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Lactation persistency, yield and prediction models in Indian dromedary

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ABSTRACT

The demand driven economy is leading to production and utilization of camel milk for nutritional security of the human population. Lactation records (65) of the she-camels belonging to the Bikaneri, Kachchhi and Mewari breeds were analysed. The average daily milk production from 2 teats was 2.9±0.04 litre with 2.7±0.05 litre in Bikaneri, 3.2±0.07 litre in Kachchhi and 2.6±0.08 litre in Mewari breed. The average daily production was 2.5±0.07, 2.8±0.06, 3.2±0.07 and 3.0±0.10 litres respectively in first, second, third and fourth parity. Highest individual average daily milk yield from 2 teats was 8.06 litre. The peak yield was observed in fifth month of lactation. The average lactation yield from 4 teats was estimated to be 1,883±75, 2,239±88, 2,520±100 and 3,017±148 litre for the lactation length of 10, 12, 14 and 16 months, respectively. Two breeding and milking models were compared. Eleven mathematical functions were fitted for the prediction lactation yield and it was observed that for the sake of simplicity, the linear equation can be utilized for the purpose. The fifth month's average daily yield gave the best predictions. Therefore, the mathematical equation $Y=106.727+ 238.597(Y_{5m})$ can be utilized for prediction of 10 months' lactation yield and respective equations for the lactation yields of 12, 14 and 16 months' lactation. The persistency of lactation was 76.20, 67.07, 55.67 and 35.87% when calculated for lactation length of 10, 12, 14 and 16 months, respectively. The present observations and analyses indicated tremendous scope in dromedary to fulfill the human aspirations which may lead to its sustenance too.

Key words: Camel, Milk, Peak yield, Persistency, Prediction

Camel is a unique species in terms of production and utilization. In different parts of the world it is serving different purposes. In Middle East countries, apart from milk and meat, camels are also reared for race whereas in North African countries it is being reared for draught and meat (Kadim *et al*. 2008) and in Indian subcontinent the species had been reared for draught and is currently in a phase of transition (Mehta 2014). The researchers are exploring it for its unique genetics i.e. in terms of adaptability to harsh climate, utilization of single domain antibody for betterment of human health, therapeutic properties of camel milk (Omidfar and Shirvani 2012, Al Haj and Al Kanhal 2010) but the demand driven economy is leading to production and utilization of camel milk and meat for nutritional security of the human population (Faye and Konuspayeva 2012). Camel dairying is coming up at several places in the world (Almutairi *et al*. 2010, Faye and Konuspayeva 2012, Mehta *et al*. 2009, 2011). The population of camel in India is 400,274 heads with 325,713 in Rajasthan and 30,415 in Gujarat and 18,845 in Haryana (Livestock Census 2012). Bikaneri, Jaisalmeri, Kachchhi and Mewari are the 4 major breeds in country (Mehta *et al*. 2007). The preliminary information on the production potential and length of lactation was presented earlier (Mehta *et al*. 2011) but the evaluation of milk production potential of the Indian dromedary breeds remains an unfulfilled task. The species has not been selected for milk production potential barring some recent attempts (Mehta *et al*. 2009, 2011, Nagy *et al*. 2013). Development of a species for milk production necessitates its evaluation for basic milk production parameters viz. lactation yield, lactation length, peak yield, persistency of lactation, phases of lactation etc., apart from genetic and non-genetic factors affecting the milk production potential.

Lactation persistency is an important economic trait and is defined as the ability of a she camel to maintain milk production at a high level after the peak yield, i.e. a persistent animal has a flatter lactation curve (Cobuci *et al*. 2003) and are preferred because of higher lactation yield. High persistency is associated with more resistance to diseases, better utilization of feed, reduced stress from high peak yield and low reproductive cost. There are several methods to measure lactation persistency. These methods are mainly based on (a) differences, ratios, or rates involving peak, partial and total milk yield, (b) variation of test-day yield, (c) parameter estimates from mathematical models of lactation curves and (d) breeding values from the random regression models (Cobuci *et al*. 2003). A she-camel can

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continue giving milk till 24 months (Mehta *et al*. 2011) but the length of lactation depends mainly on its breeding i.e. breeding immediately after calving, in the next season or thereafter. An attempt was made to estimate the lactation persistency for different lengths of lactation. Looking into the lactation length, yield, predicted yield, persistency and seasonality of its breeding behavior (Skidmore 2011) an attempt was made to suggest suitable model for breeding milch camels in Indian context.

