(4) The correlation between height and weight is about $.54 \pm .03$. For one group, hips and weight correlated .58, for the other group .51. From these observations it appears probable that the bony hip diameter for young men bears as important a relationship to body-weight as does stature.

(5) The correlation between shoulders and weight is about $.45 \pm .03$. Shoulders and hips each correlate with weight more strongly than they do with each other or with height or sitting height. Therefore, they may be assumed to contribute a factor to total body-weight that is not wholly included in the height measurements.

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A PRELIMINARY REPORT ON STUDIES OF FIREBLIGHT OF APPLE[1]

FOLLOWING the classical studies of Burrill[2] and Arthur[2] in establishing the bacterial cause of fireblight of pomaceous fruits and of Waite[2] in discovering the relation of pollinating insects to its dissemination and in developing a method for combating it by excision of affected parts, many valuable contributions[3] have been made to the knowledge of this destructive disease. Nevertheless epidemic outbreaks of fireblight continue to take their toll and commercial pear culture has been abandoned in many sections because of the ravages of blight. In view of the lack of success which has attended numerous attempts of apple growers of Wisconsin to control fireblight by the excision method, it seemed desirable to investigate certain aspects of the epidemiology and control of the disease under local conditions. This work was begun by Brooks,[4] who contributed substantially to the knowledge of the overwintering of the blight organism and the seasonal development of the disease. For three years the investigation has been continued by the present writer[5] through field and laboratory studies.

A clear understanding of the modes of dissemination of the natural inoculum and of access of the organism to the host tissues seemed to be of primary importance to the adequate understanding of the epidemiology of the disease and further development of control measures. Special attention has, therefore, been directed to these aspects of the problem. For many years the prevailing conception has been that the primary inoculum is carried by insects from the cankers where the organism overwinters to susceptible parts of the current year's growth, notably the blossoms, where it induces blighting, presumably penetrating to the interior tissues through the nectaries. Once established in the blossoms, the bacteria have been supposed to be carried to other blossoms chiefly by the agency of pollinating insects, while their direct entrance from external sources to twigs and other susceptible parts has been considered to occur chiefly through wounds. An important modification of these earlier conceptions was necessitated by the valuable contributions of Gossard and Walton,[6] who showed that rain is a very important agent in the dissemination of the inoculum for fireblight. They concluded that from 50 to 90 per cent. of the blossom blight observed in their work was caused by rain-borne inoculum. They state, however (p. 107), that "raindrip does not become an agent of dissemination until primary centers of infection have been established, in nearly all cases by insects." In somewhat similar experiments which appear to have been conducted independently and near the same time, Stevens, Ruth and Spooner[7] showed that blossom clusters and young twigs which were carefully protected from visitation by insects were blighted approximately as much as similar unprotected parts. Access of air and of meteoric water was not precluded. The writers conclude that the disease must have been transmitted by some agency other than insects and state that "the only tenable hypothesis is that wind was the chief agent of transmission."

The exact mode of dissemination of the inoculum which first establishes the fireblight organism in the current year's growth is obviously of great potential importance in relation to control measures. The conception that insects are the agents of this dissemination seems firmly established, yet the writer has been unable to find in the literature of fireblight sufficient evidence to justify such a conclusion. The conditions encountered at Gays Mills, Wisconsin, in the seasons of 1926 to 1928, inclusive, have offered a very favorable opportunity to follow the details of dissemination of the primary inoculum under natural conditions. In each of these three years the earliest infections of both blossom clusters and young shoots have been ob-

[1] Published with the approval of the director of the Wisconsin Agricultural Experiment Station.

[2] Cited (pp. 368–369) in: V. B. Stewart, "The Fireblight Disease in Nursery Stock," Cornell University Agr. Exp. Sta. Bul. 329: 313–372, 1913.

[3] A fuller discussion of literature will be given in a later paper.

[4] A. N. Brooks, "Studies of the Epidemiology and Control of Fireblight of Apple," *Phytopath.* 16: 665–695, 1926.

[5] The writer is indebted to Dr. G. W. Keitt, under whose direction these investigations were conducted, for first suggesting the importance of the problem and for helpful criticisms and suggestions during the progress of the work.

[6] H. A. Gossard and R. C. Walton, "Dissemination of Fireblight," Ohio Agr. Exp. Sta. Bul. 357: 83–126, 1922.

