



Effect of first lactation profit traits on milk production in Indian buffalo

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Buffalo breeds of India are known for their high production, potential and high efficiency for utilization of low quality roughages as well as sustaining poor quality husbandry practices better than cattle. The major population of buffalo is from rural India where farmers keep 1–4 milk animals as a subsidiary occupation to supplement their diet as well as income. The present economic conditions demand that not only should the individual animals be high producers but they should be profitable also. The most important traits contributing largely towards profit are high milk producing ability and low maintenance cost. Besides Murrah buffaloes Nili Ravi and graded Murrah buffaloes are also maintained at military dairy farms for supply of milk to military personnel. Therefore, an effort was made to estimate the profitability and its inheritance in Murrah, Nili Ravi and graded Murrah buffaloes, in order to construct a selection index with the aim to select profitable animals on organized farms.

Very little information on the economics of milk production from buffalo is available. Some of the reports from unorganized farms (Ram *et al.* 1980) and organized buffalo farms (Arora *et al.* 1994) are available, but different methods have been used. Pearson and Miller (1981) suggested a profit function of income (I) minus expenses (E) as the net economic effect of input and output items, and this appears to be function of choice for dairy animals. But I - E per day of herd life has the advantage of being understood more easily by dairymen. However, it has the disadvantage of not reflecting the limitations of the availability of labour, credit and other resources.

Income and expense on each buffalo was calculated by multiplying the various actual requirements of the animals by unit prices. Actual requirements of each animal were taken into consideration because group feeding and management

of buffalo were practiced at the six military dairy farms, namely, Agra, Ambala, Bareilly, Ferozpur, Lucknow and Meerut (all in northern India). In all, data on 1753 buffaloes sired by 185 sires and calved during 1953–84 were collected for three consecutive lactations.

The income on each animal in the i^{th} lactation was calculated as follows:

$I_i (\text{₹}) = 200 + \text{milk yield in } i^{\text{th}} \text{ lactation} \times \text{milk price} + \text{salvage value of the animal in respective lactations}$

where 200 was the price of a day old calf in ₹ produced by a buffalo, milk yield was the actual milk produced in each lactation, milk price was considered to be ₹ 10.00/kg and salvage value of the animal was the cost of rearing up to age at first calving + proportional changes in cost of rearing during i^{th} calving (i.e. { (future lactation yield – past lactation yield) / past lactation yield} × cost of rearing at previous lactation). If the buffalo died at any stage up to three lactations, her salvage value was taken as zero.

Similarly expense in the i^{th} lactation for each buffalo was estimated as follows:

$E_i (\text{₹}) = R_{ci} + M_{ci} + P_{ci} + I_{ci} + F_{xc}$
where R_{ci} was rearing cost in the i^{th} lactation = ₹ 19,777.77 + 549.38 (AFC – 36) for the first lactation while the salvage value of the first was taken as cost of the animal in subsequent lactations. M_{ci} was the maintenance cost in the i^{th} lactation = $[W_i \times CI_i \times 0.025 - (\text{total milk yield in the } i^{\text{th}} \text{ lactation} \times 0.4 \times 0.9)] \times 1.7778$ in ₹, W_i was the body weight (kg) at the i^{th} calving and CI_i was the i^{th} calving interval in days. P_{ci} was the cost of production of milk = total milk in the i^{th} lactation × 0.40 × 3.50. I_{ci} was the interest on the animal's cost during the i^{th} calving interval @ 15% = $0.00041 \times CI_i \times R_{ci}$, F_{xc} was the fixed cost, i.e. pregnancy allowance cost + cost of insemination + ₹ 4.62 × CI_i . 0.025 was the dry matter intake for every kg. of body weight of buffalo per day, 0.40 was the concentrate required for every kg. of milk produced, 1.7778 was the cost of 1 kg dry matter from fodder if fed 2/3 green and 1/3 dry fodder. 3.50 was price of 1 kg of concentrate, and 4.62 was a fixed cost for labour, veterinary expenses, depreciation, electricity, water and miscellaneous costs per day per buffalo.

