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Breeding objectives and selection criteria of farmers keeping indigenous cattle populations in north-west Ethiopia

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ABSTRACT

This study was conducted to identify farmers' breeding objectives and trait preferences for indigenous cattle in north-west Ethiopia. Multistage purposive and random sampling techniques were used to select study districts, and smallholder farmers. The required data were collected through structured questionnaires from 320 households, personal observations, and focus group discussions. The chi-square ($\chi 2$) test, least squares mean, and ranking index were statistical methods used for data analysis. The least squares mean analysis showed a difference ($p < 0.001$) and the mean herd size was 10.9 heads. Based on ranking index results, milk production (0.35) and draught power (0.25) were the main cattle production purpose/objectives of farmers. The chi-square ($\chi 2$) test results of mating practices showed a significant difference ($p < 0.001$) and 63.8% of farmers used controlled mating. According to the ranking index result, large body size (0.35), colour (0.26), and good traction (0.18) were considered the most important traits in selecting a breeding bull. High milk yield (0.4), colour (0.19), large body size (0.16), and calf growth (0.13) were the preferred traits/criterias for cow selection. Prioritizing farmer trait preference and breeding objectives in this study was critical for the design and implementation of breeding programmes.

Highlights

- Trait preferences of farmer were based on several traits
- Farmers in the area kept their bulls mainly for draft service
- milk production was the first purpose of cattle keeping

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Introduction

Ethiopia is considered a migration corridor for both *Bos Taurus* and *Bos Indicus* cattle to Africa (Mwai et al. 2015), and is an excellent breeding ground for 28 indigenous cattle breeds (Desta et al. 2011; Adugna 2014). The total number of cattle in the country is estimated at 70 million (CSA 2021), making it a country with the largest population in Africa and the fifth largest in the world. About 97.4% are indigenous breeds kept under extensive management, while crossbreeds and exotic breeds account for only 2.3% and 0.31%, respectively (CSA 2021). These indigenous cattle breeds play an important role in the livelihoods of millions of farmers. They serve as a source of draft power for the rural population and provide cattle products such as milk, meat, manure, and cash income (Endalew and Ayalew 2016). Indigenous cattle have different adaptive mechanisms that enable them to survive and reproduce under high temperatures and with seasonal fluctuations in feed and water supply. Resistance to disease incidence, and adaptation for poor quality and availability of feed and water are characteristics of indigenous cattle (Hagos 2016). However, despite the huge genetic resources, indigenous cattle breeds are characterized as having low productivity and low reproductive performance when compared to commercial breeds (Renaudeau et al. 2012; Mwai et al. 2015). On the other hand, the demand for livestock products is continuously increasing, and the sustainability of intensive livestock production is uncertain (Otten and Van den Weghe 2011). The measures taken to fill these productivity gaps in developing countries are eroding indigenous genetic resources through poorly planned crossbreeding and breed substitution (Hagos 2016). In Ethiopia, by only considering the productive potential of breeds in their home tract, development agents have played a major role in the genetic dilution of indigenous breeds through introducing them into other environments without considering their fitness traits (Alemayehu et al. 2002). This problem can be solved by designing an appropriate

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breeding programme suitable for the production environment while considering the production objectives of the farmers. Breeding companies in developed countries focuses more on determining farmers' trait preferences and breeding goals (Slagboom et al. 2016; Strucken et al. 2016). Nevertheless, due to a lack of knowledge of individual trait preferences and beneficiary involvement, genetic enhancement programmes in developing nations, including Ethiopia, are not successful (Duguma et al. 2011; Ouédraogo et al. 2020). Implementation of a sustainable participatory breeding programme depends on a good understanding of trait preference and breeding objectives (Ndumu et al. 2008; Mueller et al. 2015). Several scholars have identified and characterized the breeding objectives and trait preferences of cattle keeping farmers in different parts of Ethiopia (Wuletaw et al. 2006; Zewdu et al. 2018; Mengistu et al. 2019; Gebisa 2021). However, breeding objectives, trait preferences, and ranking of preferences for a given trait differ across societies, husbandry systems, agro-ecological zones, and market access (Scarpa et al. 2003; Roessler et al. 2008). Ouédraogo et al. (2020) reported that the local environment has a big impact on breeding methods. The north-western part of the country, particularly the Awi, East Gojjam, and West Gojjam zones, is demarcated and isolated by the Blue Nile (Abay gorge) river from the other parts of the country. The area has diversified agro-ecologies and harbours a huge (about 6.3 million) number of cattle populations under different production systems (CSA 2021). In the area, information on the farmers' trait preferences and breeding objectives is lacking or insufficent to plan a breeding programme. Therefore, the objective of this study was to identify the breeding objectives and trait preferences of indigenous cattle keepers in north-west Ethiopia in an effort to develop an appropriate breeding programme.

