Camel Husbandry Practices in Borana Zone of Oromia Regional State, Ethiopia

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Abstract: Camel husbandry is a vital means of pastoral and agro-pastoral livelihoods in Borana Zone of Oromia Region, Ethiopia. However, this has not been well documented. Thus, a cross-sectional study was conducted from August 2015 to August 2016 in Yabello, Moyale, and Gomole districts of Borana Zone. The study utilized household surveys and focus group discussions to evaluate camel husbandry practices, reproductive and production performances, and production challenges. A total of 132 households were selected and interviewed by using semi-structured questionnaire and the data was analyzed by Statistical Package for the Social Sciences (SPSS, version 20). The majority of the respondents were men (89.4%), illiterate (88.6%), and agro-pastoralists (58.3%). While all respondents possessed camels, 81.9% of their camels were females and 67.6% were adults. From August 2011 to August 2016, camel population increased by 60.8% and the median household ownership increased from 10 to 15. The findings showed that camels provide milk and meat, cash income, transportation, and social and cultural functions ranked from first to fourth. However, 62.9 %% and 97.7% ranked cattle and cattle milk first to camel and camel milk, respectively. Camel management responsibilities are shared among family members, yet more than 95% of feeding, watering, milking, breeding, healthcare, and marketing activities were performed by males. Natural browsing trees and salt supplementation were the main camel feed sources, while surface water, ponds, boreholes, and deep wells comprised the primary water sources. Age at first parturition, gestation period and calving interval were 59.86 ± 3.43 months, 12.05±0.21 months, and 24.00±2.84 months respectively; and females produced 6-15 calves in their lifetime. Breeding bulls mate about 36.36±9.42 females per year and serve for 13.39 ±4.54 years. The study identified significant milk yield differences ($p < 0.001$) between the wet (5.60±2.50 liters) and dry (3.54±1.35 liters) seasons. The major camel production constraints included recurrent drought (33.3%), feed and water shortage (22.7%) and camel diseases (19.0%). Overall, this study highlights the importance of integrated measures to address feed, water, and disease problems in order to improve camel production in Borana Zone. National and regional policymakers should pay due attention to address the pressing feed, water and health challenges.

Keywords: *Borana Zone, Camelus dromedarius, Constraints, Ethiopia, Husbandry practices*

Introduction

Camel production is an important component of livestock production in Ethiopia. The country possesses 8.14 million camels (CSA, 2021) kept mainly in Somali, Afar, and Oromia Regional States (Tadesse *et al.,* 2014; Legesse *et al.,* 2018). Camels provide milk, meat, cash income, transportation service, as well as cultural values as determinants of wealth and social status (Mehari *et al*., 2007; Simenew, 2013; Megersa *et al.,* 2014a; Sisay and Aweke, 2015; Mirkena *et al.,* 2018). Furthermore, the exports of live camels generate foreign currency (Amanuel, 2019; Doyo, 2022).

Recurrent droughts, climate change, and deterioration of rangelands are challenging animal production worldwide (FAO, 2009; Cheng *et al*., 2022). Heat stress reduces the productivity, health, and fertility of animals (Zelalem *et al.,* 2009). Due to their superior adaption mechanisms, the camels are poised to be excellent candidate species for future food production. Studies conducted in Ethiopia demonstrated the superiority of camels over the rest of livestock species in coping with the impacts of climate change (Zelalem *et al.,* 2009; Megersa *et al.,* 2014b). Thus, as the climate change impacts expand, camel production will eventually replace the production of crops and other livestock in arid areas of Africa (Faye, 2015; Bediye *et al.,* 2018; Cheng *et al.,* 2022).

The importance of camels is increasing both at local and global levels. The species is no longer only the ship of the desert but also a productive animal able to be involved in intensification processes and modern farming systems (Faye, 2015). Camel products have superior nutritional and medicinal values, especially milk is becoming very popular in global markets (Konuspayeva and Faye, 2021).

The Oromia Regional State has about 292, 908 camels kept by the Borana, Gabra, Guji, and Kerreyu of the Oromo communities. About 30% of the Region's camel resource is found in the Borana Zone (CSA, 2021). Unlike the Somali and Afar people who are known for

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their camel-keeping traditions for centuries, Borana pastoralists started camel production recently. Borana pastoralists adopted camel production due to their high drought tolerance and milk production potential. Currently, camel production is the major source of pastoral livelihoods in Borana Zone that provides food (milk and meat), cash income, transportation, as well as social and cultural services (Tadesse *et al.,* 2014; Galma *et al.,* 2017; Doyo, 2022).

Despite their enormous current contributions and promising future roles, Ethiopian camels in general and those in Borana Zone, in particular, received less attention in research. The camel researches conducted so far in the zone include those dealing with camel husbandry and product utilization (Tadesse *et al.,* 2014a; Dejene, 2015), health (Megersa *et al.,* 2008), production and marketing (Doyo, 2022), reproductive performance (Simenew, 2013), adaptation (Galma *et al.,* 2017) as well as physical and genetic characterization (Tadesse *et al*., 2014b; Yosef *et al.,* 2019).

The potential utilization of camel resources requires proper documentation of local husbandry practices. Knowledge about the local husbandry practices including feeding and watering, breeding, housing, healthcare, herd dynamics, production and reproduction performance, calf management and production challenges among others is very important (Wilson, 1998; Dioli, 2022). Understanding the reproductive performance of camels is essential for successful breeding, herd health, and overall productivity (Skidmore, 2005). Similarly, camel production performance information is essential for economic development and ensuring the well-being of camel-rearing communities (Tadesse *et al.,* 2014b; Tagesse *et al.,* 2015; Faraz *et al.,* 2019). Identifying and addressing the challenges related to management practices, such as restrictive colostrum feeding, inadequate supplementation and inappropriate housing helps improve overall productivity (Farah *et al*., 2004).

Thus, a more comprehensive study addressing such complex husbandry practices should be carried out to optimize the contributions of camels. To this end, this study was conducted with the objective to assess the camel husbandry practices, reproductive and production performance and production challenges in the Borana Zone of Oromia Regional State, Ethiopia.

