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Dairy Cattle Breeding Program in Ethiopia: Lesson Learned from Case Studies in the Tropical Countries

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Dairy farming has been considerably contributing for family nutrition and income generation in Ethiopia. Despite large cattle population and favorable climatic conditions, the self-sufficiency in milk production is not yet attained in Ethiopia. The aim of this study was to assess the dairy cattle genetic improvement in Ethiopia and draw lesson from tropical countries. The genetic improvement was mainly based on crossbreeding and the crossbred cows produce about 3-5 folds of milk yield as compared to the traditional production system. However, the low number (1% of the national cattle population) and fluctuation in performance of crossbred dairy cattle in Ethiopia could point out that there was a lack of appropriate breeding programs for sustainable genetic improvement. In some tropical countries such as in India, Australia and Brazil, there were successful long-term breeding programmers which significantly increase the number of improved dairy cattle and milk production of the countries. Based on lesson learned from tropical countries the genetic improvement efforts in Ethiopia can be further enhanced by reinforcing the crossbreeding activities by appropriate breeding programs. Furthermore, community involvement, inputs and output delivery system and human and infrastructure capacity needs to be improved to run the long term breeding program smoothly.

Keywords: crossbreeding, dairy, genetic improvement.

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INTRODUCTION

Dairy farming is an important component of agricultural system in Ethiopia. Milk and milk products are being used as source of essential nutrients required for growth, body maintenance and health of human being. In addition, research reports indicated that the sector significantly contribute for income generation in the livelihood improvement of the farmers. For instance the report of Agajie *et al* (2016) in Ethiopia, Oromia region showed that adopter of crossbred cows technology generated 44% more income than non-adopters.

Despite large cattle population (about 50 million heads) and favorable climatic conditions, the self-sufficiency in milk production was not yet attained in Ethiopia. Per capita consumption was about 16-19 kg (Getnet, 2009; CSA, 2010) which was much below the average milk intake (FAO standard requirement) to be maintained for balanced diet. The country milk import was also increased from 3.1 million USD to 9.3 USD from 2001-2008 years (Getnet, 2009). This is mainly due to poor productivity of indigenous cows and low success rate of genetic improvement.

The breeding strategies have to create genetic change in the livestock population in order to benefit livestock keepers and wider group of stakeholders (FAO, 2010). Selection among the indigenous animal exploiting the individual variation would be the most reliable way to improve the milk yield and associated traits. Past research works revealed that the genetic gain through selection of indigenous cows cannot be more than 2% (Braännäng and Person, 1990). Hence it was considered to be too slow to support the current demand of milk. Thus in Ethiopia, the genetic improvement of dairy cattle to enhance the reproductive and productive performance was mainly based on cross breeding. Using improved dairy cattle breeds and its associated technological packages, research facts show that milk production can be improved by about 300-500% as compared to the traditional production system (Beyene, 1992; Kefena et al., 2006; Yielma et al., 2006).

However, an adaptation problem on continuously upgraded crossbred generations and drastic decline in milk yield from F1 to 50% F2 crossbred cows were observed (Beyene, 1992; Kefena *et al.*, 2006; Haile *et al.*, 2011). Moreover the number of dairy cattle with exotic inheritance was about 1% of the national cattle population (CSA, 2011). As a result a substantially improvement in terms of production and number of improved animals was not achieved so far in Ethiopia.

The low number and fluctuation in performance of crossbred dairy cattle in Ethiopia could indicate that there was a lack of appropriate breeding programs for sustainable genetic improvement. In some tropical countries such as in India, Australia and Brazil, there are successful long-term breeding programmers which significantly increase the number of improved dairy cattle and milk production of the countries. The aim of this study was therefore to assess the dairy cattle improvement program in Ethiopia and draw lessens from tropical countries which could help the future genetic improvement in Ethiopia. This paper focused on case studies which address successful crossbreeding program in development of synthetic breed in the tropics.

