Matching Genotype with the Environment Using Indigenous Cattle Breed: Introduction of Borana Cattle from Southern Ethiopia into the Lowlands of North-Western Ethiopia[1]

Azage Tegegne*[2], Eshete Dejen[†] , Dirk Hoekstra*, Worku Teka*

[*]Improving Productivity and Market Success (IPMS) Project, International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia
[†]Amhara Regional Agricultural Research Institute (ARARI) , P. O. Box 527, Bahir Dar, Ethiopia

[2]Email address of main author: a.tegegne@cgiar.org

ABSTRACT

This study was undertaken in the arid to semi-arid lowlands of Metema district, North-western Ethiopia with the objective of introducing the right animal to match the environment. The Metema district covers 440,000 ha, and is mainly occupied by settlers from the highlands of Amhara and Tigray Regions, who brought the highland Zebu breeds along with them. Rutana and Felata, the local lowland cattle breeds, constitute a smaller proportion of the cattle population. The major problems associated with cattle production are diseases and biting flies, water shortage, heat stress, long distance to watering points and grazing areas. As a result of this mismatch between genotype and the environment, the performance of the highland cattle is compromised as expressed by high pre-weaning calf mortality, slow growth rates, low fertility and calving rates, low milk yield and carcass weight. Farmers would like to exploit the emerging and expanding demand for beef both in the domestic and export markets, and are demanding for more adapted and productive animals. The Improving Productivity and Market Success (IPMS) project in partnership with the Ministry of Agriculture and Rural Development (MoARD) and Amhara Agricultural Research Institute (ARARI) has introduced one of the most promising indigenous Borana cattle breed in to the district from the semi-arid lowlands of Borana in southern Ethiopia. The breed is known for its heat and drought tolerance, good walking capacity, faster growth rate, higher fertility and superior meat production potential. Simultaneously, the project partners are testing different approaches to speed up the introduction of these desirable genes into the highland cattle population. This paper reports the processes involved in this new approach and the results achieved so far.

INTRODUCTION

Ethiopia has the largest ruminant population in Africa. Pastoral, agro-pastoral and transhumance cattle production systems are important determinants of livelihoods in the semi-arid areas of northwestern, southern and eastern parts of Ethiopia (Tesfaye Mengistie, 2008). The highlands are important for mixed crop-livestock enterprise, while the arid to semi-arid lowlands are dominated by livestock production. The livestock species and breeds in these production systems have been traditionally selected, over millennia, to adapt to the challenges of the agro-ecologies. The Amhara Regional State owns 35% of the national livestock population. An action research project i.e. Improving Productivity and Market Success (IPMS) of Ethiopian farmers was initiated in the arid to semi-arid lowlands of Metema district, which shares a 60 Km border with the Sudan, in North Gondar Zone of Amhara Region (Figure 1). The IPMS project is implemented by the International Livestock Research Institute (ILRI) in collaboration with the Metema district Office of Agriculture and

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Rural Development (OoARD) and the Amhara Regional Agricultural Research Institute (ARARI). To assess smallholder marketable commodities and interventions along the commodity value chain, IPMS conducted a rapid rural assessment study (IPMS, 2005) According to this study the total area of the district is 440,000 ha, mean annual temperature ranges from 22^{o}C to 28^{o}C and reaches as high as 43^{o}C in May. The mean annual rainfall ranges from 850 mm to 1100 mm. The rainy season extends from June to September. Although 60% of the district is flatland, altitude ranges of 550 to 1,068 masl.

