



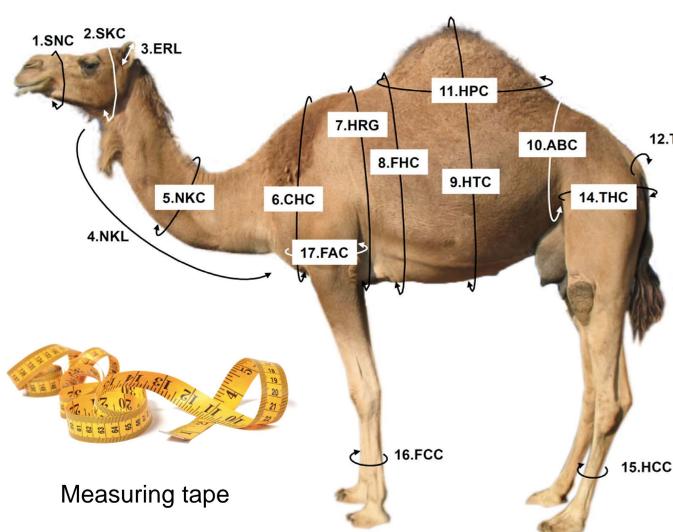
Methods of quantifying morphological variation in *Camelus dromedarius* breeds

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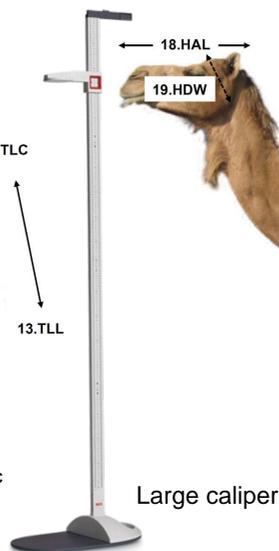
1. Introduction

- The dromedary (*Camelus dromedarius*), also known as the Arabian camel, is a single-humped ungulate—the smallest of the three extant camel species.
- All camels are characterized by having long limbs, thick lips, a humped back, and being extremely adapted to desert environments.
- Dromedaries are found throughout the Palearctic desert belt—from the Saharan Desert, spanning the Arabian Desert, and reaching parts of India (it has also been introduced to Australian deserts).
- The importance of camels to humans stems from their ability to withstand harsh conditions—most notably, the combination of being able to carry (and transport) heavy loads, and to survive long periods (up to five days) without water.
- Camels are used to produce milk, meat, wool, and leather products. Different camel breeds (bred for different traits) are also commonly used in racing competitions and 'beauty pageants' / Mezayen.
- Many studies [1-10] collected morphometric measurements from recognized camel breeds, but their phenotypic boundaries remain partly subjective.
- The main pitfalls of previous studies include:

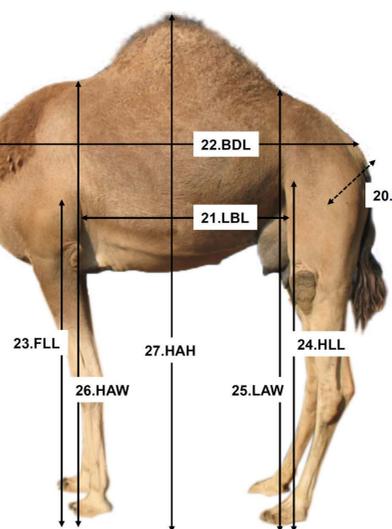
- the relatively few number of morphometric measurements collected.
- the uneven distribution of measurements (i.e. not covering all body parts and not covering all functionally important traits).
- the limited sampling, both in geographic region and in breeds (i.e. being focused on few breeds, that occur in a particular country/region).



