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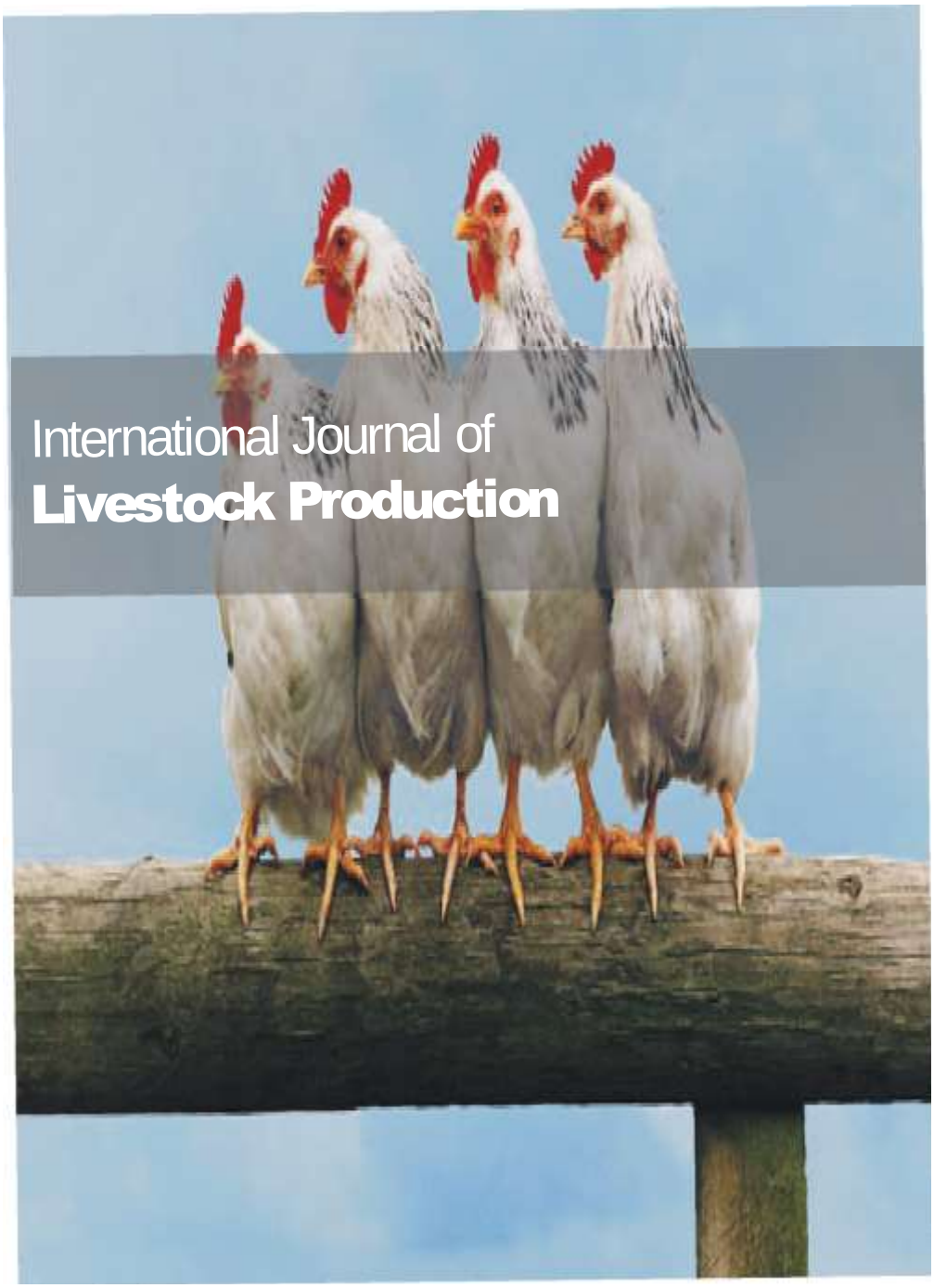

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International Journal of Livestock Production

*Full Length Research Paper*

# Immune response following Newcastle disease immunization and growth performance of kuroiler, broiler and local Tanzanian chickens

**Fulgence Ntangere Mpenda[1*], Sylvester Leonard Lyantagaye[2] and Joram Buza[1]**

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**Chicken is a major livestock species raised by smallholder households in rural areas in developing countries of Sub-Saharan Africa as a chief source of meat protein and income generation. However, Newcastle disease largely compromises the production of this precious bird under backyard production settings. The purpose of the study was to assess antibody responses and growth performance following Newcastle disease vaccination in kuroiler, broiler, and local Tanzanian chickens raised under the same tropical environmental condition. In the experiment, a total of 358 chickens comprised of 127 kuroilers, 121 broilers, and 110 local Tanzanian chickens were raised for seven weeks, and body weights were recorded weekly. Birds were vaccinated at four weeks, and blood samples were collected at days 10, and 21 post-vaccination for antibody titres quantification by ELISA test. Results demonstrated higher (P < 0.05) antibody titres in kuroilers (3.81 ± 0.06) as compared to local chicken (3.73 ± 0.07) and broilers (3.53±0.06) at day 10 post-vaccination. The growth performance of local Tanzanian chickens was comparable to that of kuroilers. The present findings contribute to on-going work in understanding chicken immune responses against NDV and inform breeding programs designed for developing chickens with increased resistance to NDV.**

**Key words:** Tanzania, local chicken, kuroilers, Newcastle disease virus, growth performance, ND vaccination, Sub-Saharan Africa, antibody responses

## INTRODUCTION

The world chickens population is estimated at 18 billion (Conan et al., 2012), and about 80% of chickens that are raised in Africa are indigenous local chickens (Conan et al., 2012). The majority (60%) of African households raise chickens under backyard production settings where chickens are left to scavenge for their nutritional need (Mapiye et al., 2008; Mtileni et al., 2009). In Tanzania, 96% of livestock farmers keep local chickens, which supply 94% of poultry meat and eggs in rural areas (Ministry of Livestock and Fisheries Development- MLFD,

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2015).

Local chickens are well adapted to harsh tropical environmental conditions and survive persistent exposure to endemic infectious diseases (Msoffe et al., 2001; Minga et al., 2004: Muchadeyi et al., 2017). The growth of chicken is rapid and its farming requires relatively small land size. More importantly, chicken has a high nutritive value from chicken eggs and meat, and serves as a chief source of high-quality meat protein among households in resource-poor countries in SSA (Ahlers et al., 2009; Mtileni et al., 2009; Martin et al., 2015). In Africa setting, chickens particularly local chickens play a crucial role in socio-cultural functions such as traditional ceremonies and rituals (Mtileni et al., 2009; Conan et al., 2012).

However, local chickens are characterized by low productivity traits like low growth performance and eggs production (Yakubu and Ari, 2018). Efforts are made to introduce improved chicken genetic resources adapted to harsh tropical environmental conditions, for example, with an introduction of kuroiler chicken, a dual-purpose scavenger hybrid chicken raised for meat and egg production, which was imported to Africa from India (Sharma et al., 2015; Fleming et al., 2016; Yakubu and Ari, 2018). Introduction of improved breeds is in an agreement with Tanzania Livestock Modernization Initiative (TLMI) (MLFD, 2015), which among other key priority actions in poultry modernization is the identification of dual-purpose breeds suitable for local free-range scavenging conditions (MLFD, 2015).

Newcastle disease (ND) caused by the Newcastle disease virus (NDV) is ranked as the number one killer of chickens under backyard production systems (Kitalyi, 1998; Gondwe and Wollny, 2007; Alders et al., 2014; Yune and Abdela, 2017; Absalón et al., 2019). Current disease prevention and control option largely depends on an appropriate vaccination of susceptible flocks (Alexander, 2001; Sharif et al., 2014). The ability of chickens to elicit protective antibody against the virus is crucial to prevent disease occurrence (Pevzner et al., 1981; Yune and Abdela, 2017). Chickens variation in antibody responses against NDV has been documented (Pevzner et al., 1981; Luo et al., 2013). Selection of chicken genotypes with high protective antibody titres may have significant contribution in preventing ND outbreak in chicken populations (Kapczynski et al., 2013; Luo et al., 2013). The present study was aimed to assess antibody titres and growth performance following ND immunization in local Tanzanian chicken, kuroilers, and broilers.

## MATERIALS AND METHODS

### Chicken population and husbandry

Three chicken breeds (local Tanzanian chicken, kuroilers, and broilers), which were raised under the same environment and management condition were involved in the present study. Local Tanzanian chicken and kuroiler eggs were obtained from Urio Cross and Pure Breeding LTD, a local farm in Tanzania (Tengeru, Arusha, Tanzania). Eggs were incubated to hatch at the Nelson Mandela African Institution of Science and Technology (NM-AIST) Laboratory egg incubators. The incubation conditions were 37.9°C temperature and 55% humidity. The eggs were candled at 10 and 18 days of incubation to detect infertile eggs and dead embryos. On the other hand, because of difficulty of obtaining broiler chicken eggs, instead, day-old broiler chicks were obtained from commercial poultry company in Arusha, Tanzania (Tanzania Poultry Farm, Usa River, Arusha Tanzania). Therefore, the experiment started with chicks of the same age, and was housed at Livestock Training Agency-Tengeru campus (LITA-Tengeru). The broiler starter feed (0 – 28 days) and finisher (29 – 50 days) were provided *ad libitum*. Light was provided throughout the experiment and was also used for room temperature adjustment during brooding. The feeds manufactured by commercial company (Harsho Milling Co.Ltd, Moshi Kilimanjaro, Tanzania) were used throughout the experiment.

### Experimental design

One-day-old chicks were kept in brooding chicken facility at LITA-Tengeru, and kept for four weeks to allow maternal antibodies to wane (Jalil et al., 2010). Birds at three weeks of age before vaccination were wing tagged and randomly distributed between the control (A) and the vaccination (B) group. Birds in control and challenge groups were kept in separate houses. Group B birds were randomly allocated in three replicates for each chicken type, and birds in each replicate were randomly kept in separate pen of 1.5 $m^2$. A total of 358 chickens (Table 1) were raised for seven weeks.

### Growth performance assessment

Body weights (BW) in grams (g) were recorded weekly using analytical balance to assess chicken growth performance. The weekly average BW was calculated for the duration of the experiment. The effect of vaccination on the chicken growth performance was evaluated by calculating the mean body weight gain (BWG). The BWG was obtained by taking the body weight difference between week 7 (BW, 21 days post-vaccination) and Week 4 (BW pre-vaccination).

### Virus and vaccination

Newcastle disease virus live vaccine (Vir 116, Freeze Dried, LaSota strain, Biovac, Akiva, Israel) was dissolved in 40 µl sterile normal saline in accordance with the manufacturer instructions to reconstitute to virus titer of $10^{6.5}$ EID50. The vaccine was stored at 4°C until use as recommended by manufacturer. The viability of the reconstituted virus was confirmed by inoculating 10-day-old embryonated chicken eggs with 0.1 ml of the virus suspension. At 4 weeks of age, birds in the vaccination group were inoculated via an ocular route with 100 µL of the virus suspension ($10^{6.5}$ EID50), and 50 µL into each eye using a micropipette. Likewise, birds in control group were given 100 µL of phosphate buffered saline (PBS) as mock infection via the same route.

### Blood sampling

Initially, blood samples were collected from chickens that were selected randomly before vaccination was conducted to evaluate if there was prior expose of chickens to NDV. Subsequent blood

**Table 1.** Description of chickens that were involved in the experiment.

| Chicken type | N[1] | Sex | | Treatment | |
|---|---|---|---|---|---|
| | | Male | Female | Control | Vaccinated |
| Broiler | 121 | 57 | 64 | 28 | 93 |
| Kuroiler | 127 | 62 | 65 | 33 | 94 |
| Local | 110 | 39 | 71 | 26 | 84 |

[1] - The total number of chicken involved in the study for each chicken type.

samples collection was done on days 10 and 21 post-vaccination. The blood samples were drawn from wing vein into sterile micro-tube. The chicken blood samples were properly labeled by using the wing tag number assigned to each bird. The coagulated blood samples were centrifuged at 3000 rpm to harvest sera, which were transferred into clean sterile micro-tube for storage at -20°C until use.

#### Antibody titers measurement

Antibody titers were quantified using NDV ELISA antibody test kit (BioCheck (UK) Ltd., Hounslow, London). Samples were tested in duplicate in accordance with the manufacturer's instructions. Sample optical density determined spectrophotometrically using 96-wells microliter plate reader (SYNERGY|$^{HTX}$ multi-mode reader, BioTek Instruments Inc, Winooski, VT, USA) at 405 nm wavelengths. The calculation and interpretation of ELISA results was in accordance with the manufacturer guidelines. Briefly, the S/P ratio was calculated by using the formula: (mean of test sample−mean of negative control)/(mean of positive control−mean of negative control), and then at 1:500 dilution, the $Log_{10}$ titer =1.0×Log (S/P) +3.52. Serum sample with S/P value ≥ 0.35 or titer value ≥ 1159 was considered positive for antibodies against NDV.

#### Data analysis

Descriptive and inferential statistical analyses were performed using R software (Team, 2017). One-way analysis of variance (ANOVA) and Turkey's HSD were conducted to assess difference in BWG and average antibody titers between chicken types. Also, the Student t-test was used to test difference between BWG between control and challenge birds, and to test difference between average antibody titers between two time points (days 10 and 21 post challenge). The relationship between BWG and antibody titers was evaluated by performing correlation test. Significance differences were taken at $p$ <0.05 levels.

#### Ethical statement

The experiment was conducted in compliance with the Guidelines on the Humane Treatment of Laboratory Animals as stipulated in the Tanzania Animal Welfare Act, 2008.

## RESULTS AND DISCUSSION

Local chickens are well adapted to harsh tropical environmental conditions and survive persistent exposure to endemic infectious diseases (Msoffe et al., 2001; Minga et al., 2004; Mpenda et al., 2019). However, local chickens are characterized by low productivity traits like low growth performance and eggs production (Yakubu and Ari, 2018). Efforts are made to introduce improved chicken genetic resources adapted to harsh tropical environmental conditions, for example, with an introduction of kuroiler chicken (Yakubu and Ari, 2018). Introduction of improved breeds is in agreement with TLMI (MLFD, 2015), which among other key priority actions in poultry modernization is the identification of dual-purpose breeds suitable for local free-range scavenging conditions. The present study was aimed to assess antibody responses following ND vaccination and growth performance of kuroilers, broilers, and local Tanzanian chickens.

Findings demonstrated higher (P < 0.05) antibody titres in kuroilers (3.81 ± 0.06) as compared to local chicken (3.73 ± 0.07) and broilers (3.53±0.06) at day 10 post-vaccination. The antibody titres remained higher in kuroilers and local Tanzanian chickens as compared to antibody titres in broilers at day 21 post-vaccination (Table 3). As expected, the highest growth performance observed in broiler chicken as compared to kuroilers and local Tanzania chickens (Table 2). However, the growth performance was not significant different (P > 0.05) between kuroilers and local Tanzanian chickens.

### Body weight and body weight gain

The weekly means ± standard errors of body weight and BWG post-vaccination are presented in Table 2. The broilers had the highest growth performance throughout the experiment followed by kuroilers. The kuroiler chickens had higher (P>0.05) body weight than local chickens except at the first three weeks (W1, W2, and W3), whereas, the body weights of kuroilers and local Tanzanian chickens were not different (P>0.05) from week four (W4) to the rest of the experimental duration. Furthermore, the BWG was higher (P>0.05) in the control group than in the challenge group (Figure 1).

The broilers average body weights of 1407.39 ± 25.12 g and 2528.06 ± 48.95 g at 4 and 7 weeks of age, respectively reported in the present study are higher as compared to the previous reports (Munisi et al., 2015; Adeleke et al., 2011). In the previous report in Tanzania, the mean broilers body weights were 396 and 1255 g at 4

**Table 2.** Weekly average body weight and body weight gain (BWG) post-vaccination of kuroilers, broilers, and local Tanzanian chicken.

| Chicken type | Average body weight ±standard Errors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W4 | W5 | W6 | W7 | BWG[1] |
| Broiler | 363.93±13.60 | 670.79±21.46 | 1114.31±27.21 | 1407.39±25.12[a] | 1830.45±35.79 | 2198.54±41.39 | 2528.06±48.95[a] | 1120.67±29.99[a] |
| Kuroller | 142.70 ±7.21 | 237.69±18.76 | 371.60±38.12 | 476.06±14.27[b] | 609.10±17.29 | 743.82±20.48 | 886.80±25.63[b] | 410.74±13.34[b] |
| Local[1] | 146.95 ±7.35 | 253.18±34.72 | 348.42±13.72 | 471.57±16.63[b] | 614.65±20.68 | 747.84±24.82 | 880.07±29.67[b] | 408.50±15.34[b] |

[1]The local Tanzania chicken; Means of the same column bearing different superscript are significantly different from each other (Tukey's HSD, P<0.05); W1, W2, W3, W4, W5, W6, and W7=, body weight at 1, 2, 3, 4, 5, 6 and 7 weeks of age.

**Table 3.** Average antibody titres at days 10 and 21 post-vaccination of kuroilers, broilers, and local Tanzanian chickens.

| Time (days) post-vaccination / Means antibody titers±Standard errors | Chicken type | | |
|---|---|---|---|
| | Broiler (N[1]=80) | Kuroiler (N[1]= 84) | Local (N[1]=79) |
| 10 | 3.53±0.06[a] | 3.81±0.06[b] | 3.73±0.07[b] |
| 21 | 3.80±0.06[a] | 4.00±0.08[b] | 3.90±0.04[ab] |

[1]The total number of chickens that were challenged for each chicken type; Means of the same row bearing different superscript are significantly different from each other (Tukey's HSD, P<0.05).

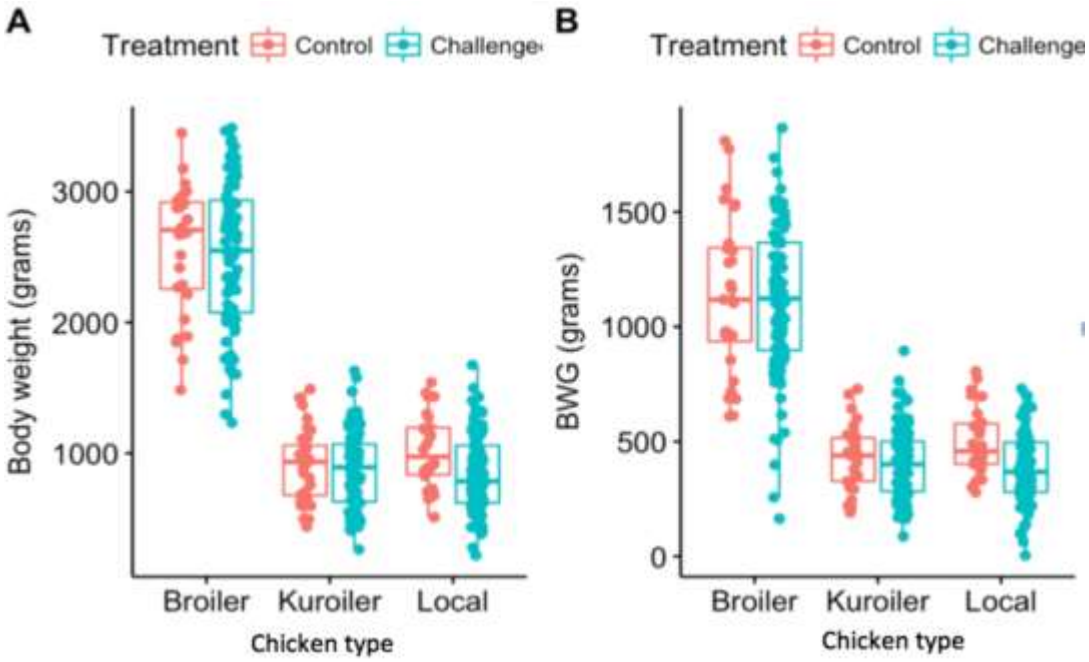


**Figure 1.** (A) Chicken growth performance and (B) body weight gain (BWG) of kuroilers, broilers and local Tanzanian chicken.

and 8 weeks of age, respectively (Munisi et al., 2015). In another study that was conducted in Nigeria, the broiler mean body weight was 2360 g at 20 weeks of age (Adeleke et al., 2011). The higher average broilers body weight observed in the present study may be explained by breed difference of the broilers involved in the studies. Also, the differences may be explained by feed content variations between the studies. For example, 4 weeks old broilers that were fed with feed supplemented with baobab seed oil cake had body weight of 1266 g, which is comparable to the broilers mean body weight of 1407.39 ± 25.12 g reported in the present study (Chisoro et al., 2018).

