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Original Research

Evaluation of alternative Breeding Strategies for Horro Cattle Herds in Western Oromia, Ethiopia

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Abstract

In order to produce suitable breeding programmes that would maximise production and productivity of the breed handled under farmers' management conditions using a deterministic approach, various breeding schemes and tactics targeting Horro cattle breeds were studied. Age at first calving (AFC), yearling weight (YWt), milk yield (MiY), and calving interval (CI) were the breeding objectives assessed. To identify breeding goal traits and profile the production system, in-depth interviews and group discussions were used. The computer programme ZPLAN anticipated the genetic response of the planned breeding strategy. Based on the proportion of breeding bull selection, three alternative breeding schemes are employed. The selection proportions of 5%, 10%, and 15% were assessed in relation to the breeding bull section. With the exception of age at first calving, the current study's results showed that the anticipated annual genetic increases of the breeding objective qualities were positive. In general, an increase in annual monetary genetic gain of 44% was obtained by reducing the percentage of breeding bull selection from 15% to 5%. The study concludes that breeding strategies centred around villages or communities can significantly enhance the genetic makeup of Horro cattle breeds in the studied area.

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INTRODUCTION

The most often cited indicator of livestock's significance to the country's economy as a whole is its contribution to agricultural GDP (Behnke and Metaferia, 2010). The value that cattle add to the economy of the country through transportation services, dung, and draft power is not included in this. Nonetheless, according to Behnke and Metaferia (2010), around 80% of Ethiopian farmers employ animal traction to clear their fields. One of the largest contributions of cattle to the nation's livestock resources is its population. For instance, 0.331 million tonnes of meat and 1.5 million tonnes of milk are produced annually from cattle (FAO, 2005). Production per animal is really low, though.

For example, a cow can produce 1.54 litres of milk on average per day (CSA, 2008). Under ideal management, the average lactation milk production of native cows falls between 494 and 850 kg (Haile et al., 2009). The per capita intake of meat and milk was found to be 13.9 kg and 16 liters/year, respectively. These figures are lower than the average per capita consumption of meat and milk in the globe and Africa, which are 100 kg and 27 kg/year, respectively (Yilma et al., 2009).

Ethiopia's human population is expanding at a 2.9% annual rate, while the country's urban population is expanding at a 4.4% annual rate (CSA, 2008). Therefore, it is anticipated that in the future, there would be a greater demand for animal products due to growing urban populations and rising consumer income. Therefore, the current reproductive and productive efficiency needs to be raised in order to fulfil the growing demand for animal products as well as potential export markets. Enhancing better husbandry, managerial strategies, and genetic improvement are typically the best ways to increase production because they have a significant impact on the success or failure of farming endeavours. However, in recent decades, the importation of exotic breeds has mostly concentrated on the genetic enhancement of native cattle, and crossbreeding has been heavily promoted in Ethiopia. The reason for the increasing disregard for local breeds is their "comparative low production." However, local breeds manage to function well in unfavourable and resource-poor environments because of their "productive adaptability." Exotic breeds have been the main champion for improving local breeds. But unlike native varieties, exotics need an intensified input. Therefore, most crossbreeds fail in farming settings with limited resources (Kaufmann, 2003).

Up until now, the problem has been how to increase native cow breeds' productivity without compromising their capacity to adjust to environmental challenges. For native species, selection is one of the most significant and useful methods of genetic modification. Ethiopia does not, however, have any planned or methodical selection programmes for improving the genetic makeup of native cattle. Currently, there are 27 native breeds of cattle that are unique to Ethiopia, including the Horro breed. The Horro district in the Horro Guduru Wollega zone, Western Oromia, Ethiopia, is home to the local Horro cow breed. Although the breed's production systems do not yield as much as those of exotic breeds, it does have several valuable traits, like heat endurance, environmental adaptation, and the capacity to thrive on subpar feeds (Epstein, 1971). The breed's overall population is estimated to be 3.3 million, and it is thought to exhibit some degree of trypanotolerance (Stein et al., 2011). (Rege, 1999). The improvement and conservation of Horro cattle breeds in their production system receive insufficient attention, despite their critical contribution to livelihood. So, the following goals served as the foundation for the proposal of the current study: to create alternative breeding plans in crop-livestock systems where the Horro cattle breed is prevalent in order to improve the genetics of this breed.

