

THE DETECTION OF POLIOMYELITIS VIRUS IN FLIES
COLLECTED DURING EPIDEMICS OF
POLIOMYELITIS*

II. CLINICAL CIRCUMSTANCES UNDER WHICH FLIES WERE COLLECTED

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In the preceding paper (1) we have described technical and other details with regard to a series of 39 tests performed on 19 samples of flies which were collected during the summer of 1941, and tested for the virus of poliomyelitis. In the present paper (the second in this series) the *clinical* and *environmental* circumstances under which some of the collections were made, will be reviewed. In particular, attention will be paid to 4 samples which yielded the virus of poliomyelitis.

Description of Circumstances under Which Flies Were Caught

For many of these tests efforts were made to capture flies within *epidemic areas* and during *epidemic times*. Both of these designations as to place and time require definition.

Epidemic Areas.—Each of these was selected arbitrarily as an area (from 15 to 20 acres in size) immediately surrounding or directly adjacent to the dwellings of one or more patients who had acquired poliomyelitis. The homes of these patients may not have been the actual place where the disease was acquired but to increase the chances of this being the case, we chose sites, whenever possible, where more than one child lived who had acquired the disease. In some of these areas we knew of local, potential sources of virus which were accessible to flies, in the form of human feces. In others we knew of no local carriers or obvious local “sources” of virus.

Epidemic Times.—This designation is also arbitrary but we have chosen to regard it as that period in which known, local, human cases (either paralytic, abortive, or suspected abortive) had had their dates of onset within 10 days. In almost all instances collections were made at the end of the epidemic season; and in several others after the epidemic was over, as for instance in summer camps which had been closed for the season, and after the juvenile contacts had left the premises.

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† Dr. Trask died on May 24, 1942.

Results on Samples Collected during and after Epidemics.—Some of our 1941 data which concern the time and place of fly collections have been assembled in Table I. Here the series has been divided into two groups: those collected

TABLE I
Results of Tests on (Non-Biting) Flies Collected (A) during and (B) after "Epidemics"

Sample No.	Place	Character of site	Date*	Days after case†	Size of population‡	Possible local sources of virus	Results	
A. During epidemic times	L-2	Rural Conn.	Camp	Aug. 4-9	8-13	150 children 12 adults	Suspected carriers. Many privies	+
	S-2	Rural Conn.	"	Aug. 6-8	8-10	20 children 20 adults	2 proven carriers. Exposed feces	+
	C-1	Urban Ohio	Lake front	Aug. 18-29	0	?	Sewage and exposed feces	-
	A-1	Suburban Ala.	Homes	Aug. 20-24	10-14	64 children 117 adults	3 proven carriers. Many privies	+
	B-1	Urban Conn.	"	Sept. 10	8	14 children 10 adults	Several suspected carriers	-
	NB-1	(?)Rural Canada	"	Sept. 21-22	6-15	?	1 case	+
	M-1	Urban Conn.	"	Sept. 6-19	9	?	1 "	-
	H-1	Rural Conn.	Home	Oct. 8	9	5 children 2 adults	Privy	-
B. After epidemic times	S-4	Rural Conn.	Camp	Sept. 9	42	1 child 4 adults	Exposed feces (old)	-
	S-5	Rural Conn.	"	Sept. 17	50	0	" "	-
	A-2	Suburban Ala.	Homes	Sept. 19	40	64 children 117 adults	1 proven carrier. Many privies	-
	Ch-1	Rural Penn.	Camp	Sept. 17 Oct. 13	21-47	1 baby 8 adults	" "	-
	P-1	Rural Conn.	"	Sept. 15	19	0	Several privies	-
	F-1	Urban Conn.	Homes	Sept. 18	12	2 adults	" "	-
	No.H-1	Rural Conn.	Home	Oct. 4	12	3 adults 3 children	None	-
	Mo-1	Suburban Conn.	Homes	Oct. 6	13	5 children 7 adults	1 suspected carrier	-

* Dates on which fly collections were made.

† Interim (in days) between the dates of fly collections and the date of onset of the most recent case of poliomyelitis in the epidemic area.

‡ No. of people in the epidemic area at the time when fly collection was made.

|| + = poliomyelitis virus present in sample of flies.

during, and those collected after *epidemic times*; other details have also been assembled in this table. At a glance it will be seen from this table that of 8 samples collected *during* epidemic times, 4 yielded the virus, whereas of 8 samples collected *after* epidemic times none yielded the virus.

