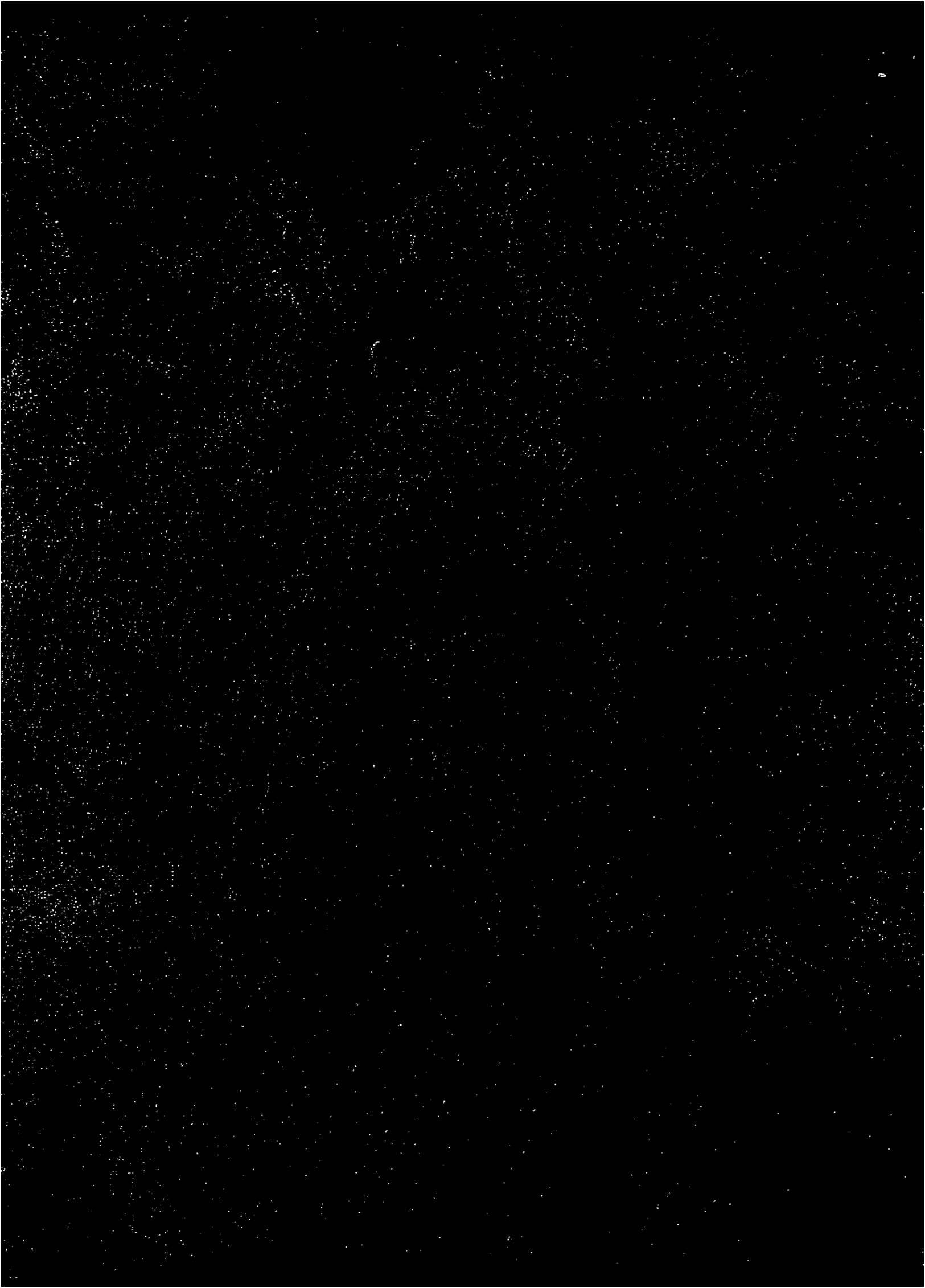


I certify that this Thesis

has been prepared under my supervision

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A STUDY ON MONTHLY MILK YIELD AND ITS PERSISTENCY IN THARPARKAR HERD AT PATNA.

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A THESIS

Submitted to the Faculty of Veterinary Science and Animal Husbandry, Magadh University, in partial fulfilment of the requirements for the Degree of Master of Science (Animal Husbandry).

BIHAR VETERINARY COLLEGE
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INTRODUCTION.

I N T R O D U C T I O N.

The importance of milk and milk products are universally recognised. In India, where majority of the people are vegetarian milk and milk products constitute the only source of Animal protein in their diets. Every individual is required to consume 10 ozs. of milk as a minimum nutritional requirement. In advanced countries, meat also constitute article of diet as majority of them are non-vegetarians.
In India, the present per capita consumption is only 5 ozs. per day, where the actual requirement is about 10 ozs. There is no known substitute for milk. Hence milk is an indespensable food. This fact is still of greater significance, when the country is faced with the pressing problem of raising the nutritional standard of people. Thus indicating the necessity and magnitude of effort to be put forth to step up the milk production in Indian cattle.

With a cattle population of over 215 millions, India has largest number of cattle, representing nearly one-third of the cattle population of the world. But the productive capacity is not commensurate with its size. The world's total milk production is 600,348 million lbs.

The following table clearly indicates the poor productivity of Indian cow. (I.C.A.R., 1961).

Table 1.

COUNTRY.	Population (thousands).	Total cattle (thousands)	Milk (1000 metric tons.	Milk yield per cow.
U. S. A. ...	1,86,174	95,592	48,729	2,720
SWEDEN. ...	7,316	2,434	3,935	2,770
DENMARK. ...	4,466	3,168	5,068	3,440
NEWZEALAND ...	2,178	5,924	3,199	2,540
U. K. ...	51,208	10,907	11,619	3,010
INDIA. ...	3,87,000	1,58,863	45,000	190

hhhh

Table (2) & (3) will give an idea of density and cost of milk when compared to the economic conditions in India and other advanced countries.

Table (2).

Cattle Population in India and other countries.
(Gosamvardhana, 1961)

COUNTRY.	Per sq. mile.	Per 100 persons.
U. S. A. ...	28	55
NEWZEALAND. ...	49	262
I N D I A. ...	123	43
DENMARK. ...	182	72

Table (3).

Price of milk, purchasing capacity, per capita consumption in countries mentioned in table (2).
(I.C.A.R., 1961)

COUNTRY.	Price per litre.		Average wage earned by a worker such as a Car driver per day.		Time for which he has to work to be able to purchase a litre of milk.		Daily per capita consumption	Proportion of wage spent on milk for a family of three.
	Rs.	nP.	Rs.	nP.	Hr.	Mts.	Oz.	in %
U. S. A.	1	00	66	67	0	10	22.0	3.0
NEWZEALAND.	0	50	18	68	0	09	22.5	6.0
INDIA.	0	50	3	34	1	07	5.5	7.5
DENMARK.	0	50	20	00	0	12	17.5	3.9

The percentage of proportion of wage spent on milk for a family and the availability of milk is inversely variable. If a common man in India has to get his minimum requirement of milk, the milk production has to be doubled.

It may be interesting to note that of the total 528 million maunds of milk produced in India, 43% or roughly 228 million maunds is the share of the cow and the remaining 300 million maunds is produced by the buffalo (54%) and goat 3%. (Gosamvardhana, October, 1961).

The high yielding cows have been known to be economical producers. Olson (1950) points out that a high producing cow is more efficient than a low producing one, and Eckles as quoted by Olson (1950) put forth the reason for the greater economy of high producing cow. He ascribed it to the inherited impulse for milk production, which in turn caused the greater efficiency in utilisation of feed. The study of the D.H.I.A. records leads to the same conclusion as found by the studies from the various experiment stations that "Increased production is accompanied by increased profit over cost of feed regardless of breed, age, herd, weight, date of freshening, or geographical location. Cost data on large number of herds kept at Wisconsin Station leads to the conclusion that as production increased from 5,500 lbs. to 8,600 lbs. per cow, the cost of

production per hundred-weight of milk decreased from ₹ 3.82 to ₹ 2.64. So, for profitable milk production high producing cows are necessary.

Milk yield has relatively more economic importance than the other economic traits. Prasad (1962) worked out the relative economic importance of milk yield, age at 1st calving, calving interval and lactation period. Based on his findings, the relative importance of the following traits were calculated in terms of percentage and it is as follows:-

Milk yield.	...	...	42%
Age at 1st calving.		...	18%
Calving interval.		...	24%
Lactation period.		...	16%

It clearly points out that stepping up total milk production has much economic significance. Milk production is a quantitative trait influenced by a large number of factors both inherited as well as environmental. It has been rather difficult to separate the effect of one from the other. The research in this direction is not conclusive, but there are evidences for the assumption that milk production is an inherited trait.

To improve lactation yield in cattle, it is essential first to know the factors which influence the ultimate quantity of milk produced. Total yield of milk in a lactation is indicated by the shape of the lactation curve. Gilmore (1952) reported that it was affected by factors that primarily determine:-

(a) The height of the initial yield.

(b) The persistency with which that maximum yield is maintained;

and

(c) The length of the lactation period.

In the present study, an attempt was made to detail the trends in monthly milk yield and its persistency in Tharparkar herd of cattle, maintained at Government Cattle Farm, Patna.

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Chapter (I).

REVIEW OF LITERATURE.

Chapter (I).

REVIEW OF LITERATURE.

A cow's milk producing ability is known by its lactation yield. Milk yield in 300 or 305 days is generally termed the 'Standard - lactation yield', and it represents the total mammary activity, over the lactation period. During this period, the rate of secretion fallows a definite trend. Immediately after calving, the milk yield rises, reaches maximum or peak in 4 to 8 weeks, and then steadily declines until secretion stops or the cow is dried off. This trend is known as the 'Lactation curve'. (Hammond, 1957).

Kartha (1934, a) pointed out that the 'period of rise' was very small compared to the period of decline, and hence the yield for the lactation would depend to a large extent on the rate at which the yield falls off. The curve can be expressed by simple mathematical equations; one such commonly used is exponential equation.

Ludwick and Petersen (1943) as quoted by Gilmore (1952) stated that three factors were responsible for bringing about variation in the total milk production; they were:

(I) Maximum initial production;

(II) The persistency with which the yields are maintained and:

(III) The length of the lactation period.

MAXIMUM INITIAL PRODUCTION.

(1) Maximum initial production is a heritable character and is influenced by the environment. Estimates of heritability for maximum yield in different breeds of cattle were worked out by different investigators and are given in table (4).

Table (4).

Breed of cattle.	Heritability.	Reference.
Ayrshire. ...	0.298	Sikka (1950)
Short horn. ...	(range) 0.27 - 0.40	Chief Bureau of Animal Industry, Agricultural Research Admn., U.S.A. (1952)
Jersey. ...	0.47	Rakes et al (1959)
Holstein. ...	0.10	
Sahiwal. ...	0.4519 ± 0.1133	Batra (1961)

??

(2) Different breeds differ in the duration they reach their peak yield. This period is represented by the ascending phase of the lactation curve.

According to Kartha (1934, a), a large majority in all the breeds of cattle attain their maximum yield between the 3rd and 6th week after calving, that is, roughly in the second month of lactation.

In European cattle, Jordao and Paula (1951) reported that maximum yield in all cases attained during the second and third weeks of lactation among twice daily milking cows.

Delage et al (1953) reported that in Dutch Friesian cows, maximum production was reached on sixtyth day of lactation in 96% of the cows.

Maymone and Malossini (1959) studied normal lactation records of Dutch Friesian, Swiss Brown, Simmental, Dutch Redpied and Holstein - Friesian breed of cows and found that on an average maximum yield was attained in 28.31 days after calving.

Maymone and Malossini (1961) reported that the average duration of the ascending phase of the lactation curve was 37.3 ± 0.80 days in water-buffaloe cows.

(3) In Indian cattle, Sikka (1933) reported a significant correlation between the mean yield of fourth lactation and maximum yield.

Sikka (1950) observed in Ayrshire cows that maximum yield rose gradually from first lactation to a peak in the fourth lactation, after which it declined.

According to Tierzucht (1952) milk yield increases with age reaching a maximum in the 5th lactation. The maximum yield on an average was 15.3% more than first lactation yield.

In Short-horn dairy cattle Bailey (1952) reported maximum yield in the 6th lactation.

Ragab et al (1954) stated that in Egyptian cows, maximum yield was reached at 5th or 6th lactation.

Yapp (1955) suggested that in most dairy cattle breeds, maximum yields are obtained at about seven years of age.

According to Hammond (1957), maximum daily yield was attained about two lactations after the lactation in which mature yield was reached. He further stated that as total lactation yield increased or decreased with increase in age in lactations, the maximum daily yield also followed the same trend.

Asker et al (1958) reported that Egyptian cows reached maximum yield in 3rd or 4th lactation.

Rakes et al (1959) dealing with lactation records of Holstein and Jersey breeds, stated that maximum yield tended to be higher after the 3rd lactation.

Batra (1961) reported maximum peak yield in the 4th lactation among Sahiwal cows.

Balu (1961) reported in German Simmental cattle, an increase in initial production upto 7th lactation, as a consequence of an increase in lactation yield. In later lactation yields, initial production and lactation yield decreased.

FACTORS INFLUENCING INITIAL MAXIMUM YIELD:-

(1) Inherent milking rate:- Hammond (1957), based on the preliminary studies carried out by Dodd and Foot (1953) on the correlation between inherent milking rate and maximum yield, concluded that the former has a direct bearing on the later, since inherently fast milking cows yield more milk than slow milkers.

Wilke (1960) reported in cows a highly significant correlation between daily yield and maximum flow per minute.

(2) Body weight:- Macha (1957) observed in Red-spotted cows an increase in yield with an increase in the body weight for the first six lactations.

(3) Weaning:-

Biswal and Rao (1960) studied lactation records of Red Sindhi cows and found that dams of weaned calves gave a lower average daily yield.

(4) Age at first calving:-

Batra (1961) observed in Sahiwal cows a significant positive correlation between age at first calving and peak yield.

Kohli et al (1961) found no significant effect of age at first calving on average daily milk yield or overall average daily milk yield in Hariana cows.

(5) Twinning:-

Gilmore (1952) stated that the effect of twinning on lactation is one of inhibitory effect on attaining a high maximum yield during the first seven weeks.

(6) Season of calving:-

Jordao and Assis (1952) observed in Friesian cows that those having calved in the hot and wet season had lower initial yield than those calved during the cold, dry season. The lactation curve of former was almost flat, whereas that of the latter declined fairly steeply.

Maymone and Malossini (1959) investigated the effect of season on peak yield in five European breeds of cattle and found a significant effect on the duration in which peak yield is attained. In spring, they attained

peak earlier than in the winter. They also found that age of cow, breed or level of production had no significant effect on the duration of the ascending phase of the lactation curve.

McNab (1960) analysed milk records of Friesian cows for seasonal variations in the production. He found that cows calving from May to August had a higher level of production and higher total yield than cows calving from January to April or from September to December.

Dutt and Singh (1961) observed in Hariana cattle a significant effect of season of calving on peak yield.

(7) Frequency of milking:-

Mahadevan (1957) reported in Indian dairy breeds an increase of 6.6% in average daily yield per cows in 3 times a daily milking over twice daily milking. He considered that the extent of increase in yield was not economical when compared to the cost involved in 3 times a day milking over twice a day milking.

(8) Feeding and management:-

Nichols (1945) suggested that early rise in production could be enhanced by extra feeding.

Maynard (1956) stated that the period to attain the peak yield depended on the management and feeding practices in the herd.

CORRELATION STUDIES:-

Sikka (1950) studied the comparative importance of maximum yield and persistency in determining the total yield and reported that the maximum yield was three times as important as persistency.

Mahadevan (1951) found in Ayrshire cattle, that persistency, initial milk yield and 180-day milk yield to be positively correlated with one another on a "between-cows-within herd" basis and concluded that it should be possible to combine high initial yield with high persistency to obtain increased total production.

Ullah (1952) found in Holstein cows significant positive correlations between initial yield and persistency, and between initial yield and total production. He also found significant, positive partial correlations for initial yield on total production when persistency was kept constant; and for persistency on total yield when initial yield was kept constant. He concluded that initial yield and persistency had a greater effect on total production; and improvement in these characteristics would lead to greater and more economical production.

Ludwick and Petersen (1943) stated correlation coefficient between maximum yield and total yields to be ranging from 0.6 - 0.9.

Mahadevan (1953) reported in Black Sinhala cattle (Ceylon) the correlation coefficient between total yield and daily milk yield as 0.82 ± 0.02.

Madden et al (1955) estimated in Holstein cows the genetic correlation of first 30 days milk yield with that of 305-days and found to be 0.96.

Lennon and Mixner (1958) studied the records of Holstein and Guernsay breed cows and reported a high correlation between lactation milk production with maximum initial yield and persistency to be 0.81 and 0.32 respectively on an "among-cows-in-lactation-in-breed" basis; whereas they found no correlation between maximum initial yield and persistency which was 0.04. They suggested that maximum initial milk yield and persistency as independent factors which collectively influence lactation milk production in a positive way (R = 0.86).

Rakes et al (1959) found in Holstein and Jersey breeds significant positive correlation between maximum yield and total production.

Jersey	...	...	0.67
Holstein	...	...	0.72

Saxena and Kumar (1960) reported in Sahiwal cows significant multiple correlation between persistency and maximum yield on total lactation yield. They stated that persistency and maximum yield accounted for more than 95% of the total variation in lactation yields.

Batra (1961) found significant intraherd correlations of peak yield with initial yield and lactation period in Sahiwal cows. Peak yield is positively correlated with milk yield and lactation period.

Mahadevan and Marples (1961) reported in the Entebbe herd of Naganda cattle in Uganda, a high correlation between lactation yield and average daily milk yield, which was 0.62.

Balu (1961) found in German Simmental cattle a high positive correlation between initial milk production and 300-day yield and also 100-day yield. On the other hand, he observed a negative correlation between initial maximum yield and persistency, which was -0.3058 ± 0.0397. A rise of 1 Kg. in initial production resulted in a drop of 0.46 % in persistency.

Suchanek (1962) found correlation coefficient between maximum daily yields and lactation yield to be 0.750 from 960 lactation records of cows in four herds.

(II) PERSISTENCY OF YIELD.

Persistency is defined as the ability to maintain a relatively high level of production throughout the lactation period, and it is one of the qualities possessed by all high yielding cows. This ability contributes a great deal towards the income from operating a milk producing herd, as stated by Fohrman et al (1954).

Relationship between persistency and rate of decline:-

Persistency is measured as rate of decline in yield, the later being represented by the symbol 'k'. The use of 'k' as a measure of persistency has been criticised because it is negatively correlated with actual persistency and hence confusing in its interpretation in correlation studies. This objection was overcome by the use of the following transformation suggested by Lennon and Mixner (1958).

Persistency Index = (P) = 100 - (k X 100)

in which (P) is now positively correlated with actual persistency and is expressed on a percentage basis.

Heridity and persistency:-

Persistency is a heriditary character and modified greatly by environmental factors. According to Petersen (1950), heridity plays a major role in accounting for variation in persistency. Beef breeds of cattle lack in persistency. Gilmore (1952) stated that persistency is an inherited character that persists throughout life. Kartha (1934, a) reported that persistency is important in affecting the shape of the lactation curve and hence in affecting the lactation yield.

The role of certain specific hormones in affecting the persistency has been reviewed by Petersen (1950), Gilmore (1952), and Hammond (1957). These harmones maintained milk production when injected into the milking animals. Petersen (1950) suggested that the inheritance of factors for persistency are concerned probably with harmones of Anterior Pitutary, but attempts at determining the nature of inheritance met with little success and have indicated only, that persistency in all probability has a complex inheritance.

Sikka (1950) estimated the heritability of persistency of milk in Ayrshire cows to be 0.292.

Mahadevan (1951) dealing with another herd of Ayrshire cattle in South-west Scotland, reported the heritability and repeatability for persistency of milk to be as follows:-

Heritability ... ... 0.10 to 0.15

Repeatability ... ... 0.242.

Mahadevan (1958) explained that the low heritability of persistency of milk permits wide range of expression of this character even under apparently similar or completely divergent conditions of feeding and management.

