AN INVESTIGATION OF LOW FERTILITY IN DAIRY CATTLE DURING HIGH CLIMATIC TEMPERATURES

by

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Date

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GENERAL INTRODUCTION

Livestock breeders in tropical and subtropical regions and research workers concerned with animal production have long been aware that high temperatures adversely affect animal reproduction (15, 20, 22, 46). The problem of fertility in dairy cattle has received added emphasis with the advent of artificial insemination. Stott (50), in summarizing the records of an artificial insemination stud in Central Arizona, found that the first service nonreturn rate at 150 days drops from a high of 59.9 percent in winter to a low of 47.5 percent during August. A rapid decline in reproductive efficiency occurs during June and July with an upswing in September and October. This is in contrast to findings in cooler climates. Mercier and Salisbury, in Eastern Canada (36) and in New York state (37), and Erb and Waldo (19), in Western Washington, found breeding efficiency at its highest in summer and fall. The northern work suggested that cattle, like many other animals, are influenced in their reproductive behavior by seasonal changes, possibly changes in day length (36, 37). This subtle influence of light is apparently overshadowed by the stress of summer temperatures in Arizona.

It has been shown that reproductive efficiency of other animals is also lowered by high temperatures (3, 55, 58).

Many workers have felt that the lowered fertility in cattle is due to the adverse affects of high temperatures on the bull. It has been well demonstrated that increasing the testicular temperature of mammals by scrotal insulation, or by confinement of the testes to the body cavity, has a deletrious affect upon spermatogenesis (5, 12, 23). In nature this occurs in bilateral cryptorchids and in highly finished males (5, 44). Casady and coworkers (9) showed that initial motility, sperm concentration, and total sperm count of semen decreased when bulls were subjected to high temperatures by artificial means. Dawson (15) states that sires used at Southern stations were consistently lower in fertility than those used at Northern and Western stations. Other investigations in subtropical areas, however, have failed to show a decrease in semen quality during summer seasons (27, 39). Swanson and Herman (53) found that spring and summer semen showed a significantly higher initial motility than fall and winter semen. They found the keeping quality of undiluted semen to be greater for summer and fall than for winter. Patrick, et al. (41), in Louisiana, found no difference in the semen quality of bulls kept under normal pasture conditions and those kept in air-conditioned chambers throughout the summer.

In some species, including man, hypothyroidism appears to be the cause of lowered fertility in the female (14, 29, 32, 43). If this is the case with cattle it is conceivable that the low reproductive efficiency seen in Arizona during summer could be due to depressed thyroid activity. This idea is not without support in the literature. It has been demonstrated that thyroid activity is influenced by prevailing temperatures. Hall and coworkers (24) found an inverse relationship between temperature and the serum protein-bound iodine (PBI) level of cows and heifers in Louisiana. Patrick, et al. (41) noted that the PBI values of eighteen dairy bulls fell sharply in June and remained low through October. Blincoe and Brody (6, 7), using other assay techniques, obtained similar results in cattle. Lennon and Mixner (30) found significant, or highly significant correlations between the PBI level and the interval from first breeding to conception and the interval from parturition to conception in Holstein cows. Hall, et al. (24) describes a condition in which cows would not stand when mounted by herdmates although examination revealed follicular development. This appears to be the same condition found by Spielman, et al. (49) in cows after thyroidectomy.

The observation that some cows are bred repeatedly during the summer months in Arizona without altering their estrous cycles suggested that fertilization fails to occur. Roberts (45) concluded that fertilization does not occur in about 40 percent of repeat breeder cows. Poor timing of insemination with respect to ovulation could conceivably be responsible to a large degree for low conception. Studies in South Africa (56) showed that anovulation and delayed ovulation were important factors in reproductive efficiency of dairy cattle. No investigations have previously been made to determine the effect of Arizona summer temperatures on ovulation in cattle.

Of the many physiological changes which high summer temperatures could produce in cattle which may affect reproduction, changes in semen quality, thyroid activity, and ovulation seemed to be among the most logical. This investigation was made to determine the influence of each of these factors on reproductivity of dairy cattle in Arizona.

SEASONAL INFLUENCE ON SEMEN QUALITY

The quality of bull and ram semen, as affected by high ambient temperatures to which animals may be subjected, has been the subject of several investigations in recent years. Glover (23) found that increasing testicular temperature of rams caused a cessation of spermatogenesis with a simultaneous rise in the initial fructose content of the semen. The increase in fructose was too great to be accounted for on the basis of the decrease in the per-cent of the ejaculate composed of spermatozoa. Mann and Parsons (34) have shown that there is a direct relationship between the fructose level of semen and the blood titer of the male hormone. It appears therefore, from the work of Glover (23), that increasing testicular temperature increases hormone secretion. The work of Casady, et al. (9) indicates that high ambient temperatures adversely affect the quality of bull semen as measured by initial motility, sperm density, and total sperm count.

