AN OUTBREAK OF PNEUMONIA IN DAIRY COWS ATTRIBUTED TO BACILLUS BOVISEPTICUS.

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PLATES 44 TO 46.

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Bollinger¹ in 1878 described under the name Wild- und Rinderseuche an acute disease in deer, wild boars, and cattle. He was able to recognize two types, exanthematous and pectoral. In 1885, Kitt² isolated a bacterium (B. bovisepticus) from a disease of cattle similar to that described by Bollinger. Many outbreaks of what is termed hemorrhagic septicemia have been described in various species of bovines. That the disease existed in cattle in this country was recognized by Theobald Smith³ in 1895. Nocard⁴ a few years before described its occurrence and succeeded in isolating the bacillus from cattle shipped from America to France. Many have confirmed Bollinger’s observation that the malady attacks practically all species of bovines. Wilson and Brimhall⁵ during 1900 studied in Minnesota eleven outbreaks of disease in cattle caused by B. bovisepticus. The disease was of short duration, death ensuing within 24 hours after the onset. On autopsy, ecchymoses and larger hemorrhages were found in the subcutis, muscles, and internal organs. Pneumonia was not observed. Woolley⁶ in the Philippines reports the pulmonary form in caribou. Mohler and Eichhorn⁷ attribute losses among the buffaloes in the Yellowstone National Park to infection with B. bovisepticus. Magnusson⁸ describes a very severe type of hemorrhagic septicemia in the reindeer of Lapland.

¹ Bollinger, O., Ueber eine neue Wild- und Rinderseuche welche im Sommer 1878 in der Umgebung von München beobachtet wurde, Munich, 1878.
⁴ Nocard, E., Rec. méd. vét., 1891, viii, 424.
⁵ Wilson, L. B., and Brimhall, S. D., Sixty cases of hemorrhagic septicemia in cattle due to Bacillus bovisepticus—A report of the State Board of Health of Minnesota, St. Paul, 1901.
PNEUMONIA IN DAIRY COWS

In this country the disease commonly occurs in beef cattle which have been shipped to various parts of the country for fattening. The outbreak with which we are concerned occurred in a dairy herd. Throughout the literature we are unable to find detailed descriptions of outbreaks of pneumonia in cattle where it was possible to obtain a definite history of the herd in which the disease occurred. In this instance it has been possible to follow cases from early in the course of the disease to autopsy or recovery. In addition, several opportunities have been afforded for observations on sporadic cases which occurred after the main outbreak had subsided. We feel that the data accumulated warrant publication.

Conditions before the Outbreak.

The herd in which the disease occurred has been under observation by members of the staff of this Department since 1917. During this time a considerable number of autopsies of cows and calves have been made. Theobald Smith noted that during 1917 cases of pneumonia occurred among the calves. One case was regarded as a primary infection with Bacillus bovisepicus. During 1919 and 1920 he studied twelve cases of calf pneumonia. In nine instances Bacillus actinoides was found. It is stated that Bacillus bovisepicus was associated with three or four of these nine cases. It will be shown in a later communication that the type of Bacillus bovisepicus which was encountered during the epidemic to be described differs in many respects from the types which were associated with the pneumonia of the calves. The inference then is that the bipolar organism associated with the epidemic was not present in the herd but was introduced through the purchase of new cows.

With this herd the policy has been to purchase cows as circumstances dictate. Usually a number of animals are procured from various farmers. They are assembled and shipped by express. It is customary to segregate newly imported animals in separate barns. Such cows are milked and fed after the regular herd. The following importations were made during the later months of 1920: August 18, 24 cows from Pennsylvania; October 1, 12 cows from Pennsylvania;

*Smith, T., J. Exp. Med., 1921, xxxiii, 441.*
October 20, 39 cows from Michigan. Both lots from Pennsylvania came by express and were unloaded only at the final destination. All animals received from Michigan came by freight in stock and box cars as it was not possible to obtain express cars at that time. This lot of Michigan cows was loaded October 16. The following day they were unloaded at Mansfield, Ohio, and there fed and watered. The same procedure was gone through at Pittsburgh, Pennsylvania, on October 18. From Pittsburgh they were forwarded directly and reached their destination on October 20. These animals, the Pennsylvania cows, and a few others purchased from local farmers, together with a few native cows, were housed in the same barn.

The Outbreak.

One of the Michigan cows was sick when received. Symptoms of pneumonia were not noted during its illness. The animal remained unthrifty and finally became valueless for dairying purposes. It was slaughtered in April, 1921. The right cephalic lobe was shrunken and a gray-red color. It cut with difficulty. The interlobular connective tissue was increased. The lobules were compressed. The bronchi were greatly dilated and filled with pus.