Materials and methods

Locations

The study was conducted in six selected districts (Jawi, Enebsie Sarmidr or Enensie, South Achefer or Achefer, Mecha, Banja, and Senan) that are found in three (Awi, East Gojjam, and West Gojjam) administrative zones of north-west, Ethiopia (Figure 1). The districts selected represent a variety of agroecologies, including lowlands (Jawi and Enebsie), midlands (South Achefer and Mecha), and highlands (Banja and Senan). Table 1 shows a detailed description of the cattle populations, agro-ecological characteristics, coordinate points, and altitude of the study areas.

During the site selection process, preliminary discussions were done with regional and zonal experts from livestock development agencies regarding the distribution and potential of indigenous cattle in the study areas.

Sampling techniques and procedures

A preliminary assessment was conducted on the general aspects of livestock production. Discussions were held with experts from the livestock development offices in the zones

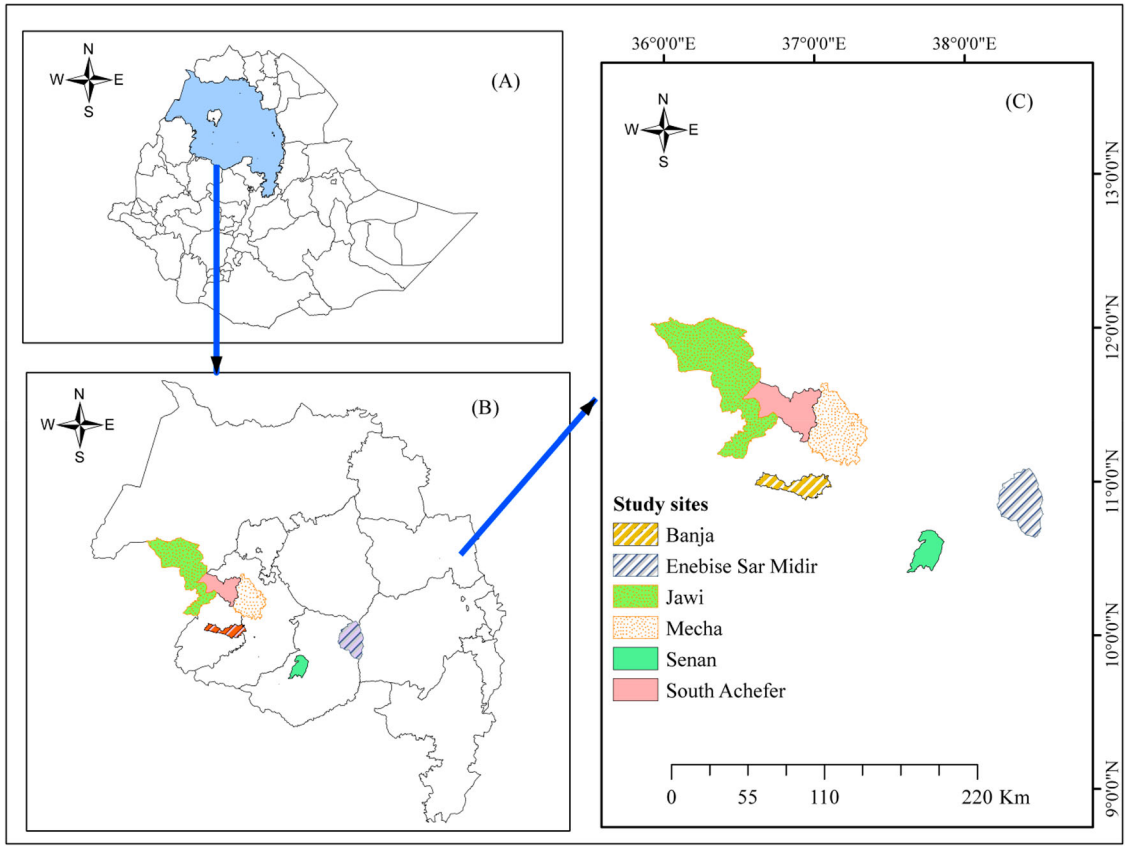

Figure 1. Map of Ethiopia (A), Amhara Regional State (B), and six study sites of north-west Ethiopia (C).

Table 1. Summary of cattle population, annual temperature, rainfall, coordinate points, and elevation of study districts in north-west Ethiopia.

Districts	*kebele*	Latitude	Longitude	Altitude (m. a. s. l)	Annual temp./ °C	Annual RF/mm	Cattle population
Jawi	1	11°57′18"N	36°24′48"E	995	12–40	1250	252,121
	2	11°25′38"N	36°37′06"E	1365			
	3	11°33′40"N	36°31′50"E	1171			
Enebsie	1	10°41′35"N	38°30′35"E	1431	10–36	900–1200	67,791
	2	10°41′41"N	38°30′40"E	1207			
	3	10°42′03"N	38°30′40"E	1271			
Achefer	1	11°31′17"N	36°56′19"E	2052	15–23	1450–1594	337,467
	2	11°16′36"N	36°57′52"E	2000			
Mecha	1	11°19′28"N	37°14′05"E	2194	23–27	1500–2200	409,502
	2	11°22′26"N	37°04′32"E	1963			
Banja	1	10°54′39"N	36°58′04"E	2409	7–25	2200–2560	69,156
	2	10°56′48"N	36°52′08"E	2337			
	3	10°58′36"N	37°00′55"E	3028			
Senan	1	10°38′27"N	37°47′53"E	3192	0–15	900–1500	37,501
	2	10°35′03"N	37°49′43"E	3081			
	3	10°38′04"N	37°49′03"E	3214			

