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MORPHOMETRIC AND MILK YIELD ANALYSIS OF CAMEL BREEDS (*CAMELUS DROMEDARIUS*) IN QUETTA, BALOCHISTAN, PAKISTAN

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Abstract
This study investigated the morphometric characteristics and milk yield of different camel breeds (Camelus dromedarius) reared in and around Quetta, Balochistan, Pakistan. A total of 63 camels representing seven local breeds—Brahvi, Larri, Kharani, Tari (Indian), Afghani, Balochi, and Marecha—were evaluated over a six-month period. Morphometric traits, including wither height, thoracic girth, neck length, and head dimensions, were measured following standardized protocols. Results showed that Marecha camels possessed the longest head length (up to 50 cm), while the Larri breed exhibited the greatest thoracic girth (up to 200 cm). Significant variation in milk yield was also observed, with the Larri and Marecha breeds producing higher quantities compared to others. One-way ANOVA confirmed statistically significant differences ($p < 0.05$) in milk yield among breeds. These findings provide valuable baseline data on camel morphology and milk production traits in Balochistan, supporting efforts toward improved breeding programs and sustainable camel management practices.

Keywords: *Camel breeds, Balochistan, Camelus dromedaries, Milk yield, Morphometric analysis*

INTRODUCTION

Camels have historically sustained human societies in arid and semi-arid regions where other livestock fail to thrive. Their remarkable resilience to extreme heat, water scarcity, and limited feed resources makes them indispensable for pastoral communities. In Pakistan, the camel (*Camelus dromedarius*) is an economically important species, valued primarily for its milk, meat, and wool. Its unique physiological adaptations—such as wide body temperature fluctuations (34–42.1°C), the ability to store more than 110 liters of water, and tolerance to water loss exceeding 32%—enable survival under harsh desert conditions (1, 2).

Pakistan hosts 21 recognized camel breeds, broadly classified into riverine and mountain types. Balochistan is home to prominent breeds such as Brahvi, Kachhi, Kharani, Lassi, Makrani, Pishin, and Rodbari, while Khyber Pakhtunkhwa maintains Gaddi, Ghulmani, Bagri, and Barela breeds. Punjab rears Thalocha, Cambelpuri, Kala-Chitta, and Mareecha, whereas Sindh is known for Dhatti, Khari, Larri, Sindhi, and Sakrai breeds. Among these, Mareecha, Dhatti, Larri, and Sakrai are riverine types, whereas Cambelpuri and Kohi are mountain types (3).

Pakistan's camel population is estimated at around 0.8 million, the majority being one-humped dromedaries. Of these, 41.51% are found in Balochistan, 22.9% in Sindh, 27.5% in Khyber Pakhtunkhwa, and 7.96% in Punjab (4, 5). Despite this substantial population, camel milk and meat remain underutilized compared to other livestock products. Nevertheless, camels contribute significantly to food security in arid zones by producing milk and meat at low cost, while subsisting on feed resources generally unsuitable for other animals (6, 7).

Camel milk production averages 3–10 kg per day, with lactation lasting up to 12 months. Its nutritional composition includes 4.9% fat, 3.7% protein, 0.70% ash, and 14.4% total solids, making it richer in several nutrients compared to cow milk. In addition to its dietary value, camel milk is widely recognized for therapeutic properties and is traditionally used in managing liver disorders, diabetes mellitus, tuberculosis, respiratory ailments, skeletal diseases, and food allergies (8).

Given the economic potential of camels, their resilience under extreme environments, and the scarcity of published data on morphometric and milk production traits of Balochistan breeds, this study was conducted to document phenotypic characteristics and assess milk yield variation among camel breeds reared in and around Quetta.

METHODOLOGY

STUDY AREA AND DURATION

The study was carried out in and around Quetta, Balochistan, Pakistan, over a period of 18 months, with field data collected during a six-month interval corresponding to peak lactation seasons. Quetta lies in a semi-arid agro-ecological zone at an altitude of approximately 1,680 meters above sea level. The region experiences harsh climatic conditions, with temperatures ranging from −2°C in winter to as high as 40°C in summer. Such environmental variability provides a natural setting for assessing the adaptability and productivity of different camel breeds.

