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THE EFFECT OF DENDROL SOLUTIONS ON BROOK TROUT AND THE LARVAL STAGES OF BLACKFLIES

by

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Introduction

During the past few years persons enjoying the facilities of the Keweenaw County Golf Course near Copper Harbor, Michigan, have been plagued by blackflies. These minute insects belong to the dipterous family Simuliidae, the females of which habitually feed on the blood of warm-blooded animals, including man. The family is known from all parts of the world. One species in Africa, and three in Central America, have been shown to transmit a filarial worm which parasitizes man (Curran, 1934). The notorious Eusimulium pecuarum of the lower Mississippi Valley has for years been responsible for much loss of livestock, through the number and viciousness of its attacks. Species inhabiting the United States and Canada are not known to carry diseases transmittable to man, although some of the species serve as vectors of the leucocytozoan disease of ducks; but, as has been noted by Johannsen (1934) "----tourists, hunters and fishermen find these insects intolerable, in

some cases even dangerous to life---". The bite itself is not usually painful, and, in fact, the victim is often unaware of the attacks until some time later. The flies have a habit of creeping in under the clothing, where they can feed unobserved. During the act of sucking blood, they inject a venom which results in subsequent swelling, inflammation and itching. As is true with most venoms, some persons are much more susceptible than others to the bites. The venom may cause a reaction in the glands about the neck and ears; the victim may run a fever for some days and sustain a general malaise; and, fortunately very rarely, death may follow.

The species common about the Keweenaw County Golf Course, which has been determined as Simulium venustum, spends its larval and pupal stages in shallow, swiftly-flowing water, as is the rule throughout the family. Adults emerge in great numbers during late spring and early summer, a period which, unfortunately, often coincides with the peak of the tourist season. So great has been the nuisance that local authorities determined to explore the possibilities for controlling the pests.

During the summer of 1940, Dr. Curtis W. Sabrosky, of the Department of Entomology, Michigan State College, made a brief survey of possible blackfly breeding areas in the vicinity of the golf course. A number of these were located, ranging in size from mere trickles and runlets to moderate-sized streams, including Aetna and French Annie Creeks (tributary to Lake Manganese) and Garden Brook (tributary to Lake Fannie Hooe).

Based in part on the findings of Dr. Sabrosky, a report was submitted to the Keweenaw County Road Commission by Professor Ray Hutson, Head, Department of Entomology, Michigan State College. The substance of Professor Hutson's control recommendations included use of Pyrocide dust

on greens and adjacent trees and shrubbery, and the treatment of the breeding areas themselves with a water-miscible oil, such as Dendrol. It was the opinion of Professor Hutson that such oil treatment would kill the blackfly larvae and pupae "without doing too much damage to any fish that might be present".

Recognizing the desirability of obtaining definite information on the success of attempts at blackfly control, the Department of Conservation authorized the Keweenaw County Road Commission to apply Dendrol to the breeding areas with the exception of Garden Brook, stipulating only that representatives of the Fish Division be allowed to witness the experiments to determine the injury, if any, to fish and fish-food organisms occupying the affected area.

On May 31, 1941, the writers, accompanied by Professor W. F. Morofsky, Department of Entomology, Michigan State College, drove to Copper Harbor, and during the five days following witnessed the treatment of Aetna and French Annie Creeks and some of the small streams near the golf course. The results of this study, and of subsequent treatments made during the summer, have been reported by Eschmeyer (1941). His findings made it apparent that Dendrol would occasion heavy trout mortality when applied in strong concentrations. It was decided, therefore, to conduct a series of tests at the Hunt Creek Experiment Station, employing known concentrations of oil over carefully-timed intervals, to learn if there could be discovered a dosage which would kill blackfly larvae and at the same time prove non-lethal to brook trout. Additional experiments were conducted later at the Watersmeet Hatchery.

Description of Experiments

Experiments were conducted during the period from February 24 to March 2, 1942, at the Hunt Creek Station, and on March 10, 11 and 17 at

the Watersmeet Hatchery. Three types of situations were employed at Hunt Creek: (1) Standard glass aquaria, with and without aeration; (2) the blackfly-rearing apparatus described by Smart (1934); and (3) a trough delivering 5 gallons per minute at a velocity of ± 2.5 feet per second. In (1) and (2), trout and larvae were exposed to definite concentrations for timed intervals, then transferred to fresh water for possible recovery. In (3), blackfly larvae and other bottom organisms, still clinging to stones and debris as they occurred in Hunt Creek, were rapidly transferred to the trough, through which spring water was flowing at approximately the same velocity as in their natural habitat. After a period of acclimatization, the pure water inflow was diverted and instantly replaced by Dendrol solution. This was constantly recirculated for a definite period of time at the same rate of flow as the previous water supply. Then pure water was again allowed to flow through the trough. This practice resulted in a close approximation of treatment under natural stream conditions.