Kuroiler is dual-purpose chicken raised for egg and

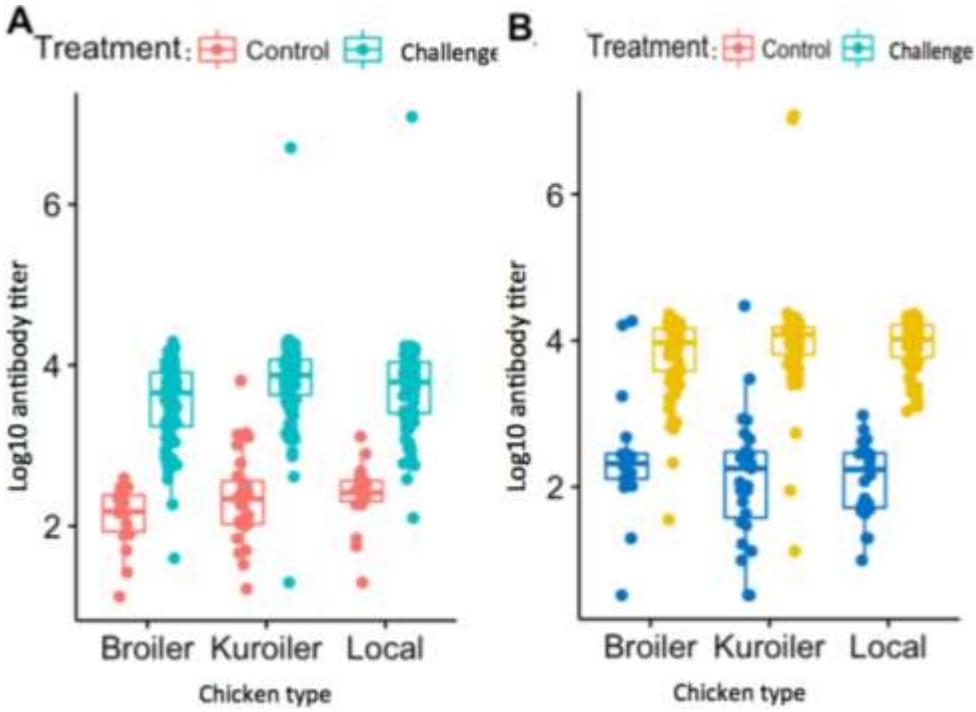


**Figure 2.** Antibody titres at days (A) 10 and (B) 21 post-vaccination of kuroilers, broilers, and local Tanzanian chicken.

meat production (Dessie and Getachew, 2016). Like local chickens, kuroilers can thrive under harsh tropical environmental conditions, and they can scavenge for nutrition needs just like local chickens (Ahuja et al., 2008; Dessie and Getachew, 2016). The breed outperforms local chickens in terms of meat and egg production (Ahuja et al., 2008; Yakubu and Ari, 2018). However, in the present study, kuroilers (886.80 ±25.63) and local Tanzania chicken (880.07 ±29.67) body weights were comparable ($P > 0.05$). The discrepancy may be explained by differences in chicken breeds involved in the studies. Local Tanzania chickens are not well characterised and due to lack of genetic resources conservation programs, possibly local chicken involved in the present study have acquired high growth performance genetic materials from improved breed through interbreeding. Also, feed regime used in the present study probably had significant contribution on growth performance observed in kuroilers and local Tanzanian chickens. This is corroborated by higher body weights observed in the present study as compared to the previous reports. For example, Egyptian chicken (Mandarah) mean body weights at 4 and 7 were 299 and 747 g, respectively (Taha et al., 2012). In another study conducted in Nigeria to evaluate growth characteristic of kuroiler and Nigerian local chicken (Fulani), at 6 weeks of age the mean body weight of kuroiler and Fulani was 450 and 228 g, respectively (Yakubu and Ari, 2018). In another study conducted in Tanzania involving local chickens, the mean body weights at 4 and 7 weeks of age were 151 and 419 g, respectively (Munisi et al., 2015).

## Antibody titres following ND vaccination

The means ± standard errors of antibody response against NDV at two time points (days 10 and 21 post-vaccination) are presented in Table 3. The antibody titers were highest in kuroiler chickens compared to antibody titers in local and broiler chickens. The antibody titers of kuroiler and local chickens at 10 days post-vaccination were different ($P < 0.05$) from that of broilers. The kuroiler chickens had higher ($P > 0.05$) antibody titres than local chickens at two time points. Overall, the antibody titers were different ($P < 0.0001$) between days 10 and 21 post challenge. Mean (3.91 ± 0.04) antibody titer at 21-days post challenge was higher than the mean (3.69 ± 0.04) antibody titer at 10-days post-vaccination (Figure 2). Furthermore, there was positive correlation of antibody titers between days 10 and 21 post challenge. The correlation of antibody titer between day 10 and 21 was intermediate in broiler ($r = 0.52$; $P = 4.1e\text{-}5$) and local ($r = 0.4$; $p = 0.006$) chickens as compared to weak correlation in kuroiler ($r = 0.1$; $p = 0.4$) chickens.

Although not supported by empirical studies, kuroilers are said to be resistant to infectious diseases (Sharma et al., 2015; Fleming et al., 2016). The higher antibody titres

observed in kuroilers likely corroborated the previous reports, which suggest increased disease resistance in kuroilers.

The antibody titers were different ($P < 0.0001$) between control and challenged group in all chicken types at the two time points (Figure 2). The antibody titers were not different ($P = 0.37$) in the three chicken types at days 10 and 21 in the control group (Figure 2).

Generally, the observed antibody titers in the present study are relatively higher compared to the previous findings in other parts of the world. For example, Luo et al. (2013), reported mean antibody titer of 3.3 at 41 days after second immunization among Chinese-yellow broiler chickens. Another report found the mean antibody titer of 3.2 at 15 days post challenge among commercial meat chicken type (Tabidi et al., 2004). Generally, the comparison of the antibody responses in the present study with the previous reports is difficult because of the difference in environmental conditions, NDV strains used in vaccination, and detection tests involved.

## CONCLUSION AND RECOMMENDATION

Kuroiler chickens demonstrated higher antibody titers following ND vaccination as compared to local Tanzania chickens and broilers raised under the same environmental and management condition. However, it remains to be established whether the high antibody titres observed in kuroiler chickens can be translated to an increased protective effect against virulent NDV infection in the field. Also, the growth performance of kuroilers and local Tanzanian chicken were not different, which suggests that breeds and feeding regiment employed in the present study had an influence on the observation. Overall, the finding contributes to on-going work on understanding chicken immune responses against NDV and informs breeding programs designed for developing chickens that have increased resistance to NDV. Also, findings suggest genetic characterisation of local chicken genetic resources and to establish the levels of gene flows between local chicken and improved commercial breeds existing in Tanzania.

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## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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# Characterization of scavenging and intensive chicken production system in Lume District, East Showa Zone, Oromia Regional State, Ethiopia

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**This study is aimed at characterizing scavenging and intensive chicken production system in Lume district of East Shoa Zone, Oromia Region, Ethiopia. Random samplings were employed to select sample kebeles and purposively select respondents based on numbers of chicken population in scavenging and production system (intensive) to identify the specific challenges affecting chicken production. Questionnaires were administered on three kebeles and 90 respondents' from scavenging chicken keepers, and 10 intensive farms were interviewed. The respondents' were stratified into 1st, 2nd and 3rd strata having 1-10, 11-20 or 21-49 chicken, respectively. Chicken houses were constructed with material stone wall and grass roof (40%). From the total respondents, those not cleaning the chicken house were 45.6%. Also, while mother took charge of sharing and offering feed for chicken, selling egg and chicken at 53 68, and 50%, respectively; and father is largely responsible for shelter constriction (17%); both mother and father participated nearly equally (29 and 28%) in purchasing drug for chicken. All respondents provided supplementary feed and water for their chicken with majority (63%) of feed supplemented being maize. Moreover, it was observed that feed supplementation can only improve egg production and growth (26.7%) in summer (July - September) session if supplemented most often (78.9%). Average egg productions per year were 76.4±3.4 whereas average age of cockerel at first mating and pullet first egg laying were 24.4±7.3 and 24.2±4.0, respectively. When the number of scavenging chicken in the household is increased, ownership pattern of males also increase. From the interviewed intensive farm, 50% joined in broiler and layer production system. There were so many opportunities available for intensive production; however, these were challenged by different factors in the study area. Overcoming the constraints of intensive production like high price of feed, poor quality and lack of sustainable market, as well as increased numbers of improved chicken per household with the minimum of 3rd strata will be able to ensure sustainable protein food source. Further research is necessary on how to increase number of chicken per households under scavenging production system.**

**Key words:** Intensive, scavenging, production system, strata.

## INTRODUCTION

Poultry farming is widely practiced in Africa and account for about 1.5 billion chicken, 80% of them belonging to local chicken population and found in the rural and per-urban area, where birds are raised in small numbers by traditional extensive or semi-intensive, low input and output system (Gueye, 1998). In Ethiopia, birds are kept for household consumption, sale, reproduction and other social and cultural roles (Dassie et al., 2009). Rural poultry production contributes over 98% of national egg and over 99% of poultry meat production (Alemu and Taddle, 1997), with annual output of 78,000 metric tons of eggs and 72,300 metric tons of meat (FAO, 2007) in the

in the country. The rural poultry sector constitutes about 98% of the total chicken population, which largely consists of the indigenous or native domestic fowl and characterized by a low level of input and output (FAO, 2007).

The local chickens of Ethiopia are estimated to be over 56.87 million CSA (2015) and traditional chicken rearing is practiced by virtually every family. More than 95% of the Ethiopian poultry production system consists of local chickens which are traditionally considered to be disease resistant and adaptive to the prevailing harsh environmental conditions. Furthermore, poultry production is a gender friendly farm activity. Women get involved in different village chicken production activities like; cleaning chicken house, provision of supplementary feed, selling of chicken and eggs. Children alone and together with other family members were also found to participate in various village chicken production activities like; cleaning of chicken house, selling of chicken and eggs and provision of supplementary feed and water to birds. Men on the other hand, were mostly involved in crop cultivation and other off-farm activities including; shelter construction and taking of sick birds to get treatment mainly at District Veterinary Health Office (Fisseha, 2009). Unfortunately, the productivity of indigenous chicken and the production system which the indigenous chicken are exposed to is little. As a means to improve poultry productivity, there are a number of farmers who have adopted improved different exotic chicken that were imported to Ethiopia with the aim of improving poultry productivity and production (Meseret, 2010). As a result, the estimate of total number of eggs produced during the year is about 106.57 million which is less than other developing countries (CSA, 2015). This condition calls for a scientific study in the area of characterization of the production system (both exotic and indigenous chicken) followed by the identification of problems and technological interventions. A number of exotic and indigenous breeds were distributed and found in the Lume district, however, little information is available on the production system. The general objective was to characterize scavenging and intensive chicken production systems in Lume district, East Shoa zone of Oromia Regional State, Ethiopia; whereas the specific objective was to study scavenging and chicken production system under village and intensive.

## MATERIALS AND METHODS

### Description of study area

This study was conducted in Lume district, of East Showa zone in Oromia Regional State of Ethiopia. The district is located 70 km South-East of Addis Ababa and cover 75,220.32 ha of land, viz; lowland (Kolla) representing 25%, midland (Weynadega) 45% and highland (Dega) 30% of land coverage of district, with the district having 117,415 total populations. Geography location ranges from 1450 to 2300 m.a.s.l, annual rainfall ranges from 500 to 1200 mm while the temperature ranges from 18 to 28°C.

### Sampling method

The survey was conducted under scavenging and intensive poultry production system. Survey for scavenging poultry production was carried out by stratification based on number of chicken in the household. Households having 1-10 chicken were first stratum, 11-20 chicken second stratum and 21-49 chicken was third stratum. Three *kebeles (Tulu Re'e, Ejere Walkite and Ejersa Joro*) were randomly selected for questionnaire administration, and from each *Kebele* 10 households per strata were selected purposively. A total of 30 household per *Kebele* and 90 households per district was interviewed by pre-test questioner. Other activities were interviewed in 10 intensive chicken production system farms available in the Lume districts that were purposively selected and interviewed by pre-test questioner.

### Statistical analysis

The qualitative and quantitative data were analyzed using appropriate statistical analysis software (SPSS, version 20 (2002)). The Duncan multiple range test and LSD were used to locate treatment means that are significantly different. More specifically, descriptive statistics and General Linear Model (GLM) were used for this study. Also, mean, SD and percentage are statistics summarized. The estimations are made by using SPSS software program, version 20 (SPSS for Windows, 8) and SAS for indicating significance difference.

## RESULTS AND DISCUSSION

### Household characteristics

From household characteristics of interviewed village chicken owner, 90% of the respondent households were male headed while the remaining 10% were female headed (Table 1). The result was similar to that reported from Western zone of Tigray, Northern Ethiopia (Shishay, 2014), and North-West (Fisseha, 2009), in which proportions of males (80, 86.3, 85.1 and 74.4%) were higher than females (20, 13.7, 14.9 and 25.6%) headed households, respectively. Regarding education level, 21% of the respondents were illiterate while 28% of them are found to be capable of reading and writing. About 33 and 9% of respondents attained primary education and secondary education respectively whereas 5 and 4% of the respondents were diploma and degree holder, respectively. The proportion of secondary education,

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**Table 1.** Demographic characteristics of household (%).

| Household character | 1st strata | 2nd strata | 3rdstrata | Intensive | Total | $\chi^2$-test | P-value |
|---|---|---|---|---|---|---|---|
| **Sex of households head** | | | | | | **0.741$^{ns}$** | **0.690** |
| Male | 28 (93.3) | 27 (93.3) | 26 (86.7) | - | 81 (90.0) | | |
| Female | 2 (6.7) | 3 (10.0) | 4 (13.3) | - | 9 (10.0) | | |
| **Who is provide interview** | | | | | | **108.992*** | **0.000** |
| HH head | 21 (70) | 15 (50) | 10 (33.3) | 3 (30) | 49 (49) | | |
| Non HH head | 9 (30) | 15 (50) | 20 (66.7) | 7 (70) | 51 (51) | | |
| **Educational status** | | | | | | **1000.913*** | **0.000** |
| Illiterate | 7 (23.3) | 6 (20.0) | 8 (26.7) | - | 21 (21) | | |
| Read and write | 10 (33.3) | 10 (33.3) | 8 (26.7) | - | 28 (28) | | |
| Primary education | 11 (36.7) | 11 (36.7) | 11 (36.7) | - | 33 (33) | | |
| Secondary education | 2 (6.7) | 3 (10) | 3 (10.0) | 1 (10) | 9 (9) | | |
| Diploma | - | - | - | 5 (50) | 5 (5) | | |
| Degree | - | - | - | 4 (40) | 4 (4) | | |

*p<0.05 or significant at P (0.05), ns (p>0.05) or insignificant at P (0.05) and n=Number of households.

**Table 2.** Chicken flock structure and size in the three strata (Mean ± SD).

| Parameter | 1st stratum | 2nd stratum | 3rd stratum | Overall |
|---|---|---|---|---|
| Indigenous chicken | 10.14±2.83$^c$ | 18.95±2.57$^b$ | 33.2±8.83$^a$ | 22.37±10.1 |
| Exotic chickens | 8.00 ±0.00$^b$ | 8.00 ±0.00$^b$ | 25.67 ±8.99$^a$ | 12.90±7.62 |
| Cross Chicken | 3.00 ±0.00$^b$ | 23.0±8.54$^a$ | 5.0 ±2.83$^b$ | 8.99±9.41 |
| Over all chicken total | 10.35 ±2.52$^c$ | 19.39 ±2.8$^b$ | 34.25 ±6.25$^a$ | 22.94±10.2 |

Different letters are significantly different (p<0.05) while values no. letter not significantly different (p≥0.05).

diploma and degree (10, 50 and 40%) in the intensive farm production system, respectively indicates that the households have equal access to education services in the three strata. Intensive chicken production needs high level of education to understand the chicken farming system like feeding, marketing. Education status was better than illiterate (41.5 and 41.3%), as reported from South-West Showa, Gurage zone of Ethiopia (Emabet, 2015) and Western zone of Tigray, Northern Ethiopia (Shishay, 2014), respectively.

## Chicken flock composition

The survey disclosed that the mean total indigenous flock size per household in the strata significantly varies across the three strata (Table 2). The mean indigenous flock size per household of the third stratum (33.2±8.83) was significantly greater than both 1st (10.14±2.83) and 2nd (18.95±2.57) stratum while the 2nd stratum (18.95±2.57) was significantly higher than 1st stratum (10.14±2.83). Regarding the mean exotic flock size per household, the 3rd stratum (25.67 ±8.99) was significantly greater than both 1st (8.00±0.00) and 2nd strata (8.00±0.00). Also, pertaining to the mean crossbred chickens flock size per household, 2nd stratum (23.0±8.54) was significantly higher than 3rd (5.0 ±2.83) and 1st stratum (3.00 ±0.00). The result of the study showed that the average flock size per stratum varied mainly due to knowledge of chicken production, economic status of chicken owners, availability of feed resource and the occurrence of diseases and predators.

## Housing

The proportions of separate chicken house, constructing material and cleaning frequency were significantly different across the strata (p<0.05). Overall, (61.1%) of the respondent construct separate house for their chicken while the rest (38.9%) of them did not construct such for theirs. As regards total households chicken house construction for their chicken, with 40% found to come from stone wall with grass roof, and 22.2% wooden made with plastic sheet roof, the corrugated iron sheet having wall, roof and stone made with corrugated iron sheet

(very short on the ground) are equally 1.1% for each. From the overall household interviewed, 54.4% of the producers clean the chicken house whereas 45.6% household interviewed do not clean chicken house (Table 3). The result is similar to that reported by Addisu et al. (2013) and Halima (2007), but contrasts with that of Shishay (2014).

**Ownership and gender role in chicken production**

It was observed also that chicken shelter construction was done more by father (17%) than mother (13%); mother, father and male sole children (10%), hired person (9%), all family members (3%); and mother with children, father with children and female sole children (1%) in the study area (Figure 1). Mother had greater responsibility in the 3rd stratum (16.7%) than both 2nd (13.3%) and 1st (13.3%) strata indicating that when chicken number increased, mother in Lobar division especially in shelter construction increased. Although hired individuals had huge responsibility in chicken shelter construction under intensive chicken production (80%), this might be because necessary skills are required for constructing intensive chicken house. However, construction result by Alem et al. (2014) has revealed that the father is more responsible in chicken house construction (100%) in father's headed household. Samssom and Endalew (2010) had also reported that the men (57.5%) had the heighest share of chicken house construction followed by children accounting for 30% in the mid Rift valley of Oromia, whereas father were mainly (63.9%) involved in chicken shelter construction (Bogale, 2008) and (97.5%) (Fisseha, 2009).

Overall, women participated more (53%) in feeding the chicken followed by father and mother (13%), and then hired person (7%). From the overall family members, mother share majorly (46%) in chicken watering, followed by father with mother (14%), all family members (10%) while mother with female children, sole male with hired person (6%) were equally watering chicken in the study area (Figure 1). This result is close to that reported by Bogale (2008) that women (59.72%) were more responsible for offering feed and water. As regards cleaning of chicken house in the three strata, mother was highly responsible, however, for intensive chicken production system, hired person were more responsible owing to its having above 50 chickens per respondent in the study area. Table 4 shows that father equally sells chicken (10%) in 2nd and 3rd strata and (50%) in the intensive chicken production. Overall, selling of eggs by mother was 68%, however, selling by father was 3.3, 3.3, 6.7 and 10% in the 1st, 2nd, 3rd strata and intensive, respectively.

The responsibility of cleaning chicken house by mother obtained in this study is fairly comparable from result (41.8%) reported by Shishay (2014) but lower than that (91%) reported by Meseret et al. (2011) and 82.5% reported by Mengesha and Tsega (2008). Father's share of responsibilities of purchasing drug/treatment/ for chicken were (10, 40, 20 and 70%), 1st, 2nd, 3rd strata and intensive respectively. This result varies with report by Shishay (2014) that father (79.7%) share the responsibilities, mother (16.6%), male children (1.6%) and mother and female children (0.5%). However, the decision making share of the household members for egg selling and purchasing drug/treatment/ did not differ among the three strata ($p<0.05$) (Table 5). The survey reveals that mother had a greater share in deciding on the chicken and egg selling (51.1 and 74.5%), drug purchased/treatment (52.3%) whereas father's decision making regarding chicken and egg selling (11 and 18.9%), and drug purchased/treatment (47.7%), respectively, indicated that father might be busy with other farming activities like cropping and managing large livestock (shoat, cattle and equine). This results were lower than that reported by both Shishay (2014) indicating that mother had the greatest share in deciding on the eggs selling (97.4%), and chicken selling (93.5%) and Alem et al. (2014) who reported that mother in female headed households were responsible for decision making on selling eggs (80 and 70%), selling chickens (82.5 and 72.5%), and purchasing of drugs (100 and 100%) in lowland and midland agro-ecology central zone Tigray. Except in the intensive production system mother participate on shelter construction according to Figure 1. The 1st strata 70%, 60%, and 43.3% chicken feed provided by mother respectively (Figures 2 to 4).

**Feeding and feed resources**

This study indicated that respondents (100%) of all strata practice supplementary feeding on the scavenging chicken. From all type of feed, supplemented maize (63%) account for scavenging chicken whereas complete feed (formulated feed) (100%) was for intensive chicken production; at scavenging, respondents has lack of knowledge in feeding chicken. This finding is fairly similar to the results reported by Shishay (2014) (100%), Werku et al. (2012) from West Amhara of Ethiopia (100%), and by Meseret (2010) (97.8%). Maize account for 76.7, 70 and 63.3% in the 1st, 2nd and 3rd strata, respectively and wheat (20, 23.3 and 23.3%) in the 1st, 2nd and 3rd strata, respectively whereas complete feed in 3rd stratum and intensive were (3.3%) and (100%), respectively. In addition, Werku et al. (2012) reported that type of grain used as supplementary feeds varied across agro-ecology and (50.4%) of the households use maize as major source of feed supplementations while 39.3 and 10.3% of them used wheat and barley, respectively.