On October 31, 1920, another of the Michigan cows was reported sick. It became worse, symptoms of respiratory disturbance developed, and the animal died during the night of November 2. Unfortunately, no autopsy was made. The man who disposed of the carcass reported a reddening of the lungs and their adherence to the chest wall. The next cow (No.531) sickened on November 3. During the next 2 weeks about twenty cases developed. It was possible to transport the first nine cases to an isolation unit at the Institute where facilities for careful study were at hand. Later two calves were also obtained from the same farm. The nine cows were the first in which the disease was recognized and are given in Table I in the order of their occurrence. One of the infections in the calves is added for completeness. Several other cases occurred in the herd but were not studied.

On the temperature charts it will be noted that certain animals were injected with vaccine and commercial hemorrhagic septicemia antiserum. The animals were not under the control of the Institute.
## TABLE I.

<table>
<thead>
<tr>
<th>Cow No.</th>
<th>Locality from which animal was obtained</th>
<th>Date of introduction into herd</th>
<th>Date first symptoms were noted</th>
<th>Temperature</th>
<th>Summary of characteristic symptoms</th>
<th>Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>531</td>
<td>“</td>
<td>“ 20</td>
<td>Nov. 3</td>
<td>41.1</td>
<td>Superficial breathing, gummy discharge from eyes, inappetence and constipation, albuminuria.</td>
<td>Recovered.</td>
</tr>
<tr>
<td>533</td>
<td>Pennsylvania</td>
<td>“ 1</td>
<td>“ 6</td>
<td>41.5</td>
<td>Depression, cough, dyspnea, dullness under areas of percussion, bronchial breathing, inappetence and constipation.</td>
<td>Killed Nov. 13. Diffuse pneumonia.</td>
</tr>
<tr>
<td>530</td>
<td>“</td>
<td>“ 1</td>
<td>“ 7</td>
<td>41.1</td>
<td>Cough, dyspnea, dullness on percussion, bronchial breathing, inappetence and constipation.</td>
<td>Killed Nov. 11. Diffuse pneumonia.</td>
</tr>
<tr>
<td>532</td>
<td>“</td>
<td>“ 1</td>
<td>“ 8</td>
<td>41.1</td>
<td>Cough, rapid respiration, dyspnea, emaciation, inappetence and constipation.</td>
<td>Recovered.</td>
</tr>
<tr>
<td>535</td>
<td>Local</td>
<td>Nov. 3</td>
<td>“ 10</td>
<td>41.8</td>
<td>Cough, rapid respiration, nasal discharge, inappetence and constipation, albuminuria.</td>
<td>“</td>
</tr>
<tr>
<td>534</td>
<td>Michigan</td>
<td>Oct. 20</td>
<td>“ 10</td>
<td>41.7</td>
<td>During observation animal revealed no characteristic symptoms.</td>
<td>“</td>
</tr>
<tr>
<td>538</td>
<td>Native</td>
<td>“ 11</td>
<td>“ 11</td>
<td>40.8</td>
<td>Cough, rapid respiration, dyspnea, inappetence and constipation.</td>
<td>“</td>
</tr>
<tr>
<td></td>
<td>Pennsylvania.</td>
<td>Oct. 1</td>
<td>Nov. 13</td>
<td>40.2</td>
<td>Chills, dyspnea, dullness on percussion, bronchial breathing, congestion of conjunctiva, inappetence and constipation, albuminuria.</td>
<td>Died Nov. 18, Diffuse pneumonia.</td>
</tr>
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</tr>
</tbody>
</table>
The injections were made by the owner's representative. Our limited observation concerning their value does not warrant any discussion.

The table indicates that the first cow to come down with pneumonia was one of those obtained from Michigan. The second case also occurred among this lot. The disease next attacked the Pennsylvania cows and further spread to the native stock. The mortality was highest in the Pennsylvania cows. The native stock suffered severely.

The records of several typical cases follow. The temperature charts are appended (Text-figs. 1 to 5).

**Text-fig. 1.** Temperature chart of Cow 530.

*Cow 530.*—A grade Holstein cow purchased in Pennsylvania on Oct. 18, 1920. On Nov. 4, she gave birth to a normal calf. Nov. 7. The animal was reported sick. The temperature was 41.5°C. The next day the highest temperature recorded was 41.4°C. at 7 p.m. The respiration rate was accelerated. The milk flow was diminished, the appetite poor. The cow was constipated.

On Nov. 9, the cow was transferred from a neighboring farm to an isolation unit at the Institute. Weakness was apparent, the gait was unsteady. The respirations were labored, dyspnea was pronounced. On expiration the dyspnea was marked and accompanied by a distinct grunting sound. At times the animal breathed through the mouth. There was a thin white mucous discharge from both nostrils.