This study was designed to determine the influence of Arizona summer temperatures upon the fructose level, initial motility, and sperm density of semen from bulls maintained under normal field conditions.

Procedures

Eight Holstein bulls at three commercial dairies in Central Arizona were used in the study. Semen was collected from each bull twice weekly for artificial insemination. From these collections samples were obtained at biweekly intervals from May 2, 1958 to November 26, 1958 for laboratory analysis. Immediately after collection motility was determined and the sperm killed to prevent fructolysis. Motility was rated from 0 to 5 as described by Herman and Swanson (26).

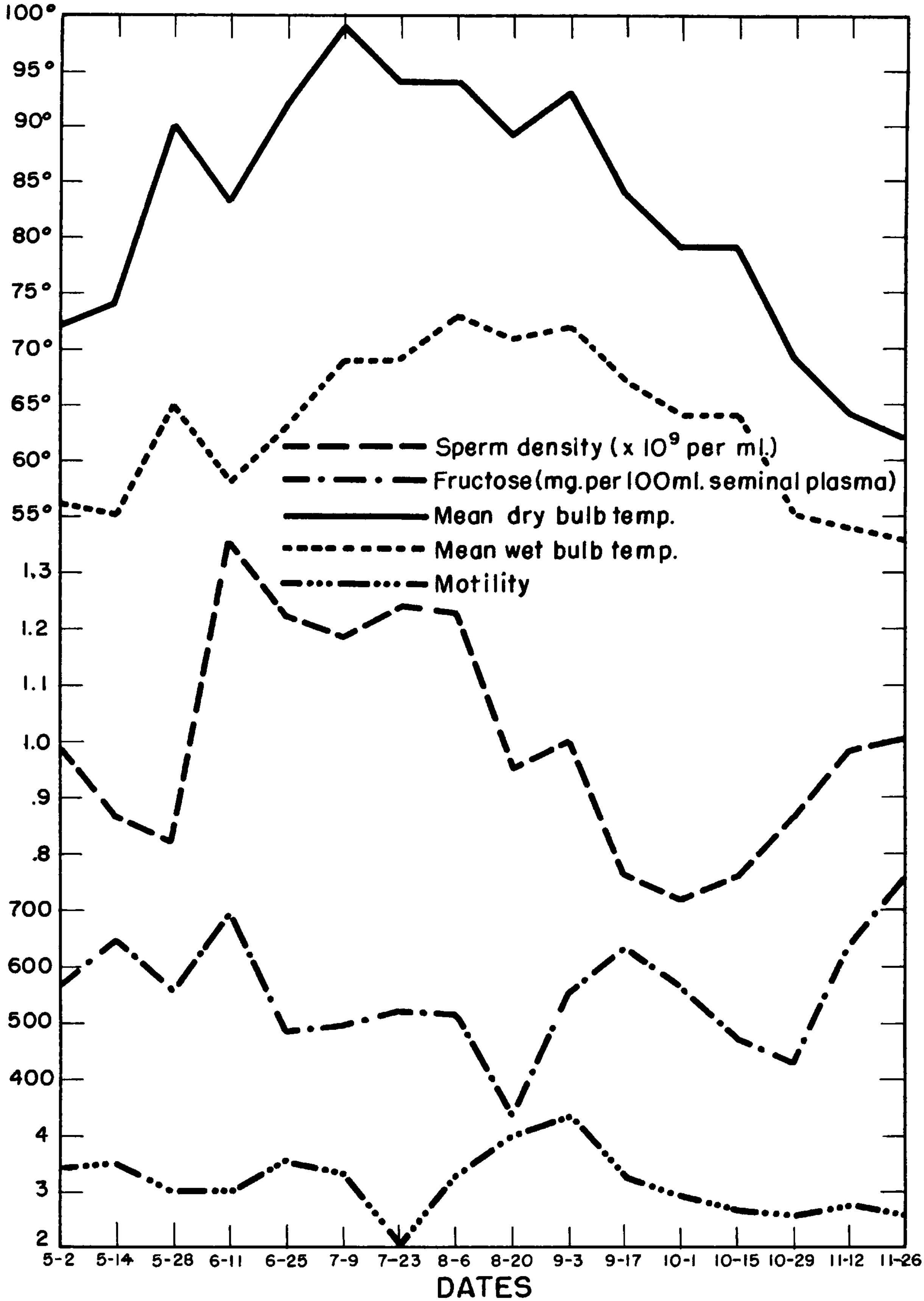
In the laboratory sperm cell counts were made with the hemocytometer and the fructose content determined by the method of Mann (33). The fructose values were adjusted for variation in sperm density as described by Flerchinger and Erb (21). The data on sperm density and fructose content were analyzed according to Li (31). Due to a rather large number of missing observations on motility the data on motility were not analyzed statistically.

