A HISTOPATHOLOGICAL STUDY OF THE BOVINE UDDER

Thesis for the Degree of M. S.

Charles Cleon Morrill

1935

Udder - Diseases

A HISTOPATHOLOGICAL STUDY
OF THE
BOVINE UDDER

A HISTOPATHOLOGICAL STUDY OF THE BOVINE UDDER

THESIS

Submitted to the Faculty of Michigan State College in partial fulfillment of the requirements for the degree of Master of Science in Animal Pathology

By

Charles Cleon Morrill

June 1935

TABLE OF CONTENTS

INTRODUCTION

From an economic standpoint, mastitis is one of the most, if not the most, important of the diseases affecting dairy cattle. The reason for its great import lies in the wide distribution and high incidence among such animals, and in the fact that both the quantity and quality of milk which the affected animal produces are lowered.

There is no sharp line of demarcation between the pathology and the clinical manifestations of a disease; alterations in structure are responsible for alterations in function. The alterations in function in mastitis are quite well known, but it remains to be revealed just what structural changes accompany them. This study has been undertaken in an effort to throw more light on the structural alterations and thereby add to our knowledge of the nature of the disease.

REVIEW OF LITERATURE

Although considerable has been written regarding work which has been done on the clinical, bacteriological, and economic aspects of mastitis in cattle, little has been found in the available literature (in English) concerning the finer histopathological detail of the bovine mammary gland. Runnells and Huddleson have described the pathological findings in three udders infected by Brucella abortus, and Sholl and Torrey have described the pathology of the udders from 92 animals. Some of the latter were infected with Brucella abortus and some with streptococci of mastitis. The paucity of literature should be added to those facts listed in the introduction as a reason for undertaking this study.

HISTOPATHOLOGICAL STUDY

Sources of materials and data

The materials used in this study were obtained during the year 1933, and, with one exception, are from two large herds of dairy cattle in which streptococcic mastitis has been prevalent for a period of at least 15 years. All five of the principal dairy breeds are represented in this study, and the animals vary in age from 329 days to nine years.

I am indebted to Mr. C. S. Bryan of the Department of Bacteriology for data regarding the bacterial and leucocytic content of the milk from these animals, to Dr. G. E. Taylor of the Dairy Department for production records and the results of physical examinations of the udders made during the lives of the animals, and to Dr. C. F. Clark of the Department of Animal Pathology for all other clinical data.

With the exception of one rachitic animal which died, all were felled by a blow on the head and bled out in the usual manner, after which they were skinned and the udders and supramammary lymph nodes removed. The reasons for slaughter were: low production, poor type, sterility, or mastitis. Fifteen were in some stage of lactation at the time of slaughter, two were in the dry state following lactation, and three had never lactated. In instances in which examination of the udder was delayed, the material was refrigerated.

Method of study in gross

To aid in the description of the udder, a system has been devised for identification of a given area for description

and orientation of lesions and selection of material for microscopic examination. The quarters are designated RR, RF, LF, and LR to represent the right rear, right front, left front, and left rear quarters respectively. The udder is also divided into three horizontal planes, which are designated 1, 2, and 3, equivalent to the upper, middle, and lower planes respectively and incision is made through approximately the middle of each plane. Each plane of each quarter is further divided into quadrants designated as follows:

A -- postero- and antero-lateral quadrants of rear and front quarters respectively,

B -- antero- and postero-lateral quadrants of rear and front quarters respectively,

C -- postero- and antero- medial quadrants of the rear and front quarters respectively, and

D -- antero- and postero- medial quadrants of the rear and front quarters, respectively.

For example: RF2C denotes the antero-medial quadrant in the middle plane of the right front quarter.

In the case reports only deviations from what is considered to be the normal are noted. The parenchyma of the normal functional gland is distinctly lobulated, the lobules bulging from the cut surface of the gland in such a manner as to obscure the strands of interlobular connective tissue. The lobules measure up to 8 mm. in diameter. Palpation reveals a soft consistency and some elasticity. The color is usually a sort of salmon pink, but may be a creamy or a grayish pink. In the normal non-functional gland the lobules are smaller (up to 5 or 6 mm.) and

do not bulge appreciably above the level of the interlobular connective tissue on the cut surface; thus the connective tissue is in evidence and appears as a net-work of shiny, white, thread-like bands. The gland is more firm and doughy in consistency and less elastic. The color usually is a yellowish salmon; occasionally even the interlobular connective tissue is a yellowish white (possibly due to fat stored therin), in which cases lobulation is less distinct, because of the similarity in colors of the lobulular and interlobular tissues.

Method of microscopic study

Blocks of tissue are taken in such a manner that sections will be in a horizontal plane and are designated by the quadrant from which they are taken. The number of quadrants from which blocks are taken is determined by the extent of grossly recognizable pathological changes. From the adult animals, the numbers of areas represented vary from 13 to 39. Because of the limited amount of glandular tissue present in the young heifers, the numbers of blocks taken from them are lower. Two blocks are taken from the same quadrant: one is fixed in 10% formalin and sectioned by the frozen section method, and the other is fixed in Zenker's fixing solution and embedded in paraffin for sectioning. The frozen sections are stained with Sudan IV and hematoxylin to demonstrate fat, and the paraffin sections are stained by the eosin-hematoxylin method for the histopathological study. Also, sections from the supramammary lymph nodes are made by the paraffin method and stained with eosin and hematoxylin.

CASE REPORTS.

CASE I. (199) was a Holstein cow, about eight years old; 119 days pregnant, in the 6th month of her 7th lactation period, and producing about 45 pounds milk daily in 3 milkings. She was slaughtered at about the afternoon milking time, March 10, 1933, not having been milked since morning, and the udder was examined in gross 1½ hours after slaughter. The reason for slaughter was the annual appearance of mastitis and foot rot for several years.

Gross examination

The left half measures up to 55 cm. antero-posteriorly, 35 cm. dorso-ventrally, and 12.5 cm. medio-laterally.

The right half measures up to 53 cm. antero-posteriorly, 33 cm. dorso-ventrally, and 12.5 cm. medio-laterally.

LF1A and 2 A - the strands of interlobular connective tissue are broader and closer together in the anterior and lateral portions.

LR1A - similar condition in posterior and lateral portions.

LR1D - area 3 cm. in diameter of non-functional parenchyma.*

LF2B and D - function apparently reduced or absent.

LF3A,B, and C - some non-functional parenchyma.

RF1A, and B and RR1A and D show less evidence of function than the rest of this plane.

RF2A and RR2A and B contain a lateral zone about 2 cm. in width which is non-functional.

RR3B and RF3B contain narrow (1-2 cm.) lateral margins

*The term "non-functional" used in these descriptions should not be taken too literally, because areas which upon gross examination appear non-functional may show some function upon microscopic examination.

of non-functional tissue.

These marginal zones contain relatively more connective tissue than normal. Many of the lobules appear spindle-shaped on the surface, and are less than one mm. in width. Most of those which are circular on section are less than 2 mm. in diameter.

The right and left supramammary lymph nodes weigh 305 and 250 grams, respectively. The cortex of the left node cuts with increased resistance, suggesting some fibrosis. Just anterior to each front teat is a small lymph node, located superficially.

Microscopic examination

In the LF quarter there is a very patchy condition. The most prominent inflammatory process is an active productive process, evidenced by suppressed function, a greatly thickened and cellular stroma, and many of the vegetative form of fibroblasts and vascular endotheliocytes. Even though the process is active, the presence of some fibrosis of the stroma, interlobular connective tissue, and duct stromas and fairly numerous foci of lymphocytes and macrophages indicate that the injury has been of long standing. Evidence of recent, acute injury is also present and consists of infiltration of the gland stroma with, and exudation into the alveolar lumina of many polymorphs. This manifestation occurs in foci involving from 2 or 3 alveoli to two lobules. All three manifestations are seen in each plane; however, the foci of acute exudation are most numerous in plane one, the fibrosis a little more extensive in plane 3, and the active productive process prominent in all levels.

In the actively functional lobules, the alveolar epithelium varies greatly in height, ranging from a flat, almost

squamous type, cell to a tall columnar one. The flattened type contains an elongated, and more dense nucleus, while the columnar type has a spherical or oval, more vesicular nucleus. The cytoplasm of the columnar type is less dense, containing, in some cases, vacuoles which contain fat, as determined by the Sudan IV stain. However, some vacuoles remain unstained by Sudan IV, which may mean that there is present a vacuolar degeneration. On the whole, the epithelial cells of the alveolus show less evidence of injury than one would expect in such highly specialized cells, but a few show pyknosis, karyorrhexis, or karyolysis.

In some of the broader strands of interlobular connective tissue, there are areas in which the collagen is hyalinized. Many arterioles show a proliferation of the cells of the intima. One arteriole is noted in which the lumen is nearly obliterated by this process. The smaller ducts are lined by a single row of epithelial cells, while the larger ones have two rows, the row next to the lumen being columnar in appearance and the other being cuboidal, or even flattened, in appearance.

There is little secretory fat present, and that is widely scattered. The globules average about 1½ to 2 times the size of erythrocytes. The secretion of the functional lobules is normal in appearance except in those foci in which there has been an exudation of polymorphs. A few small corpora amylacea are present in the alveolar lumina.

<u>LR quarter</u>, presents an appearance similar to that of the LF quarter, the only notable difference being the presence of more foci showing acute severe injury.

<u>RF quarter</u>, shows the same changes plus a few small areas

of acute injury super-imposed upon others of long standing, as evidenced by a copious infiltration of an already much thickened stroma by many polymorphs.

RR quarter, shows the same changes as the rest. It is noted that, in all quarters, where injury of long standing is evident, the lobules so affected are in groups, few lobules being affected without some others adjacent to them being involved.

All lymph nodes show large numbers of polymorphs and macrophages in the sub-capsular spaces and sinuses. Fibrosis is marked in both cortices and medullae.

- - - - - - - -

CASE II was a Holstein heifer, about 18 mo. old and 60 days pregnant. This animal did not come from the herd mentioned, but the material was obtained at an abattoir March 17, 1933, and examined 1½ hours after slaughter.

Gross examination.

Each half of the udder measures up to about 25 cm. antero-posteriorly, 12.5 cm. dorso-ventrally, and 7.5 cm. medio-laterally.

LF quarter, contains only a very small amount of glandular tissue located in the posterior quadrants. In the first plane, the area of parenchyma is about 1 x 2 cm. on the cut surface. It is only slightly larger in the two lower planes. The remaining area of the quarter is occupied with what appears to be fat.

LR quarter, contains a preponderance of gland tissue over fat in the anterior quadrants, especially in the 2nd and

3rd planes, but the posterior quadrants are made up mostly of fat.

RF quarter, shows practically no glandular tissue in the 1st plane. The 2nd plane contains an area about 2.5 x 3.5 cm. located at about the junction of the anterior and posterior quadrants, and toward the medial side, which consists of gland tissue intermixed with fat. In the 3rd plane, the glandular tissue is limited to a narrow strip in the posterior quadrants.

RR quarter, also is practically devoid of glandular tissue in the 1st plane. The second plane contains an area about 5 x 6 cm. in the anterior quadrants which consists principally of glandular tissue, but also contains some fat. In the third plane there is an area about 5 x 10 cm. which contains mostly glandular tissue. It is located in the anterior quadrants. The posterior quadrants show some glandular tissue, but mostly fat.

The left and right supramammary lymph nodes weigh 13 and 12 grams, respectively.

Microscopic examination

The parenchyma consists chiefly of a system of ducts, although there are apparently some alveoli present. The area occupied by the stroma is about equal to that occupied by the alveoli and ducts. The stroma is very cellular, most of the nuclei having the appearance of fibroblast or vascular endotheliocyte nuclei. There are, however, quite numerous eosinophiles in some areas, and 3 foci are noted which contain a marked infiltration of small lymphocytes. The largest such area is over .7 mm. in diameter.

The interlobular connective tissue serves as a storage

place for a large amount of fat. Most of the secretory fat is intracellular and present in relatively large amounts. A relatively small amount is seen in the lumina of the alveoli and ducts. Some lobules contain little or no secretory fat, while in others, every alveolus is heavily laden with it. Others contain amounts varying between the two extremes. Approximately 30 - 40% of the alveoli contain a dense secretion which takes the eosin stain very heavily, suggestive of a high protein content.

The lymph nodes contain quite numerous eosinophiles in both the cortical and medullary sinuses.

- - - - - - - -

CASE III (C171) was a Holstein heifer about 11 mo. old, which had shown clinical evidence of rachitis for nearly three months. She died sometime before 3 A.M. on a Sunday morning, March 26, 1933, and the udder was not removed until 5 P.M. of the same day, when it was placed in a refrigerator, to be examined 16 hours later. The ovaries showed no evidence of having ovulated.

Gross examination.

We are not sure of the correct position of this udder, as orientation was not recorded upon removal. Apparently the right front portion was not removed from the carcass; neither are the supramammary lymph nodes present.

What we consider to be the LF quarter consists of a glandular mass 2 x 2.5 x 1.5 cm. and embedded in fat. Each rear quarter contains a glandular mass surrounded by fat. The left mass is about 3 x 4 x 2 cm. and the right one slightly smaller.

In each case the greatest dimension is the antero-posterior one and the least is the dorso-ventral dimension.

Microscopic examination.

The parenchyma consists almost if not entirely of a system of ducts; there is no structure which can be positively identified as an alveolus. The gland stroma is quite cellular especially in the larger lobules, is very vascular, and contains an occasional focus of lymphocytes. The epithelium of most of the ducts exhibits 2 rows of nuclei. There is very little secretion in the ducts.

- - - - - - - - -

CASE IV (G4) was a 7 year old grade Holstein in the 5th month of her 5th lactation period, producing 7 to 9 pounds milk daily. She had been milked 3 times daily and slaughtered 4½ hours after the morning milking on March 31, 1933. Mastitis developed during her 4th lactation, had become pronounced, and constituted the reason for disposal. The udder was examined about 3 hours after slaughter.

Gross examination.

The left half of the udder is somewhat larger than the right, measuring up to 50 cm. antero-posteriorly by 33 cm. dorso-ventrally, by 18 cm. medio-laterally. The right half has corresponding measurements of 42x25x9 cm. respectively.