Sites from Which Positive Tests Were Obtained.—The four sites which yielded positive tests will be described in some detail. Only brief mention will be made with regard to those in which the tests were negative.

Eleven of the 16 samples of flies, recorded in Table I, were collected in Connecticut during the summer of 1941. This was not an epidemic year for poliomyelitis in New England, and only 114 cases were reported in the State of Connecticut. There were, however, small scattered outbreaks of the disease, some of which will be described below.

*Sample S-2. Camp S.*¹—This summer camp for children and adults was situated in eastern Connecticut in woodland and farming country typical of southern New England. The camp population, which was largely recruited from Brooklyn, New York, normally consisted of about 220 people of whom 120 were juveniles, ranging in age from 5 to 16 years. The remaining 100, or adult population, consisted for the most part of parents who came for short periods of time.

The children arrived at the camp on July 1, 1941. July 16 was the date of onset of the first recognized case of poliomyelitis and July 23 was the date of the second case. Both cases were hospitalized, one in Norwich, the other at New London, Connecticut. At this time, owing to the fear of a growing epidemic, a general exodus from the camp took place which temporarily reduced the population to about 20 children. Among the boys who left, a third frank case is said to have developed in New York City. We did not have the opportunity of seeing this third patient or of examining the records, but we were verbally informed, that the spinal fluid was "positive."

On July 29, at the time of our first visit, there were two boys in the camp infirmary with acute fever, unaccompanied by other notable signs or symptoms. Both of these boys had become ill on July 29. Their symptoms and the subsequent course (fever for 2 to 3 days) were compatible with the clinical picture of abortive poliomyelitis. From both of these boys serial stool specimens were obtained and both yielded the virus of poliomyelitis over a period of 4 weeks. These events are shown diagrammatically in Fig. 1. The chart indicates that the camp was "infected" throughout August, in so far as there were at least two known carriers present among the 20 to 40 remaining campers. No new frank cases of poliomyelitis appeared during this period.

This camp was equipped with flush toilets. It was apparent, however, that these were not invariably used. In other words, a potential (though not proven) source of virus in the form of fresh human feces was discovered in early August, in a sheltered grove of trees within 100 feet of the camp kitchen—see sketch in Fig. 2. It was possible, therefore, that the flies trapped on the back porch of the kitchen on Aug. 6, were within a short distance of an available source of virus.

According to the camp inmates, the experience with "ordinary" flies during the

¹ We are indebted to Dr. D. Sussler of Norwich, Connecticut, for the privilege of visiting this camp, of examining the inmates of the infirmary and their medical records, and of collecting specimens on the premises.