Materials and Methods

Study Areas

This study was carried out in Moyale, Yabello and Gomole (formerly Surupha) districts in Borana Zone of Oromia Regional State, Ethiopia, from August 2011 to August 2016. Yabello district is located between 40 30"N and 50 30" N latitude and between 370 45"E and 380 30"E longitude. It borders Dugda Dawa District in the North and North East, Dire District in the south, Arero District in the East and South East, and Taltale District in the west. The total area of the district is 5,523.31 square kilometers. From the district land, 10% is arable, 60% pasture, 10% forest, and the remaining 20% is considered degraded or otherwise unusable. Agro-pastoralists grow Teff, wheat, maize, haricot bean, sorghum, and barley (Roba, 2017).

The climate of Yabello district is semi-arid or *kola* type, with erratic and low annual rainfall. But, some parts of the district exhibit *woyina-dega* climate. The mean annual temperature of the district ranges from 16 °C to 28 °C. The district has a bi-modal rainfall regime, with mean annual rainfall ranging from 400 mm in the south to 600 mm in the north. The 73% of rainfall occurs from March to May, while the 27% of rainfall occurs from September to November (Fentahun *et al.,* 2018). The total population of Yabello district is 158,466; of whom 79,728 were men and 78,738 were women (CSA, 2023).

Moyale district is located 3° 34' 9N and 39° 4' 60E bordered on the south by Kenya, on the west by Dire, on the northwest by Arero, on the north by the Dawa River which separates it from Liben, and on the east by the Somali Region. The agro-ecology is lowland with topography consisting predominantly of plains. The altitude ranges from 900 to 1350 m.a.s.l. Moyale district comprised 9 pastoral and 8 agro-pastoral *kebeles* (the smallest administrative unit).

Moyale district has an estimated total population of 44,286 people, of whom 22,820 are males and 21,466 are females (CSA, 2023). The population density is about 11.5 persons/km2. The total area of the district is estimated at 1,130 km2, but only a small proportion of the land is suitable for agricultural use. While almost half of the rural population relies on both agriculture and livestock, 40% and 10% are crop producers and pastoralists respectively.

Moyale district receives bimodal rain, while the long rainy season '*genna*' usually falls between mid-March and late June, and the short rainy season "*hagaya*" falls between September and November (Roba, 2017). Moyale district has a tropical climate, with little rainfall throughout the year, the annual rainfall is estimated at 500–600mm. The temperature is very hot with an average of 37°C and reaching as high as 41°C. July has the lowest average temperature of the year with only 19.9°C (Isa *et al.,* 2015). In addition to rearing cattle, sheep, goats, camels, and donkeys, farmers and agro-pastoralists in Borana Zone grow maize, wheat, barley, pulses, sorghum, teff, and haricot beans (Riché *et al*., 2009). The Borana Zone has 88,174 camels, accounting for 30% of the Region's camel population (CSA, 2021).

Gomole district has 1286.99 km^2 of land area and 14 *kebeles*. The district has 67,704 total population, 35,776 males and 31,928 females. The total number of households was 10,492 with an average family size of 6. The district has about 56,551 camels (LLRP, 2021).

Survey Design and Sampling

A single-visit multiple-subject survey (ILCA, 1990) was employed to collect camel husbandry, performance, and production challenges data in Borana Zone. First, Moyale, Yabello, and Gomole districts were purposefully selected based on their large camel resource, diversity of production system (pastoral and

agro-pastoral), and accessibility. Next, by discussing with the district livestock and pastoral development office experts eleven *kebeles* were selected, four from Yabello (Dida Yabello, Areri, Harbeke, and Dharito), five from Moyale (Shewaber, Denbi, Bede, Bokkola and Harbele) and two from Gomole (Surupha and Arbora) districts based on their camel resource, accessibility and diversity of production systems.

Then, with the help of livestock experts and *kebele* management, 4,170 camel-rearing households were listed in the 11 *kebeles*. Finally, the sample size was determined by using Yamane (1967) formula, as follows:

$$n = \frac{N}{1 + N\,(e)^2}$$

Where;

n = sample size
N = total population
e = margin of error

Accordingly, a 95% confidence level and e= 0.8 were assumed and the sample size was calculated as 149. However, due to seasonal factors, the sample size was fixed to 132 households. Then, based on population proportion, 45, 43, and 44 households were randomly selected from Moyale, Yabello, and Gomole districts, and subjected to the actual interview (Table 1). In addition, six focus group discussions (FGDs) were conducted, two in each district (one with male and one with women).

Table 1. Distribution of respondents by district.

District	Number of Households	Proportion	Sample size
Yabello (4 *kebeles*)	1422	34.1	45
Moyale (5 *kebeles*)	1360	32.6	43
Gomole (2 *kebeles*)	1388	33.3	44
Total	4170	100	132

Data Collection

Data was collected via household surveys and focus group discussion (FGD) tools. The household survey was conducted by using semi-structured questionnaire formats and collected data on household characteristics, sources of livelihoods, the importance of camels, husbandry practices, feeding, watering, breeding, housing, reproductive performance, milk production, and camel production challenges among others.

Focus group discussions (FGDs) were held with 8-10 community members composed of *kebele* management, elderly people, community leaders, agro/pastoralists and women. Two FGDs (one with male group and one with women group) were conducted in every district; totally 6 FGDs were conducted. By using FGD checklist data was collected on livelihood sources, camel production systems, preference for different livestock and their milks, uses of camels, household responsibility in camel management, camel herd structure, and camel production constraints among others. On the other hand, secondary data was collected from Yabello, Moyale and Gomole districts as well as Borana Zone Livestock Agency offices, and from literature resources.

Statistical Analysis

Quantitative data was entered into Microsoft Excel spreadsheet and analyzed by using Statistical Package for Social Sciences, SPSS, 2007, Version 20. Descriptive statistical analysis was used to analyze demographic, livestock and milk yield data composition data and determined frequency and percentage; minimum and maximum, mean and standard deviation. The analysis of variance (ANOVA) was used to assess the effect of seasons on milk yield and Tukey's test was used to separate means. In all cases $p < 0.05$ was considered significantly different. Qualitative data was summarized, narrated and used for triangulation.