Suchanek (1962) estimated repeatability of persistency index which was 0.393 in four herds of cows.

Level of production and its influence on persistency:-

Kartha (1934, b) observed that the rate of decline increased with rise in level of production among the Zebu, Crossbred cows and buffaloes.

Sikka (1950) observed in Ayrshire cows that months associated with low maximum yield had a high persistency and vice versa.

Ullah (1952) stated that higher initial yield was associated with lower persistency in Holstein cows.

Maymone and Malossini (1960) found that cows yielding 375 Kg. or less in their first month had a higher persistency than those yielding more in Brown Alpine cows and it was 86.7% versus 80.0%.

ENVIRONMENTAL FACTORS INFLUENCING PERSISTENCY:-

(1) Frequency of milking:-

Petersen (1950) stated that frequency of milking has a significant effect upon persistency. Cows milked three times a day are more persistent than those milked twice a day; but from the economic point of view, he pointed out that the cost of three times milking a day is 50% higher than that of twice-a-day milking.

In Holstein cows, Ullah (1952) observed that cows milked twice a day were more persistent than cows milked once a day.

Gilmore (1952) pointed out that three times milking per day gave lower persistency than twice daily milking but higher than four times milking. He ascribed this difference, to the level of production.

(2) Age at first calving:-

Jordao and Paula Assis (1948-49) studied the lactation records of Friesian, Guernsey, Normandy, Red poll, Ayrshire and Brown Swiss cattle. He could not establish correlation between persistency and age at first calving.

Maymone and Malossini (1960) dealing with the records of Brown Alpine cows, found that persistency was greater in cows calving at 1.6 - 3.6 years of age than in cows calving at older ages i.e. between 3.7 - 11.6 years.

(3) Service period:-

Jordao and Paula Assis (1948-49) could not establish correlation between persistency and interval between calving and service among the six breeds of European cattle.

(4) Dry period:-

Maynard (1956) stated that dry period affects the persistency in the next lactation. The longer the dry period, the greater is the persistency in the next lactation.

(5) Lactation period:-

Asker et al (1958) observed in Egyptian cows a significant correlation between lactation period and persistency.

Asker and Bedeir (1961) reported a significant increase in the persistency values with increase in lactation length in Egyptian buffaloes. They found correlation coefficient between lactation period and persistency to be 0.726, which was highly significant.

(6) Gestation:-

Delage et al (1953) observed in Dutch Friesian cows that gestation tended to increase the persistency in the first four months and then it had a depressing effect.

Yapp (1955) pointed out that the rate of decline in daily yield is steady until about the fifty month of pregnancy, when the decline became somewhat more rapid. The decline, he attributed, to two factors, viz. (i) withdrawal of nutrients from the mother for the development of foetus and (ii) the effect of hormones which inhibit milk production. The later effect is presumably a provision of nature for reduction in yield of milk and restoration of body reserves in preparation for the lactation which is tog follow within a few months.

According to Maynard (1956), pregnancy exerts its effect on persistency of yield from twenty-second week after a new conception. The onset of a new pregnancy during lactation results in a more rapid decline in the secretion than otherwise occurs, and no system of feeding will counteract in any way the normal decline.

Hammond (1957) has put forward his opinion that gestation has an effect on persistency and therefore on total production. The inhibitory effect of pregnancy on yield, is regarded as caused directly by a physical inhibitor to milk secretion in the circulation rather than as due to the draft of growing foetus on the nutrients of blood. He further pointed out that since conception usually tended to occur two or three months after calving, the effect of pregnancy is shown by a change in the persistency, but not in the maximum daily yield.

(7) A g e:-

Kartha (1934, b) analysed milk records of herds of Indian and crossbred cows and buffaloes and found that the rate of decline was found to increase definitely from the first to second lactation. From the second to third, the increase was less marked and the lactation curve tended to be flat. Beyond this, no relationship between age and persistency was noticed. He indicated that persistency is influenced by level of

production than by age.

Sikka (1950) observed in Ayrshire cows , a drop in persistency after first lactation and it continued to drop more gradually with age.

In Holstein cows, Ullah (1952) observed persistency decreasing with age in lactations.

Gilmore (1952) stated that persistency decreases with age in lactations, the persistency in the second lactation is about 10% less than in the first.

Corley (1956) found that cows in the first lactation were about 8% more persistent than in the second.

Maynard (1956) explained that persistency decreased in succeeding lactations. The level at which the secretion begins increases to maturity but that the total yield for the lactation is not proportional to the rise because of a declining persistency factor.

According to Hammond (1957), persistency declines from the first lactation onwards until about 6th lactation, after which it relatively remains constant.

Balu (1961) found in German Simmental cattle, a decrease in persistency value upto 7th lactation, after which it rose in later lactations.

(8) Calving interval:-

Ullah (1952) based on his findings in Holstein cows, stated that a short calving interval depresses the persistency index, and long calving interval increases persistency.

(9) Season:-

Mahadevan (1951) observed in Ayrshire cows that the month of calving had a significant effect on persistency.

Martinez Marco (1953) observed greater rate of fall in yield in Swiss Brown cows, when calving took place in April - July.

Hammond (1957) stated that season of calving had a significant effect on persistency.

Mahadevan (1958) reported that the persistency of the cows in the tropics is lower than that in the temperature countries.

McNab (1960) analysed milk records of Friesian cows for seasonal variations in the production. He found that cows calving from September to December had the lowest persistency of yield.

(10) Feeding and management:-

Mahadevan (1951) after an extensive study in Ayrshire cows suggested that improved feeding and management can bring about greater returns in the direction of improved persistency.

Fischer (1958) based on his findings with Wurttemberg spotted mountain cows, concluded that selection for persistency can only be effective amongst fows whose feeding and management is similar.

Fuhrken (1959) investigated into the milk records of Black pied cows and he considered that the shape of the lactation curve depend primarily on environment. He suggested that the nature of the feeding must be known before any pronouncement can be made on the persistency of a milching cow.

McNab (1960) studied the production records of Friesian cows and reported that persistency in lactation was related to changing nutritional conditions.

CORRELATION STUDIES:-

In Ayrshire cows, Sikka (1950) found significant within cow correlation between:

(a) persistency and maximum yield ... - 0.17
(b) persistency and total yield ... + 0.37
(c) maximum yield and total yield ... + 0.70

Maximum yield and persistency both together correlated with total yield, and R (multiple correlation) was 0.854. These two factors accounted for most of the variation in total yield.

Mahadevan (1951) also observed that persistency, initial yield and 180-day milk yield were positively correlated with one another on a between cows within herd basis. He concluded that it should be possible to combine high initial milk yield with high persistency to obtain increased total production.

Ullah (1952) in a detailed study with the production records of Holstein cows, found negative correlation between coefficient of variation in yield and persistency of milk. Dairy animals having a high coefficient of variation were found to be less persistent. The correlation coefficient between persistency and total production had been found to be 0.4132 ± 0.1311 and partial correlation between persistency and total production when initial yield was kept constant was 0.8713. All these correlations were significant.

Asker et al (1958) found in Egyptian cows a significant correlation between persistency and total milk yield and between lactation period and persistency.

Saxena and Kumar (1960) observed in Sahiwal cows a significant positive correlation between persistency, initial yield and total lactation yield. They stated that persistency alone accounted for more than 60% of the variation in total yield.

In German Simmental cattle, Balu (1961) found a significant correlation between persistency and lactation which was 0.481 ± 0.079. A rise in persistency of 1% resulted in an increase of 35.4 Kg. milk.

Suchanek (1962) found correlation coefficient between persistency and milk yield to be 0.295 and between persistency and maximum daily yield, a negative correlation which was -0.209.

Economic importance of persistency of yield:-

Kartha (1934, a) stated that pedigree animals are able to make up in the course of a lactation a good portion of the difference in their lactation yield by virtue of their highest persistency.

Sikka (1950) stated that persistency is one-third as important as that of maximum yield in determining the total yield.

Gilmore (1952) explained that two cows may start with same initial production but because of difference in persistency of yield between them, the total production is higher for the persistant one over the lesser persistent one.

LACTATION LENGTH.

Unlike the other two characters, initial yield and persistency, lactation length is most environmental. In a well-managed farm, it is aimed at getting a calf every year out of each cow. Standard lactation length is 305 days and optimum dry period is 60 days. To achieve this, certain regular managemental practices need attention.

While the cow is in milk, it should be served early after calving, the optimum period between post calving interval to conception is 85 days. Allowing 280 days as normal gestation period in cattle, it is possible to get a calf every year. The result of such good managemental practices will be an improvement in life time production.

Yapp (1955) observed that lactation period is of considerable importance as it affects the total lactation yield. The estimates of heritability and repeatability of lactation length in different breeds of cattle are presented in the table (5). (See page 29).

Lush and Shultz (1936) expressed that less than 10% of the variance in lactation length is due to heridity in the simple additive sense.

These estimates suggest that the additive genetic variance for this character is low except in Sahiwal cattle (Batra, 1961), in which improvement can be brought about by selection. In other cattle, mentioned in the table (5), selection is ineffective in bringing about improvement in this character.

Table (5).

---	Lactation length.		Reference.
	Heritability.	Repeatability	
Egyptian buffaloes.	0.11	0.263	Asker et al (1953).
Buffaloes near Alexandria.	-	0.16	Alim and Ahmed (1954).
Native cattle in Egypt.	-	0.258	El-Itrby and Asker (1956).
European cattle.	-	0.186	
Crossbred animals.	-	0.196	
Egyptian buffaloes.	-	0.187	
Nganda cattle.	0.1	0.42	Mahadevan and Marples (1961).
Sahiwal cow.	0.3740 ± 0.1534	0.2507	Batra (1961)
Butana cattle, Sudan.	-	0.415 ± 0.043	Alim (1962).
Tharparkar herd at Patna.	0.09	-	Prasad (1962).
-do-	0.08	-	I.C.A.R. Team (1957) as quoted by Prasad (1962).

INHERITED FACTORS INFLUENCING LACTATION LENGTH:-

(1) Persistency:-

Gilmore (1952) stated that low persistency tends to shorten the length of lactation.

In Egyptian cows, Asker et al (1958) reported a positive, significant correlation between lactation period and persistency.

Non-heriditary factors influencing lactation length:-

(1) Weaning:-

Biswal and Rao (1961) observed in Red Sindhi cattle, that dams of weaned calves had a shorter lactation.

(2) Age at first calving:-

In Red Sindhi, Gir and crossbred cows, Venkayya and Anantakrishnan (1956) found significant positive coefficient of correlation and regression between age at first calving and first lactation length.

Happ and Teschner (1957) observed from the data of Black pied and Red pied low land heifers, that lactation length was shorter in heifers that calve at less than 30 months of age than those calving at 30 months or above.

(3) Season:-

Pegg (1955) surveyed lactation records of dairy cows in Queensland from 1948-53 and observed that month off calving was related to lactation length . Cows calved in the third quarter of the year had the longest lactation.

In cows kept at Konigshutte in Upper Harz, Weiland (1959) reported a significant effect of month of calving on lactation length.

Tomar and Mittal (1960) found that season of calving significantly affected the lactation period in Hariana cows.

Dutt and Singh (1961) observed in Hariana cattle, a significant effect of season of calving on lactation period.

Balu (1961) found in German Simmental cattle that lactation following calvings during the summer (June and September) were generally longer than those during the winter because of differences in nutrition.

Singh et al (1962) did not find significant effect of season of calving on lactation length in Tharparkar herd at Patna.

(4) Age:-

Singh and Desai (1961) analysed lactation records of Hariana cattle and reported that the lactation period decreased from the first lactation to the third.

(5) Service period:-

Sikka (1931) considered service period as a potent factor in determining the lactation yield by affecting the length of lactation. He found the correlation between service period and lactation length to be 0.524 in Indian cattle.

According to Kartha (1934, a), the length of milking period depends largely on the time interval between calving and conception. If conception takes place within two or three months after calving,

the animal will remain in milk for about 10 months and longer will be the lactation period if conception is delayed. He found significant correlation between service period and lactation length and it was 0.7. For every month's delay in service, the lactation is prolonged on an average by a little over a half month.

(6) Gestation:-

Delage et al (1953) observed in Dutch Friesian cows two phases of decrease in lactation, one from 60 - 250 days, and another from 250 - 300 days. The later was more rapid in decline than the former.

Maynard (1956) stated that the onset of a new pregnancy was a determining factor in the lactation length of a cow.

Correlation between lactation length and total yield:-

Sikka (1931) reported a significant coefficient of correlation between lactation length and milk yield in Sahiwal cows and it was 0.695.

In White Fulani cattle, Robertson (1950) as quoted by Batra (1961) reported a correlation of 0.9 between length of lactation and milk yield, which is highly significant.

Mahadevan (1953) found in Black Sinhala cattle of Ceylon, a significant coefficient of correlation between total yield and lactation length.

Mahadevan (1955) reported a significant correlation coefficient of 0.6 between lactation period and milk yield in Red Sindhi cattle.

Mahadevan (1956) summarised the results of correlation studies on milk yield and lactation period based on data collected on different breeds in Ceylon and also on some published data in India (1941) and they are given below:-

Sinhala cattle.	...	0.44
Red Sindhi.	...	0.60
Sahiwal.	...	0.42
Crossbred.	...	0.50 to 0.55

In Egyptian cows, Asker et al (1958) observed that an increase in the lactation period accompanied increase in milk production. The regression of milk yield on lactation length showed that for an increase of one day in lactation period, the milk production increased by an amount of 8 lbs. The correlation coefficient between the two characters was highly significant (0.731). There was a positive and significant correlation between lactation period and persistency. They concluded that an increase in the lactation length will eventually improve the producing ability of cow.

In White Fulani cattle at Shika, the correlation between length and yield was reported as 0.89 which is highly significant. (Nigeria, Northern region, Deptt. of Agriculture, 1959).

In Black pied cows, Fuhrken (1959) observed that greater the total lactation yield, the greater was the length of lactation.

Alim (1960) found in Kenana cattle of Sudan, correlation between yield and lactation length to be 0.87. The coefficient of variation decreased as yield increased.

In Sahiwal cattle, Batra (1961) reported genetic correlation between lactation period and total milk yield to be 0.6382. He stated that this high genetic correlation strongly suggest that selection on milk yield would simultaneously bring about good genetic gain in the lactation length.

Alim (1962) found in Butana cattle of Sudan, a significant correlation coefficient of 0.857 between milk yield and lactation length.

Hammond (1957) stated that milk yield for a lactation primarily depends on the number of days the cows is in milk. He further stated that production for ten months was found to be approximately 87% as much as for twelve months.

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Chapter (II).

MATERIALS AND METHODS.

Chapter (II).

MATERIALS AND METHODS.

(A) MATERIALS:-

The data used in this study included the records kept for Tharparkar herd maintained at the Government Cattle Farm, Patna. The Farm was established in October, 1926, with a foundation stock of 52 Tharparkar cows, 10 Shahabadi cows and 7 Tharparkar bulls. The Tharparkar cows were purchased from Sindh Province and Tharparkar bulls were obtained from Karnal. Since 1936 onwards, there were no additions to the female stock from outside. In 1946, the Shahabadi herd was removed and Tharparkar herd was maintained at the Farm. The objectives with which the Farm started were: (1) to produce superior and acclamatised pure bred Tharparkar bulls for grading up non-descript cattle in the State, and (2) to serve as a demonstration centre to the students of Bihar Veterinary College.

The data included in the study comprised of the records for the period from the year 1946 to 1961. During this period, the feeding and management schedule on the whole of Farm have remained almost the same.

The cows were housed in pucca byres. They were allowed to graze twice a day after morning and afternoon milking. The feeding was done in groups. The maintenance ration of the cows comprised of green fodder, dry fodder and concentrate mixture. Besides production allowance of 1 lb. of concentrate mixture for every 3 lbs. of milk was also given. Two ounces of salt and 1 ounce of mineral mixture per day was also indicated in the ration. Green fodder were grown on the farm lands.

The frequency of milking was twice a day, but high yielding cows (above 15 lbs. of milk per day) were milked thrice a day. Hand milking was practised. Weaning had not been practised regularly. Cows were bred by natural mating during the period of study.

Collection and preparation of data:-

The data for the study was collected from daily milk yield registers, and history sheets of the cows. All the history sheets of the cows from 1946-61 were arranged year and month-wise of their respective first calving. Then for each of the cow, 30-day milk yield in each of her lactation was calculated by totalling the daily milk yield for 30 days; the first 30-day period beginning the 8th day of calving in each lactation since the milk

yield in first seven days after calving was irregularly recorded or omitted. The first 7 days after calving was presumed as colostral period. For each cow, milk yield for 30-day periods was calculated for every lactation; and in case the last period happens to be less than 30 days, it was omitted, and milk yield was calculated up to the preceeding 30-day period.

From the history sheets, data on total lactation yield, data of calving and lactation length in days for each cow were collected.

Thus data from 318 cows with 1280 lactations were obtained. The maximum number of lactations any cow had, was upto 12th lactation. Table (6) shows the frequency of observations under each lactation.

Table (6).

Lactation number.	Frequency of observations.
First.	300*
Second.	254
Third.	200
Fourth.	159
Fifth.	115
Sixth.	88
Seventh.	70
Eighth.	47
Ninth.	28
Tenth.	13
Eleventh	5
Twelfth.	1
Total ...	1280

** *******

(*) The daily milk yield records of the first 18 cows for their first lactation were not available. Data of their milk yield was then calculated from their second lactation onwards and the data for these 18 cows were included in 254 records of the second lactation.

The data of 30-day milk yields, total yield, lactation length for 1280 lactation records were rearranged lactation-wise separately. This facilitated the calculation of averages of 30-day periods, total lactation yield and lactation length for each lactation.

With the rearranged data, the study included the following:-

1. Average lactation yield.

2. Economics of various lactations.

3. Average lactation length for the first four lactations and testing differences between them.

4(a). Averages of 30-day period yields for each lactation and for all the lactations as a whole.

(b) To test whether there is any significant difference between first five overall average 30-day period yields.

5. To study a graphical representation of different lactations.

6. Calculation of rates of decline and persistencies.

7. Fitting of lactation curves.

and 8. study of economic importance of persistency.

(B) METHODS OF ANALYSIS.

(A) Average lactation yield, average lactation length, average of each 30-day period:-

The method in computing the average adopted in the present study is Arithmetic mean, which is calculated by dividing the sum of observations, 'x', by their number, 'n'. Representing the mean by $\bar{x}$, the formula is:

$$\bar{x} = \frac{(\Sigma x)}{n}$$

where 'x' stands for every item successively.

(B)(1). To test the means for significant difference:-

The purpose is to test for significant difference between:

(a) first five overall average 30-day periods' yields;

and (b) lactation yields and lactation periods for the first four lactations.

Method:

(a) Bartlett's test of Homogeneity of variance (samples differing in size) and Bartlett's test of $H_g = \mu i = \mu$ if variance is heterogeneous.

(b) Analysis of variance.

The methods of computation for these tests, as given by Snedecor (1956) were adopted in the present study.

(B)(2). Test for significance of difference between means in all comparisions:-

If F' from Bartlett's test has significant, a further test as given by Snedecor (1956) in section 4.9 was applied to test for significance the difference between means in all comparisons.

(C) LACTATION curve fitting:-

A curve showing rate of milk secretion with advance in lactation is termed 'Lactation curve' and it has been shown by many investigators that the shape of the curve is capable of mathematical expression. Many previous investigators have tried different forms of mathematical expressions in an endeavour to improve the fitness of the curve, for further analysis. The mathematical expression used by various investigators can be classified into:

1. Exponential equations,
2. Parabolic exponential equations,
3. Orthogonal polynomial regression

and 4. Linear regressions.

A brief review on use of each of the above mathematical expressions in fitting lactation curves is given below:-

(1) Exponential equation:-

Sturtevant (1826) as mentioned by Sikka (1950) was the first investigator to put forward the conception that each month's milk production is roughly a constant percentage of the production of the preceeding month. In mathematical terms this means the course of the curve is exponential.

