A STUDY AND CLASSIFICATION OF BOVINE OVARIAN ABNORMALITIES

by

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Literature Review

Definition of a follicle

Dorland (1965) defined an ovarian follicle as an ovum and its encasing cells at any stage of development. Follicles develop and regress throughout a cow's lifetime. Usually, one follicle ovulates at each estrus, but double ovulations are not uncommon. Follicles that fail to rupture or become atretic and are associated with abnormal sexual behavior and abnormal ovarian morphology have long been considered a deterent to maximum fertility in the cow.

Thin Walled Follicular Cysts

Clinical Classification. McNutt (1927) and Hancock (1948) classified follicles 20 mm or greater in diameter as cystic. Marion and Gier (1968) classified follicles 20 mm or greater in diameter that persisted for 16 to 20 days as cystic. Follicles 25 mm or larger were called atretic large follicles (ALF) by Wiltbank, Tyler and Casida (1953). Morrow, Roberts, McEntee and Gray (1966) classified follicles 25 mm or larger on three palpations within a 10 day period as cystic.

Clinical Observations. Clinical observations prior to 1944 were reviewed by Casida, McShan and Meyer (1944). Garm (1949) used nymphomania to describe all cystic conditions. Symptoms of cystic follicles were interruption of sexual cycle and sexual desire, persistent cystic follicles, and absence of corpora lutea. He classified nymphomania cows into four groups. Cows with "classical nymphomania" with permanent or frequent heat, relaxed pelvic ligaments, enlarged atonic uterus, and swollen vulva composed the first group. These cows would accept the bull at any time and had large cysts "goose egg" (no measurement given) in size on one or both ovaries. Cysts were thin walled and easy to break. Cows in the second group exhibited

normal heats at normal intervals. Relaxed pelvic ligaments, swollen vulva, and a large flabby uterus were observed in 32%, 28%, and 41% of the cows in group two respectively. Cows with mild symptoms of heat at infrequent intervals (group three) had other symptoms similar to group two. The fourth classification included anestrous cows. These animals became fat and relaxation of pelvic ligaments usually was not observed. A small uterus was observed in 10% of the group four animals, but an enlarged atonic uterus was most common. Ovarian structures were similar to other groups.

Benesch and Wright (1951) classified cystic follicles as follicles that failed to rupture, developed to a size larger than normal, and persisted. They reported that the cystic follicle may or may not contain luteal tissue. Behaviorally, the cows exhibited anestrus, irregular heat, or classical nymphomania.

Wiltbank et al. (1953) used the term atretic large follicles (ALF) instead of cystic follicles and cited five classifications: 1) cows with ALF that exhibit bullish behavior, irregular heat periods, and no corpora lutea on the ovaries, 2) cows with ALF appearing during the regular estrus cycle with normal corpora lutea present, 3) cows with ALF during temporary suspension of the estrous cycle and corpora lutea may be present or absent, 4) cows that have ALF during the postpartum anestrous period with or without corpora lutea present, 5) heifers with ALF during the prepuberal anestrous period and corpora lutea may be present or absent.

Bone (1954) classified cysts as uncomplicated or as associated with a corpus luteum. Uncomplicated cysts were larger and tenser than normal follicles. Small follicles were associated with the larger ones, and not more than two large cysts per ovary were found. Ruptured, uncomplicated cysts left medullary stroma, fibrous connective tissue, and blood vessels.

Hinze (1959) found that the size of the cyst did not affect its function. He reported that cysts no larger than a graffian follicle could be responsible for either nymphomania or anestrous behavior. Small cysts were found in postpartum cows and in heifers. In several cases the ovaries felt normal per rectum, but slipping the ovary between the thumb and fingers would rupture a cyst leaving little substance to the ovary. Estrous behavior was dependent upon whether the cyst was "follicular or luteal".

Roberts (1961) classified cystic ovaries as a pathologically large follicle causing symptoms of nymphomania with frequent, irregular or continuous estrus or anestrus. Seventy-five percent of all cystic animals showed classical nymphomania. The uteri of animals in constant estrus were atonic and thick. Usually two to four cysts were found on the ovaries. These cysts were 19 to 76 mm in diameter and the walls thicker than normal follicles, but they ruptured easily. Cysts four inches or greater in diameter indicated a granulosa cell tumor.

Bierschwal (1966) found that cows with cystic ovaries were either in continuous estrus or anestrus. Cystic cows had one or more spherical, smooth-surfaced, fluctuating structures on one or both ovaries. These cysts were larger and protruded more than normal graffian follicles. Uteri were enlarged and flaccid.

Morrow et al. (1966) and Morrow (1969) reported that a cow going cystic resembled a cow coming into heat. There was an increase in uterine tone and in the number of follicles on the ovaries. Two to three days later some cows had an anovulatory estrus, but usually ovulation without estrus occurred. Uterine tone decreased, the follicles grew larger (no measurement given), and no corpus luteum formed. Cysts were palpated as single large thin walled structures on one or both ovaries. Anestrus accompanied by a swollen vulva

were the most common external signs in cows with cysts less than 60 days postpartum. Cysts forming after 60 days postpartum were smaller and thicker walled and most commonly accompanied by nymphomania and related anatomical changes.

Johansson and Rendel (1968) stated that nymphomania was usually associated with short returning heats, and that cystic ovaries were associated with "buller" cows. Nymphomania resulted in cases where thin walled cystic follicles persisted for a few weeks to several months (Marion and Gier, 1971). Zemjanis, Fahning and Schultz (1969) found that many cows with follicular cysts were anestrus, but it was not necessary to distinguish between anestrus and nymphomaniac cows because the same therapy cured both conditions.

Callahan et al. (1971) classified a cow cystic if she sxhibited one of three conditions: 1) follicles persisted for 14 days with no corpus luteum present, 2) ovulation was delayed more than seven days postestrus, or 3) a corpus luteum was not detectable seven days after ovulation. They reported that cystic cows had a later first postpartum ovulation (29± 3.9 vs. 17± 1.0 days), earlier first estrus (25± 3.0 vs. 34± 3.3 days), later formation of a 15 mm corpus luteum (39± 3.7 vs. 25± 1.5 days) and earlier formation of a 10 mm follicle (15± 1.2 vs. 20± 2.3 days) than did control cows. Erb, Randel, and Callahan (1971) reported that cows detected as cystic before 42 days postpartum had follicles 1 cm or larger by 16± 1.4 days postpartum, and 22% had ruptured within 9 days of detection. Ninety-five percent of the control cows ovulated within 9 days after detection of a 1 cm follicle. Cows usually had an anovulatory estrus prior to being diagnosed as cystic.

Macromorphology. Garm (1949) reported that multiple cysts occurred more often that did single cysts. Morrow (1969) observed only single cysts. McNutt (1927), Clapp(1934), Hancock (1948), Bierschwall (1966) and Callahan

et al. (1971) found both single and multiple cysts and did not designate which was most common. Follicular cysts may be accompanied by a corpus luteum (Wiltbank et al., 1953; Bone, 1954; Dawson, 1958) or may not (Clapp, 1934; Garm, 1949; Wiltbank et al., 1953; Bone, 1954; Marion and Gier, 1968; Morrow, 1969; Callahan et al., 1971). Roberts (1961) found the lining of cysts smooth. Fluid in thin walled cysts was clear to slightly yellow or amber in color (Garm, 1949; Roberts, 1961; Siegmund, 1970).

Micromorphology. Literature on histological structures of cysts prior to 1949 was reviewed by Garm (1949). Histological findings since this review have been reported by several workers. Stratum granulosa cells were found present in some cysts and not in others (Garm, 1949; Bone, 1954; Roberts,1961; Siegmund, 1970). Garm (1949) and Roberts (1961) found granulosa cells that seemed to be luteinized. Cells of the theca interna were edematous and showed degenerative changes (Roberts, 1961; Siegmund, 1970). Garm (1949) and Roberts (1961) observed hyalinization of cells in the theca interna. Bone (1954) described the theca externa of cystic follicles as thickened and fibrous. Roberts (1961) reported that degenerative changes were most advanced in the periphery of the cyst.

Marion, Gier, and Choudary (1968) provided detailed histological descriptions of cystic follicular atresia. Cystic atresia began with loosening and sloughing of the granulosa cells while the membrana propria remained intact. The basal granulosa layer was maintained and the cells did not appear altered. Theca interna cells appeared to be stimulated when the granulosa had regressed to one cell layer. Increased fluid caused the follicle to increase in size, thus stretching and thinning the theca interna to about 25 μ. The remaining granulosa cells stretched to the "string of pearls" orientation. Glandular theca interna cells did not appear to increase in numbers or volume.

Bone (1954) assumed that atretic follicles could be halted after destruction of the ovum and the theca interna might continue to secrete follicular fluid forming a cyst. A follicular cyst may increase to about double the diameter of the follicle at the onset of atresia (Marion et al., 1968; Marion and Gier, 1971). These cysts degenerated when the string of pearls was broken and the glandular theca interna cells disappeared (Marion et al., 1968).

Endocrine Hypotheses. Four hormones are directly important to the sexual function of the cow (McDonald, 1969). Two of these are gonadotropins: follicle stimulating hormone (FSH) and luteinizing hormone (LH), which are protein compounds released from the anterior pituitary. The others are steroid compounds: estrogen and progesterone, which are produced mainly in the ovary of the cycling animal. These compounds are synergestic and deviation from normal levels of one hormone may interrupt the entire sexual scheme.

Garm (1949) postulated that clinical symptoms of nymphomania were caused by abnormally high estrogen levels. Conversely, anestrus was not due to low estrogen levels because some anestrous cows also had relaxed pelvic ligaments. Histochemical analysis revealed that estrogen precursors in theca interna cells of cysts were constantly being mobilized. Roberts (1961) found that follicular fluid of cysts contained less estrogens per unit volume than follicular fluid of graffian follicles. Marion and Gier (1971) assumed that because of retention of theca interna cells and reduced numbers of granulosa cells, estrogens were being produced by cysts. Cows that were subsequently cystic had lower urinary estrogens than normal cows 0 to 42 days postpartum (Erb et al., 1971).

Wiltbank et al. (1953) presumed nymphomania and associated thin walled cysts to be a pituitary-ovarian malfunction. The difference between cysts of nymphomaniac and anestrous cows was assumed due to a hormonal disturbance

of a different functional level. Garm (1949) postulated the pituitary as the primary cause of nymphomania because it produces the gonadotropins and is easily affected by the nutritional status of the animal. Pituitary weights and volumes were greater in cystic cows than were pituitaries of noncystic cows. No difference was found in proportions of pituitary cell types in cows with permanent heat and in anestrous cows. He considered that constant estrogen stimulation might have changed pituitary histology, and that persistence and nonluteinization of follicles showed that basophile cells had lost their ability to produce LH. He suggested that successful gonadotropin therapy shows a disturbance of ovulatory mechanism due to pituitary dysfunction, not ovarian dysfunction.

