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*Full Length Research Paper*

# **GFSKLYFamide-like neuropeptide is expressed in the female gonad of the sea cucumber, *Holothuria scabra***

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**Neuropeptides are mediators of neuronal signalling, controlling a wide range of physiological processes that cut across many organisms. GFSKLYFamide is a neuropeptide that belongs to the Echinoderm SALMFamide group of peptides. This study was aimed at determining the expression of GFSKLYFamide-like neuropeptide in the female gonad of the sea cucumber *Holothuria scabra*. Ten female *H. scabra* weighing between 62 and 175 g were collected at different times between May, 2009 and April, 2010 from the Andaman Sea at Koh Jum Island in Krabi province of Thailand for the study. Using GFSKLYFamide polyclonal antibody and Alexa 488-conjugated goat anti-rabbit IgG as primary and secondary antibodies, respectively, indirect immunofluorescence method and confocal microscope was used to localise GFSKLYFamide-like immunoreactivity in the female gonad of *H. scabra*. The results show GFSKLYFamide-like immunoreactivity being expressed in the sub-epithelial fibres of the coelomic epithelium. This is the first report providing evidence of GFSKLYFamide neuropeptide existence in the female gonad of *H. scabra*. It was suggested that further studies be carried out to investigate if there is similar existence of GFSKLYFamide neuropeptide in male gonad of *H. scabra* and also to know the structure or activity of the peptide(s) producing GFSKLYFamide-like immunoreactivity in *H. scabra* gonads.**

**Key words:** GFSKLYFamide, SALMFamides, immunoreactivity, sea cucumber, echinoderm, gonad.

## **INTRODUCTION**

Neuropeptides have been known to play a crucial role in mediating several physiological processes in animals (Ajayi and Withyachumnarnkul, 2015; Semmens and Elphick, 2017). The neuropeptide, GFSKLYFamide (Gly-

Phe-Ser-Lys-Leu-Tyr-Phe-NH<sub>2</sub>) is a heptapeptide first isolated in the sea cucumber *Holothuria glaberrima* (Diaz-Miranda et al., 1992). It belongs to the Echinoderm SALMFamide group of peptides and like many other

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neuropeptides in this family, GFSKLYFamide is believed to play a crucial role in some physiological processes particularly those involving muscular relaxation (Melarange et al., 1999; Elphick and Melarange, 2001).

Echinoderms are of particular interest for studies on neuropeptides because as deuterostomes, they bridge the evolutionary gap between chordates and model protostomian invertebrates and provide a better understanding of the evolution of neuropeptide systems in the animal kingdom as whole (Semmens and Elphick, 2017). The sea cucumber, *Holothuria scabra* that is known as sandfish belongs to the Echinoderm phylum in the class Holothuroidea, of the order Aspidochirota and in the family Holothuriidae. It is a tropical sea cucumber species that is overexploited due to its commercial value (Conand 1998; Purcell et al., 2012).

Research activities aimed at understanding the neurohormonal regulation of reproduction in this species has been done in our laboratory (Ajayi and Withyachumnarnkul, 2013). Efficient spawning induction in the animals with minimal stress is important in culture; hence, the need to understand the neurohormonal cues regulating gamete release, particularly in the female species, which would provide the needed eggs for fertilization. Moreover, there is no evidence to show that GFSKLYFamide-like neuropeptide, which has been reported in the gonads of *H. glaberrima* exists in *H. scabra*. The present study is therefore aimed at determining the expression of GFSKLYFamide-like neuropeptide in the female gonad of the sea cucumber *H. scabra*.

## MATERIALS AND METHODS

### Animals

Ten female *H. scabra* weighing between 62 and 175 g were used in this study. The animals were collected at different times between May, 2009 and April, 2010. Samples were collected from the Andaman Sea at Koh Jum Island in Krabi province of Thailand with the following coordinates; 7.8119°N, 98.9770°E. They were maintained in filtered natural sea water within a temperature range of 28 to 31°C and salinity of about 32 ppt at the Shrimp Genetic Improvement Centre, Chiya, Suratthani before being transferred to the laboratory in Bangkok in oxygenated sealed plastic bags over a distance of 530 km by train.

### Antibody

Polyclonal antibody against GFSKLYFamide was generously provided by Professor García-Arrarás (University of Puerto Rico, USA). The antibody was raised as described by Díaz-Miranda et al. (1995), using 63 g of synthetic GFSKLYFamide coupled to 15 mg BSA with 0.3% glutaraldehyde. The reaction was stopped by the addition of 1M glycine and the mixture dialyzed. Aliquot of the dialysate BSA-GFSKLYFamide conjugate was emulsified with complete Freund's adjuvant and injected into two rabbits with half of the emulsion each, subcutaneously and intraperitoneally. Two

boosters of the aliquot mixed with incomplete Freund's adjuvant were given after the initial injection and sera was collected 7 and 14 days after each injection, preabsorbed with BSA and assayed by immunohistochemical reactivity on sections of sea cucumber gonad and by dot blot.

### Immunohistochemistry

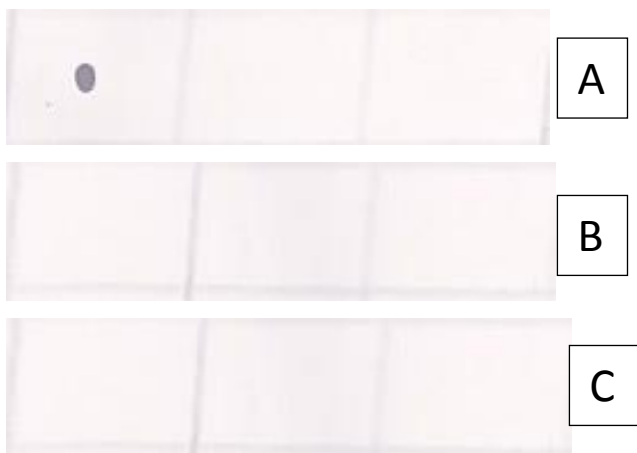
Indirect immunofluorescence method was used to localise GFSKLYFamide-like immunoreactivity in the female gonad of *H. scabra* using frozen sections. Tissues were processed for immunohistochemical analysis, thus animals were anaesthetized in ice for about 30 min before dissection. Dissected tissues were fixed immediately in 4% paraformaldehyde for 5 to 24 h at 4°C, washed three times in PBS for 10 min each and cryoprotected in 30% sucrose overnight. Sections of 7 µm thickness were cut with a cryostat (LIECA CM 1850), mounted on poly-L-lysine-coated slides and permeabilized in PBS-Triton X-100 (0.1%) for 5 min before blocking with normal goat serum (1:50 in PBS) for 1 h. Sections were incubated overnight at room temperature with primary antibody (1:1000 in PBS) followed by three washes in PBS-Tween 20 (0.05%) for 10 min each. This was followed by 1 to 2 h incubation in Alexa 488-conjugated goat anti-rabbit IgG (1:500 in PBS) at room temperature. Sections were then washed 3 times, 10 min each, in PBS-Tween 20. Slides were incubated in TOPO-3 (1:500 in PBS) at room temperature for 1 h then rinsed in PBS-Tween 20 (0.05%) and mounted in buffered glycerol (pH 8.6). Tissues were examined and photographs taken with an Olympus Confocal laser scanning microscope (FV 1000). Images were processed using OLYMPUS FLOVIEW 1.7b viewer and Adobe Photoshop CS3. Positive and negative control tests were run on a nitrocellulose membrane using a Dot Immunoblot Assay (DIA) protocol previously developed by us. The DIA protocol involves spotting 0.5 µl of synthetic GFSKLYFamide neuropeptide on three 0.22 mm nitrocellulose membranes. The membranes were air-dried at room temperature for 30 min and baked at 100°C for 30 min. After cooling to room temperature, the membranes were washed for 10 min in a small volume of 0.1M Tris buffer (pH 7.4) with 0.05% Tween 20 (v/v; Buffer 1). After washing, the membranes were incubated for 60 min in a blocking solution containing 3% BSA in 0.1M Tris buffer (pH 7.4). Following blocking, the membranes were incubated overnight in GFSKLYFamide primary antibody (1:10,000) diluted in Buffer 1. After the removal of primary antibody, the membranes were washed 3 times for 5 min each in Buffer 1 and incubated in AP-conjugated goat anti-rabbit antibody (1:500 in Buffer 1) for 1 h. Membranes were again washed 3 times for 5 min each in Buffer 1, developed with NBT/BCIP (1:100 in development buffer) and then washed in distilled water, air-dried and photographed. Preabsorption control was done by substituting the primary antibody with preabsorbed antibody or PBS. Working dilutions of GFSKLYFamide antibody (1: 1000 in PBS) were preabsorbed overnight at 4°C with 100, 50 and 10 ng/µl of synthetic GFSKLYFamide neuropeptide.

