IJAS Iranian Journal of Applied Animal Science

Phenotypic Diversity of Camel Ecotypes (*Camelus dromedarius*) in the South Region of Kerman Province of Iran

Research Article

J. Ehsaninia[1*], B. Faye[2] and N. Ghavi Hossein-Zadeh[3]

[1] Department of Agriculture, Minab Higher Education Center, University of Hormozgan, Bandar Abbas, Iran
[2] FAO/CIRAD-ES, Campus International de Baillarguet, TA C/dir B 34398 Montpellier, France
[3] Department of Animal Science, Faculty of Agricultural Science, University of Guilan, Rasht, Iran

Received on: 8 Jan 2019
Revised on: 21 Mar 2019
Accepted on: 31 Mar 2019
Online Published on: Dec 2020

*Correspondence E-mail: ehsaninia@hormozgan.ac.ir

Online version is available on: www.ijas.ir

ABSTRACT

The aims of the present study were to evaluate phenotypic diversity and to determine the live body weight of camel ecotypes elevated in the south region of Kerman province in Iran. The morphological characteristics and body measurements of 136 camels (117 females and 19 males; aged between 3 and 12 years) from eight regions of the Jazmurian were measured. The ecotypes involved Rudbari, Native and Pakistani camel populations, which are the major camels in these rearing areas. The traits evaluated were length and width of the head, ears and the hump, heart and barrel girth. The live body weight was determined using three traits including barrel girth, heart girth and the height at withers. Data were analyzed with general linear model (GLM) and CORR procedures of SAS program. The overall averages of barrel girth, heart girth, height at shoulders and body weight were 177.56 ± 16.81 cm; 222.77 ± 17.53 cm; 174.32 ± 9.14 cm and 346.21 ± 54.27 kg, respectively. The means for length and width of the head was significantly ($P<0.05$) higher in Pakistani camel population than Rudbari and Native camels, and Native camels were significantly ($P<0.05$) important for morphological variables particularly the length and the width of the ears than the other camels. The difference between Pakistani camels and other ecotypes was significant ($P<0.05$) based on the estimated body weight. There were positive correlations between estimated body weight and biometric traits and the highest value was calculated between body weight and thoracic girth ($r=0.94$). The results of this study showed that phenotypic diversity of camel ecotypes is valuable to select based on their morphological characteristics in breeding programs and the presence of different camel ecotypes based on the morphology may provide a basis for selection and improvement in these populations.

KEY WORDS body weight, camel ecotypes, Jazmurian region, morphological traits, phenotypic characteristics.

INTRODUCTION

The ecological situation of Iran and the poverty of rainfall have caused most of the rangelands to be desert or semi-desert and the camel is the best domesticated animal that can be adapted to this ecosystem and have a high economic return. There are approximately 101170 dromedary camels in the desert areas of Iran; this represents around 0.36% of the world camel population and 2.3% of the Asian camel population (FAOSTAT, 2016). The majority of country's camel population is the dromedary (*Camelus dromedarius*). It was reared by the nomads and villagers in the arid and desert zones where more than 7% camels are found in the south of Kerman province and most of them are scattered in the region's rangelands called Jazmurian. In this region, Native, Rudbari and Pakistani camel ecotypes are kept. The dromedary has a special position in the life of many nomadic and rural societies of Jazmurian region, as it is the

main supplier of meat and by providing a part of the protein needs of this population; fiber, raw materials of the textile industry; and also draught power in agriculture. Overall, the camel would appear to be the most reliable source of food for the nomadic pastoralist. Despite its significant and meaningful contribution to the livelihood and economic prosperity of low-income households, camel is one of the neglected domestic livestock in the southern region of Kerman province and its use is more traditional and there is no specialized camel ecotype for milk, meat, draft or racing.

According to FAO (2011), traditional classification should be used as a basis for phenotypic and genetic characterization studies. Considering the important role of this animal in livelihood of rural and nomadic households, identifying their phenotypic and genetic characteristics is necessary to select the camels with high performance and thus to improve its productivity. Recently, body dimensions and morphological features of camels have been considered to describe phenotypic characteristics. All over the world, there are some reports about the phenotypic diversity of camel populations like those of Baloch (2002) and Ishag *et al*. (2011a) in Sudan, Faye *et al*. (2011), Abdallah and Faye (2012), Yosef *et al*. (2014), in Saudi Arabia and Chniter *et al*. (2013) in Tunisia.

In Ethiopia, a total of 494 heads of camels were investigated in the form of seven different breeds for phenotypic characterization, and on the basis of combined differences among all morphological variables this camel, populations were categorized into five major camel groups (Yosef *et al*. 2014).

Phenotypic classification study of 212 Saudi Arabian camels (155 females and 57 males) from nine regions and 12 different camel breeds using body measurements revealed 4 four types of female camel conformation, two breeds and six groups of males (Abdallah and Faye, 2012). Also, camel classification was based on morphological characteristics, ethnic pastoral communities, and geographical distribution in Sudan (Eltanany *et al*. 2015). In Tunisia five groups of Maghrebi camels have been identified according to their tribal affiliation (Chniter *et al*. 2013). Therefore, the aims of the present study were to evaluate phenotypic diversity and to determine the live body weight of camel ecotypes in the south region of Kerman province in Iran by measuring morphological theirs characteristics and body dimensions.

MATERIALS AND METHODS

Camel habitat and study area

The study was carried out at Jazmurian region, an area of 69600 km^2 in southeastern of Iran and located between the Sistan, Baluchestan and Kerman provinces.

