THE MONTANA

STATE BOARD

OF

ENTOMOLOGY

SIXTH BIENNIAL
REPORT

1925 - 1926

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(No report was issued for the biennium 1923-1924)

MONTANA STATE BOARD OF ENTOMOLOGY

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Secretary, Bozeman, Montana

LETTER OF TRANSMITTAL

Bozeman, Mont., December 15, 1926

To His Excellency, J. E. Erickson
Governor of Montana
Helena, Mont.

Sir:

In behalf of the Montana State Board of Entomology it gives me pleasure to transmit to you the Sixth Report which covers the years from 1923 to 1926, inclusive, no report having been issued in 1925.

The work of this Board began in the year 1913 and has been continuous since that year. The primary object in passing the law which created this Board was to provide for the investigation and control of Rocky Mountain Spotted Fever, though the study of any insect borne diseases of man and domestic animals was authorized. From the first, Spotted Fever has been almost the only subject studied.

The problem has turned out to be a long and difficult one. There was very little known in medical science or in entomology to guide and aid us, and we have been obliged to make advances into the unknown in any progress we have made.

It has been the policy of the Board to enlist the cooperation of any agencies that might aid and we have had the assistance of various agencies, including the U. S. Public Health Service, the U. S. Bureau of Entomology, the U. S. Biological Survey, the U. S. Forestry Service, the Rockefeller Foundation for Medical Research, and Harvard University, all of which have rendered valuable assistance.

In the nature of the case, there has been much that the State of Montana has had to do and in the future the State will be obliged to take an active part if the problem is to be successfully completed.

We are pleased to report progress which may best be appreciated by a reading of the report.

Very respectfully,

R. A. COOLEY, Secretary.

SIXTH BIENNIAL REPORT OF THE STATE BOARD OF ENTOMOLOGY

by

R. A. Cooley, Secretary

The State Board of Entomology is made up of the following state officers, who are ex-officio members; the Secretary of the State Board of Health, the State Veterinary Surgeon, and the State Entomologist. There has been no change in the personnel of the Board since it was first established in 1913. This fact has done much to make for continuity and effectiveness in the labors of the membership. The Board was organized primarily for the investigation of Rocky Mountain Spotted Fever and for putting into effect such control measures as the investigations might uncover. Time has shown that the form of organization was an effective one, for the expert services of specialists and the organized official forces of the State have been brought to bear on the problem. At the outset it was seen that the solution of the problem must involve medical science, the health and control of domestic animals, and service in the field of the entomologist. All of these are covered in the organization and without the expense to the State of personal compensation, excepting for employees of the Board.

Formerly the Board employed Doctor R. R. Parker as Assistant Entomologist and valuable work was done by him. However, when in 1921 a sharp increase in the number of cases occurred in Western Montana, and when at the same time it became evident that the disease was getting closer to certain large centers of population in western Montana, the United States Public Health Service was called upon for assistance, and at this time Dr. Parker was transferred to the United States government pay roll. He is now an employee of the Public Health Service but, being stationed in Montana under the present plan of cooperation, we still have the benefit of his wide knowledge of the work.

In 1924 Mr. F. J. O'Donnell was employed to conduct the tick control work of the Board which involves rodent destruction and the dipping of livestock. Mr. O'Donnell has become a very valuable aid in the work. He has supervision of all of the control districts and all of the employees of the State, conducts the cooperative work with the County officers and is generally in charge for the State.

Cooperation

Since 1921 the work at the Hamilton laboratory has been conducted under an informal plan of cooperation between the State and the United States Public Health Service

which will be continued indefinitely, so for as we are now informed. Doctor R. R. Spencer, Surgeon, is in charge for the United States, and Doctor Parker is closely associated with him. A number of important publications eminating from this work have been published from Washington by the Public Health Service under the joint authorship of Doctors Spencer and Parker.

Owing to the form of organization, it is impossible to state just how much money the U. S. government is allotting to this work, but the sum is nearly twice the amount of the State appropriation.

The Montana State Board of Entomology has much pleasure in acknowledging the assistance of the United States Public Health Service and particularly desires to commend the high type of personal service rendered by Doctor Spencer and Doctor Parker. Both of these men are daily exposed to infection by spotted fever and their families are in constant danger. Both of them during the period since the last report, have gone through distressing and protracted illness from tularaemia, contracted while on duty in the laboratories.

Acknowledgement is also made of the cooperation and assistance of both the U. S. Biological Service and the U. S. Forestry Service in connection with giving information and aiding in the destruction of rodents in public domains bordering the tick control districts operated by the State.

Control Measures

It is the general policy of the Board to conduct investigations into the causes of Rocky Mountain Spotted Fever, experiment with methods of control or eradication, and, as rapidly as useful information is obtained, put it into practical use.

The control work now being conducted is covered in a paper by the Field Agent, Mr. O'Donnell, which appears on later pages and may be summarized as follows. For the purpose of conducting the control work portions of Ravalli and Missoula Counties have been set off and bounded as control districts. In these districts the destruction of rodents and the dipping of livestock is being carried on as previously. In the growth and development of the tick from the egg to the adult condition, the early stages, larvae or "seeds" and nymphs, feed on rodents and the full grown ticks or adults feed on domestic animals, principally horses and cows. The killing of ground squirrels on which the young ticks feed principally and the dipping of horses and cattle for the killing of adult ticks are the best known methods of control

which we have. This work which has been going on for some years has resulted in a very marked reduction in tick abundance and a lessening of the danger of residents being bitten.

It is highly desirable that this control work be continued, even though we now know that it is not a sufficient method for eradicating spotted fever or the tick. It is certain that the killing of rodents and dipping of livestock has greatly reduced the ticks and that a continuance of the same work will futher reduce the deplorable condition that formerly existed.

The recent investigations by the Public Health Service into the conditions concerned in the maintenance and perpetuation of the spotted fever virus in nature have pointed to new avenues of control. Their use however is being held in abeyance pending the securing of additional information on certain points and the results of the tests to determine the value of the parasite, **Ixodiphagus caucurtei** and its place in the plan of control.

The control work is being done wholly on State funds.

It should further be pointed out that in conducting the control work a large amount of valuable notes, maps and experience have accumulated which are certain to be of great value in future work, whatever it may be. For example, the notes which show present conditions will be of value in judging the measure of progress being made when the work with tick parasites is taken into the field, which we hope to do in the spring of 1927.

WORK OF THE PUBLIC HEALTH SERVICE

Throughout the whole history of the spotted fever investigations in Montana, the Public Health Service has at times allotted funds to the project and has had representatives engaged in various phases of the study. The arrangement now in force began in 1921, when Dr. R. R. Spencer took up his study and Dr. R. R. Parker, formerly employed by the Board of Entomology as Assistant Entomologist, was transferred to the government pay roll.

The investigations of the Public Health Service have been concerned mainly with the following:

1. A vaccine that will provide protection.

2. The organism of spotted fever and other microorganisms found in ticks.

3. Characteristics of the virus of spotted fever, particularly with reference to differences as it occurs in ticks and in animals.

4. The conditions physical and biological that are concerned in the maintenance and perpetuation of the virus in nature.

5. The relation of the rabbit tick **(Haemaphysalis leporis-palustris Packard)**, in the spotted fever complex.

6. Tularaemia.

7. Tick paralysis.

We are pleased to report real progress, particularly in the search of a vaccine. A brief article on this subject by Drs. Spencer and Parker appears in another part of this report. Another article on tularaemia, a disease which turned up in ticks brought in from nature for use in the work on spotted fever, is included and shows important findings which are in the nature of a bi-product of the laboratory. A third article by Drs. Parker and Spencer on the distribution and spread of spotted fever in Montana, places on record a vast amount of information which does much to emphasize the problem as one of more than local significance.

The Public Health Service workers have also found the common rabbit tick, a species entirely different from the spotted fever tick, has the spotted fever virus in nature and may transmit it from one rabbit to another. This finding is of much importance, not because this tick ever bites men, but rather because it may be a important factor in the complex conditions that harbor the infection in nature. A fuller understanding of some of the natural conditions back in the mountains that border the Bitter Root Valley has been reached. It has been found that the Rocky Mountain Goat, which occurs rather abundantly in the mountains, is a very important factor in keeping up the tick population and that the ticks on goats and in the goat ranges are particularly high in the percentage of infective individuals.

IMPORTANCE OF THE TICK PROBLEM IN MONTANA

Prior to the year 1906, when Dr. H. T. Rickitts by his admirable experiments conducted in Montana under the auspicies of the State Board of Health, definitely established the fact that the common "wood tick" is the agency of man's infection with Rocky Mountain Spotted Fever, not much interest was taken in this parasite. It was known to infest livestock and to bite man, but it was not considered to be of much importance and certainly not a factor in the development of a great commonwealth. In twenty years' time, however, we have come to realize this arachnid to be of great importance. We are concerned with it for the following reasons:

1. It is the means, and the only means, of man's infection with Rocky Mountain Spotted Fever.

2. It causes the definite but obscure disease known as tick paralysis in human beings, of which there are several cases in Montana each year. This disease generally occurs in children. It is induced by the bite of the tick generally in the region of the base of the head and is **always fatal** unless the tick is discovered and removed before the paralysis reaches vital organs.

3. It is one of the agencies of man's infection with tularaemia and is an important factor in keeping this disease alive in nature by transmitting it from one rodent to another.

4. By its bite it frequently induces resistant ulcers on man.

5. It is a generally objectionable parasite of man, causing apprenhension and discomfort to many persons who love the open air and delight in tramping.

6. It causes a definite disease known as tick paralysis in sheep and at times causes heavy loss by killing sheep and making necessary the hand picking of the ticks.

7. It is a severe parasite of both domestic and wild animals such as horses, cows, sheep, elk, deer and mountain goats. "Down with ticks" is an expression among stock men and refers to animals so heavily infested that they are devitalized and unable to get up. Whether there is a paralysis connected with this condition is not now clear.

The fact that the tick causes spotted fever is beyond doubt the principal score against it but all of the foregoing reasons, collectively, have created a real problem for Montana and for the other northwestern states. A correct idea of the prevalence and spread of spotted fever in Montana may best be gained by a study of the accompanying table and a map shown in another part of this report. The map and table show that the number of cases has increased and that the disease is spreading. The table of cases by years, if compared with the same table presented in the last report will show that during a period of four years, spotted fever has appeared in four new counties. Two of these were new in 1926. The total in the state for this four year period is 152 against 122 for the four years preceding, an increase of 30. It appears to be evident that changes in conditions brought about by the increase in population and the advancing of agriculture in new territory has brought about the increase and spread of cases.

There can be no doubt that the increase in automobiles in the United States, improved roads, extensive tourist travel together with more intermingling of people residing in different parts of the country have brought about a much greater familiarity of the people of the United States generally, with the fact that there is such a condition here. This is in evidence whenever one travels in the east and whenever residents of the east visit here, as well as by the letters received by the Board of Health in Helena and the State Entomologist. The following is an example. The Secretary of the Board of Health recently received a letter from an individual in Iowa, who stated that he represented thirteen families who were thinking of moving to the Bitter Root Valley but having heard of ticks and spotted fever, he wanted to know about the conditions that existed.

The presence of ticks and spotted fever in Montana cannot fail to be a serious obstacle in the way of normal development until an adequate solution to the problem is found.

The Spencer-Parker vaccine, now in an experimental stage, looks encouraging, but it should be understood that this vaccine can never completely solve the problem. At the present time it is costing approximately twenty dollars to make the vaccine for one person. With quantity production and more experience the cost can be reduced somewhat but we believe that it will always be so high as to make it difficult to induce the general public to use it. We can hardly expect the Federal Government to continue the production of vaccine, and administer it free much beyond the experimental stage, at least not without a special act of congress.

If this vaccine is finally demonstrated to be entirely successful, and if it may be produced at a cost to put it within the reach of all who want it, it will still be true that the presence of spotted fever is a menace to the state. If persons knew where and how they became infected with the diseases for which vaccination is ordinarily practiced, such as small pox, typhoid fever, etc, they would generally avoid the possibility of becoming infected in preference to taking the protective treatment.

With an effective vaccine for this disease available people will still continue to avoid places where ticks are found and, excepting in cases in which their habits take them into places where they are in danger, will not generally be vaccinated.

A successful vaccine will be of great value in aiding to solve the problem but we will still need to eliminate spotted fever as we would small pox and typhoid fever.

Spotted Fever Chart.

A graphic chart prepared by Doctor Frank H. Parker, under the supervision of Doctor R. R. Parker, showing the life cycle of the spotted fever tick and the supposed cycle of the virus, is presented herewith. This chart should do much to make clearer the intricate relationships between the virus, the tick and the hosts of the tick in the various stages of development.