## RESULTS

The polyclonal antibody used in this has been characterized and used extensively in previous studies. It was reported to show high specificity for GFSKLYFamide neuropeptide and does not react against CCK, galanin, proctolin, and CARP. It was also reported that in preabsorption controls, GFSKLYFamide at 1 and 10



**Figure 1.** A mature gonad of *H. scabra*



**Figure 2.** Specificity test for GFSKLYFamide antibody using Dot Immunoblot Assay. All three membranes were spotted with synthetic GFSKLYFamide neuropeptide and DIA performed with primary antibody as (A) GFSKLYFamide polyclonal antibody, (B) GFSKLYFamide polyclonal antibody preabsorbed with GFSKLYFamide neuropeptide and (C) PBS buffer.

pg/ml eliminated the observed immunoreactivity from the digestive system (Diaz-Miranda et al., 1995).

A matured gonad of *H. scabra* is shown in Figure 1. Results from our positive and negative control test using DIA show that GFSKLYFamide antibody, acting as primary antibody, reacted with synthetic GFSKLYFamide neuropeptide while preabsorbed GFSKLYFamide antibody, acting as primary antibody, did not elicit any reaction with synthetic GFSKLYFamide neuropeptide (Figure 2). Also, substituting the primary antibody with PBS failed to elicit any reactions. This shows that

GFSKLYFamide polyclonal antibody that was used is specific for GFSKLYFamide neuropeptide.

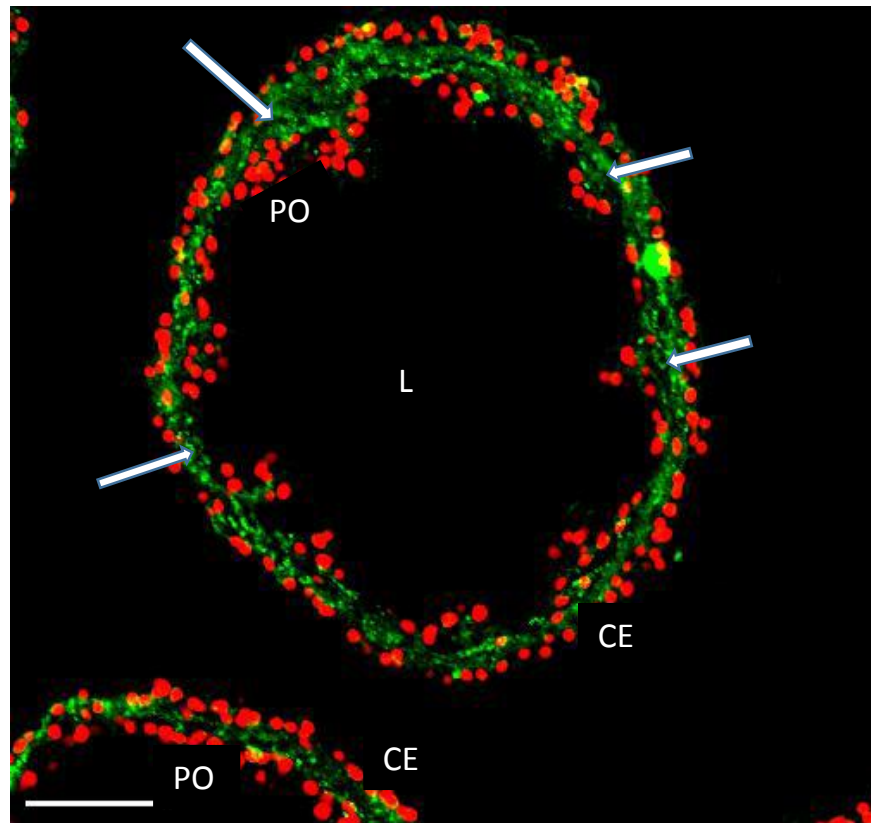
Results also show the localization of GFSKLYFamide-like immune-reactivity in the female gonad of the sea cucumber *H. scabra*. GFSKLYFamide-like immune-reactivity was expressed in the sub-epithelial fibres of the coelomic epithelium (CE). Also from the result, it was observed that the lumen (L) of the gonad was almost empty except for few previtellogenic oocytes (PO) lying within the germinal epithelium of the gonad (Figure 3).

## DISCUSSION

Neuropeptides are signalling molecules that are produced by neurons and they often play the role of neurotransmitters and neuromodulators in several physiological systems (Semmens and Elphick, 2017). In this study, GFSKLYFamide-like immunoreactivity was localized in the female gonad of the sea cucumber *H. scabra*. The GFSKLYFamide-like immunoreactivity was specifically expressed in the sub-epithelial fibres of the coelomic epithelium of female *H. scabra*. This result is similar to an earlier report in *H. glaberrima* where it was observed that the coelomic epithelium and sub-epithelial fibres of both male and female gonads of *H. glaberrima* expressed GFSKLYFamide-like immunoreactivity (Diaz-Miranda et al., 1995). Although a major difference between this report and that of the *H. glaberrima* study is the fact that the current study was limited to only the female species of *H. scabra* and GFSKLYFamide-like immunoreactivity is exclusively expressed in the sub-epithelial fibres of female *H. scabra*.

GFSKLYFamide neuropeptide could be a key signalling molecule in Echinoderms owing to the localization of immunoreactivity against this neuropeptide in the second sea cucumber species, as demonstrated in this study. It has already been suggested that GFSKLYFamide plays a significant role in the control of multiple action systems including digestion, respiration, circulation, locomotion and even reproduction (Diaz-Miranda et al., 1995). The present study confirms earlier reports that GFSKLYFamide-like immunoreactivity occurs throughout the nervous system of the sea cucumber (Diaz-Miranda et al., 1995; Elphick, 2014; Ajayi and Withyachumnarnkul, 2015).

