nificant for other groups or subgroups although almost all were in the negative direction.

The difference between the strains in terms of serotonin content was in the direction predicted by earlier studies (*1*) with emotional and nonemotional strains of mice. The differences reported here are primarily due to males, with limbic portions showing this difference most prominently. The sex differences were consistent throughout—that is, males ambulated less and had higher limbic and total 5-HT values than females, while there was no significant difference between reactive and nonreactive females in ambulation and, correspondingly, no significant difference between reactive and nonreactive females in limbic or total 5-HT values.

When considering the significant negative correlations between the limbic 5-HT values and ambulation scores, it can be seen that when males and females are combined within a group a bimodal distribution may result with males clustered because of their high 5-HT value and low ambulation and females clustered at the opposite extreme. A similar bimodal distribution may result when both reactive and nonreactive rats are grouped together. Although this type of distribution has meaning in itself, it will also affect correlation coefficients. Because of this, it is particularly interesting that the correlations between behavior and the 5-HT content of the limbic portion within the reactive male group alone, which lacks this distribution bias, were significant. Thus, a Maudsley reactive male with a low ambulation score was statistically likely to have a higher 5-HT content in the limbic portion than a reactive male with a higher ambulation score.

Since it is possible that a common denominator may regulate both the neurochemistry of the animal and the behavioral indices (for example, through genetic linkages), one cannot state that there is a cause and effect relationship between the differences or correlations presented here. To clarify the relationships further, studies in which crosses are made between the strains, and in which the progeny are analyzed for behavioral and neurochemical measures, would be helpful.

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27 July 1964

Insecticide Sevin: Effect of Aerial Spraying on Drift of Stream Insects

Abstract. *There was a rise in the rate of drift of aquatic insects in a stream contained within an area of woodland sprayed with Sevin for control of the gypsy moth. It appears from the pattern of drift that there was a drastic reduction of the standing crop of stream insects as a result of the spraying.*

Downstream drift has recently been recognized as an inherent characteristic of populations of certain stream insects (*1–3*). This drift is generally at a slow rate relative to the standing crop of individuals at any particular location. Gradual dissipation of headwater populations, which might be expected to result, is thought to be prevented by directed upstream movements of aquatic nymphs, terrestrial adults, or both (*2, 4*).

The common insecticide DDT, when allowed to enter a stream, has been observed in several studies (*5*) to cause a rapid and extensive rise in the drift rate. This rise is associated with a drastic depletion of the standing crop of bottom invertebrates. The stream organisms, most of which are normally able to resist being dislodged by currents, are apparently weakened or paralyzed by the insecticide and are easily swept away to eventual death, owing either directly to the toxicity or to predation by fish, damage by abrasion, settling in pools, and so forth.

While the effect of DDT on drift of aquatic insects has been insufficiently studied, its known toxicity to aquatic life and its other known or suspected deleterious effects have led to consideration and use of alternative formulations. One such product is Sevin (1-naphthyl-*N*-methyl carbamate). Although reported by the U.S. Department of Agriculture (USDA) to show little toxicity toward fish, mammals, and birds (*6*), the evidence concerning the effect of this insecticide on aquatic insects is scarce and contradictory. The USDA undertook field studies of Sevin in North Carolina in 1959, according to Burdick *et al.* (*6*), after which it was indicated in an unpublished report that there had been little or no effect on aquatic insects. Burdick *et al.*, however, reporting on an experimental study sponsored by USDA and the State of New York near Oneonta, noted a sharp rise in drift rate immediately after a stream had been sprayed, and a reduction (50 to 97 percent) of the standing crop. A publication of the Pennsylvania Department of Agriculture on the gypsy moth (*7*) states that Sevin "reportedly causes no loss of fish or wildlife," which presumably includes aquatic insects. No source for this information is given. Hoffmann (*8*) says that the apparent low toxicity of Sevin to fish recommends its use in important fishing streams, but he also requests field studies to evaluate the actual effect on fish-food organisms and fish.

An opportunity for further field evaluation of Sevin occurred this year. In May the Pennsylvania Department of Agriculture, in cooperation with the USDA, sprayed, by air, approximately 16,000 acres of woodland with Sevin for the control of the gypsy moth. The largest single tract (7775 acres) was immediately south of the Delaware Water Gap in northern Northampton County. Entirely enclosed within this area is the watershed of Slateford Creek, a small (flow when sampled was about 10 m^3/minute), stony, cold-water stream nearly completely canopied by trees from its diffuse beginnings in springs at the foot of Kittatinny Mountain to its mouth in the Delaware River at Slateford, Pennsylvania. The overall purpose of my study was to determine whether or not this spraying had an effect on the aquatic insects of this creek. Since the coarse stream bed was poorly suited for quantitative sampling of the bottom, observations were made of the drift rate. Allegheny Creek, a stream similar to Slateford Creek and about 11 km to the south, was used as a control.