Concept and Type of Crossbreeding

Crossbreeding is an alternative means of generating genetic change in a population. The conceptual basis of crossbreeding can be classified broadly into additive and non-additive The additive types. component is performance obtained due to the averaging of merit in the parental lines or breeds, with simple weighting according to the level of gene representation of each parental breed in the crossbred genotype (Gosey, 1991; Swan and Kinghorn, 1992). The non- additive effect is mainly expressed by heterosis. Swan and Kinghorn (1992) described that it is the amount by which merit in

crossbreds deviates from the additive component attributed to genetic interactions within loci (dominance) and interaction between loci (epistasis). In addition, according to FAO breeding strategy guideline (2010), crossbreeding program can be categorized in to three. The first is sustained crossing which involve a group of livestock keepers who produce females of a specific breed or breed combination that will be mated to sires of another breed to produce cross-bred progeny. The second is upgrading program which practices a continuous backcrossing to one parental breed. The third breeding program is creating new breed (often called synthetic breed) through long term crossing to fix the genotype at desirable level.

Development of Sunandini Cattle Breed in India

Development of Sunandini cattle breeding program in India was aimed at creating a new synthetic breed out of a crossbred population with exotic inheritance of around 50 percent from Jersey, Brown Swiss and Holstein (Chacko and Jose, 1988; Taneja, 2000). The Indo-Swiss Project Kerala (then named Kerala Livestock Development Board) has started to develop a new breed of cattle through cross-breeding in the high ranges of Kerala In 1963, with approximately 2000 farmers participating. Then, this program had expanded widely in 1980 involving about 1.8 million cattle population. Moreover because of intensive extension work, the participation of the farmers was strong to run the technical activities smoothly.

Hence this breed development program had greatly influenced the dairy economy of the state of Kerala. The annual milk production of the state increased from 0.164 million tons in 1966 to 19.3 million tons in 1993. The milk production growth was achieved through both the increased number of improved animals and the increase in the production potential (Chacko and Jose, 1988; Taneja, 2000).

The use of bull from different breeds and countries may help to combine the desired characteristics of breeds and maximize the heterosis effect. The breed development was started by importation of 22 Brown Swiss bulls and 45 cows during the period from 1964 to 1967 (Chacko and Jose, 1988). The bulls were then mated with a nucleus stock of 140 nondescript cows. Subsequently, semen from 11 more bulls was imported. Up until 1976, bulls were selected based on their pedigree. Then they had started progeny testing program in 1977 to estimate the breeding value of cross-bred bulls based on recordings of farmers' cows. A selection index for bull mothers was developed based on the standard lactation milk yield, age at calving and calving interval corrected for the herd, year and seasonal effects. All young cross-bred bulls were progeny tested before their large-scale introduction into the artificial insemination program to extend the superior genotype to production population.

According to the report of Chacko and Jose (1988) the reproduction and production performance of this breed were 350 to 400 kg mature body weight, 28 to 32 months age at first calving, 2435 kg mean lactation milk yield in 279.8 days and 4 percent milk fat.

Development of the Brazilian Milking Hybrid

The Brazilian milking hybrid (MLB) composite breed development program has been undertaken since 1977 in Brazil. It was a development oriented research program conducted by the National Dairy Cattle Research Centre of the Federal Research Organization (EMBRAPA) with the help of Food and Agricultural organization (FAO) and United Nation Development Program (UNDP) (Madalena *et al.*, 2012). According to Madalena (1999) the aim of this program was to obtain experimental information to design selection criteria for new hybrid cattle breeds combining dairy, reproduction, growth and adaptation traits, while developing cattle suitable for the dairy production systems of the Brazilian Tropics.

Different herds, which had different breed composition, managed by several institutions and private breeders were engaged in the projects for developing new synthetic B. taurus x B. indicus dairy breeds. Thus all those projects were merged together in a single progeny testing program by aligning their previous breed composition and improvement target for a common selection criterion.

The project member farms have recorded data for milk yield, fat, protein and age at first calving traits. However milk yield in standard of 305 day lactation in the existing farming conditions was the sole selection criterion in the initial phase of the project. The level of exotic inheritance of B. taurus were set at 1/2 to 3/4 for bull dams and 1/2 to 7/8 for the young bulls. Furthermore the fraction of B. taurus was not restricted at fixed point as they assume that good genes could be obtained from any breed and give a chance to exploit desirable genetic variation (Madalena, 1999; Madalena *et al.*, 2012).