Later this fact was independently proved by Brody, Ragsdale and Turner as quoted by Sikka (1950) who studied the shape of the lactation curve of cows of various breeds. The equation that they made use of the to describe the average lactation curve of a large number of cows of different breeds was:

$M_t = M_o e^{-kt}$ where M_t is the milk production during any month 't', M_o is the value of the initial theoretical rate of milk flow at the time of parturition (not attained in actual practice), 'k' is the constant measuring the relative rate of decline, and 'e' the base of natural logarithms. The investigators found that this equation fitted the data remarkably well.

Gaines and Davidson (1926) as quoted by Kartha (1934, a) were able to employ the equation of Brody and co-workers successfully by fitting the exponential equation to milk yield data.

Kartha (1934, a) adopted the same method as that followed by Gaines and Davidson to fit the curves. The equation is applied to the decline portion of the curve.

Calculation of constants in the exponential equation, viz. rate of decline and maximum initial yield.

The constants were determined by Kartha (1934, a) by the method of least squares; since he claimed that the error was least possible by this method. Since the equation

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The constants were determined by Kartha (1934, a) by the method of least squares; since he claimed that the error was least possible by this method. Since the equation

represented the decline portion of the curve only, it would be more convenient to measure time from maximum yield than from the date of calving. The table (7) was drawn up. Data were obtained and computed in a tabular form.

Table (7).

(1)	(2)	(3)	(4)	(5)
Time in months from maximum. t	Maximum yield per month in lbs. Y	Log of yields. Log Y	Product of (1) and (3) t x logY	(t - 1) X log Y.
0				
n_1				
n_2				
n_3				
.				
.				
.				
.				
Total ... n	...	...	...	...

Symbols. a b

The table given above is self-explanatory. Column 5 is added as a check on the arithmetic and the figures therein are obtained by multiplying the logarithms in column (3) successively by 1, 2, 3, 4 etc.

If the arithmetic is correct the totals of column 3 and 4 when added would give the total of column 5. In working out the results, total of columns (3) and (4) are to be considered. They are designated by 'a' and 'b'. If 'n' observations are available, the rate of decline is:

$$\frac{(n-1)a-2b}{.4343 \times n(n^2-1)/6}$$

Thus with 9 and 10 observations, the formulae are:

$$\frac{8a-2b}{120 \times .4343} \quad \text{and} \quad \frac{9a-2b}{165 \times .4343} \quad \text{respectively.}$$

The maximum yield is calculated as follows:- With n observations, 3/n+1 of the difference (n-1)a-2b (i.e. 3/8 of the figure obtained in the numerator) has to be added to 'a' and divided by the number of observations gives the logarithm of the maximum.

(2) Parabolic exponential equations:-

Sikka (1950) found improvement in the fitness of the curve with parabolic exponential equation. The equation he made use of was:

$$Y = Ae^{bt+ct^2}$$

As the fitting is carried out in two stages, it is possible to examine separately the fit of the linear and the parabolic equations to the data, and to judge whether the contribution of the parabolic constant is significant in the reduction of variation; where the parabolic term is significant, it shows that the linear constant alone does not account for all the systematic variations of the data i.e. the exponential

curve does not give the best possible fit.

According to Sikka (1950), the advantages of use of parabolic exponential equation, are: (a) apart from better fit to the curve, (b) the equation provides two separate constants, viz. the linear which measures the average slope of the curve and the parabolic, which describes how on an average the rate of this slope varies from period to period.

(3) Orthogonal polynomial regression equations:-

Mahadevan (1951) worked also with Orthogonal polynomial regression curves of higher degrees, he found such attempts were beset with numerous pit-falls.

(4) Linear regression equations:-

Fairly consistent results were obtained by Mahadevan (1951) by a measure based on the linear regression of yield on time, but he considered this method as not suitable because the shape of the individual lactation curves was far too variable to be represented by any regid mathematical curve.

(C)(2). Test for goodness of fit of lactation curves:-

Chisquare values for each of the fitted curve were calculated as follows:-

$$\frac{(O_1-E_1)^2}{E_1} + \frac{(O_2-E_2)^2}{E_2} \quad \ldots\ldots\ldots\ldots + \frac{(O_n-E_n)^2}{E_n} = \chi^2$$

where 'O' is observed yield and 'E' is calculated yield, 'n' is number of observations in each of the fitted curve.

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where 'O' is observed yield and 'E' is calculated yield, 'n' is number of observations in each of the fitted curve.

The Chisquare table was referred for finding out whether the calculated χ^2 is significant or not at 0.05 level under 'n-1' degrees of freedom.

(D) Methods for calculation of persistency:-

Johansson and Hansson (1940) as quoted by Mahadevan (1951) splitting up the lactation period of each cow into 100-day periods and used the ratios between the butterfat yields in the different periods as measures of persistency. The chief drawback of this method is that the first 100-day period which is taken to represent the time of maximum physiological activity of the cow includes a considerable portion of the declining segment of the lactation curve, and therefore it does not provide a sufficiently sensitive measure of persistency when it compared with the second 100-day period.

Pontecorvo (1940) as quoted by Sikka (1950) has used "the middle part of the lactation curve" to determine the persistency. He regards this portion as a distinct physiological component of the lactation curve and holds that its use in place of the whole lactation curve constitute a definite improvement in method.

Mahadevan (1951) estimated persistency by using the formula:

$$P = \frac{A - B}{B}$$

where 'A' is the milk yield during the first 180-days

and 'B' is the initial milk yield during the first 10 weeks of lactation. This estimate of persistency determine the degree to which the milk yield in early lactation is maintained by a cow during the rest of her lactation. The basic concept underlying this method is in essence the same as that used by Johansson and Hansson, but it corrects the drawback in that method.

Ludwick and Petersen (1943) have evolved a formula for persistency which is based on "a summation of the ratios obtained by comparing production in each of a number of sub divisions of the lactation period with the preceeding one".

A slight modification of above method is to calculate the percentage which the yield of each period is of that of the preceeding period, ignoring the first period. The percentages are then averaged. Since these figures are averages for declines, even the small differences are significant.

Rohrman et al (1954) developed another method of measure of persistency based on the hypothesis that, if there were perfect persistency, 8.33 per cent of a 360-day milk or butterfat yield would be produced in each of the 12 of the 30-day periods. The sum of the differences between 8.33 per cent and the percentages of the total milk yield actually produced in each of the 30-day period is taken as the measure of departure

from perfect persistency. By this method, low values indicate good persistency and high values indicate poor persistency.

Hammond (1957) suggested that the number of days from calving for the yield to drop to half the maximum daily yield, may be given as a measure of persistency.

Lennon and Mixner (1958) preferred to use a formula for calculation of persistency index from the rate of decline.

Persistency index = (P) = 100 - (K X 100)

The formula overcomes the criticism of using 'k' (rate of decline) as a measure of persistency. The 'P' in the formula is now positively correlated with actual persistency and is expressed on a percentage basis.

-xXx-

Chapter (III).

R E S U L T S

Chapter (III).

RESULTS.

(A) Lactation yield:-

Average lactation yield based on 1280 records for this Tharaparkar herd was calculated and found to be 2580 lbs ± 37.91 lbs.

The average milk yield according to the stage of lactation was calculated and is given in the table (8). The lactation yields are not corrected for lactation length.

Table (8).

Average lactation yield.

Lactation Number.	Milk yield (lbs.)	S. E.	No. of records.	Frequency. (%)
First. ...	2947	± 91	300	23.43
Second. ...	2418	± 94	254	19.84
Third. ...	2719	± 94	200	15.62
Fourth. ...	2580	± 104	159	12.42
Fifth. ...	2483	± 120	115	8.98
Sixth. ...	2384	± 124	88	6.87
Seventh. ...	2257	± 136	70	5.47
Eighth. ...	2124	± 192	47	3.67
Ninth. ...	1988	± 198	28	2.19
Tenth. ...	1815		13	1.02
Eleventh. ...	3231		5	0.39
Twelfth. ...	1517		1	0.08
Overall ...	2580	± 37.91	1280	

In figure (1), the lactation yield in relation to various stages of lactation of the whole herd was shown.

It was observed from the table (8) that the maximum yield was recorded in first lactation, then there was a fall in second lactation, followed by a rise in the 3rd lactation. The yield in the 3rd lactation was less than that of the first lactation yield. There was almost a gradual and steady decline from 3rd lactation onwards.

(B) Average lactation length:-

It was thought that the variation in the total milk yield of the first three lactations may be due to variations in their respective lactation length. In table (9), the length of the first four lactations may be seen.

Table (9).

Average lactation length.

Lactation No.	Lactation length in days.	No. of records.
First. ...	307	299
Second ...	266	255
Third ...	277	199
Fourth ...	269 (269)	159

It was observed from the table (9) that there existed difference in lactation in lengths between the first four lactations. On an average, the cows in this herd gave milk for more number of days in first lactation, next to it in third and fourth lactations respectively, but the second lactation being the least of all the first four lactations.

To test the means of lactation lengths for significant difference, the data was subjected to Bartlett's test of Homogeneity of variance (samples differing in size). The data was found to be heterogeneous, a further test based upon the weighted mean squares was used to test the means for significance when the data was heterogeneous (Snedecor, 1956). It was found that the difference between the means was highly significant.

Further more, applying analysis of variance, as shown in table (10), it was found that the difference between lactation lengths are highly significant.

Table (10).

Analysis of variance of lactation lengths.

Source of variation.	d. f.	S.S.	M. S.	F.
Between lactations.	3	282513	94171	11.1**
Within lactations	908	7693666	8473	
Total.	911	7976179		

(**) Highly significant.

The same tests were applied for lactation yields of first four lactations. The F' from Bartlett's test was significant. In table (11), analysis of variance of lactation yields was carried out.

Table (11).

Analysis of variance of lactation yields.

Source of variation.	d.f.	S. S.	M. S.	F.
Between lactations.	3	139353990	46451020	24.45**
Within lactations.	910	1728498100	1899448	
Total.	913	1867852090		

(**) Highly significant.

Since the F' from Bartlett's test was found significant for lactation yields and lactation lengths, it was decided to find out in which of various combinations the difference between the means are significant among the first four lactations by applying a test, described by Snedecor (1956) in section 4.9. It was found that for lactation yields, the differences in mean yields between first and second; first and fourth; and second and third lactations were found highly significant, and the other combinations were insignificant. For lactation lengths it was found that difference between First and Second; First and third and First and Fourth lactations

were found highly significant and the other combinations were insignificant.

In figure No.2, the trends of lactation yields and lactation lengths with the stage of lactations (upto 4th lactation) was shown. It would be seen from figure (2) that the trends in lactation yields followed the same pattern as that of lactation lengths either in increase or in decrease.

(C) Economics of various lactations:-

For this purpose lactation yields upto 8th lactation were taken into consideration, since the frequency of records on which the average yields for latter lactations beyond 8th were based were too low, and hence they were not considered. The average lactation yields based on yields of eight lactations was found to be 2489 lbs. The deviations in milk yield from this average for each lactation-wise given in table (12).

Table (12).

Lactation No.	Average lactation yield. (lbs.)	Average lactation yield (lbs.) for all lactations. (Upto 8th lactation).	Deviation. (3 - 2)
First. ...	2947	2489	458
Second. ...	2418	"	- 71
Third. ...	2719	"	230
Fourth. ...	2580	"	91
Fifth. ...	2483	"	- 6
Sixth. ...	2384	"	- 105
Seventh. ...	2257	"	- 232
Eighth. ...	2124	"	- 597

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It was observed from the table (12) that the average lactation yields beginning from sixth lactation were below the whole time average production, taking into account the fall in yield in second lactation would have been positive if corrected for lactation length.

(D) Trends in monthly milk yield in different lactations:-

(1) Average monthly milk yields for each lactation were calculated for the first ten months (300 days). The overall average for each month was also calculated. The results were shown in table (13). (See page 54).

(2) Preliminary graphical study:- The trends of monthly yield in different months from 1st to 11th lactation and also of that overall average months yield were represented graphically in figures 3 to 14.

It was observed that the shape of the curves were much skewed from 7th lactation onwards, and the skewness were much more marked in 9th, 10th and 11th lactations. It may probably be due to the fact that averageswere based on few records. It would be observed that upto the 6th lactation the decline in monthly milk yield was gradual and steady and the curves were smooth.

Table (13).

Average monthly milk yields for the first 10 X 30-day periods.

Lactation No.	Average milk yield in 30-day period. (in lbs.)									
	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.
First. ...	351	363	348	327	309	295	280	266	246	237
Second. ...	364	358	331	306	280	256	234	217	209	200
Third. ...	390	382	355	328	305	282	264	249	237	221
Fourth. ...	376	374	348	316	294	272	252	234	220	202
Fifth. ...	364	365	345	330	305	270	247	222	205	203
Sixth. ...	343	348	320	296	276	255	232	220	205	188
Seventh. ...	336	327	302	277	254	237	211	207	182	150
Eighth. ...	317	302	284	278	263	246	235	214	197	194
Ninth. ...	305	305	277	251	217	215	206	199	183	195
Tenth. ...	322	291	260	272	241	236	205	186	174	196
Eleventh. ...	481	502	448	372	305	255	237	182	164	178
Twelfth. ...	332	237	190	182	213	145	119	--	--	--
Overall average.	361	360	337	313	291	270	251	237	223	215

(a) Peak production:- Maximum monthly milk production or peak yields were attained in all lactation before 2nd 30-day period. In table (14), maximum monthly yields in lbs. for various lactations and the month in which they attained the maximum yield are given.

Table (14).

Maximum yield of milk per month, and the month in which it was attained.

Lactation No.	Maximum yield. (lbs.)	Month in which the peak yield was attained.	No. of records averaged.
First. ...	363	2nd	294
Second. ...	364	1st	254
Third. ...	390	1st	202
Fourth. ...	376	1st	157
Fifth. ...	365	2nd	109
Sixth. ...	348	2nd	87
Seventh ...	336	1st	70
Eighth. ...	317	1st	47
Ninth. ...	305	1st	27
Tenth. ...	322	1st	13
Overall. ...	361	1st	1275

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It was observed from the above findings that Maximum initial yield (30-day period) attained was 390 lbs. and it was attained in 3rd lactation for this herd.

(3) Production in overall lactations and test for significant difference between first five 30-day periods:

To find out whether the difference in average monthly production in first five overall 30-day periods was significant or not, the data was subjected to Bartlett's test of Homogeneity (samples differing in size). The data was found to be heterogeneous and to test the means for significant difference when the data was heterogeneous, a further test based upon the weighted mean squares was used as given in Snedecor (1956), and F' found to be highly significant.

An analysis of variance given in table (15) also pointed out that there existed a highly significant difference between the different means of production.

Table (15).

Analysis of variance of first five overall 30-day periods milk yield.

Source of variation.	d. f.	S. S.	M. S.	F.
Between 30-day periods.	4	4403795	1100949	61.7**
Within 30-day periods.	6083	108588971	17851	
Total.	6087	112992766		

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(**) Highly significant.

The difference between the mean yields in 30-day periods in all possible comparisions among first five 30-day periods, when subjected to the test given by Snedecor (1956), section 4.9 was found to be highly significant except the one between First and Second.

(E) Rate of decline and maximum yield:- Rates of decline and maximum yields for the first six lactations and for overall lactations were calculated by the method of least squares (Kartha, 1934, a). The first six lactations were chosen for calculation because (1) there were only few records available beyond 6th lactation, and (2) generally cows were not kept beyond six lactations, except under the circumstances when they were outstanding ones. The results were shown in table (16).

Table (16).

Rates of decline and maximum yields.

Lactation No.	Maximum yield. (Milk). Observed.	Calculated.	Rate of decline per lb. per month.
	lbs.	lbs.	
First. ...	363	365.1	.054
Second. ...	364	375.3	.074
Third. ...	390	398.9	.066
Fourth. ...	376	393.1	.073
Fifth. ...	365	374.6	.082
Sixth. ...	348	345.7	.076
Overall ...	361	374.3	.064

(F) Fitting of lactation curves:-

To calculate any month's yield from the calculated maximum initial yield and rate of decline, the type of mathematical expression applied in the present study was 'exponential equation' of Brody and Co-workers (1923). The equation is $M_t = M_o e^{-kt}$, where M_t is the milk production during any month, M_o is the value of maximum yield (calculated) at the time of parturition (not attained in actual practice), 'k' is the constant measuring the relative rate of decline, and 'e' is the base of natural logarithm ('e' = 2.71828). The constants of the equation viz. rate of decline and maximum yield were calculated for the first six lactations and also for overall lactations. The calculated yields in different months of lactation were given for each lactation separately in tables (17), (18), (19), (20), (21), (22) and (23).

Table (17). First lactation.

Time in months after calving.	Data of milk yield in lbs.		Deviation.
	observed.	calculated.	
2. ...	363	365.1	- 1.9
3. ...	348	345.9	2.1
4. ...	327	327.8	- 0.8
5. ...	309	310.7	- 1.7
6. ...	295	294.3	0.7
7. ~~280~~	280 (280)	278.9	1.1
8. ...	266	264.2	1.8
9. ...	246	250.4	- 4.4
10. ...	237	237.3	- 0.3

Table (18). Second lactation.

Time in months after calving.	Data of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
1 ...	364	375.3	- 11.3
2 ...	358	348.5	9.5
3 ...	331	323.8	7.2
4 ...	306	300.7	5.3
5 ...	280	279.4	0.6
6 ...	256	259.4	- 3.4
7 ...	234	241.0	- 7.0
8 ...	217	223.9	- 6.9
9 ...	209	207.9	1.1
10. ...	200	193.0	7.0

Table (19).

Third lactation.

Time in months after calving.	Data of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
1 ...	390	398.9	- 8.9
2 ...	382	373.6	8.4
3 ...	355	349.7	5.3
4 ...	328	327.4	0.6
5 ...	305	306.6	- 1.6
6 ...	282	287.0	- 5.0
7 ...	264	268.7	- 4.7
8 ...	249	251.7	- 2.7
9 ...	237	235.6	1.4
10 ...	221	220.6	0.4

Table (20)

Fourth lactation.

Time in months after calving.	Date of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
1 ...	376	393.1	- 17.1
2 ...	374	365.6	8.4
3 ...	348	339.8	8.2
4 ...	316	315.9	0.1
5 ...	294	293.8	0.2
6 ...	272	273.2	- 1.2
7 ...	252	254.0	- 2.0
8 ...	234	236.1	- 2.1
9 ...	220	219.6	0.4
10 ...	202	204.1	- 2.1

Table (21).

Fifth lactation.

Time in months after calving.	Date of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
2 ...	365	374.6	- 9.6
3 ...	345	345.1	- 0.1
4 ...	330	318.1	12.1
5 ...	305	293.0	12.0
6 ...	270	270.1	- 0.1
7 ...	247	248.8	- 1.8
8 ...	222	229.3	- 7.3
9 ...	205	211.3	- 6.3
10 ...	203	194.6	8.4

Table (22)

Sixth lactation.

Time in months after calving.	Data of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
2 ...	348	345.7	2.3
3 ...	320	320.5	- 0.5
4 ...	296	297.1	- 1.1
5 ...	276	275.4	0.6
6 ...	255	255.3	- 0.3
7 ...	232	236.7	- 4.7
8 ...	220	219.4	0.6
9 ...	205	203.3	1.7
10 ...	188	188.5	- 0.5

Table (23).

Overall lactations.

Time in months after calving.	Date of milk yield in lbs.		Deviation.
	Observed.	Calculated.	
1 ...	361	374.3	- 13.3
2 ...	360	351.2	8.8
3 ...	337	329.5	7.5
4 ...	313	309.0	4.0
5 ...	291	289.9	1.1
6 ...	270	272.0	- 2.0
7 ...	251	255.2	- 4.2
8 ...	237	239.4	- 2.4
9 ...	223	224.6	- 1.6
10 ...	215	210.7	4.3

Lactation curves were drawn both with the observed as well as with the calculated values. It may be seen from figures No.15, 16, 17, 18, 19, 20 and 21 that the curves for both the values fitted satisfactorily in all lactations. The smooth curves obtained from the calculated data were represented by the continuous lines in all figures ~~xxx~~ from 15 to 21.

When the curves were tested for goodness of fit, it was found that the χ^2 values for all curves were insiginificant at 0.05 level and hence it can be concluded that the exponential equation fitted the data very well.

