THE SWAMP FEVER OF HORSES.*

JOHN L. TODD, M.D.

(Associate Professor of Parasitology, McGill University, Montreal.)

AND

S. B. WOLBACH, M.D.

(Assistant Professor of Bacteriology in Harvard University.)

(Formerly Director of the Pathological Laboratory, Montreal General Hospital.)

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I. Introduction. — In many parts of the Canadian north-west provinces there exists a disease which is popularly called Swamp Fever. Its clinical features vary within wide limits, and it may run an acute or a chronic course. Consequently, it is not impossible that more than one disease may be included among the conditions usually diagnosed by Canadian veterinarians as Swamp Fever.

The disease is met with here and there throughout the northwest provinces from Winnipeg to Edmonton. It occurs most frequently in newly-settled, undrained districts, and especially in low-lying localities where horses are fed upon hay or grass from the sloughs or swamps. The cases

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are usually occasional and few in number; sometimes, however, the disease occurs repeatedly on the same farm, or it may become almost an epizootic and carry off at once the majority of the horses from a farm, or from the outfit of a contractor engaged in railroad construction work.

Although equine diseases which resembled Swamp Fever had been noticed previously, Swamp Fever seems to have been first recognized as a distinct disease in or about 1880,¹ and since then it has been widely identified. It has been shown to exist in many of the Western States, and several attempts have been made to determine its nature.

The object of the present communication is to review what is known of it and to record the results of the study of two cases of the disease. The first part of this paper is, consequently, almost wholly a compilation from the reports which are mentioned in the list of references; the latter part states the results of our own observations.

II. Nomenclature. — Names mentioned in the literature, which are sometimes applied to Swamp Fever, are: American surra, malarial fever or typhoid fever of horses, unknown disease, no-name disease, plains' paralysis, pernicious anemia.

III. History and distribution. — The first definite mention of Swamp Fever in the literature records its presence in about 1884 in cases under the care of Dr. Rutherford at Portage la Prairie in the Red River Valley. Since then cases clinically identical with Swamp Fever have been reported to exist as far north as Dauphin and Yorkton and as far west as Edmonton. It is not impossible that Swamp Fever may have existed unrecognized in many places in the Northwest Territory. Several cases are reported to have occurred in the early eighties about Prince Albert and at Red Deer.

In 1888 Commissioner Perry states that he lost forty horses out of a troop of one hundred and twenty from Swamp Fever at Red Deer.

More recently diseases diagnosed as Swamp Fever have been reported in the United States from Minnesota, Kansas,

Nebraska, Colorado, Wyoming, Montana, North Dakota, Texas, and Nevada. It is impossible to determine from the records whether the disease has spread recently to the fresh localities from which it has been reported, or whether it is that its existence in them has only recently been recognized.

IV. Etiology. — As its name indicates, Swamp Fever frequently occurs in low-lying districts, and horses are often said to contract it through eating swamp hay or through drinking swamp water. It is said that horses have been saved from the disease on farms where it existed by preventing them from using grass or water from swamps.⁸ The disease is less frequent than it formerly was in many localities; and it seems to disappear with the cultivation and consequent draining of the soil. The infection is particularly liable to become manifest between June and October; possibly because that is the time of the year when farm work puts the heaviest strain on horses and, consequently, tends most to make any defect in them apparent. More cases occur in wet than in dry seasons. The disease is not contagious, as is proved by the experience of farmers who frequently stable healthy horses with diseased ones without spreading the disease. Bell and Torrance, during their experiments with Swamp Fever, kept nineteen severely infected animals in Winnipeg without communicating the disease to any of the horses kept in the same stables. Nevertheless, a number of horses occasionally contract the disease at about the same time, and a farm sometimes seems to be permanently infected by it.

One farmer lost fourteen horses in four years; another, near Winnipeg, lost forty in the same length of time. In 1908, a firm of contractors, working on the Grand Trunk Pacific Railroad at Edmonton, lost seventeen out of one herd of twenty-eight horses from Swamp Fever.

The pathogenic agent which produces Swamp Fever is unknown. Various bacteria have been described in connection with it, but none of them is specific. Very careful searches have been made through the tissues and body

fluids of horses infected with Swamp Fever for a specific animal parasite; none has been found.

The virus of Swamp Fever can be transmitted to equines by the inoculation of blood from an infected horse. Infected blood, or blood serum, is still infective after having been passed through a porcelain filter; the virus, consequently, is, probably, ultra-microscopic.

V. Morbid anatomy. A. Gross appearances. — The lesions found in animals which have died of Swamp Fever are usually surprisingly few in number and their severity is slight. If, as usual, the disease has lasted for some time the body is wasted and the mucous membranes are anemic. The skin may be abraded and cut, through the animal's struggles during the period when it was too weak to rise. There may be edema of the dependent portions of the body, such as the feet, sheath, abdomen, lower part of the legs and the side upon which the animal was lying while it was in extremis. If the disease has been a very chronic one, the muscles are wasted and pale, and there is very little fat. The peritoneum, the pleuræ, and the pericardium may contain a small amount of serous fluid; both the visceral and parietal surfaces of the abdominal peritoneum and of the pleuræ and pericardium may be dotted, more or less closely, with petechiæ. The heart is often enlarged; it may weigh as much as twelve or fourteen pounds, and its muscle may be pale. The clot contained in the heart, and in the great vessels, is often very pale and yellow (chicken-fat clot); frequently the fat about the auriculo-ventricular groove is infiltrated with a yellowish, gelatinous edema. The lungs are unchanged. The liver may be congested and enlarged; sometimes it seems to be degenerated. The spleen is often considerably enlarged and weighs as much as six pounds; it is sometimes congested and friable and may contain infarcts. The kidneys, often unchanged, are sometimes soft and friable. The lymphatic glands, especially those of the various intra-abdominal groups, are often enlarged and very

hyperemic, and sometimes edematous. The bone marrow is much redder than is normal.

In Mack's series of cases,¹⁴ the petechiæ of the serous surfaces were exceedingly numerous and they were occasionally confluent; in addition there were distinct hemorrhages into many of the organs, as, for example, in the spleen and beneath the endocardium. In the same series of cases the meninges were much congested and hemorrhagic areas were described in the mucosa of the stomach.

As is mentioned below, the epidemic of "Swamp Fever," described by the members of the Minnesota State Board of Health in 1903, was probably not identical with the disease which is known by that name in Canada. At the autopsies on cases of the disease described in Minnesota abscesses were frequently found; pus has not been reported in the cases of Swamp Fever which have been examined in Canada.

B. Minute appearances. — The heart muscle frequently shows cloudy swelling; sometimes the condition has gone on to fatty degeneration and actual necrosis. Hemorrhages may occur beneath the endocardium or epicardium and into the myocardium.

The lungs may be congested and small areas of consolidation are occasionally seen. The alveolar cells often contain pigment.

The liver is congested; sometimes the hyperemia is intense, and blood may be extravasated into the substance of the organ as well as beneath its capsule. Areas of degeneration, especially at the center of the lobule, are not uncommon, and sometimes the degenerated liver cells are more or less completely replaced by immigrating leucocytes, by plasma cells and by débris. The liver cells always contain a large amount of iron-bearing pigment.

