THEESIS
on
STERILITY IN DAIRY CATTLE

Submitted to the
OREGON STATE AGRICULTURAL COLLEGE

In partial fulfillment of the requirements for the Degree of
MASTER OF SCIENCE

by
Ralph Edward Brooke

June, 1931
TABLE OF CONTENTS

Introduction 1

Review of Literature 3

The Male Genital Organs 3
The Female Genital Organs 6
The Physiology of Reproduction 9
Nutrition as a Factor in Reproduction 14
Physiological Factors Causing Sterility 22
The Bacteriology and Pathology of Sterility 29
The Male Factors Affecting Sterility 35

Survey and Experimental Data 41

Objects of the Survey and Experimental Work 41
Plan of the Work 41
Division of Data 43
Survey 43
Breeding Records of Ancestry of Animals in the College Herd 45

Experimental Data 47
The Bull - Studies from 1929-1931 47
Results of Microscopical Examinations of Semen and Pregnanacies Resulting 48
A Study of the Breeding Records of the College Herd, 1929-1931 51
The Breeding Efficiency of the Bulls 51
The Breeding Record of the Herd 52
### TABLE OF CONTENTS - Continued

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cow and Heifer - Studies from 1925-1931</td>
<td>55</td>
</tr>
<tr>
<td>Feeding, Care and Management</td>
<td>55</td>
</tr>
<tr>
<td>A Study of the Breeding Records of Animals on a Mineral Experiment, 1925-1931</td>
<td>56</td>
</tr>
<tr>
<td>Results of Feeding a Vitamin E Supplement</td>
<td>63</td>
</tr>
<tr>
<td>Results of Feeding an Iron Supplement</td>
<td>65</td>
</tr>
<tr>
<td>Physiological and Pathological Studies</td>
<td>67</td>
</tr>
<tr>
<td>Abortion - Other than Infectious</td>
<td>73</td>
</tr>
<tr>
<td>Results of Treatment with Alkaline Vaginal Douches</td>
<td>74</td>
</tr>
<tr>
<td>Practical Considerations</td>
<td>76</td>
</tr>
<tr>
<td>Summary</td>
<td>78</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>80</td>
</tr>
<tr>
<td>Bibliography</td>
<td></td>
</tr>
</tbody>
</table>
INTRODUCTION

From an economic standpoint, sterility is one of the most important diseases affecting the cattle-raising industry, and with gradual and steady development of pure-bred livestock, its importance is rapidly increasing. Sterility may be defined as the inability to produce young. It may occur in either sex, but the most disastrous effects are produced when the female is no longer capable of reproducing her kind.

The development of a family of cattle is often dependent upon the successful rearing of calves from those cows which become temporarily or permanently sterile. When no longer capable of reproduction, the value of a pure bred animal is decreased to that of beef. The importance of the disease to the owner of a grade herd is concerned with the loss of milk production and the fact that he must dispose of high-producing cows for beef prices. The cow may be regarded as a machine, and must produce from the feed she consumes, saleable goods in the form of milk and calves. If this is no longer possible, her value is that of beef.

In the male the loss from sterility is comparable, but occurs less frequently and is therefore of somewhat less concern.

It has been estimated that nearly one-fifth of the cows suffer with either temporary or absolute sterility and that the butterfat production of these cows is decreased from 50 pounds to 150 pounds per year. This lower production lessens and may even render the whole business a questionable one from the standpoint of profit. Between 3 per cent and 4 per cent of these cows are butchered as non-
breeders, bringing returns much lower than those sold as milk cows.

In the State of Oregon there are about 216,000 dairy cows. The value of the products from these cows ranks third in the industries of the state, hence one can readily realize the importance of the problem of sterility.

The objects of the investigations reported in this paper were to determine, if possible, some of the factors causing sterility and the means by which these causes might be remedied or controlled.
Sterility is not new, for mention has been made of it in veterinary and medical literature since the beginnings of these branches of science. However, the modern conception of the disease has developed during the last twenty-five years, through advances in physiology, pathology, bacteriology and therapeutics. For a clearer understanding, a review of the male and female organs of reproduction will be given, their functions and some phenomena of reproduction.

The genital system develops as an integral part of the body and is governed or influenced by many of the same factors that decide the general health of the individual. On the other hand, the general health of the individual regulates in many respects the functioning of the genital system.

**The Male Genital Organs.**

**The Testicles and Epididymises.**

The testicles (1), (4), are two glandular bodies, functioning to form spermatozoa and to secrete a substance, which, when poured into the circulation of the animal, causes the development of typical male-like characteristics. They constitute the primary and essential male glands or organs.

In the embryo, (2), (3), the testes are formed in the abdominal cavity from which during early embryonic life they descend into the scrotum through an opening in the abdominal muscles just in front of the floor of the pelvis. Each testicle is composed chiefly
of coils of microscopic tubules lined with a number of layers of cells, each layer representing a stage in the development of the spermatozoa. These tubules merge together into larger tubes to constitute the two epididymises, one for each testicle. The epididymis forms more or less of a cap over the upper end of the testicle, a ridge along its medial surface, and a small, somewhat soft, rounded eminence on its lower end. The upper part is called the head; the middle, the body; and the eminence on the lower end of the testicle, the tail of the epididymis. The tubules composing the epididymis act as reservoirs for the spermatozoa, or sexual cells, storing them until they are ready for ejaculation or service.

The Vasa Deferentia.

The tail of each epididymis is continued by a single tube, acting as an excretory duct and called the vas deferens. The vasa deferentia collect the spermatozoa from the tail and convey them to the region of the neck of the bladder where they empty into the urethra, the canal which runs lengthwise of the penis and serves the dual purpose of conveying urine from the bladder and of providing a passage through the penis for the spermatozoa at the time of service.

Accessory Genital Glands of the Male.

In the pelvic cavity there are three sets of glandular structures whose secretion is added to the spermatozoa to form what is known as semen or the seminal fluid. These consist of two Cowper's glands, a prostate gland and two seminal vesicles. In the bull,
Cowper's glands and the prostate are not highly developed and their function is not great. The seminal vesicles, however, are highly developed in the bull. Their function is to secrete mucus, which is emptied into the urethra along with spermatozoa from the vasa deferentia. The accessory glands are of importance from the clinical standpoint because an inflammation of them, especially of the seminal vesicles, is of common occurrence in the bull and leads not only to sterility, but often to the transmission of serious infection to the cow.

The Penis.

The penis is the organ of copulation. It is composed of vascular tissue (tissues with a rich blood supply) and possesses a mechanism which, at the time of sexual excitement, causes the organ to become engorged with blood and, in consequence, erected. When in the position of rest, the penis lies against the abdominal floor, immediately underneath the skin, its apical end being retracted through an aperture in the skin of the abdominal floor called the preputial opening. In this position the glans, which constitute about 3 inches of the apical end of the penis is covered by a layer of skin called the prepuce.

Formation of Spermatozoa.

The germinal cells of the male in their immature form consist of simple cells and are not materially different in appearance from the other cells of the body. When the male reaches the age of six or eight months, the immature germinal cells undergo a series of changes which ultimately result in the formation of an
entirely different type of cell. This cell is known as the spermatocyte. From these, through cell division, are formed the spermatozoas. Soon after this, the bull becomes fertile if mated with a fertile female. The spermatozoon consists of three parts: the head, tail and body. Functionally, the head is adapted to unite with the egg formed in the ovary of the cow, and the tail and body serve merely as means of locomotion to propel the spermatozoon to the ovum. The average ejaculation of spermatozoa for normal bulls at a single service is from 100,000 to one billion, and though they are so prolifically produced, only a single cell can ordinarily function in its capacity to fertilize the ovum in the female.

The Female Genital Organs.

The reproductive or genital organs of the female consist of two ovaries, the vulva, vagina, cervix, uterus and two uterine tubes, the oviducts or Fallopian tubes. The mammary gland or udder, constitutes an essential supplementary organ. In addition, there might also be included, because of their regulatory influence upon the function of the generative organs proper, the glandular structures, the thyroid, pituitary and suprarenal bodies and the mucous-secreting glands of the genital tract that pour their secretions into various portions of the genital tract.

The Vagina and the Vulva.

The vagina with the vulva is the copulatory organ of the female. It also constitutes the major portion of the birth canal for the passage of the fetus from the uterus to the exterior.
Usually it is about twelve inches long, but varies according to breed and age of the cow.

The Cervix.

The cervix, or neck of the uterus, furnishes the passage between the uterus and the vagina. It is composed chiefly of dense muscular tissue and is from 1 1/2 to 2 1/2 inches long and 3/4 to 1 1/2 inches in diameter. The canal of the cervix is ordinarily so small that it is difficult to pass a probe the size of a pencil or smaller through it. The mucous membrane lining this canal is very adaptable under changing conditions. At the time of heat it secretes a thin mucoid material that is particularly favorable to the viability of spermatozoa, and during pregnancy it secretes an un-usually thick and tenacious mucus that hermetically seals the uterus and acts to prevent infection of the fetus from the vagina during its prenatal life. The structure of the cervix with its circular bands of muscle fibers and convergent longitudinal folds, makes infection of any sort hard to combat.

The Uterus.

The uterus, or womb, consists of two tubular structures, the horns or cornua, which taper off as they pass forward from the cervix and are continued by the two small uterine tubes or oviducts. Posteriorly the uterine horns communicate with each other and with the cavity of the cervix. The walls of the uterus are composed of an inner layer of mucus membrane, a layer of muscle, and outer covering of peritoneum. During, pregnancy, the size of the
uterus increases to accommodate the fetus which it holds. There is a great enlargement of the muscular portion of the uterine wall which aids in the expulsion of the fetus. After parturition, the muscular tissue degenerates and the uterus becomes rapidly smaller until within a few weeks it is about the same size as before the advent of pregnancy.

The Uterine Tubes.

The oviducts, uterine tubes, or Fallopian tubes extend from the ovaries to the uterus. In their normal position each tube runs a rather tortuous course, supported in a layer of ligament in front of the ovary, with which it lies in close contact. It communicates at the ovarian end directly with the peritoneal cavity, and at the uterine end with the uterine cavity. The ovarian end flares out to terminate in a fine membranous structure, which embraces the ovary. The uterine tubes furnish the means of communication between the uterine cavity and the ovary, and thus act as a channel through which ova and spermatozoa may pass. Unfortunately, they also allow the passage of bacteria from the uterine into the abdominal cavity, and are, therefore, a very important factor in the production of permanent sterility.

The Ovaries.

The two ovaries, whose primary function is to form ova or eggs, lie within the pelvic cavity, one at either side of the uterus. Each ovary is held in position by a fold of the broad ligament, a tissue which serves also to fix the uterus to the side of the pelvic
wall. Through this ligament it receives its blood supply. At the
time of birth the ovary is usually no larger than a pea, but, with
age, increases in size until, when the heifer is 14 to 16 months old,
it measures 1/2 to 1 inch. The size varies in animals according to
age and various stages of its functional activity, which are
cyclically induced by heat.

The Physiology of Reproduction.

At the time of birth of the heifer calf, its ovaries are
supposed to contain the maximum number of ova present at any period
of life. Soon the ova commence to develop or mature, development
at first being only partial. When the heifer arrives at sexual
maturity (the period varying with different breeds), one ovum should
develop to maturity, or ripen periodically, causing heat or estrum.
There is a gradual reduction in the number of ova present in the
ovaries from the time of birth to old age.

As the ovum develops within the ovary, fluid collects around it
and there is formed a little sac or vesicle containing clear fluid,
which is called the ovisac or Graaffian follicle. It is the
maturing or ripening of the egg and development of the follicle that
produces heat. The follicle attains a diameter of about one-half
inch and bulges out from the surface of the ovary. In its fluid is
a substance of unknown composition which, when poured into the
general circulation of the cow, is responsible for some of the
symptoms of heat. After the cow has been in heat for 18 to 24 hours,
the follicle should rupture and liberate the ovum, or the cessation
of heat may precede its rupture by several hours. Failure of the follicle to rupture produces a condition of continuous heat, known as nymphomania.

