A SHORT-TERM INVESTIGATION OF CHIRONOMID MIDGE (DIPTERA: CHIRONOMIDAE) PROBLEM IN SALTWATER LAKES OF ORBETELLO, GROSSETO, ITALY[1]

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ABSTRACT. Chironomid larval densities in two saltwater lakes, East and West Lake, surrounding the city of Orbetello, in westcentral Italy, were assessed in the summer of 1982. Observations were made on adult midge swarms in the area surrounding the lakes. Chlorpyrifos, temephos, fenthion, malathion and Bactimos® (*Bacillus thuringiensis* serotype H-14) were evaluated in the laboratory against field-collected larvae.

Only *Chironomus salinarius* was recovered from the lakes with densities ranging from 178–25,775 and 89–33,330/m^2 in East Lake and West Lake, respectively. Larval populations within 1km of shore along the city were significantly higher than in the remaining area of each lake. Swarms of adult *C. salinarius* were the densest at night around fluorescent and incandescent white lights as compared to those lights of blue, green and red colors.

Larvae of *C. salinarius* were most susceptible to chlorpyrifos (LC_{90}=0.0032 ppm) and least to fenthion (LC_{90}=0.091 ppm). Bactimos was relatively ineffective (LC_{90}=5.07 ppm). Treatment of a partial area of each lake (within 1 km of Orbetello) with chlorpyrifos or temephos will probably produce a significant reduction of midge larvae.

INTRODUCTION

The nuisance and economic problems caused by chironomid midges in different parts of the world and their control possibilities have been reported in a number of studies (Ali and Lord 1980, Ali and Mulla 1976, Bay 1964, Edwards et al. 1964, Mulla et al. 1976, Tabaru et al. 1978). This subject was recently reviewed by Ali (1980). At present, almost all the available reports concerning chironomid control deal with the freshwater species of midges. However, some members of the family Chironomidae also occur in saltwater environments which can produce large numbers of midges. An example of this exists in central Italy where the city of Orbetello, surrounded by two lakes receiving water primarily from the Mediterranean Sea, is plagued by chironomid swarms.

Reported here is a study conducted in the summer of 1982 to assess midge larval densities in the two lakes surrounding Orbetello. Observations were also made on the prevalence of adult midges in the city and laboratory tests conducted on the susceptibility of midge larvae to four organophosphorous insecticides and a biocide.

MATERIALS AND METHODS

STUDY AREA. The two lakes (designated East Lake and West Lake) are located along the tuscanian coast of Grosseto in westcentral Italy at approximately 42° 25–29′ N latitude and 11° 10–17′ E longitude. Separating the lakes from the Mediterranean are Monte Argentario on the southwest and two narrow strips of land, the Giannella "tombolo" to the northwest and the Feniglia "tombolo" to the south. These strips of land connect Monte Argentario to the mainland (Fig. 1). Orbetello is located on a narrow peninsula between the lakes. This peninsula is connected to Monte Argentario by a 1 km long dike. The highest density of residential and industrial units along the periphery of the lakes exists only in the city. The Feniglia "tombolo" supports coniferous forest and serves as a natural park, while areas of the Giannella "tombolo" and the Monte Argentario bordering the lakes have relatively sparsely distributed homes. Thus, the densely inhabited city of Orbetello is the focus of the midge problem.

The East Lake covers ca. 1200 ha. It is 6 km long and 1.75 km wide at its widest point. The lake receives water from the Mediterranean through a narrow 1.5 km long channel located in its southeast portion. The lake is shallow with an average depth of 1 m. At certain locations, the water is up to 1.7 m deep. The lake bottom is predominantly decomposing organic matter (muck) covered with bivalve and gastropod shells. At places, patches of sand exist.