SAMPLE SIZE AND SELECTION

A total of 63 camels (*Camelus dromedarius*) representing seven local breeds—Brahvi, Larri, Kharani, Tari (Indian), Afghani, Balochi, and Marecha—were included in the study. Animals were selected through convenience sampling from private herders and smallholder camel farms located within the study area. Selection criteria included apparent good health, absence of visible deformities, and willingness of herders to participate. Both male and female camels were included for morphometric analysis, while only lactating females were considered for milk yield evaluation.

DATA COLLECTION PROCEDURES

Morphometric and production data were collected through direct physical measurements. All measurements were conducted in the early morning hours while camels were calm and at rest, to reduce variability associated with diurnal fluctuations and movement. A non-elastic measuring tape was used for linear body measurements, while weighing scales with 0.1 kg precision were used where necessary. To minimize observer bias, the same trained personnel recorded all measurements throughout the study.

PHENOTYPIC MEASUREMENTS

Standardized protocols were followed to ensure accuracy and comparability with previous studies on camel morphology. Morphometric traits were carefully recorded for each animal. Head measurements included head length, measured from the poll to the muzzle, and head width, taken between the zygomatic arches. Body measurements included wither height, taken from the ground to the top of the scapula; thoracic girth, measured at the point of maximum chest expansion just behind the forelimbs; neck length, recorded from the poll to the withers; abdominal girth, taken at the widest portion of the abdomen; tail length, measured from the base to the tip of the tail; and ear length. These parameters were selected to provide a comprehensive assessment of external body conformation, which may influence overall productivity and milk yield in camels.

MILK PRODUCTION, MILK HANDLING AND RECORDING

Daily milk yield was assessed for each lactating female using hand milking over three consecutive days. Milk output was collected in calibrated containers, averaged, and expressed in liters per day. Calves were separated for 8–10 hours before milking to standardize udder fullness.

All milk samples were handled hygienically, and containers were sterilized before use to avoid contamination. Records were maintained for parity, stage of lactation, and age of the lactating camels whenever such information was provided by herders.

STATISTICAL ANALYSIS

Data were entered and analyzed using SPSS (version XX) and Microsoft Excel. Descriptive statistics (mean ± standard deviation) were calculated for all morphometric traits and milk yield. Breed-wise differences in morphometric characteristics and milk yield were tested using one-way analysis of variance (ANOVA). When ANOVA indicated significance ($p < 0.05$), the Least Significant Difference (LSD) post hoc test was applied to identify pairwise differences between breeds. Pearson's correlation analysis was also performed to explore associations between morphometric traits and milk yield.

RESULTS

A total of 63 camels were evaluated, comprising 27 males and 36 females. Significant morphometric variation was observed among breeds, particularly in head length, wither height, and thoracic girth. Milk yield analysis revealed clear differences across breeds: Larri and Marecha camels produced the highest average yields, 5.2 L/day and 4.9 L/day respectively, whereas Balochi camels had the lowest yield at 2.8 L/day. One-way ANOVA confirmed that these differences in milk production were statistically significant ($p < 0.05$).

Breed distribution within the study area showed that the Larri breed was the most prevalent, representing 58.7% of the total sample, followed by Marecha (22.2%) and Brahvi (20.6%). In contrast, the Kharani, Tari (Indian), Afghani, and Balochi breeds were present in smaller numbers. Gender representation across breeds indicated that females constituted the majority (57.1%) of the sample, while males accounted for 42.9%. The highest proportion of female camels was recorded in the Larri breed, whereas Kharani and Balochi breeds had the lowest female representation, with only one female recorded in each case (Table I and II).