(G) Persistency of yield:-

In the present study persistency was calculated by three different methods and they were as follows:-

(I) $$P = \frac{A - B}{B}$$

where A = average lactation yield in lbs.
B = milk yield in the first two months.

The basic concept of this method is in principle same as that of Johansson and Hansson method quoted by Mahadevan (1951).

(II) According to Fohrman et al (1954) persistency is expressed as the ratio of any month's decline to that of preceeding one, ignoring the first month's yield. The ratios are expressed in percentages for different lactations.

(III) According to Lennon and Mixner (1958) persistency is calculated from rate of decline, using the formula:

P = (Persistency index) = 100 - (k X 100)

Persistency is expressed on percentage basis.

The details of different methods were given in section dealing with 'Materials & Methods'.

The estimates of persistency of milk by different methods were given in table (24).

Table (24)

Estimates of persistency by different methods.

Lactation No.	1st (I) method.	2nd (II) method.	3rd (III) method.
	$P = \frac{A-B}{B}$	Ratio of any month's yield to that of preceeding month. (%)	Persistency index = 100-(k X 100) (%)
First. ...	3.1	94.7	94.6
Second ...	2.3	92.8	92.6
Third. ...	2.5	93.6	93.4
Fourth. ...	2.4	93.0	92.7
Fifth ...	2.4	92.1	91.8
Sixth. ...	2.5	92.7	92.4
Overall. ...	2.58	93.8	93.6

(H) Persistency and its relation to age of cow and level of production:-

In figure No.22, the relationship between stage of lactation and rates of decline and also level of production in Tharparkar herd were shown for the first six lactations. The means of values of persistency for each lactation were shown by the ~~dotted~~ red lines in the figure No.22.

(a) Persistency and stage of lactation:- The relationship between persistency and stage of lactation was found to be very irregular and the relationship was not linear in any way. The level of production at maximum increased with stage of lactation upto 3rd lactation and declined gradually in later lactations.

(b) Persistency and level of production:- As the maximum yield increased from first lactation to the second lactation, the rate of decline also increased, from 2nd to 3rd, the increase in yield continued to rise, when there was a fall in rate of decline in the same period. From 3rd to 5th lactation, the level of production had fallen, consequently an increase in rate of decline was noticed. The rate of decline of the 5th lactation was maintained almost through 6th lactation but the level of production continued its fall from 5th to 6th also.

(I) Economic importance of persistency of yield:-

Kartha (1934, a) stated that yield for a lactation may be expressed as a function of the initial rate of secretion and the rate of decline. Within the herd, yield in different lactations may differ with respect to either or both of these characters. In table (25) and (26) were shown the monthly yields and total yields for nine or ten months, as the case may be. Table (25) represented two different lactations having the same initial rate of yield but different persistency. In the present study, it was found between 5th lactation and overall lactations. Table (26) represented two different lactations having different initial rates of yield but had the same persistency. (Second and fourth lactations in the present study).

Table (25).

Average monthly rate of yield in Fifth lactation and overall lactations with same initial rate of yield but different persistencies.

Time after reaching maximum yield (in months).	Yield per month in lbs.	
	Fifth lactation.	Overall lactations.
0 ...	374.6	374.3
1 ...	345.1	351.2
2 ...	318.1	329.5
3 ...	293.0	309.0
4 ...	270.1	289.9
5 ...	248.8	272.0
6 ...	229.3	255.2
7 ...	211.3	239.4
8 ...	194.6	224.6
Total for 9 months...	2484.9	2645.1
Rate of decline per lb. per month...	.082	.064
Ratio of any month's yield to that of preceeding month.	0.921	0.938

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Table (26)

Average monthly milk yields in second and fourth lactations having different initial rates of yield but the same persistency.

Time after reaching maximum yield (in months)	Yield per month in lbs.	
	Second lactation.	Fourth lactation.
0 ...	375.3	393.1
1 ...	348.5	365.6
2 ...	323.8	339.8
3 ...	300.7	315.9
4 ...	279.4	293.8
5 ...	259.4	273.2
6 ...	241.0	254.0
7 ...	223.9	236.1
8 ...	207.9	219.6
9 ...	193.0	204.1
Total for 10 months.	2752.9	2895.2
Ratio of decline per lb. per month. ...	.074	.073
Ratio of any month's yield to that of preceeding month. ...	0.928	0.930

Table (26) shows if the rate of decline is the same, the total yields are proportional to the maximum yields. On the other hand, table (25) shows that with the same maximum the total yield decreases with increase in the rate of decline. When the decline increased from 6.4 to 8.2 per cent in other words, when the persistency index decreased from

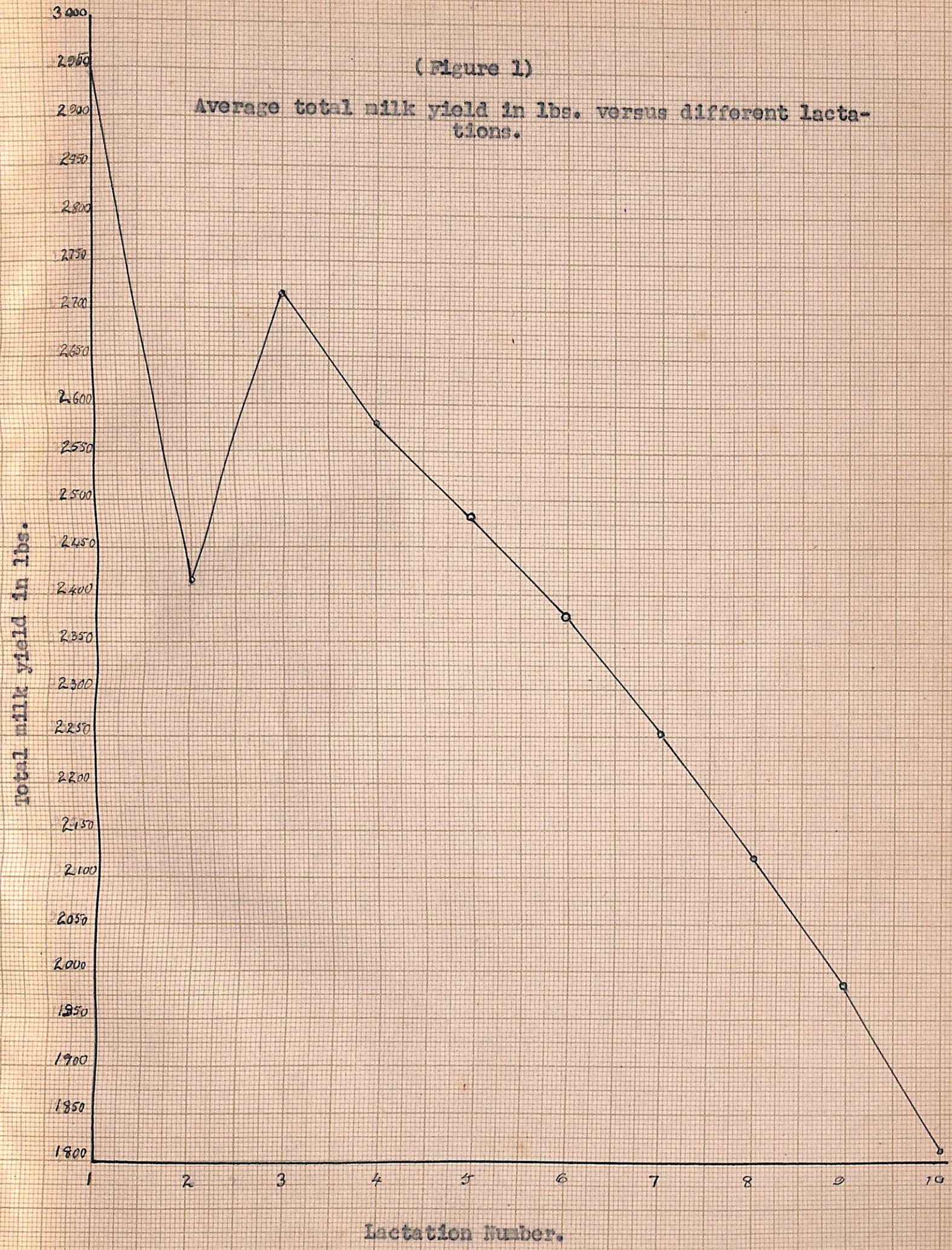
93.6% to 92.8% i.e. by 1.8%, the yield for nine months decreased by 6 percent. This shows how important persistency is, as a factor in the economical production of milk.

The tables (25)and (26) were represented graphically in figure Nos. 23 and 24 respectively. It will be seen that the slope of the curve followed the rate of decline i.e. it was greater when the rate of decline was greater and they were more or less parallel when the rates of decline were the same. For more accurate results, the curves were drawn on logarithmic scale, in figures No.23(a) and 24(a). Instead of the yields, the logarithms of yields were taken for plotting. The curves here, were straight lines, the difference in slopes can be more readily appreciated, and exactly measured. In case of lactations with same persistency , parallel lines were obtained.

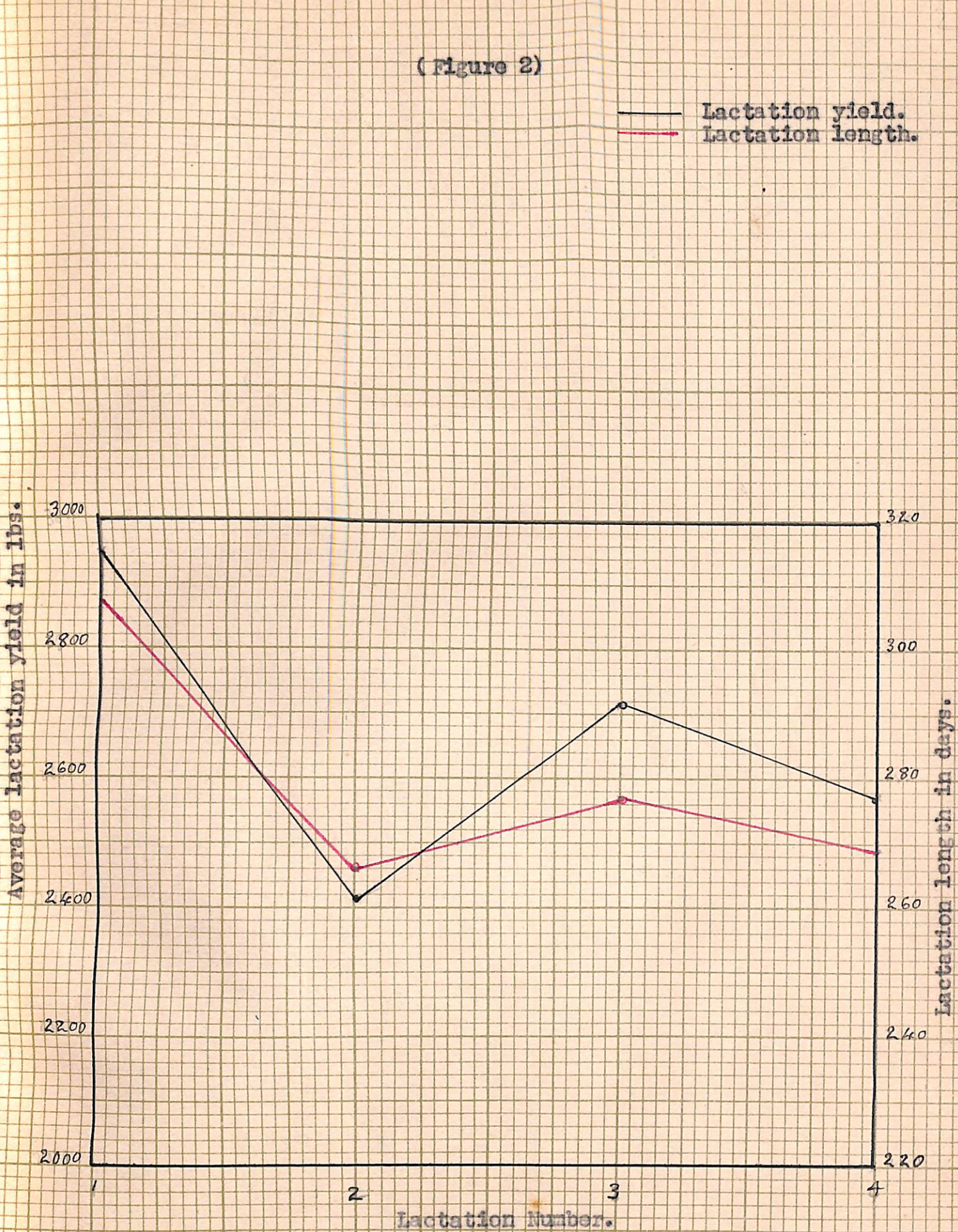
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(Figure 1)

Average total milk yield in lbs. versus different lactations.

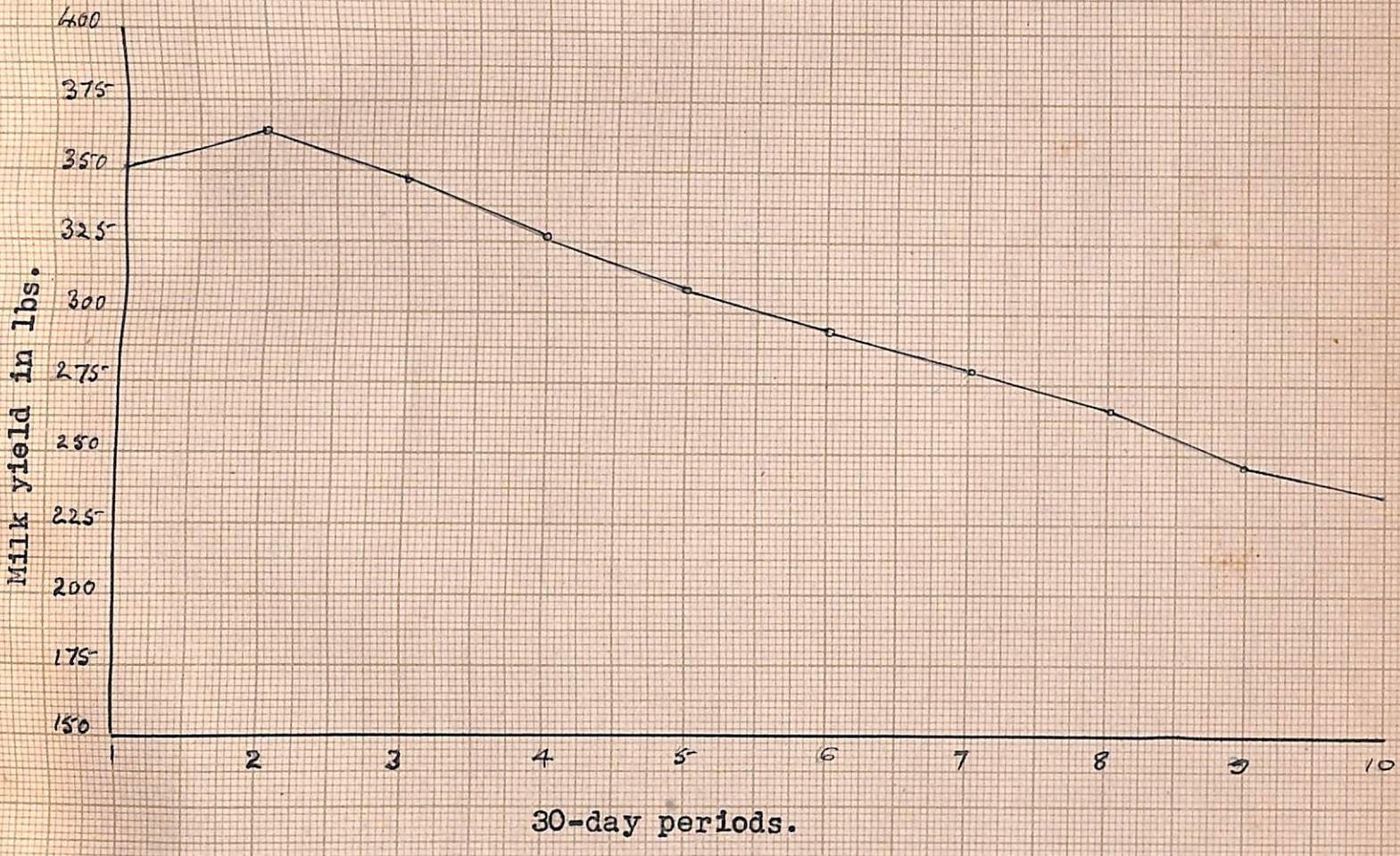


(Figure 2)


Lactation yield.
Lactation length.
Average lactation yield in lbs.
3000
2800
2600
2400
2200
2000
320
300
280
260
240
220
Lactation length in days.
1
2
3
4
Lactation Number.

(Figure 3)

First lactation.



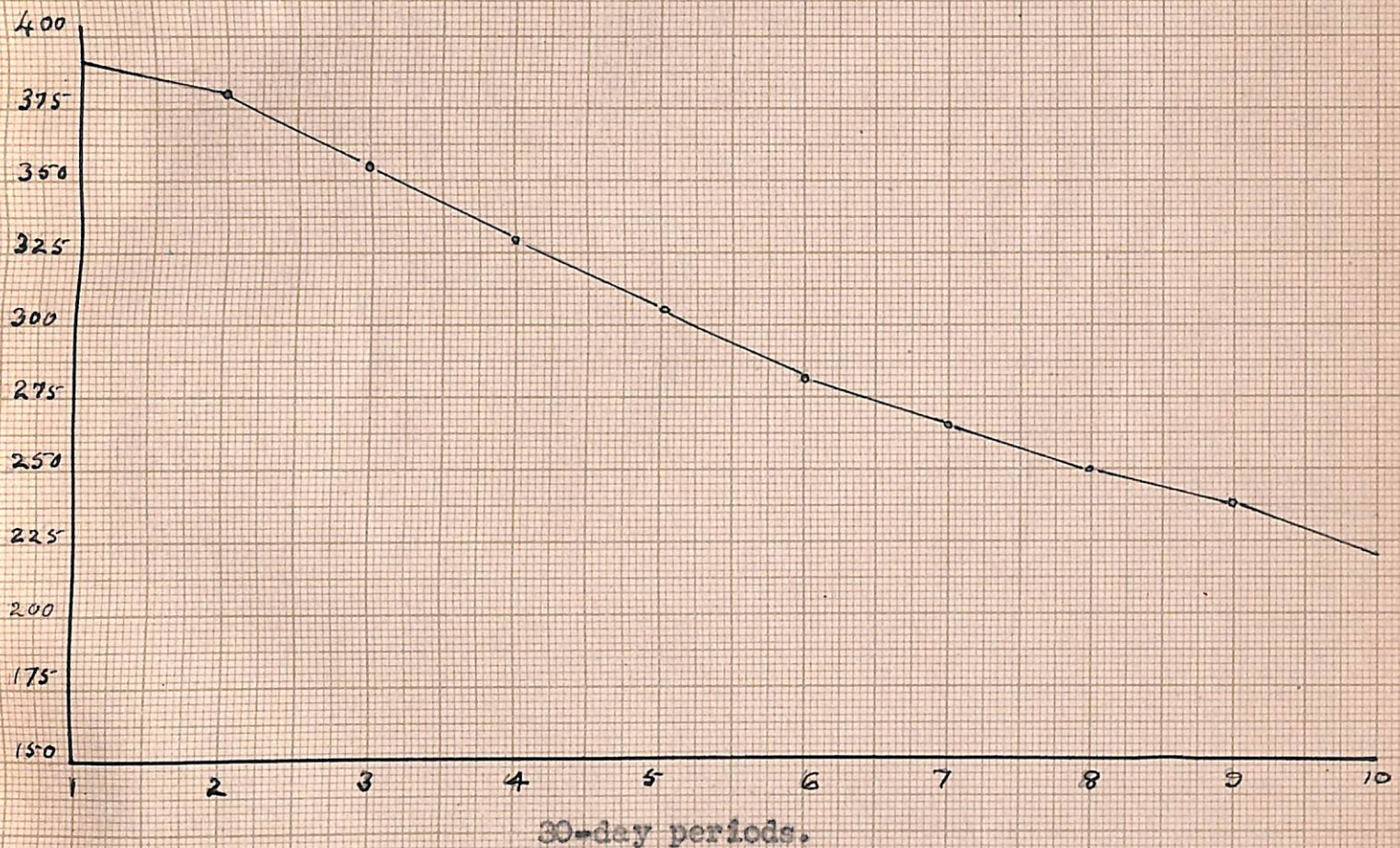
(Figure 4)

Second lactation.



