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VETERINARY DEPARTMENT.

PAUL FISCHER, B. Agr., M. V. D., Veterinarian.
A. T. KINSLEY, B. S., Assistant in Veterinary Department.

SWINE=PLAGUE.

FOR some time the Veterinary Department of the Kansas State Agricultural College Experiment Station has been conducting experiments in protective inoculation against swine-plague. The material used for the inoculations was a pure attenuated culture of *Bacillus suis* (the swine-plague germ) prepared and furnished by Prof. H. J. Detmers, of Columbus, Ohio. Although our experiments may thus far be considered successful, they have not been sufficiently extensive to warrant the publication of results that to many would, to say the least, be misleading. Instead, therefore, of devoting these pages to recording our successes, we shall venture in the opposite direction, and record what was, if not a failure, at least an experience showing an apparent drawback to the successful introduction of protective inoculation as a solution to the question of controlling the worst swine disease in America.

Protective inoculation against swine-plague is based on the same principles on which rests successful protective inoculation against smallpox, blackleg, or any other infectious disease. Common observation has shown that when men or animals have recovered from diseases like smallpox, anthrax, blackleg, Asiatic cholera, etc., they are rarely attacked a second time. This condition of the animal body

which enables it to resist disease is called immunity. The degree of immunity thus produced, within certain limits, is the same whether the first attack of the disease was a severe or mild one, natural or artificial. We make use of this knowledge to bring about immunity by producing an artificial but mild attack of the disease in question. This is done by inoculating the animal with a culture of the specific disease germs that have previously been partially robbed of their virulence. The virulence of disease germs is reduced by submitting them to various unfavorable conditions of growth, such as high or low temperatures, artificial food media, uncongenial surroundings, etc., etc., but which need not be further discussed at this place.

The characteristic symptoms of swine-plague are due, in part at least, to the production, in the animal tissues, by swine-plague germs, of poisonous substances known as toxines. When virulent cultures are introduced into the body, the toxines produced are so abundant and effective that they overcome the tissue cells, and severe disease or death follows. When attenuated cultures are thus introduced the toxines formed are milder in their action, affect the tissue cells gradually, and give the latter time to overcome the injurious effects of the former. When the cells of the body have once been exposed and have offered successful resistance to an attack of disease germs, they are prepared to resist a second, more violent, attack by the same species of germ with the same or even greater success. The individual cells of the body have the same power of becoming inured to hardships, injurious influences and uncongenial surroundings as has the body as a whole, which, in fact, may be regarded as a large, organized mass of cells.

To repeat, the action, in a general way, of attenuated cultures of germs, when these are used for protective inoculation, is precisely the same as the action of virulent cultures of germs when they produce a fatal disease. The only difference between the two is one of degree.

Now, one of the greatest difficulties encountered in our experiments with protective inoculation is to convince farmers that it is useless, or worse than useless, to inoculate sick or exposed hogs with an attenuated culture of swine-plague germs. This may be illustrated thus: Suppose an animal were poisoned by drinking a great quantity of some strong fermented liquor, like brandy, which contains about fifty per cent. of alcohol: would it not seem ridiculous to attempt to save this animal's life by beginning now to accustom it to the effects of alcohol by feeding it additional but diluted potions of the same beverage? Attempting to save an infected animal by administering dilute or attenuated doses of the poisons (toxines) that are the actual cause of the disease is an analogous case. But, on the other hand, by

feeding the diluted poisons before the full-strength poisons have been administered, the animal organism will gradually accustom itself to stronger and stronger doses, until full-strength doses can be administered without harm. There are, of course, limits to all these assertions, but within these limits the facts will bear out the statements. On these principles protective inoculation rests, and this once fully understood, there will be no danger of confounding *protective inoculation* with curative treatment. The average farmer is unwilling to go to any reasonable expense in order to protect himself against a danger not yet in sight, but when it is too late he is too often willing to go to the opposite extreme and permit himself to be imposed upon by the very worst kind of pretenders—the venders of patent medicines.

As already stated, our great difficulty lies in trying to induce farmers to inoculate their pigs *in time*, before they have swine-plague or cholera, and before their neighbors' pigs across the road begin dying of this disease (or diseases?).

When healthy pigs (pigs free from disease or from infection) have been inoculated in our experiments, no deaths from swine-plague have been observed to follow. There is one exception to this statement, but all details of this have not yet been worked out, and hence it may be premature to consider it here. However, this system of preventive treatment is not supposed to be absolutely infallible.

