MANAGEMENT PRACTICES, EGG PRODUCTION AND LINEAR BODY MEASURMENT TRAITS OF LOCAL AND EXOTIC CHICKENS REARED UNDER TRADITIONAL PRODUCTION SYSTEM IN BORICHA WOREDA, SIDAMA ZONE

MSc Thesis

SERKALEM ASSEFA

HAWASSA UNIVERSITY

College of Agriculture

Hawassa, Ethiopia

November, 2017

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MSc Thesis

SERKALEM ASSEFA

MAJOR ADVISOR: ABERRA MELESSE (PhD, Professor)

CO – ADVISOR: SANDIP BENERJEE (PhD, Associate professor)

A Thesis Submitted to the School of Animal and Range Sciences

HAWASSA UNIVERSITY

College of Agriculture

In partial Fulfillment of the Requirements for the Degree of Master of Science in Animal and Range Sciences (Specialization: Animal production)

Hawassa, Ethiopia

November, 2017

APPROVAL SHEET

Department of Graduate Committee

HAWASSA UNIVERSITY

As members of the Examining Board of the Final MSc Open Defense, we certify that we have read and evaluated the thesis prepared by Serkalem Assefa entitled "**Management practices, egg production and linear body measurement traits of local and exotic chickens reared under traditional production system in Borich woreda, Sidama zone"** and recommend that it be accepted as fulfilling the thesis requirement for the degree of the degree of Master of Science in specialization of animal production.

Name of chairman	Signature	Date
_____	_____	_____
Name of major advisor	Signature	Date
Aberra Melesse (PhD, Professor)	_____	_____
Name of co advisor	Signature	Date
Sandip Benerjee (PhD, Associate professor)	_____	_____
Name of internal Examiner	Signature	Date
Kefyalew Berihun (Msc, Associate professor)	_____	_____
Name of external Examiner	Signature	Date
Wendmeneh Eshetu (	_____	_____

Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the Department of Graduate Council (DGC) of the candidate's major department.

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Name of thesis advisor	Signature	Date
_____	_____	_____

DEDICATION

I dedicate this manuscript to the late my mother Askalu Solomon who passed away without witnessing any of my achievements in my career.

STATEMENT OF AUTHOR

I declare that this thesis is the result of my own work and that all sources or materials used in this thesis have been properly acknowledged. This thesis is submitted in partial fulfillment of the requirements for M.Sc. Degree at Hawassa University and to be made available at the University's Library under the rules of the Library. I confidently declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate.

Name of student	Signature	Date
_____	_____	_____

Place: Hawassa University, College of Agriculture, Hawassa

Date of submission _____

ACKNOWLEGEMENTS

First of all, I pay homage and thank God for making all good things happen in my life.

I would like to extend my heartfelt thanks to my major advisor Prof. Aberra Melesse for his valuable advice, insight and guidance in completion of the thesis work. I would also want to extend my deepest gratitude to my co-advisor Dr. Sandip Benerjee for his patience, interest, guidance, constructive comments and useful suggestions throughout the work.

I wish to thank Ministry of education for allowing me to join the MSc programme and for his financial support. I would also want to thank Boricha Woreda Agricultural office expert especialy animal and fishery office head of poultry production Mr. Messay Sawol and other enumerators for their effort devoted in collecting the data from the respondents with full willingness.

Last, but not least, my special thanks go to my mother Tsehay Belew and father Assefa Getu as well as my ant Genzeb Solomon and all of my parents for always believing in me, for their continuous love and supports.

LIST OF ABBREVATIONS

a.s.l.	Above sea level
AFE	Age at First Egg
AH	Albumin Height
AOB	Agricultural Office of Boricha
BB	Bovans Brown
BL	Body Length
BWt	Body Weight
C^{O}	Degree Centigrade
CW	Chest Width
EW	Egg Weight
FAO	Food and Agriculture Organization
HU	Haugh Unit
KK	Koekoek
LSFROB	Livestock and Fisheries Resource office of Boricha
SAS	Statistical Analysis System
SD	Standard Deviation
ShL	Shank Length
SNNPR	Southern Nation Nationalities and People Region
WLH	White leghorn

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MANAGEMENT PRACTICES, EGG PRODUCTION AND LINEAR BODY MEASURMENT TRAITS OF LOCAL AND EXOTIC CHICKENS REARED UNDER TRADITIONAL PRODUCTION SYSTEM IN BORICHA WOREDA, SIDAMA ZONE

By: SERKALEM ASSEFA

Major advisor: ABERRA MELESSE (PhD, Professor)
Co advisor: SANDIP BENERJEE (PhD)

ABSTRACT

This study was conducted to assess the management practice, egg production potential, quality and linear body measurement traits of three exotic and local chickens reared under traditional production system in Boricha woreda of Sidama zone. For the survey part, a total of 200 households were randomly selected from 4 purposively selected Kebles which were subdivided in midland and lowland agroecologies. Linear body measurement and egg quality traits were assessed from a total of 192 local and 3 exotic chicken breeds (Bovans, Koekoeck and Sasso) drawn from 48 households. About 480 eggs were used for the evaluation of external and internal egg qualities. The results indicated that the average numbers of eggs set for incubation per hen were 11.1 eggs with a hatchability of 60.0%. Average age at first egg was 238, 155, 157 and 174 days for local, Sasso, Bovans and Koekoeck chicken breeds, respectively. The number of eggs per hen per year was 49.1, 134, 117and 138 for local, Sasso, Bovans and Koekoeck, respectively. The Sasso breed reared in the lowland produced the highest egg number followed by Bovans being ($p<0.05$) different from Koekeock and local chickens. Moreover, the Sasso chicken breeds reared in the lowland agroecology had higher ($p<0.05$) values in most linear body measurement traits than those of other chicken breeds. Similarly, egg weight and yolk index values of Sasso breeds reared in the lowland was higher ($p<0.05$) than those of other chicken breeds. Koekoeck and Sasso chicken breeds reared in midland had higher ($p<0.05$) shape index and shell thickness values than those reared in the lowland. All chicken breeds reared in the lowland agroecology were better ($p<0.05$) in all external egg quality parameters than those reared in the midland. Yolk colour was higher ($p<0.05$) only for chickens reared in the lowland agroecology. All internal egg quality traits of Koekoeck chickens reared in the midland were superior to those of lowland agroecology. In conclusion, the Sasso chicken breed was found to be more efficient in most performance traits if it is reared in the lowland agroecology. Koekoeck chicken breed reared in the midland agroecology was superior in most internal egg quality parameters. It is thus recommended to use Sasso chicken breeds in the lowland agroecology while Koekoeck chicken in the midland agroecology for better productivity.

Key words: *Bovans; Sasso; agroecology; linear body measurements; egg quality*

1. INTRODUCTION

1.1. Background and justification of the study

In Ethiopia, majority of the chickens are raised under the traditional management system by small and marginal farmers for whom it may be the only form of savings and their own consumption. The characteristics of traditional poultry production system are small flock sizes, low input and output, chicken house which is together with their owners, hens lay a few eggs in a year, broody and hatching is by natural incubation and periodic devastation of the flock by disease and predators. Indigenous chickens are widely distributed in rural and peri-urban areas where they play the important role of income generation especially for those who are resource challenged families (Abere, 2015). Chickens are effective waste converters: they convert scavenged and unused feed resource into animal protein (Dawit, 2010; Hunduma, 2014 and Abere, 2015).

Primarily chickens reared as a source of food. Besides meat, chickens are important source of another form of animal protein i.e. egg. Eggs are considered as a complete food in human diet worldwide as it contains almost all the nutrients in balanced form such as proteins and vitamins, and are also rich in fat soluble vitamins (A, D, E, and K) (Sreenivas *et al.*, 2013). In Ethiopia it has been reported that 26.84% of the total egg production were used for household consumption while 39.55% of the total egg production were used for restaurant. About one-third of the egg production in the country was used for hatching (CSA, 2015).

Reproductively sound chickens are more efficient, help to maximize production and minimize cost of production (Heather, 2011). Study on the scenario and current chicken production, productivity and constraint as well assessing hindering factors that might be an essential prerequisite to bring the indigenous production system more productive conditions and to

develop strategies. The causes, magnitude and consequent impact of the problems for the poultry productivity under traditional management must be studied and well documented before attempting any technological intervention to improve the traditional poultry production system (Mammo *et al*., 2011). Since, development of village chicken production can be a sustainable way of helping to meet the needs of rural populations and advance their living standards; study production performance of exotic birds in Ethiopian condition needs to be monitored regularly to provide guidelines for policy makers (Fiseha *et al*., 2010).

Systematic characterization, breed improvement and conservation programs may help to sustain village chicken production system in Ethiopia and could be a useful micro-economic strategy in the on-going poverty alleviation process in the country. The indigenous chicken population of Ethiopia has been undergoing genetic erosion especially in the central and other parts of the country following the introduction of exotic stock from developed countries. Phenotypic performance data is crucial to suggest how they could be exotic under the existing village conditions of the country, designing appropriate management, selection and the development of genetic improvement programs of chickens in Ethiopia (Emebet, 2015 and Assan, 2015).

Egg quality can be divided into internal (yolk and albumin height and diameter, yolk color, yolk and albumin weight, Haugh unit) external (egg weight, length and shell thickness) parameters focusing on the egg content and egg shell (Desalew, 2012). The quality of an egg laid could be one indicator of productivity, overall care given for exotic chicken at village level and success of a poultry business because it is associated with the acceptability among the consumers, producers and embryonic development of hens. Heavier egg weight were hatched to heavier chicks also, very small eggs can't be sold as table eggs and large eggs have higher handling losses and both have poor fertility (Desalew, 2012 and Fassill *et al.*, 2010).

There are also several studies being undertaken by different researchers in different area related to comparing the production efficiency (egg production and egg quality parameters) of the native and exotic chickens reared under traditional system of management (Fassill *et al.,* 2010; Bikila, Hussain *et al.,* Merga, 2013 and Desalew, 2012). Additionaly, most of the table eggs in developing countries derive from extensive production system (Mesba *et al.*, 2012). However, Boricha woreda of Sidama zone had large population of exotic chickens which distributed by Livestock and Fishery resource office and local chicken. The production potential, egg quality and linear body measurement traits of chicken breeds are not yet assessed and documented.

1.2. Statement of the problem

With the aim of improving poultry productivity, different breeds of exotic chickens (Rhode Island Red, Australop, New Hampshire, White Leghorns, Isa Brown, BB, and dual-purpose hybrid PK) were imported to Ethiopia since the 1950ʺs particularly to smallholder farmers under backyard management. Since higher learning institutions, research organizations, the Ministry of Agriculture and Non-Governmental Organizations have disseminated many exotic breeds of chicken to rural farmers and urban-based small-scale poultry producers (Fiseha *et al.,* 2010). Ethiopia is representative of countries where village poultry plays a dominant role in total poultry production which represents an important part of the national economy in general and rural economy in particular (Aberra and Tegene, 2011). Lack of recorded data on the productive performance, management practice and marketing system of chicken makes it difficult to assess the importance and contributions of the past attempts to improve the village poultry production sector (Fiseha *et al.,* 2010).

The contribution of exotic chicken to the Ethiopian economy is significantly lower than that of other African countries. This may be attributed to poor adaptation potentials of environment and managements of the exotic chickens when compared to the native chickens (Haftu, 2016). In the same in Boricha Woreda, many dual-purpose exotic chickens such as WLH, BB, PK and Sasso were introduced over the years. However, there was no researches done and documented reports in relation to local and exotic chicken management practices and their egg production performance with respect to their quality and morphological traits which help for future decision on chicken distribution and breed improvement. Therefore, the study was conducted with the following objectives:

- To assess the management practices, constraints, egg production potentials and egg quality parameters of exotic and local chickens reared under traditional production system of study area.
- To characterize and describe the body weight and linear body measurement variations of exotic and local chickens reared in the study area.

2. LITERATURE REVIEW

2.1. Traditional poultry production systems

Traditionally poultry productions in the developing countries are synonymous to backyard or scavenging poultry production system (Mekonnen, 2007). This is more or less a family venture where the chickens are reared to satisfy the family needs and for meeting immediate cash (Bogale and Mapiye *et al.,* 2008 and Haftu, 2016). It has also been observed (FAO, 2010) that the flock size varies from location to location and averaging to about (5-10) chickens per household. Traditionally the chickens husbandry is the poorest amongst all livestock reared (Fisseha *et al.,* and Dinka *et al*., 2010 and Mammo *et al*., 2011).

2.1.1 Housing of chickens

In such type of production system the chickens are seldom well managed and are grossly devoid of any proper housing, they either perch on the trees or share the dwellings with their owners (Solomon, 2007). Further studies by Wilson (2010) and Addis and Malede (2014) suggested that provision of shelter would improve growth and reproductive rates and greatly increase survival of the chickens especially chicks, egg layers and broody hens by protects them against thefts and vagaries of nature at the villages.

2.1.2. Feeding and watering of chickens

The chickens in the country which depend solely on scavenging and grossly underfed the amount of feed also varies seasonally and if at all they are provided any supplementary feeds their quality is questionable and so is their quantity (Desalew *et al.,* 2012; Lee, 2014 and Kugonza *et al.,* 2008). Most of the time the feed provided to the chickens are scattered on the ground, thus contaminating it and as the feed is provided in groups the chicks, pullets, sick chickens remain underfed (Feleke *et al.,* 2015). According to Hyatt *et al.,* (2012), high levels of amount of wheat bran levels may cause undesirable responses due to its bulkiness and laxative effect. The quality

and quantity of feed besides feeding and watering practices as followed by the rearers of the chicken reared under the scavenging system can be exotic through the strengthening of agricultural extension services, besides regular trainings and advisory services too need to be conducted on a regular basis (Kibreab *et al.,* 2015). The chickens reared in the rural areas are mostly raised on kitchen leftovers and farm wastes sometimes the rearers in Central Oromia region also use commercial chicken rations (Ermias, 2015). Even though ways of supplementation vary across the locations and also within locations by the rearers, feed supplements have positive effects on egg production and body weight of the scavenging/village birds **(**Sonaiya and Swan, 2004); it has also been reported that, regular supply of low-cost feed (above the maintenance requirements) assists the family poultry production. Water is generally not provided at all and if provided the quality they consume is quite questionable (Tilahun, 2013). It has also been observed in seveal studies that the containers (feeders and waterers) if provided to the chickens are usually family discards and even so are rarely cleaned or disinfected (Ahimedin, 2014).

2.1.3. Diseases of chickens

Interactions between flocks from different households, exchange of birds as gifts, sales and purchases at the village level and new strains introduced to the country are the main sources of transmission of infections among both commercial poultry farms as well as backyard poultry production (Jacob *et al.,* 2015 and Meseret, 2010).Chickens mortality has been quite high among Fayoumi especially up to 8 weeks of age (Reta *et al.,* 2012). According to Alem (2014), majority of the farmers in central Tigray reported that diseases are prevalent among chickens especially during the dry season. It has also been reported in several studies (Jacob *et al.,* 2015 and Meseret, 2010) that the flocks of village chickens are susceptible to several diseases most notably among them are New Castle disease fowl cholera, coccidiosis and fowl pox. There are

also reports of several internal and external parasites infecting the chickens notably among them are ascaris and tape worm (*Anoplocephala perfoliata*) while among the external parasites are ticks (*Argas persicus*), mites (*Dermanyssus gallinae*) and lice (*Menopon gallinae*) (Tesfaheywet and Yonas, 2015).These parasites and diseases usually lead to large scale deaths and also production losses which can be considered as hidden losses (Kugonza *et al.*, 2008 and Dawit, 2010). Losses due to diseases and parasites can be minimized to a certain extent by proper husbandry practices (Alem, 2014) besides regular vaccinations and other prophylactic measures (Fisseha *et al.* 2010; Bagust, 2008 and Mammo *et al.* 2011). Many locally available and free or very cheap plant products have been reported to be in use already in the various regions and countries of Africa for the treatment of poultry diseases or Ethno veterinary medicines (Adedeji *et al.,* 2013 and Melkamu and Wube, 2013).