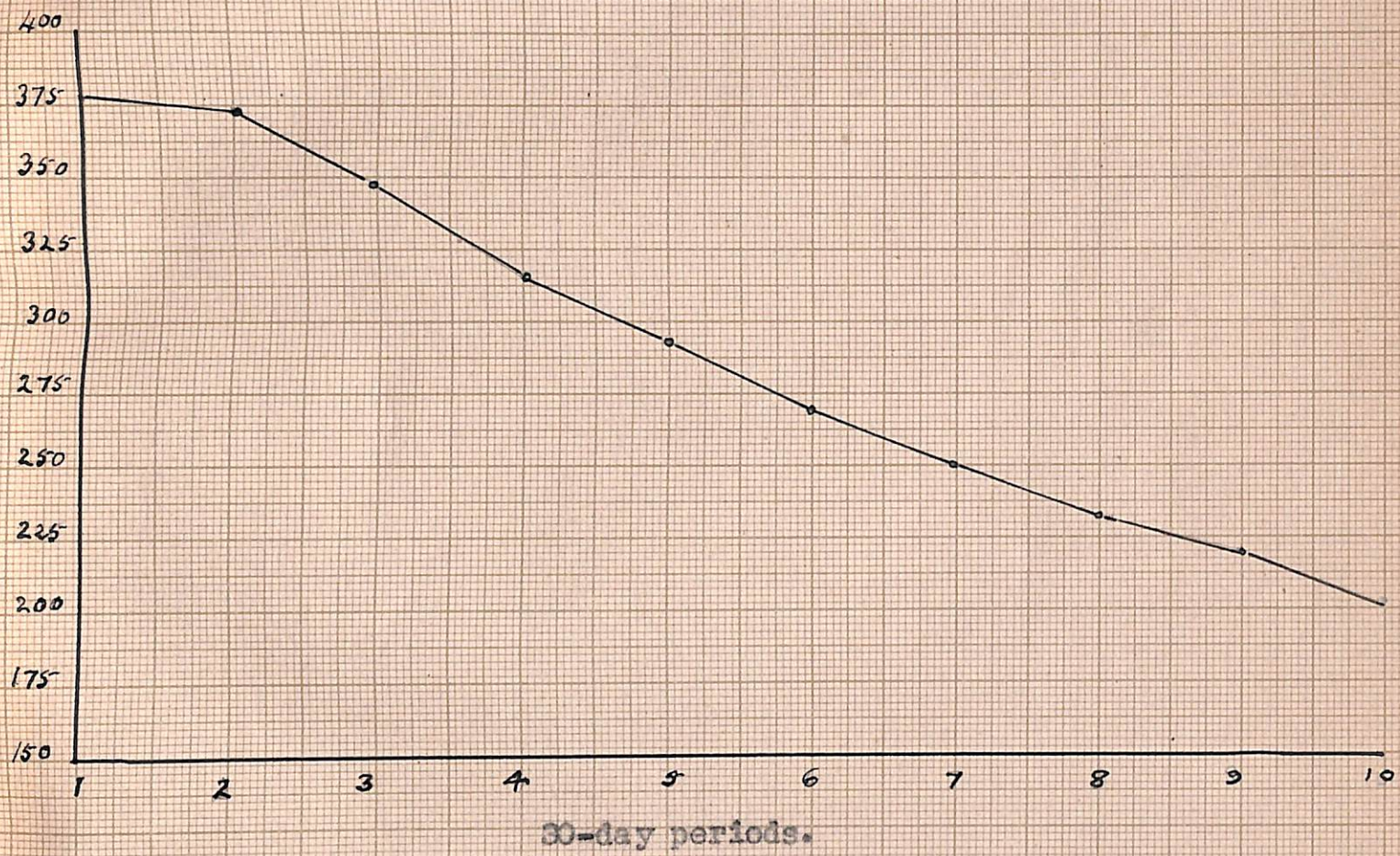
(Figure 5)

Third lactation.



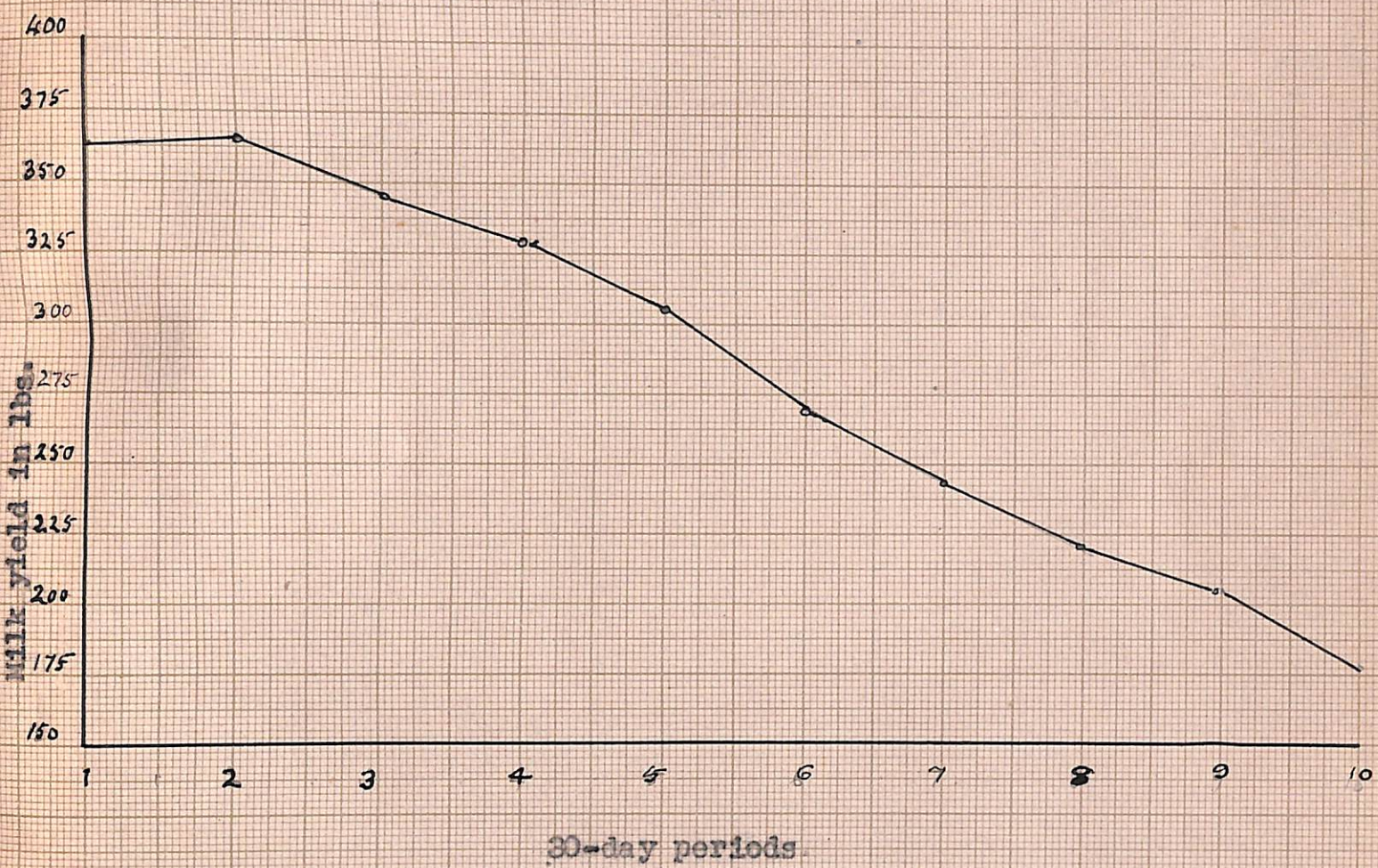
(Figure 6)

Fourth lactation.



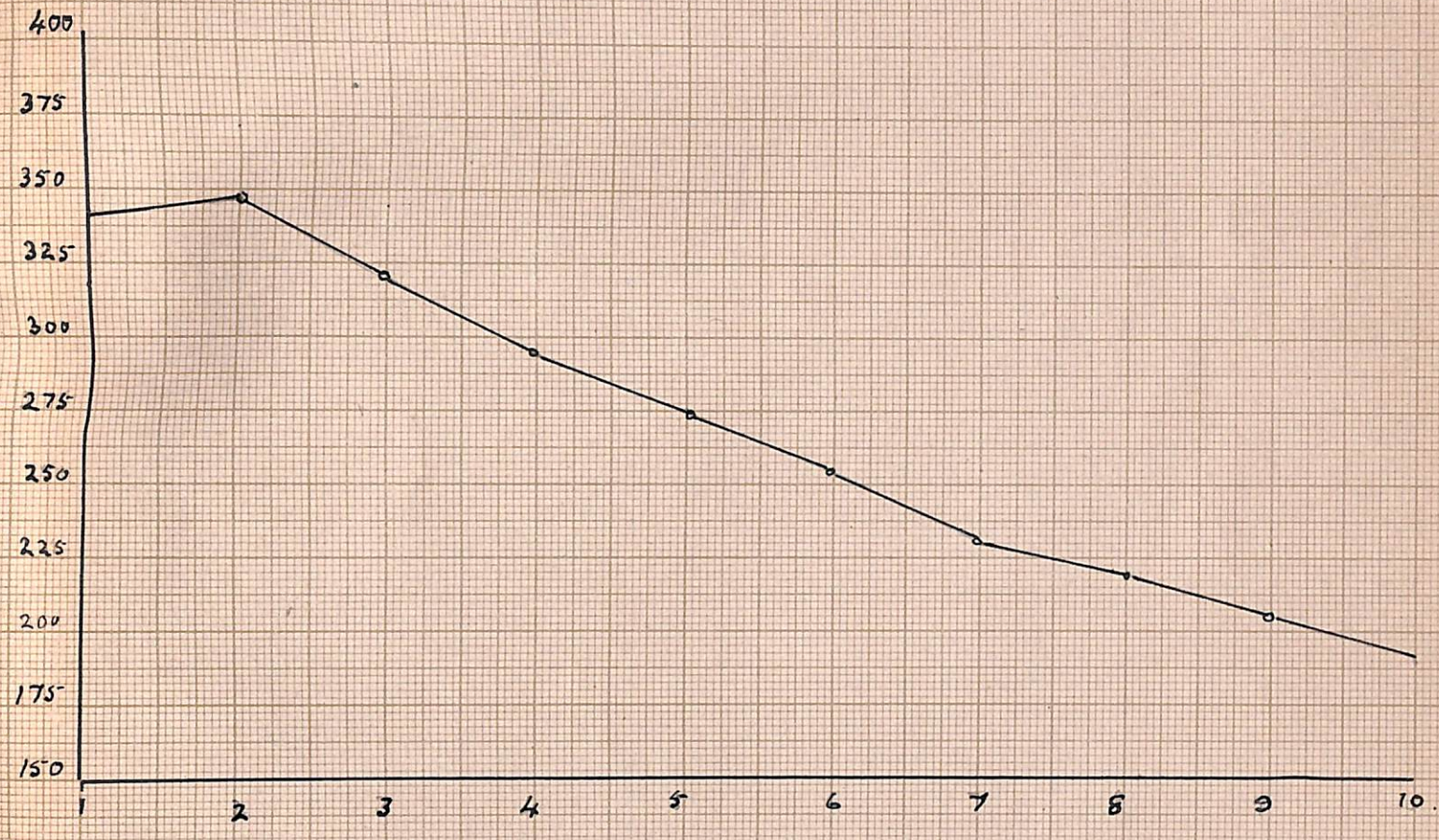
(Figure 7)

Fifth lactation.



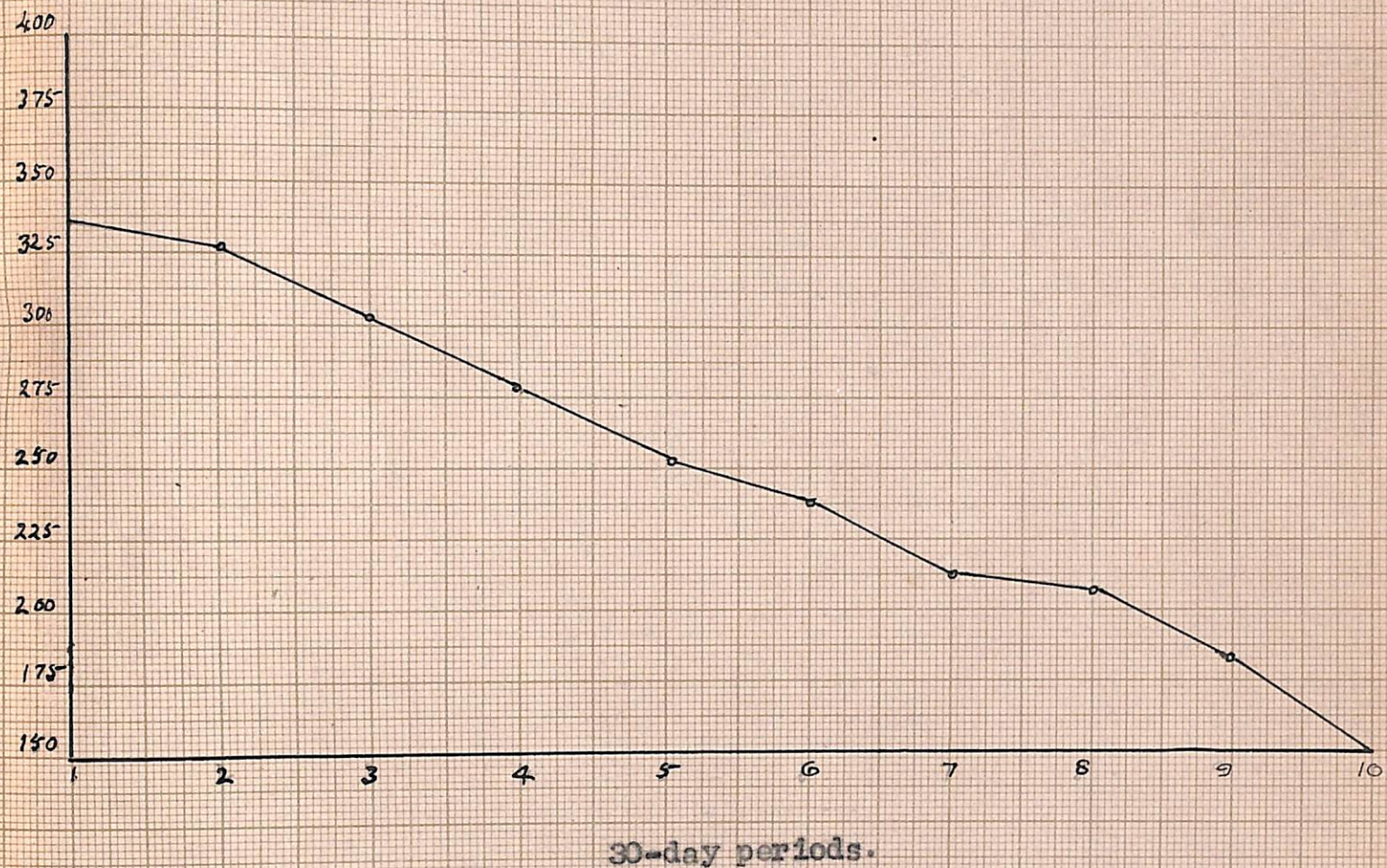
(Figure 8)

Sixth lactation.



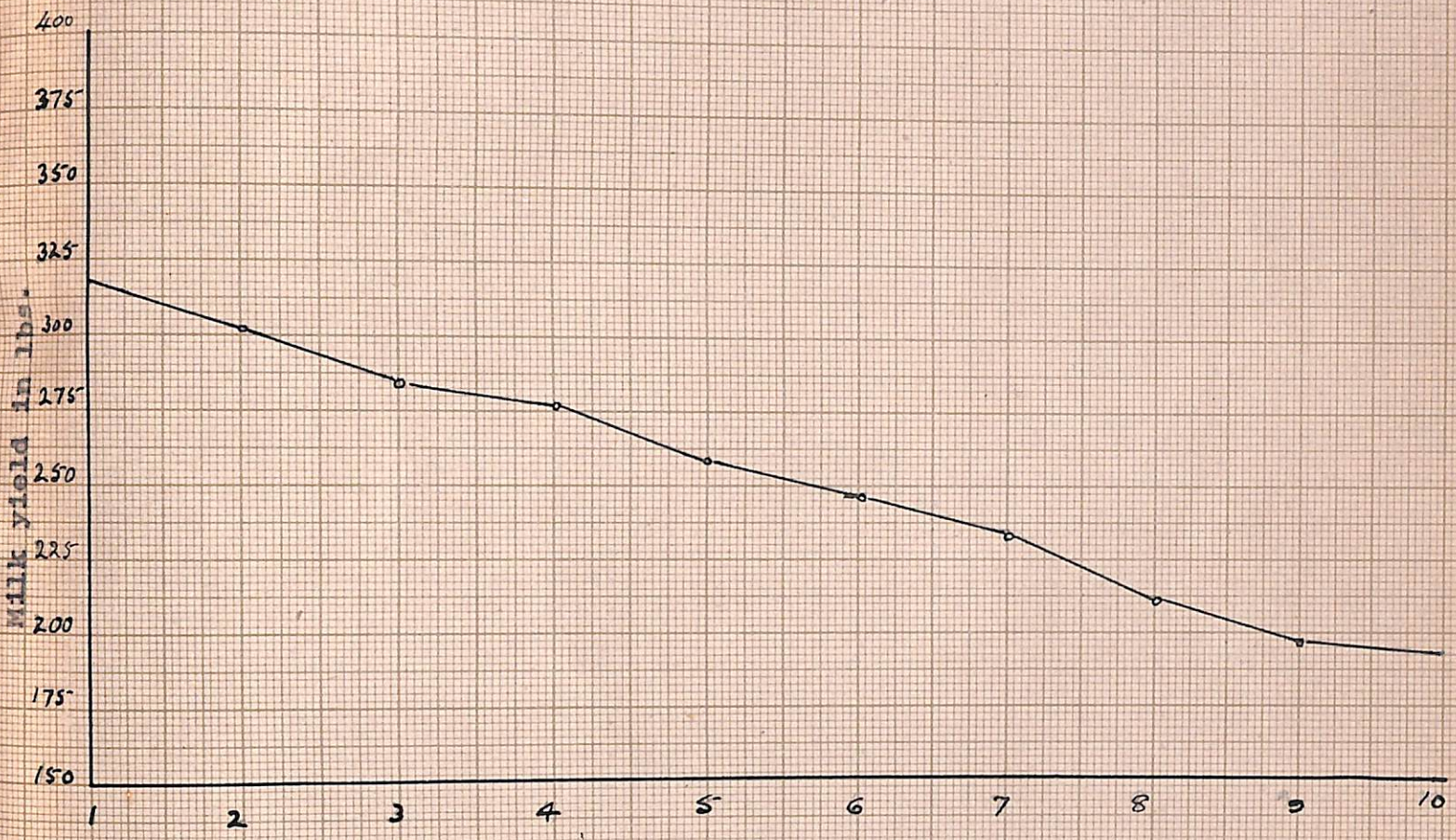
(Figure 9)

Seventh lactation.