This region is the main place and natural habitat of the camel population in the southern Kerman province and western part of Sistan and Baluchestan province. It accounted for about 90% of the camel population and it was purposively selected for the study. The study involved one of the major camels rearing geographical location viz. Jazmurian (Figure 1).

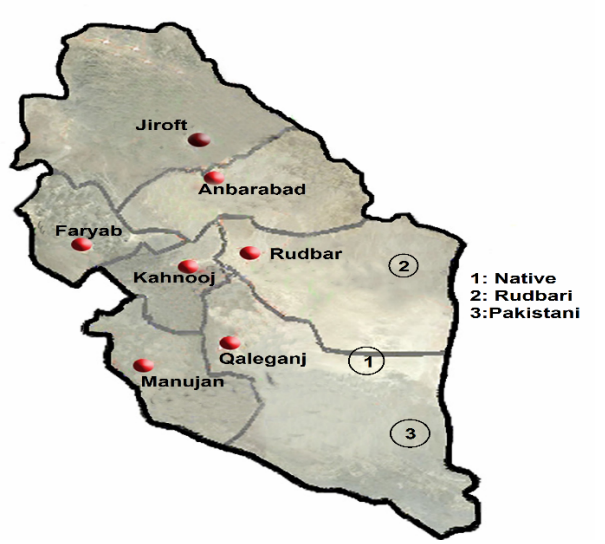

Figure 1 Distribution map of camels in southern Kerman province

There are different camel ecotypes of Rudbari, Pakistani, Zahedani, and Native in this region. Many villagers and nomads are campaigning for the maintenance and breeding of camels in various areas of Jazmurian. Animals from each ecotype were selected from their natural and original habitats according to Table 1.

Camel keeping and breeding

In the south of Kerman province, breeding and keeping of camels are carried out in different ways, including breeding camels by skilled local people, rearing of camels along with other domestic animal and keeping of camels by the nomads and villagers located around the large rangelands of the Jazmurian region. In the latter way, female camels are cauterized and then left in the desert for a long time. These camels naturally reproduce and increase generation. Indeed, uncontrolled mating in these herds is abundant. Each year, usually in spring, camels are gathered by their owners and after shearing, they are treated their young are cauterized and the fattened and culled camels are sold; then the remaining camels returned to the pastures. Camels were fed in two ways: feeding manually and using natural pasture. In order to feed, the camels travel several km each day to and from pastures where they graze on desert plants. In some cases, especially at evenings, camels are hand-fed by supplementary such as alfalfa, barley, wheat straw, and dried bread.

Table 1 Coverage of color and habitat of one-humped ecotype camels studied

Ecotype	Coverage of color	Habitat
Native	Black to reddish-brown	South and west of Jazmurian area in Qaleganj county to Bashagard mountains of Hormozgan province
Rudbari	Light brown to red	North of Jazmurian to the south of Rudbar-e-Jonub county and parts of Bam county
Pakistani	Yellow	Center and east of Jazmurian to Delgan and Iranshahr cities in Sistan and Baluchestan province

The amount of food consumed by camels varies from 10 to 30 kg depending on fodder. In all cases, they return to the early place (enclosure) for access to the water. Camels need more water in summer and as it is scarce during this season, they return to surrounding villages every day. In spring, when pastures are more suitable and water is abundant, they go deep into the ranges. As a result, camels sometimes using the rangelands which had about 50 to 80 km distance from the villages and pastoralists usually visit them by motorcycles every two weeks in terms of numbers, birth and disease control.

Methods for data collection

Questionnaire survey

Regarding the important role of the rural and nomadic households as camel's breeders, a comprehensive questionnaire was designed to complete by an interview with camel breeders throughout the Rudbar-e-jonub and Qaleganj counties. Characterization and identification of camel ecotypes carried out based on indigenous criteria adopted by nomadic and pastoral people such as they can hint on important differences, which are not obvious to outsiders. These communities were able to distinguish different types of camels within their own breed. Face to face and subsequent interviews with pastoralists were conducted in different areas of the Jazmurian. In each region, the questionnaires were used to gather information about different traits and qualitative descriptions of camels such as color of body coating. The selection of camel keeping and pastoralists was based on diversity in the combination of camel ecotype and their recognition of the special characteristics of camels and so tried that camels do not have any close family relationship in each area, and as far as possible, camels are selected from the corresponding ecotypes. The information about age, coating body color, and characteristics of each camel ecotype were completed with the help of camel owners. In this study, 117 females and 19 males dromedary with an average age of 3 to 12 years consisting of three ecotypes (Native, Rudbari and Pakistani) in the southern region of Kerman province in Iran were selected randomly from the identified camel populations (Table 2).

Measurements

A total of 10 different morphological characteristics and somatometric measurements (head length, head width, hump length, hump width, ear length, ear width thoracic girth, barrel girth, height at wither and live body weight) were recorded for each animal following the methodology given by Baloch (2002), as shown in Table 3 and Figure 2. Measurements were achieved using a measuring tape while the animals were standing on level ground and reported in cm.

Estimation of live body weight

The live body weight was estimated from linear measurements of thoracic girth, barrel girth and shoulder height using the following formula as described by Younan *et al.* (2012).

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

Where:
Y: estimated body weight in kg.
SH: shoulder height in meters.
TG: thoracic girth in meters.
BG: barrel girth in meters.

The number of 50 is the parameter calculated when the equation was established based on the product of 3 measurements on a group of camels with a known weight.

Cluster stratification

In order to define classes containing cluster with similar variability, a hierarchical cluster analysis was used. The camel ecotypes were grouped by hierarchical cluster analysis using PROC Cluster of SAS (2009), with minimum variances within groups.