Thrice a day (morning, afternoon and evening) (46%), twice a day (morning and afternoon) (34%) and morning (8%) are the predominant practiced feed supplementation

**Table 3.** Chicken house practice (%).

| Variable | 1st stratum | 2nd stratum | 3rd stratum | Total | $\chi^2$-test | P-value |
|---|---|---|---|---|---|---|
| **Separate poultry house other than family dwelling** | | | | | **7.106*** | **0.029** |
| Yes | 19 (63.3) | 13 (43.3) | 23 (76.7) | 55 (61.1) | | |
| No | 11 (36.7) | 17 (56.7) | 7 (23.3) | 35 (38.9) | | |
| **Housing constructional material** | | | | | **38.855*** | **0.028** |
| Stone wall with grass roof | 11 (36.7) | 17 (56.7) | 8 (26.7) | 36 (40) | | |
| Small, made from soil wall and plastic over | 3 (10) | - | - | 3 (3.3) | | |
| Made from soil under roof of family house | 2 (6.7) | - | 1 (3.3) | 3 (3.3) | | |
| Corrugated iron sheet both wall and roof | 1 (3.3) | - | - | 1 (1.1) | | |
| Stone made with corrugated iron sheet | 1 (3.3) | - | - | 1 (1.1) | | |
| Wooden made with grass roof | 4 (13.3) | 6 (20) | 1 (3.3) | 11 (12.3) | | |
| Wooden made with corrugated iron sheet | 2 (6.7) | - | 3 (10) | 5 (5.6) | | |
| Wooden made with plastic sheet roof | 4 (13.3) | 3 (10) | 14 (46.8) | 21 (23.4) | | |
| Wooden made with mud and corrugated iron | 1 (3.3) | 1 (3.3) | 1 (3.3) | 3 (3.3) | | |
| Small perch outside house with mesh wire and plastic roof | - | 1 (3.3) | 1 (3.3) | 2 (2.2) | | |
| Mesh wire with corrugated iron sheet | - | 2 (6.7) | - | 2 (2.2) | | |
| Made from soil and corrugated iron sheet | 1 (3.3) | - | 1 (3.3) | 2 (2.2) | | |
| **Frequency of poultry house cleaning** | | | | | **28.749*** | **0.026** |
| Not cleaning | 11 (36.7) | 21 (70) | 9 (30) | 41 (45.6) | | |
| Once per day | 10 (33.3) | 7 (23.3) | 7 (23.3) | 24 (26.7) | | |
| Twice per day | - | - | 1 (3.3) | 1 (1.1) | | |
| Ever three day | 3 (10) | - | 5 (16.7) | 8 (8.9) | | |
| Four day interval | 2 (6.7) | - | - | 2 (2.2) | | |
| Weekly | 2 (6.7) | 2 (6.7) | 6 (20) | 10 (11.1) | | |
| At two week once | 1 (3.3) | - | - | 1 (1.1) | | |
| Monthly | - | - | 2 (6.7) | 2 (2.2) | | |
| Two day interval | 1 (3.3) | - | - | 1 (1.1) | | |

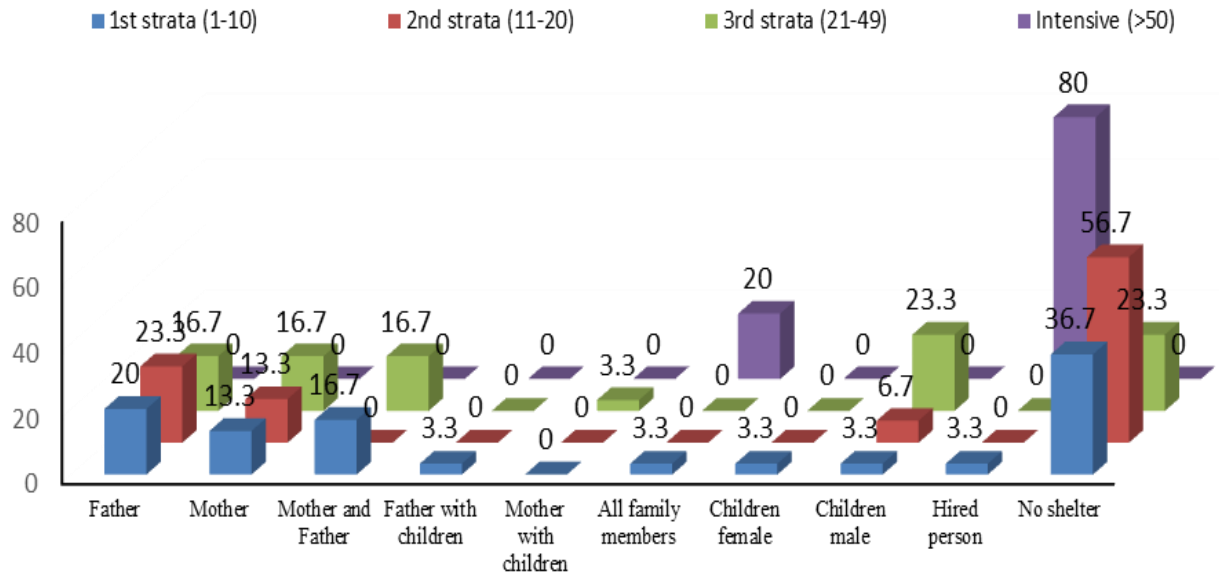


**Figure 1.** Sheclter construction.

**Table 4.** Labor division of households in chicken marketing in the strata and intensive farm (%).

| Household character | 1st stratum | 2nd stratum | 3rd stratum | Intensive | Total | $\chi^2$-test | P-value |
|---|---|---|---|---|---|---|---|
| **Selling chicken** | | | | | | **139.531*** | **0.000** |
| Mother | 21 (70) | 16 (53.3) | 17 (56.7) | - | 54 (54) | | |
| Mother and father | 5 (16.7) | 6 (20) | 3 (10) | 1 (10) | 15 (15) | | |
| Father | - | 3 (10) | 3 (10) | 5 (50) | 11 (11) | | |
| Mother and children female | 3 (10) | 2 (6.7) | 1 (3.3) | - | 6 (6) | | |
| Children male and female | - | 1 (3.3) | 1 (3.3) | 2 (20) | 4 (4) | | |
| Children female | - | 2 (6.7) | - | - | 2 (2) | | |
| Children male | - | - | 4 (13.3) | - | 4 (4) | | |
| Hired person | - | - | - | 2 (20) | 2 (2) | | |
| Note sale | 1(3.3) | - | 1 (3.3) | - | 2 (2) | | |
| **Selling egg** | | | | | | **11.600*** | **0.000** |
| Mother | 24 (80) | 23 (76.7) | 21 (70) | - | 68 (68) | | |
| Father | 1 (3.3) | 1 (3.3) | 2 (6.7) | 1 (10) | 5 (5) | | |
| Father and mother | 1 (3.3) | - | 1 (3.3) | 5 (50) | 7 (7) | | |
| Mother and children female | 2 (6.7) | 3 (10) | 2 (6.7) | - | 7 (7) | | |
| Children male and female | - | - | - | 2 (20) | 2 (2) | | |
| Children female | 1 (3.3) | 3 (10) | - | - | 4 (4) | | |
| Children male | - | - | 4 (13.3) | - | 4 (4) | | |
| Hired person | - | - | - | 2 (20) | 2 (2) | | |
| Not sale | 1 (3.3) | - | - | - | 1 (1) | | |
| **Purchasing drug/treatment** | | | | | | **134.688*** | **0.002** |
| Mother | 11 (36.7) | 8 (26.7) | 10 (33.3) | - | 29 (29) | | |
| Father | 3 (10) | 12 (40) | 6 (20) | 7 (70) | 28 (28) | | |
| Father and Mother | 5 (16.7) | 5 (16.7) | 4 (13.3) | 1 (10) | 15 (15) | | |
| Mother and children female | 2 (6.7) | - | 1 (3.3) | - | 3 (3) | | |
| Children female and male | 4 (13.3) | - | 2 (6.7) | - | 6 (6) | | |
| Children male | - | - | 6 (20) | - | 6 (6) | | |
| Hired person | - | - | - | 2 (20) | 2 (2) | | |
| Not treat | 5 (16.7) | 5 (16.7) | 1 (3.3) | - | 11 (11) | | |

times per day presented in Table 6. Greater half of the respondent in the 3rd stratum and intensive were (53.3%) and (60%), respectively whereas feeding were morning, afternoon and evening, indicating that it was due to increase in number of chicken per households. Emabet (2015) reported that 23.6% chicken owners offered supplementary feed to their chicken three times a day, 44.6% of them provided supplementary feeds two times a day and 31.7% of them provided supplementary feeds three times a day in the Southwest Showa and Gurage zones of Ethiopia. Tadesse et al. (2013) revealed that 78.9% of local chicken owners offered supplementary feed to their chicken three times a day (morning, afternoon and evening) whereas 21.9% provided supplementary feed two times a day. This implies that the perception of farmers towards proper feed supplementation of chickens improve chicken productivity (egg and meat yields) brooding egg increase (time chicken sit on egg) and health increase as time goes through acquired knowledge from their past experience and extension services. Thus, chicken under scavenging producers should be encouraged to offer diversified supplementary feed resources to chicken based on chicken age, breed categories and their production level in order to ensure sustainable improved chicken production, thereby impacting on food security of farmers and reducing the likelihood of children illnesses through diversification of consumable foods.

The study indicated that the basis for providing supplementary feeds had no variation among the strata ($p<0.05$) (Table 7). Offering of supplementary feeds were to increase egg yield, improve growth and health (36.7%), increase egg yield and growth (26.7%), increase egg yield (14.4%) and increase egg yield, improve health,

**Table 5.** Decision making household members in chicken product utilization (%).

| Household character | 1st stratum | 2nd stratum | 3rd stratum | Total | $\chi^2$-test | P-Value |
|---|---|---|---|---|---|---|
| **Egg selling** | | | | | **26.132$^{ns}$** | **0.052** |
| Mother | 24 (80) | 21 (70) | 22 (73.3) | 67 (74.5) | | |
| Father | - | 3 (10) | 7 (23.4) | 10 (11) | | |
| Father and mother | 6 (20) | 3 (10) | 1 (3.3) | 13 (14.5) | | |
| **Chicken selling** | | | | | **31.835*** | **0.023** |
| Mother | 16 (53.3) | 14 (46.6) | 16 (53.3) | 46 (51.1) | | |
| Father | 2 (6.7) | 6 (20) | 9 (30) | 17 (18.9) | | |
| Father and mother | 11 (36.7) | 10 (33.3) | 4 (13.3) | 25 (27.8) | | |
| Not sale | 1 (3.3) | - | 1 (3.3) | 2 (2.2) | | |
| **Purchase of drugs/treat** | | | | | **24.320$^{ns}$** | **0.145** |
| Mother | 17 (56.7) | 16 (53.3) | 14 (46.6) | 47 (52.3) | | |
| Father | 13 (43.3) | 14 (46.6) | 16 (53.3) | 43 (47.7) | | |

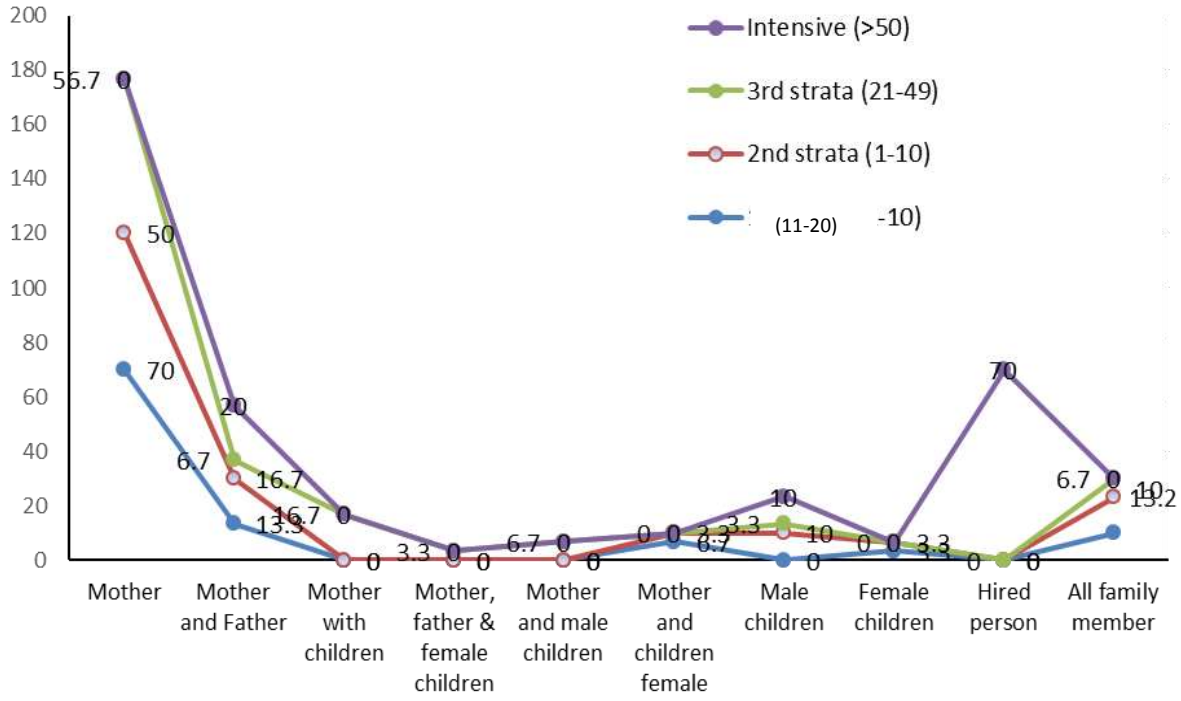


**Figure 2**. Providing feeds.

growth and broodiness (13.3%), growth and improve health (5.6%) and increase egg yield and improve health (3.3%). The result contrast with the finding of Shisay (2014) report that majority of supplementary feeds are offered to increase both meat and egg yields and to maintain health status (90.6%), and to increase both meat and egg yields (6.2%). In addition, Addisu et al. (2013) reported that the major objective of feed supplementation of chicken owners were to increase egg yields (33.99%), to increase meat yields (34.97%) and maintain health (31.7%).

The survey indicate that there were no significant variation observed with regard to improvement perceived due to feed supplementation and season of extra feeding across the three strata in the study area ($p<0.05$) (Table 6). The result obtained from extra supplementary feed (43.3, 36.7 and 20%) perceived egg yield, growth and improved health status in the 1st, 2nd and 3rd strata,

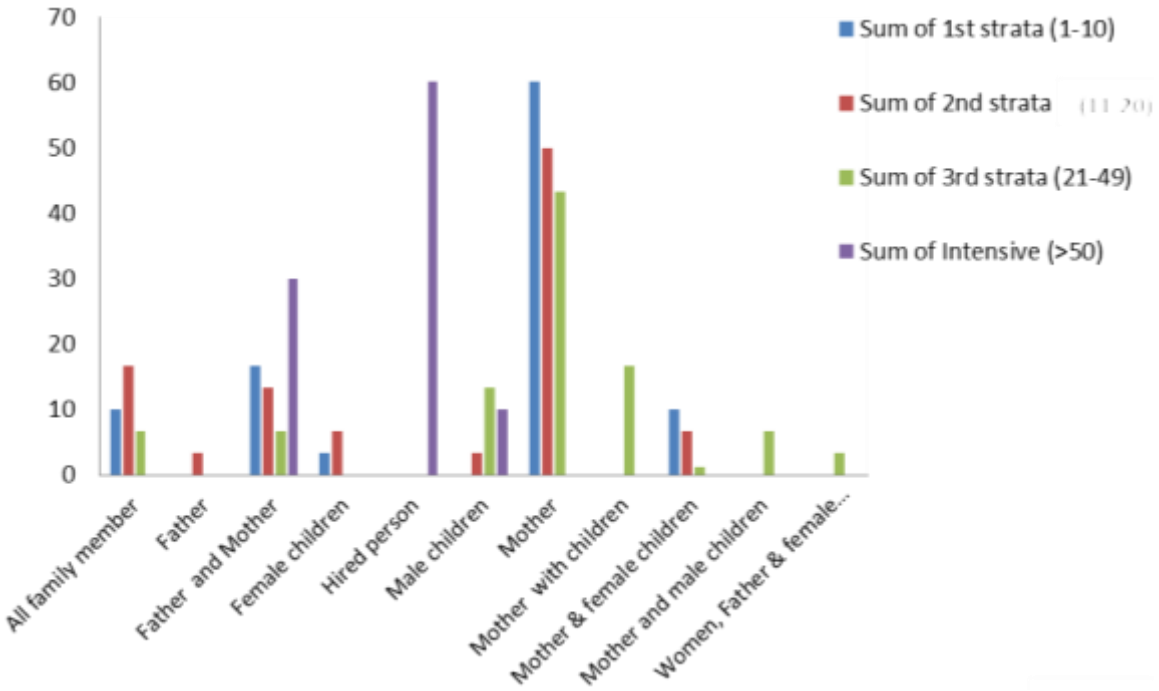


**Figure 3.** Providing water.

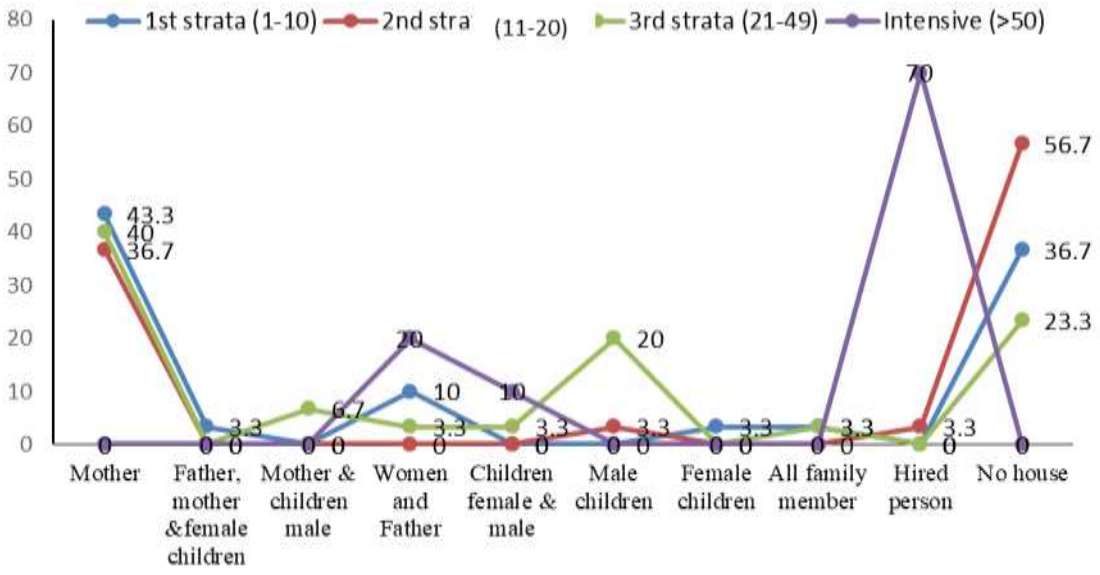


**Figure 4.** Cleaning chicken house.

respectively, and for which the 3rd stratum had lower proportion households than both 1st and 2nd strata. The summer season of supplementary feeding (Jul-Sept) indicated that the 3rd stratum (70%) had lower proportion of respondents than the 1st (83.3%) and 2nd strata (83.3%). From the entire summer season (Jul-Sept), high supplementation feed observed across the strata is possibly because at summer there is lack of feed for scavenging chicken in the study area. Overall, the result indicates that 78.9% of total households interviewed responded that season of critical extra feeding was summer (Jul-Sept). Similar finding reported by Samson and Endalew (2010) in mid rift valley of Oromia revealed that 95% of the respondents are of the opinion that the

**Table 6.** Feeding and feed resource and supplementation time (%).

| Variable | 1st stratum | 2nd stratum | 3rd stratum | Intensive | Total | $\chi^2$- Test | P-value |
|---|---|---|---|---|---|---|---|
| **Have you supplementation feed** | | | | | | **8.367$^{ns}$** | **1.000** |
| Yes | 30 (100) | 30 (100) | 30 (100) | 10 (100) | 100 (100) | | |
| No | - | - | - | - | - | | |
| **Feed types** | | | | | | **111.667*** | **0.000** |
| Maize | 23 (76.7) | 21 (70) | 19 (63.3) | - | 63 (63) | | |
| Wheat | 6 (20) | 7 (23.3) | 7 (23.3) | - | 20 (20) | | |
| *'Mitin'* | - | - | 1 (3.3) | - | 1 (1) | | |
| Barley | - | 1 (3.3) | - | - | 1 (1) | | |
| Household left over | 1 (3.3) | - | - | - | 1 (1) | | |
| Wheat bran | - | - | 2 (6.7) | - | 2 (2) | | |
| Grain leftover (*girdi*) | - | 1 (3.3) | - | - | 1 (1) | | |
| Complete feed | - | - | 1 (3.3) | 10 (100) | 11 (11) | | |
| **Time of feed supplementation** | | | | | | **119.753*** | **0.000** |
| Morning | 2 (6.7) | 1 (3.3) | 5 (16.7) | - | 8 (8) | | |
| After and evening | - | 1 (3.3) | 2 (6.7) | - | 3 (3) | | |
| Morning and evening | 1 (3.3) | - | 1 (3.3) | 3 (30) | 5 (5) | | |
| Afternoon | 1 (3.3) | - | 2 (6.7) | - | 3 (3) | | |
| Morning and afternoon | 14 (46.7) | 15 (50) | 4 (13.3) | 1 (10) | 34 (34) | | |
| Morning, afternoon & evening | 12 (40) | 12 (40) | 16 (53.3) | 6 (60) | 46 (46) | | |
| Morning and evening | - | 1 (3.3) | - | - | 1 (1) | | |

**Table 7.** Basis of offering supplementary feed and season feeding.

| Variable | 1st stratum | 2nd stratum | 3rd stratum | Total | $\chi^2$-test | P-value |
|---|---|---|---|---|---|---|
| **Basis of offering supplements feed** | | | | | **17.934$^{ns}$** | **0.118** |
| Improve egg yield | 2 (6.7) | 5 (16.7) | 6 (20) | 13 (14.4) | | |
| Improve growth and health | 1 (3.3) | 1 (3.3) | 3 (10) | 5 (5.6) | | |
| Improve egg yield and health | 1 (3.3) | 1 (3.3) | 1 (3.3) | 3 (3.3) | | |
| To improve egg yield, growth and health | 14 (46.6) | 12 (40) | 7 (23.3) | 33 (36.7) | | |
| Improve egg yield, health, growth and broodiness | 6 (20) | 3 (10) | 3 (10) | 12 (13.3) | | |
| To improve egg yield and growth | 6 (20) | 8 (26.7) | 10 (33.4) | 24 (26.7) | | |
| **Improvement perceived due to extra supplements** | | | | | **28.442$^{ns}$** | **0.056** |
| Egg yield | 2 (6.7) | 5 (16.7) | 6 (20) | 13 (14.4) | | |
| Egg yield and improve health status | 1 (3.3) | 2 (6.7) | 1 (3.3) | 4 (4.4) | | |
| Egg yield, growth and improve health | 13 (43.3) | 11 (36.7) | 6 (20) | 30 (33.4) | | |
| Yield, growth, improve health status and good hatchability | 7 (23.3) | 4 (13.3) | 6 (20) | 17 (18.9) | | |
| Egg yield and growth | 7 (23.3) | 8 (26.7) | 11 (36.6) | 26 (28.9) | | |
| **Season of extra feeding for chicken** | | | | | **10.151$^{ns}$** | **0.427** |
| Summer (July-Sep) | 25 (83.3) | 25 (83.3) | 21 (70) | 71 (78.9) | | |
| Spring (Oct-Dec) | - | 2 (6.7) | 1 (3.3) | 3 (3.3) | | |
| Autumn (Apr-Jun) | - | - | 1 (3.3) | 1 (1.1) | | |
| Summer and Autumn | 2 (6.7) | 1 (3.3) | 1 (3.3) | 4 (4.4) | | |
| Summer and spring | 1 (3.3) | - | - | 1 (1.1) | | |
| All the year | 2 (6.7) | 2 (6.7) | 6 (20) | 10 (11.1) | | |

**Table 8.** Production performance of three strata.

| Variable | 1st stratum | 2nd stratum | 3rd stratum | Grand total |
|---|---|---|---|---|
| Average eggs/hen/clutch | 15.4±3.8 | 15.8±4.2 | 16.3±3.5 | 15.8±3.8 |
| *No. egg incubated/set | 11.8±2.4 | 12.7± 2.2 | 11.7±4.2 | 12.0±3.0 |
| No. egg hatched/set | 8.9±2.0 | 9.4±2.1 | 9.2±2.8 | 9.2±2.3 |
| No. egg wasted/set | 3.5±1.2 | 2.6±1.3 | 3.2±2.3 | 3.1± 2.1 |
| No. chicken weaned/hatched | 5.9±2.2 | 6.7±1.7 | 4.8±2.1 | 5.8±2.1 |
| No. clutch per year | 4.5±1.4 | 4.9±1.2 | 4.8±1.5 | 4.8±1.4 |
| Total egg production/hen/year | 67.3±4.6 | 83.4±3.9 | 78.1±3.3 | 76.4±3.4 |
| Av. age of cockerel at 1st mating weeks | 23.2±7.1 | 25.2±4.3 | 24.9±9.9 | 24.4±7.3 |
| Av.** age of pullets at 1st egg weeks | 24.4±5.4 | 24.5±3.1 | 23.6±3.1 | 24.2±4.0 |

*No.= Number, Av.**= average.

critical time of supplementary feeding was from June-August whereas the remaining 5% of them indicated that March-May was the critical time of feed supplementation. Feed has continued to be a critical problem especially in wet season under village scavenging chicken production system, thus it may have necessitated persuading the farmer to practice strategic supplementation to increase meat and egg production thereby impacting on food security.