Preference rankings were summarized into index as weighted averages as described by Kosgey (2004). Index rankings in livestock and milk preference were calculated as Index= sum (3 x NRRF + 2 x NRRS + 1 x NRRT) given for an individual reasons divided by the Sum of (3x NRRF+ 2x NRRS + 1x NRRT) given for all reasons. Where: NRRF=Number of respondents who ranked first; NRRS= Number of respondents who ranked second and NRRT= Number of respondents who ranked third. In the case of ranking the importance of camels, there were four ranking choices and ranking was expressed as an Index = Sum of (4 for rank 1 + 3 for rank 3 +2 for rank 2+ 1 for rank 4) given for an individual reason divided by the sum of (4 for rank 1 + 3 for rank 3 + 2 for rank 2 + 1 for rank 4) for overall reasons (Kosgey, 2004).

Results and Discussion

Sociodemographic Characteristics of Study Participants

As indicated in Table 2, the majority of the respondents in the present study were males (89.4%), illiterate (88.6%), and agro-pastoralists (58.3%) with an average age and camel-rearing experiences of 48.4 ± 9.4 years and 21.5±7.2 years, respectively. It is also important to note that that more than 100%, 90.9%, and 97.7% of the respondents reared camels, cattle, and small ruminants respectively. This indicates that livestock production is the major source of community livelihoods in the study areas. The practice of keeping different livestock species is a pastoral adaptation strategy to droughts. In addition to livestock rearing, 59.9%, 33.8%, and 6.5% of the respondents grew cereals (maize, sorghum, teff, wheat, and barley), pulses (haricot beans) and vegetables (onion, tomatoes) respectively (Table 2). This implies the potential of pastoral zones for crop production and potential contribution to pastoral livelihoods during normal or good rain years. The findings are close to the work of Dirriba *et al.* (2020) who reported 85%, 65%, and 30% maize, haricot bean and *teff*, respectively. Similar findings were also reported by Riché *et al.* (2009) and Mohammed (2009). The FGD participants reported additional sources of income such as petty trade, livestock trade, and sale of forest products (firewood, charcoal), productive safety net program (PSNP), casual labor, and humanitarian aids.

Table 2. Household characteristics.

Variables	Categories	Frequency	Percent
Sex	Male	118	89.4
	Female	14	10.6
Educational status	Illiterate	117	88.6
	Literate	15	11.4
	Total	132	100
Occupation	Pastoralists	55	41.7
	Agro-pastoralists	77	58.3
	Total	132	100
Species owned	Camel	132	100
	Cattle	120	90.9
	Sheep and goats	129	97.7
Crops grown (N=77)	Cereals (maize, sorghum, *teff*, wheat, barley)	46	59.7
	Pulses (haricot beans)	26	33.8
	Vegetables	5	6.5

Preference for Different Livestock

The survey participants were also asked to rank their preference for different livestock species based on their importance. Accordingly, the majority (62.9%) ranked cattle first to camels and sheep and goats (Table 3).

As presented in Table 4, the respondents prioritized cattle to camels and small ruminants, because cattle provide large quantity of milk, meat and many calves in the desert (41.7%); produce sweet milk that can be processed into yogurt and butter and used as food or income source (25.0%); because cattle are the icon of Borana community (24.2%) and Borana cattle are highly demanded and have good market price (9.1). This was strongly supported by the FGD participants who justified their preference stating that i) they (the Borana community) are cattle breeders; ii) their cattle produce many calves and fetch good money at market; and iii) cattle milk is processed into yogurt and butter-which has important cultural value as hair food and body lotion. A similar ranking was reported by previous researchers (Megersa *et al.,* 2008; Simenew, 2013).

Table 3. Preference for different livestock in the study areas.

Species	First	Second	Third	Index
Cattle	83 (62.9%)	49 (37.1%)	0	0.44
Camel	49 (37.1%)	81 (61.4%)	2 (1.5%0	0.39
Shoats	0	2 (1.5%)	130 (98.5%)	0.17

Table 4. Reasons for prioritizing cattle in the study areas.

Reasons for prioritizing cattle	Frequency	Percent
Cattle provide large quantity of milk and meat, and many calves in the desert	55	41.7
Cattle have sweet milk that can be processed into yogurt and butter and used as food or sold and generate family income	33	25.0
There is high demand and good market price for cattle	12	9.1
Cattle are the icon and indicator of social status in Borana Community	32	24.2
Total	**132**	**100**

On the other hand, 37.1% of the respondents ranked camels first to other livestock. Their reasons included (Table 5) the superior tolerance of camels to the desert, drought, feed and water shortage, and diseases better than cattle and small ruminants (28.8%). Others said because camels can be sold for large amounts of money that can be used to buy and replace cattle lost due to drought and diseases (33.3%); for the animals produce large amounts of milk and meat and provide transportation service over long distances in the desert (23.5%); and because camel owners are perceived as wealthy and respected by the community (14.4%).

Different studies have demonstrated the unique and superior adaptation of camels over the rest livestock species under arid and semi-arid environments (Zelalem *et al.,* 2009; Megersa *et al.,* 2014b; Faye, 2015; Galma *et al.,* 2017; Bediye *et al.,* 2018; Cheng *et al.,* 2022). Numerous researchers have also described the use of camels in the Borana Zone (Megersa *et al.,* 2008; Simenew, 2013; Dejene, 2015; Galma *et al.,* 2017), as well as the Somali (Getahun and Kassa, 2002; Mehari *et al.*, 2007; Seifu, 2009; Simenew, 2013; Sisay and Aweke, 2015) and Afar (Sirak, 2010; Simenew, 2013; Tadesse *et al.,* 2014) Regional States.

Table 5. Reasons for ranking camels first in the study areas.