The spleen is congested and may contain areas of infarction. It contains much iron-bearing pigment. Areas of amyloid degeneration, increase of fibrous tissue, and proliferation of endothelial cells in the lymph spaces have also been observed.

There is marked parenchymatous degeneration of the kidneys; they are congested and between the tubules there may be free red and white cells.

The lymph glands are hyperemic and edematous.

VI. Symptoms and course of the disease. — Swamp Fever is characterized by progressive weakness, wasting, and anemia, and by an irregularly intermitting fever. Usually the first sign of the disease to be noticed is that an active horse has become listless and easily tired; at this time an examination usually fails to reveal any cause for the change. The gait becomes uncertain, and a definite weakness of the loins and hind legs appears. The temperature varies much, and is exceedingly irregular; it may be as high as 103° F.; it may reach 106°. The pulse is weak and rapid; it may run as high as fifty to seventy beats to the minute. Although the pulse rate is high its rapidity does not increase in proportion to the height of the temperature; for example, a temperature of 105° F. may be accompanied by a pulse rate of only fifty. The pulse, especially in advanced cases, is characterized by a distinctive "thrill," which is described as feeling "as though the vessel were not quite filled."

It is characteristic of Swamp Fever that the appetite remains good all through the disease, and even almost to its termination; but, in spite of the large amounts of food which they may consume, horses in the last stage of Swamp Fever are always in exceedingly poor condition. The coat stares, they are very thin, and anemia is excessive. Polyuria is often present, and in advanced cases the urine may be albuminous. The mucous membranes are very pale and petechial hemorrhages may be seen in the membrana nictitans, in the nostrils, and in the mouth. Blood serum may ooze from the mucous membranes of the nostrils.

A blood count made at this time will show that the blood only contains from two to three millions of red cells to each cubic millimeter. The white cells are slightly fewer than normal (four thousand to eight thousand); but there may be an increase in the relative number of lymphocytes present.

The hemoglobin is much reduced; an estimate of the amount present may only give thirty to fifty per cent.

As the disease nears its end the weakness and emaciation become extreme. The heart labors so that its beating is easily seen and sometimes it can be heard at some distance. Sweating, whether in small areas or over the whole of the body, often occurs; death follows from exhaustion or from syncope.

Though the disease may progress steadily towards a fatal termination there are, as a rule, temporary improvements during which the animal seems to be about to recover. Almost invariably, however, there is a relapse. A few extremely acute cases may die in two or three weeks; the disease ordinarily lasts for two or more months; chronic cases may live for many months or even for years. Most veterinarians believe that the disease is always fatal. The animal insurance companies state that seventy per cent of the death claims made in Manitoba for horses are made because of Swamp Fever.

A fatal disease, locally called Swamp Fever, occurs among horses in Minnesota. In 1903 the State Board of Health published a very complete report on it.² In addition to giving an excellent description and recording the investigations made by the Board the report contains a bibliography of Swamp Fever.

The disease described in Minnesota presents, in a much more severe form, all the symptoms as it is observed in Canada. The Minnesota disease is usually an acute one and the animal may die within a week or two and before the anemia has become excessively pronounced; the usual duration is from four to six weeks. On the other hand, the anemia may be extreme in cases in which the disease lasts longer; for example, there may be only twenty per cent of hemoglobin and less than a million red cells.

An ulcer is sometimes seen within the lower lip of horses with this affection and the petechiæ of the mucous membranes are much more marked than they are in the Canadian disease. There may be distinct hemorrhages beneath any

of the serous surfaces or into the tissues of any of the organs; subcutaneous, intramuscular or interfascial hemorrhages also occur; hemorrhages into the subcutaneous, edematous areas are frequently seen. The hemorrhages are most marked in the advanced cases. Polyuria is a marked symptom, and, at the autopsies, parenchymatous nephritis may be found to be present. Cardiac hypertrophy is well marked and thrombosis of the abdominal vessels is occasionally seen.

One group of lesions very definitely separates the disease studied in Minnesota from that observed in Canada; distinct evidence of inflammation accompanied by pus, or fibrous adhesions, were frequently found in the peritoneum, the pleuræ, the pericardium, and in the joints; abscesses were frequently found amongst the muscles. Such appearances never occur in the Canadian disease. From these lesions, as well as from other body fluids, two bacteria — *Bacillus equisepticus* and *Bacillus pyrogenes equinus* — were isolated with great constancy. Sub-inoculations of cultures of *Bacillus equisepticus* produced symptoms more severe than those observed in nature, but similar to them; the experimental disease caused death more quickly than did the natural disease.

VII. Diagnosis. — It would be surprising if other diseases were not confused with one in which the symptoms are so indefinite, and in which the course of the infection may vary so widely; indeed, where Swamp Fever is common, the tendency is to class under that heading all chronic febrile conditions of an uncertain nature.

Mack¹⁵ meets the difficulty by describing four different types: the fulminant, in which horses die after a few hours' illness; the acute, in which the attack lasts for from five to seven days; the sub-acute, in which death comes after a few weeks or several months; and the chronic type, in which the animal may live for some years.

On the other hand, Canadian authors¹⁶ are inclined to limit the name "Swamp Fever" to the more chronic type

and they recognize, under other names, more acute diseases and those which do not present the symptoms which have come to be recognized as characteristic of Swamp Fever.

Diagnosis is especially difficult in early cases, in which definite symptoms are absent. On the other hand, it is made easily in advanced cases in which the symptoms are well marked. A horse which has a good appetite and a "wobbling" gait and is suffering from an irregular fever, which is accompanied by weakness, emaciation, anemia, and, perhaps, by polyuria and a "thrilling" pulse, is said to be suffering from Swamp Fever, especially if it be seen in a locality where that disease exists.

Until the specific causes of the diseases concerned are definitely recognized it seems useless, from a consideration of the clinical manifestations, to discuss whether more than one disease may not be included among the conditions which are recognized as Swamp Fever, or whether Swamp Fever be identical with diseases, such as the European Infectious Anemia, in which similar symptoms occur.

VIII. Treatment. — Many drugs have been used in attempts to treat Swamp Fever. None of them has proved to be specific for the disease. A symptomatic treatment has often been reported to have been of benefit. Good food and tonics, such as nux vomica, iron and arsenic, are given for the anemia; the fever has been controlled by antipyretics, such as quinine and acetanilid, and by cold spongings and cold enemata. Vermifuges and intestinal antiseptics, such as salol, have been given to remove harmful fauna, or flora, from the alimentary tract. Mercury, the iodides, and silver salts have also been given; they have been valueless.

IX. Observations on two Cases of Swamp Fever. — Two horses, suffering from Swamp Fever, were sent to us in January, 1910, through the kindness of Dr. J. G. Rutherford, the Veterinary Director General and Live Stock Commissioner of the Department of Agriculture of the Dominion

of Canada. Our thanks are due to Dr. Rutherford's Department for these animals and for financial assistance, which has assisted us in undertaking the investigations recorded in the present paper. The disease was diagnosed in both animals by Dr. McGilvray of Winnipeg.