Table I. Frequency distribution of camel breeds

Camel Breed	Frequency	Percentage	Cumulative percentage
Barahvi	13	20.6	20.6
Kharani	5	7.9	28.6
Laari	19	30.2	58.7
Indian/Tari	5	7.9	66.7
Afghani/Budah	4	6.3	73.0
Balochi/Pahari	3	4.8	77.8
Marecha	14	22.2	100.0
Total	63	100.0	

Table II. Frequency distribution of gender of camels

Gender	Frequency	Percent	Cumulative Percent
Male	27	42.9	42.9
Female	36	57.1	100.0
Total	63	100.0	

Comparative analysis suggests that the predominance of the Larri breed may be linked to its higher milk productivity and adaptability, making it more favorable for herders in the Quetta region. Marecha camels, although less numerous, also demonstrated high milk yield potential, highlighting their economic importance. Conversely, the relatively low yields observed in the Balochi breed may explain their limited presence in the sampled herds. These findings underscore the influence of both productivity traits and environmental adaptability in shaping breed distribution and selection by local farmers.

Table III presents the head length measurements of camels in centimeters, highlighting clear inter-breed variation in phenotypic traits. Larri and Marecha camels exhibited the longest head lengths, ranging from 35 to 45 cm, indicating their relatively larger body conformation. In contrast, Indian (Tari) and Balochi camels displayed comparatively smaller head dimensions, with lengths ranging between 20 and 35 cm. These differences reinforce the breed-specific morphological diversity observed in the study population and suggest potential links between body size and overall productivity.

Analysis of neck length and abdominal girth revealed clear breed- and sex-based differences among the camels studied. Male camels generally exhibited longer necks compared to females, particularly in the Laari and Marecha breeds. Abdominal girth also showed marked variation, with females presenting comparatively wider girths, reflecting their higher physiological demand for reproduction and lactation. In contrast, male camels, especially in the Balochi and Kharani breeds, had relatively smaller abdominal girths. These differences were statistically significant ($p < 0.05$), highlighting the influence of both sex and breed on morphometric parameters (Fig. 2).

Table IV presents the distribution of camel breeds across different wither height categories, separated by gender. The data indicate notable phenotypic variation, with Larri and Marecha breeds predominantly occupying the higher wither height ranges. Significant differences were also observed between males and females, reflecting sexual dimorphism in body conformation.

Thoracic girth, another key morphometric trait, varied considerably among breeds as shown in Table V. Larri camels exhibited the largest thoracic girths, underscoring their robust body structure and potential link to higher milk yield. In contrast, Balochi camels recorded the smallest thoracic girths, ranging from 80 to 110 cm, suggesting comparatively smaller body frames within this breed.

Table III. Camel breed head length gender of camel cross tabulation

Gender of camel		Head length					Total
		25-30	30-35	35-40	40-45	45-50	
Male camel breed	Barahvi	0	0	4	0	0	4
	Kharani	0	0	4	0	0	4
	Laari	1	2	0	0	2	5
	Indian/Tari	5	0	0	0	0	5
	Afghani/Budah	0	4	0	0	0	4
	Balochi/Pahari	2	0	0	0	0	2
	Marecha	0	0	0	0	3	3
	Total	8	6	8	0	5	27
Female camel breed	Barahvi	0	0	9	0	0	9
	Kharani	0	0	1	0	0	1
	Laari	2	12	0	0	0	14
	Balochi/Pahari	1	0	0	0	0	1
	Marecha	0	0	3	6	2	11
	Total	3	12	13	6	2	36
Total camel breed	Barahvi	0	0	13	0	0	13
	Kharani	0	0	5	0	0	5
	Laari	3	14	0	0	2	19
	Indian/Tari	5	0	0	0	0	5
	Afghani/Budah	0	4	0	0	0	4
	Balochi/Pahari	3	0	0	0	0	3
	Marecha	0	0	3	6	5	14
	Total	11	18	21	6	7	63