It may, however, be proper to state here that the Veterinary Department has always been opposed to the inoculation of hogs whose history was such that it was practically impossible to know or find out whether or not the herd in question was free from swine-plague, or from an exposure to this disease. We further believe that no herd of swine that has been bought up from all over the country, so to speak, and then shipped by rail and unloaded in public stock-yards, can in any manner whatever lay claim to a clear bill of health. Even granting that the pigs were healthy when bought, the chances for infection during transportation are altogether too great to be left out of the question.

The most interesting incident in all our experiments, for the present, perhaps, is the inoculation of what was known as the College herd of hogs. This herd comprised 434 pigs, ranging in age from about three to five months. These pigs were bought for experimental feeding by the Farm Department in two distinct lots and at two different dates. Each lot was composed of a mixture of shoats—such as farmers were willing to sell. Lot I contained 114 pigs, and arrived at the College farm in four different lots on four different days (June 20, 21, 22, 23). These pigs were observed for nearly two weeks in order to detect symptoms of swine-plague, if such were present. In the

apparent entire absence of positive symptoms of this disease, and the statement of the purchaser that the pigs came from a region free from swine-plague, the herd was considered free from this disease, in as far as it was possible for us to determine at that time, and was inoculated July 11, 1899.

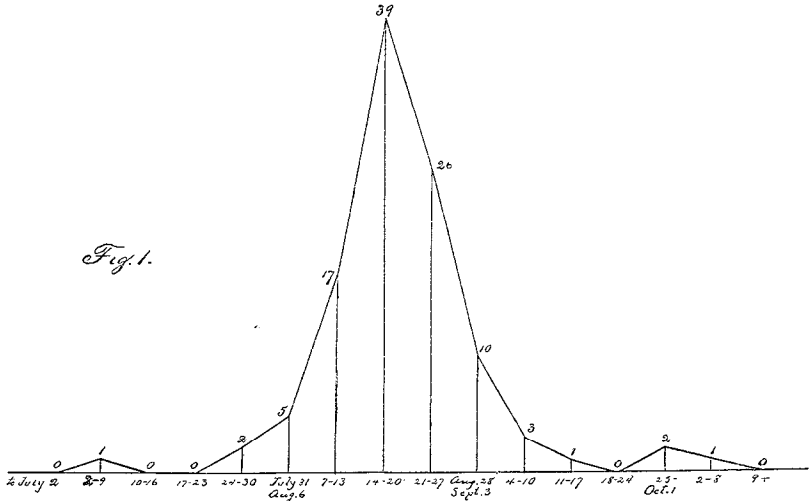
At this time we had not yet discovered the value of the fact that the temperatures of swine can be used to such great advantage in diagnosing swine-plague. In our later work this has been a great aid to us, and thus far has never failed to throw light on doubtful cases.

As it was, the very last pig inoculated turned out to be an exceedingly scrubby-looking one, greatly emaciated, rough coat of hair, no appetite, and feverish. This pig was inoculated but isolated. The attendant failed previously to call our attention to the condition of this pig, as he had been instructed to do. After a few days this pig's appetite returned; it seemed to be well, and, without orders to do so, was turned out among the rest by the attendant. Thus, unfortunately, we lost sight of this individual pig.

Now, as to lot II. This comprised 320 pigs, of the same origin as lot I, but a better-looking lot. They were received at the College August 4, placed in new and isolated pens built for this purpose, observed until August 11, and then inoculated like lot I. These pigs were observed for seven days, in order to detect, if possible, symptoms indicating the possible presence of swine-plague. During this time the men in charge had strict orders to keep the pigs isolated, so that, should they prove to be infected, the other lots would not suffer. Similarly, the men in charge were instructed to guard them carefully for ten or twelve days after inoculation, the period required to produce immunity, and thus not expose them to infection before immunity had been produced. Although the Veterinary Department did not have charge of this work, we must assume that all particulars were carefully attended to. With these statements, and others that will follow, the fact that all but fifty-six pigs out of lot II died of swine-plague during the next fifty-three days can be explained in one way only, and that is, that the pigs were infected with the germs of the disease when they arrived at the College farm. So much for the history of the two lots up to the time they were inoculated.

