^a \pm 0.45	241	16.57 ^a \pm 0.45	238	18.93 ^a \pm 0.46	235	23.11 ^a \pm 0.59
Twin	202	2.48 ^b \pm 0.04	164	10.00 ^b \pm 0.40	160	14.87 ^b \pm 0.51	160	17.91 ^b \pm 0.48	159	21.77 ^b \pm 0.47
Triplet	174	2.33 ^c \pm 0.05	136	8.55 ^c \pm 0.41	134	12.34 ^c \pm 0.53	133	15.98 ^c \pm 0.40	131	19.86 ^c \pm 0.50
Parity of dam		***		***		NS		NS		NS
1	161	2.48 ^d \pm 0.05	127	9.65 ^c \pm 0.39	123	15.07 \pm 0.43	123	17.88 \pm 0.40	123	22.43 \pm 0.33
2	177	2.62 ^c \pm 0.05	153	10.15 ^c \pm 0.48	151	15.32 \pm 0.42	150	18.14 \pm 0.46	146	22.39 \pm 0.47
3	166	2.77 ^b \pm 0.04	145	10.99 ^b \pm 0.37	144	15.96 \pm 0.38	143	18.58 \pm 0.41	141	22.58 \pm 0.55
4	134	2.95 ^a \pm 0.04	119	12.23 ^a \pm 0.47	117	16.11 \pm 0.48	115	18.65 \pm 0.58	115	21.96 \pm 0.41
Season of birth		***		***		***		NS		NS
Wet	410	2.81 ^a \pm 0.03	376	11.29 ^a \pm 0.32	369	16.70 ^a \pm 0.41	367	18.44 \pm 0.54	365	24.42 \pm 0.57
Dry	228	2.48 ^b \pm 0.03	168	9.41 ^b \pm 0.48	166	13.15 ^b \pm 0.42	164	17.99 \pm 0.46	160	22.33 \pm 0.44

Values with different superscripts (a, b, c, d) in a column for each factor differ significantly; NS: $p > 0.05$; *** $p < 0.001$; N: number of observations; BW: birth weight; 3MW: three month weight; 6MW: six month weight; 9MW: nine month weight; 12MW: twelve month weight

Season of birth had highly significant effect on body weights at birth, 3 and 6 month of age, but it had no influence on 9 and 12 month body weight of kids. Kids born during wet season were heavier than kids born during the dry season. The availability of unlimited quality forage during wet season could have contributed to this observation. Season of birth had a significant effect in pre-weaning weight gain indirectly through its influence on the dam's nutrition and therefore the amount of milk available to pre-weaned kids. During post-weaning period its influence is mainly related to its effect on the quality and quantity of pasture available to the weaned kids. In line with the present findings, Yaqoob et al. (2009) reported significant effect of season of birth on weight at birth, 3, 6 and 9 month age, and weight gains of Dera Din Panah goat. The findings of other studies (Bedhane et al. 2013; Kuthu et al. 2013; Mahal et al. 2013; Hagan et al. 2014) also supported the findings of the study. However, Mourad et al. (2000) found insignificant effect of season of birth on body weight of kids.

Table 2. Least squares means (\pm SE) for the effect of management system, sex of kid, birth type, parity of dam, season of birth affecting pre-and post-weaning daily weight gains of Begait goat

Factors	N	ADG-I (g)		ADG-II (g)	
		LSM \pm SE	N	LSM \pm SE	N
Overall	544	89.10 \pm 1.54	535	54.24 \pm 1.75	
Management		**		**	
Semi intensive	269	92.57 ^a \pm 1.57	265	59.18 ^a \pm 2.01	
Extensive	275	85.72 ^b \pm 1.88	270	49.39 ^b \pm 2.81	
Sex of kid		***		***	
Male	264	100.72 ^a \pm 1.32	259	68.65 ^a \pm 2.16	
Female	280	78.15 ^b \pm 1.83	276	40.72 ^b \pm 2.45	
Birth type		***		***	
Single	244	97.83 ^a \pm 1.65	241	65.45 ^a \pm 2.03	
Twin	164	78.90 ^b \pm 1.62	160	41.43 ^b \pm 3.41	
Triplet	136	70.40 ^c \pm 1.43	134	28.93 ^c \pm 2.77	
Parity of dam		***		NS	
1	127	77.66 ^c \pm 2.22	125	47.13 \pm 3.33	
2	153	82.50 ^c \pm 2.02	151	53.31 \pm 3.23	
3	145	91.85 ^b \pm 1.93	142	60.42 \pm 3.32	
4	119	106.47 ^a \pm 3.00	117	55.31 \pm 4.12	
Season of birth		***		***	
Wet	376	95.36 ^a \pm 1.99	369	68.27 ^a \pm 1.73	
Dry	168	75.10 ^b \pm 1.40	166	23.06 ^b \pm 2.90	

Values with different superscripts (a, b, c) in a column for each factor differ significantly; NS: $p > 0.05$; ** $p < 0.01$; *** $p < 0.001$; N: number of observations; ADG-I: pre-weaning daily weight gain; ADG-II: post-weaning daily weight gain

Reproductive performance

Reproductive parameters considered were age at puberty, age at first kidding, kidding interval and litter size.

Age at puberty

The mean age at first sign of heat of female Begait goat was 214.58 ± 1.20 days. This is within the range of values reported by Moaen-ud-Din et al. (2008) and Al-Saker (2013) for different goat breeds under diverse agro-ecology and management systems.

The results showed that the does under semi intensive management (209.93 ± 1.65 days) reach puberty earlier than the does under extensive management (219.00 ± 1.63 days) which may be due to better diet and other management practices. Robinson *et al.* (2006) reported that puberty will occur with adequate nutrition and inadequate nutrition during the growing periods retards growth and delays puberty in the young does. Birth type also exerted significant effect. The single born female kids had faster growth rates and experienced their pubertal oestrus earlier than the twin and triplet born kids. In line with this result, El Hag et al. (1995) indicated that body weight rather than age is the most important factor determining puberty of Damascus does. Parity of does, however, exerted insignificant effect on puberty. Similar reports were made by Luna-Orozco *et al.* (2008).

Season of birth had a significant effect on age at puberty. The female kids born in wet season exhibited early oestrus compared with those born during dry season. This is due to quality and quantity of feeds available during wet season, which confirms that puberty depends on body weight rather than age (Zeshmarani et al. 2007; Bushara and Abu Nikhaila 2012).

Age at first kidding

Age at first kidding is expressed as the age at which does kid for the first time. In the present study, the mean age at first kidding was recorded as 429.24 ± 6.46 days. Findings obtained

from the current study are comparable with results reported for Abergelle goats (Deribe and Taye 2014) and for Central Highland goats (Taye et al. 2013). This is, however, shorter as compared to age at first kidding for Arsi-Bale goats under on-station (Dadi et al. 2008) due to controlled breeding being practiced in the research center (Dereje et al. 2015).

The results indicated that there was a significant variation in age at first kidding between the management systems (415.09 ± 9.01 days Vs 444.33 ± 9.09 days). Semi intensively managed kids kidded their first kid at younger age than extensively managed counterparts. This is due to the fact that female kids born under semi intensive management with better feed grow faster and attain puberty earlier and therefore, were younger at first kidding. The single born kids had attained earlier first kidding as compare to twins and triplets. Earlier sexual maturity of the does born as single than twins and triplets might be due to proper nourishment by their mother at pre-weaning stage that helps for earlier maturation of reproductive organs.

Season of birth significantly influenced age at first kidding. Female kids born during wet season gave birth to their first kids at a relatively younger age as compared to those born during dry season. Effect of season of birth on age at first kidding is in relation to availability of quality feed. Bushara and Nikhaila (2012) reported that female kids born during season with ample feed grow faster, attain sexual maturity earlier and give first kidding at younger age. However, parity exerted insignificant influence on the age at first kidding.

Kidding interval

In this study, it was observed that the average kidding interval was 238.75 ± 2.04 days (Table 3). The obtained result is shorter than the findings of previous studies for other indigenous goats (Taye et al. 2013; Deribe and Taye 2014). In contrast to that a short kidding interval was reported in Black Bengal goats (Hasan et al. 2015). These differences might be due to the effect of different management practices, nutrition, lactation and level of genetic makeup on possibilities to prompt re-conception after parturition (Gbangboche et al. 2006).

Statistical differences between the two managements were found for kidding interval. Kidding interval of does under semi intensive system (233.77 ± 3.12 days) was lower than those of the does managed under extensive system (242.79 ± 2.66 days). Insufficient food was possibly considered as the main reason for higher kidding interval under extensive management. Faruque et al. (2010) revealed that malnutrition is one factor which lead to longer kidding interval.

The birth type significantly affected kidding intervals. Those does kidded single kids had shorter interval than those kidded twins and triplets. This might be due to the fact that twin and triplet born does need to produce much more milk to nurse their kids, which result in poor body condition mainly in dry season. However, the results on the effect of parity in kidding interval showed non-significant differences.

Kidding season was an important source of variation in kidding interval, perhaps due to more forage availability for consumption in wet season than dry season, with an advantage to those does kidding during wet season. This finding agrees with other studies (Dadi et al. 2008; Taye et al. 2013). Evidently, does require better feed before and after kidding to gain better body condition and come to heat again.

Table 3. Least squares means (\pm SE) for the effect of management system, birth type, parity of dam, season of birth on age at puberty, age at first kidding and kidding interval of Begait goat

Factors	Age at puberty		AFK (days)		KI (days)	
	N	LSM \pm SE	N	LSM \pm SE	N	LSM \pm SE
Overall	256	214.58 \pm 1.20	217	429.24 \pm 6.46	404	238.75 \pm 2.04
Management		***		*		*
Semi intensive	125	209.93 ^b \pm 1.65	122	415.09 ^b \pm 9.01	140	233.77 ^b \pm 3.12
Extensive	131	219.00 ^a \pm 1.63	95	444.33 ^a \pm 9.09	264	242.79 ^a \pm 2.66
Birth type		***		***		***
Single	120	209.56 ^c \pm 1.64	97	412.78 ^c \pm 7.23	258	231.67 ^c \pm 2.17
Twin	83	218.25 ^b \pm 1.75	80	431.66 ^b \pm 7.37	95	242.18 ^b \pm 2.74
Triplet	53	228.43 ^a \pm 2.27	40	440.38 ^a \pm 10.52	51	254.39 ^a \pm 3.52
Parity of dam		NS		NS		NS
1	66	216.23 \pm 1.92	57	452.39 \pm 12.70	101	236.46 \pm 4.90
2	67	215.42 \pm 2.22	57	442.17 \pm 14.44	93	240.14 \pm 3.66
3	64	214.69 \pm 2.47	52	427.75 \pm 10.90	114	232.27 \pm 3.39
4	59	211.68 \pm 2.96	51	419.64 \pm 12.16	123	245.57 \pm 4.10
Season of birth		***		***		***
Wet	150	206.98 ^b \pm 1.36	127	406.54 ^b \pm 8.89	259	230.44 ^b \pm 2.50
Dry	106	225.34 ^a \pm 1.66	90	461.28 ^a \pm 8.18	172	250.29 ^a \pm 3.27

Values with different superscripts (a, b, c) in a column for each factor differ significantly. NS: $p > 0.05$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; N: Number of observations;

Litter size

Litter size in this study ranged from 1 to 3 with the mean of 1.52 \pm 0.02 kids per kidding doe. This is comparable with the values reported for Arsi-Bale goats (Dadi et al. 2008) and goat populations in Gumara-Maksegnit (Alayu et al. 2014), however, higher than the litter size of Central Highland goats (Taye et al. 2013) and Abergelle goats (Deribe and Taye 2014). The high estimates for litter size obtained in this study suggests that Begait goat is a highly prolific breed suggesting that an appreciable rate of genetic response in litter size could be achieved through selection to increase the litter size of the breed.

The results showed that there was no effect of management (1.53 \pm 0.03 Vs 1.51 \pm 0.03) on litter size. Wilson et al. (1989) indicated that litter size is not directly influenced by management, but by both genetic and environmental factors. Parity significantly affected litter size, with an increase in parity of the doe leading to increase in litter size. This is in line with earlier reports (Dadi et al. 2008; Taye et al. 2013), who reported higher litter sizes from the higher parities.

This may be because of improved efficiency of reproduction as the doe matures (Levasseur and Thibault 1980 cited in Hamed et al. 2009).

The results showed wet season kidders had maintained large litter size as compared to dry season kidders. The large litter size during wet season can be because of the accessibility of quality forage fed during this season, which resulted in higher body condition score and body weight at mating (Bushara et al. 2016), where better body conditioned animals can shed more number of ova and fertilized (Mellado et al. 2006).

Table 4. Least squares means (\pm SE) for the effect of management system, parity of dam, season of birth on litter size of Begait goat

Factors	N	Liter size (number)
		LSM \pm SE
Overall	638	1.52 \pm 0.02
Management		NS
Semi intensive	290	1.53 \pm 0.03
Extensive	348	1.51 \pm 0.03
Parity of dam		***
1	161	1.43 ^c \pm 0.04
2	177	1.48 ^{bc} \pm 0.04
3	166	1.52 ^b \pm 0.04
4	134	1.65 ^a \pm 0.04
Season of birth		**
Wet	410	1.63 ^a \pm 0.03
Dry	228	1.41 ^b \pm 0.04

*Means with different superscripts (a, b, c) in a column for each factor differ significantly. NS: $p > 0.05$; **: $p < 0.01$; ***: $p < 0.001$; N: Number of observations*

Conclusion

From the present findings it can be concluded that growth and reproductive performances of Begait goat are better compared to other indigenous goats. Non-genetic factors under study, however, had highly significant ($p < 0.0001$) effect on growth and reproductive performance traits of Begait goat, indicating that these factors should be considered in the development of sound breeding schemes to raise production.

Acknowledgement

The authors are gratefully acknowledged all farm households participated in the monitoring study for their all round support throughout the study period. We are also grateful to Bureau of Agriculture and Rural Development of Tigray for the interest in the research and allowing animals of the ranch. The support of all the ranch workers and Teklay Tekie during the data collection period is also highly appreciated.

Conflict of Interest

The authors declare that they have no conflict of interest on the writing and publishing of this manuscript.