MATERIALS AND METHODS

Genetic improvement implementation site

It was decided to implement the breeding strategy in the Horro district, which is situated in the Oromia Regional State's Horro Guduru Wollega zone. The natural breeding area of the Horro cattle breed is known as the Horro district. Situated on the main route to Nekemte, approximately 250 kilometres west of Addis Ababa, lies the Bako Agricultural Research Centre, 64 km to the northwest of which is where it is. The Horro district is located between 2000 and 3100 metres above sea level. The district experiences between 900 and 1800 mm of rainfall and 11.8 °C of yearly temperature variation. In the Horro district, sandy loam soil is the predominant soil type. According to Diguma et al. (2012), the Horro district is made up of 1.24% lowland, 48.9% midland, and 49.8% highland. The main wet season, which runs from June to September, the dry season, which runs from October to February, and the short rainy season, which runs from March to May, are the three primary seasons in the district.

Identification of production systems and breeding objectives

To gather data on the breeding goal qualities, infrastructure, infrastructure management, breeding system, production goals, and other pertinent information, a series of comprehensive, organised questionnaires was created. 240 randomly chosen cattle owners were given the questionnaire by enumerators working closely with the first author. Mekonnen et al. provide a thorough explanation of the survey process (2012). Focus groups with important informants, village chiefs, and local livestock specialists were also conducted in order to validate the data gathered from the interviews with individual farmers.

Selection of villages

The six villages in the Horro district are the main focus of the present breeding plan for the Horro cattle breed. Oda-buluki, Ashaya-dado, Bone-Abuna, Rifenti-chabiri, Chabiri-gabari, and Laku are the names of the villages. The choices were made using secondary data from the district Agriculture and Rural Development Office, key informant interviews, PAs leaders, researchers, and local livestock specialists, as well as the findings of a prior study (Mekonnen, 2012). High Horro cattle populations, communal grazing grounds in the villages, accessibility, and village community readiness to engage in the breeding strategy were the criteria used. 40 families were arranged according to the predetermined criteria in each village.

Prediction of genetic gain for the breeding goal traits

A deterministic ZPLAN simulation predicted the genetic benefits of the breeding aim traits (Willam et al., 2008). ZPLAN is a programme that uses deterministic calculations to optimise selection tactics in animal breeding. It is predicated on an extensive technique that takes into account a single round of selection in order to assess the genetic and economic effectiveness of breeding strategies. The discounted return and discounted profit for a specific investment period, as well as the annual genetic gain for each individual trait and the annual monetary genetic gain for the aggregate genotype, are significant outputs of ZPLAN. The selection index approach and gene flow method (Hill, 1974; McClintock & Cunningham, 1974) make up the program's main components. In the selection index section, records on an individual's performance as well as the quantity and kind of relatives who contribute to the animal's index must be used to determine the information accessible for the evaluation of a specific candidate (Willam et al., 2002). The proportions in this study were selected taking into account maternal information and individual performance.

ZPLAN is unable to take into account decreased genetic diversity brought on by inbreeding and selection (the Bulmer effect). The programme may determine selection indices for breeding animals within a single selection round, even ignoring decreased genetic diversity brought on by selection and inbreeding. $\Delta F = (1/(8Nm) + (1/(8Nf))$ is a formula that can be used to predict rates of inbreeding each generation (ΔF), where Nm and Nf are the numbers of male and female breeding animals, respectively, related to the effective population size (Falconer and MacKay, 1996).

The biological parameters that were taken into consideration were gathered from the previous survey results (Mekonnen et al., 2012), whereas the phenotypic and genetic parameters were gathered from earlier studies (Kebede et al., 1991; Banjaw & Haile-Mariam, 1994; Haile-Mariam & Kassa-Mersha, 1995; Rewe et al., 2009). The essential input parameters for ZPLAN are listed in Table 1.

