Review

Characterization of productive and reproductive performances, morphometric and challenges and opportunities of indigenous cattle breeds of Ethiopia: A review

Teweldemedhn Mekonnen

Humera Agricultural Research Center, Tigray Agricultural Research Institute, Setit Humera, Tigray Regional State, Ethiopia.

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The aim was to review and summarize the fragmented characterization information of indigenous cattle breeds of Ethiopia in productive and reproductive performances, morphometric traits and their production challenges and opportunities. Cattle play vital role in ensuring food security of Ethiopia. They contributed milk which accounted above 80% of the total national annual milk production. Although Ethiopia has large indigenous cattle populations with massive diversity, breed level on-farm and on-station characterizations on lactation performance, reproductive performances, morphometric traits and identification of the major challenges and opportunities is very poor. Morphological markers particularly morphometric traits are very important for livestock characterization. Hence, on-farm and on-station characterization and improvement of indigenous cattle breeds should be practiced. Ethiopian Institute of Biodiversity Conservation, Domestic Animal Diversity Information System and Domestic Animal Genetic Resources Information System documented different types and numbers of indigenous cattle breeds of Ethiopia. Hence, the national, regional and global reporting systems should be standardized. This review also indicated that the critical challenge of the studied indigenous cattle breeds of Ethiopia is scarcity of feed which accounted 77.8% of the first ranked challenges; however, there are no reported production opportunities of each indigenous cattle. Therefore, every shareholder should solve the primary challenge and identify the opportunities. Indigenous cattle breeds of Ethiopia are adapted to harsh climatic conditions; limited and poor quality feed resources utilization and tolerance to a range of diseases. However, the current state of knowledge of indigenous scholars on each indigenous cattle breed is below 50%.

Key words: Indigenous cattle, calf crop, lactation performance, reproductive performance, morphometric traits.

INTRODUCTION

Agricultural sector of Ethiopia accounts for about 42% of the GDP, employs about 85% of the labour force, and...
contributes around 90% of the total export earnings of the country. The sector is dominated by over 15 million smallholders producing about 95% of the national agricultural production. Hence, the overall economy of the country and the food security of the majority of the population depend on smallholder agriculture (CSA, 2015, 2016). Ethiopia is rich in livestock population that owned 59.5 million cattle, 30.7 million sheep, 30.2 million goats and 59.5 million chickens (CSA, 2016, 2017). Major livestock species were imported to enhance livestock productivity of Ethiopia through crossbreeding. Accordingly, the number of breeds of cattle, sheep, goat and chicken imported so far to Ethiopia are 7, 7, 3, and 14, respectively (EIBC, 2012). Cattle are the most important species followed by goats, camels, and sheep in the pastoral livestock production system, and are source of food in the form of milk, meat and blood, and source of other products such as fiber and hides (FAO, 2009). Cattle herds are much larger in the pastoral areas and average about 75 head in Borena, Ethiopia. In the mixed farming areas, herds are much smaller being 5.7 head in East Harerghé, 8.6 in Illubabor and 11.8 in the central highlands (MoARD, 2007). In mixed farming system, cattle provide draught power and manure for cropland fertilization beside to milk production (Agajie et al., 2002), whereas the purpose of keeping cattle in pastoral production system is for breeding and selling, in agro pastoral production system for meat and draught power and in highland mixed crop-livestock production is for draught power and sale of culls (MoARD, 2007). Draft power is critical input in the central highlands of Ethiopia in the prevailing traditional mixed farming system. This is service of oxen and the oxen populations constitute 30% of the total cattle population and on average a household has two oxen (Goe, 1987). The highlands of Ethiopia are dependent on draft power of oxen in that on average an ox works for 900 h/year (Gryseels, 1988).

A more recent report indicated that 98.20% of the total cattle population in Ethiopia are local breeds while hybrid and exotic breeds accounted for about 1.62 and 0.18%, respectively (CSA, 2016/2017). FAO (1993) reported that cow milk constitutes 83.4% of the total milk produced in Ethiopia and CSA (2008/09) also indicated that cattle have the largest contribution (81.2%) of the total national annual milk output. CSA (2014/2015) report on milk utilization indicated that 46.36% of the total annual milk production was used for household consumption, 5.98% was sold, only 0.33% was used for wages in kind and the rest 43.33% was used for other products (could be for the production of butter, Cheese, and others). CSA (2014/15) also reported on beef cattle utilization in that 52.93% of the total annual production was used for household consumption, 33.18% was used sold, 0.71% was paid for wages in kind and 13.18% was used for other products. 40.02% of the total annual cattle hide production was used for household service, 53.94% of the total was sold, 0.27% was paid for wage in kind whereas 5.76% of the total annual production was used for other different products (CSA, 2014/2015). A review by Hedge (2002) indicated that cattle average daily milk yield of pastoral livestock production system varies with season which range from 0.5 to 5 kg per day. The main feed resources of pastoral production system are natural pastures; herbaceous vegetation composed mainly of grasses and forbs, and browse such as shrubs, tree leaves and pods (Adugna and Aster, 2007). Poor health services, feed shortage and low genetic potential of animals are the main constraints that restrain livestock productivity of Ethiopia (Ibrahim and Olaloku, 2000). However, adaptation to harsh climatic conditions, ability to better utilize the limited and poor quality feed resources and tolerance to a range of diseases make indigenous livestock breeds of Ethiopia to be valuable source of genetic material (DAGRIS, 2009).

