

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

RESEARCH BULLETIN 156

The Development of the Mammary Gland as Indicated by the Initiation and Increase in the Yield of Secretion

(Publication Authorized July 13, 1931)



COLUMBIA, MISSOURI

AUGUST, 1931

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PREFACE

Investigations relating to *Milk Secretion* have been under way at the Missouri Agricultural Experiment Station for more than twenty years. During recent years intensive studies of the time relations in milk secretion and mechanisms regulating variations in the composition of milk have been made. The need has been realized of a more complete knowledge of the anatomy of the mammary gland so that studies of the process of milk secretion would rest on a sound basis of anatomy and physiology.

As a consequence, studies concerned with the anatomy and physiological development of the mammary glands were initiated at this Station by Dr. C. W. Turner. These studies have as one of their principal objectives, the determination of the exact nature of the relationship of the hormones concerned with sexual activities and the growth and development of the mammary gland and milk secretion.

During the past few years progress has been made in the study of the estrus-producing, corpus luteum, and anterior pituitary hormones, which appear to be physiologically associated with the growth of the mammary gland and the initiation of milk secretion. It would appear that the general nature of the hormones regulating the extent of growth, intensity of secretion, and other factors influencing the productive ability of the dairy cow will soon be revealed.

It is believed that the present publication and others of the series shortly to appear will contribute to an understanding of the physiological mechanisms responsible for the variation in milk production.

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ABSTRACT

A study is reported concerned with the development of the mammary gland of dairy cattle. As a measure of gland development, the presence and increase in the yield of secretion is used. Dairy calves and heifers were regularly examined at birth before puberty, during the recurring estrus cycles, and during pregnancy.

It was observed that dairy calves at birth rarely, if ever, secrete the so-called witches' milk. This lack of secretory activity of the mammary gland continues until the approach of puberty. During puberty the mammary glands of cattle in many cases begin to secrete small amounts of fluid, the yield of which increases during or following the occurrence of estrum.

During the greater part of pregnancy, the yield of secretion in primipara heifers either remained at the level attained during puberty or declined to some extent. It is only during the last 20 days of pregnancy that there is a striking increase in milk secretion.

The yield of secretion during puberty and much of the first pregnancy does not measure the growth of secretory tissue. Only with the stimulus to lactation observed at the approach of parturition are the potentialities of the glands fully realized.

ACKNOWLEDGMENT

The writer wishes to express his appreciation of the cooperation of his former colleague, Professor E. C. Elting, now of the South Carolina Experiment Station, for assistance in recording the observations on some of the animals included; to Mr. I. S. Slaughter, a graduate student in the Department of Dairy Husbandry during the year 1927-28, for the data on a number of heifers included in his thesis; and to the Department of Agricultural Chemistry for the analyses of the secretions noted in the text.

The Development of the Mammary Gland as Indicated by the Initiation and Increase in the Yield of Secretion

CHARLES W. TURNER

Increases in our knowledge of the growth and development of the mammary gland may be obtained by several distinctly different methods. On one hand is the anatomical method by which is traced the structural development of the mammary gland through each succeeding sexual epoch of the animal until normal lactation is reached. Knowledge of the structure of the gland is the foundation of all further research.

On the other hand is the physiological method by which is determined the presence and activity of the hormones which may stimulate the growth and activity of the mammary gland.

A third method of study lies in the determination of the yield and composition of the secretory products of the gland during the course of development. The time when a secretion may first be obtained and the rate of increase in yield may indicate the time when hormonal stimuli first become effective and the course of growth and development of the gland coming as a result of continued stimulation.

Because of the interrelation of these various phases of the problem of milk secretion, it has been found that the most rapid progress toward our goal comes as a result of the coordination of the anatomical, physiological, and chemical investigations. As a result work is now in progress at the Missouri Agricultural Experiment Station on these various phases of the problem. Reports of certain of the anatomical and physiological studies have been made recently.

The object of this bulletin is to present a report of progress in the study of the initiation and increase in the yield of secretion during each succeeding sexual epoch from birth until parturition.

The initiation of milk secretion is usually thought to follow the termination of pregnancy. However, it has long been known that cows will begin to secrete milk in considerable abundance previous to the time of parturition. Scattered through the earlier literature on milk secretion are numerous reports of lactation in virgin animals of various ages. These animals have been considered more or less abnormal and little effort has been made to explain the precocious secretion of milk as a normal condition following puberty which may be induced by the manipulation of milking and the removal of the secretions present in the gland.

SECRETION FROM MAMMARY GLAND OF THE NEWBORN ANIMAL. (WITCHES' MILK)

The appearance of a secretion from the mammary glands of the newborn has been observed in some animals. The most authentic observations appear in the human. Some of the earlier reports are referred to by De Sinety (1875) in connection with his anatomical investigations on the breast of the newborn. He concluded from observations of premature, normal, and older infants that the secretion obtained from the gland several days after birth is not the product of the degeneration of the epithelium, but rather is the result of a real secretion.

The number of references to this phenomena in the literature are so numerous that there can be little doubt that a slight secretion is found very frequently in the breasts of infants (both male and female) shortly after birth. In personal observations, Myer (1919) recently observed that when the secretion was present at the time of birth, such infants usually showed indications of having been born postmaturely. On the other hand, in premature infants the secretion may not appear until many days after birth, and in a few cases it was not observed at all.

While the presence of a secretion in the breast of the new born infant appears to be a frequent occurrence, reports of the secretion in the mammary glands in other new born animals are rather rare. Still in many books the subject of "witches' milk" is discussed without reference to the animal in which it was observed. As a result, it is commonly assumed that a secretion is frequently present in the mammary glands of calves shortly after birth.

In connection with our studies on the initiation of milk secretion it seemed desirable to determine the frequency of the appearance of "witches' milk" in calves, the time of its appearance, duration, and yield. An examination was, therefore, made of the mammary glands of all calves born in the Missouri Agricultural Experiment Station dairy herd for a considerable period. During this period the glands of nineteen calves were examined. Of this number, eleven were bulls and eight were heifers. Their udders were manipulated for periods varying from three to thirteen days. In no case was it possible to express a secretion from the glands of the calves. To further study the problem, a casual examination has been made of the calves when they are weighed at birth and at regular intervals later. While this examination has not been made as carefully as that first reported, the presence of a secretion in any quantity would have been noted. Up to date not a single case has been observed.

In a review of the literature on the subject of lactation in virgin animals, Spann (1929) reports that Grimm observed a four day old calf

that gave milk. In comparison to the single report of lactation in the calf at birth, there are cited a number of cases of very early lactation in goats (kids) and also in horses (foals). Asdell (1925) also reports a case of a kid in lactation at three weeks.

From the fact that only a single case of secretion has been observed in the calf at birth from reports in the literature and that not a single case was observed in the Station herd during the period of examination, it is concluded that the presence of a secretion in the mammary gland is a very rare phenomena in cattle at birth.

BIRTH TO PUBERTY

The period from birth to a short time before the beginning of puberty is a period of quiescence of the mammary gland. Anatomical studies show quite definitely that the structure of the gland tissue (ducts and lobules) shows little or no growth. Any apparent increase in the size of the gland during this period results from an increase of connective tissue and the deposition of fat. In well nourished calves the amount of fat present is considerable.

Considering the secretory activity of the gland during this period, considerable confusion has arisen due to the difficulty of securing definite proof that the animals reported have not been in estrum. In some of the breeds of dairy cattle sexual maturity comes very early. Thus, in a study of Jersey Register of Merit cattle two animals were found which calved at thirteen months of age. Assuming a normal gestation period, these calves not only came in estrum but were bred by the fourth month.

In order to secure definite data concerning the initiation of secretion two grade Holstein heifers (6A and 9A) were systematically examined for the presence of mammary secretions. One animal had been ovariectomized previous to the beginning of the experiment. The ovaries were found in an infantile stage of development. This animal was examined and the teats stripped three times per week for a number of months without securing any evidence of secretory activity of the mammary glands.

The normal heifer of approximately the same age was similarly examined. In this case no sign of a mammary secretion was observed until two days after the first observed estrus period when a few drops of a very watery fluid were obtained.

Later a Jersey and two Ayrshire calves were similarly examined for the presence of a mammary secretion. The Jersey (803) was practically eleven months old when placed under observation. She had never been observed in estrum up to this time. On the third massage, a few drops of an opaque, watery fluid were obtained from the left rear quarter which alone continued to yield a few drops at each massage period. The first

observed heat period occurred about two weeks after the observations were commenced. At this time no increase in the secretion was noted. It is questionable in this case whether estrum had occurred previously or whether a secretion was being produced prior to the first estrum.

The Ayrshire heifer (343) came into the first observed estrus the day following the first observation period. This was followed by the secretion of a sticky, opaque fluid from the left fore quarter. Estrum came so soon after the beginning of the observations that it is questionable whether a secretion might not have been produced without estrum.

The second Ayrshire heifer (344) was younger than the animal reported above. She had not been observed in heat at the time observations were initiated. At irregular intervals a few drops of a watery, opaque fluid were expressed from the left rear quarter. Later when the teats were stripped very vigorously a secretion was obtained from all four quarters. With the discontinuation of the vigorous manipulation of the glands, the secretion stopped until following the first estrus period.

While these observations are insufficient to warrant any extended conclusions, they are believed to indicate that the period from birth to the approach of puberty is a time when the mammary gland displays little or no secretory activity. The fluids obtained at this time are probably in the nature of an exudate rather than a secretion.

These conclusions are supported by the anatomical observations of the udders of sexually immature calves. They are also in harmony with the experimental results obtained concerning the factors responsible for the growth and initiation of secretion of the mammary gland.

SECRETORY ACTIVITY DURING THE RECURRING ESTRUS CYCLES

With the approach of puberty, the ovaries gradually become active. Follicles increase in size and begin to secrete the estrus producing hormone. Soon there is a sufficient amount of this hormone secreted to bring the animal into estrum. Thus is initiated the estrus cycle which normally continues more or less regularly until conception occurs.

Recent investigations have quite definitely proven that the ovaries are stimulated to activity by the formation of a hormone or hormones arising in the anterior lobe of the pituitary. Smith and Engle (1927) in this country and Zondek and Aschheim (1927) in Germany independently showed that implants of the anterior pituitary into sexually immature animals quickly matured the ovary. These observations have since been confirmed and extended. It seems clear from these observations that the time of puberty is definitely determined by the activity of the anterior pituitary.

With the recurring estrus cycles, the growth of the mammary gland becomes active again. The growth at this time is chiefly in the nature of duct development. In cattle these ducts may extend for considerable distances from the gland cistern into the udder tissue. It has also been demonstrated experimentally in small animals (rabbit) by Turner and Frank (1930) that the growth of the mammary gland ducts can be developed extensively by the injection of the estrus producing hormone into spayed animals.

During the estrus cycle in cattle, the production of the estrus hormone is not the only hormone produced by the ovary. Following estrus, ovulation occurs. The corpus luteum rapidly fills the follicular cavity in the ovary. The corpus luteum also secretes a hormone which has recently been shown to cause the complete growth of mammary gland when present with the estrus producing hormone. (Turner and Frank 1931). Thus an estrus cycle in some respects may be compared to a period of pregnancy of short duration insofar as the hormones of pregnancy acting upon the mammary gland are concerned.

One further experimental observation has an important bearing on the problem under discussion. In the experiment cited above, the growth of the mammary gland was not followed by milk secretion. It appeared as though some other hormone was essential to initiate the secretory phase. The first evidence of a hormone which would stimulate the secretion of milk in the fully developed gland was presented by Grüeter and Stricker (1929). The active principle was obtained as an aqueous extract of the anterior pituitary. These observations have been confirmed recently by Corner (1930) and Turner and Gardner (1931). The evidence at hand appears to indicate that the hormone causing the activation of the secretory cells of the mammary gland is separate from the hormones stimulating the ovary. Still the gonad stimulating hormones and the lactation stimulating hormone may both increase in amount during the proestrus period. Thus growth of the gland and the stimulation to a slight secretory activity would be expected during the recurring estrus cycles.