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The linear profit traits were calculated as follows:

Profit in first lactation in ₹ (PFL) = I – E in the first lactation

Average profit per day of the first calving interval in ₹ (PCL) = PFL/ FCI

Profit in herd life in ₹ (PHL) = PFL + PSL + profit in the third lactation

Average profit per day in herd life in ₹ (APHL) = PHL/ herd life.

The profit efficiency traits were also calculated as under:

Profit per unit of investment in the first lactation in ₹ (PUI) = I/E in the first lactation.

Profit per unit of investment in herd life in ₹ (PUIH) = (income in I, II and III lactations) / (expenses in I, II and III lactations).

Cost per unit of production in the first lactation in ₹ (CUP) = 1/ PUI.

Cost per unit of production in herd life in ₹ (CUPA) = 1/ PUIH.

Since the numbers of buffalo were unequally distributed over farms, years of calving, breeds and seasons of calving, data were analyzed by least squares and maximum likelihood method (Harvey 1990) as per the following mathematical model:

$$Y_{ijklmn} = \mu + S_i + B_j + F_k + P_l + Se_m + e_{ijklmn}$$

where y_{ijklmn} was the profit traits of the n th daughter having random effect of the i th sire belonging to fixed effect of the j th breed, the k th farm, the l th period and the m th season of

calving with e_{ijklmn} as the random residual error normally and independently distributed with mean zero and variance σ^2 .

Duncan's multiple range test modified by Kramer (1957) was used to compare the least squares means. The sire component and residual variances and covariances were used to compute heritability (Falconer and Machay 1996) and genetic and phenotypic correlations (Becker 1975) methods. Standard error of heritability and genetic correlation was calculated according to Swiger *et al.* (1964) and Robertson (1959), respectively, and significance of phenotypic correlation was compared from the table value given by Snedecor and Cochran (1967).

Least squares means of PFL, PCL, PHL and APHL along with their respective standard errors have been presented in Table 1 and those of PUI, PUIH, CUP and CUPH in Table 2. Table 1 indicates that PFL in 1753 buffaloes maintained at 6 farms was ₹ 1992.02±370.70 with a coefficient of variation of 314.20%. The profits PFL and PHL were 10.07 and 43.98% of total expenses of rearing heifers up to 3 years of age (₹ 19,777.77). Results of PCL or APHL were ₹ 5.43±0.08 or ₹ 6.98±0.75, respectively.

The results of profit efficiency traits (Table 2) indicated that PUI and PUIH were ₹ 1.06±0.01 and 1.04±0.01 along with respective coefficient of variation (CV) of 18.06 and 13.98%. CUP or CUPH were 0.98±0.01 and 0.97±0.01 with respective CV as 20.74 and 18.07%.

The results of least squares analysis of variance indicated

Table 1. Least squares mean (M) and standard error (SE) of profit traits (₹) in buffaloes