[7] F. L. Stevens, *et al.*, "Pear Blight Wind Borne," SCIENCE, N. S., 48: 449–450, 1918.

served to occur, almost without exception, below hold-over cankers or twigs in positions favorable for water-borne dissemination of bacteria from these sources. In 1926 and 1927 young blossom clusters were found blighted well in advance of the opening of the blossoms and at a time when there was a striking dearth of insects which might have carried the bacteria. These field observations suggested the working hypotheses: (1) that meteoric water plays an important part in disseminating the primary inoculum of fireblight and (2) that the bacteria are able to infect unopened blossoms and young shoots without the intervention of insects. It was sought to test these hypotheses by observations and experiments. A very brief summary of the evidence relating to the first follows:

1. In observations in the orchards at Gays Mills for three consecutive seasons the earliest observed cases of blossom and twig infection have occurred, almost without exception, in situations favorable for water-borne dissemination of the inoculum from active hold-over cankers or twigs.

2. During the periods of early primary infection there was a dearth of insects which might transmit the bacteria.

3. In extensive observations of active hold-over cankers during three seasons no insect was observed to visit the bacterial exudate.

4. The time when primary infection occurred was correlated with rain periods, the symptoms becoming evident after a normal incubation period following rain, as was revealed by inoculation experiments conducted in the orchards.

Attention was next directed to the manner in which the bacteria gain access to the tissues of the host. It has long been accepted that this is accomplished in two ways: (1) through the open blossoms, presumably through the nectaries, and (2) through wounds of many kinds. Neither of these modes of entry, however, would seem to accord well with the facts observed in the field. Consequently a study was made of the possibility of infection of young shoots and unopened apple blossoms by *B. amylovorus* without the intervention of wounds. On the basis of observations, Heald[8] expressed the opinion that the bacteria may gain entrance to leaves through water-pores and stomata, but stated that it remained for further investigation definitely to substantiate this view. In his manual the same author[9] states (p. 315): "The writer studied fireblight in Washington in the summer of 1915 and found leaf invasions common in pear, apple and quince, and later produced artificial infections through the leaf margins by the use of pure broth or bouillon cultures. Leaf infections occurred through marginal breaks, insect punctures or through perfectly sound leaves." Brooks[10] reports negative results from numerous inoculation experiments with unwounded apple leaves in the field and in the greenhouse. Most of this work was done, however, after the twigs had made considerable growth. Working with potted plants in the greenhouse the present writer has induced at will abundant infection of young shoots and unopened blossom buds of apple and pear by spraying them with a suspension of the fireblight bacteria (from pure cultures on potato dextrose agar slants) in sterile distilled water and placing them for varying periods in a moist chamber at suitable temperatures. These experiments have been repeated many times with consistent results. In numerous series the plants were treated with "Derrisol"[11] before the buds opened and were kept throughout the course of the experiments in compartments designed to preclude injury from insects or other agencies. Histological studies are being made of tissues which were killed and fixed at various intervals after inoculation. While this work is unfinished, cases of stomatal penetration have been found in tissues taken from (a) an inoculated young leaf of apple and (b) from the inside of the receptacle cups of apple and pear flowers that were open when inoculated. The results of inoculation appear to be strongly influenced by the condition of the tissues at the time of the experiment.

Inoculation experiments in the field yielded results which accord well with those obtained in the greenhouses. Young shoots, unopened blossoms and open blossoms were infected when sprayed with a bacterial suspension of *B. amylovorus* and enclosed in moist chambers. The percentage of positive results, however, was much more variable than in the case of the greenhouse tests, where conditions could be controlled more satisfactorily. In certain of the field trials, precautions were taken against wounding by insects or other agencies, and infection resulted from inoculations of young shoots and unopened flowers.

The data now available appear to justify the conclusions: (1) that, under Wisconsin conditions, meteoric water is an important agent for the dissemination of the primary as well as the secondary inoculum for fireblight of apple, (2) that *B. amylovorus* may infect young leaves and unopened blossoms of apple and pear without the intervention of wounds and (3) that,

[8] F. D. Heald, "Preliminary Note on Leaf Invasion by *Bacillus amylovorus*," Wash. Agr. Exp. Sta. Bul. 125: 1–7, 1915.

[9] F. D. Heald, "Manual of Plant Diseases," 890, 1926.

