DISCUSSION

INSECTS AND EPIDEMIOLOGY OF POLIOMYELITIS*

IN SCIENCE for February 13, Professor Charles T. Brues discussed our report on flies as carriers of poliomyelitis virus[1] and probably expressed the feeling of many entomologists when he referred to our description of the insects as "naively vague" although he was kind enough to add "for an otherwise carefully executed experiment." The purpose of this communication is to remove some of this "naive vagueness" by reporting certain data which have come to light since the publication of our original note, and to comment on the possible role of insects in the epidemiology of poliomyelitis.

When it is recalled that at the beginning of our experiments there was no valid evidence of the existence in nature of non-human carriers of poliomyelitis virus, it will not be difficult to understand why in the first tests we included all insects found in our traps even the caterpillar, "four-winged insect," moth and bee. The first part of the job was to determine whether insects are carriers and the second part, which ones. By this time we have been able to demonstrate the presence of poliomyelitis virus in 8 of the 15 batches of flies trapped during outbreaks of the disease in Atlanta and Cleveland. If we had tested relatively large quantities of the stools of 15 patients during the acute stage of poliomyelitis we could not have expected a very much higher incidence of positive results. And yet it is worth noting that, with one exception, the positive results we obtained were with insects that were not caught in the vicinity of privies. Our patients had been in the hospital for days or weeks and the other probable virus carriers in the city homes used good toilets. Where these insects got their virus is one of the intriguing problems for the future.

The distinctly positive results which we obtained with collections of insects consisting only of flies leaves no doubt that they are carriers of the virus. The proportion of the different varieties of flies present in the virus-positive batches was noted and representative specimens, preserved in the frozen state, were kindly identified for us by Mr. David G. Hall, of the Bureau of Entomology of the U. S. Department of Agriculture. In Atlanta the bait consisted of sliced bananas sprinkled with sugar, and more than 95 per cent. of the flies consisted of *Musca domestica;* the virus was isolated from 1 of 3 batches tested and the flies in the positive sample consisted of 203 specimens of *Musca domestica* and 5 blowflies of which 3 can be classified as *Calliphoridae: Phaenicia sericata* (Mg.). In Cleveland fresh meat was added to the bananas and sugar, and the specimens which were caught and shown to carry the virus consisted of flies, 90 to 95 per cent. of which belonged to the *Calliphoridae* (blowflies) and the remainder to the family of *Muscidae.* The virus was demonstrated in 7 of the 12 batches tested. The large majority of *Calliphoridae* were *Phaenicia sericata,* and only few or rare specimens of the following were encountered: *Phormia regina* (Mg.), *Protophormia terrae-novae* (R.–D.), *Cynomyopsis cadaverina* (R.–D.) and *Calliphora erythrocephala* (Mg.). The *Muscidae* were mostly *Musca domestica* L. with only occasional representatives of *Muscina stabulans* (Fall.) and *Ophyra leucostoma.* Virus was isolated from one collection of flies in which only *Phaenicia sericata* (green bottlefly), *Protophormia terrae-novae* (black blowfly) and *Musca domestica* were present. While it is possible that a variety of species of the *Calliphoridae* and *Muscidae* can carry the virus, future studies with more specific baits and careful selection of individual species will greatly elucidate this question. It should be noted that we were unable to obtain positive results with Rhesus monkeys, and because Cynomolgi are needed, these studies will probably have to be postponed until importation from Java is again possible.

Because we have recently been able to demonstrate the presence of poliomyelitis virus in the blood of Cynomolgus monkeys paralyzed after oral infection with a strain of recent human origin (unpublished data), we believe that blood-sucking and biting insects should not be completely left out of consideration. Perhaps the reason the experiments of Rosenau and Brues[2] and of Anderson and Frost[3] on the experimental transmission of poliomyelitis from monkey to monkey by means of the biting stable-fly (*Stomoxys calcitrans*) could not be repeated by the same workers nor by others, is that a strain of sufficiently recent human origin may not have been used in the later experiments, rather than that epizoic parasites like fleas may have escaped attention, as Professor Brues suggests.

We can not quite agree with Professor Brues when he says that it is growing "increasingly evident that the spread of poliomyelitis can not be traced to direct human contact nor to indirect contact through healthy

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[1] A. B. Sabin and R. Ward, SCIENCE, 94: 590, 1941.

[2] M. J. Rosenau and C. T. Brues, *Bull. State Bd. Health,* Massachusetts, 7: 314, 1912.