Effect	No. sample size	PFL		PCL		APHL		PHL	
		M	SE	M	SE	M	SE	M	SE
Mean (μ)	1753	1992.02	370.79	5.43	0.08	6.98	0.75	8698.62	946.49
Agra	340	2281.65 ^b	581.77	5.52	0.12	8.17 ^b	1.19	10568.31 ^b	1482.59
Ambala	372	4396.31 ^a	602.29	5.63 ^a	0.12	12.42 ^a	1.23	15714.89 ^a	1534.77
Bareilly	255	- 60.37 ^d	624.72	5.11 ^b	0.12	2.45 ^d	1.28	3663.75 ^d	1591.80
Feroz.	227	1941.93 ^b	650.10	5.55 ^{ab}	0.13	6.37 ^c	1.33	7930.26 ^c	1656.35
Luck.	295	2681.98 ^b	594.92	5.63 ^a	0.12	8.16 ^b	1.22	10138.07 ^b	1516.03
Meerut	264	710.63 ^c	587.81	5.12 ^b	0.12	4.30 ^{dc}	1.20	4176.46 ^d	1497.96
<i>Breeds of buffaloes</i>									
Murrah	158	2741.34	741.81	5.61 ^a	0.15	8.31	1.52	10862.96	1889.61
Graded	1146	1817.24	383.98	5.40 ^b	0.08	6.81	0.78	8232.42	979.99
Nili Ravi	449	1417.48	481.11	5.27 ^c	0.10	5.82	0.98	6998.49	1226.71
<i>Seasons of calving</i>									
Winter	416	2285.11 ^b	488.38	5.35 ^b	0.10	7.46	1.00	9308.40	1245.20
Summer	195	686.15 ^c	627.44	5.30 ^b	0.13	5.41	1.29	6796.55	1598.72
Rainy	1142	3004.80 ^a	388.82	5.62 ^a	0.08	8.06	0.79	9990.93	992.28
<i>Period of calving</i>									
≥1960	158	2393.00 ^b	735.96	5.46 ^b	0.15	6.80 ^{bc}	1.51	9112.90 ^a	1874.73
1961–66	269	348.60	598.45	4.75 ^c	0.12	3.78 ^c	1.23	4502.62 ^c	1524.99
1966–72	503	2052.05 ^b	498.67	5.36 ^b	0.10	7.06 ^b	1.02	8887.59 ^b	1271.35
1973–78	715	2070.43 ^b	471.40	5.58 ^b	0.10	7.87 ^b	0.96	9519.61 ^a	1202.04
1979–84	108	3096.01 ^a	882.31	5.99 ^a	0.18	9.37 ^a	1.82	11470.39 ^a	2246.03

Figures bearing some superscripts did not differ significantly ($P < 0.05$).

Table 2. Least squares mean (M) and standard error (SE) of profit efficiency (₹) traits in buffaloes

Effect	No. (sample size)	PUI		PUIH		CUP		CUPH	
		M	SE	M	SE	M	SE	M	SE
Mean (μ)	1 753	1.06	0.01	1.04	0.01	0.98	0.01	0.97	0.01
<i>Military Dairy Farms</i>									
Agra	340	1.07 ^b	0.01	1.06 ^b	0.01	0.97 ^b	0.01	0.96 ^b	0.01
Ambala	372	1.12 ^a	0.02	1.10 ^a	0.01	0.92 ^a	0.01	0.92 ^a	0.01
Bareilly	255	1.00 ^c	0.02	1.00 ^c	0.01	1.03 ^c	0.01	1.03 ^c	0.01
Ferozpur	227	1.05 ^{bc}	0.02	1.04 ^{bc}	0.01	0.97 ^b	0.01	0.97 ^b	0.01
Lucknow	295	1.08 ^b	0.01	1.05 ^b	0.01	0.96 ^b	0.01	0.96 ^b	0.01
Meerut	264	1.02 ^c	0.01	1.01 ^c	0.01	1.00 ^c	0.01	1.01 ^c	0.01
<i>Different genetic groups</i>									
Murrah	158	1.08	0.02	1.06	0.01	0.96	0.01	0.96	0.01
Graded Buff	1 146	1.05	0.01	1.04	0.01	0.98	0.01	0.98	0.01
Nili Ravi	449	1.04	0.01	1.03	0.01	0.99	0.01	0.99	0.01
<i>Different season</i>									
Winter	416	1.06 ^b	0.01	1.05 ^{ab}	0.01	0.97 ^{ab}	0.01	0.97 ^{ab}	0.01
Summer	195	1.02 ^c	0.02	1.03 ^b	0.01	1.01 ^b	0.01	0.99 ^b	0.01
Rainy	1 142	1.08 ^a	0.01	1.06 ^a	0.01	0.95 ^a	0.01	0.96 ^a	0.01
<i>Different periods</i>									
<1960	158	1.06 ^b	0.02	1.05 ^b	0.01	0.97	0.01	0.98	0.02
1961–66	269	1.01 ^c	0.01	1.02 ^c	0.01	1.00	0.01	0.99	0.01
1966–72	503	1.06 ^b	0.01	1.05 ^b	0.01	0.97	0.01	0.96	0.01
1973–78	715	1.06 ^b	0.01	1.06 ^a	0.01	0.97	0.01	0.96	0.01
1979–84	108	1.08 ^a	0.02	1.05 ^b	0.01	0.97	0.01	0.99	0.02

Figures bearing some superscripts did not differ significantly ($P < 0.05$).

that neither the breed nor sire could affect the PFL, but farms, seasons and periods of first calving had significant effect with a result that buffaloes maintained at military dairy farm Ambala gave maximum profit. Buffalo calving in the rainy season were more profitable than those calving in summer. In general, there was improvement of profit over time.

