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Morphological Characterization and Socio-Economic Analysis of Horse (Equus caballus) Population from Arsi Highlands, Central Ethiopia

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Abstract

In Ethiopia, horses are among the most significant equines for supporting the livelihood of many smallholder farmers. The study was focused to characterize horse genetic resources of Arsi highlands of Ethiopia based on morphometric traits and analyze their socio-economic importance to enhance horse conservation and breeding objectives. Purposive sampling was used to select the study kebeles from which 270 households and 396 adult horses were selected. The majority (87.7%) of the households in the study area were male headed as the overall average number of horses per individual was (2.20±0.07) and horses are mainly used for riding, cash income and cart pulling. The coat colours varied across the districts where chestnut (43.9%), bay (15.40%), and (14.14%) across the districts. Aggregate means for sex among horses indicated there was no significant difference (p<0.05) in all morphometric traits across the study districts except height at withers exhibited significantly lower for Digaluna Tijo horses. The correlation between morphometric traits was higher in male than female participants. The majority (38.52%) of the horse owners were unable to read and write. The lack of formal education within the horse rearing farmers in the study districts was observed as a reason might have deterred the proper use and conservation of horse genetic resources. The existence of morphometric similarity among horse populations across the study districts could be due to the similarity in the agro-ecology and management practices which further requires characterization at genetic and molecular levels.

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1. Introduction

Horses (*Equus caballus*) belong to the equine group and found mainly in temperate, semi-arid or highland areas. They have been coexisted with humans throughout history and have performed a number of functions (Epstein, 1971; Kefena *et al.,* 2012; Hüppe *et al.,* 2020). Horses have been widely utilized more than any other domestic animals in military warfare and peacekeeping, communications, transportation, agricultural progresses and sports (Kefena *et al.,* 2012; Jemali *at al*., 2017). Nowadays, because of their power, agility, gracefulness and speed, horses are mostly used for personal pleasure and in sport competitions. In recent years the globalization of horses has been widely recognized being developed as sports and recreational animal (Hüppe *et al.,* 2020). The use of the horse as a sport animal or for leisure helps to stimulate the maintenance of genetic diversity within the horse population. The trade, breeding and sports significantly attracted the attention of people (Khadka, 2010). On the other hand, the wide use of selected popular stallions and their semen is seen as threat to genetic diversity within the horse population. Today, the importance of horses has scarcely diminished in parts of South America, Asia, Africa and Eastern Europe, and even elsewhere it is of great economic importance to sport and leisure industries (Fitsum and Ahmed, 2015).

The vast majority of local horse breeds still are poorly documented despite their active role in agrarian communities in the developing world and very little is known about their phenotypic diversity (Kefena *et al*., 2012; Alam *et al*., 2016). The characterization of local genetic resources depends on the knowledge of the variation of morphological traits, which have played a very fundamental role in classification of livestock based on size and shape (Leng *et al.,* 2010; Benhamadi *et al*., 2017). Knowledge of the adapted horse genetic resources is a prerequisite for designing appropriate breeding and utilization programs. Asefa *et al*. (2017) stated that characterization of livestock breeds based on their morphological traits variations are the first step towards the use of the available animal genetic resources.

Ethiopia is endowed with horse genetic resources and has approximately 2 million horses which is 33.5% of Africa's horse population (Kefena *et al.,* 2012; Fitsum and Ahmed 2015). According to livestock census (CSA, 2020) Oromia has the highest horse population (1, 176301) which is 58% of the total horse population of the country followed by SNNP 451,799 which is 22.27% and Amhara region which has 396231, 19%. Digaluna Tijo, Lemu Bilbilo, and Enkolo Wabe which are the three districts of Arsi zone of the Oromia National Regional state possess horse population as 24692, 57995, and 18720 respectively. In the livestock sector, equines play an important role in the economy of Ethiopia. They are the engines that power rural as well as urban economic development. The most important feature of animal transport in Ethiopia is the use of horses and donkeys as pack animals, for pulling carts and for riding especially horses. They have multiple functions, which are not limited to economic aspects, but are also related to socio-cultural issues. Horse and donkey have reduced the domestic transport burden of rural people, especially women, and have created employment and income generation opportunities for many people (Fitsum and Ahmed 2015). In Ethiopia, donkey (61.46%) and horse (61.32 %) were used for transportation and very few were intended for draught and other purposes (CSA, 2020). Similarly, horses of the study area have been providing multiple functions to the community. However, horses of Ethiopia, particularly, that of the study area have not been characterized in terms of their morphological traits and they have not been assessed in terms of their socio-economic importance.

Morphological traits characterization is fundamental footstep for genetic improvement of livestock to increase their productivity in a given country (Asefa *et al.,* 2017). The essential procedure for genetic improvement of livestock involves identification of the breeds or strains of livestock and the type of environment in which they are kept, description of the breed characteristics, their adaptation as well as production potentials in those environments. Moreover, for successful improvement programs, knowledge of the compatibility of the genotypes with the farmers' breeding objectives, and the production systems are crucial (Mekuria *et al*., 2013; Alam *et al*., 2016; Benhamadi *et al*., 2017; Kewareti *et al*., 2017).

Ethiopia is endowed with the horse genetic resources. It is among the top ten countries in the world in terms of number of horses Kefena *et al*. (2012). It has been estimated that Ethiopia possesses about 2 million horses with many more unreported (Fitsum and Ahmed, 2015; CSA, 2020). They are common in most agro-ecologies and livestock production systems with more population density concentrated in the north central, central, eastern and southern highlands of the country. Kefena *et al*. (2012) identified eight Ethiopian horse populations based up on the morphological diversities and ecozones of the country, Ethiopia.

Moreover, horses are the most highly valued and culturally respected domestic mammals, particularly in Arsi, Bale and Borena people in Ethiopia (Asmare and Yayeh, 2017). However, the socioeconomic relevance of Ethiopian horses has not been fully investigated or documented, and their morphological characteristics have also not yet been fully studied. This also reveals that horses of Ethiopia in general, that of Arsi highlands in particular, have not been a focus of research in the past and were neglected regardless of their great contributions in supporting the livelihoods of many resource-poor farmers (Kefena *et al.,* 2012; Fitsum and Ahmed, 2015; Asmare and Yayeh, 2017). Therefore, this study was carried out to morphologically characterize, and assess the socio economic importance of Arsi highland horses.

2. Materials and Methods

Description of the Study Area

The study was conducted at three districts namely Digaluna Tijo, Lemu Bilbilo and Enkolo Wabe of Arsi zone of Ethiopia. The detail description (Table 1) and map (Figure1) of the study areas are presented below.

Table 1: Detailed description of the study sites

	Study Districts		
Description	**Digaluna Tijo**	**Lemu Bilbilo**	**Enkolo Wabe**
Villages of the districts	Tijo	Lemu	Siltana
Distance from Addis Ababa to the villages	198Km	222Km	256Km
Altitude (meter above sea level)	2300-3600	2500-4000	2400-4245
Range of annual temperature	10°C - 20 °C	5°C - 15 °C	3°C - 20 °C
Range of annual rainfall	1000-1500 ml	1000-1200mm	800-1200 mm
GPS reading in decimal degree: Latitude	7·19-7.37	6·51-7.37	7·19-7.37
GPS reading in decimal degree: Longitude	38.33-39·21	39.09-39·25	38.33-39·21
Major livestock type include	Cattle, Sheep, horses, goats and donkey	Cattle, Sheep, horses, goats and donkey	Cattle, Sheep, horses, goats and donkey
# of Horses by 2021	25,761	33,995	21,860

Source: NMSA (National Meteorological Service Authority) 2021.