Space does not permit an extended review of all cases of precocious milk secretion. Of the recent reports in cattle, the observations of Woodman and Hammond (1922) are of interest. They report that considerable amounts of a fluid could be expressed from the teats of virgin heifers $1\frac{1}{2}$ to $2\frac{1}{2}$ years old. They state that it did not seem unreasonable to suppose that this fluid was secreted just before the period of estrus in heifers, but attempts to prove this so far have been without success. The fluid can be drawn off from the udder at any period of the cycle, and the amount varies considerably according to the individual. In animals killed at various periods of the estrus cycle, there was an indica-

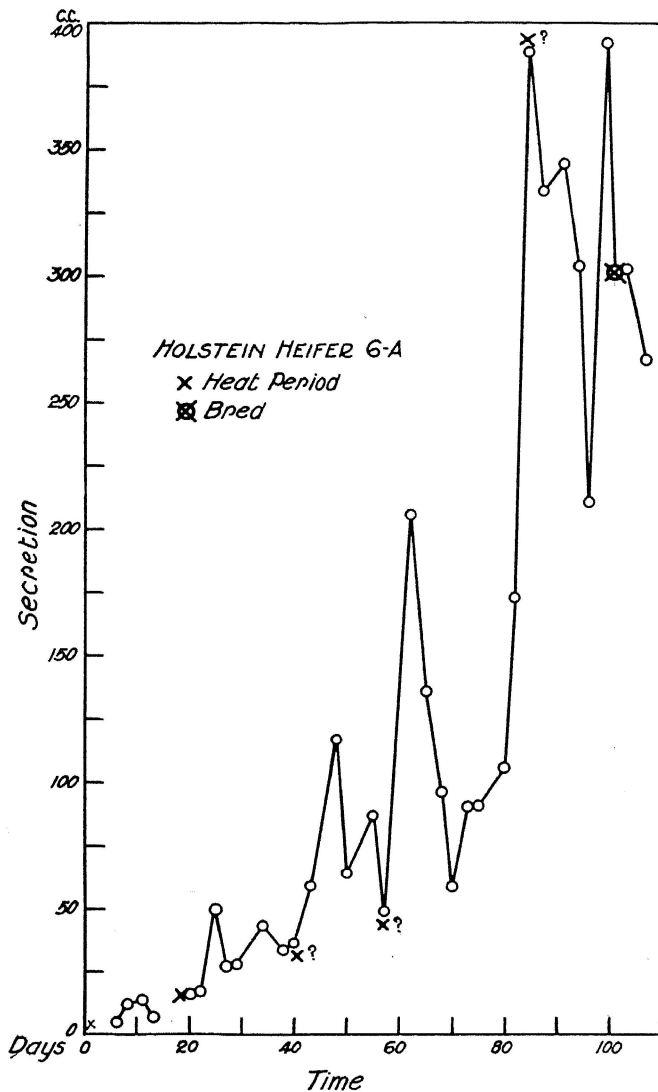


Fig. 1.—The increase in the yield of secretion following regular milking may be observed following the first estrus period.

tion that more existed just before the estrus period than at any other time.

The analysis of these secretions showed the presence of the characteristic proteins of colostrum, namely, casein, albumin, and globulin, together with small amounts of fat, lactose, and proteose.

In order to determine the possibility of cyclic changes in the yield of secretion, it seemed necessary to remove the secretion at regular intervals. Otherwise the secretion would accumulate and could be removed at any stage of the estrus cycle.

A number of heifers in the Station herd at various times have, therefore, been stripped at regular intervals in order to note the possible presence of a secretion following puberty, the changes in the yield during the estrus cycle, the relative yield of secretion in the four quarters, and the composition of the secretion:

SECRETION AFTER SEXUAL MATURITY IS REACHED

In beginning this discussion it is interesting to note first the absence of a secretion from the mammary glands of a heifer ovariectomized before the attainment of sexual maturity. In this case (9A) the mammary gland had not attained sufficient development before removal of the gonads to respond to any possible stimuli from the anterior pituitary.

The second heifer observed (6A) began to secrete a few drops of a watery fluid two days after the first observed estrus period. After the second period the secretion continued to rise. The record of this heifer is faulty in two particulars. The milkings were not made at regular intervals but rather three times per week with a three day interval each week. The second difficulty is the lack of carefully observed estrus periods for a time during the summer. If estrum was fairly regular the increase in secretion would seem to be associated with the appearance of heat in this animal (Fig. 1.)

A third animal placed under observation at the same time was a heifer with a record of irregular estrum and unsuccessful conception (171). She had been in heat many times and had been bred many times. Although over three years old only a few drops of a secretion were obtained at irregular intervals for a time. Then without estrum being observed there followed a rapid increase in secretion until about 300 c. c. were being secreted in 48-hour periods. Due to the fact that subsequent heat periods were not observed during the major part of her record it is of little value for our purpose. (Fig. 2).

Previous to the systematic observations to be reported, the next heifer (198) had been brought into lactation by being sucked by other calves. However, this occurred almost six months after the first observed estrus. With the initiation of regular stripping, 125 c. c. of an orange colored watery fluid was obtained. The yield quickly dropped to 9 c. c. by the third milking. This secretion gradually became lighter in color and in two weeks had all the appearances of normal milk.

After 24 days a very marked increase in the yield of secretion was noted. Two days later a bloody vaginal discharge was observed. While

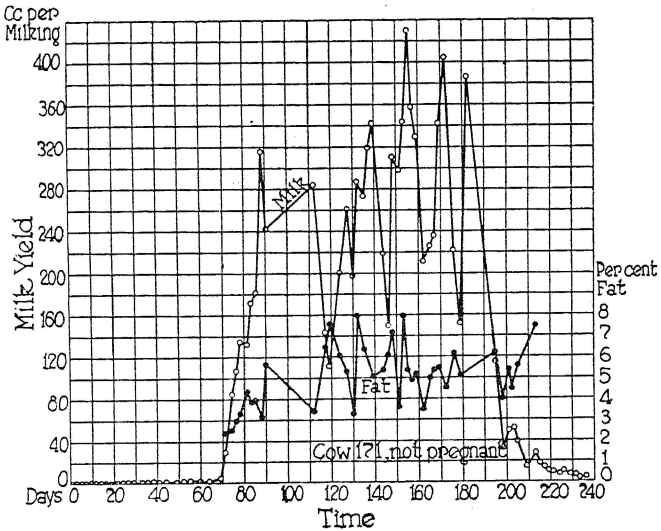


Fig. 2.—This heifer (171) was over three years old. Only a small amount of secretion was obtained for a considerable period, then without heat being observed, there followed a rapid increase in secretion.

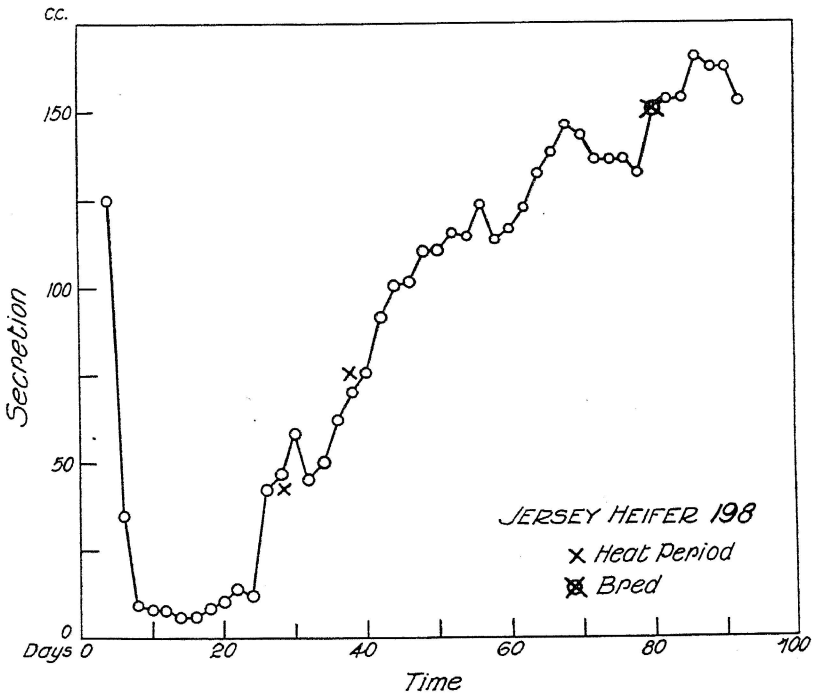


Fig. 3.—Cyclic increases in the yield of secretion are observed.

the desire for mating was not observed, it is possible that estrum occurred. Two weeks later a normal estrus period occurred and the amount of secretion obtained was substantially increased. Later, there seemed to be a tendency for a gradual increase in secretion between estrus periods (Fig. 3).

The next heifer to be considered (803) was observed to yield a few drops of a fluid in one quarter before the first observed estrus period. No increase in yield was noted at the time of the first heat period. At the second estrus period a few drops of a watery fluid were expressed from all quarters. However, the secretion became irregular and finally ceased. At the time of the third estrum all quarters became active again. Following the fifth estrus period, it became possible to begin to measure the yield of secretion from each gland. Thereafter, each period of heat was accompanied by increased mammary activity for more than ten months (Fig. 4).

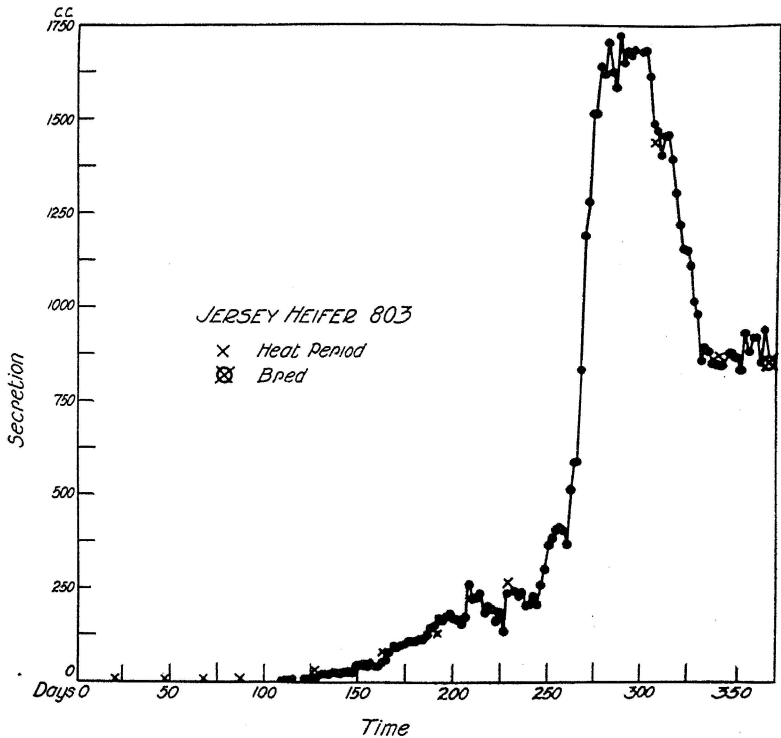


Fig. 4.—The relation between the estrus periods and the increase in the yield of secretion is noted.

The day following the first massage of the next heifer (343) she came in estrum for the first time. This was followed by the secretion of a sticky opaque fluid from the left fore quarter. The secretory activity persisted in this quarter without increase until about one month later when two other quarters came into temporary activity. Three days later a vaginal discharge was noted, although no desire for mating was observed. Following this cycle, only one quarter continued to function. The secretion increased slightly in amount but never exceeded one or two cubic centimeters. The animal conceived at the next heat period.

A second Ayrshire heifer (344) under observation, also showed very slight secretory activity during the recurring estrus cycles. The yield of secretion was never sufficient to measure.

The case of the heifer (811) in which an ovarian graft was made, furnishes further evidence of the relation between the ovarian cycle and the initiation of milk secretion. While a few drops of a fluid were obtainable at irregular intervals and a uniform flow for a period, there was a marked increase in the yield at the first definite period of heat. Further increases were observed at succeeding estrus periods.

In considering these observations, the writer is impressed with the irregularity of the results obtained. It appears that there are considerable individual differences in the amount of secretion obtainable during the recurring estrus cycles in different animals. In some animals large amounts of secretion can be obtained by continued removal of that present, in other animals the amounts were hardly measurable. One can only speculate on a possible explanation or meaning. The observations are too limited to suggest that they bear any relation to future productive ability.

The increase in the yield of the secretion in many cases indicates a close relation to the occurrence of estrum. In some cases the rise in yield precedes the heat period, in other cases it occurs during or following this period. That the increase in yield at this time is significant cannot be doubted.

At first the above observations were taken to indicate that the gradual increase in the production of the estrus producing hormone by the ovary during the proestrus period caused further growth of the mammary gland and initiated secretion in the alveoli already formed. Recent experimental evidence indicates, however, that the estrus hormone is responsible for the growth of the duct system and that the alveoli (the secretory part of the gland) develop under the combined stimuli of the estrus hormone and the corpus luteum. These hormones are probably being secreted together during part of the estrus cycle. At least a large corpus luteum is present in the ovary as a new follicle enlarges during proestrus.

Evidence which will be presented shortly in another publication indicates that the initiation of secretion is caused by a hormone coming from the anterior pituitary. Studies of the amount of this hormone in or being secreted by the pituitary during various stages of the estrus cycle have not yet been made. The observations reported might be taken to indicate that this hormone is especially active during the pro-estrus period.

The following explanation of the above observations which is in harmony with all the experimental evidence known to the writer at the present time is presented herewith.

With each estrus cycle there is produced for a time the hormones (estrus producing and corpus luteum) responsible for the growth of the mammary gland during pregnancy. Thus each estrus cycle can be considered as a period corresponding to pseudo-pregnancy in the rabbit. In animals passing through many estrus cycles considerable growth of the mammary glands might be expected.

To cause the secretory alveoli thus formed to become active requires the presence of an anterior pituitary hormone. This latter hormone acting upon the developed secretory tissue causes the secretion of milk. If this hormone is not produced during the estrus cycle, the animals would show little or no secretory activity.

The Composition of the Secretion

A number of analyses of the secretion from the heifer (6A) were made by the Department of Agricultural Chemistry, using the method of milk analysis approved by the Association of Official Agricultural Chemists. The results are presented in Fig. 5.

Secretion of Multiparous Non-Pregnant Cattle

In certain temporary disorders of the generative apparatus, conception may be delayed for an extended period. In such cases there results very frequently a long dry period. These animals differ from virgin heifers in having a well developed udder. If in such animals milking was resumed, it would be expected that milk secretion would gradually increase with the removal of the formed products.

Becker and McGilliard (1930) report such a case in which lactation was continued for a period of about 40 weeks. Unfortunately they do not report the exact time of estrus during this period although they state "she was bred five more times at various intervals and finally conceived on July 11, 1927."