Genetic parameters (Table 3) revealed that heritabilities of all the linear traits were lower with their respective standard error being less than half. The heritabilities of profit efficiency traits were also in the same range, but standard errors were more than half. The phenotypic and genetic correlation among all the profit traits (Table 3) indicated that PFL was phenotypically highly correlated with all the traits except CUP and CUPH as expected but with the same magnitude in the negative direction.

Profit in the first lactation was only ₹ 1992.02±370.70 with very high CV of 314.20%. A High CV was also reported by Gill and Allaire (1976). Such a high CV could be attributed to loss from some buffaloes and to very high profit from some others. High CV is also noticed in the traits observed by addition, subtraction, multiplication and/or division and in profit traits. The present findings were not in agreement with those of Sharma (1982), who reported a loss of ₹ 6258.64±101.23 in buffaloes maintained at eight military dairy farms. The profit of ₹ 1992.02 was 10.07% of the total cost of rearing of buffalo heifers up to 3 years of age. It was higher than the profits reported by Gill and Allaire (1976),

who reported only 3.36% of rearing cost in Holstein cows maintained in the USA.

Herd life profit in buffaloes maintained for an average herd life of 1124.08±12.75 days (total of the first, second and third calving intervals) was 43.98% (₹ 8698.62±946.49) of the cost of rearing buffalo heifers up to 3 years of age with a very high coefficient of variation of 219.07%. Margins of profit of 128.78% (Gill and Allaire 1976), 683.75% (Lin and Allaire 1977) and 32.75% (Balaine *et al.* 1981) of respective costs of rearing of heifers were reported in cows maintained in the USA, which may be higher due to the sale of cows for beef after completion of lactation while in the present case buffaloes were being maintained even after completion of the third lactation. Results of PCL and APhL were ₹ 5.43±0.08 and ₹ 6.98±0.75, respectively, with CV varying from 205 to 228%. High CV is indicative of a wide scope of selection on the basis of PCL.

Profit per unit of investment was ₹ 1.06±0.01 which was indicative of income of ₹ 1.06 over investment of ₹ 1.00 during first lactation in buffaloes. However, similar reports indicated that profit of \$ 1.19 on investment of \$1.00 in Holstein Friesian cows (Balaine *et al.* 1981) and profit of ₹ 1.10 on investment of ₹ 1.00 in various grades of crossbreds (Prasad and Manglik 1987) could be obtained. This indicated that amount of return from buffalo was comparatively less than that on Taurus or crossbred cows during the first lactation. The result of PUIH of ₹ 1.04±0.01 (Table 2) was similar to

Table 3. Heritability (diagonal and bold letters), genetic (above diagonal) and phenotypic (below diagonal) correlations between profit traits in buffaloes

	PFL	PCL	APHL	PHL	PUI	PUIH	CUP	CUPH
PFL	0.112 (0.056)	0.541 (0.229)	0.872 (0.091)	0.886 (0.079)	0.999 (0.008)	0.933 (0.080)	-0.953 (0.852)	-1.031 (1.200)
PCL	0.392	0.193 (0.063)	0.412 (0.273)	0.468 (0.254)	0.563 (0.212)	0.625 (0.247)	-0.474 (0.399)	-0.455 (0.548)
APHL	0.872	0.261	0.100 (0.056)	0.989 (0.017)	0.889 (0.076)	0.933 (0.500)	-0.754 (0.775)	-0.951 (1.246)
PHL	0.877	0.262	0.968	0.115 (0.057)	0.888 (0.073)	0.955 (0.045)	-0.747 (0.709)	-0.947 (1.145)
PUI	0.982	0.381	0.886	0.881	0.132 (0.058)	0.962 (0.067)	-0.950 (0.781)	-1.071 (1.147)
PUIH	0.849	0.348	0.941	0.922	0.859	0.097 (0.055)	-0.881 (0.852)	-0.993 (1.350)
CUP	-0.936	-0.371	-0.818	-0.778	-0.926	-0.859	0.100 (0.055)	1.036 (0.123)
CUPH	-0.772	-0.271	-0.827	-0.772	-0.769	-0.916	0.897	0.049 (0.051)

Figures within parenthesis are respective standard error.

that of PUI. The CV observed in PUI and PUIH were within the range of normal variation in physical traits of buffalo (13–18%).