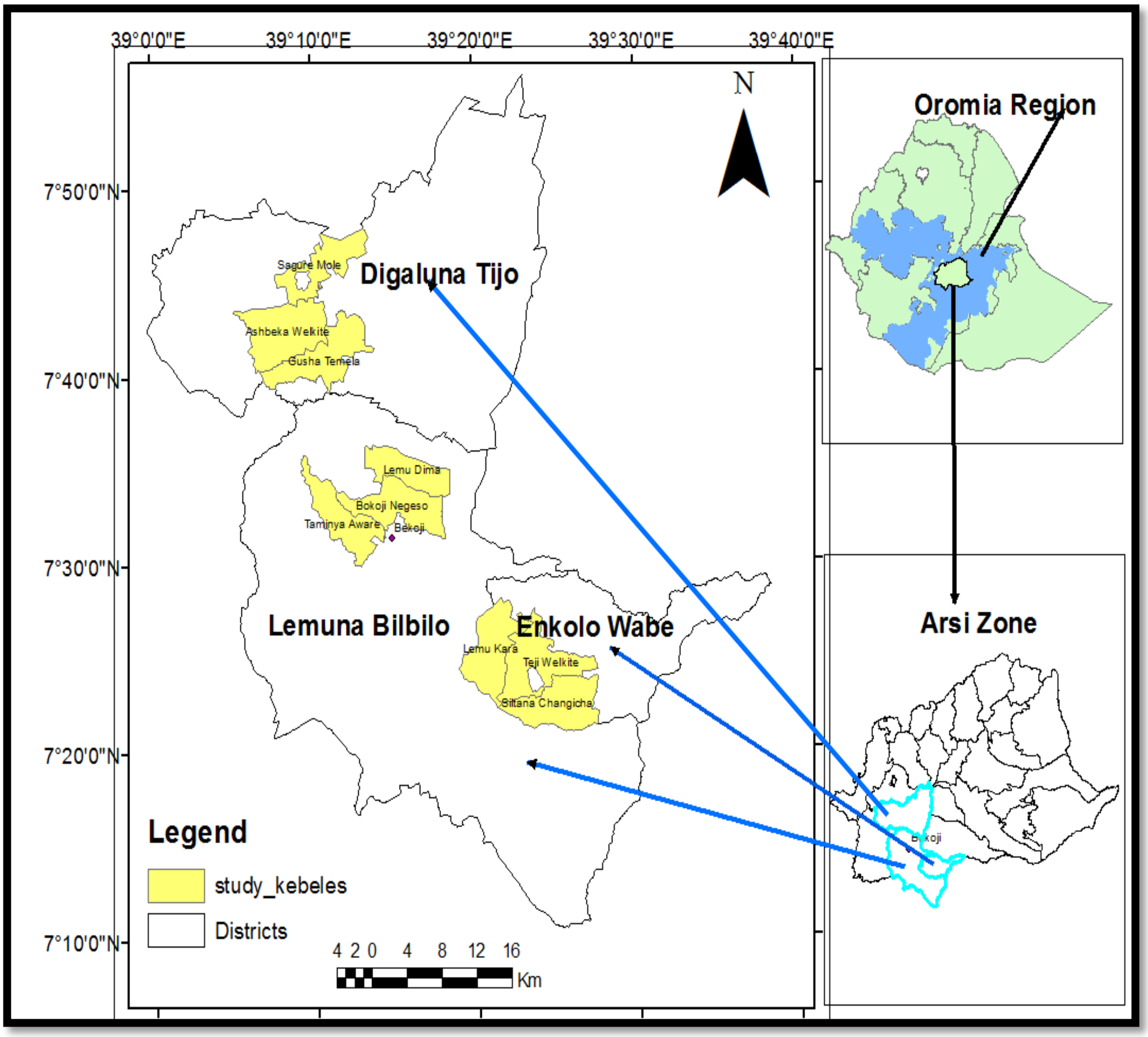

Figure 1: Map of the study area

Research Design and Study period

The study was conducted from October, 2020 to end of 2021 using community based cross sectional research design to study horse populations in Arsi highlands based on morphological characteristics in which socio-economic data was collected from each sampled household. Since the study was on farm characterization, horses in the hands of farmers were used and data regarding linear body measurements (Table 3) were collected on each measured horse early in the morning before the horses were released out of their barn and graze any feed.

Sample Size Determination and Sampling Techniques

Sample size for socio economic analysis was determined based on the formula recommended by Arsham (2007). $N= 0.25/SE^2$; where: N= Sample size, SE^2= Standard Error square. With the assumption of 3.04% standard error, a total sample size of 270 households was considered for the study. About 90 households per district and 30 households per kebele were sampled. A total of 396 horses (198 males and 198 females) belonging to these three districts (132 horses per district and 44 horses per kebele) were sampled for morphological analysis. The composition of the sample is summarized in Table 2. Purposive and multistage sampling techniques were applied with the main objective to select the study districts and kebeles. Depending on the information gathered from key informants, Agriculture and Rural development office experts and Development Agents, from Arsi zone, three districts were selected out of which three kebeles were selected based on the distribution and availability of horse populations. Households possessing at least one horse in the study districts were selected purposively as the study population. Only horses older than 4 years included, because their bodies are fully developed and considered as appropriate for linear body measurement (Druml *et al*., 2008; Kefena *et al*., 2012; Jemmali *et al*., 2017). Horses that lost their body conditions were not considered. Foals and pregnant mares were also excluded because these can confound some of the morphological variables.

Table 2: Summary of the composition of the sample

Districts	Kebeles	Sample for morphological analysis			Sample for HH survey
		Male horses	Female horses	Total	
Digaluna Tijo	Sagure Molle	22	22	44	30
	Ashebeka Welkite	22	22	44	30
	Gusha temela	22	22	44	30
Lemu Bilbilo	Lemu dima	22	22	44	30
	Bokoji negesso	22	22	44	30
	Tamagna aware	22	22	44	30
Enkolo Wabe	Lemu kara	22	22	44	30
	Taji walkite	22	22	44	30
	Siltana changicha	22	22	44	30
Total	9	198	198	396	270

Kebele is the smallest administrative unit, bellow district level; HH=Household.

Methods of Data Collection

Secondary information on the distribution and number of horses of the districts was obtained from agricultural and rural development office of Arsi zone and each district before starting the actual fieldwork. Discussions with key informants and district officials were done to have an overview about the overall horse distribution, availability and abundance. Then preliminary surveys were carried out for selected kebele of each district to generate information prior to the questionnaire preparation for the formal survey. Questionnaire was designed to address description of the socio-economic practices of the community. The questionnaire was pre-tested on sample households to evaluate appropriateness of the design, clarity and interpretation of the questions, relevance of the questions, quality of the data received and time taken for an interview. Hence, appropriate modification and correction was also made accordingly. To performed linear body measurement and recording the data two data collectors for each study district were assigned. Training on how to measure the animals, administer the questionnaire, communicate with the households (owners' consent) and record appropriate data of interest were provided for them for consecutive five days.

