NEW STRATEGIES FOR THE CONTROL OF THE PARTHENOGENETIC CHIRONOMID (*PARATANYTARSUS GRIMMII*) (DIPTERA: CHIRONOMIDAE) INFESTING WATER SYSTEMS

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ABSTRACT. Control of the midge, *Paratanytarsus grimmii*, infesting municipal water systems has proven to be difficult, because it is a parthenogenetic species that can oviposit as a pharate adult and reproduce within the system. Mean densities of *P. grimmii* in a midwestern USA water distribution system ranged from approximately 140 to 560 individuals/sampling date, and all 4 instars and pupae were present throughout the sampling period. Two products were tested as potential chemical controls: Cat-Floc LS®, a coagulant produced by the Calgon Corporation, and 35% hydrogen peroxide, a water purifier. The results of laboratory bioassays showed that Cat-Floc LS over a 15-day period was most effective against *P. grimmii*.

INTRODUCTION

Chironomid larvae commonly infest municipal water supplies (Silvey 1956, Williams 1974, Resh and Grodhaus 1983, Levy et al. 1986, Ali 1991, Bay 1993, Berg 1995). For example, Bay (1993) documented larval midge populations ranging from less than 1 larva/m² to as high as 6,000 larvae/m² inhabiting the benthos of a water reservoir in Tacoma, WA. Complaints occurred when eggs and early instars passed through the purification process and appeared at the consumption end (homes). Control recommendations for this type of midge infestation included enclosing and scouring previously open reservoirs to prevent further oviposition, thus eliminating established populations. Also, installation of microstrainers on reservoir intakes and outputs prevents larval dispersal from natural water supplies and prevents midges from entering distribution systems from reservoirs (Silvey 1956, Resh and Grodhaus 1983, Levy et al. 1986, Bay 1993).

An unusual midge infestation occurred in Essex, England, in the early 1970s that was not resolved with microstrainers (Williams 1974). The reservoirs of the water system were already covered, so microstrainers were installed to prevent further infestation from nearby natural water sources. Infested reservoirs were cleaned and treated with highly chlorinated water, and pH levels were manipulated. The distribution system also was flushed at hydrants to eliminate midge larvae in the system itself. However, consumer complaints continued to rise despite these measures. The chironomid inhabiting the Essex water system was identified as *Paratanytarsus grimmii* (Schneider), a parthenogenetic species. Control was finally achieved with multiple applications of pyrethrins directly to the water distribution system (Williams 1974, Burfield and Williams 1975).

A similar infestation of a municipal water system by *P. grimmii* occurred in Lowell, IN, in late 1987 (Berg 1995). The town's water supply is derived from groundwater sources and is pumped directly into a treatment facility from a series of wells. It is believed the infestation occurred through an air vent in a town water tower. Initial control measures were similar to those carried out in Essex, but, despite these efforts, consumer complaints continued. Because pesticide use in United States water distribution systems is generally not allowed, other chironomid control measures needed to be developed.

Reported here are: 1) the sampling procedures and estimates of the population density and instar distribution of *P. grimmii* in the Lowell, Indiana, water distribution system; and 2) the effectiveness of 2 potentially usable products: a food grade polymer, Cat-Floc LS®, and hydrogen peroxide, a water purifier, as possible control agents for the larval *P. grimmii*.

MATERIALS AND METHODS

Estimates of population density and instar distribution: Five sites were sampled once a month during July, August, and September 1993. Sampling was conducted at fire hydrants in neighborhoods where complaints had been filed by residents. The hydrants were opened and set to a velocity of approximately 454 liters per minute, during which time a standard aquatic drift net (64-µm mesh) (Merritt et al. 1996) was placed over the plume of water for a 5-min period. At the conclusion of the 5-min period, the net was removed and the net residue was placed in vials containing 70% ethanol for later processing. The number of chironomid larvae was counted using a Wild M-5 dissecting microscope at 6× magnification. Instar distribution was determined by measuring larval midge head capsule widths (Langton et al. 1988).