Reasons for prioritizing camel	Frequency	Percent
Camels are sold for large amounts of money and replace cattle killed by drought and diseases	44	33.7
Camel is resistant to drought, feed and water shortage, and disease	38	28.8
Camels provide large milk and meat yield and transportation service	31	23.1
Camels are the indicators of wealth and social status	19	14.4
Total	132	100

Changes in Livestock Population and Ownership Patterns

The household interview data revealed that from August 2011 to August 2016, the livestock population increased for all species. The rate of the increase was 60.8%, 56.3%, and 43.8% for camels, sheep and goats, and cattle respectively (Table 6). All of the study areas are agro/pastoral *kebeles* where animals are the symbol of wealth, status, and social prestige, and pastoralists keep on increasing the number of their animals. This practice might have contributed to the observed rise in livestock population. Increasing livestock numbers is also a pastoral risk management strategy. Larger herds provide a buffer against losses that may be caused by diseases, droughts, or other adverse conditions. To better withstand these risks, pastoralists increase livestock numbers which can contribute to the changes observed by the present study. Furthermore, the rising demand for livestock and livestock products, as well as disease management endeavors might have contributed their part to population increase.

Table 6. Change in livestock population (2011-2016) in the study areas.

Number of animals possessed:			Change:		General trend
Type of animals	Aug 2011	Aug 2016	Number	Percent	
Camels	1746	2808	+1062	60.8	Increasing
Cattle	3758	5404	+1646	43.8	Increasing
Shoats	4527	7074	+2547	56.3	Increasing

On the other hand, there was high variation in livestock ownership among the community, in that the standard deviation was greater than the mean for most values. For instance, mean camel ownership was 13.23+14.37 (in 2011) and 21.27+21.57 (in 2016). Therefore, median values were used to describe the trend in livestock ownership; thus, median camel ownership increased from 10 to 15 (Figure 1). According to Yosef *et al.* (2013), from 1993 to 2013 camel population increased by 10-25% and 15-25% in Somali and Afar Regions and by more than 200% in Borana Zone. The variation might be related to differences in the study area or drought and disease outbreak dynamics observed in the areas. On the other hand, Yosef *et al.* (2013) reported a decrease in cattle number than before 20 years. This may be attributed to difference in the reference period, 5 years versus 20 years. During these periods, there was a parallel increase in the number of livestock. While in 2011 the number of camels, cattle, and shoats was 0.9 million, 52 million, and 46.8 million respectively CSA (2012), in 2016 these increased to 1.4 million, 60 million, and 64 million, respectively (CSA, 2017).

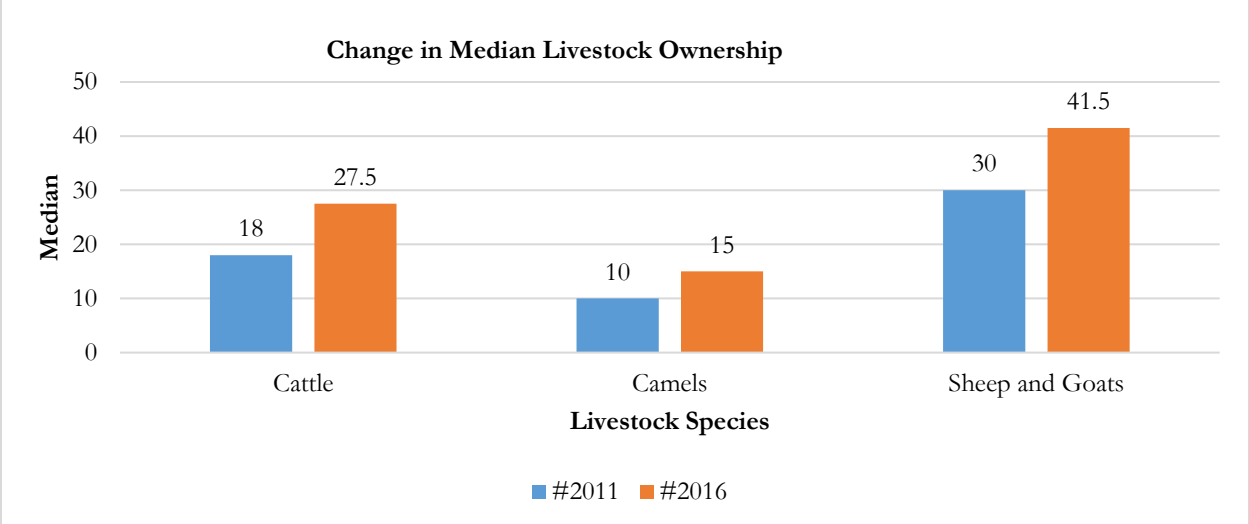

Figure 1. Change in livestock ownership, August 2011 to August 2016.

Camel Production

As indicated in Table 2 above, all of the respondents in the three districts were pastoralists (41.7%) and agro-pastoralists (58.3%). Pastoralists derive the bulk of their food supply from pastoral activities. In addition to pastoral activities, agro-pastoralists also practice rain-fed cultivation of food crops.

Importance of camels: In the study areas, camels provided milk and meat, cash income, transportation service, as well as social and cultural values ranked from first to fourth respectively (Table 7). The social and cultural values included the role of camels as determinant of wealth and social status and other contributions such as the use of camel milk and meat as remedy against diseases, use of the skin to make rope, and shoes, among others. Numerous researchers have described such attributes of camels in the Borana Zone (Megersa, 2008; Semenew, 2013; Dejene, 2015; Galma *et al.,* 2017).

Table 7. Importance of camels in the study areas.

Importance	First	Second	Third	Fourth	Index
Milk and Meat	96	21	15	0	0.36
Cash income	29	89	13	1	0.31
Transportation	0	12	90	30	0.19
Social and cultural values	7	10	14	101	0.14

Camel herd structure: The herd structures of camels possessed by the respondents were categorized based on their sex, age, purpose, and physiological statuses. The survey participants possessed a total of 2,808 camels, 81.9% were females and 18.1% were males; 67.6% of all camels were adult (4 years and older) camels and the remaining 32.4% were young (under 4 years old) camels (Table 8). The number of female camels is very close to 87.5% reported by Gebremichael *et al.* (2019) in Afar Region. On the other, 77.5% of the females were adult breeding camels. This finding is higher than 50% breeding females reported by Megersa *et al.* (2008) in Borana Zone, 51% reported by Getahun and Kassa (2002), and 56% reported by Gebremichael *et al.* (2019) in Afar Region. A higher proportion of females ensures sustainable supply of milk (Simenew, 2013; Mehari *et al.,* 2007). The Borana Zone is the major pool of export camels in Ethiopia, the majority of which are male camels. This might have resulted in larger proportion of adult female camels.

