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THE USE OF DENDROL IN CONTROL OF BLACK FLIES

IN KEWEENAW COUNTY, 1941

by

Paul H. Eschmeyer

I. Introduction

The Keweenaw County Golf Course and Resort has an open season extending from about the middle of June to mid-September. During the past four years, black flies (Simulium venustum) have been sufficiently numerous in the vicinity particularly during June and early July, to much reduce patronage at the resort and to make the use of its various outdoor recreational facilities extremely unpleasant. Previous to that time, the black flies are said not to have created an objectionable nuisance in the area.

The first investigation of the black fly problem was made by Dr. Curtis W. Sabrosky of the Department of Entomology at Michigan State College, in 1940, at the request of the Keweenaw County Board of Road Commissioners. It was at this time that the role played by the streams mentioned above (and their tributaries) in the establishment of the large black fly populations in the area, was first pointed out.

Direct measures toward alleviation of the black fly nuisance by treatment of the streams with a view toward destruction of the larvae were undertaken in 1941. The first treatments of the streams were made from

June 2 to 4, by Professor W. Morofsky of the Entomology Department of Michigan State College. Dr. J. W. Leonard and the writer, of the Institute for Fisheries Research of the Michigan Department of Conservation, witnessed the treatments made. The writer was present at several subsequent similar treatments undertaken later in the summer, which are described below.

II. Locations

The Keweenaw County Golf Course, operated by the Keweenaw County Board of Road Commissioners, is located in Section 6, T. 58 N., R. 28 W., in Grant Township, Keweenaw County. It is within $1\frac{1}{2}$ miles of the Village of Copper Harbor and is bounded on its west side by U. S. Highway 41.

Three small streams pass within a half mile of the golf course. The nearest of these is Aetna Creek, which has its headwaters in Sections 1 and 2, T. 58 N., R. 28 W., and flows in an approximate west-east direction, into Manganese Lake, in Section 5 of the same town and range. This stream, with a width of from 2 to 5 feet, meanders through densely wooded land, and flows within $1/4$ mile of the south boundary of the golf course at the rate of an estimated 600 to 700 gallons per minute (June 1, 1941).

The second stream is French Annie Creek, lying less than $1/4$ mile south of and approximately paralleling Aetna Creek, the two streams being separated by a narrow divide. The stream heads in the same section as does Aetna Creek, and likewise enters the southwest end of Manganese Lake. It is somewhat larger than Aetna Creek, and has an estimated flow of 800 to 1,000 gallons per minute (June 1, 1941).

The third stream, Garden Brook, with its headwaters in Section 35, T. 59 N., R. 29 W., flows about $1/4$ mile north of the golf course, in a west-east direction, ultimately emptying into Lake Fanny Hooe in Section 35, T. 59 N., R. 29 W. It is the largest of the three streams, being about twice the size of Aetna Creek and carrying almost double that stream's volume of water.

III. Fisheries Significance of the Streams

From the standpoint of hook and line fishing, none of the streams mentioned above is highly important. French Annie and Aetna Creeks, throughout most of their lengths, would be large enough to support legal trout only during some months of the year. No trout over 5 or 6 inches in length were seen in either stream and even fish of small size were not abundant in early June, 1941. Several young fry were observed, however, which had only very recently completed absorption of the yolk sac, which indicates that the streams at least serve as an area for natural brook trout reproduction. At the extreme lower end of these streams, near Lake Manganese, there are located several fair pools in which legal trout may occasionally be taken by angling.

Some catches of trout have been reported from Garden Brook, although it is very lightly fished. Most of the fish seen in the stream ranged from advanced fry to 5 or 6 inch fingerlings.

The three streams have their chief fisheries significance in providing spawning areas for the lakes to which they are tributary (Lake Fanny Hooe and Lake Manganese), both of which are designated trout lakes, contain established brook trout populations, and are much frequented by fishermen.

IV. Methods Used and Observations Made in the Field

1. Medium used for black fly control - The insecticide used for direct application to the streams in the black fly control experiments was "Dendrol", a petroleum derivative of the consistency of light motor oil, distributed by the Standard Oil Company. The oil functions as a contact insecticide and has the property of forming a film on vegetation, sticks, twigs, or other submerged cellulose materials. It is a miscible oil and attains a high degree of emulsification upon contact with the water

2. Observations made in the field -

A. Observations June 2 - 4.

The first treatment with Dendrol was made in Aetna Creek. A gallon of the product was mixed with an equal amount of water to effect thorough emulsification, and then applied to the stream in a single application, about 200 feet west of Highway U. S. 41. The insecticide greatly discolored the water, making it milky white, so that its progress downstream could be easily followed.