Data analysis

Data analyses involved 2 steps to achieve two objectives:

(i) To assess the morphological differences between the ecotypes. For this data were analyzed using the GLM procedure of SAS 9.1 program (SAS, 2009). The statistical model used is as follows:

$$y_{ijklm} = \mu + E_i + S_j + R_k + b(Age_l - \overline{Age}) + e_{ijklm}$$

Where:
y_{ijklm}: observation related to the trait.
μ: overall mean.
E_i: effect of ecotypes.
S_j: effect of sex.

R_k: effect of region.
Age_l: effect of age which was fitted as covariate effect.
b: linear regression coefficient of each observation on age.
e_{ijklm}: random residual effects.

(ii) To verify the correspondences between ecotypes and types of morphology identified after principal components analysis (PCA) and Automatic Hierarchical Classification (AHC). The PCA allows getting correlation circle giving the relationships between the different body measurements. After classification, the relationships between types of camel morphologies and ecotypes were assessed by Chi² test. The software used for this step of the analysis was Xlstat (Addinsoft ©).

RESULTS AND DISCUSSION

Descriptive statistics for morphological characteristics and body measurements of three camel ecotypes are summarized in Tables 4 and 5. Variability of all traits was less than 20% and hump length was the most variable trait with a coefficient of variation greater than 19% for morphological traits.

The coefficients of variation of the body measurements varied between 4% and 13% and thoracic girth was a variable trait. Therefore, the maximum coefficient of variation was related to hump length and Rudbari camels have the highest values and the least coefficient of variation was related to the length of ear in Pakistani camels.

Table 2 A number of male, female and all camel ecotypes

Camel ecotypes	Number of camels			Percentage
	Female	Male	Total	
Native	39	7	46	33.82
Rudbari	40	5	45	33.09
Pakistani	38	7	45	33.09
Total	117	19	136	100

Table 3 Type and definition of biometric traits in dromedary camel ecotypes

Biometrical trait	Trait (cm)	Morphological position
Morphological	Head length (HeL)	The distance between the occipital and the line between the forehead and the nose (J-K)
	Head width (HeW)	Internal distance between two ears (L-M)
	Hump length (HuL)	The distance from the bottom to the tip of the hump (N-O)
	Hump width (HuW)	The distance between the sides of the hump in the middle of the hump (P-Q)
	Ear length (EaL)	The distance between the beginning or the lower ear to the tip of the ear (R-S)
	Ear width (EaW)	The distance between the inner edge and the outer edge of the ear from the back (back) of the ear (T-U)
Somatometric	Thoracic girth (TG)	Around the body just behind the sternal pad (C)
	Barrel girth (BG)	The around the abdomen over the midpoint of the hump (D)
	Height at the shoulder (HS)	The height (vertical) from the bottom of the front foot to the tip of the scapula (E-F)

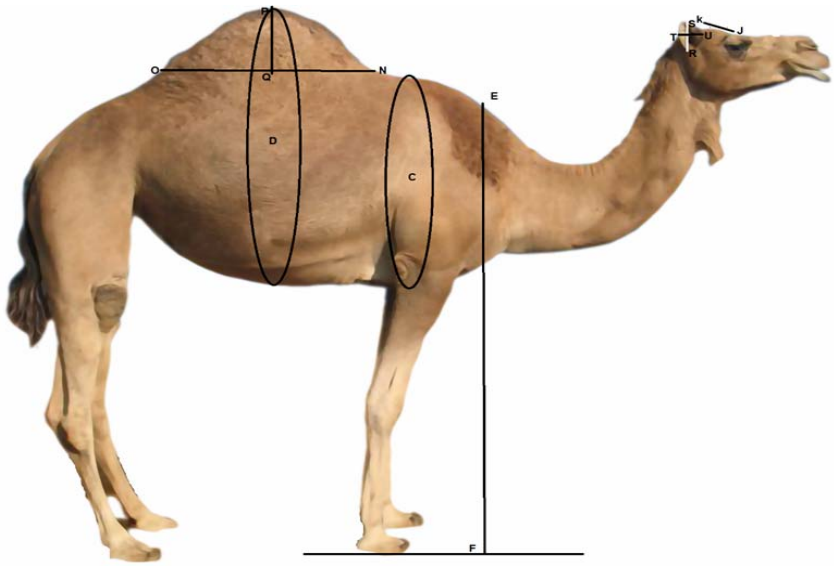

Figure 2 Somatometric measurements and morphological characteristics of camel ecotypes

Table 4 Descriptive statistics for morphological traits in different camel ecotypes

Camel ecotype	Trait	Mean (cm)	SD (cm)	CV (cm)	Min (cm)	Max (cm)
Native	Head length	24.94	8.25	15.08	19	51
	Head Width	18.94	2.17	11.94	15	23
	Hump length	47.93	9.68	19.55	28	63
	Hump width	24.60	13.17	18.89	14	50
	Ear length	12.76	1.09	8.58	10	15
	Ear width	7.53	1.32	17.54	5	8
Rudbari	Head length	34.93	15.21	13.53	15	58
	Head Width	17.29	2.16	12.49	12	24
	Hump length	54.31	15.47	18.53	36	89
	Hump width	29.33	14.68	16.82	11	69
	Ear length	10.82	1.11	9.42	9	14
	Ear width	6.94	0.91	13.05	4	7
Pakistani	Head length	45.07	3.49	7.75	38	59
	Head Width	21.58	3.90	8.07	15	31
	Hump length	58.48	15.52	18.20	39	94
	Hump width	30.07	8.12	12.99	14	48
	Ear length	11.91	0.85	7.77	10	16
	Ear width	6.62	0.75	11.29	6	9

SD: standard deviation and CV: coefficient of variation.