Information on socio-economic condition of each household, family size and their major source of income was collected. The type and number of livestock reared by the community in the study area were assessed using questionnaire. The major routine horse management practices and household members who were responsible to handle specific work such as purchasing, selling, herding, breeding, caring for sick horse, feeding, barn cleaning were assessed using questionnaire. Information on population trend in major livestock species specifically the trend in horse population and the main purpose of keeping horse were collected using questionnaire.

Qualitative data on body coat colour (chestnut, bay, grey, black, white, palomino or roan), marking on the face (plain, star, stripe, blaze, snip or bald face) and marking on the leg (plain, coronet, half pastern, and sock, half cannon, stocking or high white) were collected using visual observation following the procedure used in (Alam *et al*. 2016; Dorji *et al*. 2017).

Fifteen (15) quantitative morphological traits were measured using measuring tape (Table 3) following the procedure used by Kefena *et al*. (2012) for Ethiopian horses' phenotypic characterization. Horses were carefully handled by horse owners themselves and positioned to stand properly on flat and hard grounds with parallel legs apart. Five major reference points were carefully marked before body measurements were taken. These points are: (1) the point of wither; (2) the point of back; (3) the point of rump; (4) the point of shoulder joint (5) and the point of pin bone. Measurements were regularly taken from the right side and exceptionally repeated on the left side when there was doubt. If the measurements vary, the average value was recorded.

Table 3: Description of quantitative traits recorded on horse population in the study

No.	Variables	Definition
1	Height at withers	Distance from the highest point of the processes spinals of the vertebra thoracic to the ground
2	Height at back	Distance from the deepest point of the back to the ground
3	Height at rump	Distance from the highest point of rump to the ground
4	Body length	Distance from the most cranial point of the shoulder joint to the most caudal point of the pin bone
5	Back length	Distance from the caudal point of shoulder joint of perpendicular to the wither to the most cranial point of hip joint measured in a saddle place
6	Barrel length	Distance from the most caudal point of the scapula to the most cranial and dorsal point of the point of hip
7	Neck length	Distance from the highest point at wither to nape by normal posture of the head
8	Head length	Distance from the nape to the alveolar edge of the incisors I of the upper jaw
9	Length of cannon bone(forearm)	Distance from the lateral tubercular of the os metacarpal IV to the fetlock joint
10	Cannon bone circumference (forearm)	The smallest circumference of the cannon bone of the forelimb
11	Length of cannon bone (hind leg)	Distance from the lateral tubercular of the os metatarsal IV to the middle of fetlock joint
12	Cannon bone circumference (hind leg)	The smallest circumference of the cannon bone of hind leg
13	Width of hip	Distance from the left to the right point of hip
14	Chest circumference	Measured in a place of the saddle girth
15	Length of rear quarter	Distance from the most cranial and most dorsal point of the point of hip to the most caudal point of the pin bone

Data Analysis

All the collected data were double-checked for any type of errors occurred during data collection while in the field and on-spot corrections were made accordingly. All data were coded and recorded in Microsoft excel sheet. Quantitative data were analyzed using Statistical analyses System (SAS version 9.1). Descriptive statistics, frequency statistics, comparative statistics and association statistics were employed as convenient. Indices were calculated to provide ranking the reason of keeping horses. Qualitative morphological data such as coat colours, head and leg marks of the study populations were analysed using frequency procedure. Means of the linear body measurements of the horse populations across the districts were estimated separately for males, females and aggregated gender. Least squares means with their corresponding standard errors were calculated for each linear body measurements over the study area. Linear body measurements were analyzed using Duncan Multiple Range Test for comparison of main effects. The linear body measurements were fitted as dependent variables. Location and sex were fitted as fixed independent variables. The values were considered significant at $P \leq 0.05$. The Pearson coefficient of correlation among various body measurements of horses in the study area was also computed.

3. Results and Discussions

The characteristics of the households involved in the study

The household characteristics of the study area are presented in Table 4. The majority of the households in the study area were male headed (87.78%). This might be due to the fact that males are closely related to livestock handling and management. Female headed households were about 23.33%, 5.56% and 7.78% for Digaluna Tijo, Lemu Bilbilo and Enkolo Wabe districts, respectively. This finding is similar to the repot of Asmare and Yayeh (2017) where 92.5% of the households were male headed in Awi zone. Wolelie (2016) also reported that the majority of the households in Western Shewa zone of Oromia region, central Ethiopia were male headed. There is no significant difference between districts in average ages of the household heads. The mean ages were 45.69, 46.77 and 48.63 years, for Digaluna Tijo, Lemu Bilbilo and Enkolo Wabe districts, respectively (Table 4). The majority of the household heads were within the age groups 31- 40(30%) and 41-59(24.07%). This indicates that the community were in highly productive age group. The age structure of household heads in the study area was similar to the findings of Asmare and Yayeh (2017). The majority (38.52%) of the respondents in the study area were unable to read and write, followed by elementary school (34.07%). The educational characteristics of horse owner respondents were almost in agreement with the earlier reports in Ethiopia (Ayza, 2013; Asmare *et al.*, 2017; Wolelie, 2016) for different districts of Ethiopia. Higher population of respondents that were unable to read and write, in the study districts, might be due to poor access to adult education and lack of awareness about the importance of education. This might have negative impact on adoption of new technologies for the improvement of livestock production and productivity, particularly that of horses. The average family size was 7.10, 5.68, and 6.74 for Digaluna Tijo, Lemu Bilbilo and Enkolo Wabe, respectively; where large family size was observed in Digaluna Tijo district ($p \leq 0.05$). The overall average family size (6.51) of the study area was comparable to the report of Asmare and Yayeh (2017) whose average family size was 7.00. This medium family size of the study site might be due to the use of family planning.

Table 4: General household characteristics in the three study districts of Arsi zone

Household characteristics	District(Means±SE)			Over all
	Digaluna Tijo N=90 (%)	Lemi Bilbilo N=90 (%)	Enkolo Wabe N=90 (%)	
Respondent's sex				
Male	69(76.67)	85(94.44)	83(92.22)	237(87.78)
Female	21(23.33)	5(5.56)	7(7.78)	33(12.22)
Av. R's age	45.69 ±1.48[a]	46.77±1.47[a]	48.63±1.39[a]	47.03±0.84
Respondent's age structure				
≤30	7(7.78)	11(12.22)	9(10.00)	27(10)
31-40	34(37.78)	29(32.22)	18(20.00)	81(30)
41-50	22(24.44)	18((20.00)	25(27.78)	65(24.07)
51-60	11(12.22)	10(11.11)	19(21.11)	40(14.82)
>60	16(17.78)	22(24.44)	19(21.11)	57(21.11)
Respondent's educational level				
Unable to read and write	31(34.44)	24(26.67)	49(54.44)	104(38.52)
Religious School	5(5.56)	2(2.22)	5(5.56)	12(4.44)
Elementary(1-4)	36(40.00)	36(40.00)	20(22.22)	92(34.07)
Primary(5-8)	18(20.00)	20(22.22)	13(14.44)	51(18.89)
Secondary(9-10+2)	0(0.00)	8(8.89)	3(3.33)	11(4.07)
Respondent's marital status				
Married	84(93.33)	88(97.78)	80(88.89)	252(93.33)
Divorced	4(4.44)	0(0.00)	7(7.78)	11(4.07)
Widowed	2(2.22)	2(2.22)	3(3.33)	7(2.59)