*H. scabra* is a tropical species, found in warm shallow waters particularly in the indo-pacific region (Purcell et al., 2012). This species of sea cucumber is commonly eaten due to its medicinal properties; hence, its great commercial value. As a result of its overexploitation, it is liable to becoming an endangered species. The sea cucumber, *H. scabra* have separate sexes that are difficult to distinguish unless at spawning. Reproduction in *H. scabra* occurs through a process that involves broadcast spawning of gametes into the seawater where



**Figure 3.** GFSKLYFamide-like immunoreactivity in the female gonad of *H. scabra*. Immunoreactivity (green), as indicated by arrows, is present in the submucosa layer, muscular layer and in the coelomic lining of the serosa. Nuclei were counterstained with TOPO-3 (red). CE: Coelomic epithelium of the gonoduct; PO: previtellogenic oocytes; L: lumen. Scale bar = 50  $\mu$ m.

sperm make direct contact with eggs to begin the process of fertilization (Hamel et al., 2001). The reproductive cycle of *H. scabra* comprises a resting (resorption), growing maturity, spawning, post-spawning stages (Yoichi and Michiyasu, 2014). The estimated size of sexually matured *H. scabra* is 210 mm in females and 213 mm in males (James and James, 1994; Abdul-reza et al., 2012). The gonad of female *H. scabra* are in various stages of maturity for example in immature gonad, tubules are single and short, in maturing gonad the tubules are long, yellowish and germinal cells are visible (Baskar, 1994). In adult female gonad, the tubule, in addition to being long is yellowish in colour as well as branched (Baskar, 1994). The average weight of female gonad is 31 g while in male is 24 g (Conand, 1993). Content of the gonads in *H. scabra* include filamentous tubules which form a tuft that is attached to the dorsal mesentery in the coelomic cavity (Conand, 1993). Proceeding into the dorsal mesentery is the gonoduct which is lined by ciliated epithelium (Purcell et al., 2012). The gonoduct in female *H. scabra* is lined by ciliated

epithelia cells that are directed towards the lumen. The gonoduct also consist of connective tissue and coelomic epithelium lining it externally. Embedded in the germinal epithelium are numerous oogogonial cells (oocytes) that have nuclei which can be seen when lightly stained. The oocytes of *H. scabra* varies in shape from pyramidal to elongated and club-shaped (Hamel et al., 2001). In this study, it is shown that the lumen of the gonad was almost empty except for few previtellogenic oocytes lying within the germinal epithelium of the gonad. This suggests that female *H. scabra* used may have spawned just before it was obtained and used for the experiment. Female gonadal tubules of *H. scabra* have been reported to be shorter and wider, containing few oocytes after spawning ((Hamel et al., 2010).

### Conclusion

This study has shown that GFSKLYFamide-like immunoreactivity is present in the female gonad of the

sea cucumber, *H. scabra*. This, to the best of our knowledge, is the first report providing evidence for the existence of GFSKLYFamide neuropeptide in the female gonad of *H. scabra*. It is however suggested that further studies be carried out to determine the structure of the peptide(s) producing this immunoreactivity in *H. scabra*, as well as an investigation into the existence of GFSKLYFamide-like immunoreactivity in the male gonad of *H. scabra*.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Review*

# Phenotypic variations of indigenous sheep breed ecotypes of Ethiopia: A review

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**Updated result of the phenotypic characterization and description of the indigenous sheep population was reviewed. The reviewed paper used reporting and tabulating published descriptive phenotypic information on Ethiopian breeds with the aim of dissemination of relevant information for the beneficiaries. The original sheep breed types in Ethiopia that migrated from South West Asia to Africa and then to Ethiopia were the thin-tailed, fat-tailed and fat-rump. Through time, they evolved into 14 traditionally recognized sheep breeds which are identified and described through phenotypic characterization of the representative sample flocks. The breeds adapted to different agro ecological zones varied in topographical features and humidity. The overall reviews of the adult average live body weight variation of the local sheep population of Ethiopia are classified into 20 to 25 kg (Elle, Abergelle and Menz); 26 to 30 kg (Afar, Tikur, Highland sheep, Washera and Black Head Somali [BHS]); 31 to 35 kg (Bonga, Begait, Horro, Arusi-Bale and Farta) and 36 to 40 kg (Gumuz). The large sheep breeds of Ethiopia are Begait, Washera, Gumuz, Horro and Bonga. There is a variation on phenotypic performance among the sheep breeds of the Ethiopia in terms of body shape and size, ear profile and size, head profile, tail size and shape, coat color and on the adaptive behaviors. Molecular characterization should be done for comprehensive genetic evaluation and classification of the indigenous sheep population at national level.**

**Key words:** Sheep breed, phenotypic variation, sheep classification, tail type and tail shape.

## INTRODUCTION

The ancient process of domestication of wild mammalian species contributes for the emerging of diversified domestic animal species. More emphasis is given to the adaptability of the wild animals towards the interventions of the ancient human beings controlling them so that they can obtain valuable food products from the preferable the

wild animals. Sheep (*Ovis aries*) is considered the first domesticated livestock species during 11000 to 9000 BC in Southwest Asia from its wild ancestry of *Ovis orientalis* (Oldenbroek and Van der, 2014). It is greatly emphasized that South West Asia served as a route for distribution of domesticated sheep to different directions all over the

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world especially to Africa along with migrant peoples (Solomon, 2008). The introduced domesticated sheep develop an adaptation mechanism to different agro climatic conditions and own unique characteristics since thousand years ago. Ethiopia with its varied topographical features and diverse agro ecological Zone is believed as a home for many sheep breeds (Birara, 2016). The estimated total sheep populations of Ethiopia accounts for 30.7 million from which 27.86% of the total are male while 72.14% are female (CSA, 2017). Flock composition of the sheep breeds of Ethiopia is estimated as 26.2, 10.8, 10.9 and 52.0% for the age categorization of <6 months, 6 month to 1 year, 1 year to 2 years and 2 years and older, respectively (CSA, 2017). However, the local sheep breeds are generally characterized with low level of productivity in terms of growth rate and carcass yield (Mengesha and Tsega, 2012). Various research reports indicated as there are efforts to improve the productivity of the local sheep through improving management and husbandry interventions, implementing breed improvement through selection and crossbreeding for terminal cross breed. Nowadays with existing awareness on impact of climate change, due emphasize on production improvement is advised to take advantage of the locally adapted breeds. In favor of this recommendation, there are many research works on the phenotypic characterization of sheep breeds along with the description of their production system in different regions of Ethiopia. However, making the separately conducted characterizations of locally adapted sheep breeds as comprehensive review is the main gap at national level concerning delivering updated information on breed characterization, inventory and monitoring of sheep genetic resource management. Therefore, information dissemination by reviewing such research findings to interested readers and beneficiaries is important for developing breed improvement strategies both at regional and national level to take advantage of the locally adapted sheep breeds through implementing selection within and between the breed populations. Concerning the backgrounds, the objective of this paper was to deliver updated information by reviewing the findings of phenotypic characterization of sheep breeds to beneficiaries.

## HISTORY OF SHEEP DOMESTICATION

What changes after domestication of a wild mammalian species? The first process begins after the wild animal assumed themselves as they are under controlled environment is changing in their behavior. The changing in the behavior of the domesticated animal is directly related to the word "Tame" and it is considered as the continuous process (Oldenbroek and Van der, 2014). The process of domestication is also related to the biological context in which the domesticated sheep are benefited

from having successful reproductive while humans can get the valuable products from them. Such kind of biological relationship between sheep and human is called mutualism which is directly related to the word co-evolutionary process, the most appropriate perspective of domestication (Gifford and Hanotte, 2011). The introduction of domesticated sheep (*Ovis aries*) to Africa from their origin of domestication (South Western Asia) is reviewed as it happened within few time ranges of their domestication through North Africa "Sinai" found in Egypt society during eight and seven thousand years ago (Blench and Donald, 1999). The present sheep type of Africa are classified into two groups based on the tail types, thin tailed and fat tailed or fat rumped (Gifford and Hanotte, 2011). Due to the wide range of adaptability of the introduced sheep, the existing sheep types in different part of Africa not only differed in tail type but also differ in coat color, horn shape, face profile and body conformation.