Table 1

Breeding objectives and the corresponding selection criteria

Breeding Objectives	Selection criteria
Milk Yield (MiY)	Milk Yield (MiY)
Body size	Yearling weight (YWt)
Age at first calving (AFC)	Age at first calving (AFC)
Calving interval (CI)	Calving interval (CI)

There is a complete dearth of information on economic ideals in the nation. The breeding plan was established for each characteristic based on its relative economic weight, which was calculated by standardising the values using the additive genetic normal deviation (σA) in accordance with FAO (2010) criteria. Though these figures are simply approximations, they can still be used to make reasonable economic estimations in situations like this one where there is a complete absence of information. Three distinct ratios of bulls were chosen for every scheme during the simulation. Table 2 listed a few of the crucial input factors that were presumed. As a result, three different schemes were simulated:

Scheme 1: 5 percent of the total selection

Scheme 2: 10% selection percentage

Scheme 3: 15% selection percentage

Table 2

Input parameters for simulation of alternative breeding plans for Horro cattle breed

Parameters	Variables
Population parameters	
Population size (cows)	635
Number of bulls tested/year	163
Proportion of bulls selected for breeding	0.15;0.10;0.05
Biological parameters	
Breeding cows in use (years)	6
Breeding bulls in use (years)	3
Mean age of bulls at birth of first offspring (years)	4
Mean age of cows at birth of first offspring (years)	5
Conception rate	0.90
Calving rate	0.80
Calving interval (yr)	1.42
Number of calves/cow/year	0.71
Survival to yearling (%)	0.90
Bulls survival between subsequent time units	0.95
Cows survival between subsequent time units	0.90
Cost parameters	
Interest rate return (%)	0.03
Interest rate costs (%)	0.075
Investment period (years)	20

Table 3

Phenotypic (upper triangle), genetic (lower triangle) correlations and heritability values (diagonal, in bold) of the traits

Variables	YWT	MY	AFC	CI
YWT	**0.30**	0.20	0.00	0.00
MY	0.10	**0.27**	0.01	0.07
AFC	0.00	0.05	**0.06**	-0.21
CI	0.00	-0.11	0.09	**0.04**

YWT= yearling weight; MY= milk yield; AFC= age at first calving; CI=calving interval

Body size, milk yield (MiY), age at first calving (AFC), and calving interval (CI) were the objective features that were found. Table 1 lists the selection criteria for the objective qualities. Table 3 displays the heritability values and genetic and phenotypic correlations of the reproductive variables under consideration. Table 4 shows the selection criteria, their relative economic weights, and the phenotypic (σP) and genetic (σA) standard deviations.

Table 4

Selection criteria and their relative economic weights, phenotypic (σ_P) and genetic (σ_A) standard deviations

Objective traits	Selection criteria	Unit	σ_P	σ_A	Economic weight	Economic Value (Econ. Weight/ σA)
Body size	YWT	Kg	27.920	-	25	1.635
Milk yield	MY	Kg	85.335	-	30	0.677
Age at first calving	AFC	Month	5.933	1.453	20	13.761
Calving interval	CI	Month	2.900	0.580	15	25.862

YWT = yearling weight; MY = Milk yield; AFC = Age at first calving; CI = Calving interval

RESULTS AND DISCUSSIONS

Production system

The study area's industrial system is typified by low input and little to no necessary infrastructure. It is essentially a market-neutral subsistence-based production system. A mixed crop-livestock system is the predominant way of production in the region. The district's main limiting constraints, according to the farmers who were targeted, include illnesses, manpower difficulties, and feed shortages. Neither a pedigree recording nor a performance exist. 13.23±0.54 is the average herd size (Mekonnen et al., 2012). It was discovered that there was little to no participation from other stakeholders, such as non-governmental organisations and governmental authorities, in the genetic development of the native cattle genotypes in the area. For certain peasant groups near the towns, infrastructure is created, including services for artificial insemination. An effective service delivery system is, however, hampered by a lack of qualified labour and a scarcity of liquid nitrogen.

This farming system keeps horto cattle for multipurpose uses. According to the survey's findings, farmers primarily raise cattle for traction power, milk production, and, to a lesser extent, revenue from the sale of live animals and animal products like butter and fluid milk. Mekonnen et al. (2012) provide comprehensive information regarding the several goals of cattle raising in the district. There is broad recognition of the various applications of cattle genetic resources (Rege and Bester, 1998). In order to increase the production from these animals that can survive and reproduce in the tough tropical environment, it has become necessary to extract more than simply milk or meat. According to Rege et al. (2001), developing specialist single-purpose breeds solely for the purpose of producing milk or beef is not a suitable alternative for regions where native cattle are the most significant livestock species. Since many livestock development initiatives ignore farmers' core interest in livestock as a source of multiple goods and are geared towards the production of milk or meat for a particular purpose, they are unlikely to draw in dedicated farmer participation.

