

UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

A STUDY OF BREEDING RECORDS
OF DAIRY HERDS

C. H. ECKLES
DIVISION OF DAIRY HUSBANDRY



UNIVERSITY FARM, ST. PAUL

A STUDY OF BREEDING RECORDS OF DAIRY HERDS

C. H. ECKLES

Breeders of dairy cattle, particularly those having highly developed herds, are inclined to place reproduction troubles as the most serious problem in the maintenance and development of their herds.

The study reported was made to determine the conditions confronting the practical breeder in regard to reproduction troubles, with such generalizations as seem justified. The data are presented with a full realization of the fact that the combination of factors responsible for the breeding results experienced in the herds supplying the data may not be found in others.

The number of animals included and the long period of time covered by the data from the University herd do, however, add confidence to the results reported from that source. The fact that this herd included four breeds and that necessarily a large number of sires were used also adds to the significance of the data presented. Furthermore, the parallel data given from Branch Experiment Station herds and highly developed purebred herds show the same trends and general results as those from the University herd.

No attempt is made to deal with the causes of breeding difficulties or abortion or with their treatment. To do so would lead into the fields of veterinary medicine, genetics, and nutrition, where the data concerning these problems are decidedly limited.

Most of the data used are from the records of the dairy herd maintained by the University of Minnesota. Fortunately, complete breeding records of this herd are available beginning with the year 1900. Reasonably complete records were also available over a term of several years for herds maintained by two Branch Experiment Stations. In addition, the owners of several of the most highly developed purebred herds in the state placed their records at our disposal. Unfortunately, no way has been found to obtain satisfactory breeding and abortion records of herds maintained under average conditions, for example, those found in typical herds owned by members of a Herd Improvement Association.

TABLE I
BREEDING RECORD OF THE UNIVERSITY HERD

Year	Number of services		Total conceptions	Percentage of conceptions for fertile cows	Percentage of abortions
	Total	Including only fertile cows			
1900	41	39	5	12.8	40.0
1901	83	75	33	44.0	3.0
1902	69	60	35	58.3	20.0
1903	84	77	30	38.6	13.3
1904	80	58	22	37.9	27.2
1905	104	82	29	35.4	24.1
1906	156	112	42	37.5	23.8
1907	101	91	39	42.9	17.9
1908	150	107	50	46.7	8.0
1909	84	80	39	48.8	23.1
1910	111	81	27	33.3	18.5
1911	157	130	39	30.0	30.7
1912	272	184	47	25.5	25.5
1913	345	172	45	26.1	8.9
1914	281	98	51	52.0	9.8
1915	155	98	41	41.8	12.8
1916	114	84	45	53.5	8.9
1917	117	93	47	59.5	10.6
1918	123	93	51	54.8	9.8
1919	61	59	34	57.6	8.8
1920	92	85	49	57.6	8.2
1921	113	94	51	54.2	11.8
1922	60	50	25	50.0	12.0
1923	131	117	39	33.3	23.1
1924	156	134	53	39.5	15.1
1925	168	153	46	30.0	21.7
1926	187	155	38	24.5	21.0
1927	172	142	50	35.2	10.0
1928	110	97	49	50.5	0

The records of the University herd are practically complete, giving the data of each service and abortion as well as the milk and fat production of the cow and the reason for disposing of each animal when sold. During the period up to 1917 the policy of the management of the herd was to maintain what were considered good farm conditions. Heavy feeding for high production was not practiced. From 1900 to 1912 the roughage fed was mainly upland prairie hay and corn silage, the grain ration consisted of a mixture of bran or middlings, corn, barley, and linseed oilmeal. The use of alfalfa hay was begun in 1912 and this, with corn silage, has since constituted the roughage during the winter months. Since that date the grain ration has included feeds common to this section of the country. A typical grain mixture fed in 1915 contained 25 per cent each of corn, wheat middlings, and barley; and 12.5 per cent each of oats and wheat bran. The grain ration since 1918 has been essentially the same except that about 5 per cent of cottonseed meal has been included. The animals have been on pasture regularly during the pasturing season, extending usually from the middle of May to about the first of October. Some grain has been fed

uniformly in addition to pasturage. The bulls have been confined in individual yards opening into a pen in the bull barn. Little attempt has been made to exercise the bulls beyond what they take voluntarily in the open yard. Some of the bulls used have been older than is typical of those found on commercial dairy farms, altho probably not differing much in this respect from those found on typical farms where the breeding of purebred cattle receives attention. Since 1917 the feeding of the herd has been more liberal than before. This is reflected in much higher production. In recent years the policy has been followed of using proved sires, which undoubtedly has been a second important factor in the higher level of production. The average production of two-year-old heifers (corrected to maturity) is given in Table II.

