DOI : 10.5958/2277-8934.2015.00044.2 *Vol 22 No 2, p 265-270*

PHENOTYPIC CLASSIFICATION BASED ON BODY MEASUREMENTS AND BODY FEATURES OF SOME SAUDI CAMEL TYPES (*Camelus dromedarius*)

Abdelaziz A. Fadlelmoula[1,2], Mohammed S. Mudarris[1] and Mohammed S. Hariri[1]

[1]Faculty of Sciences and Arts, Al-Kamel, Department of Biology,
King Abdulaziz University-Jeddah, P.O. Box: 110, 21931 Al-Kamel-KSA
[2]Faculty of Animal Production, Department of Genetics and Animal Breeding,
University of Khartoum, P.O.Box:32, 13314, Shambat, Sudan

ABSTRACT

This study was conducted to identify the homogenous groups of some Saudi camel types based on their quantitative and qualitative body features, 10 body measurements (neck length, heart girth, barrel girth, hip girth, body length, leg length, hip length, wither height, body height and arm length) from 223 camels belonging to five different camel types (Homor, Majaheem, Wadha, Awadi and Saheli) were recorded and subjected to statistical analysis. Results revealed that the quantitative body measurements for both males and females in Majaheem, Wadha and Homor were significantly ($p< 0.05$) higher than the measurements in Awadi and Saheli. Correlation coefficients were found to be varied between 0.10-0.88 for males, and between 0.05-.77 for females. Cluster analysis resulted in identification of three classes of camel types according to their quantitative body measurements (large size camel type, medium size camel type and small size camel type). The study findings could be utilized for description of body conformation and contribution to camel breeding improvement programs in the area.

Key words: Body measurements, cluster analysis, description, phenotypes, Saudi camel types

The Kingdom of Saudi Arabia is endowed with diverse types of camels including Majaheem or Magateer, Sofor, Homor, Wadha, Awadi and many other locally named types, which are belonging to Dromedary camel breeds. However, the morphological and ecological classifications of camel populations in Kingdom of Saudi Arabia are not yet clear (Almathen *et al,* 2012). Based on their utility, Saudi Arabian locally raised camel populations were earlier being divided into two distinct groups which are racing and production camels (Al-Eknawh *et al,* 1997, unpublished data). Recent studies showed that with the increase of population growth, milk and meat production of indigenous camel in Saudi Arabia increased tremendously to a proportion of 5.4%/year and 6.4%/year respectively (Faye and Bonnet, 2012). Research studies showed that characterization of livestock based on their phenotypic trait variants is a step of paramount importance towards the use of the available animal genetic resources (AnGR) (Delgado *et al,* 2001 and Lanari *et al,* 2003). Faye *et al* (2011) used coat colour as a criterion for description of many Saudi camel breeds, since the classification of camel populations based on ecological and morphological features were not obvious (Almathen *et al,* 2012). In some research studies the body measurements were used as criteria for the description of camel phenotype, Abdalla and Faye (2012) found no significant correlation of body measurements as a tool for phenotypic classification, but they concluded that thigh circumference is a good indicator of camel conformation. However, Ishag *et al* (2011) found significant differences among Sudanese camel breeds in the study according to their body measurements. However, in Kenya ethnic group and geographical distribution of the pastoral communities were mostly used for classification of camel breeds, although some phenotypic variants of some breeds were obtained (FAO Yearbook, 2001). A summary of the general the phenotypic characteristics of the local Kenyan camel breeds were also given (Simpkin, 1998), but the extent of the genetic differentiation is unknown (Kaufmann, 1998).

The present study was conducted to describe the camel types in the study area on the bases of their quantitative body measurements as well as qualitative body features in order to identify the classes with similar body features.

