Phenotypic Characterization of Camels and their Production System in Yabello and Melka Soda Districts, Oromia Regional State, Ethiopia

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አህፅሮት

የዚህ ጥናት ዋና ዓላማ በያቤሎና መልካሶዳ ወረዳዎች በሚገኙ ግመሎች ውጪያዊ ባህሪያቸውን በመጠንና በብዛት መለየት መሠረት ያደረገ ነበር:: በዚህም መሠረት ከሁለቱ ወረዳዎች ከሚኖሩት አርብቶ አደሮች ለውጫዊ ባህርይ ትንተና ጥናት 192 አባወራዎችና 300 ግመሎች በነሲብ ተመርጠዋል:: በመልካሶዳ የሚገኙ ግመሎች ከፍተኛና ጉልህ የሆነ ልዩነት ከያቤሎ ግመሎች ማለትም ደረት ዙር፣ በደረት ስፋት፣ በሰውነት ክብደት፣ በሸንጥ/ዳሌ ስፋት፣ በደረት ጥልቀት፣ በጉበል ዙሮሽ እንደሚበልጡ ጥናቱ አመልክቷል:: የግመሎች ፆታ ልዩነት (ወንድና ሴት ግመል) በተመለከተ የፊት እግር ርዝመት፣ የኃላ እግር ርዝመት፣ የጫንቃ ከፍታ፣ የደረት ዙር፣ የሆድ ስፋት ዙር፣ የሰውነት ክብደት፣ የደረት ስፋት፣ ሻኛ/ጉበል ዙሮሽ፣ ሻኛ/ጉበል ርዝመት፣ የፊት ሾኪና ዙር/ስፋት፣ የኋላ ሾኪና ዙር/ስፋት ልዩነት እንዳላቸው ከጥናቱ ለመረዳት ተችሏል:: በጥናቱ የግመሎች ዕድሜ መጠን ከሁሉም የሰውነት ክብደት ልኬቶች ጋር ጉልህ የሆነ ልዩነት አዳለው ለመገንዘብ ተችሏል:: በተጨማሪ የደረት ስፋትና የደረት ጥልቀት ተለዋዋጭ ልኬት ለሰውነት ክብደት ውጫዊ ገጽታ መለኪያነት ሊያገለግሉ ይችላሉ:: የወንድ ግመሎች እከብ ናመና በቀጥታ ለሰውነት መለኪያዎች ማለትም የደረት ዙርና ሆድ ዙር/ስፋት ጠንካራ አዎንታዊ ዝምድና (r=0.03) ከሰውነት ክብደት ጋር አላቸው:: የቤት ግመሎች ክብደት ጠንካራ አዎንታዊና (P<0.05) ጉልህ ዝምድና ከደረት ዙር (r=0.95) ጋር አለው:: የዚህ የግመሎች ውጪአዊ አይታ መረጃ በዋነኝነት ለግመሎች ዝርያ ጥበቃ ለድቀባና ለመረጣ በሥነ-ባህርይ ትንተና በተደገፈ እስትራቴጂ ሊያገለግል ይችላል:: በተጨማሪ በቦረናና አካባቢ እንዲሁም በሌሎች የሀገሪቱ ክፍሎች የሚኙትን ማህበረሰብ የግመሎችን የምርት ውጤት ፍላጐት ለሚሟላት ከፍተኛ ትኩረት በመስጠት በግመሎች ላይ ብዙ መሠረት እንዳለበት ይጠቁማል:: ይህ ጥናት በያቤሎና በመልካ ሶዳ አካባቢ የሚገኙትን የግመል ሀብት ለወደፊት ዝርያቸውን ለማሻሻልና ለመጠበቅ በሚደረገው እንቅስቃሴ በዋነኝነት እንደ መረጃ ሊያገለግል ይችላል::

Abstract

The objectives of the study were to characterize the production system of camel in Yabello and Melka Soda districts and to characterize phenotypically camel based on quantitative and qualitative traits. A total of 192 households were selected for characterization of the production system and 300 camels were sampled randomly for characterization of phenotypic traits. Camels of Melka Soda had significantly higher in heart girth, barrel girth, body weight, hip width, chest depth and hump circumference (P<0.05) than Yabello camels. Sex of the camels had significant (P<0.05) effect on forelimb length, hind limb length, wither height, heart girth, barrel girth, body weight, chest width, hump circumference, hump length, fore hoof circumference and hind hoof circumference. Body weight and all the body measurements were significantly (P<0.05) affected by age. Heart girth and barrel girth were found to be the most important variables for estimation of body weight in camels. In male sample populations of linear body measurements, heart girth and barrel girth had strong positive correlation (r=0.93) with body weight. In female sample camels body weight had strong positive and significant (P<0.05) correlation with heart girth (r=0.95). This phenotypic information can serve as a basis for designing appropriate conservation, breeding and selection strategies for camels in the study area and could be complemented with genetic analyses. Thus attention should be given to exploit the performance of camels based on their specialization to fulfill the current demand of camel and camel by-products in the Borena and also in different parts of the country. The present study can be used to understand the camel resources of the study sites for future genetic improvement and conservation actions.

Introduction

The extent of phenotypic variation is valuable to select and utilize different camel populations based on their specific characteristics and body conformation in breeding program. The presence of different camel populations in morphology, productive and adaptive characters may provide a basis for selection and improvement (Yosef *et al.,* 2014).