Case I. (Black Gelding). — Age about 10 years; weight, 1,020 pounds; received January 19, 1910. This horse came from Oakville, Manitoba. It was first noticed to be ill during the latter part of June, 1909. It gradually became unfit for work, and it has been in its present condition for several weeks.

Present condition: The horse is extremely weak, the gait is unsteady, and the weakness of the hind quarters is very marked. It is very thin and the abdomen is prominent and pendulous. The coat is very rough and seborrheic. The chest and the whole of the abdomen is edematous. No edema can be detected on the legs. The mucous membranes are pale. There are no petechial hemorrhages in the mouth, nostrils or eyes. The appetite for food and drink is excellent. Urine is frequently passed. Anemia is pronounced; there are only 2,400,000 red cells to each cubic millimeter of blood, and only 20 per cent (two counts) of hemoglobin; the hemoglobin was estimated with Sahli's hemoglobinometer. There is marked poikilocytosis and basophilia of the red cells.

On the 20th of January the pulse rate was 72 and the temperature 102° F. From then until the 23d the temperature steadily fell. On January 23 the animal was in extremis and the temperature was 96° F. It was therefore killed and an autopsy was made at once.

Autopsy: (a) Gross appearances. — There is no subcutaneous fat. On the dependent side of the body the subcutaneous tissues are deep yellow, translucent, and edematous for a depth of one centimeter. The muscles are deep red, uniform and normal in appearance.

There is no free liquid in the peritoneal cavity. On the liver and hepatic diaphragm there are many fibrous tags, measuring from 8 to 12 millimeters in length and 1.5 millimeters in diameter. In addition, there is a small area of strong, firm adhesions between the liver and the diaphragm. The lymph glands of the mesocolon are distinctly enlarged, edematous and hyperemic. Two peritoneal lymph glands lying near the kidney are also distinctly hyperemic; in these glands there are small white areas from one to three millimeters in diameter. The peribronchial lymph glands are normal. The lymph duct is much distended with a clear, pale, reddish fluid.

The left pleura contains about a liter of slightly turbid fluid and there is a slight fibrous pleurisy. The right cavity contains no liquid or adhesions. The pericardial cavity contains about 300 cubic centimeters of clear fluid.

Heart (10½ pounds): The valves and endocardium are normal; the myocardium is firm and pale, but uniform in color and consistency; the aorta is normal. Lungs (right, 6½ pounds; left, 7 pounds): Both are normal. The bronchial lymph glands are not enlarged; there is marked edema of the mediastinal tissues. Spleen (4 pounds): Capsule seems slightly thickened; the substance is firm. Liver (26½ pounds): Appears to be normal. Gastro-intestinal tract: The mucosa is normal. The colon contains many *Sclerostomum armatum*; in the cecum one of these worms was found in a small submucosal abscess. Pancreas: Normal. Kidneys (together 5½ pounds): Both kidneys are similar in appearance; the cortices are translucent and yellowish; the papillæ of the pyramids are prominent but colorless, their bases are pale red, the apices yellow and translucent; the pelves are edematous. Adrenal glands: Both normal. Bone marrow: That of the long bones is yellow and fatty; that from the short bones is firm and dark red. Brain and spinal cord: Normal.

(b) Minute appearances. — Heart: Normal. Lung: Moderately injected. The alveolar walls are slightly tortuous, the capillaries are filled with blood and, in foci, are packed with cells. Some of the cells are phagocytic and contain red corpuscles, brown pigment, or nuclear remains. There are other groups of cells with basic-staining protoplasm and nuclei resembling those of lymphocytes. Throughout the sections there is much light brown pigment in granules in the alveolar capillaries, within cells, and, apparently, lying free. In a number of veins of large size there are collections, beneath the intima, of large mononuclear cells containing masses of light brown pigment, and, occasionally, clusters of delicate rod-shaped crystals. The cell masses produce elevations projecting into the lumen of the vessels. The pleura and interlobular septa show evidences of slight edema. Spleen: Moderately injected; otherwise normal. Liver: There is very extensive central necrosis throughout the organ and the lesions present various stages of the process, the earliest being represented by masses of hyaline, degenerated liver cells. The later stages show complete absence of liver cells in the centers of lobules with regenerative processes, evidenced by mitosis in liver cells at the periphery. Polymorphonuclear leucocytes are few in number; the collections of cells consist chiefly of lymphocytes and phagocytic cells which contain bile pigment and light brown refractive pigment. Throughout the liver there are collections of lymphocytes and mononuclear cells in the sinusoids. The bile ducts and vessels are negative. No bacteria were seen in sections stained by Gram's stain or by methylene blue and eosin. Many endothelial cells of the sinusoids throughout the liver contain light brown pigment. The portal spaces contain collections of lymphocytes. Pancreas: Normal. Kidney: Many glomeruli are nearly bloodless, because of the obstruction of the capillaries by cells; these cells are large, mononuclear ones, and many contain light brown pigment. Occasionally there are among them a few polymorphonuclear leucocytes and large cells containing hyaline drops. The tubules show slight

evidences of cloudy swelling and there are occasional groups of lymphoid and plasma cells between the tubules. The connective tissue of the apices of the pyramids is edematous and contains occasional mitotic figures. The blood vessels are normal. There are a few hyaline drops and vacuoles in the epithelial cells of the pelvis. Adrenal: Normal. Parotid gland: Normal. Muscle: A few of the fibers of muscle taken from the diaphragm and leg contain cysts of *Sarcosporidium*. The fibers are very slightly enlarged by the cysts. Intestines: Sections from large and small gut are negative except for lesions due to the attachment of *Sclerostomum equinum* in the large gut. Bladder: Negative, except for some edema of tissues beneath the peritoneal coat. Lymph glands: The superficial lymph glands are normal. Those from the peritoneal and thoracic cavities all showed marked congestion and dilated lymph sinuses. The surrounding areolar tissues usually contain dilated lymph vessels. Another constant finding is the presence of blood pigment in phagocytic cells in the sinuses and reticular tissue. The sinuses contain many phagocytic, mononuclear cells with inclusions of red blood corpuscles, pigment and lymphoid cells. There is no necrosis. Occasionally lymph sinuses contain fibrin and large mononuclear cells and a few red blood corpuscles. Clusters of large, mononuclear cells, containing minute granules and vacuoles, are common in the reticulum of many glands. In one gland there are several giant cells of the bone-marrow type. Bone marrow: That from the femur is fatty and contains no blood-forming elements; that from the rib is active and normal in appearance. Brain cortex: Normal. Spinal cord: Normal. Peripheral nerves: Normal.

Case II. (Grey Gelding).—Age, 17 years; weight, 1,205 pounds; received January 19, 1910. This animal also came from Oakville, Manitoba. It was first noticed to be ill in July, 1909; since then it has been only fit for work at intervals. On the 7th of January its pulse was 60° and its temperature 99° F. There was slight edema of the abdomen and marked anemia of the mucous membranes. The heart sounds were increased and polyuria was present. The horse was said to be becoming steadily thinner in spite of a good appetite.

