EVALUATION OF HOLSTEIN CROSSBRED BULLS BASED ON MILK COMPOSITION OF PROGENY

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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DECLARATION

I hereby declare that this thesis entitled "**Evaluation of Holstein crossbred bulls based on milk composition of progeny**" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled "**Evaluation of Holstein crossbred bulls based on milk composition of progeny**" is a record of research work done independently by **Dr. Radhika, G.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Animal Husbandry has been a tradition in Kerala from time immemorial and has been an integral part of the state's rural economy. The achievement that Kerala has made in the field of milk production is spectacular. During 1986-87 contribution of Animal Husbandry Sector to GDP was 5.9 per cent and it rose to 10.58 per cent by 1993-94. Income generated through this sector was 508.04 crores in 1986-87 and increased to 2308.68 crores in 1993-94. Though only 1.33 per cent of total plan outlay of the state is earmarked to the sector, the contribution of this sector is much more than 10 per cent. The contribution of Animal Husbandry Sector accounts to 40 per cent of the contribution of agriculture and allied sectors.

Local cattle of Kerala, though quite adapted to the agro climatic conditions in the state, are poor milk producers. The urgent need to increase milk production, initiated upgrading of local cattle with Red Sindhi bulls in 1950's through Key Village Scheme. Later, in the sixties considering the potential for more rapid improvement through crossbreeding with exotic breeds, extensive crossbreeding of local cattle with Jersey was practised through Key Village Blocks, Hill Cattle Development Scheme and Intensive Cattle Development Project. As a result of the inception of Indo-Swiss Project in Kerala in 1963, establishment of farm in Madupetty and crossbreeding experiments conducted there, the 70's met with widespread use of Brown Swiss semen. In 1977, Kerala had half of its cattle population, transformed to crossbreds, with an average milk production of about 1500 kg/lactation. But there has been a stagnation there after in the level of production in crossbreds with successive generations of interse mating. Breeding Policy Committees were constituted by Government to evaluate the situation and suggest programmes and policies to be adopted in the state for improvement. The most important recommendation of the expert committees had been on the needed emphasis on bull selection. In order to increase the quantity of fluid milk, infusion of Holstein Friesian genes to the crossbred population has also been recommended and is adopted now. The only way to achieve the targeted milk yield of 2500 kg/lactation, is the use of breeding bulls with a breeding value above 4000 kg for milk.

Realising the need for recording of performance in milk yield, composition and other economic traits in the farmer's premises and using this information for evaluation of bulls and cows, ICAR has launched Field Progeny Testing Units under the direct supervision of the Cattle Project Directorate of ICAR. Of the three Units sanctioned for the country, Kerala Agricultural University was fortunate to get one Unit and start the same in 1986. Main objectives were evaluation of sires under field condition and simultaneous genetic improvement of cattle population. The impact of any programme for genetic improvement will be felt in farmer's herd, only with daughters of breeding bulls commencing production. The female progenies of the Holstein Crossbred test bulls under the Field Progeny Testing Scheme commenced their first lactation during the year 1995-96.

Hitherto quantity of fluid milk was the only character which received attention in the breeding programmes. But the solids in the milk also have equal importance. Many countries make payments for the quantity of solids in milk and this principle has been adopted in India also. The fat and solids not fat percentage in milk decides the milk price. Over and above this, there has been complaints from the farmers and Milk Societies about low level of milk fat. Instances, where allegation of adulteration of milk have created problems to the farmer have also been not rare. No scientific information on solids not fat of milk is available on the crossbred cows of the farmers in Kerala, though studies on milk fat per cent have been undertaken by Kerala Agricultural University. This also has necessitated a study to understand the real situation with respect to the solid content of milk of the crossbreds in Kerala.

The present study was undertaken to gather scientific information on the composition of milk, evaluate the sires on the basis of milk composition of the progeny and look into the feasibility of selection of sires for these traits on the basis of progeny performances.

Review of literature

REVIEW OF LITERATURE

2.1 Milk yield

The milk yield is a most important economic trait in cattle. The native breeds of cattle exhibited a low level of performance in milk production. To enhance milk yield, large scale cross breeding programmes using exotic bulls, namely Jersey, Brown Swiss and Holstein Friesian have been taken up in the country. This resulted in various levels of exotic inheritance in native breeds. Literature revealed that, out of the three crossbreds, Holstein crosses performed better than the others in milk production (Annual Report, NDRI 1992-93 and Gokhale and Mangurkar, 1995). Friesian halfbreds performed better than higher and lower inherited ones in Indian conditions (Narasimha Rao *et al.*, 1981; Deshpande and Bonde, 1982; Vij and Basu, 1986; Yadav *et al.*, 1989; Jadhav *et al.*, 1991 and Nair *et al.*, 1994). However, Jadhav and Khan (1995) reported the superiority of 62.5% Holstein Friesian crossbreds.

The crossbred cattle in Kerala cannot be classified into specific breed crosses. Jersey bulls were used for crossbreeding in the beginning. Brown Swiss bulls were used subsequently and still later Holstein breeding bulls were also added (Iype *et al.*, 1993). This has resulted in a mosaic inheritance for cows of the present day. The milk production performance of crossbreds in Kerala reported by different workers are given in Table 1.

Table No. 1

Average 305 day milk yield of crossbred cattle of Kerala

References	Average 305 day milk yield (kg)	Remarks
Nair (1976)	2238 Feb-May 2397 June-Oct 2018 Nov-Jan	Red Sindhi x Jersey Crosses in Govt. Farms
Chacko *et al.* (1984)	1549 ± 0.3374	Brown Swiss crosses
Iype *et al.* (1985)	1445.5 ± 0.374	Brown Swiss crosses
Stephen *et al.* (1985)	1486.4 ± 24.5	Jersey x Local and Brown Swiss x Local
Iype *et al.* (1986)	1566.5 ± 101.0	Jersey x Local
Thomas *et al.* (1987)	1476.8 ± 114.2 1513.3 ± 130.2	Brown Swiss crosses
Iype *et al.* (1993)	1479.5 ± 10.3	Cows with mosaic inheritance
Iype (1995)	1517.2 ± 12.50	Mosaic inheritance (on the basis of 3663 cows)

The crossbreds of exotic milch breeds with Indian milch breeds were found to be performing better than the crossbreds of Kerala (Suryaprasad *et al.*, 1991; Annual Report NDRI, 1992-93 and Annual Report, Project Directorate on Cattle, 1994-95).

2.1.1 Factors affecting milk yield

Singh and Pandey (1970) observed that the cows calving in spring season were found to produce 3.7 per cent more milk than the average for the animal calving in other season.

Nair (1976) observed that the season of calving did not affect lactation length or yield significantly. Johnson (1977) observed that there were significant differences in milk yields resulting from plane of feeding, but no significant difference arising from pattern of feeding.

Subramanian (1984) reported that the environmental factors period, season and their interaction effects were not found to effect significantly 180 to 305 days milk yield of first lactation.

Chacko et al. (1984) studied the influence of environmental effects on lactation under field conditions of Kerala. Of the effects considered, Artificial Insemination centre, type of dam and sex of calf under the existing management practise contributed maximum to variance.

Stephen *et al.* (1985) made a comparison of milk production of Jersey and Brown Swiss crossbreds and found that effects of genetic group was highly significant. They also reported that there was no significant effect for season on milk yield.

Iype *et al.* (1986) reported that farms, years and farm x season interaction had significant influence on both the traits.

Vij and Basu (1986) observed that year and season of calving had significant effect on first lactation production. The effect of breed of sire was not significant for milk production traits. It is probably not the breed, but the sires that are important in causing differences among the crossbred progeny.

Nagarcenkar *et al.* (1986) concluded that for progeny testing in bovines under field conditions, bulls can be evaluated from 24 hours milk yield recorded at eight week interval.

Results obtained by Thomas *et al.* (1987) suggested that 50 per cent and 62.5 per cent Brown Swiss crossbreds under field conditions in Kerala did not differ significantly, but centre differences were significant.

Jadhav *et al.* (1991) observed that lactation and 300 day milk yield were significantly influenced by farm, genetic group and period of calving.

Rahumathulla (1992) studied the performance of Jersey x Sindhi crossbred cows in Livestock Farms, Hosur and Livestock Farm, Pudukottai and found that they were significantly different for lactation milk yield, 305 day milk yield and milk production efficiency traits in the first parity. However the reproductive traits did not show any variation in the five parities. This indicated the significance of genotype x environment interaction in milk production.

Jadhav and Khan (1995) found that the effect of genetic groups was significant on first lactation milk yield. Kuralkar, Kothekar and Deshmukh (1995) while identifying the non-genetic sources of variation influencing first lactation milk yield, found that the effect of farm and season were non-significant. The non-significant effect of season may be due to the fact that animals were raised on cultivated green fodder available round the year from irrigated land. The effect of period on first lactation milk yields was highly significant.

Sreemanarayana *et al.* (1996) found that the average daily milk yield was 9.0±0.91 kg while average peak daily milk yield was 13.72±1.02 kg. The study revealed that the performance of the crossbred Holstein Friesian cows under village condition was on a par with that of crossbred cows, maintained in organised farms.

Venkatasubramanian and Fulzele (1996) concluded that in order to derive the maximum benefit from milch animals it is necessary to keep them in a state of perfect health, nutritional status and proper housing by practical application of various approved managemental practices in the farm. Marked differences were observed in the performance of milch animals reared under organised farm and field conditions. But very little attempts have been made to study the factors influencing the performance of these cattle under field conditions.

2.2 Milk Composition

Milk is an emulsion of fat in a watery solution of sugar and mineral salts and with protein in a colloidal suspension. According to Eckles *et al.* (1957) milk fat or butter fat refers to the fat of milk and ranges from 2.6 to 6.0 percent with an average percentage of 3.80. The protein, sugar and ash of milk, termed solids not fat, ranges normally from 7.9 to 10 with an average percentage of 8.95. The drymatter, which include fat and solids not fat, is the total solids of milk and the normal range is from 10.5 to 16.

Indian breeds of cattle in contrast to exotic dairy breeds yield lower quantity of milk, but with higher percentage of fat and solids not fat (Singh *et al.*, 1961). For Indian breeds of cattle, the ranges are 4.3 to 5.9, for average fat percentage, 8.83 to 9.30 for average solids not fat percentage and 13 to 14.51 for average total solids percentage (Venkatachalapathy, 1996). As a result, Prevention of Food Adulteration (PFA) standards were fixed at 3.5 per cent for fat and 8.5 per cent for solids not fat (standards of milk prescribed under PFA rules, 1955).

2.2.1 Factors affecting milk composition

Espe and Smith (1952) observed that as the amount of milk secreted increases, the energy available for fat secretion decreases, thereby causing milk of lower fat test to be produced. A negative correlation of -0.24 between fat percentage and amount of milk was obtained by them.

Eckles *et al.* (1957) argued that the fat percentage of milk produced by any particular cow is a matter of heredity and not of feed. The value of good feed and care is reflected in the yield of milk and not in richness of the product. The reason for this stability is that, blood remains essentially the same in composition. Temporary differences will mainly affect the body reserve and in case of continued deficiency, the secretion stops.

Burt (1957) showed that significant responses of milk yield and solids not fat percentage to the feeding of concentrate above the normal standards occurred in two experiments out of the five experiments conducted. However, when mean solids not fat percentages were well below 8.5 per cent, the absence of any appreciable responses emphasizes that low values can and often occur in well managed herds fed adequate rations, due to genetic effects and that this condition may not be appreciably affected by increasing feed intake.

Wilcox *et al.* (1959) showed that the SNF content was higher in December and January and low in June and July. Solids not fat content was high shortly after parturition, dropped to a lactation low at 40-60 days, increased very slowly to six months and then increased rapidly to ten months.

Various workers reported that there was significant effect of stage of lactation on the constituents of cow milk. The major constituents tended to decline nearly in the fourth week of lactation after which there was a significant increase as lactation advanced (Singh *et al.*, 1961; Ghosh and Anantakrishnan, 1964). Parkhie *et al.* (1966) showed that cows pregnant for seven months or more produced significantly higher protein content in their milk, whereas cows pregnant for 5-7 months and 3-5 months during their 305 day lactation did not differ significantly in their protein content. Cows calving during autumn and winter produced milk significantly higher in fat content than those calving during spring and summer. They also found that, of the constituents fat was the most variable one, followed by total solids, protein and solids not fat.

Wright and Rook (1974) studied the effect of varying periods of energy undernutrition on milk yield and composition. They found that underfeeding for the beginning of lactation, depressed both milk yield and solids not fat content especially in early lactation. The restoration of normal feeding in midlactation after varying periods of underfeeding was associated with only small responses in solids not fat and protein content.

Prasad and Subramanyan (1986) studied the influence of breed, stage of lactation and time of milking on the chemical composition of milk and found that the percentage of fat in milk was higher in Jersey crossbreds than in Brown Swiss crossbreds. A significant increase in percentage of fat was noticed in both the crossbreds as lactation advanced. Evening milk produced more fat in both breeds. A total of 4.85 per cent of the samples collected was below the legal standard in Jersey cows and for the Brown Swiss crosses it was 7.41 per cent. The Jersey crosses produced a higher solids not fat and total solids content than Brown Swiss crosses. The total solids content increased as lactation advanced and the percentage of samples below the legal standard for SNF were 1.55 and 8.52 for the Jersey and Brown Swiss crossbreds respectively.

Yadav and Sharma (1988) showed that the higher rates of descent and ascent for fat percentage were observed in lactation/genetic groups with higher milk yields. Nareshkumar *et al.* (1988) observed that season had a significant effect on butter fat content of milk. Fat content was high during south west monsoon and low during north east monsoon. Rainfall depressed butter fat content of milk. The seasonal effect was not much pronounced in case of solids not fat.

Yadav *et al.* (1989) noticed that the parity and period of calving did not affect the fat percentage in milk. The seasonal differences were significant and the average fat percentage was maximum in summer calves, whereas fat content in milk during initial and peak phases of lactation was maximum in winter calves. The differences on the gene frequency controlling the quality and quantity of milk components largely account for the average genetic differences among breeds. However the differences among individuals within a breed are often greater than the average difference among breeds of cattle.

Bector and Chatopadhya (1992) found that the average fat and solids not fat contents of cow milk samples of the milkshed area of Ropar district, Punjab were well above the legal standards irrespective of the breed, the season and the time of milking. It was observed that there was significant breed differences in fat percentage and that the pure exotic breeds gave high fat compared to their crosses with local cows.

Naikare *et al.* (1992) showed that genetic group, period of calving and season of calving had significant effect on fat percentage. They reported that during summer there was less feeding of roughage and increased intake of concentrate by the cow and this leads to lesser synthesis of fat. Total fat was maximum in fifth and least in first lactation. Age of first calving on fat percentage and total fat was non-significant.

Ghani (1992) observed that tests on Jersey and Friesian cows showed higher contents of fat, protein, solids not fat and total solids in the Jersey milk samples, but test-day yields were higher in Friesian cows. Quantity and quality of milk varied greatly amongst individual cows of either breed and were significantly affected by heat stress during summer.

Iype *et al.* (1994) estimated the levels of fat percentage at different stages of lactation in crossbred cattle seen in and around Thrissur, Kerala, and the location-wise difference in milk fat percentage were significant. Evening milk fat percentage was uniformly higher than the morning milk fat percentages and there was a significant increase in fat percentage as lactation progressed. The most important finding was that the overall fat percentage in the early lactation (3.28 ± 0.02) was below the prescribed level of 3.5 per cent by the Prevention of Food Adulteration (PFA) Act. According to Sebastian and Geevarghese (1995) there is a possibility of obtaining milk with fat and solids not fat contents less than the minimum standards prescribed in the PFA Act for many states in India.

Gokhale and Mangurkar (1995) concluded that there was large variation in milk fat content of field Holstein Friesian crosses. Various genetic and environmental factors affecting milk fat content warrents consideration of development of correction factors for important environmental effects affecting milk fat content. Significant sire differences indicated sufficient genetic variation which could be exploited for genetic improvement of fat content through progeny testing.

MRCMPU (1995) reported the SNF standards in Malabar area were far below the PFA standards. Out of the samples examin tests of 73.8 per cent animals were below the prescribed standards.

Sreemannarayana *et al.* (1996) reported that the average milk fat and solids not fat were 3.4±0.08, 8.34±0.62 per cent respectively.

Venkatachalpathy and Iype (1997) reported that the fat and total solids percentage of milk showed an increasing trend as the lactation advanced, but solids not fat percentage was not having any trend during stage of lactation.