**The Corpus Luteum and Its Function.**

After the rupture of the follicle or ovisac and the liberation of its content, there forms in its empty crater a small, knob-like body of luteal cells which protrude from the surface of the ovary, and not until the very late stages of its involution does this disappear. The newly formed corpus luteum (5) is only about half as large as the follicle but enlarges rapidly until it attains a size of about 1.9 in. in diameter. The development is maintained until three days before the next heat period, when it rapidly diminishes in size and undergoes complete degeneration.

Authorities differ somewhat as to the exact function of the corpus luteum. Hammond (5) considers it, from results of studies made with cows, as being associated with the control of heat periods and the ripening of the follicles. Marshall (2) holds this (in a previous work) to be not so, but sets forth the theory that the corpus luteum is responsible for the raised nutrition of the uterus during pregnancy, in view of the fact that in the female rabbit the corpus luteum is not formed in the absence of the male and yet these animals show periodic heat periods. Beaver (4) states that the entire consideration of the function of the corpus luteum must be only theoretical until the active principles of the internal secretion of the ovaries and the corpora lutea can be isolated.
chemically and definitely separated.

For about the first three months of pregnancy, the corpus luteum is indispensable to fetal life. Its removal causes fetal death and abortion. Together with the fetus and other influences of internal secretions, it acts to prevent occurrence of heat during pregnancy and at other times. A cow with a persistent corpus luteum does not come in heat, the function thus differing from that of a cyst or ovisac, each of which operates to cause heat symptoms.

Heat and Coitus or Copulation.

Heat may be defined as sexual desire or periodic sexual excitement. The normal period between heats in the cow is usually about 21 days, varying from 19 to 23 days. The duration of heat is 12 to 24 hours. Ordinarily, when a cow's heat occurs at intervals outside of a mean of 20 to 21 days, it can be taken as an indication of genital disorders and that conception will not occur.

Coitus or copulation is the sexual union of the male and female, in which there is a transfer of male germ cells to the vagina of the female. The spermatozoa are deposited ordinarily in a pool at the anterior end of the vagina, near the cervix. From here they propel themselves forward in the genital tract, through the cervix, the uterus and uterine tubes to the vicinity of the ovary, where union with the female cell occurs. Most of them die in the vagina and only a few are able to migrate through the uterine tubes to the ovaries where only one may function to fertilize an ovum and cause pregnancy. Clinically, it has been fairly well shown that it takes
spermatozoa about four hours to reach the uterine tubes.

The normal reaction of the vagina is slightly acid and is inimical to the life of spermatozoa. The seminal fluid is slightly alkaline in reaction and is deposited in the vagina usually in sufficient quantity to overcome the slight acidity which exists there. The reaction at the anterior end of the vagina is almost neutral or alkaline, thus it appears that, as the sperms move forward into the genital tract they find an increasingly favorable environment. If they try to move in the opposite direction, the environment becomes unfavorable, which will usually cause their death. These facts have an important bearing on changing the reaction of the vagina by vaginal douches.

The Fusion of the Germinal Cells and Descent of the Ovum.

Very soon after the Graaffian follicle has ruptured, the ovum becomes available for fertilization or fusion with the spermatozoon. This union usually occurs within 48 hours after service. Fertilization takes place either in the Fallopian (uterine) tube or in the vicinity of the ovary. The ovum after its discharge from the ovary normally passes into the corresponding uterine tube. The cilia, which line these tubes, aid the ovum in its movement toward the uterine cavity. In addition to the cilia, the tube shows continual wave-like contraction, or peristalsis. This contraction and the cilia are apparently protective mechanisms to inhibit the passage of infection into the abdominal cavity.

After the rupture of the Graaffian follicle, the fertilized ovum
requires from eight to fourteen days for its descent into the uterus. Cell division takes place during this time, and by the time it reaches the uterus it is prepared to receive nourishment through the uterine wall of the mother. Attachment to the uterine wall by the fetal membrane takes place, furnishing a more intimate connection and further nutrition of the fetus. This attachment is made by means of cotyledons or "buttons" which carry the circulating blood of the mother to nourish the fetus. The gestation period of the cow is normally from 275 to 285 days, which is followed by parturition or expulsion of the fetus from the uterus. After parturition, the fetal membranes are usually expelled from the uterus in about two hours. Failure in this results in infection, causing metritis and in the extreme cases, pyometra. Sterility, either temporary or permanent, may result from this infection.
NUTRITION AS A FACTOR IN REPRODUCTION

In the last ten or fifteen years, students of nutrition have become entirely accustomed to the idea that deficiencies in the rations fed to animals are likely to interfere with reproduction. It is common knowledge that when plants are over-fertilized, the vegetative parts are developed to a remarkable degree at the expense of the part devoted to the reproduction of the species. In a like manner, the over-feeding of domestic animals will result in an over-development of the somatic tissue at the expense of the germ plasm. This leads to over-fatness, low vitality and possibly fatty degeneration of the ovaries and testicles, or stoppage of the ducts leading from the ovaries and testicles by packing fat around them.

The process of feeding may be carried to the other extreme - feeding animals an inadequate ration to maintain a healthy body and nourish a developing fetus. The general results are the same, difficulties in reproduction. Most of the experiments in nutrition have been carried out on rats, especially vitamin and some mineral studies, but the application can be made to larger animals.

The female reproductive tract (6) is especially susceptible to the effects of inanition and malnutrition, due primarily to the effect on the ovary. The atrophic and degenerative changes in the ovary concern especially the Graaffian follicles, which undergo regression and atresia. In man and mammals, this prevents not only normal ovulation, but also the formation of corpora lutea and therefore inhibits the endocrine activity of the ovary and the associated
process of menstruation or related phenomena of the estrous cycle. The more nearly mature follicles and ova are most susceptible and undergo prompt involution, with degenerative (occasionally cystic) changes and ultimately complete resorption. If inanition is not extremely severe, ovoogenesis is resumed upon re-feeding. Extreme cases result in complete sterility.

In the young, inanition usually causes a variable degree of atrophy in the ovary, or more rarely, a slight persistent growth occurs. Chronic under-feeding results in the retardation or repression of sexual development in general. Abortion or complete resorption of the embryo and membranes may result from severe inanition during pregnancy.

In the male the testes are most susceptible to the effects of inanition. Development is retarded or inhibited in the young, and in the adult there is a progressive atrophy of the seminiferous tubules with degenerative changes and decreased or (in extreme cases) completely arrested spermatogenesis. Sperms are least resistant and are first to degenerate and disappear.

Effects of Protein Deficiency.

Protein deficiency results in a delay in the age of puberty and a marked increase in sterility. A disturbance of ovulation rhythm results in sexually mature females, and reproduction failure due to impairment of germ cell vigor. The uterus has been observed to undergo a variable degree of atrophy during various conditions of inanition, with a peculiar softening and relaxation of
tissues. Protein deficiencies have been found to be more severe in results on males than on females in delayed pubescence and increased sterility in adults.

Clayton (7) in determining the comparative value of different proteins for reproduction in rats, found that the protein of egg produced better results than that of milk. Rats produced larger litters and were able to rear a higher percentage of young.

Effects of Mineral Deficiencies.

Evidence of a relation of the mineral deficient diet to reproduction has been found in the results of experimental work with animals. It was found that mineral hunger in rabbits (6) caused abortion, with poorly developed young. Also a diet low in sodium, calcium, magnesium, phosphorus and iron resulted in less vigorous chicks. Lack of minerals, especially of calcium and phosphorus, resulted in subnormal growth.

Eckles, Becker and Palmer (8) found that cows in certain areas, suffering from depraved appetite due to low phosphorus rations, developed an atrophic condition of the ovaries. Ovulation was retarded and the tendency was for milking cows to have a calf every two years. Reed and Huffman (9), in a mineral feeding investigation extending over a period of five years, experienced sterility in 3 cows out of 35 on rations low in calcium.

Extensive investigations at the Wisconsin Experiment Station (10) have shown that calcium and phosphorus are limiting factors in reproduction of cattle. Of seventeen cows fed on wheat straw (low in calcium) as the sole roughage, three never came in
heat. The other fourteen came in heat, were bred and became pregnant, but calved, on the average, 21 days too soon. Four calves were born dead and the other ten were small, weak and died. Other cows in the same herd fed on rations containing alfalfa and clover produced strong, healthy calves. This work has been confirmed at the Michigan Station by Reed and Huffman (49).

Macomber (11), working with inbred albino rats, states that there may be great individual variations in fertilities and such variation is increased by inbreeding and deficient diet. Feeding rats on diets low in calcium; low in the fat soluble A factor; low in protein and calcium, and generally deficient in nutritional requirements, with varying degrees of inbreeding, produced satisfactory growth but reproduction failed. There were individuals whose fertility was so low that they failed to reproduce with one another, but reproduced when mated to highly fertile individuals.

Deficiency of iron in rations has been found to be responsible for nutritional disturbances interfering with normal reproduction. Iron (26) is an essential element of hemoglobin and of the chromatin substances, i.e., of the body constituents most directly concerned with the processes of oxidation, secretion, reproduction and development. On diets deficient in iron (6), pregnant rabbits supplied iron from their bodies up to a certain limit, after which fetal death occurred. In humans (6), chlorosis or iron deficiency (anemia) has been found to prevent reproduction. Upon supplying iron, the condition was corrected. Ordinarily, (6) (26),
the regular rations fed to animals contain iron in sufficient amounts to supply their needs. The deficiency is in quality and not in quantity.

Effects of Vitamin Deficiencies.

A great deal of work has been done to determine the effects of vitamins on growth and reproduction, probably the most extensive being that of Evans. Working with fat soluble vitamin E, Evans (12) found that male rats reared on rations lacking in the substance, were fertile when first attaining sexual maturity, but usually became sterile at from 90 to 150 days of age. Of 180 males reared on diets lacking E, all became sterile. Fifteen second and third generation males from mothers reared on diets lacking in this vitamin were sterile from the beginning of sexual maturity. Four stages of male sterility were observed:

1. Normal numbers of sperms present but lacking fertilizing power.
2. No sperms present.
3. No vaginal plug resulting from copulation and a loss of sexual response.

Mattil and Clayton (13), using 150 rats reared from weaning time on synthetic rations low in vitamins A, B and E, obtained good growth in all but one, but normal reproduction occurred only when rations were supplemented with wheat germ oil. A few young were born while the rats were on the other rations and several resorptions occurred, but only for a short time when reproduction
ceased entirely. The gonads of the males showed more or less complete degeneration on these rations. In curative tests, male animals were given supplements of wheat germ oil or wheat germ meal. Some regained fertility while many remained sterile, the variation depending upon the length of time on the deficient ration. Fertility was restored in females when their rations were supplemented with 1 per cent of wheat germ oil but the number of young per litter did not approach normal.

Ruffner and Curtis (14) found that when cows receiving large amounts of cottonseed meal in their rations were taken off pasture, abortions, dead underweight calves and living blind calves resulted. The cows lost in weight, became stiff and suffered from edema. Supplementing with feeds rich in vitamin water-soluble B and fat soluble A, the cows produced living calves and their lactation became normal.

Evans (15) found that inadequate supplies of vitamin A injures the female reproductive system so that fertilization and implantation often fail. In this respect it differs radically from the reproductive impairment due to low vitamin E content, where typically the eggs are always healthy and implantation takes place but resorption follows. Evans also found that a level of inadequate vitamin A can be secured during which estrus and ovulation will occur, as denoted by continuous cornified cell vaginal smears. Four-fifths of the copulations eventuated in failed implantation, estrus occurring again in five days.
Mattiill (16) produced degeneration in the testes of rats deprived of vitamin B, similar to that found in rats on rations deficient in vitamin E, but no atrophy, suggesting that only vitamin E is concerned in the process of atrophy. Of 21 male rats, which succumbed under immediate or gradual vitamin B starvation, two showed severe degeneration, gauged by weight of the testes and the presence of sperms. Many of the other 19, the epididymis still contained sperms as motile as those of a normally fed animal. Mating tests showed that the group deprived of vitamin B and E lost procreative power slightly earlier than those not deprived of vitamin E, although these also became sterile.