SEND REPRINT REQUEST TO ABDELAZIZ A. FADLELMOULA email: abdelazizfadlelmoula@gmail.com

Materials and Methods

Study Area

The study occupied an area estimated to be more than 10,000 km^2 in Makkah region-KSA. The covered area extends between latitude 220 N to 230 N. Resident people in the study area are mainly farmers and livestock keepers which are traditionally raised. The area is heavily populated with livestock mainly sheep and goat and camels distributed in 10 centres. Livestock populations mainly recognised by ethnic and/or geographic nomenclature.

Data Collection

Body measurements were accomplished on standing animal using a ribbon-meter and measurements were reported in meter. Data on the following distances were collected:

(1) Neck length (NL): the distance from the base of the head to the chest.
(2) Heart girth (HRG): the circumference just in front of the hump.
(3) Barrel girth (BG): the distance from the highest point of the hump and around the body.
(4) Hip girth (HG): the circumference around the hip area.
(5) Body length (BL): the horizontal distance from the point of shoulder to the pin bone of the hip.
(6) Leg length (LL): the distance from the pin bone of the hip to the ground.
(7) Hip height (HH): the distance from the top point of the hip to the ground.
(8) Wither height (WH): the distance from the bottom of the foot to the highest point of the Wither.
(9) Body height (BH): the distance from the highest point of the hump to the ground.
(10) Arm length (AL): the distance from the point in front of the sternum to the ground.

Data involving 223 camel types (54 males and 169 females) belonging to 5 camel types at age more than 8 years from 9 different locations was collected. Age estimation was based on dentition, owners and animals attendants' information. The frequency distribution of the data collected is shown in table (1).

Data Analysis

SAS-Package (SAS, 2009) was used to analyse the data in order to identify the source of variations. Frequency distribution of camel types per location was calculated using the frequency procedure. Multivariate analysis was employed to describe each camel type in term of mean and variations within camel types to state the significant differences of quantitative body measurements between types. Pearson correlation coefficients were carried out for each sex in order to evaluate the correlation between the different quantitative body measurements. Cluster analysis was used to identify the homogenous groups of individuals in the studied herds of camels. Results are expressed as means and the level of significance set at $P< 0.05$. Analysis was carried out separately for each sex.

Table 1. Frequency distribution of sampled camel types per location.

Location	Female	Male	Total	Percentage
Algoar	15	5	20	08.97
Almazae	20	4	24	10.76
AL Dawara	10	1	11	04.93
Ehala	15	3	18	08.07
Osfan	29	7	36	16.14
Harat Al-Sharae	10	2	12	05.38
Al-Kamel	21	16	37	16.59
Al-Heno	29	12	41	18.39
Al-Ogla	20	4	24	10.76
	169	**54**	**223**	**100%**

Results

Distribution of camel herds in the region

The study revealed that camel populations in the studied area are widely distributed (Table 1).

Variations in mean body measurements

Results in table (2) clearly showed that in Homor, Majaheen and Wadha male camel types the body measurements studied were significantly higher than the same measurements in Saheli and Awadi. The variation was obvious in barrel girth, which was higher in Majaheem followed by Homor than Wadha, Salei and Awadi at the end with significant differences among the types. Between the types, Majaheem was found to have the highest body measurements that were significantly different from Homor camel types in barrel girth, body length and body height measurements.

The body measurements in females followed the same trend as in males; Majaheem, Homor and Wadha are of significantly higher quantitative body measurements compared to Saheli and Awadi (Table 3). In the first group (Majaheem, Homor and Wadha),

Table 2. Mean of male body measurements (m) in five Saudi camel types.

Body measurements	Homor	Majaheem	Wadha	Saheli	Awadi
NL	1.10^{a}	1.13^{a}	1.12^{a}	0.98^{b}	1.00^{b}
HRG	2.27^{a}	2.29^{a}	2.30^{a}	1.98^{b}	1.95^{b}
BG	2.39b	2.46^{a}	2.28^{ab}	2.13^{c}	2.07^{bc}
HG	1.55^{a}	1.59^{a}	1.56^{a}	1.49^{b}	1.40^{ab}
BL	1.70^{b}	1.77^{a}	1.67^{b}	1.56^{ab}	1.58^{ab}
LL	0.99^{a}	1.06^{a}	0.98^{a}	0.86^{b}	0.87^{b}
HH	1.34^{a}	1.37^{a}	1.29^{b}	1.16^{ab}	1.19^{ab}
WH	1.92^{a}	1.94^{a}	1.89^{b}	1.83^{ab}	1.87^{b}
BH	1.98^{b}	2.05^{a}	1.99^{b}	1.90^{c}	1.94^{ab}
AL	1.04^{a}	1.08^{a}	1.02^{a}	0.91^{b}	0.95^{b}