2.2. Storage time and hatchability of eggs and offtake of chickens and eggs

Fertility of breeder hens and cocks is a very important measure of their reproductive performance. Fertility refers to the percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch giving birth to live chicks (Gezahegn, 2016). Health of the chickens their nutrition, breed, age of the hen, egg weight, egg storage environment and time before setting, turning, humidity and ventilation after setting can affect hatchability percentage (Khan *et al.*, 2014). Additionally, lack of proper laying nest and post handling temperature of eggs are some of the major factors that cause failure of hatchability of eggs (Shishay *et al.*, 2014).

The variation in hatchability can be attributed to the high temperature in lowland leading to early spoilage of the eggs; broody hens would be restless during high temperature and difference in management practices of the poultry producers in the lowland (Alem, 2014). Findings of a study by Adem and Teshome (2016) report that the higher percentage of hatchablity observed among

the native chickens can be ascribed to fewer number of eggs incubated per hen for hatching and preparation of good nest.

Table 1: Hatching and hatchability of chicken eggs

No.	Traits	Mean ± SD	Country	References
1	Hatching/ hen / year	3.7 ±0.12	E/Hararghe	Merga (2013)
2	Egg setted / hatching	13.6±0.24	S/Wollo, Ethiopia	Melaku (2016)
3	Chicks hatched/hen	5.49 ±0.19	S/Wollo, Ethiopia	Melaku (2016)
4	Hatchability (%)	64.85	S/Wollo, Ethiopia	Melaku (2016)

Poultry products (eggs and chickens) are sold in different ways; at the farm gate to the egg collectors, in the open markets to the middlemen and consumers, at the retail shops, hotels and supermarkets in towns and the eggs pass through a relatively longer market chain to reach the consumers much later than the chicken itself (Ahimedin, 2014). The main actors in egg marketing are the producers, collectors, traders, local shop, urban shops and supermarkets (Fiseha *et al.,* 2010). According to Mapiye (2008), most farmers depend on middlemen to sell their chickens who buy the birds for the urban markets. The informal marketing of poultry and poultry products at open markets is common throughout the country and both live birds and eggs are sold on road sides (Mekonnen, 2007 and Fiseha *et al*., 2010).

2.3. Egg production of the exotic and native chickens

Sexual maturity of chickens always depends on chicken management and overall production systems of the households mainly on feeding and disease management practices (Alem, 2014). Wilson (2010) suggested that provision of shelter, regular supplies of clean drinking water and some supplementary feeding would improve growth and reproductive rates and greatly increase survival at village level. The productivity of the hens can be exotic if the management is optimized (Addis and Malede, 2014). The productivity (of the exotic chickens) can further be

exotic if they are provided with better management and feed (Aman *et al.,* 2017 and Kugonza *et al.,* 2008). Studies by Ahimedin, (2014) indicate that the egg production of the exotic chickens were higher than those of native chickens. Non infectious factors such as age of chicken, improper nutrition and omitting of feed ingredients (salt, Ca and P), toxicosis, coccidiostats and management mistakes , poor quality and inadequate feeds and improper housing have their own adverse effect on the production of the birds (Natalie, 2012). This is besides the diseases such as fowl pox, Newcastle disease, Infectious bronchitis, coccidiosis, avian influenza, ecto and endo parasites adversely influence egg production (Jacob, 2015 and Zaman *et al.,* 2005).

The productive performances of the exotic chickens indicate variation across locations which can be ascribed to the management of the chickens in the central Oromia region (Ermias, 2015). The Potchefstroom Koekoek breed has been identified as tropically adapted to smallholder production systems and productive to semi-arid Ethiopian (Gezahegn *et al.,* 2016). The breed is popular amongst South African farmers for its dual purpose, free ranging as well as its ability to hatch their own offspring (Agricultural Research Council (SA), 2011).

Sasso chickens are better than the local chicken in terms of egg production, age at first egg laying, high mature body weight of both hens and cocks, producing high carcass yields, consume more feeds and cease egg laying if not provided with supplements (Aman *et al.,* 2017). The Bovans Brown is a brown-feathered layer, which has the ability to meet the expectations of a variety of egg producers due to their better adaptability and productivity and it was mostly preferred chicken breed in the highland and mid-altitude agro-ecologies (Ermias, 2015).

Table 2: Egg production potential of local and exotic chickens

No	Trait	Genotype	Result	Country	References
		Local	190.4	C/Tigray, Ethiopia	Alem (2014)
1	AFE (day)	Sasso	142.8	SNNPR, Ethiopia	Aman *et al.* (2015)
		Koekock	153.3±6	E/Shewa, Ethiopia	Dessalew (2012)
		Bovans	165.6±13.2	E/Shewa, Ethiopia	Dessalew (2012)
2	Eggs/hen/clutch(	Local	13.6	C/Tigray, Ethiopia	Alem (2014)
	No.)	RIR	30 - 65	C/Tigray, Ethiopia	Alem (2014)
3	Clutch length	Local	15 - 28	C/Tigray, Ethiopia	Alem (2014)
	(day)	RIR	44.4	C/Tigray, Ethiopia	Alem (2014)
4	Clutch/year	Local	3.2	C/Tigray, Ethiopia	Alem (2014)
	(No.)	Exotic	4.51±0.11	E/Hararghe, Ethiopia	Ahimedien (2014)
5	Egg/ hen / year	Sasso	229.1±52.5	SNNPR, Ethiopia	Aman *et al.* (2015)
	(No.)	Koekock	187.04±8.7	E/Shewa, Ethiopia	Dessalew (2012)
		Bovans	266.3±13.5	E/Shewa, Ethiopia	Dessalew (2012)
		Local	30-60	Northern Ethiopia	Abraham and Yayneshet (2010)

2.4. Contribution of chickens and product in the smallholder sector

Findings of a study by Abera (2014) have indicated that chickens are the primary livestock reared by people who are from the poorer sections of the society and chickens are most probably the first among all the livestock procured to spiral out from the clutches of poverty. Poultry meat and eggs are widely available and can help to meet shortfalls in essential nutrients, particularly for children, adolescent, pregnant and nursing mothers and those who are suffering from debilitating diseases **(**David and Merga, 2013). Because of low performance of indigenous chickens, efforts have been made to introduce different exotic poultry breeds to small holder farming systems of Ethiopia (Bogale, 2008 and Haftu, 2016). Chickens have multiple non-cash outputs, such as manure, traditional purposes, home consumption, social obligations and status

(Mapiye *et al.*, 2008; Bogale, 2008 and Haftu, 2016). This is besides the socio economic importance of chickens as a source of sacrifice and to pay of debts (Abere, 2015).

2.5. Extension service and constraints on chicken production

Proper extensive services are quite essential for the development of livestock sector especially in the developing countries (Bereket *et al.*, 2014). It is also reported that training for both farmers and extension staff should emphasize on disease control, exotic housing, feeding, marketing and entrepreneurship, all this could help to improve productivity of the poultry sector (Fisseha *et al.*, 2010; Haftu, 2016 and Tamir *et al.*, 2015). Farmers in mid-altitude agro-ecology obtained fewer information due to existence of weak linkages between extension workers and farmers towards the technology intervention (Ermias, 2015).

The exotic chicken breeds are poor in disease and stress tolerance and in the ability to escape predators, which prevail in the rural areas (Nigussie *et al.*, 2010). Under village poultry production; prevailing diseases, predators, lack of proper health care, poor feeding and poor marketing information were reported as constraint by Fisseha *et al.* and Dinka *et al.* (2010); Feleke *et al.* and Hunde *et al.* (2015); Mammo *et al.* (2011). Predatory losses are also common among the village chickens which can be both mammals and avian (Melkamu and Wube, 2013; Feleke *et al.* and Hunde *et al.* 2015; Fiseha *et al.*, 2010a). Thus, inspite of several constraints and poor husbandry practices the chickens provide some eggs and meat to their rearers, however the productivity is much lower than their actual potential (Gezahegn, 2016; Haftu, 2016; Tamir *et al.*, 2015 and Addis and Malede, 2014).

2.6. Phenotypic characterization of chicken ecotypes

Chicken with different genetic and phenotypic character must be identified to conserve, utilize and protect from genetic erosion and dilution (Emebet, 2015). Phenotypic characterization is a systematic documentation of the distinct qualitative and quantitative nature of an animal which they have over the time developed along with the environment where they are (FAO, 2011). Chicken show heterogeneity in terms of plumage colour, shank length, comb type and growth performance (Fisseha *et al*., 2010). Large combs, large wattles and long legs are important morphological traits that allow better heat dissipation in the tropical hot environment (Assan, 2015). The knowledge of the relationship existing between live weight, carcass traits, body circumference and other performance traits in poultry is crucial because it enable us to predict the body weight and performance from linear body parts and vice versa (Assan and Liyanage *et al.,* 2015).

A lighter bird with long shank and strong wings has a greater chance of escaping from predators by fast running and flying till they reach a safer place (Nigussie *et al.,* 2010).The differences of earlobe colours are a result of adaptability of chickens to specific environmental conditions (Jamie *et al.,* 2012).The traits that show less variability within breeds indicate homogeneity and identity of those categories (Assan, 2013). Body weight appeared to be highly correlated with several body measurements and it may be useful as selection criterion, thereby providing a basis for the genetic manipulation and improvement (Guni *et al.,* 2013).

The observed variation in body weight and growth between districts indicates the existence of divergent subpopulations within the local chicken population and gives room for genetic improvement between and within subpopulations (Yakubu *et al.,* 2009). Linear body measurements variability in poultry arises due to genotypic and environmental effects, and the

magnitude of variability may differs under different management practices and environmental conditions (Assan, 2015).

Table 3: Phenotypic characterization of chicken

No	Trait	Genotype	Country	Sex		References
				Cocks	Hens	
1	BL(cm)	Local	N/Shewa, Ethiopia	37.8+0.2	36.6+0.1	Agide (2015)
		Sasso	SNNPR, Ethiopia	2.98±0.7	2.7±0.53	Aman *et al.* (2017)
		Koekock	E/Shewa, Ethiopia	-	1.6±0.3	Dessalew (2012)
		Bovans	E/Shewa, Ethiopia	-	1.55±0.3	Dessalew (2012)
2	CW(cm)	Local	N/Shewa, Amhara	24.9+0.1	25.1+0.1	Agide (2015)
3	ShL(cm)	Local	Ethiopia	6.04+0.1	5.9+0.12	Agide (2015)

2.7. Egg quality measurement parameters

The management of the hen (housing, feeding and disease control), age and strain of hen and time and temperature of egg storage significantly influence the quality of the table egg (Natalie, 2012; Farhad and Fariba, 2011). In all the egg quality parameters, chickens reared in the highland had higher values than midland except Haugh unit and the exotic breeds of chickens had higher values than indigenous and crossbreed eggs collected except shell thickness and yolk Color (Getachew *et al.,* 2016).

2.7.1. External egg quality parameters

Eggs with thick and strong shells are usually the most marketable; these traits are of importance both for table and hatching eggs (Aberra *et al.,* 2010). The differences in eggshell quality depend on the environmental conditions and the feed quality and also of strain of layers (Zita *et al.,* 2009). Eggs are available in different shapes which can be differentiated using shape index (SI). Egg length and breadth are the determinants of egg shape index. The shapes is a good indication of external egg quality and aspect for uniform packaging of eggs during transportation, most

often encountered are sharp (<72), standard (72-76) and round (>76) eggs SI value (Guni *et al.*, 2013 and Ebubekir *et al.*, 2008).

Table 4: External egg quality of local and exotic chickens

No	Trait	Genotype	Result	Country	References
		Local	55 ± 0.07	Karachi - Pakistan	Hussain *et al.* (2013)
1	Egg length (mm)	WLH	54.39±0.1	India	Rath *et al.* (2016)
		Local	44.1± 0.05	Karachi - Pakistan	Hussain *et al.* (2013)
2	Egg width (mm)	WLH	39.9±0.07	India	Rath *et al.* (2016)
		Local	0.27+0.02	W/Shewa, Ethiopia	Bikila (2013)
4	Shell thickness	Koekock	0.29±0.03	E/Shewa, Ethiopia	Dessalew (2012)
	(mm)	Bovans	0.33±0.04	E/Shewa, Ethiopia	Dessalew (2012)

2.7.2. Internal egg quality parameters

Egg weight is positively correlated with body weight (Mesba *et al.*, 2012 and Jatoi *et al.*, 2015). Egg weight influences the weight of components of eggs especially egg albumen and yolk (Zhang *et al.*, 2005).

Table 5: Internal egg quality of local and exotic chickens

No	Trait	Genotype	Result	Country	References
		Local	25-49 g	S/Nyanza, Kenya	Olwande *et al.* (2009)
1	Egg weight (g)	Koekock	48.84 ±6.7	E/Shewa, Ethiopia	Dessalew (2012)
		Bovans	60.27±6.03	E/Shewa, Ethiopia	Dessalew (2012)
4	Yolk index (%)	Local	46.49%	-	Mesba *et al.* (2012)
		WLH	40.24±0.1	India	Rath *et al.* (2016)
		Local	10.7±0.24	W/Shewa,Ethiopia	Bikila (2013)
5	Yolk colour	Koekock	10.8±1.98	E/Shewa, Ethiopia	Dessalew (2012)
		Bovans	7.77 ±3.15	E/Shewa, Ethiopia	Dessalew (2012)
		Local	69.13+2.21	W/Shewa,Ethiopia	Bikila (2013)
7	Haugh Unit	Koekock	76.57±12.2	E/Shewa, Ethiopia	Dessalew (2012)
		Bovans	81.7 ±11.3	E/Shewa, Ethiopia	Dessalew (2012)

Higher albumen and yolk weight too correlated with egg weight category where the values were higher among the heavy chickens when compared to the medium and light weight categories. Chick weight is directly linked with the weight of the eggs as heavier eggs provide more nutrients to the growing chicks, however very heavy weight eggs usually have poor hatchability (Ashraf *et al.,* 2016). The variation in egg weight of chickens has been suggested to be associated with breed, strain, size of the bird, rate of egg production, nutrition and other environmental conditions (Baishya *et al.*, 2008 and Zita *et al.*, 2009).

3. MATERIALS AND METHODS

3.1. Description of study area

The study was conducted in Boricha Woreda which is part of the Sidama Zone located at 311km south of Addis Ababa. Boricha is bordered in the south by Loka Abaya, in the west by the Wolayita Zone, in the northwest by the Oromia Region, in the northeast by Hawassa Zuria, in the east by Shebedino, and in the southeast by Dale Woredas. Its geographical location extends from 6º 46'N and 38º04'E to 7º01'N and 38 º24'E. The Boricha woreda has an estimated area of 588sq km. Its altitude extends from 1320 m.a.s.l at south west of the mouth of tributary of Bilate River to 2080 m.a.s.l. at the north east part of the Woreda. The average annual temperature of the study area varies between 21.93ºC to 25.36ºC. The rainfall pattern of the study area varies from 27.82 ml to 28.18 ml. The Woreda has mainly two agro-ecological zones. "Weinadega" (Mid-land) with an altitude range of 1500-2000m a.s.l. and and" Kolla" (Dry-low land less than 1500m above sea level) (LSFROB, 2017).