Significant differences in midge densities among sampling dates were determined by conducting a

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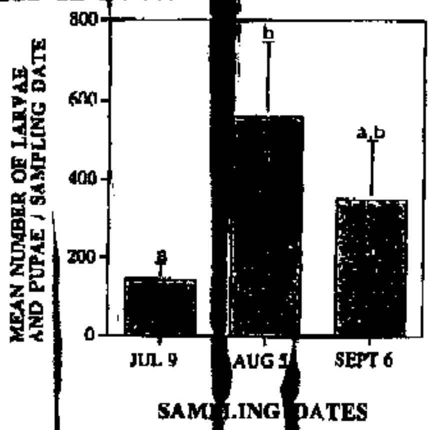

Fig. 1. Population densities of *Paratanytarsus grimmii* larvae and pupae (with standard error) collected from 5 fire hydrants in Lowell, IN, during July, August, and September 1993. Means with the same letter are not significantly different from each other.

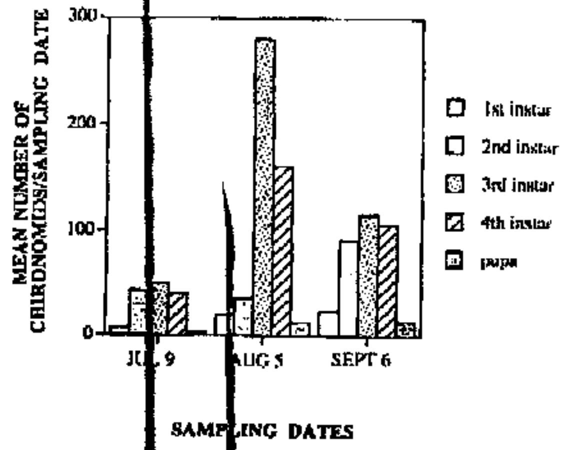

Fig. 2. Larval instar density distribution of *Paratanytarsus grimmii* collected from 5 fire hydrants in Lowell, IN, during July, August, and September 1993.

one-way analysis of variance, with repeated measures, and a single degree-of-freedom polynomial contrast (Wilkinson 1989).

Chemicals evaluated to control P. grimmii *infestation:* Two chemicals were evaluated as potential control agents for larval *P. grimmii*: a food grade polymer, Cat-Floc LS, and hydrogen peroxide (35% standard solution). These 2 chemicals were selected because of their previous use by municipalities in drinking water distribution systems. Cat-Floc LS is a liquid cationic polymer produced by the Calgon Corporation (P. O. Box 1346, Pittsburgh, PA 15230), and approved by the United States Environmental Protection Agency (EPA) as a primary coagulant in water clarification at concentrations not exceeding 100 ppm (Calgon Corporation, Material Safety Data Sheet). It also has shown some success in the control of the zebra mussel (*Dreissena polymorpha* Pallas) in the Great Lakes region of the United States (Hastreiter 1993). The hydrogen peroxide product used was produced by the FMC Corporation (2000 Market St., Philadelphia, PA 19103). It was approved by the EPA and the National Sanitation Foundation for use in water purification at concentrations not exceeding 3 ppm (FMC Corporation, Material Safety Data Sheet).

Short-term and long-term bioassays: Three-day and 15-day static lethality bioassays were conducted in the laboratory against *P. grimmii* larvae using Cat-Floc LS and the 35% H_2O_2 solution. Seven concentrations ranging from a control of 0 ppm to 500 ppm for Cat-Floc LS and 6 concentrations ranging from 0 to 500 ppm for H_2O_2 were used in the 3-day bioassays. Eight and 7 concentrations, ranging from 0 to 100 ppm and from 0 to 200 ppm, were used in the 15-day Cat-Floc LS and H_2O_2 bioassays, respectively. There were 15 replicates per concentration. Each replicate consisted of: 1) 40 ml of the concentration placed in 50-ml cups using water from the Lowell distribution system as solvent; 2) one 2-day-old 1st-instar *P. grimmii*; and 3) 0.15 g of sterilized sand for substrate. Containers were held in a constant-temperature incubator (20 ± 2°C). The concentration in each cup was monitored on a daily basis, and any material loss due to evaporation was replaced. At the conclusion of the short-term (3-day) bioassay, each replicate was examined using a dissecting scope. A larva was considered dead if it did not respond when touched with a probe. For the long-term (15-day) bioassay, 20 ml of solution was removed from each replicate and replaced with fresh solution every 2 days through day 14. This procedure allowed for the removal of excess larval waste products and maintained adequate dissolved oxygen concentrations. Larvae were fed 5 g/day of a 20 mg/ml blended minnow food. After 15 days, mortality was examined as described above. Results of both assays were analyzed using probit analysis (Finney 1971).