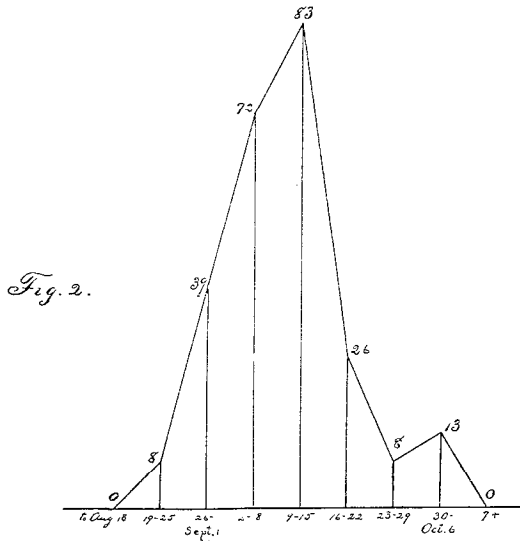
July 24, thirteen days after the inoculation of lot I, a dead pig from that lot was brought to the Veterinary Department for examination. On the following day another pig was brought in, and six days later another. The disease was pronounced swine-plague, and following will be found a diagram illustrating the rate at which the pigs died. The figures given are for successive weeks, beginning with death of first pig, July 2, and ending with death of last pig that died of swine-

plague, October 8, 100 days from time of first death. Only seven pigs out of a lot of 114 survived.



NOTE.—The death that occurred July 2 was not reported until after the pigs were inoculated, and hence could not be investigated. The probability is that it was due to swine-plague.

August 19, eight days after inoculation, the first pig in lot II died with swine-plague, and then the mortality rate in that lot steadily increased until the greater part of the herd was lost. The rate at which these died is indicated by the following diagram:



At the end of forty-five days after the first death in lot II, which originally contained 320 pigs, fifty-six were left, These are still living and doing well, December 30, 1899.

It will be noticed that the first pig in lot I died on July 2, 1899, about ten days after the arrival of the pigs on the College grounds. The next pig died July 24, more than four weeks after the arrival of the lot at the College grounds, but just twenty-two days after the death of the first pig.

In lot II, the first death occurred fifteen days after their arrival on the College grounds. In lot I, the pigs began dying about four weeks after their arrival.

This in brief, is a history of the swine-plague epidemic that visited the College herd.

As soon as the disease was recognized every possible precaution, in the way of proper use of disinfectants, quarantining, etc., that was possible on premises where a large number of students were employed for help, was taken. This did not prevent certain experiments with internal remedies on selected lots, all of which, it may be needless to state, proved ineffective. Absence from College on other duties and on a short vacation, which latter, however, was immediately interrupted upon hearing of the deaths taking place in the herds, made impossible other observations that would have been of value.

After eight pigs out of lot II (containing 320 pigs) had died, it was suggested that possibly the inoculation of the hogs with Detmers' virus was the direct cause of the outbreak of the disease. To obtain light on this question, ten average-looking hogs from a health point of view were selected from lot II: we will designate these lot II'. These pigs averaged three to four months in age and 50 to 100 pounds in weight. The dose of virus that each received when inoculated with the rest of the herd was 0.1 c.c. for each month of the pig's age, and in addition, 0.05 c.c. for each individual pig. Thus the dose for a four-months-old pig was 0.45 c.c. This was varied a little according to the weight of the animal.

These pigs were carefully examined; most of them had excellent appetites, were in good spirits and of fairly healthy appearance. Their temperatures ranged from 104.4°F. to 109.0°F., or as follows:

No. 1.	107.5°	No. 6.	104.4°
No. 2.	106.9°	No. 7.	109.0°
No. 3.	106.0°	No. 8.	108.4°
No. 4.	108.4°	No. 9.	108.4°
No. 5.	107.2°	No. 10.	108.1°

The normal temperature of a pig ranges from about 102°F. to about 105°F., varying with age, sex, surrounding temperature, time of day, and other conditions.

