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Participatory Identification of Breeding Objectives and Selection Criteria for Begaria Cattle Breed

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Abstract: The objectives of this study were to identify the breeding objectives of Begaria cattle keepers. A semi-structured questionnaire, live animal ranking, and focus group discussions were employed to identify the breeding objectives of the farmers. The study was conducted on a total of 75 conveniently sampled households. Among the total cattle population of the sampled households, 506 heads of cattle (252 male and 254 female animals) were ranked as first best, second best, third best, and/or the worst animals. Owners were asked to choose the first best, second best, third best, and worst animals from their herd for both sexes. Reasons for ranking, important morphometric measurements, and (re)production performance of the ranked animal were taken. The R Commander package version 2.6-0 was used to analyze qualitative data and analysis of variance in R software was used to analyze quantitative data. Reasons for ranking of cows in the study area were milk yield (39.14%), calving interval (15.14), temperament (12), and body size (10.86), whereas for bulls, reasons were body size (30.39%), growth (30.66), body condition score (16.85), and color (15.19). Survival rate (Sur), calving interval (CI), milk yield (MY), and lactation milk yield (LMY) for the cows and body condition score (BCS), weaning age (WA), yearling weight (YW), and weaning weight (WW) for the bulls were significantly different ($p < 0.05$) mainly between the first- and last-ranked animals. Farmers were willing to pay up to Ethiopian birr (ETB) 11,500, 10,700, 10,400, and 9500 on average for first-, second-, and third-ranked breeding females and up to ETB 6300, 5800, 5200, and 4500 for breeding males. Lactation milk yield, calving interval, mothering ability, growth rate, and age at first calving were determined as breeding objective traits of the community. with suggested selection criteria of lactation milk yield, calving interval, survival rate, yearling weight, and age at first calving, respectively.

Keywords: objective traits; own herd ranking; selection criteria; willingness to pay

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1. Introduction

Worldwide, the ongoing human population growth towards 9 billion by 2050 [1] exerts a load on the need for food of animal origin. There is an urgent need to improve livestock productivity in sub-Saharan Africa in order to meet predicted increases in demand for animal products while also reducing methane emissions [2]. Finding the right balance between the different demands is a continuous process, and anticipation of future conditions and careful planning are required to establish effective breeding programs [3–5]. Likewise, understanding the influence of selection, mating systems, and other breeding interventions helps in the sustainable improvement of farm animal genetic resources as well as designing sustainable utilization strategies.

In whatever way, the breeding projects (traditional or otherwise modern) are always preceded by definite breeding objectives and attainable goals based on the prevailing production systems [2,3,5]. Traditionally, breeding objectives are flexible enough to accommodate the gradual changes in the production systems [6,7]. The breeding goals, however, change with time and are mostly a function of the socio-cultural and economic values of the products of a particular species or breed [8]. Thus, as the breeding goals are mostly economically driven, the goals need to be set up by involving the stakeholders (at all levels) [4,9]. Therefore, the goals are set up to take into account the various levels of stakeholders and not just the farmers alone [10,11].

In earlier projects, stakeholders were rarely consulted when the breeding objectives were formulated [12]. This top-down approach method usually backfired. In most of the cases, the respondents were not aware of the needs of the animals, the husbandry practices, and the feed- and nutrition-related issues, and in many cases, the animals could not adjust to the prevailing agroclimate and also the diseases endemic to a given area [2,3,5,13,14]. In many cases, the products obtained from such livestock were not accepted by the end users [15]. It has also been indicated in several studies that many livestock breeding projects have failed because the projects were halfheartedly implemented without first putting into place the allied infrastructure needed to support them [16]. Moreover, the keeper's requirements are quite specific and the selection of these animals can vary from modern scientific principles [9]. However, over the years, the important aspect of indigenous livestock breeding has been grossly overlooked, and very little systematic work has been done so far on the possibilities of improving native breeds of tropical livestock [16]. It has also been reported in several studies that traditional livestock keepers have a better understanding of their livestock than researchers, as they are able to understand the homeostasis between the genotype and the production system where they are raised [13,17].

The participatory approach takes into account the understanding of various stakeholders (local leaders, extension agents, traders, and cattle owners) at different levels, who frankly discuss with the livestock scientists the approaches to be taken for the further lifetime of the species [3,18]. In doing so, the researchers understand the needs and aspirations of the stakeholders and, therefore, together help improve the genotype in question [2,4,13].

Over the years, there have been reports of some new breeds of livestock from different parts of the country. The Begaria cattle breed is one of the recently identified and registered indigenous cattle breeds of Ethiopia, found in the hot climates of the Benishangul Gumuz region [19]. The recent study indicates the potential of the breed for further improvements. Furthermore, its larger body frame size when compared to many other cattle breeds in Ethiopia demands due attention [19]. On the other hand, the introduction of highland zebu, illegal live animal trade, inbreeding, breed substitution, and changes in the production system are the most serious threats to the breed's genetic diversity [19]. Therefore, it has become imperative to maintain genetic diversity, improve the potentially important economic traits of the breed, and keep the interest of the farmer and other stakeholders in confidence. Therefore, the objective of the current study is to identify breeding objectives and selection criteria for Begaria cattle keepers for the breed's conservation, improvement, and sustainable utilization. The research questions and hypotheses are as follows:

Research questions:

1. What are the breeding objectives of Begaria cattle keepers?
2. How much is the farmer willing to pay for the breeding animals identified?
3. Is there a link between farmer ranking and physical measurements?

Hypotheses:

Hypothesis 1 (H_1). *Certain characteristics of Begaria cattle are more essential or desirable than others.*

Hypothesis 2 (H_2). *Farmers may have different Begaria cattle trait preferences, and some qualities may be strongly related to animal ranking.*

Hypothesis 3 (H_3). *Body measurements may differ based on the rank of the animal.*

2. Materials and Methods

2.1. The Study Area

The study was conducted in Guba (11,009′ N latitude and 35,019′ E longitude and an altitude ranging from 531 to 860 m above sea level) district, Metekel zone of the Benishangul Gumuz Regional State of Western Ethiopia. The district was selected purposively since it is the only area where the breed is naturally found. Based on an earlier survey, respondents residing in three locations, namely Mankush, Almahal, and Fanguso, were included [19]. The area has been purposely selected based on the representativeness of the breed and suitability for data collection and recording.