2.3 Inheritance of milk production traits

Constructive breeding should have for one of its goals the production of an animal which manufactures products for human consumption more economically and with a longer productive life. This is a different problem with dairy cows as it involves characters responsible for large flow of milk including the milk constituents and it becomes even more difficult when trying to improve two or more characteristics simultaneously. The progress made when selecting for two or more characteristics depend primarily on the heritabilities of these characteristics, the genetic correlation between them in the same individual and the actual intensity of selection.

Gilmore (1952) came to the conclusion that several genes affect the synthesis of each of the nonfat constituents of milk. He showed that at some level of fat production both members of identical twin pairs made protein at the same rate. Fraternal twins and unrelated cows were very unequal in these characteristics. It can be further seen that gene action plays a decidedly important role in determining the composition of milk by referring to composition of milk from various species. There is likely to be more that 18 alleles affecting milk synthesis, when the qualitative as well as quantitative features are considered.

Johnson (1957) reported that the Holstein herd had heritabilities of milk 0.30, butterfat 0.30, butterfat percentage 0.33, solids not fat 0.35, solids not fat percentage 0.34, total solids 0.34 and total solids percentage 0.38.

Legates (1962) computed intra herd - sire heritability estimates to examine the relationship between these values and the herd level of fat yield. Phenotypic and additively genetic variances showed a definite increase as the mean fat production for the herd increased.

Wilcox (1966) estimated heritability for five yields (milk, fat, solids not fat, total solids and protein) and four percentages. Heritability for protein yield were 0.39 (± 0.09) and 0.50 depending on the method of calculation. Heritabilities ranged from 0.22 to 0.28 (± 0.06) for the remaining yields. Genetic correlation between protein and other yields were positive 0.63 (milk), 0.87 (milk fat), 0.66 (solids not fat) and 0.68 (total solids). In general, positive genetic correlation were found between percentages and negative correlation between percentages and yields. Results suggested that major selection emphasis should be placed on milk yield, while maintaining acceptable percentage levels, under present economic conditions.

Amble *et al.* (1967) showed that the value of heritability for milk production obtained for most of the Indian dairy herds is in the neighbourhood of 0.25. in India. Sharma (1970) estimated values of heritability using actual records $h_1^2 = 0.33 \pm 0.24$ based on first generation data, $h_2^2 = 0.88 \pm 0.25$ based on second generation data and $h_3^2 = 0.85 \pm 0.81$ based on third generation data. The heritability estimates based on first and second generation data after taking out the generation effect, comes to 0.16 ± 0.131. The estimates of heritability reported by foreign workers are usually higher than the ones reported in India by Sharma *et al.*

Maijala and Hanna (1974) reported mean heritabilities of 0.26, 0.20 and 0.17 for milk yield and 0.25, 0.16 and 0.17 for fat yield for lactation one, two and three respectively. Estimates from subsequent studies were generally of similar magnitude. Dairy performance in all lactations is determined by more or less the same genes. Heifer yield is therefore not only an efficient selection criterion for lifetime production, but including later accords will improve the precision of sire evaluation only to a limited extent.

Chander and Gurnani (1976) stated that the estimates of heritability of first lactation production generally vary between 0.2 and 0.4 for Indian cattle. Hocque *et al.* (1980) reported that heifer yield is a good indicator of lifetime production. Evidence suggested that the heritability of fat and protein are about 0.50. With the high heritability of the milk constituents, a rather accurate assessment of the merit of a cow can be attained from a single lactation. Results obtained by Meyer (1984) suggested that dairy performance in all lactation is almost identical genetically. Estimates of heritability for lactation one to three were 0.28, 0.19 and 0.24 for milk yield and 0.27, 0.21 and 0.25 for fat yield.

Agyemang *et al.* (1985) estimated the heritabilities for milk yields as 0.21, 0.21 and 0.13 for first, second, and third 90 days in lactation and for fat yields were 0.19, 0.16 and 0.10. Heritabilities for milk and fat yields over the entire 270 days post partum were 0.22 and 0.22. They also reported that the genetic correlations among partial yields were high and ranged from 0.74 to 0.99 for milk and 0.86 to 0.99 for fat. Chauhan *et. al.* (1987) reported that the heritability of milk yield is much less than the estimates reported from several breeding populations in North America and Europe, when the analyses was done on the field data of crossbred cows and buffaloes in India.

Rahumathulla (1992) made a genetic analysis of milk records of Jersey crossbreds in Tamil Nadu and found out that the heritability estimates of milk yield and milk production efficiency traits ranged between 0.17 and 0.53. Nair *et al.* (1994) found out that the heritability estimate for first lactation milk yield range from 0.273 to 0.378. Jadhav and Khan (1995) also calculated the heritability as 0.377 $\pm$ 0.07 for first lactation milk yield.

Frietas *et al.* (1995) estimated phenotypic and genetic parameters for milk fat and protein and the heritabilities ranged from 0.1 to 0.24 when records were not adjusted for days in milk. Adjustment for days in milk lowered heritability to 0.06 - 0.22.

AppanNayar *et al.* (1995) calculated the heritability of second, fourth and tenth test day milk yields and first ten test day cumulative yields as 0.49±0.22, 0.35±0.2, 0.56±0.3 and 0.39±0.29 respectively. These traits were of higher magnitude and can be used effectively in selection programme for the improvement of milk yield.

2.4 Sire evaluation

Selection of bulls based on progeny performance is receiving more and more attention in India now-a-days, for improving dairy performance, considering its overall economic return compared to other systems of selection.

Several circumstances favours the progeny testing of dairy sires. Milk production is a sex-limited trait and the males breeding value must be predicted from the performance of close relatives and progeny. In view of the evident influence of environmental and managemental effects on performance, testing of individuals under standardized conditions at special test station was advocated. Progeny testing of bulls for milk yield began in 1902 and in 1945 dairy bull testing stations began operating. Under some circumstances the test conditions may be rather different than the farm conditions, and the possibility of a genotype environmental interaction arises. There could be a source of inaccuracy in testing under station condition, which could be minimized by testing the progeny in several herds.

Before considering the methods used in evaluating bulls, the importance of the bull himself deserves mentioning (Gilmore, 1952). The bull himself is half the herd and the value of using good bulls is exemplified atleast several times in every progressive dairy community. VanVleck *et al.* (1961) stated that the importance of proving sires have increased with the growth of Artificial Insemination. They calculated the correlations between evaluation procedures, based on deviations from the contemporaries of first records and average of records of daughters. They concluded that for more than 50 daughters a few correlations are large enough to warrant consideration of these procedures in sire evaluation when computing facilities are limited. They found out that the variance due to herd effects make up a large part of the accountable variation, about 30 per cent of the total. The sire component corresponds to 6-7 per cent of the total variance and year-season components, 2 per cent.

Sundaresan *et al.* (1965a) made comparative study of five sire indices, two involving daughter dam comparison, one with daughter production only and two using contemporary averages and concluded that the index given below was more accurate than other indices.

$$I = \frac{U + n}{n+k} (\overline{D} - C_A)$$

where,

k - was 12 and 6 for milk yield and age at first calving u - is herd average, n - is number of daughters of a sire

$\overline{D}$ - is daughter's average

C_A - average of daughter's contemporary cows

Sundaresan *et al.* (1965b) evaluated the breeding value of bulls using five of the sire evaluation methods. In view of the situation, that often under Indian farm conditions evaluation of bulls will have to be made with information from very few daughters and from records subjected to serious environmental differences, an index developed. This index called dairy search method was used to evaluate the breeding value of bulls for milk production.

$$I = \frac{u + n}{n+12} (\overline{D} - C_A) - b\,(\overline{M} - C_m A) \text{ has been}$$

where,

b - is intrasire regression of daughter on dam,

$\overline{M}$ - is bull mate's average, and

$C_M A$ - is average of mate's contemporary cows

Allaire and Gaunt (1965) studied the accuracy of various measures of a dairy sire's transmitting ability using contemporary averages. First lactation contemporary average was found to be most effective is removing herd variance, but resulted in an increased herd by sire component estimate. The measure of using all lactation records from daughters and contemporaries yielded largest expected correlation (0.93) between the mean of 100 daughters and all future daughters.

Cunningham (1965) pointed out that the herdmate comparison procedure amounts to a two stage process in which herd and year-season effects are removed by expressing the records as deviations from herd-year-season means and sires are evaluated by analysing these deviations, ignoring herd and year-season.

The results of the study of Miller *et al.* (1968) indicated that the herdmate comparison procedure gives a reasonable accurate assessment of bulls used in Artificial Insemination. The Herdmate comparison is relatively easy to program, can be computed as a sequential basis and does not have elaborate computational requirements.

Christensen (1970) estimated the genetic correlations after accepting the heritability of fat yield under field condition as 0.2 and under station condition as 0.75. It was concluded that the low correlation between a bulls station test and his field test and also the extremely large variance components between bulls at the station were caused by a non-genetic correlation between daughters within groups, which accounted for about two third of the interclass correlation between half sibs at the station. According to him, heritability was slightly higher at the station than in the farm herds and progeny tests under field condition proved more accurate than tests under station conditions even with an equal number of daughter in the group.

Jain and Malhotra (1971a) stated that it is advantageous to test bulls simultaneously at the farm and also in villages. But the use of dam's records would be difficult under village conditions and so slight modification should be done in the sire indices.

Christensen (1971) calculated the correlation between farm and station results as 0.46 with an expected value of 0.81 and that between two independent farm tests was 0.65 with an expected value of 0.69.

Allaire (1971) after comparing herdmate comparison method and contemporary comparison method concluded that contemporary comparison was less subject to errors arising from differences in culling practices and genetic advance among herds. Aljtsuler *et al.* (1971) used the differences between the variability of performance within sire groups and among contemporaries to assess the effect of individual sires on dairy performance.

Jain and Malhotra (1971b) considered relative merits of eleven methods of indexing sires, two methods using information on daughters, three using information on dams and daughters and six others using information on daughters and contemporaries, with or without information on dams.

Use of dam's records in the evaluation of bulls under village condition would be difficult since the records of dams would either not be available and if at all, would be highly unreliable. In such a situation.

$I_6 = A + \frac{1}{2} h^2 Q (\overline{D} - C_D)$ can be used.

Suller (1972) evaluated sires by using five methods and concluded that the best method for evaluation of sires over a period of several years is the contemporary comparison corrected for year differences in performance and for number of daughters per bull. He also noted that the addition of data on bull mates did not significantly change sire rankings nor improve the accuracy of evaluation. Powell *et al.* (1972) did evaluation of sires based on daughter's average and mean weighted difference of first lactation daughters. With large number of daughters per sire the daughter average had similar but generally slightly higher correlation with final predicted differences than with mean weighted difference.

Henderson (1975) compared alternative sire evaluation methods and the criteria used for comparison were unbiasedness and prediction error variance. Applying different methods to the same set of data, according to him, had limited value except possibly to conclude that methods differ much or little when applied to that particular set of data.

Kennedy and Moxley (1977) evaluated Artificial Insemination sires for fat per cent by four methods - daughter average, contemporary comparison, sire comparison (BLUP) and indirectly from BLUP evaluation for fat and milk yield. The last three methods gave similar results. In selecting a sire evaluation method for any trait, some compromise between what is conceptually optimum and what is practical is always necessary.

Jain (1982) stated that in comparison to family selection, progeny testing is almost twice as effective as the selection based on half-sib family mean and about 1.4 times that based on full-sib family mean. Since in large animals full-sibs are less common and half-sibs are only 25 per cent related, progeny records are therefore used for maximum genetic progress for traits which are expressed only in one sex.

Chacko *et al.* (1984) studied the influence of environmental effects on lactation under field conditions of Kerala. Of the effects considered, artificial insemination centre, type of dam and sex of calf under the existing management practice contributed maximum to variation. Other effects which were significant were year of calving, age of cow and sire. The effect of month of calving was found to be not significant. They also suggested that a suitable methodology has to be developed for grouping the cows in different management classes as herd effect cannot be directly studied since the average herd size of milking cows is around one.

The results from the study of Abubaker *et al.* (1986) led to strong reservation on the value of progeny testing in low to medium feeding environments that are subject to large year effects. The alternative is to compare sires on daughter performance over a short time, perhaps within an year.

Chauhan *et al.* (1987) stated that most cattle in field conditions of Kerala had 50-75 per cent Brown Swiss inheritance, and it is becoming difficult to identify them by exotic inheritance levels. Therefore, they recommended that the effect of the breed of dam shall have to be ignored in the near future. Gajbhiye and Dhanda (1987) evaluated 12 sires using four selection indices and one had a breeding value more than 20 per cent above the herd average of 1984 litres by all four methods. The rank correlation between the sires by the different methods were highly significant.

Godara *et al.* (1988) ranked sires on the basis of first lactation records for age at first calving, milk yield, fat-corrected milk yield, percentage fat, percentage solids not fat, fat yield and solids not fat yield. Rankings on the basis of the various yield characteristics were similar, and on the basis of solids not fat and fat percentages were also very similar. High rank correlation values were found amongst all yield characteristics in different genetic groups.

Parekh and Singh (1989) evaluated expected breeding value from a model constituting herd-year as fixed and sire as random effects. The accuracy of different methods were adjusted using rank correlation regression of the sire effect on the estimates and correlation between true sire effect and the estimates.

Chacko (1990) reported that the number of bulls progeny tested each year in Kerala is reduced to the number required for replacement and their semen is used for field artificial insemination before the progeny testing results are known. A small proportion of the progeny tested bulls are selected for nominated mating of the elite bull mothers to produce the next generation young bulls.

Chauhan *et al.* (1990) showed that a herd-class model with herd classification based on herd averages adjusted for genetic merit of sires showed not bias. A model with herds as fixed effects and herd-year as random effects was found to be a good alternative to a herd-class model.

Gandhi and Gurnani (1991) constructed 12 sire indices on the basis of first lactation milk yield and these indices were evaluated for accuracy, efficiency and stability. Indices based on simple daughter averages and least square models were almost equivalent in accuracy, efficiency and stability. The rank correlations among indices ranged from 0.89 to 1.00. The high rank correlation among different methods of sire evaluation revealed that there may be high genetic differences among bulls. The simple daughters average performance based on unadjusted data was found to be optimum.

Raheja (1992) found out that Herdmate and contemporary comparison methods were equally good in ranking the sires and there were very small changes in the rank of the first six to eight per cent top sires under different methods.

Murida and Tripathi (1992) evaluated the breeding values of Jersey sires by (i) simple daughter's average; (ii) least squares daughters average of adjusted data and (iii) contemporary comparison method. The estimates of rank correlation were high and significant suggesting that evaluation of sires based on any of these three methods for this set of data would result in almost similar ranking.

Gupta *et al.* (1992) evaluated Jersey bulls at Kamand, Kothipura and Palampur (both Government and University herds) in Himachal Pradesh for first lactation milk yield and the breeding values ranged from 931 to 2166 kg. They also noted that the genetic merit of 48.2 per cent of the bulls was below their herd average.

Oikawa *et al.* (1993) studied five mixed models for the genetic evaluation of sires using data for small progeny size under varied environmental effects. Model 2 in which sire and environmental effects were random, estimated breeding value with an accuracy higher than for the other models. They concluded that the total number of records and the percentage of filled subclasses were the major factors affecting accuracy of prediction of breeding values.

Parekh and Singh (1994) studied the accuracy of three different procedures (Least squares, simplified regressed least squares and best linear unbiased prediction) in dairy sire evaluation using three breed cross progeny. By accuracy and efficiency standards, simplified regressed least squares proved to be a superior procedure over the different genetic groups of sires covered.

Tailor *et al.* (1994) evaluated buffalo sires by six different methods and found out that the rank correlations were high between I_1 and I_2 (0.852), I_3 and I_4 (0.956) and I_5 and I_6 (0.957). It indicated that there is no need of adjustment for the performance level of mates for the purpose of sire evaluation.

Jain *et al.* (1994) compared five sire indices for estimation of breeding value of buffalo bulls and the rank correlation between pairs of methods ranged from 0.682 to 0.958.

Khalil *et al.* (1995) compared four methods of sire evaluation (BLUP without a relationship coefficient matrix, BLUP using variance components estimated by Restricted Maximum Likelihood, least squares and contemporary comparison. For all methods there were differences between sires in milk yield, protein yield and fat plus protein yield. Rafique *et al.* (1995) evaluated 14 Holstein crossbred bulls by contemporary comparison method and seven had positive breeding value for milk yield.