The national average lactation period per cow was estimated to be about six months and average daily milk yield per cow was about 1.32 L (CSA, 2012/13). Characterization information is essential for planning the management of farm animal genetic resources at local, national, regional and global levels (FAO, 2011). On the contrary, although Ethiopia has large livestock population with massive diversity, breed level characterization and knowledge is inadequate (Workneh et al., 2004) and DAGRIS (2009) also reported that there is little attention given to characterize, identify and conserve the diversity of the various classes of livestock. There are different cattle populations in the country, however, the national cattle characterization work of each cattle population is not well summarized and the current state of knowledge on all indigenous cattle is not known. Moreover, it is obvious and many times reported that cattle productivity in Ethiopia is extremely low. This low cattle productivity is due to different cattle production challenges. Therefore, it is essential to know cattle challenges and opportunities at national level to be an input in the future research and development works. Therefore, the specific objectives of the review system comprised to review the productive and reproductive performances of indigenous cattle, to review the status of morphometric characterization of indigenous cattle and to review the challenges and opportunities of indigenous cattle of Ethiopia.

MATERIALS AND METHODS

Geographical location of Ethiopia

Ethiopia is located in the horn of Africa and is bordered by Eritrea in the north, Djibouti and Somalia in the east, Kenya in the south and Sudan in the west. It is located in 3°N of the equator to latitude 16°N and 33°E to 48°E longitude (MoA, 2004; EIBC, 2014). Ethiopia as a country has an area of 1,127,127 km². It is a country of great geographic diversity with wide altitudinal and physiographic variations. The altitude ranges from 116 m below sea level in the Danakil Depression in Afar national regional state to the highest peak of 4,620 m above sea level on Mount Ras Dashen in Amhara national regional state. The mean annual rainfall ranges from 500
to 2800 mm whereas the mean annual temperature ranges from below 10 to 30°C (EIBC, 2014).

Review method
The review system followed reviewing of all the available works concerned on indigenous cattle breeds of Ethiopia. The fragmented available information of indigenous cattle was summarized in tabular form for ease of understanding.

RESULTS
Indigenous cattle breeds of Ethiopia
FAO (2005) reported that cattle contribute 40% of the annual agricultural output and 15% of the total gross domestic product. Ethiopia has 59.5 million heads of cattle (CSA, 2016/2017). Ethiopian Institute of Biodiversity Conservation (EIBC) (2004) reported that Sheko, Fogera, Begait and Borena cattle populations were at decreasing trend. DAGRIS (Access date: November 2017) report indicated that the current number of indigenous cattle breeds of Ethiopia are 37 (Table 1). CSA (2016/2017) reported that about 98.2% of the total cattle population was indigenous cattle population, 1.62% of the cattle populations in Ethiopia were crossbred and 0.18% exotic cattle (Table 2).

Lactation and body weight performances of indigenous cattle of Ethiopia
The Ethiopian government was highly engaged to improve cattle productivity particularly to boost dairy productivity through crossbreeding program. CSA (2008/09) reported that exotic and indigenous cattle crossbreeding program was practiced with encouraging results, however, a strictly controlled breeding program has not been practiced and there has been no dairy herd recording scheme at national level. Zemenu et al. (2014) reported that the average daily milk yield (mean± SD) of local cattle at Debremarkos of Amhara national regional state, Ethiopia was 1.50±0.68 and that of cross bred cows (exotic x local cattle) was 7.30±4.65 liters. It was reported that the annual milk production of Ethiopia from cattle was 3,055,903,834 liters and the average milk yield per cow per day at country level is about 1.37 liters whereas the average lactation period per cow was estimated to be about six months (CSA, 2015/2016). The traditional milk production system, which is dominated by indigenous breeds of low genetic potential for milk production accounts for about 97% of the country’s total annual milk production (Felleke, 2003). ILCA (1991) reported that indigenous cows produce only 1.5 to 2 liters of milk daily over a 150 to 180 days lactation period. Other national report indicated that the average lactation period per cow at country level is estimated to be about six months, and average daily milk yield (DMY) per cow is about 1.32 L (CSA, 2012/2013). It has also been well documented that, in breeding schemes, the raise in milk production through selection is about 1% per year or 3-4 kg per lactation (Zelalem and Inger, 2000). Moreover, the milk production potential of the zebu breed in the highlands of mixed crop-livestock system of Ethiopia cannot exceed 400-500 kilograms of milk per lactation per cow. Milk production potential of indigenous cattle of Boran, Horro, Barka, Arsi and Fogera is low, ranging from 494 to 809 kg per lactation (EARO, 1999; Zelalem and Inger, 2000). The reported on-station milk yield (Kg/day) performance of Arsi cattle (Kiwuwa et al., 1983), Barka (Goshu, 1981), Boran and Fogera (Gebrewold et al., 2000) was 2.97, 4.31, 2.84 and 4.49, respectively. Other reported on-farm milk yield studies on Fogera cattle (Zewdu, 2004) and Highland zebu (Solomon, 2000) revealed 2.56 and 1.91 Kg/day, respectively.

Reproductive performance of indigenous cattle breeds of Ethiopia
Ethiopia has high potential in livestock genetic resources; however, livestock productivity is below the African average. Total herd off take rate of cattle is estimated at about 7% annually; with carcass weight of 100 to 110 kg. Cows in Ethiopia do not reach maturity until 4 years of age, calve every second year (ILCA, 1991). Reproductive performance is commonly evaluated by analyzing female reproductive traits (Aynalem et al., 2011). The main indicators that would be considered in assessing reproductive performance are age at puberty, age at first calving, calving interval, days open and number of services per conception (Habtamu et al., 2010; Aynalem et al., 2011; Demissu et al., 2013).