MATERIALS AND METHODS

Animals and data recording: She-camels belonging to Bikaneri (27), Kachchhi (22) and Mewari (16) were evaluated during the period 2008–09 to 2011–12. The distribution of these records in terms of their breed, parity and year of recording is given in Table 1. The records were lost either due to the death of camels or due to their early pregnancy or due to significant reduction in production (i.e. <500 ml/ day from 2 teats). Individual she camels were measured daily during the experiment, only when the production from front as well as rear teat during morning and evening separately was greater than zero. At the end of lactation, the average daily milk yield of the month was calculated only when the production data for ≥10 days were available.

Since proper let down of milk in camel takes place with the suckling of milk by the calf (Sahani *et al*. 1998, Njanja and Oba 2010), two teat milking was followed. However, this contention was contrary to the speculation of Wernery *et al*. (2004) that the young camels could be removed from the dam without any negative effect on the milk yield. One front and one rear teat of one side was milked and the other side was left for simultaneous suckling by the calf. Three times milking was followed for initial 3 months for better nourishment of the calf; thereafter 2 times milking was followed. The total milk production of the day included the production of milk from front and rear teats during morning, noon and evening for first 3 months and that of morning and evening after 3 months. The milking females were reared under semi intensive system of management. The milking females were sent out for grazing for about 5 h a day and at the farm they were offered concentrate ration @ 3 kg / day. At the farm they were also provided fodder consisting of *guar phalgati* (*Cyamopsis tetragonoloba*), *moth chara* (*Phaseolus aconitifolius*) and groundnut fodder (*Arachis hypogea*) @ 12kg/animal/day. The milking females were provided water *ad lib*. However, no separate pens were provided to individual camel and they were housed in a group pen. Hand milking was followed and traditionally trained persons of *Raika* community were engaged in milking. The milk recording commenced from day 15th after calving and was continued till 24 months unless the animal ceased yielding milk (i.e. <500 ml / day from 2 teats).

Statistical analysis: The multivariate analysis of variance was carried out for morning and evening milk production from front and rear teats, as well the total daily milk yield. Post Hoc were performed using Duncan's multiple range test. Analysis of total daily milk yield was carried out with fixed effect of breed, parity and year. Mean separation was carried out to define different phases of lactation. The mathematical functions, viz. Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth, Exponential, Logistic were fitted for the prediction of 305

Table 1. Average daily milk yield of dromedary breeds in different lactations and years

(Two teat milking, milk yield in litres)

Breed	Parity	Year				
		2008	2009	2010	2011	Pooled
Bikaneri	Pooled	2.8±0.09 (6)	2.7±0.11 (7)	3.0±0.11 (7)	2.3±0.10 (7)	2.7±0.05(27)
	1	2.9±0.13 (3)	-	2.9±0.15 (3)	-	2.9±0.10(6)
	2	2.7±0.13 (3)	3.0±0.17 (3)	2.9±0.17 (2)	2.0±0.19 (2)	2.6±0.08 (10)
	3	-	3.1±0.16 (3)	2.9±0.25 (1)	2.3±0.16 (3)	2.8±0.11 (7)
	4	-	2.0±0.25 (1)	3.4±0.25 (1)	2.7±0.19 (2)	2.7±0.13 (4)
Kachchhi	Pooled	4.4±0.14 (4)	3.0±0.12 (7)	3.0±0.12 (6)	2.5±0.12 (5)	3.2±0.07 (22)
	1	-	2.5±0.25 (1)	2.7±0.18 (2)	2.0±0.19 (2)	2.4±0.12 (5)
	2	-	3.2±0.11 (5)	3.5±0.27 (1)	-	3.3±0.14 (6)
	3	5.1±0.2 (1)	-	3.6±0.18 (2)	3.0±0.16 (3)	3.9±0.11 (6)
	4	3.8±0.14 (3)	3.5±0.25 (1)	2.4±0.31 (1)	-	3.1±0.14 (5)
Mewari	Pooled	-	2.7±0.16 (3)	2.8±0.13 (5)	2.4±0.11 (8)	2.6±0.08 (16)
	1	-		2.5±0.15 (3)	2.2±0.26 (1)	2.4±0.15 (4)
	2	-	2.71±0.16 (3)	3.0±0.24 (1)	2.3±0.16 (3)	2.6±0.11 (7)
	3	-	-	2.9±0.27 (1)	2.7±0.14 (4)	2.8±0.15 (5)
	4	-	-	-	-	-
Over all	3.6±0.08 (10)	2.8±0.08 (17)	3.0±0.07 (18)	2.4±0.07 (20)	2.9±0.04(65)	

Figures in parenthesis indicate number of animals.

days lactation yield utilizing average daily milk yield of first to fifth and peak yield month. SPSS 17.0 was used for carrying out the statistical analysis.