References

- Abraham, H., Gizaw, S. and Urge, M. 2017. Begait goat production systems and breeding practices in Western Tigray, North Ethiopia. *Open Journal of Animal Sciences*, 7: 198-212.
- Alkass, J.E., Hermiz, H.N. and Badawi, F.S. 1996. Growth competition among twin Angora kids. *Iraqi Journal of Agricultural Sciences*, 27(1): 23-28.
- Akhter S., Husain S.S., Amin M.R. and Munzur M. 2000. Studyon the pre and post weaning growthcompetence of differentgenetic groups of Black Bengal goats. *Bangladesh Journal of Animal Sciences*, 29: 69-79
- Alayu Kidane, Surafel Melaku and Aynalem Haile. 2014. Characterization of goat population and breeding practices of goat owners in Gumara-Maksegnit watershed, north Gondor, Ethiopia. *Agricultural Journal*, 9(1): 5-14.
- Al-Shorepy, S.A., Alhadrami, G.A. and Abdulwahab, K. 2002. Genetic and phenotypic parameters for early growth traits in Emirati goats. *Small Ruminant Research*, 45(3): 217–223.
- Baneh, H. and Hafezian, H. 2009. Effects of environmental factors on growth traits in Ghezel sheep. *African Journal of Biotechnology*, 8(12): 2903-2907.

- Bedhane, M., Haile, A., Dadi, H. and Alemu, T. 2013. Estimates of genetic and phenotypic parameters for growth traits in Arsi-Bale goat in Ethiopia. *Journal of Animal Science Advances*, 3(9): 439-448.
- Bemji, M.N., Osinowo, O.A., Ozoje, M.O., Adebambo, O.A. and Aina, A.B.J. 2006. Live weight changes during lactation and its relationship with milk off take and yield in West African Dwarf and Red Sokoto goats intensively managed within the humid zone of Nigeria. *Nigerian Journal of Animal Production*, 33(1): 145-150
- Bushara, I., El Gazafey, B., Mudalal, M.O., Mekki, D.M., Umsalama, A.M.A. and Abu Nikhaila, A.M.A. 2016. Effect of different seasons on Taggar goat performance. *International Journal of Research Studies in Agricultural Sciences*, 2(7): 22-26
- Bushara, I. and Abu Nikhaila, M.M.A.A. 2012. Productivity performance of Taggar female kids under grazing condition. *Journal of Animal Production Advances*, 2(1): 74-79
- CSA (Central Statistical Agency). 2016. Federal Democratic Republic of Ethiopia, Agricultural sample survey, 2015/16 (2008 E.C) report on livestock and livestock characteristics (private peasant holdings). *Statistical Bulletin No. 583*, Vol. 2, Addis Ababa, Ethiopia
- Dadi, H., Duguma, G., Shelima, B., Fayera, T., Tadesse, M., Woldu, T. and Tucho, T.A. 2008. Non-genetic factors influencing post-weaning growth and reproductive performances of Arsi-Bale goats. *Livestock Research for Rural Development*, 20(7).
- Dereje, T., Mengistu, U., Getachew, A. and Yoseph, M. 2015. A review of productive and reproductive characteristics of indigenous goats in Ethiopia. *Livestock Research for Rural Development*, 27(2).
- Deribe, B. and Taye, M. 2014. Reproductive performance of Abergelle goats raised under traditional management systems in Sekota district, Ethiopia. *Iranian Journal of Applied Animal Sciences*, 4(1): 59-63.
- Deribe, B. and Taye, M. 2013. Growth performance and carcass characteristics of central highland goats in Sekota District, Ethiopia. *Agricultural Advances*, 2(8): 250-258.
- EARO (Ethiopian Agricultural Research Organization). 2002. An assessment of the Agricultural Production Base, Technological Packages and Innovation and Intervention Strategies for Commercial farmers in Kafta- Humera Wereda of Tigray Regional State, Addis Ababa, Ethiopia.

- E1 Hag, M.G., A.H. Azam and Al Habsi, R.S. 1995. Comparative performance of Damascus goats and Chios ewes in Oman. *Asian-Australasian Journal of Animal Sciences*, 8(5): 419-425.
- Faruque, S., Chowdhury, S.A., Siddiquee, N.U. and Afroz, M.A. 2010. Performance and genetic parameters of economically important traits of Black Bengal goat. *Journal of Bangladesh Agricultural University*, 8(1): 67–78
- Gbangboche, A.B., Adamou-Ndiaye, A.K.I., Youssao, M., Farnir, F., Detilleux, J., Abiola, F.A. and Leroy, P.L. 2006. Non-genetic factors affecting the reproduction performance, lamb growth and productivity indices of Djallonke sheep. *Small Ruminant Research*, 64(1-2): 133-142.
- Gebrelul, S., Sartin, L.S. and Iheanacho, M. 1994. Geneteic and non-genetic effects on the growth and mortality of Alpine, Nubian and crossbred kids. *Small Ruminants Research*, 13: 169-176.
- Hafez, E.S.E. 1987. *Reproduction in Farm Animals*, fifth edition. (Lea and Febiger, Philadelphia, PA.).
- Hafez, E.S.E. 1993. *Reproduction in Farm Animals*. 6th Edition. Lea and Febiger, Philadelphia, PA.
- Hagan, B.A., Nyameasem, J.K., Asafu-Adjaye, A. and Duncan, J.L. 2014. Effects of non-genetic factors on the birth weight, litter size and pre-weaning survivability of West African Dwarf goats in the Accra Plains. *Livestock Research for Rural Development*, 26 (1).
- Hamed, A., Mabrouk, M.M., Shaat, I. and Bata, S. 2009. Estimation of genetic parameters and some nongenetic factors for litter size at birth and weaning and milk yield traits in Zaraibi goats. *Egyptian Journal of Sheep and Goat Sciences*, 4(2): 55-64.
- Hary, I. and Schwartz, H.J. 2002. Effects of seasonal breeding on productive performance of pastoral goat herds in northern Kenya: a longitudinal analysis of growth in kids and body weight development of does. *Journal of Arid Environments*, 50: 641-664.
- Hasan, Md.J., Ahmed, J.U., Alam, Md.M., Mojumder, M.L.O. and Ali, Md.S. 2015. Reproductive performance of Black Bengal goat under semi-intensive and extensive condition in Rajshahi district of Bangladesh. *Asian Journal of Medical and Biological Research*, 1(1): 22-30

- Herrera, P.Z., Bermejo, J.V.D., Henríquez, A.A., Vallejo, M.E.C. and Costa, R.G. 2011. Effects of extensive system versus semi-intensive and intensive systems on growth and carcass quality of dairy kids. *Revista Brasileira de Zootecnia*, 40(11): 2613-2620.
- Husain, S.S.; Horst, P. and Islam, A.B.M.M. 1996. Study on the growth performance of Black Bengal goats in different periods. *Small Ruminant Research*, 21(3): 165-171.
- Knights, M. and Garcia, G.W. 1997. Characteristics of the goat (*Capra hircus*) and its potential role as a significant milk producer in the tropics: A review. *Small Ruminant Research*, 26(3): 203-215.
- Kolachhapati, M.R. 2006. Phenological study of hill goats under different management systems and nutritional regimes. PhD. Thesis. Institute of Agriculture and Animal Sciences, Rampur, Chitwan. 148p
- Kosgey, I.S., Rowlands, G.J., van Arendonk, J.A.M. and Baker, R.L. 2008. Small ruminant production in smallholder and pastoral/extensive farming systems in Kenya. *Small Ruminant Research*, 77: 11-24.
- Kosgey, I.S. and Okeyo, A.M. 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. *Small Ruminant Research*, 70: 76-88.
- Kumar, S., Rama Rao, C.A., Kareemulla, K. and Venkateswarlu, B. 2010. Role of goats in livelihood security of rural poor in the less favored environments. *Indian Journal of Agricultural Economics*, 65(4): 760-781.
- Kuthu, Z.H., Javed, K., Babar, M.E., Sattar, A. and Abdullah, M. 2013. Environmental effects on growth traits of Teddy goats. *Journal of Animal and Plant Sciences*, 23(3): 692-698.
- Levasseur, M. and Thibault, C. 1980. Reproductive life cycles. In: E.S.E. Hafez (Editor), reproduction in farm animals, Lea and Febiger, 4th edn., Philadelphia, PA, pp 130-149.
- Luna-Orozco, J.R., Fernández, I.G., Gelez, H. and Delgadillo, J.A. 2008. Parity of female goats does not influence their estrous and ovulatory responses to the male effect. *Animal Reproduction Science*, 106(3-4): 352-60.

- Mahal, Z., Khandoker, M.A.M.Y. and Haque, M. N. 2013. Effect of non genetic factors on productive traits of Black Bengal goats. *Journal of Bangladesh Agricultural University*, 11(1): 79–86.
- Mabrouk, O., Sghaier, N., Costa, R.G., Amor, G., Amel, B.A.E. and Delgado, J.V. 2010. The effect of non-genetic factors on the early body weights of Tunisian local goats. *Revista Brasileira de Zootecnia*, 39(5): 1112-1117.
- McGowan, C. and Nurce, G. 2000. Production factors affecting meat goat production. Department of Animal Science, Institute of Food and Agricultural Sciences, University of Florida.
- Mellado, M., Valdez, R., Garcia, J.E., Lopez, R. and Rodriguez, A. 2006. Factors affecting the reproductive performances of goats under intensive conditions in a hot arid environment. *Small Ruminant Research*, 63: 110-118.
- Moaeen-ud-Din, M., Yanf, L.G., Chen, S.L., Zhang, Z.R., Xiao, J.Z., Wen, Q.Y. and Dai, M. 2008. Reproductive performance of Matou goat under sub-tropical monsoonal climate of Central China. *Tropical Animal Health and Production*, 40(1):17-23.
- Mourad, M., Gbanamou, G. and Balde, I.B. 2000. Performance of West African dwarf goats under the extensive system of production in Faranah, Guinea. Pp227-230. *In: proceedings of the 7th International conference on goats*, 15-21 May 2000. France.
- Musa, O.M.O. 2015. The evaluation of some production and reproduction traits of the Shami Cyprus goats in eastern Sudan, Kassala State. Doctoral Dissertation, Sudan University of Science and Technology. pp 96.
- Negi, P.R., Bhat, P.P. and Garg, R.C. 1987. Factors affecting pre-weaning body weights in Gaddi sheep and its crosses. *Indian Journal of Animal Science*, 57: 489-492.
- Paramasivam, A., Sasirekha, A., Sivakumar, T. and Ramesh, V. 2002. Growth performance and carcass traits of Barbari goats under different systems of management. *The Indian journal of animal sciences*, 72(11):1016-1018.
- Rashidi, A., Mokhtari, M.S., Safi Jahanshahi, A. and Mohammad Abadi, M.R. 2008. Genetic parameter estimates of pre-weaning growth traits in Kermani sheep. *Small Ruminant Research*, 74(1-3): 165-171.

- Robinson, J.J., Ashworth, C.J., Rooke, J.A., Mitchell, L.M. and McEvoy, T.G. 2006. Nutrition and fertility in ruminant livestock. *Animal feed Science and technology*, 26(3-4): 259-276.
- SAS (Statistical Analysis System). 2008. SAS/STAT 9.2. User's Guide. Cary, NC: SAS Institute Inc.
- Stobart, R.H., Bassett, J.W., Cartwright, T.C. and Blackwell, R.L. 1986. An analysis of body weights and maturing patterns in western range sheep. *Journal of Animal Sciences*, 63: 729-740.
- Taye, M., Deribe, B. and Melekot, M.H. 2013. Reproductive performance of Central Highland goats under traditional management in Sekota district, Ethiopia. *Asian Journal of Biological Sciences*, 6(5): 271-276.
- Wilson, R.T., Murayi, Th. and Rocha, A. 1989. Indigenous African small ruminant strains with potentially high reproductive performance. *Small Ruminant Research*, 2(2): 107-117.
- Yaqoob, M., Shahzad, F., Aslam, M., Younas, M., and Bilal, G. 2009. Production performance of Dera Din Panah goat under desert range conditions in Pakistan. *Tropical Animal Health and Production*, 41:1413–1419.
- Zarkawi, M. and Al-Saker, M.B. 2013. Determination of certain reproductive and productive parameters in female Mountain (Jabali) and crossbred goats during different age stages. *Archiva Zootechnica*, 16(2): 15-30.
- Zeshmarani, S., Dhara, K.C., Samanta, A.K., Samanta, R. and Majumder, S.C. 2007. Reproductive performance of goats in eastern and north-eastern India. *Livestock Research for Rural Development*, 19(8).

PAPER III**Milk Production Performance of Begait Goat under Semi intensive and Extensive Management in Western Tigray, Northern Ethiopia**

Hagos Abraham^{1*}, Solomon Gizaw³, Mengistu Urge²

¹Bule Hora University, Department of Animal Science, P.O. Box 144, Bule Hora, Ethiopia

²Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia

³International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author: hagsabr@gmail.com

Published in Livestock Research for Rural Development (Volume 29, Article #240) and reprinted with kind permission of Livestock Research for Rural Development.

The original article is available online at <http://www.lrrd.org/lrrd29/12/hags29240.html>

Abstract

The study was conducted in Kafta humera district of Ethiopia, (i) to investigate the milk yield of Begait goat under different management and (ii) to evaluate the effects of different non-genetic factors on lactation performance. Data were collected from 428 lactating does under two managements (semi intensive and extensive) during October 2014 and March 2016. Statistical analyses were carried out using the GLM procedure of SAS version of 9.2 software. The least squares means (with standard error) for daily milk yield, lactation milk yield and lactation length were observed to be 752.64±7.37 ml, 85637.89±1040.44 ml and 110.96±1.21 days under semi intensive management, respectively whereas under extensive management these were found as 551.34±9.49 ml, 56000.00±1424.88 ml and 100.80±1.57 days, respectively. The results of this study showed that management, parity number and season of birth affected all variables highly significantly ($p<0.001$).

