# ARTICLES

## EFFICACY OF TWO TEMEPHOS FORMULATIONS AGAINST *CHIRONOMUS SALINARIUS* (DIPTERA: CHIRONOMIDAE) IN THE SALTWATER LAGOON OF VENICE, ITALY

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ABSTRACT. Two formulations of the organophosphorus insecticide, temephos (Abathion Granulare, 1% AI granular and Tambro Compresse, 2% AI tablet) were evaluated against *Chironomus salinarius* midge larvae in 50 × 50 m experimental plots in the saltwater lagoon of Venice, Italy. Each formulation was applied at 0.2 and 0.4 kg AI/ha. Abathion Granulare produced 56 to 73% larval reduction at 0.2 kg AI/ha and 69 to 83% reduction at 0.4 kg AI/ha during 3 wk after treatment. Abathion Granulare lost effectiveness at 4 wk after application at both rates. Posttreatment larval reductions resulting from Tambro Compresse applications ranged from 77 to 86% for 3 wk, and 82 to 92% for 4 wk at rates of 0.2 and 0.4 kg AI/ha, respectively. The tablet formulation (Tambro Compresse) gave better control of *C. salinarius* (magnitude and duration) than the granular formulation (Abathion Granulare) in these evaluations.

## INTRODUCTION

In the past 2 to 3 decades, massive swarms of pestiferous chironomid midges have received considerable attention in different parts of the world, especially when originating from urban and/or suburban aquatic habitats. Ali (1991a) provided details of the nuisance and economic problems posed by adult midges and reviewed the various possibilities for their control in different situations. Based on reports from different countries, it is now established that chironomids are also a potential cause of allergies worldwide (Marcer et al. 1990).

Much of the existing literature on chironomid control has focused on freshwater species inhabiting lentic and lotic man-made or natural systems covering <200 ha surface area. Besides freshwater habitats, there are a few shallow saltwater situations, e.g., in southern France (Sinegre et al. 1990) and Italy (Ali and Majori 1984, Ali et al. 1985), that produce chironomids to the degree that they become a serious nuisance to man.

In northeastern Italy, the lagoon of Venice, connected with the Adriatic Sea, spreads over thousands of ha and supports larval densities of *Chironomus salinarius* in excess of 10,000/m$^2$ in some areas (Ferrarese et al. 1990). This lagoon surrounds several islands including Venice, Murano, Burano and others, and faces several isthmic and mainland cities and Marghera Harbor which are adversely impacted by invading midge swarms. These swarms are a serious nuisance and of economic concern to waterfront residents and businesses and to transportation and tourism industries. There is an additional threat of slippery conditions prevailing in multistoried car parking lots (M. Cravero, personal communication) and at the Marco Polo airport (on mainland near Venice) due to massive accumulations of dead midges on driveways and runways. Entry of adult midges into delicate equipment mounted on airplanes also poses a danger and results in economic loss to the aviation industry (Barbato et al. 1990). In addition, chironomid-related allergies have also been reported in this area (Giacomin and Tassi 1988).

To combat the multitude of chironomid problems, the local Department of Public Health (ULSS 16) and the City of Venice (Ecology Section) collectively spend the equivalent of one million U.S. dollars annually on research and control of this pest (T. Ghio, personal communication). Present efforts include routine population assessments of *C. salinarius* larvae and adults to elucidate its spatial distribution in the lagoon (Ferrarese et al. 1990), use of organophosphate and pyrethroid insecticides (as adulticides), and cultural control techniques, such as diverting adult populations by manipulation of their responses to light (Ali et al. 1986). These methods, although providing some relief from adult midges, remain deficient in producing satisfactory control in the relatively large and wide-

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spread areas of infestation. There is an urgent need to explore other options of reducing the pest populations; therefore, the present investigation was conducted to determine the efficacy of temephos as a larvicide against *C. salinarius* in the lagoon.

## MATERIALS AND METHODS

The lagoon is located at approximately 45° 26′ N latitude and 12° 35′ E longitude. It is approximately 48 km long, 14 km wide at its widest point, and covers 55,000 ha. A map of the lagoon with relative locations of Venice, other main islands, Marco Polo airport, industrial zones, Marghera Harbor, etc., was previously provided by Ali et al. (1985). The lagoon is connected to the Adriatic Sea through 3 major openings ranging from 0.5 to 0.8 km in width. Also, there are several sources of freshwater inputs into the lagoon from surrounding land areas. There are numerous marked waterways in the lagoon maintained for navigational purposes.

Water depth in the lagoon ranges from a few cm to almost 1.5 m and is subject to daily increases of up to 1 m or more depending upon the tide. The water is generally turbid, but in most shallow sections the bottom is visible. Water pH ranges from 8 to 11 and salinity from 15 to 38 g NaCl/liter. The nutrient loading to the lagoon is heavy due to input from numerous point and nonpoint sources. The lagoon sediments composition varies spatially. Generally, the peripheral and some interior areas under the influence of organic pollutants have soft and thick deposits of up to 50 cm of decomposing organic matter and mud, while other areas are largely sand bottom covered with pelecypod and gastropod Mollusca.