## BIODIVERSITY OF SHEEP POPULATIONS AND THEIR CLASSIFICATION IN ETHIOPIA

There are different sheep breeds found in different Agro ecological Zones of the country. The factors that shaped the existing types of sheep are the process of domestication, natural selection and human intervention over thousand years ago (Hanotte and Jianlin, 2005). According to the African sheep classification method, these sheep breeds of Ethiopia are classified into two major sheep family groups of "thin tailed" and "fat tailed" (Gifford and Hanotte, 2011). Many of the reviewed papers concerned are discussed in reference to the research report work done of Solomon (2008), who has done research on sheep genetic resource analysis in Ethiopia and the current paper is also reviewed in reference to the outcome of research report of the aforementioned resource scholar. Accordingly, the early introduced major sheep families mentioned above are distributed into different part of Ethiopia and are still evolved since a long period of time to cope with the existing and dynamic environmental conditions resulting sub family within each of the two major families (Solomon, 2008). Up to 18 local sheep population types are found in the natural landscape of Ethiopia kept by different tribes in different parts of the country (Tibbo, 2006).

Classification of the local sheep based on tail type in this paper is based on the qualitative aspect of length and shape of the tail. There is a paper that reviewed the tail type classification of local sheep in Ethiopia into short-tailed, long tailed, fat-rump and thin-tailed types (Mengesha and Tsega, 2012). The current paper is reviewed on the updated research work done on currently addressed phenotypic characterization of various local sheep breeds of Ethiopia including Begait sheep with the longest thin tailed up to 50 cm long (Amare et al., 2012).

**Table 1.** Sheep breeds adapted to different AEZs of Ethiopia.

Sheep breed name	Adaptation to major AEZs	Geographical distribution	Reference
Bonga	Dry highland area (2500-3200 masl)	North shea zone of Amhara Region	Solomon et al. (2011)
Arusi-Bale	Wet highland (2000-3300 masl)	W. Harerghe zone, Borena zone of Oromia and Sidama zone	Solomon et al. (2011)
Abergelle	Dry Lowland( <1500 masl) of semi-arid	Central zone of (Tanqua-Abergelle) Tigray State	Zealelem et al. (2012)
Begait	Dry lowland (1500 masl), warm arid to semiarid seasons with extreme climatic condition (29 to 42°C)	North-Western of Tigray Regional State	Gebregiorgis et al. (2016)
Highland sheep	Dry highland (up to 2600 masl) of cool semi arid	Eastern zone of Tigray (Atsbie-Wonberta district)	Gebreyowhens and Tesfay (2016)
Washera	Wet mid highlands(1600-2000 masl) warmer	North and Western Shao; West and East Gojam and Agew Awi zones of Amhara State	Solomon et al. (2011)
Farta	Sub moist highland (2000-2500 masl)	South Gondar zone of Amhara State	Solomon et al. (2011)
Horro	Wet highlands (2991 masl) to mid-highlands (1600 masl)	East Welega, West Welega, Illubabor, Jimma and West Shoa zones of Oromia	Solomon et al. (2011)
Elle (Ile)	Dry highland (1500- 3200 masl) cool-warm semi arid	Southern zone of Tigray (Raya-Alamata)	Mulata et al. (2014)
Menz	Dry highland area (2500 to 3200 masl) cool and sub moist	North Shoa zone of Amhara State	Solomon et al. (2011)
Tikur	Moist highlands (3000 masl) cool	North Wollo zone of Amhara State	Solomon et al. (2011)
Afar	Dry lowland (<1000 masl) of arid lowland	Afar State	Solomon et al. (2011)
BHS	Dry lowland (215-900 masl) of arid lowland	Somali State; lowlands of Bale, Borena and South Omo zones; part of east Harerghe	Solomon et al. (2011)
Gumuz	Moist lowlands (<1000 masl) of warm humid	Benishangul-Gumuz State; lowlands of North Gondar	Solomon et al. (2011)

## ADAPTATION BEHAVIOR TO VARIOUS AGRO ECOLOGIES ZONES IN ETHIOPIA

The various sheep breeds along with their adaptation information are listed in Table 1 based on the published report and the information is collected from different published sources. Some authors suggested that the habitation of local sheep in Ethiopia is restricted to the ecological requirements (Solomon, 2008).

This suggestion is supported in relation to the tail type and its variation between locally adapted sheep. The variation of tail type and shape in relation to the ability of the local sheep to adapt to the change in feed availability. It might be true if the local sheep are fat tailed in feed shortage area with developed mechanism for energy reserving and thin tailed in area with excess feed available (Solomon et al., 2011; Kassahun and Solomon, 2009). Similarly, there is a variation on the adaptability of the local sheep population of Ethiopia across the varied agro ecological conditions.

## DESCRIPTION OF THE PRODUCTION SYSTEM OF INDIGENOUS SHEEP BREED OF ETHIOPIA

Almost all of the local sheep are reared kept under mixed crop-livestock, specialized pastoral and agro pastoral of the three major livestock production system in Ethiopia (Solomon et al., 2010a;b). In some areas of the western and north western zone under the regional government of Tigray, there are commercial farmers who produced Begait sheep flock for specialized mutton production (Gebregiorgis et al., 2016). Sheep flock management is mainly based on the extensive feeding system in which herded sheep flocks are freed for grazing during the day time and kept indoors during the night. It is widely known that Afar and BHS sheep population are mainly kept under the pastoral and agro pastoral production system (Gemed, 2010; Wendimu et al., 2016). The overall reviewed information on the production system of the local sheep in Ethiopia as they are kept mainly (75%) under small scale

crop-livestock mixed farming system of highland agro ecology (Tibbo, 2006).

## BREEDING OBJECTIVE OF THE LOCAL SHEEP OF ETHIOPIA

There are evidences about the breeding objectives of sheep in Ethiopia that indicate majority (52.01%) of the adult sheep with the age of 2 years and above are kept for breeding (48%), mutton (2.6%) and wool ( $\leq 1\%$ ) managed under subsistent production system which is reported by CSA (2017). However, the productivity of the local sheep is still below the requirement for international competitive market standards of mutton. The slaughter weight and carcass yield of the yearly male sheep under feedlot is very low. Recent research outputs indicated that the average slaughter weight and hot carcass yield for yearly male highland sheep found in Tigray under feedlot varied between 17.0 to 20.0 kg and 6.8 to