The average value for each of the three variables (sperm density, fructose, and motility) for each sampling date was compared with the mean wet and dry bulb temperatures of the day preceding each respective sample.

Results

The results of this experiment are summarized in Figure 1. Superimposed upon the average value for fructose, initial motility, and sperm density for each sampling date are the mean wet and dry

Figure 1


100°
95°
90°
85°
80°
75°
70°
65°
60°
55°
1.3
1.2
1.1
1.0
.9
.8
700
600
500
400
4
3
2
Sperm density (x 10⁹ per ml.)
Fructose (mg. per 100 ml. seminal plasma)
Mean dry bulb temp.
Mean wet bulb temp.
Motility
5-2
5-14
5-28
6-11
6-25
7-9
7-23
8-6
8-20
9-3
9-17
10-1
10-15
10-29
11-12
11-26
DATES

bulb temperatures of the day preceding the respective collection.

Although an analysis of variance showed a significant difference among dates in both fructose and sperm concentration, Duncan's multiple range test (tables 1 and 2) indicates that this was not due to any seasonal trends. Furthermore, no relationship can be seen between temperature and fructose level (Fig. 1). Motility, however, seemed to be temporarily depressed when climatic temperatures suddenly soared to abnormal heights (from 111° up to 118°) in mid July. Motility ratings ranged from zero to four with an average of only two. By the next sampling date motility had returned to normal. Oddly enough, a depression in sperm density, and to some extent motility, occurred in September and October after climatic temperatures had dropped considerably.

Discussion

Many approaches have been made in investigating seasonal influences upon the fertility of the bull. High summer temperatures have long been thought to reduce fertility of bulls and thus cause the low conception rate common to tropical and subtropical summers (15, 46).

The work of Casady, et al. (9) and others (12, 23) demonstrates that initial motility, sperm density, and total sperm count decline rather promptly when males are placed in heat chambers or when heat is applied to the testes. Therefore, the mean temperatures of the day preceding each sampling date were used for com-

Table 1

Duncan's multiple range test on fructose concentration (5% significance)

Dates	8/20	10/15	10/29	6/25	7/9	8/6	7/23	9/3	5/28	10/1	5/2	9/7	11/12	5/14	6/11	11/26
Means*	340	427	432	482	492	518	521	552	558	563	564	636	640	641	698	760

*Means given in mg. per 100 c c seminal plasma

$s^2 = 30,738$

Table 2

Duncan's multiple range test on sperm cell number (5% significance)

Dates	10/1	10/15	9/17	5/28	10/29	5/14	8/20	5/2	11/12	9/3	11/26	7/9	6/25	8/6	7/23	6/11
Means*	716	759	761	816	861	867	951	985	985	999	1003	1185	1222	1226	1239	1356