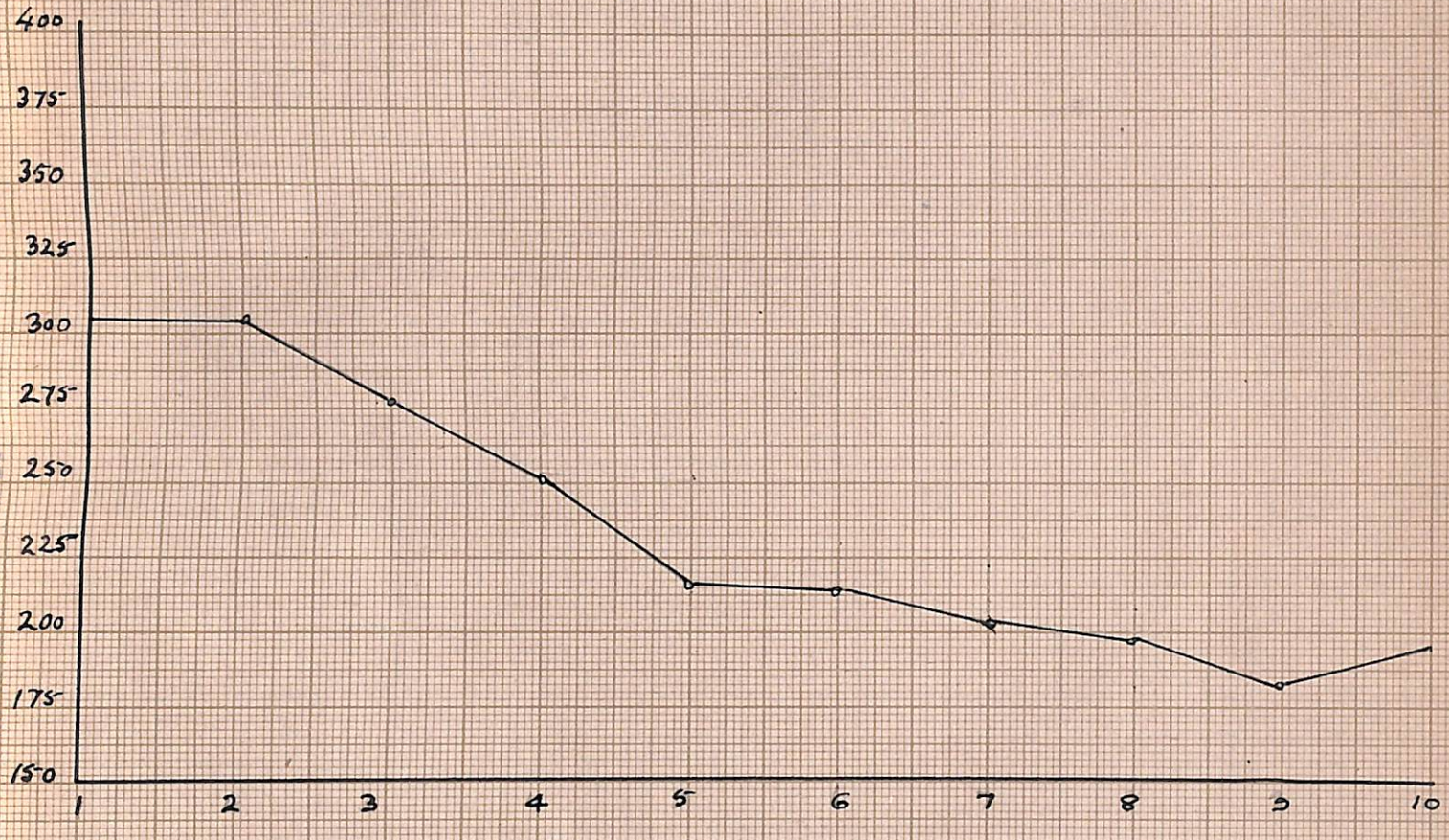
(Figure 10)

Eighth lactation.



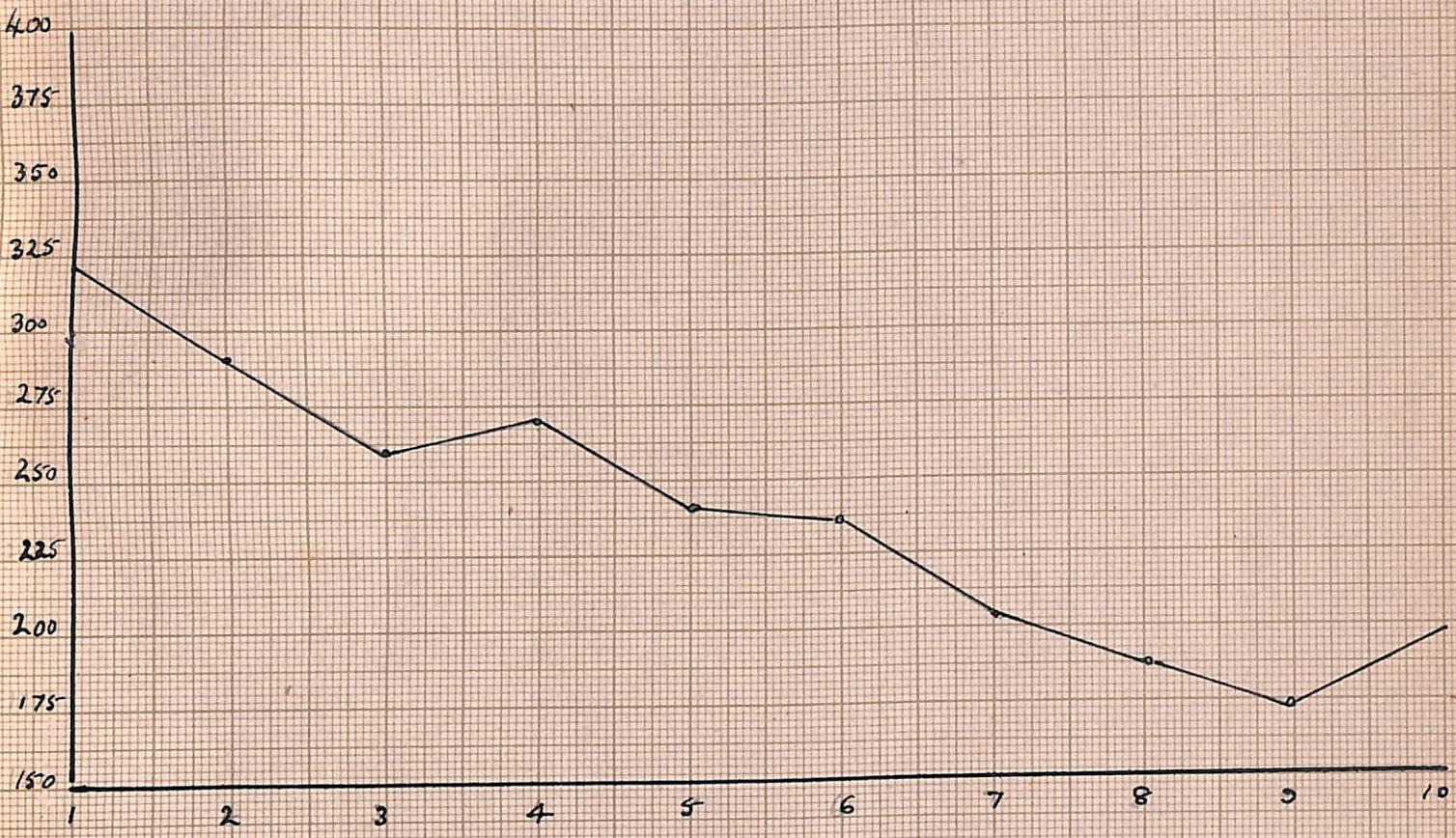
(Figure 11)

Ninth lactation.



(Figure 12)

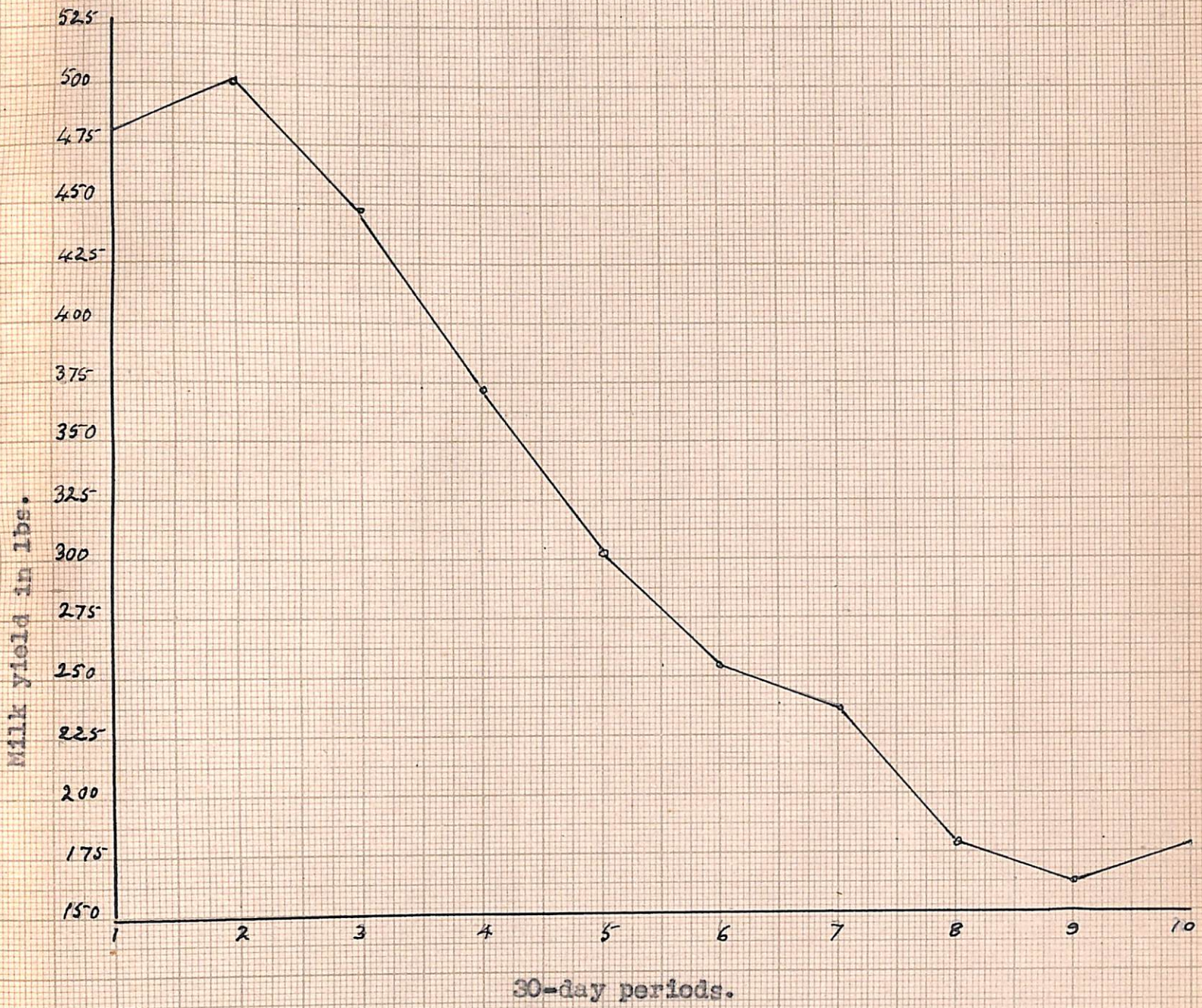
Tenth lactation.



30-day periods.

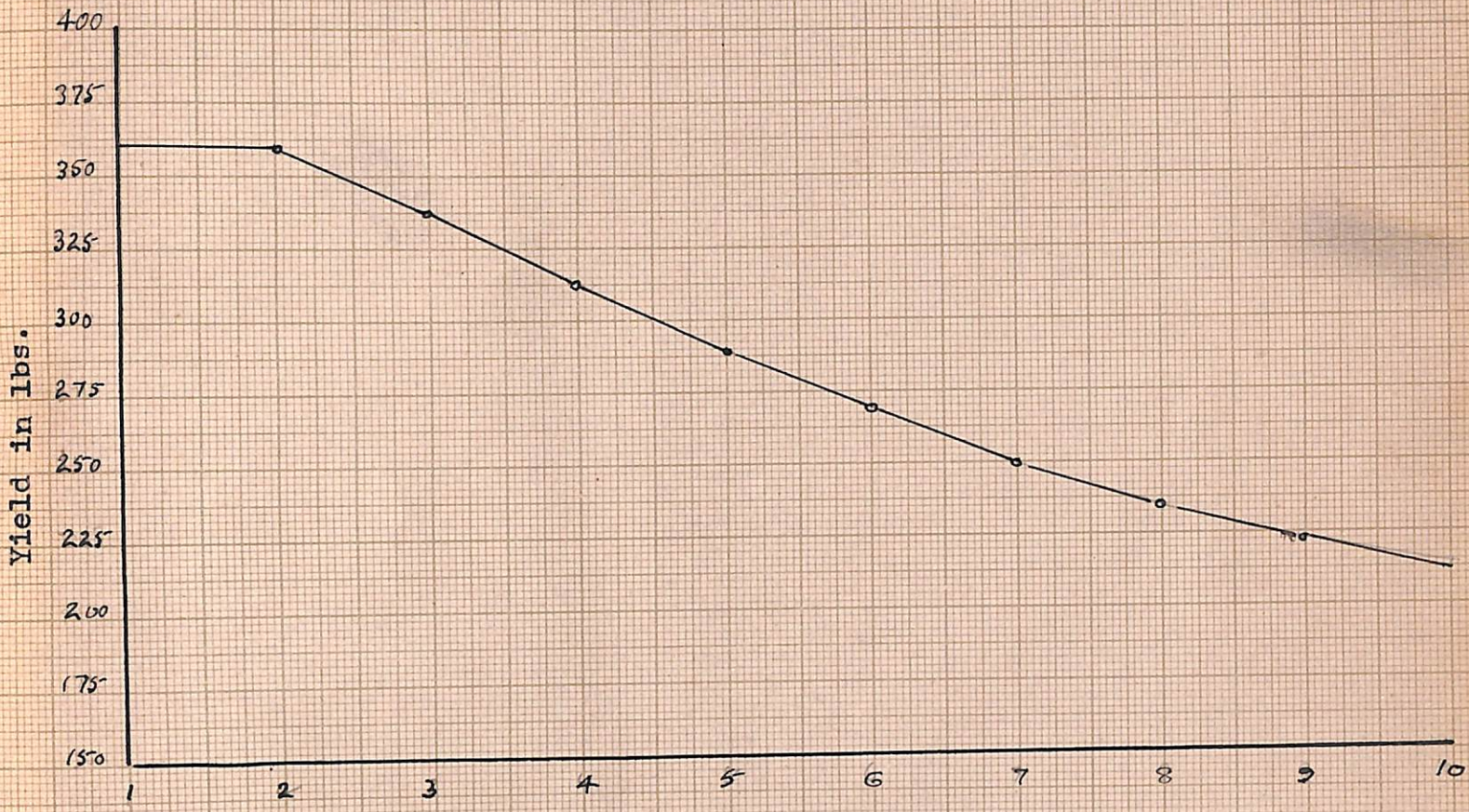
(Figure 13)

Eleventh lactation.



(Figure 14)

Overall lactations.

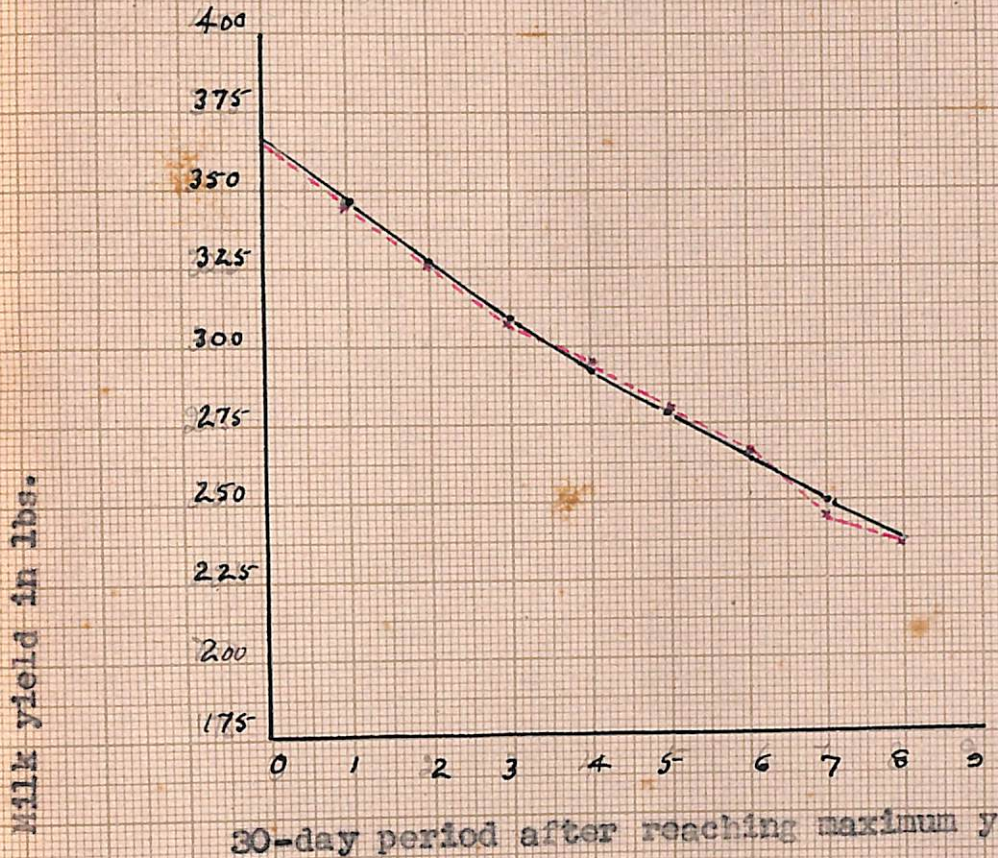


(Figure 15)

First lactation.

——— Fitter curve.

- - - - - - Observed curve.

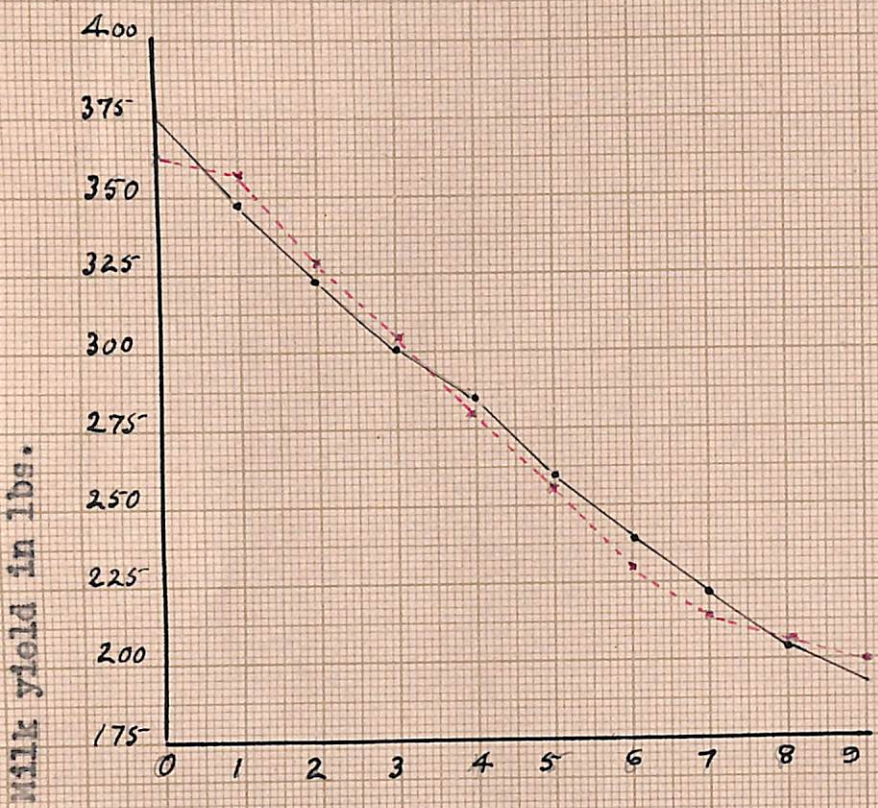


(Figure 16)

Second lactation.

——— Fitted curve.

– – – – Observed curve.