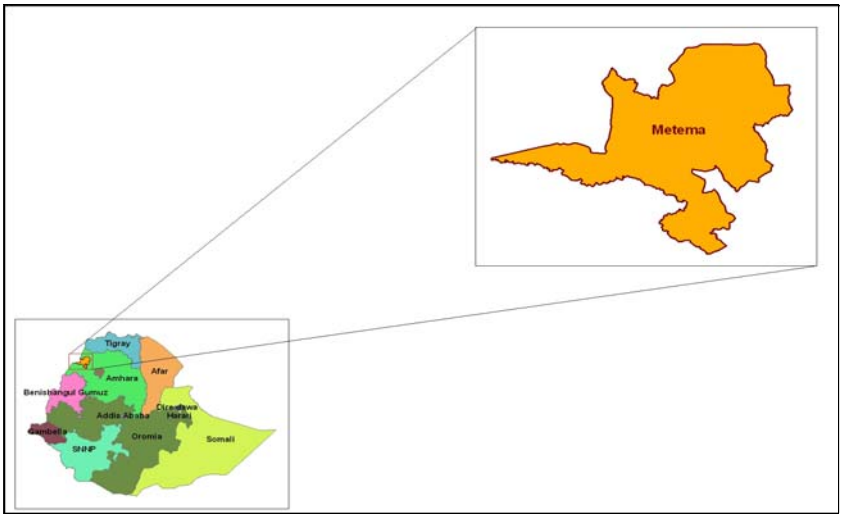

Figure 1. Location of Metema District in North-western Ethiopia

According to IPMS (2005) the human population in Metema district is estimated at 94,551. Although the original residents are the Gumuz people, the area has been gradually populated by settlers from the highlands of Amhara and Tigray Regions. As a result, sesame-livestock followed by cotton-livestock have evolved as the dominant farming systems. The dominant cattle population is the highland Zebu (mainly Fogera cattle breed crossed with other highland Zebu) brought by the highlanders. Rutana and Felata cattle breeds constitute a smaller proportion of the total cattle population. As a result, there is a mismatch between the cattle genotype and the environment. The major problems associated with this cattle production system are diseases and biting flies, heat stress, long distance to watering points and grazing areas. Cattle production is therefore characterized by high pre-weaning calf mortality, slow growth rate, low fertility and calving rates, low milk yield and carcass weight

The PRA and subsequent studies also identified that there is a potential for a market-oriented cattle fattening system in the district due to the increased domestic demand and expanding export opportunity (Elias Mulugeta *et al.,* 2007). Also, the transformation from a grazing area based system to a more crop livestock system resulted in the emergence of crop residues and other by-products which are potential sources of feed for fattening. As a result, farmers are demanding for more adapted and productive animals. In response to this challenge, the IPMS Project and partners designed an action research program which had three components i) identify potential indigenous breeds suitable for Metema, ii) conduct an on farm study to test the performance of crosses with the local Zebu, and iii) test different approaches to speed up the introduction of these genes into the highland cattle population.

MATERIALS AND METHODS

To identify potential indigenous breeds for Metema the project conducted more in depth studies on the characteristics and performance of the livestock system in Metema and did literature review on potential indigenous breeds as compared to the Highland Zebu.

The focus studies on cattle production systems and on feed resources were conducted by two graduate (MSc) students. A total of 240 representative farmers were selected using systematically random sampling method and formal and informal surveys were conducted to collect quantitative and qualitative data from primary and secondary sources. In order to understand the types and the nature of livestock production system, discussions were with experts from Zonal and Woreda Agriculture and Rural Development Offices and community groups in each village using topical guidelines. A semi-structured questionnaire was developed to collect data on socio-economic characteristics of the households, cattle production and management practices, feed resources and utilization practices, reproductive and productive performance of cattle, and live animal and animal product marketing.

To test the performance of the crosses with the local highland Zebu, highland Zebu cows from four villages were selected based on body condition score and rectal palpation for ovarian cyclic activity and randomly allocated into hormonal treatment, control (natural mating) groups for AI with Borana semen and naturally mated to highland zebu bulls. Cows included in the experiment were ear tagged for easy identification.