ROCKY MOUNTAIN SPOTTED FEVER CASES IN COUNTIES OTHER THAN MISSOULA, RAVALLI, AND GRANITE.

Beginning in 1914, the First Year That the Disease Showed a Wide Distribution Within the State.

	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	
Beaverhead	....	....	....	....	....	....	....	....	....	....	1	1	....	2
Blaine	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Broadwater	....	....	....	....	....	....	1	1	....	2	1	....	1	6
Big Horn	....	2	....	....	....	1	1	....	1	1	1	2	2	11
Carbon	2	3	1	4	2	1	1	....	3	3	2	3	....	25
Carter	....	4	....	....	....	....	....	....	....	2	2	....	1	9
Custer	....	6	....	....	....	....	....	....	1	....	1	2	3	13
Daniels	....	....	....	....	....	1	....	....	....	....	....	....	....	1
Dawson	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Fallon	....	....	....	....	....	....	....	....	2	....	3	1	1	7
Fergus	....	....	1	3	....	2	3	3	7	3	3	1	....	26
Gallatin	....	2	....	....	....	....	....	....	1	....	....	....	....	3
Garfield	....	5	3	1	....	....	1	1	7	11	4	1	3	37
Golden Valley	....	....	....	....	....	....	....	1	1	1	1	....	1	5
Jefferson	....	....	....	....	....	....	....	....	1	1	....	1	1	4
Lewis and Clark	....	....	....	....	....	....	3	1	....	2	1	1	....	8
Madison	....	....	....	2	1	....	....	....	....	....	....	....	....	3
McCone	....	....	....	....	....	....	....	2	....	....	....	....	....	2
Meagher	....	....	....	....	....	....	....	....	....	1	....	....	....	1
Mineral	....	....	....	....	....	....	....	....	....	....	....	....	1	1
Musselshell	1	2	6	1	2	1	10	2	8	....	2	1	....	36
Prairie	....	1	....	1	....	....	....	....	....	....	2	....	....	4
Phillips	....	....	....	....	....	....	....	....	....	....	....	....	2	2
Powell	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Powder River	....	4	....	....	....	....	....	....	....	....	2	....	....	6
Richland	1	....	....	....	....	....	....	....	....	....	....	....	....	1
Rosebud	....	3	....	....	1	1	1	5	4	8	3	5	4	35
Stillwater	....	....	....	2	....	....	....	....	1	....	3	....	....	6
Treasure	....	2	1	....	....	....	....	....	2	1	....	1	....	7
Yellowstone	....	....	1	1	1	....	....	....	9	....	5	2	2	21
Valley	....	....	1	....	....	....	....	....	....	....	1	2	1	5
Wheatland	....	....	....	....	....	....	....	....	....	....	....	....	1	1
	4	34	14	15	7	7	21	16	51	36	38	24	24	291

ROCKY MOUNTAIN SPOTTED FEVER CASES IN MISSOULA, RAVALLI, AND GRANITE COUNTIES

From 1913 to 1926[1]

County	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Missoula	....	5	5	1	1	1	2	2	3	4	2	2	6	3
Ravalli	....	7	3	5	5	2	3	2	8	3	9	2	0	3
Granite	....	0	0	1	0	0	0	0	0	0	1	2	0	0
Totals	11	12	8	7	6	3	5	4	11	7	12	6	6	6

1. Laboratory cases not tabulated have occurred as follows: 1922, 1; 1924, 1; 1925, 1; 1926, 3.

2. There are records of 17 cases in Carbon County between 1894 and 1904. None are reported from 1905 to 1914.

3. In 1904 single cases were reported from each of the following counties: Fergus, Park, Gallatin, and Beaverhead. These diagnoses are of doubtful reliability.

4. Cases imported from other States have been treated in Montana as follows: 1915, one Idaho case in Cascade County; 1917, one Idaho case in Golden Valley County, and two Wyoming cases in Yellowstone County; 1921, one Nevada case in Custer County; 1922, one Wyoming case in Yellowstone County.

5. Records of Montana cases treated in other States as follows: 1922, one from Stillwater County treated in Wyoming; 1924, one from Powder River County treated in Minnesota.

GEORGE HENRY COWAN

Born January 10, 1886.

Died October 29th, 1924, of Rocky Mountain Spotted Fever contracted while on duty, after twelve years of service in the investigations.

GEORGE HENRY COWAN

Yet again it becomes our painful duty to record the death from Rocky Mountain Spotted Fever of one of those engaged in the investigations. George Henry Cowan, an employee of the United States Public Health Service, contracted the disease, in some unknown manner ,while on duty and died on October 29th, 1924.

Mr. Cowan was first employed by the Public Health Service during the period of Doctor Thomas B. McClintick's service in the Bitter Root Valley about 1912, then by the United States Bureau of Entomology and later by the State in the work of dipping livestock and killing rodents and finally again by the Public Health Service. His services were therefore almost continuous to the time of his death. Of tremendous physique, with a keen intellect, and with a willing heart, which made him invaluable alike in the field and in the laboratory, he had done very much to advance the work on spotted fever.

Something more than the thought of the usual monetary compensation to be received must have actuated him to take up the work on spotted fever and to continue it with devotion for a period of twelve years. Every school boy in Montana should be told the story so they may know that true heroism still lives and that men of high motives place duty first.

A Parasite of Ticks

In years past we have had correspondence with Doctor M. E. Brumpt, of the Faculte de Medecine de Paris, an eminent parasitologist, regarding a specific parasite of ticks in which he was much interested. This parasite, scientifically known as **Ixodiphagus caucurtei** Buysson, was first described in 1912 (Un Hymenoptere Parasite des Ixodes. In Archives de Parasitology, Tome XV, p. 246.) It is a minute, dark-colored, very active insect about one millimeter in length which feeds in and destroys the tick in the nymphal stage. At Dr. Brumpt's request some of our ticks were sent to him, alive, for his experiments.

Doctor Brumpt's preliminary experiments were so encouraging that the subject was written up in an article entitled, "Utilisation des Insectes Auxiliares Entomophages dans la Lutte contre les Insectes Pathogenes," which appeared in La Presse Medicale, (No. 36, du 3 Mai, 1913).

This parasite was introduced into America during 1926. Near Woods Hole, Massachusetts, just off the shore, is a small island, Naushon, which is privately owned and used for purposes of residence and recreation. Several families, all

branches of one family, reside on the island. The island is so overrun by the American Dog Tick, **Dermacentor variabilis** Say, as to be much less desirable for residence purposes. Through Doctor S. B. Wolbach, professor of Pathology, Harvard Medical School, arrangements were made for Dr. Brumpt to send over an assistant with a brood of parasites for the purpose of attempting to colonize and establish them on the island. Accordingly, in the early part of the summer of 1926, Dr. F. Larrousse arrived in Boston and, after a conference with Dr. Wolbach, set up his experiments on Naushon. It is too early to judge reliably of the results of the experiments but since Dr. Larroussee was able later in the season to recover parasitized ticks in nature there is hope that the attempt will be successful.

Soon after Dr. Larrousse arrived in America, Dr. Cogswell, Chairman of the Board of Entomology, received a telegram from Dr. Wolbach, inviting the State to send a representative to Massachusetts for the purpose of becoming acquainted with the method of handling and rearing the parasites, with a view to attempting to introduce them into Montana. The Secretary left for Boston on July 8th and after a stay of a few days on Naushon Island in conference with the French scientist and in observation of his work, returned with a small but sufficient supply of parasitized nymphs. Every possible courtesy and assistance was extended both by Doctor Wolbach and Doctor Larrousse and our success in rearing the parasites since July is due to the careful and thorough manner in which the experience gained in France was explained.

It was learned that in France, where the insect is native, ticks are practically exterminated in those parts where the parasite is found, and it had previously been learned from Dr. Brumpt that ,in experimenting in the laboratory with different species of ticks brought in alive from different parts of the world, our spotted fever tick was the only one in which he had obtained a one hundred percent parasitism.

These facts, together with the success we have had during the few months since we obtained our stock of parasites, lead us to hope for success in their use, not only in Ravalli and Missoula Counties, but elsewhere in Montana. It must be borne in mind, however, that there may be many factors which will be against success in the enterprise. Climatic conditions, both in summer and in winter, may make it impossible for the parasite to live here. The parasites work only in the nymphal stage of the tick and it is not yet clear that the life histories of the tick and of the parasite are so timed as to enable the parasite to pass through the full year's cycle.

Such points can be determined only by experiments and steps have already been taken to conduct such investigations as are necessary. The parasites multiply very rapidly and by the spring of 1927 we shall have a supply which will enable us to begin our experiments in liberating them. This work will begin in the Bitter Root Valley and in the mountains nearby, where the ticks are very numerous.

It should be known also that the proposed investigations of the parasite will involve a tremendous amount of labor. It will be necessary to maintain at all times a reserve stock of the parasites in the laboratory. To do this it is necessary, first, to rear ticks on animals in laboratory cages. Since only the nymphs can be used, we shall have to begin with adult engorged ticks, either picked from domestic animals or fed to repletion on laboratory animals, allow them to lay eggs, wait for the eggs to hatch, feed the larvae on laboratory animals, and finally wait for the nymphs to emerge from the engorged larvae. Throughout this stage of the process it is necessary to prove that the ticks being used are non-infective, as it would be unwise to liberate infected ticks in nature.

Having the stock of unfed nymphal ticks, it is necessary to allow them to feed on laboratory animals and, while being fed, to liberate the parasites in the cloth bags in suitable temperatures. The parasitized ticks must later be separated from those not parasitized and held under suitable conditions of temperature and humidity until ready to emerge as adult parasites.

Several experimental methods will be tried in liberating the parasites in nature. One will be to obtain wild rodents by trapping, infest them with nymphal ticks and ,after parasitizing them as with laboratory animals, liberate the rodents where they may go back to their old haunts and drop the parasitized ticks where we want them to be and under natural conditions.

In order to avoid proceeding blindly with methods the effectiveness of which is unknown, it will be necessary to conduct experiments to check up results. Other wild rodents will be shot or trapped and the ticks will be carried through to determine the percentage of parasitism for comparison with other methods.

In order to carry out this work, several assistants will be needed and much more laboratory space than we now have.

PLANS AND NEEDS

The plans of the Board of Entomology contemplate continued cooperation with the Public Health Service, that the destruction of rodents and dipping of live stock shall be carried on as formerly; and that the new tick parasite shall be experimented with and made use of as far as possible.

Through the proper channels budget estimates have been submitted. The figures presented are carefully adjusted to the actual needs and are conservative. Larger and more suitable quarters are very badly needed and the present legislature should make available a sufficient fund to permit the erection of suitable building.

A LABORATORY NEEDED

During recent years the laboratory work in connection with this problem has been conducted in a vacated school building across the river to the west of Hamilton. It is an old structure wholly unadapted to our work, far too small, and badly in need of repair. It was formerly rented from the local school board but has recently been turned back to the original owners, by a court action, because no longer used for school purposes. The laboratory work has so increased that a larger and better equipped building is the Board's most urgent need.

It is impossible to place too much emphasis on the fact that this building is not suitable for the purpose of this investigation. Such work calls for order and cleanliness which cannot now be had. A very large amount of experimental work on laboratory animals is necessary, requiring the use of hundreds of caged animals. At present these are stacked up in the same rooms with equipment, records, work tables, and office desks. As would be expected unnecessary human cases of laboratory infection have occurred. Since the fall of 1921 eleven out of sixteen persons who have been engaged in the United States Public Health Service investigations have been infected either with spotted fever or tularaemia. Five of these men have contracted spotted fever and six tularaemia. Two of the former resulted fatally while the last three, who had received the vaccine, recovered. These three recovered cases all occurred during season of 1926 and resulted from attempting to produce increased quantities of vaccine without suitable facilities. Without the vaccine it is partically certain that we would have been obliged to report five deaths instead of two from accidental infections originating in this improvised laboratory. All prior laboratory cases, five in number had proved fatal.

A representative of the Public Health Service has recently stated that their work would be increased in Montana if adequate quarters are provided. The laboratory is full to the limit and there is no space in which to take up the proposed new work on tick parasites. In this work alone a large amount of space will be necessary for the cages in which laboratory animals are held and for other uses in the same connection.

It should not be understood that all danger of infection may be avoided if suitable housing is provided. The work is dangerous at best, but the state can do no less than provide every protection possible, and with every thing possible done to protect the workers there is still danger that ticks or other infectious materials will be taken to the homes of the workers. The older members of the family may be vaccinated but the younger children cannot be, at present.