Despite the camel's considerable contribution to food security in semi arid and arid areas as compared to other domestic animals, study on camel production system, phenotypic and genetic characterization is scanty (Yohannes *et al*., 2007) and there is serious lack of information on camel production potential and production systems in southern Ethiopia. These hindered the design of appropriate strategy for utilization of existing potential of camel genetic resources and establishment of breeding programs. Given the current importance of camels in contributing to the livelihoods of large human population in marginal areas, and the role it plays towards resilience to present climate change, it is imperative to identify and differentiate the phenotypic characteristics of camel populations in Borena zone of Southern Ethiopia based on FAO guidelines.

Therefore, the study was undertaken to address the information gap in production environment by conducting production system and phenotypic characterization of camel in Yabello and Melka Soda districts in Borena zone with the objectives;-to characterize the production system of camel in Yabello and Melka Soda districts and to phenotypically characterize camels based on quantitative and qualitative trait.

Materials and Methods

Description of study area

The study was conducted in two districts namely, Yabello and Melka Soda in Borena zone, Oromia regional state. Yabello district is one of the districts of Borena zone. The district is situated in Latitude/Longitude**:** N 4° 52' 59.99" E 38° 4' 59.99". Melka Soda district is located in the northeastern part of Borena zone. Astronomical location of Melka Soda Woreda is between 35^0 East& 30^0 West.

Sampling technique and data collection

Discussions were held with the experts in the zonal and district Pastoral Development Offices and representative pastoral community on the present production system and present condition and concentration of the Boren camels. Data were collected through the designed semi-structured questionnaires from 192 randomly selected households those have camels. Qualitative and quantitative traits were recorded from 51 mature males and 249 mature females.

A total of 17 linear measurments were measured by tape meter and recorded by centimeter: heart girth, body length, wither height, ear length, fore limb length, hind limb length, barrel girth, face length, hip width, chest width, chest depth, tail length, neck length, hump length, hump circumference, fore hoof circumference and hind hoof circumference, and body weight by Kg was calculated by formula of Yagil, 1994 and a total of 7 qualitative traits were examined and recorded: Coat color pattern, coat color type, hair type, face profile, ear orientation, nose shape and lip shape. The camels in both districts were categorized under two age groups (less than 5 and greater than 5 years), this is done by depending on the average age of maturity after taking the information of the age of camels when they are reaching sexual maturity from the experienced camel herders. According to the feedback from pastoralists during discussion, age less than five is the age before maturity but camels greater than five years are after maturity.

Body weight estimation was using Barymetric weight estimation formula of Yagil (1994):

$Y = SH \times CG \times BG \times 50$

Where, Y = the weight in kg.

SH = the height at shoulder in meters.

CG = the chest girth behind the chest pad in meters.

BG = the barrel girth over the highest part of the hump in meters.

Results and Discussion

Characterization of production system

General household characteristics

In this household survey work, 192 households (96 from each district) were participated. Detail of general household characteristics is presented in Table 1. The large proportions of households in both districts have illiterate educational background. Of the sampled households 77.60% were illiterate. This proportion is lower than the report of Solomon (2010) who reported that 95% of the households in Borena were illiterate.

The chi-square test for assumption of equal proportion of categorical variables in both sexes (male and female respondents), among educational background (illiterate, read and write, and primary) and among the four age were found to significantly ($P<0.05$) differ within the district.

Table 1. Socio-economic characteristics of the households.

Descriptor	Yabello (n=96)		Melka Soda(n=96)		Overall (n=192)	
	Mean ± SD		Mean ± SD		Mean ± SD	
Family size	5.83±2.45[a]		5.63±2.3[a]		5.73±2.37	
	N	%	N	%	N	%
Sex	*		*		*	
Male	89[b]	92.71	86[b]	89.58	175[b]	91.15
Female	7[a]	7.29	10[a]	10.42	17[a]	8.85
X^2	70.04		60.17			130.03
Educational status	*		*		*	
illiterate	71[c]	73.96	78[c]	81.25	149[c]	77.60
Read and write	18[b]	18.75	14[b]	14.58	32[b]	16.67
Primary	7[a]	7.29	4[a]	4.17	11[a]	7.82
X^2	47.75		36.75			76.75
Age (year)	*		*		*	
≤30	4[a]	4.16	3[a]	3.12	7[a]	3.64
31-45	48[d]	50.00	33[c]	34.38	81[d]	42.19
46-60	31[c]	32.30	42[d]	43.74	73[c]	38.02
>60	13[b]	13.54	18[b]	18.76	31[b]	16.15
X^2	73.19		159.92			288.21

* Significant at 0.05 level ($p<0.05$) in the same column with different superscripts are significantly different for each other, N=Number of households

Trends of livestock population in the study area

The trend of livestock population in the study area is summarized in Table 2. Majority of the respondents (96.88% in Yabello and 97.92% in Melka Soda) responded that, the camel population showed an increasing trend from time to time.