Hancock (1948) postulated that high blood estrogen levels as in late pregnancy or after diethylstilbestrol (DES) injections would first cause the pituitary to lose its ability to stimulate luteal function, and then lose its ability to stimulate follicular growth. After pregnancy the reverse might occur. The pituitary might first gain its ability to stimulate follicular growth, then gain the ability to ovulate and luteinize follicles, and cysts would be formed in between. Wiltbank et al. (1953) considered that cysts could result from a rebound of anterior pituitary function after the inhibition by high estrogen during pregnancy. They showed a period of cystic ovaries after cows were withdrawn from DES injections and postulated that a transient period of cyst formation might always follow withdrawal from high estrogen levels.

Casida, et al. (1943) determined that follicular growth was aided by more than FSH because cows injected with unpurified pituitary extract had larger follicles than cows injected with purified FSH. Venzke (1949) postulated that in multiple ovarian cysts the pituitary gonadotropin balance

would be on the side of FSH resulting in increased estrogen output. Roberts (1961) stated that abnormal levels of LH could be a causative factor. Johansson and Rendel (1968) stated that cystic follicles and nymphomania are due to increase of FSH and decrease of LH released from the anterior pituitary. Cows with delayed ovulation four or more days after heat did not have an LH surge as determined by radioimmunoassay but had higher blood levels of LH 8 to 40 hours after estrus than cows that ovulated normally (Garverick, et al. 1971). Callahan et al. (1971) determined by radioimmunoassay that cysts were caused by overstimulation of FSH and understimulation of LH during the first 2 to 3 weeks postpartum.

Kittok, Britt and Edgerton (1972) compared cystic and normal cows and reported that blood estrogen levels were higher and blood progesterone levels were lower in cystic cows. Estrogen levels were not different in cystic cows with normal cycles compared to cystic cows with short cycles.

Incidence. Fincher (1950) observed that 16 of 44 cows (27.5%) with ovulation failures were cystic. From a 10 year study, Casida and Chapman (1951) reported that 18.8% of 341 cows and 7% of 1280 total service periods (heat periods or breedings) were cystic. Twenty percent of the cows observed by Wiltbank et al. (1953) had atretic large follicles in at least one reproductive period, and one or more atretic large follicles were found in 31 of 274 (11.3%) reproductive periods. Seven of the 274 cows were "classical nymphomaniacs". Bone (1954) reported 16 of 155 cows (9.7%) cystic. Cystic ovaries and short estrous cycles directly delayed conception in 29.4% of the cows studied by Hinze (1959), and cysts were directly involved on 12.13% of the cases. Porter and Belling (1960) found 3.6% occurrence of cysts. Cysts were found in four percent of the examinations performed by Zemjanis, Larson and Bhalla (1961). Morrow et al. (1966) reported cystic follicles in 40 of

139 experimental cows (34.8%), and 18.2% of the experimental cows had cycles of 15 days or less. Bierschwal (1966) observed 55 of 187 cows (34%) as "classical nymphomaniacs". In a study of cows 10-50 days postpartum 306 of 2,838 cows (10.8%) were cystic (Tennant, Kendrick and Peddicord, 1967). Cysts occurred in 12% of the estrous cycles less than 60 days postpartum (Morrow, 1969).

Time of Occurrence. Garm (1949) observed that 13.0%, 30.0%, 31.0% and 15.0% of the cows were cystic during the first, second, third, and fourth month postpartum, respectively. Wiltbank et al. (1953) reported 6.0%, 5.1%, 0.67%, and 0.69% occurrence of cysts during postpartum intervals 15-29 days, 30-44 days, 45-59 days and 60-74 days respectively. Morrow et al. (1966) observed 20.0% of the cows cystic at the first postpartum estrus and 7.0% cystic at the second postpartum estrus. Sixty-one percent of the cystic cases found by Bierschwal (1966) occurred less than 60 days postpartum. Marion and Gier (1968) reported that the occurrence of cysts was the same for the first and second postpartum estrus. Occurrence of new cysts was low 36-78 days postpartum, and cysts persisted for an average of 35 days (range 25-60 days). Morrow's (1969) results showed cysts most common 15-45 days postpartum.

Luteinized Follicular Cysts

Clinical observations. Benesch and Wright (1951) described follicles that luteinized without ovulating. The ovaries felt larger than usual and fluid-filled when palpated per rectum. Sectioned cysts were about 30 mm in diameter and the wall was lined by a 2 mm thick layer of luteinized cells. The large cysts were single structures, but regressing corpora lutea were found on the ovaries. Positive identification of this condition per rectum was postulated improbable. They stated that this type of cyst had been called

a cystic corpus luteum, but many corpora lutea with a central cavity lined with collagen fibers had been found, and the two cysts should not be classified as the same. They stated that anestrous cows could have a luteinized follicle on one ovary.

Dawson (1958) reported on six cases of luteal cysts. Cysts were 10-70 mm in diameter and all lined with varying amounts of luteal tissue. Endometritis was found in all cases. One cow having a luteal cyst, two solid luteal bodies, and two thin walled cysts exhibited masculine behavior. Another cow having a single large cyst with a luteal lining exhibited regular cycles with normal estrous signs. Both of the aforementioned cows had severe endometritis.

Johnson (1960) found "luteal type" cysts in cows 39-150 days postpartum. Cysts were 50-100 mm in diameter and easily ruptured in the estrous or early metestrous stage. Ten days postestrous cysts could not be expressed. Histological examination indicated that cysts were the "luteal type".

Roberts (1961) classified spherical, smooth and tense ovarian structures that felt like thick cystic follicles as pathologic cystic corpora lutea or luteal cysts. Pathologic cystic corpora lutea were 25 to 50 mm in diameter and were single structures on the ovaries. Pathologic cystic corpora lutea developed from anovulatory follicles. A layer of luteal tissue 3 to 15 mm lined the circumference of the cysts.

Luteal cysts and anovulatory luteinized follicles were difficult to differentiate from cystic follicles rectally and were classified with follicular cysts (Morrow et al., 1966; Morrow, 1969; Morrow, 1971).

Marion et al. (1968) described luteinized cystic follicles as tough leathery cysts up to 50 mm in diameter. Luteinized cystic follicles were found in 2-3% of the ovaries examined, but could be one-third of the clinically detectable cysts. Luteinized follicular cysts persisted for an average of 35 days. Zemjanis et al. (1969) found that practically all cows with luteal cysts were anestrus.

Micromorphology. Donaldson and Hansel (1965) reported luteinization of both the theca interna and granulosa cell layers of large follicles three to four days after estrus. Marion et al. (1968) reported luteinization in follicles larger than 8 mm in diameter, and the layer of luteal tissue was 50 μ to 5 mm thick. Granulosa and theca interna cells were both luteinized if present, but they did not intermix. If the membrana propria was broken, the granulosa and theca interna were intermixed and a near typical luteal layer was formed (Marion and Gier, 1971).

Endocrine Hypothesis. Casida et al. (1944) reported that injection of unfractionated pituitary extract caused luteinization of large follicles if the stratum granulosum was not already degenerated. Roberts (1961) postulated that a follicle may ovulate but for some reason not develop into a corpus luteum, and sufficient LH would remain to luteinize small follicles that normally would degenerate. A pathologic cystic corpus luteum could develop from a mature follicle when insufficient LH is present to cause ovulation, but sufficient LH is available for luteinization of the follicle (Roberts, 1961). Marion et al. (1968) theorized that luteinized-cystic follicles developed from atretic follicles at the time of the ovulatory LH surge and were in a condition permitting them to luteinize under the influence of LH. A pathologic cystic corpus luteum developed in 13% of the cows where ovulation was delayed by progesterone injections (Trimberger and Hansel cited by Roberts, 1961). Roberts (1961) suggested that the pathologic cystic corpus luteum (luteal cyst, luteinized cystic follicle) resulted from the same endocrine disturbance that caused cystic follicles which was probably failure of LH release, and the severity of the condition was directly related to the amount of LH released. Hormones produced by the luteal tissue interrupted the normal hormonal balance resulting in anestrus.

Jones and Nalbandov (1972) reported that intrafollicular injection of LH or FSH in amounts too small to cause ovulation resulted in luteinization of granulosa cells, "membrana granulosa", cumulus oophorus and corona radiata in rabbit ovarian follicles. Blood estrogen levels were not measurable in rabbits with luteinized follicles even though untreated and unovulated follicles were present. The assay used was sensitive to concentrations of picograms per milliliter.

Incidence. Zemjanis et al. (1961) found luteal cysts in 1.7% of the cases studied. Roberts (1961) reported a pathologic cystic corpus luteum in 3% of cows with cystic ovaries. Morrow et al. (1966) concluded that the frequency of luteal cysts was low and did not differentiate luteal cysts from thin walled follicular cysts. Marion and Gier (1968) found luteinized-follicular cysts in 32 of 250 cows (12.8%) over a four year period. Marion and Gier (1971) stated that the luteinized follicular cyst was the most common cyst found.

Cystic Follicles

Influence of Hormones Other Than FSH and LH. Garm (1949) postulated that the pituitary of a cow with cystic follicles was secreting higher than normal amounts of ACTH as well as LH. His theory was that estrogen produced by the anovulatory follicle caused more secretion of ACTH resulting in hypertrophy of the zona glomerulosa and increased production of sodium-retaining hormones. The higher sodium concentration in the follicular fluid could have caused movement of fluid into the lumen of the follicle resulting in cystic dilation of the follicle. The stretching of the theca interna might have caused degenerative changes. The relaxation of the pelvic ligaments and the salty and bitter taste of the milk observed in some cows with cystic follicles could be caused by such a mineral imbalance.

Roberts (1961) stated that the adrenal gland has little significance to reproduction. Rarely, tumors of the adrenal cortex produce androgens that cause masculinization of the female. Because of demands on the body, the adrenals hypertrophy during gestation and the first one-third of lactation. Increased activity of the adrenal and thyroid glands during late pregnancy and early lactation may affect anterior pituitary function.

Wagner and Oxenreider (1971) stated that an increase in adrenal steroid production may inhibit luteal development by influencing LH activity and/or LH release. They postulated that this could contribute to a postpartum anestrus.

Anestrus. Roberts (1961) divided anestrous cows into two classes: 1) cows with a corpus luteum present, and 2) anestrous cows with small inactive ovaries and no palpable corpus luteum, including cows with cystic ovaries. Twenty-five percent of the anestrous cows had cystic ovaries with anestrus persisting from one to four months. Many of the cows had symptoms of estrus but would not stand for a bull. Pelvic ligaments were relaxed in some cases but not in all cystic anestrous cows. An anestrous cow had more uterine tone, less swelling of the vulva, and less mucus than did a cow with nymphomania. Ovarian cysts of anestrous and nymphomaniac cows were the same size and felt the same per rectum. Occasionally, a nymphomaniac cow would develop anestrus, but anestrous cows seldom became nymphomaniacs. Roberts described anestrous cows as generally fat and lazy with partially relaxed pelvic ligaments and having the appearance of a pregnant cow.