Source: Districts agricultural office, 2021; m. a. s. l = meter above sea level, temp = temperature in degree Celsius, and RF = annual average rainfall in millimetre.

and districts to understand the general livesotk management and breeding practices, and concentrations of local cattle in the study areas. Based on these discussions, multi-stage sampling methods were used. First, the study areas that had not been accessed for research before were purposively selected and divided into three strata based on agro-ecology, namely lowland, midland, and highland. In the second phase, two sites in each agro-ecology (Jawi and Enebsie SarMidr in the lowland, South Achefer and Mecha in the midland, and Banja and Senan in the highland) were chosen based on livestock potential and agro-ecological diversification. Finally, 16 kebeles and 20 households from each kebele with a total of 320 households were selected and subject to an interview with a semi-structured questionnaire. The sample size was determined based on the formula;

$$n = \frac{N}{1 + N\varepsilon^2}$$

Where; N = population size > 1000000, ε = the degree of accuracy expressed as a proportion = 0.05, ρ = the number of standard deviations that would include all possible values in the range = 2, t = t-value for the selected alpha level or confidence level at 95% = 1.96. The minimum sample is 267 households (Adam 2021).

Description of cattle breeds

In general, indigenous cattle breeds in the study areas have medium body size, a light red and stripe (white × red) coat colour, a straight horn shape, lateral ear orientation, a straight head profile, and a long tail length (Figure 2). However, different body sizes and morphological characteristics are shown across sex and agro-ecology. On average, cows in lowland agro-ecology have a medium body size, a medium udder size, a small hump size, a long tail length, and a small navel flap size. Whearas cows in midland and highland agro-ecology have small body sizes, medium udder sizes, and navel flap sizes. Bulls in highland have a small body size, a medium preputial sheath, and a small hamp size. On the other side, bulls in lowland and midland agro-ecologies have a medium body size, a small hump size, and a medium preputial sheath (Tenagne et al. 2023).

Cattle management systems and livestock composition

The most important agricultural activities in the study districts are mixed crop and livestock production. Lower altitude crops include sorghum, finger millets, maize, rice, *gobe*, and groundnut. In the midland, common crops included wheat, maize, barley, finger millet, and *teff*. In highland areas, wheat, maize, barley, oats, and *teff* were major crops. Cattle, sheep, goats, equines, and chickens are common livestock species in the study areas, and the main feed resources for cattle were natural pasture, crop residues, stubble grazing, private grazing land, and conserved forage (CSA 2021).

Data collection procedures

The data for the study was gathered from selected households using a semi-structured questionnaire interviews. The required data including the socio-economic characteristics, herd size and composition, preferred traits and breeding objectives, breeding practices, the source of breeding bulls, and bull management were collected. To obtain additional information and validate the data from the individual farmer interviews, two focus group discussions were taken from each district involving elders, well-informed farmers, livestock experts, and veterinarians, with a group of 12 participants. For the ranking of the breeding objective traits, and selection criteria, the respondent households were requested to rank all traits in order of their preference and objectives.

Data management and statistical analysis

Frequency and chi-square (X^2) test analysis

Prior to the major data analysis, homogeneity and normality checks were done. For the socio-economic characteristics of households (age, education level, and landholding) and traits related to breeding practice (possesion of bull, sources of bull, objective of bull keeping, mating type, culling method, reasons for uncontrolled mating, and trait preference), a frequency analysis and a chi-square (X^2) test were used to determine the proportion of respondents and the level of significance.

Figure 2. Coat colour types of Sinan cattle (a), large hump and preputial, sheath for Mecha bull (b), horn orientations and facial profile for Jawi cattle (c) and large tail length and navel flap for Jawi cow (d).
Source Tenagne et al. 2023.

Least square mean analysis

To evaluate the level of difference among herd structures (number of bulls, cows, heifers, oxen, and calves), least squares mean analysis was used.

Ranking index

For the reasons of using more than one bull, trait preference of bull selection, and trait preference of cow selection, ranking indices were calculated by considering the first three ranks as representative of each of the six consecutive ranks, using the formula (Kosgey 2004):

$$Index = \frac{\sum[(3 \times rank1) + (2 \times rank2) + (1 \times rank3)]individualtrait}{\sum[(3 \times rank1) + (2 \times rank2) + (1 \times rank3)]overalltraits}.$$

Effective population size and inbreeding coefficient

Effective population size ($\boldsymbol{N_e}$) is the number of individual animals that effectively participate in producing the next generation, and it is strongly related to population viability. It is an important genetic parameter because of its relationship to the loss of genetic variation and increases in inbreeding (Naveh and Lieberman 2013). The Ne for a randomly mated population was calculated as follows: $Ne = \frac{(4Nm \times Nf)}{(Nm + Nf)}$ where, $\boldsymbol{N_m}$ is the number of breeding males, $\boldsymbol{N_f}$ is the number of breeding females, and $\boldsymbol{N_e}$ is the effective population size.