To test different organizational approaches to speed up the introduction of the desired genes, discussions were held with communities and officials and two basic strategies were decided upon for the first year i.e. i) natural mating with Borana bulls ii) AI with Borana semen. Borana bulls were purchased from the Oromia Agricultural Research Institute (OARI) that has a research program on improving Borana cattle. Individual animals were identified, checked by a veterinarian and transported to Bahir Dar and quarantined at the Andassa Livestock Research Centre of ARARI. In addition, a total of 500 doses of Borana semen were purchased from the National Artificial Insemination Centre, in the outskirts of Addis Ababa. Lessons learned and processes used are described in the results session.

RESULTS AND DISCUSSION

A. Focus studies

The natural vegetation in Metema is predominantly composed of different woody and herbaceous species (Figure 2). Forest and rangeland was estimated to cover 58% of the district.. The farming system also has extensive grazing areas with natural vegetation of gum and incense trees. Sorghum is an important cereal crop. Cattle, goat and sheep and poultry production is a common practice. The ruminant livestock population is composed of 136,910 cattle, 32,024 goats and 1,686 sheep. The major cattle breed is the highland zebu (Figure 3). The lowland cattle breeds (Ruthana and Felata) constitute a smaller proportion of the cattle population. The mean ruminant cattle holding per household was 12.52±6.23. About 82.9 % of the respondents practiced crop-livestock mixed farming system (Tesfaye Mengistie, 2008).

According to Tesfaye Desalew (2008), natural pasture (55.7%), crop residues (20.7%), stubble (14.3%) and hay (9.3 %) were the major feed resources. Concentrate feed resources included local oil extract by products (sesame cake), Niger seed cake and local brewery products. Leaves from trees were provided during the end of the dry season when the main

feed resource base becomes scarce. The availability of livestock feed was influenced by season. In the wet season ((June to November), cattle depended entirely on natural green pasture. In the dry season (December to May) the natural pasture dries up and loses its quality. During the dry season, there is frequent bush fire due to the dry condition and high temperatures. Farmers also deliberately set the grass on fire to kill ticks. The total estimated annual feed supply was 833,531 tons DM and 94% came from natural pasture. Of the identified 33 herbaceous species, 14 were grasses, 6 legumes and 13 sedge species. About 20 woody species were also identified as livestock feed. Considering all grazing livestock in the district, it was estimated that there is an annual surplus of 598,258 tons DM (Tesfaye Desalew. 2008).