## Water resources and watering

Water plays an important part in the digestion and metabolism of the fowl; in addition, it serve as a media to administer some important vaccines. Generally, 71% of the respondents provided water for their chicken at '*bega*' (dry season) whereas the rest (29%) provides water for their chicken in all seasons *(bega* and *kiremt*) in all the years as stated in Table 10. Despite variations in sourceof water and frequency of watering, almost all of the respondents provided water for their chickens. This is a promising and good experience and could be considered as one aspect of their concern to their chickens. Concerning the source of water, the water given to chickens was drawn from well water (underground water) (68%), river (3%), tap water (18%) and river and tap water (11%). Majority of respondents (90%) provided water for their chicken *ad-libitum* (freely), 6% do this three times per day, 3% twice a day and 1% once per day. Concerning the drinking materials, plastic made formal waterier was (10%), plastic made (55%), earthen pot (2%), wooden trough (5%), stone made (21%), half of pot (broken) (1%), half '*jerrycan*' (4%), and metallic made (2%) (Table 10). Achievement of sustainable improved chicken productivity requires provision and adlib fresh water on clean waterier on a regular basis. Training for chicken producers on the use of water to achieve chicken productivity, thereby increases economic return and ensure food security on small farmers. According to Kathy (2012), water is critically important to chickens because it plays an important role in regulating body temperature, digesting food and eliminating body wastes. Water is by far the single greatest constituent of body and represents about 70% of total body weight. It is very crucial for egg production since egg consist of approximately 75% water; and without access to a regular clean supply of water, a hen would be physically unable to produce eggs.

## Production and reproduction performance of village chicken

The survey revealed that average eggs/hen/clutch was not significantly different across strata (Table 8). Total egg productions per hen per year was 76.4±29.4 regardless of breed type, and number of eggs wasted per set in 1st stratum was higher (3.5±1.2) than 2nd (2.6±1.3) and 3rd strata (3.2±2.3). The average age of scavenging cockerels at first mating and pullets at first egg were 24.4±7.3 weeks and 24.2±4.0 weeks, respectively. The results were comparable with Moges. et al. (2010) who reported that the average age of local cockerels at first mating and pullets at first egg were 24.6 weeks (5.74 months) and 27.5 weeks (6.42 months), respectively. Also, the results of survey were similar to that of Halima (2007) who reported that 77.4% of cocks of local chicken ecotypes reached maturity at 20-24 weeks of age.

## Intensive production

From total interviewed, intensive farms that have been rearing chicken with > 4 years' experience were only 40%. Forty percent of the respondents get the chicks from foreign country by importing parent stock and final hybrid whereas sixty percent were getting the final hybrid chicken from Bishoftu city. According to the respondents, a good available opportunity for intensive chicken farming includes good climate, more land, access to human lobar and near market root (Addis Ababa capital city and others) (90%). From the total intensive farm, 50% of them were correspondingly included in layers and broiler

**Table 9.** Intensive chicken farms marketing and management (%).

| Variable | Percent |
|---|---|
| **Chicken production for** | |
| Meat production (broilers) and egg production (layers) | 50 |
| Day old chicken selling | 10 |
| Day old chicken selling and egg production | 20 |
| Meat production (broilers) | 20 |
| **Opportunity for chicken farming in the area** | |
| Good climate, no outbreak disease | 10 |
| Good climate, more land, availability labor, near market | 90 |
| **What do you suggest to increase poultry production** | |
| Free from tax | 30 |
| Encouragement | 20 |
| Fulfill facility like road, electricity | 10 |
| Follow up | 30 |
| Make market chain | 10 |
| **What do you think in future** | |
| Continue as it is chicken production | 30 |
| Change to other farm than chicken | 40 |
| Expand to chicken industry | 20 |
| Not decided yet | 10 |
| **Who is buy hen at end of production** | |
| Holidays (consumers) | 40 |
| Supermarket | 10 |
| Trader (intermediate) | 30 |
| Yet not sale because recently start | 20 |
| **For how long rear chicken/experience** | |
| >1 year | 20 |
| 1-2 years | 10 |
| 2-3 years | 10 |
| 3-4 years | 20 |
| >4 years | 40 |
| **Name layer breed available** | |
| Bovan brown | 10 |
| Lohman brown | 20 |
| Isa brown | 30 |
| I do not know the name | 40 |
| **Chicken production constraints** | |
| High price feed and low quality | 30 |
| Lack of reliable markets | 30 |
| Lack of improved day old chick | 20 |
| Disease out break | 10 |
| Lack of capital | 10 |

production, indicating that broiler can generate income within two months but layers income will be obtained after seven months on average. This implies that broiler is used to generate income that further helps with layer chicken (egg production). Even though good opportunity is available, there are constraints with chicken production such as high price of feed (30%), lack of reliable market (30%), lack of improved chick breed (20%), disease

**Table 10.** Water and providing practice for chicken.

| Variable | 1st stratum | 2nd stratum | 3rd stratum | Intensive | Total | $\chi^2$-test | P-value |
|---|---|---|---|---|---|---|---|
| **Do you provide water to your chicken** | | | | | | **90.000$^{ns}$** | **1.000** |
| Yes | 30 (100) | 30 (100) | 30 (100) | 10 (100) | 100 (100) | | |
| No | - | - | - | - | - | | |
| **Which season year provide water** | | | | | | **2.535$^{ns}$** | **0.282** |
| *Bega (dry season)* | 24 (80) | 26 (86.7) | 21 (70) | - | 71 (71) | | |
| All (*Bega* and K*iremit*) | 6 (20) | 4 (13.3) | 9 (30) | 10 (100) | 29 (29) | | |
| **How frequent you provide water** | | | | | | **113.140*** | **0.000** |
| Once a day | 1 (3.3) | - | - | - | 1 (1) | | |
| Twice a day | 1 (3.3) | 1 (3.3) | 1 (3.3) | - | 3 (3) | | |
| Three times per day | 2 (6.7) | 1 (3.3) | 3 (10) | - | 6 (6) | | |
| Ad libitum (freely) | 26 (86.7) | 28 (93.3) | 26 (86.7) | 10 (100) | 90 (90) | | |
| **Water source** | | | | | | **107.280*** | **0.000** |
| Wale water | 23 (76.7) | 22 (73.3) | 23 (76.7) | - | 68 (68) | | |
| River | - | 1 (3.3) | 2 (6.7) | - | 3 (3) | | |
| Tape water | 2 (6.7) | 5 (16.7) | 1 (3.3) | 10 (100) | 18 (18) | | |
| River and tape water | 5 (16.7) | 2 (6.7) | 4 (13.3) | - | 11 (11) | | |
| **Water supply containers** | | | | | | **214.520*** | **0.001** |
| Plastic made waterier | - | - | - | 10 (100) | 10 (10) | | |
| Plastic made | 21 (70) | 16 (53.3) | 18 (60) | - | 55 (55) | | |
| Earthen pot | - | 1 (3.3) | 1 (3.3) | - | 2 (2) | | |
| Wooden trough | 3 (10) | 2 (6.7) | - | - | 5 (5) | | |
| Stone made | 4 (13.3) | 8 (26.7) | 9 (30) | - | 21 (21) | | |
| Half pot (broken pot) | - | 1 (3.3) | - | - | 1 (1) | | |
| Half *jerrycan* (plastic) | - | 2 (6.7) | 2(6.7) | - | 4 (4) | | |
| Metal made | 2 (6.7) | - | - | - | 2 (2) | | |

outbreak (10%) and lack of capital (10%). For sustainable chicken production, the respondents revealed that except for the freedom from tax by the government which was 30%; encouragement was 20%, fulfilled facility infrastructure like road and electricity (10%), regular follow up (30%) and make market chain (10%) is observed in the study area. The intensive farms (40%) do sell their chicken product at holidays season (to consumers) whereas 30% sell to traders (intermediate), 10% sell to supermarkets while 20% recently joined chicken farming so they have not started selling as presented in Table 9. Generally, chicken feed and nutrition is one of the most critical constraints to poultry production under both the rural smallholder and large-scale systems in Ethiopia. The problem is mainly associated with lack of processing facilities, inconsistent availability and distribution as well as sub-standard quality of processed feeds, when available (Haftu, 2016). Currently, understanding the problem, the Ethiopian Quality and Standards Authority is working with the Ethiopian Society of Animal Production (ESAP) on feed quality standards and legislation (Mazengia et al., 2012; Dessie et al., 2013).

## CONCLUSION AND RECOMMENDATION

As number of scavenging chicken per household increased, income from chicken increased; also, father participation in labor division of chicken management increased. But when number of chicken increased in each household, decision making for egg home consumption by father decreased, indicating that fathers transfer/share the responsibility with mother. Also, as numbers of the chicken increased more, the idea of incorporating compound feed for scavenging chicken feed were initiated by producer. Farmers who produced chicken under scavenging has the idea of supplementation feed for their chicken, however, the feed quality and quantities were inadequate as their contents

were majorly energy sources. Despite variations in source of water and frequency of watering, almost all of the respondents provided water for their chickens. Half of the respondent involved in intensive chicken farm participates in the production of broiler and layers chicken farming. The productivity of scavenging chicken in the study area can be enhanced by relatively simple changes in management techniques that promote improvement in productivity and reduce mortality. Also, effort is needed to solve the problem of feed quality along with price and sustainable market. Generally, in scavenging chicken production, as number of chicken increased per households the chicken production also received attention and chicken management like type of feed, feeding, treating or sharing lobar division in the family and watering were improved. To increase chicken product and production, there is need to increase or maximize number of chicken per households to a value greater than what is obtained at the third stratum (21-49) chicken under scavenging production system. Finally, further research on how to increase chicken person households is necessary.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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# Characterization of Begait cattle using morphometric and qualitative traits in Western Zone of Tigray, Ethiopia

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**The aim of the study is to characterize Begait cattle using morphometric and qualitative traits. The breed was kept under farm and ranch management systems in Western Tigray, Ethiopia. A total of 368 Begait cattle which included 24 male Begait cattle were selected using simple random sampling method and the data were analyzed using statistical packages for social sciences and statistical analysis software. Begait cows exhibited chest girth of 152.8±0.40 cm, height at withers of 129.1±0.28 cm, backline length (loin length + back length) of 88.4±0.26 cm and tail length of 96.2±0.44 cm. Whilst Begait breeding males showed chest girth of 170.7±1.35 cm, height at withers of 145.1±1.18 cm, backline length of 90.0±1.13 cm and tail length of 108.2±1.29 cm. The skeletal measurements of Begait cattle are good indicators of the breed as a potential dual-purpose breed and the gene could be improved through selection. Humera ranch should own superior male Begait cattle for genetic improvement of the breed. The correlation was significant (P<0.01) among most of the morphometric traits of Begait cows. The most frequently observed coat color patterns of Begait cows were pied (42.4%) and spotted (33.1%) whilst the body coat color types of the cows were combination of black and white (34.6%) and brown (29.7%). All males were humped and majority of Begait cows (88.1%) were humpless. Begait cows had concave face profile (72.1%) and roofy rump profile (69.2%). The information generated from this research work will be used for planning Begait cattle genetic resources management in sustainable manner for the development of Regional and National economy.**

**Key words:** Characterization, Begait cattle, qualitative traits, morphometric traits.

## INTRODUCTION

Domesticated animals contribute directly to an estimated 70% of the world's rural poor (FAO, 2015). However, the global diversity of animal genetic resources for food and agriculture is in a continual state of decline (FAO, 2014). Ethiopia has served as a gateway to domestic animals from Asia to Africa and its diverse ecology favored diversification of animal genetic resources (CSA, 2012/2013). Ethiopian livestock contribute 30-40% of Agricultural Growth Domestic Product (GDP), 16-20% of National GDP and 14-16% of foreign exchanges.

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However, there are many challenges facing the livestock production in Ethiopia mainly shortage of feeds, diseases, poor management practices, poor genetic improvement and lack of organized marketing system (Gebregziabhare, 2010). Majority (98.2%) of the cattle populations in Ethiopia are indigenous breeds kept under extensive management system, and crossbred and exotic breeds accounted for about 1.62 and 0.18%, respectively (CSA, 2016/2017). Indigenous cattle have been naturally selected for many years towards adaptive traits, high fertility, unique product qualities, longevity and adaptation to poor quality feeds (Aynalem, 2006). However, indigenous breeds are not well characterized adequately (Workneh et al., 2004; DAGRIS, 2006) although FAO (2007) declared the first strategic priority area on characterization, inventory and monitoring of trends and associated risks of animal genetic resources. Additionally, little attention is given to conserve the diversified genetic resources (DAGRIS, 2009). The first essential step towards sustainable utilization of animal genetic resources is to identify the major breed types, establish their population size along with their geographical distribution and describe their typical qualitative and quantitative phenotypic traits (Workneh et al., 2004).

According to the reports of the Institute of Biodiversity Conservation (2004) Begait cattle are registered as one of the indigenous cattle breeds of Ethiopia. Zerabruk et al. (2007) and Abraham and Abebe (2018) reported that Begait cattle are categorized under large east African Zebu classification. Whilst, DAGRIS (2014) also reported that Begait cattle belong to the North Sudan Zebu group and are reared for milk and beef; they are maintained by the Men-Amir tribes in the lowlands of Eritrea and neighboring areas of Sudan and Ethiopia.

Most widely the morphometric traits are used to characterize the different breeds of livestock as they give the idea of body conformation (Pundir et al., 2011). On-farm phenotypic characterization of cattle breed is a primary and low cost animal genetic resource characterization as compared to the on-station characterization (FAO, 2007). Characterization, inventory and monitoring of animal genetic resources are essential to the sustainable management of animal genetic resources. Breed characteristics information is substantially important for effective planning of how and where they can best be used and developed (FAO, 2015). Phenotypic characterization information contributes to the improvement of animal genetic resources in the context of country level implementation (FAO, 2012). Specifically, Begait cattle are an important indigenous genetic resource because their heat tolerance ability and milk and beef purpose animal. Proper characterization is a prerequisite for proper conservation and utilization of Begait cattle. However, presently, morphometric and qualitative information of Begait cattle kept under on-farm and ranch conditions is flimsy except the work of Ftiwi and Tamir (2015) kept under on-farm animals. However, Begait cattle in ranch were not included in the characterization work. Therefore, this research work was conducted to generate baseline information and know the breed standards on important morphometric and qualitative traits of Begait cattle kept under on-farm and ranch management systems in Western Zone of Tigray, Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

The morphometric and qualitative characterization of Begait cattle was conducted in Kafta Humera and Setit Humera districts of Western Zone of Tigray Regional State, Ethiopia; located 600 km Western of Mekelle city and 954 km North of Addis Ababa. Kafta Humera district lies at 13°40'and 14°27'N of latitude, and 36°27'and 37°32'E of longitude and has altitude range of 515 to 1863 m above sea level. The annual rainfall of the district is 449 to 1100 mm (Kafta Humera OoARD, 2015, unpublished); it is characterized by annual temperature of 33 to 41.7°C in the lowland areas and 17.5 to 22.2°C in the highland areas (Niguse and Aleme, 2015). Setit Humera is located at $14^{0}16'$ N of latitude and 36°37'E of longitude and has an altitude of 611 masl. Humera Ranch of Begait Cattle Multiplication, Improvement and Conservation Center is located within the co-ordinates of 13°4'-14°27'N of latitude and 36°27'-37°32' of longitude and has an altitude of 892 masl.

### Data collection and analysis

Kafta Humera and Setit Humera districts were selected as research areas purposively based on the availability of Begait cattle. Random sampling was used to select animals used to characterize the breed. The numbers and types of data collected were 17 quantitative and 19 qualitative traits of Begait cattle. In general, FAO (2012) cattle descriptor list was used as a guideline. Data collection methods followed were morphometric measurements and observations on the qualitative traits of Begait cattle. Body length measurement was taken from the thurl bone (not from the pin bone) to the point of shoulder. Backline length was measured from the center of the rump (between the hip bones) up to the base of the withers. Primary data were collected from a total of 344 adult females composed of 237 and 107 animals kept under on-farm and Humera Ranch, respectively. Moreover, 24 adult males kept under on-farm management system were included in the study. The research was undertaken in October 2015 to February of 2016.

### Cattle age estimation

Age of the sample cattle was estimated by the stage of eruption of permanent pair of incisors and used owners reported animal ages. Kikule (1953) work on age changes in the teeth of zebu cattle was used as a basis. Animals of four years old and above were selected for the phenotypic characterization.

### Data analysis

Data were analyzed using statistical packages for social sciences (SPSS) version 20 for the analysis of qualitative traits (http://ibm-spss-statistics.soft32.com/, 2012 updated) and statistical analysis software (SAS) version 9.1 for the analysis of morphometric traits (SAS, 2003). Female and male data were analyzed independently

due to their biological differences. Mean comparison method was employed to compare the morphometric traits of the female Begait cattle kept under on-farm and ranch management systems.

## RESULTS

### Morphological markers and characteristics of Begait cattle breed

#### *Morphometric traits of Begait cattle*

Characterization of Begait cattle using morphometric traits (mean±SE) grouped by farm type is presented in Table 1. Morphometric traits such as chest girth, height at withers, pelvic width, horn length, dewlap width and tail length of female Begait cattle were 152.8 ± 0.40, 129.1 ± 0.28, 38.0±0.13, 20.5 ± 0.42, 15.0 ± 0.18 and 96.2 ± 0.44 cm, respectively. On the other hand, chest girth, height at withers, backline length, horn length, dewlap width and tail length of male breeding Begait cattle kept under on-farm management system were 170.7 ± 1.35, 145.1 ± 1.18, 90.0 ± 1.13, 25.3 ± 1.76, 19.9 ± 0.73 and 108.2 ± 1.29 cm, respectively. Male breeding Begait cattle exhibited very large sizes of chest girth, height at withers and tail length as compared to female breeding Begait cattle. Majority of the Begait cattle are grouped under short horned cattle breeds.

Table 2 presents correlation coefficients of morphometric traits of female breeding Begait cattle. Majority of the morphometric traits of female breeding Begait cattle significantly ($P<0.01$) correlated each other. Particularly, horn length did not show correlation ($P>0.05$) with ear length, hook circumference, navel flap width and rump length. Rump length did not correlate ($P>0.05$) with with ear length, backline length, muzzle circumference, navel flap width, neck length and teat length. In general, morphometric traits which do not have correlation will not have positive or negative influence on selection of one trait on the other.

#### *Qualitative traits of Begait cattle*

Overall, pied (42.4%) and spotted (33.1%) were the most frequent observed body color patterns of Begait cows (Table 3). The overall dominant body coat color types of cows were black and white type (34.6%) and brown (29.7%) (Figures 1, 2 and 4). Majority of cows were with glossy hair (90.4%) and with pigmented muzzle color (93%). Both sexes of Begait animals were horned, and 89 and 62.2% of the female Begait cattle were with curved horn shape and upward horn orientation, respectively. Majority of the Begait cows (88.1%) were humpless animals. Medium (63.4%) and large (35.8%) were the overall dewlap widths of Begait cows. 72.1% of Begait cows were with concave face profile. The most frequently observed backline profile of Begait cows was that the backline slopes up towards the rump (70.9%). The overall most frequently observed rump profile of Begait cows was roofy profile (69.2%).

Characterization of breeding Begait bulls was taken only from the herds of on-farm management system. 37.5 and 20.8% of Begait bulls showed spotted and patchy coat color patterns, and black and white (62.5%) and black (20.8%) (Figure 3) coat color types were observed (Table 4). Majority 83.3% of the male breeding animals were with glossy hair shininess. Pigmented muzzle color was observed in 95.8% of the bulls. All bulls were horned and most of the bulls were observed with curved horn shape (87.5%) and upward horn orientation (91.7%). As presented in Table 4, all males were humped though 41.7% of the bulls were small-humped animals. Majority of the males exhibited concave face profile (66.7%), a backline profile which slopes up towards the rump (54.2%) and roofy rump profile (83.3%).