TABLE II
RECORD OF PRODUCTION, SERVICES, CONCEPTIONS, AND ABORTIONS IN THE UNIVERSITY HERD
By 5-year periods

	Average yearly fat pro- duction	Total services	Total services of fertile cows	Total concep- tions	Percentage of concep- tions of fertile cows	Percent- age of abortions
	lb.					
1900-1904	264	357	309	125	40.4	16.0
1905-1909	254	595	472	199	42.1	18.6
1910-1914	307	1166	665	209	31.4	17.7
1915-1919	377	570	427	218	51.0	23.0
1920-1924	424	552	480	217	45.2	13.8
1925-1928	500	637	547	183	33.4	12.5
1900-1928 (29 years)	350	3877	2900	1151	39.7	14.6

The health of the herd has been under the care of the members of the Veterinary staff of the University throughout the 29 years included in the study. As indicated by the data in Table I, abortion was common as far back as the records extend. It is assumed that the infection of abortion disease was introduced into the herd previous to the year 1900. Beginning with 1927, extreme sanitary precautions were taken and cows reacting to the blood test for the Bang organism were discarded as rapidly as seemed feasible. By this means the percentage of reactors was reduced and at the middle of the year 1928 all reacting animals were removed from the herd.

Beginning with 1924 the records of all two-year-olds have been made under what is termed "standard conditions." This plan gives all an equal chance by maintaining conditions as comparable as possible from year to year.

The herds at the Branch Stations are maintained largely for demonstration purposes and the policy is to keep them under conditions that can be recommended as suitable for commercial herds. These herds are on pasture during the summer and in winter are fed corn or sun-

flower silage and mixed or legume hay, with a suitable grain allowance in proportion to production. The cows are milked twice a day and are bred to calve again within a year if possible. In recent years the average yearly fat production of these herds has been approximately 350 pounds.

The purebred herds owned by individuals, from which records are available, are highly developed herds with a national reputation for records of milk and fat production under official test conditions. The conditions of management were typical of herds of this class.

BREEDING RECORDS OF THE UNIVERSITY HERD

In compiling the data presented in Table I, it seemed advisable to give the total number of services, including all cows, also the number for those that proved to be fertile by conceiving sooner or later. In the earlier years covered by the data, the practice was followed of allowing non-breeders to remain in the herd much longer than was the case during the last 10 years. For the years 1911 to 1914 the number of non-breeders was unusually large and some were kept for 2 years. To base all figures upon records which include these that should have been discarded much more promptly would give results of less value. While the total number of services is given, the percentage of conceptions is based upon the fertile cows only.

The first impression from this table is probably astonishment at the poor record exhibited. From the entire 29 years, only 39.7 per cent of the services resulted in conception. This excludes the cows that did not finally become pregnant. Of these the average abortion rate was 14.6 per cent. We believe the data in Table I give a fair picture of the breeding situation as it exists in other dairy herds where abortion has been prevalent.

Williams (1), in a report dealing with the male as a factor in genital infections, gives figures from 12 bulls used in a large purebred herd over a period of about 5 years. A marked variation was noted with the different bulls in the percentage of services resulting in conception. For 6 mature or aged animals the average was 45 per cent, for 5 young bulls 74 per cent. In another large herd the records showed a range with these bulls from 32 to 50 per cent. In these herds the abortions ranged from none to over one-third of the total. In the experimental herd maintained by the Bureau of Dairying, United States Department of Agriculture, for the fiscal year 1927-28, 24.4 per cent of the 585 services resulted in conception (2). The use of aged bulls is probably a factor in the low results obtained. For the Huntley field station maintained by the same division, the figures are 58.8 per cent for 204 services (3).

In the experimental herd maintained by the Division of Veterinary Medicine, University of Minnesota, over a period of 5 years, including both the group infected with abortion disease and the clean group, 250 services are recorded, of which 51.7 resulted in pregnancy (4).

