Dairy Cattle Cross-breeding in Ethiopia: Challenges and Opportunities: A Review

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ABSTRACT
A dairy cattle cross-breeding has been started in 1930s to improve cow milk production, using exotic breeds such as Holstein Friesian and Jersey to exploit breed complementarities of milk production and reproductive traits. Crossbred cows with 50% to 75% blood level able to produce more milk whereas, reproductive performance has decreased as exotic blood level exceeds beyond 50%. Environment and genotype mismatch, lack of appropriate breeding policy and recording system, poor infrastructure, lack of trained man power, improper use of artificial insemination and low adoption of breeding technologies are some of the constraints of dairy cattle crossbreeding in Ethiopia. Defining the suitable breed and blood level for specific production system, continuous skill updating for artificial insemination technicians and introducing appropriate recording system are the most critical points that should be considered during proposing of cross-breeding program for dairy cattle. The purpose of this review was to look at the challenges and opportunities of dairy cattle crossbreeding programs in Ethiopia.

Key words: Crossbreeding, Dairy, Exotic, Indigenous, Opportunity.

Livestock genetic resources are of vital importance to agriculture, food production, rural development and the environment. Livestock industry in Ethiopia contributes for about 16% of the national and 27-30% of the agricultural gross domestic product. About 13% of the country’s export earnings are from leather and live animal exportation of which the communal areas contributed more than 50% (CSA, 2017). Indigenous cattle breeds are playing a significant contribution to the national dairy development of the country, despite the productivity per animal is very low as compare to the exotic breeds.

Crossbreds have dominated the large scale intensive and small-scale dairy sector because of their genetic superiority over local breeds, although the adverse environmental factors may limit their performance. The demand of animal products has increased with an Ethiopian population of over 90 million people growing at an annual rate of 3.2% (CSA, 2017). Despite Ethiopia has great potential for dairy development, the sector is dominated by indigenous cows and at its infant stage of commercialization in which income is very much secondary to meet nutritional needs, storing of wealth, social security and cultural functions are the main targets.

Limited genetic potential of local genetic animal species has been cited as a major constraint to animal production. Renewable resources, especially farming and grazing land, are limited; for this reason increase in animal productivity must come from productivity gains rather than from a growing number of livestock (Efha et al., 2009). The known breeding strategies to improve dairy production are selection within local breeds and through importation of exotic livestock species or crossbreeding (Efha et al., 2009; Tegegne et al., 2010).

Dairy cattle crossbreeding have been carried out with introduction of semen of exotic breed males to improve milk productivity and milk market participation for subsistence farmers (Tegegne et al., 2010). First generation (F1crosses) of local with exotic breeds are considered to have a more efficient reproductive performance than local cows in terms of earlier age at first calving and shorter calving intervals (Ayenew et al., 2008;). The milk yield of the first crossbred generation (F1) is more than twice as the milk yield of local dairy cattle breed. F1 bring the highest economic returns under poor feeding conditions (Tadesse, 2010). Though the crossbreeding program is ongoing, the current status of the program needs updated information. Hence, the purpose of this review was to look in to the challenges and opportunities of dairy cattle crossbreeding program in Ethiopia.

Ethiopian cattle genetic resources and their purpose
Local breeds comprise 98.20% of the total cattle population. (0.18%) are highly productive exotic breeds and their crosses with local breeds (1.62%) do currently not even reach 2% of the total cattle population (CSA, 2017). Present day
Ethiopian cattle population can be classified in four main groups, the Humless Shorthorn and Longhorn (bos taurus), the humped Zebu (bos indicus), the Sanga (interbreed of Zebu and humless cattle) and the Zenga (interbreed of Sanga and Zebu type) (Rege et al., 1994; Wuletaw, 2004b). The main indigenous cattle breeds identified, characterized and recognized up to now include Boran, Fogera, Horro, Sheko and Afar (Tegene et al., 2010). Among these, Fogera, Barka and Horro are known as milk producers (Anteneh et al., 2010). Other breeds not yet recognized, are Dembia, Semelin, Arado and Wegera. These local breeds evolved mainly as a result of natural selection influenced by factors like climate, altitude, available feed supply and endemic diseases which made them adapted to harsh environmental conditions (Workneh et al., 2002).