The left half, on the cut surfaces, does not, in general, show the distinct bulging of functional lobules seen in a gland distended with milk. The exuding secretion is fairly abundant, but is thin and yellowish, and contains flocculent material. There

is some evidence of fibrosis, especially in quadrants C of all three planes of the front quarter.

The left supramammary lymph node measures 14x10x2.5 cm., weighs 320 grams, and has somewhat the shape of a flattened kidney.

The right half. On section into the usual planes, a small amount of rather thin milk - like fluid which does not contain flocculent material like that seen in the opposite half exudes. The cut surface is quite uniformly smooth, and lobulation is not distinct, except that the interlobular connective tissue is discernible as fine, wavy streaks. As a whole, the gland gives little evidence of functional activity, but there are a few small areas of apparently functional tissue which protrude above the surrounding tissue as islands rising above water. RR1B contains one such area about 2 cm. in diameter; its color is more of a grayish pink than that of the surrounding tissue. There is a cluster of 4 or 5 smaller, but otherwise similar, areas in RF2B and D and some elevation of lobules in numerous scattered areas in RF3D and RR3D.

The right supramammary lymph node weighs 134 grams, is somewhat kidney-shaped, and measures 12x7.5x2.5 cm. The cut surface shows a slight irregular injection.

Microscopic examination.

LF quarter, shows little, if any, increase in the relative amount of interlobular connective tissue. The cells of the functional alveoli vary from a cuboidal to a columnar type, many of the latter containing vacuoles. Many alveoli are noted,

the epithelial cells of which are so distended with vacuoles that no lumina are visible; in these alveoli, few nuclei are seen, and those present are indented or flattened probably due to pressure exerted by the contents of the vacuoles. Usually a large number of alveoli in a group are thus affected. It may be a type of degeneration; in many of the so affected cells, the vacuoles contain a slight amount of granular material which gives the appearance of a hydropic change. Other than this, there is little evidence of degenerative changes in the alveolar epithelium.

Practically all interlobular ducts show active productive changes in their stromas, and many are infiltrated by numerous polymorphs, lymphocytes, macrophages, and some eosinophiles. The epithelium of most of these ducts has undergone metaplasia, there now being several layers of cells, giving it a stratified character. In one instance, cornification is present. In many of the larger ducts, what has the appearance of islands of connective tissue surrounded by duct epithelium are seen in the lumina; they are apparently outgrowths, from the actively proliferating connective tissue stroma, which have remained enveloped by epithelium, and which have been sectioned through such planes that their connections with the stroma are not seen. This conclusion is reached from the observance of others which are sectioned through such planes as to reveal the sources of the structures. They consist chiefly of vegetative forms of fibroblasts and vascular endotheliocytes, with some lymphocytes and macrophages present also.

There is some apparently normal secretion, but most of it

contains varying numbers of polymorphs and an occasional mononuclear cell. In many instances, polymorphs and lymphocytes may be seen traversing the alveolar walls. In areas of exudation, much of the secretion appears more dense and takes the eosin stain more heavily than normal. Secretory fat is abundant in only one or two sections of this quarter, being small in amount and irregular in distribution in the remaining sections. Most of it is intracellular, and the globules average about twice the diameter of erythrocytes.

The stroma is much thickened in some lobules, and is the seat of an active productive process. It contains also many lymphocytes and macrophages, and, in a few foci, eosinophiles. There is also a marked exudation of polymorphs in many areas, and slight exudation in many more. It is believed, however, that the productive changes dominate.

There is some thickening of arterial intimas, and one instance of arteritis is noted in which the media and aventitia are infiltrated by polymorphs and a vacuolar condition exists in the media.

A few corpora amylacea are present.

LR quarter contains large numbers of lymphocytes in the thickened stroma. In the third plane they are slightly fewer, and there is more collagen in evidence.

RF quarter shows very little functional activity, and little exudation of cells; however, proliferation of fibroblasts is marked. Fat production is negligible.

RR quarter shows a condition practically identical to

RF. Lymph nodes show fibrosis in the medullae.

- - - - - - - -

CASE V (G23) was a Holstein cow, nearly 4 years old, in the 5th month of her 2nd lactation period, and producing about 17 pounds of milk daily. She was milked twice daily, and slaughtered about 2½ hours after the morning milking on March 31, 1933. Examination of the udder was begun about 6½ hours after slaughter.

Gross examination.

The two halves are approximately the same size, measuring 30 cm. antero-posteriorly, 23 cm. dorso-ventrally, and 12.5 cm. medio-laterally.

The left half; milk which is apparently normal exudes freely on section of the 3rd plane. LR1A and C each contain an area about 1.5 cm. in diameter in which the lobules are not elevated and the connective tissue is prominent. LR2C contains a few smaller, but otherwise similar, areas. The third plane is more or less mottled, due to the presence of numerous small areas of non-functional lobules. The consistency of the gland in this plane suggests little fibrosis, but a large proportion of non-functional alveoli.

The left supramammary lymph node measures 7.5x3.5x1 cm. resembles somewhat a kidney in shape, and weighs 49 grams.

The right half, in general, exhibits an appearance similar to that of the left half. Small areas of non-functional tissue are located in quadrants RR1A and C, RR2A and C, RR3A and C, and RF3A.

The right supramammary lymph nodes are two in number, with

a total weight of 55 grams. One has the shape of a flattened sphere 5 cm. in diameter, while the other is elongated, measuring 5 x 3.5 x 1 cm.

Microscopic examination.

LF Quarter. The alveoli are moderately distended with apparently normal secretion. Most lobules have a few alveoli which contain some fat, but, on the whole, there is little present.

The third plane contains some areas which show early productive changes, and of others, it is difficult to decide whether they show slight productive changes or are normal non-functional areas. There are also numerous exudative foci (principally polymorphs) each involving from one alveolus to a whole lobule, and numerous lobules showing extreme vacuolization of the aveolar epithelium.

LR quarter is fittingly described by the preceding paragraph except that, in the third plane, the lesions are, if anything, more extensive.

RF quarter, is almost entirely functional, but contains a few small foci of exudation of polymorphs in each plane.

RR quarter, active productive changes are present in the third plane, especially in the posterior quadrants.

- - - - - - - -

CASE VI (G21) was a 4 year old Holstein, 95 days pregnant, in the seventh month of her 2nd lactation period, and producing about 11 pounds of milk in two milkings per day. The animal was slaughtered April 7, 1933, about 3 hours after the morning milking, and the udder was examined 1½ hours after slaughter.

Gross examination.

Each half measures approximately 25 cm. antero-posteriorly, 12 cm. medio-laterally, and 15 cm. dorso-ventrally.

Left half is mostly functional, but several areas of non-functional tissue are noted in the following locations:

RF1D and LR1D - zone about 2 cm. wide along medial border.

LR1A and C - posterior 1/3 of these quadrants.

LR2A - posterior 1/4 shows functional and non-functional lobules intermingled.

LF3C and D, LR3C and D - zone 1-3 cm. wide along medial border.

LF3A and LR3A - lateral halves of these quadrants.

The left supramammary lymph nodes are two in number. One has the shape of a flattened sphere 3.5 cm. in diameter and 1.5 cm. thick, while the other is elongated and measures 7.5 by 1 cm. by an average of 2.2 cm.

Right half contains non-functional tissue in the following locations:

RR1A, 2A and 3A - practically all of quadrants.

RR1C, 2C and 3C - posterior halves of quadrants.

RF2A - lateral zone about 2 cm. wide.

RF3A and B, and RR3A and B - lateral zone varying up to 2 cm. in width. The right supramammary lymph node is somewhat kidney-shaped, 7 x 5 x 1.3 cm. and weighs 32 grams.

Microscopic examination.

LF quarter. Each section contains at least one focus of polymorph exudation, and some contain many. There are a few small areas infiltrated by lymphocytes. All planes contain some non-

functional parenchyma, but it is most plentiful in the third. The secretion is normal except in the exudative foci. Extreme vacuolization is seen in a comparatively small number of lobules and is quite constantly present in the areas of exudation. There is little secretory fat, and what is present is quite widely distributed. The interlobular connective tissue contains a relatively large amount of stored fat. Some sections contain fairly numerous small corpora amylacea.

LR quarter resembles LF quarter except that there are more lobules of non-functional parenchyma, and slight productive changes are seen in the third plane. Very little secretory fat is seen.

RF quarter answers the description of LR quarter.

RR quarter contains moderate productive changes and fairly numerous foci infiltrated by lymphocytes, as well as numerous exudative foci. Numerous structures are present which resemble corpora amylacea except that they are ring-like rather than solid.

The lymph nodes contain numerous polymorphs and macrophages in the sinuses.

- - - - - - - -

CASE VII (C100) was a Holstein heifer, 2½ years old, which had never lactated. She was slaughtered because of sterility on April 7, 1933.

Gross examination.

The extent of glandular tissue in the left half is about 16 cm. antero-posteriorly, 5 cm. medio-laterally, and 10 cm.

dorso-ventrally. In the first plane the glandular portion involves an area 12.5 x 4.5 cm. and consists of glandular tissue intermingled with fat. The proportion of glandular tissue to fat is greater in the second plane except in the posterior quadrants. In the third plane the glandular tissue is largely limited to two irregularly circular areas, each about 4 cm. in diameter, and corresponding to the front and rear quarters; however, in the surrounding fat there are scattered, grayish areas up to 1 mm. in diameter suggestive of glandular tissue. Throughout the half, the glandular tissue has a grayish, somewhat translucent appearance.

The left supramammary lymph nodes are two in number and have a total weight of 9 grams.

The right half. The maximum extent of glandular tissue is 16 cm. antero-posteriorly, 4.5 cm. medio-laterally and about 10 cm. dorso-ventrally. In the first plane it is seen only as tiny islands interspersed with fat. In the front quarter, second plane, is an area about 3½ x 5 cm. in which the glandular tissue is apparently more abundant than fat, however, in the rear quarter in this plane, fat is more abundant. The third plane is similar to that of the left half.

The right supramammary lymph node has somewhat the shape of a pig's kidney, measures 4.5 x 2 x 1 cm. and weighs 10 grams.

Microscopic examination.

There is an enormous amount of stored fat in the interlobular connective tissue. Few alveoli are present, the parenchyma being composed chiefly of a system of ducts. The stroma is

relatively abundant and cellular, the dominating cell types being fibroblasts and vascular endotheliocytes. There are numerous scattered lymphocytes in the stroma, and several foci of lymphocytes are noted in the stromas of the larger ducts.

The lymph nodes contain relatively numerous germinal centers in the cortex, and numerous cells, viz. lymphocytes, mononuclears, and polymorphs, in the cortical sinuses.

- - - - - - - -

CASE VIII (5) was a Guernsey cow, 7 years old, in the 5th month of her 4th lactation period. She had been sold as a pregnant animal, and brought back, the buyer having considered her to have been misrepresented. She was supposed to have been 113 days pregnant, and autopsy revealed the presence of twin male fetuses in the right horn of the uterus. They had apparently perished at about 65 days. Her being out of the herd accounts for the incomplete production records. The udder was examined about 2½ hours after slaughter, on April 13, 1933.

Gross examination.

The left half measures up to 35 cm. antero-posteriorly, 11.3 cm. medio-laterally, and 19 cm. dorso-ventrally. LF1A and C are apparently non-functional. The surface is smooth and the lobules have a yellowish salmon color. Lobulation is not very distinct although the interlobular connective tissue can be seen as grayish, intercrossing bands, some of which are one millimeter wide. LF1B and D show this condition, but with numerous functional lobules interspersed among the non-functional. A small zone along

the posterior margin of LR1A and C is composed of non-functional tissue also. In the second and third planes, practically the whole front quarter is non-functional, and there are areas about 2 x 7 cm. in LR2C and LR3C in which are only a few functional lobules.

The left supramammary lymph node is shaped somewhat like a flattened pig kidney, measures 10 x 7 x 1.6 cm. and weighs 105 grams.

The right half measures 37.5 cm. antero-posteriorly, 11.4 cm. medio-laterally, and 17.7 dorso-ventrally. The following locations show evidence of functional inactivity:

RF3A,B,C, and D - all of quadrants.

RR3B and D - anterior portion of quadrants.

RR3A and B - lateral margin 2½ cm. wide.

RR2A and C - nearly all of quadrants.

RF2A and C - entire quadrants.

RF2B - lateral half.

RR1A & C - nearly all.

RF1A and C - area 5 cm. along anterior margins.

The right supramammary lymph node resembles its fellow in shape, and measures 8.2x7.2x1.3 cm.

Microscopic examination.

LF quarter. The interlobular connective tissue is much increased and quite fibrotic. Most lobules in the second and third planes are non-functional, and many of them show productive changes in the stroma along with numerous foci of lymphocytes. Also there are many areas containing large numbers of polymorphs, suggestive of either an acute injury superimposed upon one of long standing

or a sudden change in virulence of an injurious agent already present. There is a large number of foci of exudation (polymorphs) in areas of functional tissue. There are also many areas of extreme vacuolization, and it is noted that they coincide largely with the exudative foci.

Little secretory fat is present, and that which is seems to be concentrated in groups of alveoli numbering from one to the total number visible in the lobule. Some is seen in the epithelium in the ducts. Productive changes are seen in the stromas of many of the larger ducts. Some arterioles show proliferation of the intima.

LR quarter. Much more of the parenchyma is functional in this quarter than in LF quarter. However, there are numerous exudative foci of polymorphs in each plane and considerable productive changes especially in the posterior quadrants in the second and third planes. The areas of extreme vacuolization, as in the front quarter, usually coincide with the areas of exudation.

RF quarter shows no appreciable differences from the LF quarter either in degree or extent of pathological changes.

RR quarter. Exudation and infiltration of polymorphs is quite diffuse in the first plane - both in functional and non-functional areas. Productive changes are more plentiful in the lower planes, but there are foci of polymorphs there also.

The lymph nodes contain many polymorphs in their sinuses, especially along the trabeculae near the medulla.

- - - - - - - -

CASE IX was an 8 year old Ayrshire, pregnant 82 days, in

the 9th month of her 4th lactation period, and producing about 3 pounds milk daily from one milking. She was slaughtered May 4, 1933, 3 hours after being milked, and the udder was examined 1½ hours after slaughter. She was slaughtered because of the presence of mastitis.