Infertility in the presence of apparently normal gonads is believed to be due to the loss of tone and vigor and the consequent lowered sex expression coincident with the lowered level of metabolism.

Sure, (17), (18) showed that reproduction in rats on vitamin A deficient diets, proved a failure. Sterility, characterized by resorption of the fetus during gestation and associated with vitamin A deficiency, was produced on a skim milk powder diet containing an abundance of vitamin E. The addition of 3 per cent to 5 per cent ethereal extracts of wheat embryo, yellow corn, kemp-seed or cotton seed oil allowed normal fertility.

Evans and Bishop (19) noted that prolongation of estrus, vaginal changes and failure of ovulation occur in 100 per cent of animals reared on diets which are low in vitamin A, but which, nevertheless, permit normal growth. This condition was cured by
the administration of small quantities of dried alfalfa leaves or butterfat.

Hogan and Harshaw (20) obtained results similar to those of Evans and Bishop, by feeding albino rats rations with no known source of vitamin E. Sterility resulted but conclusions pointed to a possibility of this vitamin being stored for long periods of time as some females did not become sterile for 6 to 8 months. Males reared on diets containing no vitamin E were sterile after 65 to 100 days, the testes showing typical atrophy and lack of sperms.

Mattill and Stone (21), Mattill and Conklin (22), and Mattill, Carman and Clayton (23), feeding rats rations in which all the protein and vitamins were supplied by varying proportions of dry milk, obtained normal growth up to 75 days of age, after which it was below normal and reproduction was not successful on any of the rations. The addition of cod liver oil, traces of potassium iodide or changing to stock rat food, did not restore reproductive function.

Mating tests with stock food rats showed that milk-fed females were sterile; the males were not always so, but their offspring did not usually live. In the female, ovulation was apparently normal but implantation was not successful, and the ovaries were underweight. Milk is probably lacking quantitatively and qualitatively in substances necessary for successful adolescent growth and reproduction.

In experiments on feeding sprouted oats (24) (25) to overcome sterility in cows, some success has been attained, though the
practice is not a definite remedy. Three heifers and two cows, which had been bred from three to nine times, conceived to the first service after feeding sprouted oats for 23 days. Of another group of four heifers, two became pregnant to the first service and two failed to conceive after feeding sprouted oats for a period of 129 days.

From the above discussion, it can be seen that nutrition plays an important role in the reproductive processes.

**Physiological Factors Causing Sterility.**

Conception depends upon the proper functioning of a biologic mechanism so complex and delicate that it is readily thrown out of action by any disturbance in any of its parts. The past twenty years have brought a better understanding of this mechanism and of the numerous details in which it may fail. Such knowledge of the causation of sterility is naturally prerequisite to intelligent investigation and efficient treatment.

Meaker (27) states that sterility is of two types: 1. Absolute, where the initiation of the reproductive process is, at any rate for the time being, entirely impossible. This condition is of two sorts; those suppressing entirely the production of sperms or ova, and those entirely preventing the access of spermatozoon to ovum. Such disability may be temporary only, and remediable by nature or by act, or it may be permanent. Absolute sterility is found in about 30 per cent of sterile matings.
2. Relative sterility — in which the initiation of the reproductive process is not definitely impossible, but is to some extent impeded and made difficult. Ova and sperms are produced, but they may be deficient in number and subnormal in quality. The access of the male gamete to the female is not entirely prevented, but obstacles of one sort or another may be placed in the way. Thus the capacity for reproduction, still actually present, is diminished. Nutrition in relation to the reproductive process has been discussed.

In investigating causes of sterility, Meaker (27) uses the term "causative factor", signifying simply a factor which, to some extent, lowers the position of the individual in the scale of relative fertility sterility. Thus in 50 cases of sterility in humans, Meaker found an average number of causative factors of 4.6 per case. There was a total of 72 male factors, 46 of which were constitutional, 28 local; and 160 female factors, 46 of which were constitutional and 114 were local.

Modern research shows that sterility is commonly due to the combined influence of multiple factors. Any single one of these, excepting the comparatively few absolute factors, may not be sufficient to cause sterility, but all of them together depress fertility below the threshold of conception. Meaker states that "about one-third of all demonstrable causative factors are extra-genital conditions of constitutional depression, which lower the inherent fertility of the gametes. Such conditions are operative, in one or both partners, in nearly 90 per cent of sterile matings." In the
male they are, in the aggregate, more important than abnormal local conditions."

Albrechtsen, (28) specifies three types of sterility:

1. Actual sterility - where reproduction is impossible.
2. Temporary sterility - where irregular lengths of time elapse between pregnancies.
3. Abortion (not infectious) at different stages of pregnancy.

Quinlan (29) also classifies sterility under the four general headings of:

2. Acquired.
3. Relative or Temporary.
4. Absolute or Permanent.

Permanent sterility may be congenital or may have arisen after gestation has occurred. Temporary sterility is that in which the condition producing it may be overcome, whether it be due to anatomical, functional or inflammatory causes. The anatomical causes may be; vulvar, vaginal, cervical, uterine, tubal and ovarian. Functional sterility is due to a metabolic disturbance of the organisms.

The Ovaries and Corpus luteum.

The ovaries are of prime importance in reproduction, since their function is to provide the female germ cell or ovum, and any serious alteration in their normal structure may, therefore, be a cause of
sterility. McFadyean (30) stated that cystic ovaries and persistent corpora lutea are the two principal conditions responsible for sterility in cows. Quinlan (29) considered that abnormalities in the estrus cycle were a reflection of the state of the ovaries, and nymphomania and anaphrodisia are secondary symptoms of diseased conditions in the ovary and are not in themselves a disease. Several theories have been advanced as to causes of cystic ovaries and persistent or cystic corpora lutea, the later ideas indicating that the primary cause is a result of infection.

Goss (31) classifies the cystic ovarian follicle with cystic tumors, which usually result in permanent sterility. Cystic degeneration of corpora lutea may be a process of degeneration resulting from long existence of the body, with other factors possibly responsible. Quinlan (29) states the cystic degeneration of the Graaffian follicle is caused by a failure of the follicle to rupture, as several cysts may be formed in the one ovary. Hammond (5) also holds this view, and in addition, that each successive development of follicles produces heat but ovulation does not occur, heat depending ultimately on the maturation of the follicle.

Since in cows with cystic ovaries no corpora lutea are formed to regulate the growth of follicles, it frequently happens that the ripening of follicles proceeds unchecked and the animal becomes a nymphomaniac. In view of the fact that either one large cyst or many small cysts are formed, it would appear that a larger cyst, by its growth utilizes the nutriments required for the growth of
follicles and prevents their development just as the corpus luteum does. If the cystic follicle, however, does not increase much in size, development of other follicles will take place and multiple cysts are formed. It has been stated that 70 per cent of cows with cystic ovaries are nymphomaniacs and 30 per cent never come in heat at all. Whether absence of heat occurs in all cases of the formation of large cysts and nymphomaniacs in the cases of multiple cysts, is not certain but this appears probable.

Hammond (32), in further studies on sterility, believes that abnormalities in the corpora lutea are responsible for fetal atrophy. It has been shown that the corpus luteum controls, to a large measure, the nutrition of the uterus, and removal from the ovaries in early stages of pregnancy in rabbits has caused resorption of the fetus rather than abortions.

Boyd (33) also has stressed the importance of the corpora lutea in sterility. The corpus luteum is a ductless gland of internal secretion and originates in the ovary following discharge of a ripe ovum. If the ovum is fertilized, the corpus luteum remains throughout pregnancy and is responsible for the raised nutrition of the uterus during the manufacturing process of the fetus. If the egg is not fertilized, the corpus luteum normally attains the normal size of the corpus luteum of pregnancy, but quite rapidly undergoes degenerative changes which are followed by the formation of a new corpus luteum at the next estral in heat period. Failure to undergo these changes causes a cessation or estrum - persistent corpus
luteum. The corpus luteum undoubtedly interferes with ovulation mechanically and by the elaboration of an internal secretion which exerts an inhibitory action on the maturation of the Graaffian follicles.

Acidity of the vagina has been designated as a possible cause of sterility. Hammond (5) observed that just before heat the mucus of the cervix liquifies and streams down the vagina to the vulva. This dilution and flow of mucus allows a free passage in the cervix and forms a liquid medium in which the spermatozoa can swim freely on their way to the Fallopian tubes. Possibly one of the reasons why acidity of the vagina is a cause of sterility is due to the action on the consistency of the mucus of the cervix. Mucus in a slightly acid medium becomes tough and stringy, while in a slightly alkaline medium it becomes fluid. Hence the benefits obtained by douching with dilute alkalies before service.

Much importance (2) may be attached to continued high production in dairy cows, forced feeding for advanced registry and high records of milk and fat, in the problem of sterility. It has been recorded that the continuance of lactation commonly exerts an inhibitory influence on menstruation in women and on heat in animals.

The Effects of Inbreeding.

The fact that inbreeding may result in reduced fertility has been definitely shown, especially with the significance of the fertilization process. A tendency towards sterility may be
associated with a constitutional loss of vigor. It has been suggested (2) that inbreeding produces males in which there is a want of vigor on the part of the spermatozoa, which either prevents them from conjugating with ova or causes abortion of the fertilized ovum or fetus, owing to its being endowed with a reduced vitality. Hammond (5) also mentions lethal factors resulting from inbreeding as an important consideration in sterility, and substantiates the statement by illustrations of reduced sterility in sheep resulting from cross-breeding and increased hatchability of eggs in fowls.

**Physiological Factors Causing Sterility in the Male.**

Sterility in the male occurs less frequently than in the female, but its importance should not be overlooked. Numerous sires affected with impaired breeding efficiency are not always affected with structural changes of the genital organs as a result of infection, but are frequently infertile on account of certain physiological conditions. Boyd (33) states that advanced age, overfeeding, underfeeding, obesity, over-condition as found in show cattle, together with lack of exercise, are all important factors to be considered in connection with sterility or failure to breed.

Marshall (2) stresses too frequent intercourse or excessive service as having a deteriorating influence on the vigor of the male. Cooper, Way, Dimock, Good and Anderson, (34), (35), state that sterility in the male may be due to the following conditions:

1. The semen may contain no germ-cells, caused by an inflammation somewhere in the genito-urinary canal
which has closed the passage, or it may be due to fibroid degeneration of the glands.

2. The semen may contain large numbers of sperms, all of which are inactive, caused by fibroid degeneration primarily, the cells being dead or in various stages of development.

3. The semen may contain a small number of active germ cells.

4. Active and inactive germ cells in the semen, indicating partial sterility.

5. The discharge of quantities of pus with the semen.

6. Inflammation in the urethra. There may be almost any combination of these factors influencing fertility of the bull.

A further discussion on the part of the male in sterility will follow under the heading of "The Male—Studies of Spermatozoa", after discussing the bacteriological and pathological factors.

The Bacteriology and Pathology of Sterility.

Sterility may be said to result, as a rule, when there are deviations from the normal in the genitalia. Factors which are considered essential to conception are:

1. A normal ovum

2. Healthy and active spermatozoa

3. Normal tubal, uterine and vaginal secretions and structure
4. A healthy endometrium in which the fertilized ovum may lodge and develop.

Carpenter (36) made one of the first systematic studies of the bacterial content of the entire bovine genital tract. The genital tracts of 114 females were cultured, from normal animals, non-breeders and virgin heifers. Cultures were made from the ovaries; oviducts; right and left uterine apices; body of the uterus; cervix; and vaginas around the os uteri. Two aerobic and two anaerobic cultures were made from each.