Nov. 10. Weakness was more apparent. The cow was restless. The head was extended, the nostrils dilated, and the mouth held open. Sudden movements of the limbs caused discomfort. The animal refused food and water. Milk secretion was suppressed. There were constipation and atony of the rumen.
The tail and buttocks were soiled with blood-stained, fetid feces. The skin was dry and hot. The conjunctiva was congested. Moderate pressure applied to the pharynx produced considerable discomfort. The cough was short, frequent, and painful. Temperature 41.6°C. The pulse was rapid and irregular (98 per minute). The respiration rate was 40. Respirations were short and superficial. Percussion of the thorax caused pain, there was dullness beneath most of the area of percussion. On auscultation the vesicular murmur was exaggerated and coarse and there was bronchial breathing.

The results of the urine examination were as follows: color, clear amber; specific gravity, 1.022; reaction, alkaline; albumin, present (Esbach 0.25 per cent); sugar, absent; bile, present; blood, absent.

Under antiseptic precautions, 15 cc. of blood were drawn from the left jugular vein into a flask containing 50 cc. of sterile bouillon. The mixture remained sterile after 7 days incubation.

On Nov. 11, the cow was killed and autopsied at once. The following autopsy notes were made.

The carcass is that of a well nourished adult Holstein cow.

Heart.—There is a large amount of fat about the pericardium. The pericardium appeared normal. On the fat overlying the right auricle there are three irregular patches of gelatinous hemorrhagic exudate. The heart muscle appears normal.

Lungs.—The process is that of an extensive pneumonia involving all lobes. The pneumonia is more pronounced on the ventral aspect. The external anterior third of the first half of the cephalic lobe of the right lung (ventral aspect) is of a reddish gray color, firm, and liver-like. The pneumatic process on the dorsal surface is confined to a dark red band, 3 to 4 cm. wide, extending from the anterior to the posterior border. The second half of the cephalic lobe is not appreciably involved. The ventral lobe is solidified. The pleura over the external two-thirds is covered with a yellow, felt-like fibrinous exudate, 2 to 6 mm. in thickness (Fig. 1). It may be peeled off with gentle traction, leaving the thickened pleura with adhering tufts of exudate. The underlying lung is mottled dark red to reddish gray. The lobules stand out clearly due to a thickening of the interlobular septum and the filling of the lymph vessels with a serous exudate (Fig. 2.) In many instances coagulation of the exudate has occurred. This material may be “shelled out” from some of the larger lymph spaces. The lobules are solid. Their color varies from deep red to reddish gray. Tiny grayish white patches are observed scattered throughout many of them. The central bronchi are often occluded with a plug of coagulated exudate. From the cut surfaces a yellow, turbid, serous fluid exudes.

On the ventral surface of the right caudal lobe the anterior half is involved. The involved portion varies from reddish gray to gray in color. It is solid and presents the same gross characters as those described under the right ventral lobe. The portion of complete hepatization is succeeded by a band in which the consolidation is irregular. On section, some of the lobules are deep red and solid, others are pink and contain air. From the cut surfaces a clear serous fluid flows.
On the dorsal surface of this lobe the process is similar but it is confined to the anterior fourth. The azygos lobe is consolidated. It is mottled reddish gray. The pleura is covered with a yellowish white, fibrinous exudate.

In the left lung the process is confined to about the same areas. There is a reddish gray consolidation of the dependent portion of the cephalic lobe which is not as large on the dorsal aspect. A complete solidification of the lower aspect of the ventral lobe is observed. A small portion of the dorsal surface still shows air-containing tissue. About half of the caudal lobe (ventral aspect) is involved, but barely one-third of the dorsal surface is affected.

The pleural cavity contains a considerable amount of clear serous fluid which coagulates on standing. The parietal pleura, especially that in contact with the ventral and azygos lobes, is covered with a thick, felt-like exudate which in certain places has adhered to the lung pleura.

There is a patch-like congestion of the mucosa of the trachea. The mucosa of the bronchi is congested. Adhering here and there to the mucous membrane are masses of viscid mucus-like material.

The bronchial and mediastinal lymph glands are edematous. They are not enlarged or discolored.

Liver.—The organ is not enlarged. The color is light brownish red. The gall bladder is distended with blackish green, gelatinous bile.

Spleen.—Not enlarged, measures 3.8 by 11.5 cm. The vessels of the capsule are injected. Here and there are round, slightly raised hemorrhages 2 to 3 mm. in diameter. On section the capsule is not thickened. The pulp is normal in color. The Malpighian corpuscles are not enlarged.

Kidneys.—They are well surrounded by fat. Their color is reddish gray. No hemorrhages are visible on the surface. The capsule is not thickened and peels off readily. On section the vessels of the cortex are injected. When scraped the epithelium is dry and appears granular. The medulla is dark red and glistening. It is clearly demarcated from the cortex.

Gastrointestinal Tract.—Appears normal.

Pieces of the various organs were fixed in Zenker's fluid for microscopic study. The following changes were observed in the stained sections. The pleura is covered by a dense mass of fibrin. The pleural lymph spaces are filled with fibrin. Both red cells and leucocytes are enmeshed in the exudate. There is an increase in the endothelial elements. The exudate becomes more cellular as the lung is neared, so that immediately adjacent to the lung densely packed masses of leucocytes are found.