**Table 2.** Growth performance of sheep breeds of Ethiopia under smallholder management condition.

Sheep breed name	Flock management	Live Body weight (kg) at different age intervals										@Average adult ( $\geq 2$ PPI) LBW		Reference
		0 PPI		1 PPI		2 PPI		3 PPI		4 PPI		Average	Ranges	
		M	F	M	F	M	F	M	F	M	F			
Bonga	Traditional/Free grazing	-	-	27.2	26.8	32.2	28.6	-	30.8	-	32.8	31.1	31.1-33.5	Zewdu (2008)
Arusi-Bale	Traditional/Free grazing	20.9	16	29.4	25	33.3	27	37.5	30	-	-	32.0	32.0-33.8	Hizkel et al. (2017)
Abergelle	Traditional/Free grazing	-	-	18.9	17.4	21.9	21.7	24.4	23.1	-	-	22.8	22.8-23.8	Seare et al. (2011)
Begait	Traditional/Free grazing	25.9		27.4		33.0		36.3		35.3		34.9	34.9-33.0	Amare et al. (2012)
Highland sheep	Traditional/Free grazing	19.3	17.1	23.0	20.1	25.7	22.3	28.9	23.4	-	-	25.1	25.1-26.2	Gebreyowhens and Tesfay (2016)
Washera	Traditional/Free grazing	19.5	20.1	27.6	23.5	29.2	25.7	33.1	27.3	32.3	28.6	29.4	29.4-30.5	Mengistie et al. (2010)
Farta	Traditional/Free grazing	18.2	17.4	28.5	23.5	30.9	25.7	34.3	27.9	-	-	29.4	29.7-31.1	Bimerow et al. (2011)
Horro	Traditional/Free grazing	-	-	19.6	24.92	20.0	26.1	20.5	28.8	20.4	30.7	24.4	24.4-32.8	Zewdu (2008)
Elle(IIle)	Traditional/Free grazing	-	-	22.4		26.3		29.1		28.7		28.0	24.3-28.0	Mulata et al. (2014)
Menz	Traditional/Free grazing	18.0	16.5	22.9	19.1	24.9	22.3	22.7*	21.5*	41.9*	23.9*	23.6	23.6	Tesfaye et al. (2009); *Gemeda (2010)
Tikur	Traditional/Free grazing	26.1	22.2	27.7	24.3	30.5	25.6	-	-	-	-	28.1	28.1	Tassew et al. (2014)
Afar	Traditional/Free grazing	12.2	13.9	21.8	21.0	26.5	23.0	-	23.4	32.6	25.0	26.1	26.1-26.8	Gemeda (2010)
BHS	Traditional/Free grazing	-	-	26.7	24.7	28.5	25.9	28.8	28.0	32.5	28.4	28.7	28.7-30.5	Wendimu et al. (2016)
Gumuz	Traditional/Free grazing	12.3	12.3	24.1	22.1	32.5	28.5	35.0	32.0	38.0	34.0	33.3	33.3-36.0	Abegaz et al. (2011)
Average LBW (kg)		19.2	16.9	24.8	22.7	28.2	25.2	30.8	27.5	31.4	29.9			

\*Indicates values calculated from the available referenced data.

9.1 kg, respectively with the range of 39.7 to 45.2% dressing percentage based on the average slaughter weight (Urge et al., 2016). Other research output for Begait yearly male sheep indicated that the average slaughter weight and hot carcass yield varied within the range of 32.5 to 30.3 kg and 14.0 to 15.3 kg, respectively with the range of 46.5 to 49.7% dressing percentage based on the average slaughter weight (Michaele et al., 2017). The aforementioned two referenced information on the carcass yield performance are based on the feedlot basis. The overall range on mutton production performance for Ethiopian local sheep is reported as 10 to 12 kg (Berhe, 2010). This information indicates a variation on the phenotypic performance of the local sheep of Ethiopia which can be an input for designing

valuable breed improvement strategies.

### PRODUCTION PERFORMANCE OF THE INDIGENOUS SHEEP BREED OF ETHIOPIA

Information on production and reproduction performance are collected from different published resources and summarized in Tables 2 and 3. The current paper reviewed the variation on production and reproduction performance of the local sheep shown subsequently with respect to the type of sheep flock management under smallholder farmers. To avoid biased flock productivity evaluation, the paper collected published research reports conducted under smallholder farmers so that the performance evaluation is under the

traditional flock management condition.

### Growth performance of the local sheep of Ethiopia

The paper presented related information on the growth performance of 14 traditionally recognized sheep population listed in Table 2 with respect to the age categories. The information is collected from different published research work done on farm phenotypic characterization conducted in different seasons and varied agro ecological and environmental conditions. Estimation of age using teeth dentition is developed for Ethiopian sheep as 0 PPI, 1 PPI, 2 PPI, 3 PPI and 4 PPI which are equivalent with the age categories of  $\leq 1$  year,



**Table 3.** Reproductive performance of indigenous sheep breeds of Ethiopia.

Sheep breed name	Major livestock production system at household level	Reproductive traits							Reference
		AP (month)		AFL (month)	LI (month)	Mortality (%)	WA (month)	Litter size	
		M	F						
Bonga	Mixed crop-livestock production	7.5	9.3	14.9	7.8	26	4.8	1.4	Zewdu (2008)
Arusi-Bale	Mixed crop-livestock production	7.1	7.7	12.8	9.6	11.9	4.6	1.3	Hizkel et al. (2017)
Abergelle	Mixed crop-livestock production	-	-	14.5	6	-	-	1.3	Seare et al. (2011)
Begait	Mixed crop-livestock production	-	9.7 *	14.8*	8.6	-	4.7*	-	Gebregiorgis et al. (2016); *Assen and Akilu (2012)
Highland sheep	Mixed crop-livestock production	6.7	7.4	12.1	6.5	16.6	-	-	Weldeyesus et al. (2016)
Washera	Mixed crop-livestock production	6.8	6.3	11.5	9	20	3*	1.3	Michael (2013); *Mengistie et al. (2010)
Farta	Mixed crop-livestock production	-	-	-	-	-	-	1.0*	*Solomon et al. (2010a); Bimerow et al.(2011)
Horro	Mixed crop-livestock production	7.1	7.8	13.3	8.9	24.4	4.8	1.6	Zewdu (2008)
Elle(IIle)	Mixed crop-livestock production	-	-	-	-	-	-	-	Mulata et al. (2014)
Menz	Mixed crop-livestock production	10.7	-	15.6	8.5	-	-	1.0*	*Solomon et al. (2010a); Gizaw et al. (2013)
Tikur	Mixed crop-livestock production	-	-	-	-	-	5.1	1.1*	*Solomon et al. (2010a); Tassew et al. (2014)
Afar	Pastoral	7.1	8.5	13.5	10.1*	-	-	1.3*	*Solomon et al. (2010b); Gizaw et al. (2013)
BHS	Mixed crop-livestock production	6.4	6.7	12.7	6.6	-	-	-	Helen et al. (2015); *Solomon et al. (2010)
	Agro-pastoral	6.3	7.1	13.8	8.8	-	-	*1.0	
	Pastoral	10.2	8.0	14.7	10.2	-	-	-	
Gumuz	Mixed crop-livestock production	-	-	13.7	6.4	-	3.95*	1.2	Solomon et al.(2010a); *Solomon (2007)

AP: Age at puberty, AFL: age at first lambing, LI: lambing interval, WA: weaning age.

1-1½ years, 1½-2 years, 2½-3 years and more than 3 years (Solomon and Kassahun, 2009). The minimum average live body weight at yearly age (1 PPI teeth dentition) was attained with 18.9 and 17.4 kg for male and female, respectively in Abergelle sheep (Seare et al., 2011) while the maximum average live body weight in the same age category was attained with 29.4 and 25 kg for male and female, respectively in Arsi-Bale sheep (Hizkel et al., 2017).