Asdell, de Alba, and Roberts (1945) theorized that an estrous block in the central nervous system could be the cause of anestrus. They found that injections of diethylstilbestrol could bring cows into heat for less than one day; and although injections were continued, standing heat ceased.

The same theory was applied to explain why psychic estrus ends before ovulation and why cows could be anestrus while large follicles were on the ovaries. This refractiveness could also be confounded in the cow because smaller amounts of estrogen per unit of body weight will produce heat in the bovine than in some other animals. Garm (1949) stated that anestrus is not always a result of decreased estrogen production because some anestrous cows showed edema of the vulva and relaxation of the pelvic ligaments.

Roberts (1961) cited three other possible causes of anestrus. 1) If enough luteal tissue was present in a follicle, the cow would usually be anestrus. 2) Anestrus could result from storage of estrogen in the theca interna thus no estrogen was released into peripheral circulation. 3) Failure of the cyst to produce enough estrogen to produce psychic estrus might cause anestrus. Cysts in anestrous cows had little estrogen and a thin theca interna layer that was partially luteinized in some cases.

Factors like the number of times a cow is milked or sucked per day could cause anestrus (New Zeland Dairy Board, 1969-70). Cows milked twice daily and cows constantly exposed to a calf were anestrus 56.9% and 100% of the time respectively during the first 60 days postpartum.

Bierschwall (1966) stated that an increase in the number of anestrous cows could be attributed to factors such as early postpartum examination, type of herd management, and higher milk production of modern dairy cows.

Erb et al. (1971) stated that release of LH at parturition may be so extensive that the pituitary cannot recover for some time so sufficient LH for ovulation may not be available later.

Stress. Selye (1950) reported that stress resulted in ACTH release. Roberts (1961) noted that enlarged adrenal glands were found in cows in the late stage of gestation and first one-third of lactation. He stated that

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increased demands on the body for adrenal secretions cause this hypertrophy. Morrow et al. (1966) reported that several cows were anestrus after regression of the corpus luteum of pregnancy. These cows usually developed cystic follicles or anestrus due to loss of body condition because of disease or high milk production. Correlations for season, herd environment, parity, and level of production on cystic follicles showed only one significant factor ($P < 0.005$) which was the period of November through January when significantly more cysts occurred. Morrow (1969) stated that stress predisposes cows to cystic follicles.

Saiduddin and Foote (1964) found that in postpartum cows that had not ovulated, pituitary LH increased in concentration as postpartum interval increased. Assays were run on collections of 5, 17, and 30 days postpartum.

Cook (1968) stated that pigs and sheep injected with LH had increased progesterone in the ovarian venous blood, but some did not. He suggested that stress could affect this hormonal relationship in two ways. The systemic release of ACTH by the animal could lead to maximal stimulation so that no response to exogenous LH could be detected. Stress resulted in growth hormone release in monkeys, and release of LH could be similarly induced so the animal would be maximally stimulated by gonadotropin and exogenous LH would not cause notable ovarian changes.

Brunner, Donaldson and Hansel (2969) found that injections of ACTH from the second to eighth days of the estrous cycle decreased the size of the corpus luteum in intact heifers but not in hysterectomized heifers. The reason for the difference between intact and hysterectomized heifers was not explained.

Relation to Milk Production. Clapp(1934) stated that level of milk production is a function of heredity and environment. He found that herds genetically capable of high milk production, and fed meagerly probably would not show a high incidence of cystic follicles; while cows not genetically

capable of high milk production but fed to produce large quantities of milk would have more cysts. Garm (1949) stated that there is no link between genes for nymphomania and genes for high milk production.

Casida and Chapman (1951) reported the incidence of cystic follicles in four production groups, Table 1. Differences between cows on official test and those not on test were cited as higher feed consumption, higher milk production, and more frequent milking.

TABLE 1. PERCENT OF SERVICE PERIODS WITH CYSTIC OVARIES IN FOUR PRODUCTION GROUPS

Group	Service Peroids	Percent Cystic
Not milking	358	3.4**
Milking (2x)	457	6.8**
On official test (3x-4x)	359	10.6**
Started on official test and moved to 2x	105	8.5**

** P <.01

Wiltbank et al. (1953) found no significant difference in occurrence of cystic follicles between production groups. Cows with a high heritability for milk production were 9.2% cystic and cows with low heritability for production were 11.6% cystic. Morrow et al. (1966) and Morrow (1969) reported that levels of milk production were not significantly different ($P < .05$) between cystic and non-cystic cows. Marion and Gier (1968) found a 7.0%, 9.9% and 22.6% occurrence of cysts in cows producing 22 kg/day, 22 to 30 kg/day, and more than 30 kg/day respectively in the first four months of lactation. All three percentages were statistically different ($P < .05$).

Johansson and Rendel (1968) stated that problems arise in high producing cows because the right balance between genotype and environment has not been reached. Under comparable environmental and feeding situations dairy cows were as fertile as beef cows even though the dairy cow produced much more milk. They stated that until a genetic correlation between high milk yield and predisposition to reproductive disturbances was proven, animals should not be selected on the basis of this correlation.

A significant rise in plasma cortisol at the time of milk removal was reported by Wagner and Oxenreider (1971). They stated that this rise may have some relation to oxytocin release. The increased level of corticoids may influence LH and thus influence ovulation in some way. Whatever the mode of action, they concluded that lactation and milk removal hinder maturation and ovulation of ovarian follicles.

Effect on Calving Intervals. A cow's calving interval was described by Buch, Tyler and Casida (1959) as the time interval between two consecutive parturitions. Morrow et al. (1966) determined the period from parturition to conception and added the days of an average lactation to arrive at the calving interval.

Wiltbank et al. (1953) reported that cystic cows with nymphomania, cystic cows without nymphomania and non-cystic cows conceived 200, 192, and 136 days postpartum respectively. The interval from parturition to first estrus was 37 days in cystic cows and 29 days in non-cystic cows (Morrow et al., 1966). This difference was significant ($P < 0.01$). Marion and Gier (1968) reported that follicular cysts were the factor most highly correlated to the increase of postpartum interval to first ovulation, first estrus and conception. Callahan et al. (1971) reported that 60% of the cows diagnosed cystic had a calving interval less than 13 months, 30% 13 to 15 months, and none

calved over 15 months. Among the control cows 77.6% calved less than 13 months, 11.2% calved 13 to 15 months and 11.2% had a calving interval of 15 months or more.

Heritability. Clapp (1934) reported that 16% of the daughters of cows with a history of cysts developed cysts. Non-cystic cows had daughters of which 10.7% developed cysts. Garm (1949) stated that in the Holstein-Friesian breed there was every reason to believe cysts were heritable. Casida and Chapman (1951) found that 26.8% of the daughters of cystic dams and 9.2% of the daughters of non-cystic dams became cystic. They calculated the heritability coefficient for cystic follicles at 0.43.

Tabler, Tyler and Hyatt (1951) stated that with current breeding practices variation between cow families was too small to select for breeding efficiency. Wiltbank et al. (1953) found a significant difference in the occurrence of cysts between six lines of cattle ($P < .01$). They calculated the heritability coefficient for follicular cysts as 0.43, and concluded that the magnitude of the cystic condition depended on the line of breeding.

Roberts (1961) stated that the two abnormalities of ovulation, cysts and twinning, are closely associated and both may be hereditary. Johansson and Rendel (1968) suggested that hormonal disturbances such as cystic ovaries are to some extent hereditary and causative genes should not be maintained in the population. They also stated that there is some relation between cystic ovaries and multiple births, and "cystic ovaries show a clear tendency to repetition".

Relation to Season of Year. Benesch and Wright (1951) observed that cysts were most common in the winter and that many cows recovered in the spring when turned out of the barn. Wiltbank et al. (1953) reported the highest occurrence of cysts during November and the lowest incidence from

April to May. Roberts (1955) found the most cysts during December, January and February. Bierschwal (1966) reported that 70.2% of the cysts were found during September through March. Marion and Gier (1968) detected a higher incidence of cystic cows during the fall (13.4%) compared to the spring (8.6%). Morrow et al. (1966) found no significant difference ($P < .01$) in occurrence of cystic follicles throughout the year.

Marion and Gier (1968) suggested the seasonal stress may add to stress of production, thus aiding in formation of cysts. Wiltbank et al. (1953) admitted that seasonal effect is hard to explain, and suggested that light, weather and management changes could be part of the cause.

Relation to Abnormal Calvings and Periparturient Diseases. Albrectson (1917) found more cysts in cows with periparturient diseases and attributed the cause of the cysts to direct infection of the ovary by the invlictor of the disease. Morrow et al. (1966) reported that 8.3% of normal cows and 23.4% of abnormal cows ($P < .005$) developed cysts. At first estrus 15.0% and 38.0% of the normal and abnormal cows, respectively, were cystic. Morrow (1971) reported that 20% of the normal cows and 27% of the abnormal cows develped cysts. Morrow et al. (1966) suggested that abnormal calvings and periparturient diseases predisposed cows to cystic follicles.

Treatment. Casida, McShan and Meyer (1944) injected unfractionated pituitary extract intravenously into cystic cows with normal uteri. Corpora lutea were formed in 55 of 71 cows (77%) within 31 days of one injection. Hancock (1948) reported that injection of LH seemed to be effective in ovulating follicles or causing them to luteinize and allowing the cows to return to normal. Manual rupture at the time of LH injection in some cases aided recovery. A high twinning rate was encountered, so he suggested breeding on the second estrus after treatment. Venzke (1949) stated that a

treatment which increased LH level and thus would increase progesterone level would cure numphomania. Intraveneous injections of dried sheep pituitary or HCG were suggested. Repeated treatments indicated uterine pathological problems. He also suggested breeding on or after the second post treatment heat period.

If cysts were detected early, Fincher (1950) suggested manual rupture as the best treatment. Valuable cows in early stages were given 5,000 rat units of chorionic gonadotropin intravenously and 5 cc of adrenalin subsequently to stop any anaphylactic reaction. Benesch and Wright (1951) suggested four modes of treatment: 1) rupturing the cyst by palpation through the rectal or vaginal wall, 2) puncturing the cyst through the vaginal wall with a needle, 3) using hormones, and 4) allowing time for the condition to correct itself.

Hinze (1959) suggested using gonadotropic hormone if it would work alone. If the cow did not respond with one or two treatments, he assumed the ovary was incapable of reactivation or a gonadotropic imbalance was not the problem. The best results were found when the cyst was manually ruptured at the time of hormone injection. Hinze reported equal results with purified LH, chorionic gonadotropin and anterior pituitary gonadotropin.