The inbreeding coefficient represents the probability that an individual has two identical alleles for the same gene (Perrin and Mazalov 2000). The inbreeding coefficient (ΔF) was calculated from the effective population size (Ne) as follows: $\Delta F = \frac{1}{(2Ne)}$ (Naveh and Lieberman 2013).

Results

Household characteristics and cattle herd structure

The age, education status, and land ownership characteristics of households are presented in Table 2. A significant ($p < 0.001$) difference was found among the age, education status, and land ownership of respondents in the study districts. Overall, most of the respondents were in the 31–45 and 46–64 age groups. In terms of educational attainment, only 4.03% of households are able to complete secondary school through regular education. The rest, 36.7%, were

Table 2. Household characteristics of cattle owners in north-west Ethiopia.

Household characteristics	Sites and percentage of samples						*p*-value	Chi-Square Value
	Jawi %	Enebsie %	Achefer %	Mecha %	Banja %	Senan %		
Age							<0.001	193.83
≤30 years	8.31	0.00	0.00	5.00	0.00	0.00		
31–45 years	45.00	53.32	45.00	30.00	53.30	45.00		
46–64 years	46.70	41.71	50	52.54	41.71	40.00		
>64 years	0.00	5.00	5.00	12.50	5.00	5.00		
Education level							<0.001	136.53
Illiterate	46.72	73.32	22.50	7.51	11.72	60.00		
Read and write	48.31	21.71	70.00	92.52	81.74	40.00		
Secondary school	5.00	5.00	7.50	0.00	6.70	0.00		
Total land owned							<0.001	250.73
≤1 ha	21.73	10.00	15.00	37.54	63.00	55.00		
1.1–2 ha	20.00	8.30	67.51	52.53	37.00	41.73		
2.1_3 ha	13.33	0.00	17.52	7.51	0.00	3.32		
3.1–4 ha	5.00	6.71	0.00	2.52	0.00	0.00		
>4 ha	40.00	75.00	0.00	0.00	0.00	0.00		
Grazing land owned								
≤0.5 ha	70.00	91.70	100.00	92.51	91.70	98.30		

illiterate, and 59% could only read and write. Overall, 71.5% of the farmers have less than 2 hectares of land, eventhough in lowland areas, 57.5% of farmers have greater than 4 hectares of land. More than 90% of the respondents had either less than 0.5 hectares or no private grazing land for their cattle. The cattle herd composition differed significantly (<0.001) among study sites, and the average total size of cattle herds was 10.9 (4.29 male and 6.61 female) animals per household. However, the numbers varied according to agro-ecology, with a larger herd size (18.32) in the lowlands (Jawi, Enebsie Sarmidr districts) and smaller (8.08) and (5.36) in the midlands (South Achefer, Mecha districts) and highlands (Banja and Senan districts), respectively. The cattle herd size was significantly larger in lowland sites, whereas the number was lower in highland agro-ecological zones. The cattle herd structure by age and sex class distribution in the districts is presented in Table 3. The highest and lowest ratios of bulls to cows were recorded in the highland and lowland agro-ecologies, respectively.

Breeding objectives of cattle

Table 4 shows the weighted ranking index of the objective of cattle keeping of farmers. Overall, milk production (index = 0.35), cash income generation (index = 0.3), and draught power for crop production (index = 0.25) were major reasons of farmers for keeping cattle. The objectives of cattle rearing varied across agro-ecologies; the source of cash income was the main objective for raising cattle in lowland areas, whereas in highland areas milk production was first ranked objective of cattle keeping.

Breeding practices

Overall, 68.7% of the farmers had at least one breeding bull. compared to 59 percent recorded in the lowland areas or Jawi, Enebsie Sarmidr districts (Table 5). Even among farmers with breeding bulls, 68.3 percent used herd-derived bulls, with 67.8 percent keeping their bull for draft purposes or objectives. Control mating/ breeding was a major breeding practice (63.9%) among farmers in the overall study areas, even if significant differences were recorded among agro-ecological zones. The highest percentages were recorded in the midland (82.5%) and the lowest percentages in the lowland (50%) (Table 5). The main reasons (80.3%) for farmers practicing uncontrolled mating were the grazing together of bulls and cows and their lack of awareness (19.7%) about control breeding. All the respondents practice culling/replacement of breeding bulls. The ranking index of the main reasons

Table 3. The herd structure, inbreeding coefficient, and composition of the cattle population in northwestern Ethiopia.