No. 6, as will be noted, was the only pig with a normal temperature. All others had a high fever. Every one of these ten pigs then received 5 c.c. (ten full doses) of a check flask of *Bacillus suis* culture, injected subcutaneously on the inner side of the left thigh. The effect that this inoculation had can be best shown by examining the temperature records which follow:

No.	August.						September.			
	26	27	28	29	30	31	1	2	3	
1*	107.5	108 0	108.0	107.6	108.8	107 4	108.3	106.3	107 0	died.
2*	106.9	106.6	106.0	108.3	108.8	108.2	108.2	108.1	107.1	
3*	106.0	107.3	106.0	106.8	106.8	107 4	107.2	108.7	107.2	108.6
4*	108.4	109.0	107.8	108.6	107.9	108.2	108.2	107.3	107.8	
5*	107.2	106.4	105.6	103.1	103.4	105.5	105.4	105.3	106 0	
6.	104.4	106.6	104.4	104.8	105 0	103.8	103.4	103.8	103.8	
7*	109.0	109.4	109 0	109.4	108.6	108.5	108.5	109.1	109 0	
8*	108.4	108.6	109.4	107.3	108.4	108.1	108.8	107.8	109.3	
9*	108.4	109 4	108.2	108.4	108.6	107.8	107.5	106.5	108.4	
10*	108.1	109.2	109.0	108.5	107.4	108.3	106.9	108.8	109.1	

No.	September.									
	4	5	6	7	8	9	10	11	12	13
2*	108.3	108.1	109 6	died.						
3*	107.8	107.4	108.0	106.2	105.5	104.7	104.9	106.1	104.7	died.
4*	107.8	108.1	107.3	106.1	105.7	104.5	105.5	105.5	106.1	105.9
5*	106.8	105.9	105 6	105 0	102.9	101.7	107.9	died.		
6.	105.0	103.9	104.2	104.7	102.6	102.7	102.2	102.8	103.2	102.1
7*	108.6	108.7	109.1	106.6	105.9	104.4	107.2	106.7	107.2	105.4
8*	109.6	107.8	108 0	106.4	106.3	99.4	died.			
9*	108.2	107.2	106.4	105.9	103.9	died.				
10*	106.4	died.								

No.	September.								
	14	15	16	17	18	19	20	21	22
4*	104.6	104.8	died.						
6.	102.0	102.4	103.4	101.6	101.8	102.1	101.6	101.4	101.2
7*	104.1	103.5	99.3	99.6	106.0	105 6	died.		

*Post-mortem examinations of these pigs immediately after death revealed the well-known lesions of swine-plague.

In Nos. 1, 3, 4, 6, 7, 8, 9 and 10 the slight rise in temperature on the second day, which dropped again on the following day, was the only observable effect produced by the lymph. In Nos. 2 and 5, which, by the way, were among the first to die, not even this effect was produced. These results would naturally be expected.

It will be seen also that pig No. 6—healthy from the beginning—was, like the rest, not materially affected by the inoculation, but was the only one that lived to see the experiment completed.

The death-rate in this lot, when compared with the death-rate of the entire lot No. II, will be found to be about the same. Of these ten animals, one, or ten per cent. (the healthy one in the beginning),

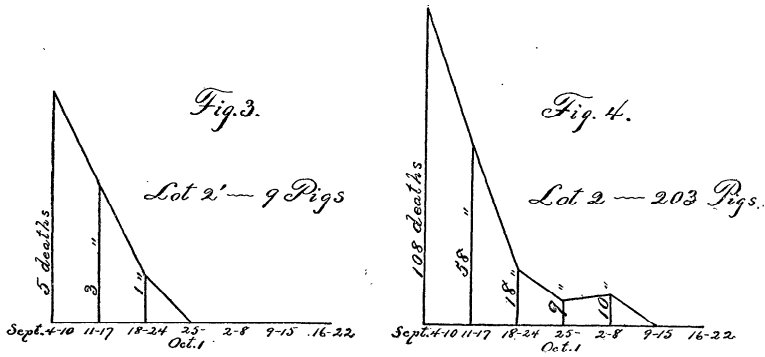
survived. Of the remainder of lot II, comprising 181* animals, whose temperatures were taken eleven days later (it being impossible to get help to do it sooner), fifty-five animals survived, or about thirty per cent.*; a figure as near that furnished by the inoculated lot as could be expected with the great difference in the ratio of healthy to diseased animals in the two lots. Results of experiments made at other times show that a healthy three-months-old pig could receive 12 c.c. of this virus without any permanent injury.