Guba is one of the 20 districts in Benishangul Gumuz Regional State of Ethiopia. It is a part of the Metekel Zone. The climate in the Guba district can be classified as arid and semi-arid. Agro-ecologically, the study area is found in the lowlands with flat to rolling topography. The district receives an average annual precipitation of 965 mm. The highest temperature recorded at Mankush reaches 31 °C in April, with a monthly mean of 26 °C calculated based on 20 years of data (1986–2006). The rainy season in the area is from June to September, which forms a unimodal character [20].

2.2. The Study Breeds

Begaria cattle breeds have been raised in the study areas since time immemorial, and without any written history, they can be associated with the traditional folklore in the area. The name "Begaria" is an Arabic word, which was usually spoken by the Sudanese and was generally associated with something big or large. There were also crosses of Begaria and other local cattle types in the area, and to differentiate such cattle, the locals usually used the term "Beledy", which again owes its origin to the term of Arabic origin, meaning "local" (they said "Ye-akababi" in Amharic). The local cattle types are mainly named Kedalo, which was the name given to tribes living in the area permanently.

According to Aseged [21], the overall Begaria cow population in the area reached roughly 12,000 heads, distributed across nine kebeles (200 to 4900 heads/kebele), with an average herd size of 23 to 51 heads per household. Begaria cattle are fast growers and high milk yielders when compared to the other cattle reared in the area [19]. Furthermore, the Begaria cows are regular breeders while the highland zebu called "Habesha" calve once in two years. The calves of Begaria cattle are larger in size at birth and mature early. The bullocks can reach plowing, breeding, and marketing age at around 24 to 42 months. As shown in Figure 1, the true type of Begaria cattle was identified by their white coat color, large body size, large udder size, large testicular flank, large belly, large tail, and large facial and short horn size.

(**a**) (**b**) (**c**)

Figure 1. Begaria breeding male (**a**), Begaria breeding females (**b**), and Begaria herd (**c**).

2.3. Methods of Data Collection

2.3.1. Data from the Production System

Prior to this work, voluntary households that wanted to participate in the community-based breeding program had been identified by Ethiopian Biodiversity Institute (EBI) workers. Therefore, conveniently, a total of 75 pre-identified volunteer households (25 from each kebele) were interviewed by trained interviewers who spoke the local language and had experience in similar studies [22]. As Amharic was widely spoken in the area, the questionnaire was translated from English to Amharic. Sometimes, for the need for translation, a translator was used to avoid the chance of any misunderstanding or confusion.

During the household interview, data pertaining to traditional selection practices as had been practiced by the farmers in the area, the farmers' traits of interest, and allied practices were included. From each selected site in the community, a focus group discussion (FGD) was carried out with stakeholders (local leaders, extension agents, traders, and cattle owners) to obtain a view of the community about cattle production as a whole.

2.3.2. Identification of Breeding Objective Traits

Breeding objective traits are attributes that an ideal animal can exhibit, whereas selection criteria are the methods by which the producer selects the animal in order to achieve the breeding objectives [4,5,13]. For example, the breeding objective of the farmer might be mothering ability, while calf survival, milk yield, and temperament might be considered as selection criteria to meet this objective.

In the current study, breeding objective traits were identified by employing a live animal/own herd ranking experiment and production system studies. These methods have been applied for breeding objective identification of Ethiopian small ruminants [14,23–26], and phenotypic ranking and choice experiments have been applied for Sheko cattle breed breeding definition [4]. However, the own herd ranking method had not yet been applied to large ruminants [26], and this work could be a pioneer in applying the methods to identify breeding objective traits of cattle in Ethiopia. The reasons why the method had not yet been applied might be associated with the need for measurements for ranked animals.

An own herd ranking experiment was carried out on 22, 21, and 21 purposely selected farmers from Almahal, Mankush, and Fanguso kebeles, respectively. A total of 506 heads (254 females and 252 males) were ranked as first best, second best, third best, and/or worst animal. Voluntary participants in the breeding program who had more than 4 animals for both sexes were asked to choose the first best, second best, third best, and the worst animals of both sexes of their herds. The reason for ranking was asked and recorded. The respondent could mention as many reasons as possible for each ranked animal. For the data quality, all mentioned reasons were recorded. Particular focus was given to the owner's way of decision-making and the most frequently mentioned reasons for the ranking. For example, if the owner selects a cow as his first choice and if the reason is good milk yield (3 L/day), and the owner again selects another cow with the same milk yield but ranked as third best for the reason of being a black color, then milk yield could be the owner's main interest, while black coat color could be the owner's second interest. Sometimes an animal ranked as worst may perform equally with the first-ranked animal except in a single characteristic. In this regard, that single characteristic would have a heavy weight, but if it is ranked under the best rank, then the trait of interest would receive great focus. Therefore, by basing the way of owner decision-making, most frequently mentioned reasons, and trait/term similarities; the recorded traits were transcribed to a broader group in an Excel spreadsheet. For example, good milk yield, better milk yield, and high milk yield were transcribed as milk yield.

To avoid the challenge of having enough samples of similar age categories, which was reported as a common problem in own herd ranking experiments [26,27], mature female animals with three or more parities and male animals below marketable ages (in this case up to three years) were considered.

Morphometric measurements such as body length, heart girth, height at withers, scrotal circumference (of the males), rump length and width, neck circumference, neck length, udder depth and length, canon circumference and length, chest width and depth, and morphological characteristics of the ranked animal which have importance for the type and function of the cattle were taken following FAO guidelines [28].

The yearling weight of the animals was estimated from the body weight measurements of 506 heads using Schaeffer's formula [29]. This was done because it was difficult to obtain a sufficient sample size for one-year-old animals.

$$BW = (BL * HG^2)/300 \quad (1)$$

where "BL" and "HG" are body length and heart girth in inches (1 inch = 2.54 cm), respectively, and "BW" is the estimated body weight of cattle in pounds. The weight was then changed to kilograms (1 pound equals 0.454 kg).