*Means are given as cells per c c ÷ 1,000,000

$s^2 = 129,11.6$

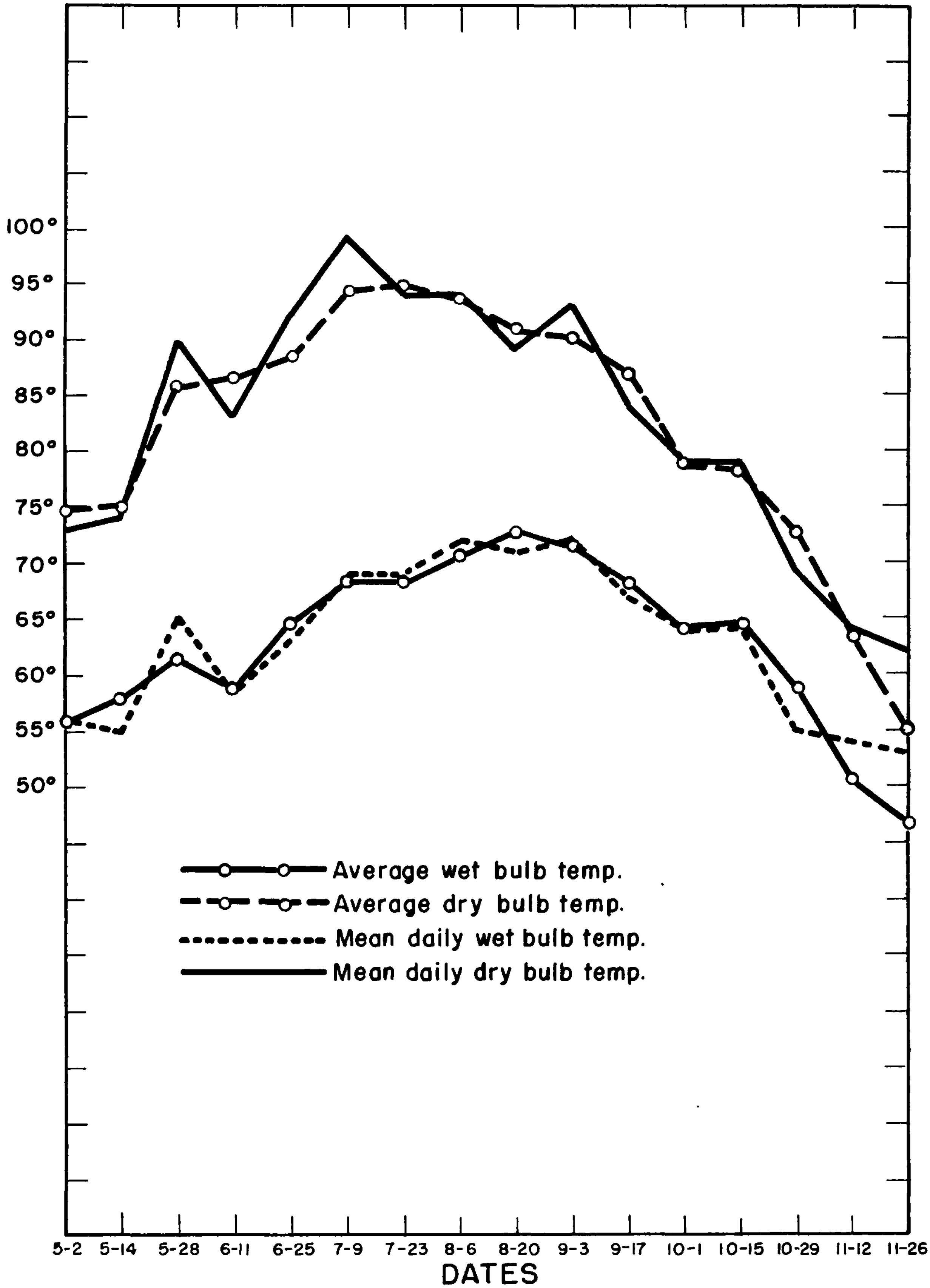
parison with the values of the variables studied.

As shown in Figure 2, the temperatures used for the comparison are highly representative of the average temperatures of the two-week period immediately preceding the respective sampling dates.

It is apparent that animals have the ability to adapt, within limits, to extremes in climatic conditions. Casady, et al. (9) noted that bulls raised under field conditions were more tolerant of high temperatures than those raised in close confinement. In the present study it is seen (Fig. 1) that the fertility of bulls (as estimated by laboratory analysis of semen) is not significantly affected by normal Arizona summer temperatures. The low average motility on July 23 may have been the result of several days of abnormally high temperatures preceding this collection. The daily maximum dry-bulb temperatures for the week of July 8 through 14, 1958 averaged 113.9° F., ranging from 111°- 118° F. It is noteworthy that motility had returned to its previous level by the next sampling date.

Some workers (38, 57) have reported fertility to be at its lowest in September. They have suggested that high temperatures may have a cumulative effect upon the bull which results in a depression of semen quality only after exposure for a period of time. Perhaps this phenomenon explains the apparent depression seen in this study (Fig. 1) in September and October. If such a depression really exists its importance is questionable inasmuch as it occurs at a time when the nonreturn rate has risen nearly to its

Figure 2


100°
95°
90°
85°
80°
75°
70°
65°
60°
55°
50°
Average wet bulb temp.
Average dry bulb temp.
Mean daily wet bulb temp.
Mean daily dry bulb temp.
5-2
5-14
5-28
6-11
6-25
7-9
7-23
8-6
8-20
9-3
9-17
10-1
10-15
10-29
11-12
11-26
DATES

normal winter level (50).