3.2. Survey sample size and sampling method

Since, all kebeles of study area are not expected to have both exotic and local chicken being raised together, 4 kebeles namely Konsore Arkie and Yirba Dowancho from midland and Dilla Anole and Boro Shebela from lowland were purposively selected. The selection of the kebeles was based on the overall population size of the chickens being reared from the total Kebeles of the Woreda, the proximity to the road, the kebeles which have both exotic and local chickens by taking secondary data from the Livestock and Fisheries Resource Office of the Woreda. The households were then selected using random sampling method from the record list of Livestock and Fisheries Resource Office. Accordingly, from the total of 200 households, 100 households from each agroecologies and 50 households from each kebeles were included in the study. The following formula was used to determine the sample size of the households (Israel, 1992).

$$n = \frac{N}{1 + N\,(e)^2}$$ Where, n = sample size needed

N = population size of the study area

e = desired level of precision (in this case, e = 7%)

Rapid field survey was carried out together with the Woreda Agricultural experts before the main survey was performed. The purpose of this survey was to know the status of distributed exotic chickens existence and concentration of local chicken in the selected kebeles of the study area. Enumerators were selected from the development agents of the Animal and Fishery office of the wereda who can speak the local language. Some primary qualitative data such as household socio-economic characteristics, husbandry practices and flock structure and production constraints and quantitative data such as flock size, family size and performance of chickens in the study area was collected by using semi-structured questioner (face-to-face interviewing) and direct observation. The secondary data were collected from published and unpublished sources and reports of the Boricha Wereda agricultural office.

3.3. Egg collection procedures

A total of 480 eggs (10 eggs per household of which 8 eggs from exotic chickens and 2 from the local chickens) were collected from both exotic and local chickens. The maximum care has been taken to collect eggs that have been stored not more than a week after being laid. Moreover, the freshness of the eggs was cheeked by immersing them in water during egg collection process. The collected eggs were properly labeled according to their origin (agroecology and breed).

3.4. Determination of egg quality parameters

For egg quality determination, the following parameters were considered: egg weight, length and width of egg, height and diameter of yolk, yolk colour, height of albumen and shell thickens. Eggs were weighed using triple beam balance. Egg length and width and yolk diameter was measured using digital caliper. A tripod micrometer was used to measure the heights of albumen and Yolk. Yolk colour was measured by using the Roche Colour Fan. Egg shell thickness was measured according to (Aberra *et al.*, 2010). Shell thickness was determined by taking the average thickens of large end, the center and narrow end. Individual Haugh unit was calculated according to the equation of Haugh (1937).

$HU = 100\text{Log}\,(AH - 1.7EW^{0.37} + 7.6)$

Where, HU = Haugh Unit

AH = Albumin Height

EW = Egg Weight

Egg shape index was calculated according to Panda (1996) by using the following formula:

$$Shape\ index = \frac{Width\ of\ egg}{Length\ of\ egg} \times 100$$

Index of yolk was calculated according to Romanoff and Romanoff (1949) using the following formula:

$$Yolk\ index = \frac{Yolk\ height}{Yolk\ diameter} \times 100$$

3.5. Body weight and linear body measurement traits

The body weight and qualitative and quantitative linear body measurement of matured age local and exotic chickens were recorded by observation and practical measurements from all households where the eggs were collected. A total of 192 (24 chickens from each breed)

individual chicken from randomly selected 48 household in lowland and midland of the study area were used to collect data on body weight and linear body measurement traits data collection.

Quantitative linear body measurements of linear traits and body weight were taken both from exotic and local chickens using a textile measuring tape (cm) and from a hanging spring balance (kg) respectively. Data on body weight, chest width (CW), body length (BL), shank length (SHL) and circumference (SHC) and wing span (WS) were taken following FAO's descriptor for the characterization of chicken genetic resources (FAO, 2012).

3.6. Statistical analysis

Data on production system and qualitative traits were analyzed using descriptive statistics and X^2 test. Data on quantitative linear measurement traits were analyzed using GLM (SAS, 2012, ver. 9.4) by fitting the two agroecologies and four breeds as independent variables. The experimental design for egg quality traits was a completely randomized design with two factors in which factor 1 was agroecology with two categories (Lowland and Midland); factor 2 was breed with four categories (Koekock, Sasso, Bovans and Local). From each agroecology and breed, 60 egg of chickens were randomly sampled consisting of a 2 x 4 factorial ANOVA design with a total of 480 (2 x 4 x 60) egg sample sizes. Data were then subjected to ANOVA with agroecology and breed as main effects and the interactions among them using the GLM (General Linear Models) procedure. Mean comparisons were conducted using Tukey's Studentized Range (HSD) Test and and values were considered significant at $P<0.05$.

Moreover, stepwise multiple regression procedure was used to regress body weight for agroecology, breed and sexes to determine the best-fitting regression equations for the prediction of live body weight. The following models were used for the statistical analysis:

The model used for the analysis of the egg quality

$Y_{ijk} = \mu + A_i + B_j + A_i*B_j + e_{ijk}$, where:

Y_{ijk} = the observations of egg quality components in the i^{th} agroecology and j^{th} breed of k^{th} birds

μ = overall mean of the observed variables

Ai = fixed effect due to i^{th} agroecology (i = lowland and midland)

Bj = fixed effect due to j^{th} breed of chickens (j = Koekock, Sasso, Bovans, Local)

Ai*Bj = the interaction effects of i^{th} agroecology and j^{th} breed

e_{ijk} = random residual error

The model used for analysis of adult body weight and linear body measurement traits

$Y_{ijkl} = \mu + A_i + B_j + S_k + A_i*B_j + A_i*S_k + B_j*S_k + A_i*B_j*S_k + e_{ijkl}$, where:

Y_{ijkl} = the observations of body weight and linear body measurement traits in the i^{th} agroecology, j^{th} breed and k^{th} sex of l^{th} birds

μ = overall mean of the observed variables

Ai = fixed effect due to i^{th} agroecology (i = lowland and midland)

Bj = fixed effect due to j^{th} breed of chickens (j = Koekock, Sasso, Bovans, Local)

Sk = fixed effect due to k^{th} sex of chickens (k = Male and Female)

Ai*Bj = the interaction effects of i^{th} agroecology and j^{th} breed

Ai*Sk = the interaction effects of i^{th} agroecology and k^{th} sex

Bj*Sk = the interaction effects of j^{th} breed and k^{th} sex

Ai*Bj*Sk = the interaction effects of i^{th} agroecology j^{th} breed and k^{th} sex

e_{ijkl} = random residual error

The regression model for the estimation of body weight from linear body measurement traits

$Y_j = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + e_j$

Where:

Y_j = Response variable or predicted mean body weight of chickens

β_0 = the intercept

X_1 + X_2+ X_3+ X_4 and X_5 are the dependent variables for body length, Chest width, shank length, shank circumference and wing span, respectively.

β_1 + β_2+ β_3+ β_4 and β_5 are the regression coefficients of the variables X_1+ X_2+ X_3+ X_4 and X_5, respectively.

e_j = the residual error

4. RESULTS

4.1. Chicken management practices and egg production potentials in the study area

4.1.1. Description of the sampled household characteristics

As shown in Table 6, out of 200 respondents, the majority of them were males (77.5%) while the rest 22.5% of them were female. Similarly, in both agroecologies, males were the major respondents. About 28% of the respondents from the lowland and 11% from the midland were illiterate while the majority of them were literate. The mean family size per household was 6.6 in both agroecologies.

Table 6: Household characteristics and livestock holdings of respondents (%)

	Lowland	Midland	Total
Sex of respondent (%)			
Male	86.0*	69.0	77.5
Female	14.0	31.0*	22.5
Educational level (%)			
Illiterate	28.0*	11.0	19.5
Read and write	46.0	46.0	45.5
Grade 1-4	4.0	10.0*	7.5
Elementary	9.0	16.0*	12.5
High school	7.0	12.0*	9.5
College and University	6.0	5.0	5.5
Average family size (Mean ± SD)			
Average family size per household	6.5±2.4	6.8±2.2	6.6±2.3

* Values are different across rows $p<0.05$; Numbers of percentage = number of respondent.

4.1.2. Livestock holding per household, source and type of exotic chicken

As indicated in Table 7, among the livestock species in the study area, local chickens per household were dominate followed by cattle (4.6), exotic chickens (4.1), sheep (3.5) and goat

(3.3). However, in lowland, the size of cattle and goat per household were dominant. The majority of the respondents (95%) in the study area received exotic chicken from LSFROB.

Table 7: Livestock holding per household and source of exotic chickens (Mean±SD)

	Lowland	Midland	Overall
Chickens holding per household			
Number of local chicken	4.9±2.2	5.4±3.4	5.2±2.9
Number of exotic chicken	3.9±2.2	4.2±2.5	4.1±2.4
Source of exotic chicken (%)			
From market	10.0	0.0	5.0
From LSFROB	90.0	100.0	95.0

* Values are different across rows at 5%.; Numbers of percentage = number of respondent.

In the study area, the households who has Sasso chickens (64.5%) were the predominant in both agroecology followed by Bovans and Koekoek individually and the other was combination of two or more species per household.

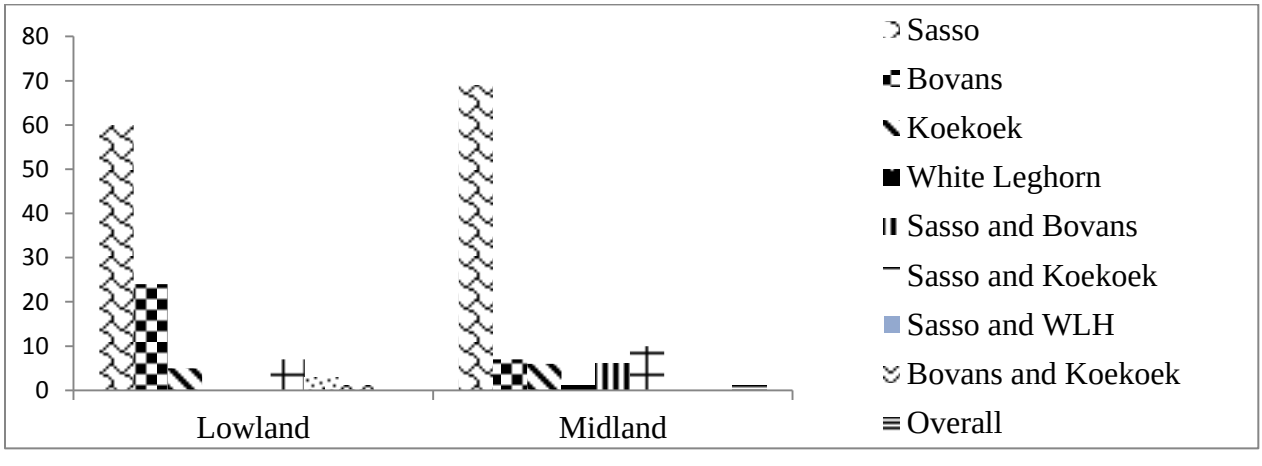

Figure 1: Type of exotic chickens reared

4.1.3. Management practice of chicken

4.1.3.1. Housing, feeding and watering of chickens

As presented in Table 8, over half of respondents in lowland (58%) and midland (52%) did not provide separated house for their chickens. However, around half (48%) of households in midland have constructed separated houses for their chickens. In the study area almost all of respondents (98.5%) provide supplement to their scavenging chickens twice a day.

Table 8: Housing, common feed and time of chicken feeding (%)

	Lowland	Midland	Total
Housing of chickens			
Separated house with litter	9.0*	0.0	4.5
Separated house without litter	33.0	48.0*	40.5
No separated house	58.0*	52.0	55.0
Common feed of chicken			
Scavenging only	0.0	3.0	1.5
Scavenging with supplement	100.0	97.0	98.5
Time of chicken feeding			
Once a day	18.0*	12.0	15.0
Twice a day	49.0	65.0*	57.0
Thrice a day	17.0	17.0	17.0
When they come back to home	16.0*	3.0	9.5
Never provide	0.0	3.0*	1.5

* values are different across rows at $P<0.05$. Numbers of percentage = number of respondent.

As shown in Figure 2, 41% of the respondents in lowland and 37.1% in the midland provide both wheat bran and grain as main supplementary feed to chickens in addition to scavenging followed by grain and household refusals.

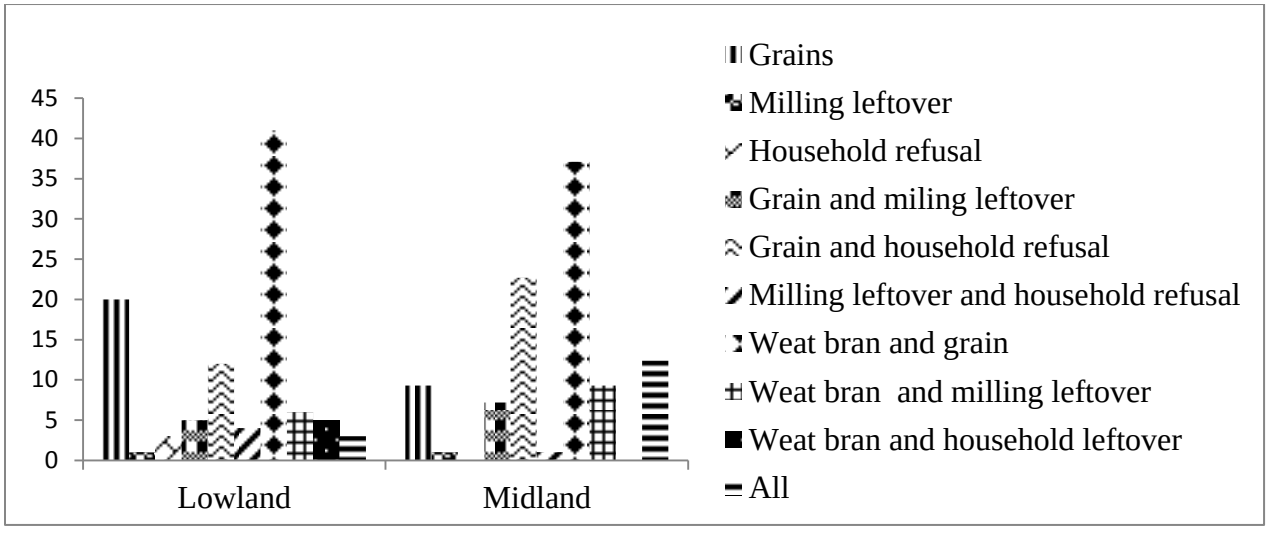

Figure 2. Type of supplementary feed for chickens

As shown in (Table 9), the majority of respondents in the study area provided supplementary feed to their chickens to enhance egg production. However, in the lowland, they provide supplementary feed during feed shortage.

Table 9: Categories of supplement to chickens (%)

	Lowland	Midland	Total
Reason of supplementing			
To increase egg production	36.0*	33.0	34.5
To broody hen	10.0	21.7*	15.8
To adapting feeding to chicks	1.0	6.2*	3.6
To incubated hen	0.0	3.1*	1.5
When there is feed shortage	40.0*	10.3	25.4
To improve egg & meat production	13.0	25.8*	19.3
Chickens breed most supplemented			
Local chicken	5.0*	3.1	4.1
Exotic chicken	70.0*	40.2	55.3
All chicken breeds	25.0	56.7*	40.6

* Values are different across rows at P<0.05; Numbers of percentage = number of respondent.