Therefore, the [30] age adjustment approach for cattle would be used to determine the projected weight for any age of cattle. As a result, the following formula was applied to calculate the animal's yearling weight:

$$WC = (W * C)/b \quad (2)$$

where "WC" is the required weight, "W" is the animal's current weight, "C" is the animal's required age, and "b" is the animal's current age.

The recall method (from different participants of the husbandry practices) was used to access the history of the ranked animal regarding health (body condition score, disease incidence, ticks, and disease resistance); reproduction performance (such as age at puberty, age at first calving, fertility, calving interval, number of calves born in the last year, survival proportion to yearling); and production traits such as milk yield, manure, growth, other attributes (such as traction power, aggression, and mating behavior), and economic values (the amount of money the farmer would be willing to pay for each of the identified animals if the farmer would like to buy the animal for breeding purposes). Survival proportion to yearling age was calculated as the total number of animals surviving to yearling age divided by the total number of calves born in the year. To support the full recollection of the history of the ranked animal, most household members participated in the ranking process.

2.3.3. Correlation

All body measurements and traits of (re)production (from the life history of ranked animals) were subjected to a Spearman rank correlation test with animal ranking for each location. This was mainly used to generate and identify traits that should be included in the trait correlation analysis (Tables S2 and S3).

2.4. Data Preparation and Statistical Analysis

Reasons for ranking from both closed and open-ended responses were checked individually. Based on their similarities, the variables were transcribed and grouped into broader categories, and then they were coded and recorded in a Microsoft Excel sheet.

2.4.1. Qualitative Data

Qualitative data such as the rank of the trait of interest and the reason for animal ranking collected through a questionnaire and the own herd ranking experiment were analyzed by using the Rcmdr package version 2.6-0 [31] in R software version 3.6.1 [32]. A contingency table was used to produce cross-tabulations. Fisher's exact test was employed to test independence between kebeles and different variables.

2.4.2. Quantitative Data

Quantitative data such as the animal life history and body measurements gathered via a questionnaire and an in-house herd ranking experiment were analyzed with ANOVA in R software [32], with animal rank (first, second, third, and worst) as an independent fixed factor and other body measurements and history data as dependent variables. The effect of location, age, and interaction was removed for both sexes as the model was not significant ($p > 0.05$). Least square means were estimated using the lsmeans function in R. When the model was significant, a post hoc test was employed using the Tukey adjusted method to separate the least square means in each group. The model was as follows:

$$Y_{ij} = \mu + Rank_i + e_{ij} \quad (3)$$

where Y_{ij} is the trait of interest, either body length (cm), heart girth (cm), body condition score (1–5), milk yield (L), or price (price if buying the breeding animal, in Ethiopian birr); μ is the overall mean for the trait; $Rank_i$ is the effect of ith ranking (i = first best, second best, third best, and worst animal) and e_{ij} is the random residual effect.

The indices were calculated for all ranked variables and reasons by employing the principle of the weighted average of Musa [33] as follows:

$$Index = \frac{R_n * C_1 + R_{n-1} * C_2 \ldots + R_1 * C_n}{\sum R_n * C_1 + R_{n-1} * C_2 \ldots + R_1 * C_n} \quad (4)$$

where R_n is the value given for the least-ranked level (in this case 5, then R_{n-1} = 4 and R_1 = 1) and C_n stands for the least-ranked level (in this case, the count of the fifth rank is C_n, and the count of the first rank is C_1).

2.4.3. Breeding Objective Traits

To see the consistency of trait ranking and for easy extrapolation, objective traits which were identified from a production system study using indices and from the own herd ranking method using proportions were weighted together. The weighted rank was computed as follows:

$$Wr = (a + b)/n \quad (5)$$

where "a" and "b" represent the rank of a trait from own herd ranking and production system studies, respectively, and "n" is the number of studies. Related traits which were expected to have direct associations were pooled together; traits such as calves' size at birth and calving ease and survival to yearling were pooled as mothering ability, and growth and body size were pooled as growth, in parallel with the work of [34]. Survival proportion to yearling age was calculated as the total number of animals surviving to yearling age divided by the total number of calves born.

3. Results and Discussion

3.1. Participatory Identification of Breeding Objective Traits

3.1.1. Findings from Focus Group Discussion

According to the focus group discussion (FGD), breeding bull sharing, herd mixing, and seasonal herd movement during difficult times or in search of feed and water were all widespread in the area. Farmers primarily prefer animals that can perform multiple functions. Heavier bulls, on the other hand, are not favored for mating purposes because of the risk of female injury. As a result, a breeding bull can only be utilized for the period of two to three breeding service years before it becomes huge. As a result, any improvement effort should strive towards faster-growing animals rather than oversized animals. Likewise, further genetic enhancement in size may result in stillbirth. In addition, the hotness of the environment and the prevalence of trypanosomiasis suggest that adaptation traits should be given more weight.

Because of the area's proximity to the Sudanese market, the chance of an export market was indicated in the FGD. As a result, because the market is always a determining factor, this would be an additional prize for the success and durability of any improvement programs that might be established in those areas.

3.1.2. Rank of Trait of Interest for Improvement

The findings presented in Table 1 and Table S1 show that the traits which the respondents indicated needed further refinement were milk yield, growth, body condition score (BCS), and survival traits, with respective index values of 0.28, 0.25, 0.14, and 0.11. This clearly shows the multi-trait interest of the respondents and the multi-use role of the breed in the area. Thus, high milk yielders, fast growers, and survivable animals would be their ideal animals. Furthermore, high-performance indices such as milk yield, growth, and reproduction are more accurate markers of metabolomic efficiency [35,36].

Table 1. Traits of interest for improvement across the three locations with their ranking indices.