HH family size				
Av. male size	3.77±0.18^{a}	3.01±0.16^{b}	3.69±0.18^{a}	3.49 ±0.10
Av. Female size	3.33±0.17^{a}	2.67±0.14^{b}	3.06±0.15^{ab}	3.02 ±0.09
AV. family size	7.10±0.23^{a}	5.68±0.24^{b}	6.74±0.26^{a}	6.51 ±0.15

Means with the same letter within the same row are not significantly different at p (0.05); Av.= Average; N = Number of observation; Av. R's age = Average Respondent's age; SE= Standard Error; HH=Household.

Farming activities

In the study area, livestock rearing and crop production are the main farming activities for the livelihood of households (78.89%) (Table 5). About 81.85% of the households were dependent on crop production for food, 46.67% of the households were dependent on both livestock rearing and crop production for cash income. This finding is in agreement with findings of the study conducted by Alam *et al.* (2015) on the socio-economic status of horse owners in rural areas of Bangladesh. This can imply that the livelihood of the community in the study area is based on both livestock and crop production. Hence, the study area is under mixed crop-livestock production system which is consistent with the findings of (Asmare and Yayeh, 2017).

Table 5: Farming Activities in the study districts of Arsi Highlands

	District			Over all
	Digaluna Tijo N=90(%)	Lemu Bilbilo N=90(%)	Enkolo Wabe N=90(%)	
Major farming activities				
Livestock rearing	1(1.11)	0(0.00)	1(1.11)	2(0.74)
Crop production	13(14.44)	23(25.560	19(21.11)	55(20.37)
Both	76(84.44)	67(74.44)	70(77.78)	213(78.89)
More depend for food				
Livestock rearing	0(0.00)	0(0.00)	2(2.22)	2(0.74)
Crop production	77(85.56)	83(92.22)	61(67.78)	221(81.85)
Both	13(14.44)	7(7.78)	27(30.00)	47(17.41)
More depend for cash				
Livestock rearing	38(42.22)	34(37.780	42(46.67)	114(42.22)

Crop production	8(8.89)	12(13.33)	10(11.11)	30(11.11)
Both	44(48.89)	44(48.89)	38(42.22)	126(46.67)

N= number of respondents; both=Livestock rearing and crop production.

Composition of Livestock

The major livestock species in the study districts are cattle, sheep, goats, horses, mules, donkeys and chickens (Table 6). The average cattle per households, in the study areas, were higher followed by sheep. There is no significant difference between Lemu Bilbilo and Enkolo Wabe districts in horse composition ($p \leq 0.05$). The overall average horse per house hold in the study area was 2.20±0.07.

Table 6: Livestock category and their number per house hold in the study areas

Live-stock	District (Means±SE)			Over all
	Digaluna Tijo N=90	Lemu Bilbilo N=90	Enkolo Wabe N=90	
Cattle	7.73 ± 0.59^{a}	6.69 ± 0.46^{a}	8.21 ± 1.07^{a}	7.54±0.43
Sheep	6.20 ± 0.31^{a}	6.26 ± 0.64^{a}	6.20 ± 0.51^{a}	6.22±0.29
Goat	1.20 ± 0.22^{a}	0.64 ± 0.17^{a}	0.98 ± 0.20^{a}	0.94±0.11
Horse	2.54 ± 0.14^{a}	2.00 ± 0.10^{b}	2.06 ± 0.12^{b}	2.2±0.07
Mule	0.14 ± 0.05^{a}	0.02 ± 0.02^{b}	0.10 ± 0.03^{ab}	0.09±0.02
Donkey	1.04 ± 0.10^{a}	0.53 ± 0.07^{b}	1.22 ± 0.12^{a}	0.93±0.06
Chicken	7.12 ± 0.40^{a}	6.46 ± 0.42^{a}	7.40 ± 0.55^{a}	6.99±0.27

Means with the same letter within the same row are not significantly different at p (0.05); SE= standard error.

Horse ownership in the family

The male head owned higher proportion of horses (55.19%). The proportion of horses owned by both husband and wife together was 40% (Table7); which is almost consistent with findings of (Padilha *et al*., 2017). The result could be due to closer relation of males to horses than female farmers.

Table 7: Horse ownership of the family in the study area

Horse ownership	District			Over all
	Digaluna Tijo N=90(%)	Lemu Bilbilo N=90(%)	Enkolo Wabe N=90(%)	
Male head	34(37.78)	66(73.330	49(54.44)	149(55.19)
Female head	5(5.56)	0(0)	8(8.89)	13(4.82)
Sons	0(0)	0(0)	0(0)	0(0)
Daughters	0(0)	0(0)	0(0)	0(0)
Husband and wife together	51(56.67)	24(26.67)	33(36.67)	108(40)
The whole family	0(0)	0(0)	0(0)	0(0)

N= number of respondents

Activities of members of households for horse management

Regarding responsibilities related to horse activities on purchasing, selling, herding, caring for sick horse, and breeding of horse, clear pattern of male dominancy was observed in the entire study districts. The responsibility of purchasing and selling of horses was dominated by male household heads. This was in agreement with the report of Gurmessa *et al.* (2015) in Arsi Negelle district for goats. Feeding of horse was shared by both male and female (62.22%). Barn cleaning which is a routine activity was dominated by females (76.30%) (Table 8). All activities of horse management in all study area were done by family labour.

Table 8: Member of house hold responsible for horse activities in the study districts of Arsi highlands

Horse activities	**District**			**Over all**
	Digaluna Tijo N=90(%)	**Lemu Bilbilo N=90(%)**	**Enkolo Wabe N=90(%)**	
Purchasing				
Male	85(94.44)	89(98.89)	70(77.78)	244(90.37)
Female	29(2.22)	0(0)	2(2.22)	49(1.48)
Both	3(3.33)	1(1.11)	18(20.000	22(8.15)
Selling				

Male	78(86.67)	89(98.89)	70(77.78)	237(87.78)
Female	10(11.11)	0(0)	3(3.33)	13(4.82)
Both	2(2.22)	1(1.11)	17(18.89)	20(7.41)
Herding				
Male	71(78.89)	60(66.67)	50(55.56)	181(67.04)
Female	14(15.56)	0(0)	6(6.67)	20(7.41)
Both	5(5.56)	30(33.33)	34(37.78)	69(25.56)
Breeding				
Male	67(74.44)	82(91.11)	63(70.00)	212(78.52)
Female	22(24.44)	0(0)	7(7.78)	29(10.74)
Both	1(1.11)	8(8.89)	20(22.22)	29(10.74)
Caring for sick horse				
Male	69(76.67)	72(80.00)	37(41.11)	178(65.93)
Female	9(10.000	2(2.22)	3(3.33)	14(5.19)
Both	12(13.33)	16(17.78)	50(55.56)	78(28.89)
Feeding				
Male	25(27.78)	42(46.67)	13(14.44)	80(29.63)
Female	18(20.00)	0(0)	4(4.44)	22(8.15)
Both	47(52.22)	48(53.33)	73(81.11)	168(62.22)
Barn cleaning				
Male	13(14.44)	0(0)	0(0)	13(4.82)
Female	65(72.22)	77(85.56)	64(71.11)	206(76.30)
Both	12(13.33)	13(14.44)	26(28.89)	51(18.89)

N= number of respondents; Both=Male and Female

Population size trends in major livestock species

The trend of livestock in the study area is presented in Table 9. According to most of the respondents, cattle and goat were in a decreasing trend while horse, mule and donkey were stable. This could be associated with the shortage of grazing land, recurrent drought and incidence of diseases. The finding is congruent with the report of Tesfaye *et al*. (2012).