The majority of respondents (43.7) in the study area practice group feeding using feeding trough. In the lowland, most of the households (82%) use pond as main source of water followed by tap water (18%). However, in the midland, the main source of water (40%) was tap water followed by pond water (36%). Type of watering troughs used by households was plastic material (69%).

Table 10: Feeding and watering practices of chickens by the households (%)

	Lowland	Midland	Total
Feeding practices			
Group feeding	44.0*	42.3	43.7
Separate by breed	40.0*	17.5	28.9
Separate by age	15.0*	7.2	11.2
Separate by production	1.0	32.0*	16.2
Where do you give feed			
On ground	51.0	43.3	47.2
On trough	49.0	56.7	52.8
Source of water chickens			
River	0.0	24.0*	12.0
Tap water	18.0	40.0*	29.0
Pond water	82.0*	36.0	59.0
Type of watering trough			
Plastic material	74.0*	64.0	69.0
Clay pots	5.0	36.0*	20.5
Material made from wooden	21.0*	0.0	10.5

* values are different across rows at P<0.05; Numbers of percentage = number of respondent

4.1.3.2 Disease and health management of chickens

As presented in Figure 3, about 50% of respondents in the midland reported that the highest occurrence of mortality was observed in chickens whose age is between 4 and 8 weeks. However, in the lowland, chickens whose age is more than 8 weeks had higher mortality than those of other age groups.

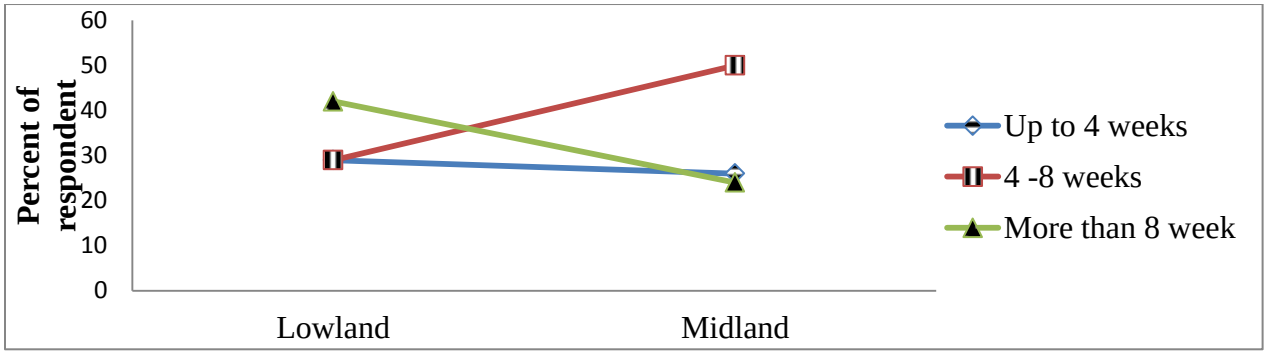

Figure 3: Occurrence of mortality in relation to the age of chickens in both agroecologies

The results presented in Figure 4 shows that in the lowland agroecology, about 56% of the disease outbreak occurs during wintertime. In the midland agroecology, however, about 29% of disease outbreaks occur at autumn followed by autumn and winter in Ethiopian calendar (22%).

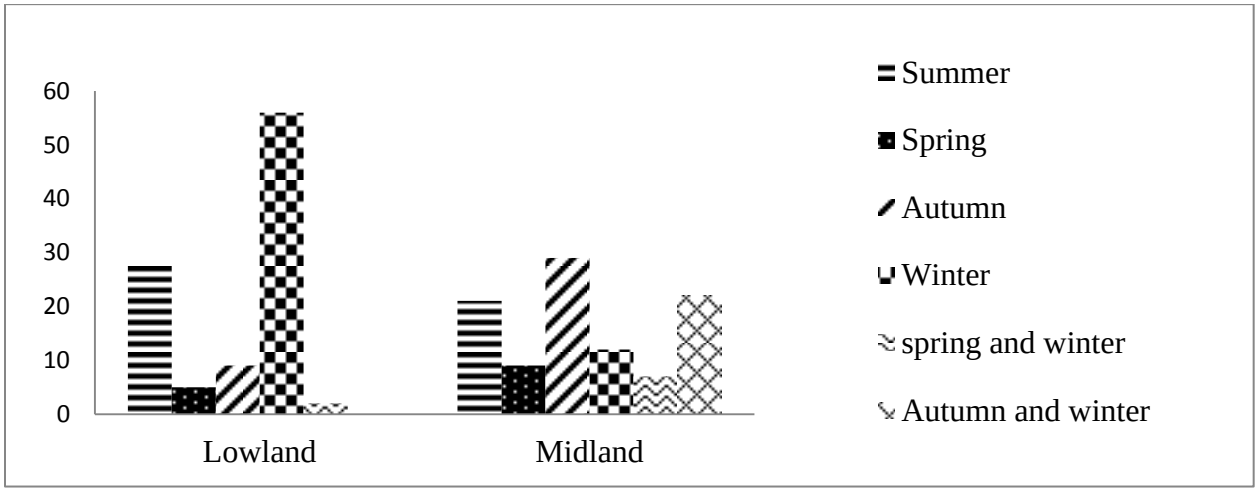

Figure 4. Pattern of diseases outbreak as affected by season in the study area

According to the respondents from the lowland agroecology, Newcastle disease (46%), coccidiosis (29%) and external parasites (19%) are reported to be the most common types of diseases affecting poultry production. In the midland agroecology, Newcastle disease (61%), external parasites (21%), coccidiosis (12%) and Infectious Bronchitis (6%) were reported as the major poultry diseases. In the lowland agroecology, 29% of the respondents tried to avoid sick chicken by selling followed by providing vaccination (23%) and treating using traditional

medicines (19%). In the midland agroecology, 47% of the respondent use traditional medicines to treat sick chickens.

Table 11: Actions taken by the households to treat their sick chickens (%)

	Lowland	Midland	Total
Action taken on sick chicken			
Selling	29.0*	10.0	19.5
Slaughtering	1.0	20.0*	10.5
Traditional medicine treatment	14.0	14.0	14.0
Vaccination treatment	23.0*	7.0	15.0
Traditional and vaccination	14.0	47.0*	30.5
No action	19.0*	2.0	10.5

* Values are different across rows at P<0.05. Numbers of percentage = number of respondent.

4.1.4. Hatchability of eggs and marketing age of chickens for sell

As indicated in Table 12, households stored the eggs for about two weeks before incubation. The average numbers of eggs set for incubation per hen were 11.1 eggs with the hatchability of 60.0%. Number of hatching per hen per year, egg sett per hatching per hen and number of chickens hatch in the lowland was significantly higher than in the midland. The maturity age of local and exotic chickens for marketing was 241 and 157 days, respectively.

Table 12: Egg storage time, hatchability, and marketing age of chickens in the study area (Mean±SD)

Parameters	Lowland	Midland	Over all
Egg storage time for incubation (Weeks)	1.7±0.8	1.7±0.8	1.7±0.8
No. of hatching per hen per year	3.9±1.2*	2.9±1.1	3.4±1.3
Egg sett per hatching	12±2.9*	10.6±2.7	11.1±2.8
No. of chicks hatched	7.1±4.1*	6.5±4.1	6.7±4.1
Hatching percent of local chicken	58.9±31	60.7±36	60±34
Age of local chickens reach for sale (d)	212±37	269±38*	241±46
Age of exotic chickens reach for sale (d)	145±21	168±19*	157±23

*Means within a row with different superscript letters differ significantly at P<0.05

4.1.5. Egg production potential of chickens between agroecologies and breeds

Average age at first egg was 238, 155, 157 and 174 days for local, Sasso, Bovans and Koekoek chicken breeds, respectively (Table 13). The number of eggs laid per clutch was higher in the midland than in lowland except for Koekoek chicken, which was not significantly different in both agroecologies. The length of clutch per hen and number of clutch per hen per year was significantly higher for local and Bovans chickens reared in the midland than those of lowland. Similarly, the number of eggs per hen per year was significantly higher for all breeds reared in the midland than those of the lowland agroecology.

Table 13: Egg production potential of local and exotic chicken breeds reared in mid and lowland agroecologies (Mean±SD)

Parametrs	Lowland	Midland	Overall
Age at first egg laying			
Local	224± 27.9[a]	252± 39.3[*a]	238±36.8
Sasso	147± 22.2[b]	162± 24.6[*b]	155±24.6
Bovans	152± 20.3[b]	167± 16.02[*b]	157±20.1
Koekoek	147.5± 17.5[b]	184± 27.3[*b]	174±29.6
Number of egg per clutch			
Local	12.4± 2.4[b]	14.2± 2.7[*b]	13.3±2.7
Sasso	23.8 ± 2.8[a]	26.0 ± 2.6[*a]	25.1±2.9
Bovans	23.9± 3.6[a]	27.3± 1.7[*a]	25.0±3.5
Koekoek	24.7± 6.8[a]	26.8 ± 3.1[a]	26.2±4.4
Length of clutch per hen			
Local	24.7± 4.97[b]	28.6± 5.4[*b]	26.6±5.6
Sasso	29.0± 3.3[a]	30.2± 3.4[a]	29.9±3.2
Bovance	28.7± 3.4[a]	32± 2.7[Aa]	29.9±3.5
Koekoek	30.4± 7.2[a]	32.7± 3.2[a]	32.04±4.7
Clutch number per hen per year			
Local	3.6 ± 0.6[b]	3.8± 0.4[*b]	3.7±0.5
Sasso	5.4± 0.7[a]	5.3± 0.6 [a]	5.3±0.7
Bovans	4.3 ± 0.6[b]	5.3± 0.6[*a]	4.7±0.7
Koekoek	4.7± 0.5[b]	5.5± 0.6[a]	5.3±0.7
Number of egg per hen per year			
Local	44.6± 12.5[c]	53.7± 10.8[*b]	49.1±12.5
Sasso	129± 24.3[a]	137± 20.2[*a]	133±22.3
Bovans	103± 20.2[b]	144± 20[*a]	117±28
Koekoek	115 ± 30.6[a]	148± 29[*a]	138±32.4

*Means between agroecologies within breeds with different superscript letters differ significantly at P<0.05

[a-c] Means between breeds within agroecologies with different superscript letters differ significantly at P<0.05

The average age at first egg of all exotic chickens was significantly lower than local chickens under both agroecologies (Table 13). Similarly, the number of eggs per clutch and length of clutch per exotic chicken breeds was significantly higher than local chickens in all agroecologies. The number of clutch per hen per year for Sasso chickens reared in lowland agroecology was significantly higher than other chicken breeds while in the midland the local chickens had the lowest value. Sasso and Koekoek chicken breeds reared in lowland produced significantly higher number of egg per hen per year as compared with other chicken breeds. However, in the midland there is no significant difference between exotic chicken breeds.

4.1.6. Extension services, purpose of rearing chickens and use of egg

As shown in Table 14, the majority of farmers in lowland received extension services during disease prevalence. The purpose of rearing chickens in the study area was for both egg and meat production. The eggs produced in the household area used mainly for household consumption, for selling and for hatching purposes. The majorly of eggs were used as a source of nutritional food for children, pregnant women, elders and lactating mothers.

Table 14: Provision of extension services, purpose of chicken rearing and use of eggs (%)

	Lowland	Midland	Total
Do you get extension service			
Within a month	10.0	38.0*	24.0
Within two month	3.0	14.0*	8.5
During disease prevalence	23.0	24.0*	23.5
Rarely	33.0*	20.0	26.5
No	31.0*	4.0	17.5
Purpose of rearing chickens			
For egg	57.0*	1.0	29.0
For egg and meat	43.0	99.0*	71.0
Use of egg			
For selling	54.0	40.0	47.0
For household consumption	44.0	53.0	48.5
For hatching	2.0	7.0	4.5
Use of egg for household			
For children	91.0	87.0	89.0
For pregnant	3.0	7.0	5.0
For lactating mothers	1.0	2.0	1.5
For elders	5.0	4.0	4.5

* Values are different across rows at $P<0.05$; Numbers of percentage = number of respondent

4.1.7. Opportunities and constraints of chicken production

On the other hand, there are constraints, which hamper the production of poultry in the study area (Figure 5). These include existence of predators, water shortage, inadequate veterinary services, extension service, thefts, shortage of supplementary feed, lack of continuous exotic chicken distribution, failure of crop plants, and lack of free land for chicken production due to permanent plant production such as enset, sugarcane, coffee and so on.

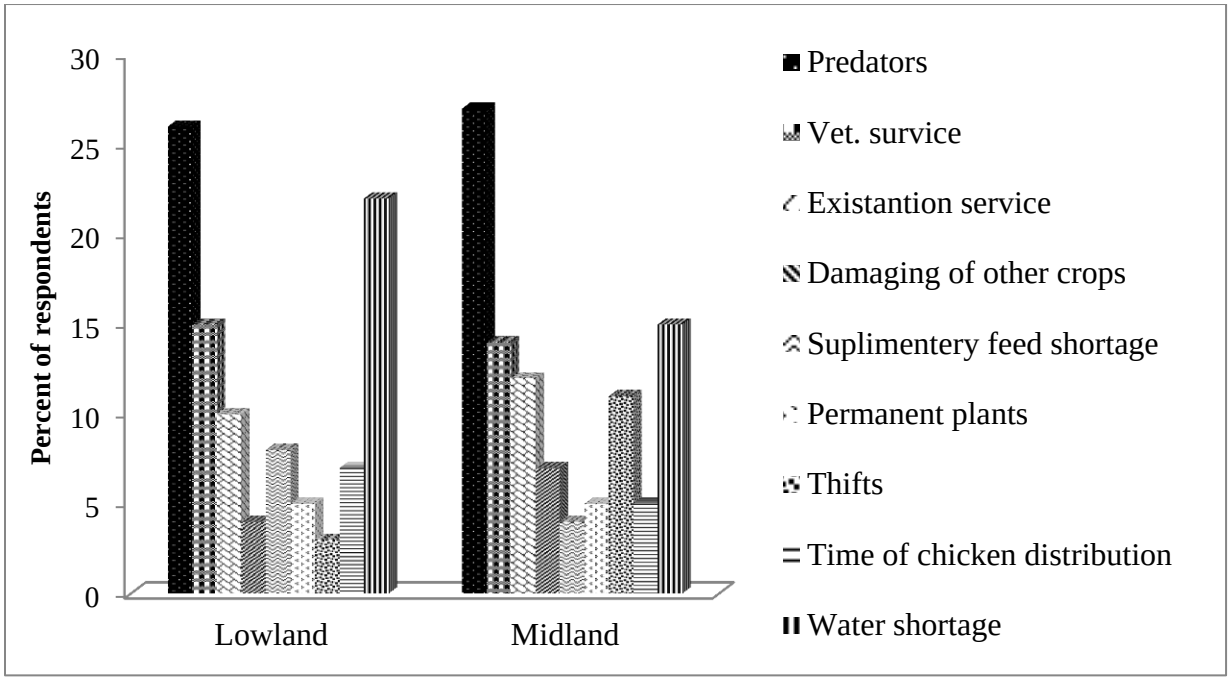

Figure 5. Constraints of chicken production in the study area

As shown in Figure 6, there are many opportunities that favors chicken production in the study area including distribution of exotic chicken with low payment by LSFOB, local feed access, relative less land requirement, market access, environment condition and extension service.

