EFFECTIVE CONTROL METHODS USED ON BITING GNATS IN UTAH DURING 1949 (DIPTERA: CERATOPOGONIDAE) [1]

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INTRODUCTION

In many parts of Utah and other western states the small biting gnat *Leptoconops (Holoconops) kerteszi* var. *americanus* Carter is extremely annoying and pestiferous each spring for a period of about six weeks. These gnats, sometimes called "punkies" or "no-see-ums," were present in abundance when the first white men began the settlement of western North America. The inhabitants of Utah until recently have vociferously, but otherwise passively, accepted these pests as an inevitable part of the spring season.

Leptoconops kerteszi var. *americanus* was described from the vicinity of Salt Lake City by H. F. Carter in 1921. Carter considered it a variety of *Leptoconops kerteszi* which was described from Egypt by Kieffer in 1908. There is at present some question concerning the synonomy of this genus and species. Some current workers such as W. W. Wirth of the U.S.D.A., Division of Insect Identification refer to this gnat as *Leptoconops kerteszi* Kieffer and at present can find no valid reason for recognizing *americanus* Carter as a variety. The authors hope to be able to establish the identity of this gnat and provide more detailed information concerning its biology as the result of an investigation now in progress. This report will therefore be confined to the results of control measures that have been directed against this gnat in the vicinity of Salt Lake City during the past two years.

In the spring of 1948 the Salt Lake Refining Company, a subsidiary of the Standard Oil Company of California, found these gnats extremely annoying and in certain cases injurious to the health of the workmen who were constructing a large oil refinery in North Salt Lake City. It was estimated by officials in charge of construction that the gnats reduced working efficiency of the men by 10 to 20 per cent. This reduction in working efficiency occurred only during the daylight hours under favorable weather conditions, when swarms of these small gnats literally covered the workmen, crawling over their clothing, hands and face, and into their eyes, ears and hair. In addition the females are voracious feeders and fearless in their attack. They prefer to bite where the clothing fits close to the skin such as around hat bands, shirt collars and cuffs. The victim does not feel the bite for the first 30 to 60 seconds; then a slight irritation becomes noticeable. In about 10 to 15 minutes a hard white swelling has formed which becomes red and inflamed in about 30 minutes. Itching and irritation may continue for 72 hours or more depending on the susceptibility of the individual. As a result of daily exposure to the attacks of these gnats a number of the workmen quit the job and others were forced to leave the job temporarily in order to recover from the bites inflicted by the gnats. In a few instances medical attention was necessary.

1948 INVESTIGATION

The officials of the Salt Lake Refining Company requested the authors to make an investigation of the gnat problem in North Salt Lake City for the purpose of control. This investigation was started May 22, 1948 at the peak of the gnat sea-

[1] Funds necessary for the experimental and control work reported in this article were provided by the Salt Lake Refining Co. of Salt Lake City, Utah.

son. As most of the gnats were on the wing the control measures were directed primarily toward the destruction of the adults. The control measures consisted of: (1), the use of head nets and gloves; (2), repellents applied to the skin and clothing; (3), 5% DDT used as a residual insecticide on the resting places of the gnats; (4), aerial insecticides in smoke or fogs; and (5), larvicides on the few remaining larvae found in the soil. As a result of this work it was found that: (1), head nets under existing working conditions were extremely uncomfortable and impracticable but would be worn by the men in preference to exposure to the gnats; (2), of the nine highly recommended repellents used none of them provided suitable protection although some, especially dimethylphthalate, reduced the number of gnats that would alight on the skin and clothing and materially reduced biting incidence; (3), 5% DDT was very effective as a residual adulticide in destroying gnats in their resting places; (4), aerosols consisting of DDT, thanite and pyrethrum were effective under favorable conditions as a "knock down" adulticide providing temporary relief; (5), DDT showed promise of being an effective larvicide if applied at the proper time and amounts.

1949 INVESTIGATION AND CONTROL PROGRAM

Survey of Breeding Area.