Morphometric characterization of indigenous cattle breeds of Ethiopia
As per this review, morphometric characterization of indigenous cattle of Ethiopia is very poor (Tables 4 and 5). A descriptive comparison of the number of indigenous cattle reported and the number of indigenous cattle studied was evaluated. As of IBC (2004) report on the number of indigenous cattle, 44% of the number of indigenous cattle reported were studied their morphometric characterization, but according to DAGRIS (2007) report on the number of indigenous cattle, 34% of the number of indigenous cattle reported were studied their morphometric characterization (Table 7).

Characterization of majority of indigenous breeds and production systems of East Africa including Ethiopia has not yet been undertaken (Ntombizakhe, 2002). Live body weight of cattle is highly correlated with linear body measurements particularly of heart girth and body length (Hamayunm, 2003). On-farm phenotypic characterization of indigenous cattle populations of Awi, East and West Gojjam Zones of Amhara Region, Ethiopia indicated that
Table 1. Reported indigenous cattle breeds and/or strains of Ethiopia.

| S/N | List of indigenous cattle breeds and/or strains of Ethiopia reported by local and international officials | EIBC (2004) | EIBC (n.d.) | DADIS (n.d.) | DADIS (2007) | DADIS (Access date: 20/11/2017) | DADIS (Access date: 21/11/2017) |
|-----|--------------------------------------------------------------------------------------------------------|-------------|-------------|--------------|--------------|----------------------------------|----------------------------------|
| 1   | Arsi                                                                                                    | Adwa        | Abergelle   | Adwa         | Abergelle    | Baherie                          | Arsi                             |
| 2   | Begait                                                                                                   | Ambo        | Abigar      | Aliab Dinka  | Abigar       | Adwa                             | Arsi                             |
| 3   | Ogaden                                                                                                   | Arado       | Abyssinian   | Ambo         | Abyssinian   | Harar                            | Abyssinian                      |
| 4   | Borena                                                                                                   | Abergelle   | Abyssinian   | Arado        | Abyssinian   | Harar                            | Abyssinian                      |
| 5   | Goffa                                                                                                    | Bale        | Ambo        | Arado        | Adwa         | Harar                            | Baherie                          |
| 6   | Arado                                                                                                    | Barka       | Ambo        | Arsi         | Ambo         | Jijiga                           | Arado                            |
| 7   | Nuer                                                                                                     | Danakil     | Arado       | Bale         | Arado        | Mahbere-Slassie                  | Arado                            |
| 8   | Guraghe                                                                                                  | Dembia      | Abergelle   | Barka        | Arsi         | Danakil                          | Abergelle                       |
| 9   | Jidu                                                                                                     | Boran       | Bambawa     | Danakil      | Bambawa      | Bale                             | Bambawa                          |
| 10  | Karayu/ Afar                                                                                              | Fogera      | DADIS       | Dembia       | Begaria      | Sheko                            | Afar                             |
| 11  | Harar                                                                                                    | Goffa       | Boran       | Ethiopian    | Begait       | Jem-Jem                          | Ethiopian                        |
| 12  | Horro                                                                                                    | Guraghe     | Danakil     | Fogera       | Boran        | Ogaden Zebu                      | Danakil                          |
| 13  | Smada                                                                                                    | Hammer      | Ethiopian    | Goffa        | Danakil      | Qocherie                         | Ethiopian                        |
| 14  | Fogera                                                                                                   | Harar       | Goffa       | Goffa        | Fogera       | Goffa                            | Ethiopian                        |
| 15  | Mursi                                                                                                    | Horro       | Goffa       | Hammer       | Goffa        | Goffa                            | Ethiopian                        |
| 16  | Raya-Azebo                                                                                               | Jem-Jem     | Guraghe     | Harar        | Goffa        | Ethiopin Boran                   | Ethiopin                         |
| 17  | Adwa                                                                                                     | Jijiga      | Hammer      | Horro        | Goffa        | Ethiopin Boran                   | Ethiopin                         |
| 18  | Jem-Jem                                                                                                  | Mahbere-Slassie | Harar   | Jem-Jem      | Hammer       | Jem-Jem                          | Jem-Jem                          |
| 19  | Sheko                                                                                                    | Mursi       | Holstein-Friesian | Jijiga    | Harar        | Anuak                            | Jem-Jem                          |
| 20  | Ambo                                                                                                     | Ogaden zebu | Horro       | Jem-Jem zebu | Kuri         | Holstein-Friesian | Mursi                           |
| 21  | Jijiga                                                                                                   | Qocherie    | Jem-Jem zebu | Mahbere-Slassie | Horro        | Jem-Jem                          | Jem-Jem                          |
| 22  | Bale                                                                                                     | Raya-Azebo  | Jidu        | Murle        | Irob         | Dembia                          | Harar                            |
| 23  | Hammer                                                                                                   | Semien      | Jijiga zebu | Mursi        | Jem-Jem zebu | Alab Dinka                       | Harar                            |
| 24  | Medense                                                                                                  | Sheko       | Medence     | Ogaden zebu  | Jiddu        | Raya-Azebo                      | Raya-Azebo                      |
| 25  | Abergelle                                                                                                | Smada       | Mursi       | Qocherie     | Jijiga Zebu  | Guraghe                          | Abergelle                       |
| 26  | -                                                                                                        | Nuer        | Raya-Azebo  | Medence      | Barka        | Sheko                           | Medence                          |
| 27  | -                                                                                                        | -           | Red Fulani  | Mursi        | Medence      | Nuer                            | Somali Boran                    |
| 28  | -                                                                                                        | -           | Red Bororo  | Semien       | Nuer         | Somali Boran                    | Somali Boran                    |
| 29  | -                                                                                                        | -           | Sheko       | Raya-Azebo   | Sheko        | Somali Boran                    | Smada                           |
| 30  | -                                                                                                        | -           | Smada       | Red Bororo   | Sheko        | Sheko                           | Sheko                           |
| 31  | -                                                                                                        | -           | Tigrey      | Somali Boran | Sheko        | Somali Boran                    | Tigrey                          |
| 32  | -                                                                                                        | -           | Wegera      | Smada        | Wegera       | Sheko                           | Wegera                          |
| 33  | -                                                                                                        | -           | -           | -            | -            | Sheko                           | Tigrey                          |
| 34  | -                                                                                                        | -           | -           | -            | -            | Hammer                          | Tigrey                          |
| 35  | -                                                                                                        | -           | -           | -            | -            | Murle                           | Holstein-Friesian               |
| 36  | -                                                                                                        | -           | -           | -            | -            | Red Fulani                      | Holstein-Friesian               |
| 37  | -                                                                                                        | -           | -           | -            | -            | Arado                           | Arado                           |