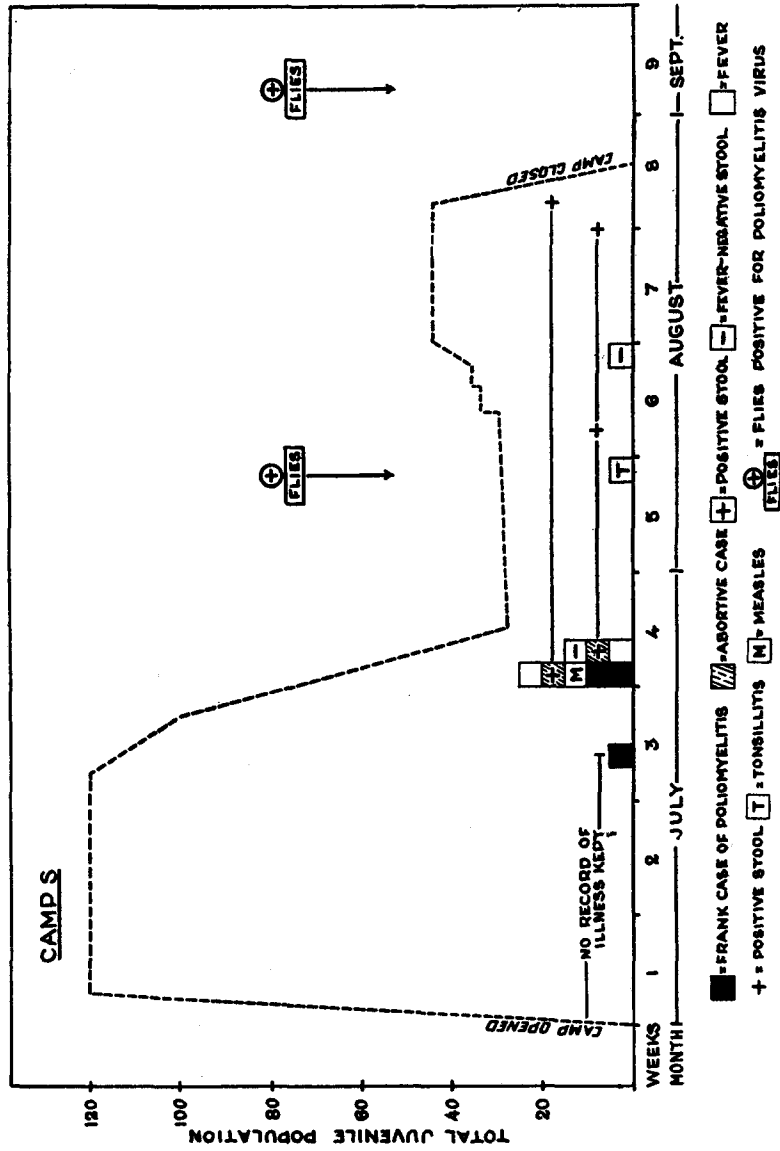


Fig. 1. A chart illustrating the course of the epidemic at Camp S. The broken line indicates the size of the juvenile population while the camp was in session.

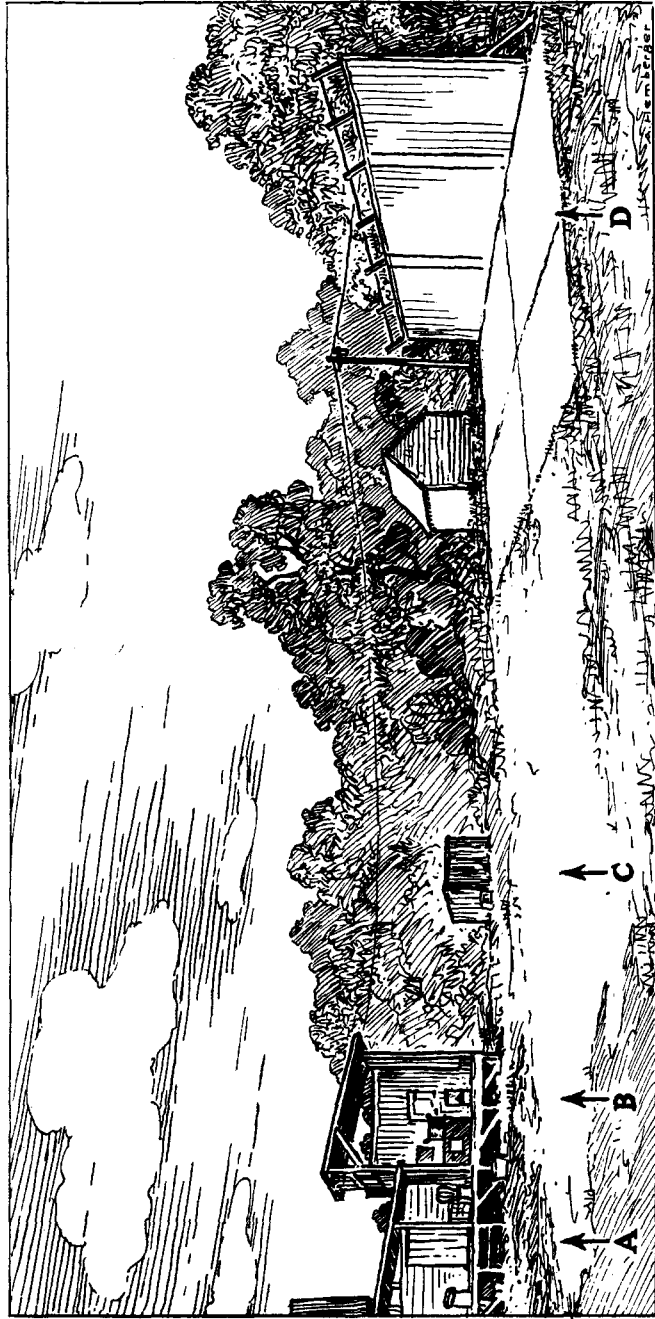


FIG. 2. Sketch of the site where fly trapping was done at Camp S. Points of emphasis have been marked with the arrows at A, B, C, and D: A, indicates the kitchen, B, the fly trap in place on the kitchen porch; C, the garbage dump; and D, a hand ball court with back stop behind which deposits of human feces were found. The distance from B to D is about 90 feet.