Gross examination.

The left half measures 37.5 cm. antero-posteriorly, 11.4 cm. medio-laterally, and 15.2 cm. dorso-ventrally. Upon incision into the usual planes it is seen that there is very little functional parenchyma in this half. LF1B & D and LR1B & D show scattered, slightly elevated areas 1 - 3 mm. in diameter. In the third plane, the interlobular connective tissue is more abundant, individual bands being as much as 2 mm. wide in some areas.

The left supramammary lymph node resembles a flattened pig kidney about 7.6x5x1.6 cm., and weighs 75 grams.

The right half measures 36.3 cm. antero-posteriorly, 11.4 cm. medio-laterally, and 14 cm. dorso-ventrally. The medial quadrants of the rear quarter contain the larger proportion of the functional tissue of this half. The remaining area is largely non-functional. The third plane contains more cicatrization than the higher planes.

The right supramammary lymph node is somewhat horse-shoe-shaped, measures 2 cm. thick and 3.7 cm. wide in its broadest part. It weighs 70 grams.

Microscopic examination.

LF quarter. There are chronic productive changes practically throughout the third plane, and there is a tendency to fibrosis.

The first plane, in general, gives the impression of waning function, and, even here, there are a few lobules containing productive changes. There are numerous foci of exudation of polymorphs and an occasional focus of lymphocytes. There are numerous areas of marked vacuolization, usually corresponding to the foci of exudation. The second plane contains a preponderance of non-functional parenchyma.

Secretory fat is quite abundant in the functional areas. Innumerable corpora amylacea are present in these areas also. From the appearance of many of them, it would seem that they are being formed from drying secretions.

LR quarter. Productive changes are slightly less marked than in the LF.

RF quarter and RR quarter show no appreciable differences from LF and LR quarters respectively. In short, it is a drying udder, with a patchy, but extensive chronic productive mastitis, and with numerous foci giving evidence of acute recent injury. The process of longest standing is in the lower planes, as usual, lending support to the belief that most infections of the udder gain entrance via the teat canal and spread from below upward.

- - - - - - - -

CASE X (3) was a Guernsey, nearly 8 years old, in the eleventh month of her 4th lactation period, and producing 5 pounds milk daily in one milking. The fifth fetus was aborted at 100 days; however, the animal never reacted to the agglutination test for Bang's disease. She was slaughtered May 19, 1933, two hours after milking, and the udder was examined 1½ hours later. Sterility

and mastitis constituted the reason for slaughter.

Gross examination.

The left half measures 33 cm. antero-posteriorly, 20 cm. dorso-ventrally, and 10 cm. medio-laterally. A very patchy condition is seen. In the first plane, nearly all of the glandular tissue is functional, while in the second and third planes the larger portion is non-functional. The following areas are non-functional:

LR1D - triangular area about 4x5x5 cm.

LF2A and C, and LR2A - nearly entire quadrants.

LF2B and D - 50-60% inactive. Active lobules are interspersed in this area.

LR2B - slightly more functional than non-functional, the lateral consisting of several areas up to 1 cm. in diameter.

LR3A,B,C,D, - almost entirely non-functional.

LF1A, LF2A, LF3A - practically entirely non-functional.

LF1B and C, LF2B and C, LF3B and C - 1/3 to 1/2 non-functional.

The left supramammary lymph node is shaped like a flattened pig kidney, 7x5x1.5 cm., and weighs 42 grams.

The right half measures 35 cm. antero-posteriorly, 19 cm. dorso-ventrally, and 10 cm. medio-laterally. The following locations contain non-functional tissue to the following extent:

RR1A and C, RR2A and C - largely inactive.

RR1B and D and RR2A and C - Inactive aside from numerous islands of elevated tissue up to 2 mm. in diameter.

RF2A,B - lateral zone 1-2 cm. in width.

In the third plane the front quarter is entirely

non-functional except for a few isolated lobules at about the junction of the anterior and posterior quadrants. About 80% of the parenchyma of RR3 is non-functional. The functional lobules are located at the junction of the anterior and posterior quadrants.

The right supramammary lymph nodes are two in number. One is a flattened, elongated mass about 10x6.3x1.6 cm., while the other has the shape of an irregular, flattened sphere, 5 cm. in diameter and 1.6 cm. thick. Their combined weights equal 123 grams.

Microscopic examination.

LF quarter. The first plane, though mostly functional, contains many foci of polymorphs, infiltrating the stroma, and exuding into the alveoli until some are entirely filled. There are also several foci containing many eosinophiles in both the alveoli and stroma. The secretion in this plane is greatly altered in many lobules, in some being solid, apparently in the process of forming concretions. In fact, a great many alveoli show evidence that these solid bodies (corpora amylacea) are formed from secretion.

The second and third planes are largely non-functional and contain marked productive changes. There are liberal sprinklings of eosinophiles, lymphocytes, and polymorphs in these areas also. There is a moderate fibrosis of the interlobular connective tissue. There is very little secretory fat, even in the functional areas of the first plane.

LR quarter, likewise shows many exudative foci, little normal secretion, and many corpora amylacea in the first plane. The second and third planes are extensively involved by productive inflammation, infiltration by many lymphocytes, and some fibrosis,

especially surrounding the larger interlobular ducts.

RF quarter shows no notable differences unless it be that eosinophiles are even more abundant in the stroma of the 3rd plane of this quarter than in the other quarters.

RR quarter resembles closely the RF as to microscopic appearance.

The lymph nodes contain numerous polymorphs and some eosinophiles in the sinuses, and an increased amount of fibrous connective tissue in the medulla.

- - - - - - - -

CASE XI (274) was a Holstein cow, 5½ years old, in the 13th month of the 3rd lactation period, and producing about 20 pounds milk daily in 2 milkings. She was slaughtered July 18, 1933, 6 hours after milking, and the udder was examined one hour later. There is a history of retained placenta and peritonitis following the 3rd parturition, at which time twins (male and female) were delivered. She was slaughtered because of sterility and mastitis.

Gross examination.

The left half measures 43 cm. antero-posteriorly, 12.6 cm. medio-laterally, and 23 cm. dorso-ventrally.

What functional tissue is seen in the first plane is interspersed with small areas of non-functional tissue, and the following areas are almost entirely non-functional:

LR1A and C - whole quadrants.

LF1A and C - approximately anterior 2/3.

Zone up to about 2 cm. wide extending the length of the plane on the medial side.

Zones in the second plane corresponding to all the above are larger. The remaining area contains relatively more non-functional tissue than in the first plane. Probably less than 40% of this plane is functional and in the third plane there is still less and it is limited to LF3B and C, and LR3B and D.

The left supramammary lymph nodes are two in number, with a total weight of 154 grams. One is shaped somewhat like a flattened kidney 8.8x6.3x1.6 cm., and the other a flattened sphere 8.8 cm. diameter and 1.6 cm. thick.

The right half measures 41 cm. antero-posteriorly, 13.9 cm. medio-laterally, and 23 cm. dorso-ventrally.

In the first plane, approximately half of the parenchyma is functionally inactive, and the greater portion of it is situated as follows:

RF1A and C, and RR1A and C - nearly the entire quadrants.

RF1D and RR1D - some small areas interspersed among functional. In the medial quadrants the interlobular septa vary up to 1 mm. in width. The second plane presents a similar appearance to that of the first. In the third plane there is little functional glandular tissue, and the connective tissue is relatively abundant. In RF3A the septa vary up to 1 mm. in width. The few functional lobules are located near the milk cisterns, or near the central portions of the quarters.

The right supramammary lymph node consists of two connected lobes, shaped, in general, like a question mark. It is 12.6 cm. long over all and 7.5 cm. across its broadest part. It weighs 120 grams.

Microscopic examination.

Essentially the same condition exists in each quarter, and most conspicuous is a marked productive inflammation which is patchy in the upper plane, but more extensive and tending to fibrosis in the lower planes. There are numerous foci of lymphocytes in these productive areas and foci of polymorphs in both the functional and inflamed portions. Some areas in which eosinophiles are very numerous are noted. These cells are seen principally in the stroma, as are the lymphocytes, but polymorphs are seen, both in the stroma, and exuding into the alveoli in widely varying numbers. A few foci are noted in which the alveoli contain many polymorphs, but eosinophiles predominate in the stroma.

There is a very moderate amount of secretory fat even in the functional portions. Corpora amylacea are numerous. There is a well-marked vacuolization of the medias of the larger arterioles.

- - - - - - - -

CASE XII (247) was a Brown Swiss, just past 3 years of age, in the 8th month of the first lactation, and producing 20 pounds milk daily in two milkings. She was slaughtered July 18, 1933, 22½ hours after the last milking, and the udder was examined one hour later. The reasons for slaughter were poor type and low production.

Gross examination.

The left half measures 30.5 cm. antero-posteriorly, 11.3 cm. medio-laterally, and 20 cm. dorso-ventrally.

In LF1A and C, LR1C, LF2C and D, and LF3C and D, are a few small areas which are non-functional. With these exceptions the glandular tissue is apparently quite uniformly active.

The left supramammary lymph node is shaped like a flattened question mark 7.6 cm. in its longest dimension, 3.2 cm. wide, 1.3 cm. thick, and weighs 31 grams.

The right half measures 32.5 cm. antero-posteriorly, 11.3 cm. medio-laterally, and 15.2 cm. dorso-ventrally. In the first plane, RF1C shows several slightly depressed areas, indicative of inactivity. There is one similar area in RR1C and another near the medial border at the junction of the front and rear quarters. In the second plane, RF2A and C and RR2A and C contain a relatively increased amount of connective tissue. RR3A and C, RF3 A and C, and the medial margin of RF3D show a large proportion of connective tissue with the glandular tissue standing out as more or less isolated, slightly elevated islands. The interlobular connective tissue bands vary up to 4 mm. in width in some places. The bulk of the actively functional tissue is in RF3D and RR3D, but these, too, show some increase in connective tissue. The condition suggests a previous mastitis in the third plane.

The right supramammary lymph nodes are two in number, with a total weight of 41 grams. One has the shape of a flattened pig kidney, the other of a flattened sphere, and they measure about 5 cm. long x 3.2 cm. wide, and 2.5 cm. in diameter, respectively.

Microscopic examination.

The LF quarter is almost entirely functional. The epithelial cells of the alveoli vary from an extremely flattened to a columnar type whose free margins bulge into the lumina. The stroma is slightly increased in some lobules and a slight congestion

is quite general. A few foci of lymphocytes are noted in the stroma. Secretory fat is relatively small in amount and the globules are, on an average, about the size of erythrocytes or smaller. There are myriads of corpora amylacea present in the alveoli. Eighty-seven are counted in one section.

LR quarter is normally functional on the whole; however, a large portion of one section (LR3C) shows little functional activity, but little inflammatory change also. In this section the interlobular connective tissue is relatively large in amount, and a few small foci of lymphocytes are seen in the stroma. Secretory fat is small in amount but quite generally distributed throughout the sections. The walls of some of the arterioles in LR3C contain minute globules of fat. Some of the larger ducts in this section show stratification of the epithelium.

RF quarter. The first and second planes show a uniform, but not especially heavy production of fat and total secretion. The third plane shows some fibrosis and a few foci of exudation and infiltration of polymorphs.

RR quarter presents a very similar condition of that of RF quarter. Corpora amylacea are very numerous; as many as fourteen are seen in a single alveolus.

- - - - - - - -

CASE XIII (276) was a 5½ year old Holstein, pregnant 188 days, in the 9th month of her 3rd lactation, and producing 12 pounds milk daily in two milkings. She was slaughtered July 18, 1933, ½ hour before time for the afternoon milking, and the udder was examined one hour after slaughter. The reason for slaughter

was the presence of mastitis.

Gross examination.

The left half measures 49 cm. antero-posteriorly, 15.2 cm. medio-laterally, and 32.5 cm. dorso-ventrally. The larger proportion of the area of this half is occupied by functionally inactive parenchyma which is located as follows:

LF1A and C and LR1A and C - all except a few isolated lobules.

LF2A and C and LR2A and C - all except a few isolated lobules.

LF1B and D and LR1B and D - non-functional lobules interspersed among functional tissue.

LF2B - a considerable portion inactive.

LF2D - medial margin 4 to 5 cm. in width.

LR2A and C - only a few lobules up to 2 cm. in diameter functional. In these areas the interlobular connective tissue bands vary up to 1 mm. in width. The remaining area is patchy, showing some small areas of non-functional areas interspersed among the functional lobules. In the third plane, the front quarter is almost entirely non-functional. In LF3D the connective tissue is especially conspicuous, reaching a width of 2 mm. in some instances. In the rear quarter, a few elevated lobules not over 2mm. in diameter near the larger cisterns constitute the functional tissue.

The left supramammary lymph node consists of 2 lobes connected by a small isthmus. One has a diameter of 8.8 cm. and a thickness of 3.2 cm. the other is 5 cm. in diameter and 2 cm. thick. Their combined weights equal 215 grams.

The right half. A few slightly elevated areas 1-2 mm. in diameter constitute the functional tissue in the first plane of the front quarter. In RR1A,B, and D are several clusters up to 6 mm. in diameter composed of functional parenchyma. RF2B contains numerous elevated foci 1-2 mm. in diameter, aside from which the second plane of the front quarter is non-functional. The lateral portions of RR2A and B contain the larger portion of active parenchyma in this quarter. This plane contains approximately 15% functional and 85% non-functional parenchyma. In the third plane there is no more active glandular tissue than in the second plane. The interlobular septa are particularly conspicuous in RF3A and C where they reach a maximum width of 3mm. What active tissue there is appears as small elevated foci not over 3 mm. in diameter.

The right supramammary lymph nodes are two in number, with a total weight of 327 grams. Each has the shape of a flattened sphere; they measure 10x3.5cm. and 8.8 x 2.2cm. in diameter and thickness respectively.

Microscopic examination.

