Bulletin No. 121 - Swamp Fever in Wyoming

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UNIVERSITY OF WYOMING
AGRICULTURAL EXPERIMENT STATION

A chronic case, early stage.

Swamp Fever in Wyoming

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Swamp Fever in Wyoming

Economic Importance, General Characteristics and Control.

JOHN W. SCOTT

INTRODUCTION.

Swamp fever, under one name or another, has long been known as a disease of the equidae, the family of animals that includes horses, asses, and mules. What appears to be the same disease has been discovered in such widely separated countries, and the losses have sometimes been so great, that the disease has frequently attracted attention and the literature on the subject would fill several volumes. But in spite of a great deal of investigational work and many observations on the disease, much remains to be discovered. Some of the experimental work has been especially interesting. And while our experiment station has conclusively demonstrated (Scott, '14; '15; '16; '17; '18) that swamp fever may be transmitted by certain biting flies, a detailed report of this work must be left to another paper. It will be the principal purpose of this bulletin to bring to the attention of the ranchmen and farmers of the state some facts relating to the nature of the disease, its economic importance, how it may usually be recognized, and how it may be controlled.

In the control of any infectious disease, one of several conditions is always necessary. One must know the nature of the cause of the disease and understand its relationships in order to keep it away from the animal usually affected; or one must build up in the animal attacked a natural or artificial resistance, in other words an immunity to the organism that produces the disease; or one must understand the usual methods of transmitting the disease from one individual to another; or finally, though perhaps least important of all, one must know an available treatment that
cures the disease, that eliminates the organism that causes it, or tends to prevent its spread to other animals. Swamp fever, or infectious anemia as it is usually called in other countries where prevalent, is one of those diseases that has sometimes been difficult to control, owing to our ignorance of some or all of these fundamental conditions. The cause of the disease has not been discovered, and there appears to be no immunity against it; no definite cure has been found, and until recently little has been known in regard to the natural methods of transmission from sick to well horses. Indeed the disease itself is frequently difficult to recognize, even by veterinarians, and owing to uncertain symptoms it has sometimes been called the "no-name-disease". Mohler ('08) has mentioned that the disease has been known as pernicious anemia, malarial fever, typhoid fever of horses, plains paralysis, American surra, and by various other names.

GEOGRAPHICAL DISTRIBUTION.

Swamp fever, or what appears to be the same disease, European infectious anemia, has been known as a disease of horses since 1843 and has a wide distribution. It has been found in various parts of Europe, South Africa, and Japan. It has been reported from not less than nineteen of the forty-eight states in this country, and from several of the provinces and territories of Canada. It has been definitely reported at different times from fourteen of the twenty-one counties in Wyoming, including Albany, Big Horn, Carbon, Converse, Fremont, Johnson, Laramie, Natrona, Niobrara, Park, Platte, Sheridan, Washakie, and Uinta. Through correspondence coming to the writer the presence of the disease has also been strongly suspected in Lincoln, Weston, and Sweetwater counties. French ('16) states that "several years ago it could be found existing extensively in nearly every county in the state". It is interesting to add that swamp fever has been known to occur in several of our neighboring states, including Colorado, Kansas, Nebraska, North Dakota, Montana, Washington, and Nevada. The prevalence of the disease considered with its wide distribution in the state is enough to indicate its economic importance, especially if one considers the high percentage of fatalities that result and the lowered efficiency in chronic cases. Further
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significance of its economic importance is brought out in this bulletin.

EARLY RECORDS. DISEASE APPARENTLY WANING.

Swamp fever has evidently existed in Wyoming for a great many years. The first mention of the disease appears to have been made by Whitehouse ('09), who came across it in 1905 when he began practice in the southeastern part of the state in that year. However, I am told by some of the older ranchmen that this same disease was prevalent in the valley of the Little Laramie river not less than twenty-five years ago, in the early nineties. About that time twenty head of horses died of swamp fever on the J. ranch, and the disease has frequently recurred on ranches in that vicinity. My own experience with the disease began in 1913, and within the past five years I have known of two cases on the ranch referred to and have heard of other cases from the same neighborhood. It is reported on apparently good authority that the E. and I. ranch, also located on the Little Laramie, lost sixty head of horses in 1901 and 1902, all attributed to swamp fever. Judging from these and other reports swamp fever existed in Wyoming many years before any written records were left concerning it. It is worth mentioning that Torrance ('02) reports that swamp fever attracted the attention of veterinarians in the Red River country of Manitoba as early as 1881 and 1882.

The general opinion prevails that swamp fever is not so common as formerly, and doubtless this is true so far as epidemics of the disease are concerned. Dr. French ('16), as mentioned above, states that the disease in former years existed extensively over the state, “but each year it has, with us, become less and less general,—for no apparent reason”. Other reports from the office of the state veterinarian appear to substantiate this conclusion, and my own observations indicate that losses from the disease are not so great as formerly. This gradual disappearance seems to be the history of the disease in eastern Nevada (Mack, '09), and along the valley of the Red River in North Dakota (Van Es, '11, '17). However, so long as sporadic cases are found in various localities throughout the state, we may expect recurrent, though localized, epidemics of swamp fever whenever a favorable season
occurs. The significance of this statement will be brought out more fully in discussing the nature of the disease. Fortunately we now have a sufficient knowledge of control and of the methods of transmitting the disease to enable us to keep it from spreading and to prevent its worst ravages. In fact, it will probably be possible within a few years to exterminate the disease entirely.

LOSES. NEED OF INVESTIGATION.

Duplicating the history in other regions, the percentage of fatalities and the losses through incapacity for work have sometimes been very large indeed. We may mention some facts to illustrate this point. Whitehouse states that in a practice extending over a period of four years, 1905 to 1908 inclusive, fully 400 cases came under his observation of which about 350 died. His practice covered the southern part of Albany county, the south-eastern part of Carbon county, and a part of the North Park region of Colorado. Within a five-year period, 1911 to 1915, in the vicinity of Manderson, about 60 head of horses were lost from swamp fever. Between July, 1915, and January 5, 1916, fifteen horses died of the disease on the M. ranch in that neighborhood, though some of these horses may have had other complications, and before the following May three other chronic cases had to be killed on the same ranch. Since that time the disease has not reappeared there. Dr. Gould, who practiced five years at Basin, 1913 to 1917, states in a letter that about 40 fatal cases were observed by him during this period. These occurred mostly near Manderson, Bonanza, and Shell Creek. Dr. Gould estimates that the 40 cases observed by him had a value of about $4,000.00, and I was informed by the county agent that the 18 head of horses lost or killed on the M. ranch undoubtedly were worth more than $2,000.00. However, owing to incomplete records, it is a difficult matter to form an idea of the annual loss to the state; this of course varies a great deal from year to year. It is even more difficult to get a satisfactory estimate of the total loss to Wyoming during the past quarter of a century. The facts recorded in the State Veterinarians' reports, and from other sources, are insufficient on which to base an adequate estimate. Still it is worth while to refer to these reports as giving an indication of the
prevalence of the disease in recent years. We have seen that French ('16) noted much greater prevalence of the disease in earlier years. Davis, in the biennial report for the period ending September 30, 1912, states that swamp fever was present in eight counties. Two years later, according to the next report, it is stated that the disease was present in no less than nine counties with twelve inquiries for help in regard to the disease. French,