Keywords: Daily milk yield, lactation milk yield, lactation length, non-genetic factors

Introduction

Farmers and pastoralists all over Africa are increasingly turning to goats as a means of survival and a way of boosting their incomes (Peacock 2005). Most importantly their products such as meat are not subjected to any religious taboos unlike the pork and beef to Muslims and Hindus, respectively (Chenyambuga et al 2012). There is also a growing awareness of the importance of goat as a source of milk off-take for home consumption (Tona et al 2015) and they are normally called the ‘poor man’s cow’ (Lemma et al 2003). Goat’s milk is better as compared to cow’s milk for people suffering from lactose intolerance, which is a common phenomenon among adults in Sub Saharan Africa (Haenlein 2004). Besides to its better digestibility, goat’s milk contains almost same amount of lactose as cow’s milk (Silanikove et al 2015) with high quality proteins and a great content of minerals and vitamins (Brito et al 2011).

Goat population of Ethiopia ranks high both in the Africa continent and the globe in general (FAOSTAT 2014). In fact, Ethiopian goats are among the neglected animal genetic resources in agricultural research centers and development of breeding programs except limited experiences of FARM Africa, the Boer goat breeding program of Ethiopian Sheep and Goat Productivity Improvement Program and recently BecA-ILRI Hub. Hence, it seems rationale to investigate milk production potential elaborately in indigenous Ethiopian goats resulting in better productivity, which will contribute in the reduction of poverty in the country. The present study was, therefore, designed to achieve the following objectives.

- ✓ To investigate the milk yield of Begait goat under different management and
- ✓ To evaluate the effects of different non-genetic factors on lactation performance.

Materials and methods

Description of the study area

This research work was conducted in Kafta humera district of western zone of Tigray National Regional State, Ethiopia. The study area is situated 1372 km away from the administrative center of Addis Ababa city to northwest direction. Geographically, it is located in between the latitudes 13°14'-14°27' N and longitudes 36°27'-37°32' E. The study district comprises *kolla* (lowland) and *weinadega* (midland) agro-climatic zones with an altitude ranging from 560 to 1849 m above sea level. The annual precipitation in the lowlands and midlands is 448.8 and 1102.5 mm, respectively (EARO 2002) occurring between June and September. The mean minimum and maximum temperatures in the lowlands are 25 °C and 27.5 °C, respectively while the corresponding values in the midlands are 20 °C and 25 °C. The hottest months are between April and June with temperatures rising up to 42 °C. Detailed descriptions of the study area are indicated in previous works (Abraham et al 2017).

Data collection procedures

The daily milk yield and lactation length were recorded on station (Humera Begait animal species conservation, breeding and improvement ranch) and on farm (farmers' houses) during October 2014 to March 2016. A total of 428 lactating does (120 on station and 308 on farm) were involved in the monitoring activity. The amount of milk suckled by kids could not measure due to financial constraints.

On-station

Humera Begait animal species conservation, breeding and improvement ranch is situated in western Tigray region, at latitude of 14°06' N and longitude of 036°13' E with an altitude of 889 m above sea level. Animals were kept under semi intensive management system where herdsmen direct grazing of animals within the confines of the ranch and housed at night. Sheds were cleaned regularly and animals were given dips against ecto-parasites. Vaccination

against anthrax, foot root, pasteurellosis, goat pox, PPR and Orf were provided every year. In wet season mineral salt supplementation was practiced. However, in dry season animals were supplemented with sorghum grain and its residues (chaff and stover), harvested hay and agro-industrial byproducts. Mating is natural and uncontrolled. Adult males move with females year-round and mated freely whenever on heat. During data collection kids had free access to their mothers for the first week after kidding. Starting from the second week until dams refused their kids to suck milk, complete hand milking was made twice a day in the morning and in the evening by enumerator recruited on the ranch. Kids were bottle fed with the collected milk according to their dams' yield. Dams were allowed to nurse their kids in the mornings and in the evenings after milking for 20 minutes.

On-farm

Flock monitoring was made in Adebay (14°12' N, 36°45' E and 660 m above sea level) and Rawyan (14°17' N, 36°37' E and 600 m above sea level) rural *kebeles* of Kafta humera district, where animals were managed extensively. Mineral salt supplement is offered in wet season. Study sites were selected based on ease of accessibility to the areas and farmers' willingness. In addition, having pregnant does per household was used as selection criteria. Participant farmers were provided a calibrated cup for measuring daily milk yield and case books in to which they recorded data.

Before commencement of the study, number of previous lactations (parity) of pregnant does was taken by inquiring owners. All animals in the study flocks were identified with numbered plastic ear tags. For each doe, data on birth date, parity, birth season and daily milk yield were recorded. Milking was done once a day in the morning starting from 7th day of kidding till the end of lactation length. The daily milk yield was then estimated for each doe, multiplying morning milk yield by 2. Kids were kept separated from their dams overnight (12 hours). Data were routinely collected by farmers under close supervision of the researcher. The researcher personally visited door to door to study sites.

Data analysis

Incomplete records were removed before analysis. Data were analyzed using the GLM procedure of SAS version of 9.2 (SAS 2008) software. The significance of fixed effects was tested using Tukey's HSD test of the same software. The following linear model was used.

$Y_{ijk} = \mu + a_i + b_j + c_k + \epsilon_{ijk}$. Where; Y_{ijk} = response variable; μ = overall mean; a_i = fixed effects of the i^{th} management system (i = semi intensive, extensive); b_j = fixed effects of the j^{th} parity (j = 1, 2, 3, 4); c_k = fixed effects of the k^{th} birth season (k = wet, dry) and ϵ_{ijk} = random error.

Results and Discussion

Milk yield

The least squares means (\pm SE) of daily and lactation milk yields (ml) are shown in Table 1. The average milk yields obtained in the present study are higher than those reported by other researchers (Tesfaye et al 2000; Lemma et al 2003; Mohammed et al 2012) for different indigenous goats, while the obtained figures are in comparison with the result of Berhane and Eik (2006) for the same breed. However, Mestawet et al (2012) reported higher daily milk yields for indigenous Arsi-Bale and Somali goats when compared to the findings of this study. The variations in milk production performance among different goat breeds can be explained by differences in breed performance and management conditions (Mohammed et al 2012) as well as by udder size and milking methods (Högberg 2011) and milking frequency (Capote et al 1999; Salama et al 2003).

The present study showed that there were highly significant ($p < 0.001$) differences in milk yields between goats under different management systems. The average daily and lactation milk yields of goats in semi intensive management were higher than that obtained in the village scavenging conditions (Table 1). These variations may be due to differences in feeding and other management practices. Berhane and Eik (2006) and El-Hassan and Abu Nikahaila (2010) found that milk yield of goats was significantly affected by supplementation. Besides,

variation in milk yields between the managements is due to the difference in data taking for daily milking frequency in the management systems. The number of daily milking is of great importance in determining milk yields in dairy animals (Salama et al 2003). Reducing milking frequency from twice daily milking to once daily milking decreased milk yield from 7-38% in dairy cows (Stelwagen and Knight 1997), 15-48% in ewes (Negrao et al 2001) and 6-35% in dairy goats (Capote et al 1999).

The effect of parity (lactation number) on daily and lactation milk yields shows a growing trend from first to fourth parity. The lowest milk yields were obtained in the first parity, whereas the highest recorded in the fourth parity, which is in agreement with several authors (Rabasco et al 1993; Hossain et al 2004; Hamed et al 2009). Milk yield increases with age because as the age of the animal increases, the hormonal status of the animal body, metabolic activity, secretary cells and nutrient intake which are used in milk synthesis increase too (Capuco et al 2001; Hansen et al 2006; Carnicella et al 2008). Besides, milk from younger goats tends to have a higher fat content than that from older goats (Park and Haenlein 2010). The seasons of birth also exerted significant effects on milk yields. Goats that kidded during the wet season had higher milk yields, whereas goats that kidded in the dry season had lower yields. The high amount of milk yield during the wet season was due to the effect of quantity and quality of feedstuffs provided by natural pasture and/or due to presumably benefitted nutritionally from leaf development by browse species. This is in good agreement with the findings of El-Hassan and Abu Nikahaila (2009), who confirmed that productivity of goats increase during the wet season.

Table 1. Least squares means (\pm SE) of some non-genetic factors affecting milk yields (kg) of Begait goat

Items	N	LMS \pm SE	
		DMY (kg)	LMY (kg)
Overall	428	0.61 \pm 0.01	64.3 \pm 1.23
Management		<i>P</i> <0.0001	<i>P</i> <0.0001
Semi intensive	120	0.75 ^a \pm 0.01	85.6 ^a \pm 1.04
Extensive	308	0.55 ^b \pm 0.01	56.0 ^b \pm 1.43
Parity		<i>P</i> <0.0001	<i>P</i> <0.0001
1	101	0.55 ^d \pm 0.02	53.7 ^d \pm 2.34
2	106	0.62 ^c \pm 0.02	66.9 ^c \pm 2.55
3	106	0.65 ^b \pm 0.01	74.8 ^b \pm 2.24
4	115	0.71 ^a \pm 0.01	76.9 ^a \pm 1.60
Birth season		<i>P</i> <0.0001	<i>P</i> <0.0001
Wet	240	0.71 ^a \pm 0.01	77.1 ^a \pm 1.39
Dry	188	0.55 ^b \pm 0.01	59.0 ^b \pm 1.77

^{a, b, c, d} Means with different superscripts for each factor differ significantly. N: Number of observations; DMY: daily milk yield; LMY: lactation milk yield

Lactation length

The lactation length of Begait goat is averaged 104.38 \pm 1.22 days (Table 2). It is higher than the findings of other researchers (Lemma et al 2003; Tatek et al 2004; Mohamed et al 2012; Mestawet et al 2012) for other indigenous goats under different management. It is, however, lower than that reported by El-Hassan and Abu Nikahaila (2010) in Sudanese Nubian goats. Average lactation length of different breeds differed significantly (Güler et al 2007) may have been due to diet, environmental conditions, breed, litter size, parity and season of kidding (Mourad 2001; Crepaldi et al 1999). Findings of the present study revealed significant effects of management system, parity and birth season on lactation length. Semi intensively managed Begait goats had the longest lactation length, whereas extensively managed does had the shortest lactation length. It was observed that the lactation length of does became lower in the first parity. Does kidded in the dry season had the shortest lactation length, but those kidded during the wet season had the longest lactation length.

Table 2. Least squares means (\pm SE) of some non-genetic factors affecting lactation length of Beagait goat

Items	N	LL (days) LMS \pm SE
Overall	428	104.38 \pm 1.22
Management		<i>P</i> <0.0001
Semi intensive	120	110.96 ^a \pm 1.21
Extensive	308	100.80 ^b \pm 1.57
Parity		<i>P</i> <0.0001
1	101	92.39 ^b \pm 2.74
2	106	108.83 ^a \pm 2.46
3	106	113.95 ^a \pm 2.36
4	115	108.33 ^a \pm 1.56
Birth season		<i>P</i> <0.0001
Wet	240	110.22 ^a \pm 2.05
Dry	188	101.53 ^b \pm 1.38

^{a, b} Means with different superscripts for each factor differ significantly. N: Number of observations; LL: lactation length

Conclusion

Overall, the results of the present study revealed that Beagait goats have good potentiality of milk yield and long lactation length indicating the breed even can be utilized in dairy farming. However, the effects of non-genetic factors such as management, parity and birth season were highly significant (p <0.001), which suggests that the influences of these factors need advance considerations.

Acknowledgment

The authors would like to thank all the farm households participated in the monitoring study for their all round support throughout the study period. We are also grateful to Bureau of Agriculture and Rural Development of Tigray region for their interest in the present study and allowing the animals maintained on Humera Beagait animal species conservation, breeding and improvement ranch to be used for this study. The support of all the ranch workers and Teklay Tekie during the data collection period is gratefully acknowledged.

References

- Abraham H, Gizaw S and Urge M 2017** Begait goat production systems and breeding practices in Western Tigray, North Ethiopia. *Open Journal of Animal Sciences* 7, 198-212.
- Berhane G and Eik L O 2006** Effect of vetch (*Vicia sativa*) hay supplementation on performance of Begait and Abergelle goats in northern Ethiopia I. Milk yield and composition. *Small Ruminant Research* 64, 225–232
- Brito L F, Silva F G, Melo A L P, Caetano G C, Torres R A, Rodrigues M T and Menezes G R O 2011** Genetic and environmental factors that influence production and quality of milk of Alpine and Saanen goats. *Genetics and Molecular Research* 10, 3794-3802
- Capote J, Lopez J L, Caja G, Peris S, Arguello A and Darmanin N 1999** The effects of milking once or 2x daily throughout lactation on milk production of Canarian dairy goats. In: *Milking and milk production of dairy sheep and goats*. Barillet, F. and Zervas, N.P. (Eds.). Wageningen, Netherlands. pp. 267-273
- Capuco A V, Wood D L, Baldwin R, Mcleod K and Paape M J 2001** Mammary Cell Number, Proliferation and Apoptosis during a Bovine Lactation: Relation to Milk Production and effect of BST. *Journal of Dairy Science* 84, 2177-2187
- Carnicella D, Dario M, Consuelo M, Ayres C, Laudadio V and Dario C 2008** The effect of diet, parity, year, and number of kids on milk yield and milk composition in Maltese goat. *Small Ruminant Research* 77, 71-74
- Chenyambuga S W, Komwihangilo D M and Jackson M 2012** Production performance and desirable traits of Small East African goats in semi-arid areas of Central Tanzania. *Livestock Research for Rural Development*. Volume 24, Article #118. Retrieved October 2, 2017, from <http://www.lrrd.org/lrrd24/7/chen24118.htm>
- Crepaldi P, Corti M and Cicogna M 1999** Factors affecting milk production and prolificacy of Alpine goats in Lombardy (Italy). *Small Ruminants Research* 32, 83-88
- EARO (Ethiopian Agricultural Research Organization) 2002** An assessment of the Agricultural Production Base, Technological Packages and Innovation and Intervention Strategies for Commercial farmers in Kafta- Humera Wereda of Tigray Regional State, Addis Ababa, Ethiopia.
- El-Hassan K E A and Abu Nkhaila A M A 2010** A study on some non-genetic factors and their impact on milk yield and lactation length of Sudanese Nubian Goats. *Australian Journal of Basic and Applied Sciences* 4, 735-739
- El-Hassan K E A and Abu Nkhaila A M A 2009** A study on some non-genetic factors and their impact on some reproductive traits of Sudanese Nubian goats. *International Journal of Dairy Science* 4, 152-158

FAOSTAT 2014 <http://faostat.fao.org/default.aspx> .Accessed on February 25, 2017

Güler Z, Keskın M, Masatçıođlu T, Gül S and Biçer O 2007 Effects of breed and lactation period on some characteristics and free fatty acid composition of raw milk from Damascus Goats and German Fawn × Hair Goat B1 Crossbreds. *Turkish Journal of Veterinary and Animal Sciences* 31, 347-354

Haenlein G F W 2004 Goat milk in human nutrition. *Small Ruminants Research* 51, 155-163.