The livestock sector in Ethiopia accounts for 16% of the national and 27-30% of the agricultural Gross Domestic Product. 13% of the country's export earnings are due to leather and live animals exportation (MOARD, 2007). Cattle herds of most Ethiopian holdings are small ranging from one to nine head of cattle. The multi-functionality of cattle is a valuable attribute for smallholder in developing countries. Cattle are kept for many purposes depending on the production system they are situated in Ethiopia. Milk production is the most important function (Wuletaw, 2004b) and based on type of production system, animal traction ranked first in both crop–livestock and milk and reproduction are of second importance in agro-pastoral systems. Manure production as an important by-product should not be underestimated (Workneh and Rowlands, 2004; Anteneh et al., 2010). Out of this total cattle population, the female constitute about 55.49 per cent and the remaining 44.51 per cent are male cattle (CSA, 2017).

During the year 2017 the total milk production in Ethiopia decreased at an average annual rate of 0.75%. During the last decade it was increased at a higher rate of 1.55%. A detailed cattle population structure in Ethiopia is shown in (Table 1). An increased coverage of extension services, increased use of improved inputs (e.g, crossbred heifers or feedstuff) and policy changes promoting dairy production have contributed to faster growth of this sector (Ahmed et al, 2004). The average lactation period at country level is estimated to be around 7 months. Multipurpose indigenous zebu cows produce 400-680 kg of milk during one lactation period with a peak of about 2 to 5 kg per day depending on the breed. The average lactation period of a local cow is 239 days (Anteneh et al., 2010).

There is great variation in milk performance between indigenous cattle breeds and genetic potentials are still not fully exploited. High producing crossbred cows produce 1120-2500 liters over a 279-day lactation period (Anteneh et al., 2010; Wuletaw, 2004b). There are a number of reasons for low average milk yield of local cows. These factors include breeding for draught purpose, disease resistance, tolerance to tropical climates and poor nutrition (Desta, 2002). In general large variations in climate and vegetation and shortage of feed across the country are major constraints to dairy production.

**Dairy cattle breeding strategies**

For the current and future challenges, it is imperative to develop and implement cattle breed improvement strategies which are sustainable and suitable to prevailing the existing production systems (Effa et al., 2009). The most productive and adapted animals for each environment must be identified for breeding purposes (Philipsson et al., 2011). Both selections within breeds and cross breeding systems are applied in Ethiopia. The goal of selection within breeds is to improve the productivity of local cattle breeds. Good results of breed improvement by pure breeding were achieved in Ethiopia and acceptable results were reported in case of Fogera cattle (Marta, 2012). Lack of infrastructure, communication and production intensity is often not compatible with requirements for an effective selection program (Desalegn et al., 2009). Crossbreeding in Ethiopia is undergoing to combine superior hardiness, heat tolerance, disease resistance and environmental adaptability of indigenous cattle with superior high milk yield, faster growth rates and early maturity of exotic, temperate breeds (Tadesse and Dessie, 2003).

The program was launched by importing exotic dairy cattle breeds during Italy invasion. Later on, Dairy Development Agency (DDA) was launched (1958 to 1963) with the main duty of developing commercial dairy farms in Addis Ababa. Following this, Ethiopia received its first exotic cattle (Holstein Friesian and Brown Swiss) in the 1950’s from the UN relief and rehabilitation administration and since then commercial liquid milk production on government stations has started (Ahmed et al., 2004). Popper application of crossbreeding for milk production held when the Chilalo Agricultural Development Unit (CADU) was formed at Asela station. After recognizing the genetic improvement possibilities, similar dairy-development programs were implemented in Ethiopia with assistances from international agencies (MOARD, 2007).

**Contribution of crossbreeding in dairy production in Ethiopia**

In Ethiopia crossbreeding has been started by the Institute of Agricultural Research, through the establishment of an on-station dairy cattle crossbreeding program, using Friesian, Jersey and Simmental sires that were crossed with the local Horro, Boran and Barka dams with the aim of testing the productivity of crossbred dairy cows with different levels of exotic blood (Ahmed et al., 2004). Since 1970’s, governmental and non-governmental organizations have made various efforts to improve the dairy sector by establishing dairy improvement ranches and distributing crossbred F1 heifers to smallholder farmers (Kelay, 2002). The objective of the program was to increase the living standard of smallholder farmers through increasing the milk productivity of local breeds through crossbreeding (Kelay, 2002). Results from different evaluation studies in
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Ethiopia in (Table 2) illustrated that the superiority of crossbred cows to local cows in reproductive performance in milk production.

Reproductive performance

Reproductive performance is a biologically crucial phenomenon, which determines the efficiency of animal production. The production of milk and reproductive stock is not possible unless the cow reproduces. Poor reproductive performance is caused by failure of a cow to become pregnant primarily due to anestrus and failure to maintain the pregnancy causes delays in age at first calving, long calving interval and calf losses (Perera, 1999). Different evaluation studies on the effect of crossbreeding on the reproductive and productive performance dairy cattle in Ethiopia.