Table IV. Camel breeds wither height gender of camel cross tabulation

Gender of camel		Wither height					Total
		155-165	165-175	175-185	185-195	155-165	
Male camel breed	Barahvi	0	4	0	0	4	0
	Kharani	0	0	4	0	4	0
	Laari	0	0	5	0	5	0
	Indian/Tari	5	0	0	0	5	5
	Afghani/Budah	0	0	4	0	4	0
	Balochi/Pahari	2	0	0	0	2	2
	Marecha	0	0	0	3	3	0
	Total	7	4	13	3	27	7
Female camel breed	Barahvi	0	9	0	0	9	0
	Kharani	0	0	1	0	1	0
	Laari	0	0	9	5	14	0
	Balochi/Pahari	1	0	0	0	1	1
	Marecha	0	0	11	0	11	0
	Total	1	9	21	5	36	1
Total camel breed	Barahvi	0	13	0	0	13	0
	Kharani	0	0	5	0	5	0
	Laari	0	0	14	5	19	0
	Indian/Tari	5	0	0	0	5	5
	Afghani/Budah	0	0	4	0	4	0
	Balochi/Pahari	3	0	0	0	3	3
	Marecha	0	0	11	3	14	0

Total	8	13	34	8	63	8

DISCUSSION

The primary objective of the current study was to identify various camel breeds present in Quetta city and to document their phenotypic characteristics. This effort contributes toward establishing a framework for a phenotypic biobank, which may support future research on camel biodiversity, conservation, and performance traits. A secondary objective was to compare milk production across these breeds, which is of particular relevance given the growing demand for camel milk as a functional food.

Numerous studies have confirmed that camels are exceptional livestock animals due to both natural selection and selective breeding (9). The present study aligns with this evidence, reaffirming the importance of camels as a source of milk, meat, and draught power in arid regions. Comparative analyses between bovine and camel milk suggest that camel milk is richer in vitamin C and niacin, which enhances its nutritional value under conditions of heat stress (10). It also contains a higher water content, which increases its utility in desert climates where hydration is critical (11). Additionally, camel milk lacks β-lactoglobulin, a major allergen in bovine milk, and has higher β-casein content, making it potentially safer for individuals with cow-milk protein allergies (12).

Table V. Camel breed thoracic girth gender of camel cross tabulation

Gender of camels		Thoracic girth					Total
		80-110	110-140	140-170	170-200	200-230	
Male camel breed	Barahvi	0	0	0	4	0	4
	Kharani	0	0	0	4	0	4
	Laari	0	0	1	4	0	5
	Indian/Tari	5	0	0	0	0	5
	Afghani/Budah	3	1	0	0	0	4
	Balochi/Pahari	2	0	0	0	0	2
	Marecha	3	0	0	0	0	3
	Total	11	1	1	13	1	27
Female camel breed	Barahvi	0	0	0	9	0	9
	Kharani	0	0	0	0	1	1
	Laari	0	0	4	10	0	14
	Balochi/Pahari	1	0	0	0	0	1
	Marecha	11	0	0	0	0	11
	Total	12	0	4	19	1	36
Total camel breed	Barahvi	0	0	0	13	0	13
	Kharani	0	0	0	4	1	5
	Laari	0	0	5	14	0	19
	Indian/Tari	5	0	0	0	0	5
	Afghani/Budah	3	1	0	0	0	4
	Balochi/Pahari	3	0	0	0	0	3
	Marecha	14	0	0	0	0	14
	Total	23	1	5	32	2	63

Despite these nutritional advantages, camel milk remains underutilized in processed food industries. Technical limitations hinder its transformation into powdered milk or its incorporation into infant formula (13). Advances in food technology, including novel enzymatic treatments and microencapsulation techniques, could provide opportunities to expand its application in nutraceuticals and functional foods (14).

Camel species exhibit distinct ecological adaptations. The one-humped dromedary (*Camelus dromedarius*) thrives in hot, arid regions across Africa, the Middle East, and South Asia, where its ability to withstand dehydration and heat stress gives it a survival advantage (15). In contrast, the two-humped Bactrian camel (*Camelus bactrianus*) inhabits cold desert regions such as Mongolia, Kazakhstan, and parts of China, where its thick coat, fat reserves, and physiological adaptability support survival in extreme cold (16). The existence of wild Bactrian camels (*Camelus ferus*) in the Gobi Desert further highlights the resilience and evolutionary diversity of the Camelidae family (17).