The West Lake is ca. 1500 ha., 5 km long, and nearly 5 km wide at its widest point. It receives water from the Mediterranean through a narrow 0.5 km long channel located in its western corner. The West Lake also periodically receives some freshwater from the Albegna River

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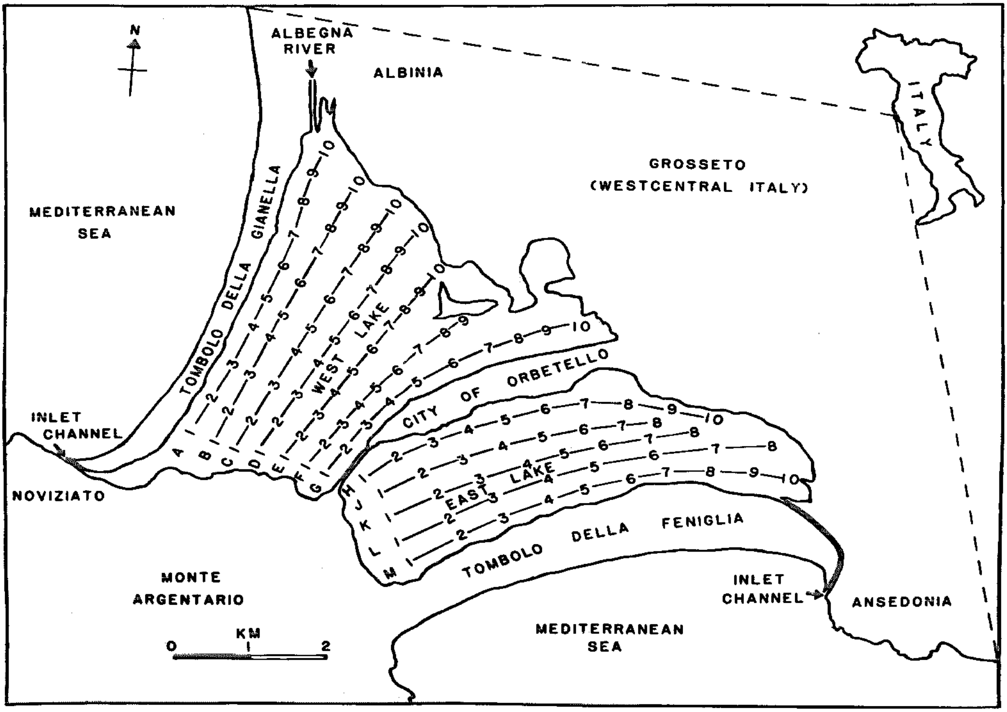

Fig. 1. The East and West Orbetello lakes (Orbetello, Grosseto, Italy) showing the sampling lines (A to G in West Lake and H to M in East Lake) for benthic chironomid larvae. The approximate location of 8–10 sampling sites in each line are marked.

emptying into the lake's northern area (Fig. 1). This lake is generally 15–20 cm shallower than the East Lake. The bottom type is similar to that of the East Lake except that patches of sand are more widespread in the West Lake. Both lakes receive treated sewage effluent in areas adjacent to Orbetello. There are several small domestic sources of raw sewage around both lakes, but the East Lake is considered to be more polluted than the West Lake; the pH of water in the lakes ranges from 7.8–9.0, salinity 27–45 g/liter, and dissolved oxygen <2–10 ppm (Anonymous 1977). The water in both lakes is turbid. The bottom is visible in some shallow areas of each lake.

LARVAL AND ADULT SAMPLING. To sample midge larval populations, 7 lines (A to G) in the West Lake and 5 lines (H to M) in the East Lake were established as shown in Fig. 1. These lines along the length of each lake, were selected at random between two visible objects located on the opposite banks. In each line, 8–10 sampling sites were randomly selected and marked with wooden stakes at an interval of 0.5–1 km. Thus, 44 sampling sites in the East Lake and 69 in the West Lake were chosen to be representative of most areas in each lake. At each site, a minimum of 3 mud samples was collected with an Ekman dredge (15 × 15 × 15 cm). Each mud sample was processed according to the method of Mulla et al. (1971). The residue of each sample was examined as in Ali et al. (1977) and midge larvae were identified and counted. At each sampling site water temperature and depth were recorded. Information concerning the seasonal changes of some physico-chemical and biological parameters in these lakes is available in a previous report (Anonymous 1977).

During this investigation (June 24–July 8, 1982), observations on the adult swarms in Orbetello were made daily in the evenings and late night hours. Samples of adult midges were routinely collected from various lakefront and interior areas of the city with a sweep net and the collections were analyzed for the species composition. On several occasions, the field-collected larvae were reared to adults in the laboratory to confirm the midge species.