In both districts, main income is generated from camel rather than other livestock may indicate the importance of camel in more arid areas than other livestock species under the current scenario of climate change. This is in agreement with earlier study (Bekele *et al*., 2008) who noted increased aridity in Borena Zone shifted the principal stock gradually from cattle combined with small stock to camels combined with small stock. In determination of wealth among the Borena pastoral community the presence and absence of camel together with cattle are considered. In this regard, CARE (2009) reported that Borena pastoralists recognized camels as providing long-term security to beneficiaries in terms of milk production and improved social status.

Table 2. Population trend of major livestock species in the study area

Species	Districts					
	Yabello		Melka Soda		Overall	
	N	%	N	%	N	%
Camel						
Increasing	93	96.88	94	97.92	187	97.40
Decreasing	-	-	-	-	-	-
Stable	3	3.12	2	2.08	5	2.60
Cattle						
Increasing	13	13.54	9	9.38	22	11.46
Decreasing	75	78.13	85	88.54	160	83.33
Stable	8	8.33	2	2.08	10	5.21
Goat						
Increasing	74	77.08	74	77.08	148	77.08
Decreasing	20	20.83	22	22.92	42	21.88
Stable	2	2.08	-	-	2	1.04
Sheep						
Increasing	80	83.33	79	82.29	159	82.81
Decreasing	16	16.67	17	17.71	33	17.19
Stable	-	-	-	-	-	-

N= Number of households

Purpose of keeping camels

The rank for purpose of camel keeping in the study area is presented in Table 3. The reasons for keeping camels are rational and related to the pastoralists' need in the long or short term. Camel milk sale was the main source of income. Few of the respondents have no opportunity of selling camel milk for the reason that either they did not have a lactating camel or the produced milk was not surplus enough to sale. The results of this survey showed that most of the pastoralists in both sample districts primarily reared camels for milk. This agrees the work of Farah *et al.,* (2004), who noted that the husbandry and management practices of the Somali camel herders are geared towards the improvement of milk production and the continuous supply of milk for the family's needs throughout the seasons. Rearing camels for meat stood second in both districts.

Pastoralists in the study area were not interested to sell their replacement stock unless they are highly in need of money for very important matters. The work of Getnet (2004) stated that, even if pastoralists expect the upcoming month would be much worse than the recent month, they still want to keep their animals, especially the camel cow for their optimistic expectation of the coming good months.

Table 3. Purpose of keeping camels in the study area

Purpose of keeping camels	Districts							
	Yabello				Melka Soda			
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index
Milk production	14	8	5	0.330	16	5	7	0.339
Meat production	9	12	6	0.297	8	15	8	0.323
Work/draught	1	3	4	0.071	0	4	4	0.063
Stud Breeding	0	0	2	0.010	1	0	1	0.021
Conflict resolution	0	1	0	0.010	0	0	1	0.005
Selling for money (income)	7	5	13	0.229	6	6	10	0.208
Social security	0	2	0	0.021	0	1	0	0.010
Dowry	0	0	2	0.011	0	1	0	0.010
Ceremonies	0	0	0	0.000	0	0	0	0.000
Cultural/Social status	1	1	0	0.021	1	0	1	0.021

Index= sum of (3 X purpose of keeping camel ranked first + 2 X purpose of keeping camel ranked second + 1 X purpose of keeping camel ranked third) given for each districts divided by sum of (3 X purpose of keeping camel first + 2 X purpose of keeping camel ranked second + 1 X purpose of keeping camel ranked third) for both district.

Milking product and milking frequency

The frequency of milking of camels in the study areas is shown in Table 4. As shown in the table below, most of the pastoralists in the study area, milking their camels two times per a day in both districts (85.42%). Milk is a usual and favorite food for Borena camel owners. Daily milk yield of Yabello camels range from 1.50-9.20 liters per day and of Melka Soda camels range from 1.05-6.0 liters per day depend on feed availability, season and water access.

Table 4. Milking frequency of camel in Yabello and Melka Soda districts.

	Districts				Overall	
	Yabello		Melka Soda			
Milking frequency	N	%	N	%	N	%
Once in a morning	3	3.13	5	5.21	8	4.17
Once in evening	7	7.29	11	11.46	18	9.38
Twice per a day (morning and evening)	84	87.5	80	83.33	164	85.42
Three times per a day (morning, mid-day and evening)	2	2.08	-	-	2	1.04

N=Number of households

Selection criteria

According to this study the traits used to select breeding camels of both sexes are shown in table 5. Body size/appearance, growth rate, color and libido were the most important traits to select breeding male camels. Male camels that have large body size and grow at faster rate are the most preferred by most of the pastoralists in both sites. Unlike for male camels, age at first calving was the most highly rated traits in selecting breeding female camels (37% in Yabello and 38% in Melka Soda). Growth rate was also considered in selecting breeding females in both Yabello and Melka Soda districts. Breeding programs should be geared towards top ranked functional traits and management practices such as better feeding and health should go in line with genetic improvement programs.

Table 5. Selection criteria to select breeding male camels and female camels as ranked by respondents

Criteria for selecting male breeding camels	Districts							
	Yabello				Melka Soda			
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index
Size /appearance	16	9	10	0.396	14	10	8	0.365
Color	5	11	7	0.229	6	9	14	0.260
Growth	11	11	14	0.359	12	12	8	0.354
Libido	0	1	1	0.016	0	1	2	0.021
Criteria for selecting female breeding camels								
Size /appearance	6	15	5	0.276	6	12	7	0.255
Color	1	3	10	0.099	0	4	7	0.078
Growth	7	8	12	0.255	9	9	10	0.287
Age at first calving	18	6	5	0.370	17	7	8	0.380

Index= sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) given for each districts divided by sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) for both district.