Roberts (1961) warned against manual rupture of cysts because of trauma, blood loss, formation of adhesions on the ovary, and poor recovery rates. Manual rupture with LH injections did not benefit recovery when compared to LH injection alone. Recovery rates for cows treated with manual rupture plus LH and cows treated only with LH were 84.3% and 84.5% respectively. Conception rates in subsequent breedings for the same treatments were 71.9% and 76.7% respectively. Progesterone, estrogens, and testosterone have been used unsuccessfully to treat cystic ovaries.

Morrow et al. (1966) reported a 48.0% recovery rate without treatment. Cystic cows that had not recovered spontaneously were treated after 60 days postpartum with 10,000 I.U. of chorionic gonadotropin, one-half intravenously and one-half intramuscularly. The cysts were not ruptured at the time of treatment and 85.7% of the cows recovered. Cysts degenerated 15 to 18 days after treatment. Marion and Gier (1968) stated that 7 of 29 cystic cows (24.2%) did not recover spontaneously by 78 days postpartum.

Zemjanis et al. (1969) used LH treatment with manual rupture and reported that the treatment worked well. Siegmund (1970) suggested four points of prophylaxis and treatment: 1) select against cysts, 2) avoid forced milk production, 3) allow time for spontaneous recovery, and 4) if treatment is necessary inject 25 mg of LH intravenously or chorionic gonadotropin 1,000 to 10,000 I. U. intramuscularly or 2,500 to 5,000 I.U. chorionic gonadotropin intravenously.

Effect of Parity. Wiltbank et al. (1953) found that 4.6%, 14.8% and 17.5% of the cows in the first, second, and third reproductive periods (interval from puberty to first parturition, and parturition to parturition intervals thereafter) respectively were cystic. Morrow et al. (1966) found no significant difference in occurrence of cysts in different lactations.

The Cystic Corpus Luteum

Clinical Observations. Dorland (1965) defined a cystic corpus luteum as "a cyst of the ovary formed by serous accumulation developed from a corpus luteum". A cystic corpus luteum in the cow was described as a follicle that has ovulated and luteinized, but contains a central cavity (Dawson, 1959; Hansel and Wagner, 1960; Staples et al., 1961; Morrow et al., 1966; Zemjanis, 1970). Dawson (1959) described cystic corpora lutea with 70% or more of the volume in luteal tissue as borderline cysts, and cystic corpora lutea with 37% or less of the volume in luteal tissue as definite cysts. Morrow et al.

reported that cystic corpora lutea contain a fluid filled central cavity approximately 10 mm or more in diameter. Cysts palpated per rectum were described as larger than normal corpora lutea, soft and fluctuating and most easily diagnosed 5 to 10 days after estrus. Marion and Gier (1968) considered corpora lutea larger than 25 mm and not firm to the touch as cystic. Marion and Gier (1971) reported that cystic corpora lutea were difficult to distinguish from luteinized follicular cysts per rectum. Presence of an obvious ovulation scar or pimple (Dawson, 1959) or a rosette of tissue at the point of ovulation (Morrow, 1969) were used to differentiate cystic corpora lutea from luteinized follicular cysts. Zemjanis (1970) observed that a cystic corpus luteum was usually single, filled with fluid, and were found in normal, culled and infertile cattle.

Cystic corpora lutea did not affect estrous cycles (McNutt, 1927; Morrow et al., 1966; Marion and Gier, 1968; Morrow, 1969; Marion and Gier, 1971). Zemjanis et al. (1969) found tendencies for estrus to last longer and for ovulation to occur earlier or later when a cystic corpus luteum resulted. Elder (1925) encountered one pregnant cow (5 to 6 months) out of 20 with a cystic corpus luteum. One of 15 cows with cystic corpora lutea was detected pregnant (30 days) by Zemjanis (1970). Bone (1954) reported cows with cystic corpora lutea were not pregnant, but eight cases of cystic corpora lutea were found in cows reported infertile. He concluded that cystic corpora lutea were abnormal and detrimental to fertility. Staples et al. (1961) observed that few cows with cystic corpora lutea would maintain an embryo. Marion and Gier (1971) noted that a large cystic corpus luteum with a central cavity of 10 mm or more was not associated with a normal pregnancy. Morrow et al. (1966) found a cystic corpus luteum in 18% of 190 pregnant cows. He suggested that the cavity was filled with luteal tissue during the second to fourth months of gestation.

Micromorphology. Elder (1925) postulated that cystic corpora lutea developed by hyaline degeneration of the luteal tissue. He described several small cavities in some corpora lutea and suggested that the smaller cavities degenerated to form a larger central cavity. A thick transparent fluid in the cavity was noted. Staples et al. (1961) encountered fluid in 10 of 11 cysts. Cysts were a single cavity and lined with fibrous tissue (Bone, 1954; Marion and Gier, 1971; Staples et al.,1961). Marion and Gier (1971) described the fibrous lining as forming by rapid infiltration of fibrocytes after ovulation. They postulated three possible causes of rapid fibrous infiltration: 1) explosive rupture of the follicle, 2) premature closure of the ovulation point, and 3) membrana propria degenerated before ovulation due to over ripe follicle. Bone (1954) observed that the "cellular structures" of cystic corpora lutea looked like the cellular structures of persistent corpora lutea. Staples et al. (1961) found low progesterone levels and few normal luteal cells in cystic corpora lutea.

Incidence of Cystic Corpora Lutea. Elder (1925) stated that cystic degeneration of the corpus luteum was one of the most common forms of corpus luteum degeneration. Incidence of cystic corpora lutea were reported as 13.2%, 10% and 10.9% of cows examined by Elder (1925), Dawson (1959) and Porter and Belling (1960) respectively. Cystic corpora lutea were detected in 25.2% and 17% of the ovulations observed by Morrow et al. (1966) and Morrow (1971) respectively. The highest incidence was found from August to January, and more cystic corpora lutea were found in young cows (Morrow et al., 1966). Roberts (1961) estimated that 25% of all corpora lutea had a non-pathologic central cavity. Tanabe and Almquist (1966) found nine cystic corpora lutea in 180 heifers slaughtered 30 days or less after estrus. Marion and Gier (1971) reported that 40% of the cysts that occurred during corpus luteum formation were detectable by rectal palpation.

Introduction to the Research

Many reports of bovine ovarian abnormalities have been published (Clapp, 1934; Casida, McShan and Meyer, 1944; Hancock, 1948; Garm, 1949; Wiltbank, Tyler and Casida, 1953; Bone, 1954; Tanabe and Almquist, 1966; Callahan et al., 1971; Marion and Gier, 1971; Morrow, 1971). Attempts to group bovine ovarian abnormalities and associated conditions have been made (Garm, 1949; Wiltbank et al., 1953; Bone, 1954; Callahan et al., 1971). Bierschwal (1966) admitted confusion after reviewing classifications of bovine ovarian abnormalities.

Pelisser (1970) estimated that low fertility cost U. S. dairymen 540 million dollars in 1970. Ovarian abnormalities were directly attributed to low fertility in 18.8%, 9.7%, 12.3%, 3.6% and 34.6% of the cows studied by Casida and Chapman (1951), Bone (1954), Hinze (1959), Porter and Belling (1960) and Morrow et al. (1966) respectively.

The need for a classification of bovine ovarian abnormalities, and the financial loss to dairymen because of such abnormalities prompted this study.

Materials and Methods

Ninety-six milking cows in the Kansas State University dairy herd were studied from January through November of 1971. Cows were rectally palpated on days 8, 12, 15, 22, 30, 45, and 60 postpartum and other days as indicated. All cows were subject to routine herd management. Observations for signs of estrus were made twice daily and more frequently when estrus was impending.

Nine cows with ovarian abnormalities were sacrificed, and one was unilaterally ovariectomized. Ovaries were fixed by infiltrating 10% formalin through the utero-ovarian artery and/or by immersion in 10% formalin within 30 minutes after slaughter or removal. After fixation, trimmed ovaries were photographed, weighed, measured and immersed in Bouins fluid to harden.

Representative sections were taken for histological study. An additional eleven abnormal ovaries were included that had been collected previous to this study from cows with known reproductive histories.

Tissues studied for micromorphology were washed in 70% ammonical alcohol, dehydrated, infiltrated with 52.5°C paraffin and embedded in 56°C paraffin. Sections of 8 to 10 µ were stained with Mallory triple or periodic acid Schiff-Harris haemotoxylin.

Observations

Abnormal ovarian structures that developed from a follicle are classified in Appendix Table I.

Definition of a Follicular Cyst

In this study ovarian follicles 20 mm or larger in diameter and associated with abnormal reproductive performance were defined cystic. McNutt (1927), Hancock (1948) and Marion and Gier (1968) classified follicles 20 mm or greater in diameter as cystic. Follicles 25 mm or greater in diameter were classified as atretic large follicles (Wiltbank et al., 1953) or cystic follicles (Morrow et al., 1966). Morrow et al. (1966) and Marion and Gier (1968) stated that large follicles had to persist 10 days or 16 to 20 days respectively to be classified cystic. Hinze (1959) found that the size of large follicles was not related to their function.

Thin Walled Cystic Follicles

These cysts were large (20 to 40 mm), spherical, tense structures. The stratum granulosa was stretched and was usually one or two cells thick (figure 9), but could be up to eight (figure 2). The membrana propria usually was not intact (figure 9). The theca interna contained glandular cells and varied in thickness from 15 to 455 µ (figures 2 and 9).

Leathery Cysts

Two types of leathery cysts distinguishable only by morphology were found. The two types were those that show evidence of no ovulation and those that show evidence of ovulation. Leathery cysts with evidence of no ovulation were lined with stratum granulosa that may be slightly expanded, and theca interna that was a few cells thick (figure 4). If the membrana propria was incomplete, the granulosa and theca interna cells usually do not intermix, but stratum granulosa and theca interna cells may be slightly intermixed in the thicker portions of the walls. Blood vessels and fibrocytes were not seen in the stratum granulosa.

The central cavity of leathery cysts with histological evidence of ovulation was lined with vascularized fibrous connective tissue 80 to 220 μ thick (figure 8). A typical luteal layer .15 to 5 mm thick, not distinguishable from luteal tissue in normal corpora lutea, lies peripheral to the fibrous lining (figures 6 and 8). Stria lined by fibrocytes as seen in normal corpora lutea were seen (figure 6). The stroma is mainly connective tissue and was greatly stretched.

Corpora Lutea with a Central Cavity

Cysts in this class have a grossly visible ovulation point (figure 19). Diameters of the central cavity vary from 7.1 mm to 20.0 mm. A layer of vascularized fibrous connective tissue 100 to 600 μ thick lined the central cavity (figure 10). Many nuclei were seen in the fibrous lining adjacent to the central cavity (figure 11). Peripheral to the connective tissue lining was a layer of normal blossom and companion cells 0.3 to 6.0 mm thick (figure 12). Fibrocytes lined the folds (stria) in the luteal tissue. Connective tissue, capillaries and epithelium covered the luteal tissue on the free surface.