Table 5 Descriptive statistics for body measurements in different camel ecotypes

Camel ecotype	Trait	Mean (m)	SD (m)	CV (m)	Min (m)	Max (m)
Native	Thoracic girth	1.76	0.11	6.43	1.51	1.96
	Barrel girth	2.31	0.11	4.76	2.08	2.65
	Height at shoulder	1.73	0.06	3.75	1.51	1.87
Rudbari	Thoracic girth	1.71	0.22	12.98	0.92	2.07
	Barrel girth	2.18	0.22	6.89	1.46	2.55
	Height at shoulder	1.73	0.10	6.06	1.26	1.92
Pakistani	Thoracic girth	1.86	0.11	5.76	1.65	2.11
	Barrel girth	2.20	0.16	7.22	1.89	2.53
	Height at shoulder	1.77	0.09	5.35	1.60	1.96

SD: standard deviation and CV: coefficient of variation.

Minimum average length and width of ears were related to Rudbari camels and ears were short and similar to ear of the wolf but maximum of them were related to Native camels. The Pakistani camel population had longer and wider hump in comparison to other camel ecotypes. The minimum and maximum thoracic girth and height at shoulder were related to Rudbari and Pakistani camels, respectively. But native camels had higher barrel girth than other camels and height at shoulder in Pakistani camels was higher than Native and Rudbari camels.

Morphological characteristics of the head, ear, and hump of three camel ecotypes are shown in Table 6. For length and width of the head, there was a significant difference between three ecotypes ($P<0.05$). Pakistani camels remained superior with higher values of their head length, followed by Rudbari and Native and the length of the head in Rudbari camel was greater than the Native camels. The highest value was observed in Pakistani camel (45.07±0.52 cm), whereas the lowest (24.94±1.22 cm) was for the Rudbari camel.

Also significant difference was observed in the head width among Rudbari and Native camels ($P<0.05$) and indigenous camels had more average head width than that in Rudbari camels. These were results are in the range of reports (Shah, 2007; Shah *et al*. 2012; Shah *et al*. 2015). In a study, the average head length of 12 camel ecotypes in Saudi Arabia was reported to be between 39.3 to 48.1 cm (Abdallah and Faye, 2012). Shah *et al*. (2015) reported the average length and width head of the Kohi camels in Pakistan were 19.41 and 18 cm, respectively. In a study on six Pakistani camel breeds, the highest average length of the head was related to the Lari breed and had a significant difference with other breeds while the average head width of Dehati breed was greater than the other breeds (Shah, 2007).

Shape, size, and appearance of ears are of particular importance in recognizing different camel ecotypes (Raziq *et al*. 2011). The length of ear for native camels was 12.66 cm, which was significantly higher than the Rudbari and Pakistani camels ($P<0.05$).

In a study, phenotypic characteristics of 494 Ethiopian camels in eight different breeds were evaluated and mean ear length was from 11.38 to 20.12 cm (Yosef *et al*. 2014). This finding was similar to the results of this study. The ear width of native camel was significantly wider (P<0.05) than other camels. No significant difference was found in the ear width among the remaining of the camel ecotypes. Raziq *et al*. (2011) reported average length and width of the ears for Raigi camels in Afghanistan and Pakistan, were 10.99 and 5.98 cm, respectively, which was consistent with result of this study.

In this study it was observed that Native camels had shorter hump length than those of Rudbari and Pakistani camels; whereas the hump width of the Native camels was significantly wider than the other camels (P<0.05) but there was no significant difference between Pakistani and Rudbari camels. In a similar study, Shah (2007) reported an average hump length of 59.1 cm for Kohi camels. In contrast to the present study, Yosef *et al*. (2014) found shorter hump length (19.73-35.84 cm) for seven Ethiopian camel populations.

Kamili *et al*. (2006) reported the hump size varies according to the body condition score of the animal. The main building of hump includes fat and fiber tissue and the hump is the main fat storage form in camel representing on average 85% of the adipose tissue (Faye *et al*. 2001b) so that hump is water tank and basically each one gram of fat is consumed in the form of 1.07 grams of water. The difference in size of hump may be due to very unfavorable environmental conditions and heat stress in different parts of the southern province of Kerman, especially Jazmurian region where this region, as the main habitat of camels, has completely dried up and the ecosystem of this wetland has generally disappeared due to successive droughts, as well as the construction of various dams including the dam of Jiroft in the upstream of the Halil river as the main source of wetland water and the camels of this area often carry very long distances for grazing in remote areas and drinking water. In this condition, camels require large hump to store water and fat as they use stored energy in the humps during the dry period and a severe shortage of food for maintenance and production.

Information related to body weight and phenotypic measures traits of thoracic girth, barrel girth and height at the shoulder for different camel ecotypes in the South of Kerman region is presented in Table 7. The results of this study showed that the mean of thoracic girth, barrel girth, and height at shoulder and body weight were 177.16 ±56.81 cm, 222.77 ± 9.14 cm, 174.32 ± 9.14cm and 346.21 ± 54.20 kg, respectively.