Both the normal and the so-called "non-fecund" lactations show rising segments for about six weeks, followed by a decline, more rapid

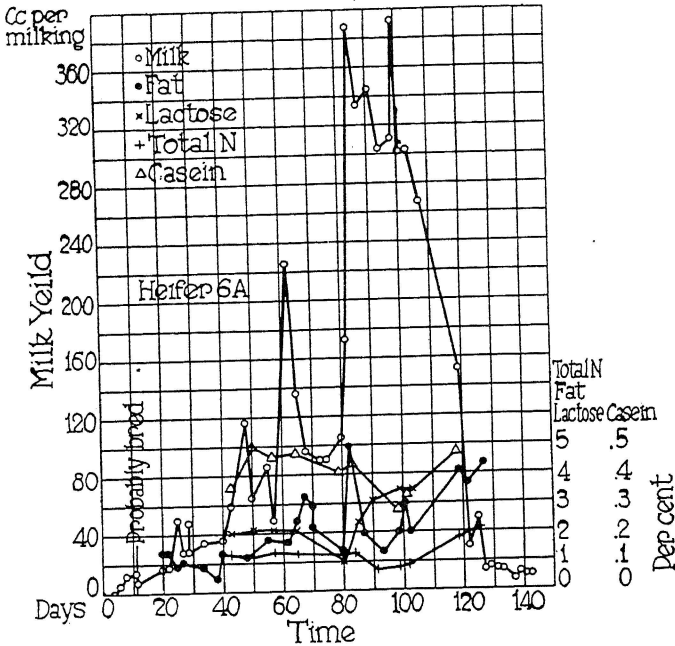


Fig. 5.—The composition of the secretion obtained from a virgin heifer is presented.

in the case of the normal lactations than in the “non-fecund” lactation. The maximum yield was only 21 to 28 per cent as high as in the normal lactations.

Their conclusion that the “non-fecund” lactation curve shows practically no influence of internal stimulus, but measures wholly the effect of the external mechanical stimulus upon milk flow does not consider the influence of the recurring estrus cycles (ovarian stimulus) or of the hormone of the anterior pituitary.

The influence of the external mechanical stimulus upon milk flow can only be measured in ovariectomized and hypophysectomized animals.

Only a single record of a similar nature is available for consideration from the Station herd. A Holstein cow with three previous lactation records, was dried off on December 30, 1924. On March 15, 1926, milking was initiated after being dry for over a year. The yield of secretion gradually increased as noted in Fig. 6. On July 2, 1926, she conceived. Soon after, the secretion of milk began to decline and at the end of 160 days of pregnancy, milking was discontinued.

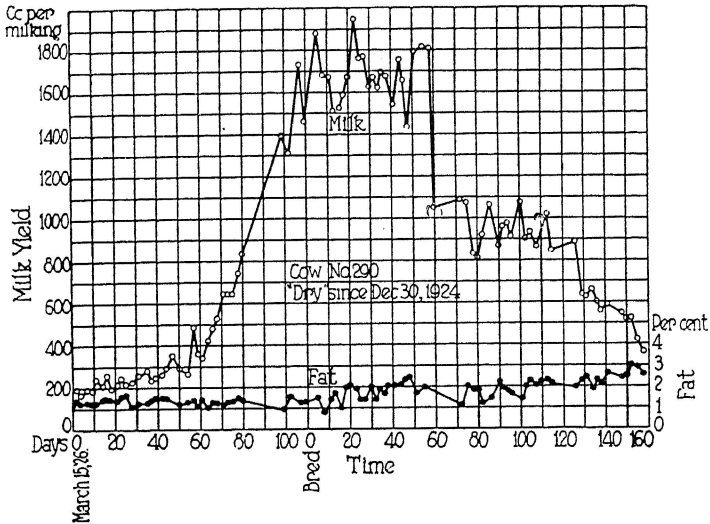


Fig. 6.—The yield of secretion in a multiparous cow previously dry for over a year is presented. The secretion increased for a time previous to conception. Following that period the secretion again gradually declined.

SECRETORY ACTIVITY DURING PREGNANCY

During the first pregnancy in heifers, the growth of the mammary glands is very great. Hammond (1927) observed a very slight increase in the weight of the udder during early pregnancy, and a rapid increase during the later months. Heifers slaughtered at monthly intervals during pregnancy showed progressive growth of the duct system with dense development of the lobes and lobules after the fifth month.

The hormones responsible for the growth of the gland are believed as a result of recent experimental work, to be the estrus producing hormone and a corpus luteum hormone. It has been shown by the studies of Turner et al (1930) that the estrus producing hormone is eliminated in the urine in increasing amounts during the advance of pregnancy. However, the rate of elimination of the corpus luteum hormone in the urine has not yet been reported. The demonstration of and the determination of changes in the concentration of this latter hormone during pregnancy will add materially to the evidence.

In multiparous cows lactation and pregnancy go together. In primiparous heifers, lactation does not ordinarily begin until after parturition. However, it is well known that more or less fluid can be removed from the udders of heifers during the first pregnancy.

Chemical analysis of these secretions were reported by Woodman and Hammond (1923). The fluids obtained at the fifteenth week of pregnancy were similar to those obtained in the early days of pregnancy. The secretion obtained at the end of the twenty-second week was characterized by its extremely high content of solids, chiefly protein. The bulk of this protein was globulin, albumin being present to the extent of only one per cent.

The abrupt change in the character of the secretion after about five months of pregnancy suggests to these workers that the mammary gland at this point has arrived at a well defined stage in its development.

At the twenty-eighth week of pregnancy a large increase in the yield of secretion from the udder was believed to denote a marked increase in the activity of the gland at this stage. The fluid bore no resemblance to the honey-like material previously obtained, but possessed the appearance of ordinary milk. Chemically the fluid was found to resemble the secretions which characterized the virgin condition and the early stages of pregnancy.

The secretion from a heifer in the last month of pregnancy was also analysed. As this animal had not been milked previously the secretion was observed to be a light brown in color and distinctly viscous. Both in physical and chemical characters, it appeared to mark a transitional stage between the occurrence of the honey-like secretion and the colostrum-like phase.

The only systematic study of the yield and composition of the secretion obtained during an entire pregnancy is reported by Asdell (1925) for a Shorthorn heifer. From the fourth to the seventh week, milkings were made twice weekly, once weekly from the seventh to the thirtieth week, twice weekly until the 34 5/7 week, daily, until the 40th week, and twice daily from the 40 5/7 week until parturition. The changes in the composition of the secretion are presented in Fig. 7. It will be noted that the first incidence of the globulin secretion occurred at the 18 1/2 week instead of the 22nd week observed by Woodman and Hammond.

The secretory activity of the mammary gland during the first pregnancy is of considerable interest. The total yield of secretion is so small that stimuli to increased activity of the gland should become apparent by increasing yields of secretion. On the contrary, if advanced pregnancy is accompanied by an inhibitor to the secretory activity of the mammary gland, the yield of secretion should be reduced.

It was hoped that the secretory activity of each quarter would furnish a measure of the growth of each gland. If the relative yield of secretion early in pregnancy or even before pregnancy by the four

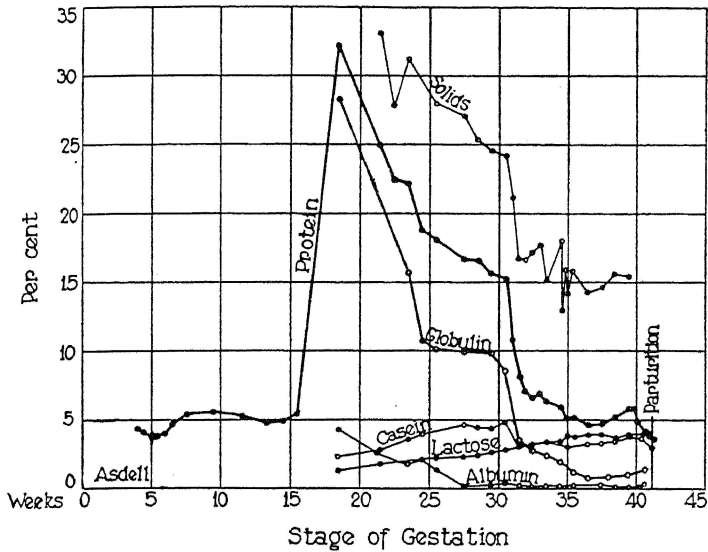


Fig. 7.—The change in the relative composition of milk from a gestating cow. (Plotted from data by Asdell).

quarters corresponded to the percentage production after parturition, valuable information as to the uniformity of the quarters would be available.

Changes in the Yield of Secretion During Pregnancy

The observations on the secretion of milk during pregnancy in a few cases extended throughout the entire period, while in other cases stripping was initiated during or toward the close of pregnancy.

The secretion during the early stages of pregnancy either remained at approximately the level attained previous to conception or declined to some extent. Thus No. 198 continued for a period of four months during pregnancy at a level previously attained. No. 803, however, gradually declined in milk flow until only half the previous yield was being produced. This low level of production continued during most of the remainder of pregnancy. At the time of conception No. 343 was yielding milk from a single quarter. For approximately four months this quarter continued to yield about the same amount of fluid. At that time the other quarter began to secrete. The total yield, however, did not rise until the sixth month but this augmented secretion was not sustained. No. 290 already noted showed a decline in secretion after conception.

These observations are believed to be of considerable significance in that they indicate the lack of stimuli to milk secretion during the major part of pregnancy. (An exception, No. 198, will be discussed later).

It would appear that the growth phase predominated. The estrus producing hormone gradually increases in the urine during this period, indicating increased formation. This hormone is believed to stimulate the development of the duct system and later, in conjunction with a hormone from the corpus luteum, to stimulate the formation of lobes and lobules containing the secretory tissue. (While experimental proof of the mammary gland growth promoting properties of these two hormones is at hand, the presence and concentration of the corpus luteum hormone in the blood or urine of cattle during pregnancy still awaits confirmation and further study).

In considering the latter part of pregnancy, several additional records are available. Jersey heifer No. 173 was milked for a period of 63 days before parturition, while No. 197 was milked about 150 days. The cow No. 170 was about seven months advanced in her second pregnancy (dry 5 months) when milking was initiated. In addition to these animals three multiparous cows were milked for approximately ten days preceding calving to study especially the changes in the composition of "precolostrum" up to parturition and a period following parturition. (No. 182, 285, 290).

Considering the records, it will be noted first that one animal (No. 198) began to increase in milk yield very decidedly about 150 days before parturition, when placed on pasture. It might be thought that pasture grass contained a stimulant to milk secretion. However, a second heifer (No. 343) showed only a transient increase in secretion when placed on the same pasture.

The other animals showed the most striking increase in milk secretion during the last 20 days before parturition. At this time (Table 1 and Fig. 8) the secretory activity of the glands increased greatly, the yield of milk showing an almost perpendicular rise in many cases. In a single case, however, that of the multiparous cow No. 182, the yield of secretion up to parturition continued at a low level.

These results are interpreted (in the light of the recent experimental evidence indicating the presence of a pituitary hormone stimulating lactation) as the result of the activity of the anterior pituitary which has been shown by Gentili (1920) to greatly increase in size during pregnancy. The mechanism governing the secretion or the release of the lactation stimulating hormone at this time is unknown. The precocious lactation of No. 198 indicates that at times external factors may have an influence upon this process.

These observations appear to offer a fertile field of investigation. It seems quite reasonable that the lactation stimulating hormone of the anterior pituitary which appears to initiate its activity shortly before

TABLE 1.—INITIATION OF LACTATION DURING PREGNANCY

Preceding Parturition	Cow No. 170 Milk Yield	Cow No. 173 Milk Yield	Cow No. 197 Milk Yield	Cow No. 198 Milk Yield	Cow No. 803 Milk Yield	Cow No. 343 Milk Yield
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0	---	---	9.8	---	---	---
1	10.61	18.3	14.6	6.9	---	3.9
2	---	20.3	13.0	8.4	---	---
3	6.62	18.7	---	9.0	---	2.4
4	---	18.0	---	9.5	---	2.0
5	3.57	17.5	9.0	10.5	---	2.2
6	---	15.1	---	10.8	13.2	---
7	---	13.8	8.1	11.6	12.5	1.6
8	1.76	12.0	---	12.5	11.0	---
9	---	---	5.7	11.6	9.6	1.6
10	---	---	---	11.9	8.2	---
11	---	---	2.8	12.6	7.1	1.8
12	0.28	---	---	15.7	5.1	---
13	---	8.8	1.8	9.1 (2)	7.3	1.2
14	0.02	---	---	13.0	---	---
15	---	8.4	.9	13.6	5.9	1.3
16	---	---	---	12.6	---	---
17	0.01	4.8	.6	13.2	4.1	1.5
18	---	---	---	13.8	---	---
19	0.01	4.5	.6	12.9	3.3	1.2
20	---	---	---	13.3	---	---
21	---	---	.6	12.2	2.3	1.4
22	---	3.6	---	12.2	---	---
23	---	---	.6	11.8	1.9	1.7
24	---	2.9	---	12.1	---	---
25	---	---	.3	13.0	2.0	1.7
26	---	4.6	---	14.6	---	---
27	---	---	.3	10.9	1.8	2.0
28	---	---	---	13.5	---	---
29	---	---	.3	13.7	1.2	1.8
30	---	4.0	---	12.6	---	---
31	---	---	.2	12.4	.9	1.6
32	---	---	---	13.6	---	---
33	---	3.3	.3	13.2	.9	1.6
34	---	---	.2	13.6	---	---
35	---	---	---	13.2	.7	1.6
36	---	2.4	---	14.3	---	1.9
37	---	---	.2	13.9	.6	---
38	---	1.9	---	13.1	---	---
39	---	---	.1	13.6	.6	1.6
40	---	.6	---	13.2	---	---
41	---	.3	.1	13.1	.4	1.8
42	---	---	---	11.5	---	---
43	---	.2	.1	13.2	.3	1.7
44	---	---	---	13.0	---	---
45	---	.2	.1	13.2	.3	1.8
46	---	---	---	14.5	---	---
47	---	.2	.1	13.2	.2	2.0
48	---	---	---	12.4	---	---
49	---	---	.1	13.9	.2	2.0
50	---	.2	---	13.4	---	---
51	---	---	.1	12.3	.2	1.9
52	---	---	---	14.7	---	---
53	---	---	---	14.5	.2	1.3
54	---	.4	---	15.1	---	---
55	---	.3	---	15.1	.2	1.2