Different superscript in the same raw indicate significance at $P < 0.05$

Table 3. Mean of female body measurements (m) in five Saudi camel types.

Body measurements	Homor	Majaheem	Wadha	Saheli	Awadi
NL	1.02^{a}	1.04^{a}	1.03^{a}	0.92^{b}	0.94^{b}
HRG	2.18^{a}	2.20^{a}	2.19^{a}	1.85^{c}	1.89^{b}
BG	2.52^{b}	2.56^{a}	2.43^{ab}	2.20^{bc}	2.18^{bc}
HG	1.62^{a}	1.65^{a}	1.61^{a}	1.42^{ab}	1.48^{b}
BL	1.60^{b}	1.68^{a}	1.60^{b}	1.53^{ab}	1.56^{ab}
LL	0.95^{a}	0.97^{a}	0.92^{b}	0.84^{c}	0.88^{ab}
HH	1.24^{a}	1.26^{a}	1.20^{b}	1.13^{c}	1.19^{ab}
WH	1.83^{a}	1.85^{a}	1.80^{b}	1.72^{c}	1.79^{ab}
BH	1.88b	1.93^{a}	1.87^{b}	1.78^{c}	1.83^{ab}
AL	0.98^{a}	1.00^{a}	0.95^{b}	0.90^{ab}	0.93^{b}

Different superscript in the same raw indicate significance at $P < 0.05$

Majaheem scored the overall significantly greater body measurements compared to Homor and Wadha. However; body girth, hip girth, leg length, wither height and arm girth were the measurements that showed significant variations between Saheli and Awadi camel types.

The mean body measurements were found to be higher in males than in females except for body and wither girths which were higher in females compared to males camel types.

Correlation matrix between body measurements

Correlation matrix was attained for males and females group of camel types. Significant positive correlations were shown among most of the body measurements (Table 4). Correlations between various quantitative body measurements varied between 0.10-0.88 for males, and between 0.05-.77 for females. Negative non significant correlations were encountered for females between neck length and heart girth (-0.03), leg length and body length (-0.01), barrel girth and arm length (-0.12) and between body height and arm length (-0.11). For males; the highest significant ($p< 0.05$) positive correlation was found between arm length and wither height (0.88), arm length and hip height (0.84) and arm length and leg length (0.80), where as the lowest significant positive correlations were between heart girth and hip girth (0.25), barrel girth and hip height (0.26) and between body length and wither height (0.28).

For females; the highest significant ($p<0.05$) positive correlation was between wither height and hip height (0.77) and the significant lowest correlation was between hip girth and neck length (0.17).

Clustering of the camel groups

Cluster analysis (Fig 1 and Table 5) revealed three groups of camel types explaining 80% of the

Table 4. Correlations between body measurements in male (above diagonal) and female (below diagonal) Saudi camel types.