RESULTS

Population density and instar distribution: Monthly population density data for *P. grimmii* (Fig. 1) were found to be significantly different between July and August ($P = 0.05$), but not between July and September ($P = 0.19$) or August and September ($P = 0.10$). Results from the instar distribution study are shown in Fig. 2. All 4 larval instars and pupae were found throughout the sampling period.

Bioassays: The results from the 3-day and 15-day static lethality bioassays are shown in Table 1. In all bioassays, control mortality equaled 0%. In the 3-day bioassay, Cat-Floc LS and the 35% H_2O_2 solution showed LC_{50} values of 112 and 125 ppm, respectively. These values were not significantly different. However, in the 15-day bioassay, the Cat-Floc LS LC_{50} value of 1[illegible] ppm was significantly lower than the 51 ppm LC_{50} of the 35% H_2O_2 solution.

Table 1. Three-day and 15-day LC_{50} values in ppm (including 95% confidence intervals [CIs]) of Cat-Floc LS® and 35% H_2O_2 against *Paratanytarsus grimmii* larvae in the laboratory.

Material	Duration	LC_{50}	95% CI
Cat-Floc LS	3 days	112	71–185
35% H_2O_2	3 days	125	91–167
Cat-Floc LS	15 days	13	9–19
35% H_2O_2	15 days	51	33–82

DISCUSSION

The instar distribution study revealed the presence of all 4 larval instars and pupae during the entire sampling period; however, there were fewer 1st instars in all samples. Possible explanations for the low number of 1st instars were: 1) the sample size was insufficient; 2) sampling occurred from mid- to late-summer (July–September), and 1st-instar densities may have been present earlier in the season and therefore missed in our sampling schedule; and 3) 1st instars were present in the distribution system throughout the sampling period but either were not effectively flushed from the system or were concentrated in some other areas of the system. The midge population structure probably had multiple cohorts throughout the sampling period, a phenological characteristic that has strong implications for the design and timing of control efforts.

The short-term (3-day) bioassay showed that neither product at the concentration used was effective at controlling these chironomids. With a longer application time, however, Cat-Floc LS was useful in controlling or suppressing midges. Tests showed that early instars were more susceptible to both chemicals than later instars. Therefore, control of the chironomids in the distribution system would be most successful if the application took place in conjunction with the presence of predominantly 1st instars. The existence of multiple cohorts of *P. grimmii* throughout the sampling period indicates the need for an even longer application time to insure effective control of the infestation. An application of Cat-Floc LS at 10–20 ppm for a period of 30 days might be effective for controlling *P. grimmii*.

An additional factor that must be considered before any application of Cat-Floc LS is the initial concentration added to the system. If an application of 10–20 ppm of Cat-Floc LS was permitted, what concentration of Cat-Floc LS must be added to the system to insure that all portions of the system receive a 10–20-ppm concentration? Cat-Floc LS is a coagulant and therefore would bind with any suspended particles in the water column, reducing its concentration in the downstream portion of the system.

Our results were presented to the City Council of Lowell, Indiana, and the appropriate governmental state agencies in 1994. Both 3-day LC_{50}s were above the allowable limits for Cat-Floc LS (100 ppm) and H_2O_2 (3 ppm), but 15-day LC_{50}s were below the limit for Cat-Floc LS but not for H_2O_2. Considering the results of our research and the lack of human health concerns from the midge infestation, the decision was made not to use either Cat-Floc LS or the 35% H_2O_2 solution as control agents. However, Cat-Floc LS was to be used as a coagulant following water treatment to remove the main food source of larval *P. grimmii*, dead sulfur- and iron-reducing bacteria (Berg 1995).

For reasons unknown to us, sampling during the spring of 1994 revealed the absence of *P. grimmii* populations in the Lowell, Indiana, potable water system. Therefore, Cat-Floc LS was not used as a coagulant. The occurrence of chironomid infestations in public water supplies is not uncommon in the United States and elsewhere; however, most infestations go unnoticed by water consumers (Berg 1995). Results from this study offer possibilities for control of *P. grimmii* when future infestations reach nuisance levels.

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