2.4.1 Number of daughters to prove a sire

Gilmore (1952) stated that it is quite largely a matter of arbitrary decision as to how many daughters should be required to furnish enough information to evaluate a sire. The Bureau of Dairy Industry required five since the start of sire evaluation programme in 1935. It should be reemphasized that the number is far less important, than is the use of all the records or of a random sample of them. According to Gilmore the most acceptable minimum number appeared to be between five and ten, if selectivity is eliminated.

Touchberry *et al.* (1960) stated that the field tests seemed to be superior to station tests if the number of daughters per sire is fifteen or more. This superiority increased as the number of daughters per sire increased. Sundaresan *et al.* (1965b) after a comparison of station and field testing with reference to number of daughters used for testing a sire, came to the conclusion that if the number of daughters per sire is seven or more, the expected genetic superiority resulting from selection based on field data is greater than that resulting from station tests.

Ivanenko (1970) calculated the rank correlation of the average milk yield of all daughters of a bull with that of the first five and ten daughters as 0.80 and 0.92 respectively. For fat content, rank correlation in respect of the first five, ten, fifteen and twenty daughters were 0.66, 0.54, 0.52 and 0.71. He concluded that the milk yield of the first 10, 15 and 20 daughters did not differ significantly from that of all daughters. Jain and Malhotra (1971b) recommended that the number of daughters required to prove a bull is roughly 12.

Fahmy (1973), estimated breeding value of buffalo and Friesian sires using the sire's first five daughters and all available daughters. The correlation coefficient between the two were highly significant and ranged from 0.510 and 0.839. The difference in values were not significant at the five per cent level. It was concluded that the records of only five daughters can be used as a preliminary evaluation.

Maijala and Vilva (1976) on the basis of heritability estimates, calculated number of daughters required in progeny testing as 35-50. Warwick and Legates (1979) noted that when heritability is low, fewer progeny are required to make the progeny test equivalent in accuracy to individual selection. If there is an environmental correlation among the progeny due to non-genetic factors, the accuracy of the progeny test is much reduced.

Random environmental influences and chance deviations tend to balance out in an offspring average. Maciejowski and Zieba (1982) stated that the offspring average provides an increasingly reliable measure of the breeding value as the number of progeny increases. The larger the progeny group used, the closer to zero will be the deviations in the value of the character caused by non-directional environmental factors. He also stated that the value of the estimated character, will then correspond more closely to the average genotypic value of the offspring.

Jain (1982) stated that for traits which are moderately heritable, selection on progeny tests is more effective than individual selection, if the size of progeny group exceeds five. Consequently this type of selection should be based on atleast six offspring, if it is to be superior to individual selection.

Abubaker *et al.* (1986) pointed out that ranking of sires with atleast five progeny were considerably influenced by record classification especially for sires with highest predicted values. There was less influence on rankings when at least ten progeny per sire were used. Sire rankings were more consistent when ten progeny per sire were used and this may be considered minimum for progeny testing purposes in tropical areas, since requiring higher number would impose a severe constraint due to a limited volume of data.

Bhuller and Dev (1986) on their studies on the effect of number of daughters on the evaluation and ranking of the buffalo bulls revealed that correlations of the preliminary sire proof based on first eight daughters with the subsequent proof based on 15 daughters were 0.86 and 0.82, indicating that the ranking of sires on the basis of preliminary proofs based on eight daughters will not be expected to be much different from the subsequent ranking on 15 daughters.

Garcha and Dev (1994) conducted an investigation of evaluate the number of additional daughters required to prove a dairy sire and found out that the requirement of additional records in evaluating dairy sires with estimated yields, increased with increasing sampling interval.

Materials and methods

MATERIALS AND METHODS

The work was conducted as a part of the ICAR Field Progeny Testing Project which envisaged the progeny testing of crossbred bulls. For the present study, ten Holstein-Friesian (HF) crossbred bulls ranging in exotic inheritance from 50-75% were selected, so that all bulls of the batch were from the same genetic group. The test bulls used in the Progeny Testing Scheme were selected on the basis of pedigree. They were from dams with not less than 450 kg milk per lactation. The average milk production of the bull dams was 4886.1 kg and the bulls' sires were superior proven bulls with much higher genetic worth. The location of work for the project included area of six Artificial Insemination (AI) centres under Intensive Cattle Development Project, situated in and around Thrissur district of Kerala state and also the Livestock Farms of Kerala Agricultural University - University Livestock Farm (ULF), Mannuthy, Cattle Breeding Farm (CBF), Thumburmuzhi and Livestock Research Station (LRS), Thiruvazhamkunnu .

The bulls selected were test inseminated during the year 1992-93. Female progenies of these bulls belonging to farmers in the field area and in the University Farms were identified by ear-tagging (Plate 1). The first lactation records of animals calved during the year 1995-96 were taken. As contemporary cows, those animals which calved during the same period, maintained by farmers in the same AI centres and University Farms, were also chosen irrespective of their parities, as otherwise enough number in first lactation were not available as strict contemporaries. For the animals chosen, computerised code number of animals, date of birth, date of calving, AI centre code number and sire code number were given as assigned numerical values.

Plate 1 A first lactation daughter from Holstein Friesian crossbred test bull identified by ear tagging

Milk recording was done both in morning and evening at monthly intervals, first recording starting within 20 days of calving. The 305-day milk yield (MY) was estimated from these records as the yield of milk (kg) from the date of calving to 305 days, irrespective of length of lactation. Some cows became normally dry before 305 days, therefore their actual yields were taken as standard lactation yields.

Milk samples of 10 ml each were collected during second month of calving (early lactation), fifth month (middle lactation) and eighth month (late lactation) of calving. Potassium dichromate, 0.6 mg/ml was added as preservative. The samples were analysed for percentages of fat, total solids and solids-not-fat during early, middle and late lactation.

Fat was estimated by Electronic Milk Tester with frequent standardisation with Gerber's test, as per the procedure described in Indian Standards 1124-part I (1977). Fat percentage is of morning and evening milk samples during early, middle and later stages of lactation denoted as F_1M, F_1E, F_2M, F_2E, F_3M and F_3E respectively. TS of milk was estimated by Gravimetric method (Indian Standards: 1479-part II, 1961) clean, dry empty stainless steel dishes were weighed with their lids. About five ml of milk was pipetted into dish and again weighed. Milk was dried by placing the open dish on a boiling water bath for 30 minutes. Then it was transferred to a well-ventilated hot air oven, maintained at 99 to 100° C. After two to three hours, the dish was covered and transferred immediately to a desiccator. Weighed the dish after 30 minutes. Procedure was repeated until loss of weight between successive weights did not exceed 0.5 mg. The percentage of TS was calculated. The morning and evening TS percentages during early, middle and late lactation were denoted as TS_1M, TS_1E, TS_2M, TS_2E, TS_3M and TS_3E respectively.

SNF content of milk was determined, by finding the difference between TS content and fat content of milk. Morning and evening SNF percentages for early, middle and late lactation were denoted as SNF_1M, SNF_1E, SNF_2M, SNF_2E, SNF_3M and SNF_3E respectively.

The milk yield in three different stages were estimated. The Fat Yield (FY) Total Solids Yield (TSY) and SNF Yield (SNFY) were calculated by multiplying the quantity of milk in each stage with the corresponding percentages and adding.

Analytical methods

The average, standard error and coefficient of variation of the traits were estimated by the methods given by Snedecor and Cochran (1967). The data were of animals calved in 1995-1996 period and this was considered as a single period. The lactation period was divided into three stages-early, middle and late, each of 100, 100 and 105 days duration respectively. Season of calving and recordings were defined by grouping the months as 1. Summer (March-June), 2. Rainy (July-October) and 3. Winter (November-February). Locations were classified into nine - six AI centres and three University farms.

Least squares technique was employed to compute the least squares means of each effect. The effect of sires, centres and seasons were estimated. The standard programme LSML (Harvey, 1986) was used for computation.

The model used was,

$$Y_{ijkl} = \mu + B_i + C_j + S_k + e_{ijkl}$$

where,

Y_{ijkl} = l^{th} observation of k^{th} season of j^{th} centre of i^{th} sire

μ = overall mean when equal subclass members exist

B_i = effect of sire (i = 1 ....10)

C_j = effect of centre (j = 1 ....9)

S_k = effect of season (k = 1 ....3)

e_{ijkl} = random error

Calculation of heritability

Paternal half sib method was used to estimate the heritability of different characters. The minimum number of progeny per sire was six.

The model used to estimate the heritability was:

$$Y_{ij} = \mu + S_i + e_{ij}$$

where,

Y_{ij} = observation of j^{th} progeny of i^{th} sire

μ = overall mean

S_i = Effect of i^{th} sire assumed to be random with mean zero and variance σ^2_S

e_{ij} = random error of each observation

Source	df	MSS	EMS
Between sires	S-1	MS_s	$\sigma^2_e + k\,\sigma^2_S$
Progeny within sire	N - S	MS_e	σ^2_e

where,

$$k = \frac{1}{S-1}\left(N - \frac{\sum n_i^2}{N}\right)$$

k = average number of progeny per sire

S = Number of sires

n_i = number of progeny within i^{th} sire

N = total number of progeny

σ^2_S = sire component of variance

σ^2_e = variance among progeny within sire

$$\sigma^2_s = \frac{MS_s - MS_e}{k}$$

t = intraclass correlation between half sibs

$$t = \frac{\sigma^2_S}{\sigma^2_S + \sigma^2_e}$$

h^2 = 4t

The standard error of heritability was estimated by the method of described by swiger *et al.* (1964).

$$SE(h^2) = 4\sqrt{\frac{2(N-1)\,(1-t)^2\,[1+(K-1)t^2]}{K^2(N-S)\,(S-1)}}$$

Sire evaluation

Sires to be evaluated had progeny spread in different centres and seasons. Fat, TS and SNF percentages and their yields were considered for evaluating the sires. The minimum number of progeny per sire was six.

Sires were evaluated using simple Daughters Average, Contemporary Comparison and Least Squares.

I_1 = D (Edwards, 1932)

I_2 = $A + \frac{1}{2} h^2 Q (\overline{D} - C_D)$ (Robertson and Rendell, 1950)

I_3 = Least square means of sires

$\overline{D}$ = Daughters' average

A = Herd average

C_D = Contemporary daughters' average

$$Q = \frac{n}{1+\left[\frac{(n-1)}{4}\right] h^2}$$

where,

n = number of daughters per sire

h^2 = heritability coefficient of the character

In the case of index I_2, $\overline{D} - C_D$ was calculated by taking each daughter record as a deviation from the contemporary average and then estimating the mean.

Results

RESULTS

4.1 Milk yield

305-day milk yield of 222 cows belonging to six Artificial Insemination centre areas and three University farms was estimated. The mean 305-day milk yields with their standard errors are given in Table 2. The overall average was 1829.68 ± 34.128 kg. The averages ranged from 1521.57 ± 84.878 kg for Livestock Research Station, Thiruvazhumkunnu to 2426.71 ± 92.103 kg for Ramavarmapuram. The least square analysis of variance for 305-day milk yield (Table 3) revealed that the effect of centre was highly significant. A comparison between 305 day milk yield of progeny and contemporary in the field is given in Fig. 1.

4.2 Milk composition

4.2.1 Milk fat percentage

The milk fat percentage for morning and evening milk samples were estimated during second, fifth and eighth month of lactation. Centre wise mean fat percentages with standard error are given in Table 4. The milk fat percentage ranged from 2.0 to 5.1 and 2.7 to 7.2 in the morning and evening milk respectively for all stages together and the range was higher for evening milk. The overall average for milk fat percentage for morning and evening were 3.461 ± 0.038 and 4.239 ± 0.056 for early lactation, 3.650 ± 0.035 and 4.460 ± 0.052 for middle lactation and 3.967 ± 0.042 and 4.932 ± 0.059 for late

Table 2

Centrewise and overall averages of 305 day milk yield

Code No.	Centre Name	Milk yield
3	Kanimangalam	1744.66 ± 113.12 (21)
5	Moorkkanikkara	1767.4 ± 118.88(20)
9	Karuvannur	1826.18 ± 77.72(33)
12	Parappur	1682.1 ± 63.058(39)
13	Ramavarmapuram	2426.71 ± 92.103(14)
15	Arimbur	1761.21 ± 125.684(19)
20	Livestock Research Station	1521.57 ± 84.878(28)
21	Cattle Breeding Farm	1923.55 ± 70.84(28)
22	University Livestock Farm	2234.0 ± 126.565(20)
20, 21, 22	University Farms	1856.26 ± 62.291(76)
3, 5, 9, 12, 13, 15	AI Centres	1816.12 ± 40.529(146)
3, 5, 9, 12, 13, 15, 20, 21, 22	Overall	1829.68 ± 34.128(222)

Table No. 3

LEAST - SQUARE ANALYSIS OF VARIANCE FOR 305 DAY MILK YIELD

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	544974.68	2.729	0.0001
MU-YM	1	648347.18	3.297	0.0711
S	10	291217.98	1.458	0.1587
C	8	885007.38	4.431	0.0000
SEA	2	23458.49	0.117	0.8892
REMAINDER	177	199710.23		

MEAN = 1839.195 ERROR STANDARD DEVIATION = 446.889 CV = 24.30

R SQUARED = 0.253 R = 0.503

Figure 1

COMPARISON BETWEEN FIELD PROGENY AND CONTEMPORARY FOR 305 DAY MILK YIELD (Kg.)

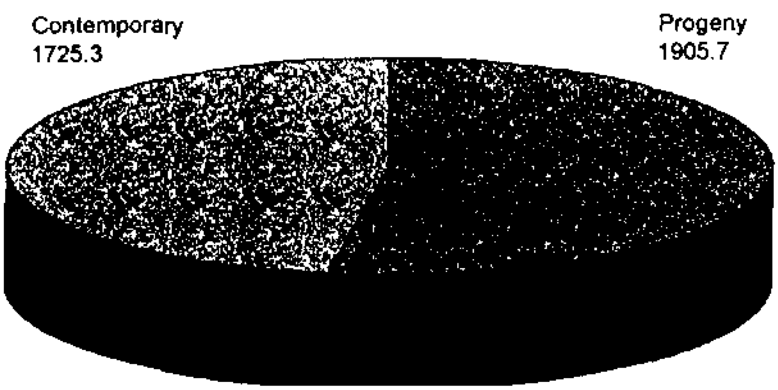

Table 4
Centrewise and overall averages of milk fat percentage at different stages of lactation

Code No.	Name	Early lactation		Mid lactation		Late lactation	
		F.M	F.E	F_2M	F_2E	F_3M	F_3E
3	Kanimangalam	3.047± 0.124(21)	3.576± 0.179(21)	3.09± 0.102(21)	3.919± 0.159(21)	3.585± 0.122	4.757± 0.172(21)
5	Moorkkanikkara	3.49± 0.092(20)	3.975± 0.113(20)	3.625± 0.099(20)	4.2± 0.153(20)	3.826± 0.112(19)	4.347± 0.140(19)
9	Karuvannur	3.239± 0.095(33)	3.912± 0.12(33)	3.472± 0.111(33)	4.366± 0.198(33)	3.821± 0.115(32)	5.046± 0.190(32)
12	Parappur	3.317± 0.084(39)	3.912± 0.118(39)	3.542± 0.048(40)	4.295± 0.096(40)	3.908± 0.097(37)	4.816± 0.144(37)
13	Ramavarmapuram	3.371± 0.098(14)	4.185± 0.205(14)	3.607± 0.101(14)	4.457± 0.191(14)	4.076± 0.133(13)	4.784± 0.691(13)
15	Arimbur	3.647± 0.115(19)	4.757± 0.202(19)	3.952± 0.099(19)	4.857± 0.155(19)	4.068± 0.103(19)	5.242± 0.158(19)
20	LRS. Thiruvazhamkunnu	3.817± 0.089(28)	4.892± 0.147(28)	4.07± 0.097(27)	4.848± 0.109(27)	4.429± 0.124(17)	5.635± 0.191(17)
21	CBF. Thumburmuzhi	3.522± 0.122(27)	4.755± 0.104(27)	3.674± 0.074(27)	4.774± 0.124(27)	3.888± 0.093(25)	4.776± 0.099(25)
22	ULF. Mannuthy	3.815± 0.088(20)	4.315± 0.135(20)	3.92± 0.079(20)	4.45± 0.103(20)	4.452± 0.126(17)	5.135± 0.138(17)
20.21. 22	University Livestock Farms	3.71± 0.062(75)	4.689± 0.080(75)	3.885± 0.053(74)	4.713± 0.069(74)	4.206± 0.073(59)	5.127± 0.092(59)
3,5,9, 12,13,15	AI Centres	3.332± 0.044(146)	4.008± 0.066(146)	3.532± 0.042(147)	4.332± 0.069(147)	3.866± 0.049(141)	4.851± 0.074(141)
3,5,9,12,13,15 ,20,21,22	Overall	3.461± 0.038(221)	4.239± 0.056(221)	3.650± 0.035(221)	4.460± 0.052(221)	3.967± 0.042(200)	4.932± 0.059(200)

Number in parenthesis denotes number of observations

lactation. The fat percentage increased with the advance of stage of lactation as can be seen from Table 4 and Fig.2. Also the evening milk fat percentage was uniformly higher than morning milk fat percentage during all stages of lactation. Fig. 2 clearly revealed this trend.