At the beginning of the program, candidate bull calves were selected based on dam performance only. Then sires of bulls were chosen from both MLB sons of the very best dams and USA and Canadian Holsteins with high milk predicted differences. Later on specific Software was developed to estimate breeding values to run the selection based on an index of cow performance, sire and dam breeding values and genetic level. Even though they did not consider for selection criterion, they had analyzed the data for progress of milk fat, milk protein and age at first calving traits. In addition, they have adopted a procedure from Australian protocols to evaluate tick resistance of young bulls before semen collection.

For the success of planned breeding program human and infrastructural capacity is essential. EMBRAPA has arranged PhD level trainings in Brazil and other countries to full fill the gap of expertise. In addition the in-service training and the logistic provided by the FAO/UNDP Project also contributed for capacity development of the sector to run and evaluate the breeding program efficiently.

Development of Australian Milking Zebu Cattle

The Australian Milking Zebu (AMZ) was initiated during the

mid-1950s by the Commonwealth Scientific & Industrial Research Organization. The main objective of this breeding program was to overcome the problems of traditional dairy breeds performing at reduced levels under hot, humid and tick-infested conditions. The program started with the introduction of Pakistani Sahiwal and Red Sindhi dairy cattle. Then these two breeds were mated initially to high-producing Jersey cattle. Later on Illawarra, Guernsey and Holstein Friesian sires were used in the crossbreeding program in order to combine the desirable characteristics of different breeds (Handbook of Australian Livestock, Australian Meat & Livestock Corporation, 1989).

The overall productive and reproductive performances of AMZ breed were 2929 liters of milk in 300 days milking, 39 months of age at first calving, 52 months of calving interval and 5.5 % fat (Handbook of Australian Livestock, Australian Meat & Livestock Corporation, 1989).

Dairy Cattle Genetic Improvement Program in Ethiopia

The report of Yielma et al (2011) indicated that there were about 27 breeds of cattle in Ethiopia. There were about 9 million milking cows in the country and 99 % were indigenous type (CSA, 2011). Even though there are few research activities being initiated, the cattle breeds in Ethiopia were not selected for dairy traits. This was mainly attributed to the assumption that the genetic gain expected from selection of indigenous cattle is 1-2 percent per year (Braännäng and Person, 1990) which is too slow to support the immediate high demand of milk in the country. Thus in spite of the fact that the indigenous cattle have qualities to withstand varying climatic conditions, shortage of feed and disease challenge, they are characterized by slow growth rate, low milk yield, short lactation length and long calving interval. Research findings showed that the reproductive and productive performance of indigenous cattle were about 57 months for age at first calving, 270-550 kg milk yield per lactation,

180-240 days of lactation length, and about 570 days of calving interval (Beyene, 1992; Yielma *et al.*, 2006; CSA, 2009; Haile *et al.*, 2011).

Hence in Ethiopia, the genetic improvement of dairy cattle has been mainly focused on cross breeding in order to combine high milk yield potential of exotic breed with adaptive potential of local breeds. The modern dairy production in the country was started in 1950s when 300 Friesian and Brown Swiss dairy cattle received as donation from the United Nations Relief and Rehabilitation Administration (Mohamed *et al.*, 2004). Haile *et al* (2011) also noted that crossbreeding for dairy cattle improvement in Ethiopia was initiated in the early 1950s. The most common indigenous breeds used as a dam line for crossbreeding were Boran, Horo, Fogera and highland zebu. Whereas Friesian and Jersey sires are being used from exotic source.

The crossbreeding programs have been conducted mainly in the central highlands and in and around towns. Different stakeholders play a key role on expansion of dairy technologies in these areas. The spillover effect of crossbreeding research and demonstration conducted by Ethiopian Institute of Agricultural Research, development efforts carried out by Dairy Development Agency (DDA) established by government of Ethiopia, Chilalo Agricultural Development Unit (CADU), Arsi Rural Development Unit (ARDU), Peasant Dairy Development Pilot Project supported by Finland Government (FINNIDA), Fourth Livestock project, National Artificial Insemination Center and other organization have significantly contributed for expansion of dairy farming in Ethiopia.