Attributes	Traits	Ranking Index (Rank)				
		Almahal	Fanguso	Mankush	Overall	*p* Value
Production	Growth	0.33 (1)	0.16 (3)	0.28 (2)	0.25 (2)	<0.001
	MY	0.23 (2)	0.29 (1)	0.31 (1)	0.28 (1)	0.002
Adaptation	Survival	0.18 (3)	0.02 (7)	0.14 (4)	0.11 (4)	0.927
	BCS	0.15 (4)	0.13 (5)	0.16 (3)	0.14 (3)	0.049
Reproduction	Age_P	0.03 (6)	0.16 (3)	0.04 (5)	0.09 (5)	0.0429
	AFC	0.00 (9)	0.00 (8)	0.03 (6)	0.01 (8)	1
	CI	0.01 (8)	0.00 (8)	0.00 (9)	0 (9)	1
Morphological	Color	0.05 (5)	0.05 (6)	0.03 (6)	0.04 (7)	0.142
Others	Agg	0.02 (7)	0.19 (2)	0.01 (8)	0.08 (6)	0.0014

MY = milk yield, Age_P = age at puberty, Agg = aggressiveness, BCS = body condition score, AFC = age at first calving, CI = calving interval.

There was a significant ($p < 0.05$) association between the rank of traits of interest of the farmer and location for the traits of growth, milk yield, BCS, age at puberty, and aggression. Relatively higher index values were observed for growth and BCS in Almahal and Mankush, milk yield in Fanguso and Mankush, and age at puberty and aggression in Fanguso. These results indicate farmers in those areas are more interested in the improvement of these traits. The Begaria cattle are well adapted to the locations and, alongside the traits, growth and reproduction go hand in hand [15]. Cattle that grow well usually have an optimal reproduction rate [37].

Aggression as has been reported by the respondents in Fanguso may be attributed to the presence of wild canines, i.e., predators [38] in the area. Therefore, aggressive bulls usually have a tendency to fight off the predators and also protect the cows in case of such eventualities. Another cause for such behavioral traits might be the keeping system of the farmer, as the animals kept out of human contact for a long time may develop wild-type behavior. It is obvious that animals reared in the range lands would be more aggressive than those kept together with the common house. Thus, improving the management system and/or increasing the body size of the animal might improve the temperament as flight speed is expected to reduce. However, as the hotness of the environment and the prevailing disease of trypanosomiasis indicate, adaptation traits should be accounted for more. Therefore, improvement work should aim to have fast-growing animals rather than oversized ones.

The reason why production traits have been given importance is because of several factors, including better access to the cities where there is a growing demand for beef and dairy products [39]. While in earlier times, cattle were raised simply as a source of social prestige, the overall family need for dairy products came from the sheer number of cattle owned rather than per unit [15,40]. Another reason that cattle husbandry is on the rise in the area is that the land holdings are diminishing over time and also that there is a migration of the younger generation to the cities; hence, crop production activities are decreasing [15].

3.1.3. Reasons for Ranking of Animals from Own Herd Experiment

The results from Table 2 are indicative of the own experimental rankings of the Begaria cattle according to their sexes. In the case of the selection of cows, the findings show milk yield, calving interval, and body size in Almahal and temperament in the other two locations. Milk yield is considered one of the most important traits as it is correlated with the survival of the calves and also the economy of cattle husbandry activities [41]. If the calving interval is optimal, the number of lifetime calves born and the milk yield are expected to be high [42,43]. Therefore, both traits go hand in hand. The other trait which was considered to be important is the temperament of the cows themselves, as cows with good temperaments are easy to handle [44] and cows with dairy temperaments can produce good milk and are economically viable for their owners. In the case of the selection of bulls (males), the traits which are preferred are body size and growth. These two traits are of economic importance both for beef production and draft ability [44]. Bulls that grow faster usually reach marketable age faster and, hence, under such conditions, are beneficial for the keeper. The beef from such animals is soft and tender and hence fetches a higher price [19]. The larger the body size, the higher the chances of muscle development and therefore higher draft ability (in case the bulls are used for draft purposes); larger body size also better enables a bull to protect itself and the herd against predatory attacks [38]. Coat color (white) is also considered a trait of importance as it has socio-cultural importance alongside adaptability in bulls [45]. While bulls are easily seen in the deep forest and can easily be traced out by the herders, white-skinned animals thrive well in the lowlands and, due to their adaptability traits, usually grow well provided they have access to feed and fodder [46,47].

Table 2. Reasons for selecting breeding males and females based on own ranking experiment across the three locations.

Sex	Attributes	Almahal F (%)	Fanguso F (%)	Mankush F (%)	Overall F (%)
Female	Milk yield	59 (47.6)	38 (32.2)	40 (37.0)	137 (39.14)
	Calving interval	25 (20.2)	17 (14.4)	11 (10.2)	53 (15.14)
	Body size	16 (12.9)	13 (11.0)	9 (8.3)	38 (10.86)
	Temperament	10 (8.1)	16 (13.6)	16 (14.8)	42 (12)
	Coat color	6 (4.8)	12 (10.2)	3 (2.8)	21 (6)
	Growth of birth	4 (3.2)	7 (5.9)	11 (10.2)	22 (6.29)
	Calf size at birth	2 (1.6)	5 (4.2)	-	7 (2)
	Calving easy	2 (1.6)	1 (0.8)	-	3 (0.86)
	Mothering ability	-	2 (1.7)	3 (2.8)	5 (1.43)
	Physical appearance	-	7 (5.9)	15 (13.9)	22 (6.29)
	Total	124 (100)	118 (99.9)	108 (100)	350 (100)
Male	Body size	42 (37.8)	34 (26.4)	34 (27.9)	110 (30.39)
	Growth	36 (32.4)	39 (30.2)	36 (29.5)	111 (30.66)
	Body condition	12 (10.8)	27 (20.9)	22 (18.0)	61 (16.85)
	Color	15 (13.5)	18 (14.0)	22 (18.0)	55 (15.19)
	Temperament	5 (4.5)	8 (6.2)	7 (5.7)	20 (5.52)
	Drought resistance	-	2 (1.6)	-	2 (0.55)
	Attractiveness	1 (0.9)	-	-	1 (0.28)
	Libido	-	1 (0.8)	-	1 (0.28)
	Mother milk	-	-	1 (0.8)	1 (0.28)
	Total	111 (99.9)	129 (100)	122 (99.9)	362 (100)

F = frequency.