Using the information obtained from different resources listed in Table 2, the paper reviewed that the average growth rate (kg) for Ethiopia male

sheep breeds was 19.2, 24.8, 28.2, 30.8 and 31.4 in the age categories of 0 PPI, 1 PPI, 2 PPI, 3 PPI and 4 PPI, respectively while in the female sheep breeds the average growth rate (kg) was 16.9, 22.7, 25.2, 27.5 and 29.9 in the respective age categories. Using the information listed in Table 2 collected for 14 sheep breed breeds from different sources, the average live body weight (kg) at adult age (2 PPI to 4 PPI) ranges from 22.8 to 34.9 for Abergelle (Seare et al., 2011) and Begait (Amare et al., 2012) sheep breeds, respectively. Based on the aforementioned information, there is a variation among the sheep breeds of Ethiopia on

the phenotypic performance which is a potential for designing appropriate breeding strategies to improve production levels of the locally adapted sheep. It is many times reviewed that sheep breeds of Ethiopia are generally characterized as slow growth, late maturity and low production performances (Mengesha and Tsega, 2012). The current paper agreed with the general suggestion on the low productivity level of the locally adapted sheep breed of Ethiopia as compared to other breed like Dorper sheep rams and ewes weighing 100 to 120 kg and 60 to 80 kg, respectively (Gavojdian et al., 2013). However, the main cause

for low productivity of the locally adapted sheep in Ethiopia might be due to the lack of appropriate breeding strategies. Some scholar indicates as there are large sized sheep breeds in Ethiopia like Begait sheep weighting 45 to 60 kg and 45 to 50 kg for adult male and female, respectively (Gebregiorgis et al., 2016).

## **REPRODUCTIVE CHARACTERISTICS AND VARIATION ON INDIGENOUS SHEEP OF ETHIOPIA**

The indigenous sheep of Ethiopia have developed important reproductive traits from twining to the possibility of multiple births (Begait up to 6 offspring per birth). Due to poor flocks management of the smallholder farmers, only two of the offspring are able to grow and survive. Indicative information regarding to the reproductive traits for some of the indigenous sheep are listed in Table 3 collected from different published resources.

### **Average age at puberty**

Male sheep have an average age at sexual maturity of 6.3 and 10.7 months for Black Head Somali [BHS] (Helen et al., 2015) and Menz sheep (Gizaw et al., 2013), respectively, whereas the female sheep have an average age at sexual maturity of 6.3 and 9.7 months for Washera (Michael, 2013) and for Begait sheep (Assen and Aklilu, 2012), respectively (Table 3). The aforementioned information is reviewed to show the range of variation on the average age at puberty of the indigenous male and female sheep of Ethiopia under extensive flock management conditions.

### **Average age at first lambing**

According to the information collected, the average age at first lambing for Ethiopian sheep breeds ranges from 12.1 to 14.9 months for Highland sheep (Weldeyesus et al., 2016) and for Bonga sheep (Zewdu, 2008), respectively. The range of average age at first lambing for indigenous sheep breeds of Ethiopia is in line with the findings of Tsedeke (2007) for Alaba sheep. The current paper reviewed that the variation on the age at first lambing may be due to agro ecological effect, breed type and season at which they are born. Some authors suggested that the variation due to the age at puberty and age at first lambing is as a result of the agro ecological effect; indicated as sheep adapted in highland reaches at puberty age earlier than sheep adapted in lowland (Assen and Aklilu, 2012).

### **Lambing interval and weaning age**

Based on the collected information on lambing interval for

Ethiopian sheep breeds listed in Table 3, there is a possibility of attaining this expectation. A potentiality of having two successive lambing per year in some of the indigenous sheep is reported for Bonga, Abergelle, Highland sheep, BHS (under mixed crop livestock production system) and Gumuz with the average lambing interval of 7.8 months (Zewdu, 2008), 6 months (Seare et al., 2011), 6.5 months (Weldeyesus et al., 2016), 6.6 months (Helen et al., 2015) and 6.4 months (Solomon et al., 2010a; b), respectively. The other possibility is having two successive lambing within the consecutive period of two years with somewhat extended lambing interval of 8.5 months to 10.2 months for Menz (Gizaw et al., 2013) and BHS under pastoral (Helen et al., 2015), respectively. The average weaning age for indigenous sheep breeds of Ethiopia varies in between 3 months for Washera sheep (Mengistie et al., 2010) to 5.1 for Tikur sheep (Tassew et al., 2014).

### **Litter size and mortality rate**

The average litter size for indigenous sheep breeds of Ethiopia varies within the range of 1.0 for BHS reared under agro-pastoral (Helen et al., 2015) and 1.6 for Horro (Zewdu, 2008). The indicative information on mortality rate for Ethiopian sheep varies in between the range of 11.9% for Arusi-Bale (Hizkel et al., 2017) to 26% for Bonga sheep (Zewdu, 2008).

## **PHENOTYPIC IDENTIFICATION AND CLASSIFICATION OF THE INDIGENOUS SHEEP**

The current reviewed paper collected information about 14 indigenous sheep population of Ethiopia so far identified and their major descriptor features are listed in Table 4. The indigenous sheep breed of Ethiopia are identified as Begait (Figure 1), Gumuz (Figure 2), Farta (Figure 3), Abergelle (Figure 4), Highland sheep (Figure 5), Elle (Figure 6), Arsi-Bale (Figure 7), Horro (Figure 8), Bonga (Figure 9), Menz (Figure 10), Afar (Figure 11), Tikur sheep (Figure 12), BHS (Figure 13) and Washera (Figure 14).

### **Tail type and shape description**

The dominant observed descriptors from the result of phenotypic characterization of the sampled sheep flock which are listed in Table 4 are collected from different sources. Based on the sourced information collected, the local sheep developed a variation on tail type and shape. Classification of the local sheep population based on the tail type and shape is reviewed by Mengesha and Tsega (2012), Solomon (2009) and Tibbo (2006). However, the previous reviewed papers were not updated to incorporate the newly identified sheep breeds by MSc student research work (Figure 15).

