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Cross breeding effect on milk productivity of Ethiopian indigenous cattle: Challenges and opportunities

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Dairy cattle genetic improvement in Ethiopia started during Italy evasion through importing of temperate breeds. Then, crossbreeding was principally applied in the tropics aimed to exploit breed complementarities. Most likely, 50% cross breeds were more productive in low input production system than higher level of inheritance. Milk production and reproduction performance traits were favored in 50% exotic cross. Non-systematic cross breeding, poor infrastructure and market system and lack of finance and trained man power were some of the problems in Ethiopia cross breeding. Defining the production system, selecting suitable breed for low-input smallholder conditions, determining blood level of inheritance were the most critical points that should be considered during proposing breeding program.

Key words: Cross breeding, reproductive performance, Ethiopia.

INTRODUCTION

The agricultural sector in Ethiopia engaging 80% of the population contributes 52% of the gross domestic product (GDP) and 90% of the foreign exchange (MoA, 2000). Ethiopia has the largest cattle population in Africa (52.13 million heads of cattle) (CSA, 2012) and contributes 40% to the annual agricultural output and 15% total gross domestic product. Cattle produce a total of 1.5 million tonnes of milk and 0.331 million tonnes of meat annually (FAO, 2005).

Although, the livestock sector has a significant contribution to the national economy, production per animal is extremely low. The average lactation milk production of the indigenous cows ranges from 494 to 850 kg under optimum management (Aynalem et al., 2009).

To meet the ever-increasing demand for milk, milk products and their contribution to economic growth, genetic improvement of the indigenous cattle has been proposed as one of the options. Genetic improvement of the indigenous cattle, basically focusing on crossbreeding has been practiced for the last five decades.

Therefore, the present review was focused on revising the impact of crossbreeding on indigenous cattle milk productivity.

LITERATURE REVIEW

Calving interval

Calving interval is a time elapsed between two consecutive successive parturitions. Average calving interval of indigenous cattle breeds and their 50% crosses were 431.5 and 429 days. Likewise, Yifat et al. (2012) reported that cross breeds have slightly shorter calving intervals than indigenous in Tatesa Cattle Breeding Center (622.6 days).

Another study supporting this verdict reported in North Showa zone indicated that indigenous breeds have larger calving interval (748.2 day) than crossbreds (660 day) (Mulugeta and Belayneh, 2013). However, in contradiction of the expectation, shorter calving interval in higher inheritance level, and longer calving interval was reported in 75 and 87.5% cross breeds respectively (Table 1).

Relatively longer calving interval might be indicative of poor nutritional status, poor breeding management, lack of own bull and artificial insemination service, longer days open, diseases and poor management practices (Belay et al., 2012).
In addition, the level of management achievable in Ethiopia is unfavorable to higher exotic inheritance levels than 50% inheritance (Aynalem et al., 2009). In low input free grazing production system, indigenous breed had shorter calving interval (474.48 days) than their cross breeds (491.35 days) (Habtamu et al., 2010). As blood level increased the management system also improved, unfortunately, this does not happen in Ethiopia.

### Milk production

The difference in milk production between indigenous and their 50% cross breeds showed steep slope (Figure 1). Another study conducted in North Showa zone indicates that 50% cross breeds (1511.5 L) produce more amount of milk than local breeds (457.89 L) per lactation (Mulugeta and Belayneh, 2013). Belay et al. (2012) reported that mean milk production per lactation between Horro and Holstein Friesian was 2333.63 L. This could be either due to complementary or heterosis effect to the achievable environment.

However, as blood level increased, reduction in their performance was observed, for example, slim difference in milk production was observed between 50 and 75% crosses. Furthermore, mean milk production of 87.5% cross breed was lower than 75% cross breeds (Figure 1). This could be justified as a reduction in epistatic effect. A cross breed would retain less than 50% heterosis effect and have an additional loss due to recombination effects. Significant recombination effect would have a negative effect on productivity of cross breeds (Mohamed et al., 2001).

### Lactation length

Lactation length of indigenous cattle increased in correspondence of exotic blood level. For example, the average lactation length of indigenous Arsi, Zebu and Boran breeds was 203.75 days while the average lactation length of their 50, 75 and 87.5% cross were 262.25, 284.25, and 294.25 days respectively. Similarly, another study conducted in North Showa zone indicated that local breeds (273.9 days) had shorter lactation length than cross breeds (333.9 days) (Mulugeta and Belayneh, 2013).

Even though there was an increment trend in lactation length as blood level increased, they could not reach generally accepted 305 days of lactation length for crossbred. This might be due to the reason of poor nutritional status, poor breeding management, diseases and poor management practices (Belay et al., 2012). Another author also support this idea in which, level of management achievable in Ethiopia is unfavorable to higher exotic inheritance levels than 50% Holstein Friesian inheritance (Aynalem et al., 2009).