Streptococci were isolated from 138 parts; Staphylococci from 76 parts; Bacillus abortus from 29; colon aerogenes from 4; Bacillus aerogenes capsulatus from 3; and B. pyogenes from 3. Strep. viridans were found in the oviducts of the non-breeders; the lumen being completely closed. It was found that calves and most cows have a secretion in the genital tract which has a decided bactericidal action.

Beaver (4) investigating the bacteriology and pathology of sterility in cattle, found that the most important organism causing infections of the genital tracts in cows were streptococci and B. pyogenes. In all cases of severe non-specific metritis and other suppurative processes about the genitalia, these two types of organisms combined, or B. pyogenes alone, were isolated. Other organisms were not regarded as playing a primary rôle.

Summarizing the pathological results of infection, Beaver (4) states that in all cases of infection about the genital tract, multiple cystic degeneration of medium-sized Graaffian follicles
were a constant finding. The uterine tubes, because of their many folds and crypts, and their delicate structure, offer the most favorable site for persistence of infection. Chronic changes in the genital tract are most frequent in this location and are usually seen in the form of hydrosalpinx.

The cervix uteri, like the uterine tubes, also offers a favorable site for bacterial reproduction. The folds of the mucosa are deep and in the crypts bacteria may gain entrance and multiply. Infection of the cervix often extends to other portions of the genital tract.

Williams (37) considers tubal infections to occupy a primary place in factors interfering with reproduction. The infections usually come from the uterus, cervix or vagina and cervicitis constitutes a reliable precursor to salpingitis. In one herd where 12 cows were sterile, 60 per cent of the herd showed intense cervicitis. When both ovarian and uterine ends of the tubes become occluded, salpingitis reveals itself clinically by enlargement of the tubes and is palpable per rectum.

Cystic degeneration of the corpus luteum is first in diagnostic value, seemingly to always follow when tubal infection extends to the papilion, causing tubo-ovarian adhesions. Later the cyst disappears and fibrous degeneration of the ovary succeeds and ends ovarian function. Williams believes there is no treatment and that dislodgment of the cystic corpora lutea only increases trouble, for manipulation releases and scatters infection and produces fresh
ovarian wounds which invite further infection.

The bull may be implicated in the spread of infection to some extent. A bull of low fertility generally ejaculates recognizable abnormal semen, non-motile or feebly motile sperms, defectively formed cells or cells deficient in numbers. Most important is the fact that the semen is usually contaminated with bacteria which endanger the health of the cow.

Fitch (38) cultured 15 ovaries containing cysts and cystic corpora lutea and obtained growth from all the cultures. Streptococci, and B. coli and B. pyogenes were the most numerous, and be associated these organisms with the cystic condition.

Hallman (39) in studying four cases of retained placentas, found a superficial, more or less general necrosis of the mucosa of the uterus. Streptococci viridans and B. coli communis were isolated. All cases were accompanied by purulent discharges from the vagina, cervix and uterus. In cases which failed to breed, numerous small cysts were found in the uterine mucosa which were considered causes of failure to breed and nymphomania. In treating these cases with Lugol's solution, it was found that a necrosis of the mucosa with an acute fibrinous endometritis were produced, similar to that caused by infection. Treatment of this type may be dangerous at estrus or menstruation.

Dimock and Edwards (40), in examining 1606 mares for barrenness, found approximately one-third of them suffered from either a severe or mild form of cervicitis and metritis due to infection.
Streptococci were the most common organisms isolated which caused the infections.

Fincher (41), in observations upon a herd of 114 dairy cattle completely negative to evidence of B. abortus, found that 36.6 per cent suffered annually from genital diseases; 20 per cent showed evidence of metritis without retained placentas or abortion, and 24.3 per cent were sterile (required three or more services). Abortions occurred frequently after untreated sterility from infection in the uterus (metritis), the organisms associated with these abortions being B. coli and streptococci.

Boyd (33) stated that results of pyometritis, a condition of the uterus in which there are chronic inflammatory changes in the uterine mucosa, cannot be over-estimated. It is characterized by sacculcation of one or both horns, flaccid muscular walls and loss of muscle tone. Pus is formed, filling the uterus, and the cervix is inflamed. B. pyogenes is largely responsible for the condition.

Quinlan (42) found that pathological changes in the Fallopian tubes caused incurable sterility in a large percentage of cows in South Africa. A history of all affected cows revealed evidence of a puerperal metritis, a cervicitis or both, following on placental retention, difficult parturition or parturition injuries. Tubal infections did not occur independently, but were due to a secondary invasion from some existing pathological lesion in the genital tract or in the peritoneum. In these infections, organisms most frequently found were Streptococci viridans, B.
pyogenes and B. coli. Tubal disease was associated with cystic degeneration of the corpora lutea as a result of infection of the ovarian crater after ovulation. This prevented normal physiological atrophy of the corpora lutea, resulting in cessation of estrum or irregularity of interovulation periods which are usually long.

After some time estrum will again occur when the lutein tissue in the wall of the cyst has become so atrophied by the internal pressure of the developing cyst that it no longer inhibits estrum. The opposite ovary then ovulates and the corpus luteum resulting is also retained and undergoes cystic degeneration in its turn, to follow the same cycle.

Work done by Albrechtsen (28) also emphasizes the importance of infection in sterility. Endometritis and metritis were shown to be caused by an infection during the last delivery. Early abortions (in which B. abortus was not isolated) were associated with an infection of the uterus, caused by the pathological condition of the uterus mucosa. The ovum cannot obtain the necessary nourishment and is incapable of initiating those changes which cause a more intimate connection between the fetal and maternal placenta during the second month. During the first month the ovum is loose in the uterus horn and is nourished by diffusion from the uterine milk. An incomplete production of this uterine milk because of pathologic conditions in the uterus, may be the cause of an early abortion and so the cause of sterility.

Cystic degeneration of the ovaries was considered a secondary
lesion, produced and sustained by the pathological condition of the uterus. Primary metritis was found with cystic degeneration of the ovaries and treatment of the metritis did away with the cystic degeneration. Of 181 cows with cysts, 25 of which had symptoms of nymphomania, more than half had a metritis; 179 had an open cervical canal, the mucosa of which was swollen and hyperemic.

Rosencow and Davis (43) have presented facts supporting the view that infection of the cervix, uterus and Fallopian tubes is associated with degeneration of the ovaries. Furthermore, that streptococci may be carried to the ovaries from the blood. They found the occurrence of fibrocystic degeneration of ovaries in which the usual streptococci were isolated in pure form, in young women with imperforate vagina. Using cultures from these organisms, intravenous injection produced similar characteristic lesions in one or both ovaries in rabbits.

The Male Factors Affecting Fertility

The part that the male plays in reproduction of life is obviously of comparable importance to that of the female. Studies related to reproduction and sterility have been more complete with the female than with the male and it would seem that our present fund of accurate knowledge of the physiology and pathology of the male reproductive system is somewhat limited. It is only in recent years that any extensive investigations have been made of the role that the male takes in reproduction.
Gilman (43) states that the bull must be regarded as at least half the herd, not only from the standpoint of the characters he imprints upon his progeny, but because of his relation to the reproductive efficiency in the herd. He made a study of 184 animals, of which 16 were mature infertile or sterile bulls. It was found that the seminal vesicles and the epididymises, especially the tail of the epididymis, are parts most subject to extensive pathological changes and bacterial invasion.

Three types of pathological changes were found:

1. Acute catarrhal type, in which the epididymises were enlarged, soft and reddened by hyperemia.

2. The suppurative or cystic type, the epididymis being abscessed, either locally or the entire gland.

3. The chronic or sclerotic type, in which the epididymis was hard and enlarged.

In experiments it has been shown that sterility is not necessarily accompanied by any apparent microscopical changes in the gonads or even at times, in the general body health. The frequency with which bulls used to excess break down sexually is probably due to the devitalizing effect upon the tissues of the genital organs, thus opening the way to bacterial invasion and other destructive influences. Infection is without doubt the greatest single factor capable of producing functional and anatomic changes resulting in varying degrees of impotency and sterility. The products of bacterial growth being toxic to seminal fluid, cause
destruction of the parenchymatous tissue of one or more contributing sexual glands.

The genital organs of the bull frequently undergo pathological changes, due to infection with the same varieties of organisms associated with genital infection in the female. These are types of Streptococci, B. pyogenes and B. coli. During infection, these organisms are often eliminated with the semen and infect the female during copulation. Lowered sexual capacity is, as a rule, accompanied by demonstrable changes in the semen.

Anderson (35) in studying sterile males, found the following causes:

1. Fibroid degeneration of the testes, possibly caused by feeding young males for show, highly conditioning on rich protein foods. In this condition, the secondary sex glands function in a normal way in secreting semen and the discharge of liquid semen is copious but lacking in sex cells.

2. Sterile males result from repeated attacks of orchitis. The inflammation of the glands, if severe enough and repeated a sufficient number of times, ends in testes unable to mature sex cells. Little is known of the cause of orchitis.

3. Males which regularly mature a large proportion of inactive sperm cells instead of all active ones, the proportion varying from an insignificant number to more than one-half.
4. Males that have pus in the discharge of semen. This indicates some center of inflammation and a possibility of spreading infection to the female.

Marshall (2) states that a want of vigor on the part of the spermatozoa reduces their fertilizing power, owing to reduced vitality. This is associated with too frequent intercourse, which has a deteriorating influence on the vigor of the male. It was found that semen from such males contained only occasional spermatozoa which showed no sign of motility.

Crew (44) working with domestic fowls found that the physiological qualities of the sperm as a fertilizing agent depreciate fairly rapidly in the female. There was a relation between the general vigor of the individual and the fertilizing power of the sperm it elaborated.

Donham and Simms (45) in studying the genital organs of 201 bulls obtained from abattoirs, found the most common gross lesions were adhesions in the scrotum. 75.88% of the genitalia showed these lesions, caused, it was thought, by mechanical injuries. No correlation could be established between the presence of these lesions and the estimated percentage of motility of spermatozoa taken from various points along the genital tract. The numbers of motile spermatozoa varied to some extent with the consistency of the secretions, thin, watery secretions containing comparatively few spermatozoa; while tenacious, thick secretions contained large numbers of motile spermatozoa.
Simms (46) studied spermatozoa from two groups of bulls:

1. Bulls used in the College dairy herd.
2. Bulls under field experimental conditions.

Classifying the spermatozoa according to motility, and using a basis of 90% active, vigorous, moving sperm as normal, it was found that of 66 specimens with estimated normal motility, 53.03% of the services resulted in pregnancies. Of 54 specimens with motility estimated below normal, 24.07% of the services resulted in pregnancies.

A variation in the percentage of motility was observed in spermatozoa from two consecutive services, those of one showing below normal, and those of the next service showing normal. There was found to be no relationship between the activity of the bull at the time of service and the motility of the spermatozoa.

No relationship existed between the frequency of service and the resulting pregnancies or the estimated motility of the spermatozoa, though the bulls were not used excessively.

In the field work there were 17 bulls used on 386 cows with a total of 621 services. Of these, 39.94% resulted in pregnancies. Of the samples showing normal motility, 55.55% resulted in pregnancies, and of those below normal, 33.33% resulted in pregnancies. An average of 2.5 services per pregnancy were required.

Anderson, Peter and Healy (27) made a study of the hydrogen-
ion concentration of semen of stallions from which the spermatozoa were motionless immediately after copulation. It was found that the H-ion concentration in normal horse semen was pH 7.31; and that of semen in which the spermatozoa were inactive, the H-ion concentration, pH 7.58. A change of .27 of a pH value less than the average of normal semen resulted in lowered vitality and death of the spermatozoa.