Fig. 1. Horse No. 31. Contracted swamp fever in September, 1915, as the result of bites of infected stable-flies (Stomoxys calcitrans). At the date of this photograph it had apparently recovered and was in good flesh but its blood was still virulent. Later in 1918 and 1919 it has had several severe attacks. Except when it has the fever it appears to be a healthy normal horse. See also Plate IV with explanation.

in his report for the biennium ending September 30, 1916, mentions that swamp fever has been reported from only four counties, Fremont, Park, Big Horn, and Uinta. In addition, the writer of this bulletin knew of several scattered cases in Albany county within the same period. These cases evidently were not reported to the office of the State Veterinarian. It is likely, therefore, that similar isolated cases in other portions of the state were unreported or overlooked. In fact the next biennial report, made September 30, 1918, notes that swamp fever had been reported from only three counties, Natrona, Niobrara, and Washakie, none
of which were mentioned in the preceding list. For various reasons, as we shall see, the disease may exist for several years in a community without attracting serious attention. If only one or two chronic cases are present the disease may not be recognized, and since these cases usually improve after a time, or may seemingly recover, the veterinarian is not called in to examine them. So the disease may be carried over from one season to the next. We now have a horse apparently in good health (See Fig. 1) in which the blood is still virulent, though nearly four years have elapsed since he first contracted the disease. Such a case would probably never be suspected if on a ranch. On many ranches the loss of one or two horses receives little attention and a veterinarian is seldom called in unless the disease becomes epidemic. Then in a large state with a small and scattered population veterinarians are frequently too far away to be available, or the time and expense involved is too great to make a visit practicable. On the other hand some of the acute or semi-acute cases probably are diagnosed as other diseases. Anemia rarely develops far in horses with this type of the disease, and the quick and fatal culmination is likely to suggest influenza or some virulent septicemia. Again some chronic cases may easily be mistaken for worm infestation, and many cases of sclerostomiasis or "worminess" probably have been called swamp fever. Considering all of the conditions mentioned or suggested it is evidently impossible to get an accurate estimate of the losses due to this disease. However the writer believes, judging from all sources of information, that 2,000 horses would represent a conservative estimate of all the horses that have died in Wyoming from swamp fever in the past twenty-five years.

While swamp fever seems to be growing much less prevalent than formerly, so long as chronic cases and healthy carriers of the virus exist there is danger of further outbreaks from the disease. It is hoped that this bulletin will aid in further control, and by giving some data with reference to the nature of the disease and its methods of transmission it is believed that the information presented should help ultimately to stamp out the disease entirely. Several years ago when the losses from swamp fever were much greater than at present, and when little was understood about the
nature of the disease, there became evident a need of investigation of the method of transmission from one horse to another. Work of this kind was first begun at the Wyoming experiment station in 1911 under the direction of Dr. L. D. Swingle. After the resignation of Dr. Swingle the present writer took charge of the work in September, 1913. On account of this work and the work of certain other investigators we are now in a position to suggest satisfactory methods for the control and probable elimination of the disease.

SEASONAL OCCURRENCE.

For a long time it has been observed that deaths from infectious anemia, or swamp fever, show a seasonal distribution. In seasons when epidemics occur, the first cases usually appear in June or July; the number of fatalities gradually increases to a maximum which comes most frequently in October, and then the deaths rapidly decrease through November and December. These all represent acute or semi-acute cases. Chronic cases as a rule get better during the winter and may have little or no fever, but these usually have recurring attacks in March, April, May, or even later. If chronic cases die during the spring, it may frequently be due to complications with other diseases or to insufficient nutrition during the winter. Sometimes a horse may have several mild attacks of the fever during the fall and apparently recover during the winter, only to have very severe, relapsing attacks the following spring or summer. Such a horse may die one or two years after contracting the disease, each season leaving him in a weaker condition than before. Or he may have a few recurrent, usually mild, attacks year after year, these attacks usually growing less frequent and less severe until he cannot be distinguished in appearance from a normal horse. An inoculation test, however, will almost invariably show that he still carries the virus. Fever relapses in chronic cases appear to be more common in the summer and fall, less frequent during the early spring, and still less frequent during the winter months. In one instance a fairly complete history of an epidemic of the disease has been obtained, partly through personal observation. The first fatal case on this ranch died during the latter half of July. Both acute and chronic cases developed.
The course of the disease in chronic cases depends largely upon the treatment and care received. For example, recurrent attacks of fever may be brought on by hard work. Hence the observation frequently made by ranchmen that they first noticed the disease soon after turning their horses out to graze at the end of the haying season. Or suckling a colt may so lower the vitality of a mare that the fever may reappear after an absence of several months. Deficient nutrition is another factor that may cause a relapse after apparent full recovery or cause a return of the disease in a more severe form. Some of these facts help to explain the well known seasonal character of the disease.

LOCAL DISTRIBUTION.

We have mentioned the wide geographic distribution of swamp fever, and it has been found from altitudes near sea level up to an elevation approaching 9,000 feet. The local distribution is no less remarkable. The disease has been known to recur year after year on one farm or ranch and the adjoining farms, similarly situated, known to be entirely free from it. Kinsley ('10) mentions a farm on which horses had been lost every year for twelve or fifteen years, while on a neighboring farm not more than sixty rods away the disease had never been known. Gould, while practicing at Basin, Wyoming, made the observation that the disease "seems to be principally confined to definite localities and farms, and does not spread rapidly". The writer has noted similar conditions elsewhere and in certain instances has been able to trace the transference of the disease from one farm to another. In general the disease is prevalent on low-lying valley farms adjacent to the larger streams, on damp and boggy pastures, or less frequently, in rolling country characterized by small streams and occasional low places. Mohler ('09, '10) found the disease most prevalent in low-lying and badly drained sections of the country, or on marshy pastures during wet seasons. Van Es, Harris, and Schalk ('11), speaking of conditions in North Dakota, state that "most of our cases come from the lower sections of the country, although many reports indicate that the disease may occur on high and dry land where deficient drainage could not possibly be an etiologic factor". Kinsley thought that wet seasons seemed to
increase the prevalence of the disease and other workers have made similar observations. The season of 1915 was the wettest in Wyoming in the past five years, and that year by far the largest number of cases of swamp fever were reported. For purposes of control it would seem that the commonly observed restriction of the disease to individual ranches or farms is of more importance than the kind of country in which the disease is usually found.