Table 9: Population size trend of livestock species in the study area

Livestock	District			
	Digaluna Tijo N (%)	Lemu Bilbilo N (%)	Enkolo Wabe N (%)	Over all
Cattle				
Increasing	24(26.97)	57(64.04)	36(40.00)	117(43.66)
Decreasing	65(73.03)	32(35.96)	54(60.00)	151(56.34)
Stable	0(0)	0(0)	0(0)	0(0)
Sheep				
Increasing	73(82.02)	54(61.36)	59(71.08)	186(71.54)
Decreasing	15(16.85)	33(37.50)	21(25.30)	69(54)
Stable	1(1.12)	1(1.14)	3(3.61)	5(1.92)
Goat				
Increasing	3(8.82)	4(18.18)	8(30.77)	15(18.29)
Decreasing	18(52.94)	11(50.00)	14(53.85)	43(52.44)
Stable	13(38.24)	7(31.82)	4(15.38)	24(29.27)
Horse				
Increasing	11(12.22)	4(4.44)	4(4.44)	19(7.04)
Decreasing	22(24.44)	26(28.89)	10(11.11)	58(21.48)
Stable	57(63.33)	60(66.67)	76(84.44)	193(71.48)
Mule				
Increasing	0(0)	0(0)	0(0)	0(0)
Decreasing	1(9.09)	0(0)	0(0)	1(4.35)
Stable	10(90.91)	2(100)	10(100)	22(95.65)
Donkey				
Increasing	12(18.18)	0(0)	1(1.39)	13(7.30)
Decreasing	12(18.18)	6(15.00)	2(2.78)	20(11.24)
Stable	42(63.64)	34(85.00)	69(95.83)	145(81.46)
Chicken				
Increasing	72(88.89)	63(79.75)	69(85.19)	204(84.65)
Decreasing	5(6.17)	16(20.25)	7(8.64)	28(11.62)
Stable	4(4.94)	0(0)	5(6,17)	9(3.73)

N= number of respondents

Purposes of keeping horses

Awareness of reasons for keeping animals is a prerequisite for deriving operational breeding goals (Alam et al., 2015). In the study area horses were kept for riding, cart pulling, wealth and/or source of cash income, insurance against emergency, cultural purpose and load carrying (Table 10). The households in Digaluna Tijo were keeping their horses mainly for riding followed by Cash income (sale)/wealth with an index of 0.52 and 0.22 respectively. However, the households in Lemu Bilbilo and Enkolo Wabe districts were keeping their horses mainly for riding followed by cart pulling with an index of 0.57, 0.26 for Lumu Bilbilo district and 0.61, 0.15 for Enkolo Wabe district, respectively (Table 10). The result was in line with the studies of Alam *et al.* (2016); Makki and Mohammad (2013) who reported equines can be used for different roles in the farm family daily chores such as transportation of goods by pack and cart due to their sturdy nature and manageable behaviour. Functions like ploughing and dowry had not received any ranking among the reasons of keeping horses in the study area. However, Abyssinian horses are used for ploughing in northern Ethiopia (Kefena *et al.,* 2012; Asmare and Yayeh, 2017).

Table 10: Purpose of keeping horse in each district and ranking of the purpose

Purpose	District											
	Digaluna Tijo				Lemu Bilbilo				Enkolo Wabe			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Riding	73	7	4	0.52	69	14	-	0.57	78	10	-	0.61
Cart pulling	-	28	7	0.14	21	22	-	0.26	6	19	5	0.15
Cash income(sale)/wealth	13	25	12	0.22	-	13	13	0.10	1	17	4	0.10
Land ploughing	-	-	-	0.00	-	-	-	0.00	-	-	-	0.00
Cultural purpose	-	-	7	0.02	-	-	1	0.00	2	-	5	0.02
Insurance	-	-	5	0.01	-	-	-	0.00	-	-	-	0.00
Dowry	-	-	-	0.00	-	-	-	0.00	-	-	-	0.00
Load carrying	4	12	9	0.10	-	9	10	0.07	3	13	13	0.12
Overall	90	72	44	1.00	90	58	24	1.00	90	59	27	1.00

R1, R2 and R3 = rank 1, 2, and 3 respectively. I= index; Index = sum of (3 for rank 1 + 2 for rank 2 +1 for rank3) given for an individual reason (attribute) divided by the sum of (3 for rank 1 + 2 for rank 2+ 1 for rank 3) for overall reason.

Qualitative morphological traits of horses in the study area are summarized in Table 11. The coat colours varied across the districts. Most common horses' coat colours were chestnut (46.97%), black (12.88%) and bay (12.12%) for Digalo Tijo horses; chestnut (40.91%), grey (17.42%) and bay (15.15%) for Lemu Bilbilo horses; Chestnut (43.94%), bay (18.94%) and grey (13.64%) for Enkolo Wabe horses. In the study conducted by (Kefena *et al.,* 2012) on morphological diversities and ecozones of Ethiopian horse populations, all horses are characterized by uniform bay coat colour and are good looking. The finding of the current study is also comparable to the other report by Alam *et al*. (2016) and Dorji *et al*. (2017). On the other hand, the major head mark of the horses in the current study across all the three districts was star while the main leg mark for Digaluna Tijo and Enkolo Wabe horses was coronet but the main leg mark for Lemu Bilbilo horses was half pastern.