Total 25 27 31 32 33 37

EIBC: Ethiopian institute of biodiversity conservation, DADIS: domestic animal diversity information system, DAGRIS: domestic animal genetic resources information system, n.d: no date
all the quantitative dependent variables (body length, chest girth, height at withers, pelvic width, mouth circumference, ear length, tail length, dewlap width, horn length) were significantly (P < 0.0001) affected by sex of the animal (Fasil and Workneh, 2014).

**Production constraints and opportunities of indigenous cattle breeds of Ethiopia**

Developing countries, such as Ethiopia, are restrained by different cattle production challenges which include technical, biological, socio-economic and institutional factors that are expressed in scarcity of quality and quantity of feed resources, low producing cattle genotypes, disease susceptibility, reproductive loss, inadequate health service, management and market access are some of the constraints (Ibrahim and Olaloku, 2000). Area and breed specific survey indicated that shrinkage of grazing land, polledness and aggressive behavior of the breed, scarcity of Sheko breeding bulls, misapprehension of importance and status of the Sheko cattle and lack of active intervention on the breed were the major constraints in Sheko cattle production (Takele et al., 2005). Other cattle breed specific survey indicated that constraints of Horro cattle owners were feed shortage, labor shortage, diseases and lack of exotic bull which ranked differently in the mid altitude and highland areas of the breed (Agere et al., 2012). According to Damitie et al. (2015), the major constraints of Fogera cattle were shortage of feed, disease outbreak and occurrences of drought, shortage of water during winter/healthy water, flooding during summer season, market and conflict by grazing land. A survey report indicated that availability of diversified breeds, good fattening weather, and good income generated, good indigenous knowledge of fattening, recent introduction of some improved forage varieties, popularity of fattened Harar bull in the country were opportunities for cattle production in the area (Abdi et al., 2013). Disease, lack of improved cattle breed and feed shortage were identified as first, second and third constraints for dairy cattle production in Debremarkos district of Amhara national regional state of Ethiopia (Zemen et al., 2014).

**DISCUSSION**

Ethiopia has more cattle than other livestock species and cattle are substantially important in the livelihood of smallholder farmers and urban people. CSA (2010/11), CSA (2012/13) and CSA (2016/17) reports indicated that the proportion of indigenous cattle versus exotic and indigenous crossbreds and exotic cattle in Ethiopia was not significantly changed. Although Ethiopia has diversified cattle breeds, the Ethiopian Institute of Biodiversity Conservation (EIBC, 2004) reported that Sheko, Fogera, Begait and Borena cattle populations were at decreasing trend. Furthermore, Zerabruk et al. (2007), Mulugeta (2015), Teweldemedhn (2016) and Tewelde et al. (2017) reports revealed that Begait cattle population was at decreasing trend. DAGRIS reported that there were 37 indigenous cattle breeds. There is no recent local report which declares the number of indigenous cattle breeds of Ethiopia except EIBC (2014) report which indicated that there were 28 indigenous cattle breeds. EIBC, DADIS and DAGRIS used the words Begait and Barka interchangeably to name for one cattle breed in which Barka is the naming of Eritrean breeders whereas Begait is the naming of Ethiopian breeders.

The current review indicated that milk yield performance study on indigenous cattle is very poor (Table 3). A comparison of the number of indigenous cattle reported and breed specific milk yield performance study was made.

Taking IBC (2004) report on the number of indigenous cattle, 76% of the number of indigenous cattle reported were studied their milk yield performance but as of DAGRIS (21 November 2017) report on the number of indigenous cattle, 51% of the number of indigenous cattle reported were studied their milk yield performance (Table 8). Live body weight, which is the most economically important, measured at different ages of each indigenous cattle, is not available except in very few indigenous cattle breeds (Table 3). The current state of reproductive performance research work versus number of indigenous cattle reported is incomparable (Table 4). A descriptive comparison of the number of indigenous cattle reported and the number of indigenous cattle studied was evaluated. As of IBC (2004) report on the number of indigenous cattle, 48% of the number of indigenous cattle reported were studied their reproductive performance but according to DAGRIS (21 November 2017) report on the number of indigenous cattle, 32% of the number of indigenous cattle reported were studied their reproductive performance (Table 8).