DISTRIBUTION AND SPREAD OF ROCKY MOUNTAIN SPOTTED FEVER IN MONTANA. [1]

By

R. R. Parker, Special Expert, and R. R. Spencer, Surgeon, U. S. Public Health Service.

(Cooperating with Montana State Board of Entomology)

During the past ten years there has been a spread[2] of Rocky Mountain spotted fever in Montana that is without precedent in any section of the northwest. The accompanying map shows the three relatively small areas in which the disease was definitely known to be endemic prior to 1914. Beginning in that year, infection has spread until now it is present in 34 counties extending from the eastern to the western and the northern and southern state boundaries.

On the map, the endemic areas known prior to 1914 are indicated by solid black. The subsequent spread is indicated by black circular dots, each of which indicates an individual case and its approximate point of origin.

1. Data subsequent to 1913 are from records of the Montana State Board of Entomology and the United States Public Health Service. Prior data are partly from records of these organizations, partly from literature.

2. The terms "spread" and "extension" as here used mean the occurrence of human cases in new localities. It is possible, however, that infection has long been endemic in the new areas, without the occurrence of earlier cases in man.

ENDEMIC AREAS PRIOR TO 1914—WESTERN MONTANA.

In western Montana, there are two areas in which Rocky Mountain spotted fever of the most virulent type has been endemic for many years, probably long before white settlement. The mortality rate has approximated 75 per cent, and in persons of adult age has been nearer 90. [3]

One of these areas is on the west side of the Bitter Root River, partly in Missoula and partly in Ravalli county. It is about 90 miles long and with an average width of less than 15 miles. Although there is strong evidence of the infection among the Indians before the Valley was settled, the earliest authentic record was in 1873. Several hundred deaths have occurred. Land values were depreciated, and, due to the actual or potential high priced agricultural value of the land, a serious economic situation has been created. [4]

The second area lies along the lower portion of Rock Creek, east of Missoula, mostly in Granite County but includes the southern corner of Missoula County. It is not to exceed 15 miles in length. The earliest recorded case was in 1891, but an unverified report indicates its occurrence at least 10 years earlier. It is a narrow mountain valley chiefly used for grazing.

In Missoula County, outside these two well defined endemic areas isolated cases have been reported as follows: 1 each in Grant and Butler Creeks and in Pattee Canyon in 1904; 2 on Rattlesnake Creek and 1 in Dry Gulch in 1909; and near the mouth of the Blackfoot River, 1 each in 1899, 1904 and 1906.

The third endemic area of long standing is southern Carbon County, east of the mountains. Prior to 1914, cases had been reported from the Clark Fork of the Yellowstone River, Dry Creek, Boulder Creek, and Sage Creek. The mortality rate was approximately 15 per cent.

The only cases reported outside these counties prior to 1914 were 1 each in Beaverhead, Gallatin, Park and Fergus counties, all in 1904. In view of their isolated occurrence and the distances from known endemic areas one can but wonder as to the correctness of the diagnoses.

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3. These percentages are based on the case records for the last ten years. Recoveries among young children are far more frequent than in adults.

4. Most sections of the northwest in which Rocky Mountain spotted fever occurs are sage brush areas, of relatively low agricultural value.

ROCKY MOUNTAIN SPOTTED FEVER

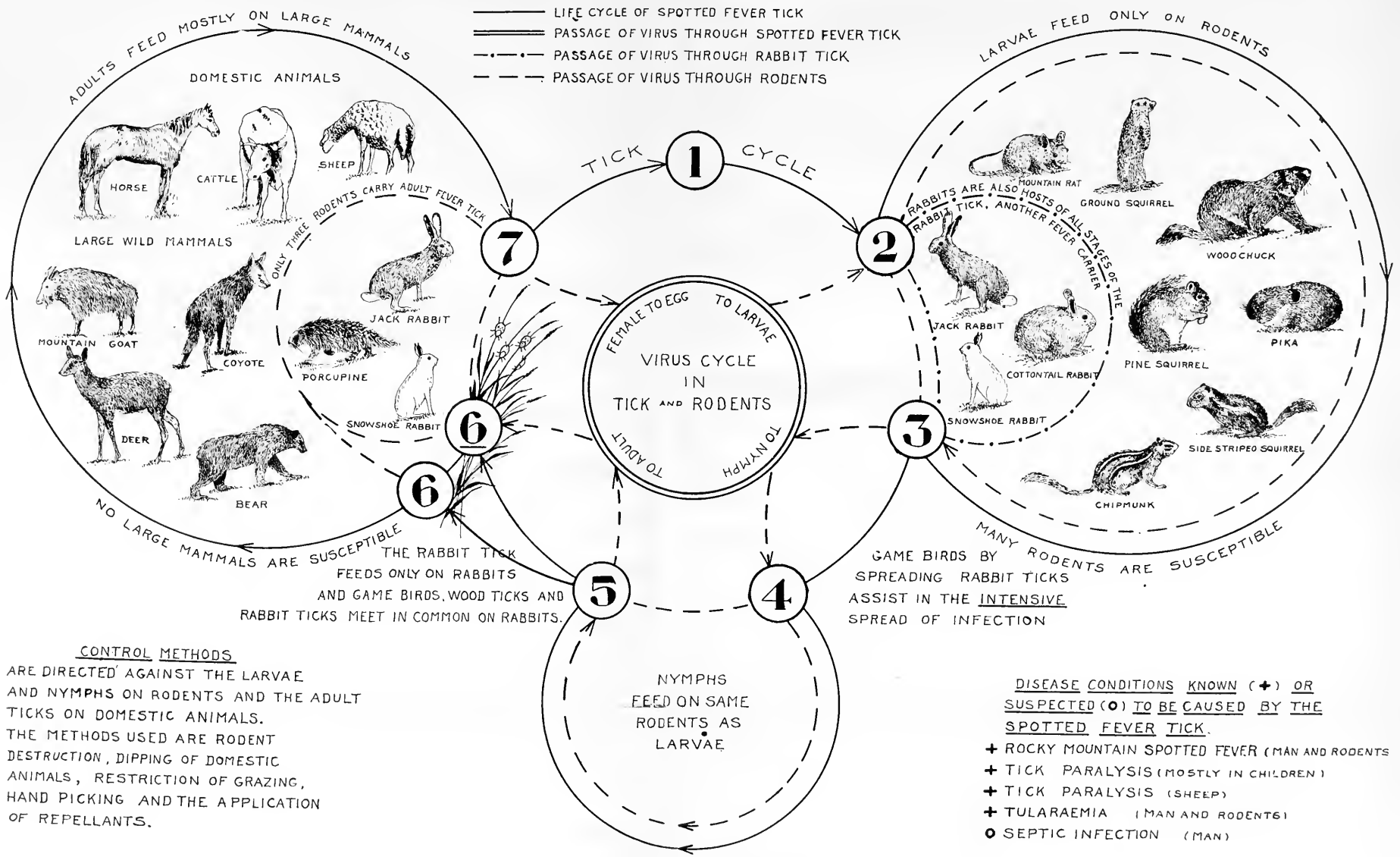
LIFE CYCLE OF THE SPOTTED FEVER TICK AND SUPPOSED CYCLE OF THE VIRUS

TICK—DERMACENTOR VENUSTUS

THE VIRUS IS TRANSMITTED BY TWO TICKS, THE WOOD TICK AND THE RABBIT TICK. IT IS MAINTAINED (1) BY PASSAGE FROM STAGE TO STAGE OF THESE TICKS AND (2) BY NEW LINES OF INFECTION STARTED IN PREVIOUSLY UNINFECTED TICKS BY FEEDING ON INFECTED HOSTS. THE WOOD TICK IS THE ONLY KNOWN AGENT OF HUMAN INFECTION.

1 EGGS
2 LARVAE
3 ENGORGED LARVAE
4 NYMPHS
5 ENGORGED NYMPHS
6 MALE AND FEMALE
7 ENGORGED FEMALE

THE WOOD TICK COMPLETES ITS LIFE CYCLE IN TWO YEARS, FEEDING THREE TIMES, FIRST AS LARVAE THEN AS NYMPHS AND LAST AS ADULTS. EACH STAGE FEEDS ON A SEPERATE HOST



CONTROL METHODS

ARE DIRECTED AGAINST THE LARVAE AND NYMPHS ON RODENTS AND THE ADULT TICKS ON DOMESTIC ANIMALS. THE METHODS USED ARE RODENT DESTRUCTION, DIPPING OF DOMESTIC ANIMALS, RESTRICTION OF GRAZING, HAND PICKING AND THE APPLICATION OF REPELLANTS.

DISEASE CONDITIONS KNOWN (+) OR SUSPECTED (O) TO BE CAUSED BY THE SPOTTED FEVER TICK.

+ ROCKY MOUNTAIN SPOTTED FEVER (MAN AND RODENTS)
+ TICK PARALYSIS (MOSTLY IN CHILDREN)
+ TICK PARALYSIS (SHEEP)
+ TULARAEMIA (MAN AND RODENTS)
O SEPTIC INFECTION (MAN)

DESIGNED BY R.R. PARKER
UNITED STATES PUBLIC HEALTH SERVICE

SPREAD OF ROCKY MOUNTAIN FEVER BEGINNING IN 1914.

The first authoritative reports of the occurrence of Rocky Mountain spotted fever outside the above three old endemic areas was in 1914. The subsequent spread can best be outlined by considering separately the eastern and western parts of the state, the former to include the plains section east of the mountains where the fever mostly occurs in sage brush areas, the latter, the western, more mountainous portion where the fever commonly occurs under mountainous conditions.

Eastern Montana. The most extensive spread has taken place in this section. Before 1914, infection was known only in Carbon County. It now occurs in 23 counties and a line drawn to connect the peripheral cases would enclose an area of many thousand square miles. This must be considered as one vast endemic area and each year there is new evidence of either extensive or intensive spread or both.

The accompanying tabulation shows the occurrence of cases in this area from 1914 to 1926, giving totals by years and counties.

The first evidence of spread was in 1914, when two cases were reported from widely separated points; one from Richland and one from Musselshell county. In 1915 cases were again reported from Musselshell county, and the following new counties: Big Horn, Carter, Custer, Garfield, Prairie, Powder River, Rosebud, and Treasure. Fergus, Valley and Yellowstone counties were added in 1916; Stillwater in 1917; Daniels in 1919; McCone and Golden Valley in 1921; Blaine, Dawson and Fallon in 1922; and Phillips and Wheatland in 1926.

The number of cases by counties has been: Blaine, 1; Big Horn, 11; Carbon, 25; Carter, 9; Custer, 13; Daniels, 1; Dawson, 1; Fallon, 7; Fergus, 25; Garfield, 37; Golden Valley, 5; McCone, 2; Musselshell, 36; Prairie, 4; Phillips, 2; Powder River, 6; Richland, 1; Rosebud, 35; Stillwater, 6; Treasure, 7; Yellowstone, 21; Valley, 5; Wheatland, 1.

The total number of cases has been 261 of which 246 have been outside Carbon County. Of the 25 which have occurred in Carbon County at least half represent new areas of infection or extension of old areas.

Reference to the year by year totals on the tabulation of eastern Montana cases shows two peaks of abundance seven years apart; one in 1915 (32 cases) and one in 1922 (48 cases). From the peak in 1915 cases decreased to 5 in 1918, then rose to the second peak in 1922, following which cases

again declined to 21 each year in 1925 and 1926. This variation in prevalence has been repeatedly noted by the writers in other sections of the northwest and is especially characteristic of the occurrence of Rocky Mountain spotted fever in sage brush plains areas. It occurs not only in large endemic areas but also in local foci. The intervals between peaks of prevalence is not constant, but is more regular over large areas than locally. In eastern Montana we are probably at a low point in one of these cycles just now, and increase in case prevalence beginning in 1927 is very probable.