LARVAL BIOASSAYS. Four organophosphorous insecticides, chlorpyrifos, temephos, fenthion and malathion were evaluated in the laboratory against 4th instar larvae collected from the lakes. The technical grade material of each insecticide was utilized to prepare a 1% stock solution in acetone, and serial dilutions in acetone were made as needed. The required amount of a toxicant was added to 150 ml disposable plastic cup containing 10 larvae in 100 ml of lake water and 5 g of sterilized sand. Each test consisted of 4–5 triplicate concentrations of a test compound plus 3 untreated checks maintained under 12-hr photoperiod and 27±2°C room temperature. Each chemical was tested on 3 different occasions. The larval mortality was checked after 24 hr and the corrected mortality (against checks) at different concentrations of a compound was subjected to log-probit regression analysis.

The larval bioassays were also conducted with Bactimos(TM), a wettable powder formulation of the bacterium, *Bacillus thuringiensis* serotype H-14, produced by Biochem Products, Montchanin, Delaware. The procedure for testing the biocide was the same as described in an earlier study (Ali et al. 1981).

RESULTS AND DISCUSSION

The identifications of the field-collected larvae and those of the adults reared from them confirmed that only *Chironomus salinarius* Kieffer occurred in the lakes during the period of investigation. This species had infested the entire bottom of both lakes. However, the larval density varied considerably in the different areas of each lake and ranged from 89 to 33,330 larvae/m² in the West Lake (Table 1). The overall mean density in the lake amounted to 4,213/m². The coefficient of variation (C.V.) of larval density among sampling lines A to G ranged from 65–107%. The value of the overall C.V. in the West Lake was 137%, thus indicating a wide range of spatial variability in the distribution of *C. salinarius* in the West Lake. It is obvious from Table 1 that the larval population in the area adjacent to the city of Orbetello (line G) was significantly higher (P = 0.05) than in any other area of the lake. The mean density of larvae in line G was 3–9X higher than in any other line sampled and the highest density occurred in the southeast section of the lake lined with a few industries.

The density and distribution of *C. salinarius* in the East Lake are shown in Table 2. The larval density ranged from 178 to 25,775/m². The overall mean density of larvae was 6,334/m². The values of C.V. of midge density among the sampling lines ranged from 65–117% with an overall coefficient of larval spatial variability reaching 100%. The East Lake supported an estimated 1.5X more larvae per unit area of the lake bottom than the West Lake and thus probably produces more midges than the West Lake although the West Lake covers ca. 1.25X more surface area. Again, the larval densities in areas of the East Lake adjacent to the city (lines H and J) were significantly higher than in the rest of the lake. The populations generally declined gradually with the increasing distance from the city (Table 2). In both lakes, the larval density had no significant relationship with water depth (r^2=0.03 West Lake and 0.09 East Lake).

The daily collections of adult midges taken from Orbetello confirmed the presence of *C. salinarius*. It was usually prevalent around the peripheral lakefront areas but on several occasions was noticed in large numbers in all parts of the city. At night, the swarms were the densest around fluorescent and incandescent white lights as compared to fluorescent and incandescent lights of blue, green and red colors (data not included). In some collections, a few Tanytarsini and an unidentified *Chironomus* sp.

Table 1. Larval density and distribution of *Chironomus salinarius* in the West Lake, Orbetello, Grosseto, Italy (June 24–July 1, 1982).

Sampling lines[a]	No. larvae/m² in lake bottom mud at various sites[a]											
	1	2	3	4	5	6	7	8	9	10	$\bar{x}$[b]	C.V.(%)
A	311	3644	711	1422	3466	889	844	1822	889	1155	1515 b	76
B	89	1244	6310	8532	5288	3555	5866	1778	1466	3777	3790 b	71
C	1333	4088	3333	6266	2844	1555	444	2444	2044	222	2457 b	74
D	444	1600	4711	2000	889	1067	889	1333	1333	308	1457 b	86
E	311	9332	3466	5332	222	267	2222	3200	1200	1333	2688 b	107
F	2814	5184	8295	4888	4444	890	533	4370	2148	—	3729 b	65
G	6222	5155	10221	4977	12665	9332	7110	33330	25775	23286	13807 a	73

[a] The approximate location of each sampling line in the lake and the sampling sites in each line are shown in Fig. 1. Water depth at the sampling sites ranged from 0.25–1.6 m; water temperature 26–28°C.
[b] Means in a column followed by a different letter are significantly different ($P<0.05$).

occurred but they collectively formed <0.1% of the total adults captured on any occasion.