Table 8. Herd structure of camels in the study areas.

Age category	Females		Males		Total	
	Number	Percent	Number	Percent	Number	Percent
Under 4 years	517	22.5	393	77.5	910	32.4
4 years and older	1,784	77.5	114	22.5	1,898	67.6
Total	2,301	81.9	507	18.1	2,808	100

Camel Husbandry Practices

Household responsibilities in camel management: According to the survey respondents, household members have specific and overlapping camel management roles. More than 95% of all camel management activities including feeding, watering, milking, breeding, healthcare and marketing are performed by males-husbands and boys. More than 60% of camel breeding was conducted by husbands, which reflects their primary role in selection of appropriate breeding stock. It is also important to note, that except in watering and breeding, wives are involved in all camel management activities (Table 9). This was especially true in female headed households. Discussions held with men and women groups of all zones revealed the following additional roles: i) husbands also provide overall guidance, they identify grazing fields, direct camels and construct kraals; ii) Wives, take care of calves, clean kraals, clean and smoke milking equipment, and sell milk; iii) Children primarily boys involve in camel feeding, herding and watering; iv) while boys take part in milking and camel health care, girls assist in cleaning milk equipment and kraals. They said the camel is a highly powerful animal that travels very fast and disappears in the rangelands, and camel management is primarily handled by males (husbands and boys). The findings are in agreement with those reported by in Borana Zone, as well as Afar and Somali Regional States (Mehari *et al.,* 2007; Seyfu, 2009; Simenew, 2013; Tadesse *et al.,* 2015).

Table 9. Household responsibilities in camel management (percentage) in the study areas.

HH member	Feeding	Watering	Milking	Breeding	Herding	Health care	Selling camels
Husband	40	58.5	78.5	62.9	48.5	73.5	93.2
Wife	4	0	4	0	2.5	4.5	1.5
Boys	56	41.5	17.5	37.1	49	22	5.3
Total	100	100	100	100	100	100	100

Feed and water: The camel feeding practice in Borana Zone is limited to the use of natural browsing trees and salt lick. This is in agreement with the work of Simenew (2013) conducted in Borana Zone, and similar works done in other parts of Ethiopia (Mohammed, 2009; Sirak, 2010; Wilson, 1998). According to FGD participants camels cannot live without salt and so all are provided with salt lick. They described four different types of salt. "Booqqee" is salt type found as big blocks of soft rocks and it is crushed and offered to camels every two weeks. There other three are known as 'Dilo', 'Magado' and 'Kulki'. While 'Dilo' and 'Magado' are given during the rainy season, 'Kulki' is given during the dry season. 'Kulki' is not given for camels in late pregnancy. It is believed to cause diarrhoea in the calf after delivery. 'Dilo', the most liked salt by camels, is crushed to pieces and fed. 'Magado' is fed as it is. The special management of pregnant and lactating she-camels is also limited to the provision of salt every week. The group discussions also revealed that the major sources of water available for camels include surface and pond water, boreholes as well as manual and motorized deep well water. Average water drinking frequency was described to about 30 days during the rainy season, 3 to 5 days at the beginning of the dry seasons, and 7 to 14 days as the dry season progresses. Simenew (2013) and Dejene (2015) reported similar water sources and watering frequencies in Borana Zone.

Housing: The respondents in all the three districts kept their camels at night in loose roofless fencing enclosures or kraals constructed close to residential homes, with doors closed by thorny trees during the night. Calves are kept in separate compartments (Figure 2).

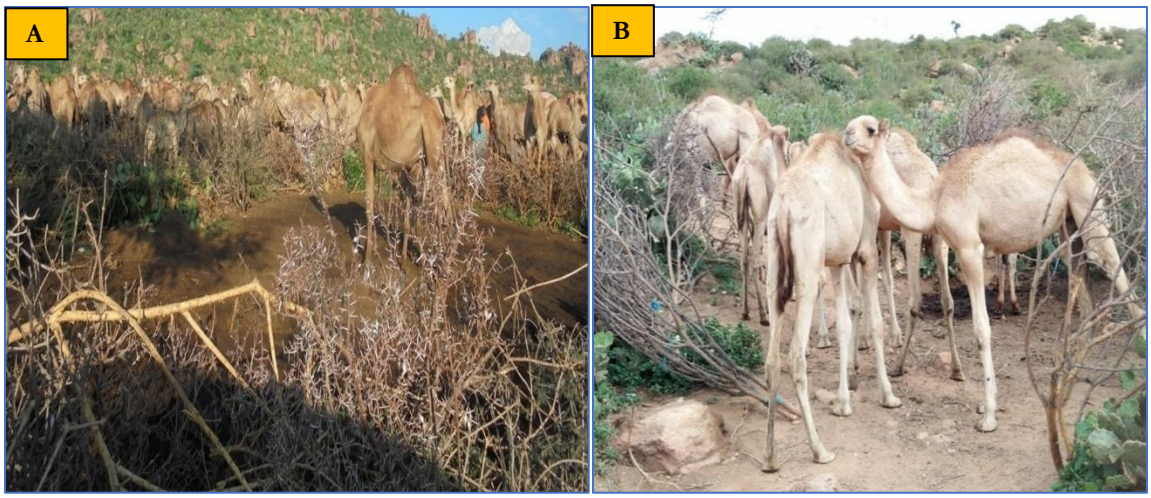

Figure 2. Typical camel kraal in Borana Zone (A for adults; B for calves).