The domestication of camels in Balochistan and neighboring regions—including Afghanistan, Iran, and India—represents a vital historical and cultural achievement. Camels remain central to the socio-economic fabric of pastoral communities in arid and semi-arid areas (18). Their milk serves as a key source of nutrition, particularly during prolonged droughts, when access to alternative food sources is limited. Moreover, camels are known to reproduce under harsh ecological conditions, ensuring herd sustainability even when environmental constraints are severe (19).

However, camel production in Pakistan is constrained by socio-economic factors, limited veterinary services, and inadequate institutional support (20). Traditional herders face challenges related to feed scarcity, lack of disease control programs, and limited access to markets (21). These constraints not only reduce productivity but also threaten the sustainability of camel populations in the region. Strengthening camel husbandry practices, improving disease surveillance, and enhancing value chain opportunities for camel milk and meat could significantly improve livelihoods in Balochistan.

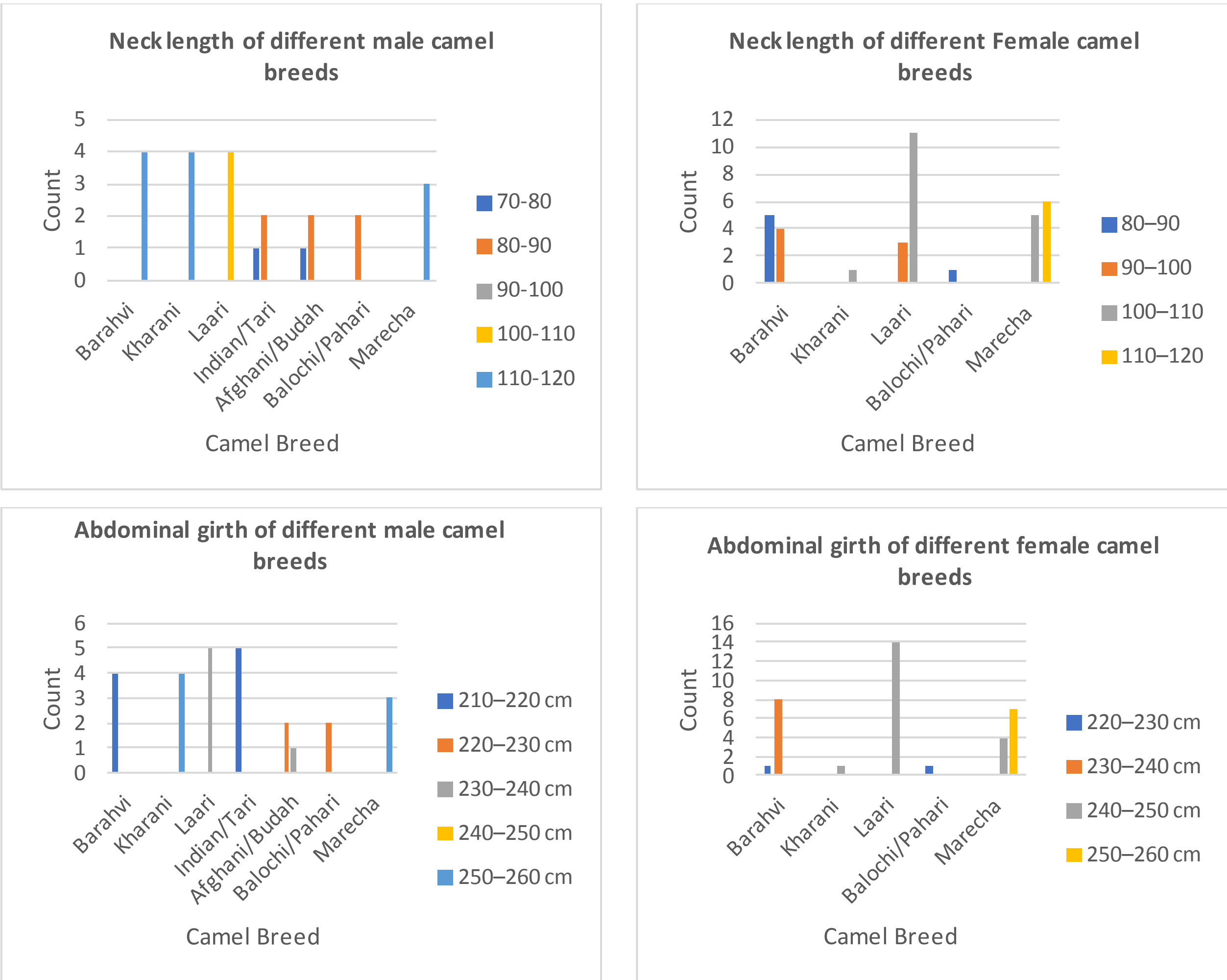

Fig. 2. Neck length and abdominal girth of different male and female camel breeds

The results of this study revealed significant morphometric variations among breeds in Quetta, particularly in head length, thoracic girth, and wither height. Such phenotypic traits are critical in breed identification and selection programs. Larri and Marecha breeds were associated with larger body sizes and higher milk production, while Balochi camels exhibited smaller body frames and lower yields. These findings are consistent with previous studies in Pakistan, which have reported breed-based differences in productivity and adaptability (22).

Phenotypic variation not only reflects genetic diversity but also indicates the influence of ecological adaptation. For instance, larger thoracic girth is associated with greater lung capacity and endurance, enabling camels to travel long distances under desert conditions (23). Similarly, wither height is an important trait linked to load-bearing capacity, which has historically been a significant function of camels in trade and transport (24).

Camel milk production is a vital livelihood resource, particularly for pastoralists in Balochistan. The present study identified Larri and Marecha breeds as superior milk producers compared to Balochi camels.

These results mirror findings from other regions of Pakistan, including Sindh and Punjab, where Larri camels are reported to yield up to 10 liters per day under optimal management (25). By contrast, Balochi camels are primarily used for transportation and draught purposes, with lower emphasis on milk production (26).