Previous to the application of Dendrol, 2 five-inch brook trout were placed in each of the two wire cages placed in the stream. The first of these was placed in midstream, very near the highway (hence about 200 feet below the point at which the Dendrol was placed in the stream) and the other was placed about 500 feet farther downstream. The fish were carefully observed as the treated water passed through their cages.

The fish nearest the highway showed very obvious signs of distress soon after the oil reached them. Both rose repeatedly to the surface, "gasping" as though in response to partial suffocation. One fish lost its equilibrium momentarily and was carried to the downstream edge of the cage on its side, but resumed a normal position almost immediately. As the concentration of the oil passing through the cage diminished, the two trout returned to the shelter of stones placed in the bottom of the cage and upon later examination showed no ill effects. The trout in the cage farther downstream showed no distress during the time the oil reached and passed the cage.

As the first rush of oil came downstream, a trout fry about $1\frac{1}{2}$ inches long was seen at the surface in midstream, in distress. It was captured and placed in the cage nearest the highway. After the toxic solution

had passed, it resumed normalcy and showed no ill effects within $\frac{1}{4}$ hours after the application of the oil, at which time it was released.

The second application of Dendrol was made in French Annie Creek, under very similar conditions, except that 2 gallons of Dendrol were used. The fish cages were moved to the stream from Aetna Creek and were placed at similar distances below the point of application of the insecticide. No new signs of distress were observed as the oil passed through the cages.

Since the first applications were not lethal to the black fly larvae, as shown by the fact that these were found alive in the stream up to 10 hours after treatment, French Annie was given a second "dose" on June 3. Five gallons of oil were applied at a single point in the stream. Its progress downstream was accompanied by vigorous activity of much of the invertebrate life in the stream. Beetles attempted to escape by climbing up on emergent vegetation, several leeches and lampreys appeared at the surface, and a number of large (occupied) caddis cases came floating downstream. The caged fish showed no new signs of distress other than a severe shaking of the head, as if to shake off the irritant. They survived the treatment without effect, and were released $2\frac{1}{4}$ hours later in an apparently healthy condition. In a bottom sample taken 200 feet below the point of application, and in observations made elsewhere in the treated area, several hours after treatment, both living black fly larvae and inactive larvae which seemed to be dead were found.

Garden Brook was not treated. Its treatment was strongly advised against, in view of its importance as a spawning area for Lake Fanny Hooe brook trout.

B. Observations on June 13 and 14.

Careful observations in both the previously treated as well as untreated portions of the streams near by, failed to reveal any black fly larvae. The larvae seen earlier in the month in this area seemed to have attained a uniformly late stage in development, and much of the first brood may have emerged by June 13. Living trout fingerlings were seen in the treated area. Vegetation, sticks, leaves, etc. were seen to have retained an oily film.

The greenskeeper of the Keweenaw Golf Course, Mr. Henry Steubenranch, having observed that the flies were particularly abundant in the presence of a southeast wind, had applied, on June 12, 5 gallons of Dendrol to French Annie Creek, southeast of the golf course, where it is crossed by the trail to the now abandoned Aetna mine. This section of French Annie is very favorable for fly production, being fast-flowing and having a bottom covered with submerged grass. The area was once flooded by a beaver pond and as a result is quite open. This factor probably helps to attract adult flies for egg laying. Large numbers of pupae and well developed larvae were present. By 48 hours after treatment, all black flies which could be found were still alive, and in apparently undiminished numbers. The greenskeeper reported later that living larvae were still found the following day in the treated area. No further observations were made during the period immediately following.

C. Observations on July 15.

Five gallons of Dendrol were applied to both Aetna and French Annie Creeks on July 9, at the same point (just above U. S. 41) where previous treatments had been made. Since it was not possible for the

writer to be present at the time the treatment was made, it was decided to postpone observations until July 15, by which time the ultimate effects of the treatment might be expected to have been fully exhibited.

An examination of the treated section of Aetna and French Annie Creeks revealed no black fly larvae. Brief examination by the greenskeeper before treatment was also asserted to have shown no larvae, however, so there remains some question of whether any were originally present. The bottom of the streams was covered with an algal mat, and the flow of water had decreased to about $1/4$ of its June 1 volume.

