FACTORS INFLUENCING RATE OF MILK FLOW OF DAIRY CATTLE AT Indian Veterinary Research Institute

By

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IZATNAGAR (U. P.)

THESIS

Submitted to the Agra University, Agra,

in partial fulfilment of the requirements for the Degree of

MASTER OF VETERINARY SCIENCE (A. H.)

IN

ANIMAL GENETICS & BREEDING

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Dated 28th April, 1968.

Certified that the research work contained in this thesis entitled "Factors Influencing Rate of Milk Flow of Dairy Cattle at Indian Veterinary Research Institute" by Krishan Chandra is an original work carried out by him under my supervision and guidance.

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C O N T E N T S

INTRODUCTION

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India has a very large number of cows and buffaloes but most of them are inefficient and uneconomical milk producers. On an average the annual milk yield of an Indian cow is only 220 kg whereas in buffaloes it is 491 kg. FAO in 1962 reported the following average annual milk yields per cow :

Country	Milk yield (kg)
Israel	4330
Netherland	4150
Denmark	3560
Switzerland	3210
Sweden	2880
U.K.	2900
U.S.A.	2860
Burma	760
Pakistan	420
India	220

This shows how low is the milk yield of an average Indian cow. On this basis, including goat's milk also, the daily consumption of milk per capita is only 5.5 ounces

against at least 10 ounces required by a man for a balanced diet. Per capita milk consumption in developed countries ranges between 18 to 22.5 ounces per day.

Efforts to improve milk production from Indian cows and buffaloes began and are in progress since long.

Rate of milking has also long been established as being related with milking potential in taurus animals as for example, studies of Babcock, Emery, Bitting, Beach and Crowther etc. Mathews et al (1928) showed that on an average 6 minutes were sufficient for milking a cow, yielding more than 12 pounds of milk and 4 minutes were sufficient for a cow yielding less than 4 lbs milk. Foot (1935) recorded that correlation coefficient between milk yield and milking time was 0.409.

Similar studies have not been attempted among Indian cows and buffaloes. They are essential to lay down a bench mark for studying this character, namely milking rate of Indian cows and buffaloes. Milk yield within a lactation is the aggregate of yields at all the milkings comprising that lactation. Even for a lactation of 300 days with twice daily milking, this will amount to the addition of yields on 600 different occasions.

Yield on each of these occasions is influenced by a number of uncontrollable factors other than the milking potentials of the cow. Examples of these are climatic factors, type and availability of the feed, change in the atmosphere of the milking barn, of the suckling calf if any, of milker etc. In general, lactational yield assumes that each one of these effects is random and thus self cancelling. However, the net result of these is to make the scale of measurement of cow's production potential slightly crude.

Milking rate on one or a few occasions has the added advantage of much closer supervision of this operation. It is thus likely to be less coarse measure of a cow's or buffaloe's production potential. As it becomes available sooner than does a full lactational yield, it can be utilized earlier in the breeding programme. Should its heritability and repeatability be higher than that for the lactational yield, the advantage will be greater.

The present study was undertaken in this context. Only hand milking was practiced and its effect was attempted to be held constant by holding the milker good and constant. Thus the following variables were proposed to be studied in

as much as they affect milking rate :

I. Hereditary factors :

(a) Breed of cows

(b) Sire effect

(c) Cow's effect and

II. Non-hereditary factors :

(a) Age of cow

(b) Stage of lactation

Relative importance of these factors was studied on each milking and on the aggregate of two milkings in twenty four hours, this being called the daily milking. Milking rate was proposed to be related to corresponding lactational yield and also to the yield within the period of trial.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The average milking rate in kilograms per minute is : the milk yield divided by the duration of milkings in minutes. Time of stripping is included in the duration of milking but the letting down period is excluded. Cows having rapid milk flow will require shorter milking time in order to leave less residual milk in their udder (Baundentistl, 1965). Larger residual milk in the udder tends to depress the rate of secretion (Johansson, 1961). The longer will be the milking time the larger will be the period during which residual milk will stay in the mammary gland and less will be its secretory activity.

Mcandlish and Cochran (1930) observed that the average time per cow was 4.8 minutes with machine and 5.4 minutes with hand milking. They also pointed out that the rate of milking increased with the yield.

Foot (1935) recorded the rate of milk flow by machine in high yielders. The correlation coefficient between milk yield and the milking time was found by him to be 0.429.

Palva (1948) studied the hand milking rate of 6014 cows and stated that the average withdrawl of 1 kg milk

took 1.17 ± 0.003 minutes from a cow yielding 6.25 kg milk per milking. But when the milk yield increased from 6.25 to 12.0 kg, the time taken for withdrawl of 1 kg milk was much reduced. Increased milk yield after 12 kilos had no effect on the average time for removal of one kilo of milk.

Pfutz and Thomas (1949) found that fast milkers obtained 7.1 kg milk with 3.7% butterfat in 6.68 minutes while the slowest milkers obtained only 3.6 kg milk with 2.7% butterfat in 9.1 minutes.

Kirsch and Parau (1950) had increased the milking rate by the application of pre-milking treatment of the udder with warm damp cloth at 50-55°C, but the difference in daily average milk and butterfat yield was very little. Ward (1950) found a marked difference between daughters of different groups in their milking rate and indicated that milking shed technique and efficiency in milking play an important part in determining the rate of milking. He also showed that milk yield increased with milking rate but not proportionately.

Turner (1951) made a survey of 7 different herds where machine and hand milkings were practised and concluded that fast rate of milking was associated more with high yield than with low yield.

Dodd and Foot (1953) showed that for an increase of one pound of milk per minute in peak flow, the lactational yield increased by 419 lbs, the maximum daily yield by 0.9 lb and lactation length by 7 to 9 days. Again in 1957 Clough and Dodd reported that there existed a positive relationship between milk yield and milking rate.

Relin (1955) found a relationship between milk yield and the duration of milking by hand. The same result with machine milking rate was also reported by British Oil and Cake Mills Ltd. (1955).

Sandvik (1957) was of the opinion that the high milking rate of cows with high lactational yields was due to their higher rate of milking at the time, when the rate of flow was recorded. After, peak flow was corrected for the amount of milk at the recorded milkings no significant correlation was found between milking characteristics and lactational yield.

Johansson (1958) studied the rate of milking for 115 Friesian cows in their first lactation. The correlation of peak flow with lactational yield (in 250 days) was 0.571. This correlation was, however, reduced to 0.147 when the amount of milk at the recorded milking was held constant. This coefficient was not significant even then.

Schwenzer (1958) took the different measurements of the udder and also recorded the milking rate. He established a relationship between milking rate and milk yield, but udder measurements and milking rate were not related.

Guba (1959) estimated the linear correlation coefficient of milk yield with milk flow rate and found it to be 0.86 and 0.81 for morning and evening milkingsrespectively. He stated that milking rate increased almost linearly with increasing amount of milk obtained.

Donald (1960) observed that there was a range in milking rate from 2 lbs per minute to over 7 lbs per minute and there was a significant increase in lactational yield viz. 50 gallons for an increase of one pound of milk per minute.

Comberg and Zschommler (1961) showed that mean and optimum amount of milk obtained per minute was related to a standard yield, which was fixed at 8 kg.

McDaniel et al (1962) expressed on the basis of p.m. milking of 254 cows that p.m. lactational yield and milking rate were significantly correlated, r = 0.83 while the correlation with 305 days milk yield was very low, r = 0.05.

Keestra (1963) obtained a highly significant correlations between milk yield, peak flow, average flow and the machine milking time. In the same year Viljoen also established a highly significant correlation between total milk yield and the average milk flow, for each cow and for each milking.

Andreae (1964) studied the data on milking rate of more than 6000 cows and found linear regression coefficients between daily milk yield and milk flow rate of, 0.09, 0.09 and 0.01; 0.09, 0.04 and 0.04 and 0.11, 0.11 and 0.09 respectively for the first, second and subsequent lactations in three groups of cows. The first two groups were from the Institute herd and the third group was from the local Cattle Breeding Association. Again in the same year he showed that the increased milk yield from 5 to 12 kg also increased the milk rate from 1.45 to 2.29 kg; 1.86 to 2.50 kg and from 1.72 to 2.54 kg in the first, second and the subsequent lactations.

Ritter (1964) analysed the data of 1072 cows including German Spotted and Brown cows. He established a correlation between milk yield and the milking rate. But the values of these coefficients were very low.

Naito *et al* (1965) established a relationship between

milk yield and milking characteristics and found a significant partial correlation (r = 0.522) between the yield at the recorded milking and the average rate of milk flow.

Politiek (1965) studied 644 daughters of 26 A.I. bulls in Overijssel and 366 daughters of 15 bulls in Noord, Holland. He reported the overall correlation coefficients between maximum rate of flow and mean milk yield per day within daughter groups as 0.14 and 0.16 in Overijssel and Noord, Holland, respectively. The correlation coefficients were 0.24 and 0.16 in Overijssel and Noord, Holland respectively when the data were taken as a whole. These correlations were positive in some groups while negative in others. He also grouped the cows according to the milking rate in 5 groups within breed, and concluded that mean milk yield per day was distinctly higher in the very good group as compared to the poor group. The difference in milk yield was 0.74 and 1.01 kg per day in Overijssel and Noord, Holland respectively.

Again Politiek and Vos (1967) took Dutch Friesian and Mense-Rhina-Yssel cows. They found the correlation between the milk index ($2\bar{D} - 1.7\bar{M} + 7.7$, where D = daughter's yield and M = dam's yield) and the milking rate of 0.23 and 0.08 for Dutch Friesian and Mense-Rhine-Yssel, respectively. After correction of the maximum milking rate, these correlations

were reduced to 0.14 and 0.01.

Ruzevskii and Kipibida (1965) on the basis of 6 groups of daughters established a correlation coefficient of 0.211 between the volume of the fore-quarter and the amount milked per minute. They also calculated the correlation coefficients between daily yield and the milking time viz. 0.489 and with milking rate viz. 0.38.