As stated, it was the intention to take the temperatures of the remaining 302 pigs immediately after those of lot II' had been taken, but proper arrangements could not be made for this until eleven days later—September 6. By this time ninety-nine of this lot had died, leaving only 203 animals, and before the 8th of September, when all the temperatures had been taken, twenty-two more died, leaving only 181 with a recorded temperature. The temperatures of these 181 animals ranged from 101.5° F. to 109.6° F.; twenty-three had temperatures exceeding 108° F.; sixty-nine had temperatures of 105° F. or below; thirty-seven of the latter had temperatures of 104° F. or below; of this lot of thirty-seven, twelve had abnormally low temperatures. Many with temperatures below 103° F. and all with temperatures below 102.4° F. were emaciated and scrubby looking and were discarded. This left fifty-seven animals in apparent good condition, with temperatures at or below 105° F. Of these fifty-seven, twenty-five had temperatures at or below 104° F.; these were kept in a separate lot, and observed for the purpose of determining whether the temperatures could be practically utilized for diagnostic purposes. At present writing, December 30, these pigs without exception are still alive and thrifty, and further comment may be unnecessary. Unfortunately the other thirty-two that had temperatures between 104° F. and 105° F. were turned in with the discarded lot. Of that lot, which then numbered 156 pigs—just thirty survived. From experiments that we made later and which are still in progress, it seems very reasonable to assume that most of these thirty pigs were included in the thirty-two that had temperatures between 104° F. and 105° F. Assuming this to be the case, and assuming also that the ninety-nine animals that died between August 26 and September 6, could have been recognized as diseased on the day lot II' was picked out, and this seems to be a very reasonable assumption, we find, on comparing the death-rate in lot II (after the ten pigs designated as lot II' had been separated) with the death-rate in lot II' (the virus-experiment lot), that it was almost exactly the same in both lots, the difference

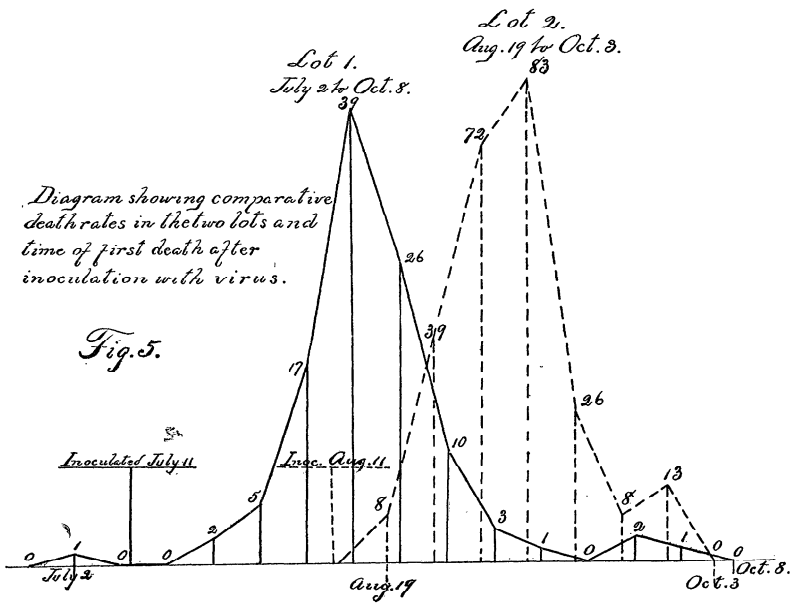
* Beginning August 26, which would be nearer correct, these figures would read 302 animals and 18.2+ per cent., respectively.

being in favor of lot II¹. From this we can only conclude that the excessive dose of virus in this case had no effect at all in increasing the rate of mortality.

The following diagrams illustrate graphically the comparative weekly death-rate in the two lots:



Comparing the death-rates in the two lots for the period between August 26 and September 4 (*nil* in lot II¹ and forty-eight in lot II), it would seem almost that it had been retarded by inoculation, but we will leave that point undiscussed.



Is it possible that the virus used for protective inoculation against swine-plague can be the cause of an outbreak of the disease?

This is a question of vital importance and must be answered before we can hope to resort to protective inoculation as a means of combating swine-plague. When improperly or carelessly prepared virus is thus used, there is no doubt but that the disease can be disseminated through its agency. When, however, carefully prepared material is used, material that comes up to a certain standard of virulence and does not exceed this beyond limits allowed for in the prescribed dose for the species for which it is intended, it may be answered that there seems to be no ground for such apprehension.