Breeding Strategy

Mekonnen et al. (2012) reported that a low-input production strategy is used to raise

Horro cattle. In low-input systems with hostile environments, limited feed resources, and high disease prevalence, selection within local populations is the suggested approach for genetic improvement projects. A straightforward organisation that can be put into practice within the limitations of the regional agricultural environment should be the foundation of an efficient breeding strategy that will benefit the farmers. In order to enhance the breeding objective qualities (milk yield, yearling weight, age at first calving, and calving interval) chosen by Horro cattle owners, a village- or community-based breeding plan is created.

The average herd size in terms of breeding scheme organisation is small (13.2), and village-level group breeding schemes provide a feasible means of achieving directed genetic change with community participation and technical support from livestock experts, researchers, and related stakeholders. The fundamental processes would involve defining membership terms precisely, reaching a consensus regarding the goals of the breeding programme, identifying desirable traits to improve, establishing important standards for the selection of genetically superior animals for subsequent breeding, and creating a foundation stock or breeding stock (Wollny, 2003). The bull groups that comprise the participating community members are determined by the quantity of breeding cows held by each group, the type of settlement among the group members, and the availability of communal grazing spaces. Community-based breeding initiatives could be best suited for settings where livestock owners already manage their herds jointly, including shared watering spots and grazing areas (Duguma, 2010). The shared grazing grounds improve the genetic transfer from the chosen bulls. The various breeding bull organisations trade breeding bulls with one another. This will reduce inbreeding and establish genetic ties between several herds, which are at least two of its main benefits.

Predicted Genetic Gains and Returns

Table 4 shows the estimated yearly genetic gain for each objective attribute. All qualities exhibited favourable genetic increases, with the exception of age at first calving, and the responses to the annual genetic gains of the majority of the breeding objective traits from all suggested schemes may be deemed adequate. Scheme 1 (which had a 5% selection proportion) produced the biggest annual genetic gain in milk yield, while Scheme 3 (15% selection proportion) produced the lowest. The current study's findings concur with those of Hailu et al. (2010), who hypothesised that the 5% selection fraction of Borana and Horro cattle breeds raised in open nucleus breeding at Dida-Tuyura and Horro-Guduru ranches would result in a greater genetic response for milk yield. In the current study, the expected genetic increment in milk output varies between 1.28 and 1.48 litres. Under the management circumstances of farmers, this degree of improvement can be positive.

In the current study, the genetic response for yearling weight varied from 1.29 to 1.47 kg. Although it is less than that reported for the Borana and Horro breeds (Hailu et al., 2010), the estimated genetic increase for yearling weight in the current study is nevertheless adequate for genetic improvement carried out under farmers' management settings. According to Hailu et al. (2010), cattle breeds using 5% to 15% selection proportions should expect yearly genetic increases ranging from 2.16 to 2.50 kg for Borana and 2.23 to 2.58 kg for Horro.

The study also showed that, in comparison to milk yield and yearling weight, genetic responses anticipated for age at first calving and calving interval had lower genetic responses. The poor heritability of the characteristics overall is reflected in the minimal genetic improvements in age at first calving and calving intervals. Given that it suggests a shorter interval between consecutive calvings, the study's projected negative genetic response for calving interval was a desirable outcome. A cow that has a short interval between calvings may be more likely to give birth to more calves throughout her lifespan. Hailu et al. (2010) also observed a negative genetic response for calving interval, which is consistent with the current prediction. On the other hand, as an increased age in the trait means a decreased likelihood of producing more calves per cow in a lifetime, the positive genetic gain anticipated for age at first calving in this study is undesirable. Since the information sources used to create the indices were the same, the selection accuracies under the various selection proportions in this investigation were generally comparable.

Table 5

Annual genetic gain for the breeding objective traits under different village selection Schemes

Breeding Objectives	Alternative Schemes		
	Scheme 1	Scheme 2	Scheme 3
Scheme 1 (r_{IH})	0.419	0.4190	0.4190
Yearling weight (YWt)	1.4675	1.3536	1.2771
Milk yield (MiY)	1.4771	1.3625	1.2854
Age at first calving	0.0034	0.0032	0.0030
Calving interval	-0.0016	-0.0015	-0.0014

Table 6 lists the yearly monetary genetic gains, generation interval, selection intensity, returns, costs, and profit under various village selection strategies. Similar to genetic gain, Scheme 1 reported the highest financial returns, whereas Scheme 3 reported the lowest. There was an improvement of around 44% in the annual monetary genetic benefit when the selection proportion of bulls was reduced from 15% to 5%. Under the management circumstances faced by farmers, these levels of progress can be encouraging. The annual monetary genetic advantage obtained in the current study varied from 2.97 to 3.41 birr.

