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Genetic and phenotypic trends of different body parameters in Indian dromedary breeds

Priyank Vyas, SC Mehta, Urmila Pannu and Pallavi Joshi

Abstract
Camel is an integral member of the desert environment and it is mainly reared for the draught purpose, especially in India. The draught ability is associated with body weight and size body parameters like body length, height at weathers and heart girth. The body parameter data belonging to the camel herd maintained at ICAR- National Research Centre on Camel, Bikaner was utilised for the present analysis. The overall least-squares means of heart girth, height at withers and body length were estimated to be 208.99 ± 1.28, 198.76 ± 0.58 and 158.79 ± 0.78 cm, respectively. The fixed effect of breed was found non-significant (P>0.05) on heart girth and body length, whereas highly significant (P<0.01) on height at withers. The fixed effect of sex was found highly significant (P<0.01) on height at withers and body length, whereas significant (P<0.05) on heart girth. The random effect of sire was found non-significant (P>0.05) on all body parameter traits. The heritability heart girth, height at withers and body length were estimated to be 0.284, 0.213 and 0.172, respectively. For the body parameter traits genetic, phenotypic and environmental trends were observed in camel at different ages from the period 2002-03 to 2008-09, phenotypic trend was positive for all the body parameter traits. The genetic trend was positive for 1, 7 and 8 years' heart girth, 6 and 8 years' height at withers and 5, 7 and 8 years' body length parameters. The positive genetic trend indicates genetic improvement of camel in respect of economic values over the years. Environmental trend was positive in all the parameters at all age groups which indicate proper and healthy management throughout the period.

Keywords: Body parameter, heritability, genetic, phenotypic and environmental trend, camel

1. Introduction

In the present context the camel is not only a draught species but also used for many other purposes like racing, desert safari and milk production. The camels are needed as a draught species to redeem the burden on oil. It has always been a point of research and investigation whether the draught is associated with body weight and size. Body parameters like body length, height at weathers and heart girth are directly related to the draught ability of animal [1]. An animal of the high body parameter is also good for draught. The body length showed positive correlation with tractive force, speed and horse power [2]. Body parameters like body length, height at withers and heart girth are directly related to the power of animal [3].

At present, though much of urbanization and mechanization have taken place, the camel is being used in the rural and urban areas of desert for the draught. Load carrying and long distance travelling capacities are two important attributes of camel and are indicative of the worth of an individual. The virtues of the camel are fairly unknown outside the communities where it is used. The prejudice against camel stemmed from the misconception of being of low economic value. The camel population of the world has been showing an overall increasing trend since 1961. The world camel reported about 12,926,638 camels [4] whereas the population was around 27,777,346 in 2014 which is spread across 47 countries [5]. About 85% of the camel population inhabits mainly eastern and northern Africa and rest in the Indian subcontinent and Middle East countries. India stands tenth in the world ranking with 669,876 camels [5]. According to F.A.O. the camel population in India has been decreasing constantly since 1991.Indian camel population is mainly confined to the north-western part of the country. In India camel population was 0.40 million in 2012, 0.51 million in 2007, 0.64 million in 2003, 0.91 million in 1997 and in 1951 it was 0.60 million according to Indian Livestock census [6].

2. Materials and Methods

The data belonging to Bikaneri, Jaisalmeri and Kachchhi breeds of camel maintained at the National Research Centre on Camel, Bikaner, India. For the biometrical analysis three traits was included viz. heart girth, height at wither and a body length of adult animals which were used for the estimation of heritability, genetic and phenotypic correlation and for estimation of fixed effect. For the study of genetic, phenotypic and environmental trends all three traits (heart girth, height at wither and body length) were studied at yearly intervals at 1, 2, 3, 4, 5, 6, 7 and 8 years with the no. of animals 36, 46, 29, 22, 41, 23, 20 and 23 respectively. Care was taken to measure the animals before they were sent out for grazing. Pregnant females and sick animals were avoided. Animals receiving special feed, fodder or attention due to their allotment to different experiments were excluded from the herd and hence not measured. Pregnant females after calving and sick animals after recovery were measured. Animals considered absolutely normal after experimentation were taken back in the herd and measured.

To find the effect of various genetic and non-genetic factors on body parameter, computer package program, LSMLMW, was used for data analysis [7].