Present condition: The horse seems to be practically healthy. The gait is slow, but not uncertain; and the horse is thin, but not emaciated. The only edema to be detected is a slight thickening of the sheath; the mucous membranes are not very pale and there are no petechiæ. The blood count shows that there is a slight anemia; there are 6,500,000 red cells and about 60 per cent of hemoglobin.

Course of the disease: On April 23d the horse was much improved; it weighed 1,360 pounds, its pulse rate was 44 and its temperature, which was usually about 100° F., had not been above 101° since its arrival. There was no anemia. A blood count gave: red cells, 8,500,000; white cells, 16,000; hemoglobin, 70 per cent. At the middle of May and at the commencement of June there were slight rises in temperature, lasting for a day, or, at most, two, to 102° F. The rise at the end of June was due

to an abscess in the hoof. At the end of June the horse weighed 1,230 pounds. It seemed healthy and was worked almost daily. A blood count gave: red cells, 8,500,000; white cells, 11,600; hemoglobin, 75 per cent. A differential count was made of 500 white cells from two slides, with the following results: Polymorphonuclears, 71.5 per cent; lymphocytes, 16.5 per cent; large mononuclears, 6 per cent; eosinophiles, 3.75 per cent; transitionals, 2.25 per cent — equals 100 per cent.

At the present date, October 31, 1910, the horse seems to be in perfect health. It weighs 1,380 pounds; its pulse rate is about 35, its temperature is normal, and there is no sign of edema or petechial hemorrhages. It seems possible that an occasional rise, during the summer, of its temperature may be accounted for by a more than usually severe day's work.

If it were not for the distinct rises in temperature which followed the inoculation of blood from this Grey Gelding, especially into Horse No. 2, and also into Horses Nos. 4 and 5, it would be permissible to question whether it were ever infected with Swamp Fever. As it is, it seems as though this were a case from which the symptoms have disappeared temporarily or, it may be, permanently.

The Black Gelding was an undoubted case of Swamp Fever; it died twelve months after symptoms were first noticed.

X. Sub-inoculations. — It has been shown¹⁵ that Swamp Fever can be transmitted to horses, mules or donkeys by the inoculation of blood, or blood serum, from infected animals; five cubic centimeters of blood is sufficient to transmit the disease. The blood of infected animals is infective up to twenty-four hours after death. The period of incubation, between inoculation and the appearance of the first symptom — a rise in temperature — lasts for from ten days to one and one-half months. In horses the experimental disease runs a chronic course and lasts for from two months to one and a half years, or longer.

Attempts to inoculate guinea-pigs, rabbits, cats, dogs, and cattle have failed.

The results of our attempts to transmit the disease are recorded below.

A. Horses. — Horse I. (Bay Gelding). — Weight, 1,656 pounds; age, 8 (?) years. This horse had a very marked elephantoid condition of both legs, caused by a chronic lymphangitis; possibly some of the irregularities of temperature may have been due to it.

The animal was inoculated intraperitoneally on January 23d with 35 cubic centimeters of pure blood taken from the Black Gelding (temperature 96° F.) a few hours before its death. A week later the temperature rose to 102° F., and although it was irregular and fell daily, the temperature continued to rise during the whole of that week until it reached 106.4° F. The temperature still remained irregular, but it fell gradually during the next week until it reached 99.4° F., when it again rose for five days and remained for three days between 104° and 105.5° F. The animal was now quite weak, and, during six weeks, the temperature usually remained between 100° and 101° F.; on two occasions it reached 102° F. On May 27th the horse was down and unable to rise. It was consequently killed in order that an autopsy might be performed.

The pulse rate was usually low. With a temperature of 103.6° F. it was 48; just before death, with a temperature of 100.4° F., it was 32.

During the course of the illness no edemas — other than the elephantoid condition mentioned — or other gross clinical signs were observed. The appetite always remained good and, until nine weeks before its death, the horse seemed to be as strong as ever.

The following blood count was made on May 27, 1910, the day on which the animal was killed: red cells, 10,640,000; white cells, 29,500; hemoglobin, 115 per cent.

Differential count: Polymorphonuclears, 85 per cent; lymphocytes, 12.50 per cent; large mononuclears, 2 per cent; eosinophiles, .50 per cent — equals 100 per cent.

Autopsy: (a) Gross appearances. — Both hind legs are greatly swollen and there is a large bruise, due to a fall, over the chest. On incision there is no subcutaneous fat; the muscles are normal in appearance. There is a small amount of subcutaneous, yellowish edema over the bruise on the chest; the muscles beneath this area are deep red and seem to contain extravasated blood. On cutting into the bruised mass small areas of pus, the size of millet grains, are found.

The peritoneal and pleural cavities contain no free liquid. The pericardium contains about 100 cubic centimeters of clear, yellowish fluid. The heart, lungs, and bronchial lymph glands are normal. One or two of the lymph glands in the mediastinum are slightly enlarged, firm, and congested.

On the under surface of the diaphragm there are a few small, old, fibrous tags.

The spleen, liver, kidneys, and pancreas are normal in size and appearance.

All the abdominal glands are normal in size and appearance with the exception of two from the mesentery and small gut, which are distinctly

enlarged and congested. The prevertebral lymph glands from the lumbar region are also enlarged and congested; the thyroid, parathyroid, parotid and submaxillary glands are normal. The brain, spinal cord, and bone marrow are normal in appearance. The intestines are normal; they contain a few *Sclerostomum tetracanthum*. The swelling on the hind legs is due to a thick layer of extremely firm, fibrous tissue. The joints are unaffected and there is no sign of recent inflammation.

(b.) Minute appearances. — Heart: Markedly injected; otherwise normal. Lung: There is very marked injection. The alveolar capillaries contain numerous phagocytic cells with blood corpuscles, pigment and polymorphonuclear leucocytes as inclusions. A few veins have small elevations of the intima caused by collections of large mononuclear cells containing light brown pigment, and lymphoid and plasma cells. In one instance there is a thrombus attached to one of these lesions. A portion of one section is composed of collapsed alveoli with greatly distended capillaries in the tortuous walls. The small bronchi are collapsed but do not contain exudate. Throughout the sections there are numerous cells containing light brown pigment, distributed chiefly in the alveolar capillaries and about small veins and arteries. Spleen: The secondary follicles are normal. The pulp is moderately injected and contains large quantities of light brown pigment in the form of spherules and granules packed in cells. There are numerous phagocytes attached to the reticulum which contain chiefly lymphoid cells. Liver: There are very many small foci of infiltration with lymphocytes and phagocytic cells, the latter containing pale brown pigment. In these foci there are often a few necrotic liver cells and polymorphonuclear leucocytes, but for the greater part these foci seem to lie between the liver columns and sinusoids and do not contain degenerated liver cells. The organ is considerably congested. There is a very slight increase of connective tissue about the portal canals. In many places there is a thin layer of hyaline material between the liver columns and sinusoids. The bile ducts and vessels are normal. Pancreas: There are occasional small areas of fibrosis in the lobules, otherwise the organ is normal. Kidney: The glomeruli are injected but are otherwise normal. There are foci of marked parenchymatous degeneration of the convoluted tubules; in these areas there are a few immigrating polymorphonuclear leucocytes. Some of the collecting tubules contain hyaline casts and leucocytes. There is a small amount of greenish brown pigment in the epithelium of the tubules. Adrenal: Normal. Thyroid: Contains traces only of colloid material. Parathyroid: Normal. Salivary gland: Normal. Muscle: Muscle fibers from the chest wall, esophagus, and one of the skeletal muscles contain *Sarcosporidium*; none are seen in muscle from two positions in the diaphragm. In the muscle from the bruised area on the chest there are abscess cavities and suppurating tracts containing clumps of bacteria (cocci in chains and pairs). In many places granulation tissue surrounds the pus cavities. Esophagus: Mucosa and wall normal, except for *Sarcosporidium* in the striped muscle coat. Lymph glands: Five sections show hemolymph glands which are negative.