Breeding management

Table 6 shows the breeding management of camels in the study area. It was found that most of the pastoralists (64.06%) practiced uncontrolled mating system. The primary reasons for uncontrolled mating were mixed herding and tradition of sharing serving camel. They didn't know about the negative effect of inbreeding and they allow a sire to mate his own mother, daughter and sister.

In domestic breeding herds, usually one male is kept for many females. There is a strict hierarchical dominance relationship between males, established by competition during the mating season. The dominant male usually performs most of the mating (El-Amin, 1984). There was no special management for breeding male camels in both districts. Almost all pastoralists used one breeding male camels for the entire herd. The reasons put forward by respondents include adequacy of one breeding male camels for the entire herd, to avoid fighting, for improved conception, and in order to get similar types of offspring, though it is leading to inbreeding. Among all the respondents in both districts only 24.48% select the male breeding camels and also only 21.87% were select female breeding camels.

Table 6. Breeding practices of pastoralists in the study area.

Breeding Management	District					
	Yabello		M/Soda		Overall	
	N	%	N	%	N	%
Selection male breeding camels						
Yes	20	20.83	27	28.13	47	24.48
No	76	79.17	69	71.88	145	75.52
Selection female breeding camels						
Yes	19	19.79	22	23.96	42	21.87
No	77	80.21	73	76.04	150	78.13
Mating Systems						
Controlled	-	-	-	-	-	-
Partially controlled	37	38.54	32	33.33	69	35.94
Uncontrolled	59	61.46	64	66.67	123	64.06
If uncontrolled could be able to identify the sire of a Kid?						
Yes	14	14.58	7	7.29	21	10.94
No	82	85.42	89	92.71	171	89.06
Allowance of female camels to be served by any male camels?						
Yes	73	76.04	67	69.79	140	72.92
No	23	23.96	29	30.21	52	27.08
Allowance male camels to serve female camels other than own?						
Yes	85	88.54	87	90.63	172	89.58
No	11	11.46	9	9.37	20	10.42
Source of breeding male camels						
Born in the herd	55	57.29	49	51.04	104	54.17
Purchased	6	9.38	7	7.29	13	6.77
From neighbor	35	36.46	40	41.67	75	39.06

N=Number of household

Camel production constraints

Major problem of camel production in the study area is indicated in table 7. Identifying the constraints of camel production is a base to solve the problems and to improve camel productivity.

This study showed that feed shortage ranked first in both study districts. On the other hand water shortage ranked second in Melka Soda whereas it is the third most important constraint in Yabello district. This indicate that the intensity of constraints to camel production vary from districts to districts. This finding is in agreement with Alemayehu (2001) who stated that the major problems of camel production in Afar and Kereyu areas were disease, feed and water shortage.

Table 7. Major constraints of camel production in the study area.

Constraints	District							
	Yabello				Melka Soda			
	Rank1	Rank2	Rank3	Index	Rank1	Rank 2	Rank 3	Index
Feed shortage	20	3	1	0.349	15	5	7	0.323
Water shortage	3	13	15	0.260	11	8	10	0.307
Disease	8	16	2	0.302	6	14	4	0.260
Thief	0	0	1	0.005	0	0	1	0.005
Conflict	1	0	11	0.073	0	4	9	0.089
Infrastructure	0	0	2	0.011	0	1	1	0.016

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular constraints divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all constraints

Characterization of reproductive performance of camels in both districts

As shown in the table 8 below, there was no significant difference (P>0.05) between the camels in both districts regarding to age at first mating for female camels, age at first calving and average calving interval.

Age at first calving was 62.03 ± 5.80 months (5.17 years) and 63.10±5.76 months for Yabello and Melka Soda camels, respectively. This study shows the longer age at first calving than Tefera and Gebreah (2001) who reported 5 years. The mean calving interval was 23.03±2.59 months for Yabello camels and 23.78±3.23 months for Melka Soda camels. The present study for age at first calving is shorter than the study undertaken by Simenew *et al.,* (2013) who reported those 63.15±6.78 months for Afar camels.

Table 8. Reproductive performance of camels in both districts.

Reproductive traits	Yabello	Melka Soda	Overall	Test
	Mean ± SD	Mean ± SD	Mean ± SD	
Age at first mating for male (month)	65.60 ± 6.18^{a}	66.84±6.52^{b}	66.22±6.46	***
Age at first mating for female (month)	49.49±5.65	50.13±5.63	49.81±5.83	ns
Age at first calving (month)	62.03 ± 5.80	63.10 ± 5.76	62.57±5.95	ns
Reproductive life span of male camels (month)	282.40 ± 28.88^{b}	279.42±29.96^{a}	280.91±30.69	***
Reproductive life span of female camels (month)	270.95 ± 27.63^{b}	263.95±31.75^{a}	267.45±30.79	***
Avg calves per camel (number)	10.39 ± 2.09^{b}	9.71±2.29^{a}	10.05±2.29	***
Avg calving interval	23.03±2.59	23.78±3.23	23.41±2.95	ns

Ns = Non-significant (P > 0.05);*P < 0.05; SD = standard deviation; Avg=Average

Phenotypic characterization of Camels in both districts

Morphological traits

The major qualitative traits of the Yabello and Melka Soda camels are presented in Table 9. The most observed coat color patterns in both study sites particularly

for females were plain coat color (93.50% in Yabello and 96.83% in Melka Soda). Dark brown coat color is dominant in Yabello for both sexes (30.37% for male and 52.03% for female.