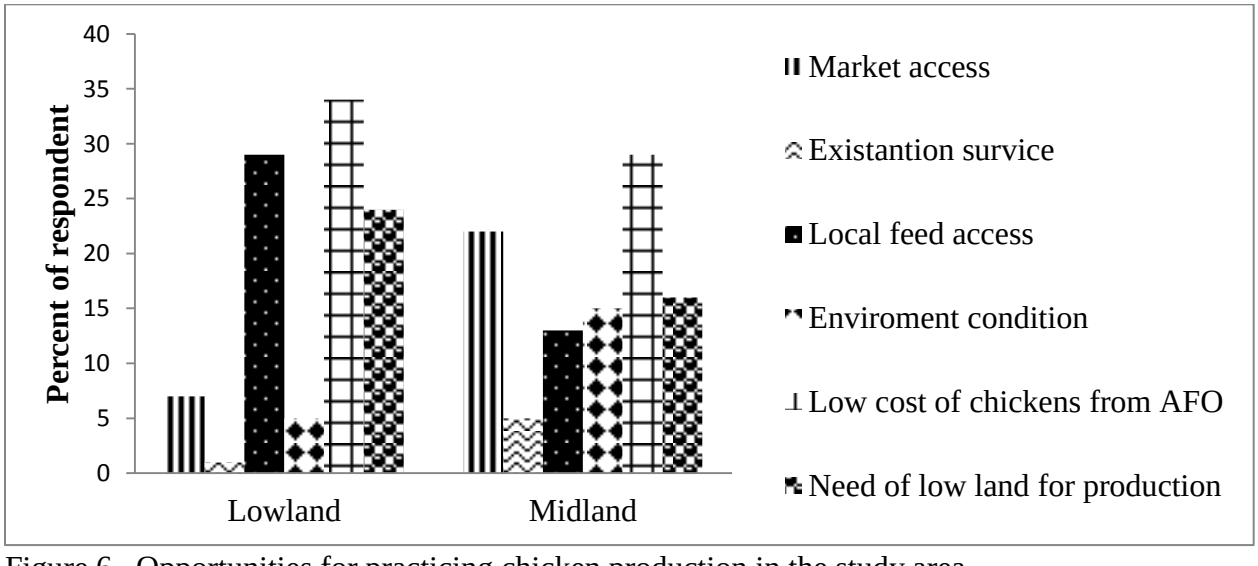

Figure 6. Opportunities for practicing chicken production in the study area

4.2. Body weight and linear body measurement traits of chickens in the study area

4.2.1. Qualitative traits of local and exotic chickens

As presented in Table 15, the predominant earlobe colour of local chickens in the study area was white followed by red and yellow. The common comb types in local chickens were both rose and single while in the midland rose and in lowland single are reported to be the major comb types. The predominant shank colour of local chickens in the study area was white followed by yellow and black color while all local chickens have weight skin color. However, all exotic chickens had red earlobe colour, single comb type, yellow shank colour and white skin.

Table 15: Qualitative treats of local and exotic chickens (%)

Traits for local chicken	Lowland	Midland	Overall
Earlobe Color			
Red	50.0	29.2	39.6
White	50.0	58.3	54.2
Yellow		12.5	6.2
Comb type			
Single	54.2	45.8	50.0
Rose	45.8	54.2	50.0
Shank Color			
White	50.0	50.0	50.0
Yellow	50.0*	20.8	35.4
Black		29.2	14.6

4.2.2. Quantitative body measurement traits

4.2.2.1. Mean comparison between independent variables

The effect of agroecology was significant only for chest width and shank length traits. However, the effect of breed on all parameters was highly significant. The effect of breed by agroecology interaction was also significant for all traits except for shank diameter. The chest width and shank length of all chickens except the Sasso reared in the midland had significantly higher values than those of lowland. The Sasso chicken breeds reared in the lowland agroecology had significantly higher values in most linear body measurement traits than those of other chicken breeds. The Bovans and Sasso chickens reared in the midland had significantly higher body length, chest width and wing span values as compared with other chicken breeds.

Table 16: Effect of agroecology, breed and interaction of body weight (kg) with linear body measurement (cm) traits (Mean ±SD)

Agroecology	Breed	BW	BL	WS	CW	ShL	ShD.
Lowland	Bovans	2.9±0.3^{b}	37.2±1.97^{b}	36.1±2.1^{b}	28.5±2.04^{b}	6.9±0.5^{b}	5.8±0.5^{a}
	Sasso	3.4±0.4^{a}	41.3±1.8^{a}	38.2±2.2^{a}	34.1±3.04^{a}	7.7±0.5^{a}	5.6±0.5^{a}
	Keokeok	2.8±0.5^{b}	36±1.7^{b}	35.4±1.9^{b}	28.9±1.9^{b}	6.7±0.8^{b}	5.8±0.5^{a}
	Local	2.1±0.2^{c}	34.2±1.6^{c}	30.4±1.8^{c}	25.4±1.04^{c}	7.6±0.7^{a}	4.4±0.7^{b}
Midland	Bovans	3.1±0.5^{a}	38.9±2.3^{ab}	37.8±1.6^{a}	33.4±2.8^{a}	7.5±0.6	5.4±0.7^{b}
	Sasso	3.2±0.5^{a}	40±2^{a}	36.4±2.1^{a}	33.3±3.1^{a}	7.6±0.5	5.5±0.6^{ab}
	Keokeok	3.2±0.4^{a}	37.5±1.7^{b}	34.4±1.8^{b}	29.4±2.4^{b}	7.3±0.9	5.9±0.7^{a}
	Local	1.9±0.2^{c}	33.9±2.1^{c}	33.4±2.2^{b}	26.5±1.2^{c}	7.7±1	4.5±0.7^{c}
Sources of variations							
Agroecology (AE)		0.1488	0.1425	0.0911	0.0001	0.0035	0.3754
Breed (B)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
AE x B		0.0027	0.0002	<.0001	<.0001	0.0401	0.1386

$^{a-c}$ Means between breeds within agroecologies with different superscript letters differ significantly at P<0.05.

4.2.2.2. Mean comparison between sexes within agroecology

As presented in Table 17, except for shank diameter, the effect of sex was significant for all linear traits. The effect of agroecology was only significant for chest width and shank length values. No interaction effect was observed between sex and agroecology except shank diameter. Cock chickens reared in the lowland had significantly higher values in all parameters than Hen chickens. Except for chest width, similar trend was also observed in all chickens reared in the midland agroecology.

Table 17: Mean comparison of sexes within agroecology in body weight (kg) and linear body measurement (cm) traits (Mean±SD)

Agroecology	**Sex**	Body weight	Body length	Wing span	Chest width	Shank length	Shank diameter
Lowland	Cock	3±0.6[a]	38.1±3.2[a]	35.9±3.3[a]	30.1±4.1[a]	7.6±0.6[a]	5.4±0.7[a]
	Hen	2.6±0.5[b]	36.2±2.9[b]	34.1±3.5[b]	28.4±3.3[b]	6.9±0.9[b]	5.4±0.9[a]
Midland	Cock	3.1±0.7[a]	38.4±3.1[a]	36.2±2.5[a]	31.3±4.3	7.9±0.7[a]	5.6±0.8[a]
	Hen	2.6±0.6[b]	36.7±2.8[b]	34.8±2.5[b]	30.0±3.5	7.2±0.7[b]	5.1±0.8[b]
Source of variations							
Agroecology		0.3340	0.3495	0.2655	0.0119	0.0027	0.5036
Sex (S)		<.0001	<.0001	0.0003	0.0074	<.0001	0.0563
AE x S		0.6246	0.8289	0.6626	0.7739	1.0000	0.0189

[a-b] Means between sex groups within agroecology with different superscript letters differ significantly at $p<0.05$

4.2.2.3. Mean comparison of sexes within breeds

The linear body measurement values of both Cock and Hen chickens within each breed and their interactions are presented in Table 18. The effect of breed and sex was highly significant for all linear body measurement traits. However, the interaction effect of sex by breed was insignificant for all traits except for shank diameter. The observed linear measurement values in all breeds were significantly higher in Cock chickens than in Hen.

Table 18: Mean comparison of sexes within breeds with respect with their body weight (kg) and linear body measurement (cm) traits (Mean±SD)

Breed	**Sex**	Body weight	Body length	Wing span	Chest width	Shank length	Shank diameter
Bovans	Cock	3.2±0.4[a]	39.2±1.96[a]	37.9±1.5a	31.9±3.5[a]	7.5±0.62[a]	5.6±0.5[a]
	Hen	2.8±0.4[b]	36.8±1.9[b]	36.1±2.1[b]	30±3.2[a]	6.9±0.76[b]	5.6±0.7[a]
Sasso	Cock	3.6±0.5[a]	41.5±1.9[a]	38±2.3[a]	34.9±3.3[a]	7.8±0.48[a]	5.8±0.6[a]
	Hen	3±0.3[b]	39.9±1.8[b]	36.6±2.1[b]	32.5±3.2[b]	7.5±0.48[b]	5.3±0.4[b]
Keokeok	Cock	3.2±0.4[a]	37.8±1.5[a]	35.3±1.8[a]	29.7±2.4[a]	7.5±0.68[a]	5.8±0.7[a]
	Hen	2.8±0.5[b]	35.6±1.6[b]	34.4±1.9[a]	28.7±1.97[a]	6.5±0.72[b]	5.9±0.6[a]
Local	Cock	2.1±0.2[a]	34.4±1.8[a]	32.98±2.5[a]	26.3±1.5[a]	8.1±0.7[a]	4.6±0.7[a]
	Hen	1.9±0.2[b]	33.6±1.8[a]	30.8±1.99[b]	25.7±0.9[a]	7.3±0.8[b]	4.2±0.6[a]
Source of variation							
Breed (B)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Sex (S)		<.0001	<.0001	<.0001	0.0001	<.0001	0.0100
B x S		0.1203	0.1300	0.4329	0.3131	0.1166	0.0476

[a-b] Means between sex groups within breeds with different superscript letters differ significantly at $p<0.05$

4.2.2.4. Overall mean comparisons between independent variables

Except for wingspan, the Sasso chicken breed was better ($P<0.05$) in all other linear body measurement traits compared with the other chicken breeds. Bovan chicken breeds had significantly higher body length, chest width and wing span than Keokeok chickens. Except for shank length, local chickens were inferior in all other linear body measurement traits. Cock chicken was significantly higher by all of quantitative body measurement traits than Hen chicken. Chest width and shank length were significantly higher under midland than lowland.

Table 19: Overall mean comparisons of body weight (kg) and linear body measurement (cm) traits between the breeds, sex groups and agroecologies (Mean±SD)

Comparison	**N**	Body weight	Body length	Wing span	Chest width	Shank length	Shank diameter
Between breeds							
Bovans	48	3.02±0.4[b]	38.01±2.3[b]	36.97±2[a]	30.97±3.5[b]	7.2±0.8[b]	5.6±0.6[a]
Sasso	48	3.30±0.5[a]	40.7±2.01[a]	37.3±2.3[a]	33.7±3.5[a]	7.7±0.5[a]	5.5±0.6[a]
Koekoek	48	2.98±0.5[b]	36.7±1.9[c]	34.9±1.9[b]	29.2±2.2[c]	7±0.9[b]	5.8±0.6[a]
Local	48	2.01±0.2[c]	34.03±1.8[d]	31.9±2.5[c]	25.97±1.3[d]	7.7±0.9[a]	4.4±0.7[b]
Sex of chickens							
Hen	96	2.6±0.5[a]	36.5±2.9[a]	34.5±3[a]	29.2±3.5[a]	7.03±0.8[a]	5.2±0.9[a]
Cock	96	3.03±0.7[b]	38.2±3.1[b]	36.1±2.9[b]	30.7±4.2[b]	7.7±0.7[b]	5.5±0.8[b]
Between agroecologies							
Lowland	96	2.8±0.6	37.2±3.2	35.0±3.5	29.3±3.8[b]	7.2±0.8[b]	5.4±0.8
Midland	96	2.9±0.7	37.6±3.1	35.5±2.6	30.7±3.95[a]	7.5±0.8[a]	5.3±0.8

[a-d] Line means between breeds within agroecology with different superscript letters are significant at $p<0.05$

4.2.2.5. Correlation of body weight and linear measurement traits

As shown in Table 20, there was significantly positive association of body weight with all linear body measurement traits. Except shank length and diameter, there was also a significant positive correlation of all linear body measurement traits. The correlation between shank length and shank diameter were negative but not significant.

Table 20: Pearson correlation coefficients of body weight (kg) with linear measurement (cm) traits (N=192)

	Body weight	Body length	Wing span	Chest width	Shank length	Shank diameter
Body weight		0.78***	0.66***	0.67***	0.19**	0.504***
Body length	0.78***		0.67***	0.69***	0.39***	0.4***
Wing span	0.66***	0.67***		0.66***	0.16*	0.417***
Chest width	0.67***	0.69***	0.66***		0.18*	0.366***
Shank length	0.19**	0.39***	0.16*	0.18*		-0.11^{NS}
Shank diameter	0.504***	0.4***	0.42***	0.37***	-0.11^{NS}	

*p<0.05 ** p<0.01 *** p<.0001 NS = Not significant

4.2.2.6. Multiple regression equation for body weight estimation

In the lowland, body weight of male chickens can be estimated using body length, chest width and shank diameter while in females body length and wing span can be used for the same purpose (Table 21). The body weight of Cock chicken reared in the midland can be estimated with only body length and shank length. However, body weight of Hen chickens in the midland can be estimated using measurements of body length, shank diameter and wing span. As to breeds, the body weight of Local and Sasso chickens reared in the lowland can be estimated using body length alone. The body weight of Bovans chickens can be estimated using chest width alone while that of Keokoeck by chest width and body length. In the midland, the body weight of Bovans, Koekoeck and Sasso chickens can be estimated using the parameters of body length, shank length and chest width.

Table 21: Stepwise multiple regression equation for estimation of body weight of chicken breeds reared in lowland and midland agroecologies

Agroecology	Sex	R^2 adj.	Fitted stepwise multiple regression equation	P –value
Lowland	Cock	0.774	Y = -3.2517 + 0.10924 (BL) +0.03409 (CW) + 0.19251 (SHD)	***
	Hen	0.753	Y = -2.50485 + 0.04717(BL) + 0.07305 (WS)	***
Midland	Cock	0.70	Y = -1.9911+ 0.18905 (BL) + (-0.27568 (SHL))	***
	Hen	0.559	Y = -3.50004 + 0.07588 (BL) +0.22212 (SHD) + 0.06393 (WS)	***
	Breeds			
Lowland	Bovans	0.633	Y = -1.93541 + 0.05823 (CW)	***
	Koekoek	0.650	Y = -5.18177+ 0.14282 (BL) + 0.09775 (CW)	***
	Local	0.227	Y = 0.05687 (BL)	*
	Sasso	0.336	Y = 0.136 (BL)	**
Midland	Bovans	0.586	Y = -3.26264 + 0.19288 (BL)	***
	Koekoek	0.546	Y = 0.37346 (SHL)	***
	Local	-	-	-
	Sasso	0.276	Y = 0.06908 (CW)	**

*p<0.05 ** p<0.01 *** p<.0001 NS = Not significant

R^2 adj. = adjusted coefficient of determination; BL = Body length; CW = Chest width; SHD = Shank diameter; WS = Wing span

4.3. Egg quality traits of chickens in the study area

4.3.1. External egg quality traits

4.3.1.1. Effect of agroecology, breed and interactions on the external egg quality traits

As shown in Table 22, there was significant ($p<0.05$) effect of agroecologies and breeds on all of external egg quality traits except for egg shape index. The interaction of agroecology by breed was also significant for all parameters. The Sasso chickens reared in the lowland were significantly superior in all observed external egg qualities.