Essentially the same condition is seen in each quarter with very little differences in extent or degree. The functional areas show numerous exudative foci in which the predominating cell type is the polymorph, though some lymphocytes are noted. In some areas, infiltrative foci of lymphocytes are quite numerous, and especially so in non-functional areas. This is seen to its greatest extent in the second plane. The third plane contains, as the outstanding change, a productive inflammation consisting of an

active proliferation of fibroblasts and vascular endotheliocytes in the stroma, and production of collagen, especially in the interlobular connective tissue. There are also many foci of lymphocytes and macrophages, as well as polymorphs, in these productive areas. In many lobules, the alveoli are surrounded by numerous lymphocytes, while others infiltrate the alveolar wall. The wide distribution of exudative foci suggests the presence of an active injurious agent of similar distribution throughout the udder.

An occasional lobule shows an extreme vacuolization of the alveolar epithelium. Much of the secretion present is very dense and takes the eosin stain deeply. Corpora amylacea are very mumerous. In the functional areas, most of them are basophilic, while in those areas in which productive changes have occurred and function has ceased, most of them are acidophilic. In some instances, the central portions are blue and outer portions red. Several are noted which are seemingly surrounded by single cell layers even though located in the lumina of alveoli. A few are seen which appear to be in the walls of the alveoli and thus probably developed there. Secretory fat is present in only a small to moderate amount and in most areas is patchy in distribution.

The lymph nodes show some hyperplastic changes and a marked congestion.

- - - - - - - -

CASE XIV (241) was a Brown Swiss, past 9 years of age, which was purchased in 1931. Since being in this herd she had calved twice and was in the 9th month of lactation, and producing 20 pounds milk daily in 2 milkings. She was slaughtered September 26,

1933, 5½ hours after the morning milking, and the udder was examined 3 hours later. The reasons for slaughter were sterility and a predisposition to placentitis and postparturient peritonitis.

Gross examination.

The left half measures 33 cm. antero-posteriorly, 12.6 cm. medio-laterally, and 16.5 cm. dorso-ventrally. The parenchyma of this plane is quite uniformly active: the lobules vary from 2-7 mm. in diameter and protrude slightly, and the interlobular connective tissue is inconspicuous. In LF3A and C and LR3A and C are a few scattered areas of less active parenchyma, more prominent in LR3C. The left supramammary lymph node weighs 31 grams.

The right half measures 33 cm. antero-posteriorly, 12.6 cm. medio-laterally, and 20.2 cm. dorso-ventrally, and presents with a few exceptions a similar uniform appearance as seen in the left half. RR1A contains inactive lobules with the interlobular connective tissue distinct as intercrossing bands less than one mm. in width. RR3A and B have a lateral margin 1 to 3 cm. in width which contains some non-functional parenchyma. The right supramammary lymph node weighs 43 grams.

Microscopic examination.

LF quarter. A few lobules are noted which show a chronic productive process. These are especially numerous in the third plane. Aside from these, the gland is functional, but contains many foci of polymorph exudation. Numerous corpora amylacea are seen, both in the alveoli and in the stroma. Many of those in the stroma are partly surrounded by what appears to be the vestiges

of alveolar walls. Very little secretory fat is present.

LR quarter, resembles LF largely except that, if anything, there is a more marked exudative mastitis. The section taken from LR1C contains about 40 foci of profuse polymorph exudation.

In RF quarter, no inflammatory process is noted. Corpora amylacea are seen as in LF quarter.

RR quarter resembles LF quarter except that a few lobules in the upper planes show productive changes as well as in the lower plane. Numerous lymphocytes are present in these areas.

The lymph nodes contain some hyperplastic changes, and numerous polymorphs are seen in the sinuses.

- - - - - - - -

CASE XV (306) was a Holstein, 4½ years old, in the 3rd lactation period. She was producing 36 pounds milk daily, in 3 milkings, until 8 days before slaughter, at which time milkings were ceased. Examination of the udder was made 1 hour after slaughter, on September 26, 1933.

Gross examination.

The left half measures 45 cm. antero-posteriorly, 16.5 cm. medio-laterally, and 32.5 cm. dorso-ventrally. Upon incision into the usual planes, about a pint of fluid containing what appears to be coagulated casein exudes. In the first plane, a distinct line of demarcation extends transversely across the anterior halves of LF1B and D. Anterior to this line the glandular tissue is non-functional; posterior to the line, it is functional with the exception of the posterior halves of LR1A and C. The second plane has a few non-functional lobules, scattered more

or less uniformly throughout the plane, and the posterior halves of LR2A and C which are non-functional. In the third plane, only about one-fourth of the area is functional, that being in LR3B and D. In LR3A and C, the connective tissue septa vary up to 4 mm. in width. In LR3D is a lymph node 17 mm. in diameter, located about 15 mm. from the medial margin.

The left supramammary lymph node is shaped somewhat like a flattened pig kidney. It measures 14 x 8.8 x 2.2 cm. and weighs 320 grams. On the cut surface it appears hyperplastic.

The right half measures 45 cm. antero -posteriorly, 15.2 cm. medio-laterally, and 32.5 cm. dorso-ventrally. In the first plane, approximately one-fourth of the parenchyma is functional but not actively so. Only RF1D and RR1D show much evidence of activity. In the second and third planes, the areas of activity coincide largely with those of the first plane.

The right supramammary lymph node is also kidney-shaped, 16.5 x 8.8 x 3.5 cm., and weighs 325 grams. Its appearance is indicative of hyperplasia.

Microscopic examination.

Almost throughout the functional areas, there is more or less exudation of polymorphs. Some lobules show only a few cells, and some are seemingly entirely filled with them. Relatively few lobules contain none. There is also an extensive and marked vacuolization of the alveolar epithelium, especially of those lobules showing a mild exudation of polymorphs. A few lobules contain a large amount of intracellular fat; however, lobules showing marked vacuolization of epithelium are so much more numerous than those with high fat content that it would seem that it must

be a degenerative change. On the whole, the secretory fat is present in relatively small amounts. A few lobules in LR1 and 3 show a so-called sub-acute interstitial mastitis, with reduced function, and a thickened stroma, containing many lymphocytes and macrophages. Much more numerous are the lobules showing active productive changes together with numerous infiltrating lymphocytes. Little secretion is entirely normal, most of it being dense and highly stained, and containing polymorphs. Very few corpora amylacea are present.

In short, there is an extensive exudative inflammation in the upper planes and a chronic productive inflammation together with areas of polymorph exudation and infiltration in the lower planes. It is very possible that the mastitis which has been present for some time in the lower planes has spread rapidly to the upper planes facilitated by the presence of the secretions which have not been removed for 8 days, and which, of course, constitute an excellent medium for propagation of the organisms present.

The lymph nodes are hyperplastic and the sinuses contain many polymorphs.

- - - - - - - -

CASE XVI (270) was a 7 year old Holstein, in the 4th month of her 4th lactation period. She was producing 30 pounds milk daily, in 3 milkings, until 9 days before slaughter, at which time milkings were ceased. The udder was examined 3 hours after slaughter, September 27, 1933.

Gross examination.

The left half measures 43 cm. antero-posteriorly, 17.5 cm. medio-laterally, and 32.5 cm. dorso-ventrally. Upon incision into

the usual planes, fluid, which has a color and consistency suggesting the presence of large amounts of clotted casein and pus cells exudes. The following areas are apparently non-functional:

LF1A, LR1A and C, LF2A and C, LR2A and C, LR3A,B,C, and D, LF3A and B are almost entirely non-functional.

LF1C - entire medial half non-functional.

LF1B and D, LF2B and C, LR2B and D, LF3D contain non-functional lobules interspersed among functional.

LF3D also shows two areas 2.5 and 5 cm. in diameter respectively which appear congested.

The left supramammary lymph node is nearly circular, 15 cm. in diameter and 2.5 cm. thick, and weighs 475 grams.

The right half measures 40 cm. antero-posteriorly, 13.8 cm. medio-laterally, and 32.5 cm. dorso-ventrally. Upon incision, a considerable amount of fluid containing grayish white coagulated material exudes from the milk cisterns and major ducts.

Probably not more than 50% of the parenchyma of this half is functional. The following quadrants contain functional tissue, the bulk of which consists of isolated, slightly protruding lobules one to four mm. in diameter:

RF1B and D, RR1B, C, and D, RF2B and D, RR3B and D, RF3B and D. The remaining quadrants are non-functional in the full extent of their areas.

The right supramammary lymph node is also circular, 16.5 cm. in diameter, 2.5 cm. thick, and weighs 540 grams.

Microscopic examination.

The functional areas in this udder contain but little

normal secretion, most of it being dense and heavily stained and, in many instances, cellular, since there is an extensive polymorph exudation. There is also an extensive and marked vacuolization of epithelium which is apparently a degeneration, since fat is not demonstrated to be present in many lobules showing this condition. The extent of the exudative changes may be indirectly due in this case, as suggested in Case XV, to retention of secretions facilitating the spread of infection.

The lower planes show active productive changes in the stroma of non-functional lobules, together with a marked damage to the alveolar epithelium which is evidenced by pyknosis, vacuolization and marked desquamation. Polymorphs, lymphocytes and macrophages are numerous in these areas infiltrating both intralobular stroma and alveolar walls. There is a suggestion of productive changes within a few alveoli; however, this point is not definitely determined. In a comparatively few lobules, especially in the second plane, numerous foci of lymphocytes and macrophages are noted.

The larger, interlobular ducts show some metaplasia of the epithelium, and a few even show cornification. There are productive changes in the walls, forming villus-like outgrowths in the lumina and tending to entrap islands of epithelium in the intervening crypts. The ducts contain many polymorphs and mononuclear type cells along with secretion otherwise altered.

There is a moderate amount of secretory fat in the functional areas.

- - - - - - - -

CASE XVII (G16) was a Holstein, nearly 5 years old,

pregnant 56 days (twin males), in the 4th month of her 3rd lactation, and producing 20 pounds milk daily in 3 milkings. She was slaughtered October 4, 1933, two hours after the morning milking, and the udder was examined 11 hours later. The presence of suppurative mastitis constituted the reason for slaughter.

Gross examination.

The left half measures 40 cm. antero-posteriorly, 6 cm. medio-laterally, and 27.5 cm. dorso-ventrally. Before incision is made, rounded protuberances, firm in consistency, are discernible by inspection and palpation of the dorsal and lateral surfaces. In the first plane, the glandular tissue of the front quarter is almost entirely replaced by several abscesses ranging up to 8 cm. in diameter. They are quite well encapsulated and contain greenish-yellow caseous material. The rear quarter in this plane is non-functional, and LR1A and C appear fibrotic. LR2B and D and LF2B and D contain multiple abscesses varying from 2 to 7 cm. in diameter, and the intervening parenchyma shows evidence of injury in that there is extreme congestion, and possibly hemorrhage, present. LF2A and C are almost completely occupied by one well encapsulated abscess containing a mass of yellow caseous material which is 7 cm. in diameter. There is a marginal zone in the lateral portions of the lateral quadrants which averages about 2 cm. in width and extends from the large abscess in the anterior quadrants of the front quarter backward around the margin to the posterior extremity of the half. In this zone and in the rest of LR2A and C there are no macroscopic abscesses, the parenchyma is non-functional, and the interlobular septa vary up to 2 mm. in width. In the third

plane, there is practically no functional parenchyma. The interlobular septa vary up to 3 mm. in width, reaching the maximum widths in LF3A and C and LR3A and C. In LR3D is an abscess 3 cm. in diameter surrounded by an area 10 cm. in diameter in which there is congestion and, possibly, hemorrhage.

The left supramammary lymph nodes are two in number. One has the shape of a flattened sphere 5.7 cm. in diameter and 2.5 cm. thick and weighs 52 grams. The second has the shape of a kidney 10.7 cm. long, 8.2 cm. wide, and 3.2 cm. thick and weighs 165 grams. The appearance of the cut surface suggests hyperplastic changes.

The right half measures 40 cm. antero-posteriorly, 14 cm. medio-laterally, and 22.5 cm. dorso-ventrally. RF1A and C and RR1A and C are entirely non-functional and contain more than the usual amount of connective tissue. RF1B and D and RR1B and D are apparently functional, but not actively so and contain a few scattered yellowish areas 1-15 mm. in diameter. The second plane presents a very similar appearance to that of the first, but contains an additional zone 1 cm. in width which extends the length of the front quarter on its lateral margin, and which contains an increased amount of connective tissue along with non-functional parenchyma. In the third plane, the parenchyma is uniformly firm, inelastic, and yellowish pink in color with the exceptions of an area 5 cm. in diameter in RR3B and a few scattered lobules in RR3D which are functional. At the junction of the two quarters, and 2cm lateral to the medial margin, is a lymph node 5 mm. in diameter.

The right supramammary lymph node is shaped like a flattened sphere 8.8 cm. in diameter and 2 cm. thick, and weighs

100 grams.

Microscopic examination.

LF quarter. Numerous abscesses are present and show typical structure, with a central zone of liquefaction necrosis and polymorphs, surrounded by a zone of macrophages, which in turn is surrounded by a zone of fibrosis. The intervening lobules show marked atrophy and replacement of alveolar epithelium by actively proliferating connective tissue heavily infiltrated with lymphocytes. There is very little secretory fat and comparatively little functional parenchyma present. There are several hemorrhagic areas in the interlobular connective tissue of LF3B.

LR quarter. The first plane contains some functional tissue in which the alveoli are moderately distended with secretion which is apparently normal. Many lobules show a marked vacuolization of epithelium with flattened or indented nuclei. The lower planes resemble the LF quarter in that a chronic, but active, productive process is going on extensively. There are several areas showing hemorrhage into the interlobular connective tissue of LR3D.

RF quarter. The first and second planes contain much more functional parenchyma than in the left half. There is an extensive vacuolization of the alveolar epithelium, but only a fairly moderate amount of secretory fat present. Several small exudative foci of polymorphs are noted and some lobules showing vacuolization contain slight productive changes in the stroma. The third plane shows chronic productive changes with fibrosis in the non-functional areas.

RR quarter. The conditions in this quarter correspond very closely to those in RF except that a few more foci of lymphocytic

infiltration are noted.

The left supramammary lymph node shows some hyperplastic changes.

- - - - - - - -

CASE XVIII (G9) was a 7 year old Holstein cow in the 2nd month of her 5th lactation period, producing 58 pounds milk daily in 3 milkings. She was slaughtered October 17, 1933, 3½ hours after the morning milking and the udder was examined 11 hours later. She was slaughtered because of mastitis.

Gross examination.