The chi-squasre test for assumption of equal proportion of categorical variables n both Yabello and Melka Soda sample camels indicated that among the variables considered in this study; coat color pattern, coat color type, hair type, ear orientation, face profile and lip shape were found to significantly ($P<0.05$) differ for their attributes. However, nose shape was not significantly ($P>0.05$) different for both attributes (almost similar proportion of camels with flat and concave shaped nose) across both districts. More of the camels in the study area had plain coat pattern (95.0%), dark brown coat color (50.33%, rough hair type (67.0%), erect ear orientation (82.0%), straight face (68.00%), and pendulous lip (81.33%).

Live body weight and linear body measurements

Information on live body weight and linear body measurements of the existing breed types has mandatory role in the selection programs. The body weight and linear body measurements for Yabello and Melka Soda camels at different ages are presented in Table 10.

District effect

District had significant effect ($P<0.05$) on quantitative variables; face length, heart girth, barrel girth, body weight, hip width and hump circumference. For heart girth, barrel girth, body weight, hip width and hump circumference, camels in Yabello district had significantly lower value ($P<0.05$) than camels in Melka Soda district. Heart girth, barrel girth and body weight were 202.22±0.83cm, 224.78±0.83cm and 423.10±4.23kg for Yabello and 210.81±0.86cm, 233.55±0.79cm and 459.94±4.48kg for Melka Soda district respectively. The measurements of Yabello camels not congruent with the result of Yosef *et al.,* (2014) who reported that 207.12±0.94cm for heart girth of Hoor camels and 440.44±7.27kg for weight of Jigjiga camels but heart girth of Melka Soda camels was similar result reported in Yosef *et al.,* (2014) 211.20±1.36cm for Gelleb camels.

Table 9. Summary of the qualitative traits of camels in both districts.

Character	Attribute	Yabello		Melka Soda		
		Sex		Sex		
		Male	Female	Male	Female	Overall
		N (%)	N (%)	N (%)	N (%)	N (%)
Coat color pattern	Plain	26(96.30)	115(93.50)	22(91.67)	122(96.83)	285 (95.00)[b]
	Patchy	1 (3.70)	8 (6.50)	2 (8.33)	4 (3.17)	15 (5.00)[a]
X^2						243.00*
Coat color type	Dark brown	19(30.37)	64 (52.03)	8 (33.33)	60 (47.62)	151 (50.33)[c]
	Golden	1 (3.70)	15 (12.20)	3 (12.50)	17 (13.49)	36 (12.00)[a]
	Whitish	7 (25.93)	44 (35.77)	13(54.17)	49 (38.89)	113 (37.67)[b]
X^2						68.66*
Hair type	smooth	6 (22.22)	41 (33.33)	10(41.67)	42 (33.33)	99 (33.00)[a]
	rough	21(77.78)	82 (66.67)	14(58.33)	84 (66.67)	201 (67.00)[b]
X^2						34.68*
Face profile	Straight	12(44.44)	80 (65.04)	17(70.83)	95 (75.40)	204 (68.00)[b]
	Convex	17(55.56)	43 (34.96)	7 (29.17)	31 (24.60)	96 (32.00)[a]
X^2						38.88*
Nose shape	Flat	13 (48.15)	51 (41.46)	13 (54.17)	72 (57.14)	149 (49.67)
	Concave	14 (51.85)	72 (58.54)	11 (45.83)	54 (42.86)	151 (50.33)
X^2						0.01NS
Ear orientation	erect	22 (81.48)	100(81.30)	19 (79.17)	105(83.33)	246(82.00)[c]
	S/P	2 (7.41)	7 (5.69)	1 (4.17)	5 (3.97)	15 (5.00)[a]
	Horizontal	3 (11.11)	16 (13.01)	4 (16.67)	16 (12.70)	39 (13.00)[b]
X^2						322.62*
Lip shape	Pendulous	23 (85.19)	102(82.93)	18 (75.00)	101 (80.16)	244 (81.33)[b]
	tight	4 (14.81)	21 (17.07)	6 (25.00)	25 (19.84)	56 (18.67)[a]
X^2						117.81*

N=number of households; Ns=non-significant;*P<0.05, S/P = semi-pendulous

The wide hip and heavy weight exhibited by Melka Soda camel populations show their potential for meat production. This result is in agreement with Abebe (1991) who reported that Gelleb and Liben camels have a greater potential in terms of meat production with wide chest and hip and heavy weight.

Sex effect

The least square means for the effect of sex had significant effect (P<0.05) on body length, forelimb length, hind limb length, wither height, heart girth, barrel girth, body weight, chest width, tail length, hump circumference, hump length, fore hoof circumference and hind hoof circumference whereas the remaining were not significantly (P>0.05) affected by sex. Male camels were consistently higher than female camels in all significantly affected variables except hump circumference and hump length (Table10).