Three other lymph glands are also negative except for a large amount of brown pigment in phagocytic cells.

One bronchial lymph gland is negative. Another bronchial lymph gland which, at the autopsy, was seen to be spongy and to contain air-filled cavities, has many round and oval cavities with smooth lining of flattened or cuboidal cells. There are many giant cells around these cysts. The intervening tissue resembles fibrosed lymphoid tissue and contains some carbon pigment. Tissue from swollen leg: Consists of dense fibrous tissue with numerous blood vessels surrounded by lymphoid and plasma cells. Brain cortex: Normal. Spinal cord: Normal. Pituitary body: Normal.

Horse II. (Chestnut Gelding).—Weight, 960 pounds; age, 6 (?). This horse was inoculated intraperitoneally on February 4, 1910, with 30 cubic centimeters of blood from the Grey Gelding (temperature 100.4° F.) Twelve days later the temperature commenced to rise and it rose steadily until, on the fifteenth day, it reached 106.1° F.; after two days it fell to between 100° and 102° F., where it remained for ten days, when it again rose to 103° F. For six weeks the temperature was exceedingly irregular; at intervals of ten days there were three rises to 103.5° F. with pulse rates of from 38 to 44. At this time the horse was much weaker; it weighed only 845 pounds, and the temperature, while still irregular, remained between 99° and 101° F. Anemia was not marked (red cells, 5,360,000; white cells, 16,200). During the last three weeks of its life the horse was extremely weak, although it fed and drank readily until its death. No edemas nor petechiæ were seen. For one day before it died it was unable to rise. It died during the night of May 12.

Autopsy: (a) Gross appearances.—The autopsy was commenced within twelve hours after death. Rigor mortis was present, but the organs were distinctly warm.

The coat is rough. There are no edemas. The animal is extremely thin; the muscles seem normal. A few adult filariæ (*Filaria papillosa*) lie among the coils of the intestine. There are no petechial hemorrhages on the peritonium and the cavity does not contain an excessive amount of fluid. The pleural cavities each contain about 500 cubic centimeters of clear yellowish fluid.

Heart (7½ pounds): The muscle is distinctly pale and seems cloudy. The pericardial fat is edematous and infiltrated with a gelatinoid, yellowish edema. The heart valves and great vessels are normal. Lungs (right, 10½ pounds; left, 9½ pounds): Both lungs are congested and slightly edematous. The right lung is the more congested of the two and, in one small area, there seems to be an extravasation of blood. Liver (17 pounds): With the exception of a few scattered spots, which are paler than the remainder of the organ, the liver seems to be normal. Kidneys (together 4 pounds): The substance seems to be normal.

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Spleen (3½ pounds): The capsule is somewhat thickened and the whole of its surface is dotted with very numerous petechial hemorrhages. Adrenals and pancreas: Normal. The bladder is normal and contains a fair amount of cloudy urine. The turbidity is caused by urates, although there are a few pus cells present. The marrow of the long bones is firm and yellow. The surface of the brain is somewhat congested; the dura seems normal. The mucosa of the alimentary canal is normal throughout; the gut contains a large number of *Oxyuris equi* and a few *Sclerostomum tetracanthum*. None of the lymph glands are markedly enlarged or congested; one small abdominal gland is hemorrhagic and on section is found to contain a small filaria (*Filaria papillosa*).

(b) Minute appearances.—Heart: Normal. Lung: Markedly congested. One section contains a very recent hemorrhagic infarct. Spleen: There is extreme congestion with small hemorrhages into the pulp. The secondary follicles are represented by a few cells. There is much bright, yellow brown pigment in phagocytic cells throughout the organ. The trabeculae contain many migrating polymorphonuclear leucocytes. Liver: There are a great many focal necroses of small size and irregular distribution, each consisting of a few necrotic liver cells or of remains and collections of endothelial cells, lymphocytes, and occasional polymorphonuclear leucocytes. Many of the endothelial cells contain light brown refractive pigment. A few bile ducts contain inspissated bile but are not distended. Kidney: There is no pronounced lesion. The tissue is much altered by post-mortem changes. Pancreas: Post-mortem changes only. Adrenal: Normal. Muscle: Tissue from a skeletal muscle and from the diaphragm contains *Sarcosporidium*. Lymph glands: All show very marked congestion, but contain only small amounts of pigment. The sinuses contain only a few endothelial cells. In two glands the reticular tissue contains clusters of endothelial cells, some of which contain brown pigment; others are vacuolated. Brain cortex: Normal. Spinal cord: Normal. Peripheral nerve: Normal.

Horse III. (Brown Mare).—Weight, 970 pounds; age, 10 +. On February 18, 1910, this horse was inoculated intraperitoneally with 20 cubic centimeters of blood taken from Horse I. (temperature 105.5° F.). Eight days later there was a rise in its temperature for one day to 103° F.; a similar rise occurred in the week following. Four weeks after the inoculation the temperature rose on two successive days to 105.5° F. The temperature then fell and, until the 20th of July, it remained between 100° and 101.5° F. The pulse rate was low; during the first rise in temperature to 103° F. it was at 46; and during the rise to 105° F. it was at 53. No edemas or other gross clinical signs occurred and the animal put on flesh until it weighed over 1,000 pounds. On the 21st of July 970 cubic centimeters of blood were transfused into its jugular vein from Horse V., which on the previous day had had a rise in temperature to 103.5° F. Sixteen days later there was a slight rise in temperature to 103.5° F. Since then to the present date, October 31, the temperature has been approximately

normal; its pulse rate is about 45, it weighs 1,030 pounds, and it has shown no sign of disease.

November 5, 1910: Yesterday the mare seemed in good health; early this morning she was noticed to be breathing quickly, and at about 11 o'clock she was down and died suddenly. The autopsy was commenced six hours later.