Since the linear equation explained the relationship between average daily milk production and the 305 days lactation yield the most, so the lactation persistency of milk yield was calculated as percentage of daily yield maintained from peak to the end of lactation. The method used by Almutairi *et al*. (2010) was used with minor modification.

$$P=\left[1-\frac{\left(Y_{pm}-Y_{lm}\right)}{Y_{pm}}\right]\times 100$$

where P, per cent persistency; Y_{pm}, average daily milk yield of peak month; Y_{lm}, average daily milk yield of 10^{th} or 12^{th} or 14^{th} or 16^{th} month of lactation.

RESULTS AND DISCUSSION

Milk production: effect of genetic and non-genetic factors

The analysis for milk production records from front and rear teats, separately during morning and evening, along with the total production has been presented in Table 2. The milk production from one front and one rear teat in the morning and evening was 740±10 and 880±11 and 497±7 and 624±8 ml respectively. Mehta *et al*. (2011) earlier reported that the production from rear teats was higher as compared to front teats and that in the morning was higher than evening. The average per day milk production from 2 teats was 2.9±0.04 litre with 2.7±0.05 litre in Bikaneri, 3.2±0.07 litre in Kachchhi and 2.6±0.08 litre in Mewari breed. The effect of breed was highly significant (P<0.01) with highest production in Kachchhi breed. The superiority of Kachchhi females with little higher production figures in Bikaneri and Kachchhi were observed by Sahani *et al*. (1998). The estimated 4 teat average daily milk yield in the present study was higher than the 4.8 kg reported by Wernery *et al*. (2004) but the figures may be rather more comparable because little lower production under machine milking in dromedary was observed by Sahani *et al*. (1998). However, Almutairi *et al*. (2010) reported 6.11 kg in Saudi camels of Al Jouf farm and Ahmad *et al.* (2012) reported 8.17±0.09 litre in camels kept under desert conditions in Pakistan. These values are little higher than the observed average production but are quite close to the average daily milk yield of the year 2008 in present study, meaning thereby that the non-genetic factors, viz. nutrition, environment and management, are mainly responsible for such differences. The average daily production was 2.5±0.07, 2.8±0.06, 3.2±0.07 and 3.0±0.10 litre, respectively, in first, second, third and fourth parity. The effect of parity was also highly significant (P<0.01). Third and fourth parity had highly significant production over first and second. Sahani *et al*. (1998) compared second and third parity and reported significant contribution of parity on milk yield with higher values for third parity as compared to the second parity in Indian dromedary breeds. However, Njanja and Oba (2010) reported higher milk yield from first parity dams than second or multi-parity dams in Turkana camel breed in north – western Kenya. Similarly the figures for the year 2008, 2009, 2010 and 2011 were 3.6±0.08, 2.8±0.08, 3.0±0.07 and 2.4±0.06 litres, respectively. The effect of year was also highly significant (P<0.01) with highest production in the year 2008–09 and lowest

Table 2. Average daily milk yield of dromedary breeds in different parities and years

(Two teat milking, milk yield in ml)

Parameter	No. of Animals	Morning		Evening		Total
		Front	Rear	Front	Rear	
Pooled	65	740±10	880±11	497±7	624±8	2871±36
Breed		**	**	**	**	**
Bikaneri	27	707±15	842±16	467±11	592±12	2730±54[b]
Kachchhi	22	838±18	984±19	543±13	675±15	3193±64[c]
Mewari	16	665±21	789±22	463±16	581±18	2607±76[a]
Parity		**	**	**	**	**
1	15	653±20	789±21	419±15	538±17	2515±72[a]
2	23	727±16	857±18	486±13	610±14	2802±60[a]
3	18	837±19	979±20	557±15	687±16	3199±70[b]
4	9	758±26	899±28	510±20	640±22	2952±97[b]
Year		**	**	**	**	**
2008	10	923±22	1127±24	616±17	769±19	3630±81[c]
2009	17	740±20	870±24	479±16	610±17	2836±75[b]
2010	18	790±18	918±24	501±14	621±16	2974±68[b]
2011	20	599±18	720±24	437±13	551±15	2380±64[a]