summer of 1941 was not unusual. However, biting flies were said to have been numerous since the latter part of July; and from descriptions these were presumably stable flies or *Stomoxys calcitrans*, although no definite specimens of this species were caught. Fly catching was started in this camp on Aug. 5, at which time biting flies were caught with a hand net. The size of the catch was not great and the sample (S-1) failed to yield the virus. Three other samples of "extrahuman material," which might conceivably have contained the virus, were collected at this time: (a) a group of night-flying insects, including mosquitoes of unidentified types, obtained with an electric light trap; (b) dust from the floor of a cabin where one of the patients (case 2) had slept; and (c) "fecal" material from the septic tank into which the toilet from this same cabin drained. All of these specimens were negative for the virus of poliomyelitis.

On Aug. 6 to 8 a fly trap was placed on the kitchen porch and sample S-2 was obtained consisting of about 1,000 flies which included blow flies, green bottle flies, and other types. See Table IV in preceding paper (1). From this sample the virus of poliomyelitis was isolated. Two subsequent samples from this site (S-3 and S-4) were negative.

In summary then we find that among the 20 boys present at Camp S on Aug. 6, there were at least two (10 per cent) proven, intestinal carriers of the virus. It is likely that the carrier rate was even higher, because the stools of only four boys in all were tested. There was a theoretical opportunity therefore for the flies to have come in contact with the virus. The positive sample was encountered in August while the carriers were still at camp. The two negative samples were obtained in September after the camp had been closed.

*Sample L-2. Camp L.*²—The location of this summer camp for children was in southern Connecticut, within 30 miles of Camp S, and in essentially the same type of country. It was organized to care for a population of a somewhat different type, consisting as it did of a group of about 150 underprivileged children (largely recruited from New Haven) whose ages ranged from 7 to 16 and whose stay at the camp was generally for brief periods of 2 or more weeks.

The camp opened on July 1 and the events with regard to febrile illnesses, in so far as they are known, appear in diagrammatic form in Fig. 3. The first indication that poliomyelitis was present in this camp occurred when a boy of 15, who was one of the more permanent members and served as a "waiter," was admitted, on July 28, to the New Haven Hospital with the diagnosis of poliomyelitis. He had been taken sick on July 27. A stool specimen from this patient failed to yield the virus but the diagnosis of poliomyelitis was confirmed by other signs. No other children at this camp developed frank poliomyelitis but it is worth recording that earlier in July, one child had been sent home because of unexplained fever, later (on July 31 and Aug. 1) three more children developed unexplained fever. In two of these latter, the

² We are indebted to Dr. A. A. Rozen of New Haven, and to Dr. M. P. Rindge, (Health Officer) of Madison, Connecticut, for the privilege of examining the patients at this camp and of collecting specimens.

clinical picture was compatible with that of *suspected abortive* poliomyelitis. We succeeded in collecting satisfactory stool specimens from only two of these children. No virus was isolated from these specimens. No further cases of illness occurred in which the diagnosis of abortive poliomyelitis was suspected, although there was a brief though extensive epidemic of acute diarrhea (Aug. 2) and another small outbreak of colds (Aug. 13). See Fig. 3.

This camp was equipped with privies and at the time of our first visit (July 31) their contents had been well covered with chloride of lime. The swimming pool also attracted attention. It was constructed by damming a brook and at the time of our visit the brook was low and water had ceased going over the dam. Two samples of water from this pond were tested and both failed to yield any virus.