Hamed A, Mabrouk M M, Shaat I and Bata S 2009 Estimation of genetic parameters and some non- genetic factors for litter size at birth and weaning and milk yield traits in Zaraibi goats. *Egyptian Journal of Sheep and Goat Sciences* 4, 55–64

Hansen S, Herkildsen M and Byrne D V 2006 Effects of A Compensatory Growth Strategy on Sensory and Physical Properties of Meat From Young Bulls. *Meat Science* 74, 628-648. 23

Högberg M 2011 Milk yield and composition in Swedish landrace goats (*Capra hircus*) kept together with their kids in two different systems. M.Sc Thesis, Swedish University of Agricultural Sciences. pp 29

Hossain S M J, Alam M R, Sultana N, Amin M R and Rashid M M 2004 Milk production from indigenous Black Bengal goat in Bangladesh. *Journal of Biological Sciences* 4, 262-265

Lemma Fita, Lemma Aberra, Nega Tolla and Tesfaye Alemu. 2003 Effect of different legume supplementation on milk production performance of Borana Goats. *In: Yilma Jobre and Getachew Gebru (eds.), Proceedings of the 10th Annual conference of the Ethiopian Society of Animal Production, 22-24 August 2002. Addis Ababa, Ethiopia. pp 363-365*

Mestawet T A, Girma A, Ådnøy T, Devold T G, Narvhus J A and Vegarud G E 2012 Milk production, composition and variation at different lactation stages of four goat breeds in Ethiopia. *Small Ruminant Research* 105, 176-181

Mohammed B, Aynalem H, Hailu D and Tesfaye A 2012 Estimates of genetic and phenotypic parameters for milk traits in Arsi-Bale goat in Ethiopia. *Livestock Research for Rural Development. Volume 24, Article #98*. Retrieved October 2, 2017, from <http://www.lrrd.org/lrrd24/6/bedh24098.htm>

Mourad M 2001 Estimation of repeatability of milk yield and reproductive traits of Alpine goats under an intensive system of production in Egypt. *Small Ruminant Research* 42, 1-4

Negrao J A, Marnet P G and Labussiere J 2001 Effect of milking frequency on oxytocin release and milk production in dairy ewes. *Small Ruminant Research*, 39: 181-187

Park Y W and Haenlein G F W 2010 Milk production. In: *Goat science and production handbook*. Chapter 14, 1st Edn, (Eds.) Solaiman S, pp 275-292

Peacock C 2005 Goats: Unlocking Their Potential for Africa's Farmers. Paper presented at the 7th Conference of Ministers Responsible for Animal Resources ,Kigali, 31 October-4 November 2005

Rabasco A, Serradilla J M, Padilla J A and Serrano A 1993 Genetic and non-genetic sources of variation in yield and composition of milk in Verata goats. *Small Ruminant Research* 11, 151–161

Salama A A K, Such X, Caja G, Rovai M, Casals R, Albanell E, Marín M P and Mart A 2003 Effects of once versus twice daily milking throughout lactation on milk yield and milk composition in dairy goats. *Journal of Dairy Science* 86, 1673-1680

SAS (Statistical Analysis System) 2008 SAS/STAT 9.2. User's Guide. Cary, NC: SAS Institute Inc.

Silanikove N, Leitner G and Merin U 2015 The interrelationships between lactose intolerance and the modern dairy industry: Global perspectives in evolutionary and historical background. *Nutrients* 7, 7312-7331

Stelwagen K and Knight C H 1997 Effect of unilateral once or 2x daily milking of cows on milk yield and udder characteristics in early and late lactation. *Journal of Dairy Research* 64, 487-494

Tatek Woldu, Hailu Dadi, Mieso Guru and Dadi Gelashe 2004 Productivity of Arsi-Bale goat types under farmers' management condition: A case of Arsi Negelle. *Proceedings of the*

13th annual conference of the Ethiopian Society of Animal Production, Addis Ababa, Ethiopia, 25–27 August 2004. pp. 67–71

Tesfaye Alemu, Alemu Ragassa and Lemma Fita 2000 Preliminary production and reproduction performance evaluation of Mid Rift Valley and Boran-Somali goats. Proceeding of a conference held at Debu University, 10-12 November 2000. Awassa, Ethiopia.

Tona G O, Adewumi O O and Olaniyi E O 2015 Milk yield (off take), composition, dam and kid weight changes of West African Dwarf goats fed dietary levels of palm kernel cake. IOSR Journal of Agriculture and Veterinary Science 8, 29-34

PAPER IV**Identification of Breeding Objectives for Begait Goat in Western Tigray,
Northern Ethiopia**

Hagos Abraham^{1,*}, Solomon Gizaw³, Mengistu Urge²

¹Bule Hora University, Department of Animal Science, P.O. Box 144, Bule Hora, Ethiopia

²Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia

³International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author: hagsabr@gmail.com, kalhagos1@gmail.com

Accepted for publication by Tropical Animal Health and Production (Springer)

Abstract

A sound breeding objective is the basis for genetic improvement in overall economic merit of farm animals. Begait goat is one of the identified breeds in Ethiopia, which is a multipurpose breed as it serves as source of cash income and source of food (meat and milk). Despite its importance, no formal breeding objectives exist for Begait goat. The objective of the present study was to identify breeding objectives for the breed through two approaches: using own-flock ranking experiment and developing deterministic bio-economic models as a preliminary step towards designing sustainable breeding programs for the breed. In the own-flock ranking experiment, a total of forty five households were visited at their homesteads and were asked to select, with reasons, the first best, second best, third best and the most inferior does from their own flock. Age, previous reproduction and production information of the identified animals were inquired; live body weight and some linear body measurements were taken. The bio-economic model included performance traits (weights, daily weight gain, kidding interval, litter size, milk yield, kid mortality, pregnancy and replacement rates) and economic (revenue and costs) parameters. It was observed that there was close agreement between the farmers' ranking and bio-economic model results. In general, the results of the present study indicated that Begait goat owners could improve performance of their goats and profitability of their farms by selecting for litter size, six month weight, pre-weaning kid survival rate and milk yield.

Keywords: Bio-economic model, economic parameters, own-flock ranking, performance traits

Introduction

Ethiopia is home for an estimate of 30 million goats (CSA 2016), which are distributed in different agro-ecological zones and mainly raised in the lowlands. In the last ten years, the goat population in the country increased more rapidly (134%) than the sheep (65%) and cattle (38%) populations (FAOSTAT 2016). Goat meat production in Ethiopia is also increased by 2% between 2005 and 2012 and it was expected to be doubled in 2016 because of increased domestic and export market demands for goat meat (Legese and Fadiga 2014).

In spite of the large goat population and increased goat meat demand in the country, the present level of productivity is low. For instance, in the year 2013 goat contributed only 11.0% and 1.4% of the national meat and milk production, respectively (FAOSTAT 2016). There are different factors that contribute for the low productivity. Among those reasons, lack of sustainable breeding programs is an important obstacle.

Genetic improvement programs focuses at a directional improvement in genetics of animals in coming generations such that they will produce the desired products more efficiently under the future economic, social and ecological production environment (Groen 2000). Development of the breeding programs involves a precise definition of breeding objectives. A breeding objective defines the direction in which the farmer would like to go towards satisfying his demand for specific products and services from the animals (Sölkner et al. 2008), which usually translates into increase of profit (Nandolo et al. 2016). Breeding objective traits have to be easy to measure, heritable, variable and not too many. Moreover, those traits should be included in the aggregate genotype according to their economic importance (Philipsson et al. 2006). Breeding objectives can be identified using participatory approaches (Dana et al. 2010; Mirkena 2010; Duguma et al. 2011; Nielsen and Amer 2007) and bio-economic models (Byrne et al. 2010; Gizaw et al. 2010; Gunia et al. 2012; Laske et al. 2012; Lopes et al. 2012). However, in most cases it has been missing while designing the breeding programs (Sölkner et al. 1998).

For this reason, the objective of the present study was to identify breeding objectives for Begait goat farmer using participatory approach and by developing bio-economic models in western lowlands of Tigray region of Ethiopia, which is the home-tract of the breed. It is believed that Begait goat was derived from Nubian type goats. The breed is also known as Barka. The key identifying features of Begait goats are tall (height at withers of 74.3 ± 7.2 and 67.9 ± 4.3 cm for males and females, respectively, and the body weight was 45.3 ± 14.1 and 33.8 ± 5.3 kg for males and females, respectively), predominantly white coat color and hairy thighs with long drooping ears (FARM-Africa 1996).

Materials and methods

Description of the study area

This research work was conducted in Kafta humera district of western zone of Tigray National Regional State. The study area is situated 1,372 km away from the administrative center of Addis Ababa city to northwest direction. Geographically, it is located in between the latitudes $13^{\circ}14'$ - $14^{\circ}27'N$ and longitudes $36^{\circ}27'$ - $37^{\circ}32'E$. The study area comprises *kolla* (lowland) and *weinadega* (midland) agro-climatic zones with an altitude ranging from 560 - 1849 meters above sea level. The annual precipitation in the lowlands and midlands is 448.8 and 1102.5 mm, respectively (EARO 2002) occurring between June and September. The mean minimum and maximum temperatures in the lowlands are $25^{\circ}C$ and $27.5^{\circ}C$, respectively while the corresponding values in the midlands are $20^{\circ}C$ and $25^{\circ}C$. The hottest months are between April and June with temperatures rising up to $42^{\circ}C$. Detailed descriptions of the study area are indicated in previous works (Abraham et al. 2017a).

Identification of breeding objectives

In the present study, we identified breeding objectives for Begait goat using participatory approach (own-flock ranking experiment) and by developing bio-economic models that are adopted from Mirkena (2010) and Gizaw et al. (2010), respectively. The methodologies are explained in the subsequent sections.

Using participatory approach: own-flock ranking experiment

The experiment was conducted during October 2016. Forty five Begait goat owners were visited in the morning before animals were released for grazing. To avoid biasness the farmers were sampled at random. Family members of selected households were asked to identify, with reasons, their first best, second best, third best and the most worst does. Some morphometric measurements were taken on the identified does. The measurements included: body size measurements (length and chest girth) and body weight. Besides, age and previous life history of each individual ranked doe were taken for reproduction (number of kids born, litter size, number of kidding and number of kids weaned) and production (average daily milk yield) parameters.

Data analysis

The proportions of traits preferred by owners were analyzed by using frequency procedure of the statistical software SAS (2008). Body weight, linear body measurements and other traits from the life history were analyzed using general linear model procedure fitting rank as fixed effect. The effect of age (categorical variable) on quantitative traits (continuous dependent variables) was tested through Analysis of Co-variance (SPSS 2007).

Using bio-economic models

Bio-economic modeling in livestock production systems presents the opportunity for incorporating some elements of human decision making and simulates the impact of such decisions using mathematical relationships produced from biological and economic parameters (Rewe and Kahi 2012). In this study, the four steps suggested by Gizaw et al. (2010) were followed in identifying the breeding objectives: (a) definition of the production and marketing systems (b) identification of sources of revenue and expenses (c) identification of breeding objective traits (determining biological traits that affect revenue and costs) and (d) derivation of economic value of each trait.

Definition of the production and marketing systems

The production system was defined as subsistence type, where feeding was based on unimproved native pastures. Begait goats spend by grazing and browsing in communal grazing areas all the daytime (Abraham et al. 2017a). As far as marketing system is concerned inferior males are remained in the flock, however, males with good body condition are sold at their early ages so as to generate direct cash. Dry matter, energy and protein requirements for maintenance, pregnancy, lactation, growth and mating/buck were calculated. The NRC (1981) standards were followed.

Sources of revenue and costs

Progeny structures for a village flock of 350 does were defined based on reproduction parameters for Begait goat to calculate revenues and costs (Table 1). Revenues and costs were calculated on per doe basis. Profit was calculated as the difference between revenues and costs per doe joined per year. Sources of revenues included only tangible (direct regular cash income from sale of six month old male and female kids, yearling unfinished male and female kids, milk, culled does and bucks) benefits. The prices used in the present study were the market prices of June 2017 in the study area, which were collected primarily through informal interview of key informants and personal observations. Costs included feed, veterinary, management, marketing and fixed costs.

Table 1. Sources of revenues and costs used for defining breeding objectives of Begait goat

Sources of revenue	Unit	Value
Male kids (6 month old)	ETB/kg of live weight	95.43
Female kids (6 month old)	ETB/kg of live weight	89.47
Unfinished male kids (yearling)	ETB/kg of live weight	38.72
Unfinished female kids (yearling)	ETB/kg of live weight	34.25
Unfinished buck	ETB/kg of live weight	85.76
Unfinished doe	ETB/kg of live weight	45.57
Milk	ETB/kg	20.00
Sources of costs		
Feed cost		
Grass hay	ETB/kg	2.38
Sesame seed cake	ETB/kg	5.40
Veterinary and management cost		
De-worming	ETB/kg BW/year	4.00
Spray against external parasites	ETB/head/year	0.00
Vaccinations	ETB/head/year	9.00
Veterinary treatment and drugs	ETB/head/year	8.00
Management †	ETB/doe/year	0.88
Marketing †	ETB/doe/year	2.65
Fixed costs	ETB/head/year	34.32

† Management (herding and feeding), marketing cost (personal expenses, marketing tax); ETB: Ethiopian birr

Identification of breeding objective traits

When considering developing a criterion for selection so as to maximize the profit in the progeny generation, the basis of selection of parents is an important issue. In the development of breeding objective/goal various traits that are known to influence profitability of livestock farm as well as observable attributes like: color, appearance, beauty, etc can be considered. In the present study, only economically relevant traits that directly influence profitability of the farm were considered. Biological traits that influence revenue and costs associated with products of the subsistence production system were six month weight, post-weaning average daily gain, mature weight, litter size, pre-weaning kid survival rate, kidding interval and daily milk yield.