Herd structure	Number of cattle by districts						*p*-value	Overall
	Jawi Mean ± SE	Enebsie Mean ± SE	Achefer Mean ± SE	Mecha Mean ± SE	Banja Mean ± SE	Senan Mean ± SE		Mean ± SE
Bull	1.18 ± 0.08^{b}	1.22 ± 0.08^{b}	1.03 ± 0.09^{b}	1.75 ± 0.09^{a}	0.20 ± 0.08^{c}	1.03 ± 0.08^{b}	<.001	1.03 ± 0.08
Oxen	2.70 ± 0.16^{a}	2.58 ± 0.16^{a}	2.13 ± 0.20^{a}	0.50 ± 0.20^{c}	0.08 ± 0.16^{c}	1.25 ± 0.16^{b}	<.001	1.57 ± 0.17
Male calf	4.02 ± 0.17^{a}	2.38 ± 0.17^{b}	1.33 ± 0.21^{c}	1.08 ± 0.21^{c}	0.78 ± 0.17^{cd}	0.23 ± 0.17^{d}	<.001	1.69 ± 0.18
Total male	7.9 ± 0.28^{a}	6.18 ± 0.28^{b}	4.49 ± 0.35^{c}	3.33 ± 0.35^{cd}	1.06 ± 0.28^{e}	2.51 ± 0.28^{d}	<.001	4.29 ± 0.31
Heifer	4.67 ± 0.17^{a}	0.08 ± 0.17^{d}	1.53 ± 0.21^{b}	0.63 ± 0.21^{c}	1.30 ± 0.17^{bc}	0.80 ± 0.17^{bc}	<.001	1.55 ± 0.18
Female calf	2.75 ± 0.18^{a}	3.12 ± 0.18^{a}	1.08 ± 0.22^{b}	0.65 ± 0.22^{bc}	0.73 ± 0.18^{bc}	0.23 ± 0.18^{c}	<.001	1.50 ± 0.19
Cow	7.07 ± 0.31^{a}	4.87 ± 0.31^{b}	2.60 ± 0.37^{c}	1.85 ± 0.37^{c}	2.25 ± 0.31^{c}	1.83 ± 0.31^{c}	<.001	3.56 ± 0.33
Total female	14.49 ± 0.56^{a}	8.07 ± 0.56^{b}	5.21 ± 0.69^{c}	3.13 ± 0.69^{c}	4.28 ± 0.56^{c}	2.86 ± 0.56^{c}	<.001	6.61 ± 0.61
Total cattle	22.38 ± 0.77^{a}	14.25 ± 0.77^{b}	9.68 ± 0.95^{c}	$6.45 \pm 0.0.95^{cd}$	5.35 ± 0.77^{d}	5.38 ± 0.77^{d}	<.001	10.9 ± 0.83
Male: female ratio	1.00:1.81	1.00:1.32	1.00:1.61	1.00:1.63	1.00:3.96	1.00:1.22		1.00:1.53
Bulls: cows ratio	1.00:62	1.00:41	1.00:2.53	1.00:1.11	1.00:11.25	1.00:1.82		1.00:3.54
Ne	20.45	14.00	9.65	6.45	3.40	8.52		10.41
ΔF	0.02	0.04	0.05	0.08	0.15	0.06		0.05

Key: ΔF = inbreeding coefficient and Ne = effective population size, SE = standard error.

Table 4. The breeding objectives of indigenous cattle keepers in north-west Ethiopia.

Breeding objectives	Study districts																								
	Jawi				Enebsie				S/Achefer				Mecha				Banja				Senan				
	Rank				Rank				Rank				Rank				Rank				Rank				
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Overall index
Milk	1	7	52	0.19	3	27	26	0.28	9	22	8	0.30	0	40	0	0.65	42	11	7	0.44	5	21	20	0.22	0.35
Income source	39	16	5	0.42	40	7	0	0.43	7	2	15	0.15	0	0	40	0.33	6	10	17	0.16	22	23	14	0.35	0.30
Draught power	20	37	6	0.39	17	15	0	0.26	24	12	4	0.37	1	0	0	0.02	12	11	1	0.17	32	6	0	0.28	0.25
Meat	0	0	0	0.00	0	0	6	0.02	0	6	34	0.17	0	0	0	0.00	0	19	16	0.15	0	8	9	0.08	0.07
Manure	0	0	0	0.00	0	2	0	0.01	0	0	2	0.01	0	0	0	0.00	0	9	9	0.08	1	2	17	0.07	0.03

for culling breeding bulls was age (0.3), lack of feed (0.22), infertility (0.21), and financial constraints (0.17). The most commonly used culling methods were sale of the bull and castration, while slaughter was scarce in north-west Ethiopia (Table 5).

Trait preferences for selection of breeding bulls and cows

The ranking of preferred traits of cattle keepers for the selection of breeding bulls and cows/heifers in the study areas is summarized in Table 6. Larger body size (0.35), colour (0.26), and good traction performance (0.18) were considered the most important traits for selecting breeding bulls. The docile character (0.09), better adaptability to the local environment (0.07), and good libido behaviour (0.05) were ranked as less important traits by the cattle keepers for bull selection. Better milk yield (0.4), colour (0.19), large body size (0.16), rapid calf growth (0.13), short calving interval (0.07), and early sexual maturity (0.05) were the traits preference for cows/heifers by cattle keepers in north-west Ethiopia. Red and white with mixed red colours were the most preferred colours throughout the study area, while black was also preferred by cattle farmers in highland areas. Whereas, except in highland, black was not the preferred colour in all other study sites (Table 5).