A sample of biting flies (L-1, which proved negative for the virus) was caught on Aug. 5 to 9 with hand nets from the back and sides of a cow which had been tethered in a central location for 4 days for the purpose of attracting these insects. Other

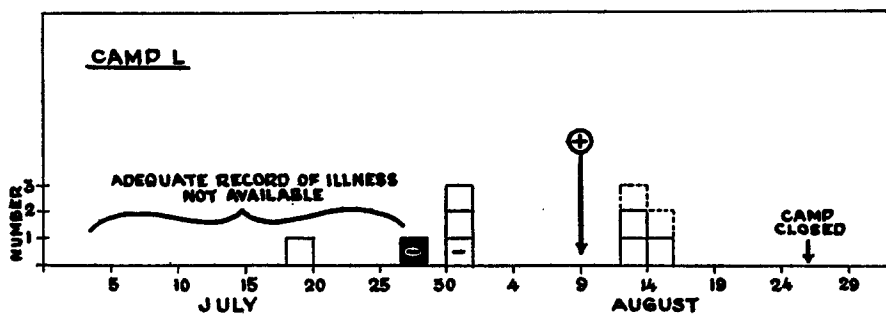


FIG. 3. The "epidemic" at Camp L. During the period indicated at the base of the chart, the juvenile population of this camp numbered about 150. Legends as in Fig. 1. The positive sample of flies was obtained from this camp on Aug. 6 to 8.

types of flies were obtained in fly traps on Aug. 6 to 8, cf. specimen L-2 in Table IV of preceding paper (1). From sample L-2 the virus of poliomyelitis was isolated.

In summary then, the flies which harbored the virus of poliomyelitis were caught from the 10th to the 12th day after the onset of the *only known* case which occurred at this camp. This boy had left the premises 9 days before fly trapping had begun. No proven carriers were found among the remaining children but our tests were inadequate. It seems likely that among 150 juvenile contacts (3 of whom had recent unexplained fever) carriers might have been present. Furthermore, there was a potential source of human virus at the camp in the form of the privy contents.

*Sample A-1, Walker County, Alabama.*³—This epidemic area which furnished two samples of flies for our series, has been recently described in some detail by Wenner

³ We are particularly indebted to Dr. A. M. Waldrup, Walker County Health Officer, Jasper, Alabama, for his assistance to us in this epidemic.

and Casey in a paper (2) to which the reader can be referred for further details. It may suffice to say that in the summer and fall of 1941, 871 cases of poliomyelitis were reported in the state of Alabama, and of these, 125 occurred in Walker County (population 67,000). One of the areas with the highest case rate in this county was the small town of Cordova (population 1670). Here, within an area of 15 to 20 acres, 12 cases of poliomyelitis occurred among a total population of 181 persons. All of these cases occurred in children and all remained in the community while sick. It is probable that there were even more cases as will be seen from the diagram in Fig. 4 designating febrile illnesses among the 64 juveniles during the period from early June until late September. Late in this epidemic, stool specimens were collected from 176 individuals (almost the entire group within the designated epidemic area) and tested by Wenner and Casey. None of the 112 tested adults yielded a positive test for the virus of poliomyelitis but 3 of the 64 children, whose stools were collected

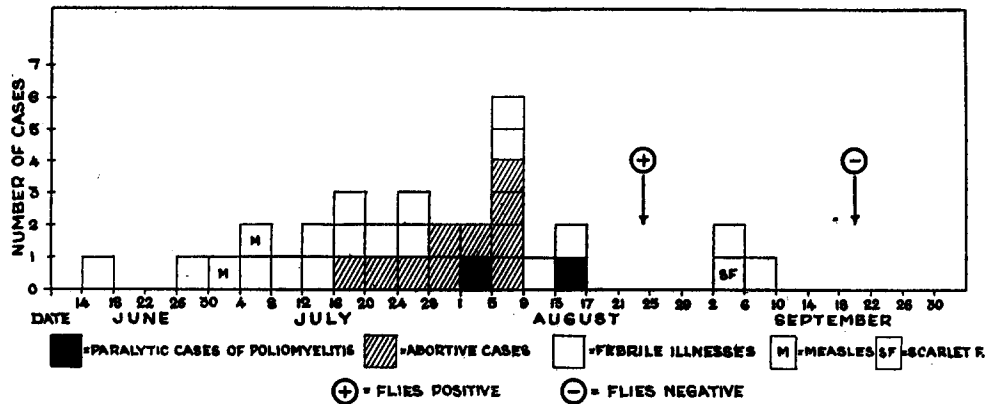


FIG. 4. The epidemic within one district of Cordova, Alabama. During the period indicated at the base of the chart, the juvenile population numbered 64.

between Aug. 15 and Oct. 6 were positive. It is safe to say then that 3 or more carriers were present in this epidemic area at the time the first collection of flies was made (Aug. 24) and only one known carrier was present at the time the second collection was made, Sept. 19.