3.1.4. Effect of Cow Ranking on Some (Re)Production Traits and Willingness to Pay

As presented in Table 3, the amount of money that the farmer would be willing to pay (WTP) for breeding cows was influenced ($p < 0.05$) by cow ranking. The farmer was willing to pay up to Ethiopian birr (ETB) 12,500, 10,700, 10,400, and 9500 on average for the first-, second-, third-, and least-ranked animals, respectively. This may be ascribed to the dairy characteristics that the cows produce alongside the calving interval, which are also correlated with the body condition score (BCS) of the cow [41]. Cows with optimal BCS usually have higher milk yield and also have enough body reserves for reproductive potential, thereby having an optimal calving interval [48]. Such cows usually fetch higher prices in all locations as they have an overall higher lifetime yield [49]. Survival proportion to yearling (SUR%) varied across ranks ($p < 0.05$). This is because cows with poor calf survival will have a short lactation length and are thereby economically unviable [50]. Significant variation ($p < 0.05$) was observed in calving interval (CI), milk yield (MY), and lactation milk yield (LMY), and a higher value was observed for the first-ranked animals. Even the lowest-ranked animals had a greater average estimated MY and CI than Fasil's reports for the breed [19], which were 1.9 ± 0.24 L and 17.3 ± 1.04 months, respectively. This would be due to the aspiration of the owners to have cattle with a multipurpose role, as most of the respondents in the tropics usually balance all their options and give higher ranking to the adaptability of the cattle [46,47] and optimum milk yield is desired for the development of a strong and healthy calf [51]. Therefore, the respondents selected their cattle based on several traits which may be correlated among themselves and can help in the early selection of the cattle [26], Traits such as coat color and also birth and weaning weight are correlated with mature body weight, which in turn is also correlated with age at first service (AFS) and AFC [52]. Moreover, selection based on different traits and from different angles can help in improving the accuracy of selection and lifetime productivity of the cattle, which consequently improves the overall economy [47].

Table 3. Willingness to pay per ETB 1000 and (re)production traits from the life history of ranked cows (LSM ± SE).

Attribute	Overall N = 254	SD	First N = 64	Second N = 63	Third N = 63	Last N = 64	*p* Value
WTP	10.5 ± 0.15	2.37	11.5 ± 0.35 ^{c}	10.7 ± 0.24 ^{bc}	10.4 ± 0.25 ^{ab}	9.5 ± 0.28 ^{a}	$<2.2 \times 10^{-16}$
BCS	3.2 ± 0.04	0.64	3.6 ± 0.07 ^{b}	3.5 ± 0.53 ^{b}	2.9 ± 0.05 ^{a}	2.7 ± 0.07 ^{a}	2.2×10^{-16} K
Nocb1	3.8 ± 0.08	1.35	4.0 ± 0.17	3.7 ± 0.15	4.0 ± 0.20	3.6 ± 0.15	0.1991
Nocs1	3.7 ± 0.08	1.25	3.9 ± 0.15	3.7 ± 0.15	3.9 ± 0.18	3.2 ± 0.13	0.0722
SUR	96.8 ± 0.56	8.89	99.7 ± 0.31 ^{b}	100 ± 0.00 ^{b}	97.9 ± 0.78 ^{b}	89.9 ± 1.79 ^{a}	3.724×10^{-13}
AFM	32.6 ± 0.38	5.98	32.6 ± 0.67	31.9 ± 0.76	32.7 ± 0.88	33.2 ± 0.69	0.6665
AFC	44.3 ± 0.38	6.07	44.1 ± 0.69	43.7 ± 0.76	44.7 ± 0.90	44.6 ± 0.70	0.8088
CI	15.1 ± 0.16	2.53	13.9 ± 0.13 ^{a}	14.7 ± 0.34 ^{ab}	15.7 ± 0.37 ^{bc}	16.0 ± 0.34 ^{c}	5.54×10^{-6}
MY	2.8 ± 0.07	1.12	3.3 ± 0.14 ^{c}	2.9 ± 0.13 ^{bc}	2.7 ± 0.13 ^{b}	2.2 ± 0.13 ^{a}	1.343×10^{-7}
LL	3.3 ± 0.07	0.75	3.1 ± 0.09 ^{a}	3.4 ± 0.09 ^{ab}	3.6 ± 0.09 ^{b}	3.2 ± 0.09 ^{a}	0.06499
LMY	263.3 ± 6.03	96.05	305 ± 10.39 ^{b}	298 ± 12.33 ^{b}	295 ± 10.34 ^{b}	205 ± 11.79 ^{a}	0.0009155

The least-square means with similar superscript letters (at least in one letter) within the row are not significantly different at $p > 0.05$. i.e., "ab" is not significantly different from "a", "b", "bc" or "ac". K is a Kruskal–Wallis chi-squared test value of body condition score of 98.298. BCS = body condition score (1–5), N = number of animals, WTP = willingness to pay per ETB 1000 (EUR 1 = ETB 35.29 or USD 1.11 in mid-December 2019), Nocb1 = number of calves per cow or cow parity. Nocs1 = number of calves that survived to yearling, SUR = survival proportion in %. AFM = age at first mating of female in a month, AFC = age at first calving in a month, CI = calving interval in a month, MY = milk yield in liters, LMY = lactation milk yield in days, LL = lactation length a month, SD = standard deviation.

3.1.5. Effect of Male Ranking and Location on Some Attributes

The results in Table 4 pertain to the willingness to pay (WTP) by the respondents for the bulls reared. The willingness as observed varied ($p < 0.05$) by ranking. The willingness to pay for breeding animals for first, second, third, and the worst animals was ETB 6300, 5800, 5200, and 4500, respectively. The willingness to pay for the worst-ranking animals may be attributed to the availability of feed and fodder in the area, as cattle with poor BCS can be improved to some extent through management [50]. Bulls with poor body condition are cheaper and, hence, if stall-fed, can improve their BCS in a couple of months [47].

Table 4. Shows willingness to pay per ETB 1000 and some production traits of ranked males (LSM ± SE).