**METHODS OF DISTRIBUTION.**

Most writers are generally agreed that swamp fever is not ordinarily contagious. In our experience we have had susceptible horses remain healthy and normal, though they ran in the same lot with infected ones, ate from the same mangers, and drank from the same drinking troughs. In fact we have never, with one possible exception, had a single case contracted in this way. Kinsley mentions instances in which a team of horses was watered from the same pail and fed from the same trough, yet one of the horses became infected while the other did not. Melvin ('10) mentions a healthy horse that was kept in a stall for seven months adjacent to a sick one without contracting the disease. Francis and Marsteller ('11) kept a susceptible pony for two years in a small pasture with infected animals, but it did not become infected. Swingle ('13) writes that “Sick horses have associated intimately with healthy ones for about two years without a transmission occurring. They have run together in the same yard, eaten from the same mangers, drunk from the same trough, and no precaution against transmission has been made. Besides all this they have drunk water and eaten grain and hay contaminated with urine and blood from various infected horses. There has never been a single case of infection”. In this connection, as tending to explain the natural spread of the disease, it is worth while to mention the various methods by which the disease has been experimentally transmitted. (1) Swamp fever has frequently been transmitted by intravenous injection of virulent blood (first demonstrated by Vallée and Carré, '04). (2) It has been transmitted by intravenous injection of blood serum (first by Ostertag, '07). (3) By the intravenous injection of filtered blood serum (Vallée and Carré, '04). (4) Swamp fever may be transmitted by subcu-
taneous injection of blood (Francis and Marsteller, '07, and later by Hempel, Van Es, Swingle, and others). (5) By the subcutaneous injection of blood serum (Van Es, Harris, and Schalk, '11). (6) By a similar injection of filtered blood serum (Ostertag and many others). (7) It can be transmitted by injecting blood into the peritoneal cavity (Todd and Wolbach, '11). (8) The disease can be transmitted by feeding blood (first by Vallée and Carré, '04); infection by this method has usually been rather difficult and several authors remark that much larger amounts are required than by inoculation methods. (9) Swamp fever may be transmitted by feeding urine (Vallée and Carré, '05); it has also been a difficult matter to transmit the disease in this way. (10) It may be transmitted by subcutaneous injection of urine (Van Es, Harris, and Schalk, '11). (11) The disease may be transmitted by biting flies (Scott, '14, '15, '16, '17, '18, Howard, '17). (12) It may be transmitted by puncturing the skin with a contaminated hypodermic needle (Scott, '17). Finally it should be noted that failure to transmit the disease has resulted from subcutaneous inoculation of extract of feces and from inoculation with saliva from an infected horse. The Japanese Commission ('14) were likewise unable to find the virus in sweat. It is evident from the facts cited that the natural method of transmission is not altogether clearly indicated, though methods (11) and (12) appear to be highly suggestive and important. Judging from the literature all ages and breeds are equally subject to infection but under certain conditions the disease has the appearance of being highly selective. The cause of swamp fever has not been discovered and for this reason we are unable to trace the disease directly from one horse to another. A further discussion of the probable methods of infection will be taken up later.

While we are not in a position to state with certainty just how the disease passes from one horse to another, we have good evidence to show how the disease spreads from one farm or locality to another. When epidemics occur they show none of the specific characteristics of air-borne diseases. Swamp fever is a slow-going disease and an epidemic is always restricted to a given locality, or even to a single farm. Instances have been recorded where the disease was introduced into a new locality by horses brought from
an infected area and this appears to be the principal if not the only method of distribution from place to place. Some interesting facts in this connection will help to show at once the difficulty in proving, and the probability that the disease is scattered in this manner. In January, 1916, the writer was called to investigate the conditions on the M. ranch where a number of horses had been lost the previous season. There were two chronic though seemingly healthy cases of swamp fever on the ranch at that time. Early in April of the preceding year the owner had noticed that case No. 1, a mare, and case No. 2, a gelding, were not doing well; the mare died July 19th and the gelding in September or October. Both of these horses had been bought from the V. ranch as yearlings in the spring of 1913 and had never done so well as the owner expected. The gelding “was gangling, never did get fat, and walked awkwardly”. This is of course no proof that these two horses were long-standing chronic cases, but it is interesting to note that eleven horses were lost on the V. ranch in 1911, though no information could be obtained as to whether any of these died of swamp fever or not. Knowing that healthy carriers may harbor the disease for several years, if we suppose the horses on the V. ranch did die of swamp fever it is easy to see how the disease was introduced on the M. ranch. However, this sort of evidence not being considered satisfactory, further inquiry developed the fact that the owner of the M. ranch had leased horses for haying in 1914 from F., who lived that year on the A. place. It was impossible to get an interview with F., who had moved away, but it was reported that he lost several horses of swamp fever in 1914. The leased horses mingled with M.’s horses on pasture from time to time between hayings. This suggests the probability that the M. cases, 1 and 2, were carried over from the preceding season and that they were infected from the leased F. horses in 1914. The development of the epidemic on the M. ranch as given by the owner is worth description. The owner of the ranch leased the A place for pasture in 1915 and it was on this pasture that the first five or six cases developed. The M. ranch is on irrigated bench land and the A. place is two miles away on bottom land along the river. For the greater part of the season most of the horses were kept on the A. pasture. On the M. place
however some work horses and mares were allowed to go out to pasture between hayings and some geldings were worked, fed grain, and kept off pasture all summer long. The third case, a yearling colt, died the latter part of July. In August a little mare, No. 16, was observed to be sick; this was one of the chronic cases found on the place the following January. Two yearling colts were also noticed not doing well during this month. On September 24 the work of putting up the second cutting of alfalfa began on the M. ranch. A week or two before this time the horses were brought up from the A. pasture. While putting up hay the disease developed in the work horses; these grew weak and thin and the disease was worst between the first and the fifteenth of October, though most horses died in November. The geldings that were fed and worked all summer and that were not allowed to go out to pasture did not contract the disease. But the work horses and mares that mingled in pasture between hayings with the horses from the A. place became infected and most of them died. Letters from the county agent and from the veterinarian who saw some of the cases indicate that complications with other diseases may have been present in some horses, but a number of them undoubtedly had swamp fever, as was found true of No. 16 by inoculation of blood. In any circumstance it is clear that the disease was introduced among the work horses on the M. ranch by allowing them to mingle in pasture with horses from the A. place, and at least one of the horses (No. 16) from the A. pasture had been sick of a disease that was later proved to be swamp fever. Another instance may be of interest. In the fall of 1913 three horses were lost on the W. farm. They were attended by a veterinarian who diagnosed the disease as swamp fever with symptoms well defined. During the fall, winter, and following spring, four or five horses died of the same disease on the neighboring P. farm. Farms P. and W. frequently swapped work, so there was a good chance for the horses to mingle together. Both of these farms are on upland and no one was able to tell how the disease got started on the W. farm. It may be significant that W. in 1910 bought three young horses, all in good shape at the time, from farmer O., who lived from 1910 to 1912 on the A. place mentioned above. In the following year,
June, 1919

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1911, O. lost 16 or 17 head of horses; it was impossible to get accurate information as to the cause of their death, but swamp fever was suspected. Knowing what we now do with reference to healthy carriers of the disease, we may have here an explanation of the spread to the W. farm. On the whole there is considerable evidence that the movement of infected horses from one farm or locality to another is an important factor in spreading the disease.