Derivation of economic value

Bio-economic models relating the different breeding objective traits with the components of production and marketing in the subsistence Begait goat production system were constructed. Microsoft Excel spreadsheets were used to develop the models (Gizaw 2017). The developed bio-economic models included performance traits and economic parameters (Tables 1 and 2). The models were designed so that effects of genetic improvement in breeding objective traits could reveal changes in values of revenue and costs in the defined production system.

Marginal economic values for each trait were estimated as a change in profit resulting from an increase in one additive genetic standard deviation in the trait value due to selection. Additive genetic standard deviations (σ_a) were calculated using the formula: $\sigma_a = \sqrt{h^2 * \sigma^2_p}$. Where; h^2 : heritability; σ^2_p : phenotypic variance. As performance recording has not yet been carried out by farmers and monitoring data were not sufficient enough, heritability estimates were taken from national and international literature summarized by Jembere (2016). Phenotypic variances were calculated from data collected from the Begait goat monitoring study (Abraham et al. 2017b; Abraham et al. in press). The production parameters that are used for defining breeding objectives of Begait goat are presented in Table 2.

Table 2. Production parameters used for defining breeding objectives of Begait goat

Production parameters	Unit	Mean
Conception rate	%	90.00
Kidding interval	days	242.86
Litter size [‡]	kids	1.52
Survival (0-3 month), singles	%	88.00
Survival (0-3 month), multiples	%	85.00
Survival (3-6 month)	%	93.00
Survival (6-12 month)	%	96.00
Mortality (breeding does/bucks)	%	3.00
Doe weight	kg	35.11
Buck weight	kg	44.90
Kid weight (3-month, male, single-born)	kg	10.48
Kid weight (3-month, male, twin-born)	kg	9.54
Kid weight (3-month, female, single-born)	kg	9.50
Kid weight (3-month, female, twin-born)	kg	8.48
Kid ADG (3-6 month, male single-born)	kg/day	0.074
Kid ADG (3-6 month, male twin-born)	kg/day	0.070
Kid ADG (3-6 month, female single-born)	kg/day	0.067
Kid ADG (3-6 month, female twin-born)	kg/day	0.065
Kid ADG, male (6-12 month on grazing)	kg/day	0.063
Kid ADG, female (6-12 month on grazing)	kg/day	0.060
Milk yield (kg/doe/day, single kid)	kg	0.650
Milk yield (kg/doe/day, twin kid)	kg	0.690
Proportion of milk harvested for sale/consumption	%	50.00

[‡]Litter size at birth; ADG: average daily gain

Results and discussion

Breeding objective using participatory approach

Frequencies of stated preferences were calculated for total respondents. Table 3 presents results of does' preferred traits from own-flock ranking experiment. Farmers preferred many traits of a breeding doe, which reflect its importance and multi-functional nature in the study

area. Previous research findings from Ethiopia (Gebreyesus et al. 2013; Abraham et al. 2017a) and elsewhere in the Africa continent (Jaitner et al. 2001; Bett et al. 2009; Kosgey et al. 2008) revealed that there are different traits preferences for breeding does. The results of the present study indicated that body size, twinning (multiple-birth), milk yield and pre-weaning kid survival rate were often listed as preferred traits of breeding does representing 21.25%, 20.00%, 18.13% and 11.25%, respectively of the total proportions of traits mentioned. Other important traits of preferences were mothering ability (9.38%), drought resistant (5.00%), kid weight at birth (3.75%) and kid sex (3.75%). In general, the reasons mentioned for the selection of the best quality does were intended to reflect what traits of Begait goat were appreciated by owners.

Table 3. List and frequencies of does' traits preferences from own-flock ranking experiment

Traits	Small-scale		Large-scale		Overall	
	Frequency	%	Frequency	%	Frequency	%
Body size	22	20.37	12	23.08	34	21.25
Milk yield	20	18.51	9	17.30	29	18.13
Kid sex	4	3.70	2	3.85	6	3.75
Kid survival	13	12.04	5	9.62	18	11.25
Twinning ability	21	19.44	11	21.15	32	20.00
Mothering ability	11	10.19	4	7.69	15	9.38
Kidding interval	5	4.63	2	3.85	7	4.38
Kid weight at birth	3	2.78	3	5.77	6	3.75
Drought resistant	5	4.63	3	5.77	8	5.00
Temperament	1	0.93	0	0.00	1	0.63
Beauty	1	0.93	0	0.00	1	0.63
Udder size	2	1.85	1	1.92	3	1.88
Sum	108	100.00	52	100.00	160	100.00

Mean (\pm SE) values for age (in years), some performance traits and linear body measurements of the identified breeding does are summarized in Table 4. The results of the present study indicated that the does chosen as the best quality had higher mean values for all traits (age, body weight, chest girth, body length, number of kidding, milk yield, number of kids born and weaned) under study compared with the other does ranked as the most inferior ones. For instance, the magnitude difference between the best quality and the most inferior does in live body weight, twinning rate, number of kids weaned and milk yield were 11.09 kg, 0.50 kids, 9.89 kids and 0.36 kg per day, respectively. In agreement with the present findings, previous

studies (Mirkena 2010; König et al. 2016; Nandolo et al. 2016) reported similar traits preferences of farmers for sheep and goats. Besides, the longer age of best does indicated that farmers keep them for long period for achieving their objectives.

Table 4. Means (\pm SE) of body weight and traits from the life history of the ranked does

	Traits								
	Age (years)	BW (kg)	CG (cm)	BL (cm)	Parity	Litter size	KB (number)	KW (number)	DMY (kg)
Overall	4.25 \pm 0.13	31.02 \pm 0.34	72.27 \pm 0.49	69.07 \pm 0.41	4.24 \pm 0.13	1.63 \pm 0.04	7.17 \pm 0.39	5.74 \pm 0.34	0.64 \pm 0.01
Systems	NS	NS	NS	NS	NS	NS	NS	NS	NS
Small-scale	4.11 \pm 0.14	30.67 \pm 0.35	71.85 \pm 0.38	68.65 \pm 0.40	4.08 \pm 0.19	1.63 \pm 0.03	6.87 \pm 0.37	5.45 \pm 0.32	0.63 \pm 0.01
Large-scale	4.53 \pm 0.24	31.19 \pm 0.23	72.48 \pm 0.41	69.28 \pm 0.43	4.57 \pm 0.24	1.64 \pm 0.05	7.78 \pm 0.44	6.33 \pm 0.39	0.65 \pm 0.02
Rank	***	***	***	***	***	***	***	***	***
1	6.47 ^a \pm 0.18	36.38 ^a \pm 0.24	77.36 ^a \pm 0.55	73.96 ^a \pm 0.49	6.49 ^a \pm 0.21	1.88 ^a \pm 0.02	12.20 ^a \pm 0.42	11.53 ^a \pm 0.40	0.79 ^a \pm 0.02
2	4.47 ^b \pm 0.13	33.14 ^b \pm 0.31	73.30 ^b \pm 0.46	70.20 ^b \pm 0.38	4.47 ^b \pm 0.15	1.70 ^b \pm 0.02	7.58 ^b \pm 0.26	6.07 ^b \pm 0.23	0.71 ^b \pm 0.01
3	3.53 ^c \pm 0.09	29.26 ^c \pm 0.31	70.99 ^c \pm 0.42	67.72 ^c \pm 0.48	3.47 ^c \pm 0.10	1.56 ^c \pm 0.07	5.38 ^c \pm 0.14	3.73 ^c \pm 0.14	0.64 ^c \pm 0.01
inferior	2.56 ^d \pm 0.07	25.29 ^d \pm 0.34	67.68 ^d \pm 0.39	64.40 ^d \pm 0.37	2.54 ^d \pm 0.09	1.38 ^d \pm 0.03	3.53 ^d \pm 0.14	1.64 ^d \pm 0.09	0.42 ^d \pm 0.01

^{a, b, c, d} Means on the same column with different superscripts are significantly different; NS: $p > 0.05$; *** $p < 0.001$; BW: body weight; CG: chest girth; BL: body length; NK: number of kidding; T/ability: twinning ability; KB: kids born; KW: kids weaned; DMY: daily milk yield;

Breeding objective using bio-economic model

The estimation of economic value for all traits was positive, except for mature body weight of doe. The positive economic values for six month weight, average daily weight gain, litter size, pre-weaning kid survival rate, kidding interval and daily milk yield obtained in the current study is an indication that selection targeting these traits would lead to improved profitability of the farm enterprise. Nevertheless, mature body weight of does was the least economically important trait. The negative economic value for mature body weight of does was in line with the results reported by different researchers (Vatankhah 2010; Bett et al. 2011; Kargar et al. 2017). The negative economic value of mature body weight of does show that revenues from sale of adult does would not compensate high costs emanating from the corresponding rise in energy requirement. Vischer et al. (1994) reported that animals with large body sizes consume more feed as they need more energy for maintenance when compared to small sized animals, and this tends to increase the cost of production.

The traits with the highest economic value were obtained for litter size, six month weight, pre-weaning kid survival and daily milk yield because they have direct relation to revenues or costs in the defined production system. Average daily weight gain and kidding interval were of little economic importance. Wolfová and Wolf (2013) demonstrated that economic values are specific to production systems and market contexts. The marginal economic values of the traits are given in Table 5.

Table 5. Undiscounted marginal economic values per unit increase in genetic merit for each trait in the defined production system

Breeding objective traits	‡ Economic values
6 month weight	121.79
Average daily gain (3-6 month)	97.58
Mature weight	-63.97
Litter size	206.82
Pre-weaning kid survival (0-3 month)	118.97
Kidding interval	60.09
Daily milk yield	110.08

‡ ZPLAN requires undiscounted economic values for further analysis

A high correspondence was observed between farmers' ranking of traits and economic values of traits. The correspondence between the two methods was evaluated for traits that were common for the two methods, namely body size/six month weight, milk yield, kid survival, twinning ability (multiple-birth) and kidding interval. The correlation between proportions of farmers ranking the traits as most preferred (first rank, see Table 3) and economic values of traits (Table 5) was 0.71. The correlation between the rankings of the traits by the two methods was 0.80. This shows that farmers consider the economic benefits from improving traits when ranking the traits although farmers do consider multiple objectives including risk aversion. Therefore, for increasing flock profit more attention should be given to genetic improvement of traits with economic value and highly preferred by owners including litter size, six month weight, pre-weaning kid survival rate and milk yield.

Conclusion

Breeding objectives were identified for Begait goat farmer through participatory approach (own-flock ranking experiment) and bio-economic models. Indeed, the use of defined breeding objectives by the goat owners is important so as to increase performance. Findings of the present study shown that the traits desired by farmers in the own-flock ranking experiment were in close agreement to those traits identified by using bio-economic models, predominantly for twinning (multiple-birth), body size/six month weight, milk yield and pre-weaning kid survival rate. Simultaneous use of farmers' preferences and bio-economic modeling would help to evaluate the economic returns to invest in the breeding program while accommodating farmers' preferences as well estimating traits weights for use in constructing selection index. It can be recommended from the present findings that a multi-trait selection program could be designed using selection index containing body size/six month weight, twinning, milk yield and pre-weaning kid survival rate.

References

- Abraham, H., Gizaw, S. and Urge, M. 2017a. Begait goat production systems and breeding practices in Western Tigray, North Ethiopia. *Open Journal of Animal Sciences*, 7, 198-212.

- Abraham, H., Gizaw, S. and Urge, M. 2017b. Milk production performance of Begait goat under semi intensive and extensive management in western Tigray, north Ethiopia.
- Abraham, H., Gizaw, S. and Urge, M. In press. Growth and reproductive performance of Begait goat under semi intensive and extensive management in western Tigray, north Ethiopia.
- Bett, R.C., Kosgey, I.S., Kahi, A.K. and Peters, K.J. 2011. Definition of breeding objectives and optimum crossbreeding levels for goats in the smallholder production systems. *Small Ruminant Research*, 96, 16-24.
- Bett, R.C., Kosgey, I.S., Kahi, A.K. and Peters, K.J. 2009. Analysis of production objectives and breeding practices of dairy goats in Kenya. *Tropical Animal Health and Production*, 41, 307-320.
- Byrne, T.J., Amer, P.R., Fennessy, P.F., Cromie, A.R., Keady, T.W.J., Hanrahan, J.P., McHugh, M.P. and Wickham, B.W., 2010. Breeding objectives for sheep in Ireland: A bio-economic approach. *Livestock Science*, 132: 135-144.
- CSA (Central Statistical Agency), 2016. Federal Democratic Republic of Ethiopia, Agricultural sample survey, 2015/16 (2008 E.C) report on livestock and livestock characteristics (private peasant holdings). *Statistical Bulletin No. 583*, Vol. 2, Addis Ababa, Ethiopia.
- Dana, N., van der Waaij, L.H., Dessie, T. and van Arendonk, J.A.M., 2010. Production objectives and trait preferences of village poultry producers of Ethiopia: implications for designing breeding schemes utilizing indigenous chicken genetic resources. *Tropical Animal Health and Production*, 42, 1519-1529.
- Duguma, G., Mirkena, T., Haile, A., Okeyo, A.M., Tibbo, M., Rischkowsky, B., Sölkner, J. and Wurzinger, M., 2011. Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits in Ethiopia: Choice model approach. *Animal*, 5, 1984-1992.
- EARO (Ethiopian Agricultural Research Organization), 2002. An assessment of the agricultural production base, technological packages and innovation and intervention strategies for commercial farmers in Kafta humera wereda of Tigray Regional State, Addis Ababa, Ethiopia.