TABLE 1.—INITIATION OF LACTATION DURING PREGNANCY—CONTINUED

Preceding Parturition	Cow No. 170 Milk Yield	Cow No. 173 Milk Yield	Cow No. 197 Milk Yield	Cow No. 198 Milk Yield	Cow No. 803 Milk Yield	Cow No. 343 Milk Yield
<i>days</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
56	----	----	----	14.5	----	----
57	----	----	----	15.0	.2	1.0
58	----	.2	----	14.5	----	----
59	----	----	----	15.0	.3	.7
60	----	.1	----	14.5	----	----
61	----	----	----	15.4	.3	.7
62	----	.1	----	14.8	----	----
63	----	----	----	14.9	.3	.8
64	----	----	----	14.1	----	----
65	----	----	----	14.9	.3	.7
66	----	----	----	14.7	----	----
67	----	----	----	14.7	.5	.4
68	----	----	----	15.5	----	----
69	----	----	----	15.4	.3	.3
70	----	----	----	15.8	----	----
71	----	----	----	15.5	.3	.2
72	----	----	----	15.7	----	----
73	----	----	----	16.3	.3	.1
74	----	----	----	16.1	----	----
75	----	----	----	14.5	.3	.1
76	----	----	----	15.3	----	----
77	----	----	----	15.4	.3	.1
78	----	----	----	16.4	----	----
79	----	----	----	16.5	.3	----
80	----	----	----	17.2	----	----
81	----	----	----	13.3	.3	----
82	----	----	----	17.0	----	----
83	----	----	----	14.9	.3	----
84	----	----	----	15.0	----	----
85	----	----	----	14.1	.3	----
86	----	----	----	15.4	----	----
87	----	----	----	15.5	.4	----
88	----	----	----	14.5	----	----
89	----	----	----	14.5	.3	----
90	----	----	----	14.7	----	----
91	----	----	----	14.6	.3	----
92	----	----	----	14.5	----	----
93	----	----	----	14.7	.3	----
94	----	----	----	14.5	----	----
95	----	----	----	14.0	.3	----
96	----	----	----	14.4	----	----
97	----	----	----	14.6	.4	----
98	----	----	----	14.7	----	----
99	----	----	----	14.4	.4	----
100	----	----	----	14.1	----	----
101	----	----	----	14.6	.4	----
102	----	----	----	14.4	----	----
103	----	----	----	13.7	.3	----
104	----	----	----	14.1	----	----
105	----	----	----	13.9	.4	----
106	----	----	----	14.0	----	----
107	----	----	----	12.7	----	----
108	----	----	----	12.3	----	----
109	----	----	----	12.6	----	----
110	----	----	----	13.2	----	----
111	----	----	----	12.9	----	----

TABLE 1.—INITIATION OF LACTATION DURING PREGNANCY—CONTINUED

Preceding Parturition	Cow No. 170 Milk Yield	Cow No. 173 Milk Yield	Cow No. 197 Milk Yield	Cow No. 198 Milk Yield	Cow No. 803 Milk Yield	Cow No. 343 Milk Yield
<i>Days</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
112	----	----	----	13.8	----	----
113	----	----	----	13.1	----	----
114	----	----	----	14.7	----	----
115	----	----	----	11.1	----	----
116	----	----	----	12.1	----	----
117	----	----	----	11.9	----	----
118	----	----	----	12.1	----	----
119	----	----	----	11.9	----	----
120	----	----	----	12.1	----	----
121	----	----	----	11.4	----	----
122	----	----	----	11.1	----	----
123	----	----	----	10.7	----	----
124	----	----	----	9.8	----	----
125	----	----	----	9.6	----	----
126	----	----	----	9.1	----	----
127	----	----	----	7.1	----	----
128	----	----	----	6.2	----	----
129	----	----	----	5.8	----	----
130	----	----	----	4.9	----	----
131	----	----	----	4.5	----	----
132	----	----	----	7.4	----	----
134	----	----	----	7.6	----	----
136	----	----	----	7.0	----	----
138	----	----	----	6.1	----	----
140	----	----	----	6.3	----	----
142	----	----	----	5.7	----	----
144	----	----	----	5.4	----	----
146	----	----	----	3.7	----	----
148	----	----	----	2.8	----	----
150	----	----	----	1.5	----	----
152	----	----	----	1.0	----	----
154	----	----	----	.7	----	----
156	----	----	----	.7	----	----
158	----	----	----	.5	----	----
160	----	----	----	.4	----	----
162	----	----	----	.5	----	----
164	----	----	----	.4	----	----
166	----	----	----	.4	----	----
168	----	----	----	.4	----	----
170	----	----	----	.4	----	----

parturition is the agent responsible for the rising segment of the lactation curve following parturition, and the regulation of the persistency of secretion during the declining segment.

The theory of a lactation inhibiting hormone in the blood during the latter part of pregnancy advanced by D'Errico (1910), Gaines (1915), Eckles (1923), and recently again by Gaines and Davidson (1926) would require modification on the basis of the observation that lactation is actually stimulated during the last 20 days or more prior to parturition.

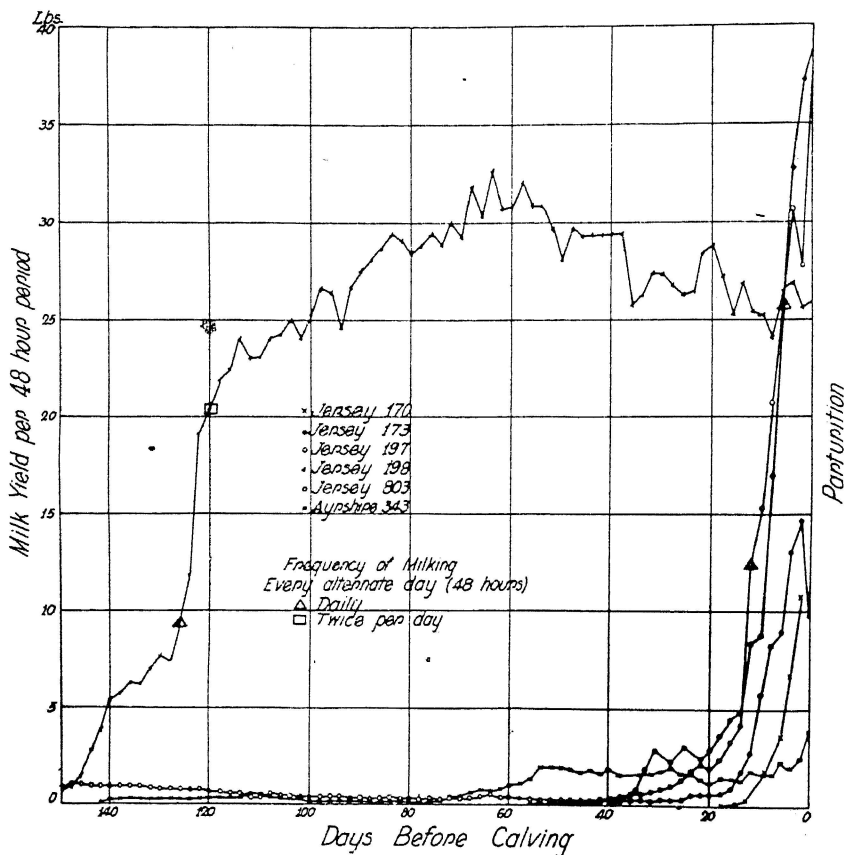


Fig. 8.—It will be noted that with one exception the secretory phase of mammary gland activity increased markedly during the 20 days previous to parturition. (Cow No. 198 was milked three times per day beginning 82 days before calving). A slight error was made in tabulating the data after that date. For the corrected values see Table 1. The trend of the curve has not been affected).

It was shown by Ragsdale, Turner, and Brody (1924) and confirmed by Gaines and Davidson (1926) that milk secretion declines more rapidly in pregnant cows than in non-pregnant cows after the fifth month of gestation. The rise in secretion at the approach of parturition only rarely is observed because cows ordinarily are not milked at that time. It is clear that if a lactation inhibiting hormone is active during pregnancy its effectiveness is lost prior to parturition.

Following parturition, the secretion of milk continued to rise more or less irregularly for a time. (Fig. 9 and Table 2). This would be expected with the release of nutrients previously required by the fetus.

TABLE 2.—RISE OF LACTATION FOLLOWING PARTURITION

Following Parturition	Cow No. 170 Milk Yield	Cow No. 173 Milk Yield	Cow No. 197 Milk Yield	Cow No. 198 Milk Yield	Cow No. 803 Milk Yield	Cow No. 343 Milk Yield
<i>days</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
0	----	21.3	----	----	----	----
1	----	17.9	----	----	----	----
2	----	23.7	21.8	4.3	24.6	----
3	----	26.5	22.1	4.6	17.4	----
4	6.5	29.3	23.0	13.1	27.0	----
5	22.2	30.4	23.1	17.8	26.8	----
6	24.2	28.3	24.2	18.7	28.8	24.3
7	22.3	32.5	26.0	18.0	30.6	26.2
8	24.3	30.2	25.8	18.8	31.8	25.7
9	22.4	32.2	26.0	18.9	29.8	26.4
10	16.1	31.9	27.1	19.6	29.1	26.1
11	37.8	32.5	28.0	20.9	28.9	24.3
12	29.2	31.2	29.6	20.8	30.8	23.9
13	37.0	34.1	29.2	20.2	31.8	25.3
14	28.9	30.3	28.3	19.1	29.7	26.0
15	34.8	31.0	29.2	22.1	33.2	24.9
16	32.2	32.0	30.7	21.7	30.3	28.1
17	32.4	29.4	29.8	20.5	31.3	28.3
18	26.2	35.5	33.0	22.7	31.1	27.7
19	38.2	27.7	31.2	21.5	31.2	28.5
20	28.1	33.0	32.2	22.1	31.6	30.2
21	35.5	30.9	32.3	21.0	30.7	28.5
22	29.4	29.8	31.3	21.0	31.5	28.5
23	29.6	33.5	32.6	21.1	32.0	30.0
24	35.3	33.0	30.0	21.5	32.3	29.4
25	24.5	32.3	30.6	20.4	31.5	29.6
26	36.4	30.4	29.4	19.7	31.7	30.0
27	34.1	32.2	33.2	20.2	31.7	29.8
28	32.7	33.7	31.1	20.7	30.5	28.1
29	28.1	32.4	30.7	20.0	30.3	30.1
30	27.2	26.9	30.4	20.5	31.4	27.5
31	35.1	33.9	31.9	20.4	31.5	27.5
32	28.3	30.6	31.8	18.4	31.0	30.5
33	29.4	31.8	32.4	20.5	31.9	28.7
34	29.5	27.7	32.7	19.5	33.2	27.7
35	29.0	28.5	32.1	18.9	34.2	28.4
36	29.2	31.7	31.2	19.1	33.1	26.5
37	27.4	27.7	33.1	17.9	32.0	28.5
38	26.6	29.7	32.5	19.2	31.9	26.9
39	26.4	27.2	32.8	21.3	31.6	27.0
40	26.7	21.4	34.7	18.0	32.6	27.1
41	29.2	28.6	33.3	19.3	31.7	27.8
42	22.1	27.3	33.2	20.3	31.8	26.5
43	30.1	27.1	33.1	19.3	32.3	25.2
44	21.3	28.4	31.9	20.4	28.3	24.3
45	24.6	28.9	31.7	20.0	33.6	23.3
46	31.2	25.2	30.1	19.3	32.8	24.0
47	22.4	22.4	30.7	19.7	30.3	23.0
48	23.5	30.5	29.4	19.2	29.9	26.3
49	25.1	29.2	29.5	18.1	30.0	25.0
50	24.4	26.8	31.4	19.0	29.5	24.4
51	23.3	26.6	32.2	19.0	34.5	23.9
52	21.9	28.7	32.4	18.5	30.8	24.9
53	24.5	26.0	32.5	17.8	30.1	24.3
54	22.3	25.7	32.2	18.6	31.3	24.8
55	23.9	31.0	32.5	18.4	32.0	25.3

TABLE 2.—RISE OF LACTATION FOLLOWING PARTURITION—CONTINUED

Following Parturition	Cow No. 170 Milk Yield	Cow No. 173 Milk Yield	Cow No. 197 Milk Yield	Cow No. 198 Milk Yield	Cow No. 803 Milk Yield	Cow No. 343 Milk Yield
<i>days</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
56	23.2	26.0	31.0	18.3	30.8	25.5
57	24.9	24.4	32.5	18.4	30.0	26.2
58	23.9	30.1	30.9	18.2	32.8	24.3
59	22.5	22.5	31.6	18.6	31.8	22.7
60	26.2	31.9	31.7	16.7	32.8	25.2