**Table 4.** Overall flock Physical body characteristics of sheep breeds of Ethiopia.

Local name of sheep breed	Habitat (environmental )			Physical body characteristics								Reference
	AEZ	Major Season		Tail shape & size	Coat color pattern	Dominant coat color	Dominant hair type	Dominant body shape	Dominant face profile	Dominant ear profile	Horn shape	
		Wet	Dry									
Bonga	Mid-highland	May-Sep.	Oct.-Apr.	Short thin	Plain	Brown	Smooth	Large	Straight	Lateral	Polled	Zewdu (2008)
Arusi-Bale	Highland	Jun.-Oct; Feb.-May	Nov.-March	Long fat	Patchy	Red	Short	Medium	Straight	Lateral	Spiral	Hizkel et al.(2017)
Abergelle	Lowland	May-Jun	Oct.-Apr.	Short fat	Plain	Dark red	Smooth	Medium	Straight	Rudimentary	Curved	Hailay et al. (2017)
Begait	Lowland	Jun.-Sep.	Oct.-May	Long thin	Plain	White	Smooth	Large body frame	Convex	Dropping	Polled	Amare et al. (2012)
Highland sheep	Highland	Jul.-Sep.	Oct.-Apr.	Short fat	Plain	Beige	Coarse Wool	Medium	Straight	Lateral	Lateral	Gebreyowhens and Tesfay (2016)
Washera	Highland	May-Oct.	Nov.-Apr.	Short fat	Plain	Reddish brown	Short*	Leggy	Concave	Lateral	Polled	Mengistie et al.(2010); *Solomon et al. (2010b)
Farta	Highland	May-Sep.	Oct.-Apr.	Short fat	Plain	White	Coarse	Medium	Straight	Lateral	Curved	*Solomon et al. (2010a) Bimerow et al. (2011)
Horro	Mid-highland	May-Sep.	Oct.-Apr.	Short thin	Plain	Brown	Smooth	Medium	Straight	Lateral	Polled	Zewdu (2008)
Elle(ille)	Mid-highland	Jul.-Sep.	Oct.-Apr.	Long fat*	Plain*	Creamy*	Smooth*	Dwarf	Concave	Rudimentary*	Polled	Mulata et al. (2014); *Solomon et al. (2010a)
Menz	Cool-highland	Jul.-Sep.	Oct.-Apr.	Short fat	Plain	Red	Coarse Wool	Small*	Straight	Lateral	Curved	Tesfaye et al. (2009); *Solomon et al. (2010a)
Tikur	Highland	Jul.-Sep.	Oct.-Apr.	Short fat	Plain	Black	Coarse Wool	Small	Concave	Lateral	Curved	Tassew et al. (2014)
Afar	Arid lowland	-	-	Long fat	Patchy	Creamy*	Coarse	Medium*	Straight	Rudimentary*	Polled	*Solomon et al. (2010a, b); Tesfaye et al. (2009);
BHS	Lowland	Apr.-Jun.; Oct.-Dec.	Nov.-Apr.	Fat rump	Plain	White	Smooth*	Medium*	Straight	Dropping*	Polled	*Solomon (2009); Wendimu et al. (2016)
Gumuz	Lowland	Jun.-Sep.	Oct.-Apr.	Short thin	Plain	Reddish- brown; White	Smooth	Dwarf*	Convex	Lateral	Polled	*Solomon et al. (2010a, b); Abegaz et al. (2011)



**Figure 1.** Begait sheep female (left) and male (right).  
Source: Amare et al. (2012).



**Figure 2.** Gumuz sheep female (left) and male (right).  
Source: Abegaz et al. (2011).



**Figure 3.** Farta sheep female (left) and flock (right).  
Source: Bimerow et al. (2011).



**Figure 4.** Abergelle sheep male (left) and female (right).



**Figure 5.** Highland sheep female (left) and male (right).



**Figure 6.** Elle sheep male (left) and female (right).



**Figure 7.** Arsi-Bale sheep male (left) and female (right).  
Source: Hizkel et al. (2017).



**Figure 8.** Horro sheep male (left) and female (right).  
Source: Zewdu (2008).



**Figure 9.** Bonga sheep male (left) and female (right).  
Source: Zewdu (2008).



**Figure 10.** Menz sheep male (left) and female (right).  
Source: Tesfaye et al. (2009).



**Figure 11.** Afar sheep male (left) and female (right).  
Source: Tesfaye et al. (2009).



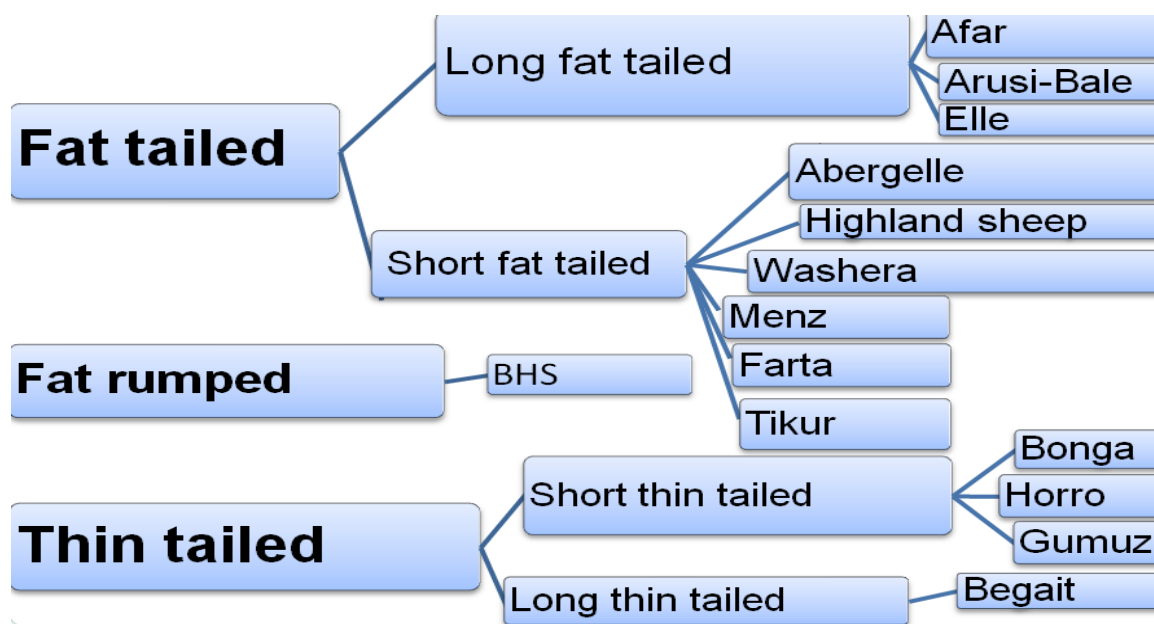
**Figure 12.** Tikur sheep.  
Source: Solomon (2009).



**Figure 13.** Black Head Somali (BHS) sheep male (left) and flock (right).  
Source: Kassahun and Solomon (2009).



**Figure 14.** Washera sheep male (left) and female (right).  
Source: Kassahun and Solomon (2009).



**Figure 15.** Classification of local sheep population of Ethiopia based on tail type and shapes.

**Coat color pattern and hair type description**

Using the information collected the dominant descriptors for coat color pattern are listed in Table 4. The local sheep population developed only two major variation of coat color pattern classified into patchy (Afar and Arusi-Bale) and Plain (Elle, Abergelle, Highland sheep, Washera, Menz, Farta, Tikur, BHS sheep, Bonga, Horro and Gumuz and Begait). The dominant observed coat colors are brown coat color (Horro and Bonga), reddish brown coat color (Gumuz and Washera), white coat color (Farta, BHS sheep, Gumuz and Begait), red coat color (Arusi-Bale, Abergelle and Menz), Creamy coat color (Afar and Elle), Beige or pale brown (Highland sheep)

and Black coat color (Tikur). Coat color pattern in the indigenous sheep of Ethiopia is not as well evolved as the tail type and shape. The hair type variation is also reviewed as smooth hair type (Elle, Begait, Horro, Bonga, Gumuz, BHS sheep and Abergelle), coarse wool hair type (Tikur, Menz, Farta, Afar and Highland sheep) and short hair type (Arusi-Bale and Washera).