**P<0.01.

production in the year 2011–12. All possible interactions of breed, parity and year were also highly significant except breed with parity. The analyses clearly suggested that the non-genetic factors influenced the production to a great extent due to which the interpretation about the superiority of breed and parity were also influenced. Therefore, an investigation of the availability of animals of different breeds and parity in different years was carried out and their production performances were analysed (Table 1). It was observed that the most congenial year for the milk production was 2008–09 during which the Mewari females were not available and most unfavorable year was 2011–12 during which 8 Mewari females out of total 16 Mewari females measured in the experiment were available. Similarly, the production was significantly higher in third and fourth parity as compared to the first and second parity and the Mewari breed was not represented in the fourth parity and of the 16 she camels of the breed evaluated for the production, 11 belonged to the first and second parity i.e. the parities with significantly lower production. Under such circumstances, the superiority of the breed as discussed above requires more measurements to establish the differences among them.

Phases of lactation and peak yield

Milk production in different months of different parities was analysed to observe the trend in milk production over lactation (Table 3). The effect of month was highly significant ($P<0.01$). Highest individual average daily milk yield of 8.06 litre from 2 teats was observed in the year 2008 in Kachchhi camel. However, the similar figures for the subsequent years viz. 2009, 2010 and 2011 were 7.06 litre observed in Mewari, 5.45 litre observed in Kachchhi and 4.21 litre observed in Bikaneri females. The arrival of peak yield in individuals varied from month 1 to month 10. The effect of breed, parity and year on month of peak yield was nonsignificant. However, pooled over individuals of parity 1, 2, 3 and 4, it was achieved respectively in fourth, seventh, sixth and fifth month. Pooled over parities the peak yield was 3.41 litre (2 teat milking) and it was achieved in fifth month. Though, the effect of year was nonsignificant but the mean separation resulted in 2 groups. The first one was represented by the year 2008 and rest of the years, from 2009 to 2011, were grouped in second group. Also, it was observed that in the year 2008, the arrival of peak yield varied from second to fifth month only, whereas it varied from 1st to 10th, 3rd to 10th and 1st to 8th month respectively, in subsequent years. In Bikaneri and Kachchhi, it was achieved in fifth month and in Mewari it was achieved in seventh month. Delay in achieving peak yield in Mewari can be attributed to the availability of majority of them in the unfavourable year 2011–12, as discussed above. Sahani *et al*. (1998) also reported that the daily milk production was highest during month 6 of lactation and then it started declining. Similarly, Musaad *et al*. (2013) reported number of weeks to reach peak yield as 28, which is also in agreement with the present observation.

Table 3. Average daily milk yield in different parities and months

(Two teat milking, milk yield in litre)

Month	Parity				
	1	2	3	4	Pooled
1	2.3 (15)	2.5 (23)	2.6 (18)	3.2 (9)	2.6 (65)
2	2.6(15)	3.0(22)	2.8 (18)	4.0(9)	3.0(64)
3	3.1(15)	3.2(23)	3.4(18)	3.8(9)	3.3(65)
4	3.2(15)	3.2(23)	3.5(18)	3.6(9)	3.4(65)
5	3.2(15)	3.3(22)	3.5(18)	3.7(9)	3.4(64)
6	3.1(15)	3.3(22)	3.6(18)	3.6(9)	3.4(64)
7	2.9(15)	3.4(22)	3.5(18)	3.4(9)	3.3(64)
8	2.8(15)	3.3(22)	3.4(18)	3.3(9)	3.2(64)
9	2.8(15)	3.2(22)	3.3(17)	3.2(9)	3.1(63)
10	2.7(15)	3.1(22)	3.1(17)	3.1(9)	3.0(63)
11	2.7(14)	2.8(23)	2.9(17)	3.0(8)	2.8(62)
12	2.4(15)	2.6(22)	2.7(14)	2.7(8)	2.6(59)
13	2.3(15)	2.1(22)	2.7(14)	2.5(7)	2.4(58)
14	2.1(12)	1.9(19)	2.6(11)	2.2(6)	2.1(48)
15	1.6(12)	1.9(14)	2.0(8)	1.9(6)	1.8(40)
16	1.4(7)	1.7(10)	1.7(6)	1.7(5)	1.6(28)
17	2.2(2)	1.7(6)	1.6(1)	3.5(1)	2.0(10)
18	2.2(2)	2.1(2)	1.4(1)	3.8(1)	2.3(6)
19	2.1(2)	2.1(2)		4.2(1)	2.5(5)
20	2.0(2)	2.1(2)		4.0(1)	2.4(5)
21	2.520(1)	1.6(2)		3.2(1)	2.2(4)
22	1.971(1)	1.4(2)		2.7(1)	1.9(4)
23	1.519(1)	1.1(2)			1.2(3)
24	1.257(1)	1.3(1)			1.3(2)

Figures in parenthesis indicate number of animals.