2.1 Effect of genetic and non-genetic factors

$Y_{ijkl} = \mu + a_i + B_j + C_k + e_{ijkl}$

Where,

y_{ijkl} = Performance record of the l^{th} progeny of i^{th} sire, j^{th} period, k^{th} sex

μ = Overall population mean

a_i = Random effect of i^{th} sire

B_j = Fixed effect of j^{th} period

C_k = Fixed effect of k^{th} sex

e_{ijkl} =Random error NID $(0, \sigma^2)$

2.2 Genetic and phenotypic trend of biometry

The trends were estimated by using Smith's procedure [8]. The procedure utilizes the fact that the progeny of sires used for several years provides some continuity of genotypes, from which genetic change can be estimated. The annual change in performance consists of two parts.

t = Environmental trend g = Genetic trend

When sires have been used for several years, there genetic contribution to the daughters is the same for all the years. Therefore, genetic change from sire side is zero. Other half of daughter genotype is contributes by changing group of females to which the sire is mated in his first, second and subsequent years of service. Hence, comparison of performance of paternal sisters freshening in continuous years should indicate t + ½ g. Thus, Smith's methods are based on the following expectation:

$E(b_{P.T}) = g + t$

$E(b_{P.T/S}) = 0.5\, g + t$

$E(b_{(P-P).T/S}) = -0.5\, g$

Where,

$(b_{P.T})$ = Regression of production on time

$(b_{P.T/S})$ = Pooled within sire regression of production on time

$(b_{(P-P).T/S})$ = Pooled within sire regression of production on time, records being deviated from the population mean

The regression of annual mean production on years $(b_{P.T})$ will estimate phenotypic trend. Estimates of genetic trend can be obtained by combining the above expectation to give two estimators of genetic trend as:

(a) $\hat{g} = 2(b_{P.T} - b_{P.T/S})$

(b) $\hat{g} = -2(b_{(P-P).T/S})$

2.2.1 Estimation of phenotypic trend (ΔP)

The phenotypic trend in different characters were estimated as $\Delta P = b_{P.T}$, regression of yearly average on the years.

2.2.2 Estimation of genetic trend (ΔG)

The genetic trends were estimated by following method:

$$\Delta G = 2(b_{P.T} - b_{P.T/S})$$

The standard error of ΔG was estimated using both standard errors of ΔP and ΔG as:

$$S.E\,(\Delta G) = 2\sqrt{Var\,(b_{P.T}) + Var\,(b_{P.T/S})}$$

2.2.3 Estimation of environmental trend (ΔE)

Phenotypic trend represents sum of genetic and environmental trend. The environmental trend, therefore, was estimated by subtracting the genetic trend from phenotypic trend.

$$\Delta E = 2\, b_{P.T/S} - b_{P.T}$$

The standard error of ΔE was estimated using both standard errors of ΔP and ΔG as:

$$S.E\,(\Delta E) = \sqrt{S.E\,(\Delta P)^2 + S.E\,(\Delta G)^2}$$

3. Results and Discussion

Across the world, there were some reports done on the phenotypic diversity of camel populations, like in Northern Kenya [9], in Sudan [10], in Saudi Arabia [11, 12]. Body measurements revealed clear morphological differences among the local camel population [9]. A recent phenotypic classification study of Saudi Arabian camel using body measurements revealed 4 types of female camel conformation, 2 breeds and six groups of males [12]. Therefore, the body parameter of adult camels was evaluated in terms of heart girth, height at withers and body length.

3.1. Averages and effects of sire, breed and sex

The averages and effects of sire, breed and sex have been discussed under following headings.

3.1.1 Heart Girth

The least-squares means of heart girth of adult camel for different breeds, sire and sex are presented in Table 1. The overall least-squares mean of heart girth was estimated to be 208.99 ± 1.28 cm. The heart girth ranged from 207.30 to 211.67 cm in different breeds. The results are in close agreement with one publication who reported 213.60 ± 9.42, 199.50 ± 6.25, 186.60 ± 4.92 and 185.40 ± 8.59 cm heart girth in different Saudi camel breeds like Meghem, Sawahli, Gamra and Awadi, respectively [13]. The higher estimates of heart girth were recorded as 225 ± 2.65 in Bikaneri, 216.33 ± 4.48 in Jaisalmeri and 219.33 ± 2.67 in kutchi [2]. The higher estimates could be due to non-genetic factors such as environment, nutrition, health management and other factors associated with time as the present results which are also for Indian camel breeds are slightly different because the data spreading over a period of 7 years from 2003 to 2008-09 were analyzed which is higher than the studies referred. Effect of sex on heart girth was significant whereas effect of breed and sire was non-significant (Table 1).

