

## NOTES ON RELAPSING FEVER IN PANAMA WITH SPECIAL REFERENCE TO ANIMAL HOSTS<sup>1</sup>

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Investigations concerning relapsing fever in the New World have been small when compared to the extensive studies that have been carried on in the Old World. Africa has been one of the principal seats of studies in relation to relapsing fever since this disease was recognized there in 1904. For several years French investigators in North Africa have been recording observations in connection with various animals acting as hosts for the disease and have obtained very interesting and important results. Very little definite work of that nature has been undertaken in the Americas. During routine blood examinations performed at this laboratory throughout the past three years, a number of mammals were found to have a spirochetosis. In order that our knowledge of the possible animal hosts of this region be increased the following data regarding these infected mammals are presented. An idea regarding the prevalence of human relapsing fever in Panama may be gained from the following notes.

Relapsing fever in man apparently was not recognized on the Isthmus of Panama prior to 1905. The American occupation of the Canal Zone and the introduction of American methods of hospitalization of the sick disclosed the presence of the disease. A paper by Darling (1) in 1909 informs us that from time to time cases were found in the Canal Zone hospitals and that approximately 31 cases were diagnosed as relapsing fever in the hospitals between 1904 and 1909. A later paper by Connor (2) in 1917 places the number of cases diagnosed in the Canal Zone hospitals from 1909 to 1917, inclusive, at seventeen. He estimated that

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about 50 cases had occurred from the time the first case was found in 1905 until 1917.

The Annual Reports of the Health Department of The Panama Canal for the years 1918 to 1930, inclusive, show that 67 cases have been received at the Canal Zone hospitals. Of this number 46 of the cases were among white patients and 21 were black. Fourteen (5 white and 9 black) were employees of the Panama Canal, 20 (11 white and 9 black) were among families of employees, 15 were members of the military forces of the Canal Zone and 18 (15 white and 3 black) were non-residents of the Zone that were admitted to the hospitals. This brings the total number of 117 recognized cases of relapsing fever received in these hospitals from 1905 to 1930, giving an average of 4.5 case a year.

While 117 cases occurring during a period of twenty-six years does not denote a very high incidence of relapsing fever in Panama it must be considered that this number constituted only the cases occurring among employees and families of employees of the Panama Canal and non-residents of the Canal Zone who were financially able to pay for treatment in the Canal Zone hospitals. It is quite probable that the cases diagnosed formed but a fraction of the total number that occurred throughout the Isthmus of Panama during the same period. We consider that many cases occur that are treated for malaria and many others do not receive or apply for any form of treatment. They recover spontaneously.

Relapsing fever in man has been endemic and fairly prevalent in the neighboring Republic of Colombia for years. A fair number of the non-resident cases of the Zone hospitals came to the Zone from Colombia and evidently acquired their infection while in that country. These patients usually represented residents of Colombia or foreigners who had visited that country on prospecting trips or on travels of other nature that brought them into the interior. Pampana (3) in his excellent paper on relapsing fever in Colombia reports 91 cases occurring in the Province of Choco. This Province is on the boundary line of Panama.

The Argasine tick, *Ornithodoros venezuelensis* Brumpt, which is the principal transmitting agent of relapsing fever of man in tropical America is present in considerable abundance in many



parts of Colombia. During 1923 and 1924 Dunn (4) made a survey to determine the prevalence of *O. venezuelensis* in Colombia and to gain information regarding the relative number and distribution of these ticks that were infected with relapsing fever spirochetes. Approximately 4880 specimens were collected from sixty-eight houses located in twenty villages, towns and cities in various parts of Colombia. A total of 2483 of these ticks representing collections from sixty-one houses, survived to be later tested for relapsing fever spirochetes by being macerated and injected into white mice and white rats. Positive results were obtained from seventeen of the lots tested, indicating that ticks infected with spirochetes of relapsing fever were present in seventeen, or 27.9 per cent, of the houses in which collections were made. These seventeen houses represented seven different villages, towns or cities. A second species of *Ornithodoros*, *O. talaje* Guer., and a transmitter of relapsing fever is also present in Colombia. Adult specimens of this species were taken in houses in the Barranquilla district and larval forms were found on a gray rat, *Mus norvegicus*, captured in that district. It seems probable that this second species accepts man mainly as a host of necessity and usually confines its attacks to rodents and larger animals and possibly plays an important part in the spread of relapsing fever among these mammalian hosts.

There have been practically no investigations undertaken to determine the prevalence of relapsing fever in Panama. It seems safe to consider, however, that if careful records were assembled the disease would be found to be nearly as common here as in Colombia. The majority of the 15 cases occurring among the military forces of the Canal Zone during the past thirteen years were soldiers. They apparently had contracted their infection in some of the villages in the interior of Panama while on Army maneuvers or hunting trips.