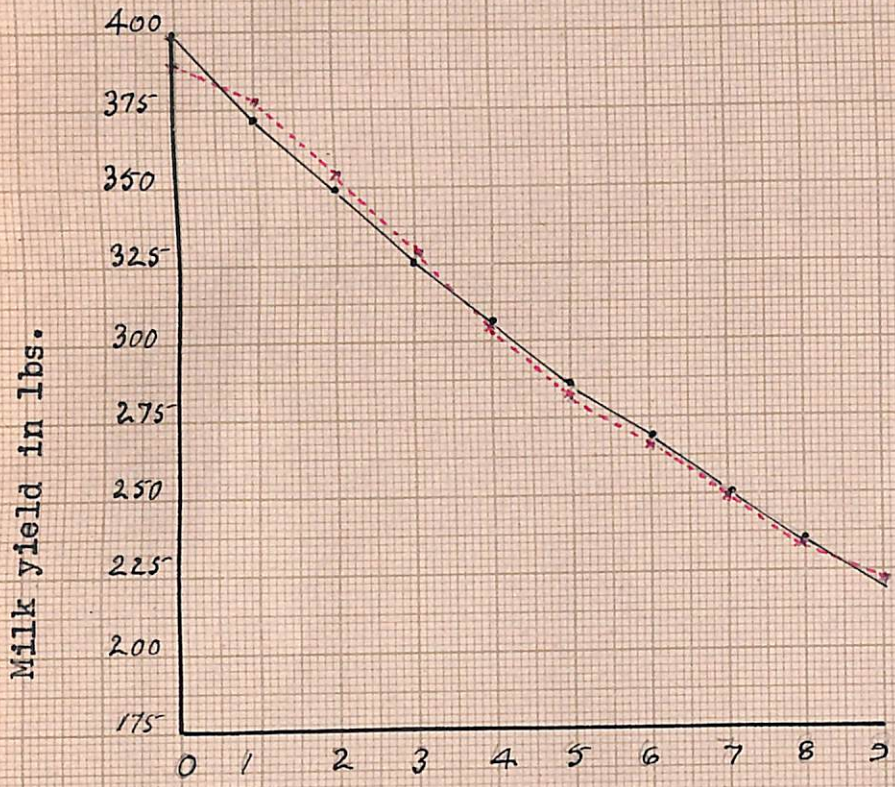


(Figure 17)

Third lactation.

———— Fitted curve.

- - - - - Observed curve.

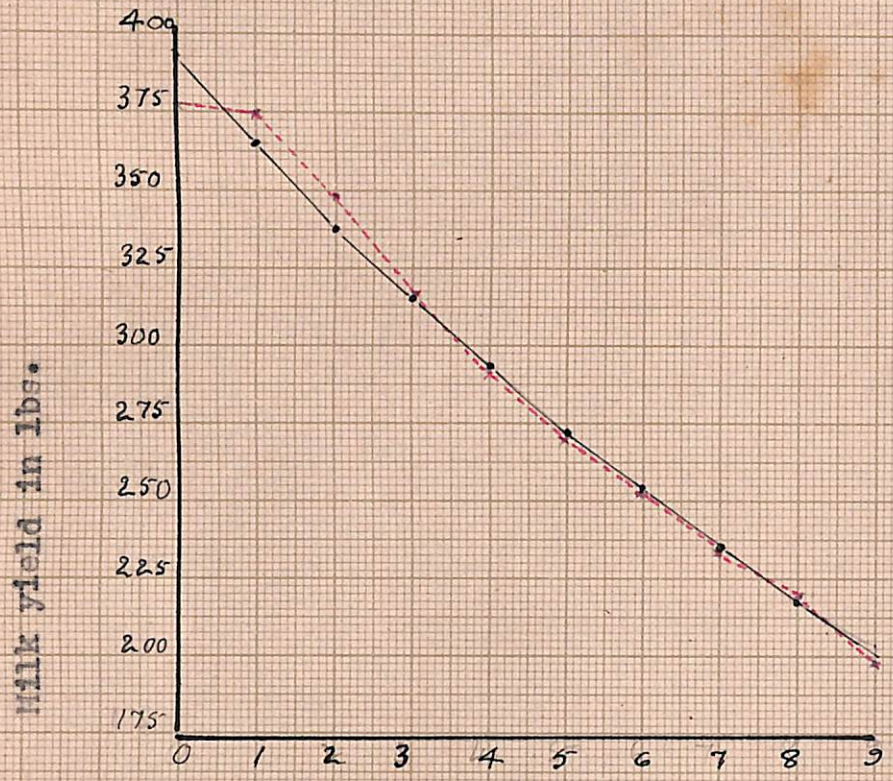


(Figure 18)

Fourth lactation.

——— Fitted curve.

- - - - - Observed curve.

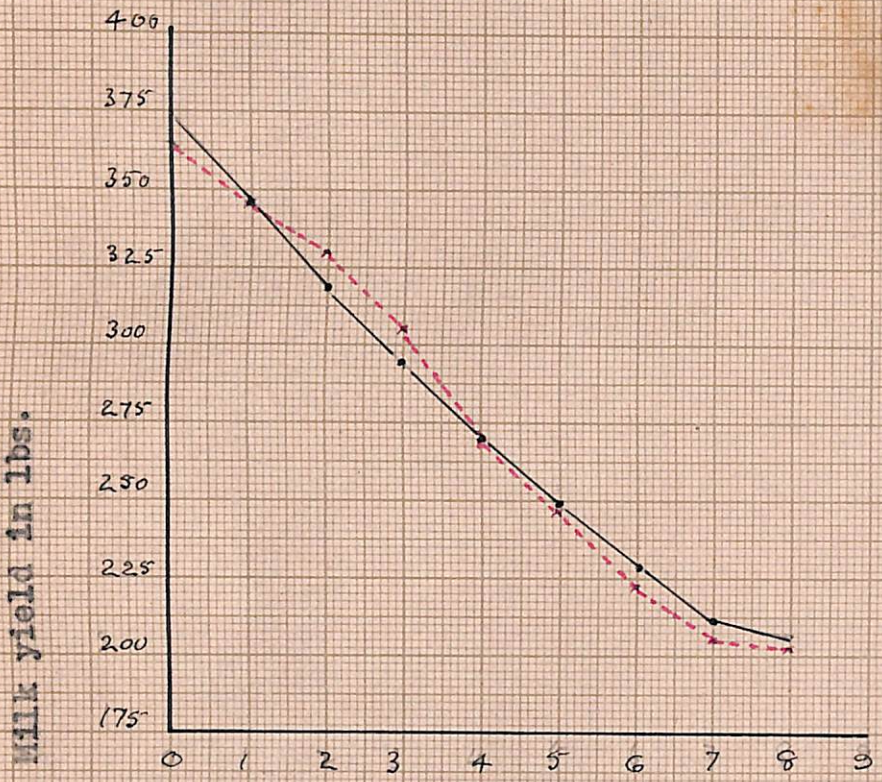


(Figure 19)

Fifth lactation.

——— Fitted curve.

- - - - Observed curve.

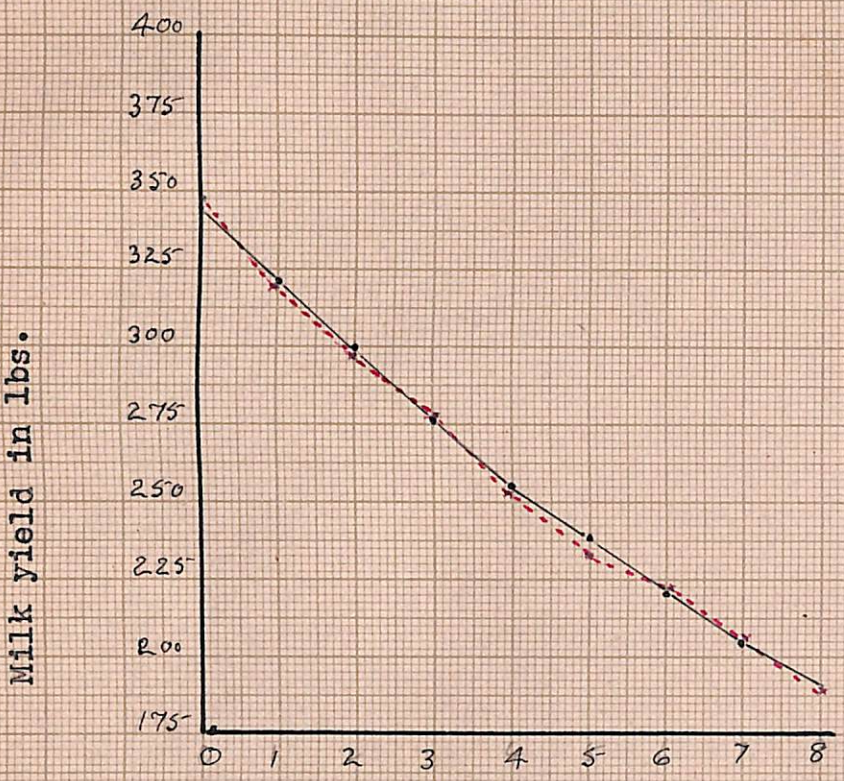


(Figure 20)

Sixth lactation.

———— Fitted curve.

– – – – Observed curve.

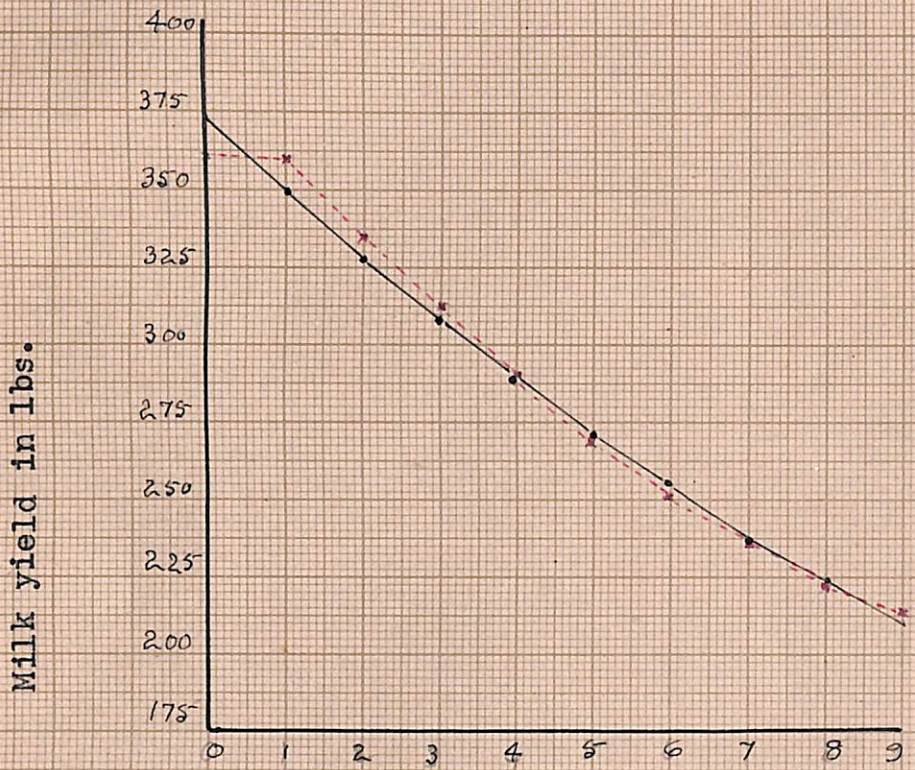


(Figure 21)

Overall lactations.

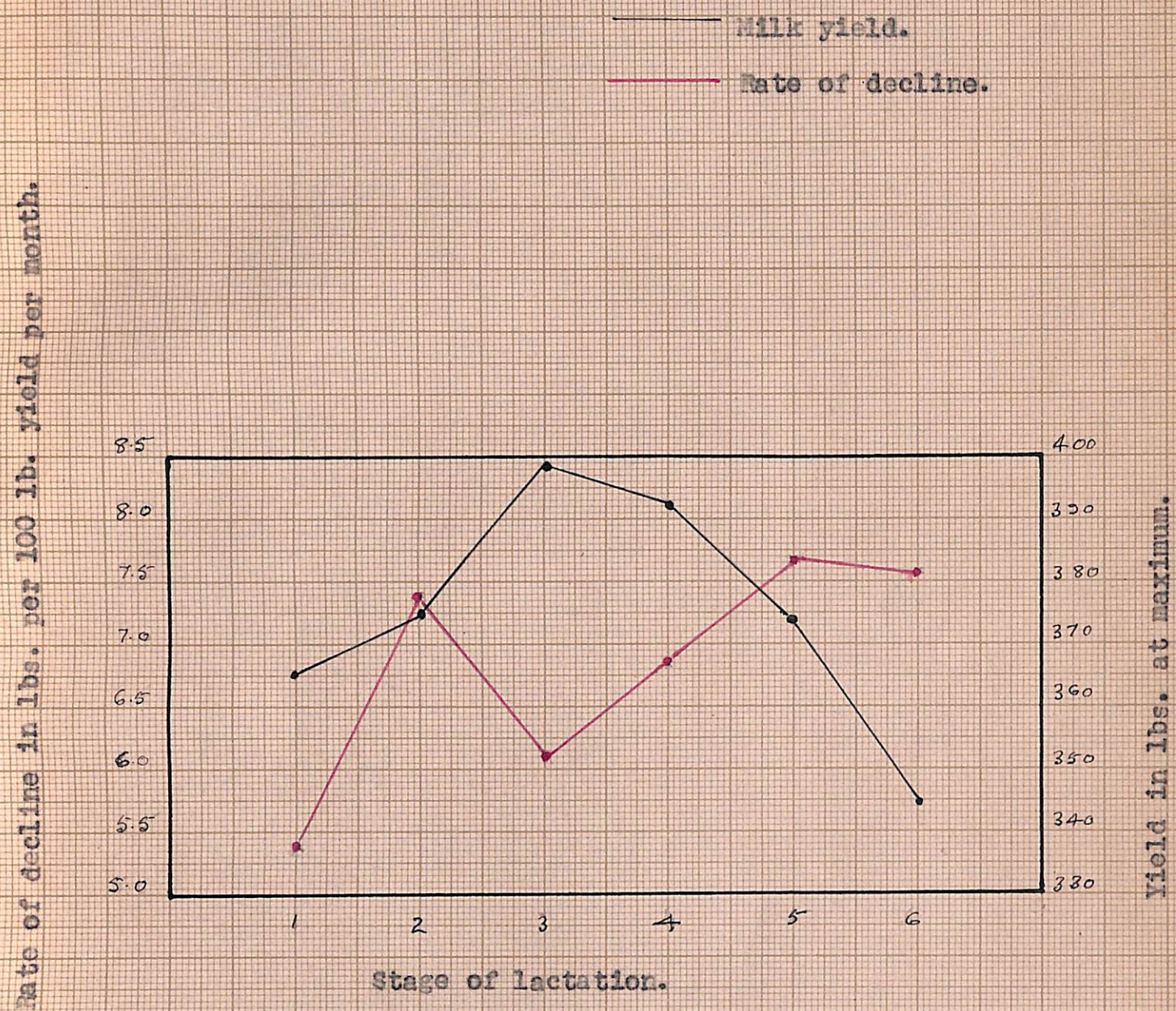
——— Fitted curve.

- - - - - Observed curve.



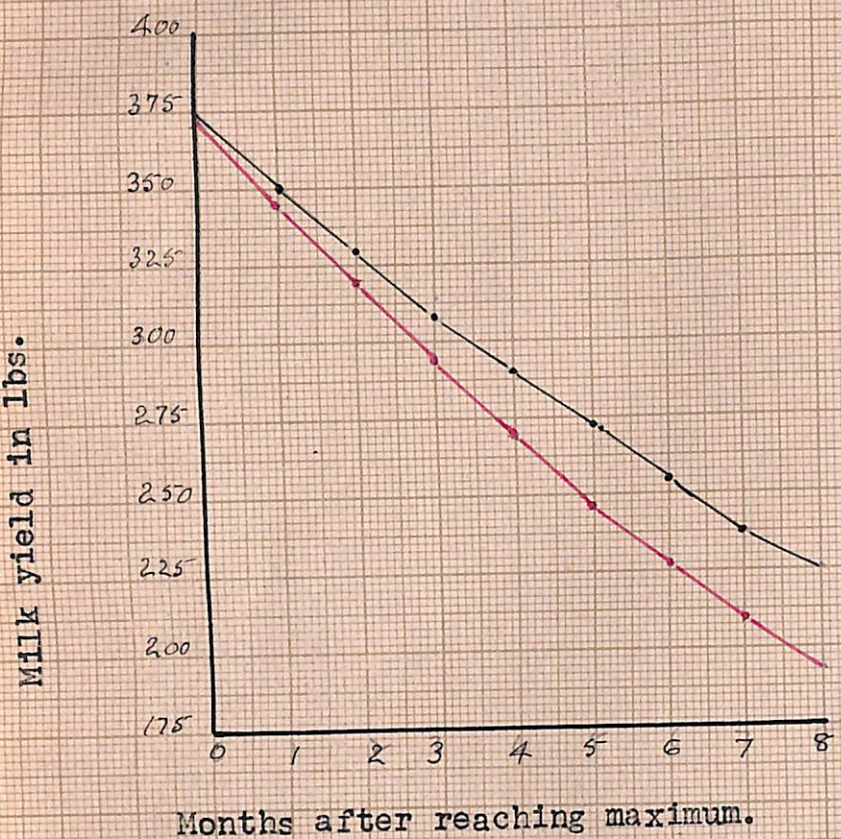
(Figure 22)

Relation between age and rate of decline and age and level of production in Tharparkar herd.

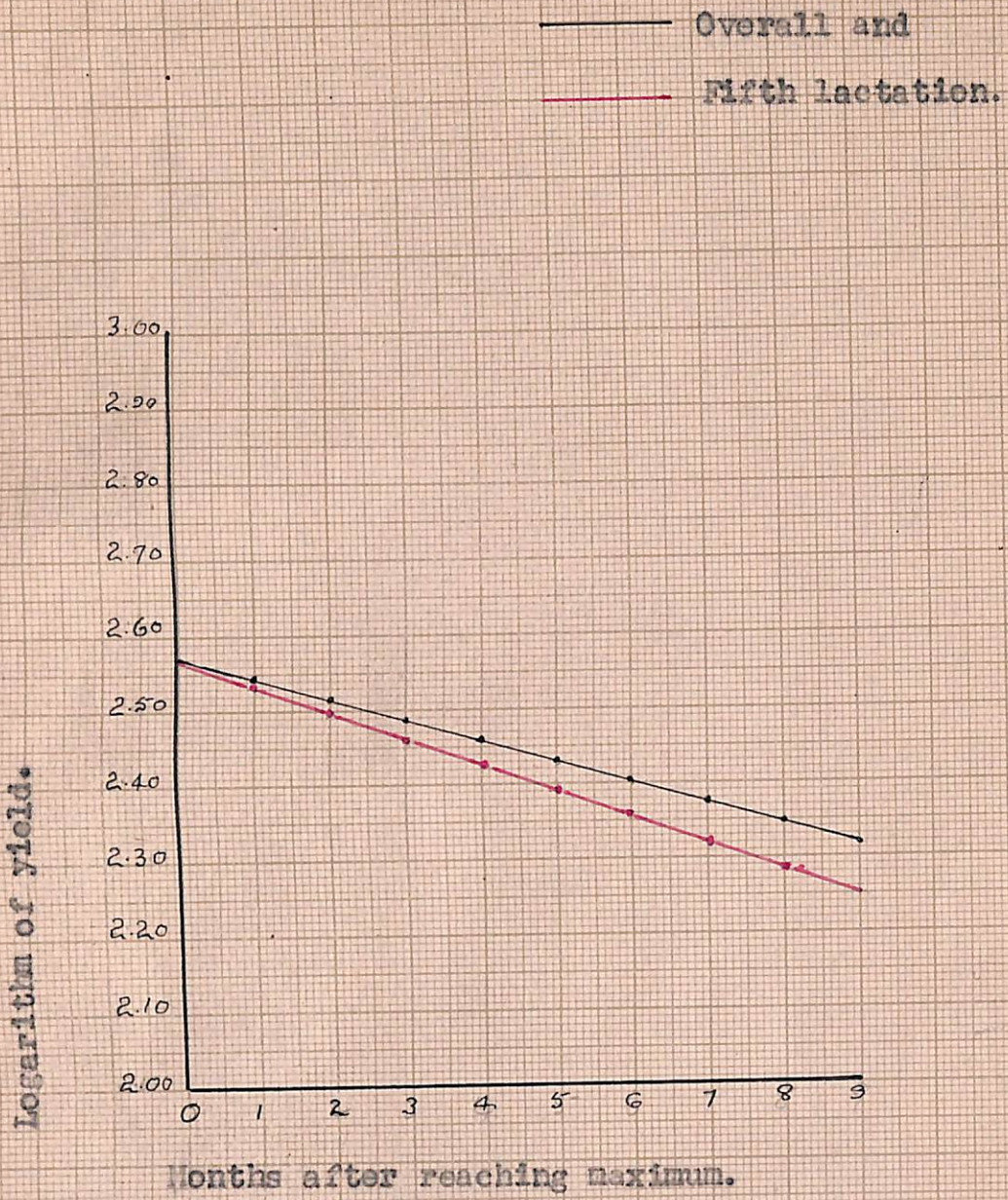


(Figure 23)

——— Overall lactations.
&
——— Fifth lactation.