Discussion

Household characteristics and structure of cattle herd

Understanding the farmer's socio-economic characteristics and livestock management practices are important components to prepare appropriate cattle improvement or breeding strategies by considering the socio-economic status of communities who are participating in cattle production (Tshuma 2022). The average age of cattle keepers in north-west Ethiopia was 47 years, and more than 90% of the respondents were under 64 years of age. This is similar to the national average (Duguma 2020; Etana et al. 2021), but lower than other studies (Duguma et al. 2011) in different parts of Ethiopia. Similar to our result, Dossa and Vanvanhossou (2016) reported that the majority of smallholder livestock owners were either illiterate or only attended primary school. The lower level of education negatively impacted the implementation of a modern breeding programme and the improvement of cattle productivity (Bereda et al. 2014). About 70% of households owned less than two hectares of land in all six study districts. However, more than 90% of the respondents had no/less than half a hectare of land used for grazing their cattle. Livestock keepers in the area use almost all their land for crop cultivation, and their cattle depend only on common grazing land and crop residues. As a result, livestock keepers should be given special attention in order for them to use their land for grazing and fodder cultivation as cropland. In lowland areas, 57.5% of the households have more than four hectares of land, respectively. In the area, there is greater potential for forage development and livestock improvement if adequate extension work is done. The average size of the cattle herd in north-west Ethiopia is larger than Duguma (2020), Bereda et al. (2014), Woldeyohannes (2020) reported in

Table 5. The breeding management and practices of indigenous cattle keepers in north-west Ethiopia.

Breeding management and mating practices		Study districts						Overall, %	*p*-value	Chi-Square Value
		Jawi, %	Enebsie, %	S/Achefer, %	Mecha, %	Banja, %	Senan, %			
Bull possession	Having no breeding bull	1.70	16.70	12.50	10.00	83.00	35.00	28.30	<.001	201.62
	Having one breeding bull	83.30	68.30	77.50	22.50	16.70	45.00	52.40		
	Having >1 bull	15.00	15.00	10.00	67.50	0.00	20.00	16.30		
Sources of bull	Born in herd	73.30	70.00	80.00	90.00	48.30	48.30	68.32	<.001	154.68
	Purchased in private	26.70	30.00	20.00	10.00	51.70	51.70	31.68		
Purposes of keeping bull	Mating	20.00	80.00	37.50	2.50	42.50	8.30	31.80	<.001	107.82
	Drought power	80.00	20.00	60.00	97.50	57.50	91.70	67.78		
	Socio-cultural	0.00	0.00	2.50	0.00	0.00	0.00	0.42		
Mating practice	Controlled	98.30	1.70	97.50	67.50	100.00	18.30	63.88	<.001	232.52
	Uncontrolled	1.70	98.30	2.50	32.50	0.00	81.70	36.12		
Reason of uncontrolled mating	Graze together	1.70	98.30	100.00	100.00	100.00	81.70	80.28	<.001	259.17
	Lack of awareness	0.00	1.70	0.00	0.00	0.00	18.30	19.72		
Culling bull/%	Yes	100.00	100.00	100.00	100.00	100.00	100.00	100.00		
Reason for culling/index	Sickness/disease	0.19	0.09	0.05	0.04	0.16	0.09	0.10		
	Age/oldness	0.42	0.11	0.38	0.17	0.40	0.30	0.30		
	Infertility	0.20	0.29	0.33	0.13	0.31	0.02	0.21		
	Financial constraint	0.07	0.32	0.08	0.25	0.03	0.25	0.17		
	Feed shortage	0.13	0.20	0.16	0.43	0.09	0.35	0.22		
Culling methods	Selling	100.00	46.70	75.00	100.00	51.70	91.70	77.50	<.001	93.36
	Castration	0.00	41.70	25.00	0.00	41.70	8.30	19.40		
	Slaughter	0.00	11.70	0.00	0.00	6.70	0.00	3.10		
Main preferred colours	Red	21.50	91.70	25.00	42.50	91.70	58.30	55.10	<.001	362.37
	White with red	68.30	0.00	47.50	55.00	1.70	0.00	28.80		
	White	6.50	6.70	0.00	2.50	0.00	0.00	2.60		
	Black	0.00	0.00	0.00	0.00	0.00	31.70	5.30		
Main Un-Preferred colours	Black	96.70	86.70	100.00	100.00	96.70	8.30	6.40	<.001	294.40
	White	0.00	0.00	0.00	0.00	3.30	35.00	8.30		
	White with black	0.00	8.30	0.00	0.00	0.00	41.70	81.40		

Index = ranking index for the reason of culling for bull.