The presence of significant differences in 13 of 18 measured linear body measurements between male and female camels suggests the existence of sexual dimorphism in camels. Likewise, Yohannes *et al*., (2007) repotted the existence of

sexual dimorphism in Jigjiga camels. This result is also in agreement with findings of Mehari *et al.,* (2007) who stated that there is quite distinctive sexual dimorphism in camels, i.e. the male camel is usually taller and of heavier in weight than those of the female. The higher values of the measured traits of male camels might be attributed to physiological induces and activities in the different sexes.

Age effect

Body weight and all the body measurements were significantly ($P<0.05$) affected by age group. All the body weight and body measurements were increased as the age increased from the younger to the older age. The results of this study showed that the age of camel had a significant effect on the linear body measurements. This result is in agreement with finding of Ishag *et al.,* (2011) who stated that the age of camel had a significant effect on the phenotypic measurements.

Table 10. Least squares Means (± S.E.) for Body Weight (kg), and Linear body measurements (cm) as affected by district, sex, age group and their interactions

Effect and level	N	EL	BL	FIL	HIL	FL	WH	HG	BG	BW	HW	CW	CD	NL	TL	HC	HL	FHc	HHc
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	300	10.55± .27	133.09±2.02	146.52±1.92	181.23±1.59	35.57±1.07	185.20±1.56	206.90±2.12	229.16±1.96	441±9.98	38.40±0.66	37.72±0.58	51.88±1.50	115.95±1.60	1.61±0.98	116.98±1.49	27.22±0.79	60.43±0.93	52.89±1.10
CV%		11.15	6.68	5.78	3.86	13.11	3.72	4.51	3.77	9.96	7.53	6.75	12.69	6.08	8.35	5.60	12.58	6.77	9.14
R^2		.34	.31	.30	.32	.16	.38	.29	.37	.40	.17	.36	.15	.17	.13	.22	.34	.30	.23
District		NS	NS	NS	NS	*	NS	*	*	*	*	NS	NS	NS	NS	*	NS	NS	NS
Yabello	150	10.53±.11	133.17±.87	146.19±.86	181.20±.66	36.06±.42^{b}	184.66±.72	202.98±.83^{a}	224.78±.83^{a}	423.10±4.23^{a}	37.63±.23^{a}	37.63±.27	51.12±.60	115.63±.53	51.36±.42	115.85±.56^{a}	27.19±.35	60.32±.40	53.18±.48
M/S	150	10.56±.12	133.01±.87	146.84±.78	181.25±.72	35.01±.40^{a}	185.74±.69	210.81±.86^{b}	233.55±.79^{b}	459.94±4.48^{b}	39.17±.26^{b}	37.81±.23	52.64±.56	115.27±.71	51.85±.32	118.11±.63^{b}	27.26±.34	60.54±.38	52.59±.42
Sex		NS	*	*	*	NS	*	*	*	*	NS	*	NS	NS	*	*	*	*	*
Male	51	10.68±.17	136.98±1.32^{b}	153.34±1.22^{b}	188.30±1.02^{b}	36.59±.68	195.37±.99^{b}	212.20±1.35^{b}	235.27±1.25^{b}	488.99±6.37^{b}	38.83±.42	40.78±.38^{b}	53.24±.95	115.34±1.03	52.94±.62^{b}	114.32±.95^{a}	22.68±.50^{a}	64.77±.59^{b}	56.50±.70^{b}
Female	249	10.54±.08	132.66±.56^{a}	145.32±.54^{a}	179.91±.44^{a}	35.52±.30	183.26±.44^{a}	206.00±.59^{a}	228.12±.54^{a}	433.00±2.79^{a}	38.35±.02	37.13±.16^{a}	51.75±.42	116.16±.45	51.42±.27^{a}	117.61±0.42^{b}	28.15±.22^{b}	59.60±.26^{a}	52.24±.31^{a}
Age group		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
>5 yrs	144	11.32±.34^{b}	141.22±1.09^{b}	153.98±1.04^{b}	187.50±.86^{b}	38.43±.57^{b}	192.41±.86^{b}	213.02±1.15^{b}	236.04±1.06^{b}	485.37±5.42^{b}	39.50±.36^{b}	39.98±.31^{b}	55.23±.81^{b}	118.29±.87^{b}	53.90±.53^{b}	118.51±.81^{b}	26.17±.42^{b}	63.76±.50^{b}	56.43±.60^{b}
<5 yrs	156	9.91± .14^{a}	128.42±.88^{a}	144.69±.84^{a}	180.71±.69^{a}	33.69±.46^{a}	186.22±.68^{a}	205.17±.93^{a}	227.35±.86^{a}	436.61±4.36^{a}	37.68±0.30^{a}	37.93±.25^{a}	49.77±.65^{a}	113.20±.70^{a}	50.47±.43^{a}	113.42±.65^{a}	24.66±.34^{a}	60.60±.41^{a}	52.31±.48^{a}
Effect and level	N	EL	BL	FIL	HIL	FL	WH	HG	BG	BW	HW	CW	CD	NL	TL	HC	HL	FHc	HHc
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Sex by age		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
Male, >5 yrs	19	11.43±.11	144.33±2.04	157.62±1.94	191.15±1.60	39.82±1.07^{c}	198.39±1.58	215.95±2.14	239.56±1.9	513.86±10.09a	39.59±.66	41.52±.58	56.23±1.51	117.14±1.62	54.83±.99	116.26±1.50	26.70±.31^{b}	65.99±.99	58.38±1.11
Female, >5 yrs	125	11.21±.27	129.63±1.57	149.07±1.50	185.44±1.23	37.05±.42^{b}	192.35±1.22	210.10±.83	232.51±.77	464.12±7.78b	38.06±.51	40.04±.45	54.23±.59	119.44±.63	52.96±.39	120.76±.59	29.60±.31^{c}	63.55±.72	54.62±.85
Male, < 5 yrs	32	10.12±.21	138.11±.80	150.34±.76	183.85±.63	34.00±.42^{a}	186.43±.62	208.45±1.65	230.98±1.53	456.89±3.93b	39.41±.26	38.44±.23	50.24±1.17	112.87±.63	51.06±.76	112.38±1.16	22.63±.61^{a}	61.53±.37	54.48±.43
Female, <5yrs	124	9.66±.11	127.20±.80	140.31±.76	175.98±.63	33.37±.82^{a}	180.09±.62	201.88±.84	223.73±.78	409.11±3.95c	37.29±.26	35.81±.23	49.27±.59	113.53±1.24	49.89±.39	114.47±.59	22.74±.79^{a}	57.66±.37	49.99±.43
Age by district		NS	NS	NS	*	NS	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS
>5yrs, Yabello	70	11.45±.16	140.03±1.18	153.98±1.12	186.84±.92^{b}	37.85±.62	192.32±.91	211.32±1.23	231.07±1.14	463.13±5.82b	38.50±.38^{b}	40.86±.33^{d}	54.17±.87	117.99±.93	53.74±.57	117.07±.86	26.63±.46	63.89±.54	56.79±.64
>5yrs, M/S	74	11.51±.15	140.66±1.15	154.63±1.09	188.99±.89^{c}	37.45±.61	192.69±.89	217.94±1.20	241.02±1.11	506.36±5.67b	40.73±.37^{c}	39.85±.32^{c}	55.82±.85	119.84±.91	53.76±.56	120.92±.84	26.93±.45	64.27±.53	56.38±.62
<5yrs, Yabello	80	9.85±.14	129.50±1.10	144.29±1.01	181.37±.83^{a}	34.90±.56	185.26±.82	202.03±1.11	223.55±1.03	421.38±5.24a	37.12±.34^{a}	37.25±.30^{a}	49.28±.78	113.23±.84	50.15±.51	112.92±.78	24.56±.41	60.39±.49	52.62±.58
<5yrs, M/S	76	9.78±.15	128.16±1.11	144.74±1.10	179.44±.86b^{a}	33.23±.59	187.15±.86	205.04±1.15	231.05±1.07c	451.99±5.47	38.00±.36^{ab}	38.39±.31^{b}	50.46±.82	112.42±.88	50.97±.54	113.28±.81	24.10±.43	60.48±.51	51.82±.60