Hordby and Bollen (47) found that a physiological disturbance resulted from feeding and management of a boar. The inefficiency of the boar in failure to produce actively functioning spermatozoa was associated with a pH value of the semen of 7.61, which was .25 higher than the pH value of the semen when it became normal in motility. A "rest-cure" and a change of ration from pea screenings to ground barley and oats, tankage, oil meal and alfalfa, with a tonic, resulted in the production of normal spermatozoa and normal health in the boar.
SURVEY AND EXPERIMENTAL DATA

Objects of the Survey and Experimental Work.

The objects of the survey were to determine the extent of sterility in dairy cattle in the state of Oregon; to ascertain whether sterility was restricted to certain areas or was prevalent throughout the State; and to ascertain under what conditions of feeding, care and management sterility existed.

The objects of the experimental work were to determine, if possible, what factor or factors were instrumental in the causes of sterility in dairy cattle; to determine the relation of the bull to the breeding efficiency of the herd; to remedy or control, if possible, by feeding, management and treatment, some of the factors which might be involved in the causes of sterility.

Plan of Work.

In order to ascertain the extent of the problem of sterility in the state, a questionnaire was made up and sent to leading breeders of dairy cattle in each county. These were also sent to the breeders reported by the County Agricultural Agents as having breeding troubles in their herds. A similar questionnaire had been sent previously to Agricultural Experiment Stations in other states, a summary of which is included in this report.

A survey of breeding troubles was made in the Oregon counties of Umatilla, Deschutes and Crook, in which 25 herds were visited and a record made of the feeding and management practices; of whether or not the farmer kept breeding records, and of the results of
examinations made of sterile animals. In Benton county two herds were investigated which were giving trouble and microscopical examinations of semen from the bulls used were made, as well as examinations of the cows.

The College herd, consisting of a total of 115 cows and heifers of breeding age, was used for experimental work. The four major breeds of dairy cattle make up the College herd and complete feeding and breeding records were kept of all animals, as well as records of rectal and vaginal examinations. Rectal examinations for pregnancies were made each month by a skilled veterinarian from the Department of Veterinary Medicine. All abnormalities were reported and carefully recorded for each animal.

A study of the breeding records of the ancestry of the animals in the College herd was made from the complete breeding records which have been kept of all animals that have been in the herd. This covers a period of 16 years.

Microscopical examinations were made of semen from the bulls used in the College herd. A record was kept of date of service; number of services; promptness of service; and all data were recorded on the amount of semen, color, turbidity, consistency, number of sperms and motility of sperms in the semen. With these data a record was kept of the number of the cow, result of vaginal examination, whether or not the cow was treated and the sympathy of the cow.

Supplemental feeds were given to 14 animals, 4 cows and 10 heifers. Three cows and 10 heifers, which showed symptoms suggestive
of vitamin E deficiency, were fed one pound of wheat germ meal per day for periods of 21 days and 74 days.

One cow and 3 heifers that were particularly difficult to get with calf were fed 5 grams of ferro citrate per day for a period of 21 days.

Discussion of Data.

Survey.

Results of a questionnaire, sent out in 1926 to Agricultural Experiment Stations in other states, show that breeding troubles were experienced at stations in Tennessee, Nebraska, Wisconsin, Kansas, Missouri, Minnesota, Connecticut, Iowa, California, Washington and Pennsylvania. Only one station, that of East Lansing, Michigan, reported having no particular breeding troubles in dairy cattle. This indicates to a certain degree the extent of the problem of sterility in the United States.

In 1930 questionnaires were sent to 74 breeders of dairy cattle in the state of Oregon. Of these, 56 were filled out and returned. Fifty of the herds reported were free from abortion, thus eliminating that factor and the complicity of troubles that accompany it.

A total of 1459 cows and heifers was reported, of which 210 cows and 109 heifers, or 21.86% of the total were reported as having sterility. Sixty-three cows and heifers, 4.318% of the total number reported, were butchered as non-breeders in the past year.

The herds which were reported may be regarded as typical of
other herds in the State, kept under various systems of feeding, care and management. Results show that more than one-fifth of the cows and heifers were sterile, and 4% of the total, or 19.75% of those having sterility, were slaughtered yearly as non-breeders.

The survey of herds in the counties of Umatilla, Deschutes and Crook where climatic conditions and feeding and management practices are very similar, showed that out of a total of 25 herds investigated, trouble from sterility was experienced in 18 herds. 7.35% of a total of 466 cows and heifers were reported as "difficult breeders" and 0.66% of the 466, or 6.06%, of the difficult breeders were butchered during 1930 as non-breeders. As far as possible, only abortion-free herds were considered in the survey owing to the complicity of troubles which ordinarily accompany this disease.

Rectal examinations made on animals in three herds in which sterility was experienced revealed no apparent abnormalities in the genital organs, which might have been factors responsible for the trouble.

Factors determined as affecting the breeding efficiency in these herds were:

1. Lack of breeding records.
2. Excessive use of the bull by pasture-breeding.
3. Lack of proper measures in sanitation.
4. Lack of exercise, poor feeding and care and management of the herd sire.

An investigation of breeding troubles experienced in two herds
in Benton county revealed a sterile bull in each herd. Vaginal examinations of the cows at the time of service showed them to be normal. In a microscopical examination of semen from the bulls no active spermatozoa were found in samples from two services of one bull. The semen from the first service of the other bull contained no sperms and semen from the second service showed sperms with 50% viability and very poor motility.

Each of these bulls was about 2 years old and had not been bred to more than 10 or 12 cows. Two samples of semen from one bull contained epithelial cells. No causes could be determined as responsible for this sterility, nor the causes for the abnormalities in the semen.

Breeding Records of Ancestry of Animals in the College Herd.

As a means of comparing the breeding efficiency of the herd during the two years 1929-1931, the breeding records have been worked out for the past 16 years for the entire herd. The following table shows the total number of foundation cows for all breeds, and the total number of offspring in the succeeding generations, with the total number of services required, average number of services per pregnancy, and the number and percentage of pregnancies requiring more than 3 services.
The figures in this table show that there has been a definite decrease in the percentage of resulting pregnancies in succeeding generations, or that the average number of services per pregnancy has increased for the succeeding generations. The table also shows an increase in the number of pregnancies requiring more than 3 services. The percentages sold as non-breeders are based on the total numbers of females reaching the breeding age in those generations.
The increase in the number of services required for pregnancies in the 4th, 5th and 6th generations may be due, in part, to the fact that 20 cows were on a mineral experiment which interfered with normal reproduction in these generations. Details of the breeding records of these 20 cows will be given in a later part of this report.

The factors of inheritance and effects of inbreeding are omitted from this report, in as much as the problem is too extensive to be included. This phase of the sterility may have some bearing on the decreased breeding efficiency indicated by the fact that the decrease has followed certain amounts of inbreeding in all the breeds, and especially in the Jersey breed.

**EXPERIMENTAL DATA**

**The Bull-Studies from 1929-1931.**

**Feeding, Care and Management.**

During the 2 years, 11 different bulls have been used in the College herd - 3 Ayrshires, 1 Guernsey, 3 Holsteins and 4 Jerseys. Ages of these bulls ranged from 1 year to 11 years. An attempt was made to keep them in good "breeding condition" at all times.

Grain was fed in amounts of 4 pounds to 8 pounds per day, depending upon the size of the bull, his condition and the amount of use required of him. The grain ration was from the regular herd mix, consisting of ground oats, ground barley, wheat bran, soybean meal, linseed oil meal, 2 per cent steamed bone meal and 2 per cent salt.
The crude protein content of this ration was about 16 per cent.
In addition to the grain, the bulls received alfalfa hay, (first
cutting), clover hay or oats and vetch hay. About 20 pounds of kale
were fed to each bull per day, when it was available, and at other
times from 5 pounds to 12 pounds of good quality corn ensilage were
fed per day.

The bulls were housed in separate pens which opened into an
exercising lot of about one-fourth acre. Each bull was turned into
this lot for half a day every other day. This formed the extent of
exercise the bulls received, and though hardly sufficient, was the
most that could be attained with the number of bulls used.

In the breeding work a practice was followed of giving the cows
one service, unless microscopical examination of the semen from that
service showed abnormalities, either in quality or the number of
sperms present in the sample. If the sample from the first service
was not satisfactory, a second service was given in an hour's time,
and whenever possible a microscopical examination made of a sample
from it. It was planned at all times to avoid excessive use of the
bulls to conserve and increase their breeding efficiency.

Results of Microscopical Examinations of Semen and Pregnancies
Resulting

A total of 87 samples of semen were taken from the 11 bulls for
microscopical examination. The procedure followed was to take the
sample from the vagina of the cow immediately after she was served.
This was done by means of a glass tube with a rubber bulb on the
end serving as a syringe. All samples were examined as soon after taking as possible.

A record was kept of the estimated motility of the spermatozoa; the viability, examined at the end of 1 hour, 24 hours and 48 hours; the promptness of coition; and the resulting pregnancies. The following table shows the results of this study:

**TABLE II**

<table>
<thead>
<tr>
<th>Motility</th>
<th>Samples</th>
<th>Viability</th>
<th>Promptness</th>
<th>Per cent of</th>
<th>Resulting</th>
<th>Per cent of Pregnancies</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100%</td>
<td>51</td>
<td>51%</td>
<td>Slow - 14)</td>
<td>4</td>
<td>28.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prompt- 37)</td>
<td>15</td>
<td>40.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total - 51)</td>
<td>19</td>
<td>37.25</td>
<td></td>
</tr>
<tr>
<td>75-90%</td>
<td>25</td>
<td>83.60%</td>
<td>Slow - 10)</td>
<td>2</td>
<td>20.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prompt- 15)</td>
<td>4</td>
<td>26.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total - 25)</td>
<td>6</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>0-75%</td>
<td>11</td>
<td>27.54%</td>
<td>Slow - 3)</td>
<td>0</td>
<td>-- --</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prompt- 8)</td>
<td>2</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total -11)</td>
<td>2</td>
<td>18.18</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>87</td>
<td>54.40</td>
<td></td>
<td>27</td>
<td>31.03</td>
<td></td>
</tr>
</tbody>
</table>

A study of the data in this table shows that the largest number of samples were normal in motility, considering 90% to 100% as normal. The highest per cent viability at one hour was found in the second group of samples, with motility of 75% to 90%. There is no apparent explanation of this higher viability of the spermatozoa showing lower motility.

A relation between promptness of coition, per cent of motility and resulting pregnancies is indicated, the greatest percentage of
pregnancies occurring from prompt services, samples of semen from these showing the highest per cent motility. The percentage of resulting pregnancies shows a corresponding decrease with the decrease in motility, viability and slower coition.

Of the 87 samples of semen taken, a study was made of the viability of 45, 25 being from the group showing normal motility (90% to 100%); 16 from the group showing good motility (75% to 90%); and 4 from the group showing poor motility (0% to 75%).

Table III shows the tabulated results of this study, with pregnancies and percentage of pregnancies.

**TABLE III**

<table>
<thead>
<tr>
<th>Motility</th>
<th>No. of Samples</th>
<th>1 hour</th>
<th>24 hours</th>
<th>48 hours</th>
<th>Total</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% to 100%</td>
<td>25</td>
<td>69.12</td>
<td>6.56</td>
<td>.04</td>
<td>2</td>
<td>8.0</td>
</tr>
<tr>
<td>75% to 90%</td>
<td>16</td>
<td>84.06</td>
<td>11.68</td>
<td>.068</td>
<td>4</td>
<td>25.0</td>
</tr>
<tr>
<td>0% to 75%</td>
<td>4</td>
<td>48.25</td>
<td>6.25</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>45</td>
<td>72.57</td>
<td>8.53</td>
<td>.046</td>
<td>6</td>
<td>15.55</td>
</tr>
</tbody>
</table>

While the number of samples in this study is relatively small, the results show a larger number of pregnancies resulting from services in which the spermatozoa had good motility (75% to 90%) and a higher percentage of viability. This indicates a possible relationship between the length of life of spermatozoa and resulting pregnancies.