Table 22: Effect of agroecology, breed, and their interactions on the external egg quality traits (Mean±SD)

Agroecology	**Breed**	Egg length (mm)	Egg width (mm)	Egg shape index (%)	Shell thickness (mm)
Lowland	Bovans	54.8±1.7^{a}	41±1.5 ^{a}	74.9±3.7	0.287±0.02 ^{a}
	Sasso	55±4.2^{a}	39.2±2.6 ^{b}	71.5±5.8	0.275±0.02^{bc}
	Keokeok	53.2±4.8^{a}	38.1±1.8 ^{c}	71.9±4.9	0.267±0.02^{c}
	Local	49.6±3.8^{b}	35.6±2.9 ^{d}	71.8±3.2	0.279±0.03^{ab}
Midland	Bovans	55.6±1.9^{a}	41.2±1.6^{a}	74.2±3.6	0.289±0.02^{ab}
	Sasso	54.9±2.2^{a}	40.6±1.5^{ab}	73.9±3.6	0.301±0.02^{a}
	Keokeok	52.5±3.99^{b}	39.4±4^{b}	74.9±3.5	0.283±0.03^{b}
	Local	43.3±5.01^{c}	29.3±4.1^{c}	67.7±4.8	0.281±0.02^{b}
Sources of variations					
Agroecology		<0.0001	0.0006	0.6963	<0.0001
Breed (B)		<0.0001	<0.0001	<0.0001	<0.0001
AE x B		<0.0001	<0.0001	<0.0001	<0.0003

$^{a-c}$ Means between breeds within agroecology with different superscript letters are significant at $p<0.05$

4.3.1.2. External egg qualities between agroecologies

For Bovans breeds, there is only significance difference between agroecologies in egg length being higher in midland than in lowland (Table 23). Koekoeck and Sasso chicken breeds reared in midland had significantly higher egg width, shape index and shell thickness values than those reared in the lowland. On the other hand, local chickens reared in the lowland had better external egg qualities (except shell thickness) than those reared in the midland.

Table 23: Comparison of external egg qualities between agroecologies (Mean±SD)

Breeds	**Traits**	Lowland	Midland	Overall	P-values
Bovans	Egg length	54.8±1.7[b]	55.6±1.9[a]	55.2±1.9	0.0241
	Egg width	41±1.5	41.2±1.6	41.1±1.5	0.5134
	Egg shape index	74.9±3.7	74.2±3.6	74.5±3.6	0.2998
	Shell thickness	0.29±0.02	0.29±0.02	0.29±0.02	0.5652
Koekoek	Egg length	53.2±4.8	52.5±3.99	52.9±4.4	0.3729
	Egg width	38.1±1.8[b]	39.4±4.01[a]	38.7±3.2	0.0251
	Egg shape index	71.9±4.9[b]	74.9±3.5[a]	73.4±4.5	0.0002
	Shell thickness	0.27±0.02[b]	0.28±0.03[a]	0.28±0.03	0.0011
Sasso	Egg length	55±4.2	54.9±2.2	55.0±3.3	0.9150
	Egg width	39.2±2.6[b]	40.6±1.5[a]	39.9±2.2	0.0004
	Egg shape index	71.5±5.8[b]	73.9±3.6[a]	72.7±4.97	0.0061
	Shell thickness	0.28±0.02[b]	0.3±0.02[a]	0.29±0.03	<.0001
Local	Egg length	49.6±3.8[a]	43.3±5.01[b]	46.4±5.4	<.0001
	Egg width	35.6±2.9[a]	29.3±4.1[b]	32.4±4.7	<.0001
	Egg shape index	71.8±3.2[a]	67.7±4.8[b]	69.8±4.6	<.0001
	Shell thickness	0.28±0.03	0.28±0.02	0.28±0.02	0.6466

[a-b] Means between agroecologies within breeds bearing different superscript letters are significant at $p<0.05$

4.3.1.3. Overall comparisons between independent variables

Bovans and Sasso chicken breeds had a better egg length than others (Table 24). Egg width and egg shape index values were higher in Bovans followed by Sasso and Koekoeck chickens. The highest shell thickness was recorded in Bovans and Sasso chickens while the lowest in Koekoeck chickens. Local chickens were inferior in all external egg qualities except for shell thickness. Surprisingly, all chicken breeds reared in lowland agroecology were better in all external egg quality parameters compared with those reared in midland.

Table 24: Overall mean comparisons of external egg quality traits between the four breeds and two agroecologies (Mean±SD)

Comparisons	N	Egg length (mm)	Egg width (mm)	Shell thickness (mm)	Egg shape index
Between breeds					
Bovans	120	55.2 ± 1.9^{a}	41.1 ± 1.5^{a}	0.29 ± 0.02^{a}	74.5 ± 3.6^{a}
Sasso	120	55 ± 3.3^{a}	39.9 ± 2.2^{b}	0.29 ± 0.03^{ab}	72.7 ± 5.0^{b}
Koekoek	120	52.8 ± 4.4^{b}	38.7 ± 3.2^{c}	0.28 ± 0.03^{c}	73.4 ± 4.5^{ab}
Local	120	46.4 ± 5.4^{c}	32.4 ± 4.7^{d}	0.28 ± 0.02^{bc}	69.8 ± 4.6^{c}
Between agroecologies					
Lowland	240	53.2 ± 4.4^{a}	38.5 ± 2.97^{a}	0.28 ± 0.02^{b}	72.5 ± 4.7
Midland	240	51.6 ± 6.1^{b}	37.6 ± 5.7^{b}	0.29 ± 0.03^{a}	72.7 ± 4.9

$^{a-d}$ Means between breeds and agroecologies with different superscripts are significant at $p<0.05$

4.3.1.4. Correlation coefficients of external egg quality traits

As expected, the correlation of egg length with width and egg width with shape index was highly significant (Table 25). The correlation of shell thickness with egg width and shape index was also significant. No significant associations were observed between egg length and shape index and shell thickness.

Table 25: Pearson correlation coefficients of external egg quality traits (N=480)

Traits	Egg length	Egg width	Shell thickness	Egg shape index
Egg length	-	0.851***	0.07^{NS}	0.06^{NS}
Egg width	0.85***	-	0.14**	0.57***
Shell thickness	0.07^{NS}	0.14**		0.14**
Egg shape index	0.06^{NS}	0.57***	0.14**	-

*p<0.05 ** p<0.01 *** p<.0001 NS = Not significant

4.3.2. Internal egg quality traits of exotic and local chickens

4.3.2.1. Effect of agroecology, breed and their interaction on the internal egg quality traits

As shown in Table 26, the effect of agroecology was significant for all internal egg quality traits except for egg weight and yolk colour. Similarly, the effect of breed was significant for all internal egg quality traits except for Haugh unit. The interaction effect of agroecology by breed was highly significant for all traits. Egg weight of Sasso breeds reared in the lowland was significantly heavier than those of other chicken breeds. However, in the midland, all the three exotic chicken breeds reared in the midland laid ($p<0.05$) heavier eggs with similar weight than local chickens. In the lowland, yolk index was ($p<0.05$) higher in Sasso and local chickens than other chicken breeds. Conversely, local chickens reared in the midland produced eggs with higher yolk index values than those of the exotic chickens. Yolk colour was significantly higher only in Koekoeck chickens reared in the lowland agroecology. Haugh unit values for Koekoeck and local chickens were higher ($p<0.05$) than other chicken egg in the midland.

Table 26: Effect of agroecology, breed, and their interactions on the internal egg quality traits (Mean±SD)

Agroecology	**Breed**	Egg weigh (g)	Yolk height (mm)	Yolk width (mm)	Yolk index (%)	Yolk colour	Albumen height (mm)	Haugh unit
Lowland	Bovans	49.5±4.9^{b}	16±1.4^{b}	42.5±2.1^{a}	37.8±4.6^{b}	9.9±1.3^{b}	5.8±0.98^{a}	78.6±7.4
	Sasso	53.8±4.9^{a}	17±1.3^{a}	40.9±2.6^{b}	41.9±4.6^{a}	10.8±2.3^{b}	6.1±1.23^{a}	78.5±8
	Keokeok	43.9±6.89^{c}	14.9±0.98^{c}	40.1±3.6^{b}	37.5±4.6^{b}	11.9±2.4^{a}	5.24±0.1^{b}	77.2±4.7
	Local	41.2±4.5^{d}	15.1±1.8^{c}	37.8±3.5^{c}	40.4±5.9^{a}	10.1±1.9^{b}	5.03±0.7^{b}	76.6±5.3
Midland	Bovans	52±3.8^{a}	16.3±1.8	40.2±1.4^{ab}	40.7±4.7^{b}	10.3±1.7	6.19±1.4^{a}	80±8.5^{ab}
	Sasso	51±4.3^{a}	16.4±1.3	40.9±2.3^{a}	40.2±3.9^{b}	10.4±1.7	5.87±1.1^{ab}	78.4±7.1^{b}
	Keokeok	49.9±5.6^{a}	16.4±1.2	38.7±4.3^{b}	42.9±7.3^{b}	10.5±1.8	6.34±1.1^{a}	81.9±7.6^{a}
	Local	39.5±4.8^{b}	15.8±0.8	32.3±4.9^{c}	50±8^{a}	11±1.9	5.62±0.8^{b}	81.3±6.6^{ab}
Sources of variations								
Agroecology		0.0625	0.0002	<.0001	<.0001	0.6120	<.0001	<.0001
Breed (B)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.6494
AE x B		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0111

$^{a-c}$ Means between breeds within agroecology with different superscript letters are significant at $p<0.05$

4.3.2.2. Comparison of internal egg quality traits between agroecologies

Egg weight and yolk index values were significantly higher in Bovans reared in the midland agroecology than other breeds reared in the lowland (Table 27). Sasso breeds reared in the lowland had significantly higher egg weight and yolk index values than those kept in the midland. All internal egg quality traits of Koekoeck chickens reared in the midland were superior to those raised in the lowland agroecology.

Table 27: Comparison of internal egg quality traits between agroecologies (Mean±SD)

Breeds	**Quality traits**	Lowland	Midland	Overall	P-values
Bovans	Egg weight	49.5±4.9[b]	52.1±3.8 [a]	50.7±4.58	0.0017
	Yolk index	37.8±4.6 [b]	40.7±4.7[a]	39.2±4.83	0.0007
	Haugh unit	78.6±7.40	80±8.5	79.3±7.97	0.3536
	Yolk colour	9.9±1.3	10.3±1.7	10.1±1.55	0.1265
Koekoek	Egg weight	44.6 ±6.9[b]	50±5.6[a]	46.9±6.93	<0.0001
	Yolk index	37.5±4.6[b]	42.9±7.3[a]	40.2 ±6.65	<.0001
	Haugh unit	77.2 ±4.7[b]	82±7.6[a]	79.6±6.73	<.0001
	Yolk colour	11.9±2.4 [b]	10.5±1.8[a]	11.2±2.22	0.0004
Sasso	Egg weight	53.8±4.9 [a]	51.1±4.3 [b]	52.4±4.80	0.0015
	Yolk index	41.9± 4.62[a]	40.2±3.93 [b]	41.0±6.65	0.0341
	Haugh unit	78.6±8.04	78.4±7.08	78.5±7.54	0.8777
	Yolk colour	10.8±2.25	10.5±1.70	10.6±2.00	0.3631
Local	Egg weight	41.3±4.47[a]	39.5±4.75 [b]	40.4±4.69	0.0401
	Yolk index	40.4±4.62[b]	50.1±8.01[a]	45.2±8.54	<.0001
	Haugh unit	76.6±8.04[b]	81.3±6.58[a]	79.0±6.39	<.0001
	Yolk colour	10.0±2.25[b]	11.0±1.85 [a]	10.5±1.91	0.0050

[a,b] Means between agroecologies within a breed bearing different superscript letters are significant $p<0.05$

4.3.2.3. Overall comparisons between breeds and agroecologies

The overall comparision of breeds and agroecologies in internal egg quality parameters is presented in Table 28. Accordingly, Sasso chicken breeds had the highest egg weight followed by Bovans, Koekoeck and local chickens that differed significantly from each other. The yolk index was significantly higher for

local chickens compared with the exotic chickens. No significant difference was observed between breeds in Haugh unit values. The highest yolk colour values were observed in both Koekoeck and Sasso chicken breeds being significantly higher than those of Bovans and local chickens. All internal egg quality values were significantly higher for those chickens reared in the midland than those of lowland.

Table 28: Overall mean comparisons of selected internal egg quality traits between the four breeds and two agroecologies (Mean±SD)

Items	**N**	Egg weight (g)	Yolk index (%)	HU	Yolk color
Between breeds					
Bovans	120	50.7±4.58^{b}	39.2±4.83^{b}	79.3±8.01	10.1±1.55^{b}
Sasso	120	52.4±4.80^{a}	41.0±4.36^{b}	78.5±7.55	10.6±2.01^{ab}
Koekoek	118	47.3±6.36^{c}	40.2±6.65^{b}	79.6±6.73	11.2±2.22^{a}
Local	120	40.4±4.69^{d}	45.2±8.54^{a}	79.0±6.39	10.5±1.91^{b}
Between agroecologies					
Lowland	238	47.3±7.0^{b}	39.4±5.27^{b}	77.8±6.52^{b}	10.6±2.14
Midland	240	48.2±6.87^{a}	43.5±7.32^{a}	80.4±7.56^{a}	10.5±1.78

$^{a-c}$ Row means with different superscript letters are significantly different at $p<0.05$

4.3.2.4. Correlation of internal egg quality traits

As presented in Table 29, there was a significant positive relationship of egg weight with yolk height, albumen height and yolk width. On the other hand, egg weight negatively correlated with yolk index and Haugh unit. Yolk index positively correlated with yolk height, albumen height and HU; but negatively with yolk width. As expected, the association of Haugh unit with albumen was highly significant with the highest correlation value. However, it was negatively correlated with yolk index and egg weight.

Table 29: Pearson correlation coefficients of internal egg quality traits (N=480)

Parameters	Egg weight	Yolk height	Albumen height	Yolk width	Yolk color	Yolk index	Haugh unit
Egg weight	-	0.344***	0.278***	0.414***	0.065^{NS}	-0.159**	-0.100*
Yolk height	0.344***	-	0.585***	-0.024^{NS}	0.033^{NS}	0.580***	0.469***
Albumen height	0.278***	0.585***	-	-0.041^{NS}	0.049*	0.364***	0.918***
Yolk width	0.414***	-0.024^{NS}	-0.041^{NS}	-	-0.090*	-0.809***	-0.211***
Yolk color	0.065^{NS}	0.033^{NS}	0.049^{*}	-0.090*	-	0.093*	0.043^{NS}
Yolk index	-0.159**	0.579***	0.365***	-0.809***	0.093*	-	0.441***
Haugh unit	-0.100*	0.469***	0.918***	-0.211***	0.043^{NS}	0.441***	-

*p<0.05 ** p<0.01 *** p<.0001 NS = Not significant

5. DISCUSSION

5.1. Chicken management practices and egg production potentials

The findings in the current study indicated that irrespective of the agro ecologies most of the respondents were males. This might be because of the social characteristics of the study area where the males of the households are the decision makers and women are responsible for chicken management. The finding was in line with Merga and Solomon *et al.,* 2013 and Aman *et al.,* 2017. However, results from studies by Emebet (2015) indicate that poultry rearing is a gender friendly affair and most of the respondents were females in southwest Showa and Gurage zones.