Rejamannan et al (1966) studied the milking rate of the Holstein cattle and found a significant correlation coefficient between milking rate and monthly milk yield of 0.288-0.416 while Admin and Migaceva (1967) on the basis of 590 females established a correlation coefficient between milk yield and milking rate of 0.508.

Nielsen and Hinks (1967) observed a very low phenotypic correlation coefficient between ease of milking and 250-days milk yield. But there was a genetic correlation of 0.3, 0.2 and 0.2 for Red Danish, Black Pied Danish and Jerseys, respectively.

Brumby (1956) could not establish any relationship between milking rate and milk yield from animal to animal. He concluded that with good milking technique slow milkers gave higher yield than normal.

Sundaresan (1956) increased the milking rate by the use of machine in Indian condition, but there was not any increase in the milk yield. Sandvik (1957) also showed that slow milking cows were not necessarily poor milk producers.

Rabek (1965) in a trial with 73 cows showed that the range in milking rate was from 0.26 to 2.19 litres per minute and the coefficient of correlation between average and maximum milking rate was very high being, 0.92. However there was no relationship between milk yield and milking rate.

HEREDITARY VARIABLES :

BREED :

Baundentistl (1965) studied 191 cows including Austrian Simmental, Austrian Brown, Pinzagau and Yellow hill cows of Austria. All these cows were in their first to sixth lactation. Milking rate was different from breed to breed.

Nielsen and Hinks (1967) analysed the records of progeny of 190 Red Danish bulls, 92 Black Pied bulls and 51 Jersey bulls for various characters. They found the highest

heritability for milking rate and for ease of milking index (i.e. corrected kg milk per minute) in Red Danish and then in Black Pied and lowest was in Jerseys.

Politiek and Vos (1967) compared Dutch Friesian, Mense-Rhine-Yssel and Groningen breeds of cattle for their milking ability. They found small difference in milking ability between breeds. In the Mense-Rhine-Yssel, the corrected maximum milking rate was higher than in the Dutch Friesian (2.35 to 2.24 kilo milk/minute).

SIRE OF COW :

Ward (1950) studied the milking rate of the daughters of 119 bulls from 68 herds and found that :

(a) daughters of 55 bulls milked faster,
(b) daughters of 37 bulls milked slower,
(c) daughters of remaining 27 bulls milked at the same rate as the rest of the cows in their herds.

British Oil and Cake Mills Ltd. (1954) reported on the basis of 4 progeny tested bulls, that there was a detectable effect of the bull on the milking rate of his daughters and the daughters of one bull yielded 5.9 lbs

milk per minute which was faster than that by daughters of the two other bulls whose daughters yielded only 4.9 lbs milk per minute.

Hansen (1954) compared the milking rates of the different bulls, each with 10 to 20 daughters. The overall average milking rate was 1.16 kilos per minute; the highest sire group averaged 1.58 kilos per minute and the lowest 0.78 kilos per minute.

Beigel (1955) studied the effect of sire on the inheritance of milking rate. He included 86 pairs of dam daughters to compare the 10 bulls from a herd, whose average milking rate was 1.22 kg per minute. In the progeny of three bulls, average milking rate of daughters was higher than that of their dams by 12 to 290 gms per minute. In the progeny group of two other bulls milking rate was depressed below that of their dams on an average by 280 gms per minute and 140 gms per minute, respectively. The rest of the bulls had no significant effect. Similar results were drawn by Schmahlsteig (1955) for 14 Lowland bulls on the basis of 8 dam-daughter pairs for each bull.

Brumby (1957) had reported on the milking characters of 13 pairs of monozygotic (MZ) and 14 pairs of dizygotic (DZ)

twins. Six observations were made on each animal for peak and average flow of milk at the morning milkings over a two months period in the early part of their lactation. The heritability estimates were made on the average of 6 recordings for each individual and the repeatability was calculated as ratio of the variance between unrelated animals to the total variance among single records.

	MZ twins	DZ twins	
	Intra-pair correlation	Repeata-bility	Herita-bility
Peak flow	0.724	0.945	0.862
Average rate of flow	0.590	0.914	0.674

Again in 1961 he reported that heritability of milk flow rate appeared high and the heritability for the peak flow was around 0.60 while the genetic correlation between lactational milk yield and peak flow was close to zero.

Johansson (1958) studied the variation in the milking characteristics within a number of herds of Swedish Friesian and Swedish Red and White cattle (field data) and at one testing station for Friesian bulls. He obtained the following results :

Field data (one milking per cow)	Peak flow	Average rate of flow	Milking time
Repeatability within breed :			
(i) Lactational stages from one day to the next (540 cows)	0.821***	0.803***	0.873***
(ii) From one lactation to next (134 cows)	0.675***	0.605***	0.503***
Correlation between paternal half sisters within breed, lactation and lactational stages :			
Total	0.218***	0.243***	0.2733**
Within breed	0.092	0.065	0.108**
Dam-daughter correlation (121 pairs) :			
Total	0.332***	0.343***	0.292***
Within herds and sire	0.159	0.225	0.236
Bull testing stations (8 progeny groups 4 milkings per cow) :			
Half-sister correlation	0.086**	0.119**	0.036

Israel Society of Applied Animal Genetics (1961) published the milking rate of 306 cows sired by 10 bulls. Twenty seven per cent of the total variation in the maximum milking rate was due to sires. However sires had not

contributed any variation in the average rate of milk flow.

Politiek (1961) found a wide variation in the milk flow rate between daughters group and there was also a significant difference in the milking behaviour of the progeny-groups.

Keestra (1963) during his investigation for ease of milking, pointed out that the bull had a significant influence on the peak and average milk flow rate. On the basis of one milking per cow and with the help of half-sib correlation he estimated, 0.65 ± 0.11 and 0.56 ± 0.1 as heritability for the peak and for the average flow of milk. The repeatability was 0.70 for peak flow and 0.69 for average milk flow within herd and within lactation.

Venge (1963) made the test milkings in morning two to three weeks after calving and every four weeks thereafter during the lactations of 163 Swedish Red and White heifers in 15 progeny groups. At another time test milkings were made on 2 consecutive days. The heritability of both average rate of flow and peak flow was 0.40; based on double test milkings, the heritability was 0.26 for average and peak milk flow rate.

Wilson (1963) calculated a heritability estimate of

80% for maximum rate of flow. He used the regression of daughters on dam for this purpose.

Rabek (1965) found large variation in the milking rate and indicated that it was genetically controlled. He also found differences in the milking rate among the daughters of different sire.

Nielsen and Hinks (1967) compared 2701 daughters of 190 Red Danish bulls, 1372 daughters of 92 Black Pied Danish bulls (B.P.D.) and 828 daughters of 51 Jersey bulls and found that bull had a significant effect on ease of milking. Politiek and Vos (1967) found a large difference between the daughter groups of 715 bulls including Dutch Friesian, Mense-Rhino-Yssel and Groningen breeds. The greatest difference between two groups was 1.94 kg milk per minute.

COW :

A difference in milking rate from cow to cow was observed by Mathews et al (1928), Mcandlish and Cochran (1930) and Foot (1935).

Beck et al (1951) studied the milk flow curves and concluded that cows differ in their response to standardized methods of machine milking in a characteristic individual fashion.

Turner (1951) during the survey of the eight different herds recorded that machine milking time per cow varied from 4 minutes 35 seconds to 7 minutes 54 seconds in all the herds. The average mean time per cow varied from 3.65 to 4.81 minutes.

Dodd (1953) observed the variation in the machine milking rate for 141 cows in 326 lactations. He calculated that the coefficient of variation between cows and within cows was 30.0-40.0% and 11.0-18.0% respectively. Thus he concluded that there was a marked variation from cow to cow.

Comberge and Zschommler (1961) made tests on the udders of 25 Black Pied Lowland cows at the interval of 10 days between the 60th and 120th day of lactation, at Oberholz Experimental Station. The cows were in first to seventh lactation. Optimum amount of milk per minute showed a characteristic milk flow curve for the udder as a whole.

Keestra (1963) found the influence of cows on their milking rate during his investigation on 1,000 cows. The other factors which he studied were farm to farm, milking interval etc.

Wilson (1963) obtained an estimate of the variance

in milking time from cow to cow. This variation was more within poorly prepared herds than in the better prepared herd.

NON-HEREDITARY VARIABLES :

AGE OF COW :

Dodd (1953) pointed out that age itself had no effect on the milking rate, even though with an increase in age there was a gradual increase both in yield and in milking rate. The increase in milk yield was more than in milking rate.

Butz and Schmahlsteig (1955) also could not find any significant difference in the milking rate in different lactations on the basis of two successive lactations.

Andreae (1964) studied milk flow rates of more than 6000 cows in their first, second, third and subsequent lactations. He found the average milk flow rates1.32, 1.52, 1.64 and 1.80 kilos per minute in one group and 1.39, 1.64 and 1.82 kilos per minute in a second group of cows. It was 2.04, 2.22 and 2.39 kg milk per minute respectively in the cattle of a local Cattle Breeder's Association. Again

in the same year, from the records of Breeder's Association having 4665 cows, he observed the increase in milk flow rate from 1.45 to 2.29 kg, from 1.86 to 2.50 kg and from 1.72 to 2.54 kg in first, second and subsequent lactations respectively. This increased milking-rate was due to increased milk yield from 5 to 12 kg.

Engeler et al. (1967) made a test on 252 machine milked and 122 hand milked cows. For the first lactation he found corrected average rate of flow per minute to be 1.61 kg and the corrected maximum rate of flow per minute was 2.02 kg. The corresponding figures for the subsequent lactations were 2.04 kg and 2.74 kg respectively.

STAGE OF LACTATION :

Dodd (1953) studied the milking rate of 141 cows in 326 lactations. He found decrease in milking rate as the lactation advanced. The rate decreased due to change in yield. The fall in milk rate was more in faster milking cows.

Guba (1959) observed that there was no effect of stage of lactation, if there was no change in the milk yield.

Brumby (1961) pointed out that milking rate was influenced by the stage of lactation. The other factor influencing milking-rate was daily milk yield.