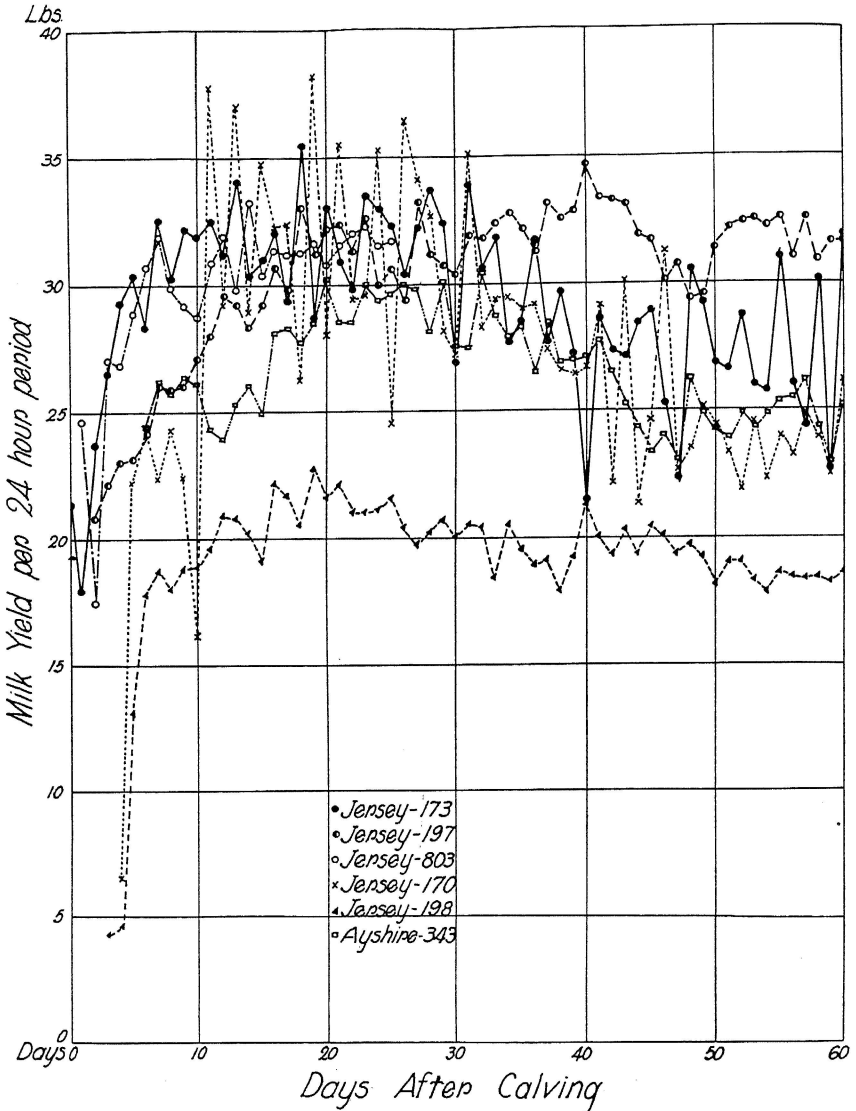


Fig. 9.—The secretory activity of the glands continue to increase for a time after parturition.

The Relative Yield Of Secretion By Quarters

Direct measurements of the growth of the four glands in the udder are practically impossible. However, it was hoped in initiating these experiments that some idea of the growth taking place in each quarter might be gained by the determination of the yield of secretion obtained from each quarter. If the quarters yielding the larger quantities of secretion during the estrus cycles and during pregnancy also yielded proportionately the larger quantities after parturition, these data might be considered as evidence of the relation between the growth of the glands and the yield of secretion at the time.

Four records are available for a study of the secretion of milk from each quarter previous to parturition and following parturition. Two of these include not only the entire gestation period but a period previous to conception whereas the other two records include only a relatively short period preceding parturition.

Heifer No. 198 showed a wide variation in the milk production of each quarter for a long period while the total yield was limited. About 150 days before parturition the yield of milk began to rise significantly. The percentage production by quarters rapidly drew together, and remained at about the same level until parturition. During this period minor variations in relative yield occurred. Following parturition, the yield from the four quarters was quite uniform. (Fig. 10 and Table 3).

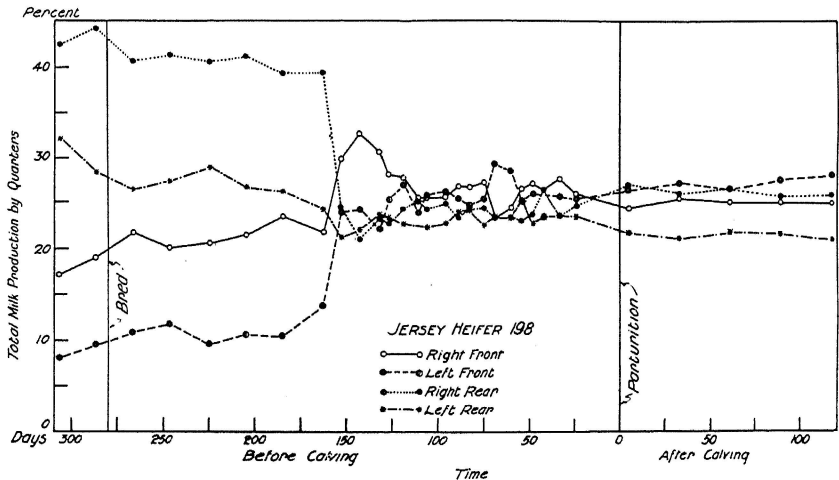


Fig. 10.—Using the percentage production of each quarter after parturition as an index, it is noted that this relative production was only attained when the yield of milk rapidly increased.

TABLE 3.—SECRETION OF MILK BY QUARTERS
Jersey No. 198

Preceding Parturition	Milk Secretion					Production by Quarters			
	Front		Rear		Total	Front		Rear	
	Right	Left	Right	Left		Right	Left	Right	Left
<i>days</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>%</i>	<i>%</i>	<i>%</i>	<i>%</i>
33	2.5	2.4	2.2	2.2		27.68	25.80	23.65	23.65
42	0.9	0.8	0.9	0.8		26.47	23.52	26.47	23.52
48	2.5	2.4	2.2	2.1	9.2	27.17	26.08	23.91	22.82
54	2.5	2.4	2.2	2.4	9.5	26.31	25.26	23.15	25.26
60	2.4	2.8	2.3	2.3	9.8	24.48	28.57	23.46	23.46
69	2.4	3.0	2.4	2.4	10.2	23.52	29.41	23.52	23.52
75 (d)	2.9	2.7	2.6	2.4	10.6	27.35	25.47	24.52	22.64
83	4.0	3.7	3.6	3.6	14.9	26.84	24.83	24.16	24.16
89	3.9	3.7	3.4	3.5	14.5	26.89	25.51	23.44	24.13
96	3.7	3.8	3.6	3.3	14.4	25.69	26.38	25.00	22.91
106	3.6	3.9	3.4	3.1	14.0	25.71	27.85	24.28	22.50
111	3.3	3.1	3.2	3.3	12.9	25.58	24.03	25.19	25.58
119 (c)	3.2	3.1	2.9	2.7	11.9	26.89	26.05	24.36	22.68
Average	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>				
127-131 (b)	3535	3185	2855	2950	12535	28.20	25.40	22.77	23.53
133-142	4650	3350	3520	2605	15125	30.74	22.14	23.27	23.83
143-152 Grass	2734	2036	1774	1854	8395	32.56	24.25	21.13	22.08
153-162	429	345	353	306	1433	29.93	24.07	24.63	21.35
163-184	354	224	638	403	1619	21.86	13.83	39.40	24.89
185-204	363	161	604	405	1537	23.61	10.47	39.29	26.35
205-224	290	144	551	360	1341	21.62	10.73	41.08	26.84
225-246	318	150	625	447	1541	20.63	9.73	40.62	29.00
247-266	312	183	642	427	1554	20.07	11.77	41.31	27.47
267-286 Bred	335	168	624	409	1537	21.79	10.93	40.59	26.61
287-306	349	125	551	372	1305	19.08	9.57	44.22	28.50
307-326 (a)	163	77	403	305	948	17.19	8.12	42.51	32.17

(a)—1 milking—48 hours

(c)—2 milkings per day

(b)—1 milking per day

(d)—2 of 3 milkings per day (by quarters)

The relative production of secretion by the four quarters before and after parturition in heifer No. 803 are even more striking. The two rear quarters yielded a much larger proportion of the total secretion during much of the period of pregnancy. Beginning at about 100 days before parturition the percentage production began to draw together. With the rapid increase in secretion the last few days before parturition the percentage production eventually approached that observed after parturition. (Fig. 11 and Table 4.)

Heifer No. 197 showed a tendency for the percentage production of the two rear and two front quarters to move together. The former increased in relative yield while the latter declined. During the last 10 days previous to parturition, however, there was a tendency for the relative yields to come together. Following parturition, the quarter production was not recorded for 192 days. The uniformity of production

TABLE 4.—SECRETION OF MILK BY QUARTERS
Jersey No. 803

Preceding Parturition	Total Milk Secretion					Production by Quarters			
	Front		Rear		Total	Front		Rear	
	Right	Left	Right	Left		Right	Left	Right	Left
<i>days</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	%	%	%	%
7-13	7370	6343	6653	8973	29339	25.1	21.6	22.7	30.6
14-18	1520	1378	1810	2890	7598	20.0	18.1	23.8	38.0
19-23	753	664	904	1878	4199	17.9	15.8	21.5	44.7
24-33	448	410	526	1050	2434	18.4	16.8	21.6	43.1
34-43	144	138	200	440	922	15.6	15.0	21.7	47.7
44-53	51	48	106	268	473	10.8	10.1	22.4	56.6
54-63	87	86	118	310	601	14.5	14.3	19.6	51.6
64-73	112	124	133	358	727	15.4	17.0	18.3	49.2
74-83	58	63	133	334	588	10.0	10.7	22.6	56.9
84-93	60	58	167	411	696	8.6	8.3	23.9	59.0
94-103	52	48	221	511	832	6.3	5.8	26.5	61.4
104-113	42	39	259	568	908	4.6	4.3	28.5	62.5
114-123	55	52	415	791	1313	4.2	3.9	31.7	60.2
124-133	48	48	590	1010	1696	2.8	2.8	34.7	59.5
134-143	34	27	756	1186	2003	1.7	1.3	37.7	59.2
144-153	45	29	853	1181	2108	2.1	1.4	40.4	56.0
154-163	47	28	875	1133	2083	2.2	1.3	42.0	54.3
164-173	45	24	882	1192	2143	2.1	1.1	41.1	55.6
174-183	37	19	801	1107	1964	1.9	1.0	40.7	56.3
184-193	42	13	888	1141	2084	2.0	0.6	42.6	54.7
194-203	49	21	944	1239	2253	2.2	0.9	41.8	55.0
204-213	59	23	963	1235	2280	2.6	1.0	42.2	54.1
214-223	58	28	1077	1428	2591	2.2	1.1	41.5	55.1
224-233	77	45	1136	1503	2761	2.8	1.6	41.1	54.4
234-243	99	40	1288	1698	3125	3.2	1.3	41.2	54.3
244-253	100	42	1375	1706	3223	3.1	1.3	42.6	52.9
254-263	135	73	1683	2159	4050	3.3	1.8	41.5	53.3
264-273	183	99	1736	2398	4416	4.1	2.2	39.3	54.3
274-283 Bred	208	103	1794	2407	4512	4.6	2.3	39.7	53.3
284-293	231	107	1772	2246	4356	5.3	2.5	40.6	51.5
294-303	245	120	1738	2213	4316	5.7	2.8	40.2	51.2
304-313	377	181	1996	2568	5122	7.4	3.5	38.9	50.1
314-323	662	357	2482	3035	6536	10.1	5.5	38.0	46.4
324-333 bred	1005	600	2760	3070	7435	13.5	8.1	37.2	41.2
334-343	1270	810	2810	3480	8370	15.2	9.7	33.5	41.5
344-353	1332	930	2635	3370	8267	16.1	11.2	31.8	40.7
354-363	1240	1020	2595	3140	7995	15.5	12.7	32.4	39.2
364-373 bred	647	569	1410	1804	4430	14.6	12.8	31.8	40.7
374-383	258	256	714	868	2096	12.3	12.2	34.1	41.4
384-393	156	159	616	579	1510	10.3	10.5	40.7	38.3
394-403	87	96	475	443	1101	7.9	8.7	43.1	40.2
404-413	103	100	424	391	1018	10.1	10.0	41.7	38.4
414-423	97	87	412	374	972	10.0	9.2	42.4	38.5
424-433	93	92	460	386	1031	9.0	9.0	44.6	37.4
434-443 In heat	77	74	394	305	850	9.1	8.7	46.4	35.8
444-453	39	35	275	191	540	7.2	6.5	50.9	35.4
454-463 In heat	31	30	208	143	412	7.5	7.3	50.5	34.7
464-473	20	20	124	96	260	7.7	7.7	47.7	36.9

TABLE 4.—SECRETION OF MILK BY QUARTERS—CONTINUED.
Jersey No. 803

Preceding Parturition	Total Milk Secretion					Production by Quarters			
	Front		Rear		Total	Front		Rear	
	Right	Left	Right	Left		Right	Left	Right	Left
<i>days</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	%	%	%	%
474-483	12	16	83	70	181	6.6	8.8	45.9	38.7
484-493	13	14	54	48	129	10.1	10.9	41.9	37.2
494-503 In heat	---	---	---	---	73	---	---	---	---
504-513	---	---	---	---	44	---	---	---	---
514-523 In heat	---	---	---	---	16	---	---	---	---