Several researchers from several parts of the developing countries (Guèye, 2007 and Ali, 2012) and Ethiopia being no exception have also observed the gender friendliness of poultry production. The findings in this study also indicate that some of the respondents were illiterate which can be an impediment in modern methods of livestock husbandry which was agree with the report of Mugisha *et al.,* (2012). Such respondents will not be able to follow the guidelines suggested in training programs, therefore special training packages need to be developed to assist them, and these suggestions are in accordance with the observations of Balija (2014) and Imaita (2013). The results also indicated that most of the respondents were literate which can help in the dissemination of extension booklets. Such booklets are specifically prepared for informing modern poultry husbandry practices among rural farmers. This suggestion was in accordance with the report of Sayeed *et al.* (2013).

The findings regarding the chicken number per household are in close accordance with those of Emebet (2015). The study further indicated that the respondents obtained their flock from the Government authorities, which is in accordance with the findings of Aman *et al.* (2017) in Wolayita and Kembata tembaro zone. This is indicative of the developmental activities planned by the Woreda authorities for the poverty alleviation program of the resource challenged people of the area. The findings also indicate that a few respondents procured the chickens from the nearby market, which is in accordance with the results

of Bikila (2013) in Chelliya district. However, such chickens need to be screened for any disease and parasites (by the local authorities) so as to prevent any disease outbreak in the region according to Bagust, (2008) suggestion.

The findings from this study also indicated that the respondents preferred the Sasso chickens followed by Bovans. This can be associated with the distribution pattern by the Woreda authorities besides the preference of the respondents keeping in mind the adaptability, production and reproduction ability of the Sasso chickens. The better adaptability of Sasso chickens (when compared to other exotic breeds) to the lowlands of the country, which was also reported by Aman *et al.* (2017). The findings also indicated that the White Leghorn were the least preferred breed among the respondents, this might be ascribable to higher predatory attacks (due to white color) and plumage color preferences among the respondents, the observations are in close accordance with the findings of Ermias (2015).

Husbandry practices of the chickens

The current findings indicated that the majority of the respondents do not provide any housing of the chickens due to poor economic status having a separate poultry house and wished to have it when their economic status permit. Housing of the chickens also provides the broody chickens a sense of security and privacy, which facilitates better hatchability as suggested by Addis and Malede, (2014); Wilson, (2010). The present observations are in close accordance with the finding of Feleke *et al.* (2015) and Dawit (2010), who also reported that housing of the chickens was not common among the residents and most of the chickens share the dwellings of their respondents. The study also indicated that some of the respondents provide separate houses for the chickens, which can facilitate better husbandry practices and hatchability; therefore, such respondents should be encouraged to share their experiences with those who do not provide housing.

In the study area, the majority of respondent feeding practice of chicken was scavenging with supplements. The findings concur with the observations of Fiseha *et al*. (2010) and Meseret (2010). Provision of supplementary feeds (besides scavenging) will have a synergistic effect on the productive

and reproductive potentials of the chickens (Addis and Malede, 2014). The exotic chickens particularly need to be provided with supplementary feed, as their maintenance requirement is higher than those of the native breeds (Gezahegn, 2016). This is besides the facts that the exotic chickens are poor scavengers as compared with local chicken types (Matiwos *et al.,* 2015). According to Kibreab *et al.,* (2015) suggestion, the developmental agents need to appraise the respondents about the types of feed which can provide adequate energy and protein and care also has to be taken to ensure that the feed is free from any exogenous materials besides are free from any fungal/pest infestations.

The findings also show that the respondents provided the supplementary feed twice a day, which is in close agreement with the observations of Feleke *et al.* (2015). The provisions of feed to the chickens depend on the availability of the grains, which may not be consistent across the years and these observations are in line with those of Feleke *et al.* (2015). The results also indicated that the provided most common feeds to the chickens are wheat bran, food leftovers and grains which are in good agreement with the observations of Ermias (2015). The supplementary feeds are more of energy sources and hence can disturb the energy protein ratio if the worms and insects from scavenging are inadequate as discussed by Lee, (2014). The respondents need to be appraised with the amount of wheat bran in the chicken feed, as high amount of wheat bran can be indigestible due to relatively high crude fiber content (Hyatt *et al.,* 2012). As scavenging predominates as a source of feed, the respondents should be taught how to identify the edible and inedible feed types. Besides the development agents can also teach the household members how to cultivate earthworms which can be a very good source of animal source of protein (Fisseha *et al.,* 2010).

The results in this study also indicated that the respondents in Boricha woreda use group feeding, which is not a good husbandry practice as the growing pullets, cockerels, and chicks usually are unable to compete with the adult chickens especially with the cocks. This can lead to poor growth of the young stock and can also be a source of disease transmitting agents among the flocks. The result was in agreement with the finding of Feleke *et al.,* (2015) and Addis and Malede, (2014). Therefore, the farmers

need to appraisal about segregating of the flocks according to sex and age along with maintaining the cleanliness of the feeding trough.

The findings also indicate that most of the respondents residing in the lowlands provide water from the ponds or borehole. Pond water may be contaminated which can lead to transmission of diseases among the flocks. The observations are in close accordance with the findings of Fisseha *et al.* (2010); Farhad and Fariba, (2011) and Mammo *et al.* (2011). Therefore, the respondents should be encouraged to use tap water wherever possible; in case it is not possible then they can be trained how to keep the water clean by protecting the entrance of external dirty. The water and feeding troughs are made of plastic which is in accordance with the findings of Meseret (2010) reported that use of plastic feed/watering trough in Gomma Wereda, Jimma zone, Ethiopia.

Mortality among the flock

The results as presented in Figure (3) indicated that mortality was highest among the 4-8 weeks of age category. This may be ascribed to the poor growth of the chickens of this age, which can be further related to the lack of available feed to the chickens according to report of Wilson, (2010). Underfed or improperly fed chickens are vulnerable to diseases and therefore can be related to high mortality (Kugonza *et al.,* 2008). The findings from this study are in line with the results of Merga (2013) who reported that chicks are more vulnerable among all the ages, which can further be ascribed to poor mothering ability of the hens. The loss of the chicks can lead to lowering of profitability as this can influence the off take and the overall flock replacement as suggested by Kugonza *et al.* (2008). The study also indicates that mortality is highest in the dry season especially from December to February when the chicks are unable to scavenge thus compromising on their immunity. This is not consistent with the findings of Merga (2013) who reported that the most common disease outbreak occurs in rainy season. High temperature and moisture during this season may also create a favorable condition to bacterial and/or viral disease outbreak and relates to poor management and cleanliness of the houses as discussed by Alem, (2014).

The results further indicated that the respondents in the lowlands prefer to cull the sick chickens by selling, which can be considered as a mechanism of avoidance. However, in doing so it can lead to spread of the disease among the flocks where they were introduced. The result was in accordance with the finding of Bagust, (2008). Thus, the development agents in the area need to train the chicken rearers about the symptoms of diseases and teach them about scientific disposal of carcass as discussed by Bereket *et al.*, (2014).

Some of the respondents also indicated that they treat the sick chickens using ethno veterinary medicines, which comprises both of floral and faunal origin. The most common floral medicines used are leaves of Kerarcho, Garlic (*Allium sativum*), human urine, and Tobacco (*Nicotina tabacum*). The use of ethno-veterinary medicines in treatment of livestock including chickens have been reported by Melkamu and Wube (2013) in DebsanTiKara Keble at Gonder Zuria. The efficacy of these ethno veterinary medicines are questionable with no regulations of the dosage and the types of plants used. However, such form of medicines are commonly used because it is cheap and the plants are easily available in the homestead of the farmers (Adedeji *et al.*, 2013).

Incubation and hatching management

The current findings as presented in Table 13 indicate that the average numbers of weeks, which the respondents kept the eggs prior to incubation is more than a week, which in the normal course would lead to poor hatchability. Ermias (2015) also reported similar results on storage time of egg before incubation from central Oromia Region of Ethiopia. The numbers of eggs incubated by the broody hens are in close accordance with the observations of Melaku (2016). Differences were observed across the agroecologies, which might be ascribed to the findings of Alem (2014) who also reported that the farmers in Central Tigray area of Ethiopia usually tried to hatch the most numbers of eggs that a hen can brood so as to maximize the numbers chicks per hen.

The hatching percentage is quite low in both the agro ecologies indicating poor hatching management and egg storage facilities, which in turn can influence the overall off take of the activity. The observed

hatchability percentage are in close accordance with the observations of Melaku, (2016). If more numbers of eggs are put under a hen for incubation, there are chances that the incubation may not be proper which can lead to lower hatchability due to difficult to turn over the egg to hatch properly by hen (Adem and Teshome, 2016). Therefore, the respondents need to be made aware about the methods in improving the hygiene and overall management of the hens during the period of brooding.

The study further indicated that the chickens (local and exotic) were sold at a later age at the midlands when compared to those at the lowlands. This might be attributed to the cool temperature of the midlands where the birds require a part of the energy (obtained from food) to maintain their basal metabolic rate means; rate at which the body uses energy while at rest to keep vital functions going, such as breathing and keeping warm. The observations are in accordance with those of Alem (2014), who reported that the chickens reared at higher altitude usually mature later than those reared at a lower altitude do. The results also indicate that the exotic chickens mature earlier when compared to the native counterparts which can be further associated with the interaction between the genotype and environment. However, if the interaction between the genotype and environment is not favorable (especially if the exotic chickens were not provided with any supplementary feed) then there are chances that they may mature quite late and attain even lower body weight when compared to the native chickens.

Egg production potential of chicken

The current findings indicate that the native chickens are slow growers when compared to the exotic counterparts due to genetic factor, because of significant effect of agro ecology on the age of maturity and subsequently their marketing, which could be attributed to the various types of stress and feed available to the chickens. The observations are in accordance with the findings of Alem (2014). The results also indicated that the Sasso chickens were the best-suited ecotype in the study area followed by Koekock for age at first egg lay. This might be ascribed to the interaction between the genotype and environment, which favor the performances of these breeds. Similar observations have been reported by

Aman *et al.* (2014) in which Sasso chickens performed better than other studied breeds of chickens at Wolayita and Kembata zones.

The results also indicate that the exotic chickens performed better in most of the production traits when compared to the native ecotype and these were observed across both the agro ecologies due to genetic factor. However, the results also indicated that the Sasso chickens were better adapted to the area than those of the other two exotic chicken breeds studied which is in good agreement with those of Aman *et al.* (2017). There are still scopes to improve the egg productivity of the exotic chickens as the numbers of eggs produced (annually) are still less than those reported by Aman *et al.* (2017) and Desalew (2012) from Wolayita and Kembata tambaro zones and in East Shewa, respectively. This can be attained through scientific feeding, management and health care to the birds so that their genetic potential can be expressed to the fullest enabling the rearers to benefit the most. Hence, the development agents in the study area need to appraise the poultry keepers about the package and practices of modern poultry farming aimed at poverty alleviation.

Average age at first egg of Sasso chicken was in accordance with the result of Aman *et al.*, (2017). In the study area, Bovans chickens laid eggs earlier than Koekoek chicken which is in line with those of Desalew, (2012) from East Shewa. The number of eggs laid per clutch and number of clutch per hen per year for the native chickens was in accordance with the result of Alem (2014). However, egg per clutch and length of clutch of the exotic chickens were fewer than RIR chickens as reported by Alem (2014). Number of eggs per hen per year of Sasso, Bovans, Koekoek and native chickens were lower than the report of Aman *et al.* (2015) and Dessalew (2012). These variations might be explained by type of management, age of the hens, type of environment in which they have been reared.

Purpose of rearing chickens and use of egg

The results of the study indicated that the respondents rear chickens primarily for home consumption, followed by selling the chickens and eggs (during disease outbreak and in need of cash). The reason for home consumption of poultry products can be ascribed to poor marketing infrastructure in the region

(especially in the lowlands). These findings are in consonance with the observations of David (2013); Bogale (2008) and Merga (2013) who reported that the main function of chickens for farmers is provision of meat and egg mainly for home consumption. Rearing chicken can ensure food security especially among the children, ill, pregnant and nursing mothers' thereby minimizing the protein malnutrition. Studies by Abere (2015) have also indicated that rearing chickens are one of the easiest ways for wealth accumulation among the resource challenged farmers as they are easy to procure and rear.

Extension service, constraints and opportunity of chicken production

The findings as presented in Table (14) show that the livestock extension service is well developed in the midlands while the contrary was true for the lowlands. This might be because of the willingless of development workers to go to lowland due to the distance. The result was in close accordance with the observations of Bereket *et al.* (2014). This might be because of the sedentary nature of the respondents in the lowlands lead to poor monitoring of the flocks. Ermias (2015) have also reported similar observations from central Oromia Region.

In the study area predator, water shortage, lack of proper market channel and poor veterinary facilities have been reported as main drawbacks by discouraging the respondents to shift towards commercial poultry production from the present subsistence based poultry rearing. These factors are in agreement with the findings of Feleke *et al.* and Hunde *et al.* (2015) who also observed that predator, diseases, poor market channel and infrastructure as the primordial reason to sheer away from chicken production for people in Arbegona Woreda and in Selected Rural Areas of Bishoftu districts of Ethiopia. The findings further showed that one of the major opportunities being restocking of the exotic chicks by Animal and Fishery office of the Woreda at affordable price when the need arises.

5.2. Morphological traits of chickens

Qualitative body measurement traits of chickens

The findings pertaining to the qualitative traits Table (15) indicate that the ecotypes of the local chickens varied across the studied locations as chickens with black shank and yellow earlobe were observed

among some chickens reared in the midlands. Studies by Jamie *et al.* (2012) have indicated in localized selection/preference by the respondents, and/or adaptability of the birds to specific agro ecology. The study further indicates that the exotic ecotypes had similar qualitative traits across the two studied locations indicating that they are being maintained without crossing with the native chickens, which of course is desired to maintain the diversity among the native ecotypes, these observations concur with the findings of Guni *et al.* (2013) and Jamie *et al.* (2012).

Quantitative traits

The results as presented in Table 17 show that all the morphometrical traits studied were recorded to be higher among the Sasso chickens reared in the lowlands. It indicates that these chickens were better adapted to the lowland area. The Bovans chickens on the other hand performed better in the midlands indicating their adaptability to that agro climate which accords with the observations of Ermias (2015). This may be due to the type of feed available in the area. Besides, the agro climate itself may be responsible for lowering the performance as observed and the findings are in consonance with the reports of Addis and Malede (2014) who also observed that the performance of the chickens are influenced by the availability of feed. The present findings are also in close accordance with Sonaiya and Swan (2004) which indicates a correlation between the amount of feed available and the numbers of eggs produced.

The findings from Table (18) and (19) are contrary to those of Remeš and Székely (2010). This may be attributed to body mass scale is isometry among domesticated chickens so as to attain a uniformity desired by the breeders and can be a fallout of lack of male: male and female: female competition and lack of sex specific selection for body weight by the commercial breeders. The body length of local chickens irrespective of the sexes was in accordance with the result of Agide (2015). However, the chest width, shank length and body weight of matured local chickens were higher than the result of Agide (2015) and Nigussie (2011). The body weight of Sasso chickens was in accordance with the result of Aman *et al.* (2017). However, the body weight of the Bovans and Koekoek hens were higher than the findings of Dessalew (2012).

