the height of the post flood outbreak, twelve species occurred. Most of the newcomers were *Aedes* and *Psorophora.* Nearly all of these species persisted for the remainder of the active breeding season, appearing graphically as regularly spaced peaks about a week apart. During the entire season, sixteen species were collected. These include six species of *Culex,* two of *Anopheles* and four each of *Aedes* and *Psorophora.*

In attempting to draw conclusions from the light trap records, the following generalizations might be mentioned:

1. The tremendous expanses of potential breeding areas provided by floods can result in abnormal numbers of mosquitoes.
2. The variety of ecological situations provided by flooding and the subsequent recession of the water increases the number of species encountered. The components of the fauna undergo progressive change as the water recedes and new ecological situations are created.
3. If the predominant preflood species is capable of breeding under the ecological conditions presented by flooding, it will continue to be predominant during the flood period. *Culex tarsalis* is, of course, readily adaptable to breeding under flood conditions.
4. Peaks, or waves, of mosquito abundance may occur regularly for some time after the highest peak of mosquito abundance. These peaks are spaced approximately the length of a mosquito generation apart. Apparently these are reflections of the principal peak.
5. Effective emergency control can be obtained by city-wide fogging. This control is temporary and must be repeated if satisfactory levels of mosquito abundance are to be maintained.

STRIP SPRAYING BY HELICOPTER TO CONTROL BLACKFLY LARVAE

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Investigations in many areas have confirmed the reports of Fairchild and Barreda (1945) that DDT will control blackfly larvae. Gjullin *et al.* (1949) showed that DDT and a number of other insecticides were effective when applied to Alaskan streams with various types of ground equipment and by aerial applications. Hocking *et al.* (1949, 1950) working in Churchill, Canada, showed similar results. Other workers (Kindler and Regan, 1949; Hocking, 1950; and Goulding and Deonier, 1950) have also obtained good results with various formulations of DDT and other new organic insecticides. The earlier aerial spray data were obtained largely from plots originally laid out and used for mosquito control experiments or for forest insect control (*e.g.* gypsy moth), or from selected sectors of streams sprayed for blackfly control. Arnason *et al.* (1949) in Canada obtained complete control for 17 miles downstream when a large amount of DDT was applied across one sector of the Saskatchewan River.

From the information cited it would appear that it should be possible to

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obtain control of blackfly larvae in a large area by applying DDT from the air in swaths flown at regular intervals over the plot instead of trying to treat each stream individually or giving a complete spray coverage to the entire area. By this method it might be economically feasible to treat large blocks of land infested with blackflies in areas where rough terrain and the large number of small streams make ground methods impractical.

An unusual opportunity for observing the results of this method on a practical basis in an area where the seasonal history of blackflies has been observed for many years was presented in the summer of 1950. Two years previously the Town of Webb, which includes Thendara, Old Forge, Eagle Bay, Big Moose and several other communities in the central Adirondacks of New York State, had inaugurated a blackfly control program. Blackflies were so numerous and such vicious biters in this region that recreational activities, on which the area now largely depends for its economic wellbeing, were virtually impossible in the spring and early summer until blackfly control was instituted on a regular basis. In 1948, DDT fogging from a helicopter was undertaken over an area of some 4,000 acres in the vicinity of Old Forge, for the control of adult blackflies. Although a conspicuous abatement of the blackfly nuisance occurred, this method, besides being topical and temporary, was also expensive. Therefore, investigation of other methods continued, and in 1949 several of the communities in the Town treated many streams with DDT impregnated plaster blocks, as had been suggested by Dr. Gustave Prévost, for the destruction of blackfly larvae. Although the block treatments did result in the killing of many blackfly larvae, and were considered by the residents to have contributed greatly to the further reduction of the blackfly nuisance, it was not possible in 1949 for the entomologists who were watching the operations to evaluate the two methods from a comparative standpoint, nor to study the effects upon other stream and forest fauna as critically as could be desired. The block method, although apparently cheaper, was actually rather expensive in terms of time and labor, since it was planned to treat all of the streams, even the smallest, up to their headwaters in an area of over 100 square miles. Therefore, in 1950, in view of the success of the aerial larviciding treatments cited above, it was decided to reserve a portion of the area of approximately equal size to be treated for a test of the swath method of aerial larvicide application.

The Town of Webb arranged to have the spraying done by helicopter. The Army Quartermaster Corps furnished the spray material; the authors of this paper supervised the operations and made the observations herein recorded.

The area selected to receive the spray was a wilderness area northwest of Thendara which was apparently responsible for the production of a large proportion of the blackflies that plagued the villages of Thendara and Old Forge. The area was laid out on the map in the form of a trapezoid in such a way that swaths flown from the southwest to the northeast a quarter of a mile apart would cross most of the streams at least once near their headwaters. The plot averaged about 12 miles long and 2¾ miles wide. The terrain was rough with an approximate range of elevation of 1700 to 2400 feet. The area was heavily wooded but the foliage had not developed at the time of spraying.

The plot was sprayed in the late evening of May 2 and the early morning of May 3, 1950. The pilot flew swaths about 100 feet wide and a quarter of a mile apart the length of the plot. The swath lines were flown by following a marked topographical map and a compass. Wind conditions were favorable, being no more than 5 to 10 miles per hour during the last two swaths, and less during the others. Good inversion prevailed except during the last two swaths, when, due to air movement, the conditions were isothermic. Flight was 25 feet or more above the trees.