Research results indicated that the performance of crossbred dairy cattle in Ethiopia is promising and comparable with other crossbred dairy cattle in the tropics. The growth, reproduction and production performances of 50 % crossbred F1 cows on average were about 26 kg birth weight, 39 months age at first calving, 2150 litters milk yield in 359 days of lactation and 422 days calving interval (Beyene, 1992; Gebeyehu, 1999; Demeke *et al.*, 2004; Kefena *et al.*, 2006; Haile *et al.*, 2011). (Table 1)

Appropriate (planned) breeding strategy can help dairy farmers to maintain the desired level of crossbred populations in a sustainable way (Philipsson et al., 2010; Ojango et al., 2015). In support of this, the level of B. taurus inheritance was set at about 50% to develop Sunandini breed in India and 1/2 to 3/4 for bull dams to develop Brazilian milking hybrid in Brazil. However in Ethiopia, despite recommendations, the level of exotic inheritance for progenies of crossbred cows was not predetermined by specific mating plan for specific area due to absence of breeding programs which shows direction to produce adaptive and productive generations at community level. The level of exotic inheritance could influence performance and adaptation of crossbred animals to the prevailing environment. For instance the study of Haile et al (2011) showed that the lifetime milk yield of 87.5 % exotic inheritance dairy cows (5820 kg) was much lower than that of 75% crossbred cows (7122) and F1 50% crosses (7998 kg) in Ethiopian. In addition, Kefena et al (2004) reported that milk yield of second-generation 50% Jersey crossbred cows (1342.66) was reduced by about 37% compared to F1 Jersey crossbred cows (2150.39) in the central highland of Ethiopia. These might indicate that the challenge of local environment (climate, feeding, disease and other management) was high on upgraded generation to express their genetic potential and gene segregation can significantly reduce performances of the cows if the breeding program is not supported with intensive selection.

The breeding program should address clear breeding goal which includes economically important traits and other associated adaptation traits. Tropical countries like India, Brazil and Australia described above had considered production, reproductive and adaptation traits based on farmers interest and agro-ecologies in the long term genetic improvement efforts. In Ethiopia, the breeding goal targeted mainly milk yield and cows were judged based on daily or lactation yield. However, very important traits such as milk quality (fat and protein),