Table 11: Frequency of coat colours and markings by district

Traits	**Districts**			**Overall**
	Digaluna Tijo N=132 (%)	**Lemu Bilbilo N=132(%)**	**Enkolo Wabe N=132(%)**	
Coat colour				
Chestnut	62 (46.97)	54 (40.91)	58 (43.94)	174 (43.94)
Bay	16 (12.12)	20 (15.15)	25 (18.94)	61 (15.40)
Grey	15 (11.36)	23 (17.42)	18 (13.64)	56 (14.14)
Black	17 (12.88)	17 (12.88)	14 (10.61)	48 (12.12)
White	4 (3.03)	2 (1.52)	4 (3.03)	10 (2.53)
Palomino	11 (8.33)	11 (8.33)	8 (6.06)	30 (7.58)
Roan	7 (5.30)	5 (3.79)	5 (3.79)	17 (4.29)
Head mark				
Star	62 (46.97)	74 (56.06)	78 (59.09)	214 (54.04)
Stripe	32 (24.24)	28 (21.21)	29 (21.97)	89(22.48)
Blaze	20 (15.15)	15 (11.36)	16 (12.12)	51 (12.88)
Snip	12 (9.09)	10 (7.78)	3 (2.27)	25 (6.31)
Bald face	6 (4.55)	5 (3.79)	6 (4.55)	17 (4.29)
Leg mark				
Plain	86 (65.15)	94 (71.21)	92 (69.70)	272 (68.69)
Coronet	18 (13.64)	14 (10.61)	15 (11.36)	47 (11.87)
Half pastern	11(8.33)	17 (12.88)	9 (6.82)	37 (9.34)
Sock	9 (6.82)	2 (1.52)	4 (3.03)	15 (3.79)
Half cannon	5 (3.79)	2 (1.52)	7 (5.30)	14 (3.54)
Stocking	2 (1.52)	3 (2.27)	4 (3.03)	9 (2.27)
High white	1 (1.76)	0 (0.00)	1 (0.76)	2 (0.5)

N= Number of horses

Regarding quantitative morphological traits, comparison of means indicated that there was no significant difference ($p \leq 0.05$) between the male horses of the study districts in all of the quantitative morphological variables except the length of rear quarter (Lrq) which was significantly lower for Lemu Bilbilo male horses($P \leq 0.05$) (Table12). The resemblance of majority of the linear body measurements of the male horses in the study area were similar to the findings of Kefena *et al*. (2012) for Selale and Kafa stallions.

Table 12: Means, standard error (SE) and pairwise comparison of morphological traits across the study districts: female horses.

Traits[1] (cm)	**Districts**		
	Digaluna Tijo N=66	**Lemu Bilbilo N=66**	**Enkolo Wabe N=66**
Hw	130.67 (0.69)[a]	131.11 (0.51)[a]	132.12 (0.61)[a]
Hb	127.18 (0.61)[a]	127.61 (0.43)[a]	127.50 (0.45)[a]
Hr	131.45(0.59)[a]	131.85 (0.49)[a]	132.58 (0.59)[a]
Bol	129.71(0.38) [a]	129.59 (0.50)[a]	129.97 (0.41)[a]
Bal	63.65 (0.37)[a]	63.50 (0.35)[a]	63.45 (0.39)[a]
Brl	67.56 (0.67)[a]	67.59 (0.62)[a]	67.83 (0.57)[a]
Nl	66.27 (0.58)[a]	66.08 (0.43)[a]	66.38 (0.49)[a]
Hl	52.82 (0.32)[a]	52.52 (0.35)[a]	52.76 (0.32)[a]
Lcb^f	25.45 (0.28[a]	25.12 (0.32)[a]	24.95(0.24)[a]
Cbc^f	17.35 (0.19)[a]	17.59 (0.25)[a]	17.55 (0.25)[a]
Lcb^h	28.47 (0.35)[a]	28.20 (0.37)[a]	28.65 (0.33)[a]
Cbc^h	18.38 (0.22)[a]	18.63 (0.20)[a]	18.30 (0.20)[a]
Wh	40.98 (0.34)[a]	40.60 (0.37)[a]	40.41(0.37)[a]
Cc	142.05 (0.41)[a]	141.98 (0.53)[a]	142.74 (0.63)[a]
Lrq	41.20 (0.26)[a]	39.89 (0.39)[b]	40.95 (0.33)[a]

Means with the same letter within the same row are not significantly different at $p \leq 0.05$); SE= standard error; centimetre; N=Number of horses. [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (forelimb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=forellimbimb. h= hind limb

There was no significant difference ($P \leq 0.05$) for all of the studied quantitative morphological characteristics among female horses across the study districts (Table13). The finding is consistent with that of Kefena *et al*. (2012) who stated the female horses showed close similarity with Selale and kafa mares.

Table 13: Means, SE and pairwise comparison of morphological traits across the study districts: female horses.

Traits[1] (cm)	Districts		
	Digaluna Tijo N=66	Lemu Bilbilo N=66	Enkolo Wabe N=66
Hw	129.65 (0.57)^a	130.09 (0.47)^a	130.65 (0.58)^a
Hb	124.30 (0.28)^a	125.03 (0.24)^a	125.00 (0.29)^a
Hr	131.24 (0.63)^a	130.62 (0.36)^a	130.14 (0.42)^a
Bol	128.05 (0.29)^a	128.27 (0.57)^a	128.71 (0.36)^a
Bal	64.17 (0.35)^a	64.08 (0.34)^a	63.41(0.37)^a
Brl	67.15 (0.65)^a	67.05 (0.41)^a	66.58 (0.50)^a
Nl	65.11 (0.55)^a	65.00 (0.39)^a	66.38 (0.52)^a
Hl	52.05 (0.30)^a	51.48 (0.27)^a	51.35 (0.33)^a
Lcb^f	24.27 (0.21)^a	23.82 (0.22)^a	24.22 (0.22)^a
Cbc^f	16.45 (0.19)^a	16.64 (0.21)^a	16.68 (0.20)^a
Lcb^h	27.59 (0.36)^a	27.65 (0.30)^a	27.72 (0.32)^a
Cbc^h	17.62 (0.18)^a	17.53 (0.16)^a	17.61 (0.21)^a
Wh	39.50 (0.25)^a	39.56 (0.31)^a	39.47 (0.39)^a
Cc	139.62 (0.35)^a	140.09 (0.52)^a	140.08 (0.55)^a
Lrq	39.35 (0.39)^a	39.09 (0.47)^a	39.47 (0.35)^a

Means with the same letter within the same row are not significantly different at p (0.05); SE= standard error; cm=centimetre; N=Number of horses. [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (forelimb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=forelimb; h=hind limb.

Comparison of least squares means indicated that there was no significant difference ($P\leq0.05$) in all of the quantitative morphological traits across the study districts except height at withers (Hw) which was significantly lower for Digaluna Tijo horses ($P<0.05$) (Table14). The similarity in linear body measurements across the study districts could be due to the similarity in the agro-ecology, production system, management system and genetic back grounds. The least squares means of the width of hip (Wh), chest circumference (Cc) and length of rare quarter (Lrq) of horses for aggregated gender in the present study were as lower as that of Abyssinian horses. This result is partially in lined the findings of the team of researchers (Kefena *et al.*, 2012) from Ethiopia and that of Padilha *et al.* (2017) from Brazil. This may be due to low body condition of the horses in the study area during data collection.

Table 14: Least squares means, SE and pairwise comparison of quantitative morphological traits of the horses in the study area: aggregated gender.