- FAOSTAT, 2016. Food and agricultural organization of the United Nations, statistical division. <http://faostat3.fao.org/browse/Q/QA/E>. Last accessed on 10 August, 2016
- Farm-Africa, 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76pp.
- Gebreyesus, G., Haile, A. and Dessie, T., 2013. Breeding scheme based on community-based participatory analysis of local breeding practices, objectives and constraints for goats around Dire Dawa, Ethiopian. [Livestock Research for Rural Development](#), 25,
- Gizaw, S., 2017. A tool for estimating economic values of traits for designing small ruminant breeding programs under smallholder systems. <https://www.researchgate.net/publication/310599739>. Accessed on July 2017.
- Gizaw, S., Haile, A. and Dessi, T., 2010. Breeding objectives and breeding plans for Washera sheep under subsistence and market-oriented production systems. *Ethiopian Journal of Animal Production*, 10, 1-18.
- Groen, A.F., 2000. Definition of breeding goal. In: Galal, S., Boyazoglu, J. and Hammond, K. (eds). *Developing breeding strategies for lower input animal production environments*. The International Committee for Animal Recording (ICAR), No. 3, 25-104.
- Gunia, M., Mandonnet, N., Arquet, R., Alexandre1, G., Gourdine, J.L., Naves, M., Angeon, V. and Phocas, F., 2012. Economic values of body weight, reproduction and parasite resistance traits for a Creole goat breeding goal. *Animal*, 7, 22-33.
- Jaitner, J., Sowe, J., Secka-Njie, E. and Dempfle, L., 2001. Ownership pattern and management practices of small ruminants in the Gambia: implications for a breeding program. *Small Ruminant Research*, 40, 101-108.
- Jembere, T., 2016. Genetic parameters, productivity indices and breeding plans for designing community-based goat breeding programs in Ethiopia. PhD Dissertation, Haramaya University, Haramaya, Ethiopia.
- Kargar, N., Ayatollahi Mehrqardi, A. and Asadi, M., 2017. Determination of economic values for some important traits of Rayeni cashmere goats reared under pasture system. *International Journal of Livestock Science and Technologies*, 5, 51-58.

- Kosgey, I.S., Rowlands, G.J., van Arendonk, J.A.M. and Baker, R.L., 2008. Small ruminant production in smallholder and pastoral/extensive farming systems in Kenya. *Small Ruminant Research*, 77, 11-24.
- König, E.Z., Mirkena, T., Strandberg, E., Audho, J., Ojango, J., Malmfors, B., Okeyo, A.M. and Philipsson, J., 2016. Participatory definition of breeding objectives for sheep breeds under pastoral systems-the case of Red Maasai and Dorper sheep in Kenya. *Tropical Animal Health and Production*, 48, 9-20.
- Laske, C.H., Teixeira, B.B.M., Dionello, N.J.L. and Cardoso, F.F., 2012. Breeding objectives and economic values for traits of low input family based beef cattle production system in the State of Rio Grande do Sul. *Revista Brasileira de Zootecnia*, 41, 298-305.
- Legese, G. and Fadiga, M., 2014. Small ruminant value chain development in Ethiopia: Situation analysis and trends. ICARDA/ILRI Project Report. Nairobi, Kenya: International Center for Agricultural Research in the Dry Areas/International Livestock Research Institute.
- Lopes, F.B., Borjas, A. de los R., Silva, M.C. da, Facó, O., Lôbo, R.N., Fiorvanti, M.C.S. and McManus, C., 2012. Breeding goals and selection criteria for intensive and semi-intensive dairy goat system in Brazil. *Small Ruminant Research*, 106, 110-117.
- Mirkena, T., 2010. Identifying breeding objectives of smallholders/pastoralists and optimizing community-based breeding programs for adapted sheep breeds in Ethiopia. PhD Dissertation, Austria, Vienna.
- Nandolo, W., Wurzinger, M., Mészáros, G., Tassell, C.V., Gondwe, T., Mulindwa, H., Lamuno, D. and Sölkner, J., 2016. Identification of breeding objectives in community based goat breeding programs in Malawi. *Acta agriculturae Slovenica*, 5, 103-108.
- Nielsen, H.M. and Amer, P.R., 2007. An approach to derive economic weights in breeding objectives using partial profile choice experiments. *Animal*, 1, 1254-1262
- NRC (National Research Council), 1981. Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries. *National Academy Press, Washington, DC. The National Academic Press*, <https://doi.org/10.17226/30>
- Philipsson, J., Rege, J.E.O. and Mwai, O., 2006. Sustainable breeding programs for Tropical farming systems. In: ILRI-SLU. Animal genetics training resource, CD- Version 2 (Eds.) Ojango, J.M., Malmfors, B. and Mwai, O. ILRI (International Livestock

- Research Institute), Nairobi, Kenya and SLU (Swedish University of Agricultural Sciences), Uppsala, Sweden.
- Rewe, T.O. and Kahi, A.K. 2012. Design and application of bio-economic modelling in livestock genetic improvement in Kenya: A Review, *Egerton Journal of Science and Technology*, 12, 113-119.
- SAS (Statistical Analysis System), 2008. SAS/STAT 9.2. User's Guide. Cary, NC: SAS Institute Inc
- SPSS (Statistical Package for Social Sciences), 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc.
- Sölkner, J., Grausgruber, H., Okeyo, A.M., Ruckebauer, P. and Wurzinger, M., 2008. Breeding objectives and the relative importance of traits in plant and animal breeding: A comparative review. *Euphytica*, 161, 273-282.
- Sölkner, J., Nakimbugwe, H. and Zarate, A.V., 1998. Analysis of determinants of success and failure of village breeding programs. In: *Proceedings of the Sixth World Congress on Genetics Applied to Livestock Production*, 25, 273-280.
- Vatankhah, M., 2010. Determination of economic weights for some important traits in native black goats. Final Report. Animal Sciences Research Institute. Iran.
- Vischer, P.M., Bowman, P.J. and Goddard, M.E., 1994. Breeding objectives for pasture based dairy production systems. *Livestock Production Science*, 40, 123-137.
- Wolfová, M. and Wolf, J., 2013. Strategies for defining traits when calculating economic values for livestock breeding: a re

PAPER V**Simulated Alternative Breeding Schemes for Optimizing Begait Goat Improvement Programs in Western Tigray, Northern Ethiopia**

Hagos Abraham^{1,*}, Solomon Gizaw³, Mengistu Urge²

¹Bule Hora University, Department of Animal Science, P.O. Box 144, Bule Hora, Ethiopia

²Haramaya University, School of Animal and Range Sciences, P.O. Box 138, Dire Dawa, Ethiopia

³International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

*Corresponding author: hagsabr@gmail.com

Submitted

Abstract

In the absence of well-designed national animal genetic improvement schemes, achieving and monitoring genetic gains is difficult. The objective of the present study was to evaluate three alternative breeding schemes for Begait goat. The breeding schemes were: a) government ranch breeding scheme b) commercial breeding scheme and c) cooperative village breeding scheme. The breeding schemes differed in the number of tiers (two tiers in the case of a and b, one tier in case of scheme c), flock size and selection method. The breeding schemes were compared for annual genetic and economic gains as well as operational feasibility. Statistical analyses were performed using ZPLAN computer program, which uses a deterministic approach to estimate genetic and economic gains in breeding programs. The results indicated that the annual genetic and economic gains increased with increased flock size and use of Best Linear Unbiased Prediction (BLUP) based selection method. The predicted genetic and economic gains were slightly higher under scheme a and b as compared to scheme c. The trait of greater economic impact was six month weight (6MW) in all schemes. However, scheme a seems more operationally feasible when compared to the other schemes. This is because the regional government showed high interest in the maintenance and development of Begait goat, sheep and cattle breeds. Government also planned to export meat by the end of Growth and Transformation Plan III and roadmap has been already developed for these animal breeds. Apparently, these are good opportunities which would make the development and implementation of the breeding program for Begait goat more feasible in the short-term when the public sector is involved.

Keywords: Economic gain, genetic gain, operational feasibility

Introduction

In spite of the large goat population and their role to the livelihood of resource-poor farmers and the national economy at large, the present level of productivity is low. Their productivity is constrained due to various factors. Among those reasons, lack of effective and sustainable breeding program is the most important reason for this failure. In Ethiopia like in the other developing world a few attempts to improve goats have been made in the past mainly by upgrading with exotic breeds through crossbreeding. However, findings (Ayalew *et al.*, 2003) suggested that crossbred goats do not perform better than the purebred indigenous goats if both groups are kept under similar management conditions.

Normally, many small ruminants (sheep and goats) cross breeding programs in tropics were not successful because of the incompatibility of the genotypes with the breeding objectives, management approaches of the prevailing low input production systems of the area, absence of involvement of livestock owners and stakeholders in decision making and ownership of the initiatives on low regard to the potential of indigenous breeds (Rewe *et al.*, 2002; Ayalew *et al.*, 2003; Kosgey *et al.*, 2006; Tibbo *et al.*, 2006).

Another approach is, therefore, required (Haile *et al.*, 2011) using indigenous purebred animal and improving production traits of local breeds that are well adapted to their environment. Genetic gain obtained from within-breed selection program has a special importance, as it is cost effective, permanent, cumulative and sustainable (HCC, 2004). Hence, the present study was conducted with the objective of evaluating alternative breeding schemes for optimizing Begait goat genetic improvement program in northwestern lowlands of Ethiopia.

Materials and Methods

Description of the study area

This study was conducted in Kafta Humera district of western zone of Tigray National Regional State. The study area is situated 1372 km away from the administrative center of

Addis Ababa city to northwest direction. Geographically, it is located in between the latitudes 13°14'-14°27'N and longitudes 36°27'-37°32'E. The study district comprises *kolla* (lowland) and *weinadega* (midland) agro-climatic zones with an altitude ranging from 560-1849 meters above sea level. The annual precipitation in the lowlands and midlands is 448.8 and 1102.5 mm, respectively (EARO, 2002) occurring between June and September. The mean minimum and maximum temperatures in the lowlands are 25°C and 27.5°C, respectively while the corresponding values in the midlands are 20°C and 25°C. The hottest months are between April and June with temperatures rising up to 42°C. Detailed descriptions of the study area are indicated in previous works (Abraham *et al.*, 2017).

Population structure and selection groups

The total number of breeding does in the population was calculated based on flock structure in the population. Based on previous works (Abraham *et al.*, 2017), does constitute the larger proportion (46.82%) of the flock. According to the same source, the total population of Begait goat is estimated to be 110,500 heads. Therefore, there is a total doe population of 51,736.

Six selection groups for two-tier breeding schemes (central nucleus-based), whereas four selection groups for one-tier breeding scheme (village-based) were defined to indicate the selection pathways. A selection group is defined by both, type of parents (one sex) passing genes and type of offspring receiving their genes. First and second selection groups are bucks born in nucleus to breed bucks (bucks to breed bucks, BB>BB) and does (bucks to breed does, BB>DB) for nucleus. Third and fourth selection groups are does born in nucleus to breed bucks (does to breed bucks, DB>BB) and does (does to breed does, DB>DD) for nucleus. Fifth selection group is bucks born in nucleus to breed bucks (bucks to breed bucks, BB>BB) for the base population. The sixth selection group is does born in base population to breed does (does to breed does, DB>DD) for the base population. The selection groups for one-tier breeding scheme include: 1) bucks to breed bucks (BB>BB) 2) bucks to breed does (BB>DB) 3) does to breed bucks (DB>BB) and 4) does to breed does (DB>DD).

Alternative breeding schemes

In this study, three alternative breeding schemes that differ in number of tiers, flock size and selection method were simulated. Comparison was made among them towards designing sustainable and operationally feasible breeding program for genetic improvement of the breed in the study area. Details of the breeding schemes are given below.

Scheme I: Government ranch breeding scheme

Government ranch (Humera Begait animal species conservation, breeding and improvement ranch) consisting of nucleus and base populations was simulated as two tier closed central nucleus-based breeding scheme. There was one way flow of genes, downward from top to bottom. Genetic gain is generated in the nucleus flocks and spread using males (bucks that do not qualify to be used in the nucleus flocks) to the base flocks through purchase, loan and communal use. It was established to address the entire Begait goat breed. The total population of breeding does was considered, with 5% forming the nucleus. Bucks to be used as sires in the base population are selected from a subset of bucks that did not qualify to be used in the nucleus flock based on Best Linear Unbiased Prediction (BLUP) of estimated breeding values. Selection criteria and selection are performed in the central nucleus using employed enumerators and animal breeding and genetics experts. The closed nucleus flocks proposed in the current study could develop into an open scheme when experience buildup in the breeding program. As far as the ranch is concerned, it was established in 2012 under the Bureau of Agriculture and Rural Development of Tigray National Regional State. It has land area of approximately 2000 hectare. The main highway that stretches from Mekelle city to Setit Humera town passes across the ranch.

Scheme II: Commercial breeding scheme

Large-scale/commercial farmers keep large flock size of Begait goat. Central nucleus-based commercial breeding scheme is, therefore, developed as an alternative scheme. In here, it was assumed that those willing and with large flock size large-scale farmers will develop an

association (Begait goat owning commercial farmers' association) and it will serve as a big central nucleus. This breeding scheme considered similar breeding structure explained under the government ranch breeding scheme, however, it is private type. Size of the nucleus was designed to be 5% of the entire population. Genetic gain is generated in the nucleus flocks and disseminated to the base flocks using young and proven bucks.

Scheme III: Cooperative village breeding scheme

The other alternative breeding scheme was one-tier cooperative village breeding scheme. It simulates a selection program addressing the entire Begait goat kept by small-scale farmers. Size of one breeding unit was designed to be 5% of the base population. Genetic generation and dissemination occur within this single breeding unit.

Breeding objectives and selection index

Four breeding objective traits (list of traits to be genetically improved because they influence Begait goat keeping farmers' income) were identified through participatory approach (own-flock ranking experiment) and developing bio-economic model (**Paper IV**). These traits were six month weight (6MW), daily milk yield (DMY), litter size (LS) and pre-weaning kid survival rate (SR). Relative economic weight for each trait was calculated as a product of its marginal economic value and the respective discounted genetic expression (DGE) coefficient. DGE and economic weights were calculated internally by using ZPLAN (Willam *et al.*, 2008) software using undiscounted economic values as inputs. The undiscounted economic values of the traits were calculated as the partial derivative of the profit with respect to the trait considered, keeping all the other traits constant using bio-economic model (**Paper IV**). One selection index was constructed containing all the identified traits.