It is obvious that Pakistani camels had significantly (P<0.05) maximum values of thoracic girth, barrel girth and height at shoulder and Rudbari camels had minimum values of the mentioned traits with the exception of height at shoulder. Higher thoracic girth and body weight in Pakistani camels indicated their higher potential for meat production than other studied camel ecotypes. These results are in agreement with the results of Abebe (1991) who reported the greater thoracic girth and the length of hump in Gelleb and Liben camels of Ethiopia which are more likely to produce more meat. The thoracic girth measured in Pakistani camel was similar to values for Amibara camels in Ethiopia (Yosef *et al*. 2014), Butana and Bishari camels in Sudan (Ishag *et al*. 2010) but was less than those described for Maghrebi camels in Tunisia (Chniter *et al*. 2013), for Zargah, Waddah and So for Arabian camels in Saudi Arabia (Abdallah and Faye, 2012). The Pakistani camels showed similar measurements of height at shoulder in comparison with some of the Ethiopian camels but these measurements were less in Rudbari and Native camels than in the Maghrebi camels Tunisia (Chniter *et al*. 2013). The barrel girth of camels in the current study was greater than that in the Ourdhaoui Médenine (Chniter *et al*. 2013), but lesser than those measured in Lahwee, Shanbali and Kenani breed camels (Ishag *et al*. 2011b).

Khojastehkey *et al*. (2020) also reported a greater average thoracic girth in Yemeni camels which is not similar to the results of this study. The reason for these differences can be attributed to type /breed of camel as well as the metric method and tools used to measure the corresponding traits. Mahrous *et al*. (2011) and Almathen *et al*. (2012) stated that differences between groups of dromedary in terms of body measurements are genetically linked and revealing geographical distribution.

The average body weight of different camel ecotypes ranged between 328.07-364.04 kg. This is in agreement with other body weight records for camels in North Africa. The average live body weight of Pakistani camels was higher than Native and Rudbari camels and had a significant difference with them (P<0.05). But there was no significant difference between the Rudbari and Native camels. The average live body weight of Pakistani camels was higher than the average live weight of Amibera camels in Ethiopia (Yosef *et al*. 2014). However, the live weight of all studied ecotypes was lower compared to the Raghi camels reared by the Pashtun tribes in Afghanistan and Pakistan (Raziq *et al*. 2011). Ishag *et al*. (2011b) reported higher body weight (426.90 to 516.69 kg) for 274 camels related to 10 different ecotypes. Also, higher live weight averages were reported in other camel breeds.

Table 6 Mean (±standard error) morphological traits (cm) of camel ecotypes in the south of Kerman province

Morphological traits	Camel ecotypes		
	Pakistani	Rudbari	Native
Head length	45.07±0.52[a]	34.93±2.27[b]	24.94±1.22[c]
Head Width	21.58±0.58[a]	17.29±0.32[b]	18.94±0.32[c]
Hump length	58.48±2.29[a]	58.31±2.31[a]	47.93±1.44[b]
Hump width	26.07±2.19[a]	27.33±1.94[a]	32.60±1.21[b]
Ear length	10.91±0.13[c]	11.82±0.17[b]	12.76±0.16[b]
Ear width	6.62±0.11[b]	6.94±0.14[b]	7.53±0.19[a]

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 7 Mean (±standard error) of biometric traits (cm) and body weight (kg) of camel ecotypes in the south of Kerman province

Biometric traits	Camel ecotype		
	Pakistani	Rudbari	Native
Thoracic girth	186.33±1.60[a]	170.82±3.31[b]	175.57±1.67[b]
Barrel girth	230.78±2.37[a]	217.60±3.21[b]	219.76±1.62[b]
Height at shoulder	177.31±1.41[a]	172.93±1.56[b]	172.76±0.96[c]
Body weight	364.04±7.28[a]	328.07±10.01[c]	341.42±5.27[b]

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Abebe *et al*. (2002) found higher body weight (425.9 kg) for Issa-Somali camels. Kurtu (2004) also reported the live weight of 465.8 kg for male Jijiga camels which is higher than the live weight of camel ecotypes in the current study. The difference may be due to large body size of the former breed.

A wider range of live body weight was reported for different types of camels with the variation apparently due to age, body condition, sex, and breed (Kadim *et al*. 2008). These variations might arise from several factors such as age, sex, type or breed of camel used in each study as well as on the general management and ecology of the area. The native camel's morphological structure (smaller body size) is one of their important characteristics for adapting to food shortages and high temperatures. There is evidence that the growth rate could be significantly enhanced by genetic, nutritional and management improvements. Therefore, in the southern regions of Kerman province, according to weight and other phenotypic characteristics, there are three different camel ecotype: Pakistani camels, camels with large body size and muscle size that are compatible with dry areas and extremely hard conditions in the Jazmurian area, are mainly cultivated for meat production and in a few cases milking is also done; Indigenous camels, medium-sized camels that are mostly used for riding purposes. They are famous for racing camels and have a great marching power (Shorepy, 2011) and now the best generation of these camels is currently grown in different southern regions of Kerman province. According to the cultural traditions and customs, camel competitions are held annually in the southern region of Kerman province and it is observed that superior camels at very low prices are mainly bought by dealers and smuggled to the Persian Gulf countries;

Rudbari camels are relatively muscular and small-sized camels that are mostly cultivated in mountainous areas and are used to produce meat and cargo in rugged areas.

Correlation coefficients between body weight and other variables are presented in Table 8. Correlation between variables varied between 0.19-0.93 and a positive correlation was found between most of the variables. The correlation circle issued from ACP showed that the main factor is explained by hump measurements (length and width) and barrel girth. In the second factor, the main parameters were head measurements (width and length) and thoracic girth. The age used as a supplementary variable was at the center of gravity, testifying of the lack of age effect on the variability of body measurements (Figure 3).

The live body weight of camels had significant (P<0.01) positive correlation with thoracic girth (r=0.93), followed in order by its correlation with barrel girth (r=0.85) and height at the shoulder (r=0.74). The highest correlation coefficients were found between body weight and thoracic girth (r=0.93), and between barrel girth and height at shoulder (r=0.90).