Both species of the incriminated ticks, *Ornithodoros venezuelensis* and *Ornithodoros talaje*, are found in Panama in considerable abundance. The former species is present in many dwellings in the interior villages while the latter may also be found in less abundance in houses. They are more commonly collected from

rats and other animals. It appears to be the larval stage, only of *O. talaje* that is found on animals. This is undoubtedly due to the larvae remaining attached to the host for several days while becoming replete. The nymphal and adult stages secure their blood meals usually in less than an hour and do not remain attached to the hosts.

During investigations of the diseases of domestic and wild animals that have been carried out at this laboratory throughout the past three years a number of mammals have been under observation. A routine examination of the blood of all animals obtained alive have been made daily for a period of from one to fourteen days after they were received. In the course of these studies naturally acquired spirochetal infections that compare favorably with the species causing human relapsing fever in Panama have been found in animals as follows:

*Monkeys.* A previous paper by Clark, Dunn and Benavides (5) reports the finding of spirochetes in three specimens of the squirrel monkey, or marmoset, *Leontocebus geoffroyi* (Pucheran), in Panama and the experimental transmission of this spirochete to man and other animals. One of these monkeys had been in captivity a short time previous to being received at the laboratory and may have become infected after being captured. The other two were captured in the jungle in the Darién Province of Panama and apparently had acquired their infection while under natural conditions. The infection in these monkeys was transferred to man by direct blood inoculations and also through the bites of *Ornithodoros venezuelensis* that had previously fed on a monkey infected with this strain. White mice, white rats and various species of monkeys were also infected with this strain. These experiments left little doubt of the spirochete found in these squirrel monkeys being identical with that causing human relapsing fever.

*Opossums.* During 1931 and 1932 a total of sixty-one opossums, *Didelphis marsupialis etensis* Allen, were received alive at this laboratory. Thirty-six of these were held for some time and daily examinations made of the blood of each animal for seven or more days. Twenty-five were used for experimental work and



were sacrificed in from two to four days after being received. Consequently, of this last group the blood of seventeen were examined on two days only, six on three days and two on four days. Of the sixty-one of these animals examined six, or 9.8 per cent, were found to be positive for spirochetes.

One of these infected animals was captured in the vicinity of Pacora, one near Patuga and one in the Chilibrillo Caves in the Republic of Panama. Three others were captured in Ancon, in the Canal Zone. Since a total of sixteen opossums were received from Ancon and three or 18.7 per cent, proved to be positive the incidence of infection in these animals in Ancon is surprisingly high. The various locations where these six animals were caught indicates that the infection among opossums in the Republic must be fairly wide spread.

Since the morphology of the spirochetes found in these opossums appear to be the same as those causing relapsing fever of man and marmoset monkeys and since white rats and white mice readily became infected when inoculated with these spirochetes we believe them to be identical with the human strain.

A number of the opossums were found to be infested with the larval form of *Ornithodoros tala e*. This not only records a new host for this tick in Panama but also explains the agent of transmission of the disease among the animals.

*Armadillos.* During the past two years thirty-two of the nine-banded armadillos, *Dasypus novemcinctus fenestratus* Peters, were received and daily examinations made of their blood. The blood of two of these animals revealed spirochetal infections, giving a percentage of 6.2 of natural infections occurring in the lot of armadillos examined. One of these infected armadillos was captured at Antone and the other at Santa Rosa in Panama.

Since we believed the spirochetes found in these animals to be identical with those causing human relapsing fever it was decided to determine the susceptibility of the armadillo to infection with spirochetes of a known human strain. Two of them were inoculated intraperitoneally with blood containing numerous spirochetes of our human strain. One animal became positive on the second day after the inoculation and developed a very heavy infec-

tion with many spirochetes present in each microscopic field in thick drop films of its blood. This animal died nine days after its inoculation. The second armadillo became positive after a three day incubation period and ran a lighter and more prolonged infection. It continued to show a fair number of spirochetes daily or at intervals of several days in its blood films for a period of approximately one month. It was necessary to sacrifice this animal a few days after its month of infection and there was no opportunity to ascertain if spirochetes would later appear in its blood.

*Calves.* During the course of a blood survey for infections with *Trypanosoma hippicum* Darling among a herd of horses and other animals at a ranch near Pacora, Panama, blood films were taken from six calves, approximately one month old, that were tied in one of the corrals near the farm headquarters. Later examinations of these films showed spirochetes present in the blood of two of these animals. These spirochetes so closely resembled the relapsing fever spirochete of man that a marmoset monkey was inoculated with blood from the two calves. This monkey became infected and spirochetes were first found in its blood ten days after the inoculation. White rats inoculated from this monkey also proved susceptible to infection.