3.1.2 Height At Withers

The least-squares means of height at withers for different breeds, sire and sex are presented in Table 1. The overall least-squares mean of height at withers was estimated to be 198.76 ± 0.58 cm. The height at withers ranged from 195.76 to 200.30 cm in different breeds. However, one researcher reported the height at withers ranged from 209.22 ± 2.55 cm to 189.80 ± 3.29 cm in different Indian breeds (Bikaneri, Jaisalmeri and Kachchhi) and both sexes [14]. The effect of the breed was highly significant ($P \leq 0.01$) on height at withers. However, in Saudi camel breeds [12] and in Algerian camel breeds [15] were found significant ($P \leq 0.05$) effect of breed on height at withers. Whereas in Sudanese camel breeds [10] and in Maghrebi camel breeds [16] were found highly significant ($P \leq 0.01$) effect of breed on height at withers.

The effect of sex on height at withers was found highly significant ($P \leq 0.01$). On an average, the males had 3.86 cm more height than the females. The difference between both the sexes can be due to the effect of genetic differences between male and female individuals and secondly, it could be due to sex hormones. Since the camels have limited geographic distribution in the world so literature is very scanty. However, double humped camel of Ladakh a researcher reported mean for height at withers were 170.2 ± 2.1 cm and 152.4 ± 3.1 cm in male and female adult, respectively [17]. The effect of sire on height at withers was estimated to be non-significant ($P > 0.05$). No contemporary literature is available to compare the present findings.

3.1.3 Body Length

The least-squares means of body length for different breeds, sire and sex are presented in Table 1. The overall least-squares mean of body length was estimated to be 158.79 ± 0.78 cm. The body length ranged from 157.18 to 160.99 cm in different breeds. However, in different Indian breeds (Bikaneri, Jaisalmeri and Kachchhi) reported similar findings on the body length ranged from 165.70 ± 2.06 cm to 156.33 ± 6.76 cm [14] and in different Saudi camel breeds like Meghem, Sawahli, Gamra and Awadi recorded 167.70 ± 2.55, 144.00 ± 2.41, 149.60 ± 5.14 and 148.50 ± 2.17 cm body length, respectively [13].

The effect of the breed was non-significant on body length. However, in Saudi camel breeds [13] and in Maghrebi camel breeds [16] were found highly significant ($P \leq 0.01$) effect of breed on body length. The effect of sex on body length was found to be highly significant ($P \leq 0.01$). On an average, the males were 10.25 cm longer than the female camels. The difference between both the sexes can be due to the effect of genetic differences between male and female individuals and secondly, it could be due to sex hormones. The effect of sire on body length was estimated to be non significant ($P > 0.05$).

3.2 Genetic and phenotypic parameters of Biometry traits

3.2.1 Heritability

Heritability estimation of body parameters in Camel was done by paternal half sib method and is presented in Table 2, the heritability of heart girth (HGr), height at withers (HW) and body length (BL) was estimated in the present study as 0.284, 0.213 and 0.172, respectively.

3.2.2 Genetic and Phenotypic correlations

Estimates of genetic and phenotypic correlations for body parameter traits were calculated by computer program LSMLMW under the mixed statistical model and are presented in Table 2.

3.2.2.1 Genetic correlations

Genetic correlations are mainly attributed to the pleiotropic effects of genes and linkage of genes governing different traits. These are helpful in predicting correlated response to selection and needed for determining optimum weightage of each trait in the selection index. In case of positive correlation between traits, response to selection is more because selection for one automatically improves other depending upon the degree of correlation.

Estimated genetic correlations between different body parameters are presented in Table 2. Estimates for direct genetic correlations (r_g) between heart girth with different traits ranged from -0.251 ± 0.692 for HGr-BL to 1.118 ± 0.815 for HW-BL. The genetic correlations of heart girth with height at withers and with body length were estimated as 0.385 ± 0.478 and -0.251 ± 0.692, respectively. The positive and moderate correlation indicates that camels with higher heart girth have higher height at withers. The genetic correlation of height at withers with body length was estimated as 1.118±0.815.

3.2.2.2 Phenotypic correlations

The phenotypic correlation is the degree of relationship between phenotypic values of different traits measured on the same animal. It is a combined function of the genotype and the environment and interaction if any, between the two traits but their relative contribution are varied. Estimated phenotypic correlations between different body parameters are presented in Table 2. Estimates for direct phenotypic correlations between heart girth with different traits ranged from 0.160 ± 0.067 for HGr-BL to 0.359 ± 0.063 for HGr-HW. However, a researcher reported 0.92 phenotypic correlation of heart girth with body length [18] and other reported 0.15 and 0.16 phenotypic correlation of heart girth with height at withers and body length, respectively [16]. The phenotypic correlations of heart girth with height at withers and with body length were estimated as 0.359 ± 0.063 and 0.160 ± 0.067, respectively. However, a researcher reported 0.289 phenotypic correlation of heart girth with height at withers [12]. The phenotypic correlation of height at withers with body length was estimated as 0.204 ± 0.066. However, other reported -0.01 phenotypic correlation between height at withers and body length [16].