Attributes	Overall	SD	First N = 63	Second N = 63	Third N = 63	Last N = 63	*p* Value
WTP	5.5 ± 0.15	2.40	6.3 ± 0.28 ^{b}	5.8 ± 0.27 ^{b}	5.3 ± 0.28 ^{ab}	4.5 ± 0.32 ^{a}	8.782×10^{-5}
BCS	5.5 ± 0.05	2.40	3.9 ± 0.08 ^{c}	3.7 ± 0.09 ^{bc}	3.5 ± 0.09 ^{ab}	3.3 ± 0.09 ^{a}	7.348×10^{-6} k
WA	4.4 ± 0.05	0.80	4.0 ± 0.00 ^{a}	4.0 ± 0.00 ^{a}	4.0 ± 0.06 ^{a}	5.6 ± 0.06 ^{b}	$<2 \times 10^{-16}$
WW	36.15 ± 0.61	8.96	38.4 ± 1.00 ^{b}	36.6 ± 1.24 ^{b}	37.0 ± 1.22 ^{ab}	32.4 ± 1.27 ^{a}	0.002742
YW	100.9 ± 1.69	25.00	107.2 ± 3.25 ^{b}	102.2 ± 3.44 ^{ab}	103.3 ± 3.27 ^{b}	90.4 ± 3.34 ^{a}	0.002742

The least-square means with similar superscript letters (at least in one letter) within the row are not significantly different at $p > 0.05$. i.e., "ab" is not significantly different from "a", "b", "bc" or "ac". K is a Kruskal–Wallis chi-squared value for body condition score (BCS) of 24.12, N = number of animals involved in the ranking process, WA = weaning age in months, WW = weaning weight in months, YW = yearling weight in kilograms, WTP = willingness to pay per ETB 1000, SD = standard deviation, SE = standard error of the mean, LSM = least square mean.

3.2. Quantitative Body Measurements from Own Herd Ranking Experiment

3.2.1. Body Measurements of Ranked Cows

The findings related to the morphometrical measurements of the cows are presented in Table 5. The study shows that body length (BL), heart girth (HG), and height at the withers (HW) are the traits of importance. This may be because those traits are correlated with the body size and weight of the cows [19]. Higher HG also ensures that most of the important organs (thoracic) such as the lungs and heart are well developed [53]. Thus, well-sprung ribs facilitate deeper breathing and are favorable for endurance [53]. The relationship between HW and canon length has been reported by [19]. Therefore, cattle with longer canons are taller and hence walk longer distances, which facilitates grazing and transhumance activities [46,47]. Udder length (UL) and udder depth (UD) are also traits of importance. This may be due to their relationship with the milk yield and health of the cow. Those traits are also related to the feminine traits of the cow [51].

Table 5. Effect of cow ranking on female body measurements (LSM ± SE).

Traits	First N = 64	Second N = 63	Third N = 63	Last N = 64	*p* Value
BL	126.0 ± 1.17 ^{b}	123.0 ± 1.18 ^{ab}	122.0 ± 1.18 ^{ab}	122.0 ± 1.17 ^{a}	0.02051
CC	16.9 ± 0.22	17.0 ± 0.22	16.9 ± 0.22	16.8 ± 0.21	0.9881
CL	26.6 ± 0.46	26.2 ± 0.46	26.3 ± 0.46	26.3 ± 0.46	0.9217
CW	48.5 ± 1.61	46.1 ± 1.62	47.9 ± 1.62	47.3 ± 1.61	0.7377
HG	158.0 ± 1.28 ^{b}	157.0 ± 1.29 ^{b}	153.0 ± 1.29 ^{ab}	152.0 ± 1.28 ^{a}	0.003079
HW	125.0 ± 0.72 ^{b}	124.0 ± 0.73 ^{ab}	124.0 ± 0.73 ^{ab}	122.0 ± 0.72 ^{a}	0.02908
NC	73.6 ± 1.07	73.8 ± 1.08	72.2 ± 1.08	71.6 ± 1.07	0.4198
NL	49.1 ± 0.81	49.8 ± 0.82	47.7 ± 0.82	48.5 ± 0.81	0.3167
RL	30.9 ± 0.47	30.5 ± 0.47	30.8 ± 0.47	29.7 ± 0.47	0.2569
RW	39.2 ± 0.53	39.8 ± 0.53	38.8 ± 0.53	38.1 ± 0.53	0.1766
UD	17.2 ± 0.27 ^{b}	17.0 ± 0.27 ^{b}	16.3 ± 0.27 ^{a}	16.3 ± 0.27 ^{a}	0.03117
UL	29.2 ± 0.53 ^{b}	27.9 ± 0.54 ^{ab}	26.7 ± 0.54 ^{a}	27.0 ± 0.53 ^{a}	0.00448

The least-square means with similar superscript letters (at least in one letter) within the row are not significantly different at $p > 0.05$. i.e., "ab" is not significantly different from "a", "b", "bc" or "ac". LSM = least square mean, N = number of ranked animals, BL = body length, CC = canon circumference, CL = canon length, CW = chest width, HG = heart girth, HW = height at withers, NC = neck circumference, NL = neck length, RL = rump length, RW = rump width, UD = udder depth, UL = udder length.

3.2.2. Body Measurements of Ranked Male Animals

Except for neck circumference (NC), canon length (CL), and chest width (CW), all considered body measurement traits were affected ($p < 0.05$) by ranking (Table 6). The differences in heart girth (HG), height at withers (HW), and body length (BL) measurements between the first and last rankings were 14, 9, and 7 cm, respectively. This is again due to the correlation of those traits with the body size and weight of the animal [19]. The BL is a trait of importance as bulls with long bodies have higher body weight and hence have sociocultural importance [19]. Studies by Dereje [54] have indicated that bulls that are masculine usually have wider scrotal circumference (SC), usually have higher levels of testosterone, and are more muscular. In cattle, scrotal circumference is also correlated with total sperm count [55,56]. The SC as observed in the study is in close accordance with that of [19] for the breed.