Body measurements	NL	HRG	BG	HG	BL	LL	HH	WH	BH	AL
NL		0.20ns	0.06ns	0.10ns	0.20ns	0.02*	0.55*	0.53*	0.15ns	0.44*
HRG	0.29*		0.34*	0.25*	0.22ns	0.12ns	0.16ns	0.21ns	0.01ns	0.19ns
BG	0.14ns	0.19*		0.36*	0.06ns	0.29*	0.26*	0.39*	0.28*	0.37*
HG	0.17*	0.24*	0.47*		0.33*	0.70*	0.65*	0.57*	0.37*	0.63*
BL	0.54*	0.32*	0.42*	0.38*		0.32*	0.38*	0.28*	0.14ns	0.35*
LL	0.35*	0.28*	0.13ns	0.26*	0.36*		0.82*	0.69*	0.31*	0.80*
HH	0.48*	0.33*	0.19*	0.37*	0.58*	0.57*		0.79*	0.35*	0.84*
WH	0.46*	0.34*	0.05ns	0.32*	0.49*	0.50*	0.77*		0.55*	0.88*
BH	0.22*	-0.03ns	0.18*	0.09ns	0.19*	-0.01ns	0.15ns	0.23*		0.58*
AL	0.20*	0.15ns	-0.12ns	0.13ns	0.12ns	0.35*	0.40*	0.41*	-0.11ns	

*= $P< 0.05$, ns= not significant ($P> 0.05$)

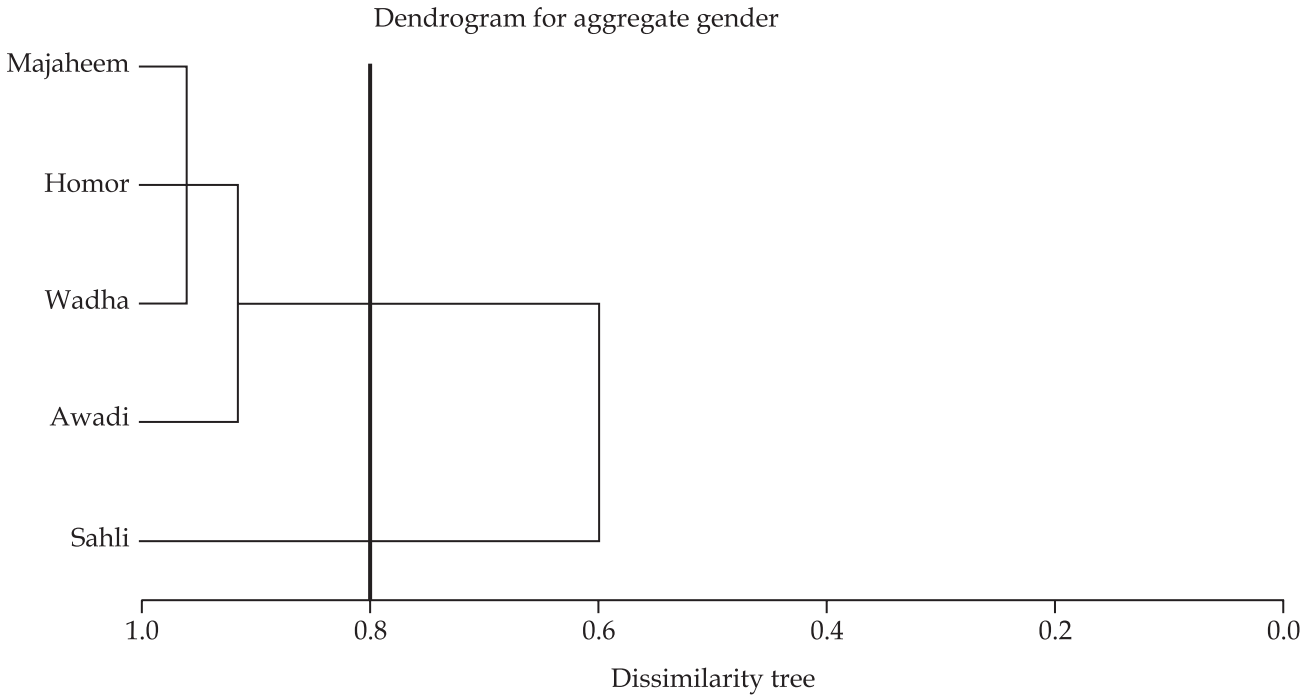

Fig 1. Hierarchical classification tree according to quantitative body measurements of five Saudi camel types in Makkah region-KSA (vertical thick line indicates 0.8 dissimilarity).

variance with optimal partitioning, the first class included Majaheem, Wadha and Homor. This group is characterized by high quantitative body measurements of neck length, heart girth, hip girth and body height. The second class included only Awadi type which is separated from the first class it is characterised by medium quantitative body measurements. In the third class found the Saheli camel type, which is characterised by relatively small quantitative body measurements compared to the other classes.