Bull selection groups yielded more genetic improvements than cow selection groups for all target qualities examined. Additionally, Kahi and Hirooka (2005) noted that in order to accelerate the rate of genetic advancement, it would be preferable to place greater focus on breeding bull selection. In comparison to the cow group (9.56 years), the bull selection group had the shortest generation interval (5.07 years). The estimated selection intensities for cows were 0.458, and the range for bulls was 2.031 to 2.403. Because of the shorter generation intervals and more intense selection, the bull selection group gained more genetic diversity. The mean generation interval is similar for all three systems.

Schemes 1 through 3 have total profitability per cow ranging from 18.50 to 23.45 over the investment term (Table 7). Milk output and yearling weight made up the majority of the entire return. The return is negatively and very slightly impacted by the Calving interval. Since the economic weights assigned to the selection criteria were only approximations, care must be taken when interpreting these results. With the breeding aims selected, there can be both financial benefit and genetic advancement, according to the existing predicted values.

Table 7

Annual monetary genetic gains, selection intensity, generation interval and returns, costs and profit per cow in the investment period under different village selection schemes

Parameters	Scheme 1	Scheme 2	Scheme 3
Monetary genetic gain	3.405	3.141	2.964
Mean generation interval	7.312	7.312	7.312
Bull generation interval	5.070	5.070	5.070
Cow generation interval	9.560	9.560	9.560
Mean selection intensity	2.401	2.178	2.104
Bull selection intensity	2.401	2.180	2.103
Cow selection intensity	0.458	0.458	0.458
Return for a single trait			
Yearling weight	22.09	20.29	19.07
Milk yield	9.21	8.46	7.95
Age at first calving	0.18	0.16	0.15
Table *continued*			
Calving interval	-0.16	-0.14	-0.13
Total return per cow	31.34	28.77	27.03
Total costs per cow	8.22	8.20	8.20
Total Profit per cow	23.15	20.56	18.55

An integrated systems approach, including the full participation and long-term commitment of the livestock owner, livestock experts, researchers, and other stakeholders, is necessary for the implementation and success of the suggested alternative breeding schemes. The conventional, well-respected communal organisations are thought to present chances for the successful application of genetic improvement. The effectiveness of community-based genetic improvement also depends on good market-oriented research and technical support that incorporates management, nutrition, health, and transformation (Kahi and Hirooka, 2005). It's also critical to remember that there is a finite amount of land that may be used for grazing and that it will continue to shrink. Therefore, it is essential to increase pasture development, conserve, and use agricultural leftovers wisely. In order to ensure the longevity of the breeding plan, it is also necessary to regularly provide basic training on recordkeeping and the significance of breed improvement initiatives. The daily operations and overall programme oversight will fall within the purview of the livestock development extension service.

CONCLUSIONS

Horro cattle provide a variety of purposes in a mixed crop-livestock production system in which they are housed. The research area's Horro cattle owners prioritized and specified various objective features in their intense desire to improve the genotypes of their cattle. The age at first calving, calving interval, body size, and milk yield are the recognised objective features. The study area's production system is distinguished by low input and minimal or nonexistent necessary infrastructure. In light of this, alternative breeding techniques were created to be used in a community-based genetic improvement initiative. In fact, an integrated systems approach is necessary for the successful implementation of the breeding strategy as specified, as well as the long-term commitment and full engagement of researchers, essential stakeholders, livestock professionals, and owners of livestock. An planned breeding programme in the research area aimed at improving the Horro cattle breed will, in general, guarantee lower external inputs, such as food and medical care, and a higher profit margin for farmers. Following that, this will help to increase food security and lessen environmental stress. Additionally, the in-situ conservation of farm animal genetic resources would be made possible by such a strategy.

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DECLARATION

There is no conflict of interest in this work.

DATA AVAILABILITY STATEMENT

All data are included in the article. Further data sets are available from the corresponding author upon request.

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