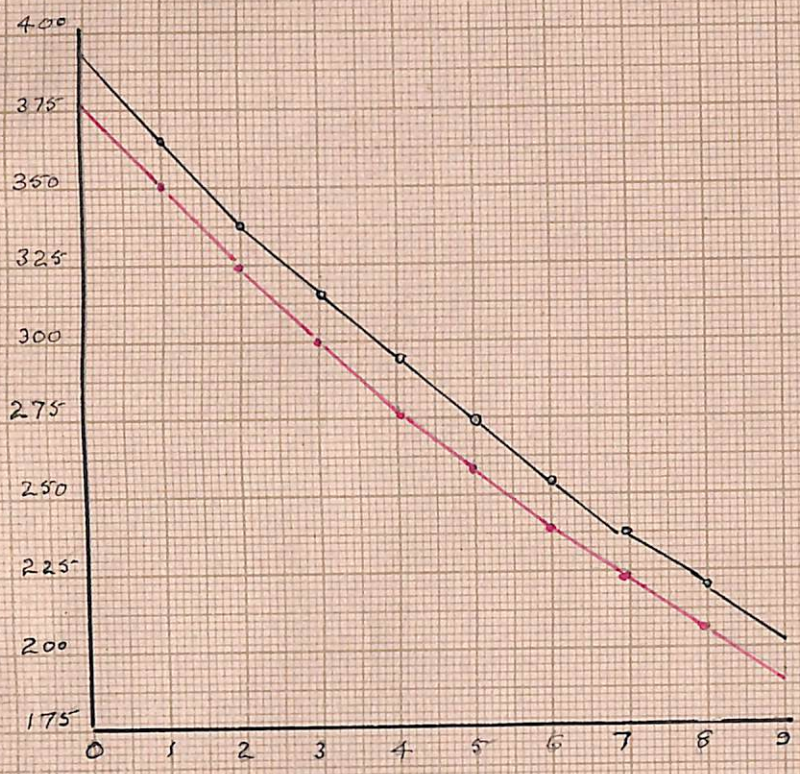
(Figure 23 a)


Overall and
Fifth lactation.
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
Logarithm of yield.
0 1 2 3 4 5 6 7 8 9
Months after reaching maximum.

(Figure 24)

——— Fourth and

——— Second lactation.



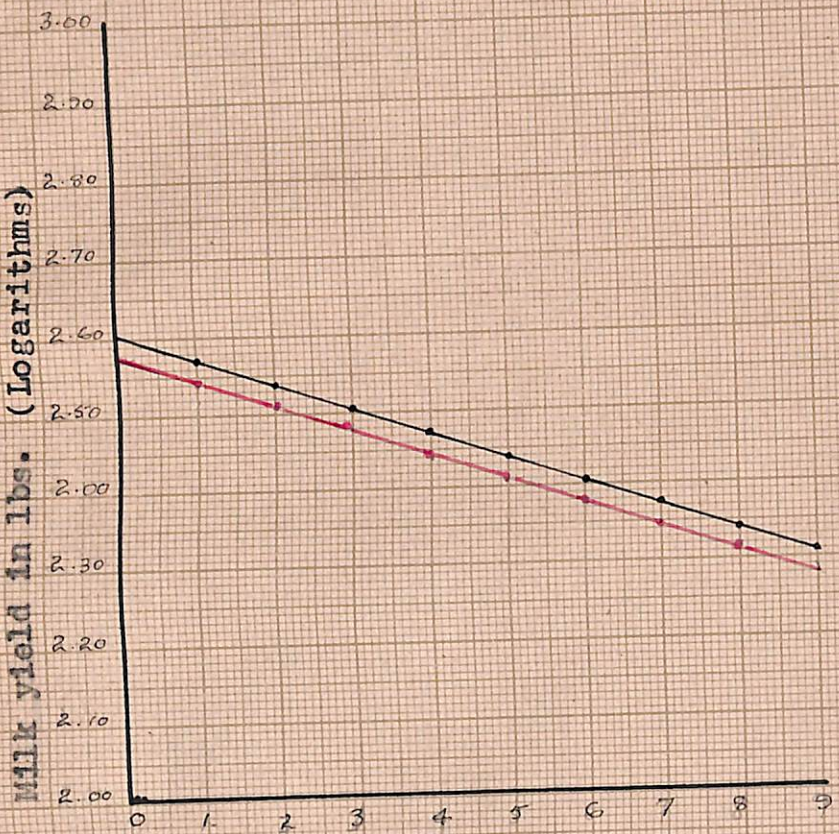
Milk yield in lbs.

Months after Maximum yield.

(Figure 24 a)

——— Fourth and

——— Second Lactation.



Months after maximum yield.

Chapter (IV).

D I S C U S S I O N.

Chapter (IV).

D I S C U S S I O N.

The objective of the present investigation was to study the trends in monthly milk yields and its persistency in Tharparkar herd at Patna. The economic importance of persistency was already mentioned in the relevant chapter dealing with 'Results'. In view of its considerable economic importance and also since no work was done in the Tharparkar breed on this important character, a study in this direction was carried out with data of milk yield for 30-day periods. The data for the study covered all lactations from the year 1946-'61. It was preferred to collect the data of milk yields in terms of 30-day periods. Each 30-day period represents total milk yield for 30-days. The study was confined on milk yields in first 10 X 30-day periods of lactations. The advantages of representing milk yields in terms of monthly intervals over intervals of lesser duration are two-fold. First, the fit of the lactation curves will be better with the monthly yields. The exponential equation with which the curves were fitted covers a significantly large part of the

lactation and secondly, the variation in milk yields will be greater if represented in short intervals of time. This variation to a certain extent can be overcome by monthly intervals over weekly or fortnightly yields of milk.

It was also decided to omit the first seven days of milk yield after calving, which may be attributed to colostral period.

Preliminarily, average lactation yields for different lactations were studied and the results were given in the table (8). The average life time milk production per lactation based on 1280 records was 2580 ± 37.91 lbs. Prasad (1962) reported the same to be 2414.36 ± 20.5 lbs. and average life time lactation length was 278.88 ± 1.2 days for this herd. This difference in average yields may be attributed to the fact that Prasad's (1962) findings were based on selected records, the milk yield of which ranged from 1000 - 4500 lbs, whereas in the present study, the average was based on 1280 unselected records, consequently the range was also higher. The maximum yield recorded was 7654 lbs.

The average lactation yields reported in table (8) were not corrected for lactation length, as such maximum yield was found to be in the first lactation

itself and the third lactation yield was higher than the second lactation yield. From the third lactation onwards there was a gradual fall in yield. This was showed in figure (1).

Sikka (1931) stated that, an Indian cow roughly does her best performance at her third lactation and maintains this yield during the fourth lactation, whereas in no other case the maximum is reached before the 6th lactation. Since the lactation yield was not corrected according to the lactation length, therefore, the results of this study is not comparable to those available in literature. It has been found that there was a significant variation in lactation yields and lactation lengths among the first four lactations, indicating the necessity to correct the records for lactation length. But this correction was not done in the present study, because the object of the present study was to study the tendency of monthly milk production with advance in lactation by fitting lactation curves, with an emphasis on finding out the duration in which the peak yield was attained and also finding out the persistency of milk yield in different lactations. So much so, before arriving at any conclusion regarding average lactation yield reported in the present study correction for lactation length seem to be necessary.

The maximum number of lactations a cow had in the present study was twelve.

Singh and Sinha (1960) reported the average number of calvings in the herd to be 4.86 ± 0.37. It would be interesting to find out as to the number of lactations upto which a cow will be an economical producer and fit to be kept in the herd. The basis of calculation adopted in the present study was to find out the number of lactations upto which the yield was higher when compared with average yield of the herd based on all lactations. In the present study, overall average yield for the first eight lactations was found out and it was 2489 lbs. The average lactation yields in the first eight lactations were compared with the overall average yield i.e. 2489 lbs. The first eight lactations were only taken into consideration because, the records of the cows beyond eighth lactation were very few. When compared, it was found that the yield for the first five lactations was more than the herd average yield, with a presumption that the fall in yield in second lactation and fifth lactation, may be due to the differences in lactation length and a correction for lactation length would have made the yield positive with overall herd average.

It can be concluded then that the average number of lactations in which a cow in the herd was an economical producer, was upto fifth lactation. This finding will be of use in effective implementation of culling of non-productive ones, which is of high economic importance because the cost of maintaining them in the herd will be saved.

Trends in monthly milk yields:- The maximum initial milk yield of peak yield was attained in the first month in Second, Third, Fourth, Seventh, Eighth, Ninth and Tenth lactations; and in the second month in First, Fifth and Sixth lactation in this herd. On the whole, the peak yield was reached within two months after calving for the whole herd. Third lactation has highest peak yield of 390 lbs. per month and Ninth lactation has 305 lbs. per month as its peak yield which is minimum when compared with first ten lactations of the herd. The overall average peak yield was 361 lbs. per month for all lactations, and it was the first month after calving in which the peak yield was attained.

The duration during which the maximum initial yield of milk attained in this herd, was in agreement with the earlier investigations among different breeds of milch cattle, reported by Kartha (1934, a), Jordao and Paula (1951), Delage et al (1953), Maymone and Malossini (1959, 1961). In this herd the maximum

yield was attained in the third lactation and it was in agreement with the results reported by Asker et al (1958) in Egyptian cows, and also as stated by Yapp (1955). Different breeds attained their maximum initial milk yield in different lactations as reported by various investigators. Sikka (1950), Mahadevan (1951, 53), Ullah (1952), Ludwick and Petersen (1943), Madden et al (1955), Lennon and Mixner (1958), Rakes et al (1959), Batra (1961), Mahadevan and Marples (1961), Balu (1961), and Suchanek (1962), reported a high correlation coefficient between maximum yield and total yield in different breeds of cattle. The literature available on estimates of heritability of maximum yield was already reviewed in table (4). The heritability of maximum yield varied with breed, herd and in short ranged from 0.25 to 0.45. In the present study, heritability and correlation studies were not conducted. But an indication can be made to the fact that what was true in other breeds for a general character like this may also be true for this herd also within limitations. Subject to further study on the data, it may be stated that selection of any one character either maximum initial yield or total yield, will bring automatically an improvement in the other.

After the milk yield has reached its peak, it slowly declined at a constant rate which varied with different lactations. The rates of decline for the first six lactations were as follows:-

First lactation	...	0.054 lbs. per lb. of yield per month.
Second lactation	...	0.074 -do-
Third lactation	...	0.066 -do-
Fourth lactation	...	0.073 -do-
Fifth lactation	...	0.082 -do-
Sixth lactation	...	0.076 -do-
Overall lactations	...	0.064 -do-

The ratio of any month's yield to that of preceeding month for different lactations were as follows:-

Lactation No.		Ratio.	In terms of percentage.
First.	...	0.947	94.7
Second.	...	0.928	92.8
Third.	...	0.936	93.6
Fourth.	...	0.930	93.0
Fifth.	...	0.921	92.1
Sixth.	...	0.927	92.7
Overall.	...	0.938	93.8

These values were slightly higher than those reported for Sahiwals by Kartha (1934, a) and which was 0.9277. The above results showed that Tharparkar herd has relatively high ability to retain its peak yield at its maximum than pedigree Sahiwal cattle.

Persistency of milk in different lactations was calculated by three different methods and the values obtained were given in table (24). It was observed that among the first six lactations, the persistency index of the first lactation was highest and that of the fifth was lowest. The persistency index of overall lactations was 93.6%. Many authors defined persistency in many ways. It was observed from the literature available, that there is no uniformity in expressing values of persistency. So much so, it could not be possible to compare the values of persistency with other published results. But it can be stated that the persistency of milk yield in this herd was higher than that reported by Kartha (1934, a) in Sahiwal cattle. When compared with temperate breeds of cattle, as reviewed by Mahadevan (1958), the value of persistency observed in this herd, was comparatively lower.

By the same method as estimated by Fohrman et al (1954) the value of persistency in this herd (overall lactations) was 93.8%, whereas as reported by Fohrman et al (1954) from the studies conducted at Beltsville, the persistency values for the foundation cows and to cross bred groups were 94.3% and 95.9% respectively. Kartha (1934, a) concluded from his study that pedigree Sahiwals were persistent than cross bred and ordinary Sahiwal cows. The value of persistency in the first lactation was highest among

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all lactations in this herd. This result was completely in agreement with the results reported earlier by Sikka (1950), Corley (1956), Hammond (1957) and Balu (1961) in different breeds of cattle.

Brody (1927) as quoted by Mahadevan (1958) reported declines of milk yield per month as 0.053, 0.056 and 0.057 respectively for groups of Holstein, Jersey and Guernsey cows. The corresponding declines reported by Kartha (1934, a) ranged from 0.0(0.075)75 in Ferozpur pedigree Sahiwals to 0.11 among ordinary Sahiwals in India. So, it can be concluded that the persistency of milk in this herd was higher than that of pedigree Sahiwals but as regards maximum yield the reverse is true. Tharparkar herd is a dual purpose breed. The maximum yield in ordinary Sahiwals as reported by Kartha (1934, a) was 492 lbs. whereas in this Tharparkar herd it was 390 lbs. per month.

The relationship between stage of lactation and persistency could not be found in the present study, but a relationship between level of production and persistency seem to exist. Kartha (1934, b) observed that persistency is influenced by level of production than stage of lactation.

The overall average monthly milk yields in the first five months of production were 361 lbs., 360 lbs., 337 lbs., 313 lbs. and 291 lbs. respectively. By carrying out Bartlett's test and running analysis of variance, it was found that the variation of yields in different months to be significant. It was interesting to find out in which of the possible combinations, the difference in yields between different months of production were significant, by carrying out a test as described by Snedecor (1956) in section 4.9. With five months of production the possible comparisions will be ten. The following table No.27 shows which of the combinations in respect to the difference in production was significant:-

Table 27.

30-day period.	Average yield in lbs.	Difference in production between (months or 30-day periods)			
First.	361	First and second.	Second & third.**	Third & fourth.**	Fourth & fifth.**
Second.	360	First & third.**	Second & fourth.**	Third & fifth.**	
Third.	337	First & fourth.**	Second & fifth.**		
Fourth.	313	First & fifth.**			
Fifth.	291				

(**) highly significant at 0.01 level.

The difference between first and second month of production was not significant. This indicates that maximum initial yield was maintained through second lactation. The difference in yields between later months of production was on expected because the milk yield after attaining the maximum declined gradually, and 100% persistency in yield cannot be expected between any two succeeding months when once the milk yield begins to decline. The findings in the table 27 in a way show this characteristic property of the lactation curve.

The economic importance of persistency was shown in table 25. Persistency was expressed in terms of rate of decline for this purpose. From the table 25, it was seen that the initial yields were nearly the same for the two groups; but the values of persistency were quite different viz. 0.082 lbs. and 0.064 lbs. in terms of rate of decline per lb. per month respectively for first group and second group respectively. This with a difference in rate of decline of 0.018 lbs. (0.082 - 0.064) per lb. of yield per month, the difference in total yield in a period of 9 months was found to be 161 lbs. nearly (2645.1 - 2484.9 lbs.) between the two groups. This much of yield was higher in the group in which the rate of decline was 0.064 lbs. per lb. of milk per month over the group where the initial yield was same but had a rate of decline in yield of 0.082 lbs.

per lb. of yield per month. This difference in yield due to difference in persistency values was when expressed in terms of percentage it was for every 1% difference in the persistency the difference in yield was 3.33% over a period of 9 months of production. It may be concluded that two cows may have different maximum yields, but the total yield will depend upon their persistency of yield. The difference in maximum yields will be made up in the course of a lactation, by a highly persistent cow over the lesser persistent one.

The heritability and correlation studies involving persistency were not taken up in the present study. The literature on this character was reviewed in chapter 'Review of literature'. From the investigations of earlier workers, Mahadevan (1951) and Ullah (1952) who reported that it should be possible to combine high initial yield with high persistency to obtain increased total production. The results of their study has a wider application for other herds of cattle also. But before arriving at any specific conclusions for this herd, further analysis of data is necessary in the direction indicated by the aforesaid investigators.

The trends of milk yield with advance in lactation can well be studied by fitting the lactation curve. Kartha (1934, a) stated that a knowledge of the properties of the lactation curve helps the

solution of many problems that are met within the course of dairy routine practice. The objective of the present study was not to go into the properties of the lactation curve, but it was confined to the fitting of lactation curves for different lactations of this herd. The form of mathematical expression used to express the shape of the curve was 'Exponential equation' of Brody and Co-workers (1923). Test for goodness of fit was carried out by finding out chisquare values. It was observed that the values of the chisquare were insignificant for all lactations, thereby showing that the exponential equation fitted to the data remarkably well. Lactation curve were fitted for the first six lactations and also for overall records of lactation. (Figures from 15 to 21). Kartha (1934,a) also made use of exponential equation in fitting the lactation curves and expressed satisfaction over the fitness of the curves to the data.

-xXx-

Chapter (V).

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S U M M A R Y.

Chapter (V).

S U M M A R Y.

A study has been made of the trend in monthly milk yields and its persistency in the Tharparkar herd at Patna. The study was based on milk records collected from the Government Cattle Farm, Patna, and the data comprised of 1280 lactations for the period from 1946 to 1961.

2. The average life time milk production per lactation based on all records was calculated and found to be 2580 - 37.91 lbs. It was indicated that it is not economical to keep a cow in this herd beyond sixth lactation, unless the cow is an exceptionally good producing one.

3. A graphical representation of different lactations were made with milk yield in 30-day periods for the first 10 x 30-day periods. The curves are much skewed from 7th lactation onwards because the average yields calculated, were based on few records in later lactations.

4. The maximum initial yield was reached in the first month in Second, Third, Fourth, Seventh, Eighth, Ninth and Tenth lactations and in the second month in First, Fifth and Sixth lactations.

Based on overall records the peak yield was attained in the first month. On the whole, the peak yield was attained within two months after calving. The fall in yield between two succeeding months of production was found to be significant when once the milk yield begins to decline.

5. Among different lactations, the maximum initial yield was attained in the third lactation and it was 390 lbs. per month. On the other hand, ninth lactation has minimum average yield as its peak, and it was 305 lbs. per month.

6. Persistency of milk was calculated by three different methods. The persistency indices for different lactations, in this herd were as follows:-

First lactation.	...	94.6%
Second lactation.	...	92.6%
Third lactation.	...	93.4%
Fourth lactation.	...	92.7%
Fifth lactation.	...	91.8%
Sixth lactation	...	92.4%
Overall lactations.	...	93.6%

High persistency was observed in first lactation records.

7. Lactation curves were fitted with exponential equation of Brody and Co-workers (1923). The equation gave a good fit to the curves. Lactation curves were fitted to the data of the first six lactations and also to the data of overall lactations of this herd.

8. The economic importance of persistency was studied. For every difference of 1% in the persistency value the milk yield was found to be effected by 3.33%.

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THE END.