Table II gives the same data grouped by 5-year periods and also the average production of the two-year-old heifers freshening during the period, corrected to maturity. The two-year-old record is used because it is available for all that came into milk, and by using this uniform age the fairest possible index is given of the producing level of the herd during the interval under consideration.

The view is often advanced that the raising of the level of milk production by better selection and feeding has increased the amount of breeding difficulties. Table I does not bear out this belief. There is no evidence that the herd in question has a lower breeding efficiency in recent years than during a period 25 years ago when the production level was little more than half what it is today. Clearly, breeding troubles are nothing new in this herd.

The abortion rate shows a wide variation, as would be expected, but perhaps rather less fluctuation than would have been expected because of the small number of animals represented and the well known characteristics of this disease. The abortion rate for the 29 years is 14.6 per cent, which compares favorably with figures from another institution herd kept under conditions reasonably comparable (5). The freedom from abortion of all cows conceiving in 1928 is the result of the careful régime of sanitary and veterinary control followed from the beginning of 1927, including the elimination of all reactors to the blood test about the middle of the year.

BREEDING RECORDS OF HIGHLY DEVELOPED PUREBRED HERDS

The data from the privately owned purebred herds and the two Branch Experiment Station herds were found to be reasonably complete for cows that conceived. In most cases no information was available regarding animals when no record of calving was given. Some of these were unquestionably sold as non-breeders, others as breeders or as unprofitable producers. The only safe plan to follow appeared to be that of using only the records in which the dates of service were given, followed by a record of freshening. For these reasons the only figures given in Table III for conceptions are for the known fertile cows. Note that the percentage of conception is higher than for the University herd, altho the data for the first 5 represent herds in which animals are pushed for the highest possible production. One of the Branch Station herds makes a showing among the poorest, altho it

was managed during the period represented under conditions that are recommended for commercial dairy herds.

The surprising thing is that when the non-breeders are taken out of the highly developed purebred herds the number of services per conception is actually rather above that in some herds kept on essentially a commercial basis.

TABLE III
BREEDING RECORDS OF HIGHLY DEVELOPED PUREBRED HERDS AND
BRANCH EXPERIMENT STATION HERDS
Fertile cows only included

	Total services	Total conceptions	Percentages of conceptions
Holstein herd A	414	228	55.0
Holstein herd B	303	135	44.5
Holstein herd C	195	96	49.1
Guernsey herd A	188	117	62.1
Jersey herd A	93	52	54.8
Branch station A	262	160	61.0
Branch station B	815	411	50.4

The conclusion of the author, based upon the data given, is that the complaint of the purebred breeder regarding his special difficulties with the breeding efficiency of his herd may be explained on another basis. In a purebred herd are certain cows the offspring of which would be especially valuable for breeding purposes. When one of these cows becomes sterile the owner keeps her for a long period hoping to get offspring. In a farmer's herd a cow developing the same trouble would be sold shortly and forgotten. It is of special interest that the owner of the private herd showing the best record of all, when only fertile cows are considered, appeared to believe that his herd was particularly affected with breeding troubles. The facts are, when a very few animals are excluded, having great records and whose offspring would be very valuable, the breeding record of his herd is really good compared to others, including some having a production level classing them with the better herds in Herd Improvement Associations.

RELATION OF HIGH PRODUCTION TO STERILITY

In recent years the opinion has been held by a large number of dairy cattle breeders that difficulties with breeding, especially with sterility, accompany high milk production. The evidence upon which this conclusion is based is the experience that a considerable number of cows prove to be sterile after making high official records. Breeders of highly developed purebred herds have also had the impression that difficulties with breeding have increased in recent years. As the level of production has also increased during the same interval, the conclusion has been drawn that the two bear the relation of cause and effect.

A study of the breeding and production records of one herd, even though it covers 29 years, will not necessarily solve the problem for all conditions but it should indicate the general results that may be expected.

Table IV shows the average production of two-year-old heifers (corrected to maturity) freshening within the intervals included, also the average production under the same conditions of those that were at any time later discarded as non-breeders. Evidently no relation exists, so far as is indicated by these figures, between the level of production by the cow and the development of sterility. In only 2 out of the 6 groups is the production by the cows that later became non-breeders higher than the average of the entire group of which they were a part.