On Aug. 19, which was the time of our first visit to this area,—a site for fly trapping was selected. It was located in the heart of the epidemic area, back of a crowded group of ramshackle houses and adjacent to several privies. The occupants of at least three houses used one of these privies and in two of these houses 3 cases of poliomyelitis had occurred with onsets between July 25 and Aug. 6. There was a reasonable chance therefore (although this is not proven) that virus was being deposited within this privy into which flies were freely passing. The fly trap was set a few feet from this privy (see Fig. 5), and the catch obtained on Aug. 24 was shipped in dry ice by air mail to New Haven where it was found positive for the virus. Another catch similarly collected and sent on Sept. 19, proved negative.

In summary then, there is little doubt that at the time the first specimen of flies was collected, there were probably several intestinal carriers in the com-

munity, although a carrier survey made 1 month later, revealed only 3. There was also some reason to believe that a potential source of virus existed in this community during the latter half of August, in a privy, to which flies in sample A-1 might have been exposed.

*Sample NB-1. New Brunswick, Canada.*⁴—During the summer of 1941, and again in the early spring of 1942, poliomyelitis appeared in epidemic form in the Province of New Brunswick, Canada. More than 200 scattered cases had been reported by mid-September, 1941.



FIG. 5. The site where flies carrying poliomyelitis virus were trapped at Cordova, Alabama. At the time (Aug. 19) at which the fly trap was first set (within the automobile tire in the foreground) several children used this privy, including at least 3 who were recently convalescent from poliomyelitis.

On Sept. 21 and 22, flies were collected by Dr. J. M. Cameron, District Medical Health Officer at Minto, New Brunswick, and these were shipped to us in dry ice by air express. Fly trapping was accomplished according to the technique described in the preceding paper, and the samples were obtained from the premises of two households: (a) those of A.L., age 3,—a paralytic case with onset on Sept. 7 whose home was described as dirty with many flies; and (b) the home of H.W., Jr., age 14, a non-paralytic case with onset Sept. 15. This patient was not sent to the hospital but

⁴ We are indebted to Dr. Arnold Branch of the Bureau of Laboratories, Department of Health, Saint John, to Dr. C. W. MacMillan, Chief Medical Officer of New Brunswick, and to Dr. J. M. Cameron of Fredericton, New Brunswick, Canada, for collecting these samples.

remained at home. The two samples were pooled for testing, and virus was isolated from the pooled specimen.

Pertinent details with regard to some of the environmental circumstances are lacking but we know that in one of these homes a patient was present who was in the 6th and 7th days of his disease.

Sites from Which Only Negative Tests Were Obtained

Sample C-1. Cleveland, Ohio.—Through the kindness of Dr. John A. Toomey, several samples of flies were collected in Cleveland and sent to us during the latter part of August and at a time when poliomyelitis was epidemic in that city. The fly traps were set in close proximity to the point where sewage-laden creeks emptied into Lake Erie. Data with regard to size of population and local cases in this *epidemic area* were obviously difficult to secure and have not been recorded. The samples were pooled. No virus was recovered.

Sample B-1. Urban Connecticut (Bridgeport).—During the late summer and fall, 11 cases of poliomyelitis were reported in Bridgeport, Connecticut. Two adjacent 4-family houses yielded 2 paralytic cases (onset Sept. 1 and 2), and in this epidemic area, among 14 remaining children, there appeared to have been 4 or 5 cases of suspected abortive poliomyelitis with onsets between Aug. 31 and Sept. 2. There were no privies in this community. A catch of flies was made on Sept. 10, and again on Sept. 18 from a fly trap set in the yard back of one of the houses. The samples were pooled and tested. No virus was isolated.