Schlolant (1963) compared the milking rate in 42 Spotted Mountain cows in the second and eighth months of lactation and found that in hand-milked cows the milking rate increased with advance in stage of lactation while in machine milking cows it decreased.

MATERIAL AND METHOD

MATERIAL AND METHOD

For the present study the animals were selected from the dairy herds of Indian Veterinary Research Institute, Izatnagar, U.P., India. The animals for this experiment were selected in two lots. The first lot was selected on the 25th of August 1967 while the second lot was selected a month later. The number of animals thus choosen was 78, being distributed in different breeds and two lots as follows :

Breed	Lot I	Lot II
Hariana	35	3
Holstein-Friesian	8	-
Gir	6	1
Murrah	14	11

The second lot was added to strengthen the group with additional fresh calvers. Only animals in good health were included on the basis that they were in early or mid portion of their lactation and that their daily yield was at least 0.5 kg per milking. This was expected to provide at least 12 weekly observations on each animal. In spite of all the precautions that were taken at the time

of the start of this experiment, one animal dried in the middle of the experiment. Thus the study had to be restricted only to 77 animals.

The milking animals were daily fed 2 kg dry fodder or 8 kg green fodder, subject to availability, per 100 kg of their body weight. Along with the fodder every animal was given 1.5 kg concentrate mixture as maintenance allowance. Production allowance constituted 1 kg concentrate mixture for every two kg milk in buffaloes and 1 kg per 2.5 kg milk in cows. The general concentrate mixture was made up of 60 parts of wheat bran, 30 parts decorticated ground nut cake and 10 parts barley. Supermindif mineral mixture was mixed at the rate of 3% in the concentrate mixture. All the ingredients were ground and mixed before feeding. The Holstein cows were given a concentrate mixture which was made up of equal parts of wheat bran, barley, ground nut cake and gram. The mineral mixture used was the same and in the same proportion as for others.

The fodder supplied to the animals in the different months of the year was as follows :

1. August to December - Green cow-pea, maize and jowar.
2. December to January - Berseem, oats and jowar silage.

All animals were housed in pucca byres and they were hand milked twice daily at 2.30 A.M. and at 2.00 P.M. As the number of animals was large and it was impossible to record all the animals daily, they were randomly divided within breed into 6 groups to enable recording on the 6 working days of the week.

One milker was choosen on the basis of high speed and of consistancy of milking. He was assigned each day to milk the cows from the experimental group. Thus milker's effect was attempted to be kept constant; only in his absence another man was asked to milk the cows. Even the second man had been selected before the start of this experiment.

Each animal was recorded once in a week and for twelve consecutive weeks. The recording was made both in a.m. and p.m. milkings. In this way 12 morning and 12 evening records were collected for each cow.

The following times were recorded in minutes and fractions of minutes :

1. Time required for calf-suckling or time for the massage of udder in weaned animals.

2. Milking time including stripping time.

A stopwatch was used to record the timings of milking during the experiment. The milk was weighed in kilograms with the help of a spring balance.

Statistical Methodology

Standard statistical procedures were used for carrying out the analysis of data.

The analysis of variance was used for comparing various group means, including breeds and animal etc. This is briefly outlined in Table I.

Table I

Analysis of Variance to Estimate Different Components and to Test Group Differences

Sources of variation	d.f.	M.S.	E.M.S.
Between breeds	B-1	MS_B	
Between animals within breed	(A-B)	MS_A	$\sigma^2_e + K\sigma^2_A$
Within animals within breed	N-A	MS_e	σ^2_e

where

B = number of breeds

A = number of animals

N = total number of observations

K = the average number of observations per animal and

$$K = \frac{1}{A-1}\left(N - \frac{\Sigma n_i^2}{N}\right)$$

n_i = number of observations on i^{th} animal

MS_B, MS_A and MS_e are the values of mean square for breed, between animals and within animals respectively. The mean square MS_B was tested against MS_A and MS_A against MS_e to assess the importance of breed and of animals.

Repeatability

The repeatability of milking rate was calculated only within breed. Thus the components of variance between animals (σ^2_A) and that within animals (σ^2_e) were obtained from the analysis of variance from Table I.

The repeatability was calculated as -

$$r_i = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_e}$$

where

r_i = repeatability

Repeatability is the correlation among more than two observations for the same character on the same individual.

Estimation of Heritability

The estimate of heritability (h^2) was obtained from the sire component (σ^2_S) and from the phenotypic variance (σ^2_P) using half-sib relationship. Thus

$$h^2 = \frac{4\,\sigma^2_S}{\sigma^2_P}$$

and the standard error of heritability was calculated from the formula given by Robertson (1959).

$$S.E.\ (h^2) = \left(h^2 + \frac{4}{K_3}\right) \cdot \sqrt{\frac{2}{S}}$$

where

K_3 = average number of observations per sire.

S = number of sires.

RESULTS

RESULTS

The average milking rates, average milk yields in the experimental period and in corresponding lactation periods along with corresponding standard errors for the different breeds are presented in Table 1. They have been presented seperately for morning, for evening and daily. Milking rate was consistently, though only slightly, higher in the mornings than in the evenings. The daily milking rate was not exactly the average of the rates in morning and in evening. It varied between the two. The highest milking rate was in Murrah, being 0.77, 0.76 and 0.76 kg per minute for morning, for evening and daily. This was followed in the same order by Holstein-Friesians, being 0.69, 0.66 and 0.67 kg per minute, by Girs,being 0.67, 0.60 and 0.61 kg per minute and by Harianas, being 0.59, 0.58 and 0.58 kg per minute. Unlike the averages the range in milking rates was highest in Harianas and was lowest in Holsteins at each of the three stages. In all the breeds the average milk yield of the experimental period was also slightly higher in the mornings than in evenings. The lactational milk yield was highest in Holsteins being followed by Murrahs, Girs and Harianas.

TABLE 1

Average Milking Rate and Milk Yield of Animal in Different Breeds

Measures	Holstein-Friesian	Gir	Hariana	Murrah	Overall
1. Average milking rate (kg/min)					
Morning	0.69±0.014	0.67±0.015	0.59±0.013	0.77±0.008	0.66±0.025
Evening	0.66±0.012	0.60±0.014	0.58±0.013	0.76±0.010	0.65±0.025
Daily	0.67±0.011	0.61±0.012	0.58±0.013	0.76±0.008	0.65±0.023
2. Range of milking rate (kg/min)					
Morning	0.43-1.05	0.37-1.09	0.04-1.30	0.28-1.20	0.04-1.30
Evening	0.46-1.00	0.34-1.10	0.05-1.46	0.33-1.16	0.05-1.46
Daily	0.46-1.00	0.31-0.93	0.04-1.36	0.30-1.06	0.04-1.36

TABLE 1 (contd)

Measures	Holstein-Friesian	Gir	Hariana	Murrah	Overall
3. Average milk yield of Experimental period (kg)					
Morning	312.27±6.87	94.60±3.10	103.17±2.83	167.51±3.10	-
Evening	253.49±5.58	92.73±2.23	92.19±2.15	154.96±4.25	-
Daily	565.33±4.47	187.33±4.47	194.29±4.97	299.18±5.43	-
4. 305-days lactational yield	3114.77±41.34	1129.74±44.33	796.46±18.29	1275.60±27.09	

An analysis of variance was carried out to show the differences breedwise in milk yield and in the milking time on the recorded milkings. This is presented in Table 2. No significant difference was found in milk yield or in milking time, either at the morning or in the evenings amongst Holsteins, Girs and Murrahs. However, in Harianas the milk yields on different days of recording were significantly different, both in the mornings as well as in the evenings; whereas the milking time differed significantly at morning milkings only.

FACTORS INFLUENCING RATE OF MILKING

I. HEREDITARY FACTORS

1. BREED OF COW AND COW TO COW DIFFERENCE

Analysis of variance of milking rate for assessing breed effect and of animals on this character has been presented in Table 3 and Fig. 1. This has been presented in three sections : for morning milkings, for evening milkings and for daily milkings. The breed effect was highly significant at morning, evening as well as at daily milkings viz. the breeds differed in milking rate, some having larger while others with smaller milking rate.

TABLE 2

Analysis of Variance of Milk Yield and of Milking Time on Test Days

Source of variation	Holstein-Friesian			Gir			Hariana			Murrah		
	D.F.	Sum of squares	Mean square	D.F.	Sum of squares	Mean square	D.F.	Sum of squares	Mean square	D.F.	Sum of squares	Mean square
Milk Yield :												
Morning :												
Between milkings	11	9.94	0.904 NS	11	4.329	0.393 NS	11	13.667	1.249*	11	4.210	0.383 NS
Within milkings	84	100.46	1.195	72	14.963	0.208	420	252.573	0.623	252	202.200	0.802
Evening :												
Between milkings	11	10.98	0.998 NS	11	1.750	0.159	11	11.250	1.022*	11	6.010	0.546 NS
Within milkings	84	92.40	1.100	72	14.180	0.197	428	225.860	0.528	253	292.290	1.155
Milking Time :												
Morning :												
Between milkings	11	29.913	2.719 NS	11	2.890	0.263 NS	11	12.085	1.099*	11	22.677	2.060 NS
Within milkings	84	244.096	2.906	72	18.754	0.260	420	208.117	0.495	252	300.299	1.190

TABLE 2 (contd)

Source of variation	Holstein-Friesian D.F.	Sum of squares	Mean square	Gir D.F.	Sum of squares	Mean square	Hariana D.F.	Sum of squares	Mean square	Murrah D.F.	Sum of squares	Mean square
Evening :												
Between milkings	11	33.671	3.061 NS	11	0.916	0.083 NS	11	6.9140	0.6285 NS	11	11.427	1.038 NS
Within milkings	84	239.756	2.854	72	21.661	0.300	428	218.8016	0.4996	253	378.488	1.496