^{a,b,c}means on the same column with different superscripts within the specified age group are significantly different (P<0.05); Ns = Non- significant (P>0.05); BW = Body weight; BL = Body Length; HG = Heart Girth; BG= Barrel girth; WH = Wither height; FIL= Forelimb length; HIL= Hindlimb length; FL= Face length; EL = Ear Length; TL = Tail Length; HW= Hip width; CW= Chest width; CD= Chest depth; NL= Neck length; HC= Hump circumference; HL= Hump length; FHc= Fore hump circumference; HHc= Hind hump circumference; yrs= years

Correlation between body weight and linear body measurements

The Pearson's correlation coefficient among quantitative variables for all age group of male and female camels is presented in Table 11. Body weight was significantly ($P<0.05$) correlated with all continuous traits of both male and female camels considered in this study except neck length, hump length, fore hoof circumference and hind hoof circumference in male camels.

In male sample populations of linear body measurements, heart girth and barrel girth had strong positive correlation ($r= 0.93$) with body weight followed by wither height ($r=0.81$).The strong positive and significant correlation of body weight with barrel girth and heart girth suggest that these variables could provide a good estimate in predicting live weight for the population.

In female sample camels body weight had strong positive and significant ($P<0.05$) correlation with heart girth ($r=0.95$) followed by barrel girth ($r=0.93$) and this indicates that heart girth could provide a good estimate in predicting live weight than other variables.

Table 11. Correlation coefficients among body measurements and weight of males and females of Yabello and Melka Soda camels (values above the diagonal are for males and below the diagonal are for females) (N= 51 for male; N= 249 for females)