3.3 Genetic, Phenotypic and environmental trends

The genetic, phenotypic and environmental trends are presented for the heart girth, height at withers and body length in Table 3 for over all period from the year 2002-03 to 2008-09. The all three traits have studied at the age of one year to eight years.

3.3.1 Genetic, Phenotypic and Environmental trends for the heart girth in period 2002-03 to 2008-09

The genetic, phenotypic and environmental trends for the heart girth in camel at different ages are presented in Table 3. In period 2002-03 to 2008-09, phenotypic trend was positive for all the heart girth traits, which indicated that the increase in phenotypic value was substantial till 5 years of age thereafter though it was positive but the rate of increase was slow down. It indicates a general improvement of the herd during this period due to phenotypic selection. The same can be substantiated by the fact that the camels have higher gain of body weight from birth to 5 years of age and thereafter the rate decrease [19]. Draught ability of animal is been difficult to measure so indirect selection remains one of the choices for carrying out indirect selection the estimates of heritability and genetic correlations. Therefore, the phenotypic selection is the only tool which was possible. The genetic trend was positive for 1, 7 and 8 years' heart girth and negative for other heart girth traits, positive genetic trend indicate genetic improvement of camel in respect of economic values over the years. Environmental trend was positive for all the age groups except 1, 7 and 8 years' trait, positive environmental trend also indicate proper and healthy management throughout the period.

3.3.2 Genetic, Phenotypic and Environmental trends for the height at withers during the period 2002-03 to 2008-09

The genetic, phenotypic and environmental trends for the height at withers in camel at different ages are presented in Table 3. In period 2002-03 to 2008-09, Phenotypic trend was positive for all the periods of height at withers traits, which indicated that the increase in phenotypic trend was substantial till 5 years of age thereafter though it was positive but the rate of increase was slow down. It indicates a general improvement of the herd during this period due to phenotypic selection. The same can be substantiated by the fact that the camels have higher gain of body weight from birth to 5 years of age and thereafter the rate decrease [19]. The genetic trend was positive for 6 and 8 years' height at withers and negative for other height at withers traits, positive genetic trends indicated genetic improvement of camel in respect of economic values over the years. Environmental trend was positive for all the age groups except 6 and 8 years' traits, positive environmental trend also indicate proper and healthy management throughout the period.

3.3.3 Genetic, Phenotypic and Environmental trends for the body length in period 2002-03 to 2008-09

The genetic, phenotypic and environmental trends for the body length in camel at different ages are presented in Table 3. In period 2002-03 to 2008-09, except 1 and 7 years' phenotypic value was positive for all the body length traits, which indicated that the increase in phenotypic trend was substantial till 5 years of age thereafter though it was positive but the rate of increase was slow down. It indicates a general improvement of the herd during this period due to phenotypic selection. The same can be substantiated by the fact that the camels have higher gain of body weight from birth to 5 years of age and thereafter the rate decrease [19]. The genetic trend was positive for 5, 7 and 8 years' body length and negative for other body length traits, positive genetic trend indicate genetic improvement of camel in respect of economic values over the years. Environmental trend was positive for all the age groups except 7 and 8 years' traits, positive environmental trend also indicates proper and healthy management throughout the period.

4. Conclusion

Heritability of heart girth, height at withers and body length were estimated in the present study as 0.284, 0.213 and 0.172, respectively so these are the low heritable traits. The fixed effect of breed was found non-significant (*P*>0.05) on heart girth and body length, whereas highly significant (*P*<0.01) on height at withers. The fixed effect of sex was found highly significant (*P*<0.01) on height at withers and body length, whereas significant (*P*<0.05) on heart girth. The random effect of sire was found non-significant (*P*>0.05) on all body parameter traits. Phenotypic trend was positive for all the body parameter traits, which indicated that the increase in phenotypic trend was substantial till 5 years of age thereafter though it was positive but the rate of increase was slow down. Positive environmental trend also indicate proper and healthy management throughout the period.

Table 1: Least-squares means (± S.E) of body parameters like Heart girth, Height at withers and Body length in adult camel.