Genetic and phenotypic parameters

Table 1 presents genetic parameters of traits used to design the breeding schemes. The genetic and phenotypic correlations and heritability estimates of the breeding objective traits were

derived from published works on indigenous and exotic small ruminants (Kominakis *et al.*, 1998; Vatankhah and Talebi, 2008; Gizaw *et al.*, 2010; Bett *et al.*, 2012; Abegaz *et al.*, 2014; Jembere, 2016) because estimates for Begait goats are not available. The phenotypic standard deviations of traits were estimated from monitoring study of the breed (**Papers II and III**).

Table 1. Phenotypic standard deviations (σ_p), heritabilities (on the diagonal), genetic (above the diagonal) and phenotypic correlations (below the diagonal) of the traits used in the simulated breeding schemes

Traits	σ_p	6MW	DMY	LS	SR
6MW	2.72	0.28	0.20	0.08	0.10
DMY	0.17	0.10	0.31	0.13	0.08
LS	0.74	0.02	0.19	0.05	-0.02
SR	0.29	0.10	0.38	0.00	0.09

σ_p : phenotypic standard deviation; 6MW: six month weight; DMY: daily milk yield; LS: litter size; SR: pre-weaning kid survival rate (proportion of kids survive or weaned)

Biological and technical parameters

Gene flow between populations and groups of animals is defined by constructing transmission matrix. The information used to build the transmission matrix were herd lifetime, survival rate and age at first kidding of animals in each selection group. Other reproductive parameters such as kidding interval, conception and twinning rates were used to calculate the proportion of selected animals and selection intensities. Table 2 describes the input variables in relation to biological and technical parameters linked with the breeding schemes.

Table 2. Biological and technical inputs used in modeling the breeding schemes

Variables	†Alternative breeding schemes		
	a	b	c
Population parameters			
Population of breeding does in the base	0.95	0.95	1.00
Population of breeding does in the nucleus	0.05	0.05	-
Biological parameters			
Age at first kidding for does in the base population (year)	1.20	1.20	1.20
Age at first kidding for does in the nucleus population (year)	1.20	1.20	1.20
Age at first kidding for bucks in the base population (year)	1.50	1.50	1.50
Age at first kidding for bucks in the nucleus population (year)	1.50	1.50	1.50
Kidding interval in the base population (year)	0.66	0.66	0.66
Kidding interval in the nucleus population (year)	0.66	0.66	0.66
Kidding rate in the base population (%)	90	90	90
Kidding rate in the nucleus population (%)	90	90	90
Mating ratio (buck to does) in the base population	35	35	35
Mating ratio (buck to does) in the nucleus population	25	25	25
Number of kids per doe/kidding in the base population (kids)	1.52	1.52	1.52
Number of kids per doe/kidding in the nucleus population (kids)	1.52	1.52	1.52
Pre-weaning kid survival rate in the base population (%)	85	85	85
Pre-weaning kid survival rate in the nucleus population (%)	90	90	90
Does in use in the base population (year)	7	7	7
Does in use in the nucleus population (year)	6	6	6
Bucks in use in the base population (year)	2.50	2.50	2.50
Bucks in use in the nucleus population (year)	2.00	2.00	2.00
Does survival rate in the base population (%)	90	90	90
Does survival rate in the nucleus population (%)	90	90	90
Bucks survival rate in the base population (%)	90	90	90
Bucks survival rate in the nucleus population (%)	95	95	95

† See text for the description of alternative breeding schemes

Parameters of investment and costs

Table 3 indicates the investment parameters and costs. The investment period considered was 10 years, by using 5% and 3% of interest rates for returns and costs, respectively. Overhead

(fixed) and variable costs were calculated per doe and per year for the considered alternative breeding schemes independently. Costs were internally discounted using ZPLAN (Willam *et al.*, 2008) computer program over the investment period. The costs are not those incurred in running the farm, but extra costs incurred due to introducing selection activities. Similarly, the returns do not include the whole return obtained from farm output, but extra return obtained due to genetic gain.

Table 3. Investment parameters and costs before discounting in the breeding schemes

Variables	†Alternative breeding schemes		
	a	b	c
Investment parameters			
Investment period (year)	10	10	10
Interest rate for returns (%)	5	5	5
Interest rate for costs (%)	3	3	3
Cost parameters			
Animal identification (doe/year, Birr)	22.68	22.68	22.68
Enumerator salary (doe/year, Birr)	11.22	11.22	23.28
Animal breeding expert salary (doe/year, Birr)	12.73	12.73	0.00
Stationary materials for data recording (doe/year, Birr)	0.76	0.76	0.75
Weighing balance (doe/year, Birr)	0.43	0.43	0.44
Electronic data processing (doe/year, Birr)	10.50	10.50	0.00

† See text for the description of alternative breeding schemes

Simulating the alternative breeding schemes

The computer program, ZPLAN version 2008 (Willam *et al.*, 2008) was used to simulate and compare the different alternative breeding schemes. The deterministic software uses gene flow methods and selection index procedures to simulate breeding programs. Based on genetic, biological and economic parameters, the computer program calculates genetic gain for the aggregate breeding value, the annual response for each trait and the profit per female animal due to selection. Profit is calculated as a difference between returns and costs.

Results and Discussion

Annual genetic gain

The objective of each breeding scheme was maximization of genetic gain per generation and per year. Table 4 provides expected annual genetic gains of the individual breeding objective traits from the different alternative breeding schemes. The results of this study indicated that annual genetic gains of the breeding objective traits were slightly higher under central nucleus-based breeding schemes when compared to village-based breeding scheme. This difference is attributable to selection method and population size differences. Genetic gain estimation is influenced by many factors including population size, testing capacity, heritability, generation interval and possibly the evaluation techniques used (selection index, BLUP and genomics) (Bijma, 2012; Nziku *et al.*, 2017). Gizaw *et al.* (2010) also noted that genetic gain could be slow under village breeding schemes as a result of inaccurate genetic gain evaluation because of the difficulties of implementing advanced selection tools such as selection on BLUP of breeding values and inefficient utilization of selected animals due to uncontrolled village breeding practices. On the other hand, Gizaw *et al.* (2009) predicted very close genetic gains from mass selection and BLUP of estimated breeding values of selection candidates in village or community based breeding schemes.

Higher annual genetic gain was obtained for 6MW. Government ranch breeding scheme and commercial breeding scheme improved 6MW equally by 0.759 kg annually. However, under cooperative village breeding scheme the trait was improved by 0.6747 kg per year. The predicted higher annual genetic gain of 6MW from all breeding schemes is due to its higher economic value, medium heritability, high and positive genetic and phenotypic correlations with all other breeding objective traits considered. The genetic gain of 6MW predicted in this study is comparable to the reported annual genetic gain of the trait for Western Lowland goats (0.8702 to 0.8724 kg) (Abegaz *et al.*, 2014). In contrast, Jembere (2016) reported lower annual genetic gain (0.174 to 0.467 kg) of 6MW for Abergelle, Central Highland and Woyto-Guji goat breeds.

The genetic gain per year for DMY was in the range of 0.0112 kg under cooperative village breeding scheme to 0.0120 kg in both government ranch breeding scheme and commercial breeding scheme. The genetic gain for DMY in this study was comparable to the genetic gains observed by Mirkena *et al.* (2012) for Afar sheep (0.018 to 0.020 kg per year) and Abegaz *et al.* (2014) for Abergelle goats (0.0066 to 0.0114 kg per year). However, higher genetic gain of DMY was predicted for Kenyan dairy goats (0.261 to 0.770 kg per year) (Bett *et al.*, 2012). In fact, milk yield comparison among studies sometimes may not be precise due to differences in objectives. For instance, dos Santos *et al.* (2015) obtained genetic gains ranging from 19.31 to 31.00 kg per year of milk yield for Brazilian dairy goats. The objective of these authors was predicting annual genetic gain of lactation milk yield, which is different from our study, under different alternative breeding schemes.

Very low, but positive annual genetic gains were predicted for LS and SR for all breeding schemes (see Table 4). In agreement with the results of the current study Abegaz *et al.* (2014) reported low annual genetic gains of LS for Western Lowland goats from different schemes. The predicted annual genetic gains for SR from the alternative schemes were also comparable with the results reported by Bett *et al.* (2012) for Kenyan dairy goats, Abegaz *et al.* (2014) for Abergelle and Western Lowland goats, and Mirkena *et al.* (2012) for Afar sheep. The low genetic gain in reproductive traits is due to their low heritability and genetic correlations with growth traits (Mirkena *et al.*, 2012; Gizaw *et al.*, 2014).

Generally, simulation results gave an acceptable range of genetic gains with little difference across the alternative breeding schemes.

Table 4. Predicted genetic gains of the breeding objective traits under different breeding schemes

†Alternative breeding schemes	Breeding objective traits			
	6MW (kg)	DMY (kg)	LS	SR (%)
a	0.7590	0.0120	0.0072	0.0046
b	0.7590	0.0120	0.0072	0.0046
c	0.6747	0.0112	0.0065	0.0041

†See text for description of alternative breeding schemes; 6MW: six month weight; DMY: daily milk yield; LS: litter size; SR: pre-weaning kid survival rate (proportion of kids survive or weaned)

Genetic improvement in within-herd performance is a result of increasing the frequency of desirable genes and preventing genetically inferior animals from passing their unfavorable genes to next generations. In the present study, results indicated that the genetic superiority of selected animals (response per generation for the breeding objective) in the different selection groups ranged between 35.62 and 60.49 birr. The annual genetic gains were higher in sire selection groups (BB>BB and BB>DB) as compared to dam selection groups (DB>BB and DB>DB; see text for notations). This was due to the higher selection intensity in sire selection groups (2.33) than in dam groups (1.51). This is an indication that sire selection is important to genetic gain in the nucleus and in the overall breeding program. This was in consistent with Gizaw *et al.* (2010), who reported higher annual genetic response from sire selection.

Costs, returns and profit

As in any other activity, a breeding program presents costs for its implementation and it is necessary to monitor them so that there are economic benefits from the program. Table 5 describes overall discounted return, returns per trait and profit per doe and per year. The comparison among the alternative breeding schemes revealed that discounted return for each breeding objective traits and discounted profit per doe and per year were higher in the government ranch breeding scheme and commercial breeding scheme than cooperative village breeding scheme indicating that there is better benefit of implementing the central nucleus-based schemes. The highest discounted return was predicted from improving 6MW across all the breeding schemes.

Table 5. Returns and profits per doe and per year in the alternative breeding schemes (Birr)

	†Alternative breeding programs		
	a	b	c
Discounted overall return	88.96	88.96	68.71
Discounted return/trait			
6MW	80.64	80.64	63.02
DMY	6.07	6.07	4.35
LS	1.32	1.32	0.82
SR	0.93	0.93	0.52
Discounted profit/doe/year (Birr)	48.26	48.26	37.47

†See text for description of alternative breeding schemes; 6MW: six month weight; DMY: daily milk yield; LS: litter size; SR: pre-weaning survival rate (proportion of kids weaned or survive)

Operational feasibility

The considered alternative breeding schemes are the most likely to be adopted. Under the evaluated central nucleus-based breeding schemes (which allowed for downward movement of genetically superior males from the nucleus to the base population to breed sires and dams) and the village-based cooperative breeding scheme, comparable annual genetic and economic gains are predicted (Tables 4 and 5). The success of animal genetic improvement breeding program should also focus on the operational feasibility. In this case, the government ranch breeding scheme seems more operationally feasible when compared to the other breeding schemes. It could be easily started because it involves setting up an independent nucleus with 5% of the base population and it is ongoing with 135 breeding Begait does. Begait sheep and cattle breeds are also found. Since the last six years, government is investing in conservation and improvement of the Begait animal species. Besides, government planned to export meat of these animals by the end of Growth and Transformation Plan III and road map has been already developed concerning genetic, health and feed improvements. Haile *et al.* (2011) also noted that during developing genetic improvement program an integrated approach that is taking into account genetics, nutrition, health, input supply and services and markets are vital. These could be considered as good opportunities. Hence, the government ranch seems fitting and can be implemented within a short period of time through incorporating public services.

Operational considerations in running such a scheme includes that farmers participating in the breeding program need to practice controlled breeding as the scheme assumes that all males in the target base population use males from the nucleus. It is also recommended to distribute males to organized villages using communal grazing and therefore communal males. Use of improved males in common will increase the mating ratio, genetic and economic gains from the investment. Gizaw *et al.* (2010) noted that by using genetically improved rams in common it is possible to increase the mating ratio, annual genetic progress and profitability of Washera sheep breed.

Despite the fact that the results from commercial breeding scheme are encouraging for large-scale farmers (private investors), the scheme seems to be operationally difficult. This could be because the nucleus flock is made up of genetically interlinked commercial flocks, which depends on commercial farmers' interest to participate in the program and their commitment to start the program within a short period of time. Therefore, this could be a big challenge in developing commercial breeding scheme within a short period of time. On the other hand, operational feasibility of village-based scheme depends on the commitment of the villagers to participate. As lack of concurrence by some of the villagers would affect the level of controlled breeding and genetic gain achievable. Besides, cooperative village-based scheme is needed within individual villages, which is technically and logistically tremendously challenging. Kosgey and Okeyo (2007) indicated that within-breed genetic improvement of small ruminants under smallholder systems is constrained by both technical and infrastructural factors. Wurzinger *et al.* (2008) also indicated that it is a very challenging task to implement a practicable program facing many constraints and difficulties like bad infrastructure, low technical ability and limited financial support. Therefore, implementation of village-based breeding program for Begait goat in the area seems challenging. This is good indication that the central nucleus-based government ranch is more fitting when compared to the other schemes for genetic improvement of the breed as it resulted in good annual genetic and economic gains with better operational feasibility.

Conclusion

The present study has brought out sustainable breeding program for Begait goat breed in western Tigray region of Ethiopia. In the current study, three alternative breeding schemes: two central nucleus-based and one village-based schemes were evaluated for annual genetic and economic gains and operational feasibility. The results showed that the breeding schemes, central nucleus-based breeding schemes, were fairly superior to the village-based breeding scheme in terms of annual genetic response and profit. The government ranch breeding scheme, however, seems much more operationally feasible because of the presence of good opportunity to organize a large government ranch in the area. The government ranch started with few Begait animal species. Besides, government planned to export meat of these animal species in a short period of time and a roadmap is developed for the realization of the plan. Overall, higher genetic gains and the sustainability of the proposed scheme can be anticipated when farmers and likely institutions or organizations are able to play role in implementation of the breeding program, while closely working with research centers and higher academic institutions. The commercial and village-based schemes seem to be challenging to operate as compared to government ranch. However, when the government ranch is not successful they are recommended for genetic improvement of the breed by considering their limitations.