The lowest positive correlation (0.74) was found between height at the shoulder and body weight. The positive correlation (r=0.93) between live body weight and thoracic girth indicated that thoracic girth had a strong influence in live body weight estimation of the camel breed.

This is in agreement with the findings of Abebe *et al*. (2002), Kuria *et al*. (2007), Chniter *et al*. (2013) and Seid *et al*. (2016), but was in contrast to the findings of Mungai *et al*. (2007). Abebe *et al*. (2002) reported a strong positive correlation between live body weight estimates and barymetric measurements, the superior being with thoracic girth (r=0.96).

Table 8 Correlations between body measurements in camel ecotypes in the south of Kerman province

Variables	Body weight	Chest girth	Barrel girth	Height at shoulder
Body weight	1	0.93**	0.85**	0.74**
Chest girth	-	1	0.19*	0.37*
Barrel girth	-	-	1	0.30**
Height at shoulder	-	-	-	1

* (P<0.05) and ** (P<0.01).

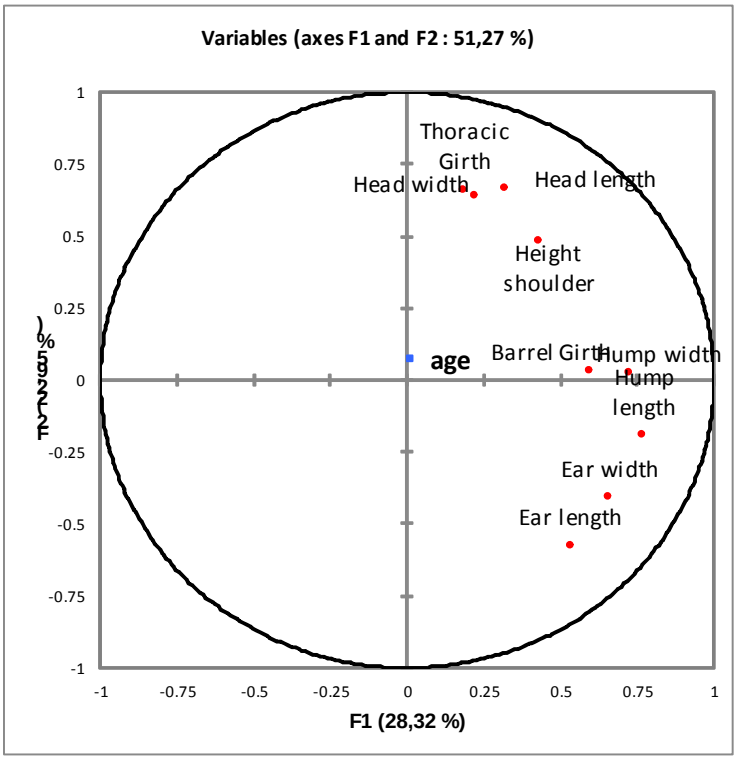

Figure 3 Correlation circle corresponding to the two first factors issued from principal components analysis (explaining 51.2% of the total variance)

Table 9 Mean values of the body measurements according to the 5 classes issued from cluster analysis

Class	TG	BG	HS	HuW	HuL	HeL	HeW	EaL	EaW
1	1.895a	2.219^{b}	1.767^{ab}	21.171^{c}	44.457^{d}	44.057^{c}	22.686^{a}	10.657^{c}	6.457^{d}
2	1.714^{bc}	2.109^{c}	1.731^{bc}	38.500^{b}	59.542^{c}	48.167^{b}	17.292^{c}	11.375^{b}	6.729^{cd}
3	1.767^{bc}	2.349^{a}	1.813a	46.538^{a}	83.308^{a}	51.154^{a}	19.769^{b}	12.692^{a}	8.154^{a}
4	1.708^{c}	2.225^{b}	1.724^{c}	17.333^{d}	46.733^{d}	20.956^{e}	17.378^{c}	12.489^{a}	7.111bc
5	1.799^{b}	2.317^{a}	1.712^{c}	39.947^{b}	68.416^{b}	23.217^{d}	19.586^{b}	12.476^{a}	7.542^{ab}
P-value	< 0.0001	< 0.0001	0.005	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

TG: thoracic girth; BG: barrel girth; HS: height at the shoulder; HuW: hump width; HuL: hump length; HeL: head length; HeW: head width; EaL: ear length and EaW: ear width.

Mungai *et al*. (2007) found that the highest correlation was between live body weight and barrel girth (r=0.957), followed by thoracic girth (r=0.934) and the least correlation was with height at shoulder (r=0.432). This difference between the findings of Mungai *et al*. (2007) and the findings of other studies is probably due to age factors, given that only calves were considered in the former study.

Yousif and Babiker (1989) found lower correlation between live body weight and thoracic girth (r=0.67). The discrepancies in the findings among different studies are likely attributed to the variation in age, body conditions and conformation of different ecotypes of camels. The correlation between thoracic girth and barrel girth was positive that is according to the result of Chniter *et al*. (2013).