Results and Discussion

Thin Walled Follicular Cysts

Six thin walled follicular cysts were studied and pertinent data is summarized in Appendix Table II.

Two animals exhibited frequent and irregular estrus prior to slaughter. One had three cysts of 22.1, 13.0 and 23.1 mm. The largest cyst had five to six layers of sloughing stratum granulosa. The theca interna containing some glandular interna cells was one to two cells thick and the membrana propria was not complete. A follicle 10 mm in diameter had one to two layers of stratum granulosa, and the 230 to 455 μ thick theca interna contained many glandular interna cells. The presence of glandular interna cells indicates that both small and large follicles were producing estrogens. The other cow had one 40 mm follicle (figure 18). The granulosa was stretched to one cell layer, referred to as the "string of pearls" (figure 9). Hyalinization was visible in the 74-110 μ thick theca interna.

One cow had a 35 mm cyst and exhibited signs of psychic estrus 2 and 6 days prior to slaughter. Clumps of hypertrophied cells 12 to 40 cells per clump were found in the stratum granulosa (figure 13). The theca interna cells were swollen and the membrana propria appeared to be intact. Hypertrophy of the glandular interna cells indicated that they could have been highly secretory.

Two cows were anestrus more than 75 days prior to slaughter. Both cows had gross abnormalities of the genitalia (figure 15). One cyst was found in each cow. Cysts from both cows had less than eight layers of granulosa and incomplete membrana propria. The theca interna layers were 45 to 55 μ thick (figure 2).

One heifer was in estrus 8 days before slaughter, but was anestrus 105 days previous to that estrus. Her ovaries contained five cystic follicles. The stratum granulosum of the largest follicle was stretched to the "string of pearls" orientation with an occasional double layer. The theca interna was 230 to 300 μ thick with glandular interna cells present. The membrana propria was not intact.

From the six pairs of ovaries studied both multiple and single thin walled cysts were found. Morrow (1969) observed only single cysts. Single and multiple follicular cysts were reported by McNutt (1927), Clapp (1934), Hancock (1948), Bierschwal (1966) amd Callahan et al. (1971). All cows in this group were in constant estrus, had irregular estrous cycles or showed no signs of psychic estrus. Garm (1949), Wiltbank et al. (1953), Hinze (1959), Bierschwal (1966) and Morrow (1969) also found similar variability of estrous behavior.

Stratum granulosa cells varying from one to eight layers thick were found in all thin walled follicular cysts. Garm (1949), Bone (1954) and Roberts (1961) reported stratum granulosa present in some cysts and absent in others. The theca interna of one cyst was hyalinized comparable to those reported by Garm (1949) and Roberts (1961). The theca interna layer of all cysts was thicker than the 30 to 35 μ found in ovulatory and cystic follicles by Marion et al. (1968).

Leathery Cysts

Data on cows with leathery cysts are shown in Appendix Table III. These cysts were palpated as large tense thick walled structures. Grossly, they had a smooth vascularized surface (figure 7), and a yellowish layer of "luteal" tissue lining the central cavity which was thicker at the basal portion (figure 3). Cysts fitting this description have been reported by

Benesch and Wright (1951), Dawson 1958), Johnson (1960), Roberts (1961) and Marion et al. (1968). Morrow (1971) found that cysts of this type were difficult to distinguish from cystic follicles and were classified with cystic follicles.

Reproductive status of the cows with leathery cysts was variable. One cow was 16 days postestrus, another was 118 days pregnant and the third 27 days postestrus. Other workers have reported anestrus (Benesch and Wright, 1951) and normal estrous cycles (Dawson, 1958) associated with leathery cysts. Dawson (1958) observed masculine behavior in cows that had both leathery and thin walled cysts. Micromorphology of one cyst was different from the other two even though they looked the same grossly. This cyst (L3) was lined with four to five layers of stratum granulosa and the theca interna was a few cells thick with some cell enlargement. Stratum granulosa and theca interna cells were slightly intermixed only in the thicker walls. The membrana propria was incomplete but no capillaries or fibrocytes were seen in the remaining stratum granulosa (figure 4). Marion and Gier (1971) studied a large number of follicles and found that capillaries normally did not penetrate the membrana propria until after ovulation. Based on this evidence follicles with this cellular arrangement were anovulatory. Marion and Gier (1968) called cysts of this type luteinized cystic follicles.

Cysts L1 and L2 were palpated as leathery cysts, and no ovulation point was visible when observed after slaughter. Microscopically, in both cysts capillaries and fibrocytes were central to a layer of typical luteal tissue (figure 8). These cysts had the same cellular arrangement as a corpus luteum with a central cavity. They differ only in their size and absence of an ovulation point.

Based on the observations of Marion and Gier (1971) and the similarity of these structures with corpora lutea with a central cavity, leathery cysts

of this type resulted from incomplete ovulation. This type of cyst may have formed from a follicle that had a small stigma at ovulation. Fluid released at ovulation resulted in a decrease in follicular pressure. Stratum granulosa and theca interna cells folded onto each other and intermixed. Capillaries and fibrocytes invaded the granulosa. The stigma closed prematurely resulting in fluid accumulation. The layer of vascularized fibrous connective tissue lining the central cavity formed when fibrocytes encompassed the accumulating fluid. The fibrous lining compacted as the cyst increased in size. The intermixed granulosa and theca interna cells developed the luteal layer (figure 8). Fibrocytic stria resulting from folding of the stratum granulosa and theca interna layers at ovulation were seen (figure 6).

Jones and Malbandov (1972) stated "Whether ovulation is a prerequisite of luteinization is unclear." They induced luteinization of rabbit ovarian follicles with intrafollicular injection of LH or FSH in amounts not large enough to induce ovulation. All granulosal elements including the cumulus oophorus, corona radiata and "membrana granulosa" (stratum granulosa) hypertrophied to form lutein cells not distinguishable from lutein cells of a normal corpus luteum. "The corpora lutea formed either as a result of ovulation or of luteinization are competent to produce progesterone. Furthermore, luteinized follicles produce as much progesterone as do corpora lutea formed after ovulation" they concluded.

Corpora Lutea with a Central Cavity

Eight of these structures were studied (Appendix Table IV). Corpora lutea with a central cavity each had a palpable and grossly visible ovulation point (figure 19). These structures were softer than normal corpora lutea when palpated as reported by Marion et al. (1966) and Marion and Gier (1968).

Mean outside diameter and diameter of the central cavity were 23.9 mm and 13.8 mm respectively. Morrow et al. (1966) stated that corpora lutea that had a central cavity of about 10 mm or larger should be defined as cystic. Marion and Gier (1968) considered corpora lutea not firm to the touch and 15 mm or greater in outside diameter cystic.

A layer of vascularized fibrous connective tissue lines the central cavity (figure 11). Peripheral to the connective tissue lining was a layer of normal luteal tissue with fibrocytic septa (figure 10).

The reproductive status of cows with a corpus luteum with a central cavity was variable. Two cows slaughtered 40 days or less postpartum had these cysts. Another cow was anestrus 73 days prior to slaughter, but microscopic observation revealed the corpus luteum was 5 to 6 days old. A fourth cow had intervals of 62 and 60 days between the second and third and third and fourth estrous periods before slaughter. She was slaughtered 14 days post-estrus and fetal membranes were present but no embryo was found. The long estrous intervals could be suggestive of early embryonic death and resulting uterine recovery. McNutt (1927), Morrow (1969) and Marion and Gier (1971) found that corpora lutea with a central cavity did not affect estrous cycle length.

None of the cows with a corpus luteum with a central cavity were pregnant. A corpus luteum with a central cavity had been found in pregnant cows (Elder, 1925; Morrow et al., 1966; Zemjanis, 1970). Bone (1954), Staples et al. (1961) and Marion and Gier (1971) did not find a corpus luteum with a central cavity larger than 16 mm associated with normal pregnancy.

Elder (1925), Bone (1954), Staples et al. (1961) and Marion and Gier (1971) also reported fibrous connective tissue lining the central cavity with luteal tissue peripheral to the connective tissue.

Corpora lutea with a central cavity were called cystic corpora lutea by Dawson (1959), Hansel and Wagner (1960), Staples et al. (1961), Morrow (1961), Zemjanis (1970) and Marion and Gier (1971).

Corpora Lutea with a Smooth or Depressed Ovulation Point

Two cows each had a corpus luteum that did not have a palpable ovulation point. The ovulation point of one corpus luteum was depressed (figure 16). The other corpus luteum had a very small ovulation point (figure 22). Histologically the luteal tissue in both was normal. A thick yellow pus and thick mucus were found in the uterus and cervix respectively of each of these cows. Neither cow was in heat within 8 months before slaughter. Both corpora lutea were probably retained due to the pus in the uterus.

Rete Cysts

Two abnormalities not resulting from follicles were examined. These abnormalities appeared to have developed from embryonic rete ovarii. A 74 mm cyst was removed by ovariectomy (figure 14). Nine days prior to removal there were no palpable structures on this ovary. She was in standing heat 4 days before ovariectomy, and the cyst was detected the next day when she was bred. This cyst had a single layer of epithelium around the outer surface. The rest of the structure was vascularized connective tissue (figure 24). Grossly this structure looked like a "granulosa cell tumor" reported by Zemjanis (1970). The other cow was 9 days postestrus when slaughtered. Small rete cysts were found in the right ovary (figure 23). Two corpora lutea were present on the right ovary and the uterus was distended with purulent material.

These structures were considered as dilitation of the embryologic rete tissue or rete ovarii. Archibald et al. (1971) reported that rete ovarii may have secretory capacity and are influenced by hormones.

Inconsistencies in Palpation

Four cows were palpated as having leathery cysts, but palpation data was not substantiated by postmortem examination. One cow had a cystic follicle (figure 1) with no luteinization (figure 2). Another had a leathery cyst with histological evidence of ovulation (figure 7). The other two cows each had a corpus luteum with a smooth or depressed ovulation point. These observations indicate that extreme care should be exercised in positively identifying ovarian structures. Follow-up examinations and reproductive records would be helpful in research or treatment situations. Precise diagnosis is not possible all of the time.

Summary

Ninety-six cows from the Kansas State University dairy herd were palpated from parturition to 60 days postpartum during 1971. Nine abnormal ovaries from these and other cows in the herd were collected. An additional eleven abnormal ovaries that had been collected previous to this study were included.

Ovarian abnormalities were classified from macromorphology and micromorphology. Four types of abnormals were classified: 1) thin walled follicular cysts, 2) luteinized follicular cysts, 3) ovulated leathery cysts, and 4) corpora lutea with a central cavity.