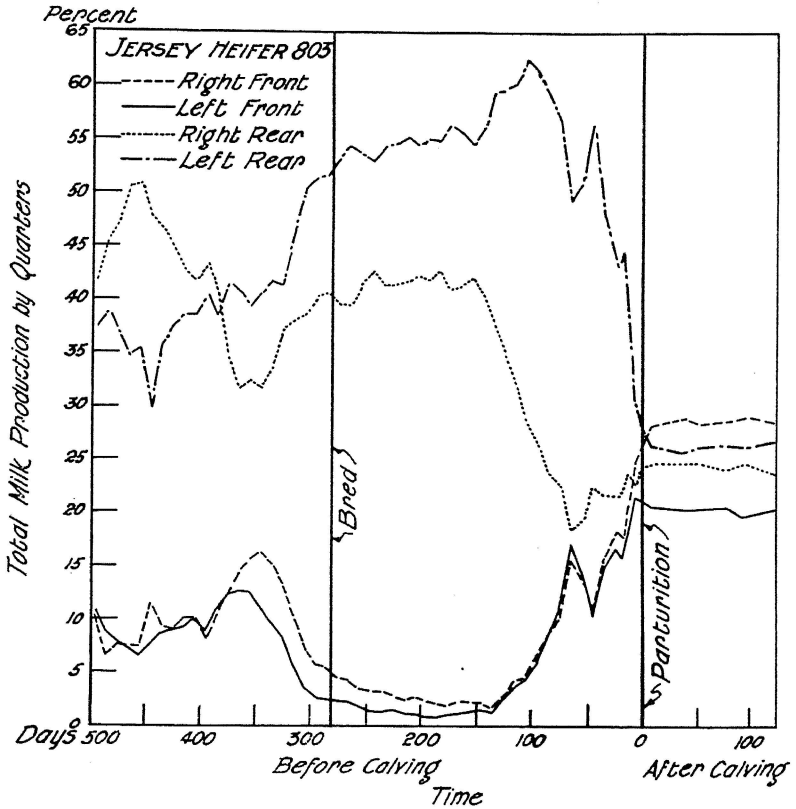


Fig. 11.—The yield of secretion during puberty and most of pregnancy does not measure the growth of secretory tissue in the glands. Only with the stimulus to lactation observed at the approach of parturition do the glands approach the relative production observed after parturition.

TABLE 5.—SECRETION OF MILK BY QUARTERS
Jersey No. 197

Preceding Parturition	Total Milk Production					Production by Quarters			
	Front		Rear		Total	Front		Rear	
	Right	Left	Right	Left		Right	Left	Right	Left
<i>Days</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	%	%	%	%
1-7*	1790	2200	3580	3190	10760	16.63	20.44	33.27	29.64
9-17	675	685	1914	1923	5215	12.94	13.13	36.70	36.87
19-27	153	152	331	331	987	15.82	15.40	33.53	33.53
29-37	100	99	179	179	557	17.95	17.77	32.13	32.13
39-47	61	61	66	67	255	23.92	23.92	25.88	26.27

*Three days not recorded by quarters.

after that time would indicate the probability of a similar relationship previously. The rear quarters in this animal continued to produce about twice the amount of milk produced in the fore quarters. (Fig. 12 and Table 5.)

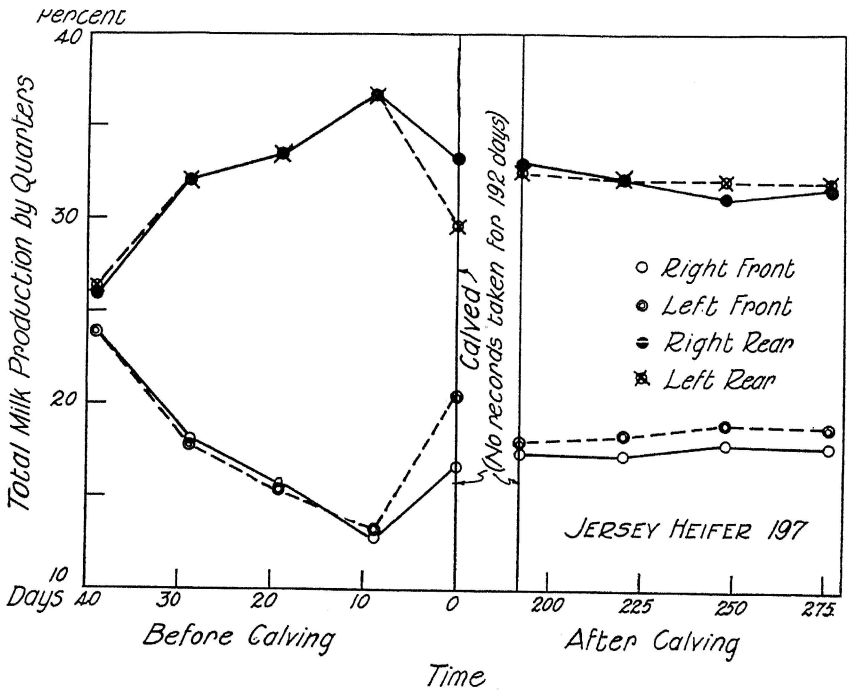


Fig. 12.—The relation between the percentage production by quarters before and after parturition is shown.

The case of heifer No. 343 is of special interest due to the fact that for a period of four months after conception only the left front quarter

continued to secrete. When the other quarters came into secretion this quarter continued to lead in production until about 40 days before parturition when the percentage production began to draw together. After parturition the four quarters continued to secrete quite evenly. It is interesting to note, however, that the left front quarter was the poorest producer. (Fig. 13 and Table 6.)

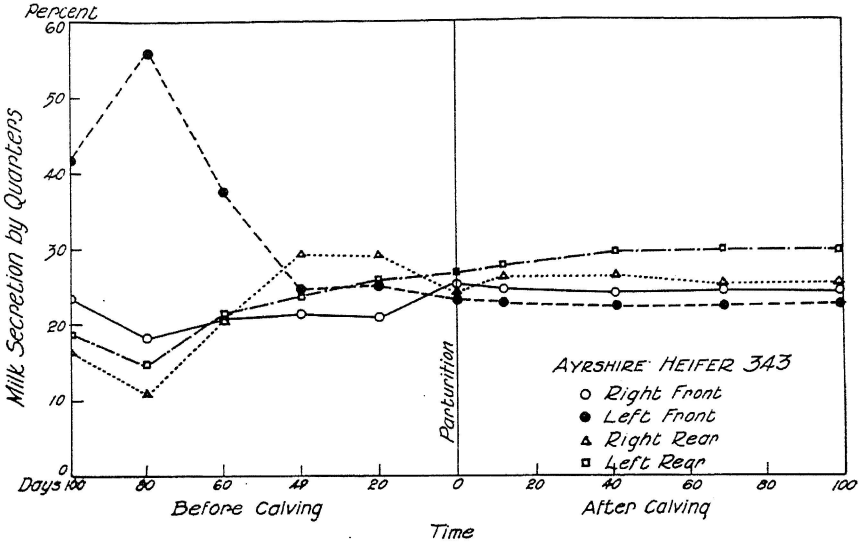


Fig. 13.—The relative production before and after parturition is shown.

TABLE 6.—MILK SECRETION BY QUARTERS
Ayrshire No. 343

Preceding Parturition	Total Milk Secretion					Production by Quarters			
	Front		Rear		Total	Front		Rear	
	Right	Left	Right	Left		Right	Left	Right	Left
<i>days</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	<i>c. c.</i>	%	%	%	%
1-20	2178	2003	2118	2311	8625	25.25	23.22	24.55	26.79
21-40	1430	1715	1940	1745	6830	20.93	25.10	28.40	25.54
41-60	1617	1857	2180	1788	7542	21.43	24.62	28.90	23.70
61-80	437	795	441	450	2123	20.58	37.44	20.77	21.19
81-100	127	393	77	104	701	18.10	56.06	10.98	14.83
101-120	255	457	181	204	1096	23.26	41.69	16.51	18.61

An examination of these data indicate clearly that the relative yield of secretion from the four quarters during the recurring estrus cycles or during a major part of pregnancy does not measure the percentage milk yield after parturition. Only when the yield of milk in-

creased at the approach of parturition does the relative yield approximate the post-partum production.

It is concluded that the yield of secretion from the quarters does not measure the amount of growth of secretory tissue in the quarter during the major part of pregnancy. Only with the increased yield of milk at the approach of parturition are the potentialities of the four quarters fully realized.

Chemical Composition of Pre-Colostrum*

In addition to the animals already mentioned three multiparous cows (Jersey No. 182, and Holsteins Nos. 285 and 290) were milked daily for approximately ten days preceding parturition and an equal number of milkings followed parturition. As noted in Tables 7 to 9, the albumin and globulin were found in abundance in the first milkings, but gradually declined in amount until at parturition the composition was almost similar to that of normal milk.

Should Cows be Milked Prior to Parturition?

Breeders of dairy cattle are frequently concerned about the advisability of milking cows before parturition. On the basis of the observations here reported certain conclusions have been reached in regard to this practice.

From the standpoint of the well being of the dam, the practice of milking the cow for a period of about ten days preceding parturition has certain advantages. The inflammation of the udder which appears to occur simultaneously with the initiation of milk secretion can be prevented largely by the removal of the milk at that time. In all cases where the milk was removed before parturition either from the first calf heifers or the cows, it was observed that the udders were soft and pliable and not painful to the cow.

It seems reasonable, although no experimental evidence is available, that bringing the cows into lactation gradually by removing the milk for a few days before parturition would have a tendency to reduce the frequency of milk fever. This theory is based on the idea that milk fever results from the rapid initiation of milk secretion following parturition, which in turn results in the rapid removal of the precursors of milk from the blood. This rapid removal comes on so suddenly that the normal mechanisms maintaining the uniformity of the composition of the blood are not equal to the emergency resulting in the undue lowering of certain

*The data presented in this section were taken from a thesis to be submitted by Mr. J. P. Wright in partial fulfillment of the requirements for the degree of Master of Arts in the Graduate School of the University of Missouri. The work was conducted under the supervision of Professor Sydney Calvert of the Department of Chemistry, to whom we are indebted for his cooperation in this project.

TABLE 7.—CHEMICAL ANALYSIS OF PRE-COLOSTRUM AND COLOSTRUM
Cow 285 (Holstein)

Date	Total Protein plus N. P. N. x 6.38	Cascin	Globulin	Albumin	Non-Protein N. x 6.38	Solids	Yield lbs.	Milkings	Specific Gravity	Fat
1928	%	%	%	%	%	%				%
*6-1	12.24	3.82	2.48	4.91	.70	18.04	1.5	1	1.0581	1.9
6-2	10.13	3.57	1.63	4.05	.66	16.71	2.2	2	1.0519	2.6
*6-3	8.36	3.25	.97	3.38	.56	15.26	4.0	3	1.0493	2.4
6-4	7.80	3.36	1.02	3.06	.46	16.02	6.02	4	1.0462	3.95
*6-5	7.24	3.58	.37	2.95	.39	18.93	8.2	5	1.0458	5.25
6-6	6.06	3.32	.23	1.82	.49	14.40	10.7	6	1.0462	4.10
*6-7	5.10	3.37	.08	1.37	.38	16.56	13.5	7	1.0417	4.95
6-8	5.10	3.59	.08	.95	.41	19.68	10.0	8	1.0364	8.05
*6-9	3.90	2.77	.02	.59	.49	12.00	5.5	9	1.0404	2.25
6-10	3.99	2.85	.03	.62	.43	12.61	8	10	1.0428	5.15
A. M.										
*6-11	4.39	2.98	.03	.86	.37	13.28	10	11	1.0431	4.10
P. M.										
6-11	3.90	2.78	.04	.56	.44	12.59	9.2	12	1.0389	3.85
A. M.										
*6-12	3.56	2.44	.02	.64	.31	11.09	8.2	13	1.0399	2.45
P. M.										
6-12	3.63	2.57	.04	.60	.33	10.68	13.7	14	1.0417	3.45
A. M.										
6-13	3.69	2.74	.06	.56	.31	10.34	9.6	15	1.0411	1.7

Calved 6-8, 2 P. M. immediately after milking.

*Analyses made on fresh samples.