Reproduction and Reproductive Performance

Breeding: According to the survey and FGD respondents in all districts, camels breed mainly during the cold and wet times of the year. This is because camels are seasonal breeders mating during the rainy season when there is adequate feed and water. The respondents confirmed that both male and female camels manifest certain characteristic signs during breeding. They described that the rutting males stop feeding, make loud and continuous roaring, become restless, continuously move their heads and necks, rub their heads on trees, and grind their teeth. They urinate now and then; produce mouthful saliva and get out red ball-like mass from their mouth. They become aggressive, chase other camel bulls and people and then approach the female. Similarly, they stated the signs manifested by the she-camel saying it becomes restless and bleat continuously; its vulva gets enlarged or swollen; she urinates now and then; lift and swish its tail, repeatedly open and close its vulva; look for male, sniff, get close to, embrace and play with the rutting male. Regarding the mating process, the respondents reported that experienced bulls come close to the female, pull it around the neck area, sometimes even biting, to force it to sit, mounts and mate in the sitting position (Figure 3). In the case of untrained or young bulls, owners handle the front legs of the she-camel and sit it in front of the rutting male, after which two or more people sit the male in the mating position and direct its penis into the vagina of the female. The rutting behaviour of camel bulls and the breeding signs of oestrus she-camels and the mating processes have been reported by different researchers (Wilson, 1998; Mehari *et al.*, 2007; Sirak, 2010; Simenew, 2013).


Figure 3. Mating in camels.

Selection of breeding camels: Borana Zone camel keepers have got their own criteria of selecting the best replacement she-camels and best breeding bulls. According to them, both the individual characteristics of males and females and that of their parents play crucial role in selection process. The FGD participants reported that the best she-camels are selected based on the quality of their mothers including early maturity, fertility and high milk yield; and their individual characteristics mainly broad and large body, legs and udder, and mass of blood vasculature around the udder, among others. Regarding, selection of the best mating bulls, the respondents reported similar mechanisms, based on the milk yield of their mothers, and individual features such as large and broad body, head, ears ('gurri battattee'), and hump; long nostrils ('konoona'); ability to mate many females; ability to resist drought, feed and water shortage and also travel long distances. The male and female breeding camels are selected at 5 and 4 years respectively. Dejene (2015) mentioned similar selection criteria for male and female camels, and nearly equal selection ages of 3.5 years and 4.85 years for the female and male camels respectively. Tadesse *et al.* (2014), Simenew (2013), and Mehari *et al.* (2007) reported similar indigenous selection criteria of pastoralists in Afar and Somali Regional States for breeding males and she-camels.

Reproductive performance of camels: The reproductive performance of Borana camels was also analyzed with the respondents. Accordingly, the male and female Borana camels begin mating at approximately 59.36±7.0 and 47.73±3.7 months of age, respectively (Table 10). The data in the current study are slightly shorter than the 5.83 years (males) and 4.88 years (females) reported by Mehari *et al.* (2007) in Somali Region, probably due to differences in environmental or camel type. The mean age at first parturition of 59.86 ± 3.43 months reported in the present study is similar to 4.99 ± 1.04 years reported by Dejene (2015) and 58.6±6 months (Simenew, 2013) reported in Borana Zone; 5 years by Ahmed (2002) in Somali Region; and 58.4±1.0 months in Kenya (Kaufmann, 2005). This factor can be affected by decision of the owner, the age and weight of the animal, management, breed, among others (Skidmore, 2005).

The present study revealed gestation period of 12.05±0.21 months and calving interval of 24.00±2.84 months (Table 10). Earlier studies conducted in Borana Zone (Simenew, 2013) and Somali Region reported gestation lengths of 12.5 ± 0.8 months and 12 months respectively. The calving interval is similar to 24 months reported in Somali Region (Mehari *et al.,* 2007), and also lies between 17.73 ± 7.16 months (Dejene, 2015) and 28.8±5.3months (Simenew, 2013) reported in Borana Zone. Variations might be related to feeding, breeding and health management; lactation length and breed (Kaufmann, 2005; Wilson, 1998). The average life time productivity of 10.27±2.13 calves (Table 10) is very close to 11.93 ± 2.68 calves reported from Borana Zone (Dejene, 2015), and 10 calves from Somali Region (Mehari *et al.,* 2007), and 8-10 calves in Somalia (Farah *et al.,* 2004).

Following every delivery, the re-mating time of she-camels was decided by the owners, based on the balance between need for a calf or milk. Accordingly, if the interest is for calf, re-mating occurs as early as 6 months; if the interest is for milk this period can be extended to as long as 16 months. The mean post-caving re-mating of 10.82±2.4 months (Table 10) is similar to the 5-15 months described by Mehari *et al.* (2007).

Table 10. Reproductive performance of camels in Borana Zone.

Parameter	Minimum	Maximum	Mean	SD
Age at puberty (Months):				
Male	48	84	59.36	7.0
Female	36	60	47.73	3.7
Age at first parturition (Months)	48	72	59.91	3.5
Gestation period (Months)	12	13	12.04	0.2
Calving interval (Months)	20	36	24.00	2.84
Life time productivity (#Calves)	6	15	10.27	2.13
Return to mating (Months)	6	16	10.82	2.4
Number of matings:				
Per day	1	6	2.58	1.04
Per season	10	40	20.70	6.00
Per year	20	60	36.36	9.42
Lifelong service (years)	5	30	13.39	4.54

Conception rate and conception failure: From 628 she-camels mated since October 2015, 507 (80.7%) conceived and were pregnant in August 2016. The rest 121 (19.3%) were reported as failed conceptions due to young age, health problems and other factors. According to FGD reports, some she-camels in good health and body condition may fail to conceive due to three main problems: i) presence of abscess in the genital tract; ii) presence of fleshy mass locally called 'Qurdudi or urdet' in cervix area; and iii) due to prolonged calf suckling, known as 'Rocha'. Traditionally, camel keepers manage the first problem by removing the abscess, washing the genital tract by soap and water and then injecting a bottle of oxytetracycline. Local surgeons cut the 'Kurdudi or

urdet', mass in the female genital tract. 'Rocha' is corrected by preventing suckling for about one week. These factors can be related to diseases, functional abnormalities and physiological problems, respectively. *Yabello district camel keepers say:*

"The male camel mates when exactly 5 years of age. If not allowed at this age, it won't mate at 6 years but again become active when 7 years old"

"*If an already conceived camel, in early pregnancy of 1-2 months, is re-mated by a different bull, she will abort immediately"*

Generally, camel bulls do not mate pregnant females; however, health and hormonal disorders in both sexes and lack of experience might lead to accidental mating and resultant uterine damages and abortion.