TABLE IV
FAT PRODUCTION OF COWS IN THE UNIVERSITY HERD AS TWO-YEAR-OLDS
Corrected to maturity

Date	Number of cows	Average fat production as two-year-olds	
		Including all	Cows later discarded as non-breeders
1900-1904	10	lb.	lb.
1905-1909	16	264	310
1910-1914	35	254	254
1915-1919	48	307	324
1920-1924	58	377	280
1925-1927	31	424	420
		500	438

During the period of 29 years a total of 47 non-breeders had records of production in the herd. The average computed to maturity in each case was 342 pounds, compared to an average of 350 for all animals in the herd during the same period. Those that became non-breeders were slightly below the average of the entire herd. Thirty-seven cows in this herd have at some time produced above 600 pounds of fat in a year. (Immature records corrected to maturity.) Of these, 35 gave birth to calves following the period during which the production was made that placed them in this group. The 2 that proved to be non-breeders represent 6 per cent of the total, which is about normal, as may be seen from Table V. These data show unmistakably that in the University herd the level of production has not been a factor contributing to sterility. The results are not interpreted to mean that the conditions maintained at times in making the maximum records under official testing conditions may not be conducive to sterility. The effect of official testing conditions, however, is likely to be overestimated. Many cows making an exceptional record are already at the age when a significant proportion of cows, regardless of their produc-

ing ability, are discarded as non-breeders. When a cow has made a great record, on account of her value the owner is extremely anxious to obtain offspring and if this is not realized great disappointment is experienced and the fact that she has become sterile is given wide publicity. Undue attention is thus drawn to animals that become non-breeders following a period of high production.

The data given for the University herd show clearly that no special fear need be felt regarding a decline in breeding efficiency or increase in sterility as the level of production for the herd is raised.

AGE IN RELATION TO BREEDING EFFICIENCY

The impression is common that the age of the cow is an important factor in the efficiency of breeding. The data studied suggest that the effect of age may be considerably overestimated. The records include 311 two-year-old heifers, of which 23 proved to be non-breeders. For the 288 fertile heifers, 42 per cent of the services resulted in conceptions. This figure is to be compared to 39.7 for the entire herd. The difference, it will be noted, is slight. The study of the relation of age to number of services required for conception did not extend beyond the first pregnancy.

TABLE V
RELATION OF AGE TO STERILITY IN DAIRY COWS
A summary of records for 29 years from the University Herd

Age, years	Total cows	Number sterile	Per cent sterile	Ratio of sterile to total
2	311	23	7.4	1:14
3	217	8	3.6	1:28
4	139	5	2.8	1:36
5	127	8	6.3	1:16
6	87	5	5.7	1:18
7	69	3	4.3	1:23
8	56	2	3.6	1:28
9	51	4	7.8	1:13
10	41	2	5.0	1:20
11	34	4	11.7	1:9
12	25	3	12.0	1:9
13	19	4	21.0	1:5
14	12	2	17.0	1:6
15	9	3	33.3	1:3
16	5	1	20.0	1:5
17	2	1	50.0	1:1

The age of the animal is a factor of considerable importance in relation to sterility. In Table V are presented the results of a study made of this relation from the records of the University herd. The classification into age groups, for example 4 years, includes those freshening within 6 months either way from this age (3½ to 4½ years) and which were thereafter non-breeders. Those classed as

two-year-olds include the heifers that never conceived. Those in the three-year-old group each had one calf and then became sterile. Data for older groups are based upon age and not upon the number of offspring.

The data in Table V bear out the popular opinion regarding the relation between age and sterility so far as it concerns animals that have reached an age which would class them as past their prime—for example, 10 years of age. Up to this age no marked variation is observed in the number of animals becoming non-breeders. Among the 311 heifers included, 23, or one to each 14 (7.4 per cent), proved to be sterile. Only when an age past 10 years was reached did the proportion of non-breeders exceed this figure. Albrechtsen (6) reports 6.2 per cent of sterile heifers among 2,209 in certain Danish herds.

RELATION OF THE NUMBER OF SERVICE PERIODS TO CONCEPTION

In this discussion "service period" is used to designate an oestrus period at which one or more copulations occurred.

One of the common complaints made by cattle breeders is the number of services so often required before conception occurs. Important questions also arise as to how long a cow should be retained before rejection as a non-breeder. In Tables VI and VII are given data concerning this question from the University herd and Branch Station herds.