Two distinct stages of pneumonia can frequently be seen in the same section (Fig. 4). The alveoli in one lobule may be filled with fibrin and the alveolar capillaries packed with masses of red cells (Fig. 6). Very few cells have invaded the air spaces in such portions. In other lobules the lesion is that of extensive hemorrhage, the air spaces are largely filled with red cells. The blood vessels are engorged and not infrequently plugged with fibrin. The bronchi and bronchioles
contain fibrin and red cells. Such lobules are separated from an older type lesion by the thickened interlobular septum (Fig. 4). The septum where it leaves the pleura is edematous and at times shows proliferation of connective tissue elements. The interlobular tissue is edematous and swollen with a fibrinous exudate. The lymph channels and blood vessels are dilated and plugged with fibrin. In the pneumonia of longer standing (Fig. 7), the interlobular congestion is more moderate. The air spaces are filled with degenerated leucocytes and desquamated alveolar cells. Considerable numbers of tiny rod-shaped organisms are found in the exudate within the alveoli (Fig. 8). The epithelium of the bronchi reveals degenerative changes. The lumen is usually filled with leucocytes and bacteria.

Sections from a number of regions were examined. Various stages of pneumonia were observed. In certain sections the process is largely that of hyperemia. Other lobules show extensive hemorrhages. In others the alveolar exudate is largely fibrinous or fibrinopurulent or purulent.

Sections of the liver show extensive fatty changes in the liver cells. The nuclei are large and vacuolated, in places they are granular.

The capsular vessels of the spleen are injected and the pulp is congested.

The vessels of the kidneys are congested. There are slight degenerative changes in the epithelium of the cortex.

Microscopic examination of one of the mediastinal lymph glands reveals a congestion of the vessels of the cortex with an occasional area of fibrinous exudate about the vessels. The medullary portion is edematous. Some of the vessels contain fibrin, others are filled with polymorphonuclear leucocytes. Polymorphonuclears have invaded the lymph sinuses.

Inoculations from all involved portions of the lung and pleural fluid were made in various media. Both the platinum loop and pieces of tissue were employed. A platinum loop when brushed over a freshly cut surface and streaked over several agar slants in succession usually gave well isolated colonies in the third or fourth tube after 24 hours incubation. Pure cultures of B. bovis septicus developed in all tubes. The tubes inoculated with the pleural fluid contained the organism in pure culture.

Pieces of spleen and kidney introduced into tubes of media remained sterile after prolonged incubation. Mention has been made that a blood culture taken 24 hours before autopsy remained sterile.

In films from the lung stained with methylene blue or dilute carbolfuchsin, B. bovis septicus could be demonstrated in large numbers. Very few of the organisms revealed the characteristic bipolar staining. In the sections large numbers of bacteria are present in the alveolar (Fig. 8) and bronchial exudate.


On Nov. 13, the cow was reported sick. The temperature at 9 a.m. was 40.2°C. and at 9 p.m. 41.8°C. The respiration rate was 48 per minute. The respirations were abdominal in character. They were superficial and rapid. The animal was constipated.
On Nov. 14, the cow was removed to the Institute for observation. The respirations were rapid and superficial. There was edema of the throat and dewlap. The appetite was poor. The temperature at 6 p.m. was 41.3°C.

The following day a severe chill was noted. The animal was weak. It stood most of the time. The edema of the throat and dewlap was more extensive. On the lower eyelids and at the inner canthus there was a gummy discharge. A slight amount of white mucus was discharged from the nostrils. The cow coughed frequently. The cough was dry, short, and strong. The temperature at 8 a.m. was 41°C. The pulse was 60, full and rapid. The jugular veins were distended. There was a slight dyspnea which was a little more pronounced on expiration. Dullness could be detected in both lungs over most of the accessible area of percussion. On auscultation the vesicular murmur was coarse and greatly exaggerated. There was bronchial breathing. The appetite was poor. The feces were firm and dry, only small amounts were voided during defecation. The milk secretion was greatly diminished.

A chill was again noted on Nov. 16. There was marked depression. The temperature at 6 p.m. was 41.8°C. The respirations numbered 48. They were short and superficial. The pulse rate was 78. The superficial blood vessels were distended. Percussion and auscultation failed to detect more marked changes in the lungs than those observed previously. The appetite was poor. There was a complete cessation of milk secretion. Constipation still persisted. There was atony of the rumen.

On Nov. 17, the cow was much weaker. It was in pain. Two severe chills were noted during the day. The temperature at 10 a.m. was 41.2°C. The pulse rate was 100. It was rapid and irregular. The respirations were 40. They were superficial. Abdominal breathing was noted. The dyspnea was more exaggerated and on expiration there was grunting. The cow refused all feed and water. The feces were soft and fetid. The urine obtained on this day was deep.
yellow in color and turbid. The specific gravity was 1.026; reaction, alkaline; albumin, present (Esbach 0.1 per cent); bile, present; blood and sugar, absent.