Table 5. Mean Body measurements (m) of the three cluster of aggregate gender of camel types.

Body measurements	A	B	C
NL	1.07[a]	0.97[b]	0.95[b]
HRG	2.24[a]	1.84[c]	1.90[b]
BG	2.44[a]	1.98[b]	1.90[c]
HG	1.60[a]	1.44[b]	1.53[c]
BL	1.40[a]	1.53[b]	1.57[c]
LL	0.98[a]	0.84[b]	0.90[c]
HH	1.28[a]	1.17[b]	1.12[c]
WH	1.87[a]	1.83[b]	1.76[c]
BH	1.95[a]	1.88[b]	1.86[b]
AL	1.01[a]	0.90[b]	0.95[c]

Different superscript in the same raw indicate significance at $P < 0.05$

Qualitative features

The five studied camel types are characterised by the following features (Fig 2):

Majaheem: a characteristic black coat colour, long leg, long hair covering the body and well developed hump.

Wadha: white to creamy coat colour, pointed ears and the body is covered with short hair.

Homor: brown coat colour, pointed ears, medium size camel type.

Awadi: red to white coat colour, characteristic small head, thin neck and round hump.

Saheli: characteristic red coat colour, small size camel type, small head and thin neck.

Discussion

Quantitative body measurements and body features were currently concurrently used in describing the phenotypic characteristics of camel breeds (Yohannes *et al,* 2007; Ishag *et al,* 2011 and Abdallah and Faye, 2012). In the present study quantitative body measurements showed a wide variation between the studied camels types, the measures obtained were closer to those reported by Abdallah and Faye (2012) for Saudi breeds and Chniter *et al* (2013) for Maghrebi camels. The Majaheem, Homor and Wadha showed a significantly