* Significant at 5% level of probability

NS - Not significant

TABLE 3

Analysis of Variance of Milking Rate by Breed and Animal

Source of variation	D.F.	Sum of squares	Mean square	E.M.S.	Estimate of component
Morning :					
Between breeds	3	5.0210	1.6737**		
Between animals within breed	71	29.0930	0.4098**	$\sigma^2_e + 11.679\ \sigma^2_a$	$\sigma^2_a = 0.0338$
Within animals within breed	801	12.1726	0.0125	σ^2_e	$\sigma^2_e = 0.0125$
Evening :					
Between breeds	3	4.4560	1.4854**		
Between animals within breed	73	31.7688	0.4352**	$\sigma^2_e + 11.63\ \sigma^2_a$	$\sigma^2_a = 0.0363$
Within animals within breed	808	11.7501	0.0132	σ^2_e	$\sigma^2_e = 0.0132$

TABLE 3 (contd)

Source of variation	D.F.	Sum of squares	Mean square	E.M.S.	Estimate of component
Daily :					
Between breeds	3	5.7724	1.9200**		
Between animals within breed	73	30.9041	0.4200**	$\sigma^2_e + 11.99\ \sigma^2_a$	$\sigma^2_a = 0.0344$
Within animals within breed	846	8.6596	0.0102	σ^2_e	$\sigma^2_e = 0.0102$

Repeatability estimates :

Morning milkings = 0.69
Evening milkings = 0.73
Daily milkings = 0.77

** Significant at 1% level of probability

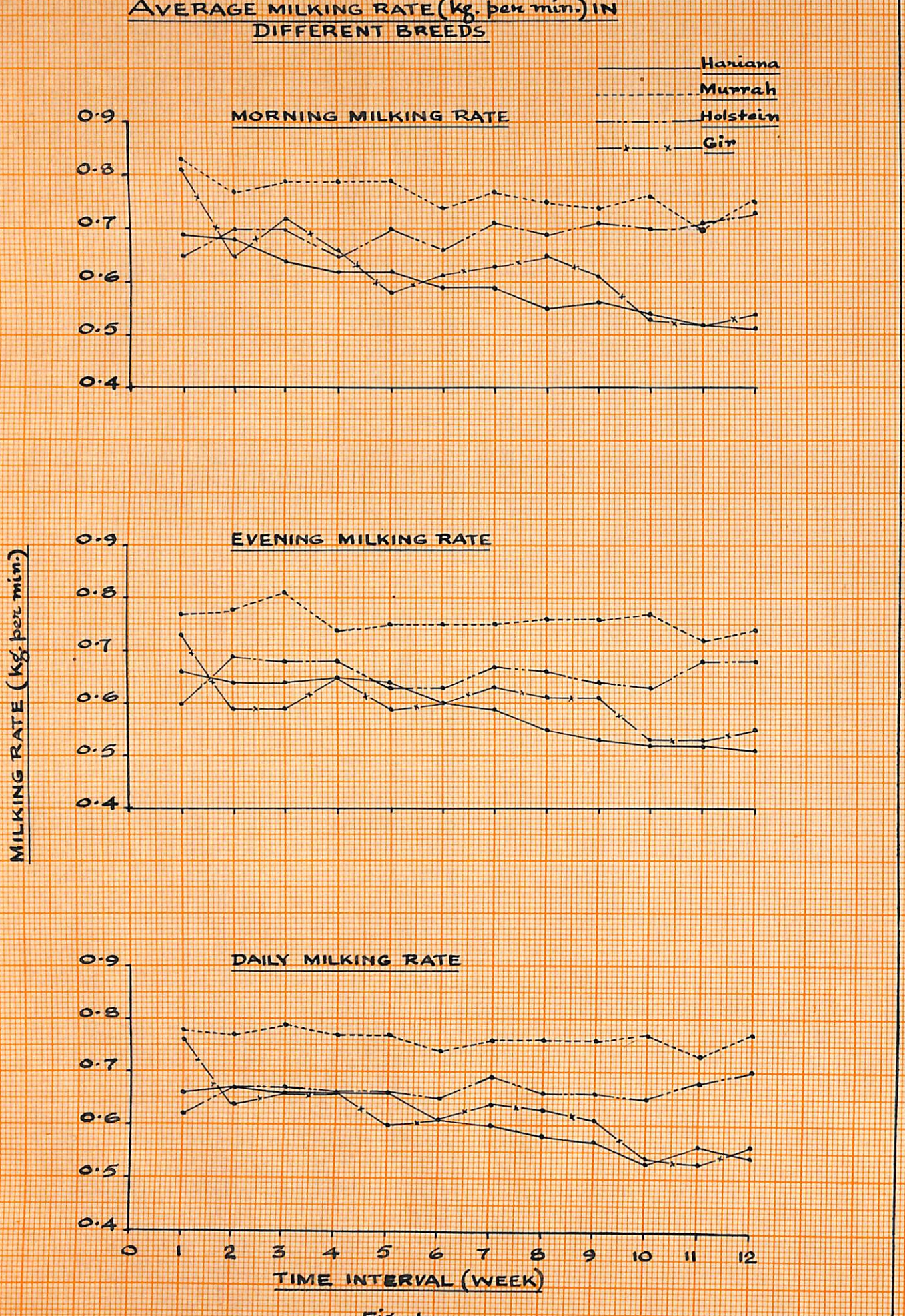

AVERAGE MILKING RATE (kg. per min.) IN DIFFERENT BREEDS
Hariana
Murrah
Holstein
Gir
MORNING MILKING RATE
EVENING MILKING RATE
DAILY MILKING RATE
MILKING RATE (kg. per min.)
0·9
0·8
0·7
0·6
0·5
0·4
0 1 2 3 4 5 6 7 8 9 10 11 12
TIME INTERVAL (WEEK)

Fig. 1

Similarly the cows had a characteristic milking rate, which differed significantly from each other. Breed accounted for more than twice as much variation as was attributable to cow to cow differences. Cow to cow variation explained more than one quarter of the total variation in the milking rate whereas intra cow variability was only about half as large. Between cow component was 20%, 22% and 18% of the total variance at morning, evening and daily milking rates respectively while the corresponding figures for within cows component were 6%, 7% and 4%, respectively.

Repeatability estimates within breed were as follows : for morning milking 0.69; for evening milking 0.73 and for daily milking 0.77. These were significant statistically.

It will be noticed that future performance of a cow or buffalo can be reasonably predicted from the previous performances.

2. SIRE EFFECT

Only the Hariana animals were large enough in number and were bred and raised on the farm. Thus their pedigree was completely known. Other herds were of a more recent origin and small in number, so that complete information on their pedigree was not known. Consequently sire effects

were examined in the Hariana herd only. This has been done only for the daily milking rate. The results have been presented in Table 4. No statistically significant difference was found in daughter groups of the nine different sires studied. As before, the cow to cow differences in daily milking rate were highly significant statistically. The estimate of heritability of daily milking rate was calculated using paternal half-sib correlations. This was 0.102 ± 0.099.

II. NON-HEREDITARY FACTORS

1. AGE EFFECT

The variation in the milking rate due to differences in age was examined within Hariana and in Murrah. Only in these two breeds sufficient animals with varying ages were available. The remaining two breeds did not have adequate numbers of animals for studying age effect. Within Harianas and Murrahs, age groups of 14 months interval were formed. The analysis of variance was then made separately for each of these two breeds. The same three sections as used earlier namely morning, evening and daily were again used. These are presented in Tables 5 and 6 for Harianas and for Murrahs respectively. The differences were statistically significant at each milking in each of these two breeds. In Harianas age

TABLE 4

Analysis of Variance of Daily Milking Rate
by Sire Grouping

Source of variation	D.F.	Sum of squares	Mean square	E.M.S.
Between sires	8	6.8518	0.8565 NS	$\sigma^2_e + 11.97\ \sigma^2_c + 36.54\ \sigma^2_S$
Between cows within sires	19	14.5895	0.7679**	$\sigma^2_e + 11.96\ \sigma^2_c$
Within cows within sire	307	9.1931	0.0299	σ^2_e

$\sigma^2_e = 0.0299$

$\sigma^2_c = 0.0617$

$\sigma^2_S = 0.0024$

$h^2 = 0.102 \pm 0.099$

** Significant at 1% level of probability
NS - Not significant

TABLE 5

Analysis of Variance of Milking Rate for Different Age Groups

HARIANA

Source of variation	D.F.	Sum of squares	Mean square
Morning :			
Between Age Groups	6	8.9196	1.487**
Within Age Groups	425	23.1861	0.054
Evening :			
Between Age Groups	6	10.0311	1.672**
Within Age Groups	433	23.5867	0.054
Daily :			
Between Age Groups	6	10.2118	1.702**
Within Age Groups	436	21.4111	0.049

** Significant at 1% level of probability

TABLE 6

Analysis of Variance of Milking Rate for Different Age Groups

MURRAH

Source of variation	D.F.	Sum of squares	Mean square
Morning :			
Between Age Groups	5	0.8820	0.1724**
Within Age Groups	249	0.5031	0.0202
Evening :			
Between Age Groups	5	2.1491	0.4296**
Within Age Groups	247	4.6654	0.0188
Daily :			
Between Age Groups	5	1.1350	0.2270**
Within Age Groups	282	4.4150	0.0157

** Significant at 1% level of probability

differences accounted for about one third of the total variation in milking rate, whereas in Murrahs it was only of the order of one fifth.

The average milking rates of Harianas and of Murrahs by age groups are presented in Table 7 and Fig. 2. In Harianas there was a rapid increase in the milking rate as animals became older than 59 months, below 59 months had a markedly lower milking rate. Thereafter marked changes did not take place, only the age group of 101.1 to 115.0 month was considerably high and animals over 129 months had a sharp decline. Evening milking rates were slightly higher than morning milking rates within age groups.

In Murrahs, the trends were not very clear except that in animals older than 144 months, the milking rate was lowered. In Murrahs also, the evening milking rates were slightly higher than morning milking rates within age groups. These results have been graphically represented in Fig. 2.