[3] J. F. Anderson and W. H. Frost, *U. S. Public Health Repts.,* 27: 1733, 1912; *ibid.,* 28: 833, 1913.

human carriers. . . ." Careful investigation of a small outbreak of the disease in a Chicago suburb last summer revealed a striking example of spread by carriers.[4] Furthermore, poliomyelitis has long been reported to occur in the winter, although the virus had not been isolated from winter cases. In recent weeks we have been able to convince ourselves of the existence of winter poliomyelitis by isolating the virus from the stools of one paralytic and one non-paralytic case in Cincinnati in the middle of January, as well as from an apparently healthy younger sibling of each of these patients. Professor Brues is especially inclined to throw suspicion on rats because as he says "the virus can now readily be propagated in certain rodents. . . ." While it is true that Armstrong established *a* strain of poliomyelitis virus in cotton rats and mice in 1939, it is unfortunately not true for numerous strains of virus of human or recent human origin which have been tested in rats and mice since that time. The virus of "spontaneous poliomyelitis" of mice (Theiler's virus) may be pathogenic for cotton rats but is without effect in monkeys.[5] And one of the criteria which we and others have found applicable to the large numbers of poliomyelitis strains that have been isolated from human beings and flies is that while producing paralysis in monkeys they are not pathogenic for mice, guinea pigs and rabbits.

We believe that the search for a reservoir of poliomyelitis virus among lower animals is worth while and should continue. It is also evident, however, that epidemiologically poliomyelitis seems more to resemble diseases like typhoid fever and dysentery in which the chief reservoir of infection is in human excreta and both direct and insect spread may be possible, rather than some or all of the summer encephalitides where the chief reservoir appears to be in lower animals with spread occurring by means of a specific insect (mosquito) vector. Having isolated the virus from winter cases, we are inclined to regard poliomyelitis as a disease which occurs the year round but has a greater incidence during the summer and autumn because greater dissemination of the virus may be made possible by a number of factors, including insects such as flies.

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PLAGIOTROPIC HABIT OF GROWTH IN NORWAY SPRUCE

LATERAL twigs from the lower branches of Norway spruce trees when used as cuttings yield some rooted cuttings with the new terminal shoot developing at an angle from the vertical. This plagiotropic habit of growth if persistent would be highly undesirable for forest planting stock. Observations of this feature have been made in connection with studies[1, 2] of the vegetative propagation of Norway spruce trees during the past three years.

In one collection of 650 cuttings from trees 26 years old plagiotropic growth was evident in 19.4 per cent. of the cuttings three months after planting. In another collection of 600 cuttings from trees 40 years old plagiotropic growth occurred to the extent of 14.4 per cent. Some of the rooted cuttings were planted outside in a nursery, while others were potted and grown in a greenhouse.

By the end of the first growing season the plagiotropic habit of growth was less evident than earlier. With maturation of the stem tissues a number of the terminal shoots which had been but slightly plagiotropic earlier now assumed a vertical or almost vertical position. This is similar to the growth habit of a lateral shoot of the terminal whorl of a conifer whose leading shoot has been injured or removed. The plagiotropic habit was maintained by some of the shoots throughout the first year but gave way to normal vertical orientation of the terminal shoot in the second year. The habit of growth of the terminal shoots of the trees during the third year was normal and indicates that subsequent growth will be normal. It is believed that an early expression of plagiotropic growth in some rooted cuttings of Norway spruce does not offer a serious objection to the employment of vegetative reproduction of this species.

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A SIMPLE AIR-RAID ALARM

A SIMPLE air-raid alarm system has been developed and installed by the Cranbrook Institute of Science, which would be suited to many other buildings, particularly those already equipped with public-address systems.

A switch and radio volume control unit are placed near the telephone switchboard, over which warnings would be received. The unit controls a bank of radio amplification tubes, which build up the unholy noise of a tone-oscillator tube, the wail of which is controlled by the operator in accordance with the official fluctuating two-minute warning or the steady "all clear" signal. The sound is broadcast through eight-

[4] E. A. Piszczek, H. J. Shaughnessy, J. Zichis and S. O. Levinson, *Jour. Am. Med. Asn.*, 117: 1962, 1941.
[5] M. Theiler, *Medicine*, 20: 443, 1941; P. K. Olitsky, *Proc. Soc. Exp. Biol. and Med.*, 45: 339, 1940.

[1] C. G. Deuber and J. L. Farrar, SCIENCE, 90: 109–110, 1939.
[2] C. G. Deuber, *Trans. Connecticut Acad. Arts and Sci.*, 34: 1–83, 1940.