TABLE VI
RELATION OF THE NUMBER OF SERVICE PERIODS TO CONCEPTION
A summary of records for 29 years from the University herd

Number of service	Number of cows	Number of conceptions	Percent-age of conceptions	Chance of conception
First	1280	547	42.7	1: 2.3
Second	729	258	35.3	1: 2.8
Third	466	146	31.3	1: 3.2
Fourth	306	79	25.8	1: 3.9
Fifth	210	55	26.1	1: 3.8
Sixth	142	29	20.4	1: 4.9
Seventh	104	17	15.8	1: 6.1
Eighth	78	9	12.0	1: 8.7
Ninth	63	6	9.5	1:10.5
Tenth	52	4	8.0	1:13.0
Eleventh to twentieth	168	4	2.3	1:42.0
Twentieth to fortieth	100	0	0	0

It appears that pregnancy resulted from 42.7 per cent of the first service periods in the University herd and from 53.1 per cent for the two other herds. Of the total conceptions that occurred as a result of all the service periods reported in the University herd, 47 per cent and in the others 55 per cent were the result of the first service. It

appears that if a cow conceives at all the chances are about equal that it will result from the first service period.

TABLE VII
RELATION OF THE NUMBER OF SERVICE PERIODS TO CONCEPTION
A summary of records from two Branch Station herds

Number of service	Number of cows	Number of conceptions	Percentage of conceptions	Chance of conception
First	595	316	53.1	1:1.9
Second	277	129	46.5	1:2.1
Third	151	67	44.3	1:2.2
Fourth	79	22	27.7	1:3.4
Fifth	47	22	46.8	1:2.1
Sixth	26	6	23.0	1:4.3
Seventh	15	4	26.6	1:3.7

The chances of conception decline with each service period—slowly at first, then rapidly. After five service periods have passed without results the chances appear to be about one to five that the sixth will result in conception. When the ninth is reached the chances have decreased to one in ten. Gowen (7) compiled the breeding records of 1,801 cows in Maine. Of these, 99 per cent of the conceptions occurred within the first five service periods.

These data show the futility of retaining cows that do not conceive in the herd over a long period, hoping for favorable results. It seems questionable to retain any but the most valuable, if pregnancy does not occur after four or five service periods. It should be kept in mind that the herds supplying these data received veterinary attention without which the number of conceptions would unquestionably have been lower. The correct practical procedure is to raise sufficient heifers to make possible a constant culling not only of unprofitable cows but of those that are difficult breeders as well.

RELATION OF SEASON OF YEAR TO CONCEPTION BY DAIRY COWS

The character of the diet may be a factor in the efficiency of breeding. Practical experience is the basis for a belief by some that the chances of conception are increased if a difficult breeder is placed on an exclusive pasture ration for several months.

The service records available for groups according to months and compared with the conceptions resulting are given in Table VIII. No significant difference is noted in the percentage of conceptions by months. It should be kept in mind, however, that while this herd was on pasture, grass did not represent the entire diet, as some grain was fed regularly except to the heifers that had not freshened. No far-reaching conclusions are justified from these data. It does appear that under conditions as found in a large portion of the dairy farms little,

if any, better results are to be expected in the way of conception during the pasturing season as compared with the months of dry feeding.

TABLE VIII
RELATION OF SEASON OF YEAR TO CONCEPTION BY DAIRY COWS

Month	Total services	Total conceptions	Percentage of conceptions
January	380	142	37.3
February	302	107	32.1
March	315	123	39.0
April	262	108	41.2
May	242	108	44.6
June	220	88	40.0
July	155	63	40.6
August	157	53	33.7
September	147	51	34.6
October	165	50	30.3
November	310	138	44.5
December	337	137	40.6

RELATION OF ABORTION TO STERILITY

Veterinarians and cattle breeders generally look upon abortion disease as an important factor in causing sterility. Data are available showing the breeding history of 112 cows following abortion. Of this 112, 72, or 64 per cent, followed the abortion by a normal calving; 17, or 15 per cent, again aborted; 23, or 21 per cent, were sterile. Following abortion the percentage of services resulting in conception was 34 compared to 39.7 for the entire herd during the 29 years included.

These data indicate that abortion was a factor in increasing sterility, as shown by the figure of 21 per cent compared to an average of about 5 per cent as indicated for cows under 10 years of age, in Table V.