2. STAGE OF LACTATION

The effect of different stages of lactation on milking rate was studied, only within Harianas and in Murrahs. The

TABLE 7

Average Milking Rate (kg per minute) in Different Age Groups

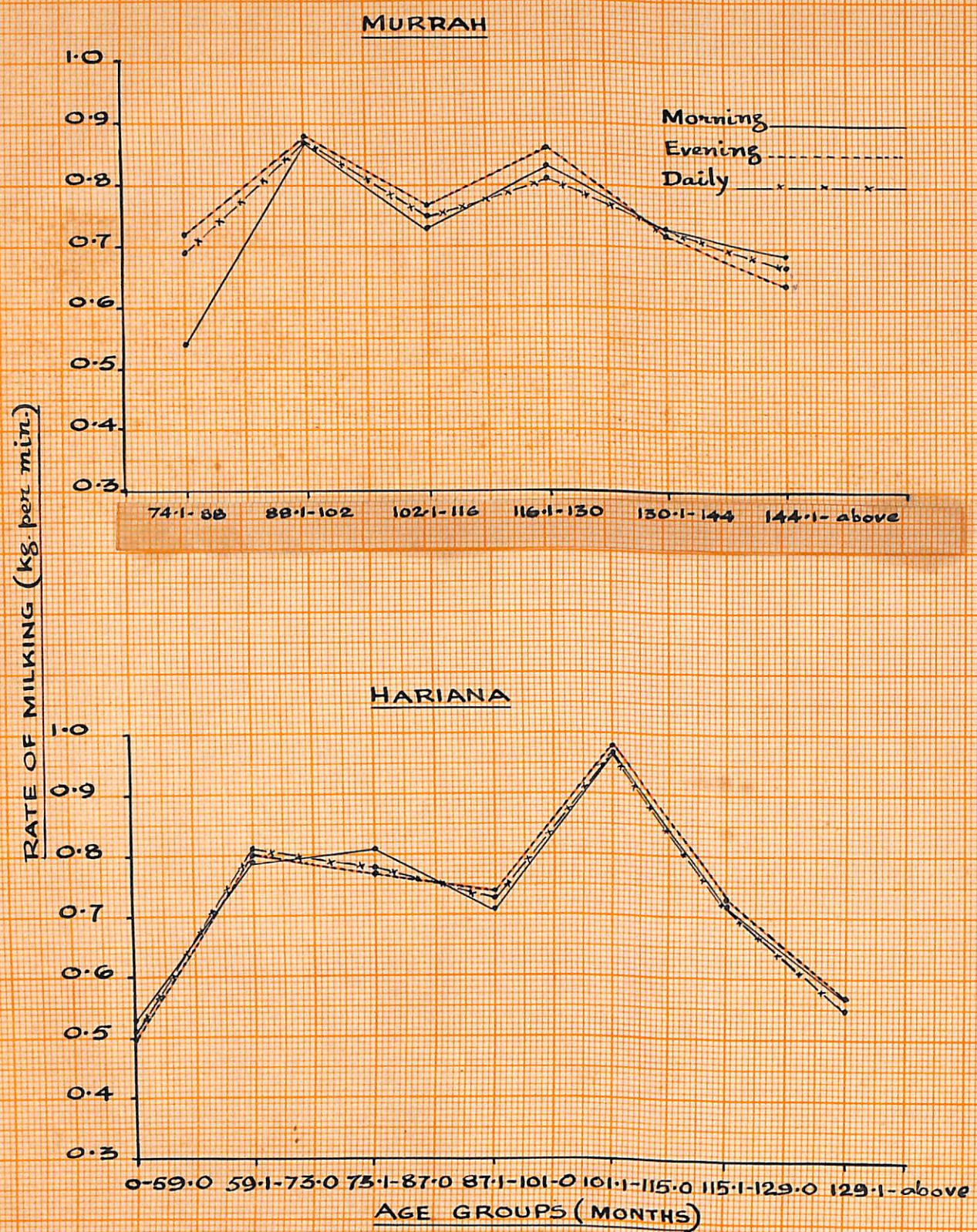
HARIANA

	Groups in Months						
	Upto 59.0	59.1-73.0	73.1-87.0	87.1-101.0	101.1-115.0	115.1-129.0	129.1-above
Number of Animals	10	4	5	4	4	4	6
Morning	0.43	0.69	0.71	0.61	0.87	0.62	0.47
Evening	0.40	0.70	0.67	0.64	0.88	0.63	0.47
Daily	0.41	0.71	0.68	0.62	0.87	0.62	0.45

TABLE 7 (contd)

MURRAH

	Groups in Months					
	74.1-88.0	88.1-102.0	102.1-116.0	116.1-130.0	130.1-144.0	144.1-above
Number of Animals	5	2	3	5	5	4
Morning	0.54	0.88	0.73	0.83	0.73	0.69
Evening	0.72	0.88	0.77	0.86	0.72	0.64
Daily	0.69	0.88	0.75	0.81	0.73	0.67



AVERAGE MILKING RATE IN DIFFERENT AGE GROUPS

Fig. 2

available animals were grouped into six different groups, each of 6 weeks interval. Analysis of variance was carried out for each breed in the three sections viz. for morning, for evening and for daily milking rate. This has been presented in Tables 8 and 9 for Harianas and Murrahs, respectively. The effect of stage of lactation was highly significant statistically in both the Harianas and Murrahs. Stage of lactation accounted for about one fourth of the total variation whereas in Murrahs this was very variable, being only about 9% in morning milkings and about 33% in evening milkings.

The average milking rates of Harianas and of Murrahs by groups of stage of lactation are presented in Table 10 and Fig. 3. In Harianas the milking rate was highest within the first six weeks of lactation. It decreased slightly after the sixth week and the decrease was gradual upto the 18th week of lactation. On the other hand in Murrahs, there was a slight increase in milking rate after the first 6 weeks of lactation, but after the 12th week of lactation the milking rate decreased. These results have been presented graphically in Fig. 3.

TABLE 8

Analysis of Variance of Milking Rate
by Different Stage of Lactation Group

HARIANA

Source of variation	D.F.	Sum of squares	Mean square
Morning :			
Between Groups	5	9.1122	1.8224**
Within Groups	426	22.9935	0.0540
Evening :			
Between Groups	5	8.3405	1.6680**
Within Groups	434	25.2773	0.0582
Daily :			
Between Groups	5	9.3631	1.8726**
Within Groups	437	22.2598	0.0509

** Significant at 1% level of probability

TABLE 9

Analysis of Variance of Milking Rate
by Different Stage of Lactation Group

MURRAH

Source of variation	D.F.	Sum of squares	Mean square
Morning :			
Between Groups	4	0.7222	0.1805**
Within Groups	259	7.1825	0.0277
Evening :			
Between Groups	4	2.4625	0.6156**
Within Groups	260	4.9766	0.0191
Daily :			
Between Groups	4	0.7896	0.1974**
Within Groups	295	4.9280	0.0167

** Significant at 1% level of probability

TABLE 10

Average Milking Rate (kg per minute) in Different Stage of Lactation Group

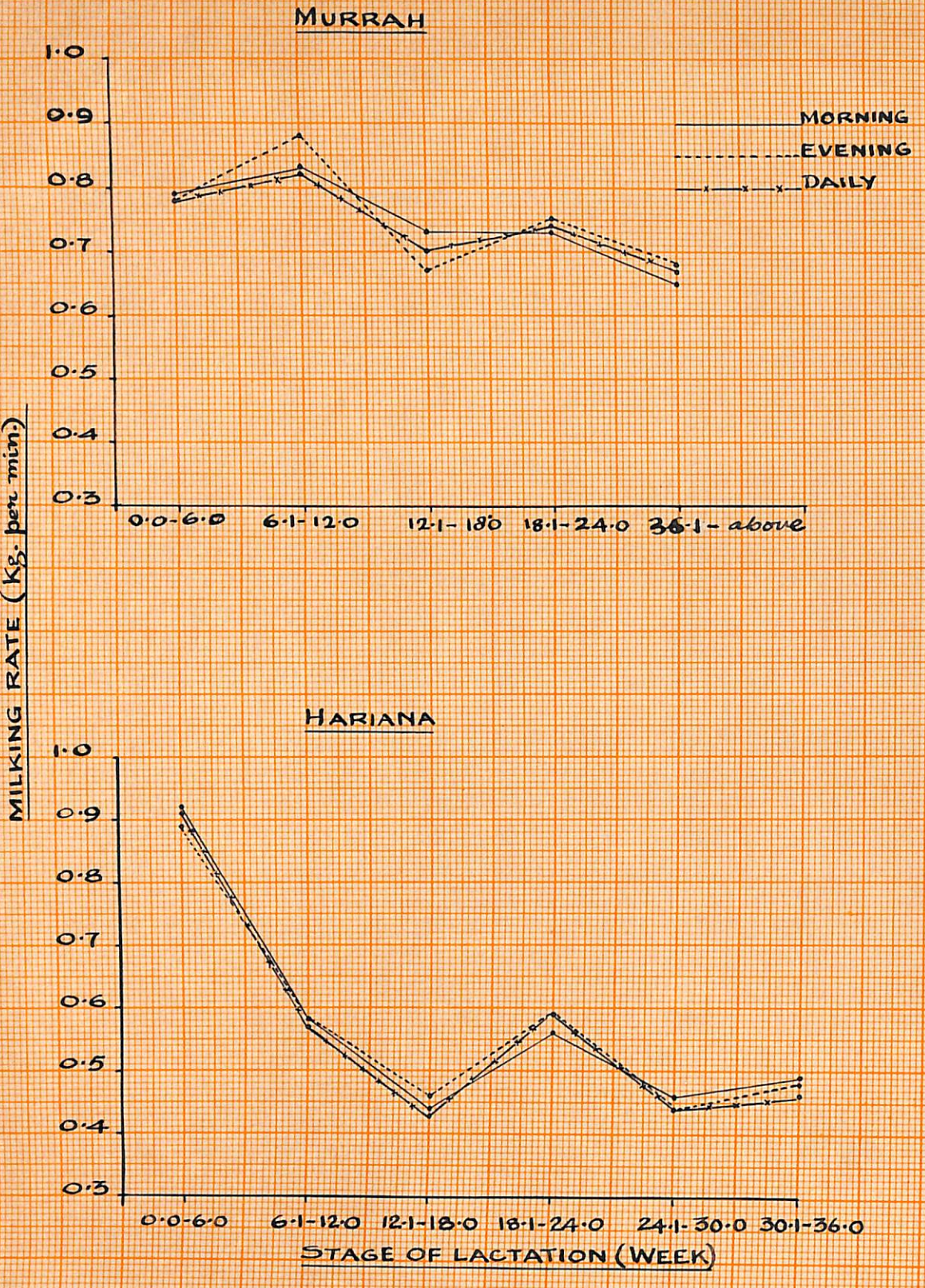
HARIANA

	Groups in Weeks					
	0-6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	30.1-above
Number of animals	5	7	3	10	9	3
Morning	0.92	0.58	0.44	0.56	0.46	0.59
Evening	0.89	0.58	0.46	0.59	0.44	0.58
Daily	0.91	0.57	0.43	0.59	0.44	0.56