Larvicidal evaluations were conducted in a northeastern area of the lagoon located between 2 waterways (Canale di Campalto and Canale di Tessera) at about 1–2 km distance from the Marco Polo airport. This area was selected for experimentation because of the relative ease of accessibility and also because previous routine population assessments of *C. salinarius* in this area had shown that it was one of the highest in terms of midge density (Ferrarese et al. 1990). Fifteen 50 × 50 m (0.25 ha) separate experimental plots were established in 3 parallel rows, with 5 plots in each row. Each corner of a plot was demarcated by driving ca. 0.5 m length of a 3 m long wooden pole into the lagoon bottom. Thus, a total of 60 poles were used to mark all 15 plots and each plot was numbered. A distance of 100 m between any 2 adjacent plots was maintained as a buffer zone.

Two formulations of temephos, Abathion Granulare (a granular formulation containing 1% AI manufactured in Italy by S.I.A.P.A. Chemical Industries, Bologna) and Tambro Compresse (a 15 mm diam × 9 mm thick tablet formulation containing 2% AI, manufactured by I.N.D.I.A. Chemical Industries, Padova, Italy) were evaluated. Each formulation was applied at the rates of 0.2 and 0.4 kg AI/ha.

Field applications were made on July 5, 1991, under high tide conditions. Each treatment rate was applied in a randomized complete block design with 3 replicates; 3 plots were left untreated to serve as controls. The required amount of Tambro Compresse in each plot was evenly distributed from a boat by making several equidistant passes in parallel rows in the plot and dispensing the Tambro Compresse by hand. To apply the granular formulation, a 14-liter capacity modified motorized backpack sprayer (Super Jolly®, Volpi and Bottoli, Italy) with air circulation suitable for the application of granular and pellet formulations was used. The amount of Abathion Granulare needed for each plot was mixed with 30 kg of sterile sand and the mixture was dispensed evenly from a boat over the entire plot. The sprayer was calibrated with blank sand prior to the insecticidal applications to ensure a uniform distribution of Abathion Granulare in the treatment plots.

Immediately before the treatments, and at 3 days, and 1, 2, 3, 4 and 5 wk posttreatment, larval densities of *C. salinarius* in the treated and control plots were assessed by randomly collecting 5 benthic mud samples from each plot with a 15 × 15 cm Ekman dredge. A distance of 15–20 m was maintained between any 2 sampling points in a plot. Measurements of water temperature with a maximum-minimum thermometer permanently placed in one plot, water depth, water pH, and salinity in the study area were routinely taken at time of sampling.

In the laboratory, each mud sample was washed through a 325 μm pore nylon net, and the residue of each sample was completely examined to identify and count chironomid larvae. The reductions of midge larval populations in the posttreatment evaluation period were calculated according to the following formula given in Mulla et al. (1971):

$$100 - \left(\frac{C_1}{T_1} \times \frac{T_2}{C_2}\right) 100$$

where $C_1$ = Populations in control plots prior to treatment
$C_2$ = Populations in control plots after treatment
$T_1$ = Populations in treatment plots

prior to treatment
$T_2$ = Populations in treatment plots after treatment.

## RESULTS AND DISCUSSION

*Chironomus salinarius* was the only chironomid in all the samples collected during this investigation. Pretreatment larval densities ranged from 2,244 to 4,620/m$^2$ (Table 1). Tambro Compresse at 0.2 kg AI/ha resulted in a maximum reduction of 86% of *C. salinarius* larvae and 92% at 0.4 kg AI/ha, 1 wk after treatment (Fig. 1). Larval reduction with the lower rate of the Compresse formulation ranged from 77 to 86% during the 3 wk posttreatment. These reductions decreased to 45 and 38% at 4 and 5 wk posttreatment, respectively. The higher rate of Tambro Compresse produced 82 to 92% reduction of larvae during the 4 wk posttreatment and reduction declined to 53% at 5 wk after treatment. Abathion Granulare proved less effective than Tambro Compresse at comparable rates of treatment. At 0.2 kg AI/ha, the granular formulation of temephos gave a maximum of 73% reduction of larvae at 1 wk posttreatment with a reduction range of 56 to 73% during 3 wk posttreatment; the larval populations recovered completely at 4 wk after treatment. The higher rate of Abathion Granulare (0.4 kg AI/ha) produced 69 to 83% reduction of larvae during 3 wk posttreatment. The granular formulation became totally ineffective at week 4 at both treatment rates.