The spray was delivered from a helicopter provided with a pressure spray

system equipped with two nozzles which delivered 0.35 gallon each per minute at 60 pounds pressure. By flying 60 miles per hour a dosage of approximately 0.1 pound per acre *over each swath* was delivered. The spray consisted of 20 per cent DDT, 20 per cent fuel oil and 60 per cent auxiliary solvent. A total of 140 gallons were used to swath-spray the approximately 40 square miles.

Results: Eighteen observation stations were established at random across the width of the plot and scattered from one end of the plot to the other. Blackfly larval populations were sampled at these stations by counting and estimating the number of larvae per square foot of surface of either submerged rocks or of vegetation or of both. Pre-treatment populations in 16 of the streams ranged from 50 to 100 per square foot and in two locations only 15 to 25 per square foot.

Prosimulium hirtipes (Fries) constituted 74 per cent of the population, and *Eusimulium mutatum* (Malloch) 24 per cent. *Simulium venustum* Say comprised the remaining 2 per cent. Most of the larvae were in the last instar except at one station, where they had begun to pupate.

Four days after treatment no blackfly larvae could be found at 7 of the 18 stations. At two stations, control was estimated to be better than 95 per cent. One station showed no reduction and one station only 50 per cent reduction. The estimated total reduction for all 18 stations was about 85 per cent.

Observations were made also on the numbers of aquatic arthropods in the stream beds and on the numbers carried downstream at various intervals of time after treatment. In one stream in the center of the plot (Indian Creek) regular observations of all stream organisms were made at weekly intervals throughout the summer, beginning before the treatments. Blackfly larval populations were estimated by counts of larvae on stones in rapids and on trailing grasses, and a square foot bottom sampler was used to obtain counts of the bottom fauna which normally exist in large numbers under stones and in bottom debris. Samples of the organisms carried downstream were taken in cross-stream nets and in square-foot nets placed in narrow sections of the stream for 5-minute periods at weekly intervals.

The numbers of blackfly larvae per stone or grass blade before treatment varied upwards from 100. By one day after treatment they had disappeared completely from the grass blades, which remained uninfested thereafter for 36 days. Larvae on stones were reduced from 100 per stone to less than 3 per stone, the complete reduction not occurring until two or three days later than the complete disappearance from the grass blades.

In one of the nets mentioned above, blackfly larvae and other arthropods appeared in increased numbers a few minutes after a swath which centered about 50 feet upstream from the net. Blackfly larvae continued to come downstream for 72 hours after the application. This extended time was caused partly by the fact that larvae were delayed in arriving at the sampling point because of the distance upstream from which they came, or because they were temporarily sidetracked into swirls and pools.

Other aquatic arthropods were disabled and washed downstream also, but in smaller numbers, for about the same period of time as the blackfly larvae. With bottom sampling methods, no measurable reduction of arthropods other than blackfly larvae was observed. In fact, a week after treatment, judged from bottom samples, the arthropod population, excluding blackfly larvae, showed an increase, or no noticeable change, averaging 41 per square foot before treatment and 45 per square foot a week after treatment. Thereafter there were fluctuations both above and below the pre-treatment level, apparently independent of the treatment.

Trout, both above and below seven inches, were observed in Indian Brook both before and after the helicopter treatments, and afterwards throughout the summer. Amphibia, including both frogs and salamanders, were numerous and apparently unaffected by the treatments.

No attempt has been made here to present the aerial dosages in terms of parts per million. The impossibility of arriving at an accurate figure applicable to the extreme range in flow and size of the treated streams is obvious. A per unit area dosage is more easily described and followed under the conditions involved in routine control work. By the swath method of application the dosage is, to a certain extent, automatically adjusted to the size of the stream.

Blackfly larvae appeared in some of the block-treated streams about two weeks after the treatment, but the species represented were *Simulium venustum* Say, *S. perissum* D. and S., and *S. vittatum* Zett., not *Eusimulium mutatum* or *Prosimulium hirtipes*, the species that had been present in the spring, before treatment. The streams were again infested the fall after treatment with the latter species.

Discussion. It was observed that blackfly larvae at the dams at lake outlets were not materially reduced in numbers. The pilot shut off the spray when passing over large lakes to avoid possible damage to fish. As a result, the dosage of spray reaching the larvae at the outlets was insufficient to be effective, since the minute amounts per unit area deposited on the streams flowing into the lakes suffered further extreme dilution from these large bodies of water. Special attention should be given in the future to such areas.

The two streams in the sprayed areas showing little or no reduction in larvae were short brooks, and ran between and parallel to the swaths. It was thought that eighth-mile swaths at the same dosage per acre might not have missed the short parallel streams and might have treated the area adequately.

With respect to the ultimate objective of the treatments, that is, the abatement of the blackfly nuisance in the populated areas, it is more difficult to make a critical analysis. It was agreed by all concerned, including entomologists and the public at large, that the control measures accomplished a significant degree of blackfly control. It was demonstrated that either method alone—fogging, DDT plaster blocks, or aerial spraying—would at least partly accomplish the objective. However, the populated areas where all three methods were used together experienced the most pronounced relief, and it is therefore difficult to assign the proper relative values to the several treatments. Since the aerial fogging is the most expensive, the logical next step is to omit this treatment and determine whether improved stream treatment techniques, supplemented by local ground fogging, can be made to accomplish satisfactory blackfly abatement.

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