TABLE 10 (contd)

MURRAH

	Groups in Weeks					
	0-6.0	6.1-12.0	12.1-18.0	18.1-24.0	24.1-30.0	30.1-above
Number of Animals	13	3	1	3	-	5
Morning	0.79	0.83	0.73	0.73	-	0.65
Evening	0.78	0.88	0.67	0.75	-	0.68
Daily	0.78	0.82	0.70	0.74	-	0.67



AVERAGE MILKING RATE IN DIFFERENT STAGE OF LACTATION

Fig. 3

RELATIONSHIP BETWEEN MILKING RATE AND MILK YIELD

The coefficients of regression and of correlation between milk yield and milking rate were calculated between animals within breed; separately for morning, for evening and for daily milkings for the experimental period and also for 305-days lactations. These coefficients are presented in Table 11. All the coefficients of regression and of correlation were positive and statistically significant at 1% level. The natures of relationship have been represented graphically in Figs. 4-7. The coefficients of correlation and of regression between 305-days lactational milk yield and daily milking rate were calculated on 52 animals that had completed their lactations upto the 16th of April, 1968.

TABLE 11

Estimates of Coefficients of Correlation and of Regression

Variables	D.F.	Correlation coefficient	Regression coefficient	Regression equation
Morning milk yield of Experimental period on morning milking rate	73	0.59**	219.77±23.58**	$\hat{Y}$ = -0.398 + 225.99 (X)
Evening milk yield of Experimental period on evening milking rate	75	0.54**	170.51±26.98**	$\hat{Y}$ = 17.69 + 170.51 (X)
Total milk yield of Experimental period and daily milking rate	75	0.57**	380.97±44.95**	$\hat{Y}$ = 18.72 + 380.97 (X)
305-days lactational yield on daily milking rate	50	0.52**	1051.98±241.79**	$\hat{Y}$ = 621.99 + 1051.98 (X)

** Significant at 1% level of probability

Fig. 4.

REGRESSION OF TOTAL MORNING MILK YIELD OF EXPERIMENTAL PERIOD OVER MORNING MILKING RATE

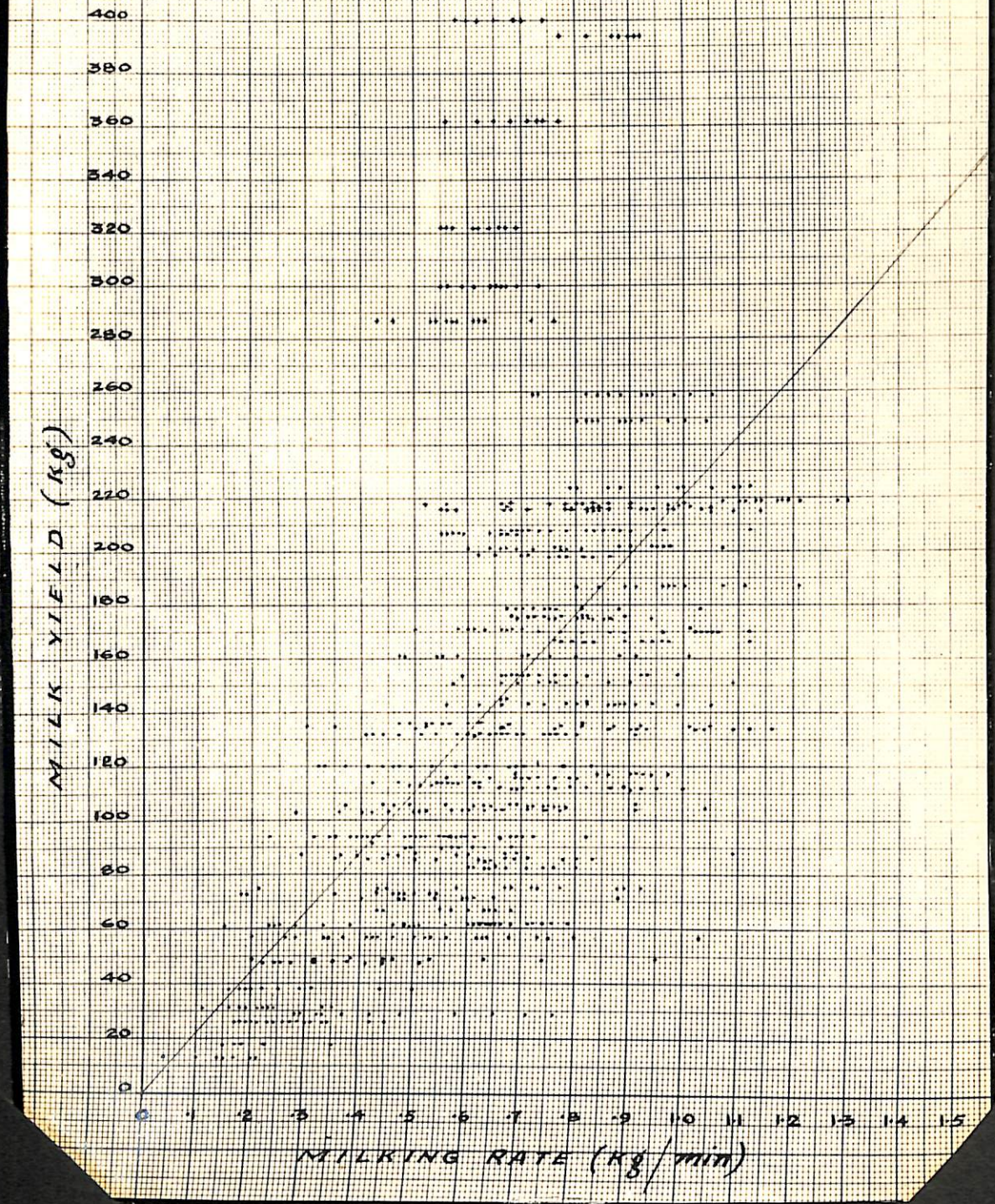


Fig. 5.

REGRESSION OF TOTAL EVENING MILK YIELD OF EXPERIMENTAL PERIOD OVER EVENING MILKING RATE

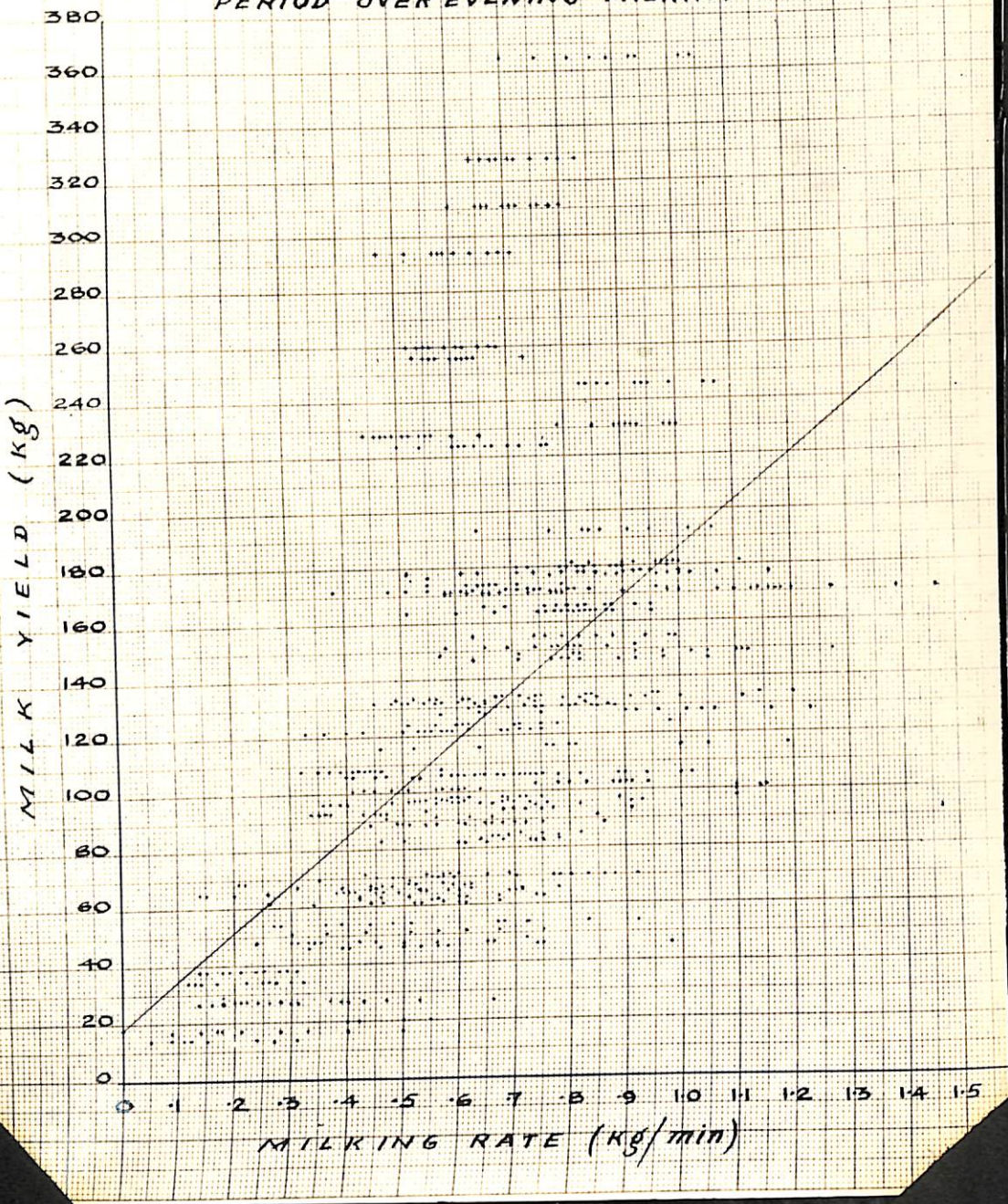


Fig. 6.