Reproductive performance of camel bulls: Camel bulls begin mating at approximately 59.36±.47 months of age. The best camel bulls can mate 2.58 ± 1.04 she-camels per day, 20.70±6.00 per season and 36.36±9.42 she-camels per year. The average reproductive age of camel bulls was 13.39 ±4.54 years (Table 11).

Table 11. Performance of breeding camel bulls in the study areas.

Traits/variables	Mean	SD
Age at mating	59.36	7.00
Breeding bull selection age (months)	55.58	10.59
Number of a breeding bull can mate per day	2.58	1.04
Number of a breeding bull can mate per season	20.70	5.98
Number of a breeding bull can mate per year	36.36	9.42
Service period of breeding bulls (years)	13.39	4.54

Milk Production Performance of Borana Camels

Camel milking practices and preparations: Borana Zone camel keepers initiate the milking process by allowing calves to suckle for about one minute. While she-camels are milked by full hand pulling in standing position, from one to four men can be involved in the milking process. Similar findings were reported by different authors (Simenew, 2013; Tadesse *et al.,* 2014a; Dejene, 2015). On the other hand, the pre-milking preparations in the study area included washing and smoking of milking and milk storage vessels. No hand, udder or teat washing was performed. This is in agreement with the findings reported in Somali and Afar Regional States (Seifu, 2009; Sirak, 2010; Tsegalem *et al.,* 2016). During the rainy seasons, camels are not milked for the first month after delivery; the calf is allowed to free suckling so that it becomes strong and healthy and the mother maintains good body condition.

Milking frequency, milk yield and lactation length: Milking frequency of camels ranged from two to four times per day, with average frequency of 2.97±0.37 and 2.69±0.46 during the wet and dry seasons, respectively. This is similar to 3.24 (wet season) and 2.57 (dry season) times per day reported in the same zone (Dejene, 2015). The average price of one liter of camel milk in 2016 was 14.02±5.32 birr during wet seasons and 18.61±5.17 birr during dry seasons. Camel calves suckled from 1 to 3 liters (mean 2.01±0.57 liters) of milk per day. Borana camels provide milk from 6 to 24 months, average lactation period being 14.24±3.82 months (Table 12).

Table 12. Milking frequency, milk price and amount of milk suckled by calves in the study areas.

Variables	Minimum	Maximum	Mean	SD
Milking Frequency				
Wet Season	2	4	2.97	0.37
Dry Season	2	3	2.69	0.46
Lactation Period (months)	6	24	14.24	3.82
Milk Price (ETB/liter):				
Wet Season	6	24	14.02	5.32
Dry Season	12	30	18.61	5.17
Milk suckled by calf (L/day)	1	3	2.01	0.57

ETB=Ethiopian Birr; in 2016, 1 USD was 21.8377 ETB.

The average daily milk yield of Borana camels was 5.60±2.50 liters and 3.54±1.35 liters for the wet and dry seasons respectively (Table 13). Regarding lactation stage-based data, while the highest milk yield (5.22 ± 2.34 liters) was calculated for the she-camels in the early lactation stage; the least milk yield of 2.48±1.48 liters was recorded for camels in late lactation phase. There was highly significant milk yield difference ($p<0.05$) between the seasons and among the lactation stages. This finding is very close to 6 liters (Megersa *et al.,* 2008) and 6.57 liters (Dejene, 2015) reported in the same study area; as well as 5 liters and 4 liters (Tezera, 1998) and 5.64 liter and 4.18 liters reported in Somali Regional State for the wet and dry seasons respectively (Mehari *et al.,* 2007).

Preference to cow and camel milk: According to the present study, Borana camel keepers commonly consume cow and camel milk; goat milk when there is

shortage of the above and rarely sheep milk. Almost all (97.70%) participants of this study preferred cow milk to camel milk (Table 14). The majority of the respondents (48.5%) justified their preference stating cow milk is very sweet and can be processed into yogurt and butter. Their accompanying details included that cow milk is very sweet and the best food for rapid growth of children; and cow milk products especially butter is a special food which makes people very strong, has cultural function as hair oil and skin lotion, and also brings good household income. While 28.8% of the respondents said cow milk is processed to yogurt and butter and has better market demand and price; 9.1% do not consume camel milk and cow milk is their major source (Table 15).

About 85.6% of the respondents ranked camel milk next to cow milk. Almost all mentioned that camel milk has medicinal value, is an easily digestible special food of children and stays fresh for a long time. According to them, if children who consumed camel milk vomit accidentally, the vomitus does not contain coagulated milk. Many researchers described reported such qualities of camel milk (Farah *et al.,* 2007; Mehari *et al.,* 2007; Seifu, 2009; Simenew, 2013; Tadesse *et al.,* 2015). On the other hand, about 15.5% of the respondents ranked camel milk as their last preference. These don't consume camel milk and cow milk is their main source. They belong to a specific Borana community group that does not consume camel meat and milk. However, they sell camel milk.

Table 13. Daily milk yield (liters) of Borana camels for different seasons and lactation stages.

Variable	Category	Milk yield (Mean ±SD)
Season	Wet	5.60±2.50[a]
	Dry	3.54±1.35[b]
Lactation stages	Early	5.22±2.34[a]
	Middle	3.97±2.02[b]
	Late	2.48±1.48[c]

Means with different superscript letters (a, b, c) in a column under the same factor are significantly different (P< 0.05).

Table 14. Preference to different milk in the study areas (N=132).

Milk	First	Second	Third	Index
Cow milk	129 (97.7%)	3 (2.3%)	0	0.50
Camel milk	3 (2.3%)	109 (85.6%)	20 (15.1%)	0.31
Sheep and Goat milk	0	20 (15.1%)	112 (84.9%)	0.19

Table 15. Reasons for cow milk preference in the study areas.