Ethiopia, and Adoligbe et al. (2020) reported in Benin. Except for less than the report of Adoligbe et al. (2020) reported in the Bonou district of Benin. The number of cattle in the herd differed significantly from place to place. In the lowlands, the herd was larger (18.32). In the other study area, the number of cattle was lower. In lowland agro-ecological zones, cattle farmers operate an agro-pastoral production system. The cattle keepers who had a larger herd were those who depended heavily on cattle for their livelihoods. A similar result was found in Nigeria (Gwaza et al. 2018). Cattle owners in the midland and highland agro-ecological zones main livelihoods depend on crop production with the integration of livestock. Consequently, in this study, the male-to-female breeding animal ratio was 1:5, which is significantly lower than the suggested ratio of 1:25 for tropical traditional production systems (Sereno et al. 2002). The higher number of breeding males than the recommended ratio is due to the fact that our results showed strong relationships between herd size and the amount of land owned by pastoralists in northwestern Ethiopia. That bulls in this area are kept not only for mating but also as draft animals and as a source of income for fattening.

Breeding objectives of cattle

Cattle in the study areas play a significant multi-functional role in the livelihood of farmers. Correspondingly, milk production, cash income generation, and draught power service were ranked first, second, and third objectives of cattle rearing by the small holder farmers. The result agrees with the reports of Frank et al. (2019) and Gebisa (2021) in different parts of Ethiopia. Yakubu et al. (2019) also reported a somewhat similar result to this study for Guinea cattle. The ranking of cattle rearing objectives varied among sites, such that in lowland areas, cash income generation was the main objective of cattle rearing. The variations in breeding purpose in the cases of lowland agro-ecology could be due to the lack of sufficient amounts of rainfall to support crop production as a primary objective. In general, cattle keepers use their cattle for multiple objectives; especially in lowland areas, milk production serves as a source of food for the family and as an additional source of income through the sale of milk and butter. While the in midland, the use of draft power for crop production was the most important reason for keeping livestock. This is in agreement with the findings of Desta et al. (2011) and Duguma and Janssens (2016) in different parts of Ethiopia where the area is ideal for crop and livestock production.

Breeding practices

Breeding practices and mating methods play an important role in improving livestock populations. According to the findings of this study, 28.3% of cattle farmers in all study areas owned breeding bulls, but 90.8% of respondents in lowland areas had breeding bulls. Owned herd bulls were the main source of breeding bulls for a long time and were only culled/ replaced when they become sick or old. This conclusion is consistent with the findings of Ouédraogo et al. (2020) in Burkina Faso and Zewdu et al. (2018) in Ethiopia and could contribute to inbreeding depression and complicate breeding development programmes. The result showed that most farmers in north-west Ethiopia kept their bulls primarily for draft service rather than mating. The possible

Table 6. Ranking of trait preferences for breeding bulls and cows of indigenous cattle keepers in north-west Ethiopia.

	Study districts																							
	Jawi				Enebsie				S/Achefer				Mecha				Banja				Senan				
	Rank				Rank				Rank				Rank				Rank				Rank				
Trait preferences	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Overall index
Breeding bull																									
Larger body size	25	35	0	0.40	29	5	21	0.33	12	10	14	0.29	13	9	18	0.31	50	8	1	0.41	35	7	8	0.35	0.35
Coat Colour	33	13	4	0.35	0	8	5	0.06	14	22	3	0.37	0	19	2	0.17	9	33	13	0.26	1	26	12	0.19	0.26
Ability to plough	2	2	3	0.04	19	18	9	0.28	9	4	4	0.16	26	1	1	0.34	5	17	4	0.13	7	12	24	0.19	0.18
Docility	0	3	2	0.02	5	7	15	0.12	4	2	15	0.13	1	11	19	0.18	1	9	18	0.10	0	2	26	0.08	0.09
Adaptability	0	0	31	0.09	7	22	3	0.19	1	2	4	0.04	0	0	0	0.00	0	5	1	0.03	1	12	14	0.11	0.07
Libido	0	7	24	0.10	0	0	7	0.02	0	1	2	0.02	0	0	0	0.00	1	9	9	0.07	16	1	0	0.14	0.05
Breeding cow																									
Milk yield	36	15	9	0.41	26	33	1	0.39	27	6	5	0.41	30	10	0	0.49	42	6	1	0.37	34	0	26	0.35	0.40
Coat Colour	4	33	8	0.24	9	4	11	0.13	10	12	10	0.27	10	0	10	0.16	1	15	8	0.11	0	39	13	0.25	0.19
Calf growth	12	3	7	0.14	0	9	25	0.11	1	6	5	0.08	0	28	2	0.23	5	15	5	0.13	1	0	12	0.04	0.13
Age at sexual maturity	0	0	3	0.01	5	1	14	0.08	0	4	5	0.05	0	0	10	0.04	2	7	11	0.08	0	3	5	0.03	0.05
Calving interval	0	6	15	0.08	0	10	11	0.08	0	1	3	0.02	0	1	10	0.04	4	14	18	0.15	0	5	9	0.05	0.07
Larger body size	8	3	13	0.12	20	7	5	0.21	2	11	12	0.17	0	1	10	0.04	11	3	17	0.16	25	13	0	0.28	0.16