As per this review, morphometric characterization of indigenous cattle of Ethiopia is very poor (Tables 5 and 6). A descriptive comparison of the number of indigenous cattle reported and the number of indigenous cattle studied was evaluated. As of IBC (2004) report on the number of indigenous cattle, 60% of the number of indigenous cattle reported, their morphometric characterization was studied, but according to DAGRIS (21 November 2017) report on the number of indigenous cattle, 41% of the number of indigenous cattle reported, their morphometric characterization was studied (Table 8). As indicated in Table 7, the production challenges of all indigenous cattle breed of Ethiopia are not identified. A descriptive comparison of the number of indigenous cattle reported and the number of indigenous cattle studied was evaluated. As of IBC (2004) report on the number of indigenous cattle, 32% of the number of indigenous cattle showed that their production challenges were studied, but according to DAGRIS (21 November
### Table 2. Proportion of indigenous, crossbred and exotic cattle breeds in Ethiopia.

| S/N | Cattle genotypes                  | CSA (2008/09) | CSA (2010/2011) | CSA (2012/2013) | CSA (2015/2016) | CSA (2016/2017) |
|-----|-----------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|
| 1   | Indigenous cattle (%)             | 99.28         | 99.26           | 98.95           | 98.59           | 98.2            |
| 2   | Exotic X indigenous crossbred (%) | 0.64          | 0.94            | 1.22            | 1.62            |                 |
| 3   | Exotic cattle (%)                 | 0.1           | 0.11            | 0.19            | 0.18            |                 |
|     | Total                             | 100           | 100             | 100             | 100             |                 |

### Table 3. Lactation performance and body weight of indigenous cattle breeds of Ethiopia.

| Cattle breed | Production parameters | Farm | Author(s) |
|--------------|-----------------------|------|-----------|
|              | DMY (L) | LMY (L) | LL (month) | BWt (kg) | Adult Wt (kg) |         |
| Horro        | -       | -       | 10.5 ± 3.03 | -        | -             | On-farm  |
|              | 1.65    | 475.85  | 9.57        | -        | -             | Aynalem et al. (2011) |
|              | -       | -       | 19.9        | -        | -             | Cited in Rege (1999) |
|              | -       | 550     | 5.8         | -        | 250           | On-farm  |
|              | 1.44±0.04 | -       | 9.57±0.25   | -        | -             | On-farm  |
|              | -       | 809     | 9.07        | -        | -             | Aynalem et al. (2011) |
|              | 2.2     | -       | -           | 250      | On-farm  | Laval and Assegid (2002) |
|              | -       | -       | 320-480 M, 210-400 F | -        | -             | On-farm  |
| Arsi         | 645     | 2.2     | 6.38±0.026  | -        | -             | Aynalem et al. (2011) |
|              | 2.7±0.3 | -       | 6.6±0.9     | -        | -             | On-farm  |
|              | 2.1±0.04 | 433.2±3.4 | 4.9±0.03   | -        | -             | On-farm  |
|              | -       | 22.6    | -           | -        | -             | Aynalem et al. (2011) |
|              | -       | 645     | 6.1         | -        | -             | Aynalem et al. (2011) |
|              | -       | -       | 360         | -        | -             | On-farm  |
|              | -       | 869     | -           | -        | Million and Tadelle (2003) |
|              | -       | -       | 335-480 M, 295-415 F | -        | -             | On-farm  |
| Begait       | 3.54±0.14 | -       | 10.5±0.17   | -        | -             | Aynalem et al. (2011) |
|              | -       | 997.5   | 9.57        | 21.9     | -             | Aynalem et al. (2011) |
|              | 2.32    | 270     | 23.3        | 304      | -             | On-farm  |
|              | -       | -       | 335-480 M, 295-415 F | -        | -             | On-farm  |
| Fogeria      | 1.5     | -       | -           | -        | -             | Belete (2006) |
|              | 3.54±0.14 | -       | -           | -        | -             | Damitie et al. (2015) |
|              | -       | 997.5   | -           | -        | -             | Zewdu (2004) |
|              | 2.32    | 270     | -           | -        | -             | Cited in Aynalem et al. (2011) |
|              | 1.5     | -       | -           | -        | -             | Belete (2006) |
|              | 1.85*/0.35** | -       | -           | -        | -             | Aynalem et al. (2011) |
|              | 1.10*/0.95** | -       | -           | -        | -             | Aynalem et al. (2011) |
|              | 5.0     | -       | -           | -        | -             | Aynalem et al. (2011) |
|              | 1.8     | 520     | 10.1        | -        | -             | Aynalem et al. (2011) |
|              | 1.7     | 507     | 8           | 22.9     | 304           | On-farm  |
|              | 1.7 ± 0.1 kg | 507±39kg | 8 ±0.13     | 23.3 ± 0.36 | -             | On-farm  |
|              | -       | -       | -           | -        | 268           | On-farm  |
|              | -       | 867     | -           | -        | -             | On-farm  |

Table 3. Contd.