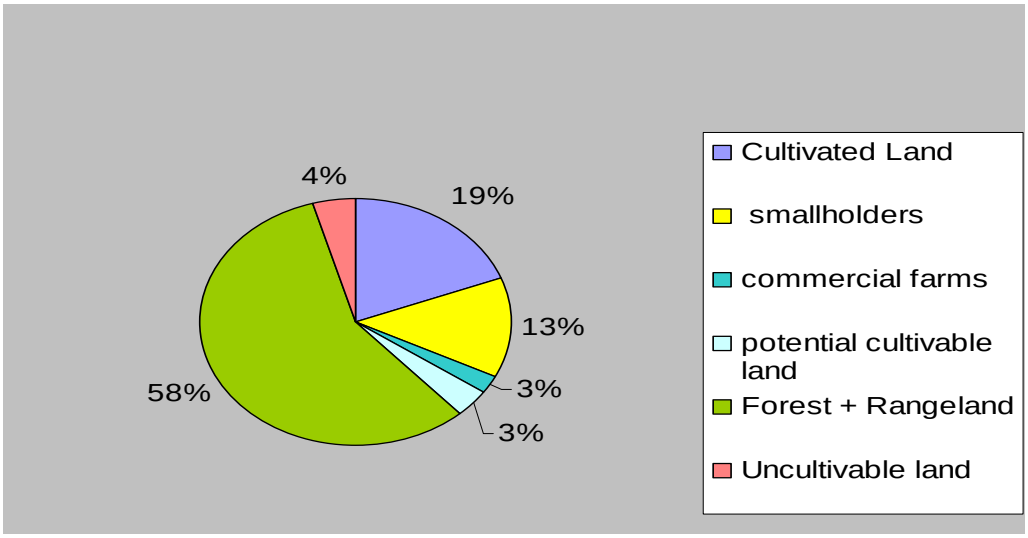

Figure 2. Land use in Metema district

Breeding system is entirely natural mating. About 66.3% of the respondents select superior indigenous bulls for milk yield, body conformation, color and breeding potential, while the remaining (33.7%) of the respondents using any available bull. The sources of local bulls were own (23.4%), neighbours (36.6%) and any bull available during grazing (34.7%). The majority of respondents (62.7%) did not show any specific preference with respect to breed. Only 10.8% of the respondents preferred Rutana bulls for higher milk yield, large frame size and better traction power, while 26.5% preferred local Zebu bulls for higher butter yield and resistance to disease and heat stress. Results from group discussion showed that milk yield potential, body frame, coat color, and behavior were used as a selection criterion for breeding bulls. Red, white, red and white mixture colors were highly preferred. Black coat color was not preferred for breeding. The breeding season for most cows is during the long rainy season, between June and August (Tesfaye Mengistie, 2008).

Figure 3. Highland Zebu cattle and production system in Metema district

Data on productive and reproductive performance of the highland cattle in Metema are presented in Table 1. Average milk off-take from indigenous cows was about 1.80±0.05 liters/head/day. Lactation yield averaged 328.3±16.56 liters over a lactation period of 5.91± 0.14 months. Farmers reported that feed shortage, infestation by biting flies and the very hot environmental conditions contributed to the shorter lactation length. Mean age at first calving (AFC) and calving interval was 4.54±0.05 years and 18.30± 0.44 months, respectively which were similar to the values reported for Wegera cattle (DAGRIS, 2008). Pre-weaning mortality of calves was exceptionally high and was attributed to the high ambient temperatures and diseases challenges (Tesfaye Mengistie, 2008).

Tick infestation, Babesiosis, Foot and Mouth Disease (FMD), Lumpy Skin Disease (LSD), Blackleg, trypanosomosis and mastitis were recognized by the farmers to be the most important diseases of cattle. The occurrence of these diseases was similar between the two farming systems. About 56.9% of the respondents do not have access to veterinary services. Among those who have access to veterinary services, the majority (68.5%) use private sources while 31.5% were provided from government clinic. Farmers use different traditional control and prevention measures for most of the diseases (Tesfaye Mengistie, 2008).

Table 1. Productive and reproductive performance of highland zebu cows in Metema district

Traits	**Farming system**		**Overall**
	Cotton-livestock	**Sesame-livestock**	
	Mean	**Mean**	**Mean**
Age at first calving, years	4.7± 0.06	4.4± 0.04	4.5± 0.05
Daily milk yield, L	1.6± 0.06	2.0± 0.05	1.8±0.05
Lactation length, months	6.7± 0.28	5.5± 0.14	5.9± 0.14
Lactation yield, L	341.9±23.30	314.7± 9.83	328.3±16.56
Calving interval, months	19.3± 0.52	17.3± 0.37	18.3± 0.44
Weaning age, months	9.5± 0.55	10.1± 0.32	9.8± 0.43
Life time calf crop, heads	6.8± 0.24	7.9± 0.13	7.3± 0.18
Pre-weaning calf mortality, %	35.0	40.0	37.5