reason for this is the influence of the crop dominated production system and the low awareness of raising cattle for milk production, meat, and other products. As a result, policies and strategies have been directed toward a production system based on cattle products and byproducts to take advantage of the country's enormous potential for cattle genetic resources. Although control mating was the main breeding practice in the study area, the results are similar to those reported by Zewdu et al. (2018) and Gebisa (2021). In lowland areas, half of the households practiced uncontrolled mating. Uncontrolled mating was also reported by Gebisa (2021) in Jimma district and Tegegne et al. (2013) and is a common practice under extensive cattle management. The main reasons for uncontrolled natural mating in the study areas were bulls and cows grazing together and a lack of awareness of the importance of controlled mating. Uncontrolled mating and small herd sizes reportedly contribute to increasing the likelihood of inbreeding (Seleka 2001). On the other hand, communal herd management can minimize inbreeding (Sheriff et al. 2020). Therefore, the inbreeding rate of 3.43% in our study is less than 6.3%, i.e. the maximum acceptable level of inbreeding, due to the cumulative effect of the above statements (Armstrong 2006). The indigenous Ethiopian cattle breeds have unique adaptive traits such as disease resistance, resistance to climatic stress, and production under feed shortage (Hagos 2016). For this reason, community grazing can be attributed to the presence of indigenous Ethiopian cattle breeds without losing their unique traits through inbreeding.

Trait preferences for selection of breeding bulls and cows

Selection of cattle in northwestern Ethiopia has followed multiple production objectives by combining several productive (milk yield, adult size, calf growth rate, calving interval, and age at sexual maturity), behavioural (libido, and docility) and adaptive traits (plough ability and coat colour). This multiple trait-based trait preference is similarly reported (Ejlertsen et al. 2012; Traoré et al. 2017; Zewdu et al. 2018; Ouédraogo et al. 2020). However, these multiple trait preferences could be an obstacle for breeding improvement activities in most developing countries because it is difficult to obtain animals that fulfill many traits simultaneously. The three most important traits for selecting breeding bulls were body size/ appearance, bull colour, and good draft performance in all study areas. Similar trends were observed in the results of (Adoligbe et al. 2020) in Benin, (Tada et al. 2013) for Nguni cattle breeders in South Africa and Zewdu et al. (2018) for the indigenous cattle of Ethiopia. Docility was also reported as the main objective for bull selection in midland areas. Similar results were reported (Traoré et al. 2017; Zewdu et al. 2018) in Mali and Ethiopia, respectively. This suggests that this trait is related to the production system of crop and livestock farming, so that the bull has a closer relationship with its owner during ploughing, threshing and other agricultural activities. In northeastern Ethiopia, coat colour has been one of the most important features in the selection of breeding bulls and cows. It is considered an important trait for livestock selection and is associated with adaptability to heat stress and tsetse fly bites (Lorato et al. 2017; Bayssa et al. 2021). Red and white mixed with red were the preferred colour types in the study areas, but black was not the preferred colour type among cattle farmers. The trait is associated with adaptability to heat stress and tsetse fly bites as white/light reflects 50–60% of direct sunlight than dark coloured and favours thermoregulation ability in tropical regions (McManus et al. 2009; Abdurehman 2019; Bayssa et al. 2021). High milk yield, coat colour, larger body size, and rapid calf growth are the most essential traits for selecting breeding cows/heifers, according to this result. Consistent with the current result, cows were selected primarily based on the owner's interest in milk production (Abdel-Salam 2019; Ouédraogo et al. 2020). Therefore, milk and milk by-products are crucial for the farmer's livelihood as they provide a balanced diet and generate cash income. High milk production is associated with adequate calf feeding, rapid growth rate, and earlier sexual maturity (Wuletaw et al. 2006; Ouédraogo et al. 2020).

Conclusions and recommendations

Designing suitable cattle breeding and development programmes requires defining breeding objectives/purposes and discovering farmers' trait preferences/selection criteria. Based on the ranking index result, large body size, colour, and good traction were considered the most important traits in selecting a breeding bull. Whereas high milk yields, colour, large body size, and calf growth were the preferred traits for cow selection, ranking index results show milk production and draught power as the main production objectives of cattle. This indicates farmers in the area followed multiple trait preferences for selecting their cattle. Therefore, designing breeding programmes based on the selection index method could improve the smallholder production system performance of indigenous cattle in smallholder production. From home, breeding bulls were the main source of breeding bulls, and a large number of respondents used uncontrolled mating. The use of breeding bulls from the own herd and uncontrolled mating could increase the likelihood of inbreeding and result in the loss of unique fitness traits in native cattle, so extension services should be informed about the effects of inbreeding.

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Ethica approval

Bahir Dar University, College of Agriculture and Environmental Science, accepted the current study and the suggested parent study (BDUCAES). Following BDUCAES approval, the study's objectives were communicated to the Bahir Dar University Department of Animal science via a support letter (Ref. 1/1199/1-1-3 dated February 24, 2020).

Data availability statement

All relevant data within the manuscript and its Supporting Information files will be made available from corresponding author if requested.

Disclosure statement

There are no potential conflicts of interest was reported by the author(s).

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