

INSECTS AS FACTORS IN THE SPREAD OF BACTERIAL DISEASES.

BY SEVERANCE BURRAGE.

From the earliest times theories have been advanced relative to the spread of disease by insects. Just what part the insect played of course was unknown, and naturally must have remained unknown until the discovery of bacteria and their relations to diseases firmly established. But since the germ theory has been established the subject of insects and disease has received much attention, although not all that it may have deserved. The bibliography on the subject, collected by Dr. George H. F. Nuttall, numbers nearly four hundred papers and articles, many of them representing exhaustive experimental work, and others are of general interest, and of practical value.

Books on hygiene and sanitary science, even the latest editions, do not mention insects as disease-spreading factors, yet they go into detailed discussions of many less important subjects. Undoubtedly many epidemics of contagious and infectious diseases have been caused directly or indirectly by insects, and then laid at the door of the water supply, infected food, or bad drainage. While water or milk may have been the immediate means of spreading the disease among large numbers of individuals, *one* insect may have caused the infection of the water or the milk.

As a disease carrier, we must regard an insect in one of two classes. He may be either the simple carrier of the bacteria, transporting the germs of disease on or in his body from an infected person to some healthy person's environment, the bacteria being wiped off from the insect's body or deposited in his excreta on the food or clothing of the susceptible healthy person; or the insect may be an intermediate host, in which the parasite or germ undergoes a part of its life cycle, and then the germ is transmitted to the healthy individual through the sting of the insect, the insect's fang acting as the inoculating needle.

In the latter class the mosquito and cattle tick are the best known, the mosquito carrying the malarial plasmodium, and the tick the organism of Texan cattle fever. Notwithstanding the importance of these diseases from the hygienic standpoint, they do not come under the head of bacterial diseases, as they are caused by animal parasites. It would, perhaps, be well to mention, however, in passing, that the theory connecting mosqui-

toes and malaria has been established beyond a doubt. More research work has been done in this connection than along any other line of the subject.

While not overlooking the importance of the mosquito theory, this paper must deal more with the strictly bacterial diseases.

HISTORICAL.

We are indebted to Dr. G. H. F. Nuttall, M. D., Ph. D., of Johns Hopkins Hospital, for collecting the facts along these lines and publishing them in one pamphlet.¹ There is much literature quoted on anthrax and its connection with various insects, particularly the fly. There are but few positive cases recorded, although scientists do not hesitate to say that insects probably do play an important part. Experimental work was carried on with anthrax and biting flies in 1869 and 1870, independently, by Rainbert and Davaine.

The bodies and the proboscides of the flies, such as *tabanus*, *haemato-pota* and *stomoxyx*, were infected with anthrax material, and after a definite time, such as two, twelve or twenty-four hours, parts of these infected animals were inoculated into healthy animals. In nearly all cases of this kind the animals died of anthrax.

Railliet sums up these and other experiments with anthrax and biting flies by saying that it is conceivable that the proboscides of *stomoxyx* and similar flies may inoculate septic organisms, having previously become contaminated on cadavers or diseased animals; "nevertheless no direct proof has been given as yet in favor of this view." Nuttall goes on to say that it seems "perfectly absurd that any value should have been attached to such experiments. When the insect sucks blood it injects uninfected saliva, and sucks up the bacteria that may adhere to its proboscis; and while it is conceivable that infection may occur, it is more probable, when we consider the process, that infection is the exception and not the rule."

Some forms of beetles are supposed to have been active agents in spreading anthrax. Proust and Hien made examinations of skins that had been supposed to cause anthrax in persons handling them. Living *dermestes vulpinus* and various larvae were found. All the living insects were found to have spores of anthrax on their bodies and in their excreta.

Nuttall carried on a valuable series of experiments with the bed bug

¹ Johns Hopkins Hospital Reports, Vol. VIII, Nos. 1 and 2, Baltimore, Md.

and flea and anthrax, but all his experiments gave negative results, and he concludes that "infection through the bite of a bed bug either does not occur or is exceptional; and further, that infection might occur if this bug were crushed, and the part scratched, is self-evident." And in regard to fleas, the anthrax bacilli die off rapidly in them, and the conclusion appears justified that they can not play much of a rôle, if any, in the spread of this disease.

The plague is supposed to be spread in some measure by means of flies and other insects. Nuttall's conclusions, as far as the biting insects are concerned, are the same as under anthrax, namely, that infection through their bites is exceptional and not the rule, but, "on the other hand, it is quite possible that a person crushing an infected bug, and scratching the spot where the insect has bitten, may thus inoculate himself with the plague bacillus. This, however, would not take place if a sufficient interval of time had elapsed after the bug had sucked blood containing the bacilli."