| Cattle breed | Reproductive parameters | Farm | Author(s) |
|--------------|-------------------------|------|-----------|
| Boran        | - 8 - - 21.5±0.29 - - 289.57 | On-farm | Aynalem et al. (2011) |
| Ogaden       | - 682 - - 280.5 F, 321 M | On-farm | Rege, 1999 |
| Sheko        | 2.79 ± 0.06 850.6±14.26 10.26±0.2 | On-farm | Bekele et al. (2009) |
| Ogaden       | - - 49.1±0.21 7.79±0.25 | On-farm | Getinet et al. (2012) |
| Boran*       | 1.8 594 - - 700 M | On-farm | Dereje (2005) |
| Ogaden       | - - 20 ±0.25 | On-farm | Bayou et al. (2015) |
| Sheko        | 300-350 F, 300-350 F | On-farm | Aynalem et al. (2011) |
| Ogaden       | - - 321 M | On-farm | Rege, 1999 |
| Sheko        | 300 F, 350 F | On-farm | Dereje (2005) |
| Ogaden       | - - 280.5 F, 321 M | On-farm | Ermias (2007) |
| Sheko        | 21.0±0.31 F, 22.0±0.33 M | On-farm | Bekele et al. (2009) |
| Ogaden       | - - 250-380 M, 200-305 F | On-farm | Getinet et al. (2014) |
| Sheko        | 9.9 1.82 | On-farm | Getinet et al. (2005) |
| Ogaden       | - - 205±430 M, 192-350 F | On-farm | Rege (1999) |
| Sheko        | 1.54 203.54±1.40 | On-farm | Getinet et al. (2005) |
| Ogaden       | - - 340-580 M, 325-430 F | On-farm | Rege (1999) |
| Abigar       | - 720 kg | On-farm | DAMIS |
| Abysinnian Shorthorned Zebu | - 6 | On-farm | DAMIS |
| Arsi         | - 240 | On-farm | DAMIS |
| Begait       | - 675 kg | On-farm | DAMIS |
| Boran*       | - 1200 kg | On-farm | DAMIS |
| Danakil      | - 225 kg | On-farm | DAMIS |
| Boran (E)    | 3.5 kg 843 kg 7 (Max.) | On-farm | DAMIS |
| Boran (E)    | - 920 kg | On-farm | DAMIS |
| Horro        | - 814 kg | On-farm | DAMIS |
| Jem-Jem      | - 720 kg | On-farm | DAMIS |
| Red Bororo   | - 900 kg | On-farm | DAMIS |
| Sheko        | - 420 kg | On-farm | DAMIS |
| National     | 1.32 6 | On-farm | CSA (2012/2013) |

*Wet season milk yield, **Dry season milk yield, F: female weight, M: male weight, DMY: daily milk yield, LMY: lactation milk yield, LL: lactation length, BWt: body weight, Wt: weight, E: Ethiopian Boran, Max.: maximum.

Table 4. Reproductive performance of indigenous cattle breeds of Ethiopia.

| Cattle breed | Reproductive parameters | Farm | Author(s) |
|--------------|-------------------------|------|-----------|
| Fogera       | MAFM (month) FAFM (month) AFC (month) CI (month) RLTB (year) RLTC (year) CBRLTC (number) DO (days) | Melakel Ranch | Melaku et al. (2011) |
| Fogera       | 50.8±0.36 50.8±0.36 50.8±0.36 50.8±0.36 | Melakel Ranch | Addis and Hedge (2002) |
| Fogera       | 59.9±0.03 59.9±0.03 59.9±0.03 59.9±0.03 | On-farm | Damite et al. (2015) |
Table 4. Contd.

| Location     | DO (days) | AFC (years) | RLTB (days) | CBRLTC (years) | DO (days) | AFC (years) | RLTB (days) | CBRLTC (years) |
|--------------|-----------|-------------|-------------|----------------|-----------|-------------|-------------|----------------|
| Fogera       | 42.24±0.05| 51.4±0.05   | 21.18±0.70  | -              | 42.4±0.05| 51.4±0.05   | 21.18±0.70  | -              |
| Horro        | 48.4±0.06 | 58.0±0.07   | 21.0±0.3    | 3.72±0.10      | 46.56±0.06| 58.0±0.07   | 21.0±0.3    | 3.72±0.10      |
| Borana       | 47.4      | 57.6        | 13.8        | 7.88           | 47.4      | 57.6        | 13.8        | 7.88           |
| Begait       | 42.5±0.05 | 47.5±0.13   | 8.3±0.2     | 17.4±0.20      | 42.5±0.05| 47.5±0.13   | 8.3±0.2     | 17.4±0.20      |
| Ogaden       | 34.4±2.28 | 49.2±4.43   | 16.43±0.44  | -              | 34.4±2.28| 49.2±4.43   | 16.43±0.44  | -              |

*Pasture feeding, MAFM: male age at first mating, FAFM: female age at first mating, AFC: age at first calving, RLTB: reproductive lifetime of bull, RLTC: reproductive lifetime of cow, CBRLTC: calves born in reproductive lifetime of a cow, DO: days open.

*Source: Adapted from various studies cited in the table.*
Table 5. On-farm morphometric characterization of indigenous cattle breeds (cows) of Ethiopia.