Reduction of age at first calving (AFC) with increasing levels of exotic genes up to a level of 62.5% exotic blood level has been reported by (Kahi, 2002). On the other hand Ahmed et al., (2007) reported that the earliest age at first calving (41.56±2.16 months) in a 37.5% exotic inheritance and the latest AFC (49.01±1.29 months) having 62.5% exotic blood level has recorded. Age at first calving of 52 months for Zebu cows and 31.06 months for crossbred cow was reported. In addition a study by Mureda and Mekuraiw (2007), Ibrahim et al. (2011), Lemma and Kebede (2011) and Dinka, (2012) was reported age at first calving of 36.2, 34.7, 33.2 and 34.8 months, respectively, for crossbred cows of unknown exotic blood level in different part of Ethiopia.

Longer gestation period reflects problems associated with management but may also give some indication of the condition of the cows’ reproductive organ. Under properly management of animals shorter calving interval was reported in crossbred than indigenes as reported by Yifat et al. (2012). Another result by Mulugeta and Belayneh (2013) and Belay et al. (2012) from crossbred born from indigenes Zebu cows with Holstein Frisian/HF with exotic blood level of 50%, 75% and 87.5% a calving interval of 458, 475 and 525 days respectively was reported. As well as crossbred of Barca XHF of 50%, 75% and 87.5% have Calving interval of 415, 474 and 512 days respectively (Million and Tadelle, 2003). The above study results on calving interval followed the pattern of lactation length shown as inferiority of F2 and backcrosses to F1 generations.

Milk production and lactation length

The major source of milk in Ethiopia if from local breed cows and it accounts for 97% of the total milk production in the country (Abaye et al., 1991). Milk yield from local cows has remained extremely low with national average of 3.4 liter/day/cow (Dagenae and Adugna 1999). Milk production per day per head is very low and this is further affected by short lactation length and extended post-partum anestrus (Azage and Alemu 1997). Daily milk yield (DMY) and lactation milk yield (LMY) normally remain approximately constant between 50% and beyond exotic blood level inheritance (Table 2). Similarly,

| Breed          | Total DMY (L) | Total LMY (L) | Total LL (month) | Source                  |
|----------------|---------------|---------------|------------------|-------------------------|
| Indigenous     | 3.4           | 771           | 7                | Dagnae and Adugna,1999; CSA, 2017 |
| Crossbred F1   | 6.2           | 2029          | 11               | Gebriel et al.,1983     |
| Crossbred F2   | 6             | 2346          | 13               | Gebriel et al.,1983     |
| Crossbred F3   | 5.6           | 2354          | 14               | Gebriel et al.,1983     |
| Crossbred F1(50%HF*B) | 5.8          | 1740          | 10               | Aynalem et al.,2011; Million and Tadelle, 2003 |
| Crossbred F2(75%HF*B) | 5.8          | 1902          | 11               | Aynalem et al.,2011; Million and Tadelle, 2003 |
| Crossbred F3(87.5%HF*B) | 5.7          | 2044          | 12               | Aynalem et al.,2011; Million and Tadelle, 2003 |

DMY= Daily Milk Yield, LMY= Lactation Milk Yield, LL= Lactation Length Z= Zebu and H=Holstein Frisian, B=Boran.
an increasing *Bos taurus* genes beyond 50% resulted in decreased lactation milk yield and herd life (Goshu, 2005). Milk production per lactation of crossbred of different indigenous cows with Holstein Frisian/HF with exotic blood level of Zebu X HF of 50%, 75% and 87.5% have milk yield ranged 1741-2318, 2352-2356 and 2318-2374L respectively (Gabriel et al., 1983). As well as crossbred of Borana X HF of 50%, 75% and 87.5% have milk per lactation of 1740, 2044 and 1902 L respectively (Millon and Tadelle, 2003).

A national average lactation length of local cows is 7 months (CSA, 2017). On the other hand lactation length of crossbred of different indigenous cows with Holstein Frisian/HF with different exotic blood level of zebu X HF of 50%, 75% and 87.5% have lactation length of 11, 13 and 14 months respectively (Gabriel et al., 1983). Crossbred cows of Boran X HF of 50%, 75% and 87.5% have lactation length of 10, 11 and 12 months, respectively (Aynalem et al., 2011). Lactation length (LL) has increased with increasing exotic inheritance (Kahi, 2002; Ahmed et al., 2007). As per the above statements as exotic blood level is increased both reproductive and productive trait performance of crossbred were increased until 75% exotic blood level and then it shows turn down. Though the performance is decreased as the exotic blood level increases crossbreeding is contributing a great role in milk production traits and reproductive traits.