It has been seen that normal Arizona summer temperatures do not adversely affect semen quality as estimated by laboratory analysis. There appears to be a delayed affect which results in a slight depression of semen quality in the fall. This depression, if real, occurs too late to be of much importance in the problem of low summer fertility in Arizona. It must be concluded, on the basis of this study, that low summer fertility in dairy cattle is not due to high temperatures adversely affecting the fertility of the bull.

THE EFFECT OF THYROIDECTOMY ON THE REPRODUCTIVE ABILITY OF DAIRY COWS AND HEIFERS

Examination of breeding records of dairy cows in Arizona reveals that the incidence of abnormally long estrous cycles increases during summer. Hall and coworkers (24) found estrus of cows in Louisiana to be considerably shorter than is generally reported for cattle in more northerly regions. They also reported that 19.9 percent more cows were found in estrus by observing the herd at six-hour intervals than would have been found had only two observations per day been made. If cows in Arizona have relatively short estrus the long estrous cycles noted could be due to inadequate observation of the herd. However, since Hall, et al. (24) found no seasonal trends in the estrus length one would expect to miss as many cows in heat in winter as in summer. The increase in occurrence of abnormally long estrous cycles during summer is apparently due to some seasonal influence. Considering the work of Spielman, et al. (49) it appears that decreased thyroid activity due to high summer temperatures (6, 7, 24, 41) could be responsible for the increase in the number of long estrous cycles during summer.

This study was made to give further information on the influence of the thyroid on the reproductive ability of dairy heifers and lactating cows.

Little is known about the relationship of the parathyroid glands to reproduction in cattle. In order that some information on this relationship might be obtained some of the animals used in this study were also parathyroidectomized.

Procedures

Six heifers (four Jersey, two Guernsey), 14 to 20 months of age, and two lactating cows (one Jersey, one Guernsey) were used in the experiment. The Jersey cow (J239) and one heifer of each breed (J254 and G171) were thyroidectomized. The other animals were thyro-parathyroidectomized. Heifer J255 was forty-four days pregnant at the time of operation. All of the others were open.

The open heifers were examined per rectum at weekly intervals for several weeks prior to and following the operation to detect any abnormalities in the reproductive system. The cows were examined by rectal palpation before breeding. With two exceptions the animals were bred at the first postoperational estrus. The interval from operation to breeding varied from ten to fifty-one days. The heifers were bred naturally to young bulls while the cows were inseminated artificially. Those which failed to show estrus within thirty-five days postbreeding were examined for pregnancy. After calving, five of the heifers were maintained in the milking herd and rebred naturally or with frozen semen.

The thyroidectomized animals were never given replacement therapy. The thyro-parathyroidectomized cow (G122) was given fifteen grams of thyroprotein and thirty-five grams of monosodium phosphate daily for short intermittent periods following her first abortion. The thyro-parathyroidectomized heifers were given no replacement therapy until they had delivered a full term calf and were in calf again, then only for short periods of time.

Serum calcium levels were determined periodically, using the method of Clark and Collip (13).

Results

The results of this study are summarized in Table 3. Following the operation in which the thyroid or thyroid and parathyroid glands were removed the animals soon began to show the normal signs of hypothyroidism, becoming fat and sluggish. During the early post-operative period the thyro-parathyroidectomized animals showed blood calcium patterns similar to those reported by Stott and Smith (51) for mature cows. Later, however, some of these animals showed definite symtoms of hypocalcemia, walking with tetanic movements and losing coordination upon becoming excited. These symptoms were especially noticeably during the first two-thirds of gestation and were more severe in some animals than in others.

No cases of prolonged anestrus were found. The two thyroidectomized heifers (J254, G171) were due to come on heat about the time of operation but were not found to have done so. Perhaps this was due to the fact that the animals were confined and taken off feed for 24 hours prior to operating, making estrus more difficult to

Table 3

Identification	G171	J239	J254	G122	G177	J252	J253	J255
Age at Operation	19mo.	4yrs.	20mo.	6yrs.	14mo.	20mo.	20mo.	18mo.
Type of Operation	T[1]	T	T	T-P[2]	T-P	T-P	T-P	T-P
First Reprod. Period								
Days from operation to 1st breeding	20	17	31	34	10	23	51	-
Days from operation to conception	78	17	31	34	10	23	51	-
Services per conception	4	1	1	1	1	1	1	-
Length of gestation (days)	284	-	277	66-80	277	63-83	25-40	275
Second Reprod. Period								
Services per conception	2	-	1	3	1	1	1	1
Length of gestation	Preg[3]	-	Preg	75	Preg	85	279	269

1. Thyroidectomized
2. Thyro-parathyroidectomized
3. Pregnant at the termination of the experiment

detect. Ten days after thyroidectomy one (J254) was found to have a corpus luteum, indicating that she had ovulated. She was the only animal not showing heat within 23 days postoperation. Her first postoperative estrus was at 31 days, at which time she was bred and conceived. She carried her calf full term and parturiated without complication and again conceived on the first service.