	EL	BL	FIL	HIL	FL	WH	HG	BG	BW	HW	CW	CD	NL	TL	HC	HL	FHc	HHc
EL		0.44*	0.	044*.53*	0.29*	0.44*	0.37*	0.37*	0.44*	0.34*	0.36*	0.20ns	0.34*	0.30*	0.44*	0.23ns	0.42*	0.43*
BL	0.50*		0.69*	0.64*	0.62*	0.63*	0.59*	0.45*	0.62*	0.41*	0.33*	0.62*	0.52*	0.42*	0.36*	0.01ns	0.48*	0.46*
FIL	0.54*	0.89*		0.66*	0.54*	0.62*	0.61*	0.53*	0.64*	0.34*	0.44*	0.34*	0.37*	0.40*	0.38*	0.36*	0.39*	0.50*
HIL	0.61*	0.72*	0.76*		0.57*	0.53*	0.60*	0.46*	0.59*	0.43*	0.35*	0.36*	0.41*	0.33*	0.41*	0.20ns	0.43*	0.42*
FL	0.34*	0.56*	0.63*	0.52*		0.43*	0.57*	0.35*	0.51*	0.34*	0.27ns	0.34*	0.49*	0.25ns	0.14ns	0.21ns	0.39*	0.33*
WH	0.52*	0.68*	0.70*	0.73*	0.50*		0.65*	0.61*	0.81*	0.43*	0.42*	0.42*	0.19ns	0.31*	0.53*	0.08ns	0.25ns	0.29ns
HG	0.40*	0.63*	0.63*	0.62*	0.40*	0.65*		0.84*	0.93*	0.54*	0.45*	0.39*	0.25ns	0.40*	0.61*	0.18ns	0.24ns	0.13ns
BG	0.42*	0.63*	0.64*	0.64*	0.40*	0.62*	0.89*		0.93*	0.52*	0.44*	0.40*	0.16*	0.40*	0.63*	0.15ns	0.20ns	0.07ns
BW	0.48*	0.70*	0.71*	0.71*	0.47*	0.80*	0.95*	0.93*		0.57*	0.46*	0.45*	0.24ns	0.41*	0.66*	0.15ns	0.25ns	0.17ns
HW	0.33*	0.33*	0.40*	0.46*	0.23*	0.40*	0.45*	0.47*	0.48*		0.32*	0.44*	0.46*	0.41*	0.45*	-0.15ns	0.27ns	0.10ns
CW	0.40*	0.44*	0.48*	0.49*	0.31*	0.46*	0.36*	0.37*	0.43*	0.38*		0.35*	0.18ns	0.44*	0.32*	0.23ns	0.45*	0.27ns
CD	0.33*	0.63*	0.57*	0.50*	0.44*	0.56*	0.59*	0.57*	0.63*	0.33*	0.37*		0.37*	0.39*	0.34*	-0.20ns	0.42*	0.35*
NL	0.49*	0.61*	0.68*	0.67*	0.53*	0.57*	0.53*	0.55*	0.59*	0.48*	0.43*	0.47*		0.37*	0.35*	-0.06ns	0.51*	0.24*
TL	0.42*	0.57*	0.58*	0.61*	0.41*	0.52*	0.50*	0.50*	0.55*	0.40*	0.45*	0.57*	0.50*		0.38*	-0.06ns	0.36*	0.09ns
HC	0.50*	0.66*	0.70*	0.73*	0.45*	0.66*	0.67*	0.68*	0.73*	0.46*	0.38*	0.57*	0.66*	0.54*		-0.12ns	0.29*	0.04ns
HL	0.49*	0.44*	0.50*	0.58*	0.37*	0.47*	0.44*	0.48*	0.50*	0.39*	0.34*	0.39*	0.48*	0.43*	0.65*		0.02ns	0.29*
FHc	0.47*	0.48*	0.60*	0.60*	0.35*	0.53*	0.58*	0.58*	0.61*	0.36*	0.39*	0.51*	0.45*	0.50*	0.61*	0.50*		0.52*
HHc	0.50*	0.59*	0.60*	0.58*	0.43*	0.57*	0.52*	0.52*	0.57*	0.33*	0.34*	0.45*	0.48*	0.42*	0.56*	0.45*	0.79*	

NS= Non-significant (P<0.05); * significant at 0.05 level; BW = Body weight; BL = Body Length; HG = Heart Girth; BG= Barrel girth; WH = Wither height; FIL= Forelimb length; HIL= Hindlimb length; FL= Face length; EL = Ear Length; TL = Tail Length; HW= Hip width; CW= Chest width; CD= Chest depth; NL= Neck length; HC= Hump circumference; HL= Hump length; FHc= Fore hump circumference; HHc= Hind hump circumference

Conclusions and Recommendation

The basic tool for improving camel production and productivity is improving the genetic makeup of the animal. In order to make this successful, identification, characterization and documentation of the existing camels and their production system has paramount importance.

There has to be extensive study to evaluate the reproductive and production performances of camel breeds of the country, so that the outcomes will suggest which breeds should be kept for what purposes as to the demand of the society and for the national economy. Breeding management should be improved and proper records should be kept of births, mating and possibly of production and awareness creation among pastoralists.

The wide hip and heavy weight exhibited by Melka Soda camel populations show their potential for meat production. But camels in Yabello have had potential for milk.

The attention should be given to exploit the performance of camels based on their specialization to fulfill the current demand of camel and camel by-products in the Borena and also in different parts of the country. The present study can be used to understand the camel resources of the Borena for future genetic improvement and conservation actions.

Acknowledgement

This work is MSc Thesis research of the first author who was supported by Ethiopian institute of Agricultural Research(EIAR) Livestock Research Directorate. We thank EIAR for financial support without which we wouldn't have done this study. We also thank employees of Yabello and Melka Soda Agriculture office for the unreserved cooperation and assistance during data collection. We also thank all pastoralists who allowed us to use their camels for free

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