1) Ovarian follicles 20 mm and larger and associated with abnormal reproductive performance were defined cystic. Thin walled cystic follicles were large (20 to 40 mm), spherical tense structures. The stratum granulosa was one to eight cells thick. The membrana propria usually was not intact. The theca interna contained glandular cells and varied in thickness from 15 to 455 μ. Such follicles were associated with nymphomania or anestrus.

2) Luteinized follicular cysts were tense thick walled structures. These cysts were lined with several layers of hypertrophied granulosa cells. The membrana propria was intact in some cysts and not intact in other cysts. In either case the granulosa was seldomly vascularized. When the membrana propria was not intact, minimal mixing of the granulosa and interna was seen. These cysts persisted for an average of 35 days.

3) Ovulated leathery cysts had not previously been described. They were larger than 40 mm and looked and felt like luteinized follicular cysts. Ovulated leathery cysts were lined with fibrous connective tissue. A layer of luteal tissue containing blossom cells, companion cells and capillaries was peripheral to the fibrous lining and central to ovarian stroma. Histology of these structures was like the histology of corpora lutea with a central cavity. In a previous study of bovine ovaries capillaries were not found in the granulosa until after ovulation. Because of these two reasons, cysts of this type apparently form after ovulation.

4) Corpora lutea with a central cavity were soft when palpated. They had a palpable ovulation point. Mean outside diameter and diameter of the central cavity were 24.9 mm and 13.8 mm respectively. The central cavity in all cases was lined with vascularized fibrous connective tissue. A layer of luteal tissue with fibrocystic septa was peripheral to the fibrous lining.

Ovarian abnormalities cost U. S. dairymen several million dollars each year. A satisfactory method of diagnosis must be achieved before effective treatment and prevention methods can be utilized. The classification system developed from this study and the comparisons of macromorphology and micromorphology are a step toward satisfactory diagnosis of ovarian abnormalities.

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Appendix

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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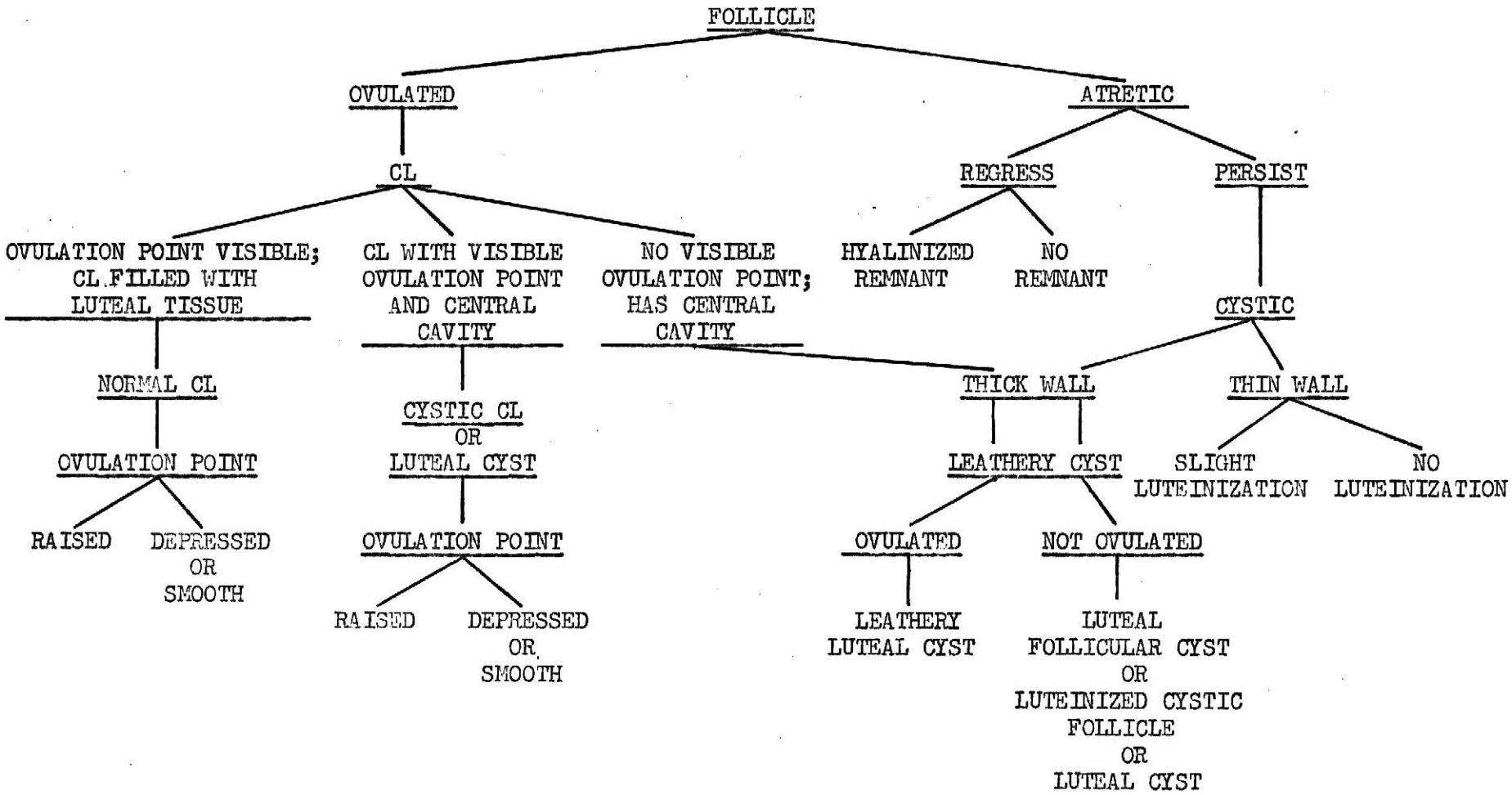
APPENDIX TABLE I. CLASSIFICATION OF OVARIAN STRUCTURES



APPENDIX TABLE II. DATA ON COWS WITH THIN WALLED FOLLICULAR CYSTS

No.	Age (years)	Reproductive history at slaughter: Days since Parturition	Days since Abortion	Days since Last estrus	Length of last 3 estrous cycles (days)	No. of cysts	Maximum diameter of cysts (mm)	Structures on opposite ovary	Thickness of SG[a] (cells)	Thickness of TI[b] (μ)	Presence of MP[c]
FC1	10	---	132	Constant	---	1 RO[d]	40.0	2, 15 mm follicles 3CR[e]	1	73 to 110	not intact
FC2	5	154	---	Constant	---	2 RO 1 LO[f]	23.1	---	1-2	228 to 455	not intact
FC3	3	---	279	8	105 32 27	4 RO 1 LO	25.0	---	1	227 to 303	not intact
FC4	5	365	---	77	---	2 RO	20.0	---	2-3	45	not intact
FC5	3	158	---	158	---	1 LO	36.1	large abcess	2-3	55	not intact
FC6	6	---	25	2	4 20 ---	1 RO	35.4	CR	Clumps 5-12	37 to 55	intact

a stratum granulosa
b theca interna
c membrana propria
d right ovary
e corpora rubra
f left ovary

APPENDIX TABLE III. DATA ON COWS WITH LEATHERY CYSTS

No.	Age (years)	Days since last estrus	Length of last three estrous cycles (days)	Cystic ovary	Maximum outside diameter of cysts (mm)	Maximum diameter of central cavity (mm)	Opposite ovary	Thickness in μ FL[a]	Thickness in μ LL[b]
LC1	4	118[c]	---	RO[d]	41.0	31.0	2 corpora lutea	227	4950
LC2	3	16	20, 23, 41	RO	47.3	46.8	---	80 to 220	146 to 500
LC3	2	27	11, 11, 21	RO, LO[e]	45.0	42.0	---	---	---

a Fibrous lining
b Luteal layer
c Pregnant
d Right ovary
e Left ovary

APPENDIX TABLE IV. DATA ON COWS WITH A CORPUS LUTEUM WITH A CENTRAL CAVITY

No.	Age (years)	Reproductive history at slaughter: Days since Partu-rition	Reproductive history at slaughter: Days since Last estrus	Length of last three estrous cycles (days)	Cystic ovary	Outside diameter of CL[a] (mm)	Inside of central cavity (mm)	Thickness in mm: FL[b]	Thickness in mm: LL[c]
CLCC 1	4	111	77	---	LO[d]	24.0	10.0	.17	3.96
CLCC 2	6	29	29	---	LO	15.0	9.0	.23	.35 to 4.40
CLCC 3	4	40	40	---	LO	20.0	17.5	.11	.55 to 2.20
CLCC 4	2	---	17	24, 18, 18	RO[e]	26.0	17.0	.17 to .40	2.20 to 2.93
CLCC 5	3	365	13	---	RO	28.0	20.0	.12 to .23	2.20 to 3.96
CLCC 6	4	112	20	23, --- ---	LO	27.2	11.0	.22	2.75 to 6.60
CLCC 7	3	70	16	24, 26, 24	RO	27.5	13.4	.61	.73 to 5.00
CLCC 8	4	365	14	21, 62, 60	LO	22.0	7.1	.28	5.00

[a] Corpus luteum, [b] Fibrous lining, [c] Luteal layer, [d] Left ovary, [e] Right ovary

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Figure 1. A 36.1 mm thin walled follicular cyst that was palpated as a leathery cyst. There was no luteinization of the follicular wall (figure 2), and an abcess was where the right ovary should have been (figure 15). The cow had been anestrus for 158 days.

Figure 2. Wall of a 36.1 mm cystic follicle (figure 1). The lumen (L) is at the top. The stratum granulosa (SG) was about 8 cells thick and the membrana propria (MP) was intact. The theca interna (TI) was thin (55 μ) and contained few glandular cells. 220 X.

Figure 3. Sagittal section of ovaries containing leathery cysts with no evidence of ovulation. The ovary on the left had two cysts 28 and 50 mm in diameter with walls 2 to 5 mm. The ovary on the right had a 45 mm cyst with a 1 to 2 mm wall and a 20 mm cyst with 5 to 6 mm wall.

Figure 4. Section of a leathery cyst with no evidence of ovulation. The granulosa (G) and theca interna (TI) were expanded but not intermixed even though the membrana propria was not present. Capillaries were in the theca externa (TE), but not in the granulosa or interna. 450 X.

Figure 5. A 41 mm leathery cyst that had evidence of ovulation. Two corpora lutea were on the opposite ovary and the cow was 118 days pregnant.

Figure 6. A portion of a leathery cyst with evidence of ovulation (figure 5). The lumen (L) was immediately to the right. Fibrocytic septa (FS) and normal luteal tissue (LT) were present. The fibrous lining was 37 μ thick and the luteal layer was 227 μ to 5.0 mm thick. 20 X.

Figure 7. A 47.3 mm leathery cyst with evidence of ovulation. This cyst looked like a follicular cyst (figure 1) but histology was not the same (figure 8).