The CUP and CUPH were estimated to be ₹ 0.98±0.01 and ₹ 0.97±0.01 (Table 2) respectively. This method of defining profit explained cost involved per unit of income as a direct indication of profit. Profit in cattle reported by Balaine *et al.* (1981) was \$0.85 over an expenditure of \$ 1.00 in 182 pure Holstein Friesian cows while that reported by Prasad (1983) was ₹ 0.91±0.01 over expenditure of ₹ 1.00 in 565 crossbred cattle.

The effect of non-genetic factor like farms was significant even though all six farms were located in northern India and standard feeding and management were practiced at all the military dairy farms. Slight changes in macro-environment (environmental temperature and humidity) played a role in generating more profit at Ambala than other farms located in comparatively hot climates. Similarly, buffaloes calving during the rainy season could get better fodder in the first and second quarters of their lactations as compared to those calving in the summer season. There was an almost continuous increase in profit over the period as expected because of improvements in management of buffalo over the period at all the military dairy farms.

The result of heritability of profit traits (Table 3) indicated similar genetic variability in PFL and PHL (heritability being 0.112 and 0.114 respectively) which was lower than that reported by Sharma (1982). The estimate of heritability of PCL and APHL showed a decreasing trend (from 0.193 and 0.100 respectively). It appears that differences among bull progeny groups other than milk yield contribute more to genetic variations of profit. Heritability of profit efficiency

traits like PUI, PUIH, CUP and CUPH were of lower magnitude than linear profit traits. Heritability of PUI and PUIH, if compared, indicated that genetic variability in the first lactation was less over herd life i.e. environmental variability was accumulating over time. Similar was situation when CUP and CUPH were compared. Lower value of heritability may result when ratio characters are subjected to genetic analysis.

Phenotypic correlation between PFL with APHL, PHL, PUI and PUIH were very high and all significant as expected because buffaloes profitable at the first lactation were profitable in subsequent lactations. The magnitude of phenotypic correlation between PFL with CUP and CUPH were the same as with other traits but in the opposite direction. The trends in genetic correlation between all the traits were similar to that of phenotypic correlations.

SUMMARY

The present genetic studies of profit traits in Indian buffaloes were taken on 1753 Murrah, Nili Ravi and graded Murrah buffalo maintained at 6 military dairy farms. The data were collected from history sheets of buffaloes, which were progeny of 185 sires and were calved during 1953–84. The costs of expenditure were calculated as per normal requirement of each buffalo because of group feeding and management. Least squares mean of profit in first lactation, average profit per day of first calving interval, profit in herd life and average profit per day of herd life were 1992.02±370.79, 5.43±0.08, 8698.62±946.49 and 6.98±0.75 rupees, respectively. Profit per unit of investment in the first lactation, profit per unit of investment in herd life, cost per unit of production in the first lactation and cost per unit of

production in herd life were 1.06 ± 0.01 , 1.04 ± 0.01 , 0.98 ± 0.01 and 0.97 ± 0.01 rupees, respectively. Heritability of these traits were 0.112 ± 0.056 , 0.109 ± 0.056 , 0.193 ± 0.063 , 0.114 ± 0.057 , 0.115 ± 0.057 , 0.100 ± 0.056 , 0.132 ± 0.058 , 0.097 ± 0.055 , 0.100 ± 0.055 and 0.049 ± 0.05 , respectively. Phenotypic and genetic correlations between profit in first lactation with all other traits except cost per unit of production in the first lactation and cost per unit of production in herd life were positive and highly significant as per expectations because buffalo profitable in the first lactation would be profitable in future lactations.

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