Sample Ch-1. Camp Ch, Pennsylvania.—Through the kindness of Dr. Joseph Stokes, Jr., and Dr. Rachel M. Winlock of Philadelphia, we were notified of an unusual and severe camp outbreak which occurred in late August at a children's camp in northern Pennsylvania. The population here consisted of 112 children and 25 adults. In the latter half of August several cases of poliomyelitis occurred, for the most part during the last few days in which the camp was open. It was closed on Aug. 27. It is not clear how many children developed the disease because a number had their onset after returning home. Probably there were 6 or 8 fairly definite cases. Our first visit to the camp was made on Sept. 9. Flies collected on Sept. 17 and Oct. 13, 21 and 47 days after the last patient had left, were negative for virus.

Sample P-1. Camp P.—This is a boy scout camp in rural Connecticut, recruited largely from the southwestern part of the state and with an average population of 130 boys whose usual stay was of 1 week's duration. Presumably 2 cases of poliomyelitis occurred among members of this group during the summer, with onsets on July 12 and Sept. 1, the latter case occurring in a boy who had left the camp 4 days previously. Flies were trapped in the deserted camp ground on Sept. 15. The results were negative for virus.

Samples M-1, No. H-1, and H-1 were all obtained from rural or semirural homes in southern Connecticut. From each of these homes one case of poliomyelitis had occurred with onset from 8 to 20 days prior to the time that the fly samples were collected. In one, H-1, a privy was present. All samples proved negative for the virus of poliomyelitis.

DISCUSSION

The four positive samples of flies listed in this paper, together with a larger number of similar positive samples reported by Sabin and Ward (3), and the single positive sample reported by Toomey *et al.* (4), leave little doubt that the virus of poliomyelitis can be detected not infrequently either in or on the surface of certain flies during epidemic times. From our own limited experience it has been easier to find the virus in association with these insects during epidemics than after the epidemic was over.

A pertinent question which arises from this finding is: Does the virus multiply within the body of certain flies or is it merely carried on their surfaces or in their alimentary tracts? We do not have sufficient data at our disposal to answer this question but one can point out that in at least three of our four positive samples of flies the insects were collected within a short distance (a few feet to a few yards) from a potential (though not proven) source of human virus in the form of freshly passed human feces. In none of the sites where negative samples of flies were obtained, did we discover an obvious source of fresh human feces which could have been recently passed by a proven carrier; but it is important to point out that the negative sites were not studied with the care that was used with the positive sites. In general nevertheless our findings suggest that mechanical transfer of the virus by flies could have been responsible for these positive tests, and it is unnecessary (for us) to postulate that multiplication of the virus within the fly must have occurred. Actually, however, this second possibility remains to be investigated. The futility of attempting to answer the question by the limited data in this paper is of course apparent, particularly as we still know little of the amounts of poliomyelitis virus in nature,—or their sources. For it is quite possible (in spite of the lack of proof) that there are sources of poliomyelitis virus in nature other than those which come directly from man.

We believe therefore that it would be unwise to read any epidemiological implications into these findings, for the presence of the virus in these particular samples of flies could be entirely a *resultant*, and not a *causal* factor in human poliomyelitis. Our findings to date therefore, merely indicate that under certain circumstances the virus is carried by flies and we suspect their feeding habits to be responsible. At least, in most of the instances in which the virus was isolated in this series of tests, the flies had had the opportunity of feeding upon fresh human feces which might have contained poliomyelitis virus.

CONCLUSIONS

During the summer and fall of 1941, 19 samples of flies were collected in epidemic areas both during and after epidemics of poliomyelitis.

Of 8 samples collected for the most part during the latter part of a local

epidemic but within 10 days of the onset of a local case of poliomyelitis, 4 yielded the virus; whereas of 8 samples collected more than 10 days from the onset of the last local case, none yielded the virus.

In 4 instances there was a potential (though not proven) source of virus (in the form of "exposed" human feces of recent origin) within a few yards or few feet of the site where fly collections were made. Collections of flies from 3 of these sites yielded the virus.

No attempt is made in this paper to develop epidemiological implications from this finding.

BIBLIOGRAPHY

1. Trask, J. D., Paul, J. R., and Melnick, J. L., *J. Exp. Med.*, 1943, **77**, 531.
2. Wenner, H. A., and Casey, A. E., *J. Clin. Inv.*, 1943, **22**, 117.
3. Sabin, A. B., and Ward, R., *Science*, 1942, **95**, 300.
4. Toomey, J. A., Takacs, W. S., and Tischer, L. A., *Proc. Soc. Exp. Biol. and Med.*, 1942, **48**, 637.