ROCKY MOUNTAIN SPOTTED FEVER—EASTERN MONTANA PREVALENCE BY COUNTIES

1914 to 1926

County	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	
Blaine	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Big Horn	....	2	....	....	....	1	1	....	1	1	1	2	2	11
Carbon	2	3	1	4	2	1	1	....	3	3	2	3	....	25
Carter	....	4	....	....	....	....	....	....	....	2	2	....	1	9
Custer	....	6	....	....	....	....	....	....	1	....	1	2	3	13
Daniels	....	....	....	....	....	1	....	....	....	....	....	....	....	1
Dawson	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Fallon	....	....	....	....	....	....	....	....	2	....	3	1	1	7
Fergus	....	....	1	3	....	2	3	3	7	3	3	1	....	26
Garfield	....	5	3	1	....	....	1	1	7	11	4	1	3	37
Golden Valley	....	....	....	....	....	....	....	1	1	1	1	....	1	5
McCone	....	....	....	....	....	....	....	2	....	....	....	....	....	2
Musselshell	1	2	6	1	2	1	10	2	8	....	2	1	....	36
Prairie	....	1	....	1	....	....	....	....	....	....	2	....	....	4
Phillips	....	....	....	....	....	....	....	....	....	....	....	....	2	2
Powder River	....	4	....	....	....	....	....	....	....	....	2	....	....	6
Richland	1	....	....	....	....	....	....	....	....	....	....	....	....	1
Rosebud	....	3	....	....	1	1	1	5	4	8	3	5	4	35
Stillwater	....	....	....	2	....	....	....	....	1	....	3	....	....	6
Treasure	....	2	1	....	....	....	....	....	2	1	....	1	....	7
Yellowstone	....	....	1	1	1	....	....	....	9	....	5	2	2	21
Valley	....	....	1	....	....	....	....	....	....	....	1	2	1	5
Wheatland	....	....	....	....	....	....	....	....	....	....	....	....	1	1
	4	32	14	13	6	7	17	14	48	30	35	21	21	262

Note A: Two doubtful cases reported in 1904, one from Fergus and one from Park County.

Note B: Imported cases reported as follows: Golden Valley County, 1 from Idaho, 1917; Yellowstone County, 3 from Wyoming, 2 in 1917, 1 in 1922; Custer County, 1 from Nevada in 1921.

The mortality rate in eastern Montana has averaged about 15 per cent, but in 1926, it was 33⅓ per cent.

Western Montana. While the spread of infection in western Montana has not been as great as in the eastern section, it has, nevertheless, been considerable. Cases have been reported from nine new counties; Gallatin, Madison, Lewis and Clark, Broadwater, Jefferson, Powell, Meagher, Beaverhead, and Mineral, and a new endemic area has appeared just north of Missoula River, partly in Missoula and partly in Granite county.

Gallatin. Two cases were reported in 1915 from the Sixteen Mile Creek country in the northern part of the county. One case in the same district occurred in 1922.

Madison. Two cases were reported from between Wall and Horse Creek on the west side of the Madison River in 1917. A third case of unknown point of infection occurred in 1922.

Lewis and Clark. The first report was of three cases in 1920. Others have since occurred, as follows: 1 in 1921; 2 in 1923; 1 in 1924; and 1 in 1925. These have been much scattered, one being close to the northern boundary near Teton County.

Broadwater. The first case was in 1920. Cases have been reported as follows: 1 in 1920; 1 in 1921; 2 in 1923; 1 in 1924; 1 in 1926. The localities of infection indicate a wide distribution of the virus in nature.

Jefferson. Four cases have been reported, one each in 1922, 1923, 1925, and 1926. These have all been in the northeastern section of the county.

Powell. Only one case has been reported. This was in 1922. There is a strong probability that the tick causing this case, which resulted fatally, was brought in on lumber shipped from Bonner in Missoula county.

Meagher. A single case has occurred in Meagher county. This was in 1923, and was just over the line from Gallatin County. It doubtless represents an extension of infection from the Sixteen Mile Creek country.

Beaverhead. Two cases, both from Brown's Lake have been reported, one in 1924, the other in 1925.

Mineral. A single case occurred near Quartz in 1926.

The new focus of infection that lies partly in Missoula and Granite counties, is on the north side of the canyon of the Missoula River. It is of interest that all four cases that have occurred in this area have recovered, whereas in the old Rock Creek area lying just south on the other side of the Missoula River cases have been almost uniformly fatal.

ROCKY MOUNTAIN SPOTTED FEVER—PREVALENCE IN WESTERN MONTANA EXCEPT MISSOULA AND RAVALLI COUNTIES

1914–1926

County	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	
Beaverhead	....	....	....	....	....	....	....	....	....	....	....	1	1	2
Broadwater	....	....	....	....	....	....	1	1	....	2	1		1	6
Gallatin	....	2	....	....	....	....	....	....	1	....	....	....	....	3
Jefferson	....	....	....	....	....	....	....	....	1	1	....	1	1	4
Lewis and Clark	...	....	....	....	....	....	3	1	....	2	1	1	....	8
Madison	....	....	....	2	1	....	....	....	....	....	....	....	....	3
Meagher	....	....	....	....	....	....	....	....	....	1	....	....	....	1
Mineral	....	....	....	....	....	....	....	....	....	....	....	....	1	1
Powell	....	....	....	....	....	....	....	....	1	....	....	....	....	1
	....	2	....	2	1	....	4	2	3	6	2	3	4	29

Note A. 2 doubtful cases reported in 1904, one from Gallatin and one from Beaverhead County.
Note B. Imported case, reported as follows: Cascade County, one from Idaho in 1915.

It is possible, though unlikely that the single case in Mineral County in 1926, which resulted fatally, represents a northward extension of the Bitter Root area. There has been a very slow northward spread that has covered many years from the higher portions of the Bitter Root Mountains in Ravalli County. The northern limit of known infection at the present time is Deep Creek, in Missoula County.

DISCUSSION

The appearance of human cases of Rocky Mountain spotted fever within a short period in many new localities scattered over the vast extent of new territory reported above has naturally led to speculation as to where the infection came from, especially since this apparent spread has been without precedent.

The obvious explanation is spread from old endemic areas, the virus being carried in wood ticks borne by their animal hosts, wild and domestic. But if this means could accomplish its spread to new areas as easily and as rapidly as necessary to account for the conditions under discussion, then it is difficult to understand why it did not take place many years ago. Our observations have shown that the virus may spread from an endemic area by a pushing out of the old boundary to include new adjacent and favorable territory, but we have never had an atom of evidence that the mere introduction of a few infected ticks would result in establishing infection in a locality at any appreciable distance from the parent focus. In fact it is our opinion that it is only under the most unusual circumstances that new foci of wood tick infection can be thus established. There is no better example of this than the fact that infection has never crossed from the west side to the east side of the Bitter Root Valley, yet no one can doubt that infected ticks have repeatedly been carried across on wild and domestic animals during the many years that west side infection has existed.

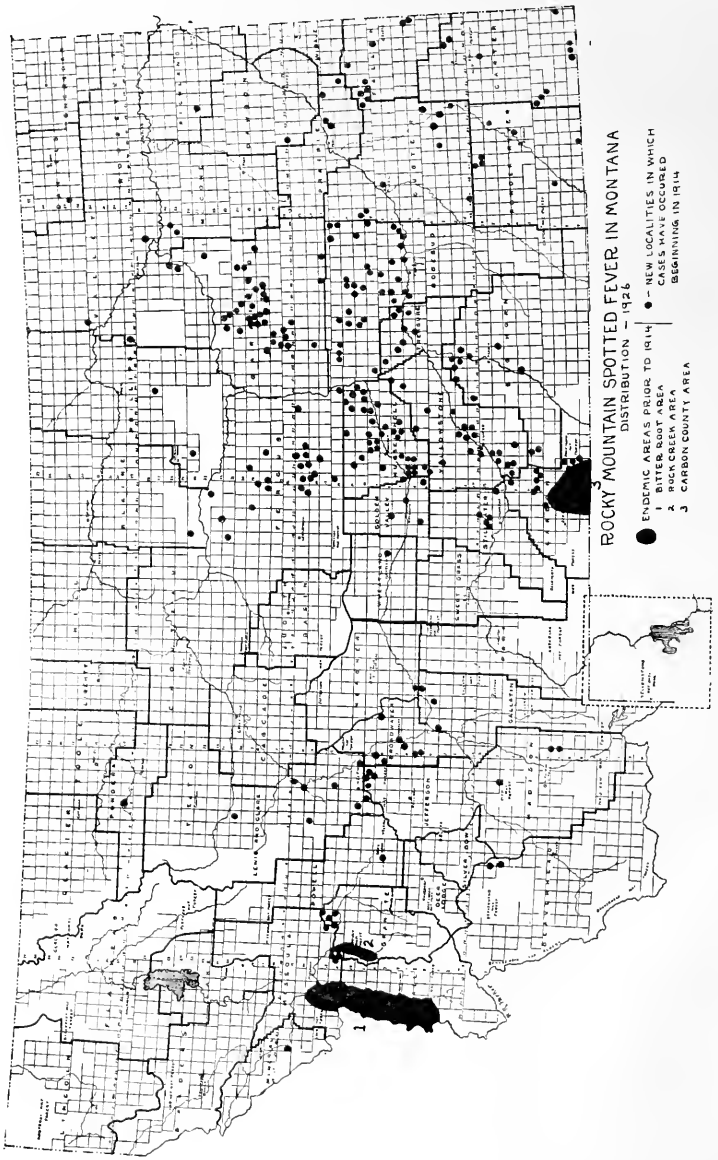
If we are correct, and the occurrence of human infection in the new sections cannot be satisfactorily accounted for by the introduction of wood tick infection, there is but one alternative, namely, that the virus has actually been present in the areas concerned for some years but that conditions have only recently become favorable for human infection. In favor of this hypothesis is the fact that all our field and experimental evidence indicates that the rabbit tick, **Haemaphysalis leporis-palustris,** is able to maintain the virus of Rocky Mountain spotted fever in nature independently of, and even in the absence of, the spotted fever tick. It does not bite man and hence in an area where this tick is the sole

transmitting agent, the virus of Rocky Mountain spotted fever could be present for years without evidence of its existence. The danger of human infection would only occur if the spotted fever tick, which is solely responsible for human infection, were introduced. It does not follow, however, that this danger would be immediate. As compared to the wood tick, the rabbit tick carries a very mild strain of spotted fever virus, and infected ticks collected in nature never cause severe infections in laboratory animals. Usually an immunity test of virus from a virulent strain is necessary before specific diagnosis can be made. It is, indeed, doubtful if the rabbit tick spotted fever virus is sufficiently aggressive to infect man. Therefore, following wood tick invasion of an infected rabbit tick area a considerable lapse of time might be necessary before human infection would occur. Rabbit ticks only infest rabbits, so that in an area infested solely by this tick the virus would be passing only through this one species of rodent. The wood tick, on the other hand, infests numerous species of susceptible rodents and the weak rabbit tick virus after being picked up by wood ticks would thereafter continually be passed through multiple susceptible species instead of only one, and it seems reasonable to believe that virulence or aggressiveness would gradually be built up in this way, until it finally reached the point of human infectiousness.

This idea, as just outlined, is admittedly hypothetical, but there is, nevertheless, considerable supporting evidence which cannot be detailed in this paper. Suffice it to state here that differences in the virulence of spotted fever virus in nature are amply proven by the differences in the virulence of human infection in the different portions of the northwest in which the disease is known to be endemic. It therefore requires no feat of the imagination to visualize still more mild strains in nature, so weak that they cannot cause human infection. That there may be a gradual stepping up of virulence in nature is indicated by reports from certain localities of gradually increasing virulence of human infection over a period of years. In a rough way, the relative virulence of the virus in different localities, as evidenced by the relative severity of human infection, seems to be in direct relation to the number of susceptible local species of host rodents, virulence increasing with increase of the number of susceptible rodents.

The conditions of this hypothesis agree especially well with known facts in the new large area of infection in eastern Montana. On a large portion of this area wood ticks are a relatively recent introduction; in fact, some sections are still uninfested. Conditions in the new western Montana

foci are far more complex than in eastern Montana, and less well understood, but there is no evidence which is opposed to the hypothesis of long resident infection prior to the first occurrence of cases in man.



PROPHYLACTIC VACCINATION AGAINST ROCKY MOUNTAIN SPOTTED FEVER

By

R. R. Spencer, Surgeon, and R. R. Parker, Special Expert, United States Public Health Service.

(Cooperating with Montana State Board of Entomology)

During the past four years the United States Public Health Service, in cooperation with the Montana State Board of Entomology has been engaged in the preparation and testing of a prophylactic vaccine for use against Rocky Mountain spotted fever.

The vaccine is a phenolized virus prepared from the tissues of infected wood ticks **(Dermacentor andersoni Stiles).** Following the demonstration of its value for the prevention of infection in guinea pigs, rabbits, and monkeys, its harmlessness for the vaccination of man was determined by its use, in 1925, in a small group of 34 persons. [1] [2]

During the season of 1926, the vaccine has been used experimentally, on as large a scale as supply permitted, for the prevention of human infection both against the virulent Bitter Root Valley type and the mild southern Idaho type. The dosage has been purely arbitrary. For adult administration two injections of 2 c. c. each were given, which is equivalent to the phenolized virus content of four adult ticks fed three days, the average live virus content per tick being 5,000 to 10,000 minimal infectious doses for a guinea pig. The results have been distinctly encouraging and suggest full protection against the mild southern Idaho type and partial protection, with sufficient modification to insure recovery, against the Bitter Root Valley type.