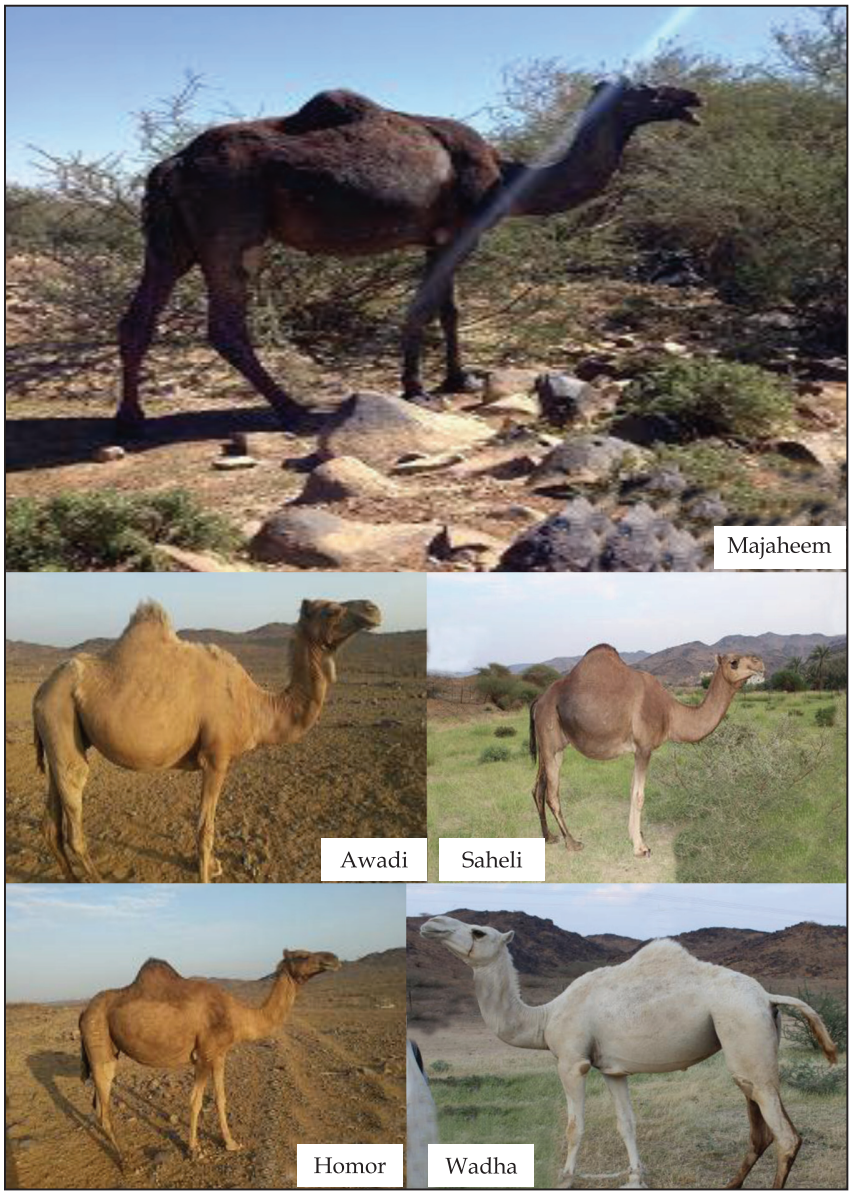

Fig 2. Phenotypes of camel types in Makkak region-KSA.

higher body measures for both males and females compared to other camels types (Awadi and Saheli), this finding is in agreement with that of Abdallah and Faye (2012). There were a slight difference in body measurements between males and females, which is relative according to camel type. The variation in body measurements in males and females could be an indicator of sexual dimorphism among the population of camel types. This finding was also observed by Yohannes *et al* (2007) in Jijiga camel populations in North Afar, Ethiopia, Ishag *et al* (2011) in camel populations in Sudan and Yosef *et al* (2014) in Ethiopian camel populations.

Unlike the study of Abdallah and Faye (2102), some of the body measurements in both sexes were encountered to be significantly correlated to other measurements. The correlation among body measurements were reported also by Chniter *et al* (2013) for Maghrebi camel breeds and Yosef *et al* (2014) for Ethiopian camel.

Clustering analysis revealed a clear similarity in body measurements between Majaheem, Homor and Wadha camel types, this class is distinctly different from the class which include only Awadi and the class occupied by Saheli camel type. This classification is in conformity with that of Mahrous *et al* (2011), Abdallah and Faye (2012) and Almathen *et al* (2012), who concluded that and depending on regional geographic distribution as well as breeding purposes of camel types, there were three genetically distinct groups of camel in the Kingdom. The classification in this study and according to body measurements could be assigned as large size camel type (Majaheem, Homor and Wadha), which could be an indication of dairy and meat production potentials. Medium camel type (Awadi), could be suitable for riding and racing purposes and small size camel type (Saheli) that could be adapted for living in mountain areas.

Qualitative description of the studied camel types revealed heterogeneous features in coat colours, five different coat colours were described in this study, however, Abdalla and Faye (2012) described twelve different coat colours for Saudi camels and Chniter *et al* (2013) were able to described 6 coat colour for five studied groups of Maghrebi camels.

Conclusion

The use of phenotypic description based on quantitative as well as qualitative body descriptions could be a valuable task for classification of camel types to pursue specific purposes in the Kingdom of Saudi Arabia. Expression of variations in quantitative body measurements in the current study could be utilised as a basement tool for selection in breeding programs for improvement of these types.

Acknowledgements

This Project was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University-Jeddah, under grant no. (42/856/1434). The authors, therefore, acknowledge with thanks DSR for technical and financial support. Thanks extend to camel herds owners for their unlimited collaboration during the data collection period

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