The left half of the udder measures 42.5 cm. antero-posteriorly, 11.3 cm. medio-laterally, and 32 cm. dorso-ventrally. The first plane is functional with the exception of a marginal zone 2 cm. wide along the medial side of LR1C in which there is an increased amount of connective tissue. In the second plane, the parenchyma of the rear quarter is slightly more firm and inelastic than that of the front quarter or the first plane of the same rear quarter, suggesting an increase in the relative amount of connective tissue and a decrease in functional activity. In the third plane the interlobular connective tissue is more pronounced, standing out as shiny, white, intercrossing bands, for the most part less than 1 mm. in width.

The left supramammary lymph nodes are three in number, measuring 4.4 x 1.6 cm., 7x5x2 cm., and 9.5 x 7.5 x 3.2 cm., and weighing 25,55, and 105 grams, respectively. Upon incision, an extreme congestion is in evidence.

The right half measures 42.5 cm. antero-posteriorly, 10 cm. medio-laterally, and 30 cm. dorso-ventrally. Situated

on the postero-lateral aspect in the first plane of this half is a lymph node measuring 3x2.2x1cm. This half resembles the left one very closely. The only exception of note is in RR3C and consists of several lobules which appear congested and protrude to a greater extent than the surrounding lobules.

The right supramammary lymph nodes are also three in number. Each has the shape of a flattened sphere. The dimensions are 8.8x2cm., 6.3x2cm., and 5x2cm., and their respective weights are 138,47, and 25 grams. The appearance of the cut surfaces suggests subcapsular hemorrhage and some hyperplasia.

Microscopic examination.

In the functional portions, occasional foci of polymorph exudation are seen. The epithelial cells of some of the lobules are markedly vacuolated and show indentation and compression of the nuclei. There are some productive changes in the third plane, being most marked in LR quarter. The RR quarter contains exudative changes which are a little more marked than in the other quarters.

There is but little secretory fat present, and the total secretion is not abundant. In most lobules, the alveoli have the appearance of being partially collapsed, resembling in shape the alveoli of the lungs in a mild atelectasis. There are a few corpora amylacea present in the alveoli, and stroma as well. A small proportion of those in the stroma are partially surrounded by what appears to be the vestiges of alveolar walls.

The lymph nodes contain many polymorphs in the sinuses and are extremely congested, if not hemorrhagic.

- - - - - - - -

CASE XX (131) was a 4 year old Ayrshire, 168 days pregnant

and in the dry state, having completed 2 lactation periods, the second of which was of only 6 months duration. She at one time (1931) constituted a typical case of nymphomania. She was slaughtered November 13, 1933 because of low production and mastitis. Examination of the udder was made 14 hours after slaughter.

Gross examination.

The left half of the udder measures 32.5 cm. antero-posteriorly, 14 cm. medio-laterally, and 16.4 cm. dorso-ventrally. Upon incision into the usual planes, a small amount of thin bloody fluid exudes from the cut surfaces, and, from LF3 especially, copious amounts of greenish yellow pus-like material flows from the ducts. The half is non-functional throughout, and parenchyma consists of lobules 1-6 mm. in diameter and salmon-pink in color. Variations are listed under their locations.

LF1D - several abscesses 3-8 mm. in diameter, and the adjacent parenchyma is mottled with yellowish foci up to 2 mm. in diameter. These are suggestive of early abscess formation.

LR1B and D - anterior extremities contain multiple small abscesses and fibrous connective tissue.

LF2D - mottled with yellow foci which vary up to 4 mm. in diameter.

LR2 - interlobular septa vary up to 2 mm. in width. There is a marginal zone averaging about 1 cm. in width extending completely around this quarter, except on the medial side of LR2D, which is composed mostly of connective tissue.

LF3 - the ducts in this quarter are filled with greenish

yellow pus and the parenchyma is of a mottled yellow and salmon-pink.

LF3C - anterior portion is actively inflammatory and contains several abscesses less than 1 cm. in diameter.

The left supramammary lymph nodes are two in number. They measure 7.5x4.5x2.5cm and 5.7x3.2x2cm., and have a combined weight pf 97 grams. The cut surface bulges somewhat and there is a suggestion of hyperplasia of lymphoid tissue.

The right half of the udder measures 35 cm. antero-posteriorly, 11.4 cm. medio-laterally, and 15.2 cm. dorso-ventrally. Upon incision into the third plane, about 20 or 25 cc. of white watery fluid exude from the cut surface. In the first plane, the anterior half tapers off anteriorly to a width of about 2.5 cm. at its extremity. About 2 cm. posterior to the anterior extremity is an abscess 4 mm. in diameter. At the junction of RF1 and RR1 is a transverse zone 2 cm. wide which extends through the full width of the half and which is composed almost entirely of connective tissue. In the rear quarter, the parenchyma is mottled with yellow, and the interlobular connective tissue bands vary up to 2.5 mm. in width. The connective tissue bands, however, do not stand out especially plainly, since their color resembles that of the adjacent lobules. A marginal zone of connective tissue extends around the medial and posterior borders of RR2C and the posterior and lateral borders of RR2A. The second plane resembles the first very closely in appearance. The third plane likewise resembles the upper planes except that the mottling with yellow is more conspicuous and connective tissue is relatively more abundant.

The right supramammary lymph nodes are two in number. They measure 5x2x3.2cm. and 6.3x3.8x2 cm., and their total weight is 70 grams. Some congestion and hyperplasia are indicated by the appearance on the cut surface.

Microscopic examination.

LF quarter contains practically no normal appearing secretion, but in quite a large number of lobules, the alveoli contain dense, highly stained masses and there is also a wide-spread exudation consisting chiefly of polymorphs, but of some mononuclears. The predominating lesion, however, is a rather patchy, chronic, productive inflammation accompanied by considerable fibrosis. Lymphocytes and macrophages are present in large numbers as well as fibroblasts and vascular endotheliocytes. A few lobules show capillary congestion. The ducts contain proliferative and infiltrative processes in their stromas: lymphocytes, macrophages, and polymorphs in order of numbers constituting most of the infiltrating cells. Numerous lymphocytes are seen in the epithelium also. The ducts contain in their lumina dense secretion, large numbers of polymorphs, fewer mononuclears, and, in some places, large numbers of erythrocytes. Also, in some places, the productive process of the stroma has pushed its way out into the lumen, forming finger-like projections. There is practically no secretory fat present.

The LR quarter shows fibrosis which is more abundant and uniform than in LF. More smooth muscle is noted in the lower planes than in LF. There are fairly numerous corpora amylacea. Other than in these points, LR resembles LF closely; no abscesses were included in blocks taken from either.

RF quarter shows the chronic productive process with

fibrosis, but it also shows a more recent and severe injury in that there are many, and widely distributed, lobules with numerous pyknotic nuclei and large numbers of exuding and infiltrating polymorphs. A relatively few lobules contain numerous eosinophiles in their stromas.

RR quarter resembles RF.

The lymph nodes contain large and prominent germinal centers. There are many cells in the subcapsular spaces, which contain pyknotic nuclei and distinctly acidophilic cytoplasms. There is proliferation of fibroblasts, and a large amount of connective tissue in the medulla.

-o- - - - - - -

CASE XXI (96) was a Jersey, 5 years old, bought into the herd. She had completed 2 lactations in this herd and was in the dry state. The udder was examined 9½ hours after slaughter, November 29, 1933. The reason for slaughter was sterility.

Gross examination.

The left half of the udder measures 23.5 cm. antero-posteriorly, 6.3 cm. medio-laterally, and 12.6 cm. dorso-ventrally.

In the first and second planes, the parenchyma, is uniform in appearance. The lobules vary up to 3 mm. in diameter and are yellowish pink in color. Lobulation is not distinct; the lobules do not protrude appreciably above the level of the interlobular connective tissue on the cut surface, and the connective tissue is a yellowish white, so that it does not stand out in distinct relief from the lobules. In the third plane, lobulation is more distinct because the connective tissue stands out as shiny bands, up to 2 mm. in width in a few instances. In LF3 this condition is more marked. The entire half is non-functional.

The left supramammary lymph node is somewhat kidney-shaped, measures 6.3x3.8x1.6 cm., and weighs 44 grams.

The right half measures 27.3 cm. antero-posteriorly, 6.3 cm. medio-laterally, and 12.6 cm. dorso-ventrally. The entire half resembles the first and second planes of the left half.

The right supramammary lymph node has the shape of a flattened sphere. It is 4.5 cm. in diameter, 1.6 cm. thick, and weighs 32 grams.

Microscopic examination.

LF quarter contains a relatively large amount of connective tissue. The parenchyma is practically entirely non-functional, the only secretion being dense and highly stained, and present only in the ducts. The stroma is relatively large in amount and highly cellular. Vegetative fibroblasts and vascular endotheliocytes predominate, but there are numerous lymphocytes present also. The large interlobular ducts show some hyperplasia in their stromas and metaplasia of the epithelium. There is a relatively large amount of storage fat in the interlobular connective tissue, possibly accounting for the yellowish color noted in gross.

LR quarter shows no features worthy of note, other than those seen in the LF quarter.

RF quarter resembles the LF quarter also, except in a few points. Lymphocytes are more numerous in the third plane of this quarter, and there is a suggestion of slight productive changes. Several arterioles contain proliferative changes in the intima. The interlobular connective tissue is relatively more abundant.

RR quarter resembles the RF quarter, with possibly a little less interlobular connective tissue, relatively.

The right lymph node is apparently slightly hyperplastic.

DISCUSSION.

Turner and Gomez, in a discussion of the development of the mammary glands of the female guinea pig (1) and the female albino mouse (2), state that fatty pads are first formed in the approximate region which is to be occupied by the glands. The ducts of the glands gradually grow into these pads until they are completely embedded in fat. Then, as the duct system continues to grow, especially at the approach of puberty, the relative mass of glandular tissue to fat becomes greater. However, growth of true alveoli similar to those developed during pregnancy takes place only slightly if at all in the virgin. In this investigation, studies of the glands from three animals which had never lactated indicate that the development of the bovine glands must be quite similar. Of these three, the youngest animal had the least glandular tissue, while, of the two which had reached the age of puberty, the younger had more glandular tissue than the older. This is explained by the fact that the younger animal was about 60 days pregnant, and during early pregnancy a marked proliferation of glandular tissue takes place. None of the glands from the non-pregnant animals of this group contains any structures which can be positively identified as alveoli; however, the glands from the pregnant heifer contain numerous structures which are tubular in form and which contain considerable secretion. Thus it would appear that the mammary gland of the cow is a tubuloalveolar gland, the alveoli becoming evident during the later stages of pregnancy and during lactation when they are distended with secretion. Most

of the ducts from the prepuberal animal have two rows of nuclei in their epithelium; they probably represent the interlobular ducts of the mature gland(4).

The arrangement of the glandular tissue of the prepuberal animal into four distinct masses, together with the fact that quite marked and extensive inflammatory changes may exist in a quarter without the other quarter on the same side being involved, lends support to the belief that there are four distinct glands in the bovine udder, even though there is no prominent connective tissue septum separating the anterior and posterior quarters on a given side (4).

Glands obtained from the two animals which had lactated, but at the time of slaughter were in the dry state, contain parenchyma which appears, from the study of single (not serial) sections, to be tubular in form, resembling in that respect glands which have never lactated (1,2). It is the belief of some, however, that there is never total regression of all alveoli, but that some remain and function during the next lactation (5). The intralobular connective tissue also presents an appearance similar to that of the gland which has never lactated, except for the fact that there are more lymphocytes present in the gland which has functioned. It is suggested that the presence of these lymphocytes is probably physiological (5). The interlobular connective tissue contains large amounts of stored-up fat, but it is relatively less plentiful than in a gland which has never lactated. The lobules, due to regression of the secreting elements, are somewhat smaller than in a functional gland, and the relative

mass of supporting tissue to parenchyma is much greater. There is some secretion seen, especially in the ducts. It is dense and highly stained with eosin. Practically no secretory fat is present and no fat is seen in the intralobular connective tissue.

In the actively functional gland the intralobular connective tissue is inconspicuous, but nearly the whole space, relatively, is occupied by the distended alveoli. This study reveals the fact that, in general, the degree of distention of the alveoli with secretion varies directly with the length of time elapsing between the last milking and slaughter. Of course, this is also influenced by the amount of milk daily being produced. It has been found that at least 80% of the milk obtained at a given milking is present before milking is begun (7). It is also believed that secretion takes place at a more or less uniform rate between milkings (7).

It is noted that those alveoli which contain fat either intracellularly or in their lumina are, as a rule, made up of cells tending toward the columnar type. Alveoli which are composed of the flattened type contain little or no fat either intra- or extra-cellularly. However, in some microscopic fields, fat is demonstrated in certain alveoli, while in other alveoli in the same lobule and showing no appreciable differences in morphology, none is seen. Some lobules contain fat in every alveolus, others in none, and others in varying numbers of alveoli. Considering this irregular distribution of secretory fat, especially among cells which have no appreciable differences in morphology, and the fact that all the secreting cells have the same origin, it seems

reasonable to believe that all alveoli are potential fat producers. However, if that be true, the factor which causes certain alveoli in a given lobule to secrete fat, and others in the same lobule not to, is unknown. An hypothesis that the fat is secreted by a separate mechanism from the one responsible for the secretion of the other constituents of the milk has been advanced (7). Fat is frequently seen in the epithelium of the ducts also.

Corpora amylacea, so called because of their morphological resemblance to starch grains, are seen in 11 of the 15 functional udders and a few are noted in one of the dry udders. Following is a table showing their incidence correlated with the stage of lactation:

Case number	1	4	6	9	10	11	12	13	14	15	16
Month of lactation	6	5	7	9	11	13	8	9	9	3	2
No. of corp. amylacea	2+	+	2+	3+	4+	4+	4+	4+	3+	∓	+

Key: ∓ = very few
+ = moderately few
2+ = fairly numerous
3+ = numerous
4+ = very numerous

It is seen that the number of corpora amylacea present, in general, varies directly with the length of the period of lactation. Opinions vary as to the origin and occurrence of these bodies. McFadyean states that once the central part is formed, it is probable that the body grows by precipitation or accretion of materials from the surrounding liquid in the alveolus (6). Numerous fields are noted, especially in cases

10, 11, 12, and 13, in which many bodies are apparently in the process of formation with nothing visible, other than an unusually dense mass of secretion, acting as a nucleus. This fact, together with the fact that they are very numerous in some areas which contain no cells nor visible foreign materials in the alveolar lumina, suggests the possibility that they are formed from secretions alone. In some areas, they are numerous in the intralobular stroma. Many such areas are seen in case 14. An explanation for their being in this location is seen in the fact that some (possibly one-third of them) are partly or completely surrounded by what appear to be the vestiges of alveolar walls. The cells of these surrounding layers are of an almost squamous type; they have the appearance of being greatly stretched. There is apprently a reduction in both size and numbers of epithelial cells, surrounding these bodies, until there are none left, thus leaving the bodies surrounded by connective tissue. Possibly this accumulation of material in the alveolus, resulting in atrophy of the epithelium, is one of Nature's methods of reducing the secretory elements in the latter stages of lactation.