NATURAL TRANSMISSION.

In stating above the known methods of transmitting swamp fever the fact was brought out that the virus is present in the blood; is excreted either continuously or at certain times in the urine; but is not present in the feces, in the sweat, or in the saliva. The virus is apparently present in the blood at all times, both between and during attacks of the fever, but this I believe has not been definitely proved. Under these conditions there is suggested two possible methods by which the virus may reach the blood of new hosts. (1) The cause of the disease may gain entrance through the membranes of the digestive tube as the result of drink or food contaminated with infective urine. (2) The organism may reach the blood through the skin by means of some abrasion, or through the agency of some intermediate host. One may ask which of these two paths represents the natural method of transmission? Or does the spread of swamp fever depend upon both of the methods suggested?

Let us consider the probability of the first method. Two methods have been used to infect horses with swamp fever by way of the alimentary canal. One method is to feed infected blood mixed with food or drink; the other method consists of giving food or drink contaminated with infective urine, or of introducing such urine directly into the stomach. A considerable number of workers have succeeded in transmitting the disease by each of the two methods. In nearly all cases, however, much difficulty has been experienced in getting any infection in these ways, and then usually only light cases have been produced; this has been true in spite of the fact that frequently large quantities of infective material have been used and some workers, for example Swingle, have obtained only negative results. It is
generally agreed that much larger quantities are required to infect by either of these methods than by the inoculation of either blood or urine. This shows the great difficulty of infecting by way of the digestive tube. Now in nature there is no possibility that a horse would find the opportunity to ingest enough blood to account for the spread of the disease. So as a matter of fact only one of the two methods is left. It is true the disease may be transmitted by means of urine and by way of the alimentary canal, but it is such a difficult matter that it would seem impossible to account for a natural transmission of swamp fever by the contamination of food and drink with infected urine. How long it would take a horse to acquire even the smallest amount, one ounce, found necessary to produce the disease will be left to the reader to infer. Horses avoid grass that has the odor of urine, and it is known that direct sunlight kills the virus in two hours. Then if this method of transmission is the usual one, how explain the occurrence of epidemics? Why is the disease most prevalent during wet seasons, when one would think there is less chance of contaminating water with any considerable amount of urine? If the theory of the contamination of food or drink by means of infective urine is correct, the amounts obtained are likely to be so small that we must assume a long incubation period of months or even years. Or the urine must be markedly more virulent at certain times. We have no proof of either hypothesis and in either case there is no explanation of the seasonal occurrence of the disease. Then one would expect to find infection frequently in a small lot where sick and well horses are fed and watered together, since the chances of contamination are greater than in the ordinary pasture. Infection under such conditions has been rarely if ever observed. One may see from this brief discussion that internal transmission of swamp fever as a natural method of propagating the disease cannot be very extensive and appears highly improbable. One will then ask what are the possibilities of external transmission.

Swingle's experiments in 1913 with internal transmission had been so entirely negative it was determined at that time to devote our attention to a study of the methods or agents that might be concerned in external transmission. Accordingly a brief study was made in reference to what could be found in the literature of
the subject of external transmission. Van Es, Harris, and Schalk had noted that evidently most of the actual transmissions take place from July to December, and while they are of the opinion that “probably most of our infections occur through the contamination of the foliage and water pools by the urine of swamp fever cases and infection carriers”, they make the suggestion that “The constant presence of the specific virus in the blood and the well known part played by biting insects in the dissemination of other diseases seems to warrant us to include the protection of our horses against those pests and the eradication of them among the preventive measures”. Brimhall, Wesbrook, and Bracken (‘03) had called attention to insects and arachnoids as possible factors, and Francis and Marsteller (‘11) had attempted to transmit swamp fever through the agency of the tick, *Margaropus annulatus*, but without success in the one case tried. Kinsley (‘09) had stated that flies and mosquitoes appear to have no relation to the disease, but the seasonal occurrence of the disease had long been noted by different workers. It must be confessed that there was little in the literature to lead one to expect success in the matter of external transmission. But if internal transmission is improbable and unable to explain epidemics the only other possible method of transmission is through the skin. It is not likely that accidental abrasions, or cuts in the mouth due to sharp-edged grass, could account for epidemics or for the distribution of swamp fever. It is true that flies sometimes bite until there flows a drop of blood which may occasionally fall to the ground and grass is often contaminated with urine. But the idea that abrasions of the skin could afford a means for transmitting the disease had to be dismissed on the ground that there was a very small chance for the blood or urine of an infected animal to ever reach the abrasion in the skin of another and such an accidental method of transmission could not account for epidemics or the seasonal occurrence of the disease. If this line of reasoning was correct there was left only one other means of transmitting swamp fever, namely through the agency of some biting parasite.

Now if an intermediate host is necessary for transmission it must fulfill certain conditions with reference to the disease. It must have a wide geographical distribution; it must have the habit
of feeding on more than one host during its life time; and finally it must have a prevalence that corresponds closely with the seasonal character of swamp fever. Of the external parasites of the horse, lice, ticks, and mites have to be excluded for one or more reasons as possible carriers of the disease. As far as could be learned the only parasites of the horse in Wyoming that meet the conditions mentioned are certain biting flies and possibly certain mosquitoes. It is probable that our native mosquitoes should also be excluded, for the principal brood is present in largest numbers in June and only a small part of a second brood appears in the latter part of August and September. On the other hand the more important biting flies reach their greatest abundance in August or September. That our reasoning with reference to an intermediate host was justified is shown by the results of our experiments which will be mentioned later. First let us consider the nature and recognition of the disease.

Nature of the Virus.

Swamp fever is essentially a septicemic disease of the blood, but the virus has been demonstrated in various organs of the body, possibly due to the presence of blood in these organs. The fact that the disease may be transmitted by subinoculations through many horses without losing its virulence has led to the conclusion that the cause of the disease is an organism and not a toxin in the blood. This appears to shut out the possibility that the disease is caused by the toxic effects of intestinal worms, or to an organism sending out toxin into the blood from any particular diseased organ of the body. It has been repeatedly shown that this organism is filterable and the Japanese Commission believe the virus is of protozoan rather than of a bacterial nature, since they found that 2.5 to 5 per cent of sodium taurocholate rendered virulent blood harmless. Carré and Vallée showed that the virus is destroyed by heating to 58° C. for one hour and the Japanese Commission showed that two hours' exposure to full sunlight had the same effect. It is known also that it resists drying for a long time. Van Es, Harris, and Schalk exposed a quantity of blood to freezing temperatures for thirty days, during which time the thermometer registered as low as −26° F., and the blood remained
virulent. The organism itself has never been discovered and no one has been able so far to raise it in culture media that give success with ordinary bacteria. The Japanese claim the virus may be present in the milk of affected mares, and in the blood of newborn foals. Outside of the facts given the exact nature of the virus is unknown.