But Nuttall's experiments with flies infected with the plague bacilli, by which he determined that infected flies could live for several days, point to the possibility as he rightly concludes, that they play no inconsiderable rôle in the spread of the plague, for they have plenty of opportunities to gain access to food into which they might fall and die, or on which, in again feeding, they would deposit their excreta laden with plague bacilli.

Nuttall was satisfied that the flies themselves could die of the plague. A few experiments are recorded with hog erysipelas, mouse septicaemia, recurrent fever, chicken cholera, and yellow fever, which result in very positive conclusions. Experimental and other evidence points conclusively, however, that Asiatic cholera is disseminated by flies. Tuberculosis and leprosy are undoubtedly spread in this way.

Particular attention was called, during the recent war with Spain, to the spread of typhoid fever through our camps. In fact, it was well demonstrated that the fly played a most important part in the spread of disease throughout the camps, making due allowance for the other factors, such as poor food and bad water. All the conditions about the camps seemed to favor the fly in his dirty work. Flies are attracted alike to food material and to filth. Fecal matters, fresh from the bowels of typhoid patients, and oftentimes without even an apology for disinfection, lay ex-

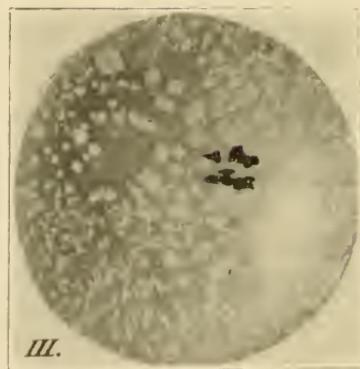
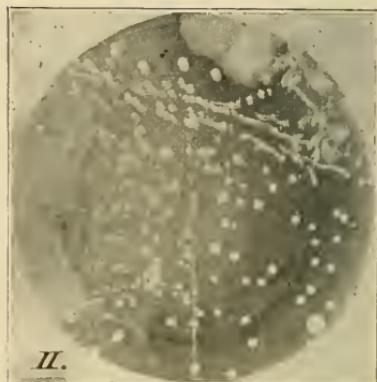
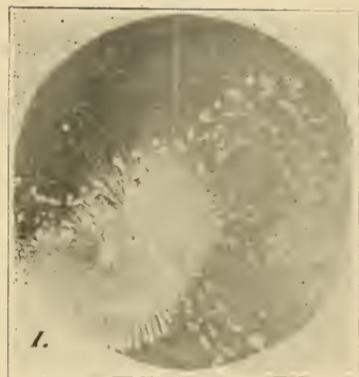
posed in open trenches, and in sultry weather millions upon millions of flies swarmed on and about this material.

Short distances away from these trenches were the cooking and dining tents, and between these two sources of fly attraction the insects were continually passing. Thus it was made only too easy for the flies to transfer infectious material from the trenches to the food; and as much of the food is not cooked at all, there is no chance for the germs to be killed.

To show the condition of affairs in the camps, as described by an eye witness, I will quote from a letter of Dr. I. W. Heysinger, of Philadelphia, to one of the medical journals: "In the hospitals, the vessels used by the patients beside their beds, were black with them (flies), and they only disappeared when the dinners were brought along, and the attendants went back to the cook house to chase off the invading inhabitants there, and bring up milk to complete the menu. The open sinks are also black with these buzzing scavengers, which rise in clouds when the surface is disturbed, and their feet loaded with fecal debris rise to seek new pastures at breakfast, dinner and supper and all through the day, intermittently around the cook house.

"Into these sinks go the discharges of the typhoid patients, and pathogenic bacteria that can not make an effective culture there on a most majestic scale are 'simply not in it.'

"Can anyone wonder that a single case of typhoid will thus infect a whole camp and increase the virulence of a mild case to the point of a necessarily mortal result? Ingenuity could not devise any plan so simple, so efficacious and so widespread as this for scattering a pestilence. Every fly leg is good for a large number of almost any required sort of pathogenic bacilli, and some flies are nearly all legs, and the rest snout and wings, which also play their part with regularity and despatch." Dr. M. A. Veeder, of Lyons, N. Y., describes the conditions around a private house. He says: "Even in a private house, not at all uncleanly, I have seen typhoid dejections emptied from a commode, and the latter thoughtlessly left standing, without disinfection, within a few feet of a pitcher of milk just left at the door, both the commode and the pitcher attracting the flies, which swarmed about and went from one to the other. Is it strange that there were numerous cases of the disease in that house, and in the house next to it? I have seen a shallow, old-fashioned water-closet fairly buzzing with flies on a hot day, and all around it open win-



dows and doors leading into kitchens, pantries and dining rooms. A single case of typhoid would start a severe local epidemic under such conditions."

Summer work in a bacteriological laboratory would convince anyone of the flies' liking for pathologic material of any kind. They are sure to light near and crawl over slides being prepared for stains, which makes it necessary to cover everything with bell-jars to prevent laboratory infection. Moreover, flies are always more attracted toward diseased persons than toward the healthy ones.