Traits/ Factors	HGr	HW	BL
Overall Mean (μ)	208.99 ± 1.28 (247)	198.76 ± 0.58 (247)	158.79 ± 0.78 (247)
Sire	NS	NS	NS
Breed	NS	**	NS
Bikaneri	207.30 ± 1.64 (117)	200.23 ± 0.74^b (117)	158.19 ± 0.10 (117)
Jaisalmeri	211.67 ± 1.77 (97)	200.30 ± 0.80^b (97)	160.99 ± 1.07 (97)
Kachchhi	207.99 ± 3.03 (33)	195.76 ± 1.37^a (33)	157.18 ± 1.84 (33)
Sex	*	**	**
Male	211.24 ± 1.75^b (112)	200.69 ± 0.80^b (112)	163.91 ± 1.06^b (112)
Female	206.73 ± 1.68^a (135)	196.83 ± 0.76^a (135)	153.66 ± 1.02^a (135)

(in cm) No. of observations are given in parenthesis. Figure with different superscripts differ significantly HGr= Heart girth; HW= Height at withers; BL= Body length ** - Highly significant (*P*≤0.01); * - Significant (*P*≤0.05); NS - Non-significant

Table 2: Matrix of heritability, genetic correlation and phenotypic correlation estimates for body parameter traits in adult Camel

Trait	Heart girth	Height at withers	Body length
Heart girth	0.284 ± 0.224	0.385 ± 0.478	-0.251 ± 0.692
Height at withers	0.359 ± 0.063	0.213 ± 0.215	1.118 ± 0.815
Body length	0.160 ± 0.067	0.204 ± 0.066	0.172 ± 0.209

Values at the diagonal are heritability estimates, and values above and below the diagonal are genotypic and phenotypic correlations, respectively.

Table 3: Estimates of Genetic, Phenotypic and Environmental Trends (±S.E.) for the heart girth, Height at withers and Body length in period 2002-03 to 2008-09

Heart girth at the age of	N	Genetic	Phenotypic	Environmental
1 year	36	2.02 ± 3.01	0.58 ± 0.46	-1.44 ± 3.04
2 year	46	-2.93 ± 1.78	2.71 ± 0.51	5.64 ± 1.86
3 year	29	-8.00 ± 1.50	2.95 ± 0.91	10.95 ± 1.75
4 year	22	-6.56 ± 2.18	2.75 ±0.85	9.31 ± 2.34
5 year	41	-3.84 ± 1.81	4.56 ± 0.78	8.40 ± 1.97
6 year	23	-0.38 ± 7.69	0.27 ± 1.41	0.65 ± 7.82
7 year	20	13.65 ± 7.47	2.63 ± 1.13	-11.02 ± 7.55
8 year	23	3.00 ± 3.22	0.69 ± 1.34	-2.31 ± 3.49
Height at withers at the age of	N	Genetic	Phenotypic	Environmental
1 year	36	-0.07 ± 3.69	0.00 ± 0.58	0.07 ± 3.74
2 year	46	-4.81 ± 1.61	2.18 ± 0.49	6.98 ± 1.68
3 year	29	-11.20 ± 1.13	1.32 ± 0.77	12.52 ± 1.37
4 year	22	-4.86 ± 1.94	2.17 ±0.80	7.03 ± 2.10
5 year	41	-0.72 ± 1.03	1.43 ± 0.56	2.15 ± 1.18
6 year	23	2.24 ± 6.75	0.15 ± 1.24	-2.09 ± 6.87
7 year	20	-5.48 ± 3.31	0.72 ± 0.54	6.20 ± 3.35
8 year	23	7.64 ± 1.54	0.78 ± 0.62	-6.85 ± 1.66
Body length at the age of	N	Genetic	Phenotypic	Environmental
1 year	36	-0.96 ± 2.95	-0.46 ± 0.46	0.51 ± 2.99
2 year	46	-6.56 ± 1.04	0.07 ± 0.38	6.63 ± 1.10
3 year	29	-17.20 ± 1.56	2.21 ± 1.03	19.41 ± 1.87
4 year	22	-2.83 ± 2.14	0.81 ± 1.01	3.65 ± 2.37
5 year	41	0.46 ± 1.29	1.01 ± 0.74	0.55 ± 1.49
6 year	23	-4.95 ± 8.99	0.54 ± 1.65	5.43 ± 19.14
7 year	20	9.74 ± 6.99	-1.51 ± 1.15	-11.25 ± 7.08
8 year	23	3.55 ± 2.80	0.43 ± 1.17	-3.12 ± 3.04

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