In Aetna Creek a dead trout about 4 inches long was observed in a pool near the road, below the point of application of Dendrol, lying on the stream bottom in a fungused condition. This observation encouraged further investigation of the stream below this point and led to the finding of 18 more dead trout ranging in length from $3\frac{1}{2}$ to about 7 inches, within $1/4$ mile downstream. No trout were seen below this point. (The stream here becomes broad and shallow, with few pools). All trout found were in the same condition, lying on the bottom of the stream, their bodies uniformly covered with fungus. All fish observed had apparently been dead for the same length of time - a period of several days. Debris on the stream bottom probably covered other dead fish, and portions of various pools were concealed from view. The figure of 19 dead trout, as a result, is probably very conservative, and the total absence of all evidence of living vertebrates in the stream conveyed the impression that the stream had been pretty well cleaned out for a minimum of $1/4$ mile of the treated area. The stage of disintegration of the fish dated back to the time of treatment, as nearly as could be determined, and the observation of 6 living fingerlings immediately above the treated area gave weight

to the supposition that the Dendrol was responsible for the mortality. The greenskeeper who applied the Dendrol more or less completed the indictment by reporting that the fish didn't seem to like the oil very well, and that he had seen several come struggling to the surface in a weakened condition soon after treatment. He was able to capture 3 trout with his hands, and removed them to a pool in a rock garden near the clubhouse, where they fully recovered.

It appears certain that the combination of a great reduction in volume of flow of the stream without a proportional decrease in the quantity of insecticide used caused the severe fish mortality.

D. Observations on July 29.

On about July 25, 50 legal or near legal size trout, taken from the Watersmeet hatchery, were planted in each of the two streams being treated with Dendrol, so that further observations on mortality might be made in the event that further treatments with Dendrol were considered necessary. On July 29, brief observations near the points at which the trout had been stocked, revealed 2 dead trout in each of the two streams and one living fish in Aetna Creek. The remainder had apparently disappeared from the immediate vicinity.

Flow of water in both streams had become much reduced. No black fly larvae could be found in either stream. Water temperatures were 63°F. in French Annie Creek and 62°F. in Aetna Creek at 8 P.M.

E. Observations on August 12 and 13.

Both Aetna Creek and French Annie Creek were carefully examined, but no black fly larvae were found in the areas of stream previously treated. A few scattered larvae were found above the treated area. A few trout fry had migrated back into the treated portions of Aetna Creek. A quart of Dendrol was applied to Aetna Creek in the usual manner, to demonstrate the

action of the oil. Several trout fingerlings were observed to suffer distress when the Dendrol reached them, but appeared to recover after the oil had passed. Both streams had a temperature of 54° at 3 P.M.

V. Variations in Abundance of Adult Black Flies During the Summer

At the time of the first observations made on June 2 to 4, adult black flies were abundant in the vicinity of the golf course, as well as in other portions of the Keweenaw Peninsula. The flies were definitely a nuisance and were the source of much discomfort to workers at the golf course. According to officials at the golf course and natives of the area, this same situation had prevailed during early June for the past 3 years, with the flies being of objectionable abundance until early or mid-July and greatly decreasing in numbers after that time. By June 15 the flies were still abundant, but appeared to have decreased somewhat in numbers. At the time of the July 16 observations, adult black fly larvae had become very scarce, with isolated individual flies being seen very infrequently. This scarcity was not in any way limited to the vicinity of treated areas, however, but was evident in other portions of the peninsula where flies had been abundant earlier in the summer. The flies did not constitute a nuisance at any time after about July 1 in the entire peninsula.

Although the management of the golf course and resort is inclined to attribute the decrease in flies to the use of the Dendrol, the fact that a decrease in numbers with the advancing summer which was observed during the three previous years must be considered a big factor in 1941 as well. In fact, the decrease in numbers might be expected to be especially marked in 1941, after the first brood of flies had died, as a result of the rather dry early summer season. Flow of streams decreased rapidly,

and many tributary rivulets (in which black fly larvae had been abundant) dried up by mid-July.

VI. Summary of Findings in Bottom Samples Taken Before and After Treatment and in Treated and Untreated Areas.

A summary of the kinds, numbers, and volumes of organisms found in bottom samples taken in Aetna and French Annie Creeks during the course of the investigations is shown below. Identifications were made by Dr. J. W. Leonard, of the Institute staff.

Sample No. 1 - Aetna Creek, June 14, 1941. Station I*
Treated Area, 11 Days After Treatment.
(1 square foot sample).

Organisms	No. of Species	No. of Individuals	Volume in CC
<u>Mollusca (clams)</u>			
<u>Sphaerium sp.</u>	1	1	Tr.
<u>Annelida (leeches)</u>			
<u>Hirudinea</u>	1	1	0.025
<u>Trichoptera (caddis larvae)</u>			
<u>Limnephilidae</u>	1	1	0.025
<u>Diptera (fly larvae)</u>			
<u>Limnophila sp.</u>	1	1	Tr.
<u>Tabanus sp.</u>	1	1	0.075
TOTALS	5	5	0.125

* Station I is located 200 feet below the point where Dendrol was applied.