## DISCUSSION

Perry et al. (2008) reported that scrotal circumference is strongly correlated with daily sperm production and fertility rates, and the scrotal circumference of Begait bulls (32.6±0.44 cm) is almost normal size. Chest girth (152.8±0.40 cm), height at withers (129.1±0.28 cm) and backline length (88.4±0.26 cm) of female Begait cattle are the major traits, which confirmed the relevance of the breed for beef production. Additionally, the result showed in tail length (96.2±0.44), teat length (5.9±0.10 cm) and navel flap width (7.8±0.17 cm) of adult Begait cows indicate the relevance of the breed for milk production. Female Begait cattle under on-farm condition were superior in most of the morphometric traits than female Begait cattle kept under ranch condition. Morphometric traits of a breed cannot be influenced by differences in management systems. But the differences in morphometric traits of the animals in the ranch and on-farm might be an indicator that there are sub populations under Begait cattle. Therefore, such differences need future attention and action. Majority of the cows (90.4%) were with glossy hair and it is believed that the shininess of the hair type characteristics help them reflection of sun light radiation. All morphometric traits of female breeding Begait cattle reported by Ftiwi and Tamir (2015) are in line with the present study except chest girth (159.6±0.24 cm) and dewlap width (18.6±0.24 cm). Additionally, height at withers (136.9±0.10 cm), horn length (19.1±0.07 cm), tail length (100.3±0.06 cm) and preputial sheath (12.1±0.04 cm) of male breeding Begait cattle reported by Ftiwi and Tamir (2015) are slightly deviated from the present measurements. The differences in chest girth and dewlap width of female breeding Begait cattle and height at withers, horn length, tail length and preputial sheath of male breeding Begait cattle might be due to differences sample size and data collection procedures. It is also noted that Gicheha et al. (2016) study on Barka cattle height at withers (125.3±0.6 cm), chest girth (156.4±0.7 cm) and dewlap width (18.7±0.6 cm) is similar

**Table 1.** Morphometric traits (mean±SE) of Begait cattle by farm type and sex.

| S/N | Trait | Sex | Farm type | | Overall |
|---|---|---|---|---|---|
| | | | On-farm (Female N=237, Male N=24) | Ranch (Female N=107) | (Mean±SE) |
| 1 | Body length (BL) | Female | 116.2±0.44 | 114.1±0.5 | 115.4±0.35 |
| | | Male | 127.9±1.16 | - | 127.9±1.16 |
| 2 | Chest girth (CG) | Female | 154.7±0.45 | 152.1±0.59 | 152.8±0.40 |
| | | Male | 170.7±1.35 | - | 170.7±1.35 |
| 3 | Height at withers (HW) | Female | 129.3±0.36 | 130.8±0.48 | 129.1±0.28 |
| | | Male | 145.1±1.18 | - | 145.1±1.18 |
| 4 | Neck length (NL) | Female | 44.8±0.28 | 43.3±0.36 | 43.9±0.22 |
| | | Male | 47.0±0.92 | - | 47.0±0.92 |
| 5 | Pelvic width (PW) | Female | 38.3±0.16 | 38.3±0.21 | 38.0±0.13 |
| | | Male | - | - | - |
| 6 | Rump length (RuL) | Female | 21.5±0.15 | 21.7±0.25 | 21.7±0.14 |
| | | Male | - | - | - |
| 7 | Backline length (BLL) | Female | 89.0±0.31 | 89.3±0.44 | 88.4±0.26 |
| | | Male | 90.0±1.13 | - | 90.0±1.13 |
| 8 | Teat length (TtL) | Female | 6.3±0.12 | 5.7±0.15 | 5.9±0.10 |
| | | Male | - | - | - |
| 9 | Ear length (EL) | Female | 22.8±0.11 | 23.2±0.17 | 22.8±0.10 |
| | | Male | 23.3±0.37 | - | 23.3±0.37 |
| 10 | Horn length (HL) | Female | 21.8±0.54 | 21.8±0.72 | 20.5±0.42 |
| | | Male | 25.3±1.76 | - | 25.3±1.76 |
| 11 | Muzzle circumference (MC) | Female | 38.1±0.14 | 38.2±0.17 | 37.8±0.11 |
| | | Male | 43.3±0.40 | - | 43.3±0.40 |
| 12 | Dewlap width (DW) | Female | 15.4±0.21 | 15.3±0.28 | 15.0±0.18 |
| | | Male | 19.9±0.73 | - | 19.9±0.73 |
| 13 | Navel flap width (NF) | Female | 7.9±0.21 | 7.8±0.29 | 7.8±0.17 |
| | | Male | - | - | - |
| 14 | HC | Female | 33.9±0.12 | 34.6±0.17 | 34.1±0.10 |
| | | Male | 36.3±0.51 | - | 36.3±0.51 |
| 15 | Tail length (TL) | Female | 97.4±0.49 | 95.8±0.76 | 96.2±0.44 |
| | | Male | 108.2±1.29 | - | 108.2±1.29 |
| 16 | Scrotal circumference (SC) | Female | - | - | - |
| | | Male | 32.6±0.44 | - | 32.6±0.44 |
| 17 | Preputial sheath (PS) | Female | - | - | - |
| | | Male | 16.0±0.80 | - | 16.0±0.80 |

Backline length=Loin length plus back length of the animal

with the present study of female Begait cattle whilst the same authors study on height at withers (114.4±0.8 cm) and chest girth (134.65±0.9 cm) of Arado cattle is not the same with the present study due to breed differences of the breeds. Aamir et al. (2010) study on Kenana cattle reported lower height at withers (123.57±0.20 cm) and

**Table 2.** Correlation coefficients of morphometric traits of female Begait cattle.

| Trait | BL | CG | DW | EL | HC | HL | HW | BLL | MC | NF | NL | PW | RuL | TL | TtL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BL | | | | | | | | | | | | | | | |
| CG | 0.475** | | | | | | | | | | | | | | |
| DW | 0.454** | 0.517** | | | | | | | | | | | | | |
| EL | 0.245** | 0.244** | 0.217** | | | | | | | | | | | | |
| HC | 0.405** | 0.439** | 0.339** | 0.253** | | | | | | | | | | | |
| HL | 0.228** | 0.260** | 0.199** | 0.104$^{NS}$ | 0.088$^{NS}$ | | | | | | | | | | |
| HW | 0.503** | 0.526** | 0.393** | 0.352** | 0.529** | 0.172** | | | | | | | | | |
| BLL | 0.387** | 0.336** | 0.184** | 0.255** | 0.273** | 0.126* | 0.329** | | | | | | | | |
| MC | 0.467** | 0.614** | 0.453** | 0.346** | 0.458** | 0.338** | 0.498** | 0.334** | | | | | | | |
| NF | 0.304** | 0.290** | 0.346** | 0.240** | 0.292** | 0.090$^{NS}$ | 0.297** | 0.199** | 0.331** | | | | | | |
| NL | 0.399** | 0.464** | 0.404** | 0.191** | 0.217** | 0.195** | 0.295** | 0.370** | 0.377** | 0.205** | | | | | |
| PW | 0.505** | 0.589** | 0.479** | 0.308** | 0.424** | 0.265** | 0.508** | 0.341** | 0.553** | 0.310** | 0.405** | | | | |
| RuL | 0.127* | 0.177** | 0.106* | 0.046$^{NS}$ | 0.178** | -0.016$^{NS}$ | 0.172** | 0.013$^{NS}$ | 0.095$^{NS}$ | 0.101$^{NS}$ | 0.076$^{NS}$ | 0.137* | | | |
| TL | 0.318** | 0.356** | 0.241** | 0.344** | 0.269** | 0.217** | 0.349** | 0.368** | 0.308** | 0.176** | 0.318** | 0.353** | -0.107* | | |
| TtL | 0.483** | 0.459** | 0.401** | 0.242** | 0.298** | 0.280** | 0.408** | 0.431** | 0.496** | 0.343** | 0.384** | 0.414** | 0.077$^{NS}$ | 0.308** | |

** =Correlation is significant at P<0.01, * =Correlation is significant at P<0.05, NS= Non-Significant.

pelvic width (33.81±0.05 cm) than female Begait cattle. However, female Begait cattle tail length, chest girth and neck length is similar with the same authors study on Kenana cattle tail length (93.76±0.35 cm), chest girth (154.07±0.40 cm) and neck length (43.04±0.07 cm). In general, most of the morphometric traits of Begait cattle are good indicators as they are of dairy type animals. Begait cattle can be less exposed to dystocia because of the reasonable pelvic width. The morphometric analysis of Begait cattle indicated that birth difficulty was very low because the rump profile of Begait cattle was dominantly roofy profile. Kenana cattle can be more exposed to dystocia than Begait cattle due to their narrow pelvic width.

A study on female Ogaden cattle kept at Haramaya University pasture reported by Getinet et al. (2009) were chest girth of 150.1±8.20 cm, height at withers of 115.5 cm, horn length of 8.0 cm, ear length of 19.7 cm and tail length of 71.6 cm, whereas males exhibited chest girth, height at withers, horn length, ear length and tail length of 148.2±14.31 cm, 115.5 cm, 5.9 cm, 19.6 cm, and 71.9 cm, respectively. Therefore, all morphometric traits of female and male Begait cattle are higher than female and male Ogaden cattle. The deviation in morphometric traits of Ogaden cattle and Begait cattle is due to the breed, agro-ecological and management variations. Chest girth (134.3±0.7 cm), height at wither (104.6±0.9 cm), rump width (35.0±0.3 cm), rump length (18.4±0.2 cm), tail length (72.1±0.5 cm) and ear length (18.9±0.2 cm) of female Mursi cattle (Endashaw et al., 2015) are inferior to the present results of female Begait cattle whereas horn length (27.0±0.8 cm) of Mursi cows is superior to horn length of Begait cows. This is due to the difference in breed classification group that the Mursi cattle breed is classified under Small East African Zebu (Rege and Tawah, 1999) whereas Begait cattle are categorized under Large East African Zebu classification (Zerabruk et al. 2007; Abraham and Abebe, 2018). Furthermore, on-farm morphometric characterization of female Fogera cattle (Endalkachew et al., 2016) tail length (82.4±0.70 cm), chest girth (146.0±0.93 cm), body length (104.1±0.93 cm), height at wither (120.8±0.56), neck length (39.2±0.39) and horn length (14.2±0.43 cm) are inferior to the current records in female Begait cattle whereas muzzle circumference (37.7±0.25 cm), ear length (23.2±0.24 cm), pelvic width (35.7±0.29 cm) and teat length (5.4±0.13 cm) of female Fogera cattle are similar to the present records of the same sex of Begait cows. The reason might be due to Begait and Fogera cattle breeds are categorized

**Table 3.** Frequency occurrence of qualitative traits of female Begait cattle by farm type.

| Major trait | Trait category | Farm type | | Overall percent |
|---|---|---|---|---|
| | | On-farm (N=237) | Ranch (N=107) | |
| Body color pattern | Plain | 6 (2.5) | 2 (1.9) | 8 (2.3) |
| | Patchy | 50 (21.1) | 26 (24.3) | 76 (22.1) |
| | Pied | 110 (46.4) | 36 (33.6) | 146 (42.4) |
| | Spotted | 71 (30.0) | 43 (40.2) | 114 (33.1) |
| Coat color type | Brown | 76 (32.1) | 26 (24.3) | 102 (29.7) |
| | Black and white | 86 (36.3) | 33 (30.8) | 119 (34.6) |
| | Beige | 54 (22.8) | 33 (30.8) | 87 (25.3) |
| | Black | 6 (2.5) | 2 (1.9) | 8 (2.3) |
| | Red brown | 8 (3.4) | 1 (0.9) | 9 (2.6) |
| | Gray (dull) | 7 (3.0) | 12 (11.2) | 19 (5.5) |
| Hair shininess | Glossy | 215 (90.7) | 96 (89.7) | 311 (90.4) |
| | Dull | 22 (9.3) | 11 (10.3) | 33 (9.6) |
| Hair straightness | Straight | 237 (100) | 107 (100) | 344 (100) |
| Muzzle color | Pigmented | 214 (90.3) | 106 (99.1) | 320 (93) |
| | Not pigmented | 23 (9.7) | 1 (0.9) | 24 (7) |
| Horn presence | Absent | 0 | 0 | 0 |
| | Present | 237 (100) | 107 (100) | 344 (100) |
| Horn shape | Straight | 24 (10.1) | 10 (9.3) | 34 (9.9) |
| | Curved | 210 (88.6) | 96 (89.7) | 306 (89.0) |
| | Lyre shape | 3 (1.3) | 1 (0.9) | 4 (1.2) |
| Horn color | Black | 202 (85.2) | 74 (69.2) | 276 (80.2) |
| | Brown | 0 | 1 (0.9) | 1 (0.3) |
| | White | 10 (4.2) | 0 | 10 (2.9) |
| | Gray | 25 (10.5) | 32 (29.9) | 57 (16.6) |
| Horn orientation | Laterally | 28 (11.8) | 8 (7.5) | 36 (10.5) |
| | Upward | 156 (65.8) | 58 (54.2) | 214 (62.2) |
| | Downward | 8 (3.4) | 10 (9.3) | 18 (5.2) |
| | Forward | 42 (17.7) | 27 (25.2) | 69 (20.1) |
| | Backward | 3 (1.3) | 4 (3.7) | 7 (2.0) |
| Ear shape | Straight-edged | 237 (100) | 107 (100) | 344 (100) |
| Ear orientation | Lateral | 237 (100) | 107 (100) | 344 (100) |
| Hump presence | Absent | 200 (84.4) | 103 (96.3) | 303 (88.1) |
| | Present | 37 (15.6) | 4 (3.7) | 41 (11.9) |
| Hump size | No hump | 200 (84.4) | 103 (96.3) | 303 (88.1) |
| | Small | 37 (15.6) | 4 (3.7) | 41 (11.9) |
| Hump shape | No hump | 200 (84.4) | 103 (96.3) | 303 (88.1) |
| | Erect | 37 (15.6) | 4 (3.7) | 41 (11.9) |
| Dewlap width | Small | 1 (0.4) | 2 (1.9) | 3 (0.9) |
| | Medium | 129 (54.4) | 61 (57) | 218 (63.4) |

**Table 3. Contd.**

| | | | | |
|---|---|---|---|---|
| | Large | 107 (45.1) | 44 (41.1) | 123 (35.8) |
| Face profile | Straight | 49 (20.7) | 35 (32.7) | 84 (24.4) |
| | Concave | 177 (74.7) | 71 (66.4) | 248 (72.1) |
| | Convex | 11 (4.6) | 1 (0.9) | 12 (3.5) |
| Backline profile | Straight | 62 (26.2) | 38 (35.5) | 100 (29.1) |
| | A | 175 (73.8) | 69 (64.5) | 244 (70.9) |
| Rump profile | Flat | 23 (9.7) | 5 (4.7) | 28 (8.1) |
| | Sloping | 51 (21.5) | 27 (25.2) | 78 (22.7) |
| | Roofy | 163 (68.8) | 75 (70.1) | 238 (69.2) |
| Hoof color | Black | 235 (99.2) | 107 (100) | 342 (99.4) |
| | White | 1 (0.4) | 0 | 1 (0.3) |
| | Grey | 1 (0.4) | 0 | 1 (0.3) |

Numbers on parentheses are in percent, A=Slopes up towards the rump.

**Figure 1.** Photograph of Begait cattle herd with large farms at Bahre-Selam.

under Large East African Zebu classification.

A study on indigenous cattle ecotypes in Rwanda (Hirwa et al., 2017) indicated that height at wither (130.4 cm), teat length (5.4 cm) and navel flap width (6.8 cm) of female Inkuku cattle and height at wither (134.6 cm), tail length (92.1 cm) and navel flap width (8.3 cm) of female Inyambo are more or less similar with the records of female Begait cows whereas chest girth (167.6 cm), dewlap width (19 cm) and horn length (101.2 cm) of female Inkuku cattle and chest girth (176.4 cm), dewlap width (18.8 cm) and horn length (107.7 cm) of female Inyambo cattle are superior compared to the records of female Begait cows. This variation is due to the differences in genetic makeup of the breeds and the agro-ecology where the breeds exist. However, height at wither and chest girth of female Begait cattle is superior

**Figure 2.** Photograph of Begait cattle herds with smallholder farmers at Rawian watering point area.

to height at wither (115.57 cm) and chest girth (147.17 cm) of Jabres cattle of Indonesia (Adinata et al., 2016). Female Pabna cattle of Bangladesh in a research station (Talukder et al., 2017) exhibited chest girth (151.1 cm) is similar to female Begait cattle whereas height at wither (118.1 cm) and tail length (83.3 cm) of female Pabna cattle is not in line with the records in female Begait cattle. The morphometric traits of male and female Begait cattle are superior to the morphometric traits of male and female (Ebadu et al., 2017) Bonga cattle. This is because the reported (Ebadu et al., 2017) body length (114.79±1.99, 110.52±0.33), height at wither (105.04±0.75, 100.48±0.29), chest girth (141.24±2.16, 135.04±0.42), ear length (16.49±0.20, 16.55±0.10) and muzzle circumference (40.63±0.30, 37.83±0.11) of male and female Bonga cattle, respectively, are lower records than both sexes of Begait cattle. Morphometric characterization of Khillar cattle of India was reported by Katkade et al. (2017). Horn length (55.85±.22 cm), ear length (26.37±0.07 cm), tail length (111.29±0.77 cm) and chest girth (163.62 cm) of Khillar cows are superior to the same traits of Begait cows. Khillar bulls are also superior to Begait bulls in Horn length (59.22±0.30 cm), tail length (114.08±1.05 cm) and chest girth (186.35 cm). But height at wither of Begait cows and Bulls are superior to height at wither of Khillar cows (124.26 cm) and bulls (140.10 cm). Shahjahan (2018) reported on hump presence and daily milk yields of Holstein Friesian crossbreds. Shahjahan (2018) found that humpless cows produced 15.89±1.16 litres of daily milk yield/cow whereas humped cows produced 4.8±0.58 litres. This might be evidence that Begait cattle are milk animals because the present study indicated that 88.1% of Begait cows were humpless animals.

The present information on hump and horn presences, horn orientation and ear orientation of Begait females do not agree with Fitwi and Tamir (2015)'s report on the same breed. Fitwi and Tamir (2015) reported an ear orientation of 97.9% of females, 96.2% of males exhibited dropping ear and some males showed dropping hump (34.6%). The deviation in the traits of the same breed might be due to the subjective behavior of data collection method followed. Aamir et al. (2010) reported that the predominant coat color type of Kenana cattle was white (57.3%) whereas the predominant coat color type of female and male Begait cattle was black and white which accounted 34.6 and 62.5%, respectively. Kenana cattle are considered as one of the best milkers in Africa (Bennett et al., 1954; Fengaly, 1980; Mason and Maule, 1960; Osman, 1972).

## CONCLUSION AND RECOMMENDATION

Based on the Begait cattle descriptor characters, there exists within breed diversity and can be utilized in genetic improvement for the traits of interest. Skeletal measurements of livestock are highly heritable. Hence, there will be quick genetic improvement of Begait cattle. The morphometric analysis of Begait cattle indicated that

**Figure 3.** Photographs of male breeding Begait cattle.

**Figure 4.** Photograph of Begait cattle of small scale farms in Bereket (Kafta Humera district) watering point.

**Table 4.** On-farm frequency occurrence of qualitative traits of male Begait cattle (N=24).

| Major trait | Trait categories | Percent (N) |
|---|---|---|
| Body color pattern | Plain | 6 (25) |
| | Patchy | 5 (20.8) |
| | Pied | 4 (16.7) |
| | Spotted | 9 (37.5) |
| Body coat color type | Brown | 2 (8.3) |
| | Black and white | 15 (62.5) |
| | Beige | 2 (8.3) |
| | Black | 5 (20.8) |
| Hair shininess | Glossy | 20 (83.3) |
| | Dull | 4 (16.7) |
| Hair straightness | Straight | 24 (100) |
| Muzzle color | Pigmented | 23 (95.8) |
| | Not pigment. | 1 (4.2) |
| Horn presence | Absent | 0 |

**Table 4.** Contd.

| | | |
|---|---|---|
| | Present | 24 (100) |
| Horn shape | Straight | 3 (12.5) |
| | Curved | 21 (87.5) |
| Horn color | Black | 18 (75) |
| | White | 3 (12.5) |
| | Gray | 3 (12.5) |
| Horn orientation | Laterally | 2 (8.3) |
| | Upward | 22 (91.7) |
| Ear shape | Straight-edged | 24 (100) |
| Ear orientation | Lateral | 24 (100) |
| Hump presence | Absent | 0 |
| | Present | 24 (100) |
| Hump size | Small | 10 (41.7) |
| | Medium | 8 (33.3) |
| | Large | 6 (25) |
| Hump shape | Erect | 24 (100) |
| Dewlap width | Large | 24 (100) |
| Face profile | Straight | 4 (16.7) |
| | Concave | 16 (66.7) |
| | Convex | 4 (16.7) |
| Backline profile | Straight | 11 (45.8) |
| | A | 13 (54.2) |
| Rump profile | Flat | 4 (16.7) |
| | Roofy | 20 (83.3) |
| Hoof color | Black | 24 (100) |

birth difficulty was very low because the rump profile of Begait cattle was dominantly roofy profile. It was also noted that the morphometric analysis of Begait cattle indicated that the breed has large body frame and diversity compared to other indigenous and some exotic breeds. The morphometric traits of Begait cattle largely declare that the body conformation of the breed suits for dairy cattle production. Additionally, Begait cattle can be used for beef and this breed looks reasonable to use as a dual-purpose breed. However, female Begait cattle in ranch are more inferior in most of the morphometric traits than female Begait cattle kept under on-farm condition. Therefore, Humera ranch should practice intensive culling and keep superior Begait cattle breed. Moreover, Begait cattle breeders` classification of the breed in to sub populations (Refein, Bowadir and Dewhin) should be further characterized in the future.

Morphological markers characterization of Begait cattle indicated that the breed exhibited different body coat color patterns and types. The different body coat color patterns and types of Begait cattle are also indicators of the breed for the existence of subpopulations. Overall analysis revealed that the most frequently observed body coat color patterns of Begait cows were spotted and pied whereas the predominant coat color types of Begait cows were black and white and brown. Therefore, further characterization of the subpopulations should be conducted, and standard selection criteria/breeding goal traits, development objectives and strategies should be developed for each subpopulation for their sustainable breeding, utilization and conservation. It should be noted that directional selection towards particular goal traits be practiced in Begait cattle breeding. Holstein Friesian, Bonsmara and Ogaden cattle are some of the good

exemplary breeds because each breed has almost single and unique coat color patterns and/or body coat color types.