On March 20 a survey was started to determine the extent and type of habitat in which gnats develop in the vicinity of the plant of the Salt Lake Refining Company. The survey consisted of taking soil samples at 200 yard intervals on a transect running due east and west for 3400 yards and on another transect that extended for 5200 yards north and south. The two transects crossed at right angles in about the middle of each transect, near the office building of the company. Soil samples were obtained by pushing a soup can, which had been opened at each end, into the soil about two inches. The can was two and one-half inches in diameter and each sample contained about ten cubic inches of soil. The gnat larvae if present were removed by washing the soil through a series of fine mesh strainers, the finest containing 76 squares per square inch. Examination and counting was done under a wide field stereoscopic microscope. The number of gnats ranged from 33 to 88 with an average of 57 per sample. In localities where larvae were present additional soil samples were taken in all directions until the limits of the breeding area were determined and plotted on a map. Approximately 250 acres of ground were found to be producing gnats. (See accompanying map, Fig. 1.)

The number of gnats per sample indicates only those present in the top two inches of soil. Larvae were usually present at greater depths at the time the samples were taken. During the 1949 gnat season 5710 gnats were collected in a trap as they emerged from 3 sq. ft. of the breeding area. At this rate approximately 83 million gnats would be produced per acre. This gives an idea of potential productivity of a gnat producing area of this magnitude.

Experimental Plots.

To determine an effective method of destroying the gnat larvae and pupae in the soil, 17 adjacent test plots, each containing 68 square feet, were selected in an area where these stages were abundant. Uniform samples were taken using the same method used in the survey. The larvae and pupae were counted and the results tabulated for each plot. One plot was used as a control and was not treated. The remaining 16 plots were treated with different concentrations of two selected insecticides in order to compare lethal effects on the gnats.

DDT and BHC (12% gamma isomer) were applied to the experimental plots in different concentrations and quantities of water. The insecticides and water were carefully measured for each plot and

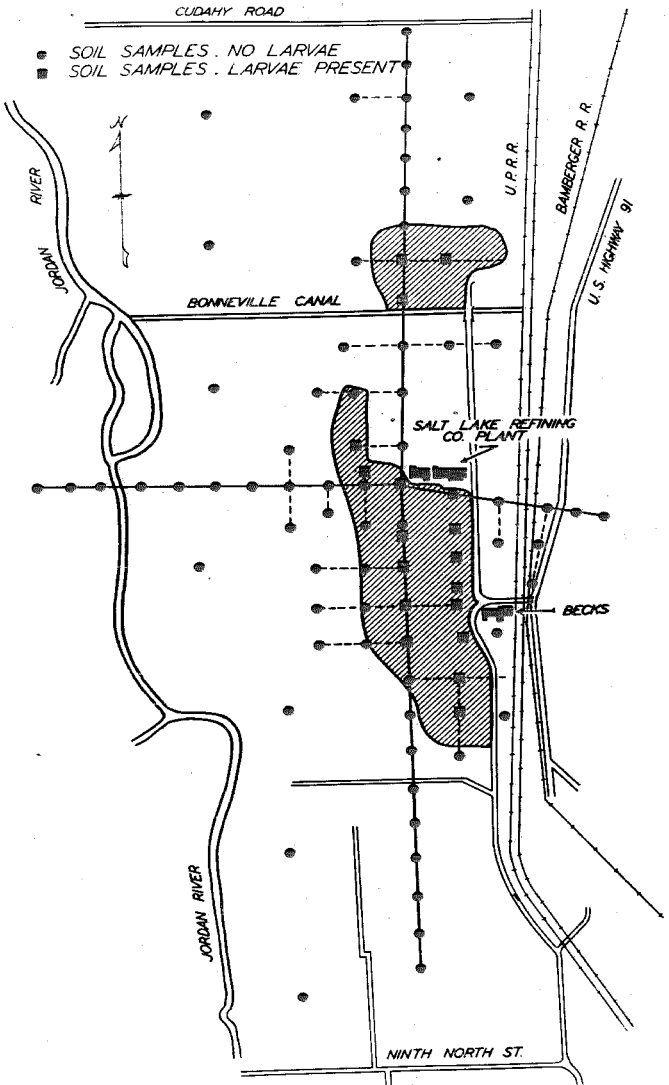

FIG. 1. (Treated areas are cross-hatched).