B. Literature review

With an overall aim of enhancing market-oriented cattle production in the area and in response to the request of farmers, the IPMS project in collaboration with the district OoARD and ARARI consulted secondary data from the literature in search of 'best bet' animal genetic resources that are available in the lowlands of Ethiopia. The Borana cattle breed was considered as one of the best options based on agro-ecological similarities (altitude, rainfall and climatic conditions) and on adaptive, productive and reproductive performance. Comparative data on agro-ecology of Borana zone and Metema district are presented in Table 2. Summary of data on breed comparison between the Borana and highland zebu cattle are also presented in Table 3. The Borana cattle breed (Figure 4) is found in the semi-arid lowland areas of Borana in Ethiopia and the adjoining areas of Kenya. The production system is a pastoral and semi-pastoral that makes use of marginal resources in the area. The Borana cattle is known for its long distance walking ability, drought resistant, reasonable conception rate under severe environmental condition, excellent mothering ability, well developed herd instinct, more docile and tractable than other zebu, tick-borne and other diseases resistance, heat tolerance, longevity and superior meat production potential (DAGRIS, 2008). Pregnancy rates of Borana cows ranged from 80 to 94 percent in four breeding units and weaning weight of calves averaged 170 kg at 8 months of age at Abernossa ranch in Ethiopia (EARO, 2000).

Table 2. Agro-ecological comparison between Borana Zone and Metema district

Attribute	**Borana Zone**	**Metema District**
Location	About 800 km south-west of Addis Ababa	About 925 km south-west of Addis Ababa
Mean annual temperature	19 to 24^{o}C	22 to 28^{o}C
Mean annual rainfall	440 to 1100 mm; bimodal; 59% - March to May; 27% Sept to Nov	850 to 110 mm; unimodal (June to Sept)
Altitude	1000 to 1,600 masl	550 to 1088 masl
Land area	95,000 Km^2	440,000 ha; 72% range and forest, 23.6% cultivated
Cattle population	2 million	138,910

Table 3. Comparative productive and reproductive data of Borana and Highland Zebu cattle in Ethiopia

Trait	**Borana**	**Highland Zebu**
Birth weight, kg	27.5	22.5
Weaning weight, kg	137.5	70.0
Mature weight for bulls, kg	318	242
Mature weight for cows, kg	287	236
Dressing percentage, %	53.4	50.6
Daily milk yield, kg	2.41	2.32
Milk yield/lactation, kg	843	570
Lactation length, days	210	170
Milk fat, %	6.10	6.15
Age at first calving, months	36-45	46.1
Calving interval, months	16.3	16.8-21.6
Calving rate, %	80-94	45

Sources: DAGRIS, 2008; various sources

Figure 4. A typical Ethiopian Borana bull

C. Action research on gene introduction processes and cattle performance

To develop an action research program on gene introduction process and cattle performance, a consultative meeting was held with district administration, experts from the district Office of Agriculture and Rural Development, researchers from the Amhara Regional Agriculture Research Institute (ARARI), community leaders and interested farmers. Presentation on the concept, coupled with video show, was made and critical discussions were held on the possibility of improving cattle production into a more market-oriented system. For the first year, agreement was reached with the community, and interested individuals were selected to participate in the program. Two strategies for gene introduction were developed. These were i) natural mating with Borana bulls and ii) artificial insemination with Borana semen. The natural mating strategy is a common practice followed in the district. Farmers who were willing to maintain breeding bulls were selected by the community and in year one, four bulls were transported to Metema and distributed to farmers in four Peasant Associations (Figure 5). Subsequently, training was given on bull management to development agents and farmers who participated in the program.

Figure 5. Locations of the origin of Borana cattle in southern Ethiopia and that of Metema district in north-western Ethiopia

The AI strategy adopted in year one was uncommon due to two reasons. The first reason was that there is no AI service available in the district, and the second one is that AI service delivery in remote areas with semen from indigenous breeds has not been practiced in the country at large as priority is given to AI using exotic dairy breeds to improve milk production in urban areas. To solve the AI service delivery problem, two AI technicians were mobilized from highland districts for a three-month period to conduct the activity. As AI was a new technology to the community in Metema, a lot of awareness creation had to be done by development agents of the OoARD. In year one, only 43 inseminations with Borana semen took place and 20 crossbred calves and one pair of twins were born (Figure 6). As the Borana bulls were young, only two of them started breeding and additional three calves were born from natural mating by these bulls.