Traits[1] (cm)	**Districts**		
	Digaluna Tijo N=132	**Lemu Bilbilo N=132**	**Enkolo Wabe N=132**
Hw	130.16 (0.45)^{b}	130.60 (0.35)^{ab}	131.39 (0.42)^{a}
Hb	125.74 (0.35)^{a}	126.32 (0.27)^{a}	126.25 (0.29)^{a}
Hr	131.35 (0.43)^{a}	131.23 (0.31)^{a}	131.36 (0.38)^{a}
Bol	128.89 (0.25)^{a}	128.93 (0.38)^{a}	129.34 (0.28)^{a}
Bal	63.91 (0.25)^{a}	63.79 (0.24)^{a}	63.42 (0.27)^{a}
Brl	67.51 (0.45)^{a}	67.32 (0.37)^{a}	67.28 (0.37)^{a}
Nl	65.69 (0.40)^{a}	65.68 (0.29)^{a}	65.69 (0.36)^{a}
Hl	52.43 (0.22)^{a}	52.00 (0.23)^{a}	52.05 (0.24)^{a}
Lcb^{f}	24.86 (0.18)^{a}	24.45 (0.20)^{a}	24.59 (0.17)^{a}
Cbc^{f}	16.90 (0.14)^{a}	17.11 (0.17)^{a}	17.11 (0.17)^{a}
Lcb^{h}	28.03 (0.25)^{a}	27.92 (0.24)^{a}	28.19 (0.23)^{a}
Cbc^{h}	18.00 (0.15)^{a}	18.08 (0.14)^{a}	17.95 (0.15)^{a}
Wh	40.24 (0.22)^{a}	40.08 (0.24)^{a}	39.94 (0.27)^{a}
Cc	140.83 (0.29)^{a}	140.96 (0.40)^{a}	141.33 (0.44)^{a}
Lrq	40.27 (0.25)^{a}	39.49 (0.31)^{a}	40.21 (0.25)^{a}

Means with the same letter within the same row are not significantly different at p (0.05); SE= standard error; cm=centimetre; N= Number of horses. [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^{f}=length of cannon bone (forelimb); Cbc^{f} =cannon bone circumference (forelimb); Lcb^{h} =length of cannon bone(hind limb); Cbc^{h} =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=fore limb; h= hind limb.

Means with the same letter within the same row are not significantly different at p (0.05); SE= standard error; cm=centimetre; N= Number of horses. [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (forelimb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=fore limb; h= hind limb.

Comparison of the quantitative morphological traits between male and female horses revealed the existence of significant differences ($P \leq 0.05$) in nearly all of the morphological traits except back length (Bal) and barrel length (Brl) which showed no significant difference between the sexes ($P \leq 0.05$) (Table15). Generally, male horses were significantly taller and longer than female horses. This indicates the existence of little sexual dimorphism in the horses of the study area. This finding is similar to the reports of (Kefena *et al*., 2012; Alam *et al*., 2016) but contradictory to the report of Dorji *et al*., 2017 where there was no significance difference between Bhutanese male and female horses ($P \leq 0.05$).

Table15: Means, SE and pairwise comparison of morphological traits of the horses in the study area: Comparison between male and female horses.

Traits[1] (cm)	**Sex**	
	Male N=198	**Female N=198**
Hw	131.30 (0.35)^a	130.13 (0.31)^b
Hb	127.43 (0.29)^a	124.78 (0.16)^b
Hr	131.96 (0.32)^a	130.67 (0.28)^b
Bol	129.76 (0.25)^a	128.34 (0.25)^b
Bal	63.53 (0.21)^a	63.88 (0.20)^a
Brl	67.66 (0.36)^a	66.92 (0.31)^a
Nl	66.24 (0.29)^a	65.14 (0.28)^b
Hl	52.70 (0.19)^a	51.63 (0.17)^b
Lcb^f	25.18 (0.16)^a	24.11 (0.13)^b
Cbc^f	17.49 (0.13)^a	16.59 (0.11)^b
Lcb^h	28.44 (0.20)^a	27.66 (0.19)^b
Cbc^h	18.44 (0.12)^a	17.59 (0.11)^b

Wh	40.67 (0.21)[a]	39.51 (0.19)[b]
Cc	142.26 (0.31)[a]	139.93 (0.28)[b]
Lrq	40.68 (0.20)[a]	39.30 (0.24)[b]

Means with the same letter within the same row are not significantly different at p (0.05); SE= standard error; cm=centimetre; N=Number of horses. [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (forelimb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=forelimb; h=hind limb.

Table16: Comparison of quantitative morphological traits of male hoses, female horses and aggregate sex of the study area with other Ethiopian males, females and aggregate sex.

Traits[1] (cm)	Males (study area)	Males (Kefena et a1. 2012)	Females (Study area)	Females (Kefena et a1. 2012)	Aggregate sex (Study area)	Aggregate sex (Kefena *et al.*, 2012)
Hw	131.30	Kaf(133.2)	130.17	Sel(129.6)	130.71	Sel(131.2)
Hb	127.43	Sel(127.8)	124.78	Sel(123.8)	126.10	Sel(125.6)
Hr	131.96	Kaf(132.6)	130.67	Sel(130.9)	131.31	Sel(131.7)
Bol	129.76	Aby(131.1)	128.34	Bal(129.0)	129.05	Aby(130.7)
Bal	63.53	Sel(60.4)	63.88	Sel(64.1)	63.71	Sel(61.9)
Brl	67.66	Bal(67.0)	66.92	Kaf(66.9)	67.37	Bal(67.5)
Nl	66.24	Bal(65.2)	65.14	Sel(65.6)	65.69	Aby(65.4)
Hl	52.70	Sel(52.9)	51.63	Kaf(49.3)	52.16	Bal(49.7)
Lcb^f	25.18	Sel(25.7)	24.11	Sel(23.6)	24.63	Sel(24.7)
Cbc^f	17.49	Kaf(17.6)	16.59	Kaf(16.1)	17.04	Kaf(16.9)
Lcb^h	28.44	Sel(28.1)	27.66	Sel(27.2)	28.05	Sel(27.7)
Cbc^h	18.44	Kaf(18.4)	17.59	Kaf(17.4)	18.01	Kaf(18.0)
Wh	40.67	Aby(41.2)	39.51	Aby(41.0)	39.99	Aby(41.0)
Cc	142.26	Aby(141.6)	139.93	Aby(139.0)	141.04	Aby(140.4)
Lrq	40.68	Aby(41.0)	39.30	Aby(40.3)	39.99	Aby(40.6)

[1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (fore limb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear

quarter; f=forelimb; h= hind limb Aby=Abyssinian; Bal=Bale; Kaf=Kafa; Sel=Selale;cm=centimetre.

Relative comparison of the horse populations in the present study with other studies indicates that they are generally similar to Bhutanese Boeta horses and Terciera Island pony horses with respect to Hw, Hb, Bol, Brl, and Cc (Table17). However, Hw, Hr, Bol, and Cc of the horse populations of the present study are by far smaller than that of the Algerian horses and Brazilian horses (Table 17). Similarly, Hw, Bol, and Cc of the horse populations of the present study are significantly smaller than that of Indian horses.

Generally, the present study horses had shorter height at withers (Overall Hw =130.71cm). This supports the report of Epstein (1971) cited in Kefena *et al.* (2012) who emphasized that the term pony usually applies to horses not over 140 cm in height. From this general assertion, though there are high body size variations within horse populations, the majority of the present study horse populations may be classified under pony horses.

Table 17: Comparison of mean of Arsi high land horses' linear body measurements of the present study with those reported by other authors with respect to some traits.