| Trait | Boran | 50% | 62.5% | 75% | 87.5% |
|-----------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Growth performance | | | | | |
| BWT, kg | 23 ± 0.4 ^e | 26 ± 0.2 ^a | 29 ± 0.4^{bc} | 31 ± 0.3 ^{cd} | 31 ± 0.3 ^{cd} |
| WWT, kg | 54 ± 1.2 ^{cb} | 57 ± 0.5 ^a | 54 ± 1.2 ^b | 55 ± 0.8^{a} | 57 ± 0.8^{a} |
| SMWT, kg | 79 ± 1.5 ^b | 92 ± 0.7 ^a | 89 ± 1.6 ^a | 90 ± 1.2 ^a | 91 ± 1.1 ^a |
| YWT, kg | 111 ± 2.4 ^c | 147 ± 1.1 ^a | 144 ± 2.6 ^a | 143 ± 1.9 ^{ba} | 145 ± 1.9 ^a |
| EWT, kg | 149 ± 3.6 ^b | 203 ± 1.8 ^a | 198 ± 4.0 ^a | 201 ± 3.4 ^a | 201 ± 3.3 ^a |
| TWT, kg | 195 ± 5.0 ^b | 258 ± 2.7 ^a | 263 ± 5.8 ^a | 261 ± 4.8 ^a | 262 ± 5.8^{a} |
| ADG1, gm | 439 ± 8.4 ^b | 512 ± 3.6 ^a | 495 ± 8.7 ^c | 502 ± 6.4^{a} | 504 ± 6.3^{a} |
| ADG2, gm | 220 ± 9.4 ^d | 303 ± 5.0 ^a | 343 ± 11 ^b | 323 ± 9.1 [°] | 310 ± 11 ^ª |
| Reproductive performance | | | | | |
| AFS, months | 32 ± 1.4 ^c | 27 ± 0.7 ^a | 28 ± 1.0 ^{ab} | 28 ± 0.9 ^b | 28 ± 1.2 ^{ab} |
| AFC, months | 44 ± 1.5 ^b | 39 ± 0.6^{a} | 41 ± 1.0 ^{ab} | 40 ± 0.9^{a} | 39 ± 1.3 ^a |
| NSC | 2.4 ± 0.1 | 2.2 ± 0.1 | 2.7 ± 0.2 | 2.2 ± 0.2 | 2.1 ± 0.3 |
| CI, days | 439 ± 10 ^b | 422 ± 10 ^a | 446 ± 12 ^b | 443 ± 11 ^b | 423 ± 21 ^{ab} |
| DO, days | 141 ± 7 ^b | 127 ± 7 ^a | 135 ± 8 ^{ab} | 142 ± 8 ^b | 134 ± 14 ^{ab} |
| BE, per cent | 72 ± 1.3 ^b | 77 ± 1.1 ^a | 78 ± 2.1 ^a | 76 ± 1.9 ^{ab} | 74 ± 4.6^{ab} |
| Milk production performance | | | | | |
| LYD, kg | 507 ± 39 ^c | 2019 ± 26 ^a | 1918 ± 51 ^a | 2182 ± 45 ^b | 2366 ± 91 ^b |
| 305YD, kg | 561 ± 28 ^e | 1831 ± 19 ^a | 1732 ± 38 ^b | 1940 ± 33 [°] | 2107 ± 67 ^d |
| LL, days | 240 ± 4 ^c | 337 ± 3 ^a | 341 ± 6^{ad} | 351 ± 6^{bd} | 355 ± 11 ^{ad} |
| DYD, kg | 1.7 ± 0.1 ^e | 6.0 ± 0.1^{a} | 5.7 ± 0.1 ^b | $6.3 \pm 0.1^{\circ}$ | 6.9 ± 0.1 ^d |
| LTYD, kg | 2630 ± 454 ^c | 7998 ± 291 ^a | 6309 ± 518 ^b | 7122 ± 468^{ab} | 5820 ± 870 ^b |

 Table 1. Least squares means and standard errors for genotype comparisons

BWT = birth weight; WWT = weaning weight; SMWT = six months weight; YWT = yearling weight; EWT = eighteen months weight; TWT = two years weight; ADG1 = daily weight gain from birth to six months; ADG2 = daily weight gain from six months to two years; CI = calving interval; BE = breeding efficiency; NSC = number of services per conception; AFS = age at first service; AFC = age at first calving; DO = days open; LL = lactation length; 305YD = 305 days milk yield; LYD = lactation milk yield; DYD = daily yield; LTYD = life time milk yield.

Least-squares mean with same superscript in the same column for same variable indicate non-significance.

Crosses – with Holstein Friesian

Source: Haile et al (2011)

reproduction, longevity and adaptation traits have got less attention. In addition, there were no appropriate recording system in placed at farmers' level to determine the level of exotic inheritance as well as to evaluate performance and survival of crosses under farmers' management condition.

Generally crossbreeding brought substantial change in milk production for income generation and family nutrition in Ethiopia. Therefore, based on lesson drawn from tropical countries the following major points can further augment dairy cattle genetic improvement in Ethiopia.

- A. The crossbreeding activities needs to be reinforced with appropriate breeding programs suitable to respective production systems or agro ecologies to produce adaptive and productive generations. Herds with different exotic inheritance or selection criteria found in the same production system or agro ecology can be merged together in to similar program by aligning their previous breed composition and improvement target for a common selection criterion. Moreover main breeding goals and the associated goal traits have to be measured and included in selection index.
- B. Community involvement and collaboration and share of responsibilities among stakeholders are critical for the success of breeding program. The awareness of farming community and stakeholders on breeding program and its long term consequences have to be enhanced.
- C. Input and output delivery systems should be efficient to run the breeding program smoothly. Artificial insemination (AI) and other reproductive biotechnology techniques were not effectively supporting the breeding program. So it is better to evaluate the existing AI delivery system and identify and test alternative service deliver at village level.

D. It is crucial to strengthen human and infrastructure capacity to enhance the success of the breeding program.

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