Both approaches for Borana gene delivery were found to be slow in the first year, and possible ways for improving the efficiency of the AI system were examined. A campaign style approach was proposed. The idea is "borrowed" from the human health sector, where the necessary resources are mobilized for a short period of time to solve a particular problem, for example, vaccination against polio or meningitis. In Metema the objective was to get as many local Zebu cattle inseminated with Borana semen in a short period of time. To accomplish this, animals needed to be in good body condition free from visible reproductive problems, and should all be in heat within a short period of time. The latter can be achieved by hormonal estrous synchronization (Azage Tegegne *et al.*, 1989). Once decided, , training was given to development agents and farmers on identification and selection of cows for crossbreeding, bull separation, oestrus detection, artificial insemination, and management of calves. In year two, three AI technicians were again mobilized from the adjacent highland districts and 318 highland Zebu cows were hormonally synchronized for insemination within a period of four weeks (Table 4; Figure 7). Another 193 cows were allocated to a control group for either insemination with Borana semen or bull mating upon natural oestrus. It was interesting to note that farmers in one of the Peasant Associations (Gubay Jejebit) could not wait for the oestrus synchronization programme and brought 28 cows for AI with Borana semen on natural oestrus.

An important observation on the innovative approach for gene introduction was that some of the animals offered for synchronization did in fact not meet the criteria set during rectal palpation. These include poor body condition, pregnancy, uterine infection and anoestrus. Also, a few farmers did not return their cows for the actual insemination because they preferred to use their own bulls for mating.

In Ethiopia, an AI technician in a district is expected to inseminate on average about 300 cows per district per year. In our study, 318 cows were hormonally treated for insemination over a period of four weeks only. Such an intervention could i) enhance introduction of desirable germplasm in a relatively short period of time, ii) help match calving with availability of feed, and iii) improve the efficiency of AI delivery service in rural areas. Treated and control cows are expected to deliver in June/July and data on calving will be collected and analyzed to study the effectiveness and economic viability of this new organizational approach to gene delivery for cattle production in rural areas.

Table 4. Number of cows used for oestrus synchronization and insemination with Borana semen in Metema district

Village	No. households	No. cows presented	Hormone treated cows	Control cows	Total
Genda Wuha	18	65	36	25	61
Meka	10	26	11	10	21
Kumer Awalala	57	235	142	78	220
Gubay Jejebit	48	213	129	80	209
Total	**133**	**539**	**318**	**193**	**511**

Figure 6. The first group of twin Borana x Highland Zebu crossbred calves born in Metema after the first year of intervention

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Figure 7. Hormonal oestrus synchronization and artificial insemination of highland zebu cows with Borana semen in Metema (year 2)

CONCLUSIONS

There is a huge potential for beef cattle production in the lowland districts of northwestern Ethiopia, of which Metema is one. The existence of extensive grazing area, conducive climatic condition, availability of concentrate feeds and access to local and export markets provide opportunities for the development of a market-oriented cattle production system. The seasonally surplus total dry matter biomass could be effectively utilized to support market-oriented ruminant production in the district. However, the existing mismatch between the highland zebu and the semi-arid agro-ecology has resulted in sub-optimal performance of cattle. The introduction of a matching lowland genotype of cattle into the area may create new and better opportunities for farmers. Such technological interventions to be successful have to be supported and strengthened with awareness creation, community mobilization, and provision of knowledge and support services. In addition, organizational and institutional innovations are key elements to success. Although farmers have traditionally been moving animal genetic resources to different parts of the country to suit their specific purposes, this is a new approach of systematic introduction of indigenous cattle breed to better match the environment. The long term comparative study on productive and reproductive performance of the highland Zebu and Borana x highland zebu crossbreds will provide further clue and insight for future actions. Developing countries may need to re-think in terms of developing strategies for optimizing the utility of their own indigenous animal genetic resources to fit appropriate production environments and to use innovative approaches to introduce desirable genes into these systems.

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