HISTORY OF NON-BREEDERS PREVIOUS TO STERILE PERIOD

Several causes are probably responsible for sterile cows and no attempt is made to enumerate them or evaluate them. The study revealed that data were available for 109 cows that were non-breeders. Of these, 23 never conceived. Of the 85 others that had one or more calves, 65 per cent of the sterility followed normal calving, 30 per cent followed abortion, and for the remaining 5 per cent no records are available.

SUMMARY

For the entire period of 29 years, 39.7 per cent of the services with fertile cows resulted in conception. The average abortion rate was 14.6 per cent.

The average yearly fat production for two-year-old heifers the first 5 years of the 29 was 265 pounds, for the last 4 years it was 500.

No tendency toward an increase in breeding difficulties during the 29 years can be observed from the records. This includes the number of services required per conception, rate of abortion, and proportion of non-breeders.

The evidence is conclusive that within the University herd the level of production has had no relation to breeding troubles, as shown by the following facts:

(a) Forty-seven cows having yearly fat records became non-breeders. The average fat records of these cows was 342 pounds per year compared to an average of 350 for the entire herd.

(b) Breeding troubles have not increased with the greatly augmented production of the dairy herd during the years represented.

(c) Thirty-seven cows have produced over 600 pounds of fat within a year. Of these only two were non-breeders following this production. This percentage is not more than normal for cows of the ages represented.

One in 14, or 7.4 per cent, of the females used in the herd never conceived. From the ages of 2 to 10 years an increase in the proportion of non-breeders is noticeable but not marked. After this age the proportion of non-breeders increases rapidly.

Taking into account fertile cows only, the percentage of services resulting in conceptions in five highly developed purebred dairy herds privately owned was from 44.5 to 62 per cent, somewhat higher than in the University herd. The percentage of conceptions in two demonstration herds maintained on a good commercial basis by Branch Experiment Stations is on a par with that of the purebred herds.

The impression that difficult breeding is especially prevalent in purebred herds is mainly the result of retaining certain valuable cows longer than is done in commercial milk-producing herds. It appears from these data that the reproduction difficulties are about the same in highly developed herds as in those maintained on the production level of good commercial practice except so far as certain cows are kept in the herd over long periods with the hope of valuable offspring.

Under conditions as maintained for the University herd, no significant seasonal variation can be found in the percentage of services resulting in conceptions.

About half the pregnancies occur from the first service. The percentage of services resulting in conception decreases with further service periods. After a cow has passed five without results the chances are about one in six that she will conceive at the sixth and only about one in thirteen when the tenth period is reached.

The small ratio of successful results after five service periods suggests the advisability of discarding ordinary cows promptly when they fail to conceive over this interval. Valuable purebred animals may justify further efforts.

The data assembled bear out the usual opinion that abortion is a factor in sterility, altho the effects of abortion in this respect are often overemphasized. Of all aborting animals, 21 per cent were sterile following abortion.

Of a total of 109 cases of sterility, 21 per cent were heifers that never conceived, 24 per cent followed abortion, 51 per cent were preceded by a normal calving, and the records are incomplete for the remaining 4 per cent.

REFERENCES

1. Williams, W. L. The male as a spreader of genital infections. *The Cornell Veterinarian*, vol. XIII, pp. 108-134 (1923).
2. Bureau of Dairying, U. S. Department of Agriculture. Report of the Chief of the Bureau for Fiscal Year Ending June 30, 1928.
3. Moseley, T. W., Stuart, D., and Graves, R. R. Dairy work at the Huntley field station 1918-1927. *Tech. Bull. 116*, U. S. Dept. of Agr. (1929).
4. Fitch, C. P., Boyd, W. L., and Delez, A. L. Report of experimental work in the control of bovine infectious abortion. *Jour. Amer. Vet. Med. Assoc.*, vol. LXXV, pp. 215-229 (1929).
5. White, G. C., Johnson, R. E., Rettger, L. F., and McAlpine, J. C. Bovine infectious abortion. Increased productivity of an abortion-free dairy herd. *Jour. Dairy Sci.*, vol. XI, pp. 359-374 (1928).
6. Albrechtsen, J. Sterility of cattle and methods of treatment. *The Cornell Veterinarian*, vol. VII, pp. 57-110 (1917).
7. Gowen, J. W. Report of progress on animal husbandry investigations in 1917. *Maine Expt. Sta. Bull. 274* (1918).