**Body shape and face profile description**

Using the information collected in Table 4, the indigenous sheep are classified into dominant body profile classification of small (Tikur and Menz); large (Bonga,



**Table 5.** Body measurement for adult ( $\geq 2$  years) male and female sheep breeds of Ethiopia.

Sheep breeds name	Linear body measurements (cm)												Reference
	LBW		HG		HW		BL		EL		TL		
	M	F	M	F	M	F	M	F	M	F	M	F	
Bonga	32.2	34.8	1.6	77.0	67.7	69.2	70.7	71.4	11.2	11.6	37.7	32.3	Zewdu (2008)
Arusi-Bale	37.5	30	74.5	71.8	65.8	62.3	62.5	61.5	10.8	10.7	39.7	38.7	Hizkel et al. (2017)
Abergelle	4.4	23.1	75.2	76.6	61.6	60.9	47.9*	47.9*	2.9	3.3	12.6	9.9	Seare et al. (2011); Zelealem et al. (2012)
Begait	34.5	31.4	70.9	66.6	63.6	64.5	63.1	62.5	-	-	50	-	Amare et al. (2012)
Highland sheep	28.9	23.4	79.1	72.1	69.6	61.6	66.5	57.9	10.8	10.3	18.6	16.3	Gebreyowhens and Tesfay (2016)
Washera	32.3	28.6	2.3	77.3	70.0	69.2	61.5	59.5	0.0	9.94	-	-	Mengistie et al. (2010)
Farta	34.3	27.9	57.3	74.3	70.2	64.8	61.5	57.3	8.8	9.8	-	-	Bimerow et al. (2011)
Horro	34.9	30.7	8.8	75.3	74.7	71.3	72.0	69.7	10.8	11.6	39.4	35.3	Zewdu (2008)
Elle(IIle)	22.7	25.9	67.9	74.4	56.4	59.9	51.2	54.0	7.4	7.4	32	26.6	Mulata et al. (2014)
Menz	24.9	22.3	67.3	68.2	60.8	59.2	55.5	56.4	-	-	-	-	Tesfaye et al. (2009)
Tikur	30.5	25.6	79.0	71.0	70.2	59.0	58.5	63.1	7.69	6.37	24.0	20.3	Tassew et al. (2014)
Afar	29.0	24.5	71.9	69.2	65.3	62.0	64.2	62.3	-	-	-	-	Tesfaye et al. (2009)
BHS	32.5	28.4	74.7	71.1	61.3	58.9	70.3	67.4	9.6	9.4	19.1	19.2	Wendimu et al. (2016)
Gumuz	38	34	77.9	76.1	67.3	63.6	68.3	66.0	7-14	11.6	35.2	34.7	Abegaz et al. (2011)

Heart girth (HG), Height at Withers (HW), Body length (BL), Tail Length (TL) and Ear length (EL).

Begait and Washera), medium (Highland sheep, Arusi-Bale, Abergelle, BHS sheep, Horro, Afar and Farta) and Dwarf (Gumuz and Elle). The face profile of the indigenous sheep are grouped into concave (Elle, Tikur and Washera), straight (Highland sheep, Arusi-Bale, Abergelle, BHS sheep, Horro, Afar and Farta, Horro and Menz) and convex (Gumuz and Begait). The current paper is different from the previous reviewed papers for indigenous sheep of Ethiopia by incorporating Begait sheep which is uniquely identified with convex dominant facial profile and leggy (largest) body conformation (Amare et al., 2012).

### Horn and ear profiles description

Based on the dominant horn profile information

collected from different source (Table 4), the indigenous sheep are classified into curved (Farta, Abergelle, Menz and Tikur), polled (Begait, Elle, Washera, BHS sheep, Horro, Bonga, Afar and Gumuz); Spiral (Arusi-Bale) and lateral (Highland sheep). The most dominant observed ear profiles (Table 4) of the indigenous sheep are lateral (Farta, Abergelle, Tikur, Horro, Menz, Highland sheep, Arusi-Bale, Gumuz and Washera), dropping (Begait and BHS sheep) and rudimentary (Elle, Abergelle and Afar).

### LIVE BODY WEIGHT AND LINEAR MEASUREMENT DESCRIPTION AND CLASSIFICATION

Information on body weight and linear

measurement for adult male and female sheep are collected from different published sources as shown in Table 5. Based on the adult ( $\geq 2$  years) average live body weight, male of the local sheep can be classified into the ranges of 20 to 25 kg (Elle, Abergelle and Menz), 26-30 kg (Highland sheep, Afar and Tikur), 31-35 kg (Bonga, Washera, BHS, Begait and Farta) and 36-40 kg (Arusi-Bale and Gumuz). Similarly, based on the adult average live body, female of the local sheep can be classified into 20-25 kg (Elle, Abergelle, Afar, Tikur, Highland sheep and Menz); 26-30 kg (Elle, Tikur, Horro, Washera, BHS, Arusi-Bale and Farta) and 31-35 kg (Gumuz, Begait and Bonga). The overall reviews of the adult average live body weight variation of the local sheep population of Ethiopia are classified into 20-25 kg (Elle, Abergelle and Menz); 26-30 kg (Afar, Tikur,

Highland sheep, Washera and BHS); 31-35 kg (Bonga, Begait, Horro, Arusi-Bale and Farta) and 36-40 kg (Gumuz). Mengesha and Tsega (2012) similarly discussed about live body weight range at the adult age reported as minimum and maximum with 21.5-41.5 kg, respectively for Ethiopian local sheep.

According to the available information in Table 5, HG measurement in the local sheep of Ethiopia varied on average from 57.3 to 82.3 cm and 66.6 to 77.3 cm in male and female, respectively. HW varied on average from 56.4 to 70.2 cm and 58.9 to 71.3 cm for male and female, respectively. BL varied on average from 47.9 to 72 cm and 47.9 to 71.4 cm in male and female, respectively. The current paper reviewed that there is variation on the morphological characteristics among the indigenous sheep breeds of Ethiopia. Solomon (2008) reported that the indigenous sheep population of Ethiopia developed a variation on morphological characteristic and the variation may be due to the effect of ecology, ethnicity, flock management and the overall production system to which they adapted. It is more emphasized that the tail size varied from 12.6 to 50 cm and 6.9 to 38.7 cm in male and female, respectively. There is a special emphasis for using the tail size and shape to classification of the local sheep of Ethiopia into families and sub families (Mengesha and Tsega, 2012; Solomon, 2009; Tibbo, 2006).

## CONCLUSION

The diversified agro ecology of Ethiopia has served as a home for ecologically distinctive sheep population that evolved into sheep breeds. Updating breed characterization research works as national strategy for monitoring the status of sheep population structure and size is not yet well developed as a tool for generating breed based comprehensive information compilation and organization. Separated result of breed characterization information contributes less information about reproductive, productive and genetic relationship information on the existing sheep populations. Representative and systematically collected viable information on the reproductive and production potential for the potential breeds (Begaite) should be done. Comprehensive characterization on morphological description is an essential component of breed characterization for describing, identifying and classification into broad categorization of sheep breeds. There is a variation on the phenotypic performance and appearance among the indigenous sheep population of Ethiopia and showing a potential for designing sustainable breed improvement strategies. Molecular characterization should be done for comprehensive genetic characterization evaluation and classification of the indigenous sheep population at national as the previous result of sheep resource genetic diversity study is not incorporating regionally recognized distinctive

sheep breeds (like Begait, Elle, Abergelle and Highland sheep). Breed improvement strategies should be coincided with the adaptive behavior of the indigenous sheep population which is an ongoing process. Participatory research for conducting community based sheep breed improvement should be done through linking village breeding scheme with nucleus breeding programs. Generally, it can be concluded that breeding strategies of the local sheep in Ethiopia should be designed under the consideration of incorporating the production objectives and trait preferences of the society and to maintain the present diversified phenotypic appearances of local sheep for future genetic potential improvement. There are relatively large body size indigenous sheep breed in Ethiopia which can be used to improve other sheep breed in Ethiopia.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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