Camel milk's nutritional and medicinal properties continue to draw global attention. It has been shown to contain insulin-like proteins with hypoglycemic effects, making it potentially beneficial for diabetic patients (27). Furthermore, its bioactive peptides and antimicrobial proteins, including lactoferrin and lysozyme, contribute to its therapeutic potential (28). Clinical studies suggest that regular camel milk consumption can aid in the management of diabetes, autism spectrum disorders, and certain gastrointestinal conditions (29).

Accurate estimation of live body weight in camels is challenging due to handling and restraining difficulties, making prediction models essential for feeding, marketing, and veterinary purposes. In a related study on eight indigenous breeds of Pakistan, artificial neural networks (ANN) provided the most accurate predictions of adult body weight, with breed emerging as the key influencing factor (30). These findings complement our current study, where phenotypic traits such as wither height, thoracic girth, and abdominal girth also reflected significant breed-based variations, reinforcing the role of morphology in assessing camel productivity. The documentation of phenotypic traits in camel breeds, as carried out in this study, contributes to conservation biology by providing baseline data for genetic resource management. With increasing threats from climate change, urbanization, and declining pastoral systems, camel genetic diversity faces potential erosion (31). Establishing phenotypic biobanks and integrating them with genomic databases can help ensure long-term preservation of these unique genetic resources (32).

In the future, camel research should focus on molecular characterization, genomic selection, and biotechnological interventions to improve productivity and resilience. Advances in reproductive technologies, such as artificial insemination and embryo transfer, could accelerate breed improvement programs (33). At the same time, policy frameworks must support camel herders through improved extension services, market linkages, and capacity-building programs.

CONCLUSION

The current study highlights the significant phenotypic variability among camel breeds in Quetta and underscores the superior milk yield of Larri and Marecha breeds. These findings reinforce the socio-economic importance of camels in arid environments and provide a basis for future genetic, nutritional, and conservation research. Strengthening camel production systems through scientific innovation, market integration, and institutional support will be crucial for harnessing the full potential of this species in Pakistan and beyond.

Authors' contribution:

NM, TA, ZH & WK Research work; NR Conceptualization, data analysis and supervision.

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