In the experiments conducted at Watersmeet, two similar situations were employed: (1) A trough 12½ feet long and 13½ inches wide, with water 5 inches deep, which entered at the rate of 9 gallons per minute; (2) a trough of the same dimensions, but with water only 1 3/4 inches deep (bringing about a faster turnover of water in the trough). Dendrol at a concentration of 1:100 was recirculated and fresh water introduced, or the fish transferred to fresh water, after a timed interval had elapsed, as in the case of the Hunt Creek Experiments.

Throughout the tests, attention was given to practical considerations of actual control conditions. The maximum dosage of Dendrol administered was believed to be the largest feasible in control practice on such streams as Aetna and French Annie Creeks. Stronger concentrations might be attained

in the tiny trickles of water adjacent to the golf course. The results of the tests made on brook trout and blackfly larvae at Hunt Creek, and on brook trout at Watersmeet are shown in Table I (page 6).

With blackfly larvae, tests were conducted first using the maximum exposure that the trout had been able to survive. In the first test, larvae were placed in a small, open-end glass cylinder suspended within a larger glass jar. Water in the larger jar was kept circulating through the smaller cylinder by means of a compressed air jet, following the method described by Smart (1934). A Dendrol concentration of 1:5,000 was placed in the jar and allowed to circulate for 40 minutes; then it was siphoned off and 3 gallons of pure water run through the tank to remove oily residues, after which pure water was allowed to remain in the tank. No mortality was observed, although a few larvae released their original hold.

Next, larvae clinging to stones and plant debris were placed in a 10-foot length of eave trough. Spring water was run through constantly until the larvae appeared to be acclimatized and all were securely fastened to some support. Then a 1:100 Dendrol solution was run through the trough for 10 minutes, at the same rate the water had previously flowed. At the termination of the exposure, spring water was again restored to the trough. Twenty-two hours after the treatment was terminated, 11 out of 65 larvae were dead. No control was possible with this experiment, and the mortality cannot, therefore, be wholly ascribed to the effect of the Dendrol. Involved in the same test were nymphs of mayflies (Ephemerella invaria and Baetis vagans) and stoneflies (Isoperla signata and Isogenus frontalis), caddis larvae (Hydropsyche sparna) and an aquatic earthworm (undetermined). None of these forms died within

Table I
Results of treatment of brook trout (Salvelinus fontinalis) and blackfly larvae (Simulium venustum) with Dendrol solutions of various concentrations and for varying periods of time.

Number of trout (or blackflies) used	Concentration of Dendrol used	Temperature range	Duration of exposure	Fate of animals
		Fingerling brook trout (80-120 mm.), Hunt Creek Station		
1	1:100	48°-51°F.	5 minutes	Lived
1	1:100	48°-51°F.	10 minutes	Lived
1	1:100	48°-51°F.	15 minutes	Lived
1	1:100	51°F.	20 minutes	Died
1	1:100	51°F.	25 minutes	Died
1	1:100	51°F.	30 minutes	Died
1	1:200	46°-49°F.	5 minutes	Lived
1	1:200	46°-49°F.	10 minutes	Lived
1	1:200	46°-49°F.	15 minutes	Died
1	1:200	46°-49°F.	25 minutes	Died
1	1:200	46°-49°F.	35 minutes	Died
1	1:1,000	48°-51°F.	5 minutes	Lived
1	1:1,000	48°-51°F.	10 minutes	Lived
1	1:1,000	48°-51°F.	15 minutes	Lived
1	1:1,000	48°-51°F.	20 minutes	Lived
1	1:1,000	48°-51°F.	25 minutes	Died
1	1:1,000	48°-51°F.	30 minutes	Died
1	1:5,000	53°-58°F.	20 minutes	Lived
1	1:5,000	53°-58°F.	40 minutes	Lived
1	1:5,000	53°-58°F.	120 minutes	Died
		Brook trout fry (2½ months old), Watersmeet Hatchery		
100	1:100	42°F.	10 minutes	All lived
130	1:100	42°F.	15 minutes	98 (75 per cent) died. 32 (25 per cent) lived.
306	1:100	42°F.	25 minutes	All died
		Brook trout (adult, 7-8½ inches total length), Watersmeet Hatchery		
10	1:100	42°F.	10 minutes	All lived
10	1:100	42°F.	25 minutes	8 (80 per cent) died. 2 (20 per cent) lived.
		Blackfly larvae, Hunt Creek Experiment Station		
About 25	1:5,000	60°F.	40 minutes	All lived
65	1:100	45°F.	10 minutes	About 83 per cent lived.
About 100	1:100	45°F.	30 minutes	About 88 per cent lived.

the 22-hour period, although the gills of the caddis larva and of the Ephemerella nymphs bore a slight oily deposit.

On March 1, an experiment was set up as in the preceding instance, except that the 1:100 Dendrol solution was kept circulating through the trough for 30 minutes. The results of this test were closely comparable to those of the one just described. Outright mortality of blackflies over a 24-hour period was approximately 12 per cent of the total number involved, and observations extending over the following five days gave no perceptible indication of any significant "delayed action" of the oil.