Estimating body weight using linear measurement traits

The results pertaining to multiple regression indicate that the body length (BL) of the birds were the most important trait which can be used for assessment of the body weight of the chickens. This can be because chickens with higher BL have higher skeletal dimensions, have higher surface area for the attachment of muscles (Assan, 2015). Moreover, birds with higher BL usually have larger space for the growth of the vital organs, which in turn will have higher body weight as reported by Ojedapo *et al.* (2012). The other trait, which influences the body weight is the chest width (CW), which correlates very well with the width of the thoracic cavity. Chickens with wider thorax will have large space for housing the vital organs viz. heart, liver and the pectoral muscles that is the prime muscle and contribute significantly to the weight of the birds. These findings are thus in good agreement with those of Liyanage *et al.* (2015) who reported that body circumference was identified as a suitable predictor trait of live weight. The low values for coefficient of determination (R^2_{adj}) can be ascribed to higher influence of environment on the traits and this can be attributed to higher coefficient of variation within a trait which can be improved by increasing the sample size.

5.3. Egg qualities traits

External egg quality traits

The current results indicated that agro ecology influenced the external egg quality parameters across the ecotypes. Which might be attributed to the interaction effect of genotype and environment as well the availability of feed. The observation was in line with the report of Sekeroglu *et al.,* (2008). While the variations in the egg length and width can be associated with the genetics of the birds, the shell thickness are correlated with the deposition of calcium, which is metabolized from the skeleton of the birds and the dietary sources as discussed by Aberra *et al.,* (2010). The shell thickness of an egg could be affected by high environmental temperature which would result in reduced blood flow through shell gland as a result of panting. This phenomenon would further affect the availability of ionic calcium content, and secretion of the carbonic anhydrase in shell gland.

The length and width of the eggs from the local chickens were higher than the findings of Hussain *et al.* (2013). The shell thickness and shape index of the eggs from the local chickens were in accordance with the finding of Bikila (2013) and Mesba *et al.* (2012). The result of length and width of the eggs from the White leghorns as reported by Rath *et al.,* (2016) was in accordance with the values of the eggs from the exotic chickens. Eggshell thickness of Bovans and Koekoek chickens were in accordance with the findings of Dessalew (2012).

Internal egg quality traits

The results pertaining to the internal egg quality significantly varied across the different ecotypes. Assan, (2015) discussed the relation the values of internal egg quality as interaction of environment with genotype and type of feed available. Moreover, it can be influenced by the duration of storage and temperature of storage. The protein content of the feed also influences the albumin content in the eggs (Zaman *et al.,* 2005). The differences in the egg quality trait among the chickens of a particular breeds also varied across the agro ecologies (Table 27). The findings indicate that the eggs quality parameters varied across the genotypes with Sasso being better adapted in the lowlands (this was also observed across the other traits discussed above). On the other hand, the egg quality traits of Bovan's and Koekoek indicated that these breeds are better suited for the midlands which agrees with the observations of Getachew *et al.* (2016) from Chelliya district of Ethiopia. Baishya et al. (2008) and Zita et al. (2009) have also reported the relationship between feed availability, body weight and egg weight.

The findings also indicate the existence of variations among the studied chicken breeds regarding the egg quality traits. Accordingly, the egg weight of Sasso chickens was the heaviest indicating that these breed is best suited for the study area. There is also a good correlation between body and egg weight of chickens. Jatoi *et al.* (2015) and Mesba *et al.* (2012) reported that heavy weight category birds had maximum egg weight followed by medium and small sized chickens. The egg weight of local chickens was in the range of 25-49 g, which was in line with the findings reported by Olwande *et al.* (2009) in South Nyanza, Kenya. The yolk index of local egg was in accordance with the result of Mesba *et al.*

(2012). Yolk color of local egg in the study area was in accordance with the finding of Bikila (2013). The Haugh unit of local egg was comparable to those reported by Fisseha *et al.* (2010). The Haugh unit is mainly influenced by the albumen height and egg weight, which demonstrate a strong positive association with the former. For Koekoek chickens, the egg weight is in accordance with the finding of Dessalew (2012). The yolk color of both Bovans and koekoek chickens in this study were better than the result of Dessalew (2012). However, the Haugh Unit of both chickens are similar with the finding of Dessalew (2012). The yolk index of local egg was in accordance with the finding of Rath *et al.*, (2016) for WLH chicken.

6. CONCLUSION AND RECOMMENDATION

6.1. CONCLUSION

This study was conducted to assess management practices, egg production and linear body measurement of exotic and local chicken reared under traditional production system of Boricha Woreda Sidama zone of Ethiopia. All of these parameters of this study were evaluated under two agro ecologies (midland and lowland) of Boricha woreda. Sasso, Koekock, Bovans were the exotic chicken breeds reared in the study area besides the native ecotypes.

Most of the respondents provided supplementary feed to their chickens. The husbandry practices, however, differed across the two studied locations. The hatching percentage was quite low which can be attributed to poor management of the hatching eggs. It was also concluded that Sasso chickens had higher body weight and morphometrical measurements at the lowlands while the values were higher among the Bovans and Koekock at midlands. Sexual difference was observed for all the morphometrical traits across all the ecotypes irrespective of the locations, the cocks being larger than the hens. The body weights of the studied ecotypes were best assessed using the body length measurements, while in some cases chest width results were promising. The egg sizes of the exotic chicken breeds were larger than the native chickens and variations have been also observed across the exotic chickens. The egg of the Sasso chickens reared in the lowlands exceeded than the other chicken breeds while those of the Bovans and Koekock were higher in the midlands. It can therefore be concluded that Sasso chickens were better suited in the lowland conditions while in the midlands the same was true for Bovans chickens.

6.2. RECOMMENDATIONS

Based on the results of the study the following recommendations are forwarded in order to improve chickens production and productivity in the study area.

1. Training for farmers and extension staffs about diseases control, improved housing and feeding practice should be settled to know and increase profitability of chicken production both local and exotic chicken under traditional production practice.
2. The extension and veterinary services should be accessed equally for all farmers in both agroecology particularly veterinarians should provide vaccination service properly before disease prevalence season.
3. Since the management, breed and agroecology were affect egg production, quality and linear body measurement, exotic chickens should be distributed according to their adaptation to poor management system and environmental hazards such as environmental temperature, feeding and predators.
4. More awareness farmers on setting of eggs for incubation and storing eggs without losing its quality should be needed to improve hatchability of eggs in the study area.
5. The results are interesting is that, from the exotic chickens, the Sasso chicken was better in egg production, almost in all of body measurement traits and egg weight in the lowland than in the midland followed by Koekoek. It is thus recommended that the Sasso chicken can be distributed to farmers in the lowland.
6. The Bovans chicken had demonstrated good performance in egg production, linear body measurement traits, internal and external egg quality traits, under midland agroecology. This chicken breed can be recommended for farmers in the midland who are interested in rearing chickens.

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APPENDIX 1

Table 30: ANOVA table for effect of agro ecology, breed and sex on body weight

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecol	1	0.34171875	0.34171875	2.65	0.1053
Breed	3	44.58223958	14.86074653	115.18	<.0001
Sex	1	8.29171875	8.29171875	64.27	<.0001
Error	186	23.99802083	0.12902162		
Total	191	77.21369792			
CV%		12.72663			

Table 31: ANOVA table for effect of agroecology, breed and sex on body length

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecol	1	7.921875	7.921875	2.47	0.1180
Breed	3	1096.109375	365.369792	113.75	<.0001
Sex	1	148.755208	148.755208	46.31	<.0001
Error	186	597.416667	3.211918		
Total	191	1850.203125			
CV%		4.797142			

Table 32: ANOVA table for effect of agro ecology, breed and sex on wingspan

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecol	1	11.0208333	11.0208333	2.68	0.1035
Breed	3	897.4218750	299.1406250	72.67	<.0001
Sex	1	121.9218750	121.9218750	29.62	<.0001
Error	186	765.630208	4.116291		
Total	191	1795.994792			
CV%		5.754794			

Table 33: ANOVA table for effect of agro ecology, breed and sex on chest width

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecol	1	93.800208	93.800208	14.19	0.0002
Breed	3	1506.392292	502.130764	75.99	<.0001
Sex	1	106.803333	106.803333	16.16	<.0001
Error	186	1229.102292	6.608077		
Total	191	2936.098125			
CV%		8.583927			

Table 34: ANOVA table for effect of agro ecology, breed and sex on shank length

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecol	1	4.68750000	4.68750000	10.96	0.0011
Breed	3	16.13020833	5.37673611	12.57	<.0001
Sex	1	23.38020833	23.38020833	54.67	<.0001
Error	186	79.5468750	0.4276714		
Total	191	123.7447917			
CV%		8.861076			

Table 35: ANOVA table for effect of agro ecology, breed and sex on shank diameter

Source of variation	DF	Sum of Squares	Mean Square	F Value	Pr > F
Agroecology	1	0.29296875	0.29296875	0.80	0.3716
Breed	3	58.37890625	19.45963542	53.27	<.0001
Sex	1	2.40755208	2.40755208	6.59	0.0110
Error	186	67.9401042	0.3652694		
Total	191	129.0195313			
CV%		11.29343			

APPENDIX 2

Semi-structured Questionnaire

INSTRUCTION TO THE ENUMERATORS

1. Make brief introduction to each farmer before starting any question and make clear the objectives of the study.
2. Please ask each question so clearly and patiently until the farmer understands.
3. Please fill up the questionnaire according to the farmers replay (do not put your opinion).
4. Please do not try to use technical terms while discussing with farmers and do not forget the local unit.

Enumerator's Name_____ Date _____Sign._____

1. Household Characteristics

1. Name of district _____ Agro-ecology _____
2. Name of household head: _____Sex: _____ Age_____
3. Family size 1. Male_____2. Female_____
4. Level of education of the household head?

A. Illiterate
B. Read and write only
C. Grade 1 – 4
D. Elementary School
E. High school
F. College and University education

2. Livestock population and land used system

5. Farming system in the study area

A. Crop-livestock B. Livestock only C. Crops only D. Others_____

6. Types of crops grown _____
7. Number of livestock kept in the household

A. Cattle_____
B. Sheep_____
C. Goat_____
D. Chickens____Local____Improved ____

3. Source and chickens type you have

8. Have you ever accessed exotic chickens breed? 1. Yes 2. No. If yes, where did you access? _____
9. Which type of exotic chicken species do you have?

A. White leghorn B. Sasso C. Bovans D. Koekoek E. other _____

4. Management of chickens

10. Have you separated house for chickens? 1. Yes 2. No. if yes, what type of house? _____
11. If No. why you didn't construct house? _____
12. What is the common diet of your chickens? _____
13. At what time of day do you feed your chickens? _____

14. Do you provide supplementary feed? 1. Yes 2. No. If yes, what type of supplement? _____

15. Why you offer supplement to your chickens? _____

16. Which breed of chicken gets supplementary feeding most frequently?

A. Local breeds B. Cross breed C. Exotic breed D. All breeds

17. What type of feeding practice you used?

A. Group feeding C. Separate feeding by age

B. Separate feeding by breeds D. Separate feeding by production

18. How do you give feeds? A. On ground B. On trough.

19. If you give on trough what type? _____

20. Do you provide water for your bird? 1. Yes 2. No. If yes, what is the source of water?

A. River B. Tap water C. Pond water D. Others _____

21. If No. why you didn't provide? _____

22. What type of watering trough you use? _____

23. Which age group has the highest mortality? A. Up to 4 weeks B. 4 to 8 weeks C. > 8 weeks

24. At which season most of your chickens become sick? _____

25. What type of disease frequently occurrence in your flock?

A. NCD B. Infectious bronchitis (IB) C. Ecto-parasites D. Cocidosis

26. What is your immediate action when you observe sick birds in the flock?

A.Isolation/selling B. Immediately slaughter C. Treat with traditional medicines or vaccine

27. Do you practice traditional medicines to your chickens? 1. Yes 2.No. If yes, specify? _____

28. Do you practice vaccination of your chicken? 1. Yes 2. No. If yes, by how many interval? _____

29. To which breed you give vaccine? A. Local B. Cross C. Exotic D. All breed

30. If not, why? _____

31. Do you use anti-ectoparasites? 1. Yes 2. No. If yes, what type of anti ecto parasite? _____

5. Reproduction and egg production potential of chickens

32. How much is the storage time of egg (after laying) used for incubation?

A. Up to 1 week B.1- 2 weeks C. 2 – 3 weeks D. More than 3 weeks

Table 1: hatching potential of local chicken in the study area (%)

	Parameters			
Chicken breed	Number of hatching per hen per year	Number of egg setted per hatchicng	Number of chicks hatched/hen	Hatchability (%)
Local				

Table 2: egg production performance of improved and local chicken in the study area

Parameters	Chickens			
	Local	**Bovans**	**Sasso**	**Koekoek**
Age at first egg laying				
No. of eggs /hen/clutch				
Length of clutch (days)				
No. of clutch/year				
No. of egg per hen per year				

6. Marketing of chicken and egg and extention service

33. At what month chicken reach for sale; Exotic _____ Local_____

34. Do you have access to the extension service? 1. Yes 2. No. If No, state the reasons? _____

35. If yes, when do you contact with extension agent? _____

36. For what purpose do you raise chickens? _____

37. What is the importance of egg?

A. For consumption B. For selling C. For incubation D. For gift E. other _____

38. What is major importance of chicken products in family nutrition?

A. To child's B. To pregnant C. To lactating mothers D. To older

1. Opportunity and constraints of chicken production

39. What are opportunities to rear chickens in the area? _____

_____

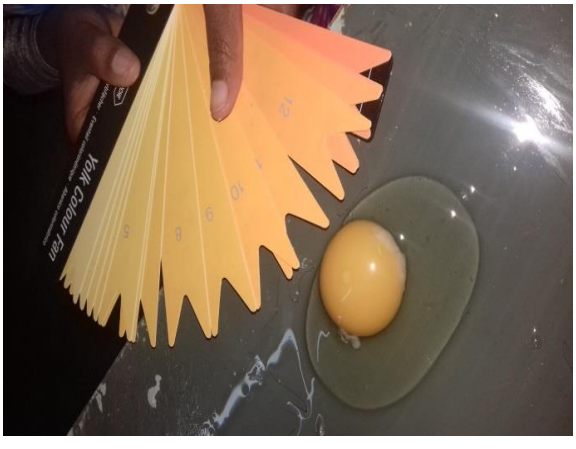
_____.

40. What are major constraints during you rear exotic breeds? _____

_____

_____.

Pictures showing taking data on linear body measurement and egg quality traits



BIOGRAPHICAL SKETCH

Serkalem Assefa was born in May 28, 1993 G. C from her father Assefa Getu and her Mother Askalu Solomon in Girmi Goba Kebele, Werejarso Woreda, West Shewa, Oromia Region. She attended her primary education at Girmi Goba Elementary School. She then attended her Secondary and Preparatory education at Gohatsion High and Preparatory schools, respectively. She joined Wollo University, Dessie Campus, Department of Animal Science in 2013 G. C and graduated with BSc degree in Animal Science in the year of 2015.

Following her graduation, she was assigned as a candidate of Assistant Lecture by the Ministry of Education at Werabe University. She was allowed by the Ministry of Education to pursue here study at a Master level. She thus joined the School of Graduate Studies of Hawassa University in 2015 to pursue her MSc study in the School of Animal and Range Sciences specializing in Animal Production.