Among the centres, Arimbur recorded the maximum milk fat percentage during all stages of lactation and Kanimangalam recorded the minimum. University farm milk samples had comparatively higher fat percentages than those from AI centres.

Seasonwise average for fat percentage are given in Table 5. But seasons were found to be not exerting a significant effect on the trait. Least squares analysis for milk fat percentage revealed that the effect of centre was highly significant (Table 6). Centrewise Least squares means for fat percentage in Table 7.

53.85 per cent of cows in early stage of lactation were found to have morning milk fat below the PFA standards of 3.5 per cent. In the case of evening milk samples, 15.38 per cent in early stage of lactation were below the standards (Fig. 3). On analysing the field milk samples alone (Table 8) it was seen that 66.67 per cent of morning milk samples and 21.77 per cent of evening milk samples from early stage of lactation had their fat per cent below legal standards, whereas in University Farms, the percentages had been 28.38

Figure 2

EFFECT OF STAGE OF LACTATION ON FAT, TOTAL SOLIDS AND SNF PERCENTAGE OF MILK

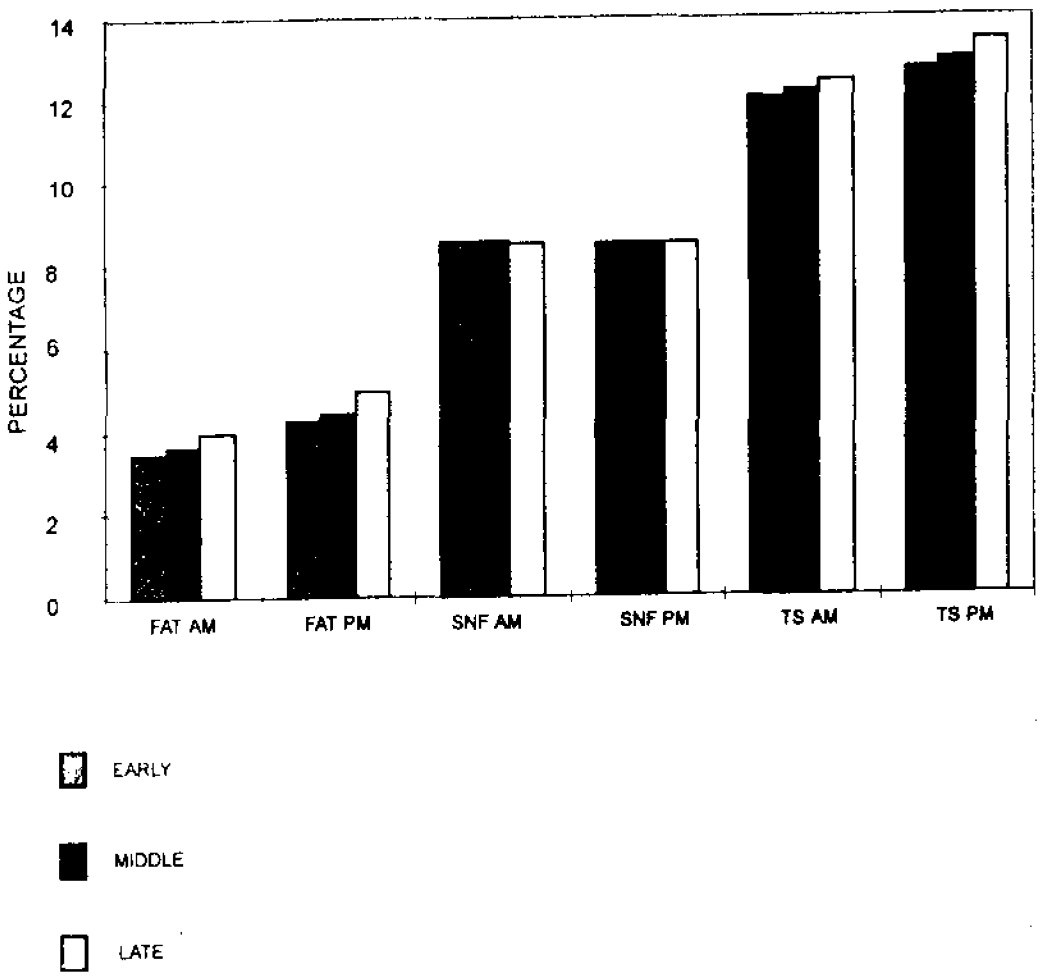

Table No. 5

SEASON WISE AVERAGES OF FAT PERCENTAGE OF MILK AT DIFFERENT STAGES OF LACTATION

SEASON	FAT		FAT		FAT	
	F1M	F1E	F2M	F2E	F3M	F3E
SUMMER	3.585 ± 0.049 (64)	4.475 ± 0.015 (64)	3.507 ± 0.061 (96)	4.406 ± 0.087 (96)	3.393 ± 0.056 (122)	4.168 ± 0.077 (122)
RAINY	3.543 ± 0.087 (51)	4.2 ± 0.118 (51)	3.554 ± 0.063 (46)	4.319 ± 0.101 (46)	3.511 ± 0.088 (27)	4.533 ± 0.156 (27)
WINTER	3.346 ± 0.058 (106)	4.116 ± 0.077 (106)	3.350 ± 0.065 (79)	3.991 ± 0.093 (79)	3.502 ± 0.062 (50)	4.162 ± 0.103 (50)

Number in parenthesis denotes number of observations

Table No. 6

LEAST - SQUARE ANALYSIS OF VARIANCE FOR FAT PERCENTAGE OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	0.739225	2.914	0.0000
MU-YM	1	0.00006	0.000	0.9961
S	10	0.410968	1.62	0.1042
C	8	1.005684	5.146	0.0000
SEA	2	0.095970	0.378	0.6856
REMAINDER	177	0.253715		

MEAN = 3.432 ERROR STANDARD DEVIATION = 0.5037 CV =14.68

R SQUARED = 0.266 R = 0.516

Table 7

Centrewise least squares means of fat percentage of milk at different stages of lactation

Centre Code No.	Centre name	FAT-1		FAT-2		FAT-3	
		F_1M	F_1E	F_2M	F_2E	F_3M	F_3E
3	Kanimangalam	2.99 ± 0.132	3.42 ± 0.184	3.08 ± 0.118	3.91 ± 0.193	3.56 ± 0.143	4.49 ± 0.209
5	Moorkanikkara	3.62 ± 0.140	4.03 ± 0.196	3.72 ± 0.126	4.33 ± 0.205	3.96 ± 0.152	4.52 ± 0.223
9	Karuvanoor	3.20 ± 0.108	3.75 ± 0.151	3.44 ± 0.097	4.32 ± 0.158	3.74 ± 0.117	4.79 ± 0.172
12	Parapoor	3.37 ± 0.102	3.88 ± 0.143	3.56 ± 0.092	4.28 ± 0.149	3.94 ± 0.111	4.69 ± 0.163
13	Ramavarmapuram	3.34 ± 0.156	4.27 ± 0.218	3.66 ± 0.141	4.59 ± 0.229	4.06 ± 0.170	4.77 ± 0.0249
15	Arimbur	3.60 ± 0.135	4.59 ± 0.189	4.02 ± 0.122	5.01 ± 0.198	4.13 ± 0.147	5.21 ± 0.216
20	Livestock Research Station,Thiruvazhamkunnu	3.74 ± 0.139	4.73 ± 0.194	3.92 ± 0.125	4.70 ± 0.204	4.36 ± 0.152	5.41 ± 0.222
21	Cattle Breeding Farm, Thumburmuzhi	3.52 ± 0.121	4.65 ± 0.169	3.67 ± 0.109	4.79 ± 0.178	3.87 ± 0.132	4.56 ± 0.193
22	University Livestock Farm, Mannuthy	3.90 ± 0.152	4.26 ± 0.211	3.96 ± 0.17	4.47 ± 0.222	4.38 ± 0.165	4.79 ± 0.242

Figure 3

PERCENTAGE OF COWS WITH MILK FAT PERCENTAGE BELOW 3.5 AT DIFFERENT STAGES OF LACTATION

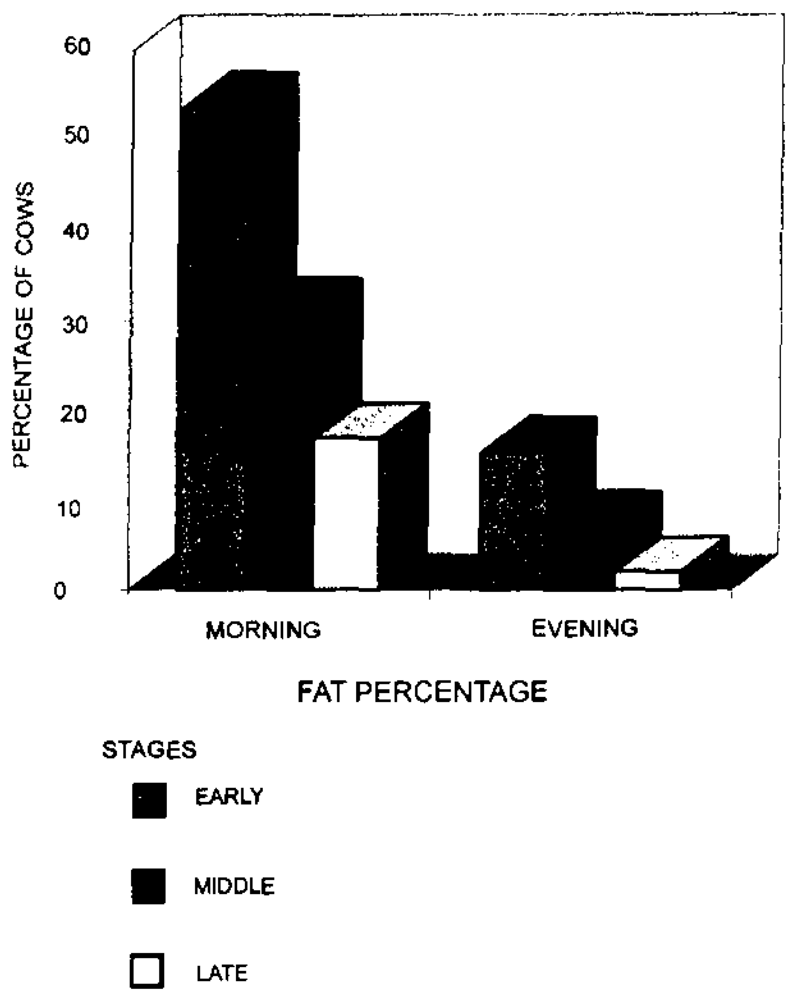

Table No. 8

Percentage of cows with fat percentage below PFA standards in field and farm

	Early lactation		Middle lactation		Late lactation	
	No.	Percentage	No.	Percentage	No.	Percentage
Field						
Morning	98 (147)	66.67	59 (147)	40.14	30 (142)	21.13
Evening	32 (147)	21.77	15 (147)	10.20	4 (142)	2.81
Farm						
Morning	21 (74)	28.38	9 (74)	12.16	4 (58)	6.89
Evening	2 (74)	2.70	0 (74)	0	0 (58)	0

Number in parenthesis denotes the number of observations and 2.7 for morning and evening respectively. The overall morning fat percentage of early stage of lactation (3.461 ± 0.038) was also below the prescribed level (Table 4).

4.2.2 Total solids percentage

The total solids percentage ranged from 10.07 to 15.06 and 10.49 to 15.80 in the morning and evening milk respectively for all stages together. The overall averages for total solids percentage of milk for morning and evening were 12.05 ± 0.059 and 12.75 ± 0.068 for early lactation, 12.20 ± 0.058 and 12.97 ± 0.070 for middle lactation and 12.47 ± 0.064 and 13.43 ± 0.071 for late lactation. Centrewise means with standard errors are given in Table 9. The total solids percentage showed an increasing trend with the progress of lactation (Fig. 2). University Farm milk samples had comparatively higher percentage of total solids than other samples.

Season wise averages of total solids percentage are given in Table 10. But least square analysis showed that season had no significant effect on the trait.

Least square analysis for total solids percentage (Table 11) revealed that the effect of centre was highly significant. Centrewise Least squares means for TS per cent given in Table 12.

Table No. 9

CENTREWISE AND OVERALL AVERAGES OF TOTAL SOLIDS PERCENTAGE OF MILK AT DIFFERENT STAGES OF LACTATION

Centre Code No.	Name	EARLY LACTATION		MID LACTATION		LATE LACTATION	
		TS1M	TS1E	TS2M	TS2E	TS3M	TS3E
3	Kanimangalam	11.074 ± 0.235 (21)	12.17 ± 0.227 (21)	11.45 ± 0.224 (21)	12.15 ± 0.271 (21)	12.09 ± 0.204 (21)	13.19 ± 0.207 (21)
5	Moorkanikkara	12.02 ± 0.145 (20)	12.44 ± 0.191 (20)	12.21 ± 0.127 (20)	12.94 ± 0.184 (20)	12.57 ± 0.147 (20)	13.10 ± 0.185 (19)
9	Karuvannur	11.79 ± 0.142 (33)	12.33 ± 0.166 (33)	11.99 ± 0.138 (33)	12.72 ± 0.210 (33)	12.32 ± 0.137 (32)	13.4 ± 0.227 (32)
12	Parappur	11.89 ± 0.106 (39)	12.45 ± 0.143 (39)	11.98 ± 0.125 (40)	12.83 ± 0.163 (40)	12.34 ± 0.190 (37)	13.35 ± 0.200 (37)
13	R.V. Puram	11.89 ± 0.208 (14)	12.70 ± 0.242 (14)	12.08 ± 0.147 (14)	12.96 ± 0.184 (14)	12.43 ± 0.186 (13)	13.21 ± 0.181 (13)
15	Arimpur	11.89 ± 0.215 (19)	12.90 ± 0.239 (19)	12.23 ± 0.175 (19)	13.15 ± 0.249 (19)	12.47 ± 0.149 (19)	13.53 ± 0.165 (19)
20	L.R.S. Thiruvazhamkunnu	12.59 ± 0.148 (28)	13.46 ± 0.193 (28)	13.09 ± 0.140 (27)	13.64 ± 0.154 (27)	13.02 ± 0.224 (17)	14.04 ± 0.247 (17)
21	CBF Thumburmuzhi	12.06 ± 0.166 (27)	13.34 ± 0.118 (27)	12.16 ± 0.134 (27)	13.23 ± 0.136 (27)	12.28 ± 0.131 (25)	13.32 ± 0.094 (25)
22	ULF Mannuthy	12.62 ± 0.197 (20)	13.08 ± 0.177 (20)	12.64 ± 0.122 (20)	13.16 ± 0.192 (20)	13.15 ± 0.209 (17)	13.93 ± 0.180 (17)
20, 21, 22	Uni. Live-Stock Farm	12.41 ± 0.101 (75)	13.31 ± 0.097 (75)	12.63 ± 0.090 (74)	13.36 ± 0.094 (74)	12.75 ± 0.116 (59)	13.70 ± 0.106 (59)
3, 5, 9, 12 13, 15	AI Centres	11.86 ± 0.067 (146)	12.46 ± 0.080 (146)	11.98 ± 0.067 (147)	12.78 ± 0.090 (147)	12.35 ± 0.074 (141)	13.32 ± 0.088 (141)
3, 5, 9, 12, 13, 15, 20, 21, 22	Overall	12.05 ± 0.059 (221)	12.75 ± 0.068 (221)	12.20 ± 0.058 (221)	12.97 ± 0.070 (221)	12.47 ± 0.064 (200)	13.43 ± 0.071 (200)