This cow died Nov. 18 between 2 and 3 a.m. The following postmortem findings were noted.

Heart.—Normal in size. The pericardium is covered with a thick, yellowish, felt-like, fibrinous exudate. There is considerable blood-stained turbid pericardial fluid. Scattered over the heart are many irregular hemorrhages. They are especially numerous over the auricles. On section, the cardiac muscle appears dry.

 Right Lung.—The ventral aspect of the cephalic, ventral, azygos, and anterior third of the caudal lobes varies in color from bright red to reddish gray. The consistency is firm. The consolidation on the dorsal aspect is not quite so extensive. A small portion of the ventral lobe (dorsal surface) is still air-containing. The area of complete solidification in the caudal lobe occupies the cephalic third of the ventral aspect. It is succeeded by a mottled portion containing both hepatized and air-containing lung. There are patches of hepatization extending well down to the caudal border. On section, the pleura is thickened. The interlobular tissue is 3 to 5 mm. in thickness, due to the presence of a coagulated exudate which fills the lymph channels (Fig. 3). The lobules are distinct. Their color varies from dark red to reddish gray. Scattered throughout the dark red lobules are tiny, irregular, gray areas. These foci in other lobules have become confluent and give the whole a reddish gray appearance. The cut surfaces of the red portions are moist and exude a serous fluid. The gray areas are dry and granular.

 Left Lung.—The anterior half of the cephalic lobe is dark red and firm. It is clearly demarcated from the surrounding emphysematous portion, where the interlobular tissue is distended with air. The interlobular emphysema extends as a narrow band backward through the ventral lobe and widens out in the caudal lobe. The ventral lobe is consolidated except for the narrow strip along the median line (dorsal aspect). The anterior third of the caudal lobe is reddish gray and firm. This portion is sharply defined from the surrounding deep red consolidation. The pink air-containing lung is clearly demarcated from the solid area.

 Trachea.—The mucosa is reddened in patches. The submucous capillaries are injected. There is a moderate amount of blood-stained, viscid exudate mixed with air. The larger bronchi reveal much the same condition. The principal bronchi of the left caudal lobe is completely occluded with clotted blood. The bronchial and mediastinal lymph glands are enlarged and congested. On section, the cortex is reddish gray, the medulla grayish white and mottled with irregular hemorrhages. The pleural cavity contains between 2,200 and 2,300 cc. of a slightly blood-stained serous fluid. Suspended in the fluid are feathery particles of fibrin. The endothelium lining the ventral floor of the cavity is sprinkled with irregular hemorrhages and here and there coagulated tufts of exudate.

 Liver.—Reddish yellow in color. The gall bladder contains a gelatinous, dark green bile.
Spleen.—The spleen is not enlarged. A few small hemorrhages are present in the capsule. The pulp is apparently normal.

Kidneys.—Both are of a deep reddish gray color. The capsule is easily stripped off. Scattered over the surface are tiny round areas of reddening, surrounded by a narrow gray zone. On section, the cortex is congested and appears granular. The line of demarcation between the cortex and medulla is indistinct. The medulla is highly congested.

Gastrointestinal Tract.—The only lesion exists in the small intestine. The serous surface is reddened, apparently due to a congestion of the small capillaries of the subserosa.

Fixed and stained sections from the lungs show much the same type of pneumonia as in the preceding case. The pleura and interlobular tissue contain dense masses of fibrin (Fig. 5). Certain lobes reveal the fibrinous pneumonia, in others the process is fibrinopurulent, or purulent. Enormous numbers of *B. bovisepticus* can be seen within the alveolar and bronchial exudate.

Much the same lesions of the liver are observed in this case as in Cow 530. The kidneys, however, show more marked changes. There is degeneration of the cells of the glomeruli and those of the tubular epithelium. Desquamation of the latter is not infrequent. Severe congestion of the larger vessels is frequent.

Films made from consolidated portions of the lung when stained reveal enormous numbers of short rods. A few stain only at the poles. About many of the organisms are clear areas which suggest capsules.

Inoculations into various media from portions of the lungs and the pleural fluid all developed *B. bovisepticus*. Other organisms could not be demonstrated.

We have previously stated that for a time the disease existed only in adult cows. There had, however, existed among the calves certain types of pneumonia. Theobald Smith has shown that *Bacillus actinoides*, an organism which can be grown only under special conditions, is really responsible for certain pneumonias in calves. *Bacillus bovisepticus* had been isolated by him from some of these cases. That such strains of *Bacillus bovisepticus* are different from the bacterium associated with this epidemic will be shown in a later communication.

On December 7, 1920, a calf (No. 550) was reported sick. It was killed on December 17. Both *Bacillus actinoides* and a type of *Bacillus bovisepticus* similar to that found in the cows were isolated from the lungs. The colonies of *Bacillus actinoides* greatly predominated in all tubes. Nearly 1 month later what may be regarded as a primary infection with *Bacillus bovisepticus* occurred in Calf 562. The clinical and pathological records follow.