tabulated on a per acre basis. DDT was used at the rate of 0.1, 0.2, 0.5 and 1.0 pound per acre. The DDT was prepared from a 25% stock emulsion. Each of these amounts was applied in water on different plots at the rate of 10, 25, and 50 gallons per acre. BHC was used on the remaining four plots at the rate of 0.1, 0.2, 0.5 and 1 pound per acre in 25 gallons of water.

All applications were made with a Hudson pressure sealed spray pump of four gallon capacity operated under 40 to 50 pounds pressure per square inch. The nozzle was a "teejet" #8001.

Each plot was then sampled, by the same method previously used, to determine the percentage of larvae and pupae killed 24, 72 and 168 hours after treatment. The following table shows the results of these experiments as determined by the number of living and dead larvae and pupae found in each soil sample.

consistently high throughout successive samplings. It is also evident that DDT in amounts as low as .1 of a pound per acre, in all dilutions used, gave an average kill, at the three intervals when counts were made, of about 70%, but the kill at this amount on the pupae was below 50%. A higher percentage of kill was obtained in both larvae and pupae as the amount of DDT was increased. The dilutions of 10, 25 and 50 gallons per acre appears to have little influence on the lethal effectiveness of DDT on the gnat larvae and pupae. However, a comparison between these dilutions using one pound of DDT per acre shows a difference by the end of the season in the number of gnats emerged. (Table 3)

The plots treated with benzene hexachloride show a high percentage of kill in the first 24 hours but the killing power of BHC shows a rapid decline in subsequent samplings. This was further veri-

Table 1—Insecticide Concentrations and Results as Determined from Soil Samples

25% DDT Emulsion			24 Hours						72 Hours						168 Hours					
			Larvae			Pupae			Larvae			Pupae			Larvae			Pupae		
Plot	Lbs. per Acre	Water Gals.	D	A	%	D	A	%	D	A	%	D	A	%	D	A	%	D	A	%
1	1	10	53	11	83	4	3	57	41	8	84	6	4	60	27	3	90	14	6	70
2	.5	"	36	5	88	3	3	50	32	7	83	2	5	29	17	9	65	18	10	64
3	.2	"	37	10	79	4	6	40	39	9	82	4	9	31	16	5	76	14	10	58
4	.1	"	39	22	64	1	7	12	26	19	58	6	9	40	19	5	80	17	12	59
5	1	25	42	3	93	16	1	94	52	2	96	9	0	100	21	3	87	17	2	89
6	.5	"	66	3	95	9	8	53	29	7	80	11	3	79	18	3	85	21	6	77
7	.2	"	32	9	78	3	2	60	63	18	78	6	1	86	24	9	73	23	5	82
8	.1	"	28	7	80	3	5	38	30	6	83	5	13	28	15	7	68	27	12	69
9	1	50	29	2	93	4	0	100	27	6	82	6	2	75	11	3	78	23	5	82
10	.5	"	33	7	83	5	3	63	30	12	72	11	6	65	19	7	73	9	7	56
11	.2	"	26	12	69	4	6	40	37	22	63	7	6	54	23	8	74	18	6	75
12	.1	"	47	21	69	3	7	30	29	20	60	7	9	44	12	9	57	22	8	73
BHC (gamma isomer) 12% wettable powder.																				
13	1	25	31	0	100	2	0	100	29	2	93	3	1	75	18	7	72	21	9	70
14	.5	"	32	2	94	9	1	90	37	11	77	6	2	75	11	4	73	27	11	71
15	.2	"	26	1	96	4	2	66	29	7	80	7	4	64	16	9	64	18	12	60
16	.1	"	34	3	92	4	3	57	30	4	88	6	9	40	19	3	86	17	13	57
CONTROL (untreated)																				
17	..	..	0	46	0	0	7	0	0	29	0	0	14	0	0	11	0	0	27	0