The significance of the fairly large numbers of lymphocytes scattered through the stroma and gathered into foci which are more numerous along the ducts, in the glands which have never functioned is not determined. Maximow states that in the human species a marked infiltration of the stroma by small lymphoid cells occurs simultaneously with the rapid increase in glandular elements in early pregnancy (5), which might account for their presence in case 2, assuming that the

same process occurs in the bovine species.

From the two udders which had lactated, but at the time of slaughter were in the dry state, no quarters are considered to be normal. Of the eight quarters, three have yielded streptococci on one or more occasions. Five show active productive processes, four of the five show acute exudative processes, and two show also areas of subacute interstitial mastitis. Three quarters which contain no appreciable productive changes also show the subacute interstitial mastitis, characterized principally by a marked infiltration of the intralobular connective tissue by lymphocytes and more or less reduction of secretory activity. Nine attempts over as many months have failed to isolate streptococci from five quarters. Each of these quarters, however, has shown evidances of abnormalities on physical examination of the udders and by yielding, at some time within the year preceding slaughter, milk which has contained more than 1,000,000 leucocytes per cubic centimeter.

Thirty-seven, of the 60 quarters from the 15 cows in lactation at the time of slaughter, have on one or more occasions yielded streptococci, and all show lesions. Twenty-two quarters from which no streptococci have been isolated in from one to nine attempts over as many months previous to slaughter show inflammatory changes. Of these, nine have at least once during the same period given milk which has contained more than 1,000,000 leucocytes per cubic centimeter and ten have shown evidence of abnormalities upon physical examination just previous to slaughter. Of these 37 quarters yielding streptococci, active productive changes

are seen in 37, exudative processes in 36, distinct fibrosis in 22, and subacute interstitial mastitis in 10. Of the 23 quarters from which no streptococci were obtained, exudative processes are seen in 20, productive changes in 16, and subacute interstitial mastitis in two. It is intersting to note that, out of 61 quarters showing some productive changes, 54 were discerned by physical examination a few weeks previous to slaughter, and in only two which were pronounced indurated in some degree were productive changes not seen.

Exudative processes are, in some quarters, as extensive in the higher planes as in the lower. In others, especially in those few which show only evidence of an early mastitis, exudative processes are more marked and extensive in the lower planes. In quarters containing chronic productive processes, and especially those showing fibrosis, alterations are greater and more extensive in the lower plane, diminishing from below upward. This fact supports the prevalent belief that most udder infections gain entrance via the teat canal.

Alteration of secretions is most marked in those areas containing acute and marked exudative processes, but is present even in areas which show no apparent damage to the alveolar epithelium. In areas showing only chronic productive processes, there is little appreciable change in the quality of the secretion; more noticeable, in areas showing this condition, is a reduction in quantity of secretion resulting from replacement of the secreting elements. Even this is relatively very moderate in areas of quite extensive fibrosis. On the whole, the alveolar epithelium

seems particularly resistant to injury for so specialized a tissue; however, a vacuolar degeneration is demonstrated in numerous areas many of which show also exudation of polymorphs.

Probably the most striking fact revealed by this study is that 21 out of 22 quarters showing decidedly chronic inflammatory processes also exhibit evidence of recent, acute injury. The one in which no exudative processes are seen contains numerous encapsulated abscesses. From a total of 53 lactating quarters showing productive changes, 51 contain areas showing recent injury and acute reactions, leaving the possibility that the two quarters in which such changes are not seen contain them in areas not sectioned. The foci showing recent injury are especially numerous in functional areas not otherwise involved; however, in numerous areas already greatly altered by chronic productive changes, myriads of polymorphs are seen infiltrating the connective tissue and exuding into what alveoli are left. Whether this phenomenon is an expression of a change in virulence or numbers of an injurious agent already present, or of a secondary invasion of the area by another agent is not determined. At any rate, the results of this study indicate that, once infection is established in a gland, evidence of acute and recent injury can usually, if not always, be found in that gland, regardless of the duration of the infection.

Streptococcic mastitis, then, is revealed as a chronic, but unmistakably progressive process. The progression may be so slow and mild as to be almost unnoticeable, or so rapid and severe as to result in wholesale destruction of glandular tissue and the conversion of the mass of the gland into a few large abscesses. The greater tendency is apparently most often toward a slow,

insidious, but certain progression, with occasional acute flareups. However, it frequently happens that such a process suddenly becomes changed into a more rapid and severe one, due to certain factors affecting either the defensive powers of the host or the numbers or virulence of the invaders.

SUMMARY.

1. A study is made of the mammary glands of 20 cows and heifers. Fifteen were in some stage of lactation, three had never lactated, and two were in the dry state following lactation at the time of slaughter.
2. The histological state of each group is discussed briefly.
3. Explanations of the origin of corpora amylacea, and of their presence in the intralobular connective tissue in some instances, are suggested.
4. A larger number of quarters shows exudation of polymorphs than show any other lesion; however, productive tissue changes in the stroma are almost as widespread. So-called sub-acute interstitial mastitis is seen much less frequently.
5. In many areas, especially those showing exudation of polymorphs, the presence of a marked vacuolar degeneration of the alveolar epithelium is demonstrated.
6. Alteration of secretions is most marked in glands showing numerous areas of recent, acute injury. Chronic productive changes affect the quantity of secretions more markedly than the quality, by causing replacement of the secreting elements.
7. Evidence is presented which upholds the belief that most udder infection is via the teat canals.
8. Streptococcic mastitis is revealed as an insidious, but unmistakably progressive disease which may, under certain conditions, suddenly gain impetus and bring about wholesale destruction of the gland.

TABLE I.

PRODUCTION RECORDS

Case	Lactation Periods													
	1st		2nd		3rd		4th		5th		6th		7th	
	milk	fat	milk	fat	milk	fat	milk	fat	milk	fat	milk	fat	milk	fat
1	9529	283	5913	192	8969	270	11413	349	12432	390	16823	463	9491	255
4	11190	413	12786	408	13345	438	9515	360	7158	270				
5	7256	256	3682	133										
6	7089	255	4786	174										
8	4713	267	5469	280	6044	292	Incomplete							
9	7317	286	9508	332	2984	102	7523	223						
10	8827	457	7788	392	6741	333	7190	344						
11	19709	610	18494	582	16739	461								
12	8197	330												
13	17746	530	13361	376	10095	391								
14*	9675	413	7473	334										
15	11283	311	12143	290	2581	47								
16	10082	370	9280	286	9543	317	3521	84						
17	9389	307	8195	253	4442	126								
18	11955	439	13879	446	15420	511	15947	549	1698	88				
20	6206	243	5759	212										
21	8891	504	7039	401										

*Bought into herd. Records are those of lactations after coming to this herd.

Notes:

Cases 2, 3 and 7, never having lactated, do not appear in this table.

See individual case reports for duration of final lactations.

TABLE II

CLINICAL DATA

Case	Q'tr	Streptococci 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Leucocyte count in excess 1,000,000 / cc 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Phys. Exam. udder just before slaughter
1	RR	+	+	-									+	-	+									VM
	RF	+	+	+									+	-	+									VM
	LF	+	+	+									+	+	-									VM
	LR	+	+	+									+	-	+									VM
4	RR		-	-	+	+								-	-	+	+							VM
	RF		-	+	+	+								-	+	+	+							VM
	LF		*	+	+	+								+	+	+	+							VM
	LR		-	-	+	+								-	-	+	+							VM
5	RR		-	-	-	-								-	-	-	-							M
	RF		-	-	-	-								-	-	-	-							M
	LF		-	-	-	-								-	-	+	-							M
	LR		-	-	-	-								-	-	-	-							M
6	RR		-	-	-									-	-	-								S-I
	RF		-	-	-									-	-	-								M
	LF		-	-	-									-	-	-								I
	LR		-	-	-									-	-	-								I
8	RR	+	Stá	+	+								-	-	-	+								S-I
	RF	+	Stá	+	+								+	-	+	+								M
	LF	+	-	-	+								-	-	+	+								I
	LR	-	-	+	+								-	-	+	+								I
9	RR	-	-	-	-	-	-						-	-	-	-	+	+						I
	RF	-	-	-	-	-	-						-	-	-	-	+	+						I
	LF	-	-	-	-	-	-						-	-	-	-	+	+						I
	LR	-	-	-	-	-	-						-	-	-	-	+	+						I
10	RR	+	+	+	-	-	+						-	+	+	+	-	+						M
	RF	+	+	+	-	-	+						+	+	+	-	-	+						M
	LF	+	+	+	-	-	+						+	+	+	-	-	+						I-M
	LR	-	-	-	+	-	-						-	-	-	-	-	-						I

Table II Con't.

Case	Q	Streptococci 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Leucocyte count in excess 1,000,000 / cc. 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Phys. Exam udder just before slaughter
11	RR	+	+	-	+	+	+	+	-	-			-	-	-	-	-	-	+	+	+			N
	RF	-	-	-	-	+	-	-	-	-			-	-	+	-	-	-	-	+	-			S
	LF	+	+	+	+	-	+	+	-	+			+	+	+	+	+	+	+	pus	-			I
	LR	+	+	-	+	+	+	+	+	+			-	+	+	+	-	-	+	+	+			I
12	RR		-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-			N
	RF		-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-			N
	LF		-	-	-	-	-	-	-	-			-	-	-	+	-	-	-	-	-			N
	LR		-	-	-	-	-	-	-	-			-	-	-	-	-	-	-					N
13	RR	+	+	-	+	+	+		+	+			-	-	+	+	+	+		+	+			I
	RF	-	+	+	+	+	+		+	+			-	-	+	+	+	+		+	+			I
	LF	-	-	-	-	-	+		-	-			-	-	-	-	-	-		+	+			I-S
	LR	+	+	-	-	+	+		-	-			-	+	-	+	+	+		+	+			M
14	RR			+	+	+	+	+	+	+	+	+			+	-	-	+	+	+	+	+	-	S
	RF			-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	+	S
	LF			-	-	-	-	-	-	-	-	-			-	-	-	-	-	+	+	+	+	I
	LR			+	+	+	+	+	+	+	+	+			+	-	+	-	+	+	+	-	+	I
15	RR										-											-		I
	RF										+											+		S-I
	LF										-											-		S-I
	LR										+											+		I
16	RR	+								-	+		+								+	-		I
	RF	+								+	+		+								+	-		I
	LF	+								+	+		+								+	-		I-M
	LR	+								+	+		+								+	-		I-M
17	RR			-	-	-	-			-	-	+			-	-	+	-			+	+	+	S
	RF			+	+	-	+			+	+	+			+	+	+	+			+	-	+	S
	LF			-	-	-	-			-	-	+			-	-	-	+			-	-	+	S
	LR			+	+	+	+			+	-	+			-	-	+	+			+	-	+	S

Table II Con't.

Case	Q't'r	Streptococci 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Leucocyte count in excess 1,000,000 / cc. 1932 No	De	1933 Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Se	Phys. Exam. udder just before slaughter
18	RR		+	+	+	+	+	+	-	-		-		+	+	+	+	+	+	+		+		N
	RF		-	-	-	-	-	-	-	-		-		-	-	-	-	-	+	-		+		S
	LF		-	-	-	-	-	-	-	-		-		-	-	-	-	-	-	+		+		N
	LR		-	-	-	-	-	-	-	-		-		-	+	-	-	-	-	+		+		S
20	RR	-	-	-			-	-	-	-	-	-	-	-	-			-	-	-	-	+		I
	RF	-	-	-			-	-	-	-	-	-	-	-	-			-	+	+	+	+		S
	LF	-	-	-			-	-	-	+	+	+	-	-	-			-	-	-	+	+		S
	LR	-	-	-			-	-	-	-	-	-	-	-	+			-	-	-	-	+		I
21	RR	-	-	-	-	+	+	±	-	+			-	+	-	+	+	+	+	pus	pus			M
	RF	-	-	-	-	-	-	-	-	-			-	-	-	+	+	+	+	+	+			M
	LF	-	-	-	-	-	-	-	-	-			-	-	-	-	-	+	+	-	-			S-I
	LR	-	+	-	-	-	-	-	-	-			-	-	-	-	-	-	+	-	-			S

Note: Cases 2,3, and 7 had never lactated; therefore they had not been examined for evidences of mastitis.