Figure 8. Wall of the 47.3 mm cyst in figure 7. The connective tissue (CT) lining the lumen (L) was 80 to 220 μ thick. The luteal tissue (LT) layer appeared normal, contained capillaries and was 146 to 500 μ thick. Both the connective tissue lining and luteal layer were thinner in the outer portion of the cyst. Ovarian stroma (S) was peripheral to the luteal tissue. 20 X.

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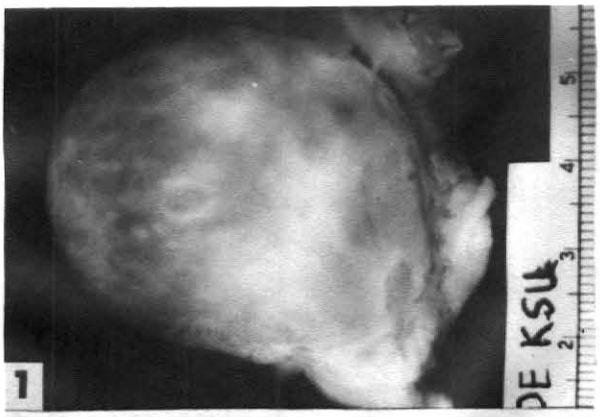
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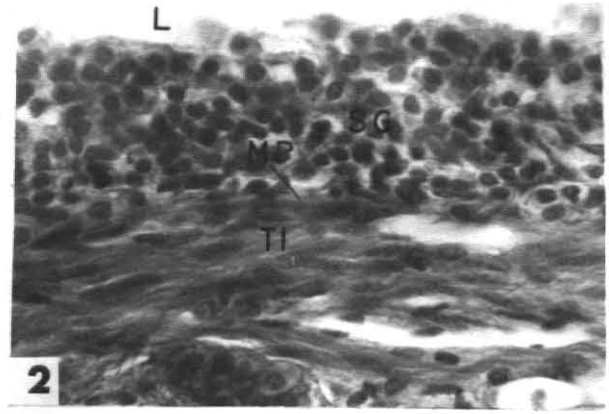
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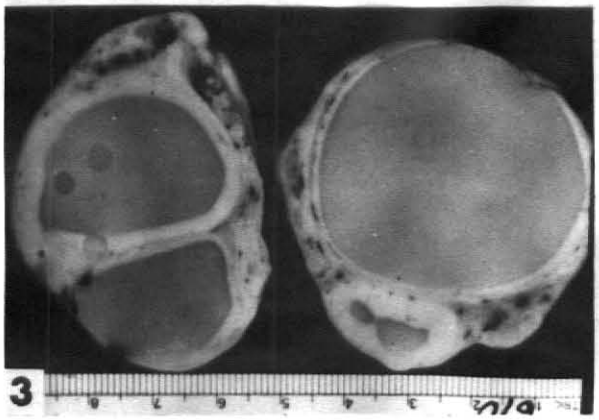
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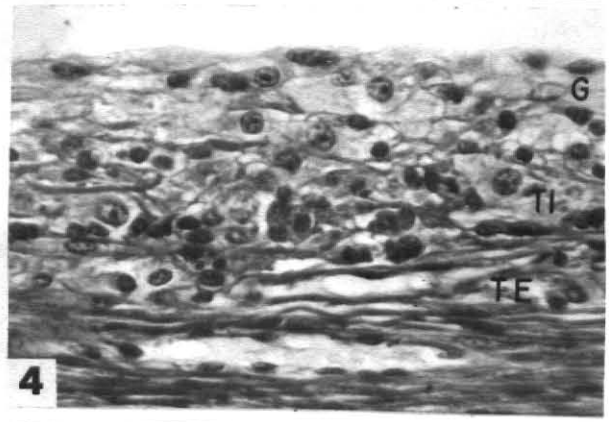
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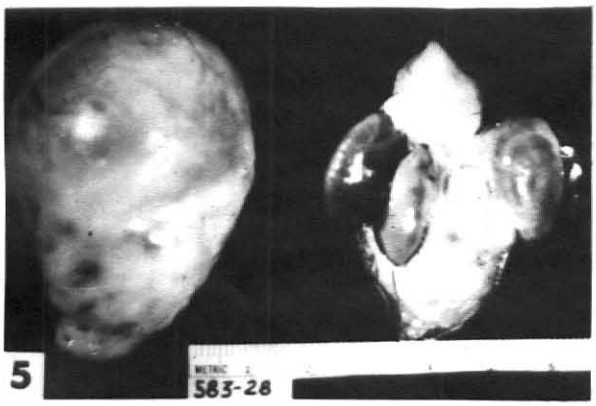
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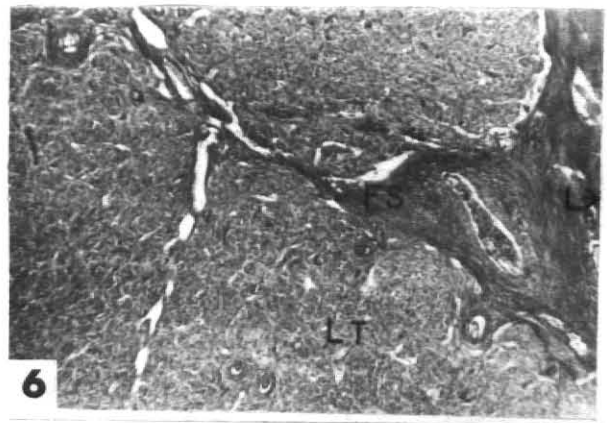
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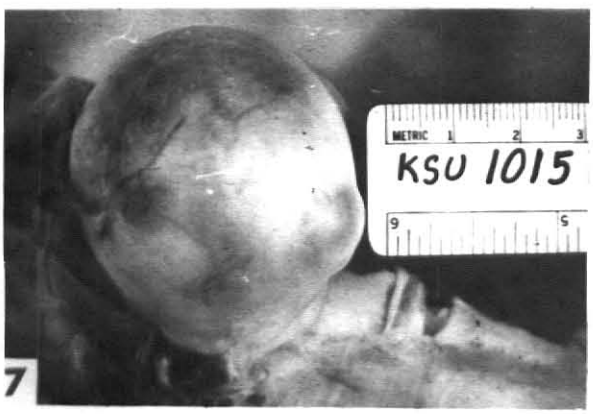
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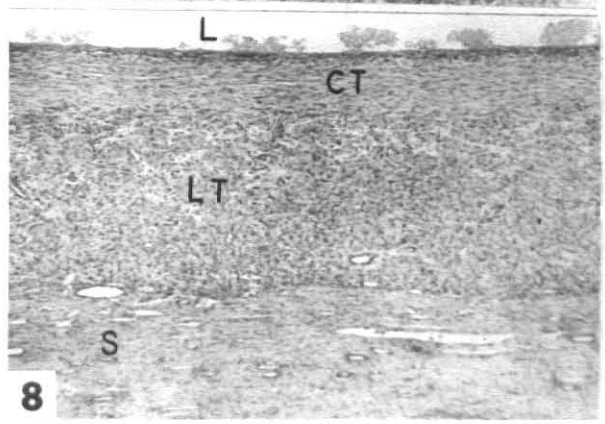
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CT
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Figure 9. Wall of a thin walled follicular cyst showing the string of pearls (SP), one layer of granulosa cells. Many glandular interna cells with rounded and expanded nuclei were in the theca interna (TI). 220 X.

Figure 10. Portion of a 14 day, 22 mm corpus luteum with a 7.1 mm central cavity. The vascularized connective tissue (CT) lining averaged 223 μ thick. Fibrocytic stria (FS) were seen in the luteal tissue (LT) which was several millimeters thick. Fetal membranes were found in the uterus. 220 X.

Figure 11. Wall of a 20 day, 27.2 mm corpus luteum with an 11 mm central cavity (figure 19). The connective tissue (CT) lining was 220 μ thick and the luteal tissue (LT) ranged from 2.8 to 6.6 mm. A large number of capillaries were seen between the connective tissue and luteal tissue. 220 X.

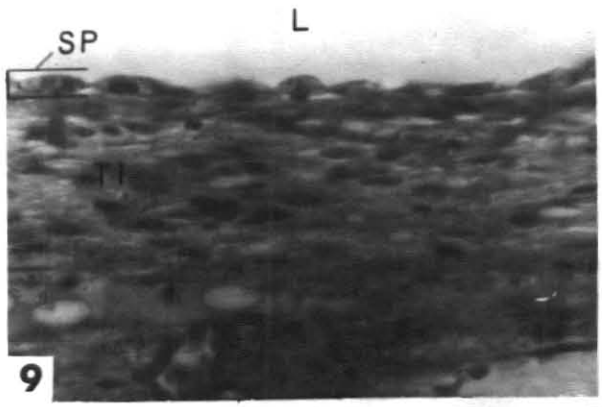
Figure 12. Section of a 13 day, 28 mm corpus luteum with a 20 mm central cavity. The connective tissue (CT) lining ranged from 120 to 228 μ and the luteal tissue was 2.2 to 4.0 mm thick. 220 X.

Figure 13. Wall of a 35.4 mm thin walled follicular cyst. Several clumps of hypertrophied cells (HC) were dispersed in the stratum granulosa. The number of hypertrophied cells in one section in one clump ranged from 5 to 12. Numerous glandular interna cells were in the theca interna (TI) and their nuclei were rounded and plump. The membrana propria was intact. This cow was in estrus 2 and 4 days before slaughter. 194 X.

Figure 14. A 74.3 mm rete cyst. This structure was palpated as a thin walled follicular cyst, but was not ovarian tissue (figure 24). An ovary had not been previously palpated on the side in which this cyst was found. The heifer was 21 days postabortion when the ovary was removed, and this cyst was detected 16 days postabortion when the heifer was in heat.

Figure 15. A 200 mm abcess where the right ovary should have been from the same cow as figure 1 and figure 2. The abcess was excised to show the thick wall and thick pus.

Figure 16. Saggital section of a 26.3 mm corpus luteum with a depressed ovulation point. The uterus contained pus and the cervix was plugged with thick mucus. This cow was anestrus for 8 months. Incorrect diagnosis was a problem with structures like this.