REGRESSION OF TOTAL MILK YIELD OF EXPERIMENTAL PERIOD OVER DAILY MILKING RATE

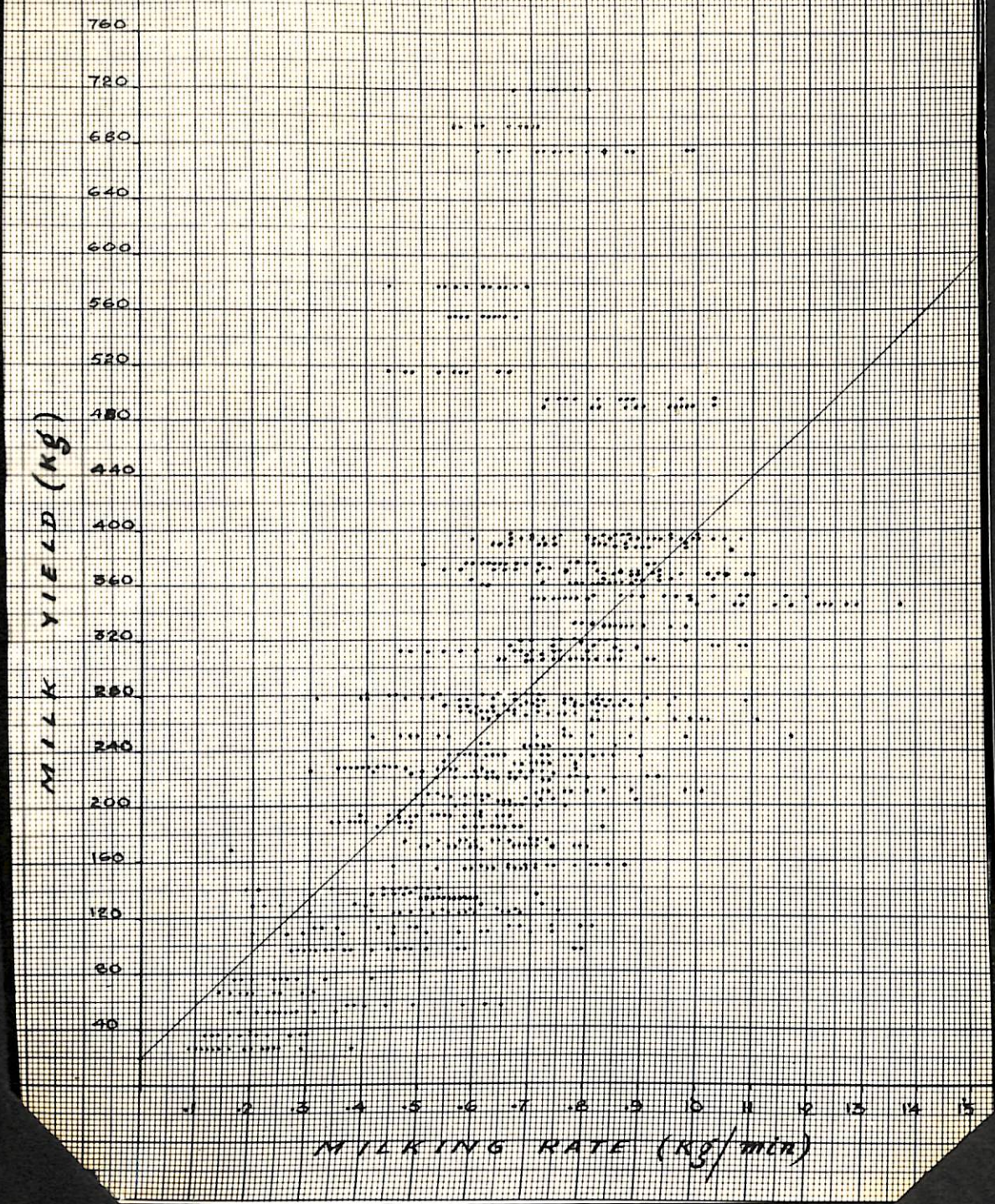
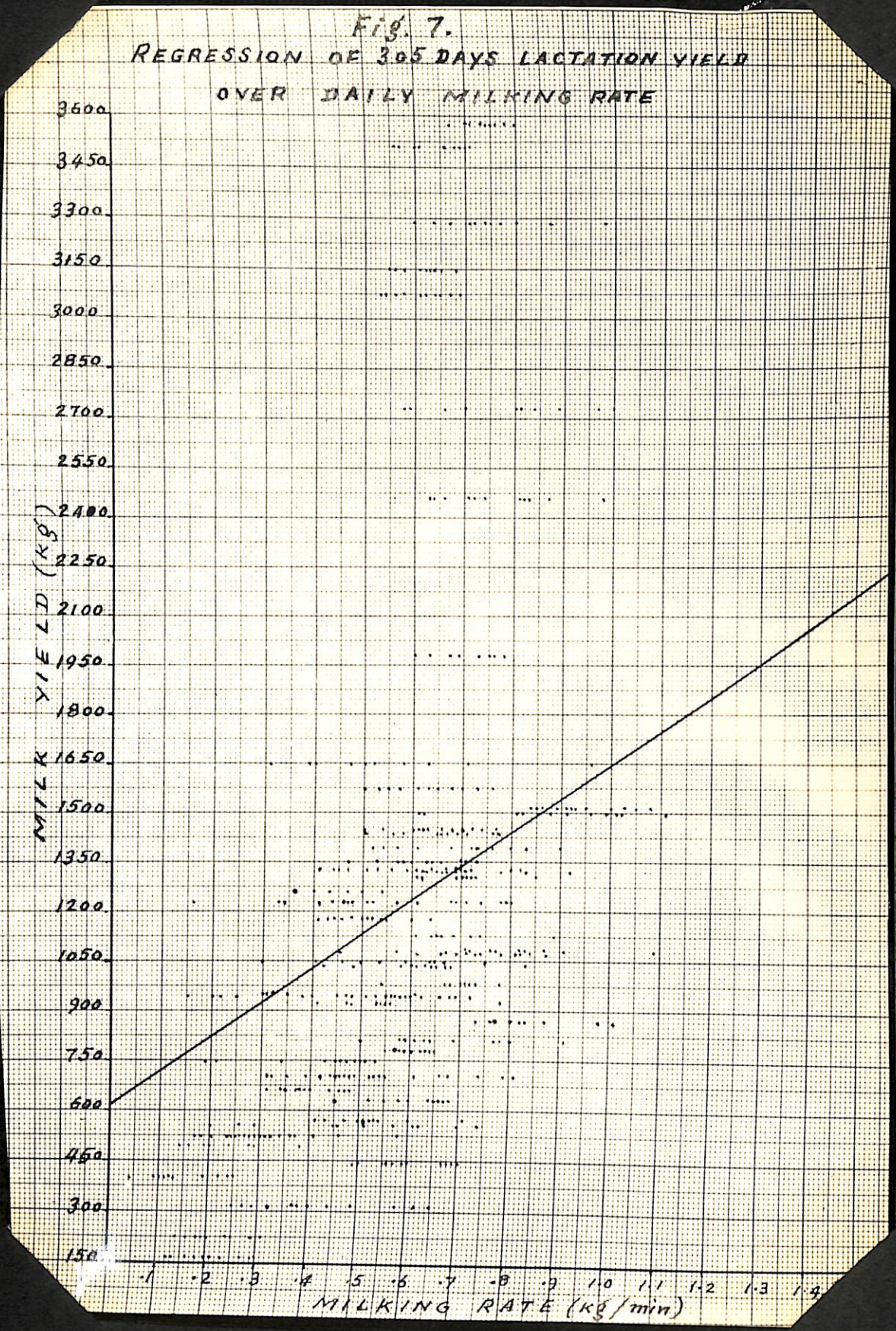


Fig. 7.

REGRESSION OF 305 DAYS LACTATION YIELD OVER DAILY MILKING RATE



DISCUSSION

DISCUSSION

Effects of some of the factors influencing hand milking rate were proposed to be examined in this study. The overall average rate in the present study was 0.66, 0.65 and 0.65 for morning, evening and daily milkings. In exotic animals with machine milking the rate had varied from 0.78 to 2.74 kg per minute (Hansen, 1954; Beigel, 1955; Hupp and Lewis, 1958; Donald, 1960; Andreae, 1964; Bennett et al, 1965; Rabek, 1965; Engeler et al, 1967; Piccot, 1967; Politiek and Vos, 1967). Even the hand milking rate reported by Szajko and Csondes (1961) was varying from 0.92 to 1.04 kg per minute. The milking rate in the present study was decidedly lower than in other countries possibly due to lower output of work by our professional milkers. Morning milking rate was consistently, though only slightly, higher than evening milking rate. This could be due to larger milk yield in the morning which may be a reflection of longer milking interval. Morning milkings took place at 2.30 A.M. and evening milkings at 2.00 P.M.

The heritability estimate of milking rate of 0.102 ± 0.099 in the Harianas was low as compared with that reported by Brumby (1957) who found it to be 0.862 and 0.674 for peak and average rates of flow. Keestra in 1963 had reported these estimates, using half-sib correlation, as 0.65 ± 0.11

and 0.56 ± 0.1 for peak and for average rates of flow respectively. The lower values of heritability estimate of milking rate in Harianas indicates lower genetic variability in this trait than is found in taurus animals. Improvement due to selection for this character will be very slow.