1. Spencer, R. R., and Parker, R. R., Rocky Mountain Spotted Fever: Experimental Studies on Tick Virus; Public Health Reports, Vol. 39, No. 48, Nov. 28, 1924, pp. 3027-3040; Reprint No. 976.

2. Spencer, R. R., and Parker, R. R., Rocky Mountain Spotted Fever: Vaccination of Monkeys and Man; Public Health Reports, Vol. 40, No. 41, Oct., 1925, pp. 2159-2167.

TULARAEMIA AND ITS OCCURRENCE IN MONTANA

By

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United States Public Health Service.

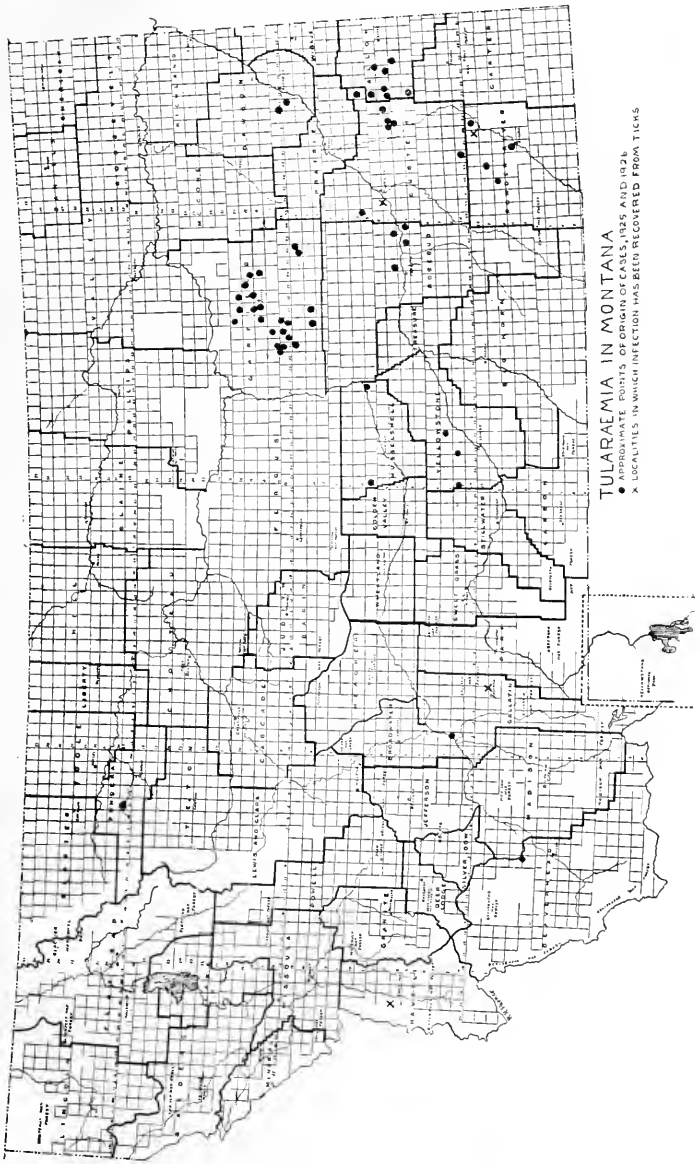
(Cooperating with the Montana State Board of Entomology)

Tularaemia is a specific infectious disease. Although it has undoubtedly been present in Montana for many years, its presence was first established in 1923 by its recovery from wood ticks **(Dermacentor andersoni)** collected in the Bitter Root Valley. Diagnosis of the first reported human case was made in the spring of 1925 by Dr. Pfunder of Miles City. During 1925 and 1926, fifty-five cases have been reported.

This paper gives a summarized account of the general information concerning this disease, followed by slightly more detailed record of what is known of its occurrence in Montana.

The disease was first described as a specific infection by Surgeon G. W. McCoy of the Public Health Service who discovered it as a plague-like disease in the California ground squirrel **(Citellus beecheyi)** in 1910, in the course of routine examination of these rodents for lesions of plague. In 1912, McCoy and Chafin described the infectious agent as **Bacterium tularense.**

There are records of human infection from Arizona in 1907, Utah in 1911, and two laboratory cases at San Francisco in 1911. The specific identity of these cases, however, was not then suspected. The first specific diagnosis was in an Ohio case which occurred in 1914. Our real knowledge of the disease as a human infection, however, dates from 1919, when Dr. Edward Francis, of the Public Health Service, began an investigation of a deer fly borne disease in man in Millard county, Utah, which he was able to identify with the plague-like infection found by McCoy in the California ground squirrel in 1910. Since that time he has devoted his entire time to the study of tularaemia, and to him we are indebted for most of our present information of this disease and the bringing together of a rapidly growing literature into concise form.


TULAREMIA IN MONTANA
● APPROXIMATE POINTS OF ORIGIN OF CASES, 1925 AND 1926
X LOCALITIES IN WHICH INFECTION HAS BEEN RECOVERED FROM TICKS

DISTRIBUTION

Tularaemia is thus far only known from the United States and Japan. In the United States human cases have been reported from the following twenty-nine states: Arizona, New Mexico, Oregon, Idaho, Utah, Wyoming, Nevada, Colorado, Iowa, Kansas, Arkansas, Montana, Missouri, Minnesota, Kentucky, Pennsylvania, Texas, Tennessee, Mississippi, Ohio, Indiana, Illinois, Georgia, North Carolina, South Carolina, Maryland, Virginia, West Virginia and Florida. They have also occurred in the District of Columbia. In California, infection has been found in ground squirrels and rats, but no naturally infected cases in man have yet been reported.

TULARAEMIA IN NATURE

The studies on tularaemia have shown that it is a disease of nature, its maintenance and perpetuation being entirely independent of human infection, which is of accidental nature. Primarily it is a disease of wild rodents. Its continuity is maintained by transmission from rodent to rodent by blood sucking parasites and by carriage over the winter in certain of these parasites, perhaps by other means as well.

It is likely that all species of rodents are susceptible to greater or less degree. The course of infection may be acute, subacute, or chronic. Jack, cottontail and snowshoe rabbits, ground squirrels and rats have been found infected in nature, anl all other wild rodents whose susceptibility has thus far been tested in the laboratory have become infected. In most of them it is highly fatal.

There is far more evidence of the prevalence of infection in wild rabbits than in other rodents, probably because man comes in contact with rabbits far more frequently, due to their use as food for man and other animals and other purposes. Certain it is that rabbits have thus far proved the most common source of human infection.

Little is known of the natural occurrence of infection in other rodents. In California since 1910, it has repeatedly been recovered from California ground squirrels from over a wide area, and in 1925, from three wild rats trapped in the city of Los Angeles.

Still less is known of its occurrence in animals other than rodents. In experiments performed at Hamilton with coyotes following a human case due to a coyote bite, it was shown that coyotes are susceptible and will acquire infection by eating infected rabbits, which in young animals, at least, may result fatally. Francis has shown opossums to be susceptible. Cats and possibly dogs may acquire mild in-

fections from eating tissues of infected animals. It is therefore evident that some carnivorous animals are susceptible and may acquire infection of greater or less severity by eating infected rodents. Of the large domestic animals, sheep and goats are mildly susceptible.

The parasites actually known to be concerned in transmission of infection among rodents are the wood tick (Rocky Mountain spotted fever tick), **Dermacentor andersoni,** and the rabbit tick **Haemaphysalis leporis-palustris.** They were first incriminated through studies made at Hamilton. Both these ticks are true biological hosts of the infectious agent, **Bacterium tularense.** The former is largely confined to the Rocky Mountain region. The larvae and nymphs are found on numerous species of rodents, the adults mostly occur on large animals, wild and domestic, but are also numerous on jack rabbits in sage brush areas. It is a frequent parasite of man. The latter, except that it is not infrequently found on birds (game birds are quite commonly infested) occurs only on rabbits, especially cottontails and snowshoes. Snowshoe rabbits particularly are heavily infested, hundreds of them often being present on a single animal. On jack rabbits they are less numerous, doubtless due solely to the different habitat conditions of this host. It is quite generally distributed throughout the United States. It rarely bites man. Both are three host ticks, that is, the larvae, the nymph and the adult all feed on separate individual hosts. Infection acquired as larvae or nymphs is passed on to the adult and can be transmitted to a rodent host by any stage that follows the one in which infection was acquired. In the case of the wood tick certainly, and probably the rabbit tick as well, infected female ticks may transmit infection through their eggs to the following generation.

Besides these parasites, others are doubtless concerned. Francis has found, in laboratory experiments, that the biting rabbit louse, **Haemodipsus ventricosus,** will transmit infection from rabbit to rabbit and the mouse louse, **Polyplax serratus,** will carry it between mice. He has further found that the deer fly, **Chrysops discalis,** carries infection from jack rabbits to man but it is not certain that it conveys it from rabbit to rabbit. McCoy experimentally transmitted infection between California ground squirrels by the squirrel flea. **Ceratophyllus acutus.** There are many species of biting lice and flees that infest rodents and it is very probable that some at least are natural carriers of infection and play a part along with ticks in maintaining the continuity of the organism in nature.

TRANSMISSION TO MAN

Records of 281 cases have shown that there are several means by which man has acquired infection.

I. By the contamination of the hands (less commonly of other exposed parts of the body) or the conjunctival sac with the tissues or body fluids of infected rabbits or ticks, or with tick excreta.

2. By the bite of an adult wood tick **(Dermacentor andersoni)** which, in some preceding stage, has acquired infection from an infected host.

3. By the bite of a deer fly, **(Chrysops discalis)**, which transmits infection mechanically, its mouth parts having become contaminated by previously biting an infected jack rabbit.

4. By the bite of an animal which is either itself infected or which transmits infection mechanically by teeth or mouth contaminated by eating an infected rodent.

Contamination.—This is the most frequently reported means of human infection. The most common source is the tissues of infected jack or cottontail rabbits. In the east where infection of man by parasites is not known, cottontail rabbits, purchased in the market or shot while hunting and prepared for the table, have caused numerous cases. The disease has been known for some years as "rabbit fever" among market-men who dress rabbits for sale. November, December and January, the months during which rabbits are on sale in the markets, are the months in which infection is most frequent east of the Mississippi. In the western mountain states, jack rabbits are more commonly the source of contamination. Cases so contracted occur most frequently during the spring and summer.

In most cases infected by contamination, the causative agent is introduced through an abrasion on the hands. In a minority of such cases, however, no abrasion is present and it is probable that infection has passed through the unabraded skin. Contamination of the conjunctival sac is by no means infrequent, the hand or fingers carrying infection to the eye. In the northwest several instances of infection in this way have followed the handpicking of wood ticks from domestic stock, the fingers carrying to the eye tick excrement or the tissues of a crushed tick, both of which are highly infectious.

Wood Tick Transmission.—Although the possibility of human infection by **Dermacentor andersoni** was first suggested only in 1924, cases so called have already been reported in Montana, Wyoming, Idaho, and Utah It is only

of importance in the western states within the limits of its natural range. Infection is acquired by the larval or nymphal tick and passed on to the adult stage which alone will bite man, or it may even be passed on from one generation to the next. The infective bite may occur on any portion of the body but in most instances thus far reported it has been on the lower extremities. It is not known whether it is the bite of the tick which infects, or if it is the getting into the bite wound of the highly infectious excrement. Perhaps both are concerned. Tick caused cases occur during the season of greatest adult wood tick activity, i. e., from March to June, inclusive. Sometimes ticks remain active into July and August but always in relatively small numbers. Judging from the evidence to date, the most acute danger of wood tick infection is in the sage brush plains sections where jack rabbits, a potent source of tick infection, abound.

Deer Fly Transmission.—The possibility of infection by the deer fly, **Chrysops discalis**, is, like that of infection by the wood tick, limited to the natural range of this parasite. It is much more spotted in its distribution than the wood tick because of its breeding habits; swampy ground is essential. It occurs in parts of California, Oregon, Utah, Idaho, Montana, Wyoming, Colorado, and North Dakota. Deer fly borne infection has been reported from Oregon, Utah, Idaho, Wyoming, Colorado and Montana. Whereas the wood tick may bite any part of the body, the deer fly usually only bites exposed portions, most often the head and neck. Deer fly infection has been reported during the months of June, July, August and September.