NUMBER IN PARENTHESIS DENOTES NUMBER OF OBSERVATIONS

Table No. 10

SEASON WISE AVERAGES OF TOTAL SOLID PERCENTAGE OF MILK AT DIFFERENT STAGES OF LACTATION

SEASON	TS1M	TS1E	TS2M	TS2E	TS3M	TS3E
SUMMER	12.26 ± 0.103 (64)	13.02 ± 0.134 (64)	12.13 ± 0.095 (96)	12.94 ± 0.104 (96)	11.98 ± 0.073 (122)	12.70 ± 0.085 (122)
RAINY	12.06 ± 0.128 (51)	12.61 ± 0.134 (51)	12.22 ± 0.127 (46)	12.85 ± 0.153 (46)	12.28 ± 0.183 (27)	13.09 ± 0.218 (27)
WINTER	11.92 ± 0.084 (106)	12.66 ± 0.093 (106)	11.85 ± 0.087 (79)	12.47 ± 0.103 (79)	12.03 ± 0.132 (50)	12.60 ± 0.152 (50)

Number in parenthesis denotes number of observations

Table No. 11

LEAST - SQUARE ANALYSIS OF VARIANCE FOR TOTAL SOLIDS PERCENTAGE OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	1.384972	2.482	0.0006
MU-YM	1	0.007823	0.014	0.9059
S	10	0.647636	1.160	0.3206
C	8	2.489014	4.460	0.0000
SEA	2	0.150846	0.270	0.7635
REMAINDER	177	0.558092		

MEAN = 12.0276 ERROR STANDARD DEVIATION = 0.74706 CV = 6.21

R SQUARED = 0.236 R = 0.486

Table 12

Centrewise least squares means of total solids percentage of milk at different stages of lactation

Centre Code No.	Centre name	Total solids-1		Total solids-2		Total solids-3	
		TS_1M	TS_1E	TS_2M	TS_2E	TS_3M	TS_3E
3	Kanimangalam	11.59± 0.195	11.96± 0.241	11.47± 0.191	12.15± 0.261	11.97± 0.227	12.88± 0.257
5	Moorkanikkara	12.26± 0.208	12.69± 0.257	12.32± 0.204	13.07± 0.278	12.64± 0.242	13.16± 0.273
9	Karuvanoor	11.78± 0.160	12.19± 0.198	11.95± 0.157	12.62± 0.214	12.16± 0.186	13.07± 0.211
12	Parapoor	12.00± 0.152	12.41± 0.187	12.10± 0.149	12.81± 0.203	12.36± 0.176	13.22± 0.199
13	Ramavarmapuram	11.84± 0.232	12.66± 0.286	12.13± 0.227	13.08± 0.310	12.38± 0.269	13.16± 0.305
15	Arimbur	11.89± 0.201	12.70± 0.248	12.29± 0.197	13.35± 0.269	12.60± 0.233	13.51± 0.264
20	Livestock Research Station,Thiruvazhamkunnu	12.63± 0.207	13.38± 0.255	13.02± 0.203	13.45± 0.276	12.94± 0.241	13.73± 0.272
21	Cattle Breeding Farm Thumburmuzhi	12.03± 0.180	13.21± 0.223	12.13± 0.176	13.19± 0.241	12.24± 0.209	13.06± 0.237
22	University Livestock Farm, Mannuthy	12.81± 0.225	13.11 0.278	12.68± 0.221	13.28± 0.301	12.03± 0.262	13.54± 0.296

4.2.3 Solids not fat percentage

The SNF percentage for early, middle and late lactation ranged from 6.69 to 10.29 in the morning and 6.56 to 10.23 in the evening milk respectively. The overall averages for solids not fat percentages of milk for morning and evening were 8.568 ± 0.041 and 8.537 ± 0.040 for early lactation, 8.593 ± 0.061 and 8.524 ± 0.040 for middle lactation and 8.518 ± 0.048 and 8.502 ± 0.039 for late lactation. Centre wise means with standard error are given in Table 13. There had been no appreciable difference in SNF per cent between different stages of lactation (Fig.2). Raw season wise average for SNF per cent are given in Table 14.

Least square analysis for SNF percentage revealed that the effect of centre, sire and season were non-significant (Table 15).

The percentage of cows with SNF in milk below the PFA standard of 8.5 per cent are given in Fig. 4. 45.17 per cent and 46.73 per cent of morning and evening milk samples were below the prescribed standards. In the field 48.3 and 46.26 per cent and in the farm 41.89 and 43.24 per cent of morning and evening milk samples from early stage of lactation were below the legal standards (Table 16).

4.2.4 Fat yield, total solids yield and solid not fat yield

The overall averages were 72.146 ± 1.498 kg for fat yield, 224.213 ± 4.477 kg for total solids yield and 152.20 ± 3.069 kg for solids not

Table No. 13

CENTREWISE AND OVERALL AVERAGES OF SOLIDS NOT-FAT PERCENTAGE OF MILK AT DIFFERENT STAGES OF LACTATION

Centre Code No.	Name	EARLY LACTATION		MID LACTATION		LATE LACTATION	
		SNF1M	SNF1E	SNF2M	SNF2E	SNF3M	SNF3E
3	Kanimangalam	8.701 ± 0.145 (21)	8.594 ± 0.126 (21)	8.363 ± 0.156 (21)	8.225 ± 0.166 (21)	8.512 ± 0.144 (21)	8.439 ± 0.111 (21)
5	Moorkanikkara	8.53 ± 0.086 (20)	8.526 ± 0.123 (20)	8.591 ± 0.062 (20)	8.749 ± 0.099 (20)	8.685 ± 0.085 (19)	8.76 ± 0.102 (19)
9	Karuvannur	8.517 ± 0.117 (33)	8.418 ± 0.125 (33)	8.809 ± 0.319 (33)	8.383 ± 0.118 (33)	8.436 ± 0.100 (32)	8.365 ± 0.110 (32)
12	Parappur	8.552 ± 0.099 (39)	8.561 ± 0.102 (39)	8.441 ± 0.104 (40)	8.571 ± 0.093 (40)	8.481 ± 0.123 (37)	8.534 ± 0.094 (37)
13	R.V. Puram	8.517 ± 0.173 (14)	8.522 ± 0.124 (14)	8.479 ± 0.128 (14)	8.492 ± 0.092 (14)	8.357 ± 0.135 (13)	8.433 ± 0.106 (13)
15	Arimpur	8.25 ± 0.169 (19)	8.141 ± 0.126 (19)	8.285 ± 0.175 (19)	8.298 ± 0.173 (19)	8.616 ± 0.219 (19)	8.307 ± 0.106 (19)
20	L.R.S. Thiruvazhamkunnu	8.708 ± 0.099 (28)	8.641 ± 0.144 (28)	9.022 ± 0.111 (27)	8.794 ± 0.089 (27)	8.575 ± 0.041 (17)	8.407 ± 0.202 (17)
21	CBF Thumburmuzhi	8.537 ± 0.096 (27)	8.586 ± 0.07 (27)	8.482 ± 0.085 (27)	8.462 ± 0.062 (27)	8.396 ± 0.094 (25)	8.553 ± 0.070 (25)
22	ULF Mannuthy	8.763 ± 0.139 (20)	8.811 ± 0.130 (20)	8.728 ± 0.093 (20)	8.713 ± 0.138 (20)	8.704 ± 0.129 (17)	8.773 ± 0.084 (17)
20, 21, 22	Uni. Live-Stock Farm	8.661 ± 0.063 (75)	8.666 ± 0.061 (75)	8.745 ± 0.063 (74)	8.651 ± 0.057 (74)	8.536 ± 0.090 (59)	8.574 ± 0.072 (59)
3, 5, 9,12 13, 15	AI Centres	8.52 ± 0.053 (146)	8.47 ± 0.052 (146)	8.516 ± 0.086 (147)	8.461 ± 0.053 (147)	8.51 ± 0.057 (141)	8.472 ± 0.046 (141)
3, 5, 9, 12, 13, 15, 20, 21, 22	Overall	8.568 ± 0.041 (221)	8.537 ± 0.40 (221)	8.593 ± 0.061 (221)	8.524 ± 0.040 (221)	8.518 ± 0.048 (200)	8.502 ± 0.039 (200)

NUMBER IN PARENTHESIS DENOTES NUMBER OF OBSERVATIONS

Table No. 14

SEASON WISE AVERAGES OF SOLIDS NOT FAT PERCENTAGE OF MILK AT DIFFERENT STAGES OF LACTATION

SEASON	SNF1M	SNF1E	SNF2M	SNF2E	SNF3M	SNF3E
SUMMER	8.62 ± 0.081 (64)	8.589 ± 0.077 (64)	8.581 ± 0.061 (96)	8.579 ± 0.062 (96)	8.571 ± 0.052 (122)	8.547 ± 0.056 (122)
RAINY	8.521 ± 0.090 (51)	8.428 ± 0.078 (51)	8.662 ± 0.091 (46)	8.561 ± 0.080 (46)	8.739 ± 0.122 (27)	8.591 ± 0.109 (27)
WINTER	8.559 ± 0.056 (106)	8.558 ± 0.059 (106)	8.497 ± 0.070 (79)	8.472 ± 0.071 (79)	8.520 ± 0.102 (50)	8.463 ± 0.88 (50)

Number in paranthesis denotes number of observations

Table No. 15

LEAST - SQUARE ANALYSIS OF VARIANCE FOR SOLIDS NOT FAT PERCENTAGE OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	0.328588	0.878	0.6240
MU-YM	1	0.011468	0.031	0.8613
S	10	0.163787	0.438	0.9265
C	8	0.509606	1.361	0.2083
SEA	2	0.006023	0.016	0.9840
REMAINDER	177	0.374339		

MEAN = 8.57121 ERROR STANDARD DEVIATION = 0.61183 CV = 7.14

R SQUARED = 0.098 R = 0.314

Figure 4

PERCENTAGE OF COWS WITH SNF PERCENTAGE BELOW 8.5 AT DIFFERENT STAGES OF LACTATION

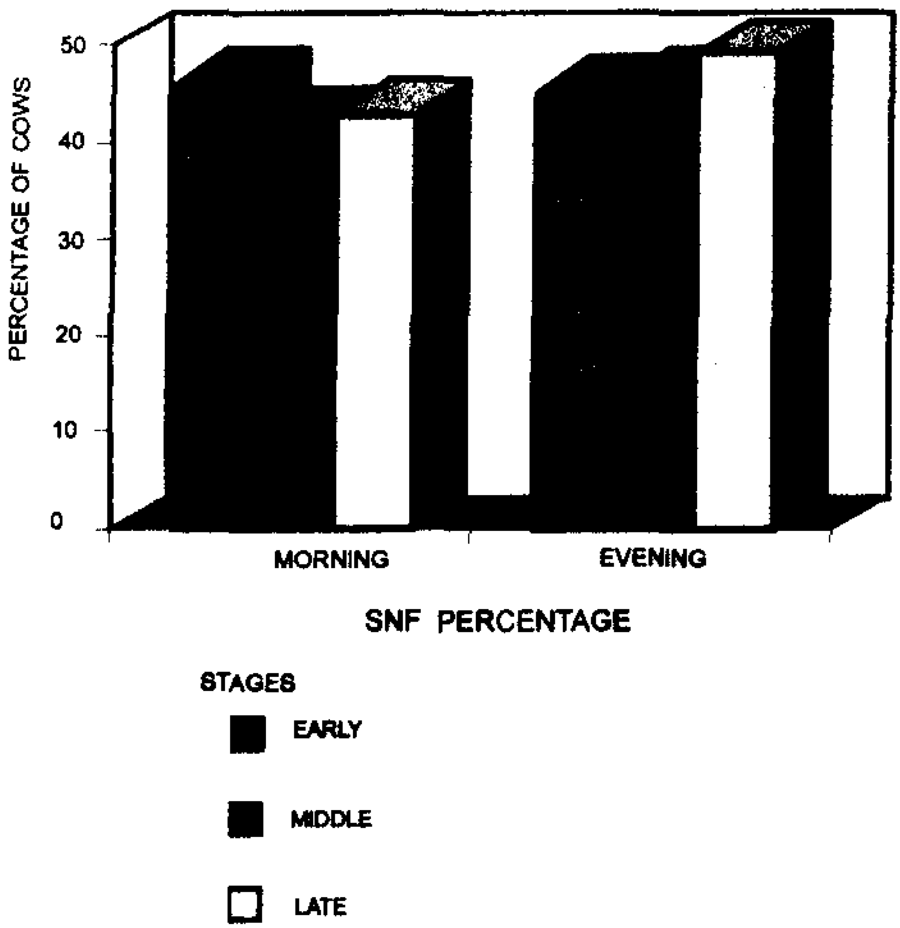

Table 16

Percentage of cows with solids not fat percentage below PFA standards in field and farm

	Early lactation		Middle lactation		Late lactation	
	No.	Percentage	No.	Percentage	No.	Percentage
Field						
Morning	71 (147)	48.30	70 (147)	47.62	70 (142)	49.29
Evening	68 (147)	46.26	69 (147)	46.94	76 (142)	53.52
Farm						
Morning	31 (74)	41.89	25 (74)	33.78	25 (58)	43.1
Evening	32 (74)	43.24	33 (74)	44.59	22 (58)	37.93

Number in parenthesis denotes the number of observations fat yield. Centre wise averages with standard error are given in Table 17. Ramavarmapuram recorded the highest fat, TS and SNF yield. But least square analysis revealed that the effect of sire, centre and season were non-significant (Table 18,19 and 20).

The significance of effects (sire, centre and season) on 305 day milk yield, fat, TS and SNF percentages and yields at different stages of lactation are given in Table 21.

4.3 Heritability

The heritability estimates with standard error for milk yield, fat, TS and SNF percentages and yields are given in Table 22. The heritability estimate for milk yield was 0.169 ± 0.2402, for fat percentage 0.326 ± 0.2342, for TS percentage 0.199 ± 0.2389, for SNF percentage 0.000. For fat yield the heritability was 0.114 ± 0.2428 for TS yield 0.113 ± 0.2429 and for SNF yield 0.157 ± 0.2407.

4.4 Sire evaluation

Evaluation of sires was done by three methods. Daughter's average, contemporary comparison and least square means. Ranking on the basis of 305 day milk yield is given in Table 23. The milk yield ranged from 1570.37±197.51 kg to 2302.37±157.51kg in daughter's average method, 1746 kg to 2002 kg in contemporary comparison and 1720±174.44 kg to 2237 1±206.66 kg in least squares.