| Cattle breed     | BL     | CG     | HW     | PW     | RL     | TtL    | EL     | HL     | MC     | HC     | TL     | Author(s)          |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------|
| Ogaden           | 141.0  | 161.4  | 116.4  | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Ogaden           | 121.0±7.18  | 150.1±8.20 | 115.5±5.17  | -      | -      | -      | 19.7±1.69  | 8.0±4.83  | -      | -      | -      | -                  |
| Ogaden           | 121.09  | 150.11±8.20 | 115.54  | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Arsi             | 118±4.4  | 139±7.0 | 113±2.7 | 29±2.3 | 35±2.5 | 16±1.7 | 21.0±7.4 | 37±2.2 | -      | -      | -      | -                  |
| Begait           | 128.1±10.16 | 159.6±0.24 | 131.5±6.25 | 60.0±0.31 | 11.5±0.03 | 18.4±0.34 | 21.1±0.11 | -      | -      | -      | 97.7±3.37 | -                  |
| Begait           | 115.5±0.48 | 155.2±0.56 | 123.1±0.64 | 23±1.09 | 21.0±0.24 | 6.5±0.14 | 22.8±0.16 | 22.4±0.69 | 38.8±0.17 | 33.7±0.17 | 96.9±0.72 | -                  |
| Barka            | -      | -      | 120-133 | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Boran            | 120    | 149.2  | 115.8  | -      | -      | -      | -      | -      | -      | -      | -      | 14.3±0.63         |
| Mursi            | 122.09±0.95 | 144.7±0.89 | 112.9±1.10 | -      | 20.4±1.25 | -      | 30.7±1.05 | -      | -      | -      | -      | -                  |
| Kereyu           | 112.6  | 141.6  | 113.2  | -      | -      | -      | -      | -      | -      | -      | -      | 48±6.34           |
| Shoko            | 110.2  | 136.5  | 99.4   | 33.5   | -      | -      | -      | -      | -      | -      | -      | -                  |
| Fogera           | 119.7±0.7 | -      | -      | -      | -      | 37.7±0.7 | -      | -      | -      | -      | -      | -                  |
| Fogera           | -      | -      | 100-121 | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Raya sanga       | 119    | -      | -      | 35.2   | -      | -      | -      | -      | -      | -      | -      | -                  |
| Afar sanga       | 126    | -      | -      | 38.7   | -      | -      | -      | -      | -      | -      | -      | -                  |
| Goffa            | 107.15±0.62 | 135.42±0.811 | 107.18±0.588 | 37.63±0.28 | -      | -      | 19.5±0.199 | 27.0±1.82 | 39.0±0.24 | 29.4±0.299 | -      | Belay et al. (2017) |
| Danakil          | -      | -      | 120-125 | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Arado            | -      | -      | 93-126  | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Jiddu            | -      | -      | 108-124 | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Abyssinian Short horned Zebu | -      | -      | 105    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Arsi             | -      | -      | 110    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Begait           | -      | -      | 125    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Boran*           | -      | -      | 121    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Danakil          | -      | -      | 128    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Boran €           | -      | -      | 118    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Fogera           | -      | -      | 112    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Tigrey           | -      | -      | 111    | -      | -      | -      | -      | -      | -      | -      | -      | -                  |

BL: Body length, CG: chest girth, HW: height at wither, PW: pelvic width, RL: rump length, TtL: teat length, EL: ear length, HL: horn length, MC: muzzle circumference, HC: hock circumference, TL: tail length.

Table 6. On-farm morphometric characterization of indigenous cattle breeds (bulls) of Ethiopia.

| Cattle breed     | BL     | CG     | HW     | PW     | RL     | EL     | HL     | MC     | HC     | TL     | SC     | Author(s)          |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------|
| Ogaden           | 141.5  | 161.3  | 118.0  | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Ogaden           | 120.4±7.27 | 148.2±14.31 | 115.5±7.71  | -      | -      | 19.6±1.05 | 5.9±3.26 | -      | -      | -      | 71.9±5.15 | -                  |
| Ogaden           | 120.45  | 148.2±14.31 | 115.47  | -      | -      | -      | -      | -      | -      | -      | -      | -                  |
| Arsi             | 125±9.8  | 152±11.0 | 115±2.3 | 303±6.8 | 37±3.5 | 16±2.3 | 22±3.3 | 40±3.2 | -      | -      | -      | Muligeta (2015)    |
| Begait           | 136.0±0.9 | 168.9±0.10 | 137.0±10 | 41.5±0.06 | 18.1±0.07 | 19.9±0.07 | -      | 100.3±0.6 | -      | -      | -      | -                  |
| Begait           | 125.6±1.21 | 167.9±1.58 | 143.4±1.24 | -      | 20.9±0.62 | 23.2±0.49 | 28.6±2.28 | 43.1±0.48 | 35.3±0.61 | 108.9±1.49 | 32.1± 0.46 | -                  |
| Barka            | -      | -      | 122-138 | -      | -      | -      | -      | -      | -      | -      | -      | -                  |

BL: Body length, CG: chest girth, HW: height at wither, PW: pelvic width, RL: rump length, EL: ear length, HL: horn length, MC: muzzle circumference, HC: hock circumference, TL: tail length, SC: scrotal circumference.
### Table 6. Contd.

| Cattle        | BL | CG | HW | PW | RL | EL | HL | MC | HC | TL | SC |
|---------------|----|----|----|----|----|----|----|----|----|----|----|
| Boran         | 127.8 | 155 | 117.9 | - | - | - | 13.7 | - | - | - | - |
| Sheko         | 114.6 | 141.2 | 103.6 | 32.8 | - | - | - | - | - | - | - |
| Goffa         | 108.0±1.03 | 138.01±1.57 | 109.05± 1.06 | 38.10±0.53 | - | 19.56±0.32 | 26.74± 1.747 | 40.157±0.41 | 30.83±0.423 | - | - |
| Danakil       | - | - | 135-145 | - | - | - | - | - | - | - | - |
| Arado         | - | - | 117-144 | - | - | - | - | - | - | - | - |
| Foger         | - | - | 110-145 | - | - | - | - | - | - | - | - |
| Jaddu         | - | - | 108-133 | - | - | - | - | - | - | - | - |
| Abyssinian Short horned Zebu | - | - | 105 | - | - | - | - | - | - | - | - |
| Arai          | - | - | 110 | - | - | - | - | - | - | - | - |
| Begait        | - | - | 132 | - | - | - | - | - | - | - | - |
| Boran*        | - | - | 130 | - | - | - | - | - | - | - | - |
| Danakil       | - | - | 128 | - | - | - | - | - | - | - | - |
| Boran (E)     | - | - | 121 | - | - | - | - | - | - | - | - |
| Fogera        | - | - | 127 | - | - | - | - | - | - | - | - |
| Tigre         | - | - | 122 | - | - | - | - | - | - | - | - |

*BL: Body length, CG: chest girth, HW: height at wither, PW: pelvic width, RL: rump length, EL: ear length, HL: horn length, MC: muzzle circumference, HC: hock circumference, TL: tail length, SC: scrotum circumference.