The regular dose of this material per animal is from one-tenth to one cubic centimeter, according to age and size of the animal, and it has been shown by experiments conducted at this station that an animal three months old (the most susceptible age almost) can receive twenty-five times this amount without any serious permanent effect. Thus this danger does not seem to be a great one. As far as the reliability of the material used in our experiments with the College hogs is concerned, it may be said that of all material used check flasks were kept on hand. These check flasks contained exactly the same kind of material as those actually used. They were afterwards examined, when *other pigs* were inoculated with them, and proved to consist of pure cultures of *Bacillus suis*. The *other pigs* referred to are the lot of ten designated as lot II' and pigs inoculated in different parts of the state for the owners. In no case was there cause for that question to arise. In one word—all of our observations point to a negative answer to the question above asked. However, the outbreak of swine-plague in the College herd has taught us a valuable lesson.

From the very beginning of our experiments, which dates back more than a year, we have insisted on inoculating healthy, unexposed pigs only. We were naturally at the mercy of the owner of the pigs to get at the facts in such cases, but fortunately were thus far never deceived in this respect. We have not yet inoculated an infected herd for any private owner of swine.

From the very beginning, also, we were, and of course still are, strenuously opposed to the inoculation of so-called stock pigs that have been bought up from all over the country for the purpose of fattening. This method is a poor one at the best, but when the factor of swine-plague infection is considered the practice cannot be too severely condemned. It is both foolish and dangerous.

We have found that pigs of this kind can be in apparently perfect

health, may be fat, thrifty, vigorous, have a good appetite, etc., and the only symptoms of disease of any kind that can be recognized will be an abnormal temperature, a symptom to which the average farmer usually pays little or no attention, and from its nature it cannot be expected that he should. The pig's normal temperature is subject to considerable variation, ranging from 102° F. to 105° F., and in some cases exceeding even these extremes. Breed, age, sex, environment and other factors all exert an influence. We have found that a herd of otherwise *thrifty* pigs can be infected with the germs of swine-plague for a period of thirty-three days at the very least, before the first deaths occur.

On September 9, 1899, Mr. John Warner, whose farm is six miles west of Manhattan, requested us to inoculate his pigs with protective virus. His neighbor, across the road, had lost almost 100 out of a lot of 300 or more hogs, and the death list was increasing rapidly. We were apprehensive concerning the condition of Mr. Warner's pigs. We took, and recorded, the temperature of each pig. In one lot of twenty-four pigs, four months old, kept separate from the rest, the temperatures ranged from 103.4° F. to 107.2° F.

*One had a temperature of 107.2° F., and one a temperature of 107.1° F. We killed the one with the higher temperature. The post-mortem examination revealed a peculiar hemorrhagic condition of the border of the spleen, noticed also in other pigs from the Colledge herd that died of swine-plague. Bacilli could not be demonstrated, but we assumed it was cholera, acted accordingly, and advised Mr. Warner to send the rest of his pigs that were in proper condition for it to the shambles. He retained the lot of twenty-four above mentioned and a number of brood sows. Two of these had eight ten-day-old pigs. The temperatures of these pigs ranged from 103.8° F. to 104° F. They were apparently in perfect health. Within ten days these pigs died of swine-plague (diagnosis verified by microscopic examination for *Bacillus suis*). On October 12 or 13 (date determined by the owner on the 19th), the first pig in the lot of twenty-four, above referred to, died of swine-plague. This was thirty-three or thirty-four days after the first symptoms of the disease appeared in the lot.*

This statement alone is sufficient to show the risk a farmer takes when he goes into the hog-buying business in the cholera season. Our advice is to "keep out of that kind of business." It shows another thing, viz.: the care that we, as experimenters, must exercise when we inoculate pigs with protective virus. If we should unknowingly inoculate a herd thus infected, the foregone conclusion, when the pigs began to die, would be that the inoculation would be held responsible for the result. We have escaped such accusations in the past, and in

the future we hope to avoid them with a still greater degree of caution by refusing absolutely to inoculate pigs which we did not have the opportunity previously to examine personally with a clinical thermometer. We have in this way examined over 1000 pigs, with results that are gratifying in the extreme.

After carrying on our experiments in this manner for a sufficiently long course of time, we hope that the results gained will be trustworthy, be they for or against this method of protective inoculation. Although we feel that the proper use of the virus could do little harm where an infected herd was treated with it, it would be unwise to expose the method to premature and misplaced criticism before final definite results are gained from accurate experiments. The case of the College herd is one that we must be on our guard not to have repeated.