References

- Abegaz, S., Sölkner, J., Gizaw, S., Dessie, T., Haile, A., Mirkena, T., Getachew, T. and Wurzinger, M. 2014. Optimizing alternative schemes of community-based breeding programs for two Ethiopian goat breeds. *Acta Agr. Kapos*: 18 (1): 47-55.
- Abraham, H., Gizaw, S. and Urge, M. 2017. Begait goat production systems and breeding practices in Western Tigray, North Ethiopia. *Open Journal of Animal Sciences*, 7(2): 198-212.
- Ayalew, W., Rischkowsky, B., King, J.M. and Bruns, E. 2003. Crossbreds did not create more net benefits than indigenous goats in Ethiopian smallholdings. *Agricultural System*, 76, 1137–1156.

- Aziz, M.A. 2010. Present status of the world goat populations and their productivity. *Lohmann information*, 45(2): 42-52.
- Bett, R.C., Okeyo, A.M., Kosgey, I.S., Kahi, A.K. and Peters, K.J. 2012. Evaluation of alternative selection objectives and schemes for optimization of village goat improvement programs. *Livestock Research for Rural Development*, 24(1).
- Bijma, P. 2012. Accuracies of estimated breeding values from ordinary genetic evaluations do not reflect the correlation between true and estimated breeding values in selected populations. *Journal of Animal Breeding and Genetics*, 1-14.
- dos Santos, L.H., Lôbo, A.M.B.O, Facó, O., Gonçalves, H.C. and Lôbo, R.N.B. 2015. Breeding programs for dairy goats generate profits in Brazil. *Livestock science*, 178: 27-34.
- EARO (Ethiopian Agricultural Research Organization). 2002. An assessment of the agricultural production base, technological packages and innovation and intervention strategies for commercial farmers in Kafta humera wereda of Tigray Regional State, Addis Ababa, Ethiopia.
- FAOSTAT. 2016. Food and agricultural organization of the United Nations, statistical division. <http://faostat3.fao.org/browse/Q/QA/E>. Last accessed on 10 August, 2016.
- FAOSTAT. 2014. <http://faostat.fao.org/default.aspx>. Accessed on February 25, 2017.
- Gizaw., S., Rischkowsky, B., Valle-Zarate, A., Haile, A. van Arendonk, J.A.M., Okeyo, A.M. and Dessie, T. 2014. Breeding programs for smallholder sheep farming systems: I. Evaluation of alternative designs of breeding schemes. *Journal of Animal Breed and Genetics*, 131: 341-349.
- Gizaw, S., Haile, A. and Dessi, T. 2010. Breeding objectives and breeding plans for Washera sheep under subsistence and market-oriented production systems. *Ethiopian Journal of Animal Production*, 10(1): 1-18.
- Gizaw, S., Komen, H. and van Arendonk J. A.M. 2009. Optimal village breeding schemes under smallholder sheep farming systems. *Livestock Science*, 124: 82–88.
- Haile, A., Wurzinger, M., Mueller, J., Mirkena, T., Duguma, G., Mwai, O., Sölkner, J. and Rischkowsky, B. 2011. Guidelines for setting up community-based sheep breeding programs in Ethiopia. ICARDA - tools and guidelines No.1. Aleppo, Syria, ICARDA.

- HCC (Hybu Cig Cymru/Meat Promotion Wales). 2004. Practical Sheep Breeding.
- Jembere, T. 2016. Genetic parameters, productivity indices and breeding plans for designing community-based goat breeding programs in Ethiopia. PhD dissertation, Haramaya University, Haramaya, Ethiopia.
- Kosgey, I.S. and Okeyo, A.M. 2007. Genetic improvement of small ruminants in low input, smallholder production systems: technical and infrastructural issues. *Small Ruminants Research*, 70: 76–88.
- Kosgey, I.S., Baker, R.L., Udo, H.M.J. and Van Arendonk, J.A.M. 2006. Successes and failures of small ruminant breeding programs in the tropics: A review. *Small Ruminant Research*, 61: 13–28.
- Mirkena, T., Duguma, G., Willam, A., Wurzinger, M., Haile, A., Rischkowsky, B., Okeyo, A.M., Tobbo, M. and Sölkner, J. 2012. Community-based alternative breeding plans for indigenous sheep breeds in four agro-ecological zones of Ethiopia. *Journal of Animal Breeding and Genetics*, 129: 244-253.
- Nziku, Z.C., Kifaro G.C., Eik L.O., Steine, T. and Ådnøy, T. 2017. Use of simulation to examine a dairy goat breeding program in Tanzania. *Livestock Research for Rural Development*, 29(3).
- Rewe, T.O., Ogore, P.B. and Kahi, A.K. 2002. Integrated goat projects in Kenya: impact on genetic improvement. In: *Proceedings of the Seventh World Congress on Genetics Applied to Livestock Production*, vol. 33, Montpellier, France, 19–23 August 2002, Pp. 385–387.
- Tibbo, M., Philipsson, J. and Ayalew, W. 2006. Sustainable sheep breeding programs in the Tropics: Framework for Ethiopia. Conference on International Agriculture Research for Development, University of Bonn, Germany.
- Vatankhah, M. and Talebi, M.A. 2008. Heritability estimates and correlations between production and reproductive traits in Lori-Bakhtiari sheep in Iran. *South African Journal of Animal Science*, 38(2): 110-118.
- Willam, A., Nitter, G., Bartenchlager, H., Karras, K., Niebel, E. and Graser, H.-U. 2008. ZPLAN-manual for a PC-program to optimize livestock selection schemes. Manual Version 2008 for Source Code “z10.for”. Institute of Animal Production in the Tropics and Subtropics. Universität Hohenheim, Stuttgart, Germany.

Wurzinger, A., Willam , J. Delgado, M. Nu"rnberg, A.V., Za'rate , A. Stemmer, G. Ugarte and S"olkner, J. 2008. Design of a village breeding program for a llama population in the High Andes of Bolivia M. *Journal of Animal Breeding and Genetics*, 125: 311-319.

8.2. APPENDIX B: QUESTIONNAIRES AND FORMS USED

Part I: Questionnaires used to describe production and breeding systems

Study site/*kebele* _____ Questionnaire № _____ Farming system _____

Interviewing Households

A. Household head demographic characteristics

1. Age (in years) _____ Sex _____
2. Marital status A) married B) single C) divorced D) widowed
3. Education level A) illiterate B) literate

B. Farming systems

1. Livestock production system A) crop-livestock system B) agro–pastorals C) pastoral D) other (Specify)
2. Order your sources of income A) livestock sale B) livestock products C) crop sale D) off-farming activity E) others (specify)

C. Total land holding size

1. Do you own land? A) Yes B) No
 - 1.1. If your answer is yes, landholding size _____ (in hectare)
 - 1.2. If your answer is yes, why do you use the owned land for goat? -----
2. Major crops (rank based economic importance) A) sesame C) sorghum C) cotton D) others (specify)
3. Trend in land holding A) decreasing B) increasing C) stable D) other (specify)

D. Animal Production

1. Total number of livestock species

Animal species	Population size	Breed type (name of the breed)
Goats		
Sheep		
Cattle		
Horses		
Donkeys		
Camel		
Mules		
Chickens		

2. Status of Begait goat A) decreasing B) increasing C) no change D) others (specify)

2.1. If increasing, reason _____

2.2. If decreasing, reason _____

2.3. Desirable qualities of Begait goat _____

E. Herd structure and herding

1. Order your herd/goats based on age and sex (in number) A) male kids < 6 month ----- B) female kids < 6 month ----- C) male kids 6 month to 1 year ----- D) female kids 6 month to 1 year ----- E) males >1 year ----- F) females >1 year ----- G) castrated male (s) -----

2. How is goat flock herded during the day time? A) males and females are separated B) kids are separated C) All in one

3. Goat flock is herded together with A) cattle B) sheep C) camel D) equines E) all herded together F) goats herded separately

4. Your flock is herded A) separately B) with other farmers' flocks in your village C) with other farmers' flocks outside of your village

F. Purpose of goat rearing/keeping

1. What are your objectives of goat production? State the production objectives and rank based on their economic importance.

Purpose	Tick	Rank
Meat		
Milk		
Income		
Social Security		
Social Prestige		
Ceremonies/Holiday		
Skin		
Manure		
Others		

G. Milking

1. Do you milk your goats? A) Yes B) No
2. If your answer is yes, who does milking? A) daughter B) husband C) wife D) employed
- 2.1. If your answer is yes, your milking frequency is A) once per day B) twice per day
3. Average daily milk yield per doe (----- liter)
4. Average lactation length (----- months)
5. Milk utilization A) family consumption only B) family consumption and source of income c) income source only
6. Proportion of milk used in A) family consumption only (----- %) B) family consumption and source of income (----- %) C) income source only (----- %)

H. Housing condition

1. Where do you house your goats? A) stone made B) open house C) closed house D) in family house E) separate barn/ shed F) others (specify)
2. Type of housing materials A) grass/bushes B) wood C) earth/mud D) concrete E) others (specify)
3. Do you house the different categories differently? A) Yes B) No
- 3.1. If your answer is no, reason -----

I. Breeding

1. Do you practice any genetic selection in breeding animals in your flock? A) Yes B) No
- 1.1. If your answer is yes, selection criteria for breeding doe. A) size/appearance B) color C) kid survival D) kid growth E) age at first sexual maturity F) kidding interval G) twinning ability H) high milk yield I) ability to walk long distance J) others (specify)

1.2. If your answer is yes, selection criteria for breeding buck a) Appearance/conformation B) color C) horn D) character/temperament E) adaptability F) growth G) age H) libido I) ability to walk long distance J) pedigree K) others (Specify)

2. If you do not have breeding buck, how you mate your does? A) neighboring B) unknown C) others (specify)

3. Type of mating used A) controlled B) uncontrolled/natural

J. Castration and culling method/marketing

1. Do you castrate? A) Yes B) No

1.1. If your answer is yes, reason/s: A) control breeding B) improve fattening C) better price D) better temperament

1.2. If your answer is yes, at what age? A) < 3 months B) 3-6 months C) > 6 months

1.3. Castration method A) modern B) traditional

2. Castration season _____. Reason _____

3. If your answer is no, reason _____

4. Average market age (months) for A) males _____ B) females _____

5. Average culling age due to old age for A) males _____ B) females _____

7. Where did you market your animals? _____

8. How far? _____

9. How is the price? _____

10. Major problems in marketing _____

K. Input delivery

1. Do you use external inputs? A) Yes B) No

1.1. If your answer is yes, give examples such as feed, medicine

1.2. How is the delivery/accessibility? A) efficient B) not efficient C) I don't know as I don't use.

L. Reproductive characteristics

1. Average age at sexual maturity for A) males _____ (months) B) females _____ (months)

2. Average kidding interval _____ (months).

3. Average reproductive lifetime of doe (years) _____

4. Average number of kids per doe life time _____

M. Constraints for goat production

Major constraints	Tick	Rank
Shortage of Feed		
Shortage of grazing land		
Health problem (vet. service)		
Theft		
Low productivity (breed)		
Predator		
Water scarcity		
Labor scarcity		
Others (specify)		

N. Feed Resources and Feeding System

	Feed resources						
	N/pasture	C/residue	Hay	Concentrate	Fodder/trees	Crop aftermath	Others
Tick							
Rank							

Major crop residues (list based on their importance)

O. Supplementation

1. Have you ever purchased supplement feed for livestock/goats? A) Yes B) No

1.1. If your answer is yes, what types of supplementation feed? A) brewery-byproduct B) minerals C) sesame cake D) cottonseed cake E) wheat bran F) molasses G) others (specify)

P. Grazing management

1. Is there communal grazing land? A) Yes B) No

1.1. If your answer is yes, its status is A) decreasing B) increasing C) no change D) others (Specify)

1.2. If it is decreasing, the reason is

	Farm land expansion	Soil degradation	Rising livestock population	Land use policy	Others
Tick					
Rank					

2. Type of grazing land utilization A) hay form B) direct grazing C) cut and carry (zero grazing) D) others (specify)

3. Measures taken to alleviate feed shortage

S/No.	Measures taken	Tick	Rank
1	Feed conservation		
2	Purchase of concentrate		
3	Purchase of forage		
4	Destocking		
5	Migration		
6	Other (specify)		

Q. Watering management

1. Water source (s) (*tick one or more*)

Water source (s)	Dry season	Wet season
River		
Pond water		
Rain water		
Wells		
Tap water		
Others (specify)		

2. Average distance traveled and watering frequency

Wet season	Average distance travelled	Watering frequency
	A) watered at home B) < 1 km C) 1-5 km D) 6-10 km E) > 10 km	A) Freely available B) Once a day C) Twice a day
Dry season	A) watered at home B) < 1 km C) 1-5 km D) 6-10 km E) > 10 km	A) Freely available B) Once a day C) Twice a day

Part II: Focus group discussion (key informants)

Kebele (rural locality) _____

1. Origin and distribution of Begayit goat _____

2. Estimated population size in your *Kebele* (in number) _____

3. Status A) increasing B) decreasing C) no change

3.1. If increasing, reason _____

3.2. If decreasing, reason _____

4. The major breeding problems that affect the herd productivity in your area

5. The most infectious diseases of goat in your area

6. Put your general comments/ideas.

Part III: Format for phenotypic ranking (own-flock ranking experiment)

Traits	First best	Second best	Third best	Worst
Age				
Body weight				
Body length				
Chest girth				
Nº of kidding				
Twinning				
Nº of kids born				
Nº of kids weaned				
Daily milk yield				

Part IV: Performance Record Sheet

8.3. APPENDIX C: SAMPLE PICTURES



Picture 1: Begait buck (left) and doe (right)



Picture 2: Triplet birth



Picture 3: Mixed herding (Begait goat and sheep)



Picture 4: Mixed housing (Begait goat and sheep)



Picture 5: Partial view of collected milk (on-station)



Picture 6: partial view of bottle feeding (on-station)



Picture 7: Flock of Begait goat and sheep