Furthermore, the different body coat color patterns and types and morphometric variation of Begait cattle kept under on-farm and ranch conditions should be further characterized through molecular study to prove whether the breed has different strains and/or gene admixtures with other common indigenous breeds found near the natural location of Begait cattle or not.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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# Indigenous browse species and goats' preferences in selected districts of Gamo Gofa and Wolayta zones, Ethiopia

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**Important browses in selected districts were identified using goats' preference and farmers' knowledge. A total of 296 plots (20 × 20 m area) were placed along 16 transect lines randomly laid in plane and sloppy communal grazing lands to assess frequency of occurrences and density of the browse species. A total of 48 browse species out of which 31 were recognized by farmers were observed being browsed by goats. According to the goat owners, *Balanites aegypetiaca* was the most and *Grewia bicolor* was the least preferred, while the goats' preferred *Acacia tortilis* as the most and *Flueggea virosa* as the least. In the plane area, the highest frequency of occurrence was seen for *Rhus natalensis* (62.4%) and *Acacia mellifera* (50.3%), while in the sloppy grazing area the most frequently occurring (43.9 to 54.4%) browses were *Terminalia brownii, Harrisonia abyssinica*, and *Grewia bicolar.* Density of *Rhus natalensis* appears to be higher both in plane (186 tree/ha) and sloppy (166 trees/ha) lands. The ranking of farmers and the goats' preference appeared closely related. Therefore, further laboratory analysis should be conducted to verify the nutritional quality of the selected browses and urgent identification and conservation of potential browse trees and shrubs should be undertaken.**

**Key words:** Browse species, goats, grazing area, indigenous, shrubs.

## INTRODUCTION

Goat farming plays a vital role in the livelihood of rural smallholders and national economy in Ethiopia. Goats are an integral part of the economic and social life of the poor smallholders in many marginal areas of the country. However, productivity of the sector is constrained by shortage of quality feeds during the dry seasons (Lorato et al., 2015; Biruh et al., 2017). The major feed sources, such as crop residues, matured and dried up natural pastures are characterized by low nitrogen and high fiber contents (Abebe et al., 2012). Moreover, the constraints in the availability of quality grasses and other forages are often aggravated by low and unreliable rainfall situations in arid and semi-arid areas. Introduction of improved pasture and forage plants under smallholder farmer's conditions have been limited due to lack of adaptation to local environment, proper technical support and faulty

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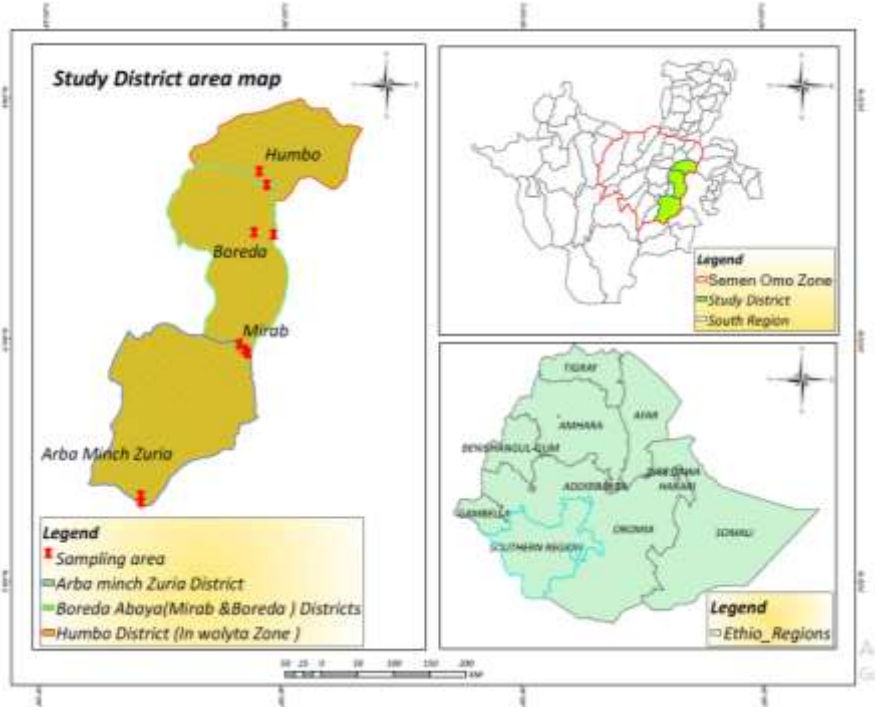


**Figure 1.** Map of the study area.

agronomic practices (Abebe et al., 2008). Supplementation of industrial by products such as oil seed cakes, wheat bran and molasses are inaccessible and high-priced in many developing countries like Ethiopia (Anbarasu et al., 2004).

In an effort to alleviate the problems of quality feed supply, indigenous browse species play vital role in animal production in arid and semiarid agro ecologies (Bamikole et al., 2004; Salem et al., 2006). Because, indigenous browse species that remain green year round, provide animals with feed resource rich in protein, energy, vitamins and minerals in dry seasons, when grasses and other herbaceous plants are scare and low in quality (Bamikole et al., 2004; Salem et al., 2006). According to Tolera and Abebe (2007) browse species have high crude protein content ranging from 10 to more than 25% which may make them to be considered as a more reliable high quality feed resource. This can help in developing sustainable feeding systems and increase livestock productivity. Therefore, indigenous browses are of great importance in dry season livestock feeding as they can provide substantial protein and energy (Abebe, 2012; Belete et al., 2012).

In this regard, the southern rift valley semi-arid areas of Gamo Gofa and Wolayta zones are among areas where rich diversity of vegetation of indigenous browse species are found widely distributed and used as feed source for animals and other purposes as well (Teshome et al., 2004; Assefa and Bork, 2014). Mixed crop livestock is the main farming practice in the area with a few agro pastoral systems (Yisehak et al*.,* 2007). Continuous expansion of crop land coupled with indiscriminate uses of vegetation for firewood and construction in these areas may lead to the disappearance of important indigenous browse trees and shrub species (Yisehak et al*.,* 2007). During the time between 1985 and 2010, rapid reduction in shrub land (28.82%) and natural grass land (33.13%) and an increase in arable land (59.15%) were observed in Abaya-Chamo Basin of Gamo Gofa and Wolayta zones (Yisehak et al*.,* 2007; Ashebir et al., 2018). Yet, there is only little information on the identification, distribution, animal preference and utilization practices of indigenous browse trees and shrub species in the entire grazing land of the basin. This suggests that there is a need for research to identify and prioritizes the beneficial browse trees and shrub species in order to efficiently utilize them. Therefore, the objective of this study were to identify and assess the distribution of important indigenous browse trees and shrub species, goats' preference and utilization practice in Rift Valley area of Arba-Minch Zuria, Mirab Abaya and Boreda districts, Gamo Gofa zone and Humbo district, Wolayta zone, Southern Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

The study was carried out in purposively selected four districts, namely, Arba-Minch, Mirab Abaya and Boreda districts in Gamo Gofa zone and Humbo district in Wolayta zone of Southern Ethiopia. The districts are located, in the Rift Valley areas around Arba-Minch and near to Soddo city, respectively (Figure 1). Arba-

Minch and Soddo cities are located at 505 and 330 km away from Addis Ababa and lies between coordinates of 5° 45' 00" N latitude and 37°00' 00" E longitude and 6° 50′ 0″ North latitude and 37° 45' 51″ E longitude.

The elevation of the study area at Gamo Gofa and Wolayta zones ranges from 1011 to 1660 and 1080 to 1700 m above sea level, respectively. The study districts represent mixed crop-livestock farming systems of Southern Rift Valley of Ethiopia (Tsige, 2015). They have semi-arid climatic zones in the Rift Valley area which is characterized by bimodal rainfall pattern with short rains from March to May and little rainfall between June and August followed by the peak rain falls in September to October. The mean annual rainfall in the arid and semi-arid low land areas of the study districts range between 600 and 1000 mm (Makin et al*.,* 1975; Tsige, 2015). The mean annual minimum and maximum daily temperature in the low land area is 14.5 and 33.3°C, respectively. The summer (June - August) and winter (November - February) months are the driest months (Azeb, 2009).

The soils types include, Calcaric fluvisol associated Eutric fluvisol and Pellic vertisol, which are brownish sandy loam, loam or sandy clay loam with variable and often calcareous subsoil are the most prevalent types of soils in the study areas. The size of the land holdings varies generally from 0.50 to 6 ha. Maize, Haricot bean, potato, cotton, fruits are among major crops produced in the area. The livestock comprised mainly cattle and goats are maintained in crop livestock production system characterized by traditional extensive feeding practices, where free grazing communal rangelands are the major feed resources throughout the year (Makin et al*.,* 1975; Tsige, 2015).

Vegetation in the semi-arid zone of the southern Rift Valley is characterized by the presence of acacias as the dominant species of the tree and shrub layers. The most common *Acacia* species are *Acacia tortilis, Acacia brevispica, Acacia mellifera, Acacia nilotica, Acacia nubica, Acacia reficiens* and *Acacia seyal*. They are accompanied by many broad-leaved trees and semi-evergreen shrubs such as *Acokanthera brownii, Balanites aegyptium, Cadaba farinosa, Capparis tomentosa, Commiphora africana, Croton macrostachyus, Dichrostachys cinerea, Euphorbia tirucalli, Euphorbia candelabra, Harrisonia abyssinica, Sclerocaryea birrea* and *Terminalia brownii.* The arid zone is characterized by dry thorn bush land. The common shrub species include *A. mellifera, Acacia etbaica, Acacia horrida, A. nilotica, A. tortilis, A. nubica, A. reficiens, Acacia senegal* and *A. seyal.* Dominant grasses include *Aristida kenyensis, Chloris pycnothrix, Hyparrhenia anthistirioides, Panicum atrosanguineum* and *Pennisetum schimperi* in the semiarid zone (Makin et al., 1975; Teshome et al., 2004; Samson et al., 2010).

**Sampling procedure and data collection**

Reconnaissance field survey was conducted to have basic understanding about the study districts prior to selecting the representative study sites. Four districts were selected based on accessibility and representation of both agro-pastoral and mixed crop-livestock farming in semi-arid agro ecological zones of southern Rift Valley region of Ethiopia. Further, the livestock experts in the districts were consulted about the communal grazing and browsing sites of the selected districts. Finally, two types of grazing sites (plane and sloppy) and 3 peasant administrations (PA) in each district which have 10 households (HH) in each PAs were identified for further studies. Therefore, the study was conducted on a total of 8 grazing sites, 12 PAs and 120 goat owners who have a better knowledge of indigenous browse species from the four districts.

Altitude is the most important factor in determining plant community type (Teshome et al., 2004). Therefore, the grazing sites were classified based on the altitude representation of the semiarid ago-climatic zones as plane (1100 to 1299 m) or sloppy (1300 to 1600 m) above sea level. Two parallel transect lines of each 2.4 km long in each plane grazing lands and two parallel transect lines of each 1.6 km long in each sloppy grazing lands were randomly constructed. Within the transect lines rope quadrant of 20 × 20 m were placed at 100 m interval along each transects lines. These quadrants were used to assess the distribution of important browse tree and shrubs identified as important feed sources for goats. The measurements of boundaries of each altitude stratum were done by geographic positioning system (GPS).

***Identification of browse trees and shrub species***

Before starting field data collection, local development agent and goat owners who have a better experience of grazing areas and vegetation were used to select representative grazing sites in each PA to identify browse trees and shrub species that goats feed on. A flock of goats belonging to farmers was followed on communal grazing areas to identify browse species browsed by goats. Key informant farmers and development agent were used to record the local name and collect sample of each browse trees and shrubs observed being browsed by goats in the grazing lands. The observed browse trees and shrub species were recorded and sample of twigs were collected for displaying to goat owner. Specimens of each species were taken, labeled and transported to the National Herbarium of Addis Ababa University for species identification.

Goat owners' preference for indigenous brows tree and shrubs: Ten (total of 120) goat owners from each peasant administration were requested to assemble at a site to observe and rank the displayed samples of browse trees and shrubs that were being consumed by goats in the grazing sites. Their experience on the browse trees and shrubs as important feeds for goats, the parts favored by the goats, feeding practices and other uses were recorded. The equivalent species names were assigned with the help of an expert as per Kelecha (1987) and Azene (1993). Indices were calculated for ranked browse trees and shrubs which were computed by employing the principle of weighted average of (Musa et al*.,* 2006).

***Distribution of important browse trees and shrubs***

The distribution of important browse trees and shrubs identified as important feed sources for goats' and utilized for other purposes were assessed. Eight parallel transect lines of 2.4 and 1.6 km long were randomly constructed in plane and sloppy grazing lands which are situated in the four districts, respectively. Rope quadrant size of (20 × 20 m) were placed at 100 m interval along each transects lines. A total of 128 sampling plots in sloppy and 168 in plane grazing sites were laid to score the frequency and density of the browse trees and shrubs. Frequency of each plant was determined by considering the number of plots in which it was recorded, as a percentage of the total plots in the respective grazing site of the four districts, while the density of the species was computed as the number of individuals of a species occupying a sampled area. The geographic location of each plot was recorded using GPS that may be used as reference points for future grazing land browse species monitoring studies. The availability of important browse trees and shrub species on the communal grazing areas were computed according to the structural parameters described by (Mueller and Ellenberg, 1974; Martin, 1995).

$$\%\ Frequency = \frac{Number\ of\ \ plots\ a\ species\ occur}{Total\ number\ of\ \ plots} \times 100 \quad (1)$$

$$Density\ of\ \ a\ species = \frac{The\ number\ of\ \ individuals\ of\ \ that\ species}{Sampled\ area} \quad (2)$$

***Goats' preference test for browse trees and shrubs***

The top ten browse trees and shrub species identified by the goat owners as important feeds for goat during group discussion were used for the goat preference test as methods described by Mtengeti and Mhelela (2006). Ten yearling goats were selected from Arba-Minch University goat farm. Then they were locked in a separate barn in farm of the university. Twigs with stems less or equal to 5 mm wood diameters of the ten selected browse species were collected each day early in the morning from the university vegetation park. The browse twigs were tied in a bundle of one kilogram and hung at 40 cm above the ground (to give easy access to the goats) at distance of 1.5 m apart by a twine rope to a horizontal wooden pole supported at both ends by two poles stuck in the ground. The goats were then allowed to browse twigs of the ten browse plant species for 15 min in a cafeteria fashion at 8:00 am before going to graze. The position of the twigs of each browse plant was changed every day so as to avoid positional bias. The data collection of the preference test was conducted for 7 days after three days of adaptation period. The fresh weight eaten from each browse species was obtained by subtracting the weight of the remaining twigs from 1 kg offered. Goat preference of browse species was determined from the coefficient of preference value calculated from the ratio between the intakes of each browse sample divided by the average intake of the total browse sample (Karbo et al., 1996; Bamikole et al., 2004). Browse species was considered relatively preferred if the COP value is greater than unity. The results were used to rank the various browse species by preference.

**Data management and analysis**

The frequency and density of the browse and shrub species in each grazing sites of the districts were similar. Thus, data of the same browse tree and shrub species in the same grazing site of the districts were then pooled together and expressed as a percentage of occurrences in all plots observed in the four districts and compared crossways the grazing sites following crosstab analysis in SPSS for windows, release 20, 2011. Differences in frequency of occurrence among percentage values were compared by Chi square test. Index method of ranking was used for ranking of goat owners browse species selection in the study districts as described by Musa et al. (2006).

$$\text{Index} = R_n \times C_1 + R_n - 1 \times C_2 ... + R_1 \times C_n \Big/ \sum R_n \times C_1 + R_n - 1 \times C_1 ... + R_1 \times C_n \quad (3)$$

where $R_n$ = Value given for the least ranked level (if the least rank is $5^{th}$, then $R_n = 5$, $R_n$-1 = 4, $R_1 = 1$). $C_n$ = Counts of the least ranked level (in the example, the count of the $5^{th}$ rank = $C_n$, and the count of the $1^{st}$ rank = $C_1$).

## RESULTS AND DISCUSION

### Identification of indigenous browse tree and shrub species as feed for goats

During field survey based on goat consumption a total of 47 indigenous browse species belonging to 47 genera and 15 families were identified in this study indicating that the area was richer in its browse plant diversity. Out of these browses 26 (55.4%) were trees while 21 (44.6%) were shrubs.

The most dominant family is Fabaceaea comprising 10 (21.3%) species, followed by Capparidaceae which comprises 6 (12.8%) species. The next dominant families were Euphorbiace and Tiliaceae with 4 (8.5%) species each followed, by Anacardiace, Burseraceae, Combertaceae and Rhamnaceae with 3 (6.4%) species each and Balanitaceae and Sapindaceae with 2 (4.3%) species each. Apocynaceae, Olaccaeae, Simaroubaceae, Celasteraceae, Flacourtiaceae, Mimosaceae and Rubiaceae were represented by 1 (2.1%) species each, which is consistent with result of Beche et al. (2016) who reported 62 useful plants belonging to 49 genera and 31 families for Awash National Park and Belete et al. (2012) who reported 18 different browse species identified being important feed for different classes of livestock in central Rift Valley areas of Ethiopia.

Browses vary in their seasonal availability as certain browse species are deciduous while some maintain their greenness all year round. For instance in the present survey, it was noticed that *Rhus natalensis, B. aegyptiaca, A. tortilis, A. mellifera, T. brownii, Ziziphus mucronata* and *Tamarindus indica* were present on the grazing areas all year round. Goats frequently browsed *A. mellifera, A. tortilis, Flueggea virosa, R. natalensis, B. aegyptiaca,* and *H. abyssinica* in the grazing areas.

### Distribution of important indigenous browse trees and shrubs

Frequency of the most important browse species at the plane and sloppy grazing lands (Table 1). Frequency reflects the pattern of distribution and gives an approximate indication of the heterogeneity of a woody plant (Haileab et al., 2006). Based on the field investigation, out of ten indigenous browse species ranked as important feed sources of goats, only 2 (*A. mellifera* and *R. natalensis*) had frequency of occurrence greater than 48% in the plane grazing lands. Conversely, only three browse species (*R. natalensis, H. abyssinica* and *Grewia bicolar*) had frequency of occurrence greater than 48.4% in the sloppy grazing areas. The occurrence of *A. mellifera* in the plane grazing area was significantly higher than in the sloppy areas. *A. mellifera* had a density of 92 and 35 trees per hectare in the plane and sloppy areas, respectively. This shows how overgrazing promotes the invasive shrubs (*A. mellifera*) encroachment in the grazing lands. This idea is consistent with the finding of Skarpe (1990) who reported that overgrazing is the main cause of *A. mellifera* encroachment in an arid savanna of Botswana.

According to this author, *A.mellifera* (the shrub browse) is shallow rooted suggesting that it was favoured by an increase in water availability in the surface soil following overgrazing of the grass layer. Similarly, Svitálek (2008) and Yisehak et al. (2007) documented that *A. mellifera* is the species responsible for the ongoing bush

**Table 1.** Frequency (%) and distribution of the most important browse species at the plane and sloppy grazing lands.

| Scientific name | Frequency of presence (%) | | | Density (Tree/ha) | | |
|---|---|---|---|---|---|---|
| | Plain (1100-1299) | Sloppy (1300-1600) | P-value | Plane (1100-1299) | Sloppy (1300-1600) | P-value |
| *R. natalensis* | 63.5 | 64.3 | 0.886 | 186 | 166 | 0.37 |
| *A. amara* | 38.9 | 28.6 | 0.065 | 120[a] | 62[b] | 0.01 |
| *Z. mucronata* | 18.6[a] | 8.0[b] | 0.009 | 11.4[a] | 5.2[b] | 0.03 |
| *F. virosa* | 18.6 | 19.0 | 0.916 | 16 | 15.7 | 0.98 |
| *A. mellifera* | 48.0[a] | 15.9[b] | 0.000 | 93[a] | 35[b] | 0.00 |
| *T. brownii* | 26.3 | 36.5 | 0.062 | 34 | 52 | 0.06 |
| *A. tortilis* | 26.9 | 24.6 | 0.651 | 20 | 13 | 0.18 |
| *H. abyssinica* | 25.1[b] | 53.2[a] | 0.000 | 28[b] | 89[a] | 0.00 |
| *B. aegypetiaca* | 33.5 | 41.3 | 0.174 | 30 | 36 | 0.44. |
| *G. bicolar* | 32.9[b] | 48.4[a] | 0.007 | 38 | 48 | 0.21 |

[a,b]Row means with different superscripts differ significantly at P<0.05. ha = Hectare.

**Table 2.** Ranked perception of the respondents on the preferred browse parts utilized by goats.

| Parts used | Farmers perception ranks | | | | |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | Index | Rank |
| Leaves | 120 | 0 | 0 | 0.50 | 1 |
| Twinges | 0 | 7 | 110 | 0.172 | 3 |
| Fruit and pods | 0 | 113 | 7 | 0.323 | 2 |
| Flowers | 0 | 0 | 3 | 0.004 | 4 |

encroachment due to crop land expansion, overgrazing and unsustainable use for firewood collection in the Nech Sar planes and around the plane grazing areas of Southern Ethiopia. On the other hand, the occurrence of *H. abyssinica and G. bicolar* in the sloppy areas were significantly higher ($P < 0.05$) than those in the plane areas. In terms of tree density, there are about 52, 89 and 48 trees per hectare observed for *T. brownii, H. abyssinica* and *G. bicolar* in the sloppy grazing areas as compared to 34, 28 and 38 trees per hectare found in the plane areas, respectively.

This could be due to plant ecological preference (Alemu et al., 1998) and protection of vegetation clearing and crop land expansion as a part of water shade/or catchments conservation program started some ten years ago in the sloppy grazing areas that might contribute for better occurrence of these species. However, there is comparable and high frequency of occurrence was observed for *Rhus natalensis* between plane (63.5%) and sloppy (64.3%) grazing areas. This is confirmed by closely similar tree density per hectare observed for this browse in plane (186 $h^{-1}$) and sloppy (166 $h^{-1}$) grazing areas in this study. Even though the reason why *R. natalensis* is equally distributed across the different slopes of lands needs further investigation, its accessibility in both slopes of land coupled with its high preference value given by farmers, makes it important browse plant as feed resource for goats. Abebe et al. (2010) reported that *R. natalensis* provide large proportion of forage consumed by goats and camels in the dry season in Southern Ethiopia.

The frequency of 8 browse species in the plain area ranges from 18.6 to 38.9% while 7 browse species in the sloppy area ranges from 8 to 41.3%. Generally, the frequency of occurrence observed for these species appears to be low. This is an indication of serious vegetation clearing due to expansion of crop land, indiscriminate use of vegetation for charcoal, fire wood and construction (poles and timber production) (Table 3). This is consistent with Fetene et al. (2016) who reported that changes in vegetation of Nech Sare National Park is attributed to degradation of existing vegetation through deforestation and replacement of existing vegetation by encroaching plants. Thus, this needs urgent identification of useful multipurpose indigenous browse trees and shrub species to conserve before they get extinct.