Two samples of semen in the group showing poor motility and less
viability contained pus cells. Whether these cells came from the bull or the cow was not determined, as the samples were collected from the vagina of the cows. The presence of these pus cells would probably reduce the viability of the spermatozoa to some extent.

A Study of the Breeding Records of the College Herd for 1929-1931.

The Breeding Efficiency of the Bulls.

The following table shows the number of pregnancies resulting from services of each bull used, with the percentage of pregnancies and the average number of services per pregnancy. "Other bulls" referred to in the table are two bulls used only for a short time.

<table>
<thead>
<tr>
<th>Breeding Efficiency of the College Bulls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulls (by breeds): Pregnancies: Services: pregnancies: percentage: services per pregnancy</td>
</tr>
<tr>
<td>Jerseys</td>
</tr>
<tr>
<td>Maori: 11: 34: 32.35: 3.09</td>
</tr>
<tr>
<td>Prince: 12: 26: 46.15: 2.16</td>
</tr>
<tr>
<td>Other Bulls: 2: 2: 100.00: 1.00</td>
</tr>
<tr>
<td>Holsteins</td>
</tr>
<tr>
<td>Paul: 21: 46: 45.65: 2.19</td>
</tr>
<tr>
<td>Artis: 4: 4: 100.00: 1.00</td>
</tr>
<tr>
<td>246B: 8: 11: 72.72: 1.37</td>
</tr>
<tr>
<td>Nugget: 1: 1: 100.00: 1.00</td>
</tr>
<tr>
<td>Ayrshires</td>
</tr>
<tr>
<td>Dignity: 22: 37: 59.46: 1.68</td>
</tr>
<tr>
<td>Pan HH: 6: 10: 60.00: 1.66</td>
</tr>
<tr>
<td>Lucky Boy: 12: 19: 63.16: 1.58</td>
</tr>
</tbody>
</table>
TABLE IV - Cont'd.

Breeding Efficiency of the College Bulls

<table>
<thead>
<tr>
<th></th>
<th>No. of</th>
<th>Percentage of services per pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guernseys Ranger</td>
<td>11</td>
<td>39 28.20 3.54</td>
</tr>
<tr>
<td>Totals</td>
<td>110</td>
<td>229 48.03 2.08</td>
</tr>
</tbody>
</table>

The average number of services per pregnancy, as shown by Table IV, are lowest for the Ayrshire bulls, which have an average of 1.65 services per pregnancy. The Holstein bulls are the next lowest, with an average of 1.82 services; the Jersey bulls have an average of 2.48 and the Guernsey bull is the highest, with an average of 3.54 services per pregnancy.

The average breeding efficiency of all the bulls is 48.03 per cent, requiring an average of 2.08 services per pregnancy. Only 4 bulls out of the 11 exceeded this number of 2.08 in services required per pregnancy - 2 Jerseys, 1 Holstein and 1 Guernsey.

The Breeding Record of the Herd for 1929-1931

During the two years' study there were 77 cows and heifers bred, resulting in 109 pregnancies. Twenty-two heifers became pregnant to a total of 61 services, and 55 cows conceived 87 times to a total of 224 services. The number of pregnancies with the total number of services and the per cent of pregnancies is shown by breeds and for cows and heifers in Table V.
TABLE V

<table>
<thead>
<tr>
<th>Breed</th>
<th>Total No. of Preganacies</th>
<th>Total No. of Services</th>
<th>Per cent of Services</th>
<th>Average No. of Services of Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jerseys</td>
<td>25</td>
<td>88</td>
<td>28.41</td>
<td>3.52</td>
</tr>
<tr>
<td>Holsteins</td>
<td>34</td>
<td>79</td>
<td>43.03</td>
<td>2.32</td>
</tr>
<tr>
<td>Ayrshires</td>
<td>40</td>
<td>76</td>
<td>51.28</td>
<td>1.95</td>
</tr>
<tr>
<td>Guernseys</td>
<td>11</td>
<td>41</td>
<td>26.43</td>
<td>3.72</td>
</tr>
<tr>
<td>Cows - 55</td>
<td>87</td>
<td>224</td>
<td>38.84</td>
<td>2.57</td>
</tr>
<tr>
<td>Heifers - 22</td>
<td>22</td>
<td>61</td>
<td>36.06</td>
<td>2.77</td>
</tr>
<tr>
<td>Totals</td>
<td>110</td>
<td>286</td>
<td>38.46</td>
<td>2.6</td>
</tr>
</tbody>
</table>

A study of Table V shows that the Ayrshire breed had the largest number of pregnancies and the smallest average number of services required per pregnancy. Guernseys required an average of 3.72 services per pregnancy, the highest for any breed, while the Jerseys required 3.52 services per pregnancy. For the four breeds, 38.46 per cent of the services resulted in pregnancies, or an average of 2.6 services were required for each pregnancy.

In comparing the breeding records of cows and heifers, the table shows that 36.06 per cent of the services resulted in pregnancies in heifers and 38.84 per cent of the services resulted in pregnancies in the cows. The average number of services per cow for each pregnancy was 2.57 and 2.77 per heifer for each pregnancy.

A comparison of the figures in Table I with those in Table V shows that the average number of services required per pregnancy for
a period of 15 years was 2.26. The percentage of resulting pregnancies was 44.18. For the two-year period, 1929-1931, the average number of services required per pregnancy was 2.6, an increase of .34, while the percentage of resulting pregnancies was 38.46, or a decrease of 5.72 per cent.

A summary of this study, as indicated by Tables I, IV and V, shows that the tendency has been an increase in the number of services required per pregnancy or a decrease in the percentage of resulting pregnancies. This is most pronounced in the Guernsey and the Jersey breeds, while the Holsteins show only a slight decrease and the Ayrshires are considerably above the average for the 16-year period.

The studies of spermatozoa (Tables II and III) show that the vigor of the bull, indicated by promptness of coition, may have an effect on the character of sperms produced, and that motility and viability of the spermatozoa are possible limiting factors in the percentage of resulting pregnancies.
Feeding, Care and Management.

The dairy herd consists of cows and heifers of the four major breeds of dairy cattle, Jerseys, Ayrshires, Holsteins and Guernseys. The purpose of the herd is to provide animals for experimental work; for student instruction and for production of milk. An application is made of all modern methods of breeding, feeding and management in handling the herd. No official testing was done during the period of this study, although some of the cows had been on test previously.

With the exception of those animals on experiment, the herd is on pasture during the summer months. A large part of the milk cows have been on Ladino clover pasture for the past three years, while the dry cows and heifers were on native grass pasture. In addition to pasture, the milk cows received grain and a good quality of corn ensilage. The grain mix consisted of ground oats, ground barley, wheat bran, linseed oil meal or soy bean meal, 2 per cent steamed bone meal and 2 per cent salt. This was fed in amounts according to the production of the individual cows. During the winter months, the heifers were fed from 2 pounds to 4 pounds of the herd mix, in addition to oat and vetch or clover hay. All animals were maintained in a good, healthy condition and received plenty of exercise.

The cows in milk, when not on pasture, were fed oats and vetch hay or clover hay or alfalfa hay, with a supplement of kale when
available, and corn ensilage at all times. The protein content of the grain mix was increased from 16 per cent to 18 per cent (crude protein) during the winter months. Potassium iodide was fed once a week to all the animals in the breeding herd. About an ounce of a solution made up of 2 ounces of potassium iodide to 1 gallon of water was given with the grain ration. During the winter months the cows were turned in the lot for about an hour twice each day, which afforded plenty of exercise. Water was available in troughs in the exercise lots.

In the breeding work, a practice was made of missing the first heat period after the previous calving, and breeding at the second heat period. This practice was followed in order that the cow might be entirely normal when bred to increase the chances of impregnation. Rectal examinations were made each month by one of the College veterinarians to diagnose pregnancies on cows bred 60 to 80 days. If the heat periods were irregular, or if estrum did not occur, vaginal or rectal examinations were made to determine the cause. Before breeding, vaginal examinations were made, and if the cow showed an abnormal discharge the cow was held over and treated to be bred after the discharge cleared up. One service was given, unless microscopical examination of the semen from that service revealed abnormalities, in which case the cow was given a second service.


Twenty heifer calves were selected for the experiment, which
was begun in 1925 and divided into four groups, A, B, C and D. All the calves received whole milk and skim milk until 6 months of age, when they were fed rations as follows:

Group A, consisting of #68, Jersey; #511 and #518, Ayrshires; #261, Holstein; and #642, Guernsey, were fed alfalfa hay and a grain ration made up of 1 part ground oats and 2 parts ground barley.

Group B, consisting of #67, Jersey; #512 and #516, Ayrshires; #260, Holstein; and #644, Guernsey, were fed oat hay and a grain ration made up of 1 part ground oats, 2 parts ground barley and a protein supplement of peanut meal.

Group C, consisting of #70, Jersey; #514 and #517, Ayrshires; #269, Holstein; and #645, Guernsey, were fed oat hay; and a grain ration made up of 1 part ground oats; 2 parts ground barley; peanut meal and steamed bone meal.

Group D, consisting of #72, Jersey; #515, #519 and #520, Ayrshires; #640 and #648, Guernseys, were fed oat hay; and a grain ration made up of 1 part ground oats, 2 parts ground barley, peanut meal, steamed bone meal and cod liver oil.

Tables VI to IX show the breeding history of the animals in each group.
TABLE VI.

Breeding History of Group A.

<table>
<thead>
<tr>
<th>No. of cow</th>
<th>1st Pregnancy</th>
<th>2nd Pregnancy</th>
<th>3rd Pregnancy</th>
<th>4th Pregnancy</th>
<th>Average No. of Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td></td>
<td>7.00</td>
</tr>
<tr>
<td>511</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td>3.66</td>
</tr>
<tr>
<td>518</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>261</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>642</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>2.00</td>
</tr>
</tbody>
</table>

Average No. of Services per Pregnancy for the Group: 3.00

(1) #68 was bred 24 times and was not pregnant 4/18/31. Rectal examination 10/8/30 showed cervicitis and a cystic left ovary. Other examinations showed no abnormalities.

(2) #642 died of bloat 11/6/28. She was pregnant, having conceived to a service 7/5/28.

Table VI shows that in Group A the greatest number of services were required for the first pregnancies, the average number for 5 pregnancies being 5. With the exception of #68, #518 was the only one of the group showing abnormalities. Rectal examination of #518 11/9/28 showed the presence of a small cyst in the left ovary; 12/10/28 her uterus was flabby and lacked tone, both ovaries were small. 12/30/28, both ovaries were small and apparently not
functioning - possibly a case of functional sterility.

She became pregnant to a service 1/21/29 and calved 11/1/29. Following partuition no heat was shown until 7/26/30, and during this time cysts were removed from the left ovary 3/6/30; from the right ovary 5/9/30; and a cystic corpus luteum removed from the left ovary 6/25/30. She conceived to a service 7/26/30.

**TABLE VII.**

<table>
<thead>
<tr>
<th>Breeding History of Group B.</th>
<th>No. of Services</th>
<th>No. of Services</th>
<th>No. of Services</th>
<th>No. of Services</th>
<th>Av. No. of Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 67</td>
<td>512</td>
<td>11 (aborted)</td>
<td>1</td>
<td>2</td>
<td>4.66</td>
</tr>
<tr>
<td>(2) 516</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>6.00</td>
</tr>
<tr>
<td>(3) 260</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>644</td>
<td>3</td>
<td>1</td>
<td></td>
<td>3</td>
<td>2.33</td>
</tr>
</tbody>
</table>

*Average number of services per pregnancy for the group: 3.5*

(1) #67 was bred 13 times and failed to conceive and sold for beef 10/6/28.