% = Kill A = Alive D = Dead

It is evident from the above table that 1 lb. of DDT in 25 gals. of solution per acre produced a high kill of larvae and pupae 24 hours after treatment and remained

fied by the number of gnats that emerged during the season from the plots treated with BHC. (Table 3)

As a result of these tests and after due

consideration of the kind of soil, vegetation, animals present, and equipment available, it was decided that one pound of DDT per acre in 25 gallons of water would be the most practical insecticide under existing conditions.

Equipment Used.

A Dodge "Power Wagon" truck with four wheel drive and a Jeep were used to transport spraying equipment. A Bean and an Essick spray pump equipped with agitators were used and operated under 150 to 200 lbs. pressure per square inch. A spray boom containing "teejet" #8001 nozzles was attached to the back of each truck about 18 inches from the ground. A 200 foot hose equipped with similar nozzles was also attached to each pump in order to reach places inaccessible to the trucks. A few small areas that could not be reached with the power equipment were treated with Hudson pressure sealed knapsack spray pumps. The trucks were equipped with thermal aerosol generators attached to the exhaust.

Ground Treatment.

The dry salt grass *Distichlis stricta* covering much of the area in which the gnats were found developing, was burned before the soil was treated with DDT. This permitted a more even distribution and direct contact of the insecticide with the soil. The trucks were driven at a speed of approximately 3 miles per hour and the rate of discharge of the solution was regulated to about 28 gallons per acre.

The time of application of the DDT was found to be important in obtaining the best results. It was found that the most effective time for treatment was when most of the gnat larvae were concentrated in the top ¼ inch of soil and pupae were beginning to appear on the surface of the ground. This period in the development of the gnat is determined from the examination of soil samples as they are taken each day from different parts of the breeding area. As the time of development varied somewhat throughout the breeding area, it was possible and necessary to direct the work each day to the areas where it would be most effective.

Residual Insecticide.

Five per cent DDT was used as a residual on buildings, oil tanks, building materials and other possible shelters of adult gnats. The application was made, with the power spraying equipment, at the time when the first adult gnats began to emerge. The shelters were only treated on the outside surfaces as the gnats seldom enter buildings or other structures. The residual was applied on the structures from the surface of the ground to about four feet above, as it was observed that most of the gnats remain near the ground on these shelters. The surfaces were thoroughly wet with the spray in the same manner used for fly and mosquito residual control. This residual treatment apparently destroyed the gnats seeking shelter on these structures as none were observed remaining on these treated surfaces.

Smoke Aerosol.

A smoke aerosol consisting of 7½% DDT in fuel oil was used when necessary to destroy adult gnats. It was produced by the thermol aerosol smoke generator on the exhaust of the Dodge truck. The smoke produced by this method was found to be very effective in killing adult gnats when climatic conditions were favorable. This aerosol was used occasionally from the latter part of April until the end of May. It was used effectively on areas where there was a report, or even a suspicion, of the presence of gnats. The results were immediate but the effects were temporary, lasting for only a few hours. This spectacular control measure had an excellent psychological effect on employees.

RESULTS OF CONTROL MEASURES

Control of Immature Stages.

The numbers of larvae and pupae present in the soil in a given area were

determined by counting the numbers present in uniform soil samples taken from the area. After treatment of 1 lb. of DDT per acre of the 250 acres in which gnats were found developing, samples were taken at different intervals from different parts of the treated area. The numbers of living and dead larvae and pupae from these samples were determined and compared with counts taken from samples from the same area before treatment. It was determined by this method that the overall kill of larvae and pupae as a result of ground treatment was about 90%.

Collecting Traps.