Autopsy: There were no edemas and little fat; the muscles were normal in color; the peritoneal and pericardial cavities contained no fluid. Over the lower part of the colon, and over the upper surface of the liver, there were numerous, old, fibrous tags. With the exception of the spleen (weight, 2½ pounds) all the peritoneal organs were normal in appearance. The capsule of the spleen was covered with very numerous pinhead petechiæ. The heart was normal. The left lung was normal; the whole of the lower lobe of the right lung was consolidated. The abdominal and lymphatic glands were normal. Cause of death: Pneumonia.

Horse IV. (Red Gelding). — Weight, 775 pounds; age, 26 years. This animal was inoculated intraperitoneally on March 17, 1910, with 40 cubic centimeters of blood from the Grey Gelding (temperature steadily normal). The temperature remained unchanged for two weeks, when it rose to 103.2° F. It then fell and remained between 100° and 101° F. for five weeks save for one period when it rose, for three days, to 103° F. After that the temperature was rather irregular, but it never went above 101° F.; pulse 45. No edema or other gross clinical signs were seen in this animal at any time. There was distinct anemia; red cells, 5,100,000; white cells, 6,900. On the 21st of July 860 cubic centimeters of blood were transfused into it from Horse V. (on the previous day the temperature of this animal had been up to 103.5° F.). No rise in temperature followed the transfusion and the animal seemed to be as well as usual and ate with its usual appetite. On July 31st it was down and unable to rise; it struggled continually and perspired very freely; it was killed and an autopsy was commenced at once.

Autopsy: (a) Gross appearances. — Rigor mortis came on very quickly. The muscles seemed to be normal. The only edema found is a light infiltration of the subcutaneous tissues on the side on which the horse lay before death. There is no excessive fluid in the peritoneal cavity; it contains a few filariæ (*Filaria papillosa*). The pleural cavities are normal. Heart: The epicardium, heart muscle and endocardium are normal. On the mitral valve there is a small, sub-endocardial extravasation of blood and, on its auricular surface, there is an old firm vegetation. The great vessels are normal. Lungs: Normal. Spleen: The spleen is not enlarged. The surface is thickly covered with small irregular, petechial hemorrhages; these are particularly marked on the lower portion of its diaphragmatic surface. Liver: Seems normal in size and substance. Kidneys: Are somewhat injected but otherwise normal. Pancreas: Normal. Genito-urinary

system: Normal with the exception of two cysts filled with clear fluid in the left ovary. Alimentary tract: Normal. There are many bots attached to the stomach and many *Sclerostomum equinum* in the intestine. The mesenteric lymph glands are enlarged and deeply congested; the other lymph glands are normal.

(b) Minute appearances. — Heart: Negative. Lung: Moderately injected only. Spleen: Markedly injected. There is a moderate amount of brown pigment in the pulp. Liver: Markedly injected. There is a lymphoid and plasma-cell infiltration of the portal canals, which also contain numerous brown pigment-containing cells. Pancreas: Normal. Kidney: Normal except for occasional clusters of green pigment granules in cells of convoluted tubules. Rarely the amount of green pigment is large, filling all the cells in the cross section of a tubule. Adrenal: Normal. Muscle: There are numerous cysts of *Sarcosporidium* in the diaphragm. There are very many large ones in the voluntary muscle coat of the esophagus; in this situation the cysts are more numerous and of larger size than in any of the horses (Black Gelding, Horses I. and II). Duodenum: Normal, except for curious collections, in the submucosa, of cells containing large hyaline drops and bluish-green pigment; the latter is possibly iron pigment acted upon by H_2S . Bone marrow: The marrow of the long bones is fatty and contains no blood-forming cells. Lymph glands: One bronchial lymph gland is normal. Another shows moderate congestion. Another gland, containing carbon pigment, has blood in all of the sinuses and resembles a hemolymph gland. It contains many phagocytic cells enclosing pigment, red corpuscles, and lymphoid cells.

Horse V. (Black). — Weight, 950 pounds; age, 10+. This animal was kept under observation for thirteen weeks; its temperature throughout this period remained very regular, between 99° and 101° F., and its pulse rate was about 52. On the 9th of July 450 cubic centimeters of blood were transfused into its jugular vein from the Grey Gelding (temperature steadily normal). Twelve days later the temperature rose to 103.5° F., and on three occasions during the first and second weeks in September it reached 104° F. It is possible that these rises may be partially accounted for by heavy work; for the animal has been worked continually and the temperature has frequently risen to 102° , or even to 103° F. No edemas, petechiæ, or other gross clinical signs have been observed in this animal. It is, nevertheless, becoming steadily thinner although the appetite remains good and the pulse rate and temperature are low. October 12, 1910: Weight, 940 pounds; pulse, 50. There are no edematous areas or other physical signs beyond slight wasting of the muscles. November 7, 1910: This animal has been becoming steadily weaker; wasting of the adductor muscles of the thighs has been especially marked. Two days ago the horse was down and was raised to his feet with difficulty. To-day he was down again and it was impossible to raise him.

He was consequently killed. The autopsy was commenced four hours later.

Autopsy: There are no edematous areas. The fat is scanty. Muscles are normal in color. There is no fluid in the abdominal or thoracic cavities. There is a large, verminous aneurism, filled with recent clot, in the superior mesenteric artery. There are pin-point petechiæ over the surface of the spleen (weight, $2\frac{3}{4}$ pounds); they are present on no other serous surface. With the exception of a few fibrous tags on the upper surface of the liver, all the organs, both abdominal and thoracic, are normal in appearance. Some of the lymph glands in the mesocolon are enlarged and edematous; the glands of all the other groups, both internal and external, are normal in appearance.

An examination of the records of the inoculation of these horses yields the following facts:

The inoculations of blood were followed in every instance by a rise of temperature in from eight to twenty-six days (average fourteen and one-half days).

It is interesting to note that a distinct rise in temperature occurred in Horse III. in fifteen days after it had received into its jugular vein a large quantity of blood from Horse V. Horse V. received its infection from the Grey Gelding; Horse III. was first inoculated from Horse I., which had received its infection from the Black Gelding; when it was first inoculated there was a distinct rise in its temperature. It is interesting that the infection, originating from the Grey Gelding, was able to produce a rise in temperature in an animal which had already reacted to an inoculation with blood which derived its infection from the Black Gelding.

The disease led to the death of four horses in about four months after their inoculation; one died of pneumonia nine months after inoculation.

The course of the disease in these horses and the appearances observed at the autopsies were not dissimilar from those which are described in Swamp Fever.

B. Other animals. — Four guinea-pigs, two mice, nine rats, two rabbits, ten dogs and puppies, two kittens and one sheep were inoculated at different periods from the two

original horses and from the horses (Nos. I., II., III., IV., and V.) inoculated from them.

Large quantities of blood were always used; rats often received ten cubic centimeters and the kittens as much as thirty cubic centimeters; other animals received proportionate amounts. So far as it was possible the blood for inoculation was always taken from the horse while its temperature was higher than normal.