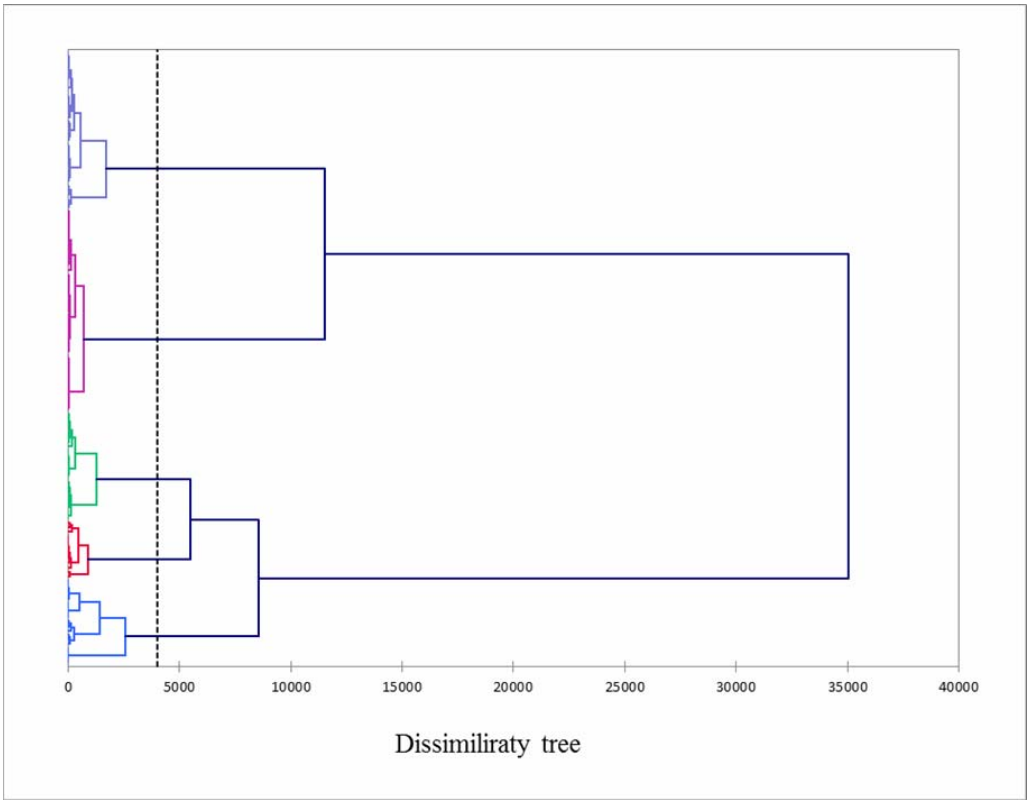

Figure 4 Dendrogram obtained after automatic classification of the body measurements showing 5 homogenous entities

Table 10 Distribution of the ecotypes among the 5 classes issued from the cluster analysis

Item	Classe-1	Classe-2	Classe-3	Classe-4	Classe-5
Ecotype-N	0.00	0.00	30.76	51.11	100.00
Ecotype-R	0.00	58.33	69.23	48.88	0.00
Ecotype-p	100.00	41.66	0.00	0.00	0.00
Total	100	100	100	100	100

The cluster analysis allowed to identify 5 classes representing 80.6% of the total variance A significant relationship was observed between these 5 classes of body measurements and the 3 ecotypes (chi^2=15.5; P<0.0001). Class 5 was including only camels of ecotype N mainly characterized by small head's measurements and medium hump size. Class 1 was including only ecotype P characterized by significant smaller hump, big head, and big thoracic girth. The ecotype R appeared more variable and was distributed in the types 2, 3 and 4 (Table 10).

CONCLUSION

The presence of phenotypic diversity in different camels, in the selection of different camels based on the characteristics and the body type, has been valuable in breeding programs and different ecotypes of camels in terms of morphological traits and physical dimensions may be the basis for genetic selection and improvement of camel production in the region. The obvious and significant difference between morphological traits and physical dimensions of Pakistani camels and other camels in the south region of Kerman province suggests that there has not been any significant management and breeding behavior in the camels in under study area. Therefore, it is essential that owners of camel in south region of Kerman province should be supported by the Iranian government with short-term and long-term programs, so that they improve livestock production and preserve camels as a genetic resource for future generations.

ACKNOWLEDGEMENT

The authors acknowledge the camel breeders and local communities in the south of Kerman Province Particularly villagers and tribes of Chah Dadkhoda and Jazmurian districts in the counties of Qaleganj and Rudbar-e-Jonub, for the cooperation in collecting the data and completing the questionnaires.

REFERENCES

Abdallah H.R. and Faye B. (2012). Phenotypic classification of Saudi Arabian camel (*Camelus dromedarius*) by their body measurements. *Emirates J. Food Agric.* **24(3),** 272-280.

Abebe W. (1991). Traditional husbandry practices and major health problems of camels in the Ogaden (Ethiopia). *Nomadic Peoples*. **29,** 21-30.

Abebe W., Getinet A. and Mekonnen H.M. (2002). Study on live weight, carcass weight and dressing percentage of Issa camels in Ethiopia. *Revue. Méd. Vét.* **153(11),** 713-716.

Almathen F., Mwaracharo J. and Hanotte O. (2012). Genetic diversity and relationships of indigenous Saudi Arabia camel (*Camelus dromedarius*) populations. Pp. 40-41 in Proc. 3rd ISOCARD Conf., Mascate, Oman.

Baloch M.N. (2002). Documentation and characterization of camel breeds of Pakistan. MS Thesis. Sindh Agriculture Univ., Tando, Jam, Pakistan.

Chniter M., Hammadi M., Khorchani T., Riadh Krit R., Benwahada A. and Ben Hamouda M. (2013). Classification of Maghrebi camels (*Camelus dromedarius*) according to their tribal affiliation and body traits in southern Tunisia. *Emirates J. Food Agric.* **25(8),** 625-634.

Eltanany M., Elfaroug O.S. and Distl O. (2015). Assessment of genetic diversity and differentiation of two major camel ecotypes (*Camelus dromedarius*) in Sudan using microsatellite markers. *Arch. Anim. Breed.* **58,** 269-275.