### Trends in dairy cattle improvement

Cattle genetic improvement program in Ethiopia started with dairy cattle improvement to enhance milk production of local breeds. The program was launched by importing exotic dairy cattle breeds during Italy evasion. Later on, Dairy Development Agency (DDA) was launched (1958 to 1963) with the main duty of developing commercial dairy farms in Addis Ababa (Fekadu, 1990). Following this,

<table>
<thead>
<tr>
<th>Breed</th>
<th>Calving interval/day</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exotic blood level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0% (pure)</td>
<td>50%</td>
</tr>
<tr>
<td>Arsi</td>
<td>439</td>
<td>403</td>
</tr>
<tr>
<td>Zebu</td>
<td>451</td>
<td>458</td>
</tr>
<tr>
<td>Boran</td>
<td>439</td>
<td>440</td>
</tr>
<tr>
<td>Barca</td>
<td>397</td>
<td>415</td>
</tr>
<tr>
<td>Total milk yield/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsi</td>
<td>809</td>
<td>1741</td>
</tr>
<tr>
<td>Zebu</td>
<td>929</td>
<td>2352</td>
</tr>
<tr>
<td>Boran</td>
<td>867</td>
<td>1740</td>
</tr>
<tr>
<td>Barca</td>
<td>869</td>
<td>2055</td>
</tr>
<tr>
<td>Lactation length/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsi</td>
<td>272</td>
<td>334</td>
</tr>
<tr>
<td>Zebu</td>
<td>303</td>
<td>378</td>
</tr>
<tr>
<td>Boran</td>
<td>240</td>
<td>337</td>
</tr>
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Chilalo Agricultural Development Project (CADU) was established jointly by the Ethiopian and Swedish Governments in Arsi region. This opened intensive small scale dairy development in Ethiopia in 1967/1968 (Kiwuwa et al., 1983).

Wolaita Agricultural Development Project (WADU) was established in 1971 by World Bank fund (Haile, 1994). Production of deep-frozen semen started at CADU in 1973. CADU in Assela and WADU in Welai continued breeding and distributing crossbreds to farmers. In 1987, a FINNIDA funded project of the MOA started to improve dairy cattle productivity at the highlands of Ethiopia through the establishment of the Selale Peasant Dairy Development Pilot Project (SPDDPP).

SPDDPP introduced crossbred dairy cattle and improved management skills with the objective of improving the living standard of smallholder farmers (Kelay, 2002). The focus of the program was on increasing the milk productivity of local breeds through crossbreeding and distribution of F₁ heifers to farmers (Ethiopian Agricultural Research Organization 2, 2001).

Furthermore, crossbred dairy cows and purebred Friesian and Jersey breeding bulls were distributed with introducing improved methods of fodder production in the project areas (MOA/SDDP, 1996). Despite all of these trials, the numbers of crossbred cattle made only 1% of the total cattle population of Ethiopia (Workneh et al., 2002). Then, national artificial insemination center was established in 1981, with the aim of country coverage in artificial insemination service (rural, peri-urban, and urban areas) through the regional offices.

Consequently, production and use of fresh semen liquid nitrogen plant was installed in 1984. Bulls donated by the Cuban Government (25 Holstein and 10 Brahman) and importation of 44,800 doses of Friesian and 2,000 doses of Jersey semen were the source of semen used for frozen semen technology. To date, semen was collected from exotic, indigenous, as well as, crosses of these breeds, namely Friesian, Jersey, Brahman, Boran, Barka, Fogera, Hito, Sheko, and crosses of 50, 62.5, 75, and 87.5% Holstein-Friesian indigenous bulls. The NAIC at Kality is serving as the main semen collection and preservation center. Later, productions of semen from crossbred animals (Friesian × Fogera, Friesian × Boran, Friesian × Barca, Friesian × Arsi) and from indigenous breeds (Barca, Borana and Fogera) were undertaken and some doses distributed.

**Trends of milk production**

Total milk production in Ethiopia increased during the 1961 to 2000 period at an average annual rate of 1.55%. Additionally, during the last decade, milk production was grown at even higher rate (3.0%). This might be as a
result of increased coverage of extension services (such as better management skills) and increased use of improved inputs (improved breeds and feed) and technology and policy changes promoting dairy production (Mohamed, 2004). Similarly, Central Statisical authority data on milk production also showed an increment to 3.33 billion liters in 2012 (CSA, 2012) from 2.4 billion liters in 2004 (CSA, 2004). Therefore, crossbreeding program has been contributing its impact on alleviating the ever increasing demand of milk and its product in the country.

CHALLENGE AND OPPORTUNITY

Environment and genotype mismatch

Use of crossbreds is also advised under suitable production system. Most likely, 50% cross breeds were more productive in low input production system than higher level of inheritance. This could be either due to complementary or heterosis effect. The idea also supported the level of management achievable under most smallholder conditions in Ethiopia which has been rather unfavorable to higher exotic inheritance levels than 50% inheritance (Aynalem et al., 2009).