Table 17

Centrewise and overall averages of fat yield (FY) total solids yield (TSY) and solids not fat yield (SNFY)

Code No.	Centre Name	Fat yield	TS yield	SNF yield
3	Kanimangalam	63.186 ± 4.988(21)	211.314 ± 14.739(21)	148.10 ± 9.938(21)
5	Moorkkanikkara	68.226 ± 5.392(20)	219.963 ± 16.388(20)	151.64 ± 11.08(20)
9	Karuvannur	71.528 ± 3.315(33)	226.286 ± 10.111(33)	155.45 ± 7.360(33)
12	Parappur	67.112 ± 2.680(39)	212.914 ± 8.084(39)	146.02 ± 5.597(39)
13	Ramavarmapuram	97.409 ± 4.779(14)	300.213 ± 11.745(14)	202.73 ± 7.407(14)
15	Arimbur	76.833 ± 4.139(19)	222.685 ± 12.393(19)	146.43 ± 8.694(19)
20	Livestock Research Station	68.467 ± 3.326(28)	202.253 ± 9.745(28)	133.67 ± 6.474(28)
21	Cattle Breeding Farm	81.490 ± 3.267(27)	246.097 ± 9.901(27)	164.56 ± 6.829(27)
22	University Livestock Farm	95.717 ± 5.395(20)	290.217 ± 17.392(20)	194.50 ± 12.168(20)
20, 21, 22	University Farms	81.070 ± 2.594(76)	244.297 ± 8.174(76)	163.15 ± 5.663(76)
3, 5, 9, 12, 13, 15	AI Centres	71.817 ± 1.802(146)	226.119 ± 5.268(146)	154.57 ± 3.611(146)
3, 5, 9, 12, 13, 15, 20, 21, 22	Overall	72.146 ± 1.498(222)	224.213 ± 4.477(222)	152.20 ± 3.069(222)

Table 18

LEAST - SQUARE ANALYSIS OF VARIANCE FOR FAT YIELD OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	370.709	1.104	0.3462
MU-YM	1	112.965	0.336	0.5626
S	10	424.333	1.264	0.2542
C	8	472.290	1.407	0.1876
SEA	2	47.761	0.142	0.8675
REMAINDER	177	335.760		

MEAN = 72.92884 ERROR STANDARD DEVIATION = 18.32378 CV =25.13

R SQUARED = 0.121 R = 0.347

Table 19

LEAST - SQUARE ANALYSIS OF VARIANCE FOR TOTAL SOLID YIELD OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	4434.987	1.133	0.3161
MU-YM	1	2531.392	0.647	0.4223
S	10	5015.132	1.281	0.2441
C	8	5418.457	1.384	0.1976
SEA	2	544.839	0.139	0.8702
REMAINDER	177	3914.289		

MEAN = 231.504 ERROR STANDARD DEVIATION = 62.562 CV =27.03

R SQUARED = 0.123 R = 0.351

Table 20

LEAST - SQUARES ANALYSIS OF VARIANCE FOR SOLIDS NOT FAT YIELD OF MILK

SOURCE	D.F.	MEAN SQUARES	F	PROB
TOTAL	199			
TOTAL REDUCTION	22	1755.616	1.047	0.4102
MU-YM	1	993.93	0.593	0.4424
S	10	2095.96	1.250	0.2625
C	8	1728.32	1.031	0.4176
SEA	2	711.13	0.424	0.6550
REMAINDER	177	1676.91		

MEAN = 158.82 ERROR STANDARD DEVIATION = 40.95 CV = 25.78

R SQUARED = 0.115 R = 0.339

Table 21

SIGNIFICANCE OF THE EFFECTS (SIRE, CENTRE AND SEASON) ON MILK PRODUCTION TRAITS

TRAIT	SOURCE		
	SIRE	CENTRE	SEASON
305 DAY MY	NS	**	NS
F1M	NS	**	NS
F1E	*	**	NS
TS1M	NS	**	NS
TS1E	NS	**	NS
SNF1M	NS	NS	NS
SNF1E	NS	NS	NS
F2M	NS	**	NS
F2E	NS	**	NS
TS2M	NS	**	NS
TS2E	NS	**	NS
SNF2M	NS	*	NS
SNF2E	NS	*	NS
F3M	NS	**	NS
F3E	NS	**	NS
TS3M	NS	**	NS
TS3E	NS	NS	NS
SNF3M	NS	NS	NS
SNF3E	NS	NS	NS
FY	NS	NS	NS
TSY	NS	NS	NS
SNFY	NS	NS	NS

NS - Non-significant

* - Significant at 5% level

** - Significant at 1% level

Table 22

Heritability estimates for milk production and composition

Trait	Heritability estimates
305 day milk yield	0.169±0.240
Fat percentage*	0.326±0.234
Total solids percentage*	0.119±0.238
Solids not fat percentage*	0.000
Fat yield✣	0.114±0.242
Total solids yields✣	0.113±0.242
Solids not fat yield✣	0.157±0.240

* Early lactation morning milk
✣ Milk fat, SNF and TS yield on 305 day basis

Table 23

Evaluation of sires on the basis of 305 day milk yield by daughter's average, contemporary comparison and least square means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	1784.27^{VII} ± 149.4	1777^{IX}	1746.3^{VIII} ± 149.01
2	Dany	17	1886.94^{V} ± 121.059	1880^{V}	1966.3^{V} ± 123.71
3	Dara	6	2147.33^{II} ± 249.796	1946^{III}	2237.1^{I} ± 206.66
4	Dayal	10	1945.7^{IV} ± 166.04	1911^{IV}	2076.6^{III} ± 178.22
5	Dilbaugh	9	1741.55^{VIII} ± 175.11	1795^{VII}	1858.6^{VII} ± 177.16
6	Gopal	11	2302.37^{I} ± 157.51	2002^{I}	2195.8^{II} ± 168.01
7	Gorakh	8	1570.37^{X} ± 197.51	1786^{VIII}	1724.1^{IX} ± 180.75
8	Hemanth	7	2092.42^{III} ± 290.22	1857^{VI}	1903.4^{VI} ± 224.85
9	Horror	16	1874.25^{VI} ± 150.06	1948^{II}	2059.9^{IV} ± 132.51
10	Ideal	8	1605.62^{IX} ± 87.78	1746^{X}	1720^{X} ± 174.44

Superscripts indicate the ranks

Ranking on the basis of milk fat percentage given in Table 24. The fat percentage ranged from 2.9±0.115 to 3.775±0.207 in daughter's average method, 3.0 to 3.7 in contemporary comparison and 2.92±0.199 to 3.9±0.203 in least squares. Sirewise least squares means of fat percentages at different stages of lactation given in Table 25.

Ranking on the basis of total solids percentage of milk given in Table 26. The total solids percentage ranged from 11.02±0.242 to 12.26±0.224 in daughter's average method, 11.476 to 12.214 in contemporary comparison 11.22±0.296 to 12.43±0.302 in least squares. Sirewise least squares means of total solids percentage at different stages of lactation given in Table 27.

Ranking on the basis of solids not fat percentage of milk given in Table 28. The solids not fat percentage ranged from 8.125±0.175 to 8.743±0.165 in daughter's average methods, 8.432 to 8.605 in contemporary comparison and 8.19±0.243 to 8.94±0.308 in least squares. Sirewise least squares means of solids not fat at different stages of lactation given in Table 29.

Ranking on the basis of fat yield of milk given in Table 30. The fat yield ranged from 60.512±7.777 kg to 89.14±5.358 kg in daughter's average method, 67.30 kg to 74.79 kg in contemporary comparison and 53.99±8.47 to 86.54±7.41 kg in least squares.

Table 24

Evaluation of sires on the basis of milk fat percentage by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	3.554^{IV} ± 0.134	3.4^{V}	3.39^{VII} ± 0.168
2	Dany	17	3.512^{VI} ± 0.102	3.6^{II}	3.55^{III} ± 0.139
3	Dara	6	3.316^{VIII} ± 0.127	3.3^{VIII}	3.18^{IX} ± 0.232
4	Dayal	10	3.6^{III} ± 0.269	3.4^{IV}	3.63^{II} ± 0.201
5	Dilbaugh	9	2.9^{X} ± 0.115	3.0^{X}	2.92^{X} ± 0.199
6	Gopal	11	3.545^{V} ± 0.123	3.4^{VI}	3.47^{V} ± 0.189
7	Gorakh	8	3.775^{I} ± 0.107	3.7^{I}	3.90^{I} ± 0.203
8	Hemanth	7	3.242^{IX} ± 0.124	3.3^{IX}	3.44^{VI} ± 0.253
9	Horror	16	3.468^{VII} ± 0.127	3.4^{VII}	3.31^{VIII} ± 0.149
10	Ideal	8	3.725^{II} ± 0.193	3.5^{III}	3.50^{IV} ± 0.196

Superscripts indicate the ranks

Table 25

SIREWISE LEAST SQUARE MEANS OF FAT PERCENTAGES OF MILK AT DIFFERENT STAGES OF LACTATION

Sire Code No.	Sire Name	FAT - 1		FAT - 2		FAT - 3	
		F1M	F1E	F2M	F2E	F3M	F3E
1.	ADMIRAL	3.39 ± 0.168	4.08 ± 0.235	3.54 ± 0.151	4.05 ± 0.247	3.80 ± 0.183	4.66 ± 0.268
2.	DANY	3.55 ± 0.139	4.23 ± 0.194	3.76 ± 0.125	4.45 ± 0.204	3.93 ± 0.151	4.79 ± 0.222
3.	DARA	3.18 ± 0.232	4.01 ± 0.325	3.49 ± 0.209	4.48 ± 0.253	3.84 ± 0.253	4.64 ± 0.371
4.	DAYAL	3.63 ± 0.201	4.48 ± 0.280	3.35 ± 0.181	4.03 ± 0.294	3.47 ± 0.218	4.11 ± 0.320
5.	DILBAUGH	2.92 ± 0.199	3.40 ± 0.278	3.62 ± 0.179	4.87 ± 0.292	3.76 ± 0.217	4.63 ± 0.318
6.	GOPAL	3.47 ± 0.189	4.09 ± 0.264	3.40 ± 0.170	3.97 ± 0.277	3.83 ± 0.206	4.57 ± 0.301
7.	GORAKH	3.90 ± 0.203	4.76 ± 0.284	4.08 ±0.183	4.99 ± 0.298	4.43 ± 0.221	4.99 ± 0.324
8.	HEMANTH	3.44 ± 0.253	3.71 ± 0.352	3.61 ± 0.228	4.27 ± 0.371	4.04 ± 0.276	4.76 ± 0.404
9.	HORROR	3.31 ± 0.149	4.22 ± 0.208	3.68 ± 0.134	4.58 ± 0.219	3.89 ± 0.162	4.59 ± 0.238
10.	IDEAL	3.50 ± 0.196	3.93 ± 0.274	3.50 ± 0.177	4.10 ± 0.288	4.06 ± 0.213	4.90 ± 0.313

Table 26

Evaluation of sires on the baisis of total solids percentage of milk by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	12.04^{VII} ± 0.258	12.062^{VII}	12.00^{VII} ± 0.250
2	Dany	17	12.09^{V} ± 0.175	12.214^{I}	12.13^{IV} ± 0.207
3	Dara	6	12.06^{VI} ± 0.223	12.036^{VIII}	11.79^{IX} ± 0.345
4	Dayal	10	11.93^{IX} ± 0.222	11.926^{IX}	12.14^{III} ± 0.298
5	Dilbaugh	9	11.02^{X} ± 0.242	11.476^{X}	11.22^{X} ± 0.296
6	Gopal	11	12.17^{IV} ± 0.201	12.089^{VI}	12.04^{VI} ± 0.281
7	Gorakh	8	12.17^{II} 0.239	12.148^{III}	12.43^{I} ± 0.302
8	Hemanth	7	12.02^{VIII} ± 0.278	12.162^{II}	12.39^{II} ± 0.376
9	Horror	16	12.17^{III} ± 0.202	12.120^{IV}	11.93^{VIII} ± 0.221
10	Ideal	8	12.26^{I} ± 0.224	12.105^{V}	12.10^{V} ± 0.291

Superscripts indicate the ranks

Table 27

SIREWISE LEAST SQUARE MEANS OF TOTAL SOLIDS PERCENTAGES OF MILK AT DIFFERENT STAGES OF LACTATION

Sire Code No.	Sire Name	TS - 1		TS - 2		TS - 3	
		TS1M	TS1E	TS2M	TS2E	TS3M	TS3E
1.	ADMIRAL	12.00 ± 0.250	12.58 ± 0.308	12.17 ± 0.245	12.46 ± 0.334	12.13 ± 0.291	13.19 ± 0.329
2.	DANY	12.13 ± 0.207	12.82 ± 0.269	12.18 ± 0.203	13.05 ± 0.276	12.42 ± 0.240	13.43 ± 0.272
3.	DARA	11.79 ± 0.345	12.62 ± 0.425	11.92 ± 0.339	13.31 ± 0.461	12.40 ± 0.402	13.25 ± 0.454
4.	DAYAL	12.14 ± 0.298	12.93 ± 0.368	11.63 ± 0.292	12.20 ± 0.398	11.66 ± 0.346	12.29 ± 0.391
5.	DILBAUGH	11.22 ± 0.296	11.88 ± 0.366	11.82 ± 0.290	13.31 ± 0.395	12.01 ± 0.344	12.90 ± 0.389
6.	GOPAL	12.04 ± 0.281	12.66 ± 0.347	11.89 ± 0.275	12.71 ± 0.375	12.59 ± 0.326	13.40 ± 0.369
7.	GORAKH	12.43 ± 0.302	12.89 ± 0.373	12.76 ± 0.296	13.45 ± 0.404	13.18 ± 0.351	13.55 ± 0.397
8.	HEMANTH	12.39 ± 0.376	12.72 ± 0.464	12.62 ± 0.368	12.83 ± 0.502	12.96 ± 0.437	13.23 ± 0.494
9.	HORROR	11.93 ± 0.221	12.50 ± 0.273	12.40 ± 0.217	13.21 ± 0.296	12.52 ± 0.258	13.23 ± 0.291
10.	IDEAL	12.10 ± 0.291	12.44 ± 0.360	12.16 ± 0.286	12.72 ± 0.389	12.24 ± 0.339	13.25 ± 0.383

Table 28

Evaluation of sires on the basis of solid not fat percentage of milk by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	8.486^{VII} ± 0.202	8.59^{II}	8.62^{II} ± 0.205
2	Dany	17	8.556^{V} ± 0.163	8.468^{IX}	8.55^{VI} ± 0.169
3	Dara	6	8.743^{I} ± 0.165	8.605^{I}	8.60^{III} ± 0.283
4	Dayal	10	8.335^{IX} ± 0.226	8.506^{VIII}	8.50^{IX} ± 0.244
5	Dilbaugh	9	8.125^{X} ± 0.175	8.432^{X}	8.19^{X} ± 0.243
6	Gopal	11	8.624^{IV} ± 0.112	8.585^{V}	8.58^{V} ± 0.230
7	Gorakh	8	8.401^{VIII} ± 0.217	8.524^{VII}	8.51^{VII} ± 0.247
8	Hemanth	7	8.634^{III} ± 0.253	8.589^{III}	8.94^{I} ± 0.308
9	Horror	16	8.641^{II} ± 0.117	8.588^{IV}	8.50^{VIII} ± 0.181
10	Ideal	8	8.541^{VI} ± 0.155	8.562^{VI}	8.59^{IV} ± 0.239

Superscripts indicate the ranks

Table 29

SIREWISE LEAST SQUARE MEANS OF SOLIDS NOT FAT PERCENTAGES OF MILK AT DIFFERENT STAGES OF LACTATION

Sire Code No.	Sire Name	SNF - 1		SNF - 2		SNF - 3	
		SNF1M	SNF1E	SNF2M	SNF2E	SNF3M	SNF3E
1.	ADMIRAL	8.62 ± 0.205	8.48 ± 0.199	8.61 ± 0.198	8.41 ± 0.202	8.52 ± 0.214	8.54 ± 0.183
2.	DANY	8.55 ± 0.169	8.61 ± 0.165	8.40 ± 0. 640	8.59 ± 0.167	8.49 ± 0.177	8.64 ± 0.151
3.	DARA	8.60 ± 0.283	8.58 ± 0.276	8.42 ± 0.274	8.81 ± 0.279	8.53 ± 0.295	8.61 ± 0.252
4.	DAYAL	8.50 ± 0.244	8.44 ± 0.238	8.12 ± 0.236	8.16 ± 0.241	8.16 ± 0.255	8.16 ± 0.217
5.	DILBAUGH	8.19 ± 0.243	8.63 ± 0.236	8.19 ± 0.235	8.56 ± 0.239	8.21 ± 0.253	8.27 ± 0.216
6.	GOPAL	8.58 ± 0.230	8.57 ± 0.224	8.48 ± 0.223	8.74 ± 0.227	8.72 ± 0.240	8.83 ± 0.205
7.	GORAKH	8.51 ± 0.247	8.15 ± 0.241	8.59 ± 0.239	8.46 ± 0.244	8.79 ± 0.258	8.55 ± 0.221
8.	HEMANTH	8.94 ± 0.308	9.03 ± 0.300	8.98 ± 0.298	8.51 ± 0.304	8.93 ± 0.321	8.46 ± 0.275
9.	HORROR	8.50 ± 0.181	8.30 ± 0.176	8.71 ± 0.176	8.61 ± 0.179	8.58 ± 0.189	8.64 ± 0.162
10.	IDEAL	8.59 ± 0.239	8.53 ± 0.233	8.65 ± 0.231	8.63 ± 0.236	8.19 ± 0.249	8.34 ± 0.213

Table 30

Evaluation of sires on the baisis of milk fat yield by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	73.93^{VII} ± 5.247	69.44^{VIII}	75.46^{IV} ± 6.13
2	Dany	17	80.25^{V} ± 4.867	74.32^{II}	78.07^{II} ± 5.07
3	Dara	6	86.64^{II} ± 9.431	73.41^{III}	53.99^{X} ± 8.47
4	Dayal	10	80.58^{IV} ± 8.939	70.48^{VI}	67.97^{VIII} ± 7.31
5	Dilbaugh	9	67.21^{VIII} ± 8.406	67.30^{X}	73.03^{V} ± 7.26
6	Gopal	11	89.14^{I} ± 5.358	71.83^{IV}	77.22^{III} ± 6.89
7	Gorakh	8	60.512^{X} ± 7.777	71.24^{V}	86.54^{I} ± 9.41
8	Hemanth	7	80.85^{III} ± 5.978	69.65^{VII}	64.25^{IX} ± 9.22
9	Horror	16	75.637^{VI} ± 7.305	74.79^{I}	70.82^{VII} ± 5.43
10	Ideal	8	64.75^{IX} ± 4.211	68.52^{IX}	71.37^{VI} ± 7.15

Superscripts indicate the ranks

Ranking of sires on the basis of total solids yield of milk given in Table 31. The total solids yield ranged from 205.074±26.69 kg to 283.78±19.323 kg in daughter's average and 211.9 kg to 231.9 kg in contemporary comparison and 275.62±25.3 kg to 169.28±28.93 kg in least squares.