Key:
N - normal
S - slightly indurated
I - indurated
M - markedly indurated
VM - very markedly indurated
Sta- staphylococci

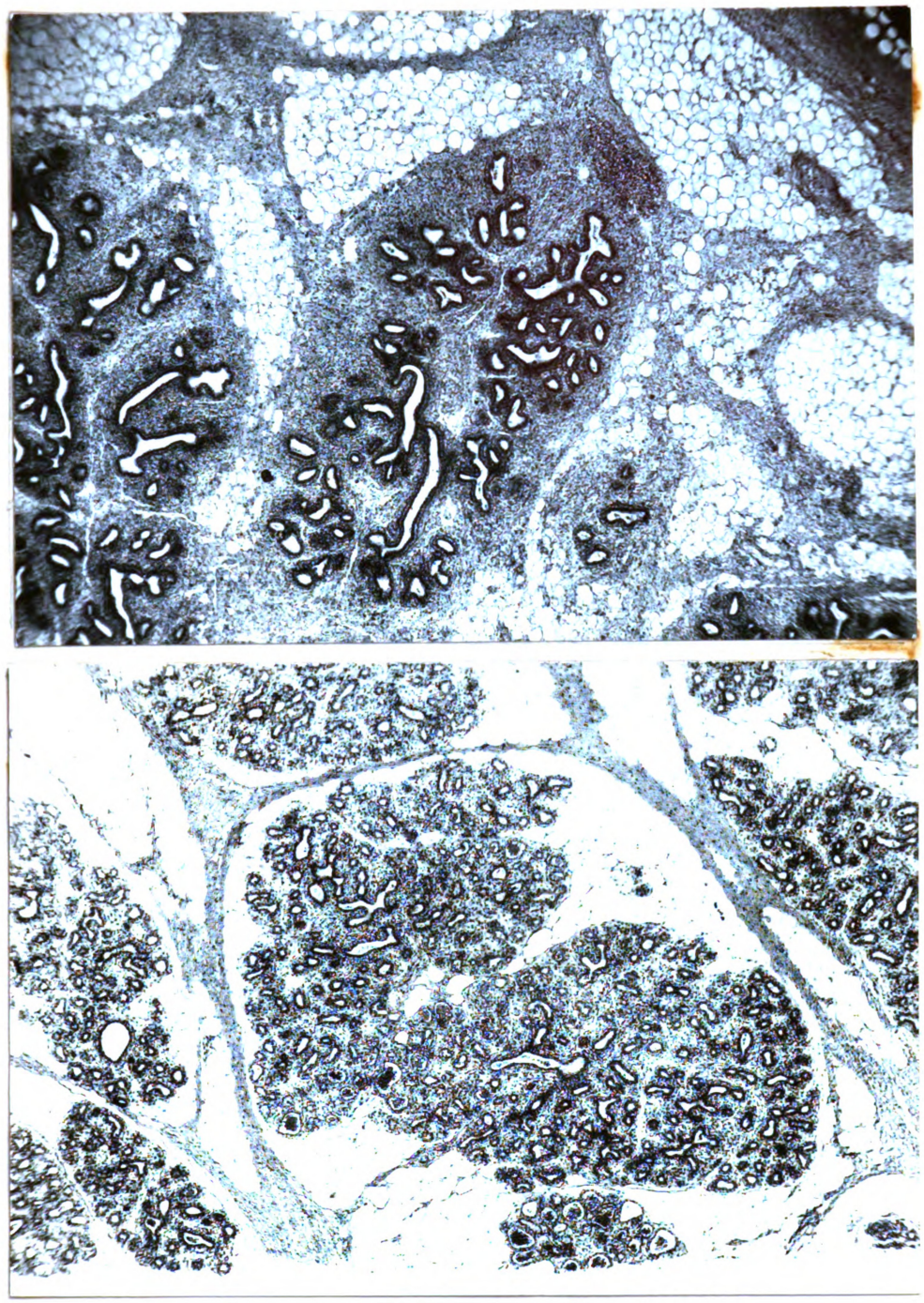

Fig. 1. (above) Case 3. Prepuberal gland. Note the large amount of interlobular fat, also the apparent absence of true alveoli. Eosin-hematoxylin 60X.

Fig. 2. (below) Case 2. Gland of animal in first pregnancy (60 days). Note the presence of a few alveolus-like structures containing dense masses of secretion. There is also relatively less interlobular fat than in figure 1. Eosin-hematoxylin 60X.

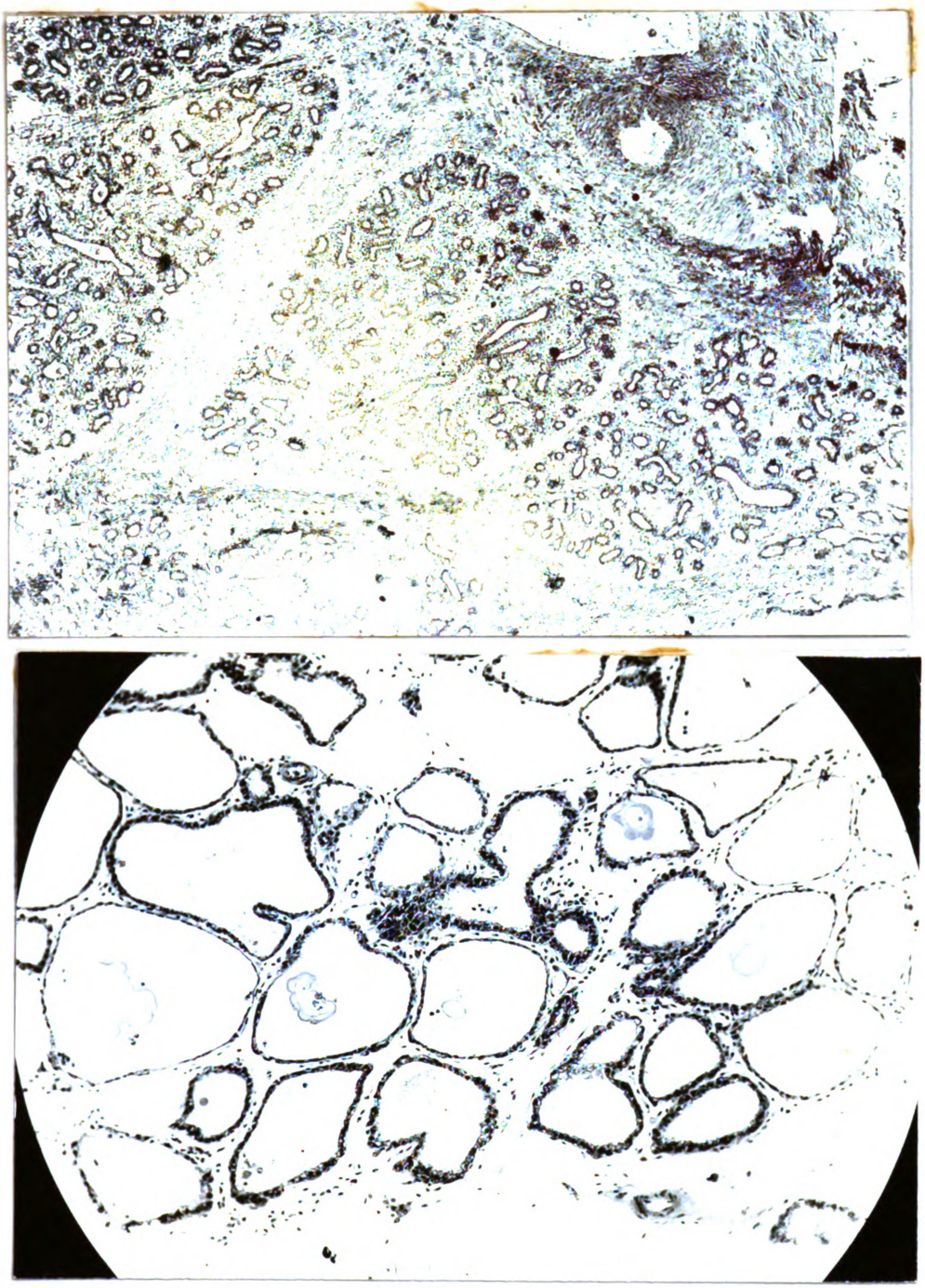

Fig. 3. (above) Case 20. Gland in the dry state.
Eosin-hematoxylin 60X.

Fig. 4. (below) Case 10. Early stages in the formation of corpora amylacea in an otherwise normal field.
Eosin-hematoxylin 100X.

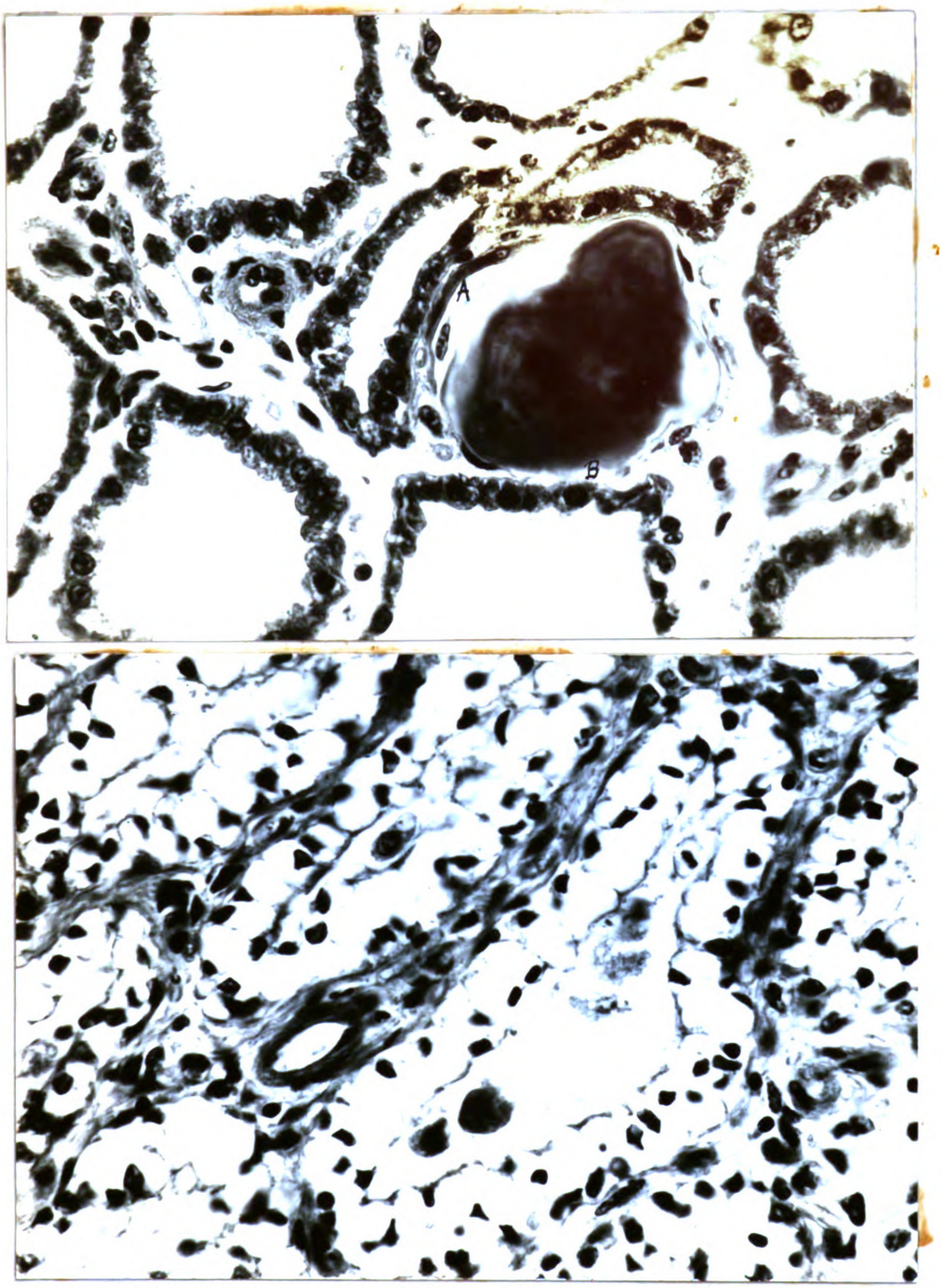

Fig. 5. (above) Case 14. Corpus amylaceum which is apparently located in the stroma. Atrophied alveolar epithelial cells are seen at "A", but are entirely absent at "B". Eosin-hematoxylin 675X.

Fig. 6. (below) Case 5. Section showing what is interpreted as a vacuolar degeneration of the alveolar epithelium. Note the much compressed nuclei as compared with those of figure 5. Eosin-hematoxylin 675X.

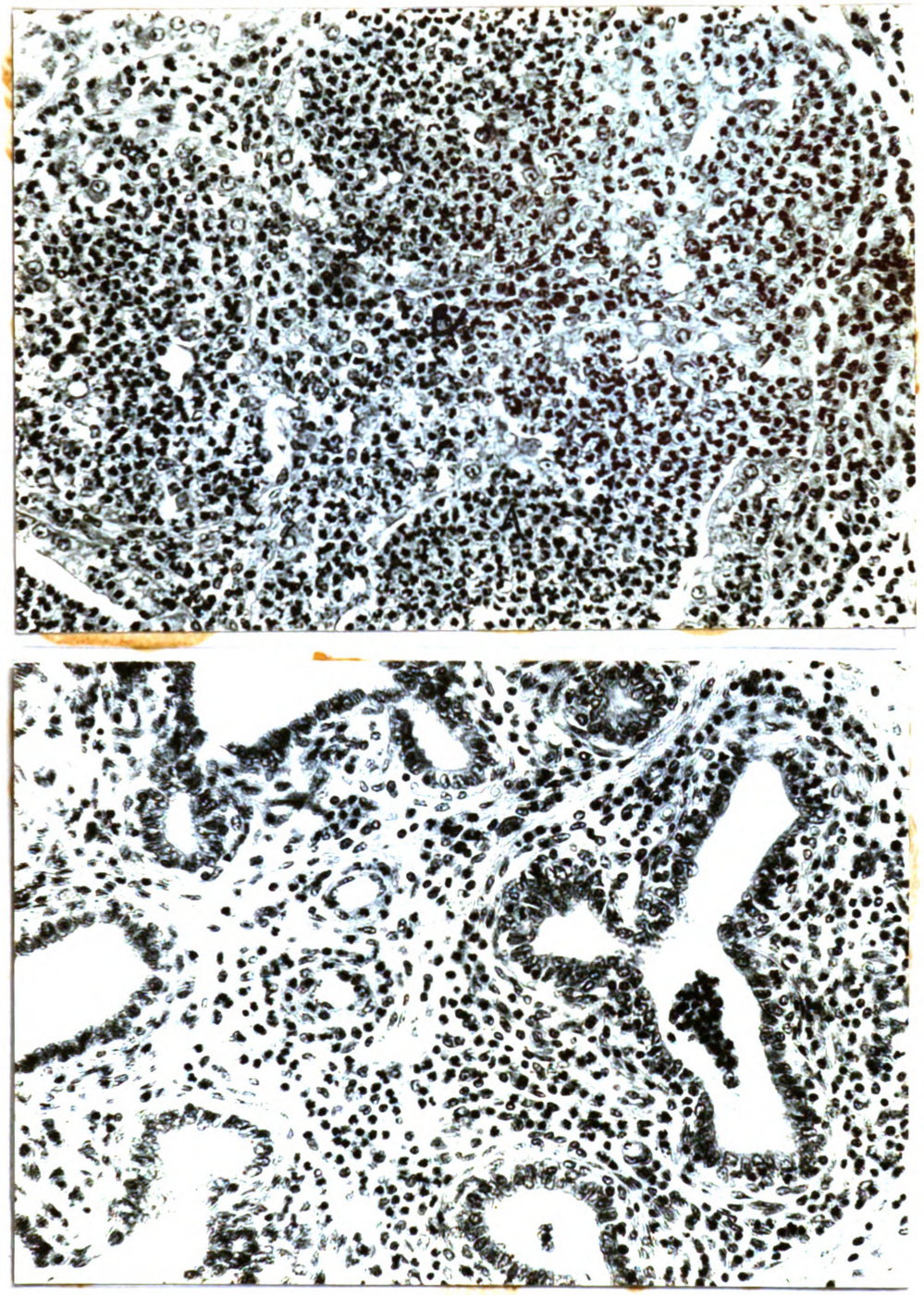

Fig. 7. (above) Case 11. Acute exudation of polymorphs. Note their presence in alveolar lumina (A), alveolar walls (B), and intralobular stroma (C). Eosin-hematoxylin 360X.