In present analyses the lactation length was considered to be 16 months (Mehta *et al*. 2011), but to get a comparative picture of production, the lactation yield and persistency of lactation was calculated at an interval of 2 month after 10th month till 16th month. The lactation length in camel varying from 9 to 18 months has been well documented by the researchers. However in recent reports, Wernery *et al*. (2004) studied the lactation in camels up to 12 months, Njanja and Oba (2010) studied the lactation characteristics of Turkana camel breed over a period of 60 weeks and Musaad *et al*. (2013) reported 12.5 months as the lactation length in camels. As explained earlier (Mehta *et al*. 2011) and discussed below, it is better to milk a camel up to 16 months. The mean separation, correlation and regression analysis done to define the lactation curve, revealed three production groups (Fig. 1). The 1st and 10th to 12th month formed one production group. The second production group encompassed the month of peak yield and was continuous from 2nd to 9th month. The third production group was from 13th to 16th month. Higher individual variation across parities and breeds indicated lack of selection for the trait under study in Indian dromedary. Nagy *et al*. (2013) also expressed similar opinion while discussing the use of assisted reproduction for the improvement of milk production in dairy camels.

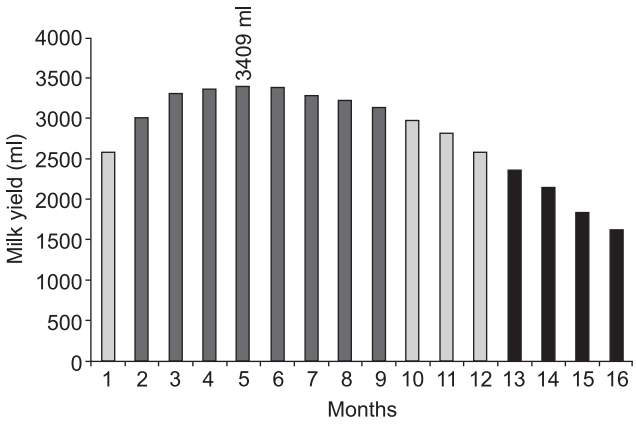

Fig. 1. Phases of lactation in dromedary.

Model for breeding and milking of Indian dromedary

Lactation yield was computed on the rationale of equal production from the 2 teats of either side. The average lactation yield, thus calculated, was 1883±75, 2239±88, 2520±100 and 3017±148 litre for the lactation length of 10, 12, 14 and 16 months, respectively. The effect of breed on lactation yield was nonsignificant. The effect of parity was significant (P< 0.05) only when the lactation yield was considered for 10 month duration. However, the effect of year was mostly significant (Table 4). Comparable production figures of 1,970±790 litres for a 12 month lactation was reported by Musaad *et al*. (2013). Similarly Almutairi *et al*. (2010) reported 1816.5 kg in 305 days in Saudi camels, however, Wernery *et al*. (2004) reported 21,959.9 kg milk out of 16 camels in 12 months lactation, which comes out to be 1,372.49 kg/ she camel. The lower production (Wernery *et al*. 2004) may be attributed to the use of automatic bucket milking machine versus the use of hand milking in present study as compared by Sahani *et al*. (1998).

It was observed that the animals which were conceived in next breeding season continued producing milk up to 14 to 16 months whereas the animals which did not conceive in next breeding season continued beyond 16 months. It was also observed that the animals which were bred immediately after calving i.e. after 30 days or so, continued the lactation for about 10 months period. The average lactation yield for 10 months' duration was worked out to be 1,883±75 litre and for 16 months was worked out to be 3,017±148 litre which is 60.22% higher than the 10 months' yield. We traced the same animal and found that when it was bred in the next breeding season, its 10, 12, 14 and 16 months' yield was 1,694, 1,924, 2,134 and 2,204 litres but when it was bred immediately after calving, i.e. 39 days post parturition, it gave milk only up to 10 months and the yield was 1,350 litres, i.e. only 79.69% of its 10 months' production and only 61.25% of its 16 months' production when bred in the next breeding season. When the she camels are bred in this manner, there is bound to be reproductive and production stress on the animal. Also, the seasonality of breeding behavior of camel is also a constraint in this, even if the same is managed, the calving will shift from cooler months to hotter months and the calf mortality is expected to increase significantly (Mehta *et al*. 2012). However, in theory, it is possible to get 3 calves in 40 months and 1350×3 = 4,050 litre of milk under the Intensive Reproduction Model (Model 2) in place of 2 calves in 3 years with 2204×2= 4,408 litre of milk without any reproductive intervention and stress to dam as well as calf in Model 1 (Fig.2). It is therefore suggested that in Indian dromedary, the appropriate lactation model should be to take 2 calves and to have two full lactations of 16 months