Ranking on the basis of solids not fat yield of milk given in Table 32. The solids not fat yield ranged from 134.28±19.081 kg to 194.51±14.78 kg in daughter's average method, 142.71 kg to 159.20 kg in contemporary comparison and 121.02±18.94 kg to 189.39±16.56 kg in least squares.

Table 31

Evaluation of sires on the baisis of total solids yield of milk by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	223.62^{VII} ± 17.08	217.6^{VIII}	231.38^{V} ± 20.95
2	Dany	17	249.705^{V} ± 13.479	227.6^{IV}	253.96^{II} ± 17.32
3	Dara	6	278.10^{II} ± 32.948	230.7^{II}	169.28^{X} ± 28.93
4	Dayal	10	249.74^{IV} ± 26.419	220.2^{V}	209.06^{VIII} ± 24.95
5	Dilbaugh	9	218.46^{VIII} ± 25.106	211.9^{X}	231.48^{IV} ± 24.80
6	Gopal	11	283.78^{I} ± 19.323	228.7^{III}	246.52^{III} ± 23.52
7	Gorakh	8	205.074^{X} ± 26.69	219.0^{VII}	275.62^{I} ± 25.3
8	Hemanth	7	260.82^{III} ± 17.70	219.8^{VI}	206.12^{IX} ± 31.48
9	Horror	16	237.27^{VI} ± 21.434	231.9^{I}	225.26^{VI} ± 18.55
10	Ideal	8	206.05^{IX} ± 13.661	213.9^{IX}	211.53^{VII} ± 24.42

Superscripts indicate the ranks

Table 32

Evaluation of sires on the baisis of solids not fat yield of milk by daughter's average, contemporary comparison and least squares means

Sire No.	Name	No. of daughters	DA	CC	LSM
1	Admiral	11	152.62^{VII} ± 12.14	147.71^{VII}	159.51^{V} + 13.71
2	Dany	17	168.95^{V} ± 9.155	153.78^{IV}	171.77^{II} ± 11.33
3	Dara	6	191.46^{II} ± 23.58	159.20^{I}	121.02^{X} ± 18.94
4	Dayal	10	169.14^{IV} ± 18.06	149.12^{VI}	140.75^{IX} ± 16.33
5	Dilbaugh	9	151.87^{VIII} ± 17.014	142.71^{X}	160.27^{IV} ± 16.23
6	Gopal	11	194.51^{I} + 14.78	158.36^{II}	168.18^{III} ± 15.40
7	Gorakh	8	134.29^{X} ± 19.081	146.38^{VIII}	189.39^{I} ± 16.56
8	Hemanth	7	180.31^{III} ± 11.979	149.42^{V}	143.44^{VII} ± 20.60
9	Horror	16	161.23^{VI} ± 14.271	158.22^{III}	155.92^{VI} ± 12.14
10	Ideal	8	139.30^{IX} ± 10.211	143.49^{IX}	142.24^{VIII} ± 15.98

Superscripts indicate the ranks

Discussion

DISCUSSION

5.1 Milk yield

Overall average for 305 day milk yield was 1829.7±34.128 kg from six Artificial Insemination centres and three University farms (Table 2). Among the AI centres, Ramavarmapuram recorded the maximum 305 day yield of 2425.71±92.103 kg. The closeness to Thrissur town offers Ramavarmapuram better marketing facilities for milk which in turn forms a probable reason for higher milk production in the area. There is a tendency to procure better animals in this area and the animals are generally managed better. The animals in Ramavarmapuram produced more than animals in other centres under the Field Progeny Testing (FPT) Scheme (Iype *et al.* 1993). The progenies from bulls under FPT Scheme exhibited still higher milk yield and this indicates the superiority of bulls under evaluation. When compared to the average reported from Ramavarmapuram previously by Iype *et al.* (1993), there is a remarkable improvement for the average 305 day milk yield obtained from the present study. But the average for all animals considered in this study, are from progenies of the superior test bulls only.

University Livestock Farm, Mannuthy (ULF) had the next best average of 2234.0±126.565 kg. But when the progenies of the test sires were considered separately, ULF had the highest average (2800 kg). This farm already had animals with good genetic potential and the daughters born out of these dams and sires under good managemental conditions, showed high level of milk production, thus proving the superiority of the sires. These daughters are expected to perform better in subsequent lactations and there will not be any difficulty for an average over 3000 kg. Cattle

Breeding Farm, Thumburmuzhi also exhibited superiority for the progenies from test bulls compared to their contemporaries considered. At Livestock Research Station, Thiruvazhamkunnu, the basic stock and the progenies from test bulls performed the least (Table 2). But Thiruvazhamkunnu farm being endemic for tuberculosis, the calves were probably more affected than the others, resulting in poor performance in the first lactation. At Livestock Research Station, Thiruvazhamkunnu, the average 305 day milk yield was 1521.57±84.877 kg. More than 50 per cent of the progenies at the Livestock Research Station produced less than 1500 kg and four animals produced less than 1000 kg, which was not probable under normal conditions.

Among the centres Parappur recorded the minimum with 1682.1±63.058 kg Parappur being an agriculture oriented area, apart from milk production, manure is also an important requirement to the farmer. Generally, the stress for high milk production is not relatively great as in centres near the town. Good milch animals are being sold out to other centres at high price. Kanimangalam, Arimbur and Moorkanikkara have more or less the same average of around 1750 kg.

Least squares analysis of variance for 305 day milk yield (Table 3) revealed that the centres had a significant effect on milk yield. These results concur with the findings of Chacko *et al.* (1984) and Thomas *et al.* (1987) who conducted the study at Mavelikkara and Kattapana and also with the report of Iype *et al.* (1993) who conducted the study in farmers herds at Thrissur area which included the six AI centres in this study. Significant farm differences were reported by Jadhav *et al.* (1991) and Rahumathulla (1992). Least square analysis revealed that season had no significant effect on 305 day milk yield and this result agreed with the reports of Nair (1976), Subramanian (1984) and Stephen *et al.* (1985). But disagreed with that of Singh and Pandey (1970) and Vij and Basu (1986). Disagreement was with the North Indian studies and the reason may be that the seasons are not very clearcut in Kerala, like in other places. Green grass is scarcely available in summer months, but farmers make a compensatory concentrate feeding.

When the overall average of progenies and contemporaries in the field were compared, progenies performed better with an yield of 1905.7 kg and contemporaries had an yield of 1725.3 kg (Fig.2). The apparent superiority of 180 kg for the progenies, is to be considered as an underestimated superiority because progenies were in first lactation while contemporaries were in different parities. The real differences would be much higher than this when subsequent lactations of these daughters are also considered, when available.

5.2. Milk composition

5.2.1 Milk fat percentage

Centrewise and overall milk fat percentages and given in Table 4. University Livestock Farms have comparatively higher averages for fat percentage. Livestock Research Station, Thiruvazhamkunnu, recorded maximum fat percentage during all three stages of lactation and this could be due to less amount of milk produced by the animals. But Kanimangalam with a lower 305 day milk yield had least fat percentage during all three stages of lactation. Among the AI Centres, Arimbur is the only centre with morning milk fat per cent well above the PFA standards during early stage of lactation. During other stages also Arimbur topped the list for morning and evening fat percentages. This could be probably due to high quantity of roughage available to animals in this area.

Least squares analysis revealed that the effect of centre on milk fat percentage was highly significant (Table 6). Centrewise least squares means given in Table 7.

In the present study as the daily milk yield decreased constantly from early to late lactation there was a simultaneous increase in fat percentage (Table 4). It was noted from the literature that the amount of milk rather than the fat percentage is the greater variable (Espe and Smith, 1952). As the amount of milk secreted increases, the energy available for fat secretion decreases and this probably results in milk of lower fat percentage.

Fat per cent of milk increased uniformly as the lactation advanced as can be clearly seen from Fig.2. These findings concur with the results of Singh *et al.* (1961); Ghosh and Ananthakrishnan (1964); Prasad and Subramanyan (1986); Iype *et al.* (1994) and Venkatachalapathy and Iype (1997). The evening milk fat percentage is uniformly higher during all stages of lactation than morning milk fat percentage. This was also in agreement with the reports made by Prasad and Subramanyan (1986); Iype *et al.* (1994) and Venkatachalapathy and Iype (1997). The higher milk fat in evening milk may be due to the difference between milking intervals. The larger the interval, the greater the quantity of milk and lower the fat test.

Seasonwise averages given in Table 5. No definite trend was visible. Least squares analysis (Table 6) revealed that season has no significant effect on fat percentage of milk.

On analysing the number of cows with fat percentage below the PFA standards, it was seen that 53.8 per cent of morning milk samples in early lactation were below 3.5 per cent, the minimum standards as per PFA act (Fig.3). Considering the field milk samples alone (Table 8), it was seen that 66.67 per cent of morning milk samples in the early stage of lactation recorded a fat percentage below the legal standards. This result was in agreement with the reports of Iype *et al.* (1994). On considering the morning milk samples of farm animals in early stage of lactation, 28.38 per cent of cows produced milk with less than 3.5 per cent fat. Prasad and Subramanyan (1986) reported that a total of 4.85 per cent of samples from Jersey crosses and 7.4 per cent samples from Brown Swiss crosses, irrespective of stage of lactation were below legal standards under farm conditions.

The more number of cows with low fat percentage in the field, may due to two reasons. One reason could be the availability of sufficient roughage under farm condition and inadequacy of roughage under field condition. The areas with more roughage in the field (Moorkkanikkara and Arimbur) recorded higher percentage of milk fat. The second reason could be the absence of weaning practice under field conditions.

In milk societies the pricing of milk is based on percentage of fat and SNF and the farmers had a common complaint that they were getting less money for milk because of lower milk fat and SNF. Also they had to face the allegation of adulterating the milk. The PFA standard of 3.5 per cent was fixed for Indian cattle which were not intensely managed. With substantial differences in the genetic structure of crossbred cattle population and in the managemental practices, a lowering of the fat percentage has been observed. This situation pinpoints to the need to lower the minimum percentage milk fat stipulated in the PFA Act.

Detailed studies are required to assess the effects of different managemental factors like quantity of roughage fed and practice of weaning to analyse their effects, if any on milk fat percentage.

5.2.2 Total solid percentage

The centrewise and overall averages of total solid percentage given in Table 9. Total solids percentage was higher for Livestock Research Station, Thiruvazhamkunnu and University Livestock Farm, Mannuthy. It was lowest for Kanimangalam. The higher amount of total solids percentage at Livestock Research Station, Thiruvazhamkunnu may be explained by the lesser amount of milk secreted. Converse is true for Kanimangalam and University Livestock Farm, Mannuthy.

As the daily milk yield decreased constantly from early to late lactation, there was a simultaneous increase in total solids percentage. The total solids thus showed an increasing trend with progress of lactation (Fig.2). These findings were in close agreement with the reports made by Singh *et al.* (1961); Ghosh and Anantakrishnan (1964) and Venkatachalapathy and Iype (1997). The total solids in the evening milk was higher than that of morning milk. The higher milk fat percentage in evening milk led to higher total solids also in evening milk.

Seasonwise averages of total solids percentage (Table 10) revealed no definite trend. Least squares analysis of variance (Table 11) showed that the effect of centre was highly significant and that of season was non-significant. Centrewise least squares means of total solids percentage of milk given in Table 12.

5.2.3 Solids not fat percentage

Centrewise and overall averages of solids not fat percentage given in Table 13. Among the centres, Livestock Research Station, Thiruvazhamkunnu and University Livestock Farm, Mannuthy, reported high SNF percentage when compared to other centres. Arimbur recorded low SNF for morning and evening milk samples in all stages of lactation. Unlike fat and total solid percentages, solids not fat percentage did not exhibit much variation with the progress of lactation (Fig.2). This result was in close agreement with the findings made earlier by Ghosh and Anantakrishan (1964) and Venkatachalapathy and Iype (1997). But this was in disagreement with the reports of Wilcox *et al.* (1959) and Singh *et al.* (1961).

The seasonwise averages are given in Table 14. No definite trend was visible. Least squares analysis of variance (Table 15) revealed that the effect of centre and season were non-significant. The non-significant effect of season was in disagreement with the findings of Wilcox *et al.* (1959).

In case of SNF irrespective of stage of lactation and time of milking almost half the animals produced milk below the FA minimum (Fig.4 and Table 16). This alarming low level of SNF is to be viewed with the deserving seriousness. The situation calls for an immediate action for modifying the PFA Act. The factors leading to the situation are to be thoroughly investigated and remedial measures taken.

Unlike fat percentage, where the problem was more or less oriented towards the morning milk samples of early stage of lactation, here almost all the stages are equally affected. Though reports were available about the low milk fat percentage of crossbred cows under field conditions of Kerala, scientific information was seriously lacking about the SNF percentage under field conditions. MRCMPU (1995) reported that 73.8 per cent samples were below the prescribed standards. But here the SNF percentage was calculated on the basis of lactometer reading and evening milk samples alone were considered for the study. Prasad and Subramanyan (1986) reported that 1.55 and 8.52 per cent for Jersey and Brown Swiss crossbred respectively, produced milk with SNF percentage below the legal standards, under farm conditions.

5.2.4 Fat yield, total solids yield and solids not fat yield

Centrewise and overall averages for fat yield, total solids yield and solids not fat yield given in Table 17. Ramavarmapuram recorded the maximum for all the yield traits (97.409±4.77 kg, 300.213±11.75 kg and 202.73±7.41 kg respectively). In spite of the fact that Ramavarmapuram recorded a low percentage of milk fat, this centre topped the list for fat yield, because the 305 day yield was maximum for the centre as can be seen from Table 2.

The least squares analysis of variance (Table 18, 19 and 20) revealed that the effect of sire, centre and season were not significant. Considering the effects of sire, centre and season on 305 day milk yield, morning and evening percentages of fat, total solids and solids not fat at early, middle and later stages of lactation and also the fat, total solids and solids not fat yields (Table 21) revealed that the effect of centre was highly significant for almost all the traits, except total solids percentage of evening milk of late lactation (TS_3E), solids not fat percentages at early and later stages of lactation (SNF_1M, SNF_1E, SNF_3M and SNF_3E) and also for fat, total solids and solids not fat yields (FY, TSY, SNFY). Season exerted a non-significant effect on all the traits, irrespective of stage of lactation and time of milking.

5.3 Heritability

The heritability estimates (Table 22) for 305 day milk yield and its composition ranged from 0.000 to 0.326. Rahumathulla (1992) reported a range of 0.17 to 0.53 for milk yield and milk production efficiency traits.

The estimates of heritability reported by foreign workers (Johnson, 1957 and Wilcox, 1966) were higher than the ones reported in India (Amble *et al.*, 1967, Sharma, 1970 and Chauhan *et al.* 1987). The heritability obtained from the present study concur with the Indian reports. The different make up of foreign breeds, large data and greater environmental uniformity to which the animals are exposed might be the possible explanation for this deviation. The heritability estimate for 305 day milk yield was 0.169 ± 0.240. The heritability estimates for fat, total solids and solids not fat percentages calculated for early lactation, morning milk was 0.326 ± 0.234, 0.119 ± 0.238 and 0.000 respectively. The heritability calculated for solids not fat percentage gives a negative estimate, which was considered as zero ie., the genetic variation of the trait (SNF%) is practically nil. The heritability estimates for fat yield, total solids yield and solids not fat yield were 0.114 ± 0.242, 0.113 ± 0.242 and 0.157 ± 0.240 respectively. This result was comparable to the reports of Maijala and Hanna (1974) and Agyemang *et al.* (1985).