(2) #616 had a retained placenta following her first parturition. Heat occurred again 11/30/28, at which time she was bred but failed to conceive. She was bred 20 times but to date is not pregnant. Rectal examination 4/27/29 showed that both ovaries were small. 12/31/29 - a small cyst was removed from the left ovary. 12/8/30 a cyst was removed from the right ovary. Examination 3/26/31 disclosed adhesions on the right ovary.
Examination 4/18/31 showed her not pregnant but both ovaries and uterus were normal.

(3) #260 was bred 13 times following her first calving, developed cystic ovaries and became a nymphomaniac. She was sold for beef 5/27/30, after injuring her back jumping the other cows. (See Plate I).

PLATE I.

#260 of Group B, showing the typical symptoms of a nymphomaniac - relaxation of the ligaments at either side of the root of the tail, giving the cow a high tail-setting.

Table VII shows that only 2 of the 5 cows conceived more than once. In this group the first pregnancies required an average of 5.25 services, slightly more than those in Group A.
Following an abortion 11/12/28 and retained placenta in the first gestation period of #612, no heat was observed until 3/22/29. The abortion was not caused by B. abortus, indicated by negative reaction to the agglutination test. Rectal examinations showed a persistent corpus luteum 2/20/29 and 3/19/29, at which times it was expressed. #644 showed no abnormalities of the genital organs or in reproduction.

**TABLE VIII.**

Breeding History of Group C

<table>
<thead>
<tr>
<th>Cow</th>
<th>No. of</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>Av. No.</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>514</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>517</td>
<td>6</td>
<td>1 (aborted)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>259</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>645</td>
<td>2</td>
<td>1</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average number of services per pregnancy for the group: 2.93

(1) #514 became sick, was sold 10/9/29.

(2) #517 failed to show heat after the last calving 11/25/30, until 3/12/31. Rectal examination 2/16/31 showed small ovaries with slight atrophy.

Reproduction in this group was almost equal to that of the rest of the herd not on experiment, receiving balanced rations, succulent feeds and pasture.
TABLE IX.

Breeding History of Group D.

<table>
<thead>
<tr>
<th>Cow</th>
<th>No. of Services</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>Av. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.00</td>
</tr>
<tr>
<td>515</td>
<td>2</td>
<td>3</td>
<td>1 (aborted)</td>
<td></td>
<td></td>
<td>2.00</td>
</tr>
<tr>
<td>519</td>
<td>4</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td>2.33</td>
</tr>
<tr>
<td>520</td>
<td>5</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2.33</td>
</tr>
<tr>
<td>640</td>
<td>5</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
<td>3.33</td>
</tr>
</tbody>
</table>

Average number of services per pregnancy for the group: 2.81

(1) #72 was sold to the butcher, an abortion reactor, 1/28/29.

(2) #648 died of chronic pyometra 12/9/30 from infection following a retained placenta 11/21/30.

Group D had the lowest average number of services per pregnancy of any of the groups, with .19 services less than that of Group A; .69 less than Group B; and .12 less than Group C.

#515 failed to come in heat after calving 11/1/29, until 7/19/30, at which time she was bred and conceived to the one service. Cysts were removed from the left ovary 5/9/30 and 6/25/30. 1/20/31 she aborted a 186-day fetus. This proved to be non-infectious abortion indicated by a negative reaction to the agglutination tests for B. abortus.

A cyst was removed from the left ovary of #519, 11/9/28, heat occurring again 11/30/31. She was bred and conceived 1/25/29 to the second service.
A study of this data shows that the group receiving the more complete rations had almost normal reproduction. The abnormalities occurring in the other groups were possibly due to nutritional deficiencies interfering with normal functioning of the reproductive organs. It will be noted that Group B, receiving oat hay and a grain ration made up of 1 part ground oats, 2 parts ground barley and peanut meal, a ration low in minerals, especially calcium, showed more abnormalities in reproduction than the other three groups.

The abortions occurring in Groups B, C and D were probably further evidences of nutritional deficiencies, especially of minerals. The animals having the abortions were negative to the agglutination tests for B. abortus infection.

Results of Feeding a Vitamin E Supplement

During the two years, 1929-1931, wheat germ meal was fed to 13 animals, 3 cows and 10 heifers. Extreme difficulty was experienced in getting these animals with calf. They had all been on pasture for periods of 3 months to 10 months and had received similar feed, care and management as other animals which had become pregnant to 1 and 2 services.

Abnormal lengths of time between heat periods were characteristic of each case, ranging from 40 days to 221 days. This suggested a possible pregnancy with resorption of the fetus, as found in animals on rations deficient in vitamin E, (18), (50).

The object of this experiment was to determine if, by feeding
one pound of wheat germ meal, which is high in vitamin E content (50) for a period of 21 days or longer, the abnormally long intervals between heat could be overcome and conception aided. The meal was fed for a 21 day period and a 74 day period. Table X shows some of the details of this experiment.

### TABLE X.

<table>
<thead>
<tr>
<th>Age of Animal</th>
<th>No. of Times Breed</th>
<th>Condition of Reproductive Organs</th>
<th>Start of Experiment</th>
<th>No. of Experiment per Period</th>
<th>Condition of Ovaries</th>
<th>Start of Meal Feeding</th>
<th>Length of Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 73</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>1</td>
<td>Normal</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(2) 74</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>No record</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(3) 78</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>1</td>
<td>Normal</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(4) 79</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>No record</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(5) 86</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>No record</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(6) 263</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>2</td>
<td>Uterus small</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ovaries small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) 268</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>Normal</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(8) 468</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>Normal</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ovaries cystic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) 529</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>Normal</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td>(10) 653</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>No record</td>
<td>21 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ovaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11) 91</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>Normal</td>
<td>74 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>small but normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) 93</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>Normal Normal</td>
<td>74 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(13) 94</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>Normal</td>
<td>74 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ovaries cystic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Sold as a non-breeder 36 days after the close of the experiment, not pregnant.
(2) Conceived to a service 71 days after experiment started.
(3) Conceived to a service 16 days after the experiment started.
(4) Conceived to a service 19 days after the experiment started.
(5) Conceived to a service 114 days after experiment started.
(6) Sold as a non-breeder 36 days after the close of the experiment, not pregnant.
(7) Apparently conceived to a service 4/20/29 before experiment started.
(8) Conceived to a service 99 days after experiment started.

Two of the 13 animals conceived to one service, either during the experiment or within 30 days after the close of the experiment.

The results of this experiment would seem to indicate that wheat germ meal will not correct the condition of cows or heifers showing abnormal lengths of time between heat periods. The periods between estrum ranged from 15 days to 166 days before the experiment, and from 8 to 127 days after the close of the experiment. Indications also are that wheat germ meal will not cause heifers to conceive that show abnormalities in the reproductive organs.

Results of Feeding an Iron Supplement.

Several mineral mixtures containing small amounts of iron, in addition to other mineral elements, on the market, are claimed by the manufacturers to give good results in reproduction when fed to dairy cows. In view of this, and the fact that the water
supplied to the cows in the College herd is snow water, containing negligible amounts of minerals, an experiment was planned to feed an iron supplement to four heifers giving breeding trouble.

The supplement was fed in the form of ferric citrate at the rate of 5 grams per feed per day. Five grams were calculated to be sufficient for the requirements of a 700-800 pound animal. The ferric-citrate was fed for 21 days. Haemoglobin checks were made before the experiment started with a Haemoglobin scale and after the experiment with a "Dare" Haemoglobinometer. Checks were made on the herd cows in order to ascertain the normal haemoglobin content of other animals in the herd. Table XI shows the results of the experiment.

<table>
<thead>
<tr>
<th>TABLE XI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results of Feeding an Iron Supplement - Ferric Citrate</td>
</tr>
<tr>
<td>Item of Comparison</td>
</tr>
<tr>
<td>Haemoglobin value before feeding</td>
</tr>
<tr>
<td>ferric citrate</td>
</tr>
<tr>
<td>Haemoglobin value after feeding</td>
</tr>
<tr>
<td>ferric citrate</td>
</tr>
<tr>
<td>Number of services before feeding</td>
</tr>
<tr>
<td>ferric citrate</td>
</tr>
<tr>
<td>Number of services after feeding</td>
</tr>
<tr>
<td>ferric citrate</td>
</tr>
</tbody>
</table>

*These values were taken with a Haemoglobin chart, which proved to be somewhat lower than those taken with the "Dare" Haemoglobinometer.

Making allowances for the difference in values between the "chart" method and the "plate" method, the haemoglobin values of
the blood of the heifers were apparently normal, comparing these values with the average of the herd. There was no indication of an increase in the haemoglobin values of the heifers fed a supplement of 5 grams of ferric citrate for 21 days. Pregnancy results were negative, indicated by rectal examination 60 days after the close of the experiment, which showed none of the heifers to be pregnant.

**Physiological and Pathological Studies.**

Retained Placentae and Breeding History Following.

Retained placenta constitutes one of the most common and serious maladies among the diseases of the cow. While the condition is met with in all domestic animals and acquires importance in mares (1), there is no such number of instances in any other domestic animal as in the cow. The fetal membranes usually do not become detached until one-half hour to twelve hours after delivery of the fetus. If they are retained for a longer period, the condition is abnormal. Hammond (5) states that the average normal length of time for the placenta to be retained is 5 hours.

The part that retained placentae takes in the problem of sterility, due to pathological changes in the reproductive organs caused by infection, has been stressed by several authorities, (1), (3), (4), (5), (28) and (29). Some of the causes stated by these obstetrists are: prolonged labor at time of parturition followed by fatigue; inflammation of the cotyledons and fetal membranes as a result of bruise or infection with resulting adhesions; and poor
condition of the cow at calving time. Cystic ovaries; salpingitis; metritis and cervicitis are found to be closely associated with retained placentae.

During the period from 1925 to 1931, 32 cows had retained placentae. The following table shows in detail some of the effects of this trouble:

**TABLE XII.**

<table>
<thead>
<tr>
<th>No. of Cow</th>
<th>Estrum of</th>
<th>Services for History following retained placenta</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td></td>
<td>Sold for beef</td>
</tr>
<tr>
<td>32</td>
<td>90</td>
<td>2 Enlarged left ovary</td>
</tr>
<tr>
<td>52</td>
<td>85</td>
<td>1 Bred twice — not pregnant</td>
</tr>
<tr>
<td>216</td>
<td>59</td>
<td>1 Aborted</td>
</tr>
<tr>
<td>218</td>
<td>221</td>
<td>Metritis — uterus full of pus — sold as a non-breeder</td>
</tr>
<tr>
<td>222</td>
<td>80</td>
<td>Sold to butcher</td>
</tr>
<tr>
<td>228</td>
<td>216</td>
<td>Persistent corpus luteum</td>
</tr>
<tr>
<td>229</td>
<td>47</td>
<td>7 Cystic ovaries</td>
</tr>
<tr>
<td>(240)</td>
<td>61</td>
<td>1 Cystic ovaries</td>
</tr>
<tr>
<td>(240)</td>
<td></td>
<td>Metritis</td>
</tr>
<tr>
<td>244</td>
<td>33</td>
<td>12 Cystic ovaries</td>
</tr>
<tr>
<td>245</td>
<td>129</td>
<td>Chronic cervicitis — sold as non-breeder</td>
</tr>
<tr>
<td>(254)</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>(254)</td>
<td>31</td>
<td>2</td>
</tr>
</tbody>
</table>
TABLE XII - Cont'd.