The whole subject is of great interest to the sanitarian, because it opens up a comparatively new field in preventive medicine. It applies to the home as well as to the community in regard to general cleanliness and methods of garbage disposal.

STRUCTURE OF HOUSE FLY.

Any one who has examined the fly's foot under the microscope can not fail to see how perfectly it is constructed for the retention of dirt and filth. The fine hairs and the suctorial discs afford magnificent opportunities for infectious material to be lodged in and thus transported from one spot to another. In fact, in making a microscopical examination of several flies' feet for the purpose of making a photograph, it was next to impossible to find one that did not have considerable dirt attached to it.

The proboscis of the fly also affords an excellent resting place for dirt of any kind, and the wings and body also serve to retain material. Thus the fly seems to be made for the purpose of carrying small quantities of dirt around with him all the time, a circumstance that is quite alarming if we could follow in the wake of the fly in his daily and hourly travels, instances of which have been cited above.

LABORATORY WORK.

While laboratory experiments are not always satisfactory in a subject of this kind, yet I take the liberty of describing here some that were undertaken in the Purdue laboratories during the past year. While the experiments, in part at least, have been done in other laboratories, the results obtained here were very satisfactory, and the plates were so well marked that I deem them well worth the attention of the Academy.

Experiment No. 1. Typhoid Fever and Fly.—The fly was placed under the bell-jar with filter paper saturated with fresh bouillon culture of *B. typhi* abdom., twenty-four hours old. The fly was closely watched, and after he had been observed to walk over the filter paper several times, the bell-jar was carefully moved from the filter paper. After twenty minutes had passed, a Petri plate containing a thin film of sterile agar was placed under the jar, and the fly again watched. He did not seem to be attracted to the agar, and after waiting perhaps half an hour, it was decided to force the fly to walk over the agar film. So he was carefully caught between the agar film and the Petri dish cover, and he then walked over the agar beautifully. The agar plate was incubated for twenty-four hours and the result was very significant. It is shown on plate No. 1, on which the clearly defined fly path, marked by bacteria colonies, is clearly shown. A further examination determined the presence in these colonies of the typhoid bacilli.

Experiment No. 2.—A similar experiment with some filter paper, saturated with typhoid fever, using another fly, somewhat less time elapsing between his inoculation, and being made to walk over the agar. This fly did not enjoy walking on the agar and jumped around over the plate considerably, as shown by the large number of colonies; plate II. Once or twice he made a fairly straight track, however, as may be seen. These colonies were also proved to contain typhoid fever.

Experiment No. 3. Prodigiosus.—Large fly. After one-half hour walked over gelatine; too lively to make tracks; infected whole plate; plate III.

Experiment No. 4. Prodigiosus.—Fly's wings removed, and then he was allowed to walk over infected paper and agar plate; plate IV.

Experiment No. 5. Prodigiosus.—After eighteen hours fly, that had been infected with prodigiosus, was allowed to walk over plate; plate V.

CONCLUSIONS.

It is evident that the fly can become infected with bacterial filth and hold on to it for sufficient time to inoculate food materials or other materials surrounding human lives. They must always be regarded as a menace to health as long as they have access to filth in the neighborhood

of human dwellings, be they temporary or permanent. All evidence points to the strong need of disinfecting or destroying all the wastes from ourselves and other animals, destroying all excreta in which the flies deposit their eggs, and to do all to eliminate this factor in the spread of infectious and contagious diseases that heretofore has received so little attention.

HOUSE BOATS FOR BIOLOGICAL WORK.

BY ULYSSES O. COX.

House boats for pleasure are not at all uncommon on the Mississippi River, but one built and equipped for scientific purposes was, until the past summer, entirely unknown on that stream, and, I am told, on most streams in this section of the country. Last March the writer was called to Minneapolis by the director of the State Zoological Survey, Professor Nachtrieb, and asked to suggest plans for further study of the fishes of the State. Among these suggestions was the one that a house boat, or rather, in this case, a floating laboratory, be built at Mankato to float down the Minnesota and Mississippi rivers, at least as far as the State line.

There were a number of things to be taken into consideration. It had been several years since the Minnesota River had been navigated by any craft larger than a row boat, and just how large the floating laboratory could be made and still float and be manageable was a question. There were numerous bridges to pass, many sand and gravel bars to interfere and hundreds of snags to be avoided. It was finally decided to build the barge portion of the boat twelve feet wide, twenty-two feet long, two feet deep and with a flat bottom. It was estimated that a boat so built would draw, when empty, no more than five or six inches of water, which estimate proved later to be correct. On top of the barge was built a cabin twelve feet wide, fourteen feet long and six and one-half feet high. The roof of the cabin was covered with boards and then with canvas. At each end of the cabin a door opened out on the platform, which was as long as the width of the boat, and four feet wide. On each side of the