Table 4. Lactation yield in Indian dromedary breeds at different stages of lactation

(milk yield in liters, estimated for four teats)

Parameters	Lactation length			
	10 Months	12 Months	14 Months	16 Months
Overall	1883±75 (63)	2239±88 (59)	2520±100 (48)	3017±148 (28)
Breed	NS	NS	NS	NS
Bikaneri	1816±114 (25)	2152±134 (24)	2357±150 (21)	2795±199 (16)
Kachchhi	2137±129 (22)	2590±155 (20)	2873±175 (17)	3479±255 (9)
Mewari	1597±154 (16)	1887±180 (15)	2295±211 (10)	2627±441 (3)
Parity	*	NS	NS	NS
1	1596±150 (15)	1892±173 (15)	2135±198 (12)	2676±303 (7)
2	1833±126 (22)	2160±146 (22)	2473±164 (19)	2822±243 (10)
3	2150±145 (17)	2545±175 (14)	2845±201 (11)	3639±312 (6)
4	1933±192 (9)	2379±237 (8)	2623±267 (6)	2980±337 (5)
Year	**	*	*	NS
2008	2597±185 (10)	3027±214 (10)	3448±232 (9)	3684±265 (9)
2009	1930±159 (15)	2234±184 (15)	2586±195 (14)	2700±255 (9)
2010	1962±136 (18)	2351±162 (17)	2629±172 (15)	2907±241 (10)
2011	1375±127 (20)	1709±155 (17)	1862±208 (10)	

Figures in parenthesis indicate number of animals; *P<0.05; **P<0.01; NS, nonsignificant.