The relative activity of chlorpyrifos, temephos, malathion and fenthion against 4th instar *C. salinarius* is shown in Table 3. The larvae were most susceptible to chlorpyrifos (LC_{90}=0.0032 ppm) and least to fenthion (LC_{90}=0.091 ppm). The former insecticide was 28X more active against *C. salinarius* than the latter. Malathion and temephos relatively showed 2X and 4X better activity than fenthion.

The WP formulation (Bactimos) of *B. thuringiensis* serotype H-14 was not effective against larvae of *C. salinarius* (Table 4). The biocide was 56X less active against the larvae than the least active organophosphate fenthion, and that even in double the exposure time (48 hr) than the 24 hr exposure time used for the evaluation of the organophosphates.

Both the lakes around Orbetello support large populations of *C. salinarius* during June and July. Whether this species prevails in large numbers throughout the year or some other midge species also occupy the lakes in significant numbers can only be elucidated by year-round larval and adult sampling. The larval densities encountered in this study are equal to or higher than those reported in a variety of man-made and natural freshwater habitats producing chironomids at nuisance levels and requiring frequent management (Ali and Baggs 1982, Ali and Mulla 1976, Ali et al. 1977, Mulla et al. 1976). In the Orbetello lakes, chlorpyrifos and temephos, as larvicides, could be used at the time of acute need to control *C. salinarius*. Treatment of approximately a 1 km area of each lake adjacent to the city (supporting higher larval densities than the rest of each lake) will probably provide satisfactory control. Although the insecticidal treatments will simultaneously reduce some important components of the aquatic food chain, partial area treatments of each lake will perhaps facilitate their rapid recolonization and population restoration from the untreated areas.

Table 2. Larval density and distribution of *Chironomus salinarius* in the East Lake, Orbetello, Grosseto, Italy (July 3–8, 1982).

Sampling lines[a]	No. larvae/m² in lake bottom mud at various sites[a] 1	2	3	4	5	6	7	8	9	10	$\bar{x}$[b]	C.V.(%)
H	16709	13288	3866	24442	4884	11999	10043	25775	8443	3866	12331 a	65
J	1422	10443	8532	5777	5644	8443	17776	11954	—	—	8748 ab	56
K	2666	2000	1022	10000	4000	14665	5555	7999	—	—	5988 b	78
L	1067	2134	178	356	222	2400	1067	1200	—	—	1078 c	78
M	267	3955	4666	622	11466	2889	356	1555	1289	1777	2884 bc	117

[a] The approximate location of each sampling line in the lake and the sampling sites in each line are shown in Fig. 1. Water depth at the sampling sites ranged from 0.3–1.7 m; water temperature 26–29°C.
[b] Means in a column followed by a different letter are significantly different ($P<0.05$).

Table 3. Comparative susceptibility of *Chironomus salinarius*[a] to organophosphorous insecticides in the laboratory.

Insecticides	24-hr lethal concentration (ppm) LC_{50}	C.L.[b]	LC_{90}	C.L.[b]	
Chlorpyrifos	0.00044	0.00031–0.00062	0.0032	0.0018–0.0059	0.89
Temephos	0.0013	0.00087–0.0021	0.021	0.0079–0.053	0.92
Malathion	0.0023	0.0016 –0.0036	0.040	0.015 –0.10	0.85
Fenthion	0.012	0.0067 –0.024	0.091	0.032 –0.157	0.78

[a] Fourth instar field-collected larvae from Orbetello lakes, Grosseto, Italy, June–July 1982.
[b] 95% confidence limits.

Table 4. Susceptibility of *Chironomus salinarius*[a] to a wettable powder formulation of *Bacillus thuringiensis* serotype H-14 (Bactimos) in the laboratory.

48-hr lethal concentration (ppm) LC_{50}	C.L.[b]	LC_{90}	C.L.[b]	r^2
0.86	0.86–1.09	5.07	2.85–9.03	0.90

[a] Late 3rd and early 4th instar field-collected larvae from Orbetello lakes, Grosseto, Italy, July 1982.
[b] 95% confidence limits.

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