Collections of drifting material in both Slateford and Allegheny Creeks were made continuously in Surber square-foot bottom sampler nets from approximately 7:00 a.m. on 11 May to approximately 7:00 a.m. on 26 May. Collected material was removed at 24-hour intervals. Two nets were placed side-by-side in each stream, in a manner similar to that pictured by Waters (*3*), to provide nearly duplicate samples for each station for each 24-hour period and to insure against the possibility of loss of either sample. The organisms and plant debris collected by each net were placed in quart Mason jars, in 10 percent Formalin. When the jars were returned to the laboratory, the organisms (exclusive of Tendipedidae) were removed from the debris by flotation in sugar solution (*9*) and by hand picking. Aquatic and emerging insects were separated from terrestrial insects, other invertebrates, and small fish, which were also collected by the nets; all were stored in 70 percent ethyl alcohol. Biomass was determined by liquid displacement.

Spraying was carried out in the area on 19, 21, 22, and 23 May with the immediate sampling area hit on the first two dates at least. Marker balloons, escort planes, and ground observers were used as guides to provide nominal protection against spraying of farms, ponds, and exposed streams. Loading of the spray planes and preparation of the spray mixtures were done at a distance many miles from the watershed of Slateford Creek. The insecticide was applied at a dosage of 1.1 kg of Sevin in 4.2 liters of water per hectare. No rain fell in the region during the sampling period.

Table 1 presents the volume of aquatic insects per one foot (0.3 m) of stream width (exclusive of those emerging) collected in each stream for each 24-hour period. The values for both streams for the 6 days of sampling prior to spraying in the Slateford Creek watershed can be seen to be low; only one collection exceeds 0.5 ml, and this was due to the unusual presence of two large tipulid larvae. The collections in Allegheny Creek remained in this general low range throughout the period of sampling, although there was a slight rise at the later dates. This rise can probably be attributed to a noticeable decrease (by about one-third) in volume of water flow in the creek during the sampling period; the decrease in flow is suspected of causing an increase in population density within the still-wet region. Competition between individuals, which is cited by Müller (*10*) as the main cause of drift, would thus be increased, thereby increasing the drift rate. A considerable increase in the number of emerging insects was seen in Allegheny Creek after 20 May, which may also indicate high population pressure in the stream at this time. No natural fluctuations in drift rate in this stream were correlated with the dates of spraying in the Slateford Creek watershed.

Data for Slateford Creek, on the other hand, show a drastic increase in drift at the time of spraying. The average biomass of the two collections from the first day of spraying is over six times that of the average biomass for the preceding 6 days, and the peak of drift, reached 2 days after spraying had begun, is over 160 times the normal average. Thereafter the drop to near normal levels was rapid. This drop probably resulted from a depletion of the standing crop, due to mortality of drifters rather than to reattachment of recovered insects, and a return to truly normal conditions since few bottom stones examined after the morning of 22 May revealed any living immature insects clinging to them. Caddis-fly larvae not generally found in the drift samples were observed dead in their cases, and dead nymphs could be seen collected along with bodies of terrestrial caterpillars behind natural stone sieves in the creek. It is suspected that a decline in drift rate to a level far below that observed in this stream prior to spraying would have been shown had this study been concerned with effects beyond the immediate period of spraying.

Organisms represented in the drift of both streams were predominantly mayflies (Ephemeroptera) and stoneflies (Plecoptera). Most common genera in Slateford Creek were *Ameletus, Iron,* and *Heptagenia* (Ephemeroptera), and *Brachyptera*, and *Alloperla* (Plecoptera). *Ameletus, Ephemerella,* and *Simulium* were most common in Allegheny Creek. Since the Tendipedidae (Diptera) were found abundantly only in the drift of Allegheny Creek, they were not considered in this study.

The data indicate that aerial spraying with Sevin had a pronounced effect upon the aquatic insect community of Slateford Creek in spite of precautions against direct spraying of open water, washing of spray equipment in the stream, and other "misuses" often blamed for kills. The observed effect of the spraying was a definite increase in the rate of drift over several days after spraying was begun. The carrier could hardly have contributed to the effects, as is sometimes claimed, since the insecticide was in water suspension. In view of previous studies relating increase in drift with loss of standing crop and visual observations made at the sprayed stream, it seems reasonable to conclude that this increase in drift represented a considerable reduction of the standing crop of stream insects. While the full ecological significance of this reduction is not yet understood, it can hardly have a beneficial effect upon the food-chain relationships of the stream and surrounding woodland.

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Table 1. Biomass (number of milliliters of liquid displacement) of drifting aquatic insects per 1 foot (0.3 m) of stream width. Collections were from approximately 7 a.m. on the first date to 7 a.m. on the second. AC, Allegheny Creek; SC, Slateford Creek.

Date (May)	SC (sprayed)	AC (unsprayed)
11–12	0.68, (0.25)*	0.08
12–13	.20, (0.10)	.02
13–14	.20, (0.20)	.08
14–15	.10, (0.25)	.10
15–16	.16, (0.15)	.36
18–19	.30	.42
19–20	1.78, (1.05)†	.40
20–21	6.08	.40
21–22	37.16†	.48
22–23	1.25†	.60
23–24	0.55†	.58
24–25	.30, (0.15)	.38
25–26	.20, (0.12)	.46

* Figures in parentheses indicate the volume of insects in the second of the two nets placed at each station. Close agreement of each of these values with its mate indicated that complete analysis of one sample per date would be sufficient at other times. † Spray.

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31 July 1964