SYMPTOMS AND MANIFESTATIONS.

The clinical manifestations are hard to describe. Scarcely any one symptom is true of all cases. In active cases the more or less irregularly intermittent, or remittent, fever is the most constant characteristic. A horse may die as the result of a single attack of fever or it may die after three or four attacks (see Plate I); in our experimental cases if a horse survives several attacks it usually improves gradually; sometimes the improvement is permanent or with only slight remissions, but more frequently improvement is only temporary, in spite of the fact that the fever may disappear for months at a time. In this way chronic cases develop which may last for many weeks, months, or several years, or which may apparently completely recover. In some cases the fever is so mild, and other symptoms so indefinite, that it requires a subinjection of blood to determine the disease. The blood of such a case however may be very virulent for another horse. In two instances after very mild attacks of fever, many months elapsed before a second attack of fever occurred. One of these horses recovered, the other died. The fact that swamp fever may affect horses in such different ways leads to many different manifestations of the disease. I have never seen acute field cases, but these undoubtedly occur and may be mistaken for other septicemic diseases. I have, however, seen sub-acute and chronic cases in the field and two cases that had apparently recovered; however it was proved by sub-injection that one of them still had virulent blood. During severe attacks of fever a bloody serum may drop from the nostrils.

Of other symptoms, anemia characterized by the diminution of the red blood corpuscles and pale yellowish or saffron-colored mucous membranes may or may not be present. It does not develop to any marked extent in the acute cases but in sub-acute
cases there may be a considerable decrease in the number of red corpuscles. In chronic cases there are various degrees of anemia; in some cases it is very pronounced; in some a comparatively moderate degree of anemia develops before death; in others a mild anemia develops followed by apparent recovery though death may later occur following recurrent attacks of fever; in still other horses no noticeable anemia develops. In field cases anemia is common, probably due to the fact that this is the type of the disease that usually attracts attention. On the other hand the non-anemic cases, if acute, may frequently be mistaken for other diseases, and if mildly chronic may escape observation altogether. As might be expected, a rough staring coat accompanies the anemia (See Fig. 2 and cut on cover).

During attacks of fever, a horse frequently appears dull, with head lower than usual, and not so alert in its movements. In some horses the fever attacks may produce scarcely any noticeable effect. In most horses the appetite is not so good as usual and
they may be off feed altogether. Some horses have a voracious appetite whether in good or poor flesh and do not stop eating during fever attacks. I have had a horse continue to eat ravenously even after it had gotten down and was too weak to rise. This is true of some long-standing anemic cases and seems characteristic of cases complicated with "worms", or sclerostomiasis. Noticeable, frequently rapid, loss of flesh nearly always accompanies fever attacks. Between periods of fever improvement is commonly observed but the loss of weight may be progressive if the fever is more or less continuous, and a degree of extreme emaciation usually accompanied by anemia may be reached in long-standing chronic cases. The anus is frequently relaxed in such cases for some time before death.

Edematous swellings of the belly, sheath, and legs are rather common. They occur independent of the fever attacks and are more common in anemic than in other cases. Weakness appears to be the result of anemia, but we have had one case in which there was stiffness and lameness in the hind quarters without much indication of anemia. The pulse is influenced by the temperature as a rule but may be independent of it. Van Es states that albumen in the urine is a frequent but is not a constant symptom. I have occasionally observed polyuria in such horses shortly before death. In some instances the symptoms were so indefinite that it required an inoculation of blood to determine infection.

**TYPES OF THE DISEASE.**

As suggested by the preceding description, there are four general types of the disease; but it must be remembered that these pass insensibly into each other and are convenient chiefly for purposes of description. The four types are the acute, the sub-acute, the chronic, and the recovered, apparently normal carrier. Observations indicate that unfavorable conditions like hard work or poor nutrition tend to convert a recovered carrier into a chronic, or a chronic into a sub-acute type of the disease. On the other hand, good care and attention seems to aid in converting a sub-acute to a chronic type and the latter type to apparent recovery. Plate I, No. 6, shows the temperature record of an acute type of the disease. Fig. 3 shows the appearance of a sub-
acute type shortly before death. Plate I, No. 22, shows the temperature curve of another sub-acute case. Fig. 2 illustrates a chronic case that lived a little more than two years after the initial infection. This horse lived about four months after the photograph was taken and grew much more emaciated but was considered only mildly anemic. Plate III shows the temperature record of the same horse. Fig. 1 shows a chronic case that developed into an apparently healthy carrier. His initial attack occurred early in October, 1915; there were a few mild attacks during the following winter and spring, and during the summer of 1916 there were several severe attacks, beginning in July. Only one or two fever remissions occurred between October, 1916, and June, 1918, and he steadily improved in flesh and appearance. Since that time he has had a number of severe attacks but is now, June, 1919, in as good or better flesh than when the photograph was taken in May, 1918. Plate IV illustrates the complete temperature record to date, of this horse. Remissions still occur and he will prob-
ably sooner or later die of the disease. Of course, much milder cases occur than any of those given (See Fig. 5). Fig. 4 also represents a mild type of the disease, but one which nevertheless resulted fatally in about eighteen months.

![Horse No. 39. Infected by means of Tabanid bites (horse flies) in August, 1916. A comparatively mild case that resulted fatally in December, 1917. This picture taken about one month before death. The fever never rose above 102.4° but an injection of its blood into another horse clearly distinguished the nature of the disease.]

**DIAGNOSIS.**

As may be expected from the clinical symptoms described the diagnosis of swamp fever may be comparatively easy, but more frequently it is difficult or even practically impossible. In our experimental work the inoculation of blood is the only sure test in some cases. This method is not practicable for field diagnosis but is the only method by which one at the present time would be able to prove the presence of certain virus carriers and some mild chronic cases. After swamp fever has been present in a herd daily temperature records should be kept of the survivors for a period of several months. If an otherwise healthy horse in such a herd shows occasionally sudden remissions of fever that in turn quickly subside, and no other satisfactory explanation can
be given for the rise in temperature, it is safe to diagnose the attack as a chronic case of swamp fever; such a horse should be isolated for further observation. If in addition the horse shows great fatigue after light exercise, or after the usual amount of work, or develops in mild form some of the other symptoms mentioned above, the diagnosis of swamp fever may be regarded as further assured. If an anemic case shows several of the clinical symptoms previously described including always remissions of fever and the history shows the earlier presence of swamp fever in the same herd, or in the same locality, it is relatively easy to diagnose the disease. As indicated above some of the symptoms to be looked for include loss of flesh, edema, a change in color of the mucous membranes, swaying or staggering gait, and the occasional presence of albuminuria. If such a horse is examined when fever is not present, a diagnosis of swamp fever can only be inferred, and then on condition that the disease has been present

Fig. 5. Horse No. 42. Represents a very mild case of swamp fever in which there were practically no outward symptoms of the disease. The fever attacks were comparatively light and few in number. The disease was produced by a hypodermic injection of 60 cc. of blood from another light case. After seven or eight months it had apparently completely recovered but its blood was still virulent.
in that locality. Isolation and further observation, including temperature records or inoculation of blood, will be necessary to determine the diagnosis. According to several investigators, it does not seem possible to distinguish acute cases from certain other septicemic diseases unless preceded or accompanied by known cases of the disease. Such a horse may show high fever and other symptoms of acute blood poisoning that may last until death.