The other thyroidectomized heifer (G171) was the only animal which did not settle at the first service. On at least two occasions she failed to ovulate normally. She settled on the fourth service and carried her calf to term. Following parturition she conceived again on the second service while in high production and was in the fifth month of gestation at the termination of the study.

The thyroidectomized cow (J239) settled on the first service and was slaughtered two months postbreeding.

The heifer that was pregnant at operation (J255) give birth to a normal full term calf. Heifer G177 conceived at the first service and gave birth to a normal full term calf despite the fact that she appeared to be in considerable stress during the fourth and fifth months of gestation.

Several abortions occurred among the other thyro-parathyroidectomized animals. Early embryonic death occurred in one heifer (J253). She conceived on the next service and gave birth to a dead calf at full term. The animal which showed the greatest degree of hypocalcemia was J252. She was found pregnant on day 35 postcoitum and appeared normal when examined on day 63. On day 83 she returned to heat. Six weeks later, at the third normal estrus, she was bred and conceived. Examination on day 85 of the second gestation revealed that this pregnancy was terminating also. Following the second abortion her ovaries became small and showed no further activity. She died of hypocalcemia five weeks after aborting the second fetus.

The thyro-parathyroidectomized cow (G122) conceived at the first postoperative service but aborted after 60 days postbreeding.

On day 80 post breeding she returned to heat. Three services were required before she conceived again. She maintained the second pregnancy only 75 days and returned to heat twenty days later. At this time she was bred and conceived. At slaughter in the fifth month of gestation normal fetal development was found.

The two animals in which abortion occurred (G122, J252) were most severely affected by the thyro-parathyroidectomy. At the time of her first abortion J252 appeared to be in considerable stress. Her back was somewhat arched and she walked with jerking movements. When she attempted to run upon being frightened, she would lose co-ordination and fall down with her head and neck extended. When these symptoms first appeared her blood calcium level was 8.1 milligrams percent. At the time of her second abortion her blood calcium level was 6.3 milligrams percent. No such symptoms were seen the cow (G122) although her blood calcium level was only 6.2 milligrams percent when her first abortion occurred and only slightly higher (6.4 milligrams percent) when the second occurred.

Summarizing, sixteen (72.7 percent) of the twenty-two inseminations resulted in pregnancy. This is somewhat above the average generally reported (1, 36, 37, 46). Of these sixteen pregnancies, five (31.25 percent) terminated in spontaneous abortion, all of which occurred in thyro-parathyroidectomized animals.

Discussion

The results of this work are in contrast with Brody and Frankenback (8) in which a thyroidectomized heifer displayed anestrus until thyroprotein was administered. The difference may lie in the fact that they performed the thyroidectomy before the onset of puberty. The thyroid is perhaps more important in the development of the reproductive system than in its function. The complete lack of mammary development in the heifer they used is indicative of sexual infantilism. One would expect a rapid response to treatment in a sexually mature animal, whereas their heifer had only two estrous periods within six months of continuous replacement therapy. The absence of sexual development in cretins indicates the importance of thyroid function in developing the reproductive system in humans (5).

The present study supports the findings of Spielman, et al. (49) in which thyroidectomy was not found to lower reproductive efficiency in dairy cattle. Unlike their findings, however, no difference was found in the manifestation of the normal physical signs of estrus following thyroidectomy.

The early embryonic death which occurred in J253 occurred when the serum calcium level was normal and there was no visible evidence of hypoparathyroidism. Early embryonic death cannot be totally unexpected. Erb and Holts (18) estimated the embryonic death loss to be 20.6 percent in dairy cows and indicated that heifers have a higher loss than young cows. Tanabe and Casida (54) found that in problem cows 39.2 percent of the ova fertilized were lost before thirty-four days. Stott and Williams (52) found a high incidence of embryonic mortality during hot weather in young Holstein cows. In view of these findings, and the fact that no other early embryonic loss occurred among the animals of this study, it seems unlikely that it was due to the thyro-parathyroidectomy.