3.2.3. Correlation between Ranking and Animal Attributes

A total of 21 traits for females and 15 for males were considered to see their association with animal ranking (Table 7). The Pearson correlation pairwise analysis test, as indicated in Tables S2 and S3, can then be performed based on the level of association with the animal ranking and determinant effect (representativeness of the trait) for the breeding objective. Most considered traits were positively associated with animal ranking. Weaning age, survival proportion, and body condition score (BCS) were consistent in their strong association with ranking across the study location for both sexes, with the exception of BCS for males in Fanguso. This could be due to the farmers' attachment to the animal coat color masking other traits. This is clearly shown by the moderate association of coat color (0.45) with the site. Linear measurements such as heart girth, height at whithers, and body length for the two sexes; RW, NL, SC, and CC for male animals; and UD and UL for females have a strong correlation. Milk yield and calving interval were also consistent in their significant association across the study sites.

Table 6. Effect of ranking on male body measurements (LSM ± SE).

Traits	First N = 63	Second N = 63	Third N = 63	Last N = 63	*p* Value
BL	112 ± 1.70^{b}	111 ± 1.70^{ab}	108 ± 1.54^{ab}	105 ± 1.44^{a}	0.03665
CC	16.5 ± 0.20^{b}	16.0 ± 0.19^{ab}	16.0 ± 0.20^{ab}	15.4 ± 0.19^{a}	0.003149
CW	39.1 ± 0.96	38.3 ± 0.94	38.5 ± 1.00	37.4 ± 0.93	0.6896
HG	142.0 ± 1.65^{b}	135.0 ± 1.61^{a}	134.0 ± 1.70^{a}	128.0 ± 1.59^{a}	4.81×10^{-16}
HW	118.0 ± 1.15^{c}	115.0 ± 1.12^{bc}	113.0 ± 1.19^{ab}	109.0 ± 1.11^{a}	0.000192
RL	27.4 ± 0.51^{b}	26.7 ± 0.50^{ab}	26.4 ± 0.53^{ab}	25.2 ± 0.49^{a}	0.03994
RW	32.6 ± 0.57^{b}	31.3 ± 0.56^{b}	30.7 ± 0.59^{b}	28.5 ± 0.55^{a}	0.000137
NC	70.8 ± 1.24	69.7 ± 1.21	68.6 ± 1.29	67.1 ± 1.20	0.3285
NL	44.2 ± 0.80^{b}	42.5 ± 0.78^{ab}	42.0 ± 0.83^{ab}	40.8 ± 0.77^{b}	0.03174
CL	26.0 ± 0.38	25.1 ± 0.37	24.9 ± 0.39	24.4 ± 0.36	0.1001
SC	24.0 ± 0.59^{b}	22.3 ± 0.57^{ab}	21.8 ± 0.61^{ab}	20.9 ± 0.57^{a}	0.006284

The least-square means with similar superscript letters (at least in one letter) within the row are not significantly different at $p > 0.05$. i.e., "ab" is not significantly different from "a", "b", "bc" or "ac". LSM = least square mean, SE = standard error of mean, N = number of ranked animals, BL = body length, CC = canon circumference, CL = canon length, CW = chest width, HG = heart girth, HW = height at withers, NC = neck circumference, NL = neck length, RL = rump length, RW = rump width, SC = scrotal circumference.

Table 7. Correlation of some (re)production and morphometric body measurements with animal ranking across the three locations.

Trait	Female				Male			
	Almahal	**Fanguso**	**Mankush**	**Overall**	**Almahal**	**Fanguso**	**Mankush**	**Overall**
BL	0.26 *	−0.02	0.24 *	0.18 **	0.35 ***	0.04	0.05	0.16 *
HG	0.3 **	0.06	0.3 *	0.23 ***	0.42 ***	0.2	0.2	0.28 ***
HW	0.31 **	0.07	0.08	0.17 **	0.37 ***	0.18	0.22*	0.26 ***
CC	0.26 *	0.03	0.1	0.11	0.41 ***	0.17	0.04	0.21 ***
CW	0.02 **	0.03	0.1	0.03	0.03	0.11	0.09	0.07
RL	0.02	0.13	0.23 *	0.11	0.3 **	−0.02	0.22 *	0.17 **
RW	0.07	0.03	0.22	0.1	0.4 **	0.21	0.25 *	0.29 ***
NC	0.2	0.05	0.03	0.09	0.04	0.11	0.24 *	0.15 *
NL	0.02	0.1	0.11	0.07	0.47 ***	0.14	0.02	0.22 ***
CL	−0.01	−0.01	0.05	0.0	0.24 *	0.19	0.09	0.15 *
Age	0.05	0.03	0.09	0.07	0.17	0.08	0.07	0.06
WA	−0.59 ***	−0.79 ***	−0.82 ***	−0.72 ***	−0.7 ***	−0.66 ***	−0.7 ***	−0.07 **
BCS	0.71 ***	0.5 ***	0.6 ***	0.61 ***	0.51 ***	0.19	0.26 *	0.34 **
Sur/SC	0.27 **	0.50 ***	0.41 ***	0.40 ***	0.35 ***	0.14	0.14	0.21 ***
Color	0.15	0.01	0.01	0.13	0.24 *	0.45 *	0.09 *	0.15 *
UD	0.48 ***	0.02	0.07	0.19 **				
UL	0.37 ***	0.1	0.2	0.2 **				
AFC	0.01	−0.12	−0.03	−0.04	-	-	-	-
CI	−0.37 ***	−0.26 *	−0.46 ***	−0.36 ***	-	-	-	-
MY	0.30 **	0.37 ***	0.41 ***	0.35 ***	-	-	-	-
LL	−0.03	−0.09	0.07	−0.01	-	-	-	-
BW					0.40 ***			0.23 ***

*, ** and *** represents the level of association at $p < 0.005$, $p < 0.001$, and $p < 0.0001$, respectively. BL = body length, HG = heart girth, HW = height at withers, CC = canon circumference, CW = chest width, RW = rump length, NC = neck circumference, NL = neck length, CL = canon length, WA = weaning age, Sur/SC = survival proportion for females and scrotal circumference for males, BC = body condition, UD = udder depth, UL = udder length, AFC = age at first calving, CI = calving interval, MY = milk yield, LL = lactation length, BW = body weight.