Hutyra and Marek state that in infected localities the clinical symptoms, the course of the disease, and the negative findings in the various organs, usually afford sufficient indications for a diagnosis; in locations which have been free from infection the disease is recognized with certainty only on autopsy or from animal inoculation, while clinical symptoms arouse only well-founded suspicions. Infectious anemia is indicated especially by changes of a septicemic character, such as hemorrhages in the serous or mucous membranes, further by the discoloration of the bone marrow, degeneration of the parenchymatous organs, swelling of the spleen and edematous infiltration without other changes in the organs.

Van Es, Harris, and Schalk state that the disease is essentially a septicemia, anatomically marked by sub-serous or sub-endocardial hemorrhages in the more acute forms, by occasional involvement of the lymphnodes and spleen, by degenerative changes in parenchyma of heart, liver, and kidneys, and probably also by certain alterations in the bone-marrow of the long bones of the limbs.

While we have not made any special study of post-mortem findings some of the more important anatomical changes frequently noticed include hemorrhages in the serous or mucous membranes, an excess of pericardial fluid, enlargement of the spleen, of the lymphnodes, and occasionally of liver and kidneys, as well as certain degenerative changes in some of these organs.

HOW DISTINGUISHED FROM OTHER DISEASES.

There are probably three other diseases of horses in Wyoming with which swamp fever has sometimes been confused. These are sclerostomiasis, or infection with certain parasitic worms, influenza, and simple anemia. By far the most important
of these in this state is infection with sclerostomes, or parasitic worms.

According to Hutyra and Marek, sclerostomiasis in the chronic form runs an afebrile course and attacks colts exclusively, while in its more acute form only the autopsy or the demonstration of sclerostome larvae in the intra-abdominal hemorrhages is decisive; however, the presence of a few sclerostome larvae in the subserous or submucous tissues must not be misleading. Hartman ('16) states the typical symptoms of sclerostome infection are as follows: A gradual wasting and listlessness, a peculiar wabbly gait of the hind legs, a dejected appearance of the head, a grayish-white color of mucous membranes of mouth, nose, and eyes, occasional attacks of colic preceding the emaciation, diarrhea in colts, a pounding action of the heart, and a peculiar lameness which increases much on exercise. It will be observed that several of these characteristic symptoms are also common to swamp fever. However, in cases of swamp fever that show anemia and loss of flesh the mucous membranes are apt to be yellowish-red or yellowish-gray, attacks of colic are not commonly found, diarrhea is absent, and the pulse is soft instead of the "water-hammer" type. Mack ('09) and Mohler believe that reduction of red blood corpuscles without eosinophilia differentiates swamp fever from anemia due to internal parasites. Moore has found that marked eosinophilia was present in subjects having numerous worms but that a few worms might be present without producing such an effect. Van Es states that periodic febrile eruptions and more or less constant albuminuria should go a long way towards establishing a diagnosis of swamp fever, especially in districts where this disease is more or less at home. In the worm disease the febrile periods are not always to be excluded, but the fact that you will meet the most of this trouble in colts and young horses should have some bearing on the differential diagnosis. Our own observations on differentiating the two diseases have been limited, but such as they are they bear out the conclusions of Van Es and in most cases it is believed the two diseases may be easily distinguished. In some few cases inoculation or post mortem examination may become necessary. (See Fig. 6.)
The acute form of swamp fever may sometimes be mistaken for the catarrhal form of influenza. The latter disease spreads rapidly through the stable or herd, lasts in most cases about a week, sometimes only two or three days, and the horses soon recover. The infected horses seldom die and then only when severe complications set in. These symptoms differentiate it from swamp fever.

Simple anemia may be distinguished from swamp fever by the fact that it takes its course without the presence of fever, is traceable to deficiency in nutrition, or some other outside influence is demonstrated.

COURSE AND PROGNOSIS.

Enough has already been said to indicate the general course of the disease. As a rule the outcome of the disease is very unfavorable. Different writers estimate the fatalities from 50 to nearly 100 per cent unless suitable treatment is begun early; in
the latter case some believe the loss need not be over 15 to 25 per cent. However, since the so-called "cured" or recovered cases are subject to sudden and unexpected relapse, the last named figures appear too low. Late in December, 1917, Van Es personally informed me that his case No. 636 still had virulent blood ten years after the initial infection, but of course this horse had received unusual care. Had he been subjected to the usual hardships of farm conditions perhaps he would have died years ago. The acute case, No. 6 (Plate I), died after having the fever six days, on the twenty-first day after inoculation. Our work indicates that cases could be found to fill in a complete series between these extremes. In some of the older cases the blood is known to grow less virulent, and some may recover altogether. On the whole prognosis is decidedly unfavorable. As mentioned, actually there is no division line between the different types and the general course of the disease has been sufficiently indicated under symptoms, types, and diagnosis. An inspection of the Figures 1 to 6 will show the effects produced in these cases, and a reference to Plates I, II, III, and IV will show the course of the disease so far as a temperature record is concerned.

TREATMENT OF THE DISEASE.

A great many attempts have been made to obtain a curative treatment but so far no specific curative agent has been discovered. Attempts to obtain a prophylactic or curative serum have likewise failed. Of the numerous drugs tested none appear to have any lasting beneficial effect so far as recovery from the disease is concerned. Numerous veterinarians have reported good success with certain kinds of treatment and arsenical preparations in particular have been claimed to produce a favorable influence on the disease. However the effect is undoubtedly only temporary for it is frequently added that relapses occurred later. So also the palliative treatment of certain symptoms may meet with temporary success. For example Hutyra and Marek state that intensive feeding and rest from work produce temporary improvement. Van Es, Harris, and Schalk suggest that arsenic and iron carbonate combined with gastric stimulants, good food, and attention to hygienic conditions, exert a favorable influence. The Japanese
state that exercise should be avoided, and the animals be kept from exposure to heat, cold, snow, etc.; that cardiacs, tonics, and digestives tend to abate the symptoms of the disease; that nutritious and digestible food improves the condition and increases the resistance. Considering the nature of the disease and the generally unsatisfactory results obtained by others, we have paid no particular attention to methods of treatment. In one rather long-standing chronic case treatment was begun with sodium cacodylate, but the horse died before this was completed without showing any favorable influence. Among our own cases favorable effects have been noted resulting from rest, nourishing food, and good care.