<table>
<thead>
<tr>
<th>No. of cows</th>
<th>Estrum</th>
<th>Pregnancy</th>
<th>History following retained placenta</th>
</tr>
</thead>
<tbody>
<tr>
<td>(259)</td>
<td>59</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>(259)</td>
<td>77</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>445</td>
<td>56</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>457</td>
<td>25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>459</td>
<td>127</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>469</td>
<td>107</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>483</td>
<td>57</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>497</td>
<td>69</td>
<td>1</td>
<td>Aborted</td>
</tr>
<tr>
<td>(503)</td>
<td>71</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(503)</td>
<td>128</td>
<td>1</td>
<td>Cystic ovaries</td>
</tr>
<tr>
<td>(503)</td>
<td>49</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>510</td>
<td></td>
<td></td>
<td>Died of chronic pyometra</td>
</tr>
<tr>
<td>511</td>
<td>136</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>512</td>
<td></td>
<td></td>
<td>Cystic corpus luteum in right ovary no heat since.</td>
</tr>
<tr>
<td>514</td>
<td>102</td>
<td>2</td>
<td>Right ovary small and hard</td>
</tr>
<tr>
<td>515</td>
<td>137</td>
<td>3</td>
<td>Cystic ovaries</td>
</tr>
<tr>
<td>516</td>
<td>102</td>
<td>1</td>
<td>Cystic ovaries - bred 21 times</td>
</tr>
<tr>
<td>517</td>
<td>134</td>
<td>1</td>
<td>Aborted</td>
</tr>
<tr>
<td>518</td>
<td>195</td>
<td>1</td>
<td>Cystic ovaries</td>
</tr>
<tr>
<td>520</td>
<td>55</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>641</td>
<td>74</td>
<td>1</td>
<td>Died of chronic pyometra</td>
</tr>
<tr>
<td>648</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>656</td>
<td>57</td>
<td>1</td>
<td>Chronic metritis - very poor condition</td>
</tr>
</tbody>
</table>

Av. 90.6 days Av. 2.44 services
Numbers in brackets indicate successive retention of placentae in those cows. No. 503 had retained placenta following her first three parturitions.

This table shows that the average number of days before heat appears following retained placenta, is 90.6, and that the average number of services required for the next conception is 2.44, ranging from 1 to 12 services in individuals. Compared to the average of 39.34 days for cows having normal parturition, there is a difference of 51.26 days in the period before estrum first appears after calving. Of the 32 cows having retained placentae, 4, or 12.5 per cent of the total were sold as non-breeders; 2, or 6.25%, died from chronic pyometra (systemic infection); 9.37% aborted during the following gestation period, and 53.12% showed pathological changes of the reproductive organs.

Apart from the fact that the retention of placentae may result in infection causing sterility, the long interval of 90 days before estrum again appears is of practical significance. The average number of services required for the next conception is 2.44, covering two and one-half interovulation periods or about 52 days. The addition of this time to the 90 days would mean that it would be possible to have only two calves every three years, which would result in loss of time and production.

Although no bacteriological studies were made of these cases to ascertain the types of organisms present in infections following retained placentae, the data presented in Table XII supports the work of Williams (3), Beaver (4), Albrechtsen (28) and Quinlan (42),
who maintain the theory of cystic ovaries and other pathological changes of the genital tract as secondary lesions of infection. However, the theory of infection does not explain all of cystic ovaries or of sterility. Where there is no evidence of past or present infection, it would be difficult to explain or determine the factor or factors which cause these abnormalities in the normal reproduction of cows and heifers.

Cystic Ovaries.

Cystic changes are the most frequently encountered diseases of the ovaries. Several theories have been advanced as to the causes, among which is the rather popular belief that they are secondary lesions produced and sustained by the pathological condition of the uterus. Albrechtsen (28) found cystic degeneration of the ovaries associated with primary metritis, and that treatment of the metritis did away with the cystic degeneration. Of 181 cows with cysts, he found that more than half of them had a metritis and 179 had open cervical canals, the mucosa of which was swollen and hyperemic.

Supporting the theory of infection as a cause of cystic corpora lutea and cystic ovaries is the work done by Pitch (38), who obtained cultures from 15 ovaries containing cysts and cystic corpora lutea, from which he isolated streptococci and S. pyogenes. Rosenow and Davis (50) produced ovarites in rabbits experimentally by injecting intravenously pure cultures of these organisms. Lesions were produced in one or both ovaries, similar to those found
in the ovaries from which the organisms had been isolated.

Another theory (42) as to the cause of cystic degeneration of the ovaries and corpora lutea is that of a disturbance of the influence of the uterine or ovarian hormone, due to malnutrition, which has a decided effect on the normal functioning of the ovaries. Failure of the corpus luteum to undergo physiological resorption after a normal interovulation period, has been found to result in cystic degeneration.

A total of 30 cows and heifers were found, on rectal examination, to have cystic ovaries and cystic corpora lutea during the period from 1925 to 1931. Eleven of these were cows which had suffered from retained placentae (mentioned in another part of this report), and the other 19 were cows which were apparently normal in every way. Only 3 of the 30 were heifers. Twelve had not come in heat and 18 had been bred several times but failed to conceive. Ovulation, in all probability, did not occur, thus preventing conception. Lack of evidence of abnormal conditions in the 19 animals having cystic ovaries, such as purulent discharges, indicating infection, makes it impossible to suggest any factors which might cause the condition.

It is worthy of note in this study of cystic degeneration of the ovaries, that there is a tendency for recurrence of the disease. Nine of the total of 30 cows had cystic ovaries two or more times. The disease made its appearance again after a normal gestation period and a normal parturition. Eight cows were sold as non-
breeders during this period because of chronic cystic condition of the ovaries and the failure of treatment in the way of massage and operative removal, to correct the trouble.

Abortions - Other than Infections.

Of rather common occurrence among the cows of the herd were non-infectious abortions. All animals were negative to the abortion test, being tested once a month by the agglutination method. There were 16 abortions occurring during the period from 1928 to 1931 at intervals, from 2 to 8 months elapsing between each abortion. These cows were from 80 to 251 days along in their gestation period, the average number of days being 162.2. All necessary sanitary precautions were taken with each cow, including isolation, disinfecting and retesting for B. abortus.

An interesting history is afforded by one case of abortion. An aged Ayrshire cow was pronounced not pregnant on rectal examination, 167 days after her breeding date. Examination a month later showed the uterus filled with liquid. The uterus was irrigated by means of a catheter, and shortly after a mummified fetus was expelled, accompanied by a quantity of pus. After further irrigation of the uterus, the cow cleaned up and came in heat about a month later, was bred and conceived. The cow again aborted 123 days after conception. The cause, in all probability, of these two abortions was that of infection, which prevented the intimate connection of the fetal membrane to the uterine wall. Abortion followed, due to death of the fetus. Unfortunately this abortion occurred while
the cow was in pasture and the fetus and membranes were so badly contaminated with foreign material that the bacteriological study of it revealed nothing.

Results of Treatment with Alkaline Vaginal Douches.

A common practice among breeders of dairy cattle, and one which is recommended by many veterinarians, is that of administering alkaline or saline vaginal douches to cows that give breeding troubles. The recommendations are to give douches with 2% salt or 2% sodium bi-carbonate (baking soda) solutions, just prior to breeding.

During 1930, 29 cows, showing tenacious mucus secretions or abnormal vaginal discharges during the heat period, were douched with about 2 quarts of a 2% solution of sodium bicarbonate. Twenty-seven of these cows had been bred an average of 3.23 times and two were showing the first heat after calving. The douche was given immediately before breeding, the solution being drained out of the vagina by means of a glass speculum before the cow was bred. Eleven of these cows, or 37.93% became pregnant to the first service after douching, and 10.38% to the second service after treatment.

Comparing the percentage of pregnancies resulting after treatment with vaginal douches, 37.93%, with the average for the herd, 38.46%, it can be seen that the practice of douching did not increase the number of conceptions. However, since 27 of these cows
had been bred from 1 to 11 times, douching may have had some value in these particular cases.

In as much as sodium bicarbonate solutions or solutions of common salt of 2% strength have no or very slight antiseptic qualities, the benefits derived from these douches would be due to two factors. First, the mucus secreted by the mucosa of the genital tract becomes tough and stringy in an acid medium, while in a slightly alkaline medium it becomes fluid (5). Thus, the alkaline douche changes the consistency of the mucus, making a more favorable medium in which spermatozoa may show vigorous motility, thereby increasing the chances of the sperms in reaching the cervical canal and ultimate fertilization of the ovum. At the same time, excessive mucus is removed at the time of drainage.

Secondly, if the condition of the vagina is acid, the alkaline douche serves to neutralize the acid, again creating a more favorable environment for the spermatozoa, since a slightly acid medium is fatal to spermatozoa, (5), (51). This, however, may also be detrimental. The slightly acid condition of the vagina acts as an influence to cause the spermatozoa to seek a more favorable environment in the cervical canal where the condition is slightly alkaline. If this acidity is removed, part of the influence which urges the spermatozoa to go forward is also removed.

These results would seem to indicate that, in aiding conception, the practice of douching the vagina of the cow before service with an alkaline douche has but a limited value.
Evidence points to the fact that sterility in dairy cattle may be due to a number of factors which, singly or in any combination, results in reduced fertility of the male or female. The results of the survey showed that sterility is widespread and that losses in reduced milk and butterfat production and in reduced values of breeding stock due to this, are of vast economic importance to the industry. It is not confined to any one condition or area, but is prevalent in a great variation of climatic conditions and under many systems of feeding, care and management practices.

The results of the survey and experimental data indicate that the extent of sterility in many herds might be considerably reduced by improved methods of feeding and management of the bulls and of the cows. This is especially true of the cow at calving time, when there is definite need of preparation of the cow for parturition and the proper sanitary precautions to prevent infection. The experimental data showed conclusively that retained placentae result in reduced fertility of the cow. Nutrition, with special reference to minerals, has been shown to have an important bearing on the problem.

Those cases in which abnormalities occurred which were not accounted for may be secondary results of other factors. This work has been limited in its scope and from the results obtained the indications are that the problem requires a great deal of further investigation, especially in the fields of inheritance and in-
breeding and their relation to fertility. The bacteriological and pathological factors of sterility have been merely touched upon in this investigation. From the importance of these phases as stressed by other investigators of the problem (4), (36), (37) and (38), much work remains to be done to determine the extent of sterility caused by infection and the resulting pathological changes.
SUMMARY

1. Results of a survey showed that 21.86% of the cows and heifers in 56 herds had sterility, and 4.32% had been slaughtered as non-breeders during the year. These herds represented nearly all dairy sections of the state of Oregon.

2. Sterility was most prevalent in those herds in which no breeding records were kept; pasture breeding was practiced; and poor systems of management of herd sires existed.

3. There was found to be a definite relation between the bull and the breeding efficiency of the herd.

4. Microscopical studies of spermatozoa indicated a relation between the motility and the viability of the spermatozoa and the percentage of conceptions following the matings at which such specimens were collected.

5. There was found to be evidence of a relation between promptness and vigor of the bull at the time of service and the percentage of resulting pregnancies.

6. The percentage of services resulting in pregnancies in the College herd was 48.02, an average of 2.08 services per pregnancy.

7. Mineral deficient rations were found to interfere with normal reproduction in cows.

8. Cystic degeneration of the ovaries was found to recur after operative removal.
9. No apparent causes were determined for abortion occurring in cows which were negative to the agglutination test for B. abortus.

10. Both temporary and permanent sterility resulted from pathological changes caused by retention of placentae.

11. The feeding of wheat germ meal, a supplement rich in vitamin E, had little value in aiding conception.

12. The feeding of 5 grams of ferric citrate per day to sterile heifers for a period of 21 days did not seem to increase the haemoglobin values of the blood of the heifers, nor did it overcome sterility.

13. The practice of administering vaginal douches of 2½ sodium bicarbonate solution to cows before breeding, did not increase the percentage of resulting pregnancies over the average of the entire herd.
ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. I. R. Jones and to Professor P. M. Brandt for their assistance in planning and carrying out this work, and for their helpful criticism in the preparation of this thesis; to the Department of Veterinary Medicine for cooperation in the work, especially to Dr. A. M. McGapes and to Dr. O. H. Muth.
BIBLIOGRAPHY


42. Quinlan, John - Researches into Sterility of Cows in South Africa. Union of South Africa Dep't. of Agr., 13th and 14th Reports of Vet. Education and Research, 1929.