Weaning age and calving interval have a consistent negative correlation with rank across the study sites. This indicates animals are preferred mainly for their reduced weaning age and calving interval; therefore, a greater number of fast-growing animals can be available for sale. Canon length in Almahal and Fanguso, and lactation length across the study were correlated negatively with insignificant association with animal ranking.

3.3. Determination of Objective Traits

The breeding objectives of the community were derived by considering the preferred traits of the owners from the own herd ranking experiment (OHR) and production system study (PS) (Table 8). The traits were identified based on the preference of the community, ease of trait measurement, and the future contribution of the breed; five traits were identified as the breeding objectives of Begaria cattle owners. The study shows that OHR and PS studies indicate that milk yield followed by growth of the cattle are traits that are of importance. The observations are also in close accordance with the findings of [5,27]. The findings also correlate with the observations from the earlier tables (Table 2). The animals with higher and optimal growth usually reach puberty quite early [57] and are expected to have a higher lifetime calving number (provided they are taken care of) and consequently higher milk yields [42]. Therefore, the traits associated with growth have to be considered in the selection of heifers and bulls [58]. The potential milk yield of the calves can be accessed through the records of the dams and also the female relatives [58]. Therefore, the records need to be maintained for the dams and the female relatives so that indirect selection can be carried out. A breeding program including reproduction (AFC and CI) and adaptability qualities would have a good impact on the farm's overall economy, in terms of available animals for sale, selection, and lifetime milk production. Even if considering a small number of traits is recommended from the perspective of ease of implementation [7,27], including a variety of qualities in the breeding program would help to maintain the genetic diversity of the breed. The rate of improvement in the breeding program may be slow, especially for antagonistic features. As a result, unfavorable traits should be optimized, or else they would be nullified. The body condition score (BCS) is related to economic traits such as milk yield, growth, and calving interval (CI) [59]. BCS has been identified as an important criterion for Nguni cattle selection in low-input in situ conservation production systems [60].

Table 8. A list of traits and their weighted rank from the own herd ranking experiment and production system study.

Traits	OHR(a)	PS(b)	Wr
Growth	17.15(2)	0.25(2)	2(2)
Milk yield	39.14(1)	0.28(1)	1(1)
Mothering ability	4.29(7)	0.11(4)	5.5(6)
BCS	-	0.14(3)	3(3)
Age at puberty	-	0.09(5)	5(4)
AFC	-	0.01(8)	8(10)
CI	15.14(3)	0(9)	5.5(6)
Aggression	12(4)	0.07(7)	5.5(6)
Coat color	6(6)	0.08(6)	6(9)
Physical appearance	6.29(5)	-	5(4)

OHR = own herd ranking, PS = production system study, BCS = body condition score, AFC = age at first calving, CI = calving interval, WR = weighted rank (higher values indicate lower importance), Wr = weighted rank.

Suggested Selection Criteria for the Identified Breeding Objective Traits

Bull side selection clearly has a high rate of genetic progress. As a result, breeding bulls must be chosen based on an individual's own performance as well as the performance of its collateral relatives. As the transmission abilities for dairy parameters are accessed through information obtained from the dam and other female relatives, the closeness and distance between the relatives are given due weight. Yearling weight would thus be used as a selection criterion for this growth trait. One advantage is that a sufficient number of animals are available for selection before they reach marketable age. The other is to account for both the bull's and the dam's data in the selection process. Farmers mainly preferred to have larger numbers of animals exhibiting faster growth rather than rearing large-sized ones. The faster growth is also correlated with the ability of the growing steers and heifers to optimally utilize the green fodder available in ample quantity during the shorter growing season [21]. Even though size and growth have a strong positive correlation, from an adaptation standpoint, the breeding goal should aim to increase the fast growth rate because the animals need adequate body reserves to develop immunity against various diseases such as trypanosomiasis [22,60].

Because milk yields are primarily desired for calf growth and household income, lactation milk yield has to be considered as a selection criterion when selecting a breeding bull. The farmers' preference was used to develop a selection criterion for mothering ability. The farmers primarily link good mothering to the calves' growth and survival. The number of calves weaned is also an important factor in the overall economy and profitability of dam rearing. As a result, the survival rate of yearlings must be taken into account. Similarly, ref. [7] considered survival traits for mothering ability in sheep breeds. To account for AFC and CI, the dam's age at her first birth and the time interval between consecutive births are taken into account. In order to obtain CI data, the dam must have at least two births.

4. Conclusions and Recommendations

Breeding objective traits can be identified using participatory tools. Farmers consider (re)production, behavioral, and survival traits in the participatory identification methods. Therefore, live animal ranking methods supplemented with production system studies can identify the farmers' breeding objective, particularly when recorded information is absent, especially for low-input systems.

Furthermore, having the owners' decisions on ranked animals and the measurements taken from them aids in the integration of indigenous knowledge with the science of animal breeding and conservation strategy, as well as knowing their preferences.

In general, the farmers' ranking is mainly based on minding multiple directions, and the farmers would like to have multipurpose animals. In own herd ranking method, a single superiority may not guarantee that the animal is considered the best breeding animal.

Despite the farmer's consideration of numerous functions when selecting a breeding animal, some traits of Begaria cattle breeds, such as milk yield, growth, and survival, received high preference and were valued highly. As a result, every alternative hypothesis is accepted.

Even though the consideration of a few easily measurable traits is worthy for the program implemented under farmer conditions, the genetic variability of the breed can be maintained when a greater number of traits are considered in the program. Breed improvement programs should aim to improve their growth rate rather than the animal size. In this sense, damages when mating with heavier bulls, abortion, and adaptive trait leaking can all be decreased.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su141912766/s1, Table S1: Traits of interest for improvement across the location; Table S2: Pearson correlation of selected traits (upper diagonal) and associated *p* values (below diagonal) for female Begaria cattle; Table S3: Pearson correlation of selected traits (upper diagonal) and associated *p* values (below diagonal) for male Begaria cattle.

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