SOME EXPERIMENTAL RESULTS.

Until 1914 only two general methods had been demonstrated in the experimental transmission of swamp fever. One method was by artificial inoculation of infected blood or urine through the skin, the other was the entrance of the virus through the walls of the alimentary canal following the ingestion of food or the drinking of water contaminated with infective blood or urine. The Japanese in 1914, as the result of pasturing experiments and a series of observations lasting five years, came to the conclusion that certain biting insects were responsible for transmitting the disease. However, they did not demonstrate such a transmission.

As previously explained, from a study of the problem in 1913 the writer became convinced that the internal method of transmission could not adequately explain epidemics and certain other facts known to be true of swamp fever. Accordingly, a series of experiments was planned to ascertain whether insects were or were not capable of transmitting the disease. A full account of these experiments will be given elsewhere. It will suffice here to give the general results obtained. By using a screened cage it was shown in the summer of 1914 that swamp fever may be transmitted by certain flies, with the evidence pointing toward the stable-fly, Stomoxys calcitrans, as the active carrier (Plate I, No. 22). In 1915 use was made of two screened cages. A system of exchange was used by which the same sick horses were exposed equally in both cages; stable-flies were raised in only one of the
cages, the other being kept fly-free. Well horses were kept in both cages so they were all equally exposed to the sick horses. The disease was transmitted only in the cage that contained the stable-flies and two out of three horses so exposed took the disease. In this and the following year additional experiments fully demonstrated that the stable-fly may act as a carrier of swamp fever; this involved the isolating of sick horses in one cage, the well horses in the other, and the controlled transfer of flies from the backs of sick to the backs of well horses (Figs. 1 and 2). In 1916, by a similar use of small screen cages for transferring the flies from isolated sick to isolated well horses, it was shown that swamp fever can be transmitted by the bites of certain horse-flies belonging to the genus *Tabanus* (Fig. 4). This work was further confirmed in 1917 (Fig. 3). In all of the later experiments the plan of interrupted feeding was adopted and the transmission of the disease was undoubtedly a mechanical one. It was further shown by using a medium fine hypodermic needle for puncturing the skin of a sick horse and then a well horse, and by repeating the process a number of times on following days, that a very minute quantity of blood is sufficient to produce the disease. Without denying in any way the possibility of a natural transmission of swamp fever by means of infective urine, it is believed, on account of the great difficulty experienced in transmitting the disease by way of the digestive tube, that our experiments demonstrate the probability that insects play an important part in transmitting swamp fever, especially during epidemics of the disease. This theory helps to account for the seasonal presence of swamp fever, since the biting flies mentioned are most abundant in Wyoming during August and September. Coinciding with the prevalence of the disease, the biting flies are most abundant during wet seasons and in wet regions and these are the conditions best suited to their breeding habits.

**SUGGESTED MEASURES FOR CONTROL.**

In view of the fact that the virus of swamp fever has not been discovered, we do not know its natural habitat. Is it capable of living free and reproducing independent of any warm-blooded animal? Or has the habit of parasitism become so firmly fixed
that it requires horses' or asses' blood in order to complete a part or all of its life history? It is evidently capable of reproducing by some method in horses' blood. Is it also capable of reproducing by another method outside of the horse's body? All these questions are as yet unanswered. The deadly character of the virus would seem to indicate that it is a comparatively recent parasite of the horse and the presence of apparently healthy carriers would suggest the contrary idea that it may have been a parasite of the horse for a long time. However this may be, it is clear in our present state of knowledge that we can use no measures of control aimed directly at the parasite that produces the disease. It has likewise been impossible to guard the horse against the disease by building up an immunity, and the methods of treatment so far devised have proved far from satisfactory. While we may alleviate the symptoms of swamp fever in some cases, none of these treatments reaches the organism that produces the disease. Accordingly, such measures as one may take for the satisfactory control of swamp fever must be directed along the following lines: (1) One must consider the possible, and the probable, natural methods of transmission from horse to horse, including infective urine and biting flies. (2) The manner of spreading from ranch to ranch or from one community to another must receive serious attention. (3) It is well to keep in mind and take advantage of the tendency of the disease to be confined to poorly drained or swampy pastures and to be local in distribution. (4) The fact that most transmissions take place from July to October is a characteristic of value in determining upon quarantine measures with reference to horse traffic. (5) The nature of the virus in being able to withstand heat, drouth, cold, and putrefaction is a matter of importance in dealing with the disposal of diseased horses and in preventing contamination of healthy ones. (6) The detection of the chronic carrier is of peculiar interest in taking measures to prevent the spread of the fever. Before outlining measures for control let us mention the work of some other authors.

A great many suggestions have been made by different writers for the control of swamp fever or infectious anemia. The limits of this bulletin will not permit a reference to all of them,
but some of the more important should be noted. Van Es, Harris, and Schalk ('11) have paid particular attention to the matter of control under conditions in North Dakota. They advocate the suspension of all movements of horses from infected areas for a part of the year from July to December; any horse that has once shown suspicious symptoms, though recovered, should not be moved at any time from place to place; they advise great care on the part of farmers in purchasing new horses, and advise owners of non-infected horses in infected areas to make their purchases outside of such areas; they recommend complete and rigid segregation by removing the horses still in good health and believe it is better to kill the actual cases; after the apparent cases are destroyed or isolated, the temperatures of the rest should be kept in order to detect "infection carriers" and the urine should be examined for albumen with the same purpose in view; stables should be thoroughly disinfected; in infected districts wet, swampy pastures are to be avoided or they should be carefully drained; horses should be prevented from using water in ditches and pools of such pastures, and should be provided with water from wells that are protected from contamination; since the virus is in the blood and the role of biting insects in some other diseases is well known, they recommend preventive measures against these pests.

The Japanese Commission ('14), which is convinced that horse-flies are the main transmitters of the disease, pays more attention to measures directed against biting insects. Details are given for the detection of infected horses, rules are laid down for pasturing and movements of horses in infected areas, and the conditions for suitable isolation are described. Cases must be reported and horse owners are required to kill or isolate infected horses. If the isolated cases recover, they must be given the exercise test, and if normal they are set free.

Carré and Vallée ('16), who still believe chiefly in the theory of urine infection, state that isolation, surveillance of the sick, disinfection of the excretions and the protection of water used for drinking are imperatively indicated. The slaughter of the sick and destruction of their carcasses represent indispensable measures, in the pasture especially.
It will be observed that there is rather close agreement on recommendations of a general nature and that differences are due to local conditions or to difference in opinion as to how transmission takes place. Though we have a high average altitude in Wyoming, the general nature of the places where the disease is prevalent corresponds closely with the conditions found in other regions. An outline of the conditions upon which adequate measures of control must be based has been previously given; keeping these in mind, the following suggestions are made for the purpose of aiding the farmers and ranchmen of infected areas in gaining complete control over the disease, and it is hoped that they will help to eliminate the disease altogether.