TABLE 8.—CHEMICAL ANALYSIS OF PRE-COLOSTRUM AND COLOSTRUM
Cow 290 (Holstein)

Date	Total Protein plus N. P. N. x 6.38	Casein	Globulin	Albumin	Non-Protein N. x 6.38	Solids	Yield lbs.	Milkings	Specific Gravity	Fat
1928	%	%	%	%	%	%				%
*5-9	28.70	1.85	18.06	6.36	1.21	36.39	.4	1	Too thick	-----
*5-10	30.87	3.35	15.90	10.79	.77	37.01	.4	2	Too thick	0.5
5-11	28.62	2.61	12.55	12.08	1.13	33.68	1.1	3	Too thick	1.6
5-12	26.56	3.26	10.23	12.14	.74	31.72	1.8	4	Too thick	2.7
*5-13	22.35	5.82	8.42	7.05	.83	28.69	2.9	5	1.0841	2.5
5-14	16.96	3.82	4.55	7.54	.76	23.91	6.0	6	1.0679	3.2
*5-15	10.94	4.23	1.88	3.89	.88	17.15	9.1	7	1.0558	2.0
5-16	7.74	2.98	.44	3.25	.78	14.82	13.5	8	1.0477	2.95
5-17	6.60	3.02	.59	1.97	.87	16.19	13.6	9	1.0458	5.6
*5-18	5.20	3.13	.23	1.12	.66	16.28	16.7	10	1.0392	5.75
*5-19	4.68	2.74	.22	1.14	.56	15.22	21.0	11	1.0377	6.0
5-20	Calved									
P. M.										
*5-21	4.06	2.44	.17	.84	.61	15.01	23.4	12	1.0389	6.2
A. M.										
*5-22	3.89	2.21	.12	.80	.60	14.22	31.5	13	1.0355	5.8
1 P. M.										
5-22	3.78	2.15	.11	.70	.62	12.20	12.5	14	1.0333	6.5
A. M.										
*5-23	3.66	2.10	.12	.59	.55	11.61	15.2	15	1.0385	2.8
1 P. M.										
5-23	3.50	2.01	.10	.68	.65	11.07	19.8	16	1.0359	4.8
9 P. M.										
5-23	No sample						12.8	17		
5 A. M.										
*5-24	3.43	1.96	.14	.65	.53	13.8	21.7	18	1.0388	6.2
1 P. M.										
5-24	3.34	1.74	.11	.65	.68	9.95	17.6	19	1.0383	4.5
9 P. M.										
5-24	3.15	1.61	.12	.58	.67	10.41	13.4	20	1.0378	2.75

Calved Sunday, May 20, A. M.

*Analyses made on fresh samples.

Analyses on May 9 sample did not check.

TABLE 9.—CHEMICAL ANALYSIS OF PRE-COLOSTRUM AND COLOSTRUM
Cow 182 (Jersey)

Date	Total Protein plus N. P. x 6.38	Casein	Globulin	Albumin	Non-Protein N. x 6.38	Solids	Yield lbs.	Milkings	Specific Gravity	Fat
1928	%	%	%	%	%	%				%
8-16	14.01	3.56	1.42	7.81	.88	18.01	.4	1	1.0687	1
8-17	12.21	3.51	.50	7.39	.63	16.19	.8	2	1.0562	
8-18	10.48	3.44	2.01	4.33	.46	14.24	.8	3	1.0475	
8-19	10.89	3.58	2.03	4.47	.63	14.88	.6	4	1.0533	
8-20	11.39	3.78	1.43	5.31	.62	16.19	.7	5	1.0548	
8-21	10.49	3.87	1.86	4.10	.42	14.71	.7	6	1.0514	
8-22	11.07	3.86	1.66	4.72	.56	15.30	.6	7	1.0528	
8-23	9.76	3.52	3.52	4.54	.57	13.80	.8	8	1.0519	.9
8-24	10.11	3.78	3.78	4.42	.57	14.83	1.2	9	1.0565	.7
8-25 A. M.	No Sample				Calved					
8-26 P. M.	4.90	2.85	.34	1.09	.48	11.78	4.9	10	1.0430	1.95
8-26 A. M.	4.68	3.02	.14	.96	.47	10.56	4.8	11	1.0421	1.20
8-27 P. M.	4.60	3.17	.13	.80	.50	11.96	13.5	12	1.0407	2.60
8-27 A. M.	4.38	3.20	.13	.64	.33	12.04	9.4	13	1.0402	2.85
8-28 P. M.	4.53	3.34	.08	.62	.33	13.72	13.4	14	1.0403	4.12
8-28 A. M.	4.49	3.26	.04	.61	.41	12.97	9.5	15	1.0446	3.65
8-29 P. M.	4.39	3.32	.05	.60	.32	13.57	13.5	16	1.0421	3.85
8-29 8-30	4.33	3.09	.05	.57	.33	15.69	9.4	17	1.0481	5.83 4.15

constituents of the blood, especially calcium. With the more gradual initiation of milk secretion the mechanism regulating the composition of the blood would gradually accommodate itself to the increasing needs of the mammary gland.

From the standpoint of the well-being of the calf, however, the initiation of milk secretion prior to parturition is not as satisfactory. Recent investigations have demonstrated the importance of colostrum for the well being of the new born calf. For reviews of this work the reader is referred to the papers by Ragsdale and Brody (1923), Nelson (1924), and Associates of Rogers (1928). When cows are milked previous to parturition, the colostrum character largely disappears. At parturition the globulin content of the milk has been reduced to that of normal milk. As a result it might be expected that difficulty would be experienced in raising such calves if colostrum was not available.

Of three heifers milked prior to parturition, the progeny of the first appeared at all times to be in a normal condition and was raised successfully. The calf of the second died on the fifth day after birth. The calf of the third died at two and one-half months of age. Bacterial cultures from the visceral organs indicated abundant bacillus coli infection.

Of four cows milked daily for ten days to two weeks before calving, the progeny of one died ten days after birth with a bacillus coli infection. The other three survived and continued in good health.

In conclusion it may be said that the removal of milk before parturition may be beneficial for the dam, but the lack of colostrum for the calf may increase the mortality rate.

THE EFFECT OF AN OVARIAN TRANSPLANT ON LACTATION

The observations of a cyclic increase in the yield of secretion in virgin heifers during recurrent estrus cycles and the entire absence of secretion in the udder of a heifer spayed before puberty made it desirable to determine the effect of an ovarian transplant in a spayed heifer.

As noted in the protocol, heifer No. 811 was available for this experiment and an autoplasmic ovarian graft was made by Dr. Andrew W. Uren of the Veterinary Department, to whom the credit is due for the success of the experiment. (Fig. 14).

For five months after the operation the site of the graft was scarcely visible and it was feared that the graft had been unsuccessful. When the heifer was twelve months old, definite signs of heat were observed. The site of the graft became swollen and presented a definite elevation on the neck. (Fig. 15.)

The secretion of milk began to increase rapidly several days before the appearance of heat was observed. Within 20 days the secretion of



Fig. 14.—The heifer No. 811 showing the site of the successful ovarian graft in her neck. Her ovaries were removed through an incision in the flank. (Photo taken March 19, 1928).

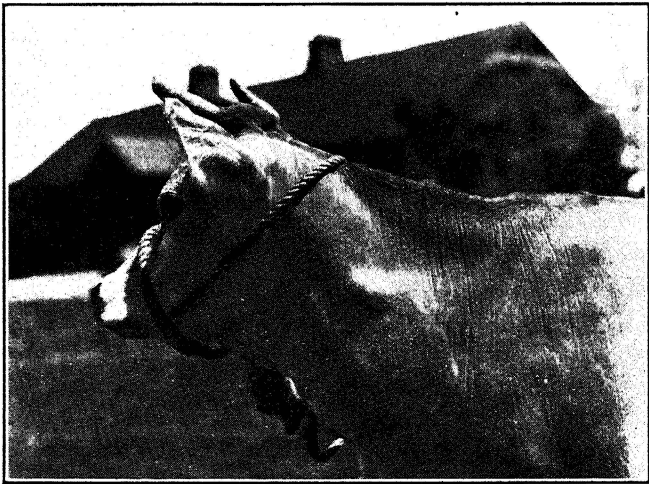


Fig. 15.—The site of the graft became swollen and presented a definite elevation on the neck. (Photo taken in June 1929).

milk increased about 60 c. c. each alternate day to 700 c. c. (Fig. 16.)

The periods of heat were not regular, but at each period a considerable increase in secretion was usually observed. The milk was of normal appearance, fat content, and specific gravity. At the time of maximum production over 5.6 pounds of milk were produced daily. The ovary gradually became inactive and for a considerable period before the animal was sacrificed no further heat periods were observed.

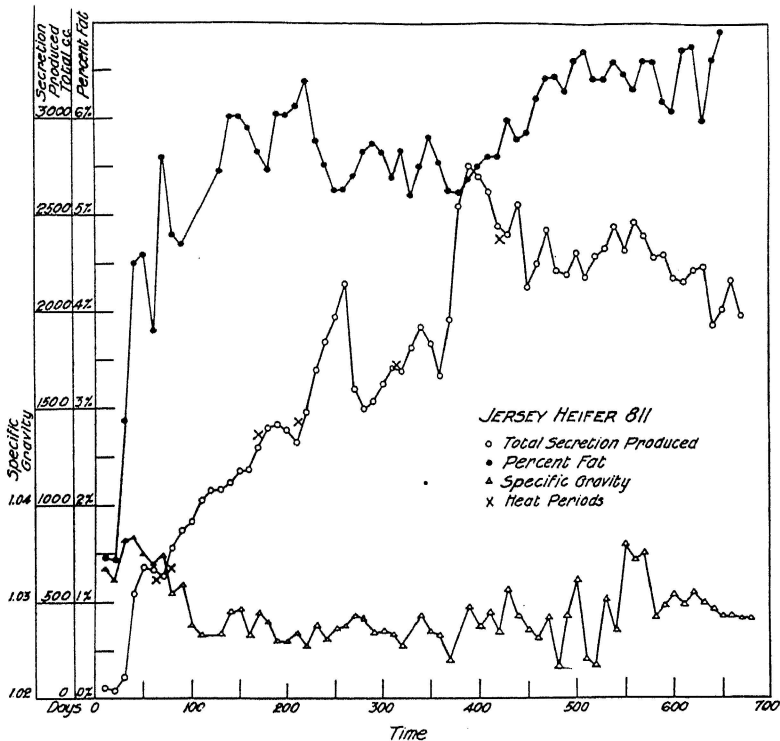


Fig. 16.—The yield of milk produced by No. 811 is shown in conjunction with the fat content and specific gravity.

The structure of the udder is shown in Fig. 18. It indicates considerable development of gland tissue, especially in the rear quarters. It is interesting to note in this connection that the rear quarters produced about 70 per cent of the total production and the front quarters about 30 per cent (Fig. 17).

Two attempts were made to graft an ovary into a dairy steer without success. As our experience with ovarian grafts is limited to these cases further observations will be required to determine the possibilities of successfully grafting ovarian tissue into a steer.

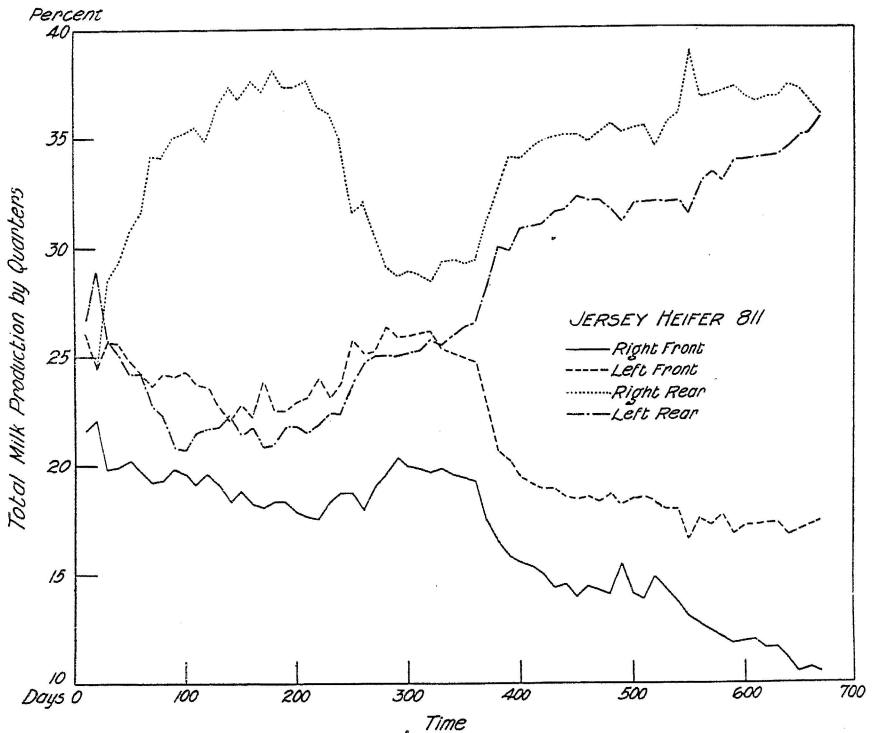


Fig. 17.—The relative yield of milk by the four quarters changes with the total secretion.

SUMMARY AND CONCLUSIONS

1. As an examination of a number of calves at birth failed to show the presence of a secretion (witches' milk) which could be withdrawn from the teat, it was concluded that the presence of such a secretion is a rare phenomena in cattle.

2. The period from birth to the approach of puberty is a time when the mammary gland displays little or no secretory activity.

3. With puberty and the recurrence of estrus cycles, the mammary glands of cattle in many cases begin to secrete small amounts of fluid, the yield of which increases during or following the occurrence of estrum.

4. During the greater part of pregnancy, the yield of secretion in primipara heifers either remains at the level attained during puberty or declines to some extent. This observation is taken to indicate the lack of a stimulus to initiate milk secretion during this period. Instead, the stimulus for the growth of the mammary gland predominates.