Bites of Animals.—This is not a common source of infection. Only three cases thus infected have been reported. One was bitten by a coyote, one by a ground squirrel, and the third by a hog. In the last case, the hog not itself susceptible, is supposed to have previously eaten a rabbit, many of which were dying in the locality concerned, with a resulting mechanical transfer of infection. Coyotes and ground squirrels are both susceptible. The salivary glands of infected coyotes contain the bacterium and resulting infection in the mouth could doubtless cause infection in a person bitten, but mechanical transfer from an infected rabbit recently devoured, as in the case of the hog, is also likely.

THE DISEASE IN MAN

Tularaemia in man follows a subacute course that sometimes approaches chronicity. Clincial manifestations have resulted in the distinguishing of two principal types, the **glandular** and the **typhoidal.** The course of infection is much the same in both. In the glandular type, into which most cases fall, there is an enlargement of certain of the regional lymph gland which may or may not proceed to suppuration. A primary lesion indicating the site of infection is usually present, but is absent in a minority of cases. Infection occurs by contamination of the conjunctival sac, the primary lesion is a conjunctivities which is accompanied by enlargeemnt of the regional lymph glands of the same side of the head. If elsewhere, the primary lesion is a papule which later becomes an ulcer of the skin and is accompanied by an enlargement of the lymph glands which drain the site of infection.

In the typhoidal type, there is no enlargement of the regional lymph glands or any evidence of a primary site of infection. Most cases of this type have occurred among laboratory workers.

The average incubation period is about three days, but may be as short as one day or as long as nine.

The onset is usually sudden and is characterized by headache, chills or chilly sensations, muscular pains, vomiting, sweating, fever and prostration.

The usual febrile period is two or three weeks, but may be much longer. There is an initial fever which lasts one to three days. This is followed by a remission of one or more days duration which is accompanied by general amelioration of symptoms. A secondary rise of temperature follows, then a gradual decline to normal. Prostration is marked and there is a continually increasing weakiness. A skin eruption is present only in small percentage of cases. If present, it is most frequently confined to the upper portion of the body. Its character is not constant, and it may be popular. Only eight deaths have been reported, or less than 3 per cent of recorded cases.

Convalescence is slow and if the course of infection is at all severe it is usually several months before the patient is able to perform full time work. Return to normal health may require a year or even longer in extreme cases. Relapses, eight months after the original infection, have occurred in cases of the typhoid type.

Tularaemia has been confused with glanders, typhoid fever, influenza, septic infection, sporotrichosis, undulant fever, glanders, and tuberculosis.

Diagnosis may be confirmed by an agglutination test Blood for this test should not be taken before the middle of the second week of illness, agglutinins being absent during the first week. Agglutinins are persistent and have been demonstrated in the blood as long as eighteen years after recovery.

NATURAL OCCURRENCE OF TULARAEMIA IN MONTANA

Since tularaemia is maintained and perpetuated in nature independently of man, it is of interest to record what is known of the natural conditions under which it occurs in Montana. Since it is primarily a rodent infection we are fundamentally interested in the kinds of rodents that are susceptible. As a matter of fact, it is probable that all Montana rodents are susceptible in greater or less degree. The following list, however, includes only those species that have either been found infected in nature or have been proven susceptible by laboratory tests.

White tailed jack rabbit, **Lepus campestris**
Cottontail rabbit, **Sylvilagus nuttalli**
Snowshoe rabbit, **Lepus bairdi**
Woodchuck, **Marmota flaviventer**
Mountain rat, **Neotoma cinerea**
Yellow-bellied chipmunk, **Eutamias b. luteiventris**
Pine squirrel, **Sciurus h. richardsoni**
Porcupine, **Erethizon epixanthus**
Deer Mouse, **Peromyscus m. artemisiae**
House mouse, **Mus musculus**

To all these rodents the disease is highly fatal, death occurring a few days after infection.

In Montana, the jack rabbit is by far the most important rodent concerned. It is one of the most common sources of human infection because of the frequency with which it is used for human food and for other purposes. Cottontails and snowshoes are not less dangerous but are less commonly used, snowshoes quite rarely. Tularaemia is frequently, at least, the cause of the epidemics which periodically decimate rabbits populations. They are sometimes local and sometimes they involve large areas. It is during these epidemics that the danger is greatest and that infection in man is most prevalent. Besides human infection, the deaths of cats, dogs, and chickens following the eating of rabbits

killed during these eqidemics have been reported in the state, but it is not clear that tularaemia was the inciting cause, since in the dogs and cats at least, laboratory evidence thus far has only indicated mild susceptibility.

One must next turn to the parasites that spread infection among these rodents for it is the combination of the two which results in the perpetuation of the disease. Both species of ticks known to carry infection are numerous in Montana. One, the common Montana wood tick, **Dermacentor andersoni,** which has already acquired an evil reputation as the carrier of Rocky Mountain spotted fever and the cause of tick paralysis, not only infests all the known susceptible rodents but also many other species whose susceptibility is probable. It is an important parasite of rabbits and in sage brush areas where jack rabbits and ticks abound, is a frequent cause of human infection.

The rabbit tick, **Haemaphysalis leporis-palustris,** is another important carrier. Its importance, however, as previously brought out, is purely in relation to the part which it plays in the natural maintenance of the disease since it rarely bites man. It infests only rabbits and game birds, [1] [2] but is often present in enormous numbers.

As previously noted it is less numerous on jackrabbits than on cottontails and snowshoes. An uninfested rabbit during the spring and summer months is uncommon.

It seems certain that natural infection is widely distributed in the State. Thus far there is evidence of its prevalence in the following localities; the Bitter Root Valley and adjoining mountains, Gallatin and Madison counties, and over a large portion of eastern Montana.

The first evidence of infection in the State came from the Bitter Root Valley and adjoining mountains when the infection was recovered from wood ticks which had been injected into guinea pigs in the course of routine tests for the presence of the virus of Rocky Mountain spotted fever. In this area it has been repeatedly recovered from wood

1. What may have been a case of tularaemia following the bite of a rabbit tick occurred in the practice of Dr. Weldon of Lewistown, in 1923. This is the only record of this tick biting man in Montana. The patient, Mrs. G., had dressed a grouse shot in the Judith Mountains on September 29 and became ill on October 1, with chills and rather marked aching over entire body.

2. Game birds are probably susceptible to tularaemia. A joint investigation by the U. S. Public Health Service and the Bureau of the Biological Survey to determine the relationship of tularaemia to epidemics of unknown cause occurring among grouse is being carried on at Hamilton laboratory. Recent tests indicate their susceptibility, and therefore point to the dressing of grouse as another possible source of human infection.

ticks, rabbit ticks and snowshoe rabbits. Although no cases in man have thus far been reported, the evidence of local physicians is suggestive that they have occurred.

Wood ticks collected from Owl Canyon, near Bozeman in Gallatin county, in April 1925, proved heavily infected. Guinea pigs and Belgian hares on which these ticks were fed died to tularaemia. Infection in these lots of ticks was entirely unexpected and was the direct cause of three laboratory cases. During the summer of 1926, infection in the vicinity of Logan was proven by the occurrence of a case in a section laborer treated by Dr. A. R. Foss, of Missoula. This man had been bitten by a deer fly.

In November 1926, Dr. H. F. Carmen of Butte, reported a case which originated near Reichel in Madison County. The sourse of infection was not determined.

In eastern Montana, there has been the most evidence of a widespread distribution of infection in nature. During both 1925 and 1926, a high mortality among jack rabbits which began following the appearance of ticks in the spring was reported. That tularaemia was rampant among them was shown by the fact that a considerable portion of the cases occurring in the same area resulted from the handling or cutting up of these rabbits. High jack rabbit mortality associated with the known prevalence of tularaemia among them has in other instances (notably in Utah and New Mexico) been coincident with epidemics of human cases. Reports further told of greater numbers of ticks noted on dead rabbits, and it is certain that they played an important part in the occurrence of the disease among them. Ticks also caused a considerable number of human cases. Tick caused human cases and the mortality among tick infested rabbits, however, was not the only evidence of infection in ticks. As the result of an investigation of reported "tick paralysis" in sheep in this area, made in conjunction with the Montana Livestock Sanitary Board, tularaemia infection was recovered from ticks collected from sheep of several widely separated bands. In each instance the sheep concerned were "down with ticks" and supposed to be affected with tick paralysis. Of one lot of ticks collected from two sick ewes, from Calabar, a minimum of 50 per cent were found infected. Infection in coyotes in this same area was indicated by a human case treated by Dr. Garberson of Miles City, in which all evidence pointed to a coyote bite as the source of infection. Infection in Richardson ground squirrels was indicated by another case, treated by Dr. Pigot of Roundup, in which the bite of a ground squirrel of this species was the cause of infection.

TULARAEMIA IN MAN IN MONTANA

During the season of 1925 and 1926, fifty-five cases of tularaemia have been reported in Montana, all but 2 being in the eastern part of the State. These are exclusive of 6 cases of laboratory infections which have accurred at Hamilton. Twenty-three of these cases have been in Garfield County, 4 in Powder River, 7 in Custer, 4 in Rosebud, 2 in Musselshell, 7 in Fallon, 2 in Dawson, 3 in Yellowstone, and one each in Gallatin and Madison. For one case the locality of infection is unknown except that it was in eastern Montana.

Of the total cases, 18 have been reported by Dr. B. C. Farrand of Jordan, 14 by the Miles City Clinic, (Drs. Garberson, Pfunder and Winter), 3 by Dr. W. H. Blackmore of Baker, 9 by Dr. G. H. Crary of Ismay, 2 each by Drs. W. R. Morrison of Billings and E. S. Murphy of Glendive and one each by Drs. A. R. Foss of Missoula, S. E. Light and W. H. Young of Glendive, V. L. Oler of Billings, C. T. Pigot of Roundup, G. T. Hayward, Forsyth, and H. F. Garman of Butte.

For 47 of these 55 cases the diagnoses have been confirmed by agglutination tests.

Thirteen cases were definitely due to ticks and in 10 others tick bite or contamination by tick tissues or excreta was the probable source. Of the latter group 4 were engaged in handling sheep. One of these four definitely recalled pricking the fingers on burs which were being removed from a ewe's wool and all had primarly lesions of the hands and all denied having handled or cut up rabbits. The handling of the wool on sheep might easily result in introducing infection into an abrasion, since the highly infectious tick excrement is held by the wool. Sheep sometimes crush ticks by rubbing to allay irritation and such crushed tissue could also cause infection. Three of the definite tick cases were primary infections of the eye. They occurred in persons who had been handling ticks from horses or cattle, and who, by rubbing the eye with the hand, had contaminated the conjunctiva either with tick tissue or excreta. These tick caused cases occurred in the months of March, April, May, June, and July, the largest number having been infected in May.

Fourteen cases were definitely due to the handling or cutting up of infected rabbits, and 2 other cases were probably thus infected. In two instances 3 cases resulted from handling a single rabbit, in one 3 brothers cut up a jack rabbit, and in the other 3 persons used the flesh of the same

rabbit for fish bait. Two rabbit caused cases were primary eye infections. June, July, August and October were the months in which these cases were reported.

Two cases were caused by the bites of animals and have been previously referred to. One was infected by a coyote, the other by a Richardson ground squirrel.

Deer fly bites are apparently a less frequent cause of infection in Montana than in certain other northwestern states. Only one case definitely so caused has been reported. This man was bitten near Trident in Gallatin county. The species of deer fly concerned is not known. One case reported from Billings was supposed to have been due to the introduction of crushed fly tissue into the eye. There was no information to suggest what kind of fly was concerned, but **Chrysops discalis**, the species concerned in Utah and other sections is known to occur locally.

For 6 cases the primary lesion occurred at the site of abrasions on the hand caused as follows: One by briar pricks, one by sage brush, one by splinters (both hands infected), one (railroad employee) by the corner of an old trunk, and two by barbed wire. None of these gave history of contact with rabbits or of tick bites, and there was no evidence of the means by which infection was introduced introduced into the abrasions. Another case had a primary lesion on the dorsum of the left foot, but cause of abrasion and source of infection were not determined. For seven other cases there is even less information.

CONTROL WORK: ROCKY MOUNTAIN SPOTTED FEVER CONTROL DISTRICTS, BITTER ROOT VALLEY, FOR THE PERIOD JANUARY 1, 1923, TO DECEMBER 31, 1926.

By

F. J. O'Donnell, Field Agent
Montana State Board of Entomology

As there was no published report of the State Board of Entomology for the biennium ending December 31, 1924, this report of the control work, therefore covers the period January 1, 1923, to December 31, 1926. During the first thirteen months of this period, that is, January 1, 1923, to February 29, 1924, the control work was in charge of Mr. W. E. Pollinger. The writer took charge March 1, 1924, with R. R. Parker, Special Expert, U. S. Public Health Service, serving in an advisory capacity.