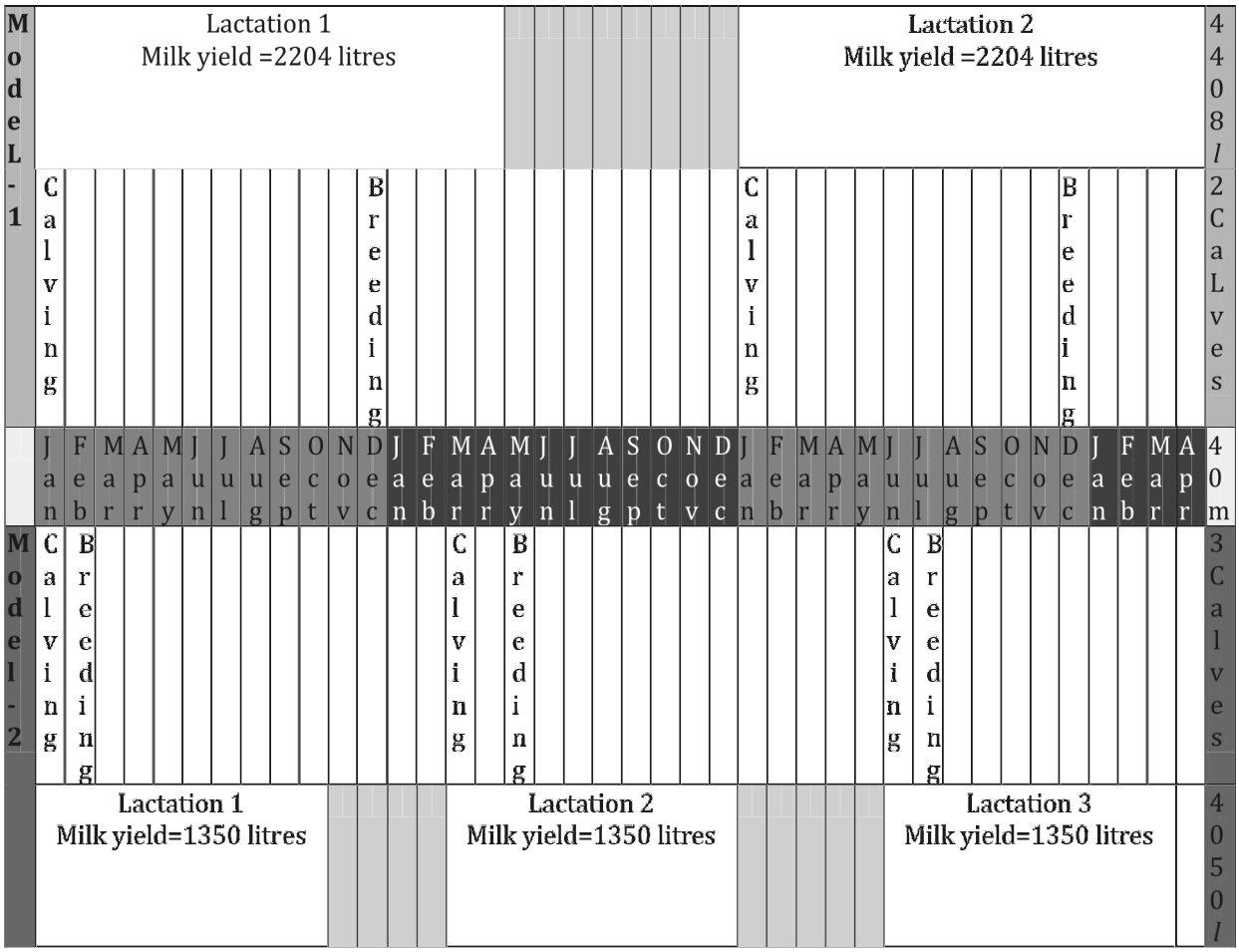

Fig. 2. Breeding and milking models in Indian dromedary.

duration in 3 years (Model 1) especially in the desert climatic situations.

Persistency of lactation

Persistency of lactation is one of the important considerations to evaluate the production potential of an animal. The animals that remain on or around peak production for a longer time are preferred because of higher lactation yields. There are several methods to calculate the persistency, but to start with we preferred the one which

Table 5. Persistency of lactation in Indian dromedary at different lactation lengths

Parameters	Persistency (%)			
	10 Months	12 Months	14 Months	16 Months
Overall	76.20±2.25 (63)	67.07±1.93 (59)	55.67±2.70 (48)	35.87±3.29 (28)
Breeds	NS	NS	NS	NS
1	76.86±3.42 (25)	68.16±2.92 (24)	58.24±4.04 (21)	37.62±4.42 (16)
3	74.00±3.88 (22)	64.91±3.39 (20)	49.22±4.70 (17)	34.70±5.67 (9)
5	78.51±4.63 (16)	68.29±3.94 (15)	60.48±5.68 (10)	31.52±9.82 (3)
Parity	NS	NS	NS	NS
1	78.10±4.49 (15)	70.72±3.79 (15)	60.86±5.32 (12)	35.18±6.75 (7)
2	81.44±3.78 (22)	71.38±3.19 (22)	49.31±4.43 (19)	41.72±5.40 (6)
3	74.69±4.35 (17)	61.13±3.83 (14)	58.80±5.40 (11)	31.55±6.95 (6)
4	68.17±5.76 (9)	63.68±5.19 (8)	54.87±7.19 (6)	33.58±7.50 (5)
Year	NS	**	*	NS
2008	69.51±5.55 (10)	65.60±4.69 (10)ab	53.72±6.24 (9)	35.85±5.90 (9)
2009	75.20±4.78 (15)	62.22±4.03 (15)a	47.94±5.25 (14)	38.52±5.67 (9)
2010	75.41±4.08 (18)	62.57±3.55 (17)a	48.47±4.64 (15)	33.61±5.38 (10)
2011	81.53±3.80 (20)	77.66±3.38 (17)b	72.41±5.60 (10)	-

Figures in parenthesis indicate number of animals; *P<0.05; **P<0.01; NS, nonsignificant.