*Horse.* A survey for trypanosomiasis in horses near Chorrera, Panama, was made by the Veterinary Department of the United States Army in November, 1930. A number of blood films taken during this survey was received for examination on November 21. One of these films was found to contain numerous spirochetes identical with those found in man and much different in morphology from those found in other horses in Panama on several previous occasions. The number on this film indicated that it had been taken from a native pony belonging to a resident of Chorrera. Apparently this pony was infrequently used for pack purposes and was sometimes kept in the back yard at the owner's home. The greater part of the time, however, it ranged on the open plains near Chorrera to graze with a large number of other native horses and cattle. Five days after this positive film was received a visit was made to Chorrera and more blood films taken from what was believed to be the same animal. A marmoset monkey,



white rat and white mice were also inoculated with blood from this horse at this time. No spirochetes were ever found in these blood films and no results were obtained from the animal inoculations. The horse was later brought to Panama and examinations made each day of its blood for a period of one month but no spirochetes were ever found. So many of the native ponies carry similar brands that there is a possibility of a mistake having been made in the identification of the animal and the later blood films and inoculations may have been made from a different horse.

#### DISCUSSION

The finding of spirochetes in these various animals in Panama may have particular significance in relation to our knowledge of this disease. It is probable that similar conditions prevail in other countries in the New World where this fever is present. Cases of relapsing fever have been discovered in various parts of the United States during recent years. Several of these have occurred in regions in which this disease was not previously known and since the infections were contracted in mountainous areas or other places apart from the centers of habitations it would appear that animals naturally infected with spirochetes may be present in these areas also.

In 1922 Briggs (6) reported 2 cases from California. These patients, a man and wife, had evidently acquired their infection while on a fishing and camping trip along the Truckee River in eastern California. In 1931 Graham (7) wrote of 4 cases of relapsing fever in Texas that became infected through visiting caves in which *Ornithodoros turicata* were numerous. He suggests the possibility of an animal reservoir of relapsing fever in Texas that might be of importance in maintaining and spreading the disease. Darling (8) directed attention to the probable rôle of the rat as a disseminating agent of relapsing fever in Panama and other countries of tropical America. His presumptions were mainly based on the susceptibility of the rat to the disease, the infestation of rats with *Ornithodoros talaje* and the fact that both the tick and the rat may be found in human habitations.

It is possible that mammals may prove to be the source of origin

in many cases of human infection of relapsing fever and this opens the field for more extensive investigations along these lines in various parts of this hemisphere.

#### SUMMARY

1. Relapsing fever of man was first diagnosed on the Isthmus of Panama in 1905 and has been known to be endemic since that date.

2. Approximately 117 cases of human relapsing fever were diagnosed in the Canal Zone hospitals during the twenty-six years from 1905 to 1930, inclusive.

3. Relapsing fever has been known to be endemic in Colombia, the country adjoining Panama, for a number of years.

4. Two species of Argasine ticks, *Ornithodoros venezuelensis* and *Ornithodoros talaje*, that have been proven to be transmitters of relapsing fever are prevalent in Panama and Colombia.

5. Earlier investigations on *Ornithodoros venezuelensis* in Colombia showed that a fairly high percentage of them were infected with spirochetes.

6. Naturally occurring spirochetel infections have been found in marmoset monkeys, opossums, armadillos, calves and a horse during the past three years in Panama.

7. In each instance the spirochetes found in these animals so closely resembled those found in human cases of relapsing fever that we believe them to be identical.

8. The infection in the monkeys was successfully transferred to man and also to white rats, white mice and various species of monkeys.

9. The spirochetes found in the opossums were readily transferred to monkeys, white rats and white mice.

10. Inoculation experiments with clean armadillos proved them to be highly susceptible to the human strain of relapsing fever.

11. The spirochetes found in the calves were transferred to a marmoset monkey and white rats.

12. *Ornithodoros talaje* in the larval stage have been found infesting marmoset monkeys and opossums.

13. During recent years cases of relapsing fever have occurred



from time to time in the United States. Several of these apparently acquired their infection while in isolated areas which would indicate that naturally infected mammals may be concerned in the propagation and dissemination of the disease in the United States.

14. From the literature available, we are unable to find any record of either opossums or armadillos having previously been found naturally infected with spirochetes and we believe that this indicates two new and hitherto unsuspected sources of the disease.

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