No symptoms, such as emaciation and rise of temperature, which might be attributed to Swamp Fever, followed the inoculation of any of these animals. Four of the rats and two guinea-pigs which received blood from the Black Gelding died, from no apparent cause, about two months after the inoculation. Some of the animals died of intercurrent infections, such as pneumonia; others were killed in order that they might be examined. The remainder of the animals are still living and healthy. Careful post-mortem examinations were made of all the animals that are dead; no constant lesions, either macroscopical or microscopical, have been found in any of them; in one or two the spleen was slightly enlarged; in one dog the abdominal lymphatic glands were much enlarged and hemorrhagic. Very marked anaphylactic phenomena, such as vomiting, purging, dyspnea and, at the autopsy, edema of the lungs and congestion of the liver, were noted in puppies, rabbits, and cats. The symptoms were observed at the first, second, and third repetitions of inoculations of horse blood into animals which had previously received doses of blood from either the same or from another horse. The first doses of blood given measured about ten cubic centimeters; the last ones about thirty cubic centimeters for each animal.

XI. Observations on Cases and on Sub-inoculations. — The blood of the original horses and of all of the experimental animals was examined very carefully and almost daily, either in coverslip preparations or in stained films; and from time to time ten cubic centimeters or more of blood from the horses was centrifugalized and examined.

During the summer of 1908 one of us spent five weeks in traveling* through the Canadian Middle West in search of cases of Swamp Fever. The trip was made in July, when cases are exceptionally scarce and only four horses which seemed to be certainly suffering from the disease were found. In three of these horses the diagnosis was probably correct; in one it was doubtful. In the three animals, which were probably infected, anemia was marked; one of them had only 2,000,000 red cells, 8,000 white cells, and a hemoglobin count of 35 per cent. In one horse auto-agglutination of the red cells in fresh coverslip preparations of blood was very marked; it was also present in the Grey Gelding. The blood of all these three animals was carefully examined in fresh preparations, in smears, and by centrifugalization. Nothing resembling a parasite was seen in any of them.

Although previous observers had examined the blood of animals suffering from Swamp Fever during long periods and at all hours of the day and night, we made extremely careful examinations of the blood of all of our animals because the symptoms of Swamp Fever are precisely those which are present in many trypanosome infections, and experience has shown that, as—for example—in Dourine and, sometimes, in infections by *Trypanosoma dimorphon*, an examination extending over months may fail to reveal the presence of the parasite which is causing the death of the animals infected by it. In spite of our search no such parasite was found in any of our horses or in any of the animals inoculated from them.

At the autopsies of the horses infected with Swamp Fever, and of the various experimental animals of all sorts which were inoculated from them, smears were made from all of the tissues and body fluids. These smears were stained by a modification of Romanowsky's method and they were examined with extreme care, on a mechanical stage, with the highest magnifications (Zeiss Comp. No. 8 ocular; 1.5 millimeters Apo. objective). No appearances which could be thought to be parasites were seen in any of them. Many smears, particularly those from the liver, lymph glands, and spleen, contained peculiar bodies similar to

*Thanks are due to the Canadian Pacific Railway for the possibilities given us on this occasion.

those which have been described by Mott¹⁰ in the organs of Dourine-infected animals. It is believed that in our preparations these bodies are merely the products of degenerated cells or of cells destroyed in the making of the smears.

These bodies measure from two to five microns in diameter. They are usually round or oval in shape. They consist of a dense area and of a matrix enclosing it. The denser area usually occupies about one-fourth of the whole area of the body and consists of a single granule, although occasionally there may be two. These areas stain very deeply with the color taken by chromatin. The matrix usually takes a pinkish color; occasionally it is stained a bright blue.

Such bodies are usually found lying free in the organ smears. Occasionally they seem to lie within mononuclear white cells; frequently appearances are seen which make it very evident that these bodies are formed by the fragmentation of the nuclei of cells.

The late Dr. Ballah, while he was attached to the Pathological Laboratory at McGill University, and later to the Government Laboratories at Regina, did much work on Swamp Fever. Some of his results were published before his death;²⁰ he described the disease, his attempts to transmit it by inoculation and the appearances seen at autopsies and of animals dead from it. He also described bodies which he found in the livers.

Case IV. (Dr. Ballah). — Post-mortem changes are marked. Lung: Normal. Spleen: Moderately congested. There is much dark brown crystalline pigment in the pulp. Liver: Moderately congested. There are many focal necroses, similar to those described in the Black Gelding (see above), though the central necroses are not so abundant. The sinusoids contain many mononuclear cells, some of which are phagocytic. Others are lymphocytes, the remainder are probably endothelial in origin. The necroses contain large numbers of phagocytic cells and relatively few polymorphonuclear leucocytes. The liver cells adjacent to the necroses show degenerative changes, evidenced by pale staining vacuolation and, occasionally, invasion by leucocytes. There are groups of liver cells about the necroses which are filled with minute eosin-staining rings one to two microns in diameter; some of these rings contain central, or eccentric, eosin-stained dots. These bodies stand out more strikingly in sections

stained by Gram's method and by iron hematoxylin, and bear some resemblance to Leishman's bodies; this is particularly so in specimens stained by Gram's method.

There is much dark brown pigment scattered throughout the liver cells and a smaller amount of paler brown perinuclear pigment.

The portal spaces are markedly infiltrated with lymphocytes.

The liver, as a whole, is very similar to that of the Black Gelding, but the post-mortem changes are too great for a careful cytological study. Kidney: Congested. Glomeruli normal. There is very slight lymphocytic infiltration of the interstitial tissue. There is probably slight cloudy swelling but the state of the tissues makes a reliable report impossible.

Case V. (Dr. Ballah).—Post-mortem changes are marked. Lung: Normal. Spleen: There is extreme hyperemia. The Malpighian bodies are very small. The structure of the pulp is not distinguishable, owing to the blood and, possibly, also, because of post-mortem changes. There are many large cells containing dark brown pigment in the pulp. Liver: There are many small necroses similar to, but less extensive than, those seen in the preceding case. The pigmentation is also less marked and the ring bodies, though present, are less conspicuous. Kidney: The glomeruli are normal. There is marked perivascular and interstitial infiltration with lymphoid and plasma cells. Slight cloudy swelling. Lymph glands: Both sections show congestion. The sinuses contain blood and many large phagocytic cells containing red blood corpuscles and pigment.

A portion of a liver, taken from a horse which died from Swamp Fever, was sent to us by Dr. Torrance of Winnipeg. Sections were made of it and examined. The appearances seen were similar to those observed in the livers of our own cases.

XII. Cultures.—The fact that *Leishmania* will develop conspicuous flagellating forms in tubes containing infecting material, diluted with sodium citrate, and kept at room temperature, suggested that blood from our horses should be examined in the same way.

On January 23, 1910 (temperature 96° F.), blood was taken from the Black Gelding; two cubic centimeters of it were placed in each of one dozen tubes and the blood was diluted with solutions so as to give tubes containing a mixture of blood and from .5 per cent to .12 per cent of sodium citrate; other tubes contained a mixture with from 1.4 per cent to .35 per cent of sodium chloride. These tubes were placed in an incubator at 37° C. and for two and a half

weeks they were examined daily in fresh or stained preparations; no visible bacteria nor other parasites were seen in them.