Table 6. Prediction of lactation yield by utilizing fifth months' average daily yield

Equations	R^2	Parameter estimates			
		Constant	b_1	b_2	b_3
Linear	0.900	106.727	238.597		
Logarithmic	0.794	128.833	684.120		
Inverse	0.542	1329.085	–1179.835		
Quadratic	0.901	141.281	218.752	2.535	
Cubic	0.901	86.948	272.525	–12.417	1.190
Compound	0.797	348.882	1.306		
Power	0.897	318.619	0.866		
S	0.801	7.357	–1.708		
Growth	0.797	5.855	0.267		
Exponential	0.797	348.882	0.267		
Logistic	0.885	0.003	0.638		

Prediction of lactation yield

In order to take a decision to retain an animal in milk production or not, it is always important to know the expected quantum of milk that is expected out of it during the lactation. Eleven mathematical models were fitted to observe the accuracy of prediction (Table 6) and it was observed that linear, quadratic and cubic functions gave better fit ($R^2 \geq 0.90$) as compared to other functions. For the sake of simplicity, without losing much accuracy, the linear equation can be utilized for the purpose. Since the month with peak production was highly variable and was at a quite later stage, an attempt was made to predict the lactation yield as early as possible. We tried first to fifth month and the peak months' average daily yield in individual case to predict the lactation yield (Table 7). It was observed that fifth month gave the best R^2 values and the gain in accuracy was from 0.634 to 0.900. Use of peak month's average daily yield did not result in higher prediction accuracy. The results therefore clearly suggested that instead of shifting the *Ypm* in individual case it is better to use average daily yield of fifth month and even the gain from fourth to fifth month was also very marginal. This was evident from the 3 production groups defined earlier in the paper that the second group starts from month second and continues up to ninth month, so the gain in accuracy was very high from first to second month and thereafter it reduced significantly in each month with marginal gain between fourth and fifth month. However, it was observed that the prediction of lactation yield for the lactation length of 10, 12,14 and 16 months, fifth months average daily yield gave the best fit. Therefore, the mathematical equation $Y=106.727+238.597(Y_{5m})$ can be utilized for prediction of 10 months' lactation yield. For the prediction of lactation yields of lactation lengths of 12, 14 and 16 months, the constants and regression coefficients as defined in Table 7 may be utilized with acceptable accuracy ($R^2 \geq 0.90$) and suitable decision to retain an animal in production can be taken accordingly.

Table 7. Prediction of lactation yield using average daily yield of different months and linear mathematical function

Month	Lactation length											
	10 Months			12 Months			14 Months			16 Months		
	R^2	Constant	b_1	R^2	Constant	b_1	R^2	Constant	b_1	R^2	Constant	b_1
1st	0.63	314.300	238.806	0.64	426.744	261.410	0.67	492.445	293.343	0.57	567.303	302.831
2nd	0.78	302.043	208.621	0.75	424.964	223.789	0.75	569.188	230.076	0.67	506.139	268.378
3rd	0.83	249.316	202.760	0.80	358.621	220.087	0.81	429.395	238.609	0.75	494.234	249.219
4th	0.89	134.788	233.807	0.89	224.376	257.243	0.89	324.703	269.927	0.86	373.957	284.632
5th	0.90	106.727	238.597	0.90	173.848	267.195	0.90	281.961	279.456	0.91	317.148	298.527
Peak	0.898	48.392	232.063	0.89	140.741	252.212	0.90	257.474	261.622	0.88	233.928	289.316

Looking at the increased need of non-cattle milk for human consumption (Faye and Konuspayeva 2012), the selection of dromedary for genetic improvement of milk production potential has become essential. The present

was used by Almutairi *et al*. (2010) with minor modifications. The persistency was 76.20, 67.07, 55.67 and 35.87% when calculated for lactation length of 10, 12, 14 and 16 months, respectively. The effect of breed and parity was nonsignificant but that of year was significant at some stages. Higher persistency was observed in year 2011 but the same was not due to the fact that the animals remained around peak production for longer time but was due to the fact that this was the year of lowest lactation yield and the peak yield in the year was substantially lower as compared to the previous years (Table 5). However, Almutairi *et al*. (2010) reported 87.3% persistency for the lactation of 305 days and Musaad *et al*. (2013) reported even higher lactation persistency of 94.7%. Although the figures may not be exactly comparable as the measure of persistency may vary with the formulae used, however, the persistency observed in the present study (76.2%), for the similar lactation length, was significantly lower but the average daily yield in the three cases was quite comparable. This indicates that a flatter lactation curve was observed by Almutairi *et al*. (2010) and Musaad *et al*. (2013) as compared to relatively bell shaped curved in the present investigation. In present investigation also lowest peak yield (4207 ml) and highest persistency (81.53%) was observed in the year 2011 with relatively flatter lactation curve.

observations and analyses indicated tremendous scope in dromedary to fulfill this human aspiration which may also lead to its sustenance in the present era of mechanization.

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