Among the milk constituents, milk fat percentage appears to be a highly heritable trait with a heritability estimate of 0.326 ± 0.234.

5.4 Sire evaluation

The estimates of sire merit of different bulls for first lactation 305 milk yield computed by three methods of sire evaluation viz., Daughters' average, Contemporary comparison and Least squares means are given in Table 23. The range of sire merit values was smaller for Contemporary comparison because of multiplication of the deviation with low weightage factor. $\frac{1}{2}h^2$ was only 0.085. Sire were ranked on the basis of sire merit as obtained from the three methods. Ranks are also given in the Table. Sire No.6, Gopal was ranked first by Daughters' average and Contemporary comparison and was ranked second by Least squares means. Sire No.3, Dara which got first rank for Least squares mean, was ranked second and third respectively for Daughters' average and Contemporary comparison. There were small changes in the ranking of sires by different methods. But the sires 2, 3, 4, 6, 8 and 9 became the best six, although ranking changed in different methods. Sire No.10, Ideal was ranked tenth by Contemporary comparison and Least squares means, whereas Daughters' average method ranked Ideal as ninth. Sire No.7, Gorakh was ranked eighth, ninth and tenth by Contemporary comparison, Least squares means and Daughters' average respectively.

The sires to be evaluated had dam's average of 305 day milk yield as 4886.1 kg (Annual Progress Report, Field Progeny Testing Scheme, Mannuthy 1994-95). From Fig.1, it is clear that the progenies, though in first lactation, performed better than the contemporaries from all parities. Comparison between the progenies and contemporaries showed significant superiority for the progeny. The overall first lactation average for 305 day milk yield of the progeny under field conditions was 1 06.7 kg and contemporaries in different parities had a 305 day milk yield of 1725.3 kg only (Fig.1). The apparent superiority of 180 kg for the progenies is to be considered as an underestimated superiority, because the progenies were in first lactation and the contemporaries were in different parities. A further study with larger number of observations on milk yield of cows in different parities is called for, to prove this superiority.

Table 24 gives the ranking of bulls on the basis of fat percentage. Since the traits in early stage of lactation showed relatively higher heritability, morning fat percentage of early lactation was taken for the purpose of ranking bulls. The fat percentage ranged from 2.90 to 3.90 in different methods. Sire No.7, Gorakh was ranked first by all the three methods. Sire No.10 Ideal was ranked second by Daughters' average, while Sire No.2, Dany was ranked second in Contemporary comparison and Sire No.4, Dayal ranked second in Least squares means. It may be noted that these sires had lower ranks for 305 day milk yield (Table 23). Sire No.5, Dilbaugh was ranked last by all three methods. The sirewise Least squares means of fat percentages for morning and evening milk at different stages of lactation given in Table 25. The sirewise means of fat percentage at different stages of lactation and the ranking of sires, bring out the necessity for sire evaluation based on either an average for the lactation period or on the basis of fat yield.

Table 26 gives the evaluation of sires on the basis of total solids percentage by the three methods, viz., Daughters' average, Contemporary comparison and Least squares means. Sire No.7, Gorakh was ranked first, second and third by Least squares means, Daughters' average and Contemporary comparison methods. Sire No.10, Ideal was ranked first by Daughters' average and Sire No.2 Dany by Contemporary comparison. The sires sharing top three ranks in case of fat and total solids percentage, were ranked low in case of 305 day milk yield. Also Sire No.5, Dilbaugh, which was ranked last for fat percentage, was ranked last for total solids percentage also by all the three methods. Sirewise least squares means of total solids percentages for morning and evening milk at different stages of lactation given in Table 27. It is to be thought that either the lactation average per cent or lactation yield of total solids would be better for evaluating sires.

Table 28 gives ranking of sires on the basis of solids not fat percentage. Sire No.3, Dara was ranked first by Daughters' average and Contemporary comparison methods. Hemanth was ranked first by Least squares mean. Sire No.1 Admiral got second rank in Contemporary comparison and Least squares means, while Sire No.9, Horror got second rank by Daughters' average. The top ranks were shared by Sire No.7, Gorakh, Sire No.2, Dany and Sire No.10, Ideal for fat and total solids percentage, but ranking was different for solids not fat percentage. Sire No.5, Dilbaugh was ranked last by all the three methods for fat, total solids and solids not fat percentages. Sirewise Least squares means of solids not fat percentages for morning and evening milk at different stages of lactation given in Table 29. The range of solids not fat averages by all three methods was low. There were slight differences in ranking by the three methods. The results of analysis have already led to the conclusion that this trait remains more or less constant with times of milking stages of lactation, seasons and centres. The genetic differences also had not been appreciable as evidenced by the heritability estimate of zero. Solids not fat yield is much more variable trait and the genetic variance is also more. Hence it is to be taken that solids not fat yield should be preferred for sire evaluation than solids not fat per cent.

Ranking on the basis of fat yield, total solids yield and solids not fat yield are given in Tables 30, 31 and 32. Sire No.3, Dara had top ranks for fat, total solids and solids not fat yield, when ranked on the basis of Daughters' average and Contemporary comparison, but Dara had tenth rank for these traits by Least squares means. It should be noted that Dara had top ranks for 305 day milk yield by all the three methods. Sire No.6, Gopal acquired top ranks for all the yield characters including milk yield, fat yield, total solids yield and solids not fat yield. Sire No.5, Dilbaugh and Sire No.10 Ideal shared the last ranks for yield characteristics. In the present study, the ranking of sires by Daughters' average method for 305 day milk yield, fat yield, total solids yield and solids not fat yield had exactly the same rankings. This result agreed with that of Godara *et al.* (1988) who reported that rankings on the basis of yield characteristics of milk were similar. In the case of Contemporary comparison and Least squares means, the rankings were similar for fat, total solids and solids not fat yields, but was different from that of milk yield. Godara *et al.* (1988) also reported that rankings on the basis of fat and solids not fat percentages were similar. the present study disagreed with this results.

Daughters' average evaluated the sires by finding out the raw sirewise averages and comparing them. Daughters' average performance based on unadjusted data is the simplest to compute and is preferred by many workers

(Powell *et al.*, 1972; Gandhi and Gurnani, 1991 and Murida and Tripathi, 1992). It is likely that there could be some bias in it, as no adjustments are made. But in the present study, the sire comparison was made over a single period and hence the period to period variations were reduced (Abubaker *et al.*, 1986). Breed had a significant influence on milk yield and composition (Prasad and Subramanyan, 1986; Yadav *et al.*, 1989; Bector and Chatopadya, 1992; Ghani, 1992 and Jadhav and Khan, 1995). In the present study the sires to be evaluated were all Holstein Friesian crossbred bulls. Hence the daughters obtained were all Holstein Friesian crossbreds. Breed of dam is also important as it contributes half the genes to the progeny. But it is becoming difficult to identify most cattle in field conditions of Kerala, by exotic inheritance levels. Therefore the effect of dam shall have to be ignored (Chauhan *et al.*, 1987 and Iype *et al.*, 1993). Many workers were of the opinion that Contemporary comparison was less subject to errors when compared to other methods of sire evaluation (Sundaresan *et al.*, 1965a; Allaire, 1971; Jain and Malhotra, 1971b; Suller, 1972 and Raheja, 1992). In the present study, for Contemporary comparison each daughter's record was deviated from the contemporary average calculated for the centre to which that particular progeny belongs. Since the effect of season was found to be non-significant for all the traits, season was not taken into consideration for calculating contemporary average. Also since the number of observations were limited, if we consider the average for a particular season within a centre, the number will be very much reduced and this could lead to a major error.

The three methods of evaluation showed slight differences in the ranking of sires. There is a need to study the accuracy of evaluation by different methods and choose the best method for evaluation under field conditions. There is also a need for a more thorough and deep investigation into the sources of variation, as the Least squares model adopted in this study explained only about 25 per cent of the variation. It should be possible to bring out genetic differences and sire differences in a more pronounced way with proper identification of environmental effects causing variation. But it is a gratifying fact that the milk production potential of the test bulls is higher than their herd mates which is attributed to the superiority of the sires used. The use of sires which had undergone rigorous selection on a national basis was able to bring in genetic improvement in the crossbred cattle population of Kerala.

The fat, total solids and solids not fat yields were in general found to be more variable compared to the percentages at definite stages of lactation and hence it is to be considered that these yields would be more suitable for evaluating sires.

Summary

SUMMARY

1. Ten Holstein Friesian crossbred bulls ranging in exotic inheritance from 50-75 per cent were evaluated on the basis of their daughter's milk yield, fat, total solids and solids not fat percentages and yields.

2. Out of the female progenies identified and monitored, 103 daughters, which commenced their first lactation during the period 1995-96, were utilised for the study.

3. 119 contemporaries irrespective of their parities, freshened during the same season and belonging to the same centre as the progenies were also included in the study.

4. The 305 day milk yield of the animals were estimated from monthly recordings, starting within 20 days of calving, extending to a period of 10 months.

5. Milk samples from these animals were collected during early, middle and late stages of lactation both in morning and evening and total of 1284 samples were analysed for fat, total solids and solids not fat percentages.

6. Milk fat percentage was estimated by Electronic Milk Tester with frequent standardisation with Gerber's method. Total solids percentage was determined by Gravimetric method and solids not fat by finding the difference between total solids and fat percentage of milk.

7. Fat yield, total solids yield and solids not fat yield were calculated by multiplying the quantity of milk in each stage of lactation with the corresponding percentage and adding.

8. Centrewise and seasonwise averages were calculated for all the traits (305 day milk yield, fat, total solids and solids not fat percentages)

9. Least squares technique was employed to find out the effects of sire, centre and season.

10. The overall average 305 day milk yield was found to be 1829.68 kg. The progenies had higher averages compared to the contemporaries. Field contemporaries in different parities had an average of 1725.3 kg and progenies 1905.7 kg. The daughters were in their first lactation and in their subsequent lactations, they are expected to produce more. With the possible increase of 300 kg in the second lactation and another 300 kg in the third lactation, the real superiority of the daughters over the herdmates would be more than double the apparent superiority of 180 kg.

11. The overall average of fat percentage for morning and evening milk samples were 3.46 ± 0.03 and 4.23 ± 0.05 for early lactation, 3.65 ± 0.03 and 4.46 ± 0.05 for middle lactation and 3.96 ± 0.04 and 4.93 ± 0.05 for late lactation respectively. Fat percentage was high for Arimbur during all stages of lactation. University farm milk samples had higher values for fat, total solids and solids not fat percentages, when compared to field milk samples.

12. On analysing the milk samples from the field, it was found that two third of the cows (66.67 per cent) in the early stage of lactation had less than 3.5 per cent of milk fat in their morning milk samples and 28.38 per cent of cows from the farm recorded milk fat per cent below the legal standards.

13. The overall averages of total solids percentage for morning and evening milk samples were 12.05±0.059 and 12.75±0.068 for early lactation, 12.20±0.058 and 12.97±0.070 for middle lactation and 12.97±0.070 and 13.43±0.071 for late lactation respectively.

14. The overall averages of solids not fat percentages for morning and evening milk samples were 8.57±0.041 and 8.54±0.04 for early lactation, 8.59±0.061 and 8.52±0.040 for middle lactation and 8.52±0.040 and 8.50±0.039 for late lactation respectively.

15. Almost half the cows (46.5 per cent) recorded solids not fat below the legal standards of 8.5 per cent, irrespective of stage of lactation and time of milking. Farm and field later did not show remarkable difference.

16. Total solids and fat percentage increased uniformly with the progress of lactation. Similarly total solids and fat percentage were uniformly higher for evening milk when compared to morning milk. Such an increasing trend with stage of lactation and time of milking was not observed for solids not fat percentage.

17. Least squares analysis revealed that the effect of centre was highly significant for 305 day milk yield, morning and evening fat and total solids percentages of early, middle and late lactation. The effect of season was non-significant for all the traits at all stages of lactation.

18. The Least squares model explained only about 25 per cent of the variation and hence a more detailed study on different factors causing variation under field conditions is required, with respect to all traits for a better understanding about the real genetic variance.

19. Heritability estimates of milk yield and composition were calculated by paternal halfsib method. Heritability estimates were 0.169 ± 0.240, 0.326 ± 0.234, 0.119 ± 0.238 and 0.000 for 305 day milk yield, fat percentage, total solids percentage and solids not fat percentage respectively. The heritability estimates were 0.114 ± 0.242, 0.113 ± 0.242 and 0.157 ± 0.240 for fat yield, total solids yield and solids not fat yield.

20. The ten Holstein Friesian test bulls were ranked on the basis of 305 day milk yield, fat, total solids and solids not fat percentages and yields by Daughters' average, Contemporary comparison and Least squares means. There were slight differences in the ranking by these three methods in all traits. There is a need to study the accuracy of evaluation of different methods and choose the best method for evaluation under field conditions.

21. The characteristics of fat yield, total solids yield and solids not fat yield were found to have more genetic variation, than the corresponding percentages and hence should be preferred for sire evaluation.

22. The observation that two third of the cows in early stage of lactation have low milk fat percentage and about half the cows, low solids not fat percentage, calls for the need for immediate action to amend the PFA Act.

23. The result of this study revealed that the crossbred cattle population could be improved considerably in a single generation, and is indicative of the feasibility of achieving the targeted milk yiled of 2500 kg per 305 day lactation in the comprehensive livestock breeding policy of the state, if bulls of superior genetic worth are used.

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EVALUATION OF HOLSTEIN CROSSBRED BULLS BASED ON MILK COMPOSITION OF PROGENY

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ABSTRACT OF A THESIS

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ABSTRACT

Sire evaluation programmes in Kerala state, so far have been hinged around milk production alone, and no emphasis has been laid on milk constituents. The milk constituents like fat and solids not fat determined the market value and consumer's receptivity of milk. Reports on sire evaluation on the basis of milk constituents were seriously lacking in literature and hence the present investigation was undertaken with a view to compare the crossbred sires on the basis of milk yield, fat, total solids, and solids not fat percentages and their yields.

1284 milk samples belonging to 222 animals (103 progenies of Holstein crossbred bulls with superior genetic worth and 119 contemporaries) calved during the period 1995-96 formed the material for the study. These animals belonged to farmers in the area of six AI centres around Thrissur and also the animals maintained in three University Livestock farms. Milk samples were collected during early, middle and late lactation both in morning and evening, and the samples were analysed for fat, total solids and solids not fat percentages. Milk fat percentage was estimated by Electronic Milk Tester with frequent standardisation with Gerber's method. Total solids percentage was determined by Gravimetric method and solids not fat by finding the difference between total solids and fat percentages of milk. Fat, total solids and solids not fat yields were calculated by multiplying the percentages of these constituents with cumulative milk yield for each stage for lactation and adding.

The statistical analysis was done as per standard procedure. Least squares technique as described by Harvey (1986) was employed to analyse the effects of centre, sire and season on the characters studied. The effect of centre was highly significant, while effects of sire and season were non-significant.

The overall average 305 day milk yield was found to be 1829.68 kg. The progenies in the first lactation had higher averages compared to the contemporaries in different parities. Among the centres progeny average of 305 day milk yield was maximum for University Livestock Farm, Mannuthy (2800 kg) followed by Ramavarmapuram (2426.71 kg).

University farm milk samples revealed higher values for 305 day milk yield, fat, total solids and solids not fat percentages compared to field milk samples. Among the centres, Arimbur recorded comparatively higher fat percentages during all stages of lactation.

An important result from legal point of view was that, 66.67 per cent of cows in the early stage of lactation, recorded morning milk fat per cent below the legal standards of 3.5. In case of solids not fat, 46.5 per cent were below the PFA standard of 8.5 per cent.

Total solids and fat percentage showed an increasing trend with the progress of lactation. But such a trend was not observed for solids not fat percentage.

Heritability estimates were calculated by paternal half-sib method for milk yield and its composition. Milk fat percentage had the highest heritability estimate of 0.326 ± 0.234.

The estimates of sire merit of Holstein Friesian test bulls for 305 day milk yield, fat, total solids and solids not fat percentages and yields, were computed by three methods of sire evaluation viz., daughter's average, contemporary comparison and least squares means. The yield characteristics were found to have more genetic variance than the corresponding percentages and hence preferred for sire evaluation. Since there was slight difference in the ranking of sires by these methods there is a need to study the accuracy of evaluation by different methods and then to choose the best method for evaluation under field conditions. The observation on the low milk fat and solids not fat percentages pinpoints the necessity of urgently amending PFA act for the benefit of the farmers.