Fig. 8. (below) Case 11. Early stage of an acute process superimposed upon a chronic one. Note the polymorphs in the alveolus and especially infiltrating the stroma. Eosin-hematoxylin 360X.

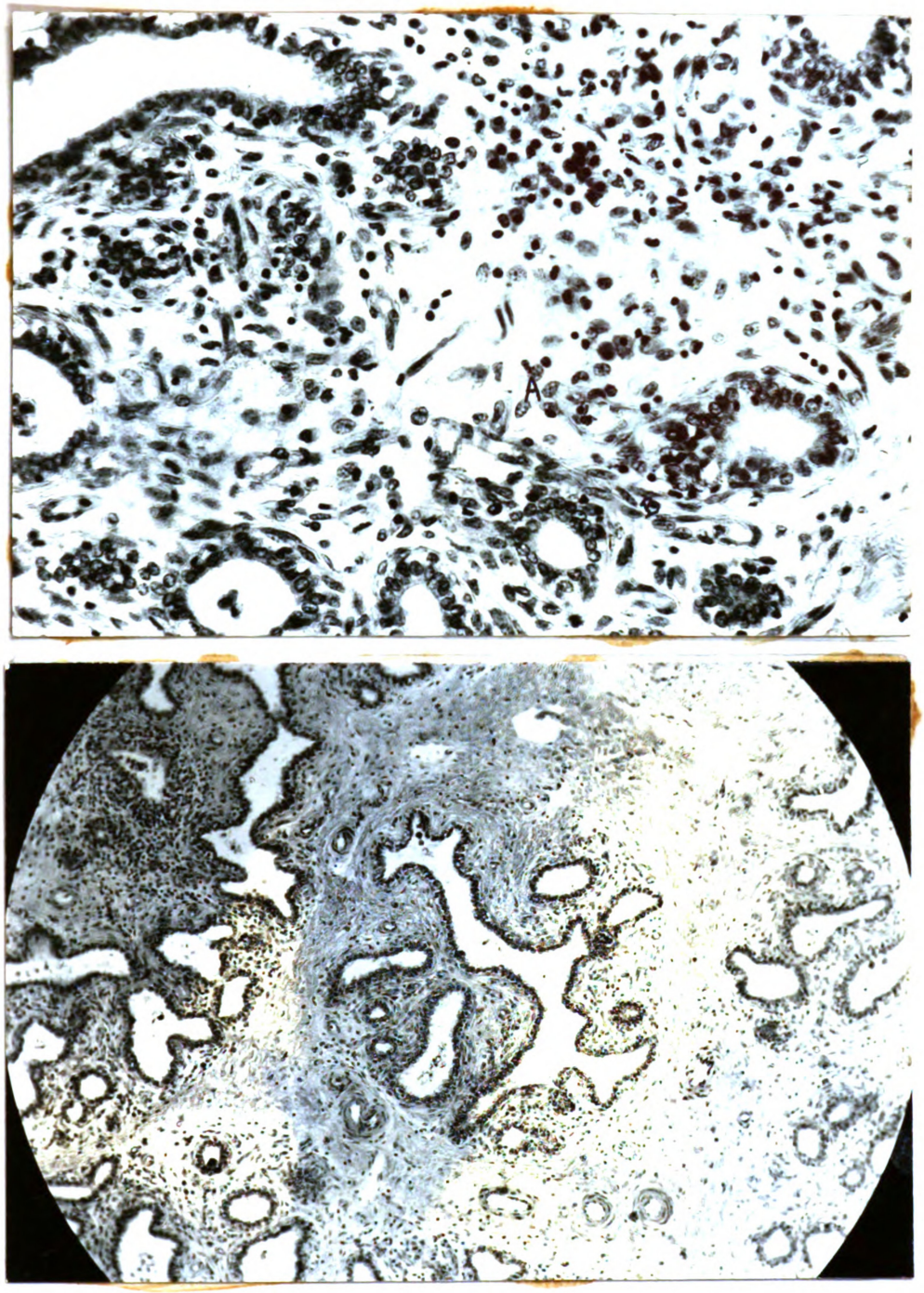

Fig. 9. (above) Case 13. Active productive mastitis. Note the vegetative fibroblasts (A) and vascular endotheliocytes (B). Eosin-hematoxylin 360X.

Fig. 10. (below) Case 11. Marked fibrosis in a non-suppurative mastitis. Note the large amount of collagen which has replaced much of the secreting element.
Eosin-hematoxylin 100X.

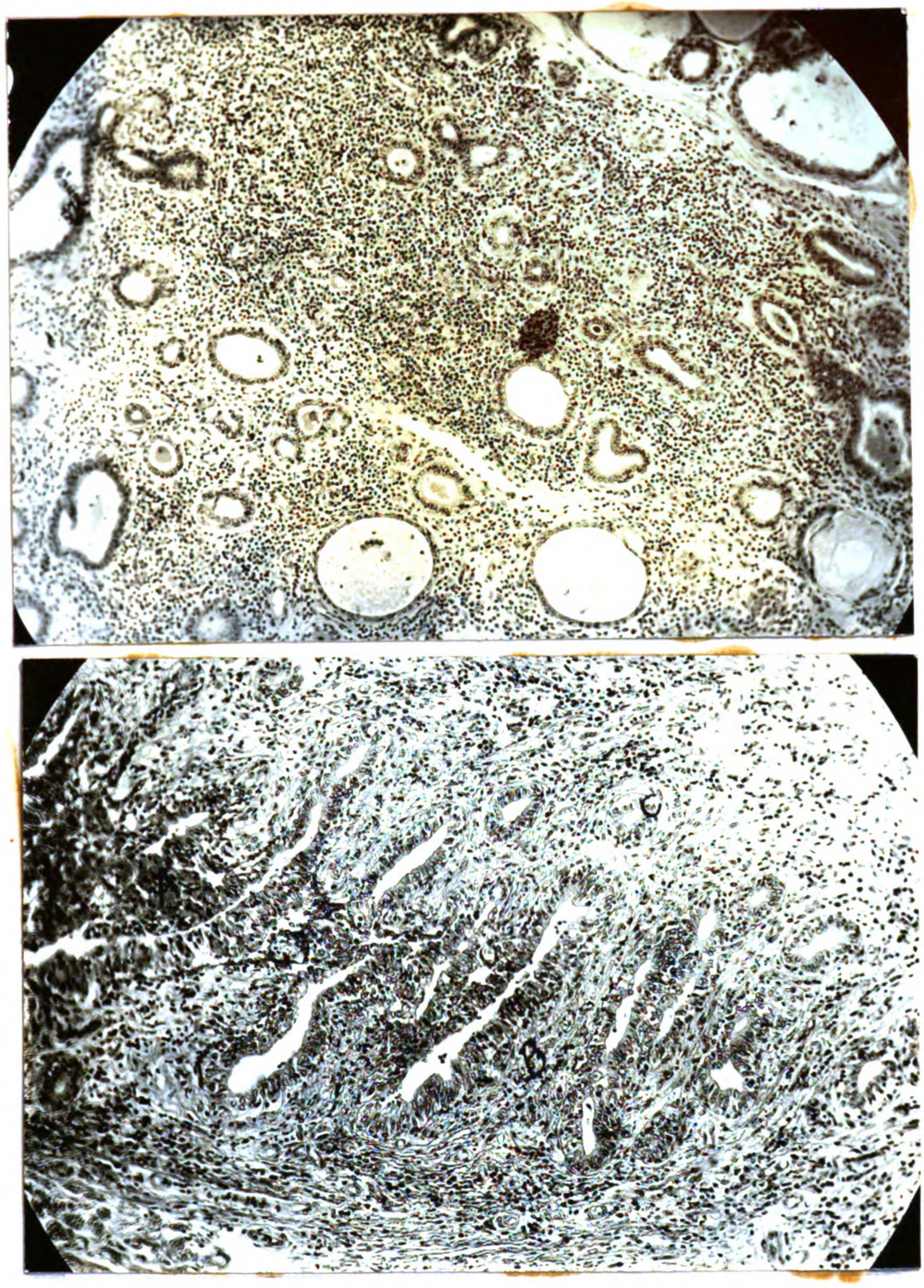

Fig. 11. (above) Case 11. Subacute interstitial mastitis. Note the large numbers of lymphocytes and macrophages. Eosin-hematoxylin 110X.

Fig. 12. (below) Case 16. Proliferative changes in the epithelium (A) and stroma (B) of a lactiferous duct sectioned longitudinally. Note the islets of epithelium (C) presumably formed by being entrapped in the crypts between the villus-like projections of proliferating connective tissue. Eosin-hematoxylin 110X.

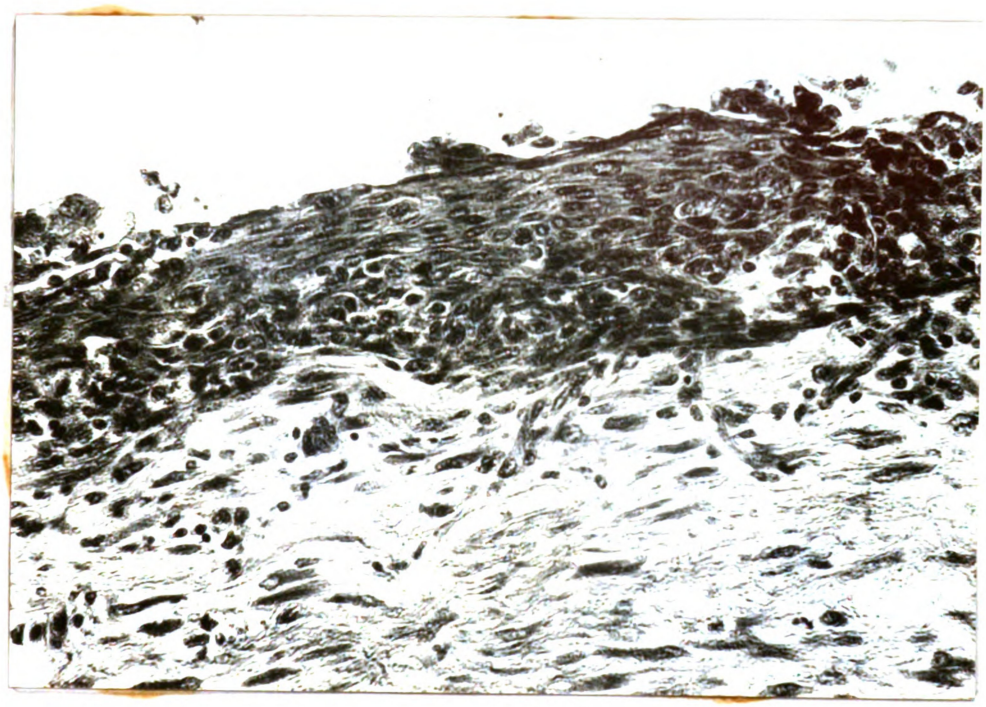

Fig. 13. Case 16. Ectodermizing of the epithelium of a lactiferous duct. Note the striking resemblance to the stratified squamous epithelium of the skin. Eosin-hematoxylin 360X.

BIBLIOGRAPHY

1. Turner, C. W., and Gomez, E. T., The Normal Development of the Mammary Gland of the Male and Female Guinea Pig. University of Missouri, Agr. Exp. Sta. Research Bulletin 194, pp. 30-31, June, 1933.
2. Turner, C. W., and Gomez, E. T., The Normal Development of the Mammary Gland of the Male and Female Albino Mouse. University of Missouri, Agr. Exp. Sta. Research Bulletin 183, pp. 40-41, February, 1933.
3. Sholl, L. B., and Torrey, J. P., A Contribution to the Bacteriology and Pathology of the Bovine Udder. Michigan State College, Agr. Exp. Sta. Technical Bulletin 110, pp. 5-6, January, 1931.
4. Turner, C. W., The Structure of the Cow's Udder. University of Missouri, Agr. Exp. Sta. Bulletin 344, pp. 4-9, January, 1935.
5. Maximow, A. A., Textbook of Histology (W. B. Saunders Co.) 1930, pp. 683-6.
6. McFadyean, Sir John, Corpora Amylacea of the Mammary Gland of the Cow. Jour. Comp. Path. and Therap. XLIII, 291-300. September, 1930.
7. Petersen, W. E., Palmer, L. S., and Eckles, C. H., The Snythesis and Secretion of Milk Fat — I. The Time of Milk and Fat Secretion. Amer. Jour. Physiology, XC, (3), 573. November, 1929.

ACKNOWLEDGMENTS

It is with pleasure that the writer expresses his most sincere gratitude to Dr. E. T. Hallman for his encouragement and invaluable assistance in carrying out this project. He wishes also to express his thanks to Mr. C. S. Bryan for the loan of data regarding the bacterial and leucocytic content of milk from the glands studied, to Dr. G. E. Taylor for data regarding production records and physical examinations, and to Dr. C. F. Clark for all other clinical data. He is likewise indebted to Mr. W. E. Laycock for the photomicrographic work.