## Utilization practices and favored parts of browse trees and shrub species

Favored parts of browse species as assessed by the farmers (Table 2). According to the key informants and conclusions derived from the group discussions, cattle

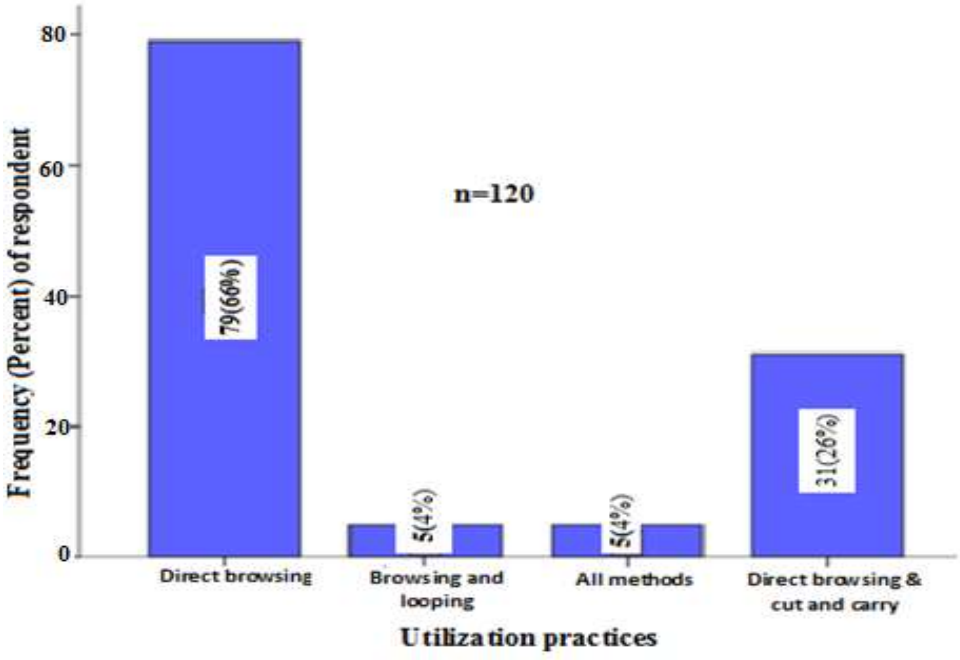


**Figure 2.** Browse species utilization practices.

survive on natural pastures which provide abundant grazing during rainy seasons, but quickly mature and dry up with the onset of the dry season; whereas, goats browse on trees and shrubs throughout the year. Likewise, Sanon et al. (2007) reported for the Sahelian zone of Burkina Faso that browse represented 43 to 52%, of the daily diet of grazing goats while it covers only 4 to 7% of the daily diet of grazing cattle. Similarly, Jamala et al. (2013) documented that browse can contribute as much as 30% of cattle's and 60% of goats' in Guyuk, Adamawa State (Nigeria). Utilization of browse species by livestock as a feed source has been described by Ethiopian authors as well (Takele et al., 2014; Angassa and Berhan, 2015).

Goat owners were able to identify which parts of the browse plants favored by the goats (Table 2). Accordingly, leaves, fruits and pods and twinges were the most preferred parts utilized by goats with index of 0.5, 0.32, and 0.17, respectively. For example, pods and fruits of *A. tortilis*, *A. seyal* and *B. aegyptiaca* as well as fruits and wilted fallen leaves of *A. mellifera* were mentioned as important feeds for goats during dry seasons. Herders tend to loop and cut branches from various palatable browse trees like *A. tortilis*, *B. aegyptiaca*, *T. brownii, Z. mucronata* and *G. bicolar* species to feed their goats during the dry season.

Browse species utilization practices as assessed by the goat owners (Figure 2). Nearly, all goats that are able to walk long distance and look healthy directly browse on the browse species in the grazing areas.

Most of the farmers (66%) in the area directly let their goats to browse in the grazing areas while browsing and cut-carry; browsing and lopping as well as all feeding methods were practiced by 26, 4 and 4% of the farmers, respectively. Fodder feeding by cut and carry system are practiced only for young kids, sick goats, pregnant goats and castrated male kept at home for fattening. In Arbaminch area, some goat owners feed *T. brownii* leaf for fattening goats by cut and carry system. The collected browse leaves were wilted under shade before offered to the goats. The reasons why farmers wilt the leaves under shade are to prevent bloating caused by feeding fresh leaf and to increase intake of the leaves.

This result agrees with the report of Gaiballa and Lee (2012) and Getachew et al. (2017) who reported that leaves of browse trees were fed to livestock by cut and carry system. Similarly, Hassen et al. (2010) also documented that leaves, pods, twigs and flowers were parts of the browse species mostly utilized by livestock. Furthermore, Teferi (2006) has concluded that goats are better than cattle by feeding directly on foliage of browse species.

## Goat owners' ranking of browse trees and shrub species

Indigenous browse tree and shrubs species identified and ranked by goat owners as important feed for goats (Table 3). From the initial list of 48 browse species identified, the first top ten ranked by the goat owners were taken as important feed for goats. The most important browse

**Table 3.** Indigenous browse species, their use and ranking by goat owners as important feed for goats.

| Scientific name | Index | Rank | Other uses |
|---|---|---|---|
| *B. aegypetiaca* | 0.113 | 1 | 1, 3, 7, 9,10 |
| *R. natalensis* | 0.108 | 2 | 1,2, 5,10 |
| *A. amara* | 0.097 | 3 | 1,6,7, 9 |
| *H. abyssinica* | 0.083 | 4 | 1, 6 |
| *T. brownii* | 0.067 | 5 | 1, 2, 3, 4 |
| *A. mellifera* | 0.060 | 6 | 1, 5, 8 |
| *F. virosa* | 0.059 | 7 | 1, 2 |
| *A. tortilis* | 0.059 | 8 | 1,3,5,7, 8, 9 |
| *Z. mucronata* | 0.054 | 9 | 1,2, 6,7, 9 |
| *G. bicolar* | 0.047 | 10 | 1, 2, 5,10 |

1= Firewood, 2 = fruit for human consumption, 3 = charcoal, 4 = farm tool handler, 5 = fencing, 6 = life fence, 7 = home construction (Timber and poles), 8 = bees forage, 9 = shade, 10 = medicine.

species mentioned as feed for goats in ranking order was *B. aegypetiaca* while the least was *G. bicolor.* Among the ten species, *R. natalensis, Albizia amara, H. abyssinica* and *Flueggea virosa* were shrub, while *B. aegypetiaca, A. tortilis, Z. mucronata, G. bicolor,* and *T. brownii* were trees.

The goat owners mentioned that browse species which stayed green throughout the year are much more useful than those species shedding their leaves during the dry season. For example, *B. aegypetiaca* and *R. natalensis* were the most preferred species reported in terms of providing green forage in the dry seasons. Some of the fodder species favored by goats are similar to those described by many authors in Ethiopia (Teferi, 2006; Dargo and Hailu, 2019; Belete et al., 2012). Belete et al. (2012) identified *A. tortilis*, *B. aegyptiaca*, *G. bicolor* and *D. cinerea* are the most widely utilized browse species in the mid Rift Valley areas. Dargo and Hailu (2019) documented *G. bicolor, T. brownii* and *Ziziphus spina-christi* in Babile district. Teferi (2006) documented the wide distribution of *B. aegyptiaca* and *T. brownii* in Northern Ethiopia.

On the other hand, many of these browse species had several other uses. All browse species were used for firewood, 5 for construction (Timber and poles), 5 for shade, 5 for human edible fruit, 3 for making charcoal, 3 for making live fence, 3 for fence, 2 for making tool handles and 2 for bees forage. This is consistent with 54 multipurpose plants reported by Beche et al. (2016) for Awash National Park that includes 35 medicinal species, 22 wild edible species, 39 forage species and 45 species used for construction, fuel and firewood. This indicates that the multiple uses of browse trees and shrubs coupled with expansion of crop land in the area may lead to disappearance of some important browse species. Most of the goat owners were able to identify and name the different indigenous browses, those with beneficial browse value and other uses. However, all of them neither knew how to manage indigenous browses nor conserve to improved and for sustainable use in feeding their animals.

## Goats' preference for browse trees and shrub species

Ranks of indigenous browse trees and shrubs species preferred by goats (Table 4). The rank order of preference (highest to least) for goats during 7 days of feeding was *A. tortilis, B. aegyptiaca, H. abyssinica, A. mellifera, A. amara, T. brownii, Z. mucronata, R. natalensis, G. bicolar* and *F. virosa.* Coefficient of preferences (COP) showed that only six of them have their COP be up to unity while the rest plants were below unity.

Some of the browses species favored by goats in this study are consistent with *A. mellifera, B. aegyptiaca* and *A. tortilis* reported by Emiru et al. (2014) in Aba'ala district of Afar region and *A. mellifera* and *Z. mucronata* reported by Skarpe et al. (2007) in a semi-arid savanna of Botswana. This study revealed that, *A. ortilis* was the first favored browse consumed by goats followed, by *B. aegypetiaca,* while *B. aegypetiaca* was the first and *A. tortilis* was the 8th choice of the farmers.

The differences between the farmers choice and goat preference could be attributed to the physical structure such as the shape and size of thorns, and low leaf yield of *A. tortilis* might have biased the farmer to choose *A. tortilis* leaf at 8th ranking position. Moreover, according to the conclusion derived from the group discussion, prior experience of feeding goats on *A. tortilis* pods during dry seasons appears to be another reason that contributes for its leaf being the 8th choice of the farmers. This is confirmed by Devendra (1989) that observed herdsmen

**Table 4.** Mean intake and coefficient of preference of selected indigenous trees and shrubs fed to Woyto Guji goats.

| Scientific name | Mean ± SD g/head/15 min | COP | Rank |
|---|---|---|---|
| *G. bicolar* | 449.3 ± 12.5 | 0.957 | 10 |
| *A. amara* | 500.0 ± 217.9 | 1.065 | 5 |
| *B. aegyptiaca* | 564.3 ± 134.5 | 1.202 | 2 |
| *H. abyssinica* | 548.6 ± 86.8 | 1.169 | 3 |
| *Z. mucronata* | 478.6 ± 111.3 | 1.019 | 7 |
| *F. virosa* | 450.0 ± 170.4 | 0.959 | 9 |
| *R. natalensis* | 477.2 ± 56.8 | 1.016 | 8 |
| *A. tortilis* | 665.7 ± 54.5 | 1.418 | 1 |
| *A. mellifera* | 521.4 ± 132.9 | 1.111 | 4 |
| *T. brownii* | 488.5 ± 150.3 | 1.041 | 6 |

SD= Standard deviation, COP = coefficient of variation.

in semi-arid Kenya taking their flocks to *A. tortilis* land during dry seasons to feed on ripe pods shaken from the trees. According to this author, the pods make up about 50% of total daily intake during this period and potentially invaluable protein concentrate for small ruminants.

Based on rank order, *R. natalensis* was the 7th favored browse of the goats, but it was the 2nd choice of the farmers. The reason why the goat owner ranked second could be due to its readily available, remain green throughout the year and easy accessibility for browsing might bias the farmers as if it is more preferred by the goats. Moreover, the focus group discussion revealed that relative abundance, palatability and accessibility necessarily determine the selection of browse species by the farmers. On the other hand, the lower preference of the goats to the browse could be attributed to the high condensed tannin contents of the browse, which might reduce its palatability as compared to those favored browses. This is evidenced by its high condensed tannins content (224.5 g/kg DM) reported by Abebe et al*.* (2012). Similarly, in support of the present study Nampanzira et al. (2016) reported that *R. natalensis* leaf were inferior in rumen degradability compared to *H. abyssinica* which may best explain the observed low coefficient of preference of the *R. natalensis.* On the contrary, Mengistu et al*.* (2016) reported that despite high tannin levels, *R. natalensis* was the most preferred species by goats. According to this author, the condensed tannin levels at the observed DMI of the browse species did not determine preference of the goats, instead it appeared to be based on hemicelluloses level. The other 6 indigenous browse tree and shrub species choice of the farmers was closely similar with the preference of the goats.

## CONCLUSIONS AND RECOMMENDATIONS

Most of the farmers were browsing their goats freely in the communal grazing areas. Some important browses trees and shrub species identified as important feed sources of goats and have other uses; frequency of occurrence in the communal grazing areas were low. These species includes *B. aegyptiaca, A. tortilis, Z. mucronata* and *F. virosa.* Whereas, few species such as *A. mellifera* which is favored by goats, but considered as invasive shrubs of the grazing areas and *R. natalensis* occurrence along both plane and sloppy areas were relatively high due to their drought and browsing tolerance. As perceived by the goat owners, other uses of *A. mellifera* and *R. natalensis* were low compared to others. Identifying important multipurpose indigenous browse trees and shrub species is essential to exploit them efficiently for sustainable livestock production. It is therefore, important to identify and conserve such vital plant resources before it gets extinct. Nutritional quality of important indigenous browse trees and shrub species identified based on goat preference and farmers' needs to be verified by conducting laboratory chemical analysis.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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# Estimation of major livestock feed resources and feed balance in Moyale district of Boran Zone, Southern Ethiopia

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**The study was conducted to assess the major livestock feed resources and estimating annual feed production and feed balance in Moyale district of Boran Zone, Southern Ethiopia. A simple random sampling technique was employed to select the household's (HHs) and 96 representative households were selected. Data were collected using group discussions, structured questionnaire, secondary data and personal observations. As it was identified in the study district, natural pasture, crop residues and agro-industrial by-product were major feed resources for the livestock. An average of 129,461.0156 tons of feed dry matter (DM) per year was produced in the district from the major available feed resources, and the demand for maintenance requirement of the livestock population in the district was 190,054.416 (tons DM/year) and this showed that a deficit off 60,593.4004 (31.88%) tons of DM per year in the district. Drought, feed shortage, water scarcity, disease and parasite, market and theft and predator were assessed to be the major livestock production constraints. Generally, the results from this study confirmed that the total dry matter produced from different feed resources in to the study area was not enough to satisfy the dry matter requirement of livestock to support the livestock production in to the study area, which suggest that the main focus needs to be refining the existing feed resources through restoration of tainted grazing areas, introduction compliant feedstuff production, improving feed utilization practices and introduce and promote the crop residue feed improvement.**

**Key words:** Feed availability, feed balance, feed requirement, feed resources.

## INTRODUCTION

Feed is the most important input in livestock production and its adequate supply throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production (Samuel et al., 2008; Legesse et al., 2010). According to Sefa (2017) animal feeds including; natural pasture, fodder crops, fodder trees, crop residues and non-conventional feeds are used in different parts of Ethiopia. Green fodder (grazing) is

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the major type of feed (54.59%) followed by crop residues (31.60%), hay (6.81%) and industrial by-products (1.53%), (CSA, 2017).

Alemayehu et al. (2017) reported that feed in terms of both quantity and quality is bottleneck to livestock production in Ethiopia. This problem of feed shortage is more aggravated during the dry season (Zewdie, 2010). Even during years of good rainy season, forage is not sufficient to feed livestock in the highlands (Melese et al., 2014). Data from different parts of the country also indicated that available feed satisfy about 78.2% of demand (Sefa, 2017).

To obtain improvement in animal production and productivity, an assessment should be done on the types and sources of livestock feed (Endale, 2015). Further studies that aim to integrate feeds that have better nutritive values into the feeding system are required to evaluate feed intake, digestibility, level of inclusion (supplementary feeds), animal's responses, and anti-nutritional factors for more efficient utilization of these indigenous and well adapted feed resources for sustainable animal production (Deribe, 2015).

The pastoral population occupies a large area of Ethiopia mainly the arid and semi-arid lowlands that are characterized by high spatial and temporal variability in rainfall distribution and pattern (Kula et al., 2016). In these areas, livestock production is dependent mainly on natural vegetation composed of herbaceous and woody species. There is a marked seasonal fluctuation in the availability and quality of the natural vegetation. Availability of such information is paramount importance in designing the development strategies, research plans and intervention options for both livestock production and natural resource management. Therefore, this study was initiated with the objective to assess the major available feed resources, estimating annual feed production and feed balance in Moyale district of Boran Zone, Southern Ethiopia.

## MATERIALS AND METHODS

### Sampling procedures and data collection

This study was carried out in Moyale district of Borana Zone, Southern, Ethiopia. The district is located at 775 km south of Addis Ababa and has an area of 14,810 km$^2$. The altitude of the district ranges from 1150 to 1350 m above sea level. Out of the total 16 kebeles of the district, 5 kebeles were selected purposively, based on feed resources availability and livestock production potential. Simple random sampling technique was employed to select the households (HHs). The total number of households sampled for the study was calculated based on the formulas given by Cochran (1977) $n = Z^2(1.96)^2 pq/d^2$, where, *n*, desired sample size; *Z*, abscissas of the normal curve (The acceptable likelihood of error of 10%): 1.96. The value of *Z* at 90% confidence interval; *P*, estimated proportion that one is trying to estimate in the population, that is, 50% ; *q*, *1-p*; *d*, desired absolute precision level at 90% confidence interval. The primary data was collected through interview and it was supported by secondary data from associations, developmental workers, experts, local administrations, pastoralist and rural development office of the study district, and non-governmental organizations.

### Methods of data analysis

The quantitative data collected from individual respondents were entered into the Microsoft Excel template and analyzed. Qualitative data were examined and summarized for each topic. Indexes were developed to provide the aggregated ranking of major feed resources in the study district [(5 × number of responses for 1$^{st}$ rank + 4 × number of responses for 2$^{nd}$ rank + 3 × number of responses for 3$^{rd}$ rank + 2 × number of responses for 4$^{th}$ +1× number of responses for 5$^{th}$)] divided by (4 × total responses for 1$^{st}$ rank + 3 × total responses for 2$^{nd}$ rank + 2 × total responses for 3$^{rd}$ rank + 1 × total responses for 4$^{th}$ rank) the higher the rank for a given reason, the greater its importance. All the collected data were arranged, organized and analyzed by using simple descriptive statistics such as mean, frequency and percentage by using SPSS version 20.

### Estimation of feed balance

Feed demand in district was estimated by considering all ruminant and non-ruminant with exception of poultry livestock species reported by the district offices of agriculture and converting to tropical livestock units (TLU) using FAO (1987) methodology. The daily DM requirement for maintenance of one TLU is estimated to be 2.5% of the body weight (ILCA, 1991). Livestock to TLU conversion factors were used (Jahnke, 1982). The feed balance for district was estimated by subtracting the demand for maintenance requirement of the livestock population in the district (tons DM/ year) from the available feed DM (tons/ year) which was acquired from pastoral development office. The amount of feed DM attained annually from diverse land use types was calculated by multiplying the hectare of land under each land use types by its conversion factors (FAO, 1984). The quantities of available crop residues produced by farmers were estimated by converting crop yield to straw yield (FAO, 1987) and (De Leeuw and Tothill, 1990) and considering 10% wastage (Adugna and Said, 1994). The potential fodder yield of shrubs and trees are estimated by using an equation of Petmak (1983). Accordingly, leaf DM yield of fodder trees were predicted using the allometric equation of log W = 2.24log DT-1.50, where W = leaf yield in kilograms of dry weight and DT is trunk diameter (cm) at 130 cm height. Available concentrate feeds also considered.

## RESULTS AND DISCUSSION

### Socio–economic conditions of the study community

#### *Household characteristics*

The household characteristics of the respondents are presented in Table 1. From the interviewed households 1.0, 93.8 and 5.2% were single, married and divorced, respectively. The present finding is little far apart with that reported by Bizelew et al. (2016) in Gambella regional state, southwestern Ethiopia. The observations were in line with the report of Tesfaye and Melaku (2017) from Dendi district, West Shoa zone, Ethiopia. Out of the overall respondents, 67.7 and 32.3% were male and female headed households, respectively, the result was

**Table 1.** Marital status, sex, ethnic group and religion of respondents in the study area.

| Variable | Kebeles | | | | | Overall (n=96) % |
|---|---|---|---|---|---|---|
| | Buladi (n=12) | Beede (n=13) | Bokola (n=27) | Tilemado (n=18) | Dambii (n=26) | |
| Marital status | | | | | | |
| Single | 0.0 | 0.0 | 3.7 | 0.0 | 0.0 | 1.0 |
| Married | 100.0 | 92.3 | 96.3 | 94.4 | 88.5 | 93.8 |
| Divorced | 0.0 | 7.7 | 0.0 | 5.6 | 11.5 | 5.2 |
| Household heads | | | | | | |
| Male | 58.3 | 69.2 | 59.3 | 66.7 | 80.8 | 67.7 |
| Female | 41.7 | 30.8 | 40.7 | 33.3 | 19.2 | 32.3 |
| Religion | | | | | | |
| Muslim | 83.3 | 69.2 | 70.4 | 66.7 | 46.2 | 64.6 |
| Orthodox | 0.0 | 7.7 | 7.4 | 0.0 | 0.0 | 3.1 |
| Protestant | 0.0 | 15.4 | 11.1 | 5.6 | 15.4 | 10.4 |
| Waqefata | 16.7 | 7.7 | 11.1 | 27.8 | 38.5 | 21.9 |

**Table 2.** Educational status and main source of income of the respondents in the study area.

| Variable | Kebeles | | | | | Overall (n=96)% |
|---|---|---|---|---|---|---|
| | Buladi(n=12) | Beede (n=13) | Bokola (n=27) | Tilemado (n=18) | Dambii (n=26) | |
| Educational status | | | | | | |
| Illiterate | 91.7 | 30.8 | 88.9 | 61.1 | 46.2 | 64.6 |
| Reading and writing | 8.3 | 30.8 | 7.4 | 27.8 | 26.9 | 19.8 |
| Elementary | 0.0 | 23.1 | 3.7 | 0.0 | 7.7 | 6.2 |
| Secondary | 0.0 | 15.4 | 0.0 | 11.1 | 19.2 | 9.4 |
| Main source of in come | | | | | | |
| Crop selling | 0.0 | 7.7 | 0.0 | 0.0 | 0.0 | 1.0 |
| Livestock selling | 0.0 | 15.4 | 0.0 | 5.6 | 0.0 | 3.1 |
| Livestock products selling | 66.7 | 53.8 | 92.6 | 77.8 | 84.6 | 79.2 |
| Both livestock and their products selling | 33.3 | 23.1 | 7.4 | 16.7 | 15.4 | 16.7 |

slight similarly with that of Gebreegziabher et al. (2016) indicated that 79.6 and 20.4% were male and female, respectively, from Humbo district of Wolaita zone, southern Ethiopia. These findings are not in close with reports of Zewdie and Yoseph (2014) who reported that 93.35 and 6.65% were male and female, respectively and Amistu et al. (2017) who stated that 82 and 18% were male and female, respectively, from the central rift valley of Ethiopia and Gibe district of Hadiya zone, southern Ethiopia respectively. From the overall respondents 64.6, 3.1, 10.4 and 16.7% of them was Muslim, orthodox, protestant and Waaqefata, respectively (Table 3).