In addition to soil sampling, gnat production in a given area from treated and untreated ground was determined by collecting the adults in traps as they emerged. The traps were rectangular boxes 18" x 24" and 8" high. The tops were covered with heavy black cloth, the bottoms open to the soil. In one end of the traps small holes were made in which the neck of a 12 oz. bottle, partially filled with water, was securely fastened. As the gnats emerged from the ground covered by the darkened trap they attempted to escape through the hole where the bottle was attached. Upon entering the bottle they were eventually drowned. In this manner they were secured in the water within the bottle where they were available for counting.

The results obtained from one trap operated on an untreated area and the average of three traps operated under typical conditions on the area treated for control are given in Table 2.

The above table shows by comparison the difference in the number of gnats that emerged from the treated and untreated area. It is noted that the percentage of kill gradually decreased from 94% to 16% as the season progressed. It is also evident that the number of gnats emerging has a corresponding decrease. The correlation between the two would indicate about a 90% kill for the season over the entire area treated. The above table is also indicative of the seasonal emergence of these gnats showing a single brood within a short period of time. It likewise tends to substantiate the use of 1 lb. of DDT per acre as a suitable amount for soil treatment and also emphasizes the importance of selecting the proper time for application of this insecticide.

Table 2. Trap Records

Dates of Collection	*Total Emerged Untreated Area*	*Average of Three Traps on Treated Area*	*Percentage Kill*
April			
20–23	18	0 (no traps)	0
24–27	3896	234	94%
28–29	673	74	89%
30–May 1	362	65	82%
2–3	325	67	79%
4–5	130	38	69%
6–7	75	15	80%
8–9	126	40	68%
10–11	62	30	52%
12–13	25	17	32%
14–15	0	0	0
16–17	0	0	0
18–19	12	9	25%
20–21	0	0	0
22–23	0	0	0
24–25	6	5	16%
26–27	0	0	0
	5710	594	

No more gnats emerged after this date.

Results from additional traps operated throughout the season over experimental plots that had been treated are presented in Table 3.

Table 3. Trap Records

1 lb. DDT.	*Adults emerged*
10 gals. water	127
25 " "	85
50 " "	92
1 lb. BHC 25 gals. water	769

It is evident that emergence of adults on experimental plots where 1 lb. of DDT per acre was used was much lower than the average from the three traps operated on the controlled area as shown in Table 2. This was undoubtedly due in part to the care and uniformity with which the insecticide was applied to the experimental plots. The much higher number of gnats

emerging from the experimental plot treated with BHC was the result, as explained previously, of the BHC losing its lethal effect more rapidly than DDT as the season progressed.

Observations.

Careful observations were made from about April 20 to May 28, the period in 1949 when the adult gnats were on the wing, to determine the effectiveness of the control program. Adult gnats were collected whenever they appeared. Workmen were questioned daily about annoyance from gnats. Company officials were requested to report any gnats called to their attention. Residents in the area were asked to comment on the gnat situation as compared with previous seasons. All information obtained in this manner proved the control program to be very effective. The control work reduced the number of gnats in the area to such an extent that no noticeable annoyance was reported by workmen or company officials. Long residents of the area stated it was the first spring they could remember when gnats had not been annoying in North Salt Lake City.

SUMMARY AND CONCLUSIONS

As the result of a survey it was determined that approximately 250 acres of ground comprised the area in which the gnats were developing in North Salt Lake City during the spring of 1949. As a result of experimental investigation 1 lb. of DDT in 28 gallons of solution per acre was used to treat this area in an attempt to destroy the gnat larvae and pupae. The insecticide was applied with ground equipment at the time when most of the gnat larvae were concentrated in the top quarter inch of soil and at the time pupae were beginning to appear on the surface of the ground. This treatment produced about a 90% overall kill of larvae and pupae.

Five percent DDT was used effectively on adults as a residual applied to buildings and other resting shelters used by the gnats. Thermal smoke aerosol consisting of 7½% DDT emulsion in fuel oil was used to destroy adult gnats in areas where men were working. This aerosol provided immediate local but only temporary relief from gnat annoyance.

The gnat control work conducted in North Salt Lake City during 1949 was practical and successful. The control work will undoubtedly be improved as the result of practical experience and field experiments now in progress.

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