On Jan. 19, 1921, the animal had a chill. The respirations were rapid. There was a discharge from both nostrils. The temperature was 40.5°C. Jan. 20. The temperature was 41.2°C., the respiration rate 100. The appetite was good. There was slight constipation. On auscultation the vesicular murmur was greatly increased. Râles were not heard. On Jan. 21, the temperature and respirations were the same. The calf coughed frequently. On Jan. 23, the temperature and respirations were about the same. Diarrhea had set in.

Jan. 25. Pulse 80, respiration 60, temperature 41.5°C. There was marked weakness. The respirations were shallow and accompanied on expiration with a distinct "grunt." On auscultation there was an absence of vesicular murmur in the cephalic lobes. There was a loud bronchial murmur especially over the caudal lobes (both lungs). Pressure over the lungs produced pain. The animal died between 5.30 and 7.30 p.m. It was removed to the refrigerator over night and autopsied on Jan. 26. The following autopsy notes were made.

On removing the skin from the neck, the subcutis and fascia overlying the muscles are edematous. The small veins are dilated and many have ruptured, producing hemorrhages.

Heart.—Punctiform hemorrhages under the epicardium. The left auricle is distended with a large dark red clot. The ventricles also contain clots. There is a moderate hemorrhagic infiltration into the auriculoventricular valves.

Lungs.—There is nearly complete consolidation of the anterior lobes (cephalic and ventral) of both lungs. The azygos lobe is completely hepatized. The more dependent portions are reddish gray in color, the dorsal aspect is a darker red. The interlobular markings are distinct but are not appreciably thickened. On section these lobes are liver-like. The lighter colored portions reveal throughout the lobules tiny indistinct gray areas. These gray patches are larger about the bronchi.
In the dark red portions the gray areas are very tiny or absent. Blood oozes from the cut surface. Some of the smaller bronchi are occluded with purulent exudate. There is an extensive hepatization of both caudal lobes. The pneumonia occupies the anterior four-fifths of the right caudal and the anterior two-thirds of the left caudal lobe. It is less extensive on the dorsal aspect. The anterior portion varies from grayish red to dark red in color. This is succeeded by mottled areas of dark red consolidation and pink air-containing lung.

The pleura is not thickened and the pleural cavity does not contain an excess of fluid.

Trachea and Large Bronchi.—Scattered over the serosa of the trachea are round hemorrhages varying from very tiny points to extravasations 2 to 3 mm. in diameter. The mucosa is deep red. There are patches of mucopurulent exudate containing blood clots adhering to the mucosa. The same condition exists in the larger bronchi. Many of the smaller air tubes contain plugs of exudate and clotted blood.

The mediastinal and bronchial lymph glands are edematous. Tiny irregular hemorrhages are present throughout their substance.

The liver shows evidence of cloudy swelling. The spleen is normal in size. The kidneys are enlarged and of a deep red color. On section, blood oozes from the cut surfaces. The cortex is gray with deep red striations. Between the cortex and medulla is a deep red zone. The medulla is congested.

Gastrointestinal Tract.—The abomasum contains a few curds. The mucosa is deeply reddened. The small intestine contains much turbid fluid. The mucosa is deeply congested. The congestion is in the form of points, lines, and patches of varying size. The mucosa of the cecum and rectum is uniformly congested. Examination of a sample of straw-colored, turbid urine obtained from the bladder at autopsy revealed the following: specific gravity, 1.012; reaction, acid; albumin, present (Esbach 0.1 per cent); sugar, absent.

Examination of stained films from the involved lung shows characteristic bipolar bacilli in moderate numbers in all preparations. Pure cultures of B. bovis septicus developed from all tubes inoculated with bits of tissue or loopfuls of material obtained from cut surfaces.

Microscopic examination of fixed and stained sections reveals in general a pneumonia in which the air spaces are largely filled with polymorphonuclear leucocytes and desquamated alveolar cells. The interalveolar capillaries are congested. The bronchi are filled with leucocytes. In some the epithelium is intact. In others it is degenerated and often desquamated. The pleura is not thickened. There is a moderate edema of the interlobular septum. Scattered throughout some of the lobules are circular deep-blue-staining areas. They are composed of large numbers of intensely stained, degenerated leucocytes. Here the bacteria are present in large numbers.

In sections of the more recent pneumonia in the caudal lobes the process resembles more nearly that described for Cows 530 and 537. Here the pleura is thickened with masses of fibrin. The interlobular septa are also thickened, due to
the dilatation and plugging of the blood and lymph spaces with fibrin. The peribronchial tissue is edematous. The surrounding blood vessels are dilated and plugged with fibrin. The interalveolar capillaries are highly congested. Hemorrhages into the air spaces have occurred. In certain lobules the extravasations of blood have obliterated the whole lobular structure.