FAO. (2011). Draft Guidelines on Phenotypic Characterization of Animal Genetic Resources. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

FAOSTAT. (2016). Database of the Food and Agricultural Organization (FAO) of the United Nations. Availabe at: http://www.fao.org/faostat/en/#home.

Faye B., Abdallah H., Almathen F., Harzallah B. and Al-Mutairi S. (2011). Camel Biodiversity. Camel phenotypes in the Kingdom of Saudi Arabia, Camel Breeding, Protection and Improvement Center, Project UTF/SAU/021/SAU, Food and Agriculture Organization of the United Nations (FAO) Publication, Riyadh, Saudi Arabia.

Faye B., Bengoumi M., Messad S. and Chilliard Y. (2001b). Fat storage and adipocyte patterns in camel: A tool for management of reproduction. *Adv. Reprod. Sci.* **5(3),** 10-16.

Ishag I., Eisa M. and Ahmed M. (2011a). Effect of breed, sex and age on body measurements of Sudanese camels (*Camelus dromedarius*). *Australian J. Basic Appl. Sci.* **5(6),** 311-315.

Ishag I.A., Eissa M.O. and Ahmed M.K.A. (2011b). Phenotypic characteristics of Sudanese camels (*Camelus dromedarius*). *Livest. Res. Rural Dev.* **23,** 99-105.

Ishag I.A., Reissmann M., Peters M.J., Musa L.M.A. and Ahmed M.K.A. (2010). Phenotypic and molecular characterization of six Sudanese camel breeds. *South African J. Anim. Sci*. **40(4),** 27-36.

Kadim I.T., Mahgoub O. and Purchas R.W. (2008). A review of thegrowth, and of the carcass and meat quality characteristics of theone-humped camel (*Camelus dromedaries*). *Meat Sci*. **80,** 555-569.

Kamili A., Bengoumi M. and Faye B. (2006). Assessment of body condition and body composition in camel by barymetric measurements. *J. Camel Pract. Res.* **13(1),** 67-72.

Khojastehkey M., Kalantar Neyestanaki M., Roudbari Z., Sadeghipanah H., Javaheri H. and Aghashahi A.R. (2020). Feasibility of body weight estimation of Kalkoohi camels using digital image processing. *Iranian J. Appl. Anim. Sci*. **10(2),** 333-340.

Kuria S.G., Wahome R.G., Gachuiri C.K., Wanyoike M.M. and Mwangi J.N. (2007). Use of linear body measurements in estimating live weight of camel (*Camelus dromedarius*) calves in Kenya. *J. Camel Pract. Res.* **14(1),** 21-25.

Kurtu M.Y. (2004). An assessment of the productivity for meat and the carcass yield of camels (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. *Trop. Anim. Health Prod.* **36(1),** 65-76.

Mahrous K.F., Ramadan H.A., Abdel Aziem S.H., Abd-El Mordy M. and Hemdan D.M. (2011). Genetic variations between camel breeds using microsatellite markers and RAPD techniques. *J. Appl. Biosci.* **39,** 2626-2634.

Mungai I.P., Githaiga W.R. and Margaret W. (2007). Correlation of actual live weight and estimates of live weights of camel calves (*Camelus dromedarius*) in Samburu district of northern Kenya. *J. Camelid Sci.* **3,** 26-32.

Raziq A., Tareen A.M. and Verdier K.D. (2011). Characterization and significance of Raigi camel, a livestock breed of the Pashtoon pastoral people in Afghanistan and Pakistan. *Livest. Sci.* **2,** 11-19.

SAS Institute. (2009). SAS®/STAT Software, Release 9.2. SAS Institute, Inc., Cary, NC. USA.

Seid A., Kurtu Y.M. and Urge M. (2016). Effect of age and body condition on slaughter characteristics of dromedary camels (*Camelus dromedarius*) in Eastern Ethiopia. *J. Camelid Sci.* **9,** 35-52.

Shah M.G.U. (2007). Differentiation of six Pakistani camel breeds by phenotype and molecular genetics analysis. Ph D. Thesis. University of Agriculture, Pakistan.

Shah M.G.U., Reissmann M., Qreshi A.S., Schwartz H.J., Khan M.S., Ali T., Zaman A., Safdar K., Muhammad K. and Ullah S. (2012). Determination of genotype differences through restriction endonuclease in camels (*Camelus dromedarius*). *African J. Biotechnol.* **11(53),** 11543-11547.

Shah M.G.U., Sarwar A., Reissmann M., Schwartz H.J., Gandahi J.A., Nisha A.R., Lochi G.M., Arivudainambi S., Umer M.M. and Khan S. (2015). Phenotypic characteristics and performance traits of Kohi camel (*Camelus dromedarius*). *Int. J. Pharm. Bio Sci.* **2(2),** 13-19.

Shorepy S.A. (2011). Identification of environmental factors affecting the racing performance of race camels in the United Arab Emirates. *Emirates J. Food Agric*. **23,** 424-430.

Yosef T., Kefelegn K., Mohammed Y.K., Mengistu U., Solomon A., Tadelle D. and Han J. (2014). Morphological diversities and eco-geographical structuring of Ethiopian camel (*Camelus dromedarius*) populations. *Emirates J. Food Agric.* **26(4),** 371-389.

Younan M., Zaidi A. and Sikuku P. (2012). Camel Manual for

Service Providers. Kenya Agricultural Research Institute (KARI), Nairobi, Kenya.

Yousif O.K. and Babiker S.A. (1989). The desert camel as meat animals. *Meat Sci.* **26,** 245-254.