Within breed repeatability estimates were high being 0.69, 0.73 and 0.77 for the morning, evening and daily milking rates respectively; over 12 consecutive weeks. Similar high values of repeatability had been reported by Beck et al (1951) being 0.8 to 0.9 for daily and weekly milking rates and by Brumby (1957) being 0.812 for peak flow and 0.674 for average rate of flow; by Donald (1960) being 0.8 to 0.9 from lactation to lactation and by McDaniel (1962) being 0.73 from lactation to lactation. This high repeatability estimate of weekly milking rate indicates that the first weekly milking rate can be reasonably relied upon as an indicator of subsequent weekly milking rates.

The milking rates differed significantly from breed to breed. The different values of the milking rates were 0.69, 0.66 and 0.67 in Holsteins, 0.67, 0.60 and 0.61 in Girs, 0.59, 0.58 and 0.58 in Harianas and 0.77, 0.76 and 0.76 kg per minute in Murrahs for morning, evening and daily milkings.

Similar breed differences had been reported by Szajko and Csondes (1961) in Hungarian Spotted and Kostroma breeds of cattle; by Baundentistl (1965) in Austrian Simmental, Austrian Brown, Pinzgau and Yellow hill cows in Austria and by Politiek and Vos (1967) in Mense-Rhine-Yssel and Dutch Friesians. These breed to breed differences incorporate herd to herd differences also, though they are largely genetic in origin.

The milking rate varied from 0.04 to 1.46 kg per minute from animal to animal. The cows had a significant effect on the milking rate. The between animal variation was found to be 20, 22 and 18% of the total variation for the morning, evening and daily milking rates, respectively, while the corresponding figures for within animals were 6, 7 and 4 per cents only. Such animal to animal variation in milking rate had also been studied by Mathews et al (1928), MCandlish and Cochran (1930), Foot (1935) and Baxter et al (1950). Dodd in 1953 reported that between cows coefficient of variation was 30 to 40% while within cows was 11 to 18%; Brumby (1961) obtained the coefficient of variation between animals of 30-40% while within animals part was only 10%. This study showed that the milking rate is an individual character of the cow and may be influenced by her genetic

make up and by the permanent environmental influences to which she is exposed.

Sires had a significant effect as was shown by Ward (1950) who found that out of the 119 bulls studied, 55 bulls increased the milking rate, 37 bulls decreased it and the remaining 27 bulls had no effect. His findings were confirmed by the report of the British Oil and Cake Mills Ltd. (1954), by Hansen (1954) and by Beigel (1954). The Israel Society of Applied Animal Genetics in 1961 reported that 27% of the total variation in the peak flow was attributable to sires, though the sires contributed only negligibly to the variation in the average milking rate. The variation due to sires in peak as well as in average rate of flow was also reported by Politiek (1961); Keestra (1963); Venge (1963); Rabek (1965); Nielsen and Hinks (1967) and Politiek and Vos (1967). The sire effect was not found to be statistically significant on the milking rate in Harianas at Indian Veterinary Research Institute.

Majority of the workers have reported that with increase in age milking rate also increased. But Dodd (1953) did not detect any effect of age on milking rate. The same results were obtained by Butz and Schmahlsteig (1955). Andreae (1964) explained that the increase in

milking rate with increased age was due to increased milk yield.

The present study tends to support the earlier reports regarding the effect of age on milking rate. In Harianas there was a rapid increase in the milking rate as animals became older than five years. The rate for animals below five years was very low. After fifth year not much change occurred except that in animals over 10.5 years there was a decline which in Murrahs occurred after 12 years. No other trend in age effect of Murrahs was noticeable. Even within age groups morning milking rate was slightly higher than in the evening.

The trend for an increase in milking rate from early calver to maturity suggests that as maturity came milking machinery tended to improve and probably milk yield increased. Milking rate accompanied milk yield. As milk yield stayed more or less levelled upto a certain age and then declined so did the milking rate.

In both Harianas and Murrahs the stage of lactation had a statistically significant effect on the milking rate. The maximum rate was seen upto 6th week of lactation in Harianas then there was a decrease with the advancing stage

of lactation. The different groups formed on the basis of stage of lactation had animals of different ages. The numbers of animals had to be small. As a result of this mixture of two factors, the trends on milking rate were not very sharp. Variation in the milking rate as affected by stage of lactation had been reported by Dodd (1953) who found that milking rate decreased with advancing lactation. Simultaneously milk yield also changed. His finding was supported by the report of Guba (1959) and of Brumby (1961); on the other hand Schlolant (1963) found that in hand-milked cows, the milking rate increased with increased stage of lactation.

The milk yield of a cow was related to her milking rate. The regression coefficient was significant at one per cent level of probability. There was an increase, in morning milk yield of 220 kgs; in evening milk yield of 171 kgs; and in the total milk yield of 381 kgs within the experimental period for an increase of 1 kg milk per minute in the milking rate. The increase in 305-day's lactational yield was about 1052 kgs. for every kilo increase in milking rate.

Dodd and Foot (1953) had shown that with one pound increase in milking rate, the total lactational yield was

increased by 419 lbs, while Donald (1960) had found an increase of 50 gallons of milk in the lactation yield, for an increase of one pound milk in the milking rate.

The correlation coefficients between the same set of variables ranged between 0.52 to 0.59 and were all statistically significant. The correlation between the milk yield and the milking rate had been reported by a number of workers. Foot (1935) observed a correlation of 0.429 between milk yield and the milking time.

Clough and Dodd (1957) reported that there existed a positive correlation between milk yield and milking rate,. Johansson (1958) obtained a correlation between peak flow and 250-days lactational yield of 0.571 but after correction of the milking rate it was reduced to 0.147. Guba in 1959 estimated the linear correlation coefficient between milking rate and milk yield and found it to be 0.86 and 0.81 for morning and for evening milkings, respectively. His findings were supported by McDaniel et al (1962) who calculated, 0.83 as correlation coefficient between p.m. milking and p.m. milk yield while the correlation with 305-days milk yield was very low.

Brumby (1956); Sundaresan (1956); Sandvik (1957); and Rebak (1965) showed that no correlation existed between

milking rate and milk yield, Brumby even suggested that with a good milking technique the slow milkers were able to give higher yields.

The let down of milk is a transitory process. If the cow can not be quickly milked during her let down period, the milk will remain in the alveolar tissue. The residual milk decreases the milk yield in two ways : (1) decreased milk yield at that milking and (2) the residual milk in the alveolar tissue decreases further milk secretory activity of udder. This will reduce the total milk yield.

With a positive and significant correlation coefficient between milking rate and milk yield in the corresponding test period and in a lactation, milking rate could be used as an index of cow's producing ability. This could assist a breeder in earlier screaning out of very poor or unusually good producers.

Additional factors that affect this character need to be studied and even the observed relationships further analysed to enable greater use of this tool. The present study however furnishes some basic landmarks for planning suitable trials with the Indian cattle. It thus fulfils a lacuna that existed so far.

SUMMARY

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The present investigation was carried out to study the hand milking rate, factors influencing it, and its relationship with milk yield in the herd of dairy cows and buffaloes in Farm Animal Genetics Section, Indian Veterinary Research Institute, Izatnagar. The number of animals included was 77, comprising of Holstein-Friesian, Gir and Hariana cows and Murrah buffaloes. These were divided into six groups. The following observations were taken :

1. time of suckling (or of massaging the udder in the weaned cows),
2. time of milking and
3. milk yield in kilogram.

Observations were taken once in a week for each group at the morning and at the evening milkings. Study extended over a period of twelve consecutive weeks.

The overall average milking rate was 0.66 kg per minute for morning milking, 0.65 kg per minute for evening milking and 0.65 kg per minute for daily milking, with the range between 0.04 and 1.46 kg per minute.

The heritability estimate for daily milking rate in Harianas was 0.102 ± 0.099.

Within breed intra-cow repeatability estimates were 0.69 for morning milkings, 0.73 for evening milkings and 0.77 for daily milkings.

The milk yield and the milking time of Holsteins, Girs and Murrahs did not differ significantly over the 12 weeks in the mornings as well as in the evenings, however, in the Harianas the milk yield did differ significantly both in the morning and in the evening, but the milking time differed significantly in the mornings only.

The milking rate differed significantly from breed to breed. The average milking rates in kilograms per minute were 0.69, 0.66 and 0.67 in Holsteins; 0.67, 0.60 and 0.61 in Girs; 0.59, 0.58 and 0.58 in Harianas and 0.77, 0.76 and 0.76 in Murrahs for morning, for evening and for daily milkings, respectively. In all the cases morning milking rate was slightly but consistantly higher than that in the evenings.

A statistically significant difference was found among animals in their milking rate. The component of variance in milking rate among animals was 20, 22 and 18 per cent of the total variance at morning, evening and daily milkings whereas the magnitude of within cow component was 6, 7 and 4 per cent, respectively.

The sire effect was studied on the daughters of 9 bulls in Harianas. No statistically significant difference was found in the milking rate in different daughter groups.

The effect of age on milking rate was studied in Harianas and in Murrahs. It was statistically significant in both the breeds. In Harianas, one third of the total variation in milking rate was due to age differences while it was one fifth in Murrahs.

The effect of stage of lactation on the milking rate was also studied in Harianas and in Murrahs. A highly significant difference was found among stages of lactation. In Harianas it accounted for about 25 per cent of the total variation whereas in Murrahs it was associated with only nine per cent in the morning and 33 per cent in the evening milkings.

Highly significant and positive coefficients of correlation between milk yield and milking rate were found. These were calculated among animals within breeds, separately for morning, for evening and for daily milkings for the experimental periods and also for 305 days lactations. The correlation coefficients were 0.59, 0.54, 0.57 and 0.52

respectively. The linear regression coefficients for the same variables were 219.77, 170.51, 380.97 and 1051.98 kgm per kilo per minute. The regression coefficients were significant at one per cent.