5. The striking increase in milk secretion during the twenty days preceding parturition is interpreted as indicating the activity of the

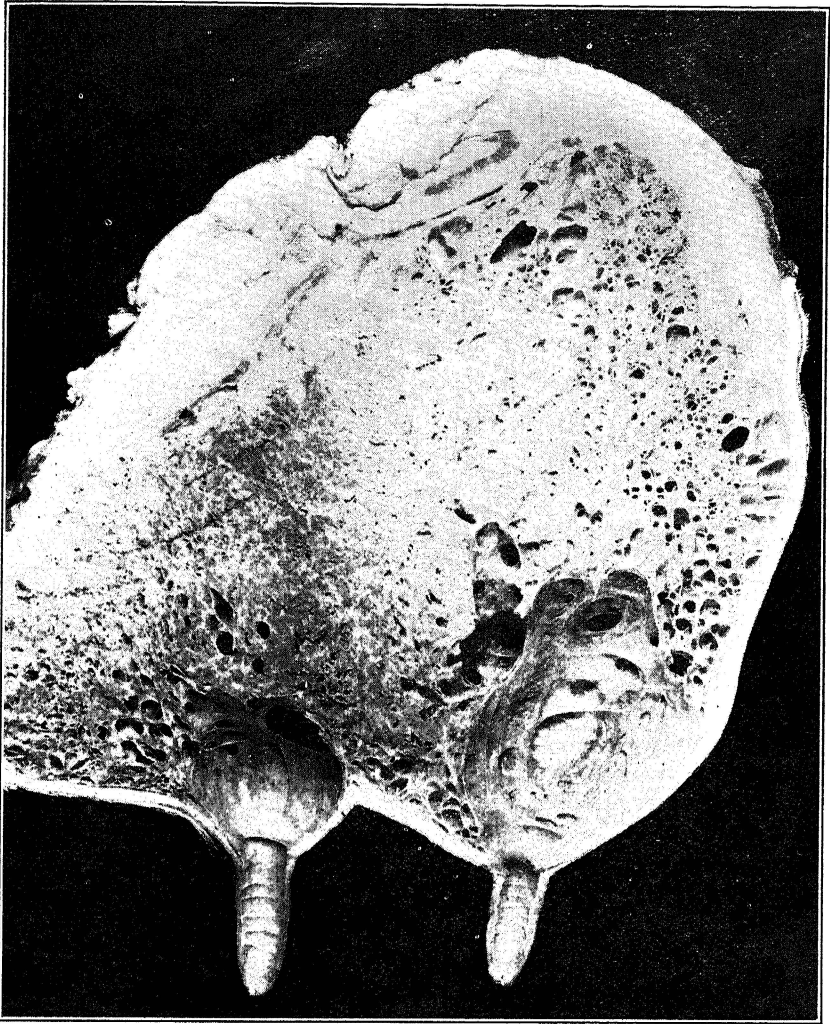


Fig. 18.—The structure of the udder of heifer No. 811 indicates considerable growth of gland tissue.

lactation stimulating hormone of the anterior pituitary.

6. The theory that a lactation inhibiting hormone is present in the blood during the latter part of pregnancy cannot be reconciled with the above observations.

7. The yield of secretion during puberty and much of the first pregnancy does not measure the growth of secretory tissue. Only with the stimulus to lactation observed at the approach of parturition are the

potentialities of the glands fully realized.

8. Animals milked prior to parturition yield milk at calving time approaching normal milk in composition.

9. It is concluded that the removal of milk before parturition may be beneficial from the standpoint of the dam, but the lack of colostrum for the calf may increase the difficulty of raising the progeny.

10. Following a successful autoplasmic ovarian graft, a spayed Jersey heifer gradually increased in milk secretion until at the maximum over 5.6 pounds of milk were produced daily.

DESCRIPTION OF ANIMALS USED IN THE EXPERIMENT

Heifer No. 9A was a grade Holstein heifer born April 9, 1925. This animal was spayed on Dec. 31, 1925 by Dr. John Adams of Philadelphia, Pennsylvania, before sexual maturity had been attained. Beginning on March 15, 1926, the udder of this heifer was vigorously massaged and stripped for five minutes three times per week. No secretion was obtained, although continued on the experiment for a number of months.

Heifer No. 6A was a grade Holstein heifer born March 30, 1925. Beginning March 15, 1926, this heifer's udder was massaged and stripped for five minutes three times per week. The first heat period was observed on May 18, 1926.

While no sign of secretion was observed until the first period of heat, a few drops of secretion, very watery in nature, were obtained. At the following milkings from five to 15 c. c. of a secretion were obtained. This heifer came in heat again June 8. On June 14 sufficient milk was being secreted to enable each quarter to be measured separately.

It became necessary to place the heifer in a pasture and the succeeding heat periods were not observed until August 27, 1926 when she was bred. Calculating the preceding periods at 21 day intervals, it will be noted that there was a notable increase in secretion on August 9, three days after the preceding period. Similarly the calculated period preceding (July 16) was followed by a decided increase on July 20, the next milking period.

Due to a misunderstanding on the part of the milker, the heifer was not milked September 2 to 14. At that time the yield was much less than previously. Although milking was continued the secretion steadily decreased until in about one month the amount was so small that milking was discontinued.

Cow No. 170, a Jersey heifer, was dropped November 17, 1922. She was bred May 31, 1924 and calved March 10, 1925. She was an inferior dairy cow, producing 3796 pounds of milk and 166.7 pounds

of fat in 232 days. She dried up in October 1925. She was bred on August 5, 1925. On March 15, 1926 after being dry about five months, massage and manipulation of the teats was begun. A few cubic centimeters of a light yellow, syrupy secretion were obtained. Milking was continued three times per week. The yield of milk began to increase very greatly eight days before parturition which occurred May 15, 1926.

Heifer No. 171 was a Jersey dropped November 29, 1922. She was bred a number of times beginning July 5, 1924, but never conceived apparently, although the intervals between successive periods were long and irregular. She was bred next January 13, 1925, February 4, March 20, May 25, October 5, January 14, 1926, and February 18.

Beginning March 16, 1926, this heifer's udder was massaged and stripped three times per week. Only a few drops of secretion were secured at irregular intervals until May 14, 1926, when all four quarters began to yield measurable amounts of secretion. However, no record of heat was made. In fact, she was not again bred until September 11, 1926. Due to the fact that the heat periods were not observed, her record is of little value.

Heifer No. 173 was a Jersey dropped February 2, 1923. She was bred August 14, 1925. On March 15, 1926 milking was initiated. She calved May 16, 1926, or 63 days later.

Heifer No. 197, a Jersey, was dropped November 23, 1925. She was bred June 15, 1927. Her udder was massaged regularly every 48 hours beginning November 4, 1927 and continued until March 22, 1928, when she freshened. The secretion of milk began to increase about thirteen days before parturition.

Heifer No. 198, a Jersey, was dropped February 14, 1926. Her first recorded estrus period was December 4, 1926. For a time during the summer of 1927, while on pasture, she was sucked by other calves and was observed to be secreting considerable amounts of milk. She was separated from these calves and dried off as quickly as possible. Her udder appeared to be unaffected by this premature secretion. At the beginning of the experiment, November 4, 1927, milking was again started and continued at 48-hour intervals.

At the first milking she produced 125 c. c. of an orange colored watery fluid. The amount of secretion dropped to 35 c. c. at the second, and to 9 c. c. at the third milking. The secretion gradually became lighter in color, and in two weeks it had all the appearances of normal milk. After 24 days a very marked increase in the secretion was noted. Two days later a bloody vaginal discharge was observed. While the desire for mating was not observed, it is possible that estrum occurred.

Two weeks later a normal estrus period occurred and the amount of secretion obtained was substantially increased. Later there seemed to

be a tendency for a gradual increase in secretion between estrus periods.

Beginning on December 6, 1927, the yield of secretion from each quarter was separately recorded in order to note any changes in the relative rate of secretion in the four glands.

Upon coming in heat January 19, 1928, she was bred and became pregnant. As a result no further observations on the relation of recurring estrus cycles to mammary secretion were secured. For the first four months during pregnancy, the secretion each 48 hours was practically constant, averaging between 150 and 175 c. c. On May 26, 1928, she was turned on grass. She immediately began to increase markedly in the yield of secretion. This increase began about 150 days before parturition and continued until about 60 days before parturition. On June 15, 1928 milking once per day began, on June 22, twice per day milking seemed essential. On August 4, milking three times per day was begun and continued until parturition, October 24, 1928. During the last sixty days before parturition there was a slight gradual decline in milk production.

Heifer No. 803, a second Jersey used in this experiment, was dropped November 23, 1926. She was placed under observation on October 19, 1927, when she was ten months and twenty-six days old. She had never been observed in heat up to that time. The udder was examined and massaged regularly every 48 hours. On the third massage, a few drops of an opaque watery secretion was obtained from the left rear quarter, which alone continued to yield a few drops at each massage period.

The first heat period was observed on November 7, 1927. At this time no increase in the secretion was noted. The second period of heat occurred December 4, 1927 or 28 days later. At this time a few drops of watery secretion were expressed from all quarters. By Dec. 8, 1927, or 72 hours later, a fluid was obtained from only two quarters. On December 10, three quarters were active, but again on December 12, only two were active. This was followed by two days during which no secretion could be expressed.

The next heat period (3) followed in 20 days, and all four quarters again became active. All quarters continued to secrete a few drops of fluid.

Following the fifth heat period, it became possible to begin to measure the yield of secretion from each gland. Thereafter, each period of heat was accompanied by increased mammary activity for over ten months. During the last forty days before successful service took place the yield of secretion decreased.

The animal was bred repeatedly but service was not successful until October 19, 1928, just a full year after the beginning of our observations. After conception the yield of secretion continued to decline and remained at a very low level during most of pregnancy. About 40 days before

parturition, the yield of milk began to increase again, being most rapid during the last 15 days, calving on July 21, 1929.

Heifer No. 343, an Ayrshire, was dropped July 21, 1926. The udder was examined and massaged regularly every 48 hours beginning October 19, 1927, when she was one year, two months and twenty-eight days old. The day following the first manipulation she came in heat. This was followed by the secretion of a sticky, opaque fluid from the left fore quarter. This secretion persisted without increase until November 26, 1927, when three quarters came into activity. Since this increased secretion was followed in about 72 hours by a vaginal discharge, it is possible that some ovarian activity was asserting itself, although no desire for mating was observed. The last drop or two expressed had the appearance of normal milk.

Following this cycle, only one quarter continued to function. The secretion increased slightly in amount but the total quantity remained very small.

This heifer was bred at the next period of heat (Dec. 22, 1927). She became pregnant and one quarter (left front) continued for about four months to function on about the same plane of activity it had attained at the time of inception of pregnancy. On April 13, 1928, three quarters began to secrete and on April 19, all four quarters. By April 27, 50 c. c. of a honey-like secretion were being obtained. On May 24 the yield of secretion from each quarter was recorded and continued until parturition. On May 26 she was turned on grass. The yield was doubled the next milking and trebled at the following milking, but then declined within a few days to the former production.

The milk yield began to rise distinctly about July 15, reaching almost two pounds each 48 hours; however, it was not maintained. The secretion declined slightly and continued at a reduced level until about 7 days before parturition, September 18, 1928.

Heifer No. 344, a second Ayrshire heifer, was dropped December 21, 1926. Her udder was also examined and massaged regularly every 48 hours beginning October 19, 1927, when she was 11 months and 28 days old. She had not been observed in heat up to this time.

At irregular intervals, a few drops of watery opaque fluid were expressed from the left rear quarter. Extremely vigorous massage of the udder was initiated January 25, 1928, resulting in a secretion from all four quarters. The secretion, however, stopped with the discontinuance of the vigorous manipulation of the gland.

Heat was first observed April 27, 1928. On April 29, several drops of secretion were expressed from each quarter. Secretion continued irregularly and very small in amount. Heat was next observed on June 23, at which time she was bred. Secretion from all quarters became

regular on July 1 but the volume was too small to measure. She was bred again August 16, and also September 7, 1928. The secretion did not increase at these times. In fact she did not at any time secrete more than a few drops from each teat. Observations were discontinued on September 27.

Heifer No. 811, a Jersey, was dropped August 27, 1927. The ovaries of this heifer were removed February 24, 1928 by Dr. A. W. Uren of the Veterinary Department. One ovary was split open and grafted into the muscle of the neck. The graft healed quickly without infection.

The udder was regularly massaged and stripped. On March 17 a small amount of an orange colored thick mucous like secretion was obtained from all quarters. A few drops of secretion were obtained until about the end of March. At irregular intervals later a few drops were obtained but not enough to measure. This condition persisted into July 1928. During this time the site of the ovarian graft was scarcely visible and the conclusion was reached that the graft had been unsuccessful.

However, on July 25, a considerable amount of secretion was found in the udder, but as it was unexpected it was not measured. From July 27, until August 22 the secretion varied from 50 to 60 c. c. every other day. The heifer was not observed to be in heat at the time of the initiation of this secretion. However, on August 24, she was very definitely in heat. The secretion more than doubled and continued to increase for a few days.

The site of the graft became swollen and very evident. Upon palpation it felt as though a large follicle was present. By September 1 the graft became softer to the touch. By September 7, the site had become more nearly level and it seemed as though a solid corpus luteum had formed.

The details of the increase in yield of secretion and subsequent heat periods are presented in Figs. 16 and 17.

Bull No. 425, a Guernsey, was dropped June 27, 1927. He was castrated February 14, 1928 by Dr. O. S. Crisler of the Veterinary Department. On February 24 an ovary which had been removed from No. 811 was grafted into the neck muscle by Dr. A. W. Uren. The rudimentaries were indeed rudimentary, scarcely showing the shape of a teat but rather almost flat surfaces on the scrotal sac. The teats were regularly examined and by June had developed to some extent. One or two drops of fluid at times were expressed from the teats.

The ovarian graft never showed any activity. Therefore, on January 17, 1929, parts of two ovaries from cow No. 507, a Holstein, were grafted on the right side of the neck by Dr. Ferguson of Lake Geneva, Wisconsin. This also was unsuccessful.

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