**Challenges of dairy cattle cross breeding**

**Environment and genotype mismatch**

The purpose of crossbreeding is either to get complementary or Heterosis effect on a certain blood level. Application of crossbreeding is also advised under suitable production system. Given suitable government recognition, access to market and services, there is great potential for development of smallholder dairy scheme in peri-urban and urban areas (Staal and Shapiro, 1996). In Ethiopia, for traditional highland mixed farming and the smallholder dairy farming systems, introduction of exotic genes at 50% level could be considered best (Aynalem, 2006). The same author also suggested, it is possible to upgrade to 62.5% with improving management aspect. Draft policy of Ethiopia livestock development master plan also recommends crossbred cattle whose exotic blood level ranging 50-62.5% ignoring the adaptation problems (CSA, 2017). This shows, the current crossbreeding program in Ethiopia, unfortunately, was not based on a clearly defined breeding policy with regard to the level of exotic inheritance and the breed type to be used.

It has been accepted that the first-generation cross is well adapted to the low input production environment and can performs satisfactorily and is accepted by farmers. Records analyzed from over 21 years (1981-2002) of work on three large dairy farms, namely, Holleta, Stella and Selale, milk yield of crossbred cows indicate that crosses beyond F, were showing decreasing trends (Mukugeta et al., 1990). In generally; in Ethiopia crossbreeding is non-systematic and uncoordinated and with the present increasing trend for introduction of high-output animals, unorganized crossbreeding program and absence of crossbreeding policies would put a threat to Ethiopia farm animal genetic resources in the future (Effa et al., 2009).

**Lack of breeding policy and recording system**

Dairy cattle genetic improvement program started in Ethiopia in early 1970s but there is no legal framework to regulate crossbreeding or to distribute exotic genetic materials (Effa et al., 2009). In an increasingly globalized market, the absence of breeding policies and regulations, as well as the absence of gene bank for animal genetic resource conservation, could put indigenous breeds at risk and endanger the future generations of livestock in Ethiopia and the rest of the world (Desalegn, 2008). With the present increasing trend for high-out animals, unorganized crossbreeding program and absence of crossbreeding policies would put a threat to FAAnGR of Ethiopia in the future (Effa et al., 2009). On the other hand the program has never been subjected to notional level periodic evaluation and the effectiveness of this program is not clearly known. Moreover, sufficient information is not available on the rate of genetic improvement that guide policy makers, development planners and breeders to redesign appropriate breeding programs that respond to the current scenarios in Ethiopia. Lack of record keeping and reporting by breeders and farmers has adversely affected national data analysis and decision making on progress and it is also highly believed to have increased the incidence of inbreeding in the country (Desalegn, 2008). Lack of appropriate livestock policies have been identified as one of the increasing key factors causing threats to Farm Animals Genetic Resource in the developing world (Gibson et al., 2006).

**Improper use of artificial insemination (AI)**

AI is one the main reproductive tool in crossbreeding program. From a genetic improvement point of view AI is beneficial because it increases selection intensity of bulls and allows efficient bull usage. This tool has been successful in developed countries but due to lack of infrastructure, inefficient use of AI service and high costs of liquid nitrogen developing countries are currently challenging (Desta, 2002). In Ethiopia AI service is mainly provided by a government Artificial Insemination Centers (Tegegne et al., 2010). Genetic improvement and breed multiplication centers were established with the aim to distribute improved animals to smallholders (Tegegne et al., 2010).

A study report by Desalegn et al. (2009) revealed that 82% of the technical staff at national AI center and all participants of focus group discussions confirmed that there are no appropriate collaborations and communications between the national AI center, regional bureaus of agriculture and rural development and other stakeholders. In addition, about 73.3% of the AI technicians do not provide AI service during weekends (Bekele et al, 2005). Further factors like poor heat detection skills, absence of insemination service on holidays, shortage of experienced inseminators, poor feeding and management of dairy cows/ heifers, early embryonic mortality and ovarian cysts are mentioned as possible reasons for poor AI efficiency.
Improper use of AI for crossbreeding indigenous cattle with exotic breeds may be disastrous when information is needed to maintain the appropriate level of exotic genes in an environment for long-term strategy. The pros and cons of using AI should therefore be critically reviewed for each case before designing breeding programmes. The same author reported that the use of AI has also failed in many situations because of the lack of infrastructure and the costs involved, such as for transportation and liquid nitrogen for storage of semen or because the breeding program has not been designed to be sustainable. For effective delivery of input services, decentralization of semen production to regions and continuous capacity building for AI could help to use properly.