The control program for the past four seasons does not differ essentially from the program as outlined in the Fifth Biennial Report of the Board of Entomology (1921-1922), with the exception that the quarantine regulations have not been enforced, and is briefly as follows:

Rodent control is given first consideration, both because it is the control measure which can be most effectively applied under present working conditions and at the same time affords a considerable degree of protection to the residents of the agricultural section of the infected area. Dipping is second in importance. Other measures such as grazing control, hand picking of stock and quarantine, etc., have been dropped temporarily for the reason that sufficient funds have not been available to properly enforce them.

RODENT CONTROL

Rodent control work is confined largely to the extermination of the Columbian ground squirrel as this rodent is by far the most numerous of the immature tick hosts, and is also most difficult to exterminate. Ground hogs or woodchucks, while being considerably less of a factor as tick hosts, because they are relatively few in number in the control area as a whole are, nevertheless, a potential menace in these areas where they are more or less abundant, and for this reason a special effort is made to exterminate them. Rabbits, chipmunks, and other rodents are also baited where it is convenient to do so. Two poisonings are required each season; one in the early spring when the rodents first become active, and a second in June following the appearance of the young rodents.

The boundaries of the control districts up to and including 1921, extended from the Missoula-Ravalli county line on the north to Lost Horse Creek south of Hamilton. In 1922, a control district was created in Missoula County. In 1923, the southern boundary of the control district was extended from Lost Horse Creek to Burnt Ridge south of Darby, and in 1925 a narrow strip of land on the west bank of the Bitter Root River, extending from the Missoula-Ravalli county line to a point west of Hamilton, which had been released by the Board in 1917, was again included within the control area, thus making a continuous control area extending from Burnt Ridge on the south to the Big Flat north of Missoula, a distance of about 69 miles, varying in width from three to seven miles and embracing an area of 212,180 acres on which active control work is performed.

In order to systematically carry on the rodent control work the area has been divided into districts as follows: Darby North, Darby South, Gold Creek, Hamilton, Victor, Stevensville, Florence, and Missoula County. These districts are then grouped with one district supervisor in charge of each of the following groups: Darby North, Darby South, and Gold Creek; Hamilton and Victor; Stevensville and Florence; and Missoula County. The area in charge of each supervisor varies from 3 to 7 miles in width and from 13 to 18 miles in length.

It is the duty of the supervisor to employ a sufficient number of suitable field men to properly poison the infested lands in his district. It is also his duty to supervise and direct the field men, to establish and move camp when necessary, to transport field men to and from their work when transportation is necessary, to see that field notes are properly made by the poisoners relative to the amount of poison and labor expended on each parcel of land treated, to establish contact with the resident land owners or renters in his district, to inspect land both before and after treatment, to supervise stock dipping operations, to file a weekly report with the Hamilton office, and to attend to such other matters as may arise in his district pertaining to control work. The supervisors are employed by, and are directly responsible to the Field Agent in charge at the Hamilton field Station. They receive a definite monthly salary, and must be equipped with a suitable car for transporting men, moving camp, etc., for which they receive a fixed monthly allowance. The men employed to do the actual field work, or poisoning, are active, trustworthy young men, and are generally familiar with the area in which they are working. The field crews are usually quartered in camps established by the supervisor, conveniently located adjacent to or within the area to be treated. The camp equipment, tents, stoves, dishes, etc., are furnished by the Board. The active work of poisoning is accomplished by the field men by placing the poisoned grain at or near the rodent burrow, or, when calcium cyanide is used, this material is placed into the burrow.

The rate of pay for the field men is fixed by law at $3.50 for an eight hour day, or $0.4375 per hour, and the field men average between nine and ten hours per day in the field. There is an average of about twenty field men employed each season.

The method of financing the rodent control work in Ravalli County during the past season (1926) differed somewhat from the method used during the season just preceding. For the year 1919 to 1922, inclusive, the full cost of

poison and labor was charged against the land; from 1923 to 1925, inclusive, one-third of the expense was borne by the land owners, and two-thirds jointly by the County and State. This plan was not satisfactory for the reason that many of the land owners availed themselves of a provision in the law—Chapter 27 Sessions Laws, 1919—which gives them the privilege of poisoning their own land and thereby avoiding payment of the additional tax. Land thus poisoned frequently had to be re-poisoned by the State, as the land owner seldom does thorough work, and the work was not done at the time when it would be most effective. This plan was also unsatisfactory in that it required a large amount of detailed records on the part fo the field men, (the poisoners), and a great deal of office work and expense were involved in preparing maps showing each individual land holding in the control area, in maintaining up-to-date files of land ownership and areas, and in preparing cost summary data for the county assessment roll. With these facts in mind, it was therefore decided to take the matter up with the Commissioners of Ravalli County with the request that the county appropriation for rodent work be increased so that it would not be necessary to assess any part of the expense directly against the land treated. The Commissioners acted favorably in the matter, and made an appropriation from the County general fund, thereby relieving the land owner of a direct rodent tax. This change in the method of financing the rodent control work created a much better feeling among the land owners toward the control program as a whole, resulted in better cooperation, and therefore much more effective control work.

In Missoula County rodent control has been on the same basis as during the preceding biennium; that is, a part of the funds for labor and material has been appropriated from the general fund of the county, supplemented by funds from the State. There is, therefore, no direct charge made against the land. The general plan of rodent control is the same as in Ravalli County and is in direct charge of the Field Agent of the Board of Entomology.

The following table summarizes the rodent control work for the years 1923 to 1926, inclusive. The years 1919 to 1922, inclusive, are for comparative purposes.

STATE BOARD OF ENTOMOLOGY

SUMMARY COLUMBIAN GROUND SQUIRREL CONTROL, RAVALLI AND MISSOULA COUNTIES

(TABLE NO. 1) RAVALLI COUNTY CONTROL DISTRICTS

Year	County Revolving Fund	County Appropriation	Poisoned Once Acres	Poisoned Twice Acres	Poison Quarts	Labor Hours	No. of Baits Used	Average Baits the Acre	Average Cost per Acre per Treatment	Additional Poison Distributed Qts.	Calcium Cyanide Distributed Lbs.	Re-poisoning
1919	$3,500	.....	44,396.50	40,547.3	2,798.	4,283.	266,611.	3.17	.0378	1,204.5	.....	.....
1920	3,000	.....	48,299.	40,983.	2,308.	4,395.	209,521.	2.35	.0329	522.3	.....	151.
1921	2,250	.....	48,456.8	38,331.	3,025.5	3,703.	242,032.	2.79	.0292	515.	.....	200.
1922	2,400	.....	41,749.	44,401.	4,760.	4,091.	380,800.	4.42	.0318	1,197.	.....	344.
1923	2,500	.....	42,498.61	35,321.32	3,886.57	4,172.85	280,925.6	3.61	.0334	1,200.	.....	579.5
1924	2,000	$1,500	56,405.1	41,215.42	3,233.27	5,455.64	258,661.6	2.65	.03209	2,212.25	1940	172.5
1925	2,000	1,500	68,029.8	50,133.67	6,704.	5,883.028	480,200.	4.063	.0343	1,451.71	.....	.....
1926	.....	3,000	85,043.28	65,388.31	8,178.37	7,840.08	654,270.	4.32	.0334	3,091.	1088	.....
RAVALLI COUNTY Farms Between Control Districts and Bitter Root River												
1920	.....	.....	15,460.5	.....	819.5	828.5	75,021.	4.85	.0393	152.	.....	.....
1921	.....	.....	16,040.	.....	1,081.	1,091.	86,480.	5.39	.0473	137.	.....	.....
1922	.....	.....	3,160.	.....	612.5	249.	49,000.	15.80	.0713	373.	.....	45.
1923	.....	.....	790.	.....	161.	48.48	12,880.	16.3	.0676	279.	.....	.....
*1924	.....	.....	7,091.18	.....	309.5	278.25	24,760.	3.49	.0252	312.75	460	.....
MISSOULA COUNTY CONTROL DISTRICTS												
1920	.....	.....	750	9,670.5	8,930.5	881.	901.	40,905.	2.19	.0308	82.	.....
1921	.....	.....	500	8,301.	8,223.1	241.9	555.5	17,352.	1.058	.0198	127.	.....
1922	.....	.....	3,000	66,532.	56,070.	6,056.	4,811.	484,480.	3.91	.0231	291.	.....
1923	.....	.....	2,300	66,739.	54,432.	2,570.	3,543.5	205,600.	1.614	.01704	.....	.....
1924	.....	.....	2,000	69,915.	51,431.	1,370.	3,039.5	109,600.	.8207	.0132	556.5	300
1925	.....	.....	2,000	58,520.	36,042.	2,189.	4,130.50	157,000.	1.66	.0242	.....	.....
1926	.....	.....	2,000	65,280.	51,538.	1,586.	3,979.50	161,248.	1.37	.0283	122.	1074
		Federal Appropriation			**RAVALLI COUNTY—Federal Lands in Control Districts**							
1921	.....	.....	292.21	6,680.	.....	233.	.....	.....	.....	.04375	.....	.....
1922	.....	.....	308.96	6,640.	.....	448.	.....	.....	.....	.04653	.....	.....
1923	.....	.....	190.16	6,840.	6,480.	235.50	327.	18,740.	1.30	.025	.....	.....
1924	.....	.....	213.13	6,920.	1,440.	162.50	390.	13,000.	1.79	.024	.....	.....
1925	.....	.....	49.87	2,360.	1,080.	137.5	188.75	11,000.	3.19	.0319	.....	.....
1926	.....	.....	31.60	960.	560.	76.5	81.5	6,120.	4.00	.0334	.....	.....
NATIONAL FOREST—Ravalli County												
1921	.....	.....	803.40	35,000.	.....	777.	.....	.....	.....	.0229	.....	.....
1922	.....	.....	493.15	40,000.	.....	671.	.....	.....	.....	.01232	.....	.....
1923	.....	.....	1,063.00	24,936.	.....	1,017.	1,802.	81,360.	3.25	.0397	.....	.....
1924	.....	.....	344.87	17,894.	.....	534.50	983.75	42,760.	2.39	.03	.....	.....
1925	.....	.....	488.88	32,400.	2,580.	810.50	1,211.25	64,840.	1.85	.0226	.....	.....
1926	.....	.....	465.40	22.360.	.....	813.	1,136.	65,040	2.90	.0295	.....	.....

*Placed in Ravalli County Control Districts, March, 1925.

DIPPING

Although stock dipping is recognized as an important and effective accessory control measure, it has not been compulsory since 1921. This has been due largely to insufficient funds, and inadequate dipping facilities.

An inspection of the vats in the spring of 1924, showed that all of them needed more or less repairing. The O'Brien Creek vat which is constructed of heavy galvanized iron, has been crushed by a ground movement and rendered useless in its present location. No attempt has yet been made to repair it. The Florence vat which is also of galvanized iron construction was found to be open at the seams, due to ground pressure but was repaired at a relatively small cost and again placed in service. Repeated efforts made to repair leaks in the Stevensville and Blodgett Creek vats, which are of concrete construction, proved useless, and the Stevensville vat was therefore not used during the season of 1924. A galvanized iron lining was installed in the Blodgett Creek vat and it was made serviceable for the 1924 season. In February 1925, a similar lining was installed in the Stevensville vat. The Victor vat was in a leaky condition, but with some temporary work was in service for a part of the 1924 season. A galvanized iron lining was also installed in this vat early in 1925. The Gold Creek vat, of concrete construction, has developed some slow leaks which permit ground seepage into the vat, thereby diluting the dip solution and rendering it useless. It is hoped that funds will be available to install a lining in this vat before the next season. Dipping pens, chutes, corrals and fencing at all of the vats were in a poor state of repair, and several were unfit for use. These conditions have gradually been improved until they are all now serviceable. It is, however, necessary to do considerable repairing each spring before the dipping season begins.

Experience has shown that to be most effective dipping must be done at not greater than ten day intervals and that usually the stock should be dipped at least three times each season. The actual number of dippings, however, depends; (a) on the season, whether early or late; (b) the length of time during which ticks are active; (c) whether cattle or horses are concerned; and (d) the condition under which they are being grazed.