The lesions in the kidney are much more severe in this case. The glomerular epithelium shows degenerative changes. Throughout the section congestion is severe. The tubular epithelium is degenerated. The remains of the cells appear as pink-staining, finely granular material often without definite nuclear structure.

**Cow 533.**—This cow was also killed after having been under observation for 10 days. Symptoms similar to those described under Cows 530 and 537 were noted. Autopsy revealed the same type of diffuse pneumonia. A blood culture taken late in the course of the disease remained sterile. *B. bovisepticus* was isolated in pure culture from various portions of the involved lung.

**Cow 536.**—This cow presented symptoms of an acute pneumonia similar to those described. The temperature chart, however, shows that the temperature remained above the normal for a considerable period. It finally reached normal and stayed so until the animal was slaughtered. The lungs were severely affected. The anterior lobes of both lungs were shrunken. They varied from gray to reddish gray in color. Scattered throughout these lobes were grayish white abscesses. On section the involved lobes cut with difficulty. The interlobular connective tissue was increased. The lobules were compressed and made up of distended bronchi filled with pus. The little remaining alveolar tissue was gray in color and dry in consistency. In many instances the lobules were entirely composed of thick walled connective tissue abscesses. Such abscesses often replaced a number of lobules. The anterior lobes adhered to each other and to the chest wall. A nail was found embedded in a dense mass of connective tissue in the anterior ventral tip of the left ventral lobe. The azygos lobe appeared normal. The trachea and large bronchi contained pus.

Many cultures were made from various portions of the lung. *B. pyogenes* was present in every tube. An unidentified micrococcus and anaerobes also developed in certain tubes. *B. bovisepticus* was not recovered from this case.

**Cow 535.**—The temperature record of this cow is appended. This animal suffered from what appeared to be a severe infection. Characteristic symptoms of pneumonia were observed. Albumin and bile were found in the urine. A blood culture taken 2 days after the first symptoms were noted remained sterile. The prognosis was grave but the temperature began to fall at the end of the 8th day. On the 9th day it fell from 41° to 39.5°C. From this day recovery was rapid.

**DISCUSSION.**

The outbreak is noteworthy in several respects. The origin of the infection appears at first glance more or less obscure. However,
evidence points toward the introduction of the disease with the Michigan cows. These animals were the last animals introduced into the herd. They had been fed and watered at two shipping points where the disease may have been contracted. One cow was sick on arrival, but pneumonia was not detected during life. This cow was killed 6 months later and examination of the lungs revealed a complete fibrosis with purulent bronchiectasis of the right cephalic lobe. Probably this cow gave rise to the epidemic. Another cow of this lot died 11 days after arrival. The clinical symptoms suggested pneumonia. No autopsy was made, but the man who cut up the carcass noted a reddening of the lungs and their adherence to the chest wall. The brief history which we were able to obtain in this instance indicated an illness of 2 days duration. From these animals the disease probably spread to the Pennsylvania and native cows. The greatest mortality occurred in those from Pennsylvania.

An outbreak with a similar history is recorded by Woolley and Jobling.\textsuperscript{10} A shipment of caribou was received at Manila, P. I., from Shanghai on May 28, 1903. The animals were kept aboard ship until June 1 when they were sent to an estate. On June 2, two animals were sick. One died and the other was killed. The average time required to ship cattle from Manila to Shanghai is 5 days. The first cases occurred about 10 days after embarkation.

There is evidence that more cases occurred than the records indicate, especially when Cow 536 is considered. Since this outbreak subsided, two animals which were slaughtered revealed multiple abscesses of the lungs and purulent bronchitis. As far as could be learned, neither of these had ever shown recognizable symptoms. It is possible that a number of cows suffered from a very mild infection which passed unnoticed. During March and April, 1921, a few sporadic cases have occurred from which it has been possible to cultivate, in one instance, an organism identical with those met with in Cows 530, 533, and 537. These sporadic infections may continue to appear for some time.

The appearance of the disease in the calves is difficult to explain. They are kept at a considerable distance from the cows and have

separate attendants. Inquiry brought out the fact that calves born of the Michigan cows had been placed in the calf barns. We have no record of the epidemic type of *bovisepiticus* pneumonia among the calves until December 7, 48 days after the purchase of the cattle from Michigan. Some of the Michigan calves, however, may have suffered from a very mild disease which may have been overlooked. It is possible that one may have been a virus carrier. It is of interest to note that the first calf (No. 550) from which the epidemic organism was isolated suffered from a primary infection with *Bacillus actinoides*. The other calf developed a pure *bovisepiticus* infection. Both were of native stock. More recently another calf died after a short illness. *Bacillus bovisepiticus* was obtained from the internal organs.