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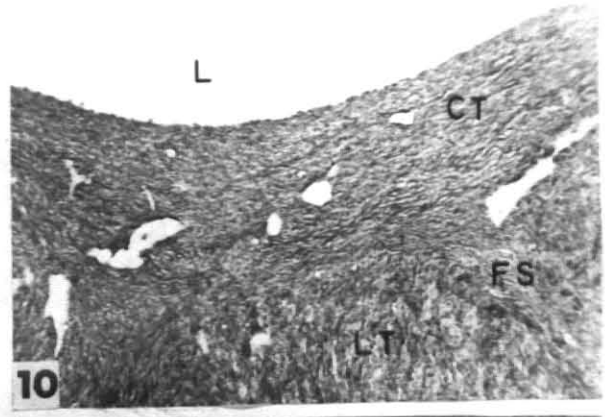

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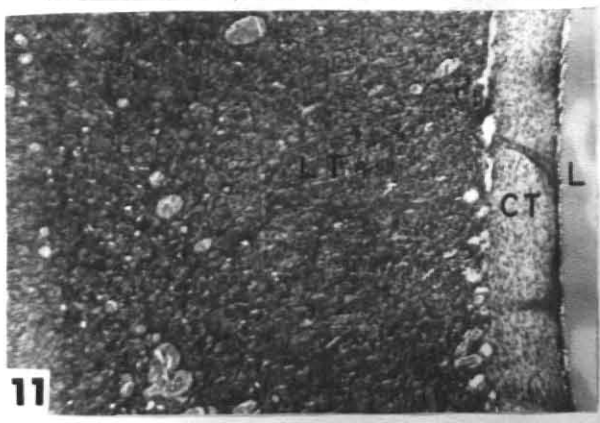

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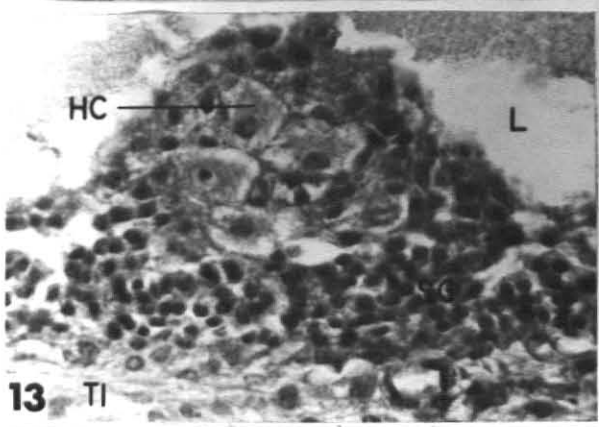

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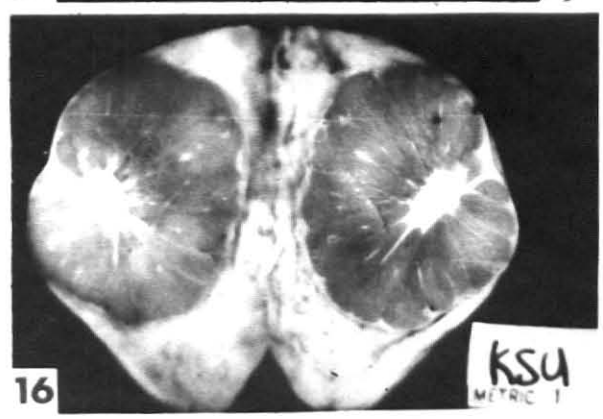

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Figure 17. Sagittal section of both ovaries from a cow that was in constant estrus. Thin walled cystic follicles were multiple.

Figure 18. Sagittal section of both ovaries from a cow that was in consta estrus. The ovary on the left contained a 40 mm thin walled cystic follicle. This cyst was lined with the string of pearls as in figure 9. Both follicles on the other ovary were 15 mm in diameter.

Figure 19. Ovary on the left shows the well vascularized ovulation point of a 27.2 mm corpus luteum with an 11 mm central cavity. The lining of this cyst is shown in figure 11.

Figure 20. Sagittal section of a corpus luteum with a central cavity. The ovulation point is at the top.

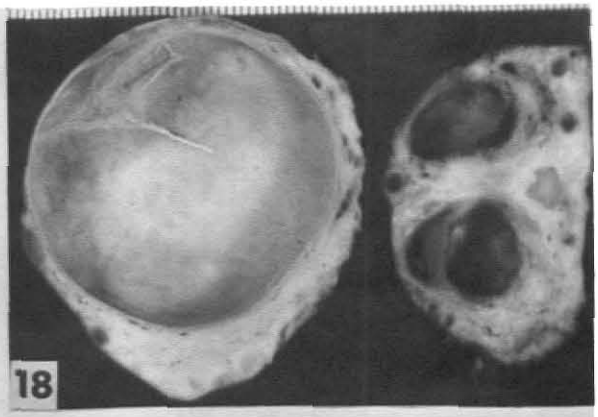
Figure 21. Sagittal section of two corpora lutea with a central cavity from a heifer.

Figure 22. Ovary on right shows a small ovulation point that was flush with the surface of the ovary. This corpus luteum was 30.9 mm in diameter and was not cystic. This structure felt like a leathery cyst by rectal palpation. The cow was anestrus for 11 months prior to slaughter and the uterus and cervix contained pus and thick mucus respectively.

Figure 23. Small rete cysts (RC) that were in the basal portion of an ovary from a cycling cow. Cysts were lined with a single layer of epithelium. 20X.

Figure 24. Lining of a large rete cyst (figure 14). Connective tissue (CT) fibers were more compacted close to the lumen (L). The entire wall of this structure was connective tissue. 194 X.


17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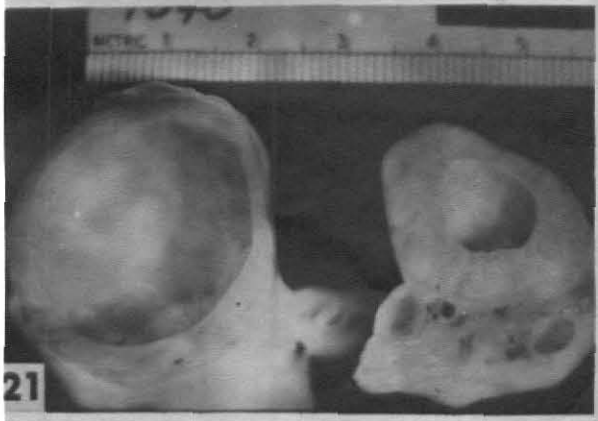
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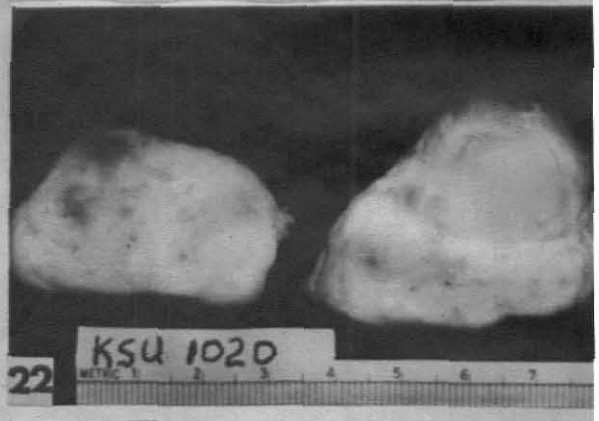

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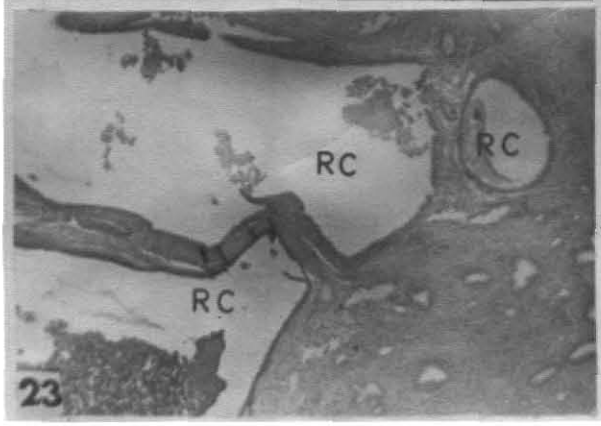

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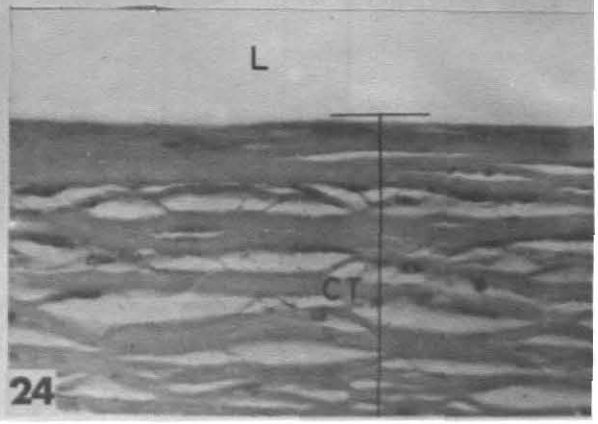

24

A STUDY AND CLASSIFICATION OF BOVINE OVARIAN ABNORMALITIES

by

GEORGE HEERSCHE JR.

B. S., Kansas State University, 1970

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Dairy and Poultry Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Ninety-six cows from the Kansas State University dairy herd were palpated from parturition to 60 days postpartum during 1971. Nine abnormal ovaries from these and other cows in the herd were collected. An additional eleven abnormal ovaries that had been collected previous to this study were included.

Ovarian abnormalities were classified from macromorphology and micromorphology. Four types of abnormals were classified: 1) thin walled follicular cysts, 2) luteinized follicular cysts, 3) ovulated leathery cysts, and 4) corpora lutea with a central cavity.

1) Ovarian follicles 20 mm and larger and associated with abnormal reproductive performance were defined cystic. Thin walled cystic follicles were large (20 to 40 mm), spherical tense structures. The stratum granulosa was one to eight cells thick. The membrana propria usually was not intact. The theca interna contained glandular cells and varied in thickness from 15 to 455 μ. Such follicles were associated with nymphomania or anestrus.

2) Luteinized follicular cysts were tense thick walled structures. These cysts were lined with several layers of hypertrophied granulosa cells. The membrana propria was intact in some cysts and not intact in other cysts. In either case the granulosa was seldomly vascularized. When the membrana propria was not intact, minimal mixing of the granulosa and interna was seen. These cysts persisted for an average of 35 days.

3) Ovulated leathery cysts had not previously been described. They were larger than 40 mm and looked and felt like luteinized follicular cysts. Ovulated leathery cysts were lined with fibrous connective tissue. A layer of luteal tissue containing blossom cells, companion cells and capillaries was peripheral to the fibrous lining and central to ovarian stroma. Histology of these structures was like the histology of corpora lutea with a central cavity.

In a previous study of bovine ovaries capillaries were not found in the granulosa until after ovulation. Because of these two reasons, cysts of this type apparently form after ovulation.

4) Corpora lutea with a central cavity were soft when palpated. They had a palpable ovulation point. Mean outside diameter and diameter of the central cavity were 24.9 mm and 13.8 mm respectively. The central cavity in all cases was lined with vascularized fibrous connective tissue. A layer of luteal tissue with fibrocytic septa was peripheral to the fibrous lining.

Ovarian abnormalities cost U. S. dairymen several million dollars each year. A satisfactory method of diagnosis must be achieved before effective treatment and prevention methods can be utilized. The classification system developed from this study and the comparisons of macromorphology and micromorphology are a step toward satisfactory diagnosis of ovarian abnormalities.