To enforce a practical as well as an effective dipping program, it is necessary that a sufficient number of conveniently located vats be available. As there are only five vats in the control districts in a serviceable condition, at the present time, it is, therefore, obvious that to require dipping of all stock at ten day intervals would work an hard-

ship on stock owners living at considerable distances from the vats. Though dipping has not been compulsory for several years, the value of this method of control has, nevertheless, been emphasized to the stock owners, and such vats as could be used have each season been filled with dip solution, and with the assistance of the District Supervisors, a considerable number of stock has been voluntarily dipped by the owners. During the season just passed (1926) 2,191 head of stock (horses, mules and cattle) were passed through the vats. This is a somewhat larger number than was dipped during the preceding seasons, due in part to the fact that more vats are available and also due to the result of personal interviews by the District Supervisors with the stockmen. As there is a better spirit of cooperation gradually developing among the stockmen, it is hoped that the number of stock dipped in the future will greatly exceed the record of the past.

Compulsory dipping should be made a part of the control program, but in order to properly carry out this phase of the program, it will first be necessary to increase the number of vats so that there would be not to exceed five miles between the vat sites. State controlled pastures, acquired by purchase or long lease, should provide for range stock and all stock now grazing on unfenced areas in the control districts. These pastures should be equipped with vats so that dipping could be done at the proper intervals. State controlled pastures properly operated would make grazing control possible, and would also, to a great extent, solve the problem of dipping range stock which, under present conditions, graze in timbered areas and brushy pastures where it is at times impossible to round them up and deliver them at the vats at regular intervals and at a reasonable expense.

RODENT POISONS

During the past four seasons, as in preceding years, an effort was made to develop new poison formulas for rodent extermination. However, no grain mixture has thus far been found which equals the preparation now in use and which is as follows:

Crushed whole oats	8 quarts
Strychnine alkaloid	1 ounce
Saccharine	1 teaspoonful
Gloss starch	½ pound
Water	1 pint
Molasses (stock)	1 pint

The substitution of various materials such as dried apples, prunes, corn meal, rolled oats, wheat , barley, etc., for the crushed oats now used, failed to improve our present mixture, and usually were more expensive and less effective.

In 1924, experiments were made with calcium cyanide flakes. This material is placed into the burrow, where, coming in contact with the soil moisture, it readily decomposes and releases hydrocyanic acid gas. The gas thus released is very deadly to rodents, and only a small amount is required, in the case of the Columbian ground squirrel, for a lethal dosage. Six hundred pounds of calcium cyanide were used in 1924, and the results obtained as to its effectiveness were highly satisfactory. The initial cost of this material, however, together with the additional expense in labor required in treating the land would make its general use, as a substitute for grain poison, prohibitive. A quart of grain poison costs about twenty cents, and will average about 80 baits, while a like amount of calcium cyanide will cost about thirty-two cents and contains not more than 35 baits. Also, calcium cyanide requires from one-fourth to one-third more time in distribution than is required when grain poison is used. Even with this disadvantage, however, it is felt that calcium cyanide is a valuable aid in control of the Columbian ground squirrel, particularly in hog and sheep pastures, as these animals will eat the poisoned grain readily, and also near farm dwellings where there may be ducks and geese, and in areas where the poisoned grain has not been effective.

In order to determine the relative stability of calcium cyanide, a number of experiments were carried on during the season of 1925. The material was exposed in the burrows in the same manner as when poisoning rodents and then recovered at stated intervals varying from 30 minutes to 15 days. The recovered material was then sent to Dr. Starz, Chemist, Livestock Sanitary Board, Helena, and the following report from Dr. Starz gave the result of the laboratory tests:

June 8, 1925.

Mr. F. J. O'Connell, Field Agent,
State Board of Entomology,
Hamilton, Montana.

Dear Sir:

With reference to the matter of investigation of the more or less exposed calcium cyanide samples, I beg leave to report as follows:

Technical calcium cyanide, as is used in the eradication of rodents, is not of a definite chemical composition, frequently containing calcium carbide and other chemical compounds. The sample you forwarded and which was taken from the lot used by your field force in poisoning

rodents, was made up of brownish, black flakes, which upon exposure to the air gave off the odor of hydrocyanic acid and when put in water rapidly developed hydrocyanic acid gas and some acetylen gas, the latter from the calcium carbide present.

At your request I have made a series of experiments and tests to determine the relative amount of hydrocyanic acid left in the more or less exposed samples. The hydrocyanic acid was determined volumetrically with the aid of a 1/10 normal silver nitrate solution. There might have been other methods than the above but for the purpose of making quick comparative tests with the samples submitted, the volumetric silver nitrate method was found to be all right.

Preliminary tests showed that all samples gave off gaseous hydrocyanic acid upon exposure to air. That was proven by inserting strips of solium Picrate paper and Gaujac copper paper, the former turning brownish red rapidly, and the latter sapphire blue.

Tests showed the unexposed crude calcium cyanide flakes to yield 50.1% hydrocyanic acid. The inclosed chart shows the relative loss of hydrocyanic acid during a definite time of exposure in dry and damp ground. It seems that the loss of hydrocyanic acid from the calcium cyanide by exposing it in dry ground is not so very rapid, while the calcium cyanide exposed in damp ground shows considerable loss in proportion to the time of exposure and presence of humidity, of course. Naturally, the presence of moisture is essential in liberating quickly the poisonous gas in the gopher holes.

In conclusion I may state that the tests showed that sufficient hydrocyanic acid gas was set free from the calcium cyanide to kill the rodents in their burrows.

Respectfully submitted,

EMIL STARZ, Chemist.

CALCIUM CYANIDE (TECHNICAL FLAKES) TESTS, SHOWING RELATIVE LOSS OF HYDROCYANIC ACID BY DEFINITE EXPOSURE IN DRY AND DAMP SOIL.

TABLE NO. 2.
June 8, 1925.

	DRY SOIL EXPOSED SAMPLES						DAMP SOIL EXPOSED SAMPLES						
Sample No.	1	2	3	4	5	6	1	2	3	4	5	6	Unexposed sample of Calc. cyanide
Time of exposure	½ hr.	1 hr.	2 hr.	4 hr.	8 hr.	16 hr.	½ hr.	1 hr.	2 hr.	4 hr.	8 hr.	16 hr.	
Residual hydrocyanic acid found	50%	49.68%	48.6%	48.2%	43.35%	39.4%	37.8%	38.3%	34.0%	32.4%	30.25%	29.7%	50.15%
Sample exposed to: Sodium Picrate paper	Positive for HCN reddish brown	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same	Same
Exposed to Guajac copper paper	Positive for HCN Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
Date when samples were taken	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/30/25	5/29/25	5/30/25

Signed

EMIL STARZ, Chemist.

July 9, 1925.

Mr. F. J. O'Donnell, Field Agent,
State Board of Entomology,
Hamilton, Montana.

Dear Sir:

Inclosed find tabulated result of tests made with the exposed samples of calcium cyanide flakes to determine the residual hydrocyanic acid.

Naturally, the residual amount of hydrocyanic acid was found greater in the samples exposed in dry than in those exposed in damp ground. That was very noticeable in the samples which had been exposed fifteen days in dry and damp ground. From the tests it can be noticed that there is a more or less progressive loss of hydrocyanic acid corresponding to time exposure and humidity of the soil. After fifteen days of exposure of the cyanide of calcium in the ground, only small amounts of hydrocyanic acid were found to be left and the danger from accidental poisoning of livestock may be considered practically nil.

Some of the samples were so intimately mixed with particles of soil, sand, and other extraneous material that it was impossible to completely remove these impurities and for this reason you will notice some discrepancy in the amounts of residual hydrocyanic acid found. Some of the samples were wet and these also, naturally, showed considerable differences from those in dry condition.

The investigation is insofar interesting and of value for your purpose, as it has shown clearly that after the fifteenth day of exposure of the calcium cyanid under proper conditions there could no longer be any danger of poisoning live stock if they should accidentally get hold of the exposed material.

It also shows the initial rapid liberation of the gaseous hydrocyanic acid, which ceased after a short time if sufficient moisture were present to decompose the material.

These facts are of value in cases of lawsuits, and disputes where losses of livestock are claimed to have been due to cyanide poisoning with exposed calcium cyanide. The investigation also proved the great efficiency of the cyanide of calcium in the destruction of rodents and its comparatively greater safety with regard to live stock than that of other poisons used heretofore.

Trusting the above will furnish you some data which will be of value in your work, I remain

Very truly yours,

EMIL STARZ, Chemist.

DETERMINATION OF RESIDUAL HYDROCYANIC ACID IN SAMPLES OF CALCIUM CYANIDE FLAKES AFTER EXPOSURE

TABLE NO. 3. July 7, 1925.

EXPOSED IN DRY GROUND

Number of Sample	Condition of Sample	Time Exposed in Days	Residual Hydrocyanic Acid Found in Sample	
1	Dry	1-day	Flakes	8.80%
2	Dry	1-day	Granules	8.23%
3	Dry	2-day	Flakes	2.75%
4	Damp	3-day	Flakes	1.25%
5	Damp	4-day	Flakes	1.90%
6	Damp	5-day	Flakes	0.81%
7	Damp	6-day	Granules	0.435%
8	Dry	7-day	Flakes	0.410%
9	Dry	10-day	Flakes	0.52%
10	Damp	10-day	Granules	0.270%
11	Dry	15-day	Flakes	0.325%

EXPOSED IN DAMP GROUND

Number of Sample	Condition of Sample	Time Exposed in Days	Residual Hydrocyanic Acid Found in Sample	
1	Dry	1-day	Flakes	6.50%
2	Dry	1-day	Granules	4.90%
3	Dry	2-day	Flakes	2.56%
4	Dry	7-day	Flakes	1.40%
5	Damp	10-day	Flakes	0.40%
6	Damp	10-day	Granules	0.375%
7	Dry	15-day	Flakes	0.185%

Signed

EMIL STARZ, Chemist.

REPELLANTS

During the spring of 1924, a series of experiments was carried on for the purpose of developing, if possible, a suitable tick repellant for farm and range stock. Various oils such as raw cotton seed oil, raw linseed oil, lard, some petroleum oils, and others, have for some time been known to certain tick repelling properties, but are of value only where the animals are being handled frequently and the repellants can be applied as indicated. The purpose of our experiment was to develop a repellant that could be applied early in the spring before the ticks became active and that would remain on the animals and serve as a repellant over the greater portion of the active tick season. For the purpose of our xperiments 65 animals were used; three dairy herds of 12 animals each, one herd of 8 animals, 15 range cattle and six horses. The horses were grazed in the Stevensville district and the cattle were grazed; one each in the O'Brien Creek, Florence, Stevensville and Darby districts, and two herds in the Hamilton district.

Before applying the repellant each animal was carefully inspected and a record made of the number of ticks found attached, of the number found crawling, the condition of the animal and other data.

The repellants used in our experiments were as follows.

Raw linseed oil, raw cottonseed oil, linseed plus para cresol, cottonseed oil plus pinene, lanolin plus cottonseed oil, lanolin plus vaseline, cottonseed oil plus pine tar, cottonseed plus derrisine, vaseline plus para cresol, linseed plus derrisine, lanolin plus sulphur, plus cottonseed oil, plus pine tar, plus pinene, heavy crankcase oil and paraffine oil. These oils and other substances were used in various proportions, and on cattle, were applied to the base of the horns, along the neck and withers, and on horses, under the jaws, on the breast, between the fore legs and between the hind legs. Six ounces of the preparation were used on each animal at each treatment. After the repellants were applied, the animals were pastured in tick infested areas and inspected in about seven days, when note was again made of the number of ticks attached, the number found crawling on the animal, the general condition of the animal and the condition of the repellant; that is, whether the repellant was still on the animal in sufficient quantities to prevent ticks attaching. In a few instances there was apparently sufficient amount of the material still in evidence to act as a repellant; on other animals there was only a slight trace of the material, and in most cases the repellant had entirely disappeared in from seven to ten days.

Our experiment was a failure so far as developing a suitable repellant was concerned, but it did demonstrate that it would be extremely difficult to develop a repellant with an oil base that would be effective for any considerable length of time. Lack of funds and personnel has thus far prevented further experiments along these lines, but it is hoped that these experiments will be again taken up in the near future.

The Bureau of the Biological Survey, has, as in previous years, cooperated with this office in the control work on federal lands lying within the control districts and on the National Forest lands which border the districts on the west. The amount of money made available by the Bureau for control work has not been large, but it has helped considerably in reducing the migration of rodents from the mountains to the adjoining valley areas.

Our relations with the County Commissioners of both Ravalli and Missoula counties have been most cordial. They have given us their hearty cooperation at all times, and have expressed themselves as pleased at the manner in which the work has been conducted.

This station is indebted to the Livestock Sanitary Board, and particularly to Dr. Emil Starz, Chemist, for the splendid service rendered us in making laboratory tests of our dip solutions, in making analyses of the stomach contents of animals killed, allegedly, as the result of eating rodent poison, and other laboratory work.