### Table 7. Challenges of indigenous cattle production in Ethiopia.

| Cattle               | First ranked                  | Second ranked                  | Third ranked                  | Author(s)                  |
|----------------------|-------------------------------|--------------------------------|--------------------------------|---------------------------|
| Fogera               | Feed scarcity                 | Disease                        | Drought                       | Damitie et al. (2015)     |
| Fogera               | Shrinkage of grazing land     | Shortage of land for forage development | Absence of health follow-up and clinic | Assemu et al. (2017)     |
| Fogera               | Inbreeding                    | Uncontrolled inter- and crossbreeding | Diseases and drought          | EIBC (2004)               |
| Fogera               | crossbreeding                 | -                              | -                             | EIBC (2014)               |
| Mursi                | Animal diseases and parasites | Seasonal water and feed shortage | Drought                       | Endashaw et al. (2011)    |
| Horro (midland areas)| Feed shortage                 | Labor shortage                 | Disease                       | Agere et al. (2012)       |
| Horro (highland areas)| Feed shortage               | Disease                        | Labor shortage                 | Agere et al. (2012)       |
| Horro (mid-altitude) | Feed shortage                 | Labor shortage                 | Disease                       | Agere et al. (2012)       |
| Horro (highland)     | Feed shortage                 | Diseases                       | Labor shortage                 | Agere et al. (2012)       |
| Harar                | Feed shortage                 | Animal health problem          | Market problem                 | Abdi et al. (2013)        |
| Arsi                 | Feed shortages                | Grazing land shrinkage         | Shortage of improved breed    | Chali (2014)              |
| Begait               | Feed shortage                 | Diseases                       | Water shortage                 | Mulugeta (2015)           |
| Begait               | Rangeland and feed scarcity   | Theft                          | Scarcity of water              | Teweldemedhin (2016)      |
| Begait               | High off-take rate (during Ethio-Eritrea war) | - | - | - | - |
| Sheko                | Trypanosomiasis               | Inbreeding                     | Interbreeding with other local breeds | EIBC (2004)               |
| Sheko                | Crossbreeding                 | Production system shift        | Interbreeding and diseases     | EIBC (2014)               |
| Borena, Afar and Ogaden | Feed shortage             | Recurrent drought              | -                             | EIBC (2004)               |
Table 7. Contd.

| Cattle breeds       | Major challenge       | Overall challenge       |
|---------------------|-----------------------|-------------------------|
| Boran (highland)    | Feed shortage         | Feed shortage (77.8%)   |
| Boran (mid-altitude)| Feed shortage         | -                       |
| Boran (lowland)     | Feed shortage         | -                       |
| Number of records   | 18                    | 17                      |
| Major challenge     | Feed shortage (77.8%) | -                       |
| Overall challenge   | -                     | Feed shortage (36.5%)   |

Table 8. Percent of indigenous cattle breeds studied in their milk yield performance, reproductive performance, morphometric characterization and their major production challenges.

| Categories                          | Number of indigenous cattle breeds studied | Percent of breeds studied in reference to EIBC (2004) report of indigenous cattle list | Percent of breeds studied in reference to DAGRIS report (Access date: 21/11/2017) of indigenous cattle list |
|-------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Milk yield performance evaluation   | 19                                         | 76                                                                        | 51                                                                  |
| Reproductive performance evaluation | 12                                         | 48                                                                        | 32                                                                  |
| Morphometric traits characterization | 15                                         | 60                                                                        | 41                                                                  |
| Cattle major challenges identification | 8                                          | 32                                                                        | 21.6                                                               |

2017) report on the number of indigenous cattle, 21.6% of the number of indigenous cattle showed that their production challenges were studied (Table 8). As presented in Table 7, the major challenge of the studied indigenous cattle breeds of Ethiopia is scarcity of feed which accounted 77.8% of the first ranked challenges.

CONCLUSION AND RECOMMENDATIONS

Ethiopia has diversified indigenous cattle genetic resources kept under hundreds of millions of poor smallholder farmers. However, most of the indigenous cattle populations of Ethiopia remained largely uncharacterized; characterization work is at its rudimentary stage and the characterized cattle breeds of Ethiopia are even not well characterized. Productivity per unit of animal is extremely poor and some indigenous cattle populations are at decreasing trend which is largely affected by scarcity of feed. This review system ensured that the major challenge of indigenous cattle breeds of Ethiopia is scarcity of feed which accounted 77.8% of the first ranked challenges of cattle production. However, the critical challenge of all indigenous cattle is not yet well identified. Therefore, identification of the major cattle production and breeding challenges of each indigenous cattle breed should be taken into account and further breed specific research and development works should be accomplished so as to enhance their productivity. There are many performance studies on cattle breeds of Ethiopia which entitled local or indigenous cattle productive and/or reproductive performances. Therefore, in this case, the performance study should be on specific cattle breed because local or indigenous cattle performance cannot reflect the performance of specific breed. Indigenous cattle production opportunities are not yet identified and need due attention in the future.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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