### *Educational status and main source of income*

Educational level and main source of income of respondents is presented in Table 2. Accordingly, the results pertaining to the educational status of the respondents indicate that most (64.6%) of the respondents were illiterates. The findings were not in close accordance with that of Belete et al. (2017) (27.67%), but in close with those of Amistu et al. (2017) (72%) and Gashe et al. (2017) (56.7%) from Bale zone, Oromia regional state, Gibe district of Hadiya zone, southern and Gozamen district, east Gojam zone, Amhara region, Ethiopia respectively. High level of illiterate demand for better appropriate livestock husbandry extension services which can be easily followed by the respondents (Mulugeta et al., 2015).

The proportion of respondents capable of reading and writing was 19.8%; few of the respondents have attended elementary school (6.2%) and secondary school (9.4%) education. A similar result was reported for pastoral

**Table 3.** Land holding size (Mean ± SE), trend of land holding (%) and the reason for land holding change (%) in the study area.

| Variable | Kebeles | | | | | Overall (n=96) |
|---|---|---|---|---|---|---|
| | Buladi (n=12) | Beede (n=13) | Bokola (n=27) | Tilemado (n=18) | Dambii (n=26) | |
| Total land holding (ha) | | | | | | |
| Homestead | 0.1±0.05 | 0.04±0.04 | 0.1±0.04 | 0.1±0.04 | 0.1±0.03 | 0.1±0.02 |
| Crop land | 0.8 ± 0.2 | 0.8 ± 0.1 | 1.1 ± 0.1 | 0.7 ± 0.1 | 0.8 ± 0.1 | 0.9 ± 0.1 |
| Grazing land | 0.6± 0.3 | 0.3± 0.1 | 0.2 ± 0.1 | 0.5 ± 0.2 | 0.4 ± 0.1 | 0.4 ± 0.1 |
| Trend over time | | | | | | |
| Decreasing | 58.3 | 23.1 | 81.5 | 50.0 | 65.4 | 60.4 |
| Increasing | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| No change | 41.7 | 76.9 | 18.5 | 50.0 | 34.6 | 39.6 |
| The reason for change | | | | | | |
| Settlement | 33.3 | 23.1 | 81.5 | 44.4 | 61.5 | 55.2 |
| Tribal conflicts | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 |
| Variability of rainfall | 8.3 | 0.0 | 0.0 | 5.6 | 0.0 | 2.1 |
| Other(demarcation) | 0.0 | 0.0 | 0.0 | 0.0 | 3.8 | 1.0 |

n= number of respondents, SE= standard error.

production system in Gambella regional state, southwestern Ethiopia (19.4, 26.1 and 7.8%), reading and writing, elementary school and secondary school, respectively, by Bizelew et al. (2016).

The major sources of income for all respondents were livestock product sale, and both livestock and their product sale (79.2%) and (16.7%), respectively (Table 4). This finding were similar with a review of Kula et al. (2016) who stated that livestock rearing is the main means of livelihoods and source of income. Furthermore, the findings show that most of the respondents in the study area is pastoral and partially dependent on agronomic activities, the production of crop was too small and that is not exceed for house consumption.

## Land holding

In Moyale district the mean total land holding per household was 1.4ha, out of which, the size of homestead, crop land and grazing land were 0.1, 0.9 and 0.4 ha, respectively (Table 3). There was no significant (P>0.05) difference in land holding among the studied kebeles. The total land holding of the study was comparable with total land holding of 1.34 ha and 1.3 ha respectively, reported by Bizelew et al. (2016) and Jimma et al. (2016) in Gambella regional state, southwestern Ethiopia and SNNPRS of Ethiopia, respectively. However, the present result was lower than the values of 1.8 ha reported by Gebreegziabher et al. (2016) in Humbo district of Wolaita zone, Southern Ethiopia and 3.23 ha reported by Kenenisa and Meles (2016) in Adami Tullu Jiddo Kombolcha district, Oromia regional state, Ethiopia. The present study indicated that the crop land was higher than other land holding types due to the grazing land and homestead area were occupied by people for settlement, there was illegal inhibition of land, locally called *kaloo* as informal reported by the respondents.

Out of the overall respondents, the majority (60.4%) reported that there was decrease in land holding size in the district while, 39.6% of the respondents reported no change. The reasons for the changes of land holdings were settlements (55.2%), tribal conflicts (2.1%), rainfall variability (2.1%) and illegal inhabitation (1.0%), (Table 3). The results of the present study also showed that most of the respondents could access communal grazing lands.

## Available feed resources in Moyale district

In the present study, three major different feed resources were identified and categorized into (1) natural pasture (grasses, browse and herbaceous legumes), (2) concentrates (wheat bran) and (3) crop residues. However, the contribution of agro-industrial by products such as noug seed cake, linseed cake, molasses, brewery by products, non-conventional feed resources like food refusal, vegetable refusal, sugarcane residue and improved forage were uncommon and rarely used. These findings were similar to the reports of Yadessa

et al. (2016) in Meta-Robi district, West Shewa zone, of Oromiya regional state, Ethiopia.

## Seasonal variations in the availability of feed resources

The respondents were asked to identify and rank the major feed resources in both dry and wet seasons (Table 4). Accordingly, fodder trees, hay, crop residues, concentrates and stubble grazing were ranked 1st, 2nd, 3rd, 4th, and 5th, respectively, during the dry season. During the wet season, natural pasture (1st), fodder trees (2nd), hay (3rd), crop residues (4th) and stable grazing and concentrates (5th) were ranked by the respondents. The major feed resources identified in the present study were in agreement with the reports of Emana et al. (2017) in Abol and Lare district of Gambella region, Ethiopia; Dawit et al. (2013) in Adami Tullu Jiddo Kombolcha district, Oromia regional state, Ethiopia and Kassahun et al. (2015) from Horro and Guduru districts of Oromia regional state. In consistent with results of the present study, Alemayehu (2004) reported fodder trees and shrubs are important feeds in Ethiopia especially in the arid and semi-arid areas; and Sefa (2017) reported crop residues are the main feeds during the dry season. Moreover, Andualem (2016) stated that, most browse species have the advantage of maintaining their greenness throughout the dry season when grasses dry up and deteriorate in quality and quantity.

## Estimation of annual feed availability and feed balance

### *Dry matter production from different land types*

According to Pastoral Development Office (2016) report, there are different land types; around private (individual) grazing land (8,284.52 ha), open/communal grazing land (24,559.58 ha), fallow land (1,340.88 ha) and forest land (1502 ha) in the study area. From this area of land, the higher tons of dry matter (49,119.16) were produced from open grazing land, and whereas, approximately the lowest tons of dry matter (1,051.4) feed was produced from forest land (Pastoral Development Office of Moyale, 2016). Productivity (t/ha) were obtained by multiplying the hectare of land under each land use types by its conversion factors for private (individual) grazing land (3.0), open (communal) grazing land (2.0), fallow land (1.8) and forest land (0.7) (FAO, 1984). Productivity of DM t/ha from different land types are shown in Figure 1.

### *Grazing land dry matter production*

Rendering to data adapted from pastoral development office of the study area (2016), the total hector of communal and individual grazing lands were 24,559 and 8,284.52 ha, respectively. Besides the total amount of DM available in natural pasture was determined by multiplying the average value of grazing land holding with conversion factor of 2t DM/ha/year for communal grazing land and 3tDM/ha/year for individual grazing land (FAO, 1984). Amount of DM obtained from communal grazing land and individual grazing land was factored into total communal grazing areas of the district. Accordingly, 49,119.16 and 24,853.56 tDM/ha/year were produced from communal grazing land and individual grazing land, respectively.

### *Forest land dry matter production*

Conferring to data obtained from pastoral development office of study area (2016), the total hector of forest land 1,502 ha. Moreover, the total amount of DM available in forest land was determined by multiplying the average value of forest land holding with conversion factor of 0.7 t DM/ha/year (FAO, 1984). Amount of DM obtained from forest land was factored into total forest land areas of the district. Accordingly, 1051.4 t DM/ha/year were produced from forest land.

### *Fallow land dry matter production*

According to data obtained from pastoral development office of study area (2016), the total hector of fallow land was 1,340.88 ha. Moreover, the total amount of DM available in fallow land was determined by multiplying the average value of fallow land holding with conversion factor of 1.8 tDM/ha/year (FAO, 1984). Amount of DM obtained from forest land is factored into total forest land areas of the district. Accordingly, 2413.584 t DM/ha/year were produced from fallow land.

### *Crop residues dry matter production*

The crop and natural resource office of Moyale district (2016) report had demonstrated that 19,726 ha of land are covered by cropping land. The agro pastoral communities in study area currently have been produced crop residues from maize, teff and haricot bean. The total area of different crop types grown is 18,109, 1,154.8 and 461.92 ha, for maize, haricot bean and teff, respectively. The crop residues (38,296.64 tons) are the second dominant feed resource in Moyale district next to open grazing land with supply of 49119.16 tons of DM from crop residues to feed livestock. Crop residues dry matter productions are shown in Figure 2.

### *Crop aftermath dry matter production*

Rendering to crop and natural resource office of

**Table 4.** Major feed resources during both dry and wet seasons in the study area.

| District (n=96) | Priority levels | | | | | index | Rank |
|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | FIFTH | | |
| Feed types in dry season | | | | | | | |
| Natural pasture | 0 | 0 | 0 | 9 | 87 | 0.07 | 5 |
| Crop residues | 12 | 38 | 29 | 18 | 0 | 0.23 | 3 |
| Hay | 32 | 32 | 28 | 3 | 0 | 0.26 | 2 |
| Fodder trees | 40 | 23 | 28 | 6 | 0 | 0.27 | 1 |
| SG and concentrate(WB) | 12 | 3 | 11 | 60 | 9 | 0.16 | 4 |
| | | | | | | | |
| Feed types in wet season | | | | | | | |
| Natural pasture | 96 | 0 | 0 | 0 | 0 | 0.33 | 1 |
| Crop residues | 0 | 1 | 15 | 36 | 44 | 0.11 | 5 |
| Hay | 0 | 2 | 50 | 36 | 8 | 0.17 | 3 |
| Fodder trees | 0 | 90 | 6 | 0 | 0 | 0.26 | 2 |
| SG and concentrate (WB) | 0 | 3 | 25 | 24 | 44 | 0.12 | 4 |

SG=Stubble grazing, WB= wheat bran, n= number of respondent, Index = [(5 × number of responses for 1$^{st}$ rank + 4 × number of responses for 2$^{nd}$ rank + 3 × number of responses for 3$^{rd}$ rank + 2 × number of responses for 4$^{th}$ +1× number of responses for 5$^{th}$)] divided by (4 × total responses for 1$^{st}$ rank + 3 × total responses for 2$^{nd}$ rank + 2 × total responses for 3$^{rd}$ rank + 1 × total responses for 4$^{th}$ rank) the higher the rank for a given reason, the greater its importance.

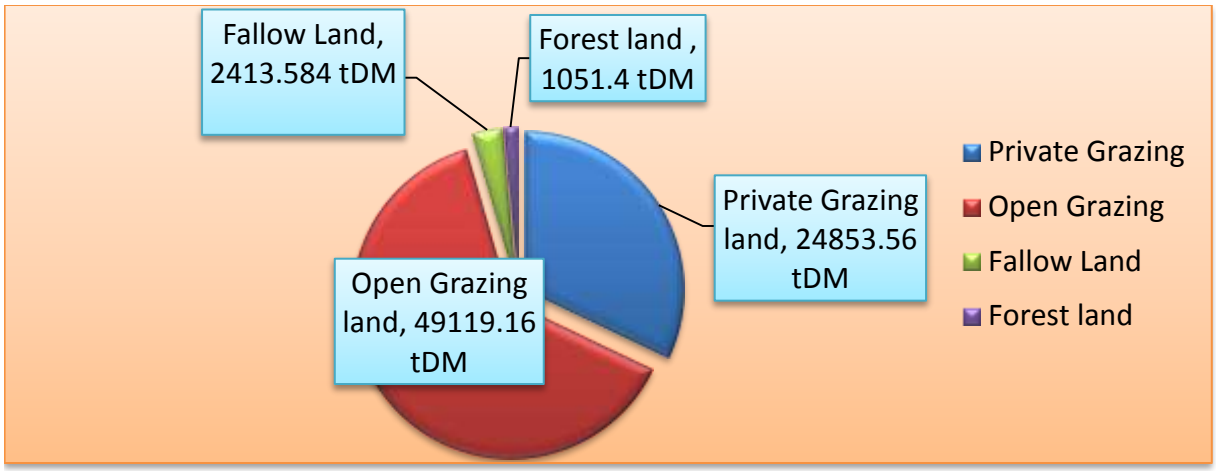


**Figure 1.** Total DM productivity (ton) from different land types in the study area (own computed).

Moyale district (2016) report had demonstrated that 19,726 ha of land covered by the cropping land. The quantities of available DM in crop aftermath grazing were determined by multiplying the available land by the conversion factors of 0.5 for grazing aftermath (FAO, 1987). Accordingly, 9,863 tons DM/ha/year was produced from crop aftermath.

### *Contribution of concentrate feed (wheat bran)*

The quantity (DM basis) of concentrates (wheat bran) available for each household was obtained by interviewing the farmers during questionnaires survey. Accordingly, 1.3216 tons of DM was obtained from wheat bran in the study area; the contribution of wheat bran was very little as compared to other feed resource.

### *Trees and shrubs dry matter production*

The potential fodder yield of shrubs and trees were estimated by measuring stem diameter using measuring tape and applying the equation of Petmak (1983). In quantifying tree feed resources from common property resources (e.g. open forest areas) at individual household

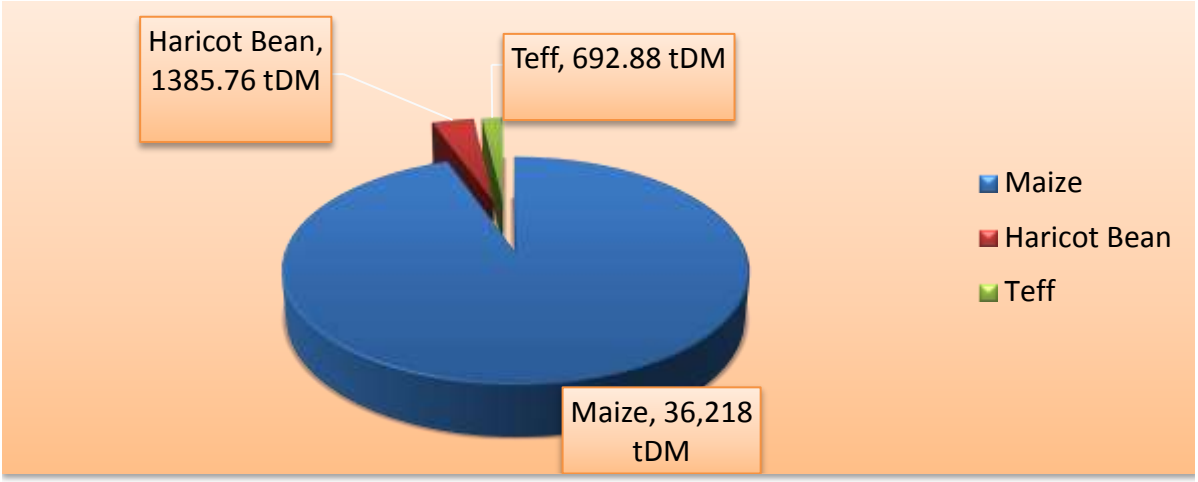


**Figure 2.** Crop residues dry matter production in the study area (own computed).

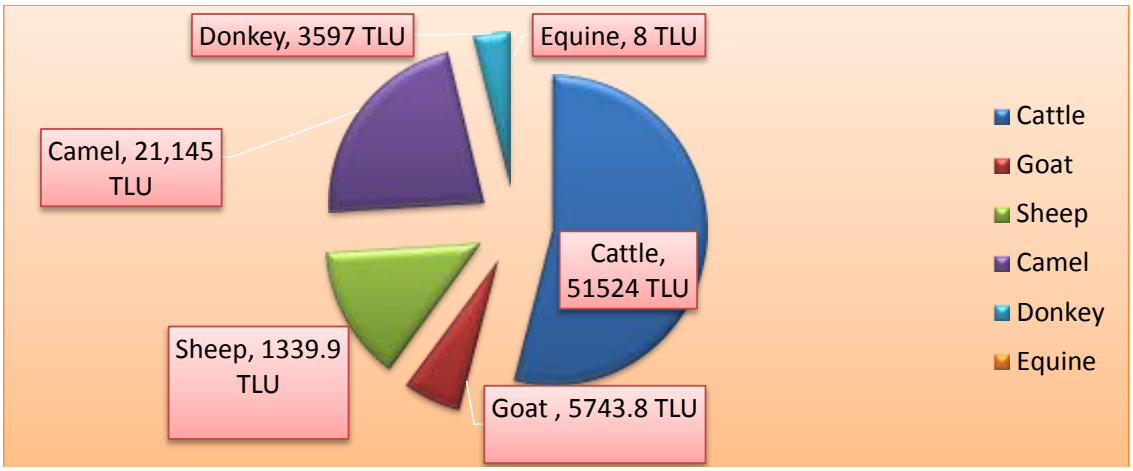


**Figure 3.** Different species of livestock population (TLU) in the study area (own computed).

level similar approaches, as communal grazing area mentioned earlier, was used. Empirical evidence from WBISPP (2004) suggests that only about 75% of all available DM is accessible by livestock for use and therefore this study area was used the same accessibility factor to quantify total DM utilized by livestock from grazing and browsing areas. Accordingly the total DM production of shrubs and trees in the study was 3,862.35 tons obtained from communal and forest land.

### *Total tropical livestock unit (TLU) and their dry matter requirement*

Based on the reported data of pastoral development office of livestock (2016) of Moyale district, the district had an average (83,357.2) tropical livestock unit (TLU); comprising (51524 cattle, and 5,743.8 goats, 1,339.9 sheep, 21,145 camels, 3,597 donkey and equine, 7.5), (Figure 3). Assuming that DM requirement for maintenance of one TLU is 6.25 kg/day (2.28 ton/year/TLU) (ILCA, 1991). Accordingly, the estimated total annual requirements of DM by the dominant livestock species were cattle (117474.72), goat (13095.8 64), sheep (3054.972), camel (48210.6), donkey (8201.1 6) and equines (17.1). Totally about 190,054.416 tons of DM per year for different livestock species is required in the district. Different species of livestock population (TLU) in the study area are shown in Figure 3.

### *Feed balance*

The open grazing land, private grazing land, fallow land

**Table 5.** Major constraints to livestock production in the study area.

| Constraints | Priority levels | | | | | | Index | Rank |
|---|---|---|---|---|---|---|---|---|
| | First | Second | Third | Fourth | Fifth | Sixth | | |
| Drought | 87 | 7 | 3 | 0 | 0 | 0 | 0.28 | 1 |
| Water scarcity | 2 | 14 | 44 | 13 | 11 | 16 | 0.17 | 3 |
| Feed shortage | 6 | 75 | 10 | 0 | 0 | 0 | 0.22 | 2 |
| Disease and parasite | 1 | 0 | 35 | 55 | 4 | 1 | 0.16 | 4 |
| Market and theft | 0 | 0 | 3 | 21 | 54 | 18 | 0.10 | 5 |
| Predator | 0 | 0 | 1 | 7 | 27 | 61 | 0.07 | 6 |

n= number of respondent, Index = [(5 × number of responses for 1$^{st}$ rank + 4 × number of responses for 2$^{nd}$ rank + 3 × number of responses for 3$^{rd}$ rank + 2 × number of responses for 4$^{th}$ +1× number of responses for 5$^{th}$)] divided by (4 × total responses for 1$^{st}$ rank + 3 × total responses for 2$^{nd}$ rank + 2 × total responses for 3$^{rd}$ rank + 1 × total responses for 4$^{th}$ rank) the higher the rank for a given reason, the greater its importance.

and forest land, concentrate feed (wheat bran), indigenous browse, shrubs and crop residues were used to calculate feed supply for livestock in the study area. The total of 81,300.054 tons of DM per year was produced from different land use types with exception of crop land; concentrate feed (wheat bran) and aftermath grazing which produce 38,296.64, 1.3216 and 9,863 tons of DM per year, respectively.

As it had been calculated the total DM produced in the study area from different feed resources was 129,461.0156 tons and the demand for maintenance requirement of the livestock population in the district was 190,054.416 (tons DM/ year). The feed balance for the district was estimated by subtracting the demand for maintenance requirement of the livestock population in the district (tons DM/ year) from the available feed DM (tons/ year), and this showed that a deficit off 60,593.4004 (31.88%) tons of DM per year in the district. In general, the feed balance data showed that the DM produced in the study area per year was imbalanced with the minimum maintenance requirements of dominant livestock species. Similarly, in previous studies, challenges in Ethiopia showed that the dry season is characterized by inadequacy of grazing resources, because of which animals are not able to meet even their maintenance requirements and lose of substantial amount of their weight (Aster et al., 2012). This further recalls that there is need to introduce the feed improvement interventions in the study area in order to save the livestock.

### *Major constraints to livestock production*

Livestock production in the study area has been primarily hampered by drought (mean rank 0.28), feed shortage (0.22), water scarcity (0.17), disease and parasite (0.16), market and theft (0.10) and predator (0.07) (Table 5). Furthermore, drought was one of the main constraints which lead the farmers to travel a long distance in search of feed. In agreement to the results of the present study, Hidosa and Tesfaye (2018) reported that climate change is one of the non-technical livestock feed production constraints, which has been affected livestock production through induce decline in pasture availability. Furthermore, Bizelew et al. (2016), Gebreegziabher et al. (2016), Kenenisa and Melese (2016) and Amistu et al. (2017) reported that feed shortage is one of the major constrains to livestock production in Ethiopia, which is in support of the results of the present study.

## CONCLUSION AND RECOMMENDATIONS

The natural pasture, crop residues and agro-industrial by-product are major feed resources in the study area. Drought is one of the main constraints which lead the farmers to travel along distance for feeding livestock. Moreover, as it had been calculated the total DM produced in the study area from different feed resources was 129,461.0156 tons and the demand for maintenance requirement of the livestock population in the district was 190,054.416 (tons DM/ year). The annual feed DM production in the district could not satisfy 31.88% of the DM requirement of livestock kept in the area. The study described that the contribution of the open grazing area is declining from time to time and livestock may not fulfill the DM requirements. Therefore, this calls for interventions that improve the productivity of declining grazing areas such as rehabilitations of retreated grazing area through the introduction and promoting area closures, over sown with locally adaptable legume forages and fertilization with livestock dungs and droppings. For more efficient utilization of the available feed resources such as crop residues feed treatments should be introduced and practiced.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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