Trait [1] (cm)	Present study	Dorji *et al.,* 2017*; Bhutan	Benhamadi *et al.,* 2017; Algeria	Kewareti *et al.,* 2017 ; India	Padilha *et al.*, 2017; Brazil	Lopes *et al.,* 2015; Terciera Island; Portugal
Hw	130.71	128.00	152.5	149.46	162.00	128.48
Hb	127.43	122.90	-	-	-	122.70
Hr	131.96	-	150.10	-	163	128.48
Bol	129.76	135.8	160	150.23	160.00	127.67
Brl	67.66	73.30	-	-	-	57.97
Cc	142.26	151.9	175.5	169.53	184	147.60

[1]Hw=height at withers; Hb= height at back; Hr= height at rump; Bol= body length; Brl=barrel length; Cc= chest circumference; cm= centimetre; *= Bhutanese Boeta horses.

Correlation between linear body measurements

The Pearson coefficient of correlation among various body measurements of horses in the study area is presented, Table 18. Generally, the correlation of linear body measurements ranges from weak to moderate correlation for both sexes (Table 18). The correlation between linear body measurements was higher in male than female counter part. There was strong correlation between Hw and Hb=0.72;

Hw and Hr=0.82; Hb and Hr=0.75 in males compared to Hw and Hb=0.44; Hw and Hr=0.65; Hb and Hr =0.40 in females. This variation might be due to the difference in body dimension between male and female horses. Manly (1986) demonstrated that morphological variables that have the highest correlation among themselves are good raw materials for multivariate analysis. This implies that selecting horses for one of these morphological variables, especially for Hw simultaneously improves other variables that have high correlation with it. Most of the correlation coefficients between linear body measurements was positive and significant ($P \leq 0.05$) for both sexes in the study area. The association may be useful as selection criteria since positive correlation of traits suggest that the traits may be under the same genetic influences (Asefa *et al.*, 2017).

Table 18: Correlation coefficients among linear body measurements of male and female horses in the study area (values below the diagonal are for males and above the diagonal are for females; N= 198 males, N=198 females).

	Hw	**Hb**	**Hr**	**Bol**	**Bal**	**Brl**	**Nl**	**Hl**	**Lcb^f**	**Cbc^f**	**Lcb^h**	**Cbc^h**	**Wh**	**Cc**	**Lrq**
Hw1		0.44*	0.65*	0.26*	0.19*	0.40*	0.23*	0.08	0.11	0.45*	0.13	0.36*	0.27*	0.43*	0.03
Hb	0.72*		0.40*	0.07	-0.01	0.19*	0.12	-0.06	-0.02	0.27*	0.09	0.22*	0.19*	0.09	-0.08
Hr	0.82*	0.75*		0.16*	0.13	0.38*	0.28*	-0.03	0.18*	0.41*	0.30*	0.30*	0.27*	0.27*	-0.05
Bol	0.29*	0.25*	0.18*		0.09	0.15*	0.07	0.01	0.02	0.23*	0.16*	0.08	0.13	0.19*	0.12
Bal	0.20*	0.22*	0.20*	0.03		0.22*	0.35*	-0.02	-0.04	0.12	-0.12	0.15*	-0.03	0.11	-0.11
Brl	0.45*	0.27*	0.47*	0.17*	0.13		0.29*	0.10	0.11	0.08	-0.04	0.07	0.05	0.14*	-0.10
Nl	0.28*	0.36*	0.37*	0.15*	0.22*	0.23*		-0.01	0.06	0.32*	0.07	0.14*	0.19*	0.08	-0.05
Hl	-0.06	-0.04	-0.02	-0.03	0.14*	-0.08	0.10		0.12	-0.09	-0.09	-0.07	-0.04	-0.12	0.08
Lcb^f	0.22*	0.19*	0.31*	-0.02	0.16*	0.14*	0.01	0.12		0.07	0.26*	0.16*	0.13	-0.18*	0.04
Cbc^f	0.34*	0.38*	0.35*	0.16*	0.11	0.13	0.13	-0.08	0.31*		0.23*	0.52*	0.38*	0.38*	0.11
Lcb^h	0.32*	0.26*	0.34*	0.09	-0.06	0.07	-0.03	-0.01	0.40*	0.35*		0.25*	0.30*	0.07	0.06
Cbc^h	0.44*	0.42*	0.47*	0.20*	0.07	0.30*	0.20*	-0.03	0.41*	0.45*	0.45*		0.34*	0.26*	0.15*
Wh	0.31*	0.27*	0.34*	0.04	-0.06	0.30*	0.07	0.03	0.15*	0.15*	0.25*	0.30*		0.24*	-0.12
Cc	0.49*	0.42*	0.47*	0.16*	0.14*	0.40*	0.24*	0.03	-0.01	0.25*	0.12	0.29*	0.33*		0.13
Lrq	0.22*	0.18*	O.15*	0.27*	-0.07	0.08	0.12	-0.14	-0.14	0.24*	0.11	0.26*	0.11	0.18*	

*$P \leq 0.05$; [1]Hw=height at wither; Hb=height at back; Hr=height at rump; Bol=body length; Bal=back length; Brl=barrel length; Nl=neck length; Hl=head length; Lcb^f=length of cannon bone (fore limb); Cbc^f =cannon bone circumference (forelimb); Lcb^h =length of cannon bone(hind limb); Cbc^h =cannon bone circumference (hind limb); Wh=width of hip; Cc=chest circumference; Lrq= length of rear quarter; f=forelimb

4. Conclusions

Generally, the finding of this study revealed that there are considerable similarities among horse populations across the study districts of Arsi highlands of Ethiopia, predominantly in terms of linear body measurements characters. There were observed variations in defining qualitative and few morphometric traits among the studied horses. This may enable farmers and breeders to select horses with useful traits in terms of size, color and others traits of interest to improve performance, marketability, soundness and functions of horses in the area. This may again contribute to set future conservation strategies for horses breeding improvement. Horses in the study areas exhibited a deep back, a paunchy belly, and an unsound conformation. They put in a lot of work and are used for a variety of tasks as the main sources of animal power for the transportation system and crop production. Based on the studied quantitative traits, the observed insignificant differences among horse populations across the study districts could be due to the similarity in the agro-ecology, management practices and genetic backgrounds. This further needs phylogenetic study and molecular characterization of these horse genetic resources of the area. The present study areas were observed to be home for huge potential of horse genetic resources and where horses are multipurpose animals in supporting and improving livelihood, contemporary socio-economic aspects, of the smallholder farmers. The majority of the households were male headed in the productive age group. However, most of them were unable to read and write which might have negative impact on the proper use of horse genetic resources and adoption of modern technologies to plan and implement horse management and conservation programmers. Therefore, farmer based adult education and training must be provided to alleviate the problems due to lack of education. Training on proper management and conservation practices are very important to enhance the socio-economic roles of the horses. As this study was an initial assessment on horse population status of the study areas, based on few sample and limited morphological traits further comprehensive studies including molecular characterization should be conducted in future.

Conflicts of interests

The authors declare no conflicts of interest.

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Authors' contributions Temesgene Bedassa Gudeta designed the study, Supervised, managed data quality and performed data analysis and interpretation. Wagari Diriba conducted study, collected the data and wrote the paper. The two authors, together, read and approved the final manuscript.

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