1. If swamp fever is suspected or discovered in a group of horses, a veterinarian should be consulted and the diagnosis verified. The State Veterinarian has charge of the control of infectious diseases and all cases of swamp fever should be reported to him or to one of his deputies. If no veterinarian is available, write to "The State Veterinarian, Cheyenne, Wyo.," for advice.

2. If the diagnosis of swamp fever is correct, all affected cases should be immediately killed or isolated. Since many of the infected horses die anyway and the remainder as carriers of the virus become a menace to the rest of the herd, it is frequently best to kill all serious cases at once to avoid the expense of their care and feed. Owing to the persistent nature of the virus, the carcasses of all horses that are killed or that die of the disease should be carefully burned or deeply buried.

3. If all affected horses are not killed at once it is necessary to segregate the sick and well horses to avoid further infection. If no barn or stable is available remove the well horses to a new, preferably dry, pasture at a distance far enough away to prevent the passage of biting flies from one group of horses to the other. Simply putting a sick horse in another pasture or lot may be effective in preventing the contamination of food or drink from infective urine, but is a doubtful procedure so far as protection from biting flies is concerned, unless one pasture is not frequented by flies or the pastures are a long distance apart. The safest sort of isolation is to put the sick horses in a barn with openings screened or in a sanitary stable somewhat darkened to aid in ex-
cluding biting flies. Keeping infected horses in a dry lot which is not frequented by biting flies probably affords sufficient protection, but if well horses are turned with them care must be taken to prevent contamination of food and drink with urine.

4. The isolation of infected horses should be permanent. If this is not practicable, in order to avoid probable infection, the isolation must be repeated year after year during the infective season. Plate IV shows the temperature record of a horse that after a number of severe attacks of fever furnished practically no evidence of the disease from November, 1916, to June, 1918; but his blood was virulent and he has since had several severe attacks. The history of this case explains the need of continued isolation of chronic cases.

5. Since the incubation period may be two to four weeks and probably in some cases a much longer period, it is highly important that a careful watch be kept over all horses that have been exposed to infection; their temperatures should be taken once a day, and if any fever or other symptoms of swamp fever develop the affected horse should be isolated for further observation. If possible the urine should also be examined for albumen. Fourteen head of horses were lost on the M. ranch in 1915 and one early in January, 1916. A careful watch of the rest of the herd in which temperatures were kept revealed three chronic cases in April and May, 1916; these three horses were killed and I am informed by the owner that no case of swamp fever has since appeared on that ranch.

6. Our present knowledge indicates that a very important method of spreading the disease from one district to another is by means of chronic, or healthy carriers. To detect the chronic carrier is undoubtedly the most difficult problem involved in the control of swamp fever. Some methods used for this purpose have been mentioned in the preceding paragraph. After it is detected and if it is not killed, under no circumstances should it be taken to another ranch or district, and the usual precautions to prevent further infection should be observed. If it were easy to detect the apparently healthy carrier it probably would be an easy matter to exterminate the disease. The Japanese recommend that recovered cases that can pass the exercise test without showing a
weak heart, undue fatigue, or any other symptoms of the disease are to be set free. But if the blood is still virulent this plan is not entirely safe, for we have shown that a severe mild case may arise from a very mild one.

7. Wet, poorly drained, or swampy pastures should be avoided. Such places should be carefully drained or not used at all for pasturing horses. Measures should be taken to provide a pure water supply, either from springs or from open running streams. Van Es recommends keeping horses away from water in pools and ditches and we have seen that Carré and Vallée strongly recommend protecting barn wells from contamination with urine.

8. Traffic in horses where an infectious disease is concerned furnishes a difficult problem, and swamp fever is no exception to the rule. It is undoubtedly best to suspend all movements or shipments of horses from a swamp fever area during and somewhat beyond the infective season, from July to December, and quarantine regulations should be enforced to this effect. Suspicious cases or chronic carriers should not be moved from such an area at any time. Ranchmen or farmers should take great care in purchasing new horses, and if in or near an infected area the new horses should be kept apart three months or more for observation before turning them in with the horses known to be uninfected. Farmers or ranchmen with uninfected horses but living within an infected district will find it best to make their purchases outside of such districts.

9. Disinfection of stables and of the excreta has been strongly recommended as a protective measure by the authorities cited above. Apart from keeping the stable and watering place in a sanitary condition the writer is of the opinion that there is little value in this procedure.

10. Since there is no specific remedy for the virus of swamp fever no recommendation is made in regard to treatment. If the reader desires a palliative treatment of the symptoms he is referred in particular to the work of Van Es, Harris, and Schalk, to the report of the Japanese Commission, to Hutyra and Marek, and to various papers by Carré and Vallée.
REFERENCES.


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EXPLANATION OF PLATES.

Degrees in temperature are shown at the left margin of each plate. Dates are given below each section of the temperature record; the day of the month is given on every tenth line, except the name of the month is substituted for the second place in each month. The year is given at intervals for convenience. The record is read from left to right, and in Plates III and IV it continues from page to page.

Plate I. Horse No. 6. Represents the temperature record of an acute case of swamp fever following a hypodermic (H) injection of 10 cc. of virulent blood on Nov. 13, 1912. Data from Swingle. A type that may be confused with other acute septicemic diseases.

Horse No. 22 (marked 31 by mistake). Represents a sub-acute type of the disease. Contracted swamp fever while confined in a screened cage containing a great many stable flies and infected horses, the infected horses being in adjacent stalls. Was put in cage on Aug. 3, 1914 (1), and taken out Sept. 11 (0).

Plate II. Horse No. 51. This represents the temperature record of a sub-acute type of the disease following a hypodermic (H) injection of 6 cc. of blood on Sept. 23, 1917; this blood was taken from the jugular of horse No. 31 (Fig. 2), whose temperature record is shown in Plate IV.

Plate III, p. 1-7. Horse No. 40. This shows the temperature record of the chronic case shown in Fig. 2. This mare was placed in a fly-free screened cage July 19, exposed to bites of stable flies (S) on dates indicated by arrowheads, and taken out Oct. 1. A mild fever reaction occurred Sept. 12, and other mild reactions followed. A case characterized by great emaciation.

Plate IV, pp. 1-7. Horse No. 31 (See Fig. 1). This shows the temperature record of a chronic case that apparently recovered (Nov., 1916, to June, 1918), but which later showed severe attacks of fever (1918 and 1919). The arrowheads at E, p. 1, show dates on which it was exposed to bites of stable flies which had previously had an opportunity to bite infected horses.
Note that severe and repeated fever reactions may not signify early termination of the disease.
PLATE II, HORSE NO. 51
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PLATE III, PAGE 1, HORSE NO. 40
PLATE IV, PAGE 1, HORSE NO. 31
PLATE IV, PAGE 2, HORSE NO. 31
PLATE IV, PAGE 3, HORSE NO. 31
PLATE IV, PAGE 5, HORSE NO. 31