In conclusion, a few remarks as to our method of carrying on our experiments with protective inoculation.

Although this Station is conducting original experiments with serum treatment for hogs already affected with cholera, that subject will not be discussed here.

The virus for protective inoculation is furnished by Prof. H. J. Detmers, of Columbus, Ohio. It consists of a pure attenuated culture of *Bacillus suis*, put up in hermetically sealed flasks, each containing 100 c.c. of virus. The cost of this material is three dollars per flask, containing virus sufficient to inoculate from 100 to 200 or more pigs. The virus to inoculate the College herd was furnished gratis by Professor Detmers. On account of the lack of funds at our disposal for this purpose, the farmers whose hogs we inoculate are asked to pay actual expenses and \$3.10 per flask for virus used. The additional ten cents is to pay expressage.

Following is an outline of the method pursued:

As soon as possible after receiving a request to inoculate a herd of hogs, and with this request an agreement on the part of the owner to pay the expenses of the trip and the cost of the virus, a member* of the Veterinary Department visits the herd in question. A careful examination of the general appearance of the herd is made, the sanitary condition of pens and enclosures is inspected, notes are taken on the methods of feeding and otherwise caring for the animals; then the rectal temperature of each individual pig is taken and recorded. If at the end of the examination these temperatures, together with the general appearance and other conditions of the herd, indicate a healthy condition of the herd, the pigs are inoculated, and the owner is in-

*Most of this work has been done by Mr. A. T. KINSLEY, B. Sc.

structed to make such improvements in sanitary conditions as we think necessary. Only three-fourths of the entire number of animals in the herd are inoculated. The other fourth is marked by tagging the left ear with an ear mark bearing a running number and the letters "Kas. Ex. Sta." In case an infection occurs these will serve as a check lot. We have concluded that this is the only satisfactory way of carrying on this experiment.

Thus far we have recorded temperatures of 1242 pigs. This does not include the College pigs. Only 955 of these were inoculated, because in some herds we found swine-plague already existing, and although no deaths had at that time occurred, our diagnosis, which was made principally with the aid of the clinical thermometer, soon proved to be correct when we received a report from the owner to the effect that his hogs were dying.

Of the 955 pigs above mentioned, not one has yet died of swine-plague, although to our certain knowledge several herds have been exposed to the disease. But in the course of time alone can the real value of these inoculations be ascertained.

This method of protective inoculation seems to be a rational one, and we believe that the possibility exists that it can be so perfected as to be practical value. Our experiments are intended to give light on this subject. As yet we are not recommending protective inoculation for the prevention of swine-plague or hog-cholera—we are simply asking the swine owners of Kansas to help us solve the question of its advisability.

Summary.

1. The proper use of Detmers' virus for protective inoculation against swine-plague does not seem to be attended with serious results as far as the use of the mere virus is concerned.

2. Care must be exercised in using virus of this nature, in order to avoid the inoculation of already infected swine and thus arrive at misleading results. Only such persons as have made a careful study of this disease can be expected to recognize it in its early stages.

3. To determine the presence or absence of swine-plague in a herd of swine concerning whose history nothing is known except the owner's statements, it is absolutely essential to determine the body temperature of every pig in the herd, and then base a diagnosis on the results of the temperature and the surrounding conditions.

4. Perfectly healthy swine can receive large doses of attenuated cultures of the swine-plague bacillus without harm.

5. The cause of the outbreak of swine-plague in the College herds was the presence of a number of pigs suffering with a chronic form of the disease at the time the pigs were purchased.

6. The pig that died July 2 was very probably one of these. The same must be said of the last pig inoculated in lot I, to which we referred on pages 8, 9.

7. It has been reported from several reliable sources that the pigs comprising lot I had swine-plague, or had been exposed to swine-plague-infected hogs, before they were sold to the Experiment Station. This alone is sufficient to explain the presence of the disease and make all theorizing needless.

8. Buying stock hogs in the swine-plague or cholera season, or at any other time, and shipping these by rail or by any other route, is a dangerous practice.

9. Farmers should breed and feed their own hogs.

10. When buying breeding animals seek reliable dealers in regions where swine-plague does not exist. This applies also to the purchase of all other farm animals, since any of them can be the means of spreading this disease.