Conversely, the later abortions in the thyro-parathyroidectomized animals were probably the result of hypocalcemia. The abortions occurred in the two animals displaying the greatest stress of hypocalcemia. This agrees with earlier work with rats (11), dogs (16, 28), goats (48), and sheep (47) in which reproductive efficiency is not affected by parathyroidectomy, but intrauterine mortality and abortion is greatly increased when serum calcium falls to subnormal levels.

OVULATION TIME OF HOLSTEIN COWS DURING SUMMER IN CENTRAL ARIZONA

Introduction

The time of ovulation with respect to estrus and the influence of various phenomena on it have been the subject of several investigations (1, 25, 35, 40). Few cases have been reported, however, of anovulation or ovulation delay. Van Rensburg (56) reported a high incidence of ovulation failure in Africander and Friesian cows in South Africa. Perkins, *et al.* (42) reported a high incidence of ovulation failure in repeat-breeder dairy heifers. The time of insemination in relation to the time of ovulation is very important to good conception (4). Van Rensburg (56) obtained no conception where insemination preceded ovulation by more than 24 hours.

Little is known of the cause of ovulation delay or anovulation and the frequency with which they occur. Probably the most extensive study of this problem was made by Van Rensburg (56). He found that ovulation failure or ovulation delay was responsible for a decrease of 19.2 percent in the conception of Africander and Friesian cows. It may be significant that no such reports have come from temperate areas. The possibility that heat stress supresses ovulation justifies investigation. This study was conducted to determine the incidence of anovulation and late ovulation in lactating dairy cows in Central Arizona.

Procedures

Lactating Holstein cows in four large commercial dairy herds were used in studying ovulation time during a period of high climatic temperature. The cows were examined per rectum at the onset of estrus to determine the location of the follicle(s). Subsequent examination of the ovaries were made at approximately twelve-hour-intervals thereafter until ovulation had occurred or until 48 hours had elapsed. In order to determine the reproductive efficiency of cows ovulating late each cow was inseminated at each examination following the first until she was found to have ovulated.

The experiment began on September 1 and terminated September 14, 1959. A total of 120 cows were examined for ovulation during one estrous cycle. All cows not returning to heat were examined after 42 days for pregnancy.

Bulls were not available with which to make periodic checks to determine the end of estrus. Cows are very inactive between the hours of 10:00 A. M. and 6:00 P. M. during summer and cannot be relied upon to mount those in estrus. Therefore, the onset of estrus was used as the reference point for ovulation time.

Results

Table 4 shows that 20.85 percent of the 120 cows examined failed to ovulate within 48 hours after the onset of estrus. Two of these ovulated soon after the 48 hour examination as evidenced by the two pregnancies in this group. Nine (36 percent) of the cows in which ovulation did not occur within 48 hours returned to heat within 15 days. No estrous cycles shorter than 18 days followed estrus in which ovulation occurred within 48 hours. Examination of the ovaries of the animals having short estrous cycles revealed that the yet unruptured follicle had enlarged and became thick-walled.

Table 4

*Ovulation time (hours)	1-12		12-24		24-36		36-48		Not Within 48		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cows per group	13	10.83	49	40.83	27	22.5	6	5.0	25	20.83	120	
Pregnancies/ group	2	15.4	11	22.4	7	25.9	3	50.0	2	8.0	25	20.83

*Time from onset of estrus.

In five of the animals not ovulating within 48 hours abnormally long estrous cycles (27, 29, 31, 32 and 44 days) followed.

The low conception rate (20.83 percent) of this group of animals is not considered abnormal for this area during this season of the year.

Discussion

It is evident from the work of others that ovulation in cattle should occur not later than 48 hours after the onset of estrus (1, 35, 40). Barrett (4) found the average time of ovulation in heifers to be approximately 30 hours after the beginning of estrus.

Asdell (2) suggested that follicles which fail to rupture become cystic. Van Rensburg (56) found evidence in one cow that the so-called corpus luteum cyst may originate from follicles which fail to rupture but become luteinized. In the present study nine cows were found in which this appeared to be the case. All returned to heat from 2 to 14 days after the estrus in which ovulation did not occur. None of these animals had previously shown symptoms of nymphomania. Examination during these off-cycle heat periods revealed that the yet unruptured follicle was enlarged and thick-walled, perhaps due to luteinization.

One cow showing symptoms of nymphomania was found upon rectal palpation to have somewhat enlarged ovaries. Each ovary felt as though a large thick-walled follicle covered most of its surface. Nymphomania persisted for several months during which no apparent change occurred in the size, shape, or texture of the ovaries. Upon slaughter it was found that most of the entire mass of the ovaries consisted of small thick-walled follicles. These follicles were embedded in the ovaries in such a way that the surfaces of the ovaries were smooth.