Potential opportunities of dairy cattle crossbreeding

Livestock genetic resources and production system
Ethiopia is endowed with large and diverse dairy animal which are widely distributed across the various agro-ecologies and climatic conditions in the country. The country with different breeds of cattle, indigenous animals have evolved over time through natural selection and adaptation to the existing diverse ecological zone of the habitat (DAGRIS, 2007). Consequently, dairy cattle crossbreeding in Ethiopia forms a continuum with postural form of production system dominating the lowland agro-ecological set up (livestock production is dominant to sustain the livelihood of society) to market oriented urban and peri-urban dairy production system that exists in mid to upper highlands (ILCA, 1993). There are indications that milk yield is among the indigenous animals variable improving that there are opportunities for improvement (Belete, 2006).

The existence of diverse production system and agro-ecologies coupled with diverse flora of species rendered the country to have indigenous knowledge, especially in the areas of livestock production and dairy processing. For instance, strong indigenous knowledge exists in the preservation of milk in the agro-pastoral dairy system and milk products in the rural highland dairy system using various sources of herbs (Belete, 2006).

Accesses to services and land inputs
Dairy development depends on reliable inputs and services such as artificial insemination, health service and improved forage seeds supply (Murukia and Thorpe, 2001). Currently, the numbers of AI service centers have been increasing and cover most urban and peri-urban areas and some parts of rural highlands (Ibrahim and Oialolu, 2000). This is an opportunity to improve the genetic potential of indigenous dairy animals in the areas where there is critical shortage of milk and milk products (Solomon et al., 1991). Aware of the fact that diseases and parasitic infestations are economically important to reduce production, several public veterinary clinics have been established across the different dairy production systems in the country, although its efficiency of operation is low (Kedija, 2008).

Income generation and employment
Dairy farming supports livelihoods of society under low input production systems, generates income and creates employment opportunity under market-oriented production system. Dairy farmers in urban, peri-urban and rural dairy production system demonstrated strong interest to expand dairying as one of the means of income generating activity.

Expansion of research institutions
In Ethiopia, research on dairying started over 5 decades ago. Since the dairy research system has passed through a lot of transformations. The existence of various institutions involved in dairy research and development across the different parts of the country is an opportunity to come up with a solution for challenges that constrain dairy production and for low uptake of dairy technologies in the country (Tangaka et al., 2002). Currently, the number of public universalities has reached 31 compared to 9 universalities 10 years ago and most of them have programs to train students in the area of animal science and animal health at under graduate level. Agriculture technical and vocational education training collages are producing quite a large number of development agents to work grass root levels to meet the demands of farmers (Tilahun, 1995).

Increased demand and milk consumption
Although, the contribution of cow milk is dominant, milk from camels and goats are also consumed in Ethiopia, especially in pastoral and agro-pastoral systems of production. In Ethiopia there is long standing and strong culture of consumption of dairy products. In addition to raw row milk, milk products, such as butter, cottage cheese, fermented milk (yogurt) and whey are also commonly consumed (Yoseph, 1999).

CONCLUSION
This review confirms that Ethiopia has huge local cattle genetic potential but low in milk yield and dairy crossbreeding has been undergoing by introducing exotic semen from abroad to improve milk production. Because of unfavorable level of management to exotic blood level higher than 50%, performance of most milk production traits has remained constant, while gross country milk production increased. On the other hand decreasing in some reproductive traits has been reported as exotic blood level exceeds beyond 50%. Environment and genotype mismatch, lack of appropriate breeding policy and recording system, poor infrastructure facility, lack of trained man power, improper use artificial insemination and low adoption of dairy technologies were major challenges in dairy crossbreeding. Dairy development as a sector is much expected to be one of the major targets of the prospective agro-processing industries in the country. A cross-breeding strategy requires description of production environment, identifying the availability of infrastructure, setting appropriate breeding objective, selecting traits to be...
improved based on their influence on returns and costs to the producer and consideration of stockholders. Thus, the success of any breeding strategy followed to improve results obtained from cross-breeding depends greatly on long-term financial commitment of governments, well designed breeding program, matching of the inheritance level with the production environment and on the successful combination of advances in dairy technologies like AI technology.

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