Discussion

In both of the trough experiments with blackfly larvae, several observations made may deserve mention. One is the well known fact that blackfly larvae, when frightened or disturbed, often release their hold on their support and drift away with the current. As they do so, they spin a fine thread (similar to spider web) from the specialized salivary glands. With the aid of this thread they check their progress after drifting anywhere from a few inches to several feet. They then hang suspended in the current until the effects of the frightening stimulus subsides, after which they may seek reattachment in their new position, or, less commonly, attempt to work back to their original location. Considerable numbers of the larvae subjected to Dendrol released their hold and a number estimated at 30 per cent of the total washed out of the trough and were caught on a screen placed just below the outlet end. Here they were held and continued to be subjected to the Dendrol until the treatment was concluded. Subsequently the screen bearing the dislodged larvae was placed in a trough of pure running water and their survival or death noted, together with that of the larvae remaining in the experimental trough.

Another observation was that organic debris (dead leaves, fragments of moss and algal filaments) submerged in the treatment trough trapped out much larger quantities of the oil than did the smooth stones and pebbles. Clambering insects, such as the nymphs of mayflies and stoneflies, and the Hydropsyche, were seen to pick up oil on their bodies by creeping about over oil-coated debris. Those which clung to stones (including a great majority of the blackfly larvae) picked up negligible quantities of oil. In general, the only visible oil on the blackfly larvae was in the form of one or two minute droplets clinging to the fan (the paired food-gathering organs on either side of the mouth). They appeared to be able to rid themselves of these during the period allowed for recovery.

The above suggests that the use of Dendrol might be more lethal to organisms inhabiting debris and vegetation than to forms occurring on smooth stones and gravel. Persistence of oil on the debris several days after treatment had been discontinued, and the flow of pure water restored, suggests also that biologically deleterious effects of Dendrol might be expected to remain longer in streams containing much debris than in those having but little of this material.

All the trout which were treated with Dendrol repeated to a greater or less degree the symptoms of distress which had been observed when similar treatments were made in Aetna and French Annie Creeks (Eschmeyer, 1941). Immediately after being placed in the Dendrol-treated water, great irritability was shown. Trout attempted to leap out of their enclosures, moved about with spasmodic motions, frequently swam for short distances with the head and nape entirely out of water, and breathed convulsively. Attempts to rise above the surface became increasingly feeble with continued exposure to treatment. If not removed, fish finally turned on their sides at the bottom of their enclosures in a dying condition,

with breathing becoming more and more convulsive and movement becoming restricted to occasional ineffectual spasms. Recovery was often slow, when it occurred at all, after fish were removed to fresh water. One of the adults which survived the 25 minute treatment with 1:100 Dendrol at the Watersmeet Hatchery lay inactive on its side for over 3 hours after the treatment had been completed and did not appear normal until about 24 hours later.

Trout fry, after exposure to Dendrol, showed a distinct tendency to collect food particles, filaments of algae, and bits of debris on their gills and body during the period immediately following treatment. This may have contributed to the mortality in the experimental troughs, just as it would probably increase mortality after treatment under stream conditions.

The data as shown in Table I seem to clearly show that there does not exist a concentration and duration of exposure which would cause a significant mortality among blackfly larvae without almost complete destruction of the trout population in the treated water. Dendrol concentrations of 1:100 were much more damaging to trout fry after a 15 minute exposure than to blackfly larvae after a 30 minute exposure at comparable temperature; fingerlings apparently cannot endure 20 minute exposures at that concentration, and most adults die after a 25 minute exposure.

The writers do not question that Dendrol applications of sufficient strength and duration would result in a large-scale mortality among blackfly larvae. The tests described above were designed simply to determine whether or not a dosage known to be non-lethal to brook trout would produce any appreciable mortality to blackfly larvae; and to permit, incidentally, observations on the reactions of other aquatic insects, valuable as fish food, to such treatment.

The tests here reported show that there is little likelihood of controlling blackfly larvae by the use of Dendrol without occasioning heavy, if not complete, loss of the brook trout population of the stream so treated. This observation confirms the suggestion made in an earlier report (Eschmeyer, 1941) that the ultimate decision of whether or not to sanction such treatments is a matter to be ruled upon by administrative personnel having authority to choose the course of procedure which appears to best serve the public interest.

Literature Cited

Curran, C. H. 1934. The families and genera of North American Diptera. Ballou Press, N. Y., pp. 1-512, illust.

Eschmeyer, Paul H. 1941. The use of Dendrol in control of blackflies in Keweenaw County, Institute for Fisheries Research Report No. 697. (Manuscript).

Johannsen, O. A. 1934. Aquatic Diptera. Pt. I. Nemocera, exclusive of Chironomidae and Ceratopogonidae. Cornell Univ. Agric. Exp. Sta. Mem. 164: 1-71. pls. 1-24.

Smart, John. 1934. Proc. Roy. Physical Soc. 22:217 in Culture Methods for invertebrate animals, by P. S. Galtsoff, F. E. Lutz, P. S. Welch, J. G. Needham, et al., 1937. Comstock Publ. Co., pp. 402-404.

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