[10] A. N. Brooks, *loc. cit.*

[11] "Derrisol" is a proprietary contact insecticide. It was applied as a spray, the chief purpose being to kill any aphids which might be present.

under suitable conditions, *B. amylovorus* may cause infection following penetration through stomata. In the light of these results it appears that the rôle of insects in the dissemination of fireblight is less important than was earlier believed and needs to be reevaluated. The possibilities of using the excision method as one part of a successful control program seem to be considerably enhanced. Strong potentialities appear to lie in the use of chemical treatments designed to inactivate such primary inoculum as escapes the excision process. Experiments on this phase of the problem are in progress but the results are, as yet, inconclusive. The investigation is being continued, and the results will be reported in more detail in later papers.

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FURTHER OBSERVATIONS ON SCHISTOSOME DERMATITIS IN THE UNITED STATES (MICHIGAN)[1]

IN a recent publication[2] I discussed the production of a dermatitis by the penetration into the human skin of a non-human species of schistosome cercaria, *Cercaria elvae*. This experimental schistosome dermatitis was identified as the same condition as that occasionally contracted by wading at certain places near the University of Michigan Biological Station on Douglas Lake, Michigan. It was suggested that this type of dermatitis might be widespread and might be produced by other schistosome cercariae besides the one implicated experimentally. Since the publication of this paper some new evidence has been obtained on both these points.

A popular discussion of this subject based on the original paper was syndicated by a writer of health articles and published in May in a number of newspapers throughout the United States. Following this, a number of letters were received asking questions or volunteering information on various sorts of skin conditions. Ten of these letters gave accounts of a definite dermatitis contracted by the contact of some part of the body with water, in most cases in wading or swimming. All these reports were alike in recounting the extreme itching and the spontaneous disappearance of the dermatitis after a few days or at most several weeks, depending on its severity. In certain of the cases the letters report that physicians consulted were unable to give a diagnosis. Rather detailed descriptions were given in some cases of the development of papules. The reports of the "water itch" which these ten individuals identified as the same as the schistosome dermatitis were from widely separated places, including in the United States the states of Iowa, Washington, Illinois, Florida, Minnesota, Wisconsin and Michigan, as well as Haiti and France. Whether these records really represent accounts of schistosome dermatitis is difficult to determine. It is, however, very suggestive, when an eruption of a papular nature, which produces extreme itching and disappears in a few days or a week is contracted from wading or bathing in shallow water where the bottom is muddy. Some of these records were of such interest that they are being followed up further so that further details will not be given in this preliminary note. I would be glad to hear of further cases of dermatitis contracted from wading or bathing under conditions which might make possible infection from cercariae escaping from snails.

It has also been possible this summer to produce the dermatitis experimentally by placing on the human skin three further species of schistosome cercariae. One of these was identified as *Cercaria douthitti,* which was originally reported from specimens of *Lymnaea reflexa* from a small pond in the suburbs of Chicago, Illinois.[3] This cercaria is present although not common in *Lymnaea stagnalis appressa* and *L. stagnalis perampla* from the shores of Douglas Lake. A few specimens of *C. douthitti* placed on the skin of two volunteers produced the same kind of lesions as those produced by the penetration of *C. elvae*. Two other species of schistosome cercariae which resemble *C. elvae,* but differ in certain definite and easily distinguished characters were found during this summer. Since these cercariae are being studied by one of the research students at the Biological Station any description of them will be reserved until later. The important point here is that both of these cercariae penetrated into the human skin and produced schistosome dermatitis. This means that four of the five species of schistosome cercariae which have been found in the region of Douglas Lake in the last two summers have been shown to penetrate into the human skin and to produce a definite schistosome dermatitis. This gives support to the view expressed earlier that this condition is probably rather widespread and may be produced by a variety of cercariae of this group.

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[1] This paper is a joint contribution from the University of Michigan Biological Station and the Department of Helminthology of the Johns Hopkins University School of Hygiene and Public Health.

[2] Cort, W. W., "Schistosome dermatitis in the United States (Michigan)." *J. A. M. A.*, Vol. 90, pp. 1027–1029 (March, 1928).

[3] Cort, W. W., "Larval trematodes from North American fresh-water snails." Preliminary report. *Jour. Parasit.*, 1: 65–84 (1914).