Another striking feature is the low virulence of the isolated bacteria, although the organism was capable under certain conditions of causing serious disturbances once it gained a foothold within the lung. The many apparent recoveries and the mild type of disease manifested in certain animals are also indicative of a low virulence. This fact is further borne out by inoculation experiments with rabbits and calves. In one experiment a calf was injected subcutaneously with 2.5 cc. of pleural exudate from Cow 537. Cultures made from this exudate revealed over 25,000 colonies per cc. The calf suffered no apparent ill effects. Another calf (No. 293B) was injected intratracheally with 10 cc. of a 24 hour bouillon culture of the organism isolated from Cow 530. The calf remained well. Similar negative results from intratracheal injections of cultures have been reported by others. Magnusson injected a sheep intratracheally with reindeer pasteurella without result. Pfeifer\(^1\) states that infectious material obtained from cases of buffalo disease injected into the pectoral cavity or lungs of calves produced disease. On the other hand, when the material was introduced into the nasal passages or trachea the calves remained well.

The resemblance of the lung lesions in certain outbreaks of bovine septicaemia haemorrhagica to those of contagious pleuropneumonia has been commented on by many. To rule out contagious pleuropneumonia at the start, a calf was injected subcutaneously with a

\(^{1}\) Pfeifer, W., in Friedberger, E., and Pfeiffer, R., Lehrbuch der Mikrobiologie, Jena, 1919, ii, 879.
filtrate prepared by grinding 5 gm. of lungs with sterile sand. The ground material was suspended in 100 cc. of 0.85 per cent salt solution and shaken vigorously. The suspension was centrifuged at moderate speed. The supernatant liquid was passed through a Berkefeld V bougie. This calf was under observation for 30 days, during which time a local reaction did not develop. The calf's temperature remained well within the normal limits. Mention has been made of an experiment in which a calf was injected with pleural exudate. Only negative results were obtained.

Another striking feature is the localization of the virus within the lungs and chest cavity. Blood cultures taken from seven cases during the height of the disease remained sterile. *Bacillus bovis septicus* failed to develop in tubes inoculated with bits of spleen and kidney from the cow that died and those that were killed.

**SUMMARY.**

An outbreak of pneumonia in dairy cows attributed to *Bacillus bovis septicus* is described. About twenty cows and two calves were affected. The first cases were noted in cows purchased in Michigan. The disease next appeared in another lot of cows from Pennsylvania and subsequently attacked native stock. Of the ten cases which came under our observation, five apparently recovered, two died, and two severely affected cows were killed. The other case developed multiple abscesses of the lung and was finally killed.

The more characteristic symptoms observed were high temperature, rapid respiration, dyspnea, cough, dullness on percussion, bronchial breathing, and albuminuria.

The pneumonia was diffuse but first affected the cephalic and more dependent lobes. The process varied from hyperemia and hemorrhage to exudation of fibrin and leucocytes within the air spaces. The plugging of the interlobular lymph channels and blood vessels with fibrin was frequent.

*Bacillus bovis septicus* was isolated in pure cultures from all involved portions of lung at autopsy. It was not found in blood cultures during the height of the disease, nor could it be obtained from the spleen and kidney after death.
PLATE 44.

Fig. 1. Lung of Cow 530. Showing the thickening of the pleura and interlobular septum. The lobules are consolidated. In the center the lobules are gray, at the periphery the color is deep red.

Fig. 2. Lung of Cow 530. Interlobular septa are thickened with fibrin. The consolidation of all lobules is complete. A few are red in color, the others gray.

Fig. 3. Lung of Cow 537. Moderate pleuritis with large plugs of fibrin in the interlobular lymph spaces. Hepatization varies from red to gray.

PLATE 45.

Fig. 4. Lung of Cow 530. The interlobular septum, greatly increased by a fibrinous exudate, separates two lobules. The alveoli in the upper lobule are filled with fibrin. Below the septum the air spaces also contain fibrin at the border of the lobule, but toward the center they have been invaded by leucocytes. × 17.

Fig. 5. Lung of Cow 537. Lesions about the same as those in Fig. 4. Note fibrinous plugs in the vessels and lymph spaces of the interlobular septum. Above, the pneumonia is largely fibrinous; below, it is cellular. × 17.

PLATE 46.

Fig. 6. Lung of Cow 530. Reveals at the right the fibrinous exudate within the septum. The interalveolar capillaries are filled with red cells and the alveoli contain fibrin. A few leucocytes are observed within some of the air spaces. × 110.

Fig. 7. Lung of Cow 530. A portion of a lobule adjacent to the one in the preceding photograph. The fibrinous exudate within the interlobular septum appears above. Below, the alveoli are packed with leucocytes. Some contain both leucocytes and fibrin. The interalveolar congestion is not marked. × 110.

Fig. 8. Lung of Cow 530. B. bovis or B. septicus in considerable numbers is shown in the space between the alveolar wall and the cellular exudate. A dense mass of the organism is visible within the exudate. × 1,000.
(Jones and Little: Pneumonia in dairy cows.)
(Jones and Littler: Pneumonia in dairy cows.)