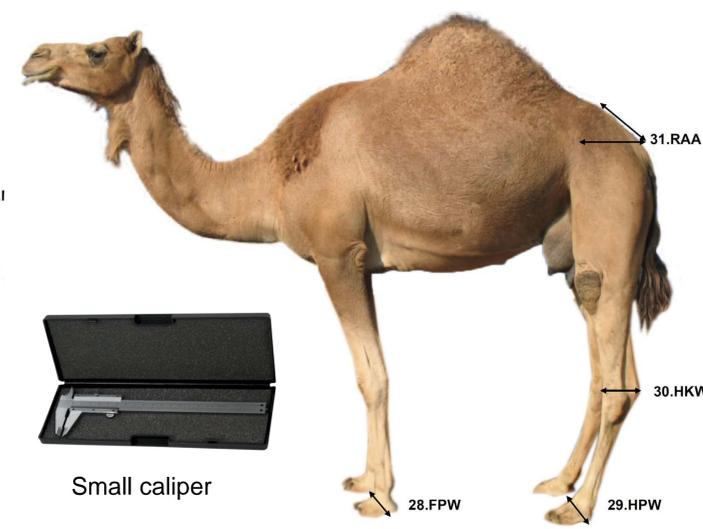
Measuring tape



Large caliper



Small caliper



- | | | | | | |
|-------------------------------------|--|---|--|------------------------------------|-------------------------------------|
| 1. SNC : snout circumference | 6. CHC : chest circumference | 11. HPC : hump dorsal circumference | 16. FCC : front cannon bone circumference | 21. LBL : lower body length | 26. HAW : height at withers |
| 2. SKC : skull circumference | 7. HRG : heart girth | 12. TLC : tail circumference | 17. FAC : forearm circumference | 22. BDL : body length | 27. HAH : height at hump |
| 3. ERL : ear length | 8. FHC : frontal hump circumference | 13. TLL : tail length | 18. HAL : head length | 23. FLL : forelimb length | 28. FPW : forefoot pad width |
| 4. NKL : neck length | 9. HTC : hump body circumference | 14. THC : thigh circumference | 19. HDW : head width | 24. HLL : hindlimb length | 29. HPW : hindfoot pad width |
| 5. NKC : neck circumference | 10. ABC : abdominal circumference | 15. HCC : hind cannon bone circumference | 20. MRW : rump width | 25. LAW : length at hips | 30. HKW : hock width |
| | | | | | 31. RAA : rump area angle |

4. Other morphological traits

- Geometric shape and discrete characters can be extracted from photographs.
- Photographs were taken with the recently developed iOS application, SampleEase (Alhaddad and Alhajeri, in prep.), which directly associates samples with photographs.
- Labels of known size (e.g. orange stickers - 3 cm in diameter) were placed on the camels prior to photography, to enable the extraction of size information from photographs using a scaling factor.



2. Objectives

- The objectives of this research endeavor are to:
 - develop a standardized approach to quantify the morphological variation within and among dromedary camel breeds.
 - collect morphological measurements of most camel breeds that occur in the Arabian peninsula.
 - establish a world-wide database of camel attributes, that includes:
 - linear and geometric body measurements.
 - discrete (e.g. ear type) and continuous (e.g. coat color) data.
 - quantitative traits (e.g. milk production and racing performance).
 - medical condition.
 - develop a predictive test of camel performance in different fields, based on camel morphology (e.g. B-score: Beauty score, H-score: Hijin score, M-score: milk production score).

3. Morphometric measurements

- Over 100 measurements were initially selected to encompass the external morphology of camels.
- Only 31 of these measurements were retained for being: (1) used in most studies conducted on camels and other similar mammals, (2) relatively easy to collect, (3) measurable by widely available tools, (4) fast to measure, and (5) sufficient to provide an overall representation of camel morphology.
- Linear measurements are collected using calipers of different sizes; circumferences and angles were collected with a tape measure and an angle measurement tool, respectively.

5. Want to participate?

Are you interested in learning more about camels?

Do you want to assist in data collection?

Do you know someone who has access to camels that we can examine?

If so, please contact us by email at: bader.alhajeri@gmail.com

6. Acknowledgments

We thank all the camel breeders who generously provided access to their camels. Without their cooperation, this scientific research endeavor would not be possible.

7. References

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