Reasons for cow milk preference over camel milk	**Frequency**	**Percent**
Cow milk is sweet and processed to yogurt and butter	64	48.5
Cow milk is processed to yogurt and butter and has better market demand and price	38	28.8
Cow milk is sweet and good for rapid growth of children	18	13.6
I don't consume camel milk	12	9.1
Total	132	100

Fresh keeping time of different kinds of milk: The study also revealed the time length (hours) the milk of different animals stayed fresh. The fresh keeping times of camel, cow, and shoat milk were estimated at 31.70 ±18.92 hours and 9.71 ±5.28 and 2.61±1.39 hours respectively; thus camel milk stays fresh about three times longer than cow milk and more than ten times more than shoat milk (Table 16). This is lower than 7 days for camel milk and 24-48 hours for cow milk reported by Seifu (2009) in Somali Region.

Table 16. Fresh keeping time (hours) of different kinds of milk in the study areas.

Milk	**Fresh keeping hours (Mean ±SD)**
Camel milk	31.70±18.92
Cattle milk	9.71±5.28
Shoat milk	2.61±1.39

Health benefits of camel milk: Almost all respondents were aware of and also mentioned some health benefits of camel milk. Camel milk was suggested to have a healing role for disease conditions like gonorrhea, diarrhea, vomiting, constipation, malaria, and fever. Camel milk is generally acknowledged for its medicinal value (Konuspayeva and Faye, 2021; Dugassa, 2022; Seifu, 2022). The milk is safely taken by children allergic to cow's milk or people intolerant to the same milk (El-Agamy *et al.,* 2009). Diabetes Mellitus can be controlled by camel milk (Agrawal *et al.*, 2005). Its anti-bacterial and anti-viral effects are well documented (Yagil, 2004). In Ethiopia, the medicinal value of camel milk has been reported against gastritis, asthma, jaundice, tuberculosis, urinary problems, constipation, pneumonia and malaria (Tezera, 1998; Alemayehu, 2001; Seifu, 2007; Mehari *et al.,* 2007). According to FGD respondents in Yabello district, when people with fever of malaria are given camel milk, they vomit a bile like fluid and get cured. The provision of camel milk to constipated individuals rapidly initiates profuse diarrhea followed by recovery. The provision of camel milk to delivered women hastens rapid return to normal conditions.

On the other hand, the respondents strongly agree that the medicinal value of camel milk is far less than the of modern medicines. Despite widespread belief about the role of camel milk in curing diabetes mellitus, they

reported that many camel milk users are not only suffering but dying from the same disease among their community.

Camel Calf Management

When a pregnant she-camel shows signs of parturition, Borana camel keepers separate it from the herd, follow and keep in the vicinity, including to stay it in resting position. During delivery, if the dam stands, the legs of the new born will hang, and the dam tries to kick and throw it. However, if the dam is in standing position, its legs are tightly tied together, after which the limbs of the calf are kept out of its sight and pulled down.

Peri-parturient care made to the pregnant she-camel include, preparation of smooth bedding, and assisting in pulling out the calf. Then, the newborn is assisted to stand and suckle colostrum within 1-6 hours post-delivery (mean 2.61 ±1.36 hours). According to FGD participants, they carefully observe the removal of placenta and finally discard it. The health of the dam and the calf is closely monitored and if delivery occurred in the range, children carry the calf to homesteads.

According to FGD discussants in Yabello district, newborn calves are helped to stand and allowed to suckle. Within 6 hours, the calves are drenched with two tablets of tetracycline human preparation dissolved in water. Then, it is helped to sucked colostrum. Colostrum from a single teat is allowed to the calf; the rest teats are milked and discarded. After two days, two more tetracycline tablets are drenched again. Others drench on the fourth day. Some give oral tetracycline syrup preparations on the fifth day. According to the respondents, tetracycline drenching prevents diarrhea and enable the rearing of strong calves. Tetracycline drenching during the first month of calves was also reported by FGDs held in Moyale and Gomole districts. After lactating camels are mated, the calves are usually weaned; this can occur as early as 4 months to as long as 24 months; the mean was 14.90±4.96 months.

Camel Production Constraints

Multiple camel production constraints were reported by the survey participants in Borana Zone. The major constraints were recurrent drought (33.3%), shortages of feed and water (22.7%) and camel diseases (19.0%). All the remaining constraints including crop failure, lack of food and money; conflict; small market price; lack of health service, abortion; and predation by wild animals accounted for 22.0% (Table 17). Since the Borana Zone is repeatedly hit by drought, this might eventually lead to feed and water shortage, disease outbreaks as well as crop failure and food shortage. The resultant lack of capital reserve during such times force the pastoralists to sell their camels for lows price, thus compromising the herd status. These constraints were also reported by Galma *et al.* (2017), Dejene (2015) and especially Simenew (2013), who reported feed and water shortage (51.8%), disease (40.9%) and other problems (7.3%) in Afar Region.

Table 17. The major camel production constraints in Borana Zone.

S/N	Constraint	(N=132)
1	Recurrent drought	44 (33.3%)
2	Feed and water shortage	30 (22.7%)
3	Camel diseases	25 (19.0%)
4	Crop failure, lack of food and money	12 (9.1%)
5	Conflict	8 (6.1%)
6	Small market price	4 (3%)
7	Lack of health service	4 (3%)
8	Abortion	3 (2.3%)
9	Predators	2 (1.5%)
	Total	132 (%100)

Conclusion

Being originally cattle breeders, Borana pastoralists have high affinity to cattle production and cattle milk. However, due to its superior adaptation and economic, social, and cultural advantages, camel production is becoming very important. During the assessment period, camel population increased both at the zonal and household levels. With an average age at first calving of about 5 years and calving interval was two years, Borana camels produced 6-15 calves in their lifetime. The average daily milk yield of 3 to 5 liters, also makes the camels good milk producers. Recurrent drought, shortages of feed and water, camel diseases, abortion, lack of quality camel health service, conflicts, bite of wild animals, and illegal livestock marketing hampered camel production in the zone. Therefore, regional and national policymakers should pay due attention to address the pressing feed, water, and health challenges. In addition, the composition and importance of the four types of salt and the causes of conception failure have to be investigated.

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Conflict of Interests

The authors declare that they have no competing interests.

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