On April 2d blood was taken from the jugular vein of Horse IV. (temperature 103.2° F.). A mixture containing .2 per cent of sodium chloride and another mixture containing .3 per cent of sodium citrate was centrifugalized. Four hanging-drop preparations were made of the white layer from each mixture; these preparations were kept at 37° C. and carefully examined at intervals during four days; no parasites nor bacteria were seen in them. Four tubes, two containing five cubic centimeters of the sodium chloride mixture and two containing five cubic centimeters of the citrate mixture were kept at room temperature; four other such preparations were kept at 37° C. All were examined at intervals during four days; no parasites nor bacteria were seen in them.

Quantities of blood, varying in amount from two cubic centimeters to five hundred cubic centimeters, were taken from the Black Gelding and from Horse IV.; these were kept at room temperature or at 37° C. They were examined constantly for a fortnight; no bacteria nor other parasites were seen in them.

Many observers (Peters, Torrance and Bell, Mack) have unsuccessfully attempted to cultivate a specific organism from the body fluids and tissues of cases of Swamp Fever. Dr. F. C. Harrison, Professor of Bacteriology at Macdonald College, attempted to cultivate an organism from our cases; his efforts were also unsuccessful; they are briefly recorded below:

Black Gelding. — Material for inoculating the culture media was taken from a vein in the leg, a vein in the abdomen, from the lymph duct, from the pericardium, from the spleen, from the kidneys, lungs, brain, and from the bladder. Cultures on the following media were made with each material: beef broth, glycerine broth, beef peptone, beef peptone agar, beef peptone glucose agar, glycerine agar, milk, coagulated blood serum, and urine.

The cultures made from the lung were contaminated. The culture tubes from the brain were also contaminated. The cultures made from

the kidney showed a slight turbidity in glycerine broth and some growth on the blood serum and on the glucose agar. Plates from this material showed the presence of microscopic colonies of a diplococcus which stained by Gram's method. A similar organism was present in the lymphatic glands. The attempts to grow this organism in broths of various kinds failed; it would not live for more than four days in culture media.

Horse II. — With the exception that the culture media containing blood were prepared with blood drawn off a few hours previously from this animal, the routine followed in making the cultures from the Black Gelding was followed in making cultures from this horse.

With the exception of a few colonies which could be attributed to aerial contamination from the stable, the results obtained were entirely negative.

Cultures on blood peptone agar, beef peptone agar, and water agar were carefully examined with high magnifications at frequent intervals for a fortnight without result.

At the autopsy of this horse culture tubes were again inoculated in the same way as before. Three organisms, none of them pathogenic to guinea-pigs, were isolated. Two were unidentified; one was *Micrococcus varians lactis*.

It is of interest that this organism has been met with on several occasions at Macdonald College in the organs of animals. In one instance it was isolated from the udder of a virgin heifer.

XIII. Summary. — The symptoms which were constant in our infected horses were: an irregular temperature, accompanied by weakness, emaciation and anemia of varying severity; edemas rarely occurred and petechiæ of the mucous membranes were not seen. When death occurred it followed in from four to eight months after the appearance of symptoms. One horse, which has possibly recovered from the disease, is still healthy sixteen months after the appearance of the disease.

At the autopsies, emaciation was the most constant feature. The spleens were markedly enlarged * and, sometimes, congested; in two instances their capsules were dotted with petechial hemorrhages; sub-serous hemorrhages, other than these, were not seen. With the exception of an infarct of the lung in Horse II. and of microscopical extravasations

*The normal weight of the spleen of a horse of the weight of the Black Gelding is about two and a half pounds.

of blood into the spleen, hemorrhages into the substance of organs were not seen. The internal lymphatic glands have usually been enlarged and much congested. Cloudy swelling of the heart muscle and of the kidneys, and, also, marked yellowish gelatinous edema of the pericardial fat were constantly seen. Pus, and other evidence of active inflammatory changes, occurred in none of our autopsies; the abscess on the chest of experimental Horse I. was due to a fall, and the fibrous tags which were found on the diaphragmatic surface of the liver of the same animal were of too long standing for them to have been due to a disease produced by the inoculation.

The results of the microscopical examination of the organs were very constant. There has always been focal or central necrosis of the liver and a varying degree of acute parenchymatous degeneration of the kidneys; blood pigment has been deposited in the lungs, spleen, liver and lymph glands and these organs have contained many phagocytic endothelial cells which had often taken up red blood cells.

The ring bodies seen by us in the preparations of Ballah's Cases (IV. and V.) and reported by him (Annual Report of the Department of Agriculture of the Province of Saskatchewan, 1907, 223-226) have also been seen by us, especially in Case I. (Black Gelding). Similar bodies have been found by us in the liver of a normal dog, which was incubated at 27° C. for four and a half hours before fixation in Zenker's fluid. They have also been seen in a case of liver necrosis in man, due to streptococcus infection. Our belief is that these bodies are formed by coagulation or precipitation of protein about droplets of soluble material.

Sarcosporidia were found in all of the horses, while *Sclerostomum equinum* or *S. tetracanthum* were almost always present. The liver lesions are of long duration and are evidently present throughout the course of the disease; the kidney lesions, in one case at least, must be regarded as terminal.

There is a marked anemia; the red cells are greatly

reduced in number and stain irregularly. The anemia is probably due to a blood destruction; to it is due the pigmentation of all the organs which is so striking in all cases of the disease. The enlargement and changes in the lymph glands and spleen are probably secondary to the blood destruction.

All those who have worked with Swamp Fever agree in looking on blood destruction as the chief feature of the disease. The virus which caused the blood destruction and the method by which it acts remain unknown.

Because of their failure to find any pathogenic agent, some observers have suggested that the symptoms of Swamp Fever might be produced by a toxin, and that the toxin might possibly be absorbed from the alimentary tract, where it might be produced by bacteria or by animal parasites; it is well known that auto-intoxication occurs in constipation, and that verminous anemia may be produced by *Sclerostomes*. It has also been suggested that *Sarcosporidia* might account for some of the symptoms of Swamp Fever.

Neither of these suggestions is tenable, for the virus which causes Swamp Fever exists and can be transmitted by the inoculation of the blood of infected animals. *Sarcosporidial* spores were not seen, outside of their cysts, in any of the numerous smears and sections which were made from our animals; and even although *Sarcosporidia* may possibly produce an intoxication,¹¹ they did not occur in our cases in sufficient numbers to account for the symptoms which existed.

XIV. CONCLUSIONS.

Our cases were too few in number for it to be possible to draw definite conclusions from them. Our results do not differ from those obtained by previous observers; consequently, our observations will merely serve to confirm those of others who have preceded us in studying the disease.

Swamp Fever is a disease of horses which is widely distributed in the Western United States and in Western Canada.

It is usually a chronic disease and is characterized by emaciation, weakness, irregular temperature and anemia.

It is caused by an infecting agent which can be transmitted

from horse to horse by the inoculation of blood taken from an infected animal.

All search for a parasite which might cause the disease has been unsuccessful; although very large numbers of preparations of body fluids and tissues have been examined at all stages of the disease by microscopical and bacteriological methods.

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