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 (Stall and Shapiro, 1996). However, it could still be argued whether the gains attained were commendable when compared to the substantial investment involved in the genotype improvement undertakings, and recent hypothesis suggested that the economic benefits of crossbreeding may have been overestimated as non-market effects and environmental values have not been included in breed comparison studies (Workneh et al., 2002).

Lack of cross breeding policy

Crossbreeding has principally been applied in the tropics aimed to exploit breed complementarities. Specifically, specialized exotic breeds have been crossed with indigenous breeds to combine the high productivity of the former with adaptive attributes of the latter (Kahi, 2002). Exotic animals used in crossbreeding are not naturally adapted to local conditions, so large scale (beyond optimal exotic blood level) crossbreeding should be carried out with caution (FAO/IAEA, 2009).

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 to 62.5% is recommended in avoiding the adaptation problems (EARO 2, 2001). However, the current the crossbreeding work 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. In general, in Ethiopia, crossbreeding is non-systematic and has an uncoordinated Ethiopian Society of Animal Production (ESAP, 2009).

Infrastructure, market, financial and trained manpower problem

Artificial Insemination (AI) technology has also led to one of the most successful smallholder dairy systems in the developing world (Stall et al., 2008). However, the use of AI has also failed in many situations in developing countries 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 programme has not been designed to be sustainable (Mpfou and Rege, 2002; Philipsson et al., 2005; Azage et al., 1995).

Improper use of AI for crossbreeding indigenous cattle with exotics 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 development of market infrastructure and market institution is also very important for inducing efficiency and incentives for market participants on the value chain (Azage et al., 2010).

Breeding for dairy through crossbreeding

Development of any genetic improvement 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 (Zewdu, 2004). Thus, designing a breeding program needs decision on a series of such interacting components (Dansh and Jean, 2011). Some of the most important components of this breeding program are subsequently discussed.

Production system

Any breed improvement program should be designed in accordance with the production system. To the extent that not all the components of the environment can be
changed, particularly in low-input tropical production systems, one needs to know which genotypes can be used under such environmental conditions, that is, different types of production environments need different types of animals.

The climatic conditions in Ethiopia vary from humid tropical in the western lowlands through mild subtropical in the highlands to the arid tropical conditions of the eastern lowlands (Aynalem et al., 2011). Due to this extreme variation in climatic conditions as well as, variations in feed and water supplies and population density, the livestock production systems and their objectives vary considerably (Haile, 1994).

The Ethiopian dairy production system can be distinguished into five categories: the traditional pastoral livestock farming, traditional highland mixed farming, smallholder dairy farming, urban and peri-urban dairy farming and the specialized commercial intensive dairy farming (Getachew and Gashaw, 2001). Therefore, it is necessary to propose the appropriate breeding program for each production environment.

**Choice of the exotic breed**

When the strategy of breed improvement is based on introduction of exotic improver breed, an important question that has to be addressed is choice of the exotic breed to be used. The choice among the different foreign breeds to be used for crossbreeding could be made based on available information on the limited experience of crossbreeding work in Ethiopia and/or experiences of other tropical developing countries (Aynalem et al., 2011).

Literature reports strongly emphasized the need to utilize different breeds under varying production systems. For example, Jersey breed has been suggested as one suitable breed for low-input smallholder conditions because of having smaller body size, fair amount of milk with higher fat content, better reproductive performance and some heat tolerance. In intensive and semi-intensive production systems, however, the Holstein Friesian will remain the choice. This situation also applies to temperate climates (Aynalem et al., 2011).

**Level of exotic inheritance**

When designing breed improvement program, the level of exotic inheritance to be used in the crosses also needs to be decided. Milk production, reproduction performance and milk composition traits were all in favour of the 50% exotic cross (Aynalem et al., 2011). Cunningham and Syrstad (1987) made an extensive analysis of results from crossbreeding in the tropics. They concluded that consistent improvements in most performance traits were achieved in ‘upgrading’ cattle to as much as 50% with temperate dairy breeds. Beyond that, results were variable.

A general conclusion is that crossbreeding to produce animals with up to 50% of the genes from temperate breeds can be recommended where crossbreeding is an option for genetic improvement. Crosses with less than 50% *B. taurus* genes have been found to be poor dairy animals (Syrstad, 1989).

**CONCLUSION**

Since the level of management achievable in Ethiopia is unfavorable to higher exotic inheritance levels than 50%, milk production, lactation length and calving interval decreased or remained constant in higher cross inheritance from 50% crossbreed, while cross country milk production increased. Environment and genotype mismatch, lack of cross breeding policy, infrastructure, market, financial and trained manpower problem were major challenges in dairy farm. Any breed improvement program should be designed in accordance with the production system.

Furthermore, choice of the exotic breed and determining level of inheritance are some of the factors that should be considered during designing any breed improvement.

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