Sample No. 2 - Aetna Creek, July 16, 1941. Station I.
Treated Area, 7 Days After Treatment
(5 square foot sample).

Organisms	No. of Species	No. of Individuals	Volume in CC
<u>Neuroptera (alder fly)</u>			
<u>Sialis sp.</u>	1	1	0.025
<u>Hemiptera (water strider)</u>			
<u>Gerridae</u>	1	1)	
<u>Diptera (flies)</u>			
<u>Cricotopus sp.</u>	1	2)	Tr.
<u>Tabanus sp.</u>	1	1	0.075
TOTALS	4	5	0.100

Sample No. 3 - Aetna Creek, July 16, 1941. Station II*
Treated Area, 7 Days After Treatment.
(1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC
Odonata (dragonflies)			
<u>Cordulegaster maculatus</u>	1	3	0.200
Trichoptera (caddis)			
<u>Limnephilidae</u>	1	1	0.075
Diptera (flies)			
<u>Limnophila</u>	1	1)	Tr.
<u>Tanypodinae</u>	1	4)	
<u>Palpomyia</u> group	1	1)	
TOTALS	5	10	0.275

* Station II is located 500' below point where Dendrol was applied, in area analogous to Station III, as to depth, water flow, bottom type, degree of shading, etc.

Sample No. 4 - Aetna Creek, July 16, 1941. Station III*
Above Treated Area
(1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC
Ephemeroptera (mayflies)			
<u>Baetis</u> sp.	1	8)	0.025
<u>Ephemerella</u> (bicolor group)	1	1)	
Plecoptera (stoneflies)			
<u>Nemoura</u> sp.	1	14)	0.025
<u>Capnia</u> sp.	1	1)	
Coleoptera (beetles)			
Haliplid	1	1	Tr.
Trichoptera (caddis)			
<u>Hydropsyche</u> sp.	1	1)	0.050
<u>Porapsyche</u> sp.	1	39)	
<u>Chimarra</u> aterrima	1	21	0.100
<u>Limnephilidae</u>	2	3)	0.025
<u>Leptoceridae</u>	1	1)	
Diptera (flies)			
<u>Rhapidolabis</u> sp.	1	5	Tr.
<u>Tipula abdominalis</u>	1	1	0.650
<u>Pelicia albivitta</u>	1	1	0.400
<u>Simulium venustum</u> (black fly)	1	6	0.025
<u>Chrysops</u> sp.	1	2	0.050
<u>Tabanus</u> sp.	1	1	0.300
<u>Tanypodinae</u>	1	4)	0.025
<u>Chironomidae</u>	2	10)	
<u>Palpomyia</u> group	1	1	Tr.
TOTALS	21	121	1.675

* Station III is located above treated area, in bottom type, etc. similar to Station II.

Sample No. 5 - Aetna Creek, August 13, 1941. Station I.
 Before Treatment
 (1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Annelida (worms and leeches)			
Oligochaeta (fragments)	1	2	Tr.
Hirudinea	1	2	0.100
Mollusca (snails)			
Physa sp.	1	4	0.075
Diptera (flies)			
Chironomidae	1	6	Tr.
Tabanus sp.	<u>1</u>	<u>3</u>	<u>0.500</u>
TOTALS	5	17	0.675

Sample No. 6 - Aetna Creek, August 14, 1941. Station I.
 After Treatment
 (1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Annelida (worms)			
Oligochaeta (fragments)	1	5	Tr.
Mollusca (snails)			
Physa sp.	<u>1</u>	<u>3</u>	<u>0.075</u>
TOTALS	2	8	0.075

Sample No. 7 - Aetna Creek, August 13, 1941. Station III
 Above Treated Area
 (1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Odonata (dragonflies)			
<u>Cordulegaster maculatus</u>	1	5	1.100
Plecoptera (stoneflies)			
<u>Nemoura</u> sp.	1	2	0.025
Trichoptera (caddis)			
<u>Hydropsyche</u> sp.	1	1	0.025
<u>Parapsyche</u> sp.	1	7	0.025
<u>Chimarra</u> <u>aterrima</u>	1	5	
<u>Leptoceridae</u>	1	2	0.025
Diptera (flies)			
<u>Simulium venustum</u> (black fly)	1	2	Tr.
<u>Chironomidae</u>	1	2	
<u>Palpomyia</u> group	1	1	
TOTALS	9	27	1.200

Sample No. 8 - French Annie Creek, June 14, 1941. Station I*
 11 Days After Treatment
 (1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Annelida (worms)			
<u>Oligochaeta</u>	1	2	0.100
Crustacea (scuds)			
<u>Hyalella</u> sp.	1	2	Tr.
Odonata (dragonflies)			
<u>Cordulegaster maculatus</u>	1	2	0.175
Trichoptera (caddis)			
<u>Hydropsyche</u> sp.	1	8	0.150
TOTALS	4	14	0.425

* Station I is located 200 feet below point where Dendrol was applied.