Numerous studies on the field activity of emulsifiable concentrate and granular formulations of temephos against nuisance midges in freshwater habitats have been reported in the literature and reviewed by Ali (1991a). In a saltwater situation, temephos was shown to reduce >90% emergence of midges (including *C. salinarius*) for 3 wk or longer at 0.15 and 0.45 kg AI/ha (Sinegre et al. 1990). This study, how-

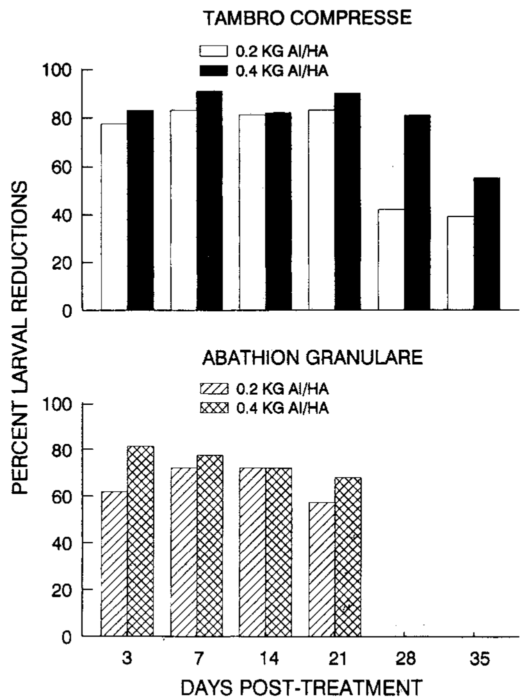


Fig. 1. Percent reductions of *Chironomus salinarius* larvae due to treatments with temephos formulations, Tambro Compresse and Abathion Granulare, each applied at rates of 0.2 and 0.4 kg AI/ha to experimental plots in the lagoon of Venice, Italy.

Table 1. Effects of 2 formulations of temephos (Abathion Granulare 1% and Tambro Compresse 2%), each applied at 0.2 and 0.4 kg AI/ha, on *Chironomus salinarius* larval populations in field plots marked in the saltwater[1] lagoon of Venice, Italy (July–August 1991).

| | Mean no. (± SD) larvae/m$^2$ pre-, and posttreatment (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| Pretreatment | 3 | 7 | 14 | 21 | 28 | 35 |
| Tambro Compresse (0.2 kg AI/ha) | | | | | | |
| 2,816 ± 1,000 | 836 ± 214 | 308 ± 60 | 484 ± 207 | 616 ± 410 | 1,408 ± 810 | 5,676 ± 2,922 |
| Tambro Compresse (0.4 kg AI/ha) | | | | | | |
| 2,904 ± 1,427 | 528 ± 102 | 176 ± 36 | 440 ± 162 | 440 ± 210 | 484 ± 144 | 4,488 ± 1,620 |
| Abathion Granulare (0.2 kg AI/ha) | | | | | | |
| 4,620 ± 2,960 | 2,200 ± 812 | 968 ± 560 | 1,232 ± 616 | 3,168 ± 1,410 | 4,180 ± 3,010 | — |
| Abathion Granulare (0.4 kg AI/ha) | | | | | | |
| 3,300 ± 2,011 | 704 ± 105 | 616 ± 270 | 880 ± 316 | 1,584 ± 940 | 3,258 ± 1,821 | — |
| Control | | | | | | |
| 2,244 ± 641 | 2,860 ± 1,240 | 1,760 ± 712 | 2,244 ± 1,162 | 3,520 ± 1,610 | 2,024 ± 816 | 7,348 ± 5,310 |

[1] Ambient water temperatures: 22–29°C; pH 7.9–8.7; salinity 2.6–2.8%; and water depth 20–95 cm.

ever, was conducted in closed square plots isolated in the field by using <1 $m^3$ plastic boxes.

In the present study, Tambro Compresse gave better control (magnitude and duration) than Abathion Granulare. This may be due to the gradual release of temephos from the Compresse formulation prolonging its residual activity. The importance of using an appropriate sustained-release formulation of a pesticide for chironomid control was recently demonstrated by Ali (1991b). In a dynamic situation, such as the lagoon affected by the daily tidal currents, heavier solid formulations (Tambro Compresse) would probably be less likely to disperse from the targeted area than the granular or liquid formulations. Solid formulations therefore, appear better able to reach the larval biomass in the benthos where sufficient active ingredient is released to provide effective long-term midge control.

Tambro Compresse offers a good potential for *C. salinarius* control in the lagoon of Venice and provides an additional option to combat midge nuisance in the area. This formulation used between 0.2–0.4 kg AI/ha would be economical and will result in a >80% reduction of *C. salinarius* larvae for 3–4 wk despite the daily exchange of water because of the tide. A large-scale application of Tambro Compresse at the rates used in the present study may produce even better control of *C. salinarius* in the lagoon because of the reduced possibility of displacement and dilution of the chemical. In any practical larviciding program in the lagoon, treatment of only partial areas (5–10% of the total lagoon area) supporting *C. salinarius* densities in excess of 10,000/$m^2$ (Ferrarese et al. 1990) would be necessary to significantly reduce midge nuisance in the area.

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