In contrast to the reports of Van Rensburg (56), five cows not ovulating within 48 hours of the onset of estrus had abnormally long cycles (27, 29, 31, 32, and 44 days) following the estrus studied. Two explanations for this phenomenon are offered: (1) Ovulation eventually occurred and a new cycle of normal length was then initiated, and (2) ovulation occurred soon after the 48 hour examination and fertilization took place but resulted in early embryonic death, thus delaying the succeeding estrus. In view of Van Rensburg's (56) findings the first seems unlikely. The second gains support from the findings of Barrett (4) in which there appeared to be a high rate of early embryonic mortality in heifers inseminated more than four hours after ovulation. This suggests a rapid histological degeneration of the unfertilized ova following ovulation. It is not known whether such degeneration or overripening would occur in the ova maintained unduly in the follicle. The possibility exists that preovulatory luteinization results in the formation of a poor quality corpus luteum whose function is insufficient to maintain pregnancy. Inasmuch as the cows were inseminated at the 48 hour examination, it is reasonable that fertilization would occur if ovulation took place within a few hours. This is seen (Table 4) by the two pregnancies in the group in which ovulation did not occur within 48 hours. Van Rensburg (56) obtained conception in one cow which did not ovulate until seven days after estrus.

The overall importance of anovulation or ovulation delay as affecting the breeding efficiency of dairy cattle in Arizona is not known. Under normal conditions (one insemination about 12 hours after the onset of estrus) conception probably would be nil in those animals ovulating later than 36 hours. Ovulation delay (beyond 36 hours) or anovulation would thus have caused up to 25.8 percent (Table 4) decrease in conception in the animals used in this study. It was noted that the condition was more prevalent in some herds than others. Of the 19 cows examined in one herd all ovulated within 36 hours. There appeared to be no relationship between age or production and ovulation time. The influence of heredity and management practices are not known. Casida and Chapman (10) estimated the heritability of cystic ovaries (which suggests anovulation) to be .43 in one herd. They also found the incidence of cystic ovaries to be considerably higher in animals milked four times daily than in those milked only twice. In this study the herd having the highest incidence of anovulation or retarded ovulation was the only herd milked three times daily, the others being milked twice. Here the relative influence of heredity and management practice cannot be separated.

Casida and Chapman (10) make no mention of seasonal trends in the incidence of cystic ovaries. Further work will be necessary to determine if the incidence of anovulation and delayed ovulation is significantly higher in summer than winter in Arizona. Since only one estrus per cow was studied it is not known whether some cows habitually fail to ovulate properly (excluding nymphomaniacs) or whether it is not uncommon for many cows to have ovulation failure occasionally.

The conception rate (Table 4) of this group of cows is considerably lower than that given by Stott (50) but corresponds closely with that found by Stott and Williams (52). The difference is probably due to the fact that Stott (50) used the 150 day non-return rate. Here, and in the work of Stott and Williams (52) pregnancy was diagnosed by rectal palpation.

GENERAL SUMMARY AND CONCLUSIONS

The semen quality of dairy bulls kept under normal Arizona management practices; the reproductive efficiency of thyroidectomized or thyro-parathyroidectomized cows and heifers; and the ovulation time of dairy cows under high climatic temperatures have been studied.

The quality of semen, as measured by laboratory analysis, was not found to be lowered in bulls maintained under normal management practices during summer. There appears to be a depression in semen quality in September and October. However, this occurs to late to be a contributing factor in the low reproductive efficiency common to Arizona summers.

Neither thyroidectomy nor thyro-parathyroidectomy was found to alter the estrous cycle, or the physical manifestations of estrus. Conception rate, as determined by rectal palpation, was above average in the animals used in the study. Parathyroidectomy, with the resulting hypocalcemia, was found to increase intrauterine mortality materially.

Of the 120 cows examined to determine ovulation time, 25 (20.83 percent) failed to ovulate within 48 hours of the onset of estrus. Nine (36 percent) of the cows which failed to ovulate normally returned to heat within 15 days. The enlargement of the yet unruptured follicles found upon examination of these cows during the off-cycle heat suggests that the so-called cystic ovary may originate with ovulation failure. Abnormally long estrous cycles exhibited by five cows which did not ovulate normally may indicate early embryonic death, perhaps due to over-ripening of the ova in the follicle. A difference was noted among the four herds in the occurrence of ovulation delay or ovulation failure but the influence of heredity and environment could not be separated.

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