Sample No. 9 - French Annie Creek, July 15, 1941. Station I.
6 Days After Treatment
(1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Odonata (dragonflies)			
<u>Boyeria vinosa</u>	1	2	0.200
<u>Cordulegaster maculatus</u>	1	4	0.400
Trichoptera (caddis)			
<u>Hydropsyche sp.</u>	1	3	0.050
Diptera (flies)			
Chironomidae (Tanypodinae)	1	6)	
<u>Palpomyia group</u>	1	1)	Tr.
	5	16	0.650

Sample No. 10 - French Annie Creek, August 13, 1941. Station I.
35 Days After Treatment
(1 square foot sample)

Organisms	No. of Species	No. of Individuals	Volume in CC.
Annelida (worms)			
Oligochaeta	1	1	Tr.
Odonata (dragonflies)			
<u>Cordulegaster maculatus</u>	1	6	1.100
Trichoptera (caddis)			
<u>Hydropsyche sp.</u>	1	1	Tr.
Diptera (flies)			
<u>Palpomyia group</u>	1	1	Tr.
	4	9	1.100

The only black fly larvae appearing in the samples were collected in Aetna Creek, above the Dendrol-treated area. The absence of larvae below this point cannot, however, be attributed entirely to the use of Dendrol, since following the June treatment, no larvae could be found either before or after treatment. Large numbers of larvae and pupae were seen 3/4-mile below the point of treatment (in early June), on June 13 and 14, however.

Attention should be called to sample no. 2, taken in Aetna Creek on July 16, 7 days after the treatment was made which was lethal to trout in the stream. A virtual clean-up of bottom organisms seems to be indicated, since 5 square-foot samples were required to produce 5 organisms, with a volume of 0.10cc. On June 14, 11 days after the initial (proportionally lighter) treatment, the same spot in the stream had yielded 5 organisms having a volume of 0.125 cc. in a single square-foot sample. It should be noted, however, that on July 16, at a point 500 feet below the upstream end of the treated area, a somewhat better representation of bottom organisms was found, a square foot sample yielding 10 organisms with a volume of 0.275 cc. A more detailed analysis of this sample shows that 3 Diptera were among the organisms collected, the sizes of which are entirely comparable to the size of the black fly larvae. It would seem to follow that if the lethal action of Dendrol at a given concentration is dependent directly upon the size of the organism concerned, then black fly larvae, had they been present in the stream before treatment, might well have survived a concentration of Dendrol which was fatal to trout.

VII. Suggestions and Recommendations*

Since observations have indicated that the use of Dendrol is not certainly uniformly lethal to black fly larvae, it is suggested that controlled tests using this oil be made at the Hunt Creek Experiment Station. Work with known quantities of both water and oil should make it possible to determine rather finely the lethal concentration, and to determine whether or not a given concentration may be lethal to black fly larvae and not to trout.

* Contributed by Dr. J. W. Leonard, in charge, Hunt Creek Experiment Station, Institute for Fisheries Research.

Mortality of trout due to Dendrol treatment has already been mentioned above. While in some areas freedom from black flies might better serve the public interest than the presence of limited numbers of trout, the role of streams such as Aetna and French Annie Creeks and Garden Brook in providing spawning areas for lake-inhabiting trout should not be discounted. The most effective black fly control would be treatment applied in early spring, before any adults had emerged, as this might greatly reduce the size of subsequent broods. But at this time, trout fry would still be in the stream, and an entire year's production lost to the lake.

The indications derived from the Keweenaw County test are that concentrations of oil adequate to control black fly larvae are also sufficient to make a rather complete kill of all animal life, both vertebrate and invertebrate, and it has not been established conclusively that concentrations not lethal to trout are effective against the larvae (vide - observations of July 13 and 14). In anticipation of requests from other sources for permission to make similar treatments, it would seem advisable to secure a more conclusive series of observations.

INSTITUTE FOR FISHERIES RESEARCH

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