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Abstract

There were 1,405 lactation records of 336 cows at the Central Livestock Research-cum-Breeding Station, Haringhata, India from 1958 to 1968 used to estimate the potential dairy merit of Deshi cattle. This breed is native to northeast India and one of the smallest breeds in India (mature females 200 kg and males 250 kg).

Averages and standard deviations for milk yield (exclusive of that suckled), age of first calving, calving interval, lactation length, days open, and days dry were 412 ± 178 kg, 44.5 ± 6.8 months, 419 ± 90 days, 264 ± 81 days, 135 ± 86 days, and 139 ± 80 days. Mortality, culling, and retention rates for females from birth to first calving were 24, 27, and 49%. Lactation number, season of calving, and death of calf early in lactation had significant effects on milk yield.

Repeatabilities of milk yield, lactation length, calving interval, dry period, and days open were .42, .19, .21, .03, and .23 with corresponding heritabilities .64, .19, .09, .19, and .27. Heritability for age of first calving was .84. Confounding by some environmental effects probably biased heritability estimates upward. Potential genetic improvement of milk yield by mass selection was estimated at .8% per year.

Contemporary Jersey × Deshi crosses exceeded Deshi for milk yield, age of first calving, lactation length, calving interval, and days open by +923 kg, −15 months, +41, −84, and −96 days. At least one generation of crossing with European breeds is recommended over mass selection of Deshi.

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Introduction

The Deshi type of Zebu cattle originated in the humid tropics of eastern India and Bangladesh. Mason (17) classified Deshi in the *Bos indicus* group of "hill type or small cattle" of the southeast Himalaya region. It is the smallest breed in India (Fig. 1). Coat color varies from white to shades of gray and reddish brown with the males being darker. Deshi type cattle were used principally by seminomadic peoples of the forested foothills of the Himalayas. They are highly agile and can readily protect themselves from predatory animals. Like many other Zebu breeds of India, the Deshi is temperamental and has undergone little selection for improved milk yield.

The sparse grazing in the forest and a high density of human population on the agricultural lands of the Deshi's home area, means feed supplies have been limited to poor grazing or paddy straw and other low quality forages.

In 1956, 143 first lactation Deshi cows with their calves were purchased to establish a herd at the Central Livestock Research-cum-Breeding Station, Haringhata, India to evaluate the potential of the Deshi type cattle for dairy pro-

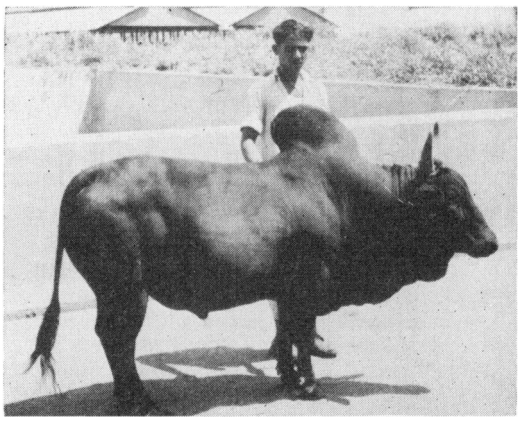

FIG. 1. Mature bull of the Deshi type cattle native to northeast India and Bangladesh. Deshi is one of the smallest breeds of India, cows weigh 200 kg and males about 250 kg.

duction. This report covers the first 10 years of this project (1958 to 68).

Materials and Methods

There were 1,405 calvings of 336 cows. Lactation records, irrespective of duration, up to 300 days were included, except for the last records of 45 cows which died. After first parturition, cows were housed continuously in stanchion barns with calf pens attached. They were hand milked twice-a-day with the calf present or without calf when the calf was lost. Until 4 to 5 months of age, the calf was allowed to suckle one quarter at each milking. Afterwards, calves were used to stimulate milk let-down but were not allowed to suckle. Milk yields were recorded, excluding the calf's share, until production declined below 200 g per day.

Heat detections were by vasectomized bulls twice-a-day. Breeding usually commenced at the first estrus both for heifers and lactating cows.

While in lactation, cows were fed a 65% total digestible nutrients concentrate mixture at 40% of their production in addition to an allowance for maintenance plus roughage consisting of green chopped sorghum, maize, Para grass, or Berseem clover and paddy straw.

Lactation records were grouped into three seasons — summer (March-June), monsoon (July-October) and winter (November-February) and by lactation number up through the eighth lactation to study the influence of season of freshening, sequence of calving, and condition affecting record, such as death of suckling calf, on milk yield. The method of unweighted means analysis was used with the following model:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{ik} + (BC)_{jk} + (ABC)_{ijk} + E_{ijkl}$$

where:

Y_{ijkl} = the l^{th} record of i^{th} condition affecting record of j^{th} sequence of calving in the k^{th} season,
μ = constant common to all records,
A_i = effect peculiar to i^{th} condition affecting record,
B_j = effect peculiar to j^{th} sequence of calving,
C_k = effect peculiar to k^{th} season of calving,
$(AB)_{ij}$, $(AC)_{ik}$, $(BC)_{jk}$ and $(ABC)_{ijk}$ = first and second order interactions of the fixed effects, and
E_{ijkl} = independent random variable, distributed with zero mean and common variance.

After adjusting the records for important factors, heritabilities and repeatabilities were estimated from a nested model:

$$Y_{ijk} = \mu + S_i + D_{ij} + E_{ijkl}$$

where:

Y_{ijk} = k^{th} record of the i^{th} daughter of the i^{th} sire,
μ = population mean,
S_i = random effect due to the i^{th} sire,
D_{ij} = random effect of j^{th} daughter of i^{th} sire, and
E_{ijk} = random error associated with ijk^{th} record.

S_i, D_{ij}, and E_{ijk} are independently distributed with zero means and variances σ^2_S, σ^2_D, and σ^2_E.

Standard errors for heritabilities and repeatabilities were computed according to procedures described by Becker (7).

Estimated genetic progress (ΔG) was determined according to procedures recommended by Rendel and Robertson (24) for a closed herd.

Crossing of Deshi with Jersey sires was adopted on a modest scale at the station. First lactation records on 25 first generation crosses were used to study the suitability of Deshi cattle for crossing with European breeds.

Results and Discussion

Milk yield. Means for milk yield by lactation number of records up to 300 days duration are in Table 1. Few of the records exceeded 300 days; hence, the means are essentially complete records. Average yield, exclusive of that drawn by the calves, for the 1,360 records 300 days or less was 412 with a standard deviation of 178 kg. Average lactation length was 264 (SD ±81) days (Table 1). Average coeffi-

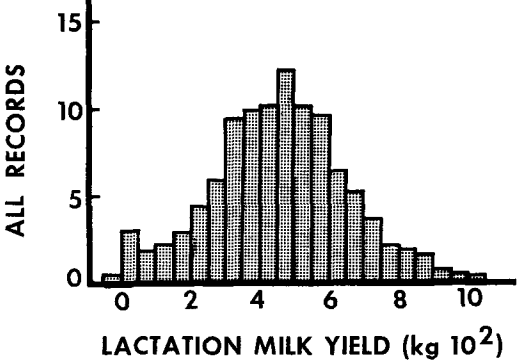

FIG. 2. Distribution of 1,405 lactation records by 50 kg intervals for pure Deshi cattle.

TABLE 1. Means and standard deviations for age of calving, milk yield, and length of lactation by lactation number of records 300 days or less of Deshi cows.

Lact.	Record	Age of calving[a]	300 Days or less		
			Days	Milk	CV
(no.)	(no.)	(months)		(kg)	(%)
1	245	44.5 ± 6.8	256	357 ± 147	41
2	247	58.7 ± 7.5	249	404 ± 171	42
3	216	70.6 ± 8.0	259	443 ± 167	38
4	179	83.3 ± 8.3	255	430 ± 170	39
5	152	95.6 ± 7.6	256	448 ± 178	40
6	120	107.1 ± 6.5	249	420 ± 162	38
7	78	..	238	423 ± 178	42
8	48	..	241	428 ± 170	40
9+[b]	75	..	227	374 ± 163	40

[a] Means for farm born animals only.
[b] Includes lactations 9 through 11.

cients of variation for milk yield and lactation length were 42 and 25%. These values are nearly double those for temperate breeds but agree with other data from the tropics (16, 19). Even though average yields were low and highly variable, the distribution was approximately normal (Fig. 2). The average yield for Deshi is as good or better than for Sinhala, a small breed from Ceylon (183 kg body weight). The Sinhala averaged 426 kg, excluding all records of <100 days duration (14).

Milk yield for the Deshi gradually increased from the first to the third lactation with little change thereafter. This trend coincides with other studies (2, 3, 5, 14, 15). The third and fifth lactations for the Deshi cows occurred between 70 and 95 months of age, representing mature production. Yields increased about 20% from the first lactation to the peak production stage which is more than reported for most Zebu breeds where estimates have been based on only records >100 days.

Death of suckling calf. Identifiable conditions affecting records of production were classified into 7 groupings (calf died, foot and mouth disease, mastitis, abortion, physical injury, cow died, and unknown). These accounted for 16.4, 2.0, 1.3, .5, 3.2, 2.3, and .4% of all records. Calf died, abortion, physical injury, unknown causes, and death of cow in lactation resulted in significantly lower ($P<.05$) lactation yields than records where no conditions were identified. Factors were derived for extension of records where the calves died while those associated with abortion, physical injury, and death of cow were dropped from further analysis since they were too few in number to warrant development of adjustment factors.

Death of the suckling calf had a significant

TABLE 2. Average milk yields for normal records and where calf died (first 300 days or less) by season and sequence of calving.

Lactation	Summer				Monsoon				Winter			
	Normal		Calf died		Normal		Calf died		Normal		Calf died	
	No.	Milk	No.	Milk	No.	Milk	No.	Milk	No.	Milk	No.	Milk
		(kg)		(kg)		(kg)		(kg)		(kg)		(kg)
1	99	342	18	246	31	414	7	435	56	404	27	367
2	83	405	17	249	27	471	11	339	88	437	16	324
3	84	419	8	374	32	477	4	420	73	474	11	414
4	59	415	18	376	28	473	6	495	57	468	9	299
5	47	420	13	415	31	478	5	562	44	476	9	360
6	47	365	8	250	37	467	2	194	25	506	2	628
7	26	394	5	355	18	381	4	291	20	539	2	542
>7	25	400	7	227	29	417	10	283	43	440	8	346
Avg		392		310		451		380		457		365

effect on lactation milk yield (−16.1%), mainly by shortening the time in lactation. Since this influenced a sizeable proportion of the records, projection factors were developed for extension of these records.

Although the interactions of calf loss with lactation number and with season were insignificant, losses in first lactation tended to be higher (21.8% versus 15.5% for later lactations), and 2 to 4% more calves died in summer than during the monsoon or winter periods (Table 2). The rapid termination of lactation following loss of calf indicates a strong maternal instinct and the value of the calf in stimulating milk let-down. In general, these features appear characteristic of most cattle indigenous to tropical areas and may have some hereditary basis. Ngere (22) reported 16% lower milk production in Hariana cattle (*Bos indicus*) at the Haringhata station due to death of the suckling calf. Pearson et al. (23) found that lactation yields were about 30% less when Blanco Orejinegro cattle of Colombia, a *Bos taurus* breed, were milked without presuckling. McDowell (19) reported similar findings with Costenõ Con Cuernos, another *Bos taurus* breed of Colombia, and that 25% of the Harro cattle in Ethiopia (*Bos indicus*) refused to be milked following early weaning of the calves.

The loss of milk because of attachment to the calf, having to keep all calves for many months, the increased time required for milking due to handling the calf, and the indication that suckling may increase calving interval (19) show that strong attachment to the calf would be a serious deterrent to the use of Deshi, as well as other indigenous breeds, for efficient commercial dairy enterprises.

Season of calving and lactation number. Both season of calving and lactation number had significant effects on lactation yield. The interaction effects were also important. Cows calving during the winter averaged 19.6% more milk than for summer calving while monsoon calvings were intermediate (Table 2). There was significant variation in number of calvings among seasons, 42.2% for summer, 21.1% for monsoon, and 36.7% in the winter months.

For age correction factors of milk yield by season, production of the third lactation for the summer season was a base. Multiplicative correction factors developed from season-lactation subclass means, corrected for death of suckling calf, are in Table 3. The factors are variable due to small numbers; nevertheless, records corrected for lactation number and season did not indicate any significant three factor second order interactions in subsequent analysis of variance. However, applying these factors to other data with different environment and possible genetic differences is not recommended.

Due to low yields and long calving intervals, cows were actually milked until they spontaneously became dry; hence, forced drying due to advanced gestation seldom occurred. There were 48% of the lactation periods in the range 280 to 300 days. Lactation number had a low relationship to length. Average days in milk were similar for lactations one through five (254) but declined gradually through lactation eleven.

Age of first calving. The average age of first calving was 44.5 (S.D. ± 6.8) months (Table 1). The distribution of age of first calving (Fig. 3) indicates skewness which might have occurred for a number of reasons including season of birth. Females born in the winter months calved about 4 months earlier than average. The age at first calving is earlier than for most breeds in India by .5 to 6.8 months (8, 13, 16, 22). The calving interval of Deshi was 55 days shorter than for Hariana

TABLE 3. Milk yield age correction factors by lactation number and season of calving.

Lact.	Season of calving		
	Summer	Monsoon	Winter
1	1.31	.94	1.02
2	1.19	.98	1.04
3	1.00	.89	.90
4	1.00	.83	1.03
5	.95	.78	.95
6	1.26	1.18	.72
7	1.05	1.16	.75
8 and above	1.24	1.12	1.01

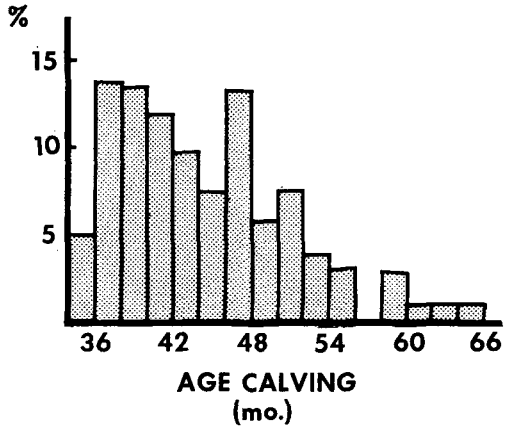

FIG. 3. Distribution of ages for first calving of pure Deshi by two month intervals.

TABLE 4. Means and standard deviations for calving interval and days open.

Interval between calvings	Calving interval		Days open	
	Record	Days	Record	Days
	(No.)		(No.)	
1-2	182	450 ± 99	222	175 ± 104
2-3	193	426 ± 81	221	140 ± 82
3-4	179	405 ± 78	203	118 ± 79
4-5	152	402 ± 72	172	118 ± 73
5-6	120	408 ± 78	139	121 ± 77
6-7	78	405 ± 120	99	119 ± 74
7-8	48	420 ± 96	60	136 ± 93
8-9	38	432 ± 132	40	155 ± 131
9-10	29	390 ± 81	31	119 ± 84
10-11	8	369 ± 36	22	106 ± 42

at the same station; thus, the Deshi were nearly one year younger at fourth lactation than Harianas.

Late age of first calving is a problem in most breeds indigenous to tropical areas. McDowell et al. (14) demonstrated that the average age of first estrus regressed toward the mean of Jerseys with increasing Jersey inheritance in Red Sindhi × Jersey crosses. In all crossbred groups, as well as purebred Jerseys, the age of first estrus was later in southern Louisiana (subtropical) than Maryland (temperate) indicating that both genetic and environmental factors were involved in sexual maturity.

Days dry, calving interval, and days open. The mean for all dry periods was 139 with a standard deviation of 80 days. The longest average (164 days) followed first lactation. This was reduced to 146 days after second lactation and thereafter remained at about 125 days.

The means for calving interval and days open between subsequent calvings are in Table 4. The mean and standard deviations for all calving intervals was 419 ± 90 days and for days open, 135 ± 86. Both calving interval and days open were considerably longer between first and second calvings. These two traits show considerable advantage for the Deshi over other Zebu breeds from India. Ngere (22) reported a calving interval of 474 days and days open of 199 in Hariana cattle maintained at the same farm.

Suckling of the calf appears to have contributed to the delay in rebreeding. The mean in days open for 194 calvings when the calf died early in lactation (<4 months) was 117 days or about 15% less than the overall mean. The magnitude of the influence of suckling compares with estimates for the Hariana breed (12, 22). Biswal and Rao (9) reported a postpartum interval to first estrus as 110 days for weaned versus 157 days for natural suckling in Red Sindhi cows. They also reported rate of conception to first insemination as being higher in cows when the calf was weaned.

TABLE 5. Repeatability and heritability estimates for various traits with standard errors.

Trait	Repeatability	SE	Heritability	SE
Milk yield	.42	.08	.64	.26
Lactation length				
<300 Days	.18	.06	.24	.13
Complete	.19	.06	.19	.12
Calving interval	.21	.08	.09	.13
Dry period	.03	.07	.19	.14
Days open	.23	.07	.27	.16
Age at first calving	..	..	.84	.33

Repeatabilities and heritabilities. The 185 cows with sire identification were used for estimating repeatabilities and heritabilities of various traits (Table 5). These were the progeny of 20 sires. Except for age at first calving, estimates for Deshi fall within the ranges reported in other studies based on records from single herds in tropical areas (20).

The reason for high estimates of heritability is not clear. Except for calving interval and complete lactation length, heritabilities are larger than the repeatability coefficients. Although standard errors of heritabilities are high, the high heritabilities may not be explained by sampling error alone. Probably the sire component of variance contained variation other than one-fourth the additive genetic variance. Year effects were not eliminated from the milk production records; therefore, confounding of sire and year effects may have biased heritability upward. Since the Deshi cows were hand-milked, some bias may have arisen due to the interaction between temperament of the cows and the milkers. If contemporary daughters of the same sire were fed and milked by the same milker, the sire effect would be confounded with the milker effect resulting in a higher value for heritability. Touchberry et al. (28) obtained a heritability for milk yield of .66 in Danish progeny testing stations as compared to .29 for field data. These authors suggested that among sire variation under testing station conditions was inflated with environmental differences. Shrode et al. (25) demonstrated changes in repeatability estimate with changes in herd environment.

In European dairy breeds heritability of age

of first calving has been estimated at near zero, but studies on Zebu breeds have given conflicting results. Amble et al. (4) reported estimates from .16 to .66 in three breeds of Zebu while in three others the estimates were negative. Guha et al. (11), Stonaker (27), and Singh and Desai (26) reported this character to be heritable.

Herd life and viability. Mortality, culling, and retention rates of female calves from birth to first calving were 24, 27, and 49%. Losses due to death from birth to first calving showed a wide range among years (13 to 46%). The main contributor to the variability was periodic serious outbreaks of foot and mouth disease among the young calves. Losses by culling were mainly due to poor development following a disease infection, sterility, and physical injury. In addition some calves were sold because the dam did not milk long enough to rear the calf to weaning age. The 49% of the females born alive which completed a first lactation compares with 49, 48, and 50% reported by McDowell (19) for Blanco Orejinegro, Harro, and Hariana cattle. Amble et al. (6) reported 28% mortality in the Sahiwal breed from birth to first calving.

There is no conclusive evidence on whether the high rate of mortality of young cattle in tropical breeds has any genetic basis. McDowell and McDaniel (21) observed marked differences in viability of Ayrshire, Brown Swiss, and Holstein cattle from 150 days of pregnancy to first calving. Further evidence of a genetic basis in viability stems from comparisons of crosses to pure breeds. Amble et al. (6) and Pearson et al. (23), among others, have reported better viability in European-Zebu crosses and European-Criollo crosses than for the pure indigenous types.

Potential for Improvement

A. *By selective breeding.* Progeny testing was not practiced during the period of study but should be considered in estimating the expected rate of genetic progress. There were 509 females born in the herd of which 123 died before first calving. From the remaining 386, there were 249 or 64% selected as herd replacements. If selection of heifers were based on top 64% of dams' single record of production, heritability for milk yield is .25, and records are normally distributed, the average genetic superiority of the cows to breed cows is $(.5 \times .59 \times 73) = 22$ kg ($\sigma_P = 147$ kg). Assuming selection of young sires was based on the highest 10% of the cows with records, the average genetic superiority of dams of the bulls is $(.5 \times 1.75 \times 73) = 64$ kg. Due to incomplete information on foundation cows, an appropriate generation interval could not be determined; however, several reports on other groups (1, 2, 10, 14, 15) average about 6.25 years. This interval would give an annual expected genetic improvement $(22+64)/25 = 3.4$ kg or about .8% of the lactation yield which agrees with the estimate of genetic improvement of .7% in a British herd reported by Rendel and Robertson (24). The probable rate of genetic change for improvement of milk yield in Deshi is meager and cannot be regarded as encouraging when considered in terms of absolute increase in yield per year.

B. *Response to improved environment.* Production and breeding efficiency would perhaps have shown some change by increased feeding, but in an environment similar to that around Haringhata it will soon reach a point of diminishing returns because of still other limiting factors like disease, quality of feed, and management techniques. Improvement of the environment involves inputs in terms of capital and other investments; thus, the genetic capabilities and other limitations of the animals to be used ought to receive consideration.

Poor temperament and strong maternal instinct will be deterrents in the overall dairy merit of the Deshi. These traits have a hereditary basis; therefore, it will be difficult to bring about rapid adjustments by improved feeding and management.

The average age of first calving of the Deshi is 14 to 18 months later than for temperate dairy breeds. Heritability (Table 5) indicates that some emphasis on selection for early maturity would be warranted; however, age of puberty can be reduced 3 to 6 months in other Indian breeds through improved feeding, especially from birth to one year (20). The calving interval for Deshi is shorter than for other Indian breeds but about 30 days longer than for DHI Holstein herds in the U.S. Unlike European dairy breeds in the temperate zone, Zebu breeds in India do not express outward symptoms of estrus, the duration of estrus is short, and estrus often occurs during the hours of darkness. This indicates a possibility of reducing calving interval by vigilant heat detection. Suckling by the calf also interferes with normal onset of estrus (19); thus, early weaning of the calf would be expected to reduce calving interval.

There were 15.2% of the lactations affected by mastitis and other maladies which shows

TABLE 6. Average first lactation performance and standard deviations of Jersey × Deshi F_1 crosses in comparison to contemporary Deshi cows.

Trait	Deshi		Cross	
	Record	Mean	Record	Mean
	(no.)		(no.)	
300 Days or less:				
Milk yield (kg)	42	350 ± 149	25	1,213 ± 319
Lactation length (days)	42	250 ± 76	25	288 ± 31
Complete lactation:				
Milk yield (kg)	42	374 ± 172	25	1,296 ± 389
Lactation length (days)	42	276 ± 109	25	317 ± 76
Age of 1st calving (months)	42	47 ± 7	25	32 ± 4
Days open	31	187 ± 104	18	91 ± 30
Calving interval (days)	18	452 ± 90	11	368 ± 34

that some improvement could be realized in performance by close attention to managerial practices.

C. *Crossbreeding.* Selective breeding does not hold much promise for rapid improvement of Deshi cattle; therefore, an alternate breeding system should be considered. This was done by mating Deshi cows to Jersey sires. The crosses are too few in number as yet for a comprehensive evaluation; nevertheless, it appears the Deshi can be mated to a much larger breed without encountering serious difficulties in calving and the crossbreds are markedly better in performance up through first lactation (Table 6). Although the crosses calved at a much younger age, their average milk yield was 3.4 times greater than for contemporary Deshi. The crosses not only milked for a longer time but had a higher yield per day of lactation, 4.2 vs. 1.4 kg. If the crosses continue their marked superiority in length of calving interval, their total merit for milk yield (milk yield/day of calving interval) will exceed the Deshi by more than 400%. The crossbred cows were milked without presuckling which solved the problem of calf handling at each milking time.

The preliminary evidence from crossing both Deshi and Hariana with Jerseys at Haringhata (19) shows that at least one generation of grading up with a European dairy breed on breeds like the Deshi and Hariana holds promise for both the introduction of genes for higher milk yield and alleviates the influence of other factors, such as temperament and maternal instinct, that are serious deterrents to the usefulness of most Zebu breeds in India for commercial dairy enterprises. Since the Deshi appears considerably better than other Indian breeds in reproductive efficiency — expressed as days open or calving interval — and the bulls have high libido, this breed ought to be tested for the improvement